DOE/NV-429

Nevada Environmental Restoration Project

# Corrective Action Investigation Plan: Cactus Spring Waste Trenches

Controlled Copy No.: UNCONTROLLED

Revision: 2

February 1997

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Environmental Restoration Division

U.S. Department of Energy
Nevada Operations Office

DOE/NV--429

# CORRECTIVE ACTION INVESTIGATION PLAN: CACTUS SPRING WASTE TRENCHES

DOE Nevada Operations Office
Las Vegas, Nevada

UNCONTROLLED
Controlled Copy No.: ___

Revision: 2

February 1997

## DISCLAIMER

**Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.**

**CORRECTIVE ACTION INVESTIGATION PLAN:**
**CACTUS SPRING WASTE TRENCHES**

Approved by: Sabine T. Curtis Date: 7/30/96
Sabine T. Curtis, Manager
Industrial Sites Subproject

Approved by: Janet Appenzeller-Wing Date: 7/30/96
for David S. Shafer, Acting Project Manager
Nevada Environmental Restoration Project

# Table of Contents

List of Figures . . . . . . . . . . iii

List of Tables . . . . . . . . . . iv

List of Acronyms and Abbreviations . . . . . . . . . . v

1.0 Introduction . . . . . . . . . . 1-1
1.1 Purpose . . . . . . . . . . 1-1
1.2 Scope . . . . . . . . . . 1-1
1.3 Federal Facility Agreement and Consent Order Requirements . . . . . . . . . . 1-1

2.0 Facility Description . . . . . . . . . . 2-1
2.1 Historical Information . . . . . . . . . . 2-1
2.2 Investigative Background . . . . . . . . . . 2-1
2.3 Waste Inventory . . . . . . . . . . 2-3
2.4 Release Information . . . . . . . . . . 2-3

3.0 Objectives . . . . . . . . . . 3-1
3.1 Conceptual Model . . . . . . . . . . 3-1
3.2 Data Quality Objectives . . . . . . . . . . 3-5
3.2.1 Problem Statement . . . . . . . . . . 3-5
3.2.2 Identification of Decision . . . . . . . . . . 3-6
3.2.3 Identification of Inputs to the Decision . . . . . . . . . . 3-6
3.2.4 Definition of the Study Boundaries . . . . . . . . . . 3-7
3.2.5 Development of Decision Rules . . . . . . . . . . 3-9
3.2.6 Specifications on Decision Error Limits . . . . . . . . . . 3-9
3.2.7 Optimization of the Design for Obtaining Data . . . . . . . . . . 3-10
3.3 Technical Approach . . . . . . . . . . 3-10

4.0 Corrective Action Investigation . . . . . . . . . . 4-1
4.1 Soil Sampling Approach . . . . . . . . . . 4-1

## *Table of Contents (Continued)*

5.0 Waste Management Plan ..... 5-1
5.1 Waste Minimization ..... 5-1
5.2 Potential Waste Streams ..... 5-1
5.3 Waste Determination ..... 5-2
5.4 Waste Management ..... 5-2

6.0 Reporting ..... 6-1

7.0 References ..... 7-1

Appendix A - Leachate Transport Evaluation Model Results ..... A-1
Appendix B - Response to NDEP Comments ..... B-1
Appendix C - Technical Changes ..... C-1

# List of Figures

| Number | Title | Page |
|---|---|---|
| 1-1 | Tonopah Test Range Location Map | 1-2 |
| 2-1 | Location of the Cactus Spring Waste Trenches, Tonopah Test Range | 2-2 |
| 2-2 | Site Location Map of the Cactus Spring Waste Trenches | 2-4 |
| 3-1 | Conceptual Site Model for the Cactus Spring Waste Trenches | 3-2 |
| 3-2 | Cross-Sectional Schematic of Potential Area Affected by Leachate From the Cactus Spring Waste Trenches | 3-4 |
| 3-3 | Soil Boring Location Map for the Cactus Spring Waste Trenches | 3-8 |
| 4-1 | Generalized Decision Logic for Corrective Action Site Sampling | 4-3 |

# *List of Tables*

| Number | Title | Page |
|---|---|---|
| 4-1 | Summary of Soil Sampling Requirements | 4-4 |
| 5-1 | Action Levels for IDW Contaminants | 5-2 |

## List of Acronyms and Abbreviations

| | |
|---|---|
| bgs | Below ground surface |
| BN | Bechtel Nevada Corporation |
| CADD | Corrective Action Decision Document |
| CAIP | Corrective Action Investigation Plan |
| CAS | Corrective Action Site(s) |
| CAU | Corrective Action Unit(s) |
| Cd | Cadmium |
| CFR | Code of Federal Regulations |
| DOE | U.S. Department of Energy |
| DOE/NV | DOE Nevada Operations Office |
| DOT | U.S. Department of Transportation |
| DQO | Data Quality Objective(s) |
| EPA | U.S. Environmental Protection Agency |
| EQL | Estimated Quantitation Limit |
| ER | Environmental Restoration |
| ERP | Environmental Restoration Project |
| FFACO | Federal Facility Agreement and Consent Order |
| ft | Foot (feet) |
| gal | Gallon(s) |
| HASP | Health and Safety Plan |
| HELP | EPA Hydrologic Evaluation of Landfill Performance |
| Hg | Mercury |
| IDW | Investigation-derived waste |
| in. | Inch(es) |
| INEL | Idaho National Engineering Laboratory |
| IT | IT Corporation |
| km | Kilometer(s) |
| $km^2$ | Square kilometer(s) |
| LLW | Low-level waste |
| m | Meter(s) |
| $m^3$ | Cubic meter(s) |

## *List of Acronyms and Abbreviations (Continued)*

| | |
|---|---|
| MCL | Maximum Contaminant Level |
| MEK | Methyl ethyl ketone |
| mg/kg | Milligram(s) per kilogram |
| mg/L | Milligram(s) per liter |
| mi | Mile(s) |
| NAC | Nevada Administrative Code |
| NDEP | Nevada Division of Environmental Protection |
| NEPA | National Environmental Policy Act |
| PCB | Polychlorinated biphenyl(s) |
| pCi/g | PicoCurie(s) per gram |
| PPE | Personal Protective Equipment |
| ppm | Part(s) per million |
| Pu | Plutonium |
| QA/QC | Quality Assurance/Quality Control |
| QAPP | Quality Assurance Project Plan |
| RCRA | Resource Conservation and Recovery Act |
| SVOC | Semivolatile Organic Compound(s) |
| TC | Toxicity Characteristic |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TPH | Total Petroleum Hydrocarbon(s) |
| TRU | Transuranic |
| TTR | Tonopah Test Range |
| U | Uranium |
| VOC | Volatile Organic Compound(s) |
| $yd^3$ | Cubic yard(s) |

# 1.0 Introduction

This Correction Action Investigation Plan (CAIP) has been developed in accordance with the Federal Facility Agreement and Consent Order (FFACO) agreed to by the U.S. Department of Energy, Nevada Operations Office (DOE/NV), the Nevada Division of Environmental Protection (NDEP), and the U.S. Department of Defense. A CAIP is a document that provides or references all of the specific information for planning investigation activities associated with Corrective Action Units (CAUs) or Corrective Action Sites (CASs) (FFACO, 1996).

This CAIP contains environmental sample collection objectives and logic for the CAU No. 426, which includes the Cactus Spring Waste Trenches, CAS No. RG-08-001-RG-CS. The Cactus Spring Waste Trenches are located at the Tonopah Test Range (TTR) which is part of the Nellis Air Force Range, approximately 255 kilometers (km) (140 miles [mi]) northwest of Las Vegas, Nevada, by air (Figure 1-1). This CAIP will be implemented in accordance with the FFACO (1996), the *CAU Work Plan for the Tonopah Test Range, Nevada* (DOE, 1996a), the *Industrial Sites Quality Assurance Project Plan* (QAPP) (DOE, 1994a), and all applicable NDEP policies and regulations (NDEP, 1994).

## 1.1 Purpose

The purpose of this investigation is to generate sufficient data to establish the types of waste buried in the trenches, identify the presence and nature of contamination, determine the vertical extent of contaminant migration below the Cactus Spring Waste Trenches, and determine the appropriate course of action for the site. The potential courses of action for the site are clean closure, closure in place (with or without remediation), or no further action.

## 1.2 Scope

The scope of this investigation will include drilling and collecting subsurface samples from within and below the trenches. Sampling locations will be biased toward the areas most likely to be contaminated.

## 1.3 Federal Facility Agreement and Consent Order Requirements

The FFACO requires that CAIPs address the following elements: management, technical aspects, quality assurance, health and safety, public involvement, field sampling, and waste

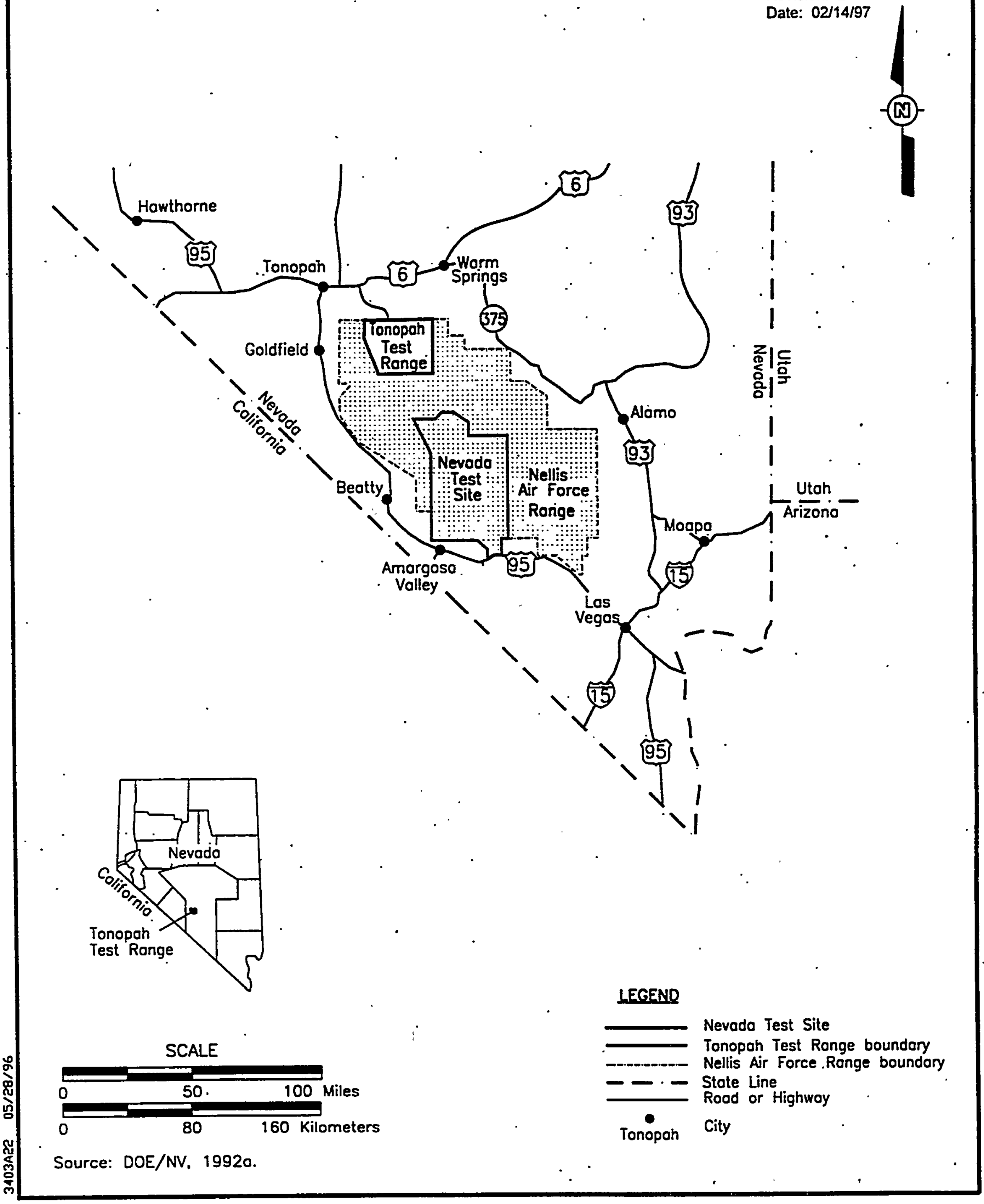



**Figure 1-1**
**Tonopah Test Range Location Map**

management. All of these elements have been accounted for in project documentation. The managerial aspects of this project are discussed in the DOE/NV *Environmental Restoration Project* (ERP) *Management Plan.* The technical aspects of this CAIP are contained in the TTR CAU Work Plan (DOE, 1996a) and in this document. Field and laboratory quality assurance and quality control (QA/QC) issues are detailed in the Industrial Sites QAPP (DOE, 1994a), and the specific aspects of field QA/QC are also discussed in approved procedures. The health and safety aspects of this project are documented in the DOE/NV ERP Health and Safety Plan (HASP) (DOE, 1994b) and will also be supplemented with a site-specific HASP written just prior to commencement of field work. Public involvement is documented in the *Public Involvement Plan* in Appendix V of the FFACO (1996). Field sampling activities are documented in Section 4.0 of this CAIP; waste management is discussed in the TTR CAU Work Plan (DOE, 1996a) and in Section 5.0 of this CAIP. Reporting requirements and project schedule information are discussed in Section 6.0 of this CAIP.

# 2.0 Facility Description

## 2.1 Historical Information

The Cactus Spring Waste Trenches Site (also referred to as the "trenches") is identified as one of three potential locations for buried, radioactively contaminated materials from the Double Tracks Test (the other locations are discussed in Appendix B of the CAU Work Plan [DOE, 1996a]). The Double Tracks Test was the first of four storage-transportation tests conducted in 1963 as part of Operation Roller Coaster. The experiment involved the use of live animals to assess the inhalation uptake of a plutonium aerosol (Wilson, 1965).

The trenches are located on the east flank of the Cactus Range in the eastern portion of the Cactus Spring Ranch (Figure 2-1). Facilities constructed at the Cactus Spring Ranch to support the Operation Roller Coaster Double Tracks Test served as an animal holding compound and a laboratory. See Appendix B.5.0 in the CAU Work Plan (DOE, 1996a) for additional site information.

The trenches can be seen as four parallel excavations in oblique aerial photographs taken in 1963 (Wilson, 1995a). The trenches were dug for the purpose of receiving waste generated during Operation Roller Coaster, primarily the Double Tracks Test. The trenches may contain animal carcasses and feces, and chemical, radioactive, municipal, and construction waste generated during the test operation. A historic photograph of one of the trenches shows garbage and construction debris in the trench (Wilson, 1995a). The other components of the waste trenches are unknown; however, based on an understanding of the waste operations associated with the Roller Coaster Tests, the contents of the Roller Coaster Lagoons North Disposal Trench may be indicative of the type of materials disposed of in the Cactus Spring Waste Trenches (see Section 2.0 in DOE, 1996b) with the exception of ordnance. It is believed that the Cactus Spring Waste Trenches do not contain ordnance because (1) there is a great physical separation between the testing range and the range clean-up areas, and (2) ordnance was typically collected and staged in proximity to the test location.

## 2.2 Investigative Background

A geophysical survey conducted by IT Corporation (IT) in 1995 (IT, 1995) verified the estimated locations of the trenches by revealing four magnetic anomalies with varying amplitudes. The anomalies correlate to subtle surface depressions that exist in the area of the trenches and are

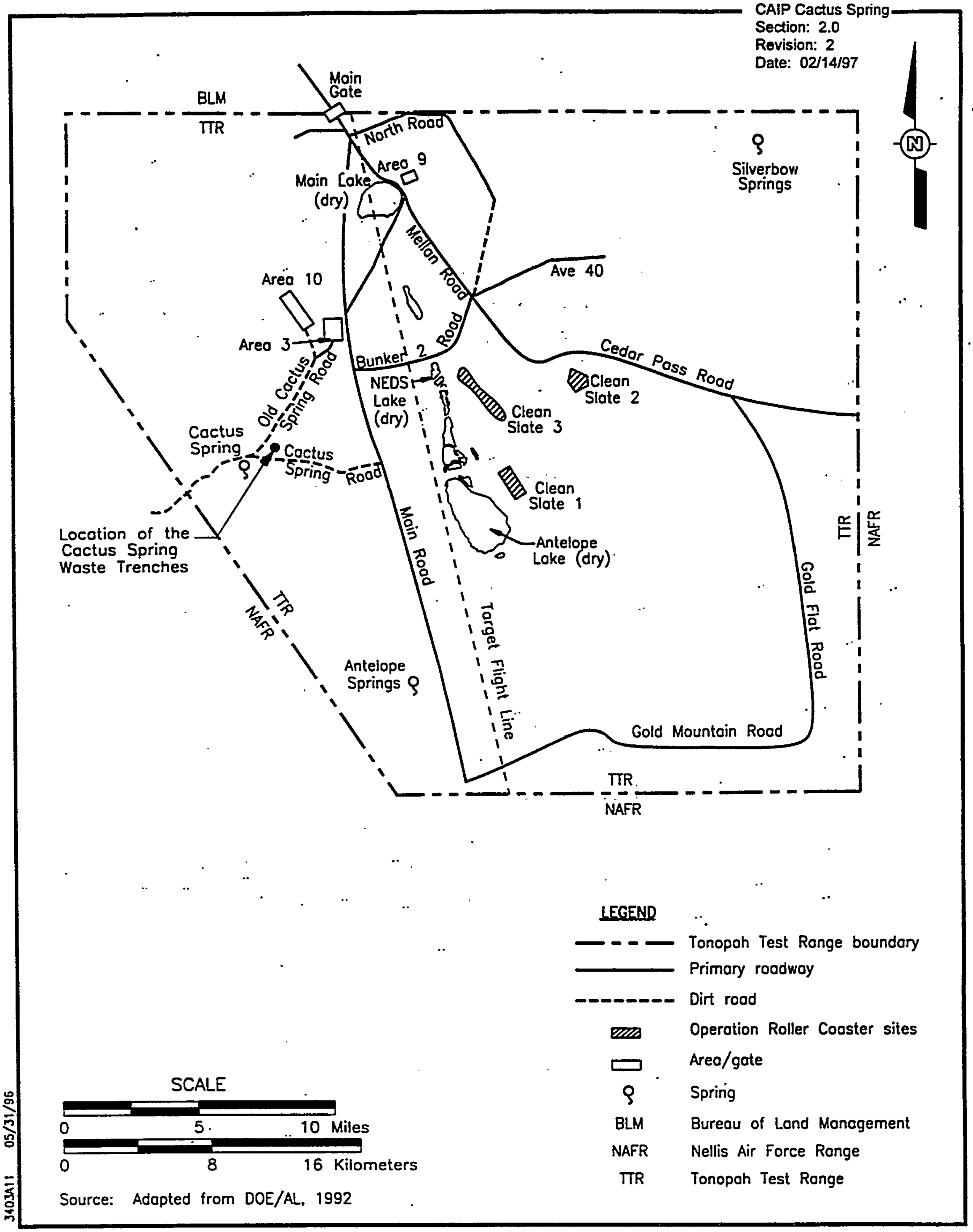



**Figure 2-1**
**Location of the Cactus Spring Waste Trenches, Tonopah Test Range**

thought to approximate the location and dimensions of the trenches; however, there is still uncertainty as to the depth of the trenches and the exact width of the undisturbed sections between the trenches. Figure 2-2 shows the locations of the trenches.

Using the geophysical survey results and process knowledge, scientists estimated the dimensions of each trench to be approximately 5 meters (m) in width by 27 to 30 m (15 feet [ft] by 90 to 100 ft) in length, with the long axis oriented approximately east-west. The depth of the trenches is estimated to be approximately 2 m to 3 m (7 ft to 10 ft).

In addition to the geophysical survey results, other sources of information were evaluated including site reconnaissance documentation, review of historical documents, interviews with former TTR employees, and inspection of historic photographs (i.e., surface and aerial photographs and documentary motion pictures).

### *2.3 Waste Inventory*

The trenches were excavated for the purpose of receiving waste generated during Operation Roller Coaster, primarily the Double Tracks Test. It is not known exactly what type or amount of waste was disposed of in the trenches because inventories were not kept. However, based on process knowledge, the trenches may contain waste from animal autopsies, animal feces, municipal waste, construction waste, pesticides, minor amounts of laboratory chemicals, and minor amounts of radioactive materials related to the Double Tracks Test. The radioisotopes, if present, may be associated with shroud fabric which covered animals during the test. The trenches were used for approximately three months during the spring and early summer of 1963 (Wilson, 1995b).

Based on the estimated trench dimensions discussed in Section 2.2 (assuming a trench depth of 2.4 m [8 ft] and a trench length of 30 m [100 ft], the volume of waste per trench is estimated to be approximately 360 cubic meters ($m^3$) (444 cubic yards [$yd^3$]), not including the estimated soil cover thickness of 0.6 m (2 ft). A small percent of the total volume per trench is assumed to be liquid.

### *2.4 Release Information*

Historical knowledge indicates the primary waste components buried in the trenches are probably solid, rather than liquid materials. Based on historical photograph review, solid materials identified within the trenches include boards, cardboard, paper, culvert piping, wire, and soil

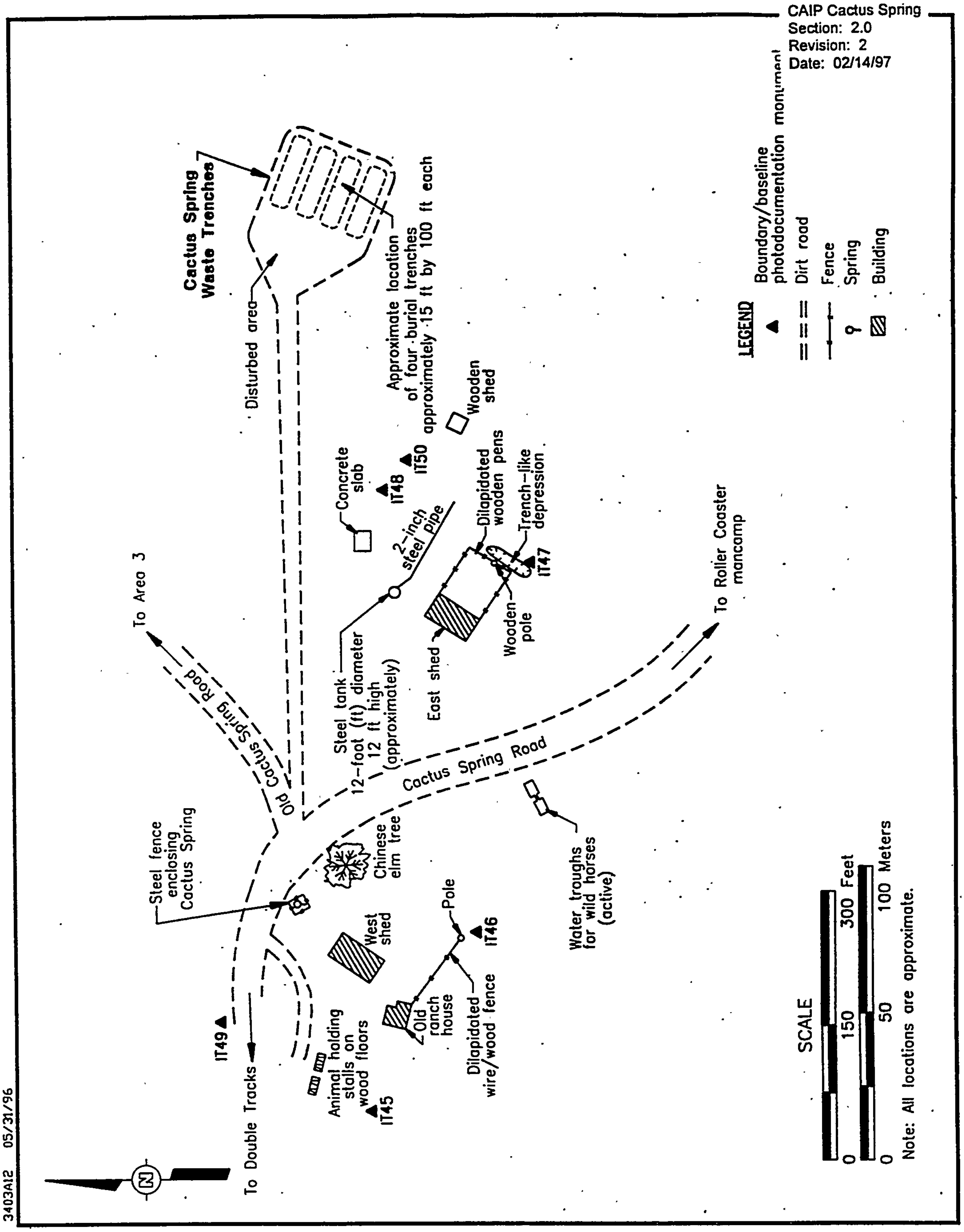



**Figure 2-2**
**Site Location Map of the Cactus Spring Waste Trenches**

(Wilson, 1995a). Other solid materials which may have been disposed of include animal remains from autopsies, laboratory glassware, surgical instruments, lead acid batteries, and animal feces. In addition, layers of soil and lime which would contribute to the overall volume of waste in the trenches were probably applied to the animal remains in order to control vectors (i.e., flies) and odors.

Liquids suspected to have been disposed of and/or released in minor amounts in the trenches include waste oil, paints, paint thinner, gasoline, diesel fuel (DOE, 1996a), pesticides, and methyl ethyl ketone (Sygitowicz, 1995). These liquids were probably mostly associated with ranch operations and waste disposal activities similar to those at Roller Coaster Lagoon North Disposal Trench (DOE, 1996a).

These trenches may or may not be the location of the muslin shrouds which covered the animals during the Double Tracks Experiment. Conflicting reports from former experiment participants (Sorem, 1993; Penwell, 1995) and a vague description in an Operation Roller Coaster report (Wilson, 1965) indicate this is not the likely location of the shrouds. Information from the interviewees and the report indicates the shrouds were removed immediately after the shot and disposed of at the Double Tracks Rad Safe/Muster Station area (Appendix B.3.3, DOE, 1996a). If the shrouds are present, they may have radioactive contamination adhering to them consisting of plutonium and depleted uranium. Other potential radioactive materials sources are not considered to be significant because of the following reasons:

- Decontamination following the Double Tracks Experiment occurred at a radiation decontamination area located in close proximity to the shot (e.g., the Double Tracks Rad Safe Area).
- The animal organs containing radioisotopes (e.g., the lungs) were shipped off site (Wilson, 1995b).
- The personnel protective equipment (PPE) was sent for laundering to the Nevada Test Site rather than being disposed of in the trenches (Sygitowicz, 1995).

The former Project Officer for Biological Studies for Operation Roller Coaster reported that a conscious effort was made to keep extraneous radiation away from the Cactus Spring Ranch in order to minimize interference with the animal experiments (Wilson, 1995b). Personnel who worked at the Cactus Spring Ranch are assumed to have been free from radioactive contamination; therefore, wastes associated with them (such as PPE) would be free from contamination.

A list of potential contaminants of concern based on field and historical knowledge are:

- Inorganics
- Volatile organic compounds (VOCs)
- Semivolatile organic compounds (SVOCs)
- Pesticides
- Hydrocarbons
- Plutonium (Pu)
- Uranium ($U^{238}$)

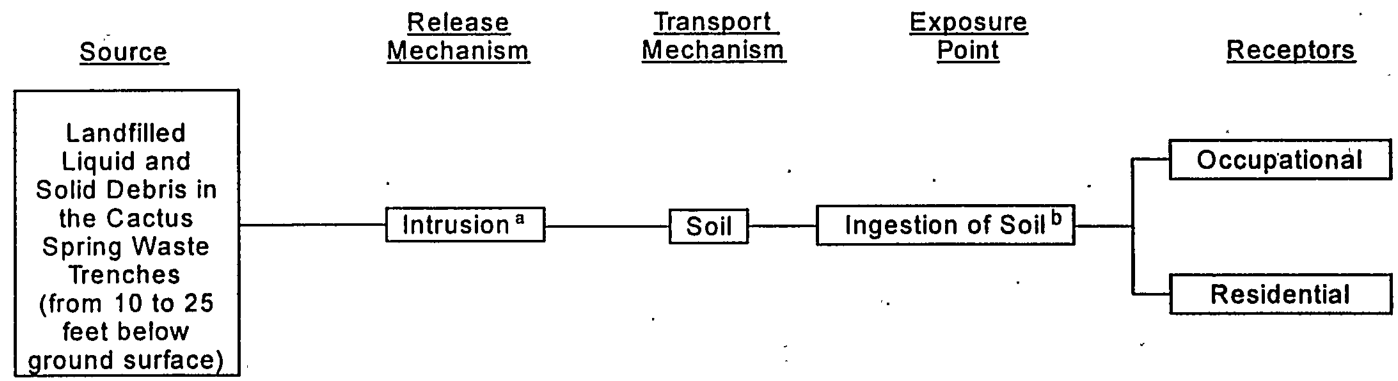
# 3.0 Objectives

The sampling objectives were determined using the data quality objective (DQO) process outlined by the U.S. Environmental Protection Agency (EPA) in their *Guidance for the Data Quality Objectives Process* (1994). The DQOs are qualitative and quantitative statements that specify the quality of the data required to support potential courses of action for the trenches. The DQOs were developed to clearly define the purpose(s) for which environmental data will be used and to design a data collection program that will satisfy these goals. One tool used in the DQO process is the formulation of site conceptual models.

## 3.1 Conceptual Model

A conceptual model has been developed to postulate potential exposure pathways from likely contaminant sources at the trenches (Figure 3-1). The model is based on assumptions formulated primarily from process knowledge and analogous sites. If the conceptual model is proven incorrect from the results of environmental sampling, then NDEP will be notified and the site rescoped. The following statements are the primary assumptions that were considered regarding the Cactus Spring Waste Trenches:

- The debris that was disposed of is heterogeneous in nature; however, its potential leachate is relatively homogeneous.
- Groundwater (although depth to groundwater is undetermined) is not thought to have been impacted because liquids were not disposed of in large quantities, and the environmental conditions at the site (i.e., the desert) are not conducive to downward migration.
- There are no significant sources of volatile constituents or radiation in the trenches; therefore, a direct exposure hazard does not exist.
- Intrusion by site personnel (or future land users such as ranchers or miners) into the trenches may be a hazard because the site is not posted with signs or restricted by fences. Because of this, the potential for exposure to contaminated soil or to waste exists.
- Although surface water could pond on the trenches, the volume of contaminated source material and/or hazardous waste is assumed to be low, and infiltration of surface water is not anticipated to cause significant contaminant migration.




[a] The intrusion release mechanism encompasses present workers and future workers/residents. Any health impacts to current site workers will be discussed in the Site-Specific Health and Safety Plan.

[b] "Ingestion of soil" includes general consumption through the mouth or nose and includes inhalation of vapors and dermal contact.

ttr\caip\cactus\fig_3-1 pre

**Figure 3-1**
**Conceptual Site Model for the Cactus Spring Waste Trenches**

The following statements are known facts regarding the Cactus Spring Waste Trenches:

- Aerial and surface photographs (Wilson, 1995a) as well as the geophysical survey (IT, 1995) have established the approximate location of the trenches and their approximate length, width, and depth.

- The trenches were used for waste disposal for a relatively short duration of time (Wilson, 1995b).

- The waste is covered; therefore, exposure to contaminated dust is mitigated by the soil cover.

- Encroachment from a nearby arroyo may have the potential to erode the edge of the southernmost trench. If erosion of a small portion of the surface cover of the southernmost trench occurred, it is possible that buried waste, if present, may be exposed.

These factors were considered, and from them a conceptual model was created (Figure 3-1). Based on this data, it was conceptualized that the primary contaminant source in the trenches is landfilled liquid and solid debris from which leachate may potentially have been created. The primary area affected is located immediately beneath the trenches from approximately 3 m to 7.6 m (10 ft to 25 ft) below ground surface (bgs) (Figure 3-2). Leachate, if present, is assumed not to have migrated laterally much beyond the waste trench boundaries.

The conceptual model indicates that the site has only a shallow soil source and one exposure route, ingestion of soil. Intrusion into the site (such as digging with a backhoe or from a future land user such as a rancher) could disturb the soil or unearth the waste and cause a release of contamination. If the soil is contaminated, ingestion of the soil (or general consumption through the mouth or nose) could be a potentially harmful exposure route. Site access is not restricted by fences or posted with signs, and the potential for inadvertent disturbance exists. In addition, the potential for exposure of waste in the southernmost trench exists because intermittent flow within an arroyo adjacent to the site may cause some encroachment to the south side of the trench. Management of this small, localized erosional problem will be evaluated and presented in the Corrective Action Decision Document (CADD) prepared for this CAU.

Environmental sample data will be used to determine a course of action for this site. If environmental sample data indicate that no analytes are above the following criteria, then no further action or closure in place will be recommended:

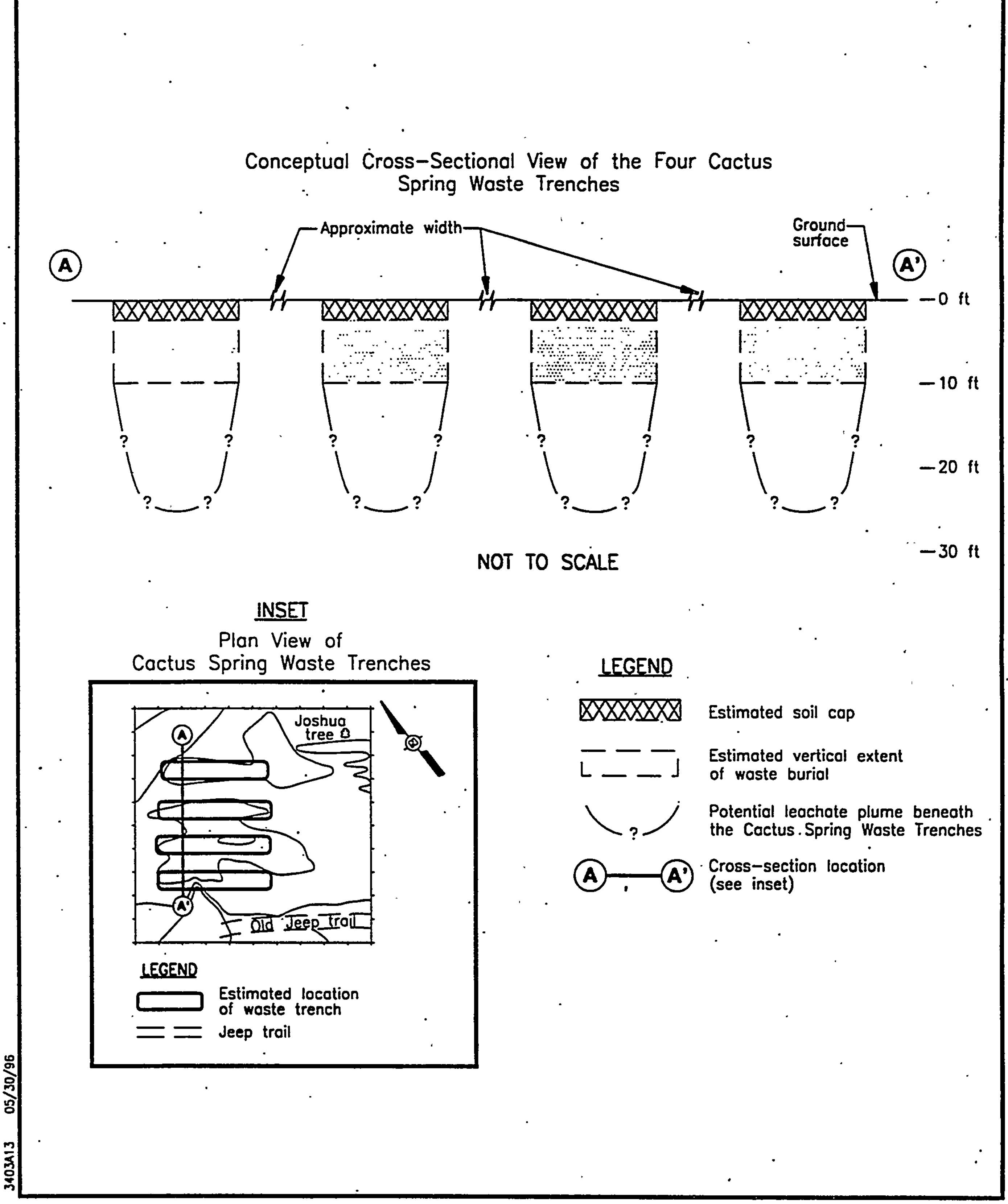



**Figure 3-2**
**Cross-Sectional Schematic of Potential Area Affected by Leachate From the Cactus Spring Waste Trenches**

- Resource Conservation and Recovery Act (RCRA)-calculated Toxicity Characteristic Leaching Procedure (TCLP) limits for VOCs, SVOCs, or metals (CFR, 1996)

- 100 milligrams per kilogram (mg/kg) for total petroleum hydrocarbons (TPHs) (NDEP, 1994)

- 100 times the maximum contaminant level (MCL) (RCRA Subpart S criteria) (NDEP, 1994)

- Alpha/gamma radiation detected above 10 picoCuries per gram (pCi/g) for depleted uranium ($U^{238}$) or 0.5 pCi/g for Pu (BN, 1995).

If environmental data detect analytes which exceed the criteria, then either closure in place or clean closure will be recommended. Closure in place or clean closure will entail characterization of the leachate plume, removal of the source (worst case), and/or containment of contamination. Although not anticipated, reassessment of the site is also an option, depending on the type and extent of contamination. If reassessment is deemed necessary, NDEP will be notified.

After sampling, if it is determined that the groundwater may be impacted, then the NDEP will be notified, the site rescoped, and the groundwater pathway will be investigated. The site is, however, not anticipated to contain contaminants at concentrations greater than regulatory clean-up action levels. In addition, contamination, if present, is anticipated to be managed so that further migration of a leachate plume is prevented.

### 3.2 Data Quality Objectives

The DQO process is a systematic planning tool for establishing criteria for data quality and for developing data collection programs. It is an iterative, seven-step process which results in a design to collect the right type, quality, and quantity of data needed to support a course of action for the site. The DQOs were developed to clearly define the purpose(s) for which environmental data will be used and to design a data collection program that will satisfy these goals. The seven steps and their applications to the Cactus Spring Waste Trenches are discussed in the following text.

#### 3.2.1 Problem Statement

Unregulated disposal activity was conducted in 1963 at the Cactus Spring Waste Trenches. Although process knowledge indicates that the trenches contain debris and waste from the animal holding facility (associated with the Double Tracks test), it is unknown if hazardous materials, which may have caused contamination above regulatory thresholds, were disposed of in the trenches. Furthermore, if contamination is present in the trenches, it is not known if the contamination is migrating below the trenches. For more background information see Sections 2.0 and 3.1.

### *3.2.2 Identification of Decision*

There are two decisions to be made with regard to the potential threat the Cactus Spring Waste Trenches pose to human health and the environment. The first decision is whether or not hazardous and/or radioactive materials have been disposed of in the trenches. The second decision is whether or not the soil below the trenches is contaminated (above regulatory limits) with constituents of RCRA-characteristic hazardous waste and/or radioactive materials. Process knowledge is not sufficient to make these determinations. Therefore, these decisions will be determined from the analytical results of environmental sampling. The sampling program includes: 1) sampling the contents of the trenches and 2) sampling the *in situ* soil below the trenches to determine if constituents of hazardous and/or radioactive waste are present and, if so, to what vertical extent. The possible contaminants of concern (see Section 2.4) are based on limited process knowledge and past waste disposal practices conducted at the Roller Coaster North Disposal Trench (see DOE, 1996b).

More information is provided in Section 2 (brief history of the site including release information), Section 3.1 (assumptions and uncertainties associated with the site), and Table 4-1 (soil sampling requirements) of this report.

### *3.2.3 Identification of Inputs to the Decision*

Contaminated materials may be present in the trenches; if so, contamination is likely to be located immediately beneath the trenches in the form of a leachate plume. A model was run to evaluate the potential for contaminants to leach and determine how far they may have traveled vertically. This information is presented in Appendix A of this CAIP. Based on the model results, using conservative parameters, the soil area beneath the trenches (up to approximately 25 ft below the ground surface) is potentially affected by the leachate. This area will be investigated and sampled. The constituents of concern are not well documented by process knowledge; therefore, the laboratory analysis will include total VOCs, total SVOCs, TPH, total pesticides, RCRA metals, and gamma/alpha spectroscopy. Table 4-1 presents a summary of the soil sampling requirements. Identification of these constituents by laboratory analysis will provide information about the concentration and extent of contamination and will determine the course of action for the site (i.e., closure in place, clean closure).

The available historical information for this site is mostly incomplete and/or highly subjective; therefore, process knowledge is insufficient to confirm the presence of RCRA listed wastes in the trenches. There is, however, limited evidence to suggest that small quantities of methyl ethyl ketone (MEK) (MEK is an "F" listed waste when used as a solvent) were used as a cleaner/solvent in association with Rad Safe activities during Operation Roller Coaster (Sygitowicz, 1995). The animal holding facility was intentionally kept isolated from any Rad Safe activity to minimize extraneous radiation exposure to the animals (Wilson, 1995b). However, because of the remote location of the animal holding facility (and associated trenches), the possibility exists that the trenches may have on occasion, received debris from Rad Safe activities rather than having the debris transported for proper disposal at the Roller Coaster Rad Safe Area. This is not deemed likely due to the strict radiological controls that were established for the operation. Regardless, if MEK is present in the trenches or soil, the laboratory analytical method selected for total VOCs (e.g., EPA 8240) has a method detection level established that is low enough to satisfy the land disposal restriction limit for MEK. If MEK is detected above the land disposal limit, then investigation-derived waste (IDW) and remediation waste will be treated as a "F" listed waste and will be subject to land disposal restrictions accordingly. Due to the lack of adequate process knowledge that is required to determine which of the listed waste codes would be appropriate, any contaminated soils (other than soil contaminated with MEK above regulatory limits) removed during a future remediation would be considered characteristic waste unless new process knowledge and/or sampling indicates otherwise.

### *3.2.4 Definition of the Study Boundaries*

The physical definition of the investigation boundaries includes: 1) a vertical profile from ground surface to approximately 3 m (10 ft) below ground surface to assess the contents of each trench and 2) soil potentially affected by leachate migration below the bottom of the trenches, which extends from approximately 3.6 m (10 ft) below ground surface to approximately 8 m (25 ft) below ground surface. Appendix A presents the results of models that were run in order to help answer the question of how far leachate could potentially migrate below the trenches. Figure 3-2 presents a schematic cross-sectional view of the trenches; Figure 3-3 depicts a plan view of the trenches.

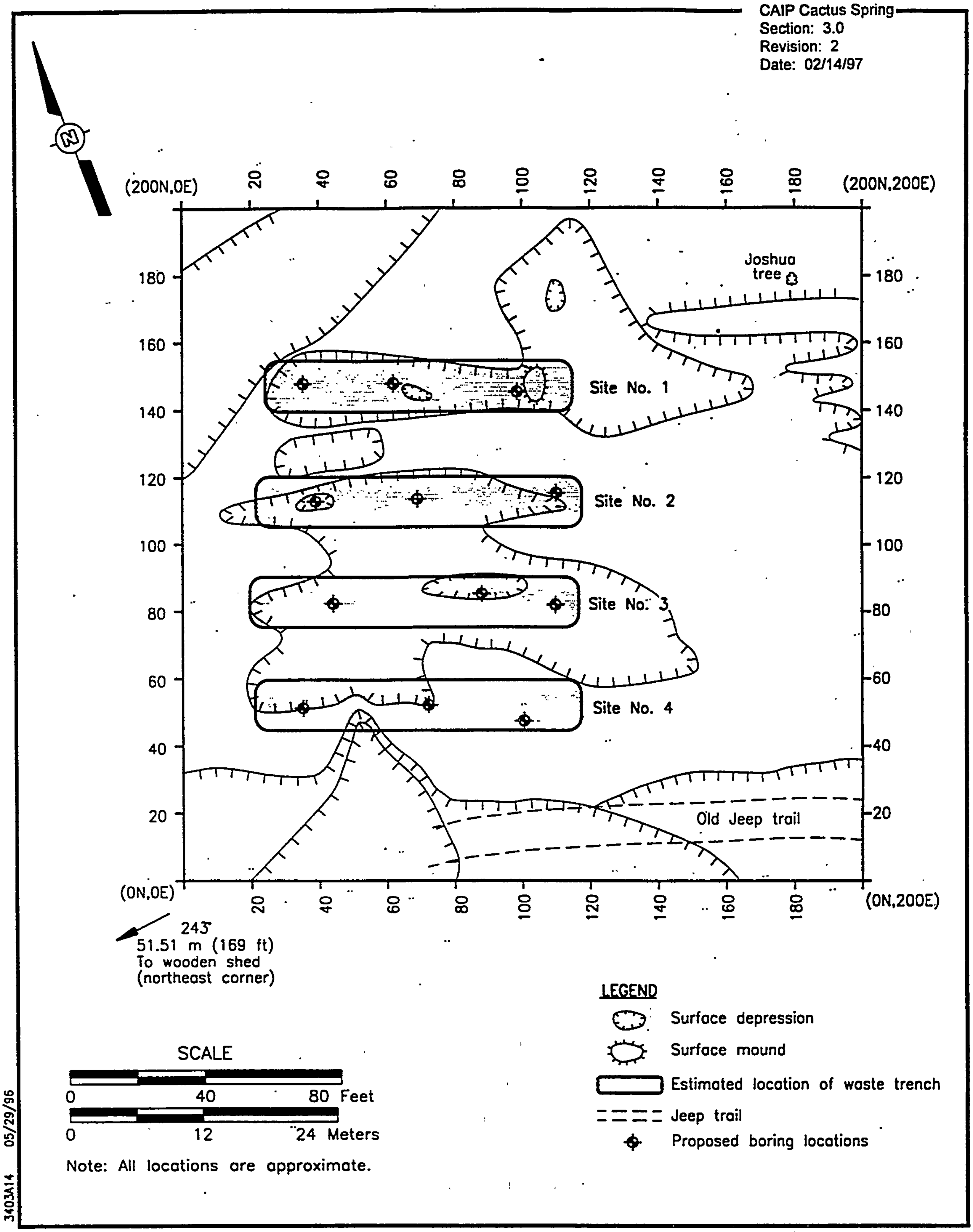



**Figure 3-3**
**Soil Boring Location Map for the Cactus Spring Waste Trenches**

### 3.2.5 Development of Decision Rules

The results of the environmental laboratory analytical data will determine whether a decision is made for no further action, closure in place, or clean closure. If environmental sample analytical data indicate that analytes are not: 1) above TCLP and 100 mg/kg TPH criteria, 2) 100 times the MCL, or Subpart S criteria for other analytes, and 3) if no alpha/gamma radiation is detected above the criteria given in Section 3.1, then either no further action or closure in place will be recommended. If no further action is not a closure option, engineering studies will be used to determine whether closure in place or clean closure is the most appropriate strategy. After sampling, if it is determined that the groundwater may be impacted, the NDEP will be notified, the site rescoped, and the groundwater pathway investigated.

### 3.2.6 Specifications on Decision Error Limits

There are two types of decision errors possible in implementing this CAIP. These errors are described as a false positive, judging a clean area to be contaminated, and a false negative, judging a contaminated area to be clean. This CAIP is designed to minimize both types of errors.

The consequences of a false positive are:

- Remedial activities may encompass a greater quantity of media than is necessary.
- Media incorrectly judged to be contaminated may be disposed of as a regulated or mixed waste instead of solid waste.

Both of these consequences may lead to increased remediation and disposal costs.
The consequences of a false negative are:

- Regulated contaminants may not be appropriately addressed by remedial treatment activities.
- Contamination may continue to leach.
- Contaminated media may be disposed of improperly.

These consequences may lead to unacceptable risks to human health and the environment and to potential fines from regulatory agencies.

Decisions depend foremost on an accurate conceptual model as well as an accurate interpretation of the model (Section 3.1). Interpretation of the model dictates the sampling approach and, ultimately, the course of action that will be taken for a site. The current conceptual model postulates that the plume does not and will not reach groundwater. A consequence of error is that contamination has or will in the future impact groundwater and cause degradation to occur. However, by conducting vertical field screening and sampling until the extent of contamination is known, the model will be tested with regard to the possibility of groundwater impact.

If field screening and/or laboratory analysis indicates contamination is much more extensive than anticipated, an alternate conceptual model that may include the groundwater pathway will be considered. If the alternate conceptual model is found to be representative of site conditions, the site will be rescoped; the NDEP requirements for groundwater assessment will be complied with; the investigation will continue deeper, and the groundwater pathway will be investigated.

Statistical sampling is not appropriate for this type of investigation. When biased samples are collected in a vertical boring to determine the boundary of a potential plume, equation 8 of SW-846 does not apply (EPA, 1986). In lieu of a quantitative determination of sampling error, error will be minimized by the following actions. Two consecutive clean samples, confirmed clean through offsite laboratory analysis, should adequately define the lower limit of the affected soils, based on the type of soils expected (sands and gravels), and the properties of the contaminants (liquid phase, wetting the grains). If unexpected geologic conditions are encountered which affect the contaminant migration pathway, then NDEP will be notified, and a change to the investigation may be considered. The specific sampling approach to be followed at this site is described in Section 4.1.

### *3.2.7 Optimization of the Design for Obtaining Data*

The sampling and analysis approach for the Cactus Spring Waste Trenches described in Section 4.0 of the CAIP was developed to optimize the design for obtaining data. If this approach results in insufficient data to support the decisions to be made, the NDEP will be notified, and the DQO process will be reevaluated.

## *3.3 Technical Approach*

It is not known whether contamination, if present, is migrating beneath the Cactus Spring Waste Trenches. Therefore, the subsurface soil (from ground surface to at least 7.6 m [25 ft]) beneath the trenches will be sampled by drilling borings which directly penetrate the interior of the trenches and the subsurface area below the trenches that may be impacted by leachate (see Appendix A).

The waste that was disposed of in the trenches was heterogeneous in nature. In order to ensure that potentially contaminated areas are sampled, sampling will be biased toward potential areas of contamination (e.g., the soil beneath the trenches). Process knowledge of the site is not sufficient to determine which trench may be more likely than another to contain contaminated media. To account for this, boring locations were selected to penetrate each trench interior in three locations along the linear axis (Figure 3-3). Results of a geophysical survey performed at the trench site in 1995 (IT, 1995) were also evaluated to help ensure the borings are advanced marginally to, rather than directly through, areas of possible metallic subsurface debris.

# 4.0 Corrective Action Investigation

This CAIP contains the sampling approach for investigating the Cactus Spring Waste Trenches. All sampling activities will be conducted in compliance with the Industrial Sites QAPP (DOE, 1994a) and with other applicable, approved procedures. Requirements for field and laboratory environmental sampling QA/QC are contained in the Industrial Sites QAPP (DOE, 1994a).

## 4.1 Soil Sampling Approach

The soil beneath the trenches will be investigated at the locations shown on Figure 3-3. Field screening will be used to provide qualitative data and guide the investigation deeper, if necessary. The following process is used for field screening and sampling.

Sampling will entail collecting environmental and field screening samples from the subsurface. The subsurface soil will be investigated using a sonic drill rig equipped with a core barrel sampler. The primary purpose for using the sonic drilling method (versus hollow-stem auger) is to significantly reduce the amount of IDW. This will also allow drilling to be performed directly through the waste in the trenches to provide definitive data about actual waste types and subsurface conditions.

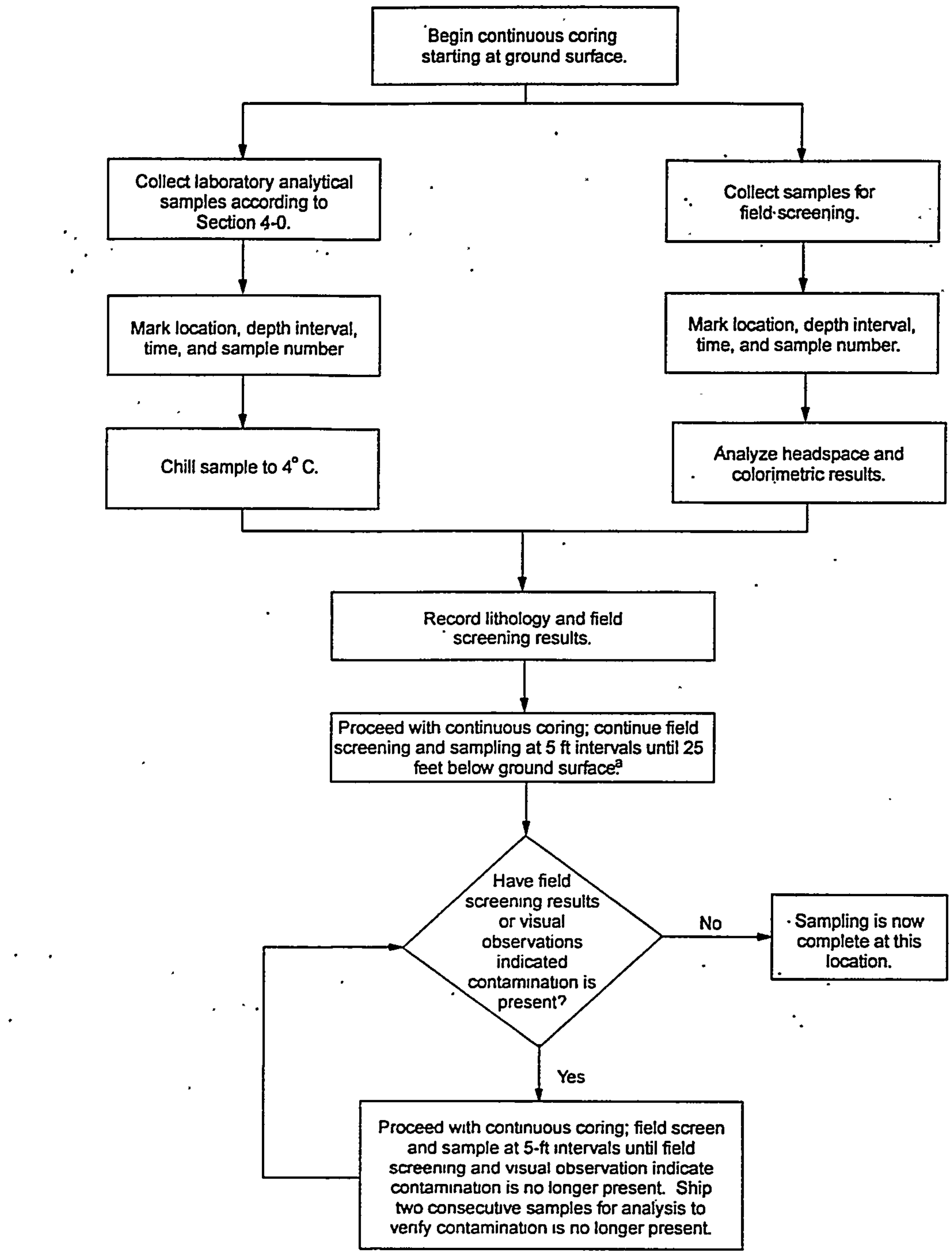
Continuous core samples will be retrieved from soil borings using a core barrel equipped with a sampling sleeve. The soil retrieved from the core barrel will be field screened, and soil samples will be collected from selected intervals within each core barrel beginning at ground surface and continuing to at least 25 ft below ground surface. Field screening will entail headspace testing for volatiles, TPH screening using a colorimetric method, and beta/gamma screening for radioactivity.

During the process of drilling directly through the waste trenches, it is possible that solid materials such as wood, rubber, or glass, in addition to soil, may be encountered. This may preclude the continuous retrieval of sample material appropriate for laboratory analysis. Therefore, collection of sample media for field screening and laboratory analysis will be done, as feasible, based on best field judgement and may require on-site decisions regarding site-specific sample intervals.

In each boring, if no contamination is detected by field screening, a soil grab sample from a location closest to the waste at approximately 1.5 to 3 m (5 to 10 ft) below ground surface will be shipped for laboratory analysis. If field screening detects contamination, grab samples from the interval with the highest field screening measurements will be shipped for laboratory analysis. The vertical boundaries or the "bottom of contamination" will be established by two successive, negative field screening measurements, and environmental samples will be collected at these depths for laboratory analysis. These two environmental samples, collected beneath the contamination, will serve to quantitatively bound the vertical extent of contamination and to verify the accuracy of the field screening methods. Figure 4-1 presents a generalized decision logic for sampling.

Soil within the core barrel sampler will be retained for both sample collection and field screening. Starting near the bit of the core barrel, the first two portions of soil will be retained for total VOCs and for total SVOCs analyses, respectively. The next portion of the sample will be retained for screening using the volatiles headspace method and colorimetric testing for TPH. Four additional sample portions will be retained for TPH, pesticides, RCRA metals, and alpha and gamma spectroscopy analyses. Two successive, core barrel samples may have to be collected in order to obtain sufficient sample amount for the analytical laboratory. Table 4-1 presents the soil sampling requirements for the Cactus Spring Waste Trenches.

Each boring will be drilled using approved procedures. All equipment which contacts the soil will be decontaminated, and clean core barrel liners will be used for each sampling event. This will minimize the potential for cross contamination between sample locations. All samples collected for laboratory analysis will be grab samples of fresh media (rather than reusing the sample media used for screening). Collection of the sample to be submitted for total VOC laboratory analysis will be collected first to minimize the escape of VOCs. Records will be kept of the soil description, field screening measurements, and all other relevant data. The date, time, and sample interval (depth) will be recorded on field activity daily logs and on the sample containers. If field screening indicates that contamination is more extensive than predicted, the field investigation may have to continue deeper, or completely cease (worst case), and the sampling may have to be replanned. All boreholes will be filled to the surface with grout to minimize the potential for contaminant migration downward.




[a] The sample will be shipped for laboratory analyses from the interval showing the highest field screening measurements If no contamination is detected, the sample closest to the waste will be shipped for laboratory analysis.

ttr\caip\cactus\fig_4-1 pre

**Figure 4-1**
**Generalized Decision Logic for Corrective Action Site Sampling**

## Table 4-1
## Summary of Soil Sampling Requirements

| Analyte[a] | Analytical Method | Minimum Reporting Limit |
|---|---|---|
| Total VOCs | 8240[b] | Analyte-specific estimated quantitation limits[c] |
| Total SVOCs | 8270[b] | Analyte-specific estimated quantitation limits[c] |
| RCRA metals | | |
| Arsenic | 1311/6010/7470[b] | 1 mg/kg |
| Barium | | 20 mg/kg |
| Cadmium | | 0.5 mg/kg |
| Chromium | | 1 mg/kg |
| Lead | | 0.3 mg/kg |
| Mercury | | 0.1 mg/kg |
| Selenium | | 0.5 mg/kg |
| Silver | | 1 mg/kg |
| Total petroleum hydrocarbons | 8015 modified[b] | Gasoline - 0.5 mg/kg<br>Diesel - 25 mg/kg |
| Total pesticides | 8080[b] | Analyte-specific estimated quantitation limits |
| Gamma Spectroscopy | HASL 300, 4.5.2.3[d] | 1 pCi/g[f] |
| Alpha Spectroscopy for<br>$U^{238}$<br>$Pu^{238}$<br>$Pu^{239/240}$ | Alpha Spectroscopy for Pu and U isotopes[e] | 0.5 pCi/g[f] |

[a]All sample matrices are soil.
[b]EPA Test Methods for Evaluating Solid Waste, 3rd edition, Parts 1-4 SW-846 (EPA, 1986).
[c]Estimated Quantitation Limit (EQL) as given in SW-846 Method, U.S. EPA (1986).
[d]*Environmental Measurements Laboratory Procedure Manual*, HASL-300, U.S. Department of Energy (DOE, 1992a).
[e]National Academy of Science, Nuclear Science Series, September 1, 1963.
[f]Minimum detectable activity

mg/kg = milligrams per kilogram
pCi/g = picoCuries per gram
Hg = mercury
U = uranium
Pu = plutonium

# 5.0 Waste Management Plan

The requirements for management of the wastes derived from the characterization will be determined based on regulatory requirements, field observations, and the results of laboratory analysis of site characterization samples. Administrative controls (e.g., decontamination procedures, drilling method, and characterization strategies) will minimize waste generated during site investigation activities. Hazardous and/or mixed waste, if it is generated, shall be managed and disposed of in accordance with DOE Orders and U.S. Department of Transportation (DOT) and RCRA regulations (see Section 4.0 of the CAU Work Plan). Decontamination activities will be performed in accordance with approved procedures as specified in the field sampling instructions and will be designated according to the contaminants of concern present at the site.

## 5.1 Waste Minimization

The characterization activities have been designed to minimize the amount of IDW produced. Initial site preparation activities have been planned to avoid removing soil from the units. Through the use of sonic drilling, the volume of soil cuttings will be significantly minimized.

## 5.2 Potential Waste Streams

Based on process knowledge, radioactive wastes or mixed wastes are not expected to be generated. It is also unlikely that hazardous wastes will be produced from the sampling activities in large quantities; all hazardous constituent concentrations, if present, will be low.

Wastes generated during the characterization activities may include, but are not limited to, the following:

- Decontamination rinsate
- Contaminated disposable sampling equipment (e.g., plastic, paper, aluminum foil, and sample containers)
- Personal protective equipment
- Contaminated soil
- Contaminated debris from trenches

## 5.3 Waste Determination

The status of IDW (e.g., TPH-contaminated, RCRA-hazardous, low-level radioactive waste [LLW], mixed waste) will be determined through the application of statistical analyses of sample data as described in Chapter 9 of SW-846 (EPA, 1986) for the determination of the RCRA status of waste. Similar procedures will be used to evaluate the TPH and radioactive status of the IDW. Waste characterization sampling will be conducted in accordance with the TTR Waste Characterization Sampling and Analysis Plan (DOE, 1996c). The action levels for IDW contaminants are presented in Table 5-1..

**Table 5-1**
**Action Levels for IDW Contaminants**

| Parameter | Action Level | Source | Comments |
|---|---|---|---|
| TPH[a] | 100 ppm[b] | NAC[c] 459.9973 | Regulated by the NDEP[d] |
| Total VOCs[e], SVOCs[f], pesticides, and inorganics | See note below | 40 CFR[g] 261<br>40 CFR 268.40 | ------------ |
| Total PCBs[h] | 50 ppm | 40 CFR 761.1(b)<br>NAC[c] 444.940 to 444.9555 | NDEP requires manifesting as hazardous waste for shipping and disposal purposes. |
| Radiological | Isotope specific | NTS PO[i] | ------------ |

[a]Total petroleum hydrocarbons
[b]Parts per million
[c]Nevada Administrative Code (NAC)
[d]Nevada Division of Environmental Protection
[e]Volatile organic compounds
[f]Semivolatile organic compounds
[g]*Code of Federal Regulations*
[h]Polychlorinated biphenyls
[i]Nevada Test Site Performance Objective for Certification of Nonradioactive Hazardous Waste (BN, 1995)

Note: Total VOCs, SVOCs, pesticides, and inorganic concentrations of the samples will be determined through laboratory analysis. The laboratory-derived concentration will be divided by a factor of 20 and compared to the TC limit (mg/L) for hazardous parameters. If the total value divided by 20 is greater than the TC limit, IDW associated with these samples will be considered hazardous waste.

## 5.4 Waste Management

Solid materials other than soil wastes are waste only by virtue of contact with contaminated media. The same is true of decontamination rinsate. Therefore, sampling and analysis of the investigation-derived waste (other than soil from the borings), separate from site characterization analyses, will not be required. The data generated as a result of contaminant characterization will be used to assign the appropriate waste type (i.e., unregulated TPH, hazardous, LLW, or mixed) to the IDW.

By adhering to administrative controls, sampling personnel will ensure that no additional contaminants are added to the waste. For administrative purposes, the waste will be managed as at least three waste streams: soil, contaminated solid trash, and liquid wastes such as decontamination rinsate. Each waste stream will be segregated, and additional segregation may occur within each waste stream. For example, the soil waste and decontamination rinsate will be segregated, and liquid low-level or mixed wastes, if present, will be absorbed or solidified prior to disposal or storage.

Most IDW streams will be placed in waste containers such as U.S. DOT-approved drums (e.g., for contaminated PPE and decontamination rinsates) or roll-off bins (e.g., contaminated soil). The contents of each container will be recorded, and each container will be appropriately marked and labeled in accordance with RCRA and DOE requirements. Wastes will be managed on site within the defined site boundaries until analytical results are received to determine the disposition of the waste. Access to wastes temporarily staged at the project site will be controlled through placing the waste packages or waste soil piles within an access-controlled area. All waste containers (e.g., drums or roll-off bins) or soil piles will be covered and/or locked and appropriately labeled. Waste containers will be periodically inspected while awaiting laboratory results to ensure that the waste containers are not leaking or damaged.

Soil from the boreholes will be containerized in drums until analytical results are available and the soil can be properly disposed. Soil that is either impacted or unimpacted will be staged on plastic and covered with plastic awaiting off-site analysis. If analysis indicates that the staged soil is contaminated with RCRA-regulated waste (i.e., above toxicity characteristic or land-disposal restriction levels), the soil will be containerized and staged to await disposal. The anticipated volume of waste-contaminated soil to be generated during the characterization is less than 3.8 $m^3$ (5 $yd^3$).

If mixed waste is produced, the appropriate data on the status of the waste must also be obtained or developed in accordance with the Transuranic (TRU) Waste Pad waste storage criteria. The number of samples necessary to satisfy the various mixed waste management requirements (e.g., RCRA, NVO-325 [DOE, 1992b]), will depend on the volume of IDW produced and/or the variability in the analytical values for the IDW produced.

# 6.0 Reporting

Following approval of this CAIP, the following is a tentative schedule of activities (in working days):

- Day 0: Preparation for field work will begin.
- Day 30: The field work, including field screening and sampling, will begin.
- Day 45: The field work will be completed and samples shipped to the laboratory for analysis.
- Day 90: The quality-assured laboratory analytical sample data will be received.
- Day 150: The CADD will be submitted to NDEP.

The following information will be reported in the CADD:

- Introduction, including purpose, scope, an FFACO cross-walk, and a discussion about the need for further action
- The results of the corrective action investigation
- A corrective measures study, including initial screening of alternatives, evaluation of alternatives, and comparison of alternatives
- The recommended alternative

# 7.0 References


BN, see Bechtel Nevada Corporation.

Bechtel Nevada Corporation. 1995. *Nevada Test Site Performance Objective for Certification of Nonradioactive Hazardous Waste.* Las Vegas, NV.

CFR, see Code of Federal Regulations.

*Code of Federal Regulations*. 1996. Title 40 CFR Part 261.24, "Toxicity Characteristic." Washington, DC: U.S. Government Printing Office.

*Code of Federal Regulations*. 1996. Title 40 CFR Part 261, "Identification and Listing of Hazardous Wastes." Washington, DC: U.S. Government Printing Office.

*Code of Federal Regulations*. 1996. Title 40 CFR Part 268.40, "Treatment Standards for Hazardous Waste." Washington, DC: U.S. Government Printing Office.

*Code of Federal Regulations*. 1996. Title 40 CFR Part 761.1(b), "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." Washington, DC: U.S. Government Printing Office.

DOE, see U.S. Department of Energy.

EPA, see U.S. Environmental Protection Agency.

FFACO, see Federal Facility Agreement and Consent Order.

*Federal Facility Agreement and Consent Order (FFACO) of 1996.* Prepared by the Nevada Division of Environmental Protection, U.S. Department of Energy, and U.S. Department of Defense.

IT, see IT Corporation.

IT Corporation. 1995. *Geophysical Survey, Tonopah Test Range, Cactus Spring Site, August, 1995.* Prepared for DOE/NV. Las Vegas, NV.

NAC, see Nevada Administrative Code.

National Academy of Science, Nuclear Science Series, September 1, 1963.

NDEP, see Nevada Division of Environmental Protection.

Nevada Division of Environmental Protection. 1994. *Contaminated Soil and Groundwater Remediation Policy, June 25, 1992.*

*Nevada Administrative Code*. 1990. NCR 459.9973, "Storage Tanks." Carson City, NV.

*Nevada Administrative Code*. 1990. NCR 444.940 to 444.9555, "Polychlorinated Biphenyl." Carson City, NV.

Penwell, Cliff. 1995. Telephone conversation with Brad Schier for IT Corporation, 11 April.

Sorem, Earl. 1993. Telephone conversation with Randy Dubiskas, 5 May.

Sygitowicz, Lee. 1995. Personal interview conducted by Brad Schier and Keith Roberson for IT Corporation, 3 May.

U.S. Department of Energy, Albuquerque Operations Office. 1992. *Environmental Monitoring Plan for the Tonopah Test Range, Nevada.* Las Vegas, NV.

U.S. Department of Energy. 1992a. *Environmental Measurements Laboratory Procedures Manual*, HASL-300, Revised February 1992, New York, NY.

U.S. Department of Energy, Nevada Operations Office. 1992b. *Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements, NVO-325*, Rev. 1. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1994a. *Resource Conservation and Recovery Act Industrial Sites Quality Assurance Plan, Nevada Test Site, Nevada*, Rev. 0. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1994b. *Environmental Restoration Project Health and Safety Plan, Rev. 1.* Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1996a. Draft *Corrective Action Unit Work Plan, Tonopah Test Range, Nevada.* Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1996b. *Corrective Action Investigation Plan: Roller Coaster Lagoons and North Disposal Trench, Tonopah Test Range.* Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 1996c. Draft *Waste Characterization Sampling and Analysis Plan for Tonopah Test Range: Corrective Action Units 400, 407, 426, 430, and the Wind Radar Antenna Pedestal.* Las Vegas, NV.

U.S. Environmental Protection Agency. 1986. *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846*, 3rd edition. Washington, DC.

U.S. Environmental Protection Agency. 1994. *Guidance for the Data Quality Objectives Process* (EPA QA/G4). Washington, DC.

Wilson, R.H. and J.L. Terry. 1965. "Plutonium Uptake by Animals Exposed to a Non-Nuclear Detonation of a Plutonium-Bearing Weapon Simulant, Part I. In *Field Operations*. Rochester, NY: University of Rochester.

Wilson, R.H. 1995a. Photographic collection of Operation Roller Coaster, 2 May.

Wilson, R.H. 1995b. Taped Interview with Bob Wilson, TTR Double Tracks Investigation, 2 May. Rochester, NY.

# Appendix A

# Leachate Transport Evaluation Model Results

## Introduction

The objective of this modeling effort is to estimate the extent of migration of contamination below the Cactus Springs Waste Trenches at the Tonopah Test Range (TTR), Nevada. The results of the model will be used to assist in the design of a sampling plan to assess actual migration. No site specific data are available other than qualitative descriptive information concerning the size of the trenches, materials present, and waste source term. Modeling must, therefore, be conducted using generic or regionalized information. This approach is suitable for the intended use of this modeling results.

## Code Selection

Three modeling tools were considered. The EPA Model CHEMFLO (Nofzinger et al. 1989) was considered because it models both water and solute movement in unsaturated soils. The emphasis of CHEMFLO, however, is short term movement over small distances (response to a spill, infiltration during a rainstorm). Because of the time frame involved for the Cactus Springs site (almost 25 years), CHEMFLO was not considered the most applicable model.

A model that was developed to calculate water movement in a landfill environment over periods of many years is the EPA Hydrologic Evaluation of Landfill Performance (HELP) Model (Schroeder et at. 1994a, Schroeder et al. 1994b). The HELP model is very good for moisture movement, but does not incorporate solute transport.

The GWSCREEN model was developed at the Idaho National Engineering Laboratory (INEL) to simulate solute release and transport from buried waste under steady state moisture conditions. The GWSCREEN model (Rood 1994) has been reviewed and accepted by EPA Region 10 for use at the INEL. The approach adopted for this project was to use the HELP model to determine an appropriate net downward flux of water and soil moisture conditions. These data were then used in GWSCREEN to simulate the release and transport of solutes. This is a very simplified approach, but one that is consistent with the lack of site specific data.

## Hydrologic Model

The HELP model simulates the water balance for a landfill, using meteorologic data to determine moisture input (precipitation as rain or snow) evapotranspiration and downward flow. One of the tools available in the HELP model can be used to generate meteorological data. Parameters necessary to generate meteorological data are in the code for Las Vegas, NV. These parameters were used to generate 25 years of synthetic data for the Cactus Springs site. The only modification that was made was to slightly increase the mean monthly precipitation values given for Las Vegas to account for the different mean annual precipitation between Las Vegas (10.6 cm) and TTR (14.7 cm). Table 1 shows a comparison between the synthetic data and the summary meteorological data provided. The Las Vegas data provides reasonable approximations to the TTR data, and the additional work needed to develop site specific data was not considered necessary.

Table 1. Summary Meteorological information.

| | Simulated Data Used in Model | Summarized TTR Data |
|---|---|---|
| Precipitation | | |
| Range (cm/yr) | 7.2 - 30.6 | 13 - 15 |
| Average (cm/yr) | 14.0 | 14.7 |
| Avg. Daily Max. Air Temperature (°C) | 7 - 32 (winter - summer) | 8 - 30 (winter - summer) |
| Relative Humidity (%) | 30 | 30 |
| Wind Speed (m/sec) | 3.9 | 2.7 - 4.5 |

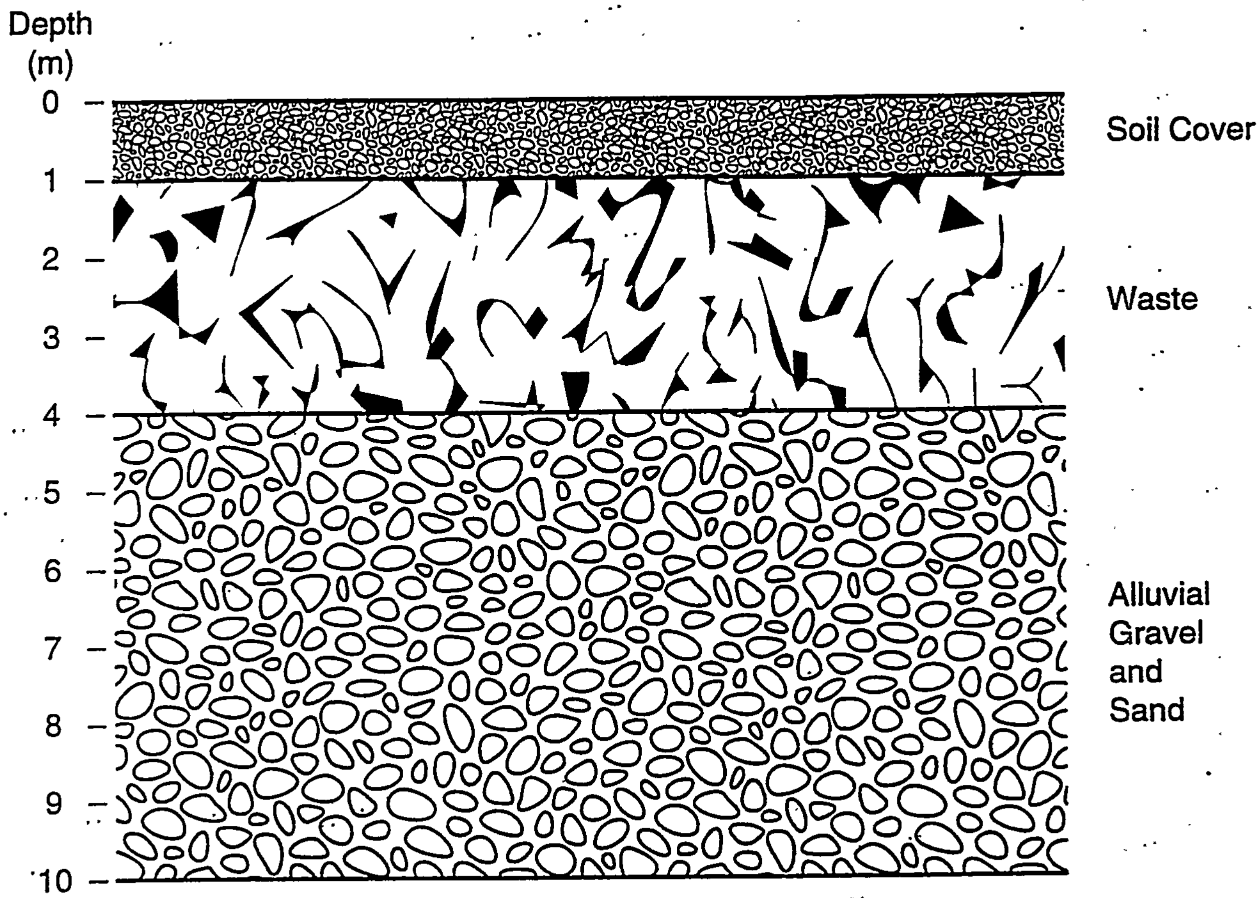
A very simple conceptual model of the site was developed (Figure 1) with a surficial layer of soil cover, a layer of waste in the trench, and two underlying layers of alluvial gravel. The assumptions for the layering at the site were a 1 m cover of native alluvium, 3 m of waste, and a thick sequence of unsaturated alluvial gravel beneath the waste.

The landfill area was set to the general area of the trenches, an area of 36 m north to south and 30 m east to west, or approximately 0.1 hectare.

Standard materials defined in HELP were used. To assess the sensitivity of the flux calculation to the material properties of the native alluvium, runs were made using three different materials. The materials used for the native alluvium were gravel (material code 21), coarse sand (material code 1), and fine sand (material code 3). All native material (above and below the waste) was the same for a run. The waste was assumed to have the properties of municipal waste (material code 18) defined in the HELP default materials.

A number of simulations were carried out to determine approximate equilibrium moisture contents for the materials. These moisture contents were used to initialize simulations to minimize the effects of changes in soil moisture content on net downward flux calculations. Table 2 shows the results for the three soil materials modeled. There is little difference in the

**Figure 1.** Conceptual model of the Cactus Springs Waste Trenches.




IT IF 505

calculated net downward flux. Moisture content increases as grain size decreases to compensate for decreasing hydraulic conductivity. These estimates of net downward flux are about 10% of precipitation, which is significantly higher than regional estimates of 0.5%.

The net downward flux estimates and soil moisture contents for coarse sand were used in GWSCREEN to estimate solute transport.

Table 2. Equilibrium moisture contents and net downward flux.

| Material | Surface (vol/vol) | Waste (vol/vol) | Underburden (vol/vol) | Net Flux (cm/yr) |
|---|---|---|---|---|
| Gravel | 0.03 | 0.29 | 0.05 | 1.7 |
| Coarse Sand | 0.05 | 0.29 | 0.08 | 1.6 |
| Fine Sand | 0.08 | 0.29 | 0.13 | 1.3 |

Solute Transport Model

The GWSCREEN Code (Rood 1994) was developed to assess the groundwater pathway for leaching of radioactive and non-radioactive substances from surface or buried sources. It has been used extensively in support of the INEL Environmental Restoration (ER) Program and has been accepted by EPA Region 10. The code assumes steady state moisture flux and moisture content in the vadose zone and does not incorporate dispersion in the vadose zone. As such, the vadose zone calculation is little more than a velocity times time calculation. This is sufficient for this assessment given the generic nature of the input data. The code does incorporate a source term model to allow leaching of waste.

Data for soil moisture conditions and net downward flux were taken from the results of the HELP simulations. The trench geometry was the same as used in the HELP simulations. There are a number of risk calculation and groundwater parameters in GWSCREEN that were not used for this assessment. Sufficient vadose zone thickness was used (10 m) so that transport would not extend into the water table. Sorption coefficients were taken from the low end of ranges given in a compilation of literature values done for the INEL ER Program (U.S. DOE 1992)

Three simulations were made to show the effects of sorption on the migration of contaminants. The first simulation assumed no sorption. This is probably most applicable to major chemical species, anions, and major organic components such as solvents and volatile organic compounds. The second simulation used hexavalent chromium as a surrogate for slightly sorbed compounds. Finally, plutonium-238 was used as a surrogate for strongly sorbing compounds. Table 3 summarizes the extent of vertical migration for these three scenarios. Figure 2 shows plots of solute mass with depth.

Table 3. Results of GWSCREEN solute transport calculations.

| | $K_d$ (mL/yr) | $R_f$* | Depth of Migration in 25 Years (m) |
|---|---|---|---|
| Nonsorbing | 0 | 1 | 4.8 |
| Slightly Sorbing | 1.2 | 22 | 0.2 |
| Strongly Sorbing | 20 | 351 | 0.01 |

*Retardation Factor: $1+\frac{\rho}{\theta}K_d$

Significant Assumptions

There are many simplifying assumptions in the codes used for this project that are discussed in the user's manuals for the codes. There are some site assumptions, however, that are worth mentioning. No runon to the landfills is allowed by the HELP model. The figure of the trenches implies the area is a depression, and may receive runon from the surrounding area. This would increase the amount of water available for leaching and increase the downward movement of solutes. A check should be made of the site concerning the validity of the no runon assumption

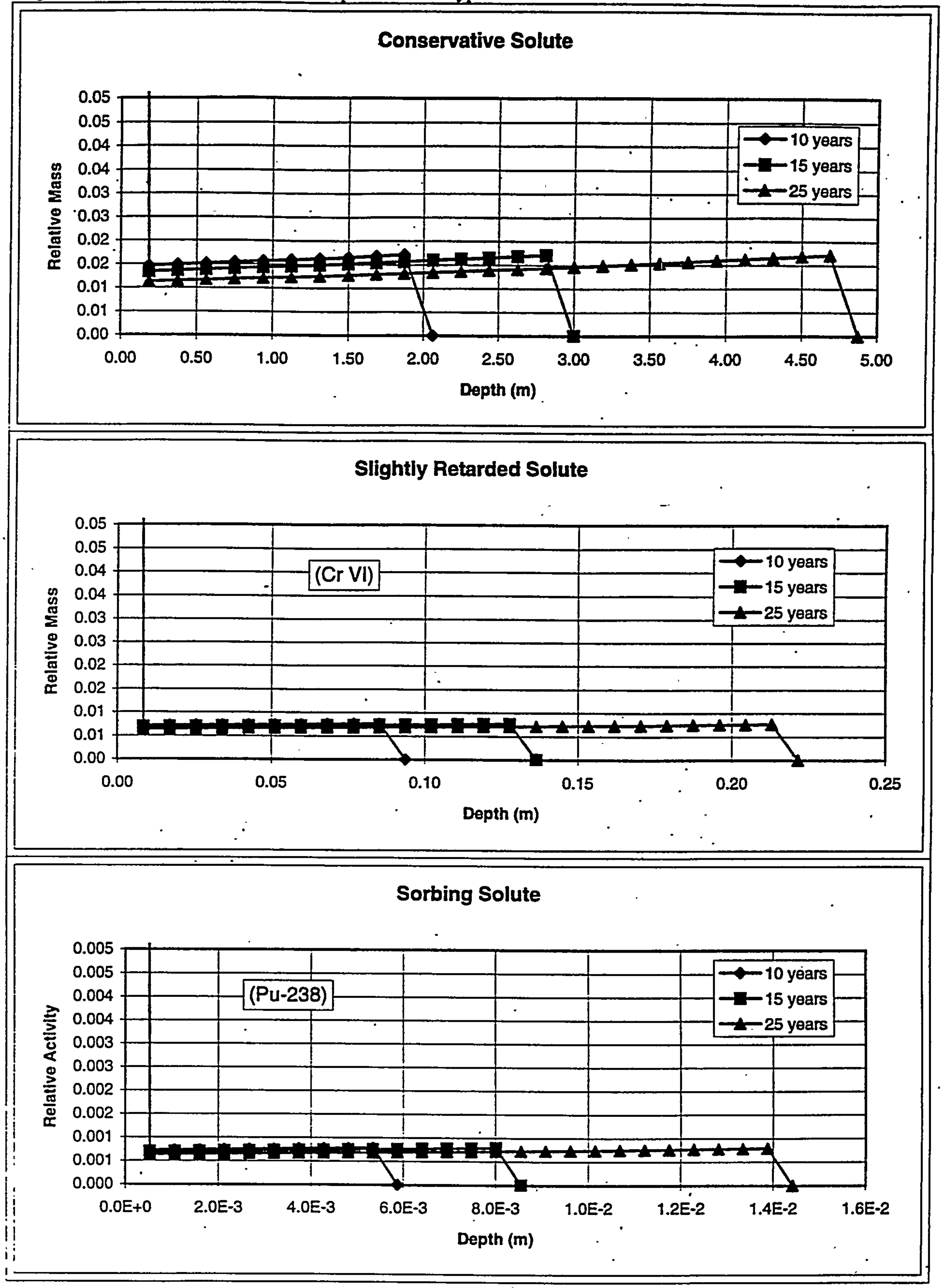
Default properties for sanitary waste included in the HELP code were used for the buried waste. The waste is not considered to be a source of water or other liquids that could enhance transport. This is an important assumption that could be violated if significant quantities of liquids were disposed in the trenches.

Because conditions are near steady state, the actual properties of the waste will not affect the moisture flux calculations. The waste properties will affect the GWSCREEN source term model and release concentrations are sensitive to waste characteristics. However, what is of concern for this simulation is the extent of migration, not actual concentrations. The initial release is not sensitive to waste properties and so the uncertainty in waste characteristics should not have a significant affect on the conclusions.

Discussion

This computer simulation effort was performed to support the design of a sampling program for the Cactus Springs Waste Trenches. No site specific information was available for

**Figure 2.** Plots of solute mass with depth for three types of solutes.



the model. The results provide a rough estimate of the extent to which contamination may have moved under the trenches.

Nonsorbing solutes, may have moved to a depth several meters below the waste trench. This may include the major organic compounds as there is likely little organic matter in the soil to retard the migration of organics. For compounds that even slightly sorb to native soil materials, migration will be much less, on the order of centimeters rather than meters. A sampling program to measure the migration of solutes beneath the trenches will have to concentrate on the vicinity immediately beneath the waste.

References

Nofzinger, D. L, K. Rajender, S. K. Nayudu, and Pei-Yao Su, 1989, *CHEMFLO: One-Dimensional Water and chemical Movement in Unsaturated Soils*, EPA/600/8-89/076, U. S. Environmental Protection Agency, Ada, OK.

Rood, A. S., 1994, *GWSCREEN: A Semi-Analytical Model for Assessment of the Groundwater Pathway from Surface or Buried Contamination*, EGG-GEO-10797, EG&G Idaho, Inc., Idaho Falls, ID.

Schroeder, P. R., C. M. Lloyd, and P. A. Zappi, 1994a, *The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3*, EPA-600-R-94/168a, U.S. Environmental Protection Agency, Cincinnati, OH.

Schroeder, P. R., T. S. Dozler, P. A. Zappi, B. M. McEnroe, J. W. Sjostrom, and R. L. Peyton, 1994b, *The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3*, EPA/600/R-94/168b, U. S. Environmental Protection Agency, Cincinnati, OH.

U. S. Department of Energy, 1992, *Track 1 Sites: Guidance for Assessing Low Probability Hazard Sites at the INEL*, DOE/ID-10340, U. S. Department of Energy, Idaho Falls, ID.

## Attachment

## Output From Computer Runs

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                 HELP MODEL VERSION 3.04a  (10 JULY 1995)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     a:\lasvegas.D4
TEMPERATURE DATA FILE:       a:\lasvegas.D7
SOLAR RADIATION DATA FILE:   a:\lasvegas.D13
EVAPOTRANSPIRATION DATA:     a:\lasvegas.D11
SOIL AND DESIGN DATA FILE:   a:\cactusgr.D10
OUTPUT DATA FILE:            a:\cactusgr.OUT


TIME:  13:45     DATE:   2/29/1996


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

     TITLE:  Cactus Springs Waste Disposal Trenches

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


     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  21
          THICKNESS                    =    100.00    CM
          POROSITY                     =      0.3970 VOL/VOL
          FIELD CAPACITY               =      0.0320 VOL/VOL
          WILTING POINT                =      0.0130 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.0300 VOL/VOL
```

```
   EFFECTIVE SAT. HYD. COND.    = 0.300000012000     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                    =    300.00   CM
   POROSITY                     =      0.6710 VOL/VOL
   FIELD CAPACITY               =      0.2920 VOL/VOL
   WILTING POINT                =      0.0770 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.2920 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    = 0.100000005000E-02 CM/SEC


                         LAYER  3
                         --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  21
   THICKNESS                    =    300.00   CM
   POROSITY                     =      0.3970 VOL/VOL
   FIELD CAPACITY               =      0.0320 VOL/VOL
   WILTING POINT                =      0.0130 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.0540 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    = 0.300000012000     CM/SEC


                         LAYER  4
                         --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER  21
   THICKNESS                    =    300.00   CM
   POROSITY                     =      0.3970 VOL/VOL
   FIELD CAPACITY               =      0.0320 VOL/VOL
   WILTING POINT                =      0.0130 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.0530 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    = 0.300000012000     CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE #21 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 100. METERS.

| | | | |
|---|---|---|---|
| SCS RUNOFF CURVE NUMBER | = | 69.00 | |
| FRACTION OF AREA ALLOWING RUNOFF | = | 100.0 | PERCENT |
| AREA PROJECTED ON HORIZONTAL PLANE | = | 0.1000 | HECTARES |
| EVAPORATIVE ZONE DEPTH | = | 50.0 | CM |
| INITIAL WATER IN EVAPORATIVE ZONE | = | 1.500 | CM |
| UPPER LIMIT OF EVAPORATIVE STORAGE | = | 19.850 | CM |
| LOWER LIMIT OF EVAPORATIVE STORAGE | = | 0.650 | CM |
| INITIAL SNOW WATER | = | 0.000 | CM |
| INITIAL WATER IN LAYER MATERIALS | = | 122.700 | CM |
| TOTAL INITIAL WATER | = | 122.700 | CM |
| TOTAL SUBSURFACE INFLOW | = | 0.00 | MM/YR |

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM LAS VEGAS NEVADA

| | | | |
|---|---|---|---|
| STATION LATITUDE | = | 36.08 | DEGREES |
| MAXIMUM LEAF AREA INDEX | = | 1.00 | |
| START OF GROWING SEASON (JULIAN DATE) | = | 62 | |
| END OF GROWING SEASON (JULIAN DATE) | = | 321 | |
| EVAPORATIVE ZONE DEPTH | = | 50.0 | CM |
| AVERAGE ANNUAL WIND SPEED | = | 14.00 | KPH |
| AVERAGE 1ST QUARTER RELATIVE HUMIDITY | = | 39.00 | % |
| AVERAGE 2ND QUARTER RELATIVE HUMIDITY | = | 21.00 | % |
| AVERAGE 3RD QUARTER RELATIVE HUMIDITY | = | 24.00 | % |
| AVERAGE 4TH QUARTER RELATIVE HUMIDITY | = | 36.00 | % |

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (MM)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 17.6 | 16.2 | 14.4 | 7.8 | 7.1 | 3.2 |
| 15.8 | 19.0 | 11.2 | 8.7 | 15.1 | 11.2 |

```
NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    LAS VEGAS          NEVADA

          NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

  JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
  -------     -------     -------     -------     -------     -------
    7.0        10.1        13.0        17.5        23.0        28.7
   32.4        31.1        26.7        19.8        12.0         7.5


NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    LAS VEGAS          NEVADA
           AND STATION LATITUDE  =  36.08 DEGREES


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

                        ANNUAL TOTALS FOR YEAR    1
-------------------------------------------------------------------------------
                                         MM          CU. METERS     PERCENT
                                     ----------      ----------     -------
 PRECIPITATION                           98.80          98.800      100.00

 RUNOFF                                  0.000           0.000        0.00

 EVAPOTRANSPIRATION                     89.127          89.127       90.21

 PERC./LEAKAGE THROUGH LAYER  4         25.812595       25.813       26.13

 CHANGE IN WATER STORAGE               -16.140         -16.140      -16.34

 SOIL WATER AT START OF YEAR          1227.000        1227.000

 SOIL WATER AT END OF YEAR            1210.860        1210.860

 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          0.000        0.00

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


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

ANNUAL TOTALS FOR YEAR 2

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 169.70 | 169.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 149.489 | 149.489 | 88.09 |
| PERC./LEAKAGE THROUGH LAYER 4 | 20.858877 | 20.859 | 12.29 |
| CHANGE IN WATER STORAGE | -0.648 | -0.648 | -0.38 |
| SOIL WATER AT START OF YEAR | 1210.860 | 1210.860 | |
| SOIL WATER AT END OF YEAR | 1210.212 | 1210.212 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 3

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 119.40 | 119.400 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 117.895 | 117.895 | 98.74 |
| PERC./LEAKAGE THROUGH LAYER 4 | 10.617976 | 10.618 | 8.89 |
| CHANGE IN WATER STORAGE | -9.113 | -9.113 | -7.63 |
| SOIL WATER AT START OF YEAR | 1210.212 | 1210.212 | |
| SOIL WATER AT END OF YEAR | 1201.099 | 1201.099 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 4

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 252.70 | 252.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 213.072 | 213.072 | 84.32 |
| PERC./LEAKAGE THROUGH LAYER 4 | 13.971820 | 13.972 | 5.53 |
| CHANGE IN WATER STORAGE | 25.656 | 25.656 | 10.15 |
| SOIL WATER AT START OF YEAR | 1201.099 | 1201.099 | |
| SOIL WATER AT END OF YEAR | 1226.755 | 1226.755 | |
| 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 | 0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 5

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 131.50 | 131.500 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 105.313 | 105.313 | 80.09 |
| PERC./LEAKAGE THROUGH LAYER 4 | 28.147579 | 28.148 | 21.41 |
| CHANGE IN WATER STORAGE | -1.961 | -1.961 | -1.49 |

| | | | |
|---|---|---|---|
| SOIL WATER AT START OF YEAR | 1226.755 | 1226.755 | |
| SOIL WATER AT END OF YEAR | 1224.795 | 1224.795 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 6

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 175.10 | 175.100 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 157.042 | 157.042 | 89.69 |
| PERC./LEAKAGE THROUGH LAYER 4 | 18.320465 | 18.320 | 10.46 |
| CHANGE IN WATER STORAGE | -0.262 | -0.262 | -0.15 |
| SOIL WATER AT START OF YEAR | 1224.795 | 1224.795 | |
| SOIL WATER AT END OF YEAR | 1224.532 | 1224.532 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 7

| | MM | CU. METERS | PERCENT |
|---|---|---|---|

| | | | |
|---|---|---|---|
| PRECIPITATION | 127.30 | 127.300 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 123.565 | 123.565 | 97.07 |
| PERC./LEAKAGE THROUGH LAYER 4 | 15.150811 | 15.151 | 11.90 |
| CHANGE IN WATER STORAGE | -11.416 | -11.416 | -8.97 |
| SOIL WATER AT START OF YEAR | 1224.532 | 1224.532 | |
| SOIL WATER AT END OF YEAR | 1213.117 | 1213.117 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 8

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 142.00 | 142.000 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 138.943 | 138.943 | 97.85 |
| PERC./LEAKAGE THROUGH LAYER 4 | 19.517950 | 19.518 | 13.75 |
| CHANGE IN WATER STORAGE | -16.461 | -16.461 | -11.59 |
| SOIL WATER AT START OF YEAR | 1213.117 | 1213.117 | |
| SOIL WATER AT END OF YEAR | 1196.655 | 1196.655 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 9

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 122.80 | 122.800 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 118.042 | 118.042 | 96.13 |
| PERC./LEAKAGE THROUGH LAYER 4 | 14.086472 | 14.086 | 11.47 |
| CHANGE IN WATER STORAGE | -9.329 | -9.329 | -7.60 |
| SOIL WATER AT START OF YEAR | 1196.655 | 1196.655 | |
| SOIL WATER AT END OF YEAR | 1187.327 | 1187.327 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 10

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 148.80 | 148.800 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 142.263 | 142.263 | 95.61 |
| PERC./LEAKAGE THROUGH LAYER 4 | 11.767769 | 11.768 | 7.91 |
| CHANGE IN WATER STORAGE | -5.230 | -5.230 | -3.51 |
| SOIL WATER AT START OF YEAR | 1187.327 | 1187.327 | |
| SOIL WATER AT END OF YEAR | 1182.097 | 1182.097 | |

| | | | |
|---|---|---|---|
| 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 | -0.0003 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 11

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 306.50 | 306.500 | 100.00 |
| RUNOFF | 0.129 | 0.129 | 0.04 |
| EVAPOTRANSPIRATION | 221.822 | 221.822 | 72.37 |
| PERC./LEAKAGE THROUGH LAYER 4 | 9.432447 | 9.432 | 3.08 |
| CHANGE IN WATER STORAGE | 75.116 | 75.116 | 24.51 |
| SOIL WATER AT START OF YEAR | 1182.097 | 1182.097 | |
| SOIL WATER AT END OF YEAR | 1257.213 | 1257.213 | |
| 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 | 0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 12

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 117.20 | 117.200 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |

| | | | |
|---|---|---|---|
| EVAPOTRANSPIRATION | 113.323 | 113.323 | 96.69 |
| PERC./LEAKAGE THROUGH LAYER 4 | 51.160915 | 51.161 | 43.65 |
| CHANGE IN WATER STORAGE | -47.284 | -47.284 | -40.34 |
| SOIL WATER AT START OF YEAR | 1257.213 | 1257.213 | |
| SOIL WATER AT END OF YEAR | 1209.928 | 1209.928 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 13

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 90.60 | 90.600 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 75.243 | 75.243 | 83.05 |
| PERC./LEAKAGE THROUGH LAYER 4 | 21.772928 | 21.773 | 24.03 |
| CHANGE IN WATER STORAGE | -6.415 | -6.415 | -7.08 |
| SOIL WATER AT START OF YEAR | 1209.928 | 1209.928 | |
| SOIL WATER AT END OF YEAR | 1203.513 | 1203.513 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 14

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 137.90 | 137.900 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 126.432 | 126.432 | 91.68 |
| PERC./LEAKAGE THROUGH LAYER 4 | 13.742772 | 13.743 | 9.97 |
| CHANGE IN WATER STORAGE | -2.275 | -2.275 | -1.65 |
| SOIL WATER AT START OF YEAR | 1203.513 | 1203.513 | |
| SOIL WATER AT END OF YEAR | 1201.238 | 1201.238 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 15

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 149.70 | 149.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 147.474 | 147.474 | 98.51 |
| PERC./LEAKAGE THROUGH LAYER 4 | 12.090868 | 12.091 | 8.08 |
| CHANGE IN WATER STORAGE | -9.865 | -9.865 | -6.59 |
| SOIL WATER AT START OF YEAR | 1201.238 | 1201.238 | |
| SOIL WATER AT END OF YEAR | 1191.373 | 1191.373 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 16

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 129.70 | 129.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 123.965 | 123.965 | 95.58 |
| PERC./LEAKAGE THROUGH LAYER 4 | 9.999625 | 10.000 | 7.71 |
| CHANGE IN WATER STORAGE | -4.264 | -4.264 | -3.29 |
| SOIL WATER AT START OF YEAR | 1191.373 | 1191.373 | |
| SOIL WATER AT END OF YEAR | 1187.109 | 1187.109 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 17

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 95.60 | 95.600 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 89.937 | 89.937 | 94.08 |
| PERC./LEAKAGE THROUGH LAYER 4 | 10.585753 | 10.586 | 11.07 |

| | | | |
|---|---|---|---|
| CHANGE IN WATER STORAGE | -4.923 | -4.923 | -5.15 |
| SOIL WATER AT START OF YEAR | 1187.109 | 1187.109 | |
| SOIL WATER AT END OF YEAR | 1182.186 | 1182.186 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 18

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 131.60 | 131.600 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 121.286 | 121.286 | 92.16 |
| PERC./LEAKAGE THROUGH LAYER 4 | 8.967316 | 8.967 | 6.81 |
| CHANGE IN WATER STORAGE | 1.346 | 1.346 | 1.02 |
| SOIL WATER AT START OF YEAR | 1182.186 | 1182.187 | |
| SOIL WATER AT END OF YEAR | 1183.533 | 1183.533 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 19

| | MM | CU. METERS | PERCENT |
|---|---|---|---|

| | | | |
|---|---|---|---|
| PRECIPITATION | 127.50 | 127.500 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 115.687 | 115.687 | 90.73 |
| PERC./LEAKAGE THROUGH LAYER 4 | 7.265569 | 7.266 | 5.70 |
| CHANGE IN WATER STORAGE | 4.548 | 4.548 | 3.57 |
| SOIL WATER AT START OF YEAR | 1183.533 | 1183.533 | |
| SOIL WATER AT END OF YEAR | 1188.080 | 1188.080 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 20

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 72.20 | 72.200 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 71.838 | 71.838 | 99.50 |
| PERC./LEAKAGE THROUGH LAYER 4 | 4.712901 | 4.713 | 6.53 |
| CHANGE IN WATER STORAGE | -4.351 | -4.351 | -6.03 |
| SOIL WATER AT START OF YEAR | 1188.080 | 1188.080 | |
| SOIL WATER AT END OF YEAR | 1183.729 | 1183.729 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 21

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 82.10 | 82.100 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 65.288 | 65.288 | 79.52 |
| PERC./LEAKAGE THROUGH LAYER 4 | 8.314489 | 8.314 | 10.13 |
| CHANGE IN WATER STORAGE | 8.497 | 8.497 | 10.35 |
| SOIL WATER AT START OF YEAR | 1183.729 | 1183.729 | |
| SOIL WATER AT END OF YEAR | 1192.227 | 1192.227 | |
| 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 | -0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 22

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 143.00 | 143.000 | 100.00 |
| RUNOFF | 0.148 | 0.148 | 0.10 |
| EVAPOTRANSPIRATION | 84.873 | 84.873 | 59.35 |
| PERC./LEAKAGE THROUGH LAYER 4 | 8.578674 | 8.579 | 6.00 |
| CHANGE IN WATER STORAGE | 49.401 | 49.401 | 34.55 |
| SOIL WATER AT START OF YEAR | 1192.227 | 1192.227 | |

| | | | |
|---|---|---|---|
| SOIL WATER AT END OF YEAR | 1241.627 | 1241.627 | |
| 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 | 0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 23

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 100.50 | 100.500 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 95.538 | 95.538 | 95.06 |
| PERC./LEAKAGE THROUGH LAYER 4 | 39.646229 | 39.646 | 39.45 |
| CHANGE IN WATER STORAGE | -34.684 | -34.684 | -34.51 |
| SOIL WATER AT START OF YEAR | 1241.627 | 1241.627 | |
| SOIL WATER AT END OF YEAR | 1206.944 | 1206.944 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 24

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 197.90 | 197.900 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |

| | | | |
|---|---|---|---|
| EVAPOTRANSPIRATION | 158.140 | 158.140 | 79.91 |
| PERC./LEAKAGE THROUGH LAYER 4 | 22.018141 | 22.018 | 11.13 |
| CHANGE IN WATER STORAGE | 17.741 | 17.741 | 8.96 |
| SOIL WATER AT START OF YEAR | 1206.944 | 1206.944 | |
| SOIL WATER AT END OF YEAR | 1224.685 | 1224.685 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 25

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 130.00 | 130.000 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 110.345 | 110.345 | 84.88 |
| PERC./LEAKAGE THROUGH LAYER 4 | 18.842402 | 18.842 | 14.49 |
| CHANGE IN WATER STORAGE | 0.812 | 0.812 | 0.62 |
| SOIL WATER AT START OF YEAR | 1224.685 | 1224.685 | |
| SOIL WATER AT END OF YEAR | 1225.497 | 1225.497 | |
| 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 | 0.000 | 0.00 |

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

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

AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 25

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 10.92 | 14.20 | 9.72 | 10.24 | 8.98 | 2.18 |
| | 17.01 | 22.32 | 11.83 | 5.62 | 17.47 | 9.50 |
| STD. DEVIATIONS | 12.95 | 16.48 | 11.48 | 7.67 | 10.97 | 4.16 |
| | 24.29 | 19.56 | 18.26 | 5.60 | 18.55 | 7.76 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.000 | 0.006 | 0.005 | 0.000 | 0.000 | 0.000 |
| STD. DEVIATIONS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.000 | 0.030 | 0.026 | 0.000 | 0.000 | 0.000 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 10.639 | 13.010 | 8.046 | 10.407 | 8.966 | 2.327 |
| | 14.563 | 17.742 | 8.506 | 6.545 | 11.962 | 10.325 |
| STD. DEVIATIONS | 11.987 | 11.061 | 8.700 | 8.102 | 10.093 | 4.350 |
| | 21.525 | 14.300 | 9.715 | 6.197 | 13.477 | 9.109 |
| **PERCOLATION/LEAKAGE THROUGH LAYER 4** | | | | | | |
| TOTALS | 1.1462 | 1.3025 | 1.7129 | 1.5357 | 1.5876 | 1.4858 |
| | 1.5123 | 1.4717 | 1.3788 | 1.3511 | 1.2823 | 1.2484 |
| STD. DEVIATIONS | 0.7638 | 0.9603 | 1.4381 | 1.3700 | 1.2828 | 1.1615 |
| | 1.0865 | 0.9608 | 0.9065 | 0.8752 | 0.8601 | 0.9542 |

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

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

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

| | MM | | CU. METERS | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 140.00 | ( 51.480) | 140.0 | 100.00 |
| RUNOFF | 0.011 | ( 0.0384) | 0.01 | 0.008 |

| | | | | |
|---|---|---|---|---|
| EVAPOTRANSPIRATION | 123.038 | ( 38.4937) | 123.04 | 87.882 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 17.01533 | ( 10.57513) | 17.015 | 12.15346 |
| CHANGE IN WATER STORAGE | -0.060 | ( 0.9392) | -0.06 | -0.043 |

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

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

PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

| | (MM) | (CU. METERS) |
|---|---|---|
| PRECIPITATION | 68.20 | 68.200 |
| RUNOFF | 0.148 | 0.1475 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.229740 | 0.22974 |
| SNOW WATER | 26.30 | 26.3000 |
| MAXIMUM VEG. SOIL WATER (VOL/VOL) | 0.1534 | |
| MINIMUM VEG. SOIL WATER (VOL/VOL) | 0.0130 | |

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

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

FINAL WATER STORAGE AT END OF YEAR 25

| LAYER | (CM) | (VOL/VOL) |
|---|---|---|
| 1 | 2.9705 | 0.0297 |
| 2 | 87.6000 | 0.2920 |
| 3 | 16.1386 | 0.0538 |
| 4 | 15.8406 | 0.0528 |
| SNOW WATER | 0.000 | |

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

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                 HELP MODEL VERSION 3.04a  (10 JULY 1995)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     a:\lasvegas.D4
TEMPERATURE DATA FILE:       a:\lasvegas.D7
SOLAR RADIATION DATA FILE:   a:\lasvegas.D13
EVAPOTRANSPIRATION DATA:     a:\lasvegas.D11
SOIL AND DESIGN DATA FILE:   a:\cactuscs.D10
OUTPUT DATA FILE:            a:\cactuscs.OUT


TIME:  14: 2     DATE:   2/29/1996


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

     TITLE:  Cactus Springs Waste Disposal Trenches

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


     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   1
          THICKNESS                     =    100.00   CM
          POROSITY                      =      0.4170 VOL/VOL
          FIELD CAPACITY                =      0.0450 VOL/VOL
          WILTING POINT                 =      0.0180 VOL/VOL
          INITIAL SOIL WATER CONTENT    =      0.0500 VOL/VOL
```

```
   EFFECTIVE SAT. HYD. COND.    = 0.999999978000E-02 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                    =    300.00   CM
   POROSITY                     =       0.6710 VOL/VOL
   FIELD CAPACITY               =       0.2920 VOL/VOL
   WILTING POINT                =       0.0770 VOL/VOL
   INITIAL SOIL WATER CONTENT   =       0.2920 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    = 0.100000005000E-02 CM/SEC


                           LAYER  3
                           --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   1
   THICKNESS                    =    300.00   CM
   POROSITY                     =       0.4170 VOL/VOL
   FIELD CAPACITY               =       0.0450 VOL/VOL
   WILTING POINT                =       0.0180 VOL/VOL
   INITIAL SOIL WATER CONTENT   =       0.0820 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    = 0.999999978000E-02 CM/SEC


                           LAYER  4
                           --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   1
   THICKNESS                    =    300.00   CM
   POROSITY                     =       0.4170 VOL/VOL
   FIELD CAPACITY               =       0.0450 VOL/VOL
   WILTING POINT                =       0.0180 VOL/VOL
   INITIAL SOIL WATER CONTENT   =       0.0820 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    = 0.999999978000E-02 CM/SEC
```

## GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 1 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 100. METERS.

| | | | |
|---|---|---|---|
| SCS RUNOFF CURVE NUMBER | = | 72.20 | |
| FRACTION OF AREA ALLOWING RUNOFF | = | 100.0 | PERCENT |
| AREA PROJECTED ON HORIZONTAL PLANE | = | 0.1000 | HECTARES |
| EVAPORATIVE ZONE DEPTH | = | 50.0 | CM |
| INITIAL WATER IN EVAPORATIVE ZONE | = | 2.500 | CM |
| UPPER LIMIT OF EVAPORATIVE STORAGE | = | 20.850 | CM |
| LOWER LIMIT OF EVAPORATIVE STORAGE | = | 0.900 | CM |
| INITIAL SNOW WATER | = | 0.000 | CM |
| INITIAL WATER IN LAYER MATERIALS | = | 141.800 | CM |
| TOTAL INITIAL WATER | = | 141.800 | CM |
| TOTAL SUBSURFACE INFLOW | = | 0.00 | MM/YR |

## EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM LAS VEGAS NEVADA

| | | | |
|---|---|---|---|
| STATION LATITUDE | = | 36.08 | DEGREES |
| MAXIMUM LEAF AREA INDEX | = | 1.00 | |
| START OF GROWING SEASON (JULIAN DATE) | = | 62 | |
| END OF GROWING SEASON (JULIAN DATE) | = | 321 | |
| EVAPORATIVE ZONE DEPTH | = | 50.0 | CM |
| AVERAGE ANNUAL WIND SPEED | = | 14.00 | KPH |
| AVERAGE 1ST QUARTER RELATIVE HUMIDITY | = | 39.00 | % |
| AVERAGE 2ND QUARTER RELATIVE HUMIDITY | = | 21.00 | % |
| AVERAGE 3RD QUARTER RELATIVE HUMIDITY | = | 24.00 | % |
| AVERAGE 4TH QUARTER RELATIVE HUMIDITY | = | 36.00 | % |

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (MM)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 17.6 | 16.2 | 14.4 | 7.8 | 7.1 | 3.2 |
| 15.8 | 19.0 | 11.2 | 8.7 | 15.1 | 11.2 |

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 7.0 | 10.1 | 13.0 | 17.5 | 23.0 | 28.7 |
| 32.4 | 31.1 | 26.7 | 19.8 | 12.0 | 7.5 |

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR LAS VEGAS NEVADA
AND STATION LATITUDE = 36.08 DEGREES

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

ANNUAL TOTALS FOR YEAR 1

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 98.80 | 98.800 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 92.683 | 92.683 | 93.81 |
| PERC./LEAKAGE THROUGH LAYER 4 | 13.812114 | 13.812 | 13.98 |
| CHANGE IN WATER STORAGE | -7.695 | -7.695 | -7.79 |
| SOIL WATER AT START OF YEAR | 1418.000 | 1418.000 | |
| SOIL WATER AT END OF YEAR | 1410.305 | 1410.305 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 2

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 169.70 | 169.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 151.588 | 151.588 | 89.33 |
| PERC./LEAKAGE THROUGH LAYER 4 | 17.754377 | 17.754 | 10.46 |
| CHANGE IN WATER STORAGE | 0.357 | 0.357 | 0.21 |
| SOIL WATER AT START OF YEAR | 1410.305 | 1410.305 | |
| SOIL WATER AT END OF YEAR | 1410.662 | 1410.662 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 3

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 119.40 | 119.400 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 111.882 | 111.882 | 93.70 |
| PERC./LEAKAGE THROUGH LAYER 4 | 18.661875 | 18.662 | 15.63 |
| CHANGE IN WATER STORAGE | -11.144 | -11.144 | -9.33 |
| SOIL WATER AT START OF YEAR | 1410.662 | 1410.662 | |
| SOIL WATER AT END OF YEAR | 1399.519 | 1399.519 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 4

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 252.70 | 252.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 225.686 | 225.686 | 89.31 |
| PERC./LEAKAGE THROUGH LAYER 4 | 9.736466 | 9.736 | 3.85 |
| CHANGE IN WATER STORAGE | 17.277 | 17.277 | 6.84 |
| SOIL WATER AT START OF YEAR | 1399.519 | 1399.519 | |
| SOIL WATER AT END OF YEAR | 1416.796 | 1416.796 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 5

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 131.50 | 131.500 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 104.533 | 104.533 | 79.49 |
| PERC./LEAKAGE THROUGH LAYER 4 | 6.397977 | 6.398 | 4.87 |
| CHANGE IN WATER STORAGE | 20.569 | 20.569 | 15.64 |

| | | | |
|---|---|---|---|
| SOIL WATER AT START OF YEAR | 1416.796 | 1416.796 | |
| SOIL WATER AT END OF YEAR | 1437.365 | 1437.365 | |
| 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 | 0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 6

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 175.10 | 175.100 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 153.377 | 153.377 | 87.59 |
| PERC./LEAKAGE THROUGH LAYER 4 | 21.457165 | 21.457 | 12.25 |
| CHANGE IN WATER STORAGE | 0.266 | 0.266 | 0.15 |
| SOIL WATER AT START OF YEAR | 1437.365 | 1437.365 | |
| SOIL WATER AT END OF YEAR | 1437.631 | 1437.631 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 7

| | MM | CU. METERS | PERCENT |
|---|---|---|---|

| | | | |
|---|---|---|---|
| PRECIPITATION | 127.30 | 127.300 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 124.706 | 124.706 | 97.96 |
| PERC./LEAKAGE THROUGH LAYER 4 | 16.871733 | 16.872 | 13.25 |
| CHANGE IN WATER STORAGE | -14.277 | -14.277 | -11.22 |
| SOIL WATER AT START OF YEAR | 1437.631 | 1437.631 | |
| SOIL WATER AT END OF YEAR | 1423.354 | 1423.354 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 8

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 142.00 | 142.000 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 133.844 | 133.844 | 94.26 |
| PERC./LEAKAGE THROUGH LAYER 4 | 12.610322 | 12.610 | 8.88 |
| CHANGE IN WATER STORAGE | -4.455 | -4.455 | -3.14 |
| SOIL WATER AT START OF YEAR | 1423.354 | 1423.354 | |
| SOIL WATER AT END OF YEAR | 1418.899 | 1418.899 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 9

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 122.80 | 122.800 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 111.776 | 111.776 | 91.02 |
| PERC./LEAKAGE THROUGH LAYER 4 | 17.981466 | 17.981 | 14.64 |
| CHANGE IN WATER STORAGE | -6.958 | -6.958 | -5.67 |
| SOIL WATER AT START OF YEAR | 1418.899 | 1418.899 | |
| SOIL WATER AT END OF YEAR | 1411.941 | 1411.941 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 10

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 148.80 | 148.800 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 137.021 | 137.021 | 92.08 |
| PERC./LEAKAGE THROUGH LAYER 4 | 17.154823 | 17.155 | 11.53 |
| CHANGE IN WATER STORAGE | -5.376 | -5.376 | -3.61 |
| SOIL WATER AT START OF YEAR | 1411.941 | 1411.941 | |
| SOIL WATER AT END OF YEAR | 1406.565 | 1406.565 | |

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 11

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 306.50 | 306.500 | 100.00 |
| RUNOFF | 0.779 | 0.779 | 0.25 |
| EVAPOTRANSPIRATION | 246.941 | 246.941 | 80.57 |
| PERC./LEAKAGE THROUGH LAYER 4 | 15.952391 | 15.952 | 5.20 |
| CHANGE IN WATER STORAGE | 42.828 | 42.828 | 13.97 |
| SOIL WATER AT START OF YEAR | 1406.565 | 1406.565 | |
| SOIL WATER AT END OF YEAR | 1449.393 | 1449.393 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 12

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 117.20 | 117.200 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |

| | | | |
|---|---|---|---|
| EVAPOTRANSPIRATION | 111.375 | 111.375 | 95.03 |
| PERC./LEAKAGE THROUGH LAYER 4 | 9.672312 | 9.672 | 8.25 |
| CHANGE IN WATER STORAGE | -3.848 | -3.848 | -3.28 |
| SOIL WATER AT START OF YEAR | 1449.393 | 1449.393 | |
| SOIL WATER AT END OF YEAR | 1445.545 | 1445.546 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 13

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 90.60 | 90.600 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 76.763 | 76.763 | 84.73 |
| PERC./LEAKAGE THROUGH LAYER 4 | 31.476234 | 31.476 | 34.74 |
| CHANGE IN WATER STORAGE | -17.639 | -17.639 | -19.47 |
| SOIL WATER AT START OF YEAR | 1445.545 | 1445.545 | |
| SOIL WATER AT END OF YEAR | 1427.906 | 1427.906 | |
| 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 | -0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 14

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 137.90 | 137.900 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 121.929 | 121.929 | 88.42 |
| PERC./LEAKAGE THROUGH LAYER 4 | 23.524208 | 23.524 | 17.06 |
| CHANGE IN WATER STORAGE | -7.553 | -7.553 | -5.48 |
| SOIL WATER AT START OF YEAR | 1427.906 | 1427.906 | |
| SOIL WATER AT END OF YEAR | 1420.353 | 1420.353 | |
| 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 | 0.000 | 0.00 |

ANNUAL TOTALS FOR YEAR 15

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 149.70 | 149.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 141.098 | 141.098 | 94.25 |
| PERC./LEAKAGE THROUGH LAYER 4 | 20.405369 | 20.405 | 13.63 |
| CHANGE IN WATER STORAGE | -11.804 | -11.804 | -7.88 |
| SOIL WATER AT START OF YEAR | 1420.353 | 1420.353 | |
| SOIL WATER AT END OF YEAR | 1408.549 | 1408.549 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 16

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 129.70 | 129.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 117.690 | 117.690 | 90.74 |
| PERC./LEAKAGE THROUGH LAYER 4 | 12.453591 | 12.454 | 9.60 |
| CHANGE IN WATER STORAGE | -0.443 | -0.443 | -0.34 |
| SOIL WATER AT START OF YEAR | 1408.549 | 1408.549 | |
| SOIL WATER AT END OF YEAR | 1408.106 | 1408.106 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 17

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 95.60 | 95.600 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 88.427 | 88.427 | 92.50 |
| PERC./LEAKAGE THROUGH LAYER 4 | 14.383836 | 14.384 | 15.05 |

| | | | |
|---|---|---|---|
| CHANGE IN WATER STORAGE | -7.210 | -7.210 | -7.54 |
| SOIL WATER AT START OF YEAR | 1408.106 | 1408.106 | |
| SOIL WATER AT END OF YEAR | 1400.895 | 1400.895 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 18

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 131.60 | 131.600 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 116.060 | 116.060 | 88.19 |
| PERC./LEAKAGE THROUGH LAYER 4 | 13.181441 | 13.181 | 10.02 |
| CHANGE IN WATER STORAGE | 2.358 | 2.358 | 1.79 |
| SOIL WATER AT START OF YEAR | 1400.895 | 1400.895 | |
| SOIL WATER AT END OF YEAR | 1403.253 | 1403.253 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 19

| | MM | CU. METERS | PERCENT |
|---|---|---|---|

| | | | |
|---|---|---|---|
| PRECIPITATION | 127.50 | 127.500 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 115.000 | 115.000 | 90.20 |
| PERC./LEAKAGE THROUGH LAYER 4 | 14.576571 | 14.577 | 11.43 |
| CHANGE IN WATER STORAGE | -2.076 | -2.076 | -1.63 |
| SOIL WATER AT START OF YEAR | 1403.253 | 1403.253 | |
| SOIL WATER AT END OF YEAR | 1401.177 | 1401.177 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 20

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 72.20 | 72.200 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 67.474 | 67.474 | 93.45 |
| PERC./LEAKAGE THROUGH LAYER 4 | 10.297286 | 10.297 | 14.26 |
| CHANGE IN WATER STORAGE | -5.571 | -5.571 | -7.72 |
| SOIL WATER AT START OF YEAR | 1401.177 | 1401.177 | |
| SOIL WATER AT END OF YEAR | 1395.606 | 1395.606 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 21

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 82.10 | 82.100 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 67.849 | 67.849 | 82.64 |
| PERC./LEAKAGE THROUGH LAYER 4 | 11.661680 | 11.662 | 14.20 |
| CHANGE IN WATER STORAGE | 2.589 | 2.589 | 3.15 |
| SOIL WATER AT START OF YEAR | 1395.606 | 1395.606 | |
| SOIL WATER AT END OF YEAR | 1398.195 | 1398.195 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 22

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 143.00 | 143.000 | 100.00 |
| RUNOFF | 0.907 | 0.907 | 0.63 |
| EVAPOTRANSPIRATION | 104.454 | 104.454 | 73.04 |
| PERC./LEAKAGE THROUGH LAYER 4 | 12.539234 | 12.539 | 8.77 |
| CHANGE IN WATER STORAGE | 25.100 | 25.100 | 17.55 |
| SOIL WATER AT START OF YEAR | 1398.195 | 1398.195 | |

| | | | |
|---|---|---|---|
| SOIL WATER AT END OF YEAR | 1423.295 | 1423.295 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 23

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 100.50 | 100.500 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 86.111 | 86.111 | 85.68 |
| PERC./LEAKAGE THROUGH LAYER 4 | 8.840143 | 8.840 | 8.80 |
| CHANGE IN WATER STORAGE | 5.549 | 5.549 | 5.52 |
| SOIL WATER AT START OF YEAR | 1423.295 | 1423.295 | |
| SOIL WATER AT END OF YEAR | 1428.844 | 1428.844 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 24

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 197.90 | 197.900 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |

| | | | |
|---|---|---|---|
| EVAPOTRANSPIRATION | 173.862 | 173.862 | 87.85 |
| PERC./LEAKAGE THROUGH LAYER 4 | 18.378492 | 18.378 | 9.29 |
| CHANGE IN WATER STORAGE | 5.660 | 5.660 | 2.86 |
| SOIL WATER AT START OF YEAR | 1428.844 | 1428.844 | |
| SOIL WATER AT END OF YEAR | 1434.504 | 1434.504 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 25

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 130.00 | 130.000 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 121.620 | 121.620 | 93.55 |
| PERC./LEAKAGE THROUGH LAYER 4 | 23.391867 | 23.392 | 17.99 |
| CHANGE IN WATER STORAGE | -15.012 | -15.012 | -11.55 |
| SOIL WATER AT START OF YEAR | 1434.504 | 1434.504 | |
| SOIL WATER AT END OF YEAR | 1419.492 | 1419.492 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 25

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 10.92 | 14.20 | 9.72 | 10.24 | 8.98 | 2.18 |
| | 17.01 | 22.32 | 11.83 | 5.62 | 17.47 | 9.50 |
| STD. DEVIATIONS | 12.95 | 16.48 | 11.48 | 7.67 | 10.97 | 4.16 |
| | 24.29 | 19.56 | 18.26 | 5.60 | 18.55 | 7.76 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.000 | 0.036 | 0.031 | 0.000 | 0.000 | 0.000 |
| STD. DEVIATIONS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.000 | 0.181 | 0.156 | 0.000 | 0.000 | 0.000 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 10.961 | 12.072 | 8.822 | 9.676 | 9.203 | 2.296 |
| | 15.074 | 18.289 | 9.373 | 6.481 | 11.549 | 10.355 |
| STD. DEVIATIONS | 11.575 | 9.620 | 8.761 | 8.271 | 10.037 | 3.797 |
| | 23.330 | 14.679 | 12.017 | 5.954 | 13.904 | 10.287 |
| **PERCOLATION/LEAKAGE THROUGH LAYER 4** | | | | | | |
| TOTALS | 1.3882 | 1.3313 | 1.5026 | 1.4147 | 1.4384 | 1.2188 |
| | 1.1842 | 1.2629 | 1.1144 | 1.1528 | 1.2955 | 1.4231 |
| STD. DEVIATIONS | 0.4896 | 0.5140 | 0.4564 | 0.4987 | 0.5468 | 0.5190 |
| | 0.6405 | 0.7423 | 0.7132 | 0.6693 | 0.5287 | 0.4736 |

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

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

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 140.00 ( 51.480) | 140.0 | 100.00 |

**Coarse Sand**

| | | | | |
|---|---|---|---|---|
| RUNOFF | 0.067 | ( 0.2342) | 0.07 | 0.048 |
| EVAPOTRANSPIRATION | 124.150 | ( 42.7176) | 124.15 | 88.676 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 15.72692 | ( 5.58056) | 15.727 | 11.23319 |
| CHANGE IN WATER STORAGE | 0.060 | ( 0.5439) | 0.06 | 0.043 |

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

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

          PEAK DAILY VALUES FOR YEARS    1 THROUGH   25
   ------------------------------------------------------------------------
                                                (MM)        (CU. METERS)
                                             ----------    ------------
     PRECIPITATION                              68.20          68.200

     RUNOFF                                     0.907           0.9071

     PERCOLATION/LEAKAGE THROUGH LAYER  4       0.133152        0.13315

     SNOW WATER                                 26.30          26.3000

     MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.1617

     MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0180

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

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

              FINAL WATER STORAGE AT END OF YEAR   25
     ----------------------------------------------------------------------
              LAYER            (CM)          (VOL/VOL)
              -----           ------         ---------
                1             4.9658          0.0497

                2            87.6000          0.2920

                3            24.8500          0.0828

                4            24.5334          0.0818

             SNOW WATER       0.000

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

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                 HELP MODEL VERSION 3.04a  (10 JULY 1995)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     a:\lasvegas.D4
TEMPERATURE DATA FILE:       a:\lasvegas.D7
SOLAR RADIATION DATA FILE:   a:\lasvegas.D13
EVAPOTRANSPIRATION DATA:     a:\lasvegas.D11
SOIL AND DESIGN DATA FILE:   a:\cactusfs.D10
OUTPUT DATA FILE:            a:\cactusfs.OUT


TIME:  14:15     DATE:   2/29/1996


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

     TITLE:  Cactus Springs Waste Disposal Trenches

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


     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   3
           THICKNESS                      =    100.00   CM
           POROSITY                       =      0.4570 VOL/VOL
           FIELD CAPACITY                 =      0.0830 VOL/VOL
           WILTING POINT                  =      0.0330 VOL/VOL
           INITIAL SOIL WATER CONTENT     =      0.0810 VOL/VOL
```

```
       EFFECTIVE SAT. HYD. COND.    = 0.310000009000E-02 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                    =    300.00    CM
       POROSITY                     =      0.6710 VOL/VOL
       FIELD CAPACITY               =      0.2920 VOL/VOL
       WILTING POINT                =      0.0770 VOL/VOL
       INITIAL SOIL WATER CONTENT   =      0.2920 VOL/VOL
       EFFECTIVE SAT. HYD. COND.    = 0.100000005000E-02 CM/SEC


                              LAYER  3
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   3
       THICKNESS                    =    300.00    CM
       POROSITY                     =      0.4570 VOL/VOL
       FIELD CAPACITY               =      0.0830 VOL/VOL
       WILTING POINT                =      0.0330 VOL/VOL
       INITIAL SOIL WATER CONTENT   =      0.1260 VOL/VOL
       EFFECTIVE SAT. HYD. COND.    = 0.310000009000E-02 CM/SEC


                              LAYER  4
                              --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   3
       THICKNESS                    =    300.00    CM
       POROSITY                     =      0.4570 VOL/VOL
       FIELD CAPACITY               =      0.0830 VOL/VOL
       WILTING POINT                =      0.0330 VOL/VOL
       INITIAL SOIL WATER CONTENT   =      0.1240 VOL/VOL
       EFFECTIVE SAT. HYD. COND.    = 0.310000009000E-02 CM/SEC
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 3 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 100. METERS.

| | | | |
|---|---|---|---|
| SCS RUNOFF CURVE NUMBER | = | 80.00 | |
| FRACTION OF AREA ALLOWING RUNOFF | = | 100.0 | PERCENT |
| AREA PROJECTED ON HORIZONTAL PLANE | = | 0.1000 | HECTARES |
| EVAPORATIVE ZONE DEPTH | = | 50.0 | CM |
| INITIAL WATER IN EVAPORATIVE ZONE | = | 4.050 | CM |
| UPPER LIMIT OF EVAPORATIVE STORAGE | = | 22.850 | CM |
| LOWER LIMIT OF EVAPORATIVE STORAGE | = | 1.650 | CM |
| INITIAL SNOW WATER | = | 0.000 | CM |
| INITIAL WATER IN LAYER MATERIALS | = | 170.700 | CM |
| TOTAL INITIAL WATER | = | 170.700 | CM |
| TOTAL SUBSURFACE INFLOW | = | 0.00 | MM/YR |

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM LAS VEGAS NEVADA

| | | | |
|---|---|---|---|
| STATION LATITUDE | = | 36.08 | DEGREES |
| MAXIMUM LEAF AREA INDEX | = | 1.00 | |
| START OF GROWING SEASON (JULIAN DATE) | = | 62 | |
| END OF GROWING SEASON (JULIAN DATE) | = | 321 | |
| EVAPORATIVE ZONE DEPTH | = | 50.0 | CM |
| AVERAGE ANNUAL WIND SPEED | = | 14.00 | KPH |
| AVERAGE 1ST QUARTER RELATIVE HUMIDITY | = | 39.00 | % |
| AVERAGE 2ND QUARTER RELATIVE HUMIDITY | = | 21.00 | % |
| AVERAGE 3RD QUARTER RELATIVE HUMIDITY | = | 24.00 | % |
| AVERAGE 4TH QUARTER RELATIVE HUMIDITY | = | 36.00 | % |

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR LAS VEGAS NEVADA

NORMAL MEAN MONTHLY PRECIPITATION (MM)

| JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|
| 17.6 | 16.2 | 14.4 | 7.8 | 7.1 | 3.2 |
| 15.8 | 19.0 | 11.2 | 8.7 | 15.1 | 11.2 |

```
      NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    LAS VEGAS             NEVADA

               NORMAL MEAN MONTHLY TEMPERATURE (DEGREES CELSIUS)

   JAN/JUL     FEB/AUG     MAR/SEP     APR/OCT     MAY/NOV     JUN/DEC
   -------     -------     -------     -------     -------     -------
     7.0        10.1        13.0        17.5        23.0        28.7
    32.4        31.1        26.7        19.8        12.0         7.5


      NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
                COEFFICIENTS FOR    LAS VEGAS             NEVADA
                   AND STATION LATITUDE  =  36.08 DEGREES


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

                         ANNUAL TOTALS FOR YEAR    1
-------------------------------------------------------------------------------
                                              MM          CU. METERS    PERCENT
                                          ----------      ----------    -------
  PRECIPITATION                              98.80          98.800      100.00

  RUNOFF                                      0.000          0.000        0.00

  EVAPOTRANSPIRATION                         99.403         99.403      100.61

  PERC./LEAKAGE THROUGH LAYER  4             12.030613      12.031       12.18

  CHANGE IN WATER STORAGE                   -12.633        -12.633      -12.79

  SOIL WATER AT START OF YEAR              1707.000       1707.000

  SOIL WATER AT END OF YEAR                1694.366       1694.366

  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                 0.0001         0.000        0.00

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


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

ANNUAL TOTALS FOR YEAR 2

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 169.70 | 169.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 147.516 | 147.516 | 86.93 |
| PERC./LEAKAGE THROUGH LAYER 4 | 11.058376 | 11.058 | 6.52 |
| CHANGE IN WATER STORAGE | 11.126 | 11.126 | 6.56 |
| SOIL WATER AT START OF YEAR | 1694.366 | 1694.366 | |
| SOIL WATER AT END OF YEAR | 1705.492 | 1705.492 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 3

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 119.40 | 119.400 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 115.952 | 115.952 | 97.11 |
| PERC./LEAKAGE THROUGH LAYER 4 | 18.891409 | 18.891 | 15.82 |
| CHANGE IN WATER STORAGE | -15.444 | -15.444 | -12.93 |
| SOIL WATER AT START OF YEAR | 1705.492 | 1705.492 | |
| SOIL WATER AT END OF YEAR | 1690.049 | 1690.049 | |
| 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 | -0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 4

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 252.70 | 252.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 229.537 | 229.537 | 90.83 |
| PERC./LEAKAGE THROUGH LAYER 4 | 16.944080 | 16.944 | 6.71 |
| CHANGE IN WATER STORAGE | 6.218 | 6.218 | 2.46 |
| SOIL WATER AT START OF YEAR | 1690.049 | 1690.049 | |
| SOIL WATER AT END OF YEAR | 1696.267 | 1696.267 | |
| 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 | 0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 5

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 131.50 | 131.500 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 106.008 | 106.008 | 80.61 |
| PERC./LEAKAGE THROUGH LAYER 4 | 11.327345 | 11.327 | 8.61 |
| CHANGE IN WATER STORAGE | 14.165 | 14.165 | 10.77 |

| | | | |
|---|---|---|---|
| SOIL WATER AT START OF YEAR | 1696.267 | 1696.267 | |
| SOIL WATER AT END OF YEAR | 1710.432 | 1710.432 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 6

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 175.10 | 175.100 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 151.971 | 151.971 | 86.79 |
| PERC./LEAKAGE THROUGH LAYER 4 | 4.836679 | 4.837 | 2.76 |
| CHANGE IN WATER STORAGE | 18.292 | 18.292 | 10.45 |
| SOIL WATER AT START OF YEAR | 1710.432 | 1710.432 | |
| SOIL WATER AT END OF YEAR | 1728.724 | 1728.724 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 7

| | MM | CU. METERS | PERCENT |
|---|---|---|---|

| | | | |
|---|---|---|---|
| PRECIPITATION | 127.30 | 127.300 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 122.717 | 122.717 | 96.40 |
| PERC./LEAKAGE THROUGH LAYER 4 | 13.806053 | 13.806 | 10.85 |
| CHANGE IN WATER STORAGE | -9.222 | -9.222 | -7.24 |
| SOIL WATER AT START OF YEAR | 1728.724 | 1728.724 | |
| SOIL WATER AT END OF YEAR | 1719.501 | 1719.501 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 8

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 142.00 | 142.000 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 137.592 | 137.592 | 96.90 |
| PERC./LEAKAGE THROUGH LAYER 4 | 12.462837 | 12.463 | 8.78 |
| CHANGE IN WATER STORAGE | -8.055 | -8.055 | -5.67 |
| SOIL WATER AT START OF YEAR | 1719.501 | 1719.501 | |
| SOIL WATER AT END OF YEAR | 1711.446 | 1711.446 | |
| 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 | 0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 9

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 122.80 | 122.800 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 116.188 | 116.188 | 94.62 |
| PERC./LEAKAGE THROUGH LAYER 4 | 14.044257 | 14.044 | 11.44 |
| CHANGE IN WATER STORAGE | -7.432 | -7.432 | -6.05 |
| SOIL WATER AT START OF YEAR | 1711.446 | 1711.446 | |
| SOIL WATER AT END OF YEAR | 1704.013 | 1704.013 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 10

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 148.80 | 148.800 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 136.553 | 136.553 | 91.77 |
| PERC./LEAKAGE THROUGH LAYER 4 | 17.433994 | 17.434 | 11.72 |
| CHANGE IN WATER STORAGE | -5.187 | -5.187 | -3.49 |
| SOIL WATER AT START OF YEAR | 1704.013 | 1704.013 | |
| SOIL WATER AT END OF YEAR | 1698.827 | 1698.827 | |

| | | | |
|---|---|---|---|
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 11

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 306.50 | 306.500 | 100.00 |
| RUNOFF | 6.145 | 6.145 | 2.00 |
| EVAPOTRANSPIRATION | 238.267 | 238.267 | 77.74 |
| PERC./LEAKAGE THROUGH LAYER 4 | 16.062769 | 16.063 | 5.24 |
| CHANGE IN WATER STORAGE | 46.025 | 46.025 | 15.02 |
| SOIL WATER AT START OF YEAR | 1698.827 | 1698.827 | |
| SOIL WATER AT END OF YEAR | 1744.852 | 1744.852 | |
| 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 | 0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 12

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 117.20 | 117.200 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |

| | | | |
|---|---|---|---|
| EVAPOTRANSPIRATION | 138.830 | 138.830 | 118.46 |
| PERC./LEAKAGE THROUGH LAYER 4 | 18.603401 | 18.603 | 15.87 |
| CHANGE IN WATER STORAGE | -40.234 | -40.234 | -34.33 |
| SOIL WATER AT START OF YEAR | 1744.852 | 1744.852 | |
| SOIL WATER AT END OF YEAR | 1704.618 | 1704.618 | |
| 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 | -0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 13

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 90.60 | 90.600 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 76.878 | 76.878 | 84.85 |
| PERC./LEAKAGE THROUGH LAYER 4 | 6.468447 | 6.468 | 7.14 |
| CHANGE IN WATER STORAGE | 7.254 | 7.254 | 8.01 |
| SOIL WATER AT START OF YEAR | 1704.618 | 1704.618 | |
| SOIL WATER AT END OF YEAR | 1711.872 | 1711.872 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 14

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 137.90 | 137.900 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 122.345 | 122.345 | 88.72 |
| PERC./LEAKAGE THROUGH LAYER 4 | 16.641733 | 16.642 | 12.07 |
| CHANGE IN WATER STORAGE | -1.087 | -1.087 | -0.79 |
| SOIL WATER AT START OF YEAR | 1711.872 | 1711.872 | |
| SOIL WATER AT END OF YEAR | 1710.785 | 1710.785 | |
| 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 | 0.0004 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 15

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 149.70 | 149.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 138.878 | 138.878 | 92.77 |
| PERC./LEAKAGE THROUGH LAYER 4 | 17.191803 | 17.192 | 11.48 |
| CHANGE IN WATER STORAGE | -6.370 | -6.370 | -4.25 |
| SOIL WATER AT START OF YEAR | 1710.785 | 1710.785 | |
| SOIL WATER AT END OF YEAR | 1704.415 | 1704.415 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 16

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 129.70 | 129.700 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 118.587 | 118.587 | 91.43 |
| PERC./LEAKAGE THROUGH LAYER 4 | 18.103363 | 18.103 | 13.96 |
| CHANGE IN WATER STORAGE | -6.991 | -6.991 | -5.39 |
| SOIL WATER AT START OF YEAR | 1704.415 | 1704.415 | |
| SOIL WATER AT END OF YEAR | 1697.424 | 1697.424 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 17

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 95.60 | 95.600 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 89.437 | 89.437 | 93.55 |
| PERC./LEAKAGE THROUGH LAYER 4 | 10.228971 | 10.229 | 10.70 |

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| CHANGE IN WATER STORAGE | -4.066 | -4.066 | -4.25 |
| SOIL WATER AT START OF YEAR | 1697.424 | 1697.424 | |
| SOIL WATER AT END OF YEAR | 1693.358 | 1693.359 | |
| 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 | -0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 18

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 131.60 | 131.600 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 115.076 | 115.076 | 87.44 |
| PERC./LEAKAGE THROUGH LAYER 4 | 14.084309 | 14.084 | 10.70 |
| CHANGE IN WATER STORAGE | 2.440 | 2.440 | 1.85 |
| SOIL WATER AT START OF YEAR | 1693.358 | 1693.359 | |
| SOIL WATER AT END OF YEAR | 1695.798 | 1695.798 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 19

| | MM | CU. METERS | PERCENT |
|---|---|---|---|

| | | | |
|---|---|---|---|
| PRECIPITATION | 127.50 | 127.500 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 115.617 | 115.617 | 90.68 |
| PERC./LEAKAGE THROUGH LAYER 4 | 13.692079 | 13.692 | 10.74 |
| CHANGE IN WATER STORAGE | -1.809 | -1.809 | -1.42 |
| SOIL WATER AT START OF YEAR | 1695.798 | 1695.798 | |
| SOIL WATER AT END OF YEAR | 1693.989 | 1693.989 | |
| 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 | -0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 20

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 72.20 | 72.200 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 69.637 | 69.637 | 96.45 |
| PERC./LEAKAGE THROUGH LAYER 4 | 15.588384 | 15.588 | 21.59 |
| CHANGE IN WATER STORAGE | -13.026 | -13.026 | -18.04 |
| SOIL WATER AT START OF YEAR | 1693.989 | 1693.989 | |
| SOIL WATER AT END OF YEAR | 1680.964 | 1680.964 | |
| 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 | 0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 21

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 82.10 | 82.100 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 70.707 | 70.707 | 86.12 |
| PERC./LEAKAGE THROUGH LAYER 4 | 9.682813 | 9.683 | 11.79 |
| CHANGE IN WATER STORAGE | 1.710 | 1.710 | 2.08 |
| SOIL WATER AT START OF YEAR | 1680.964 | 1680.964 | |
| SOIL WATER AT END OF YEAR | 1682.673 | 1682.673 | |
| 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 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 22

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 143.00 | 143.000 | 100.00 |
| RUNOFF | 5.994 | 5.994 | 4.19 |
| EVAPOTRANSPIRATION | 117.496 | 117.496 | 82.17 |
| PERC./LEAKAGE THROUGH LAYER 4 | 12.330116 | 12.330 | 8.62 |
| CHANGE IN WATER STORAGE | 7.180 | 7.180 | 5.02 |
| SOIL WATER AT START OF YEAR | 1682.673 | 1682.673 | |

| | | | |
|---|---|---|---|
| SOIL WATER AT END OF YEAR | 1689.853 | 1689.853 | |
| 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 | -0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 23

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 100.50 | 100.500 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 88.312 | 88.312 | 87.87 |
| PERC./LEAKAGE THROUGH LAYER 4 | 11.376358 | 11.376 | 11.32 |
| CHANGE IN WATER STORAGE | 0.811 | 0.811 | 0.81 |
| SOIL WATER AT START OF YEAR | 1689.853 | 1689.853 | |
| SOIL WATER AT END OF YEAR | 1690.664 | 1690.664 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 24

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 197.90 | 197.900 | 100.00 |
| RUNOFF | 0.046 | 0.046 | 0.02 |

| | | | |
|---|---|---|---|
| EVAPOTRANSPIRATION | 174.487 | 174.487 | 88.17 |
| PERC./LEAKAGE THROUGH LAYER 4 | 14.684868 | 14.685 | 7.42 |
| CHANGE IN WATER STORAGE | 8.683 | 8.683 | 4.39 |
| SOIL WATER AT START OF YEAR | 1690.664 | 1690.664 | |
| SOIL WATER AT END OF YEAR | 1699.347 | 1699.347 | |
| 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 | -0.0002 | 0.000 | 0.00 |

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

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

ANNUAL TOTALS FOR YEAR 25

| | MM | CU. METERS | PERCENT |
|---|---|---|---|
| PRECIPITATION | 130.00 | 130.000 | 100.00 |
| RUNOFF | 0.000 | 0.000 | 0.00 |
| EVAPOTRANSPIRATION | 116.860 | 116.860 | 89.89 |
| PERC./LEAKAGE THROUGH LAYER 4 | 5.961359 | 5.961 | 4.59 |
| CHANGE IN WATER STORAGE | 7.179 | 7.179 | 5.52 |
| SOIL WATER AT START OF YEAR | 1699.347 | 1699.347 | |
| SOIL WATER AT END OF YEAR | 1706.526 | 1706.526 | |
| 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 | 0.0001 | 0.000 | 0.00 |

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

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

AVERAGE MONTHLY VALUES (MM) FOR YEARS 1 THROUGH 25

| | JAN/JUL | FEB/AUG | MAR/SEP | APR/OCT | MAY/NOV | JUN/DEC |
|---|---|---|---|---|---|---|
| **PRECIPITATION** | | | | | | |
| TOTALS | 10.92 | 14.20 | 9.72 | 10.24 | 8.98 | 2.18 |
| | 17.01 | 22.32 | 11.83 | 5.62 | 17.47 | 9.50 |
| STD. DEVIATIONS | 12.95 | 16.48 | 11.48 | 7.67 | 10.97 | 4.16 |
| | 24.29 | 19.56 | 18.26 | 5.60 | 18.55 | 7.76 |
| **RUNOFF** | | | | | | |
| TOTALS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.004 | 0.242 | 0.242 | 0.000 | 0.000 | 0.000 |
| STD. DEVIATIONS | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | 0.019 | 1.199 | 1.210 | 0.000 | 0.000 | 0.000 |
| **EVAPOTRANSPIRATION** | | | | | | |
| TOTALS | 11.054 | 11.554 | 8.763 | 10.137 | 10.702 | 2.760 |
| | 15.115 | 18.491 | 9.016 | 6.694 | 11.728 | 10.180 |
| STD. DEVIATIONS | 11.150 | 9.026 | 8.706 | 7.418 | 10.044 | 4.263 |
| | 23.312 | 14.953 | 11.087 | 6.251 | 13.737 | 10.165 |
| **PERCOLATION/LEAKAGE THROUGH LAYER 4** | | | | | | |
| TOTALS | 1.0634 | 0.9268 | 1.1405 | 1.0304 | 1.2352 | 1.2282 |
| | 1.1678 | 1.2342 | 1.1473 | 1.1149 | 0.9809 | 1.0718 |
| STD. DEVIATIONS | 0.4395 | 0.3902 | 0.4792 | 0.4344 | 0.4956 | 0.4354 |
| | 0.4002 | 0.5059 | 0.4695 | 0.4720 | 0.3900 | 0.3445 |

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

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

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 25

| | MM | | CU. METERS | PERCENT |
|---|---|---|---|---|
| PRECIPITATION | 140.00 | ( 51.480) | 140.0 | 100.00 |

| | | | |
|---|---|---|---|
| RUNOFF | 0.487 ( 1.6802) | 0.49 | 0.348 |
| EVAPOTRANSPIRATION | 126.194 ( 41.1087) | 126.19 | 90.136 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 13.34146 ( 3.90516) | 13.341 | 9.52934 |
| CHANGE IN WATER STORAGE | -0.019 ( 0.6006) | -0.02 | -0.014 |

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

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

PEAK DAILY VALUES FOR YEARS 1 THROUGH 25

| | (MM) | (CU. METERS) |
|---|---|---|
| PRECIPITATION | 68.20 | 68.200 |
| RUNOFF | 6.052 | 6.0523 |
| PERCOLATION/LEAKAGE THROUGH LAYER 4 | 0.093004 | 0.09300 |
| SNOW WATER | 26.30 | 26.3000 |

| | |
|---|---|
| MAXIMUM VEG. SOIL WATER (VOL/VOL) | 0.1736 |
| MINIMUM VEG. SOIL WATER (VOL/VOL) | 0.0330 |

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

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

FINAL WATER STORAGE AT END OF YEAR 25

| LAYER | (CM) | (VOL/VOL) |
|---|---|---|
| 1 | 8.0607 | 0.0806 |
| 2 | 87.6000 | 0.2920 |
| 3 | 37.8223 | 0.1261 |
| 4 | 37.1696 | 0.1239 |
| SNOW WATER | 0.000 | |

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

```
TIME OF RUN 07:55:37.0
DATE OF RUN 03/01/96
INPUT FILE NAME: GWSCREEN.PAR
OUTPUT FILE NAME:. GWSCREEN.OUT
=========================================================
ACKNOWLEDGEMENT OF GOVERNMENT SPONSORSHIP AND
LIMITATION OF LIABILITY
```



```
=========================================================

**************************************************
*                                                *
*     This output was produced by the model:     *
*                                                *
*                   GWSCREEN                     *
*        Version Control Copy, Version 2.03      *
*   A semi-analytical model for the assessment   *
*   of the groundwater pathway from the leaching *
*   of surficial and buried contamination and    *
*  release of contaminants from percolation ponds *
*                   03-08-94                     *
*                Arthur S. Rood                  *
*      Idaho National Engineering Laboratory     *
*                EG&G Idaho Inc.                 *
*     Subsurface and Environmental Modeling Unit *
*                  PO Box 1625                   *
*             Idaho Falls, Idaho 83415           *
**************************************************
>>> TITLE OF PROJECT:
Cactus Flats Waste Trenches,  Conservative Contaminant
---------------------------------------------------------
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 4
KFLAG: 0 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE
>>> INPUT DATA
*********************************************************
```

| | |
|---|---|
| NUMBER OF RADIOACTIVE PROGENY | 0 |
| LENGTH OF SOURCE PARALLEL TO GW FLOW (m) | 3.60E+01 |
| WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m) | 3.00E+01 |
| THICKNESS OF SOURCE (m) | 3.00E+00 |
| PERCOLATION RATE (darcy vel m/y) | 1.50E-02 |
| VOLUMETRIC WATER CONTENT IN SOURCE | 2.90E-01 |
| VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE | 8.00E-02 |
| BULK DENSITY AT SOURCE (g/cm**3) | 3.00E-01 |
| SORPTION COEFFICIENT AT SOURCE (ml/g) | 0.00E+00 |
| BULK DENSITY IN UNSAT ZONE (g/cm**3) | 1.40E+00 |
| UNSATURATED ZONE THICKNESS (m) | 1.00E+01 |
| SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) | 0.00E+00 |
| OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) | 0.00E+00 |
| INITIAL MASS OR ACTIVITY (mg or Ci) | 1.00E+00 |
| MOLECULAR WEIGHT (g/mole) | 1.00E+02 |
| SOLUBILITY LIMIT (mg/L) | 1.00E+04 |
| HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) | 1.00E+38 |
| BULK DENSITY OF AQUIFER (g/cm**3) | 2.00E+00 |
| POROSITY OF AQUIFER | 1.00E-01 |
| SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) | 0.00E+00 |
| DISPERSIVITY X DIRECTION (m) | 1.00E-03 |
| DISPERSIVITY Y DIRECTION (m) | 5.00E-04 |
| PORE VELOCITY (m/y) | 1.00E+02 |
| WELL SCREEN THICKNESS (m) | 1.00E+00 |
| DISTANCE TO RECEPTOR ALONG X AXIS (m) | 2.00E+01 |
| DISTANCE TO RECEPTOR ALONG Y AXIS (m) | 0.00E+00 |
| LIMITING CONTAMINANT GW CONCENTRATION (mg/L) | 1.00E+00 |
| UNITS OF CONTAMINANT | mg |

INPUT DATA FILE CREATED BY:____________________ DATE / /

INPUT DATA CHECKED BY: ____________________ DATE / /

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

>>> VALUES CALCULATED IN SOURCE SUBROUTINE

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

| | |
|---|---|
| LEACH RATE CONSTANT (1/y) | 1.72E-02 |
| UNSATURATED PORE VELOCITY (m/y) | 1.88E-01 |
| DECAY CONSTANT(S) (1/y) | 6.93E-39 |
| RETARDATION FACTOR(S) (SATURATED) | 1.00E+00 |
| RETARDATION FACTOR (UNSATURATED) | 1.00E+00 |
| SOLUBILITY LIMITED MASS (mg) | 9.40E+09 |
| SOLUBILITY LIMITED ACTIVITY (Ci) | 0.00E+00 |
| TRANSIT TIME IN UNSAT ZONE (years) | 5.33E+01 |
| FRACTION DECAYED DURING UNSAT TRANSPORT | 0.00E+00 |

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

>>> EXPOSURE DATA FOR LIMITING SOIL CONCENTRATION

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

| | |
|---|---|
| INTEGRATION TIME (years) | 0 |
| BODY WEIGHT (kg) | 7.000E+01 |
| AVERAGING TIME (days) | 2.555E+04 |
| WATER INTAKE RATE (L/d) | 2.000E+00 |

```
EXPOSURE FREQUENCY (days/year)      3.500E+02
EXPOSURE DURATION (years)           3.000E+01
RADIOLOGICAL DOSE LIMIT (rem/y)     4.000E-03
CARCINOGENIC RISK CRITERIA          1.000E-06
HAZARD QUOTIENT                     1.000E+00
-------------------------------------------------------
>>> RESULTS OF CALCULATIONS
*******************************************************
>>> CONCENTRATION VS TIME MODE
```

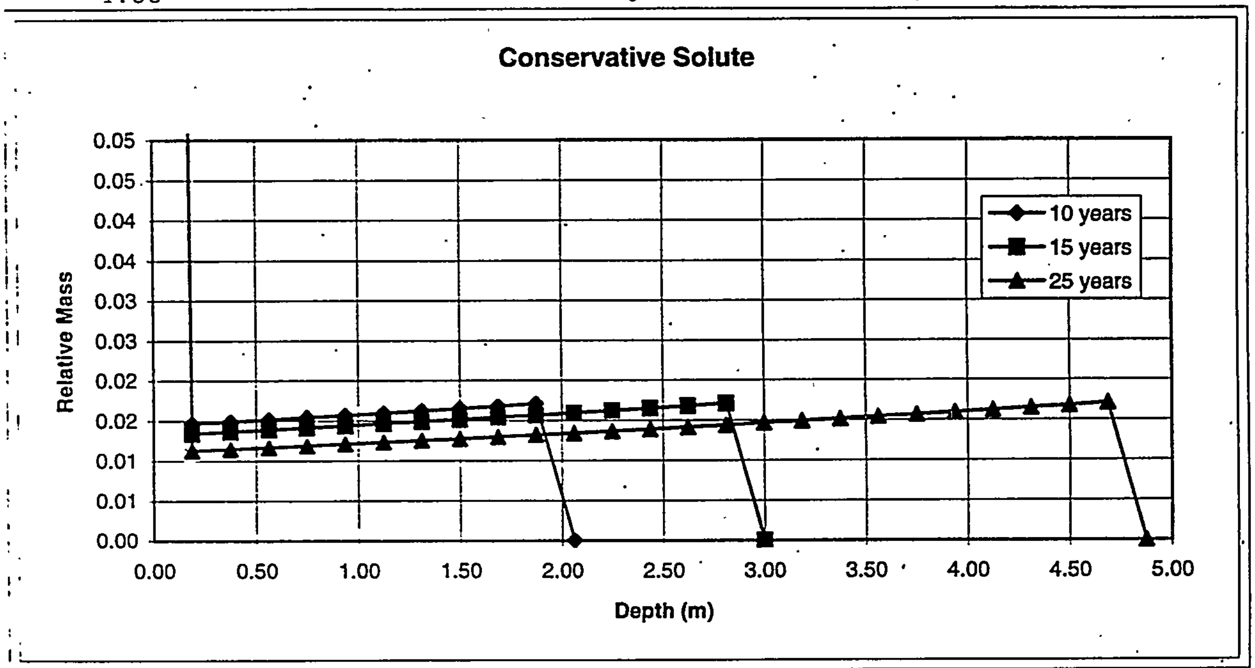
| TIME (years) | SOURCE FLUX (mg) | AQUIFER FLUX (mg) | AQUIFER FLUX (mg/year) | GW CONC (mg/m**3) | SOURCE FLUX (mg/year) |
|---|---|---|---|---|---|
| 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.71E-02 |
| 1.00E+00 | 1.71E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.68E-02 |
| 2.00E+00 | 3.39E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.65E-02 |
| 3.00E+00 | 5.04E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.62E-02 |
| 4.00E+00 | 6.66E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.60E-02 |
| 5.00E+00 | 8.26E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.57E-02 |
| 6.00E+00 | 9.83E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.54E-02 |
| 7.00E+00 | 1.14E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.52E-02 |
| 8.00E+00 | 1.29E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.49E-02 |
| 9.00E+00 | 1.44E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.46E-02 |
| 1.00E+01 | 1.58E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.44E-02 |
| 1.10E+01 | 1.73E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.41E-02 |
| 1.20E+01 | 1.87E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.39E-02 |
| 1.30E+01 | 2.01E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E-02 |
| 1.40E+01 | 2.14E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.34E-02 |
| 1.50E+01 | 2.28E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.32E-02 |
| 1.60E+01 | 2.41E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.30E-02 |
| 1.70E+01 | 2.54E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.28E-02 |
| 1.80E+01 | 2.67E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.25E-02 |
| 1.90E+01 | 2.79E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.23E-02 |
| 2.00E+01 | 2.92E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.21E-02 |
| 2.10E+01 | 3.04E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.19E-02 |
| 2.20E+01 | 3.16E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.17E-02 |
| 2.30E+01 | 3.27E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.15E-02 |
| 2.40E+01 | 3.39E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.13E-02 |
| 2.50E+01 | 3.50E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.11E-02 |
| 2.60E+01 | 3.61E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.09E-02 |
| 2.70E+01 | 3.72E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.07E-02 |
| 2.80E+01 | 3.83E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.06E-02 |
| 2.90E+01 | 3.93E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.04E-02 |
| 3.00E+01 | 4.04E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | |

```
MAXIMUM CONCENTRATION(S) mg/m**3
  2.61E-05
TIME(S) OF MAXIMUM CONCENTRATIONS (years)
  1.00E+02
EXECUTION TIME (seconds)      0
```

Water Flow Rate 1.88E-01 m/yr
Retardation 1.00E+00
Solute Flow Rate 1.88E-01 m/yr

Solute Masses By Depth

| Depth (m) | 10 years | 15 years | 25 years | |
|---|---|---|---|---|
| 0.00 | 0.842 | 0.772 | 0.650 | (mass remaining in source) |
| 0.19 | 0.015 | 0.013 | 0.011 | |
| 0.38 | 0.015 | 0.014 | 0.012 | |
| 0.56 | 0.015 | 0.014 | 0.012 | |
| 0.75 | 0.015 | 0.014 | 0.012 | |
| 0.94 | 0.016 | 0.014 | 0.012 | |
| 1.13 | 0.016 | 0.015 | 0.012 | |
| 1.31 | 0.016 | 0.015 | 0.013 | |
| 1.50 | 0.017 | 0.015 | 0.013 | |
| 1.69 | 0.017 | 0.015 | 0.013 | |
| 1.88 | 0.017 | 0.016 | 0.013 | |
| 2.06 | 0 | 0.016 | 0.013 | |
| 2.25 | | 0.016 | 0.014 | |
| 2.44 | | 0.017 | 0.014 | |
| 2.63 | | 0.017 | 0.014 | |
| 2.81 | | 0.017 | 0.014 | |
| 3.00 | | 0 | 0.015 | |
| 3.19 | | | 0.015 | |
| 3.38 | | | 0.015 | |
| 3.56 | | | 0.015 | |
| 3.75 | | | 0.016 | |
| 3.94 | | | 0.016 | |
| 4.13 | | | 0.016 | |
| 4.31 | | | 0.017 | |
| 4.50 | | | 0.017 | |
| 4.69 | | | 0.017 | |
| 4.88 | | | 0 | |



```
TIME OF RUN 08:32:24.3
DATE OF RUN 03/01/96
INPUT FILE NAME: GWSCREEN.PAR
OUTPUT FILE NAME: GWSCREEN.OUT
========================================================
ACKNOWLEDGEMENT OF GOVERNMENT SPONSORSHIP AND
LIMITATION OF LIABILITY

This material resulted from work developed under U.S. Department of
Energy, Office of Environmental Restoration and Waste Management,
DOE Field Office, Idaho, Contract Number DE-AC07-76ID01570.
This material is subject to a limited government license:
Copyright 1993, EG&G Idaho Inc., Idaho National Engineering Laboratory,
all rights reserved.  Neither the United States nor the United States
Department of Energy, nor any of their employees, makes any warranty
expressed or implied, or assumes any legal liability or
responsibility for the accuracy, completeness, or usefulness of any
information, apparatus, product or process disclosed, or represents that
its use would not infringe on privately owned rights. Subroutines GOLDEN,
QSIMP, QGAUS, and TRAPZD are Copyright (C) 1992, Numerical Recipes
Software.  Reproduced by permission from the book, Numerical Recipes,
Cambridge University Press.
========================================================

**************************************************
*                                                *
*     This output was produced by the model:     *
*                                                *
*                    GWSCREEN                    *
*        Version Control Copy, Version 2.03      *
*    A semi-analytical model for the assessment  *
*    of the groundwater pathway from the leaching *
*    of surficial and buried contamination and   *
*  release of contaminants from percolation ponds *
*                    03-08-94                    *
*                 Arthur S. Rood                 *
*       Idaho National Engineering Laboratory    *
*                 EG&G Idaho Inc.                *
*     Subsurface and Environmental Modeling Unit *
*                   PO Box 1625                  *
*              Idaho Falls, Idaho 83415          *
**************************************************
>>> TITLE OF PROJECT:
Cactus Springs Waste Trenches,  Low Sorption Contaminant (Cr VI)
----------------------------------------------------------
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 4
KFLAG: 0 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE
>>> INPUT DATA
*********************************************************
NUMBER OF RADIOACTIVE PROGENY                                 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)              3.60E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)          3.00E+01
```

| | |
|---|---|
| THICKNESS OF SOURCE (m) | 3.00E+00 |
| PERCOLATION RATE (darcy vel m/y) | 1.50E-02 |
| VOLUMETRIC WATER CONTENT IN SOURCE | 2.90E-01 |
| VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE | 8.00E-02 |
| BULK DENSITY AT SOURCE (g/cm**3) | 3.00E-01 |
| SORPTION COEFFICIENT AT SOURCE (ml/g) | 1.20E+00 |
| BULK DENSITY IN UNSAT ZONE (g/cm**3) | 1.40E+00 |
| UNSATURATED ZONE THICKNESS (m) | 1.00E+01 |
| SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) | 1.20E+00 |
| OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) | 0.00E+00 |
| INITIAL MASS OR ACTIVITY (mg or Ci) | 1.00E+00 |
| MOLECULAR WEIGHT (g/mole) | 5.00E+01 |
| SOLUBILITY LIMIT (mg/L) | 1.00E+04 |
| HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) | 1.00E+38 |
| BULK DENSITY OF AQUIFER (g/cm**3) | 2.00E+00 |
| POROSITY OF AQUIFER | 1.00E-01 |
| SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) | 1.20E+00 |
| DISPERSIVITY X DIRECTION (m) | 1.00E-03 |
| DISPERSIVITY Y DIRECTION (m) | 5.00E-04 |
| PORE VELOCITY (m/y) | 1.00E+02 |
| WELL SCREEN THICKNESS (m) | 1.00E+00 |
| DISTANCE TO RECEPTOR ALONG X AXIS (m) | 2.00E+01 |
| DISTANCE TO RECEPTOR ALONG Y AXIS (m) | 0.00E+00 |
| LIMITING CONTAMINANT GW CONCENTRATION (mg/L) | 1.00E+00 |
| UNITS OF CONTAMINANT | mg |

INPUT DATA FILE CREATED BY:____________________ DATE / /

INPUT DATA CHECKED BY: ____________________ DATE / /

-----------------------------------------------------------

>>> VALUES CALCULATED IN SOURCE SUBROUTINE

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

| | |
|---|---|
| LEACH RATE CONSTANT (1/y) | 7.69E-03 |
| UNSATURATED PORE VELOCITY (m/y) | 1.88E-01 |
| DECAY CONSTANT(S) (1/y) | 6.93E-39 |
| RETARDATION FACTOR(S) (SATURATED) | 2.50E+01 |
| RETARDATION FACTOR (UNSATURATED) | 2.20E+01 |
| SOLUBILITY LIMITED MASS (mg) | 2.11E+10 |
| SOLUBILITY LIMITED ACTIVITY (Ci) | 0.00E+00 |
| TRANSIT TIME IN UNSAT ZONE (years) | 1.17E+03 |
| FRACTION DECAYED DURING UNSAT TRANSPORT | 0.00E+00 |

-----------------------------------------------------------

>>> EXPOSURE DATA FOR LIMITING SOIL CONCENTRATION

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

| | |
|---|---|
| INTEGRATION TIME (years) | 0 |
| BODY WEIGHT (kg) | 7.000E+01 |
| AVERAGING TIME (days) | 2.555E+04 |
| WATER INTAKE RATE (L/d) | 2.000E+00 |
| EXPOSURE FREQUENCY (days/year) | 3.500E+02 |
| EXPOSURE DURATION (years) | 3.000E+01 |
| RADIOLOGICAL DOSE LIMIT (rem/y) | 4.000E-03 |
| CARCINOGENIC RISK CRITERIA | 1.000E-06 |

HAZARD QUOTIENT 1.000E+00

---------------------------------------------------------------

>>> RESULTS OF CALCULATIONS

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

>>> CONCENTRATION VS TIME MODE

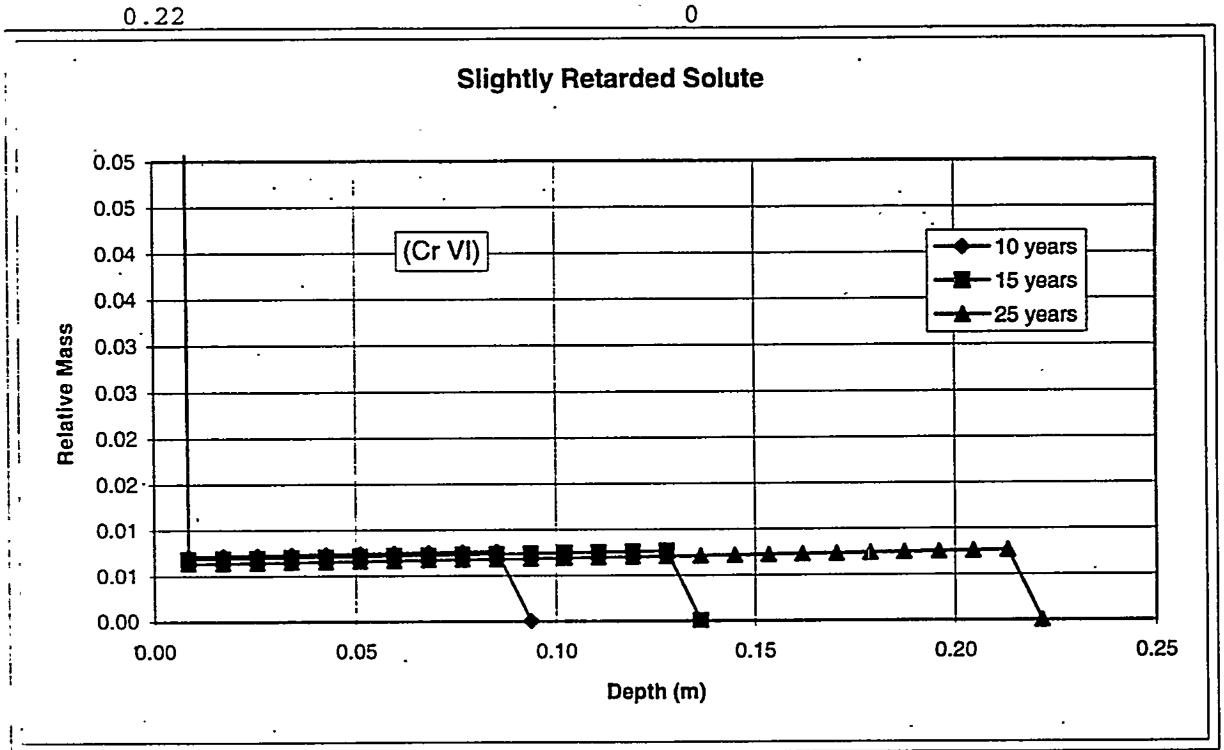
| TIME (years) | SOURCE FLUX (mg) | AQUIFER FLUX (mg) | AQUIFER FLUX (mg/year) | GW CONC (mg/m**3) | SOURCE FLUX (mg/year) |
|---|---|---|---|---|---|
| 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.66E-03 |
| 1.00E+00 | 7.66E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.60E-03 |
| 2.00E+00 | 1.53E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.55E-03 |
| 3.00E+00 | 2.28E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.49E-03 |
| 4.00E+00 | 3.03E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.43E-03 |
| 5.00E+00 | 3.77E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.37E-03 |
| 6.00E+00 | 4.51E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.32E-03 |
| 7.00E+00 | 5.24E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.26E-03 |
| 8.00E+00 | 5.97E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.21E-03 |
| 9.00E+00 | 6.69E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.15E-03 |
| 1.00E+01 | 7.40E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.10E-03 |
| 1.10E+01 | 8.11E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.04E-03 |
| 1.20E+01 | 8.82E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.99E-03 |
| 1.30E+01 | 9.52E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.94E-03 |
| 1.40E+01 | 1.02E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.88E-03 |
| 1.50E+01 | 1.09E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.82E-03 |
| 1.60E+01 | 1.16E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.78E-03 |
| 1.70E+01 | 1.23E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.72E-03 |
| 1.80E+01 | 1.29E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.68E-03 |
| 1.90E+01 | 1.36E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.62E-03 |
| 2.00E+01 | 1.43E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.57E-03 |
| 2.10E+01 | 1.49E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.52E-03 |
| 2.20E+01 | 1.56E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.47E-03 |
| 2.30E+01 | 1.62E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.42E-03 |
| 2.40E+01 | 1.69E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.37E-03 |
| 2.50E+01 | 1.75E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.32E-03 |
| 2.60E+01 | 1.81E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.27E-03 |
| 2.70E+01 | 1.88E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.23E-03 |
| 2.80E+01 | 1.94E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.18E-03 |
| 2.90E+01 | 2.00E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.13E-03 |
| 3.00E+01 | 2.06E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | |

MAXIMUM CONCENTRATION(S) mg/m**3
2.16E-08
TIME(S) OF MAXIMUM CONCENTRATIONS (years)
2.10E+03
EXECUTION TIME (seconds) 0

| | | | | |
|---|---|---|---|---|
| Water Flow Rate | 1.88E-01 m/yr | | | |
| Retardation | 2.20E+01 | | | |
| Solute Flow Rate | 8.52E-03 m/yr | | | |

Solute Masses By Depth

| Depth (m) | 10 years | 15 years | 25 years | |
|---|---|---|---|---|
| 0.00 | 0.926 | 0.891 | 0.825 | (mass remaining in source) |
| 0.01 | 0.007 | 0.007 | 0.006 | |
| 0.02 | 0.007 | 0.007 | 0.006 | |
| 0.03 | 0.007 | 0.007 | 0.006 | |
| 0.03 | 0.007 | 0.007 | 0.007 | |
| 0.04 | 0.007 | 0.007 | 0.007 | |
| 0.05 | 0.007 | 0.007 | 0.007 | |
| 0.06 | 0.007 | 0.007 | 0.007 | |
| 0.07 | 0.008 | 0.007 | 0.007 | |
| 0.08 | 0.008 | 0.007 | 0.007 | |
| 0.09 | 0.008 | 0.007 | 0.007 | |
| 0.09 | 0 | 0.007 | 0.007 | |
| 0.10 | | 0.007 | 0.007 | |
| 0.11 | | 0.008 | 0.007 | |
| 0.12 | | 0.008 | 0.007 | |
| 0.13 | | 0.008 | 0.007 | |
| 0.14 | | 0 | 0.007 | |
| 0.14 | | | 0.007 | |
| 0.15 | | | 0.007 | |
| 0.16 | | | 0.007 | |
| 0.17 | | | 0.007 | |
| 0.18 | | | 0.007 | |
| 0.19 | | | 0.007 | |
| 0.20 | | | 0.008 | |
| 0.20 | | | 0.008 | |
| 0.21 | | | 0.008 | |
| 0.22 | | | 0 | |



```
TIME OF RUN 08:56:56.7
DATE OF RUN 03/01/96
INPUT FILE NAME: GWSCREEN.PAR
OUTPUT FILE NAME: GWSCREEN.OUT
=============================================================
ACKNOWLEDGEMENT OF GOVERNMENT SPONSORSHIP AND
LIMITATION OF LIABILITY

This material resulted from work developed under U.S. Department of
Energy, Office of Environmental Restoration and Waste Management,
DOE Field Office, Idaho, Contract Number DE-AC07-76ID01570.
This material is subject to a limited government license:
Copyright 1993, EG&G Idaho Inc., Idaho National Engineering Laboratory,
all rights reserved.  Neither the United States nor the United States
Department of Energy, nor any of their employees, makes any warranty
expressed or implied, or assumes any legal liability or
responsibility for the accuracy, completeness, or usefulness of any
information, apparatus, product or process disclosed, or represents that
its use would not infringe on privately owned rights. Subroutines GOLDEN,
QSIMP, QGAUS, and TRAPZD are Copyright (C) 1992, Numerical Recipes
Software.  Reproduced by permission from the book, Numerical Recipes,
Cambridge University Press.
=============================================================

**************************************************
*                                                *
*     This output was produced by the model:     *
*                                                *
*                   GWSCREEN                     *
*       Version Control Copy, Version 2.03       *
*    A semi-analytical model for the assessment  *
*    of the groundwater pathway from the leaching *
*    of surficial and buried contamination and   *
*  release of contaminants from percolation ponds *
*                   03-08-94                     *
*                 Arthur S. Rood                 *
*       Idaho National Engineering Laboratory    *
*                 EG&G Idaho Inc.                *
*     Subsurface and Environmental Modeling Unit *
*                  PO Box 1625                   *
*            Idaho Falls, Idaho 83415            *
**************************************************
>>> TITLE OF PROJECT:
Cactus Springs Waste Trenches,  Plutonium-238
-------------------------------------------------------------
GAUSSIAN QUADRATURE SOLUTION
MODEL OPTIONS
IMODE: 3
KFLAG: 0 (0)CONC VS TIME; (1)PEAK CONC AND LIMITING SOIL CONC
IMODEL:1 (1) SURF OR BURIED SOURCE
>>> INPUT DATA
*************************************************************
NUMBER OF RADIOACTIVE PROGENY                                 0
LENGTH OF SOURCE PARALLEL TO GW FLOW (m)              3.60E+01
WIDTH OF SOURCE PERPENDICULAR TO GW FLOW (m)          3.00E+01
```

| | |
|---|---|
| THICKNESS OF SOURCE (m) | 3.00E+00 |
| PERCOLATION RATE (darcy vel m/y) | 1.50E-02 |
| VOLUMETRIC WATER CONTENT IN SOURCE | 2.90E-01 |
| VOLUMETRIC WATER CONTENT IN UNSATURATED ZONE | 8.00E-02 |
| BULK DENSITY AT SOURCE (g/cm**3) | 3.00E-01 |
| SORPTION COEFFICIENT AT SOURCE (ml/g) | 2.00E+01 |
| BULK DENSITY IN UNSAT ZONE (g/cm**3) | 1.40E+00 |
| UNSATURATED ZONE THICKNESS (m) | 1.00E+01 |
| SORPTION COEFFICIENT IN UNSAT ZONE (ml/g) | 2.00E+01 |
| OPTIONAL LOSS RATE CONSTANT FOR SOURCE (y**-1) | 0.00E+00 |
| INITIAL MASS OR ACTIVITY (mg or Ci) | 1.00E+00 |
| MOLECULAR WEIGHT (g/mole) | 2.38E+02 |
| SOLUBILITY LIMIT (mg/L) | 1.00E+04 |
| HALF-LIFE(S) OF CONTAMINANT AND PROGENY (y) | 8.77E+01 |
| BULK DENSITY OF AQUIFER (g/cm**3) | 2.00E+00 |
| POROSITY OF AQUIFER | 1.00E-01 |
| SORPTION COEFFICIENT(S) IN AQUIFER (ml/g) | 2.00E+01 |
| DISPERSIVITY X DIRECTION (m) | 1.00E-03 |
| DISPERSIVITY Y DIRECTION (m) | 5.00E-04 |
| PORE VELOCITY (m/y) | 1.00E+02 |
| WELL SCREEN THICKNESS (m) | 1.00E+00 |
| DISTANCE TO RECEPTOR ALONG X AXIS (m) | 2.00E+01 |
| DISTANCE TO RECEPTOR ALONG Y AXIS (m) | 0.00E+00 |
| LIMITING RADIONUCLIDE GW CONCENTRATION (Ci/L) | 1.00E+00 |
| UNITS OF CONTAMINANT | Ci |

INPUT DATA FILE CREATED BY:____________________ DATE / /

INPUT DATA CHECKED BY: ____________________ DATE / /

---

>>> INITIAL ACTIVITY CONVERTED TO MASS (mg) 5.84E+01
>>> VALUES CALCULATED IN SOURCE SUBROUTINE
*****************************************************

| | |
|---|---|
| LEACH RATE CONSTANT (1/y) | 7.95E-04 |
| UNSATURATED PORE VELOCITY (m/y) | 1.88E-01 |
| DECAY CONSTANT(S) (1/y) | 7.90E-03 |
| RETARDATION FACTOR(S) (SATURATED) | 4.01E+02 |
| RETARDATION FACTOR (UNSATURATED) | 3.51E+02 |
| SOLUBILITY LIMITED MASS (mg) | 2.04E+11 |
| SOLUBILITY LIMITED ACTIVITY (Ci) | 3.49E+09 |
| TRANSIT TIME IN UNSAT ZONE (years) | 1.87E+04 |
| FRACTION DECAYED DURING UNSAT TRANSPORT | 1.00E+00 |

---

>>> EXPOSURE DATA FOR LIMITING SOIL CONCENTRATION
*****************************************************

| | |
|---|---|
| INTEGRATION TIME (years) | 0 |
| BODY WEIGHT (kg) | 7.000E+01 |
| AVERAGING TIME (days) | 2.555E+04 |
| WATER INTAKE RATE (L/d) | 2.000E+00 |
| EXPOSURE FREQUENCY (days/year) | 3.500E+02 |
| EXPOSURE DURATION (years) | 3.000E+01 |
| RADIOLOGICAL DOSE LIMIT (rem/y) | 4.000E-03 |

```
CARCINOGENIC RISK CRITERIA          1.000E-06
HAZARD QUOTIENT                     1.000E+00
------------------------------------------------------------
>>> RESULTS OF CALCULATIONS
************************************************************
>>> CONCENTRATION VS TIME MODE
```

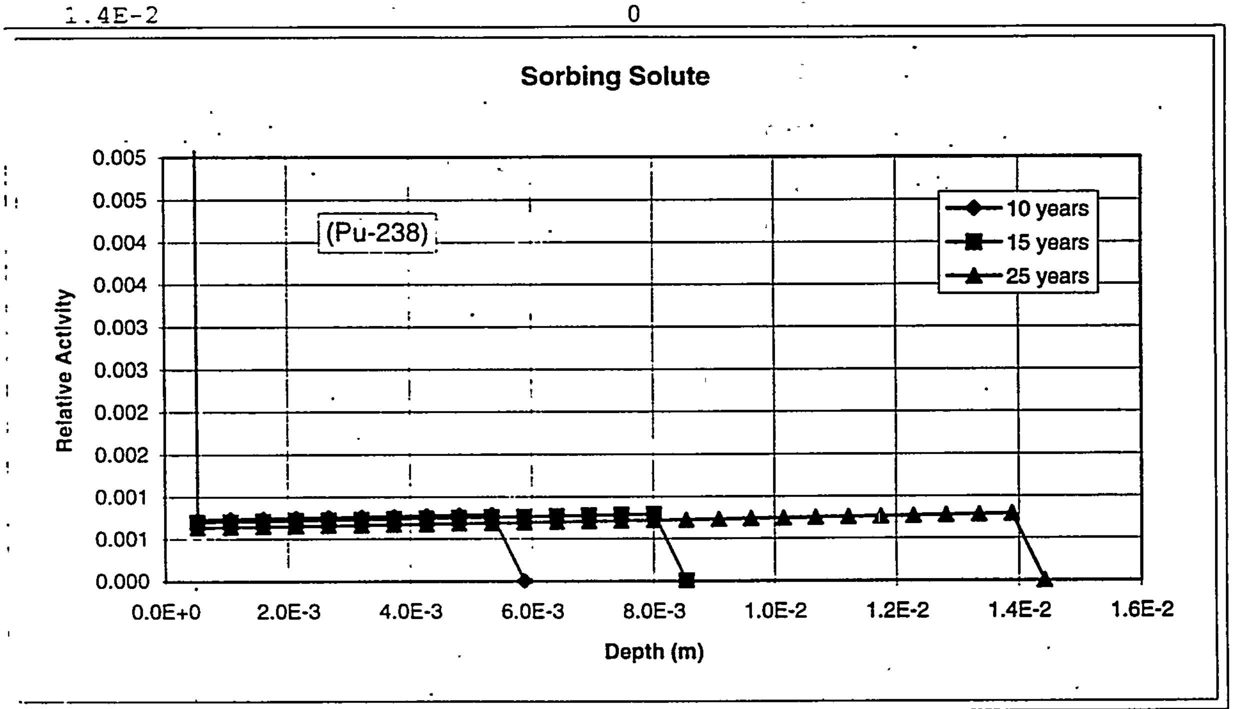
| TIME (years) | SOURCE FLUX (Ci) | AQUIFER FLUX (Ci) | AQUIFER FLUX (Ci/year) | GW CONC (Ci/m**3) | ..SOURCE FLUX (mg/year) |
|---|---|---|---|---|---|
| 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.91E-04 |
| 1.00E+00 | 7.91E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.85E-04 |
| 2.00E+00 | 1.58E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.78E-04 |
| 3.00E+00 | 2.35E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.71E-04 |
| 4.00E+00 | 3.13E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.64E-04 |
| 5.00E+00 | 3.89E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.58E-04 |
| 6.00E+00 | 4.65E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.51E-04 |
| 7.00E+00 | 5.40E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.45E-04 |
| 8.00E+00 | 6.14E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.38E-04 |
| 9.00E+00 | 6.88E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.32E-04 |
| 1.00E+01 | 7.61E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.26E-04 |
| 1.10E+01 | 8.34E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.19E-04 |
| 1.20E+01 | 9.06E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.13E-04 |
| 1.30E+01 | 9.77E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.07E-04 |
| 1.40E+01 | 1.05E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.01E-04 |
| 1.50E+01 | 1.12E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.95E-04 |
| 1.60E+01 | 1.19E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.88E-04 |
| 1.70E+01 | 1.26E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.83E-04 |
| 1.80E+01 | 1.32E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.77E-04 |
| 1.90E+01 | 1.39E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.71E-04 |
| 2.00E+01 | 1.46E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.65E-04 |
| 2.10E+01 | 1.53E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.59E-04 |
| 2.20E+01 | 1.59E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.54E-04 |
| 2.30E+01 | 1.66E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.48E-04 |
| 2.40E+01 | 1.72E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.42E-04 |
| 2.50E+01 | 1.79E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.37E-04 |
| 2.60E+01 | 1.85E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.31E-04 |
| 2.70E+01 | 1.91E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.26E-04 |
| 2.80E+01 | 1.98E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.21E-04 |
| 2.90E+01 | 2.04E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.15E-04 |
| 3.00E+01 | 2.10E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | |

```
MAXIMUM CONCENTRATION(S) Ci/m**3
 0.00E+00
TIME(S) OF MAXIMUM CONCENTRATIONS (years)
 0.00E+00
EXECUTION TIME (seconds)      0
```

| | | |
|---|---|---|
| Water Flow Rate | 1.88E-01 | m/yr |
| Retardation | 3.51E+02 | |
| Solute Flow Rate | 5.34E-04 | m/yr |

Solute Masses By Depth

| Depth (m) | 10 years | 15 years | 25 years | |
|---|---|---|---|---|
| 0.0E+0 | 0.992 | 0.989 | 0.982 | (mass remaining in source) |
| 5.3E-4 | 0.00073 | 0.00070 | 0.00064 | |
| 1.1E-3 | 0.00074 | 0.00071 | 0.00064 | |
| 1.6E-3 | 0.00074 | 0.00071 | 0.00065 | |
| 2.1E-3 | 0.00075 | 0.00072 | 0.00065 | |
| 2.7E-3 | 0.00076 | 0.00073 | 0.00066 | |
| 3.2E-3 | 0.00076 | 0.00073 | 0.00067 | |
| 3.7E-3 | 0.00077 | 0.00074 | 0.00067 | |
| 4.3E-3 | 0.00078 | 0.00074 | 0.00068 | |
| 4.8E-3 | 0.00078 | 0.00075 | 0.00068 | |
| 5.3E-3 | 0.00079 | 0.00076 | 0.00069 | |
| 5.9E-3 | 0 | 0.00076 | 0.00069 | |
| 6.4E-3 | | 0.00077 | 0.00070 | |
| 6.9E-3 | | 0.00078 | 0.00071 | |
| 7.5E-3 | | 0.00078 | 0.00071 | |
| 8.0E-3 | | 0.00079 | 0.00072 | |
| 8.5E-3 | | 0 | 0.00073 | |
| 9.1E-3 | | | 0.00073 | |
| 9.6E-3 | | | 0.00074 | |
| 1.0E-2 | | | 0.00074 | |
| 1.1E-2 | | | 0.00075 | |
| 1.1E-2 | | | 0.00076 | |
| 1.2E-2 | | | 0.00076 | |
| 1.2E-2 | | | 0.00077 | |
| 1.3E-2 | | | 0.00078 | |
| 1.3E-2 | | | 0.00078 | |
| 1.4E-2 | | | 0.00079 | |
| 1.4E-2 | | | 0 | |



# Appendix B

# Response to NDEP Comments

# NEVADA ENVIRONMENTAL RESTORATION PROJECT
## DOCUMENT REVIEW SHEET

| | |
|---|---|
| 1. Document Title/Number Corrective Action Investigation Plan: Cactus Spring Waste Trenches, Final; DOE/NV-429 | 2. Document Date May 1996 |
| 3. Revision Number 0 | 4. Originator/Organization DOE/NV ERD |
| 5. Responsible DOE/NV ERP Subproject Mgr. Sabine T. Curtis | 6. Date Comments Due |
| 7. Review Criteria | |
| 8. Reviewer/Organization/Phone No. Karen Beckley/NDEP/702-687-4670 | 9. Reviewer's Signature |

| 10. Comment Number/ Location | 11. Type[a] | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 1/Page 1-1 | M | The work Plan for the Tonopah Test Range has not yet been reviewed and approved by NDEP; any changes to that Plan may necessitate changes to this site's CAIP. | The Work Plan for the Tonopah Test Range has been revised to match this CAIP where necessary. In the future, the CAIP will supersede the sampling strategies outlined in the CAU Work Plan. | |
| 2/Page 1-1 | M | The Industrial Sites Quality Assurance Project Plan has not yet been approved by NDEP. Any modifications to the QAPP may require changes to this Plan. | The QAPP is currently being revised and will be submitted to NDEP for review prior to finalization. | |
| 3/Page 1-3 | M | DOE needs to define what approved procedures they are utilizing. | The "approved procedures" stated at the end of the fifth line on page 1-3 refer to the contractors Standard of Quality Practices. In a DOE document such as a CAIP, it is inappropriate to cite contractor procedures. However, for reference purposes the NDEP has been included in the controlled distribution of the contractor's Standard of Quality Practices. | |
| 4/Page 1-3 | M | NDEP is requesting to receive a copy of the site specific HASP. | A draft copy of the Site Specific Health and Safety Plan will be sent to the NDEP for pre-field preparation; a final copy will be forwarded before field operations begin. | |
| 5/Page 3-1 | M | DOE is using a model to establish assumptions for the Cactus Spring Waste Trenches. There are no statements to address the "what ifs". Potentially, at least one of these assumptions will prove to be false. What happens then? | The following new sentence was added to the first paragraph in section 3.1: "The model is based on assumptions formulated primarily from process knowledge and analogous sites. If the conceptual model is proven incorrect from the results of environmental sampling, then NDEP will be notified and the site rescoped." | |

# NEVADA ENVIRONMENTAL RESTORATION PROJECT
## DOCUMENT REVIEW SHEET

Document Title/Number Corrective Action Investigation Plan: Cactus Spring Waste Trenches, Final: DOE/NV-429 Revision Number 0

Reviewer/Organization Karen Beckley, NDEP

| 10. Comment Number/ Location | 11. Type[a] | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 6/Page 3-3 | M | If DOE determines that the groundwater may be impacted, NDEP must be notified. | The first sentence of the last paragraph in Section 3.1 (page 3-3) was revised to state: "If after sampling it is determined that the groundwater may be impacted, then the NDEP will be notified, the site rescoped, and the groundwater pathway will be investigated." | |
| 7/Page 3-5 | M | Reference DOE, 1996c is a draft document. Any changes made to this document may affect activities at this site. | This CAIP was carefully compared to the DOE, 1996c document for consistency; the following statement in the first paragraph on page 3-5 of the CAIP was found to be in error: "...;or alpha/gamma radiation detected above 2 picocuries per gram (pCi/g) for depleted uranium (U238) or 0.1 pCi/g for plutonium (Pu) (DOE, 1996c)...".<br>The corrected sentence (now the last bullet on page 3-5) states: "Alpha/gamma radiation detected above 10 picoCurries per gram (pCi/g) for depleted uranium (U238) or 0.5 pCi/g for Pu (BN, 1995)." | |
| 8/Page 3-5 | M | If DOE needs to reassess the site, NDEP must be notified. | The last sentence in the first paragraph was revised. The last two sentences of the sixth paragraph in Section 3.1 comprise the revision. The revised sentences state: "Although not anticipated, reassessment of the site is also an option depending on the type and extent of contamination. If reassessment is deemed necessary, NDEP will be notified." | |
| 9/Pages 3-5 through 3-7 | M | Pgs. 3-5 through 3-7 will be addressed in a subsequent letter which will be forthcoming later this month. Basically, the DQO's have not been discussed. For example, 3.2.2 is the Identification of Decision. This section does not adequately discuss how the decisions were made. What types of constituents or problems have been identified/discovered to prompt DOE to make decisions on how to approach the site? | The entire DQO section (Section 3.2) has been revised to reflect the requested changes outlined in the letter from NDEP to DOE on June 25, 1996. See attached for DQO revisions.<br><br>The rewrite of Section 3.2.2 explains how the lack of process knowledge impacts the decisions and approach to the site. | |

# NEVADA ENVIRONMENTAL RESTORATION PROJECT
# DOCUMENT REVIEW SHEET

Document Title/Number Corrective Action Investigation Plan: Cactus Spring Waste Trenches, Final; DOE/NV-429 Revision Number 0

Reviewer/Organization Karen Beckley, NDEP

| 10. Comment Number/ Location | 11. Type[a] | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 10/Page 3-6 | M | Pg. 3-6 3.2.5 In this section, DOE appears to have made the determination that the hazardous waste decision will be made solely on the basis of any contamination at the site being the result of a characteristic waste and not listed waste. What is the potential for contamination at the site to originate from a listed waste, particularly since this site is identified as receiving lab wastes. | The laboratory which is referenced in Section 2.3 was not a chemical analysis laboratory; it was used for dissection of animals. Historical interviews indicate that only alcohol and ice were used in the laboratory. Historical information also implies that pesticides may have been used ("sheep dip"); however, there is not adequate information to show that unused pesticides (which could be listed waste) were disposed of in the Cactus Springs Waste Trenches. Section 3.2.3 of the CAIP was rewritten and supplemented with a Record of Technical Change (number 1) to address the issue of listed versus characteristic waste. Please see attached revisions. | |
| | | Also, when determining DQO's for this site, solid waste regulations need to be evaluated for applicability and data collection detection limits based on this criteria. | The solid waste regulations were evaluated during the DQO process, and the data collection detection limits were based on these criteria. | |
| 11/Page 1 of Appendix A | M | Pg. 1 of appendix A The HELP model is a very basic model used primarily for determining the need for the establishment of monitoring at solid waste landfills in high rainfall areas of the country. DOE needs to provide justification as to the appropriateness of this model for this hazardous waste site. | There were two primary reasons for selecting the HELP code for modeling unsaturated flow at the site. First, the model has received general acceptance from the EPA for unsaturated flow modeling. Second, the model yields conservative results due to over-estimating vertical flux in arid conditions. The attached publication by Fleenor and King (1995) documents the HELP model's tendency for over-estimating downward flux in arid environments. | |
| | | | | |

[a] Comment Types: M = Mandatory, S = Suggested.
Return Document Review Sheets to DOE/NV Environmental Restoration Division, Attn: QAC, M/S 505.

# CACTUS SPRING WASTE TRENCHES

**DQO section from the CAIP-Revision 1**

(redline text indicates significant revision)

### 3.2 Data Quality Objectives

The DQO process is a systematic planning tool for establishing criteria for data quality and for developing data collection programs. It is an iterative, seven-step process which results in a design to collect the right type, quality, and quantity of data needed to support a course of action for the site. The DQOs were developed to clearly define the purpose(s) for which environmental data will be used and to design a data collection program that will satisfy these goals. The seven steps and their applications to the Cactus Spring Waste Trenches are discussed in the following text.

### 3.2.1 Problem Statement

Unregulated disposal activity was conducted in 1963 at the Cactus Spring Waste Trenches. Although process knowledge indicates that the trenches contain debris and waste from the animal holding facility (associated with the Double Tracks test), it is unknown if hazardous materials, which may have caused contamination above regulatory thresholds, were disposed of in the trenches. Furthermore, if contamination is present in the trenches, it is not known if the contamination is migrating below the trenches. For more background information see Sections 2.0 and 3.1.

### 3.2.2 Identification of Decision

There are two decisions to be made with regard to the potential threat the Cactus Spring Waste Trenches pose to human health and the environment. The first decision is whether or not hazardous and/or radioactive materials have been disposed of in the trenches. The second decision is whether or not the soil below the trenches is contaminated (above regulatory limits) with constituents of RCRA-characteristic hazardous waste and/or radioactive materials. Process knowledge is not sufficient to make these determinations. Therefore, these decisions will be determined from the analytical results of environmental sampling. The sampling program includes: 1) sampling the contents of the trenches and 2) sampling the *in situ* soil below the trenches to determine if constituents of hazardous and/or radioactive waste are present and, if so, to what vertical extent. The possible contaminants of concern (see Section 2.4) are based on limited process knowledge and past waste disposal practices conducted at the Roller Coaster

North Disposal Trench (see DOE, 1996b).

More information is provided in Section 2 (brief history of the site including release information), Section 3.1 (assumptions and uncertainties associated with the site), and Table 4-1 (soil sampling requirements) of this report.

### 3.2.3 Identification of Inputs to the Decision

Contaminated materials may be present in the trenches; if so, contamination is likely to be located immediately beneath the trenches in the form of a leachate plume. A model was run to evaluate the potential for contaminants to leach and determine how far they may have traveled vertically. This information is presented in Appendix A of this CAIP. Based on the model results, using conservative parameters, the soil area beneath the trenches (up to approximately 25 ft below the ground surface) is potentially affected by the leachate. This area will be investigated and sampled. The constituents of concern are not well documented by process knowledge; therefore, the laboratory analysis will include total VOCs, total SVOCs, TPH, total pesticides, RCRA metals, and gamma/alpha spectroscopy. Table 4-1 presents a summary of the soil sampling requirements. Identification of these constituents by laboratory analysis will provide information about the concentration and extent of contamination and will determine the course of action for the site (i.e., closure in place, clean closure).

The available historical information for this site is mostly incomplete and/or highly subjective; therefore, process knowledge is insufficient to confirm the presence of RCRA listed wastes in the trenches. There is, however, limited evidence to suggest that small quantities of methyl ethyl ketone (MEK) (MEK is an "F" listed waste when used as a solvent) were used as a cleaner/solvent in association with Rad Safe activities during Operation Roller Coaster (Sygitowicz, 1995). The animal holding facility was intentionally kept isolated from any Rad Safe activity to minimize extraneous radiation exposure to the animals (Wilson, 1995b). However, because of the remote location of the animal holding facility (and associated trenches), the possibility exists that the trenches may have on occasion, received debris from Rad Safe activities rather than having the debris transported for proper disposal at the Roller Coaster Rad Safe Area. This is not deemed likely due to the strict radiological controls that were established for the operation. Regardless, if MEK is present in the trenches or soil, the laboratory analytical method selected for total VOCs (e.g., EPA 8240) has a method detection level established that is low enough to satisfy the land disposal restriction limit for MEK. **( NOTE: the following lined-out**

**text was originally included in the CAIP-Revision 1 and subsequently deleted and has been rewritten and is superseded by the text provided in the attached Record of Technical Change No. 1)** ~~If MEK is detected above the land disposal limit, then investigation-derived waste (IDW) and remediation waste will be treated as a "F" listed waste and will be subject to land disposal restrictions accordingly. Due to the lack of adequate process knowledge that is required to determine which of the listed waste codes would be appropriate, any contaminated soils (other than soil contaminated with MEK above regulatory limits) removed during a future remediation would be considered characteristic waste unless new process knowledge and/or sampling indicates otherwise.~~

### 3.2.4 Definition of the Study Boundaries

The physical definition of the investigation boundaries includes: 1) a vertical profile from ground surface to approximately 3 m (10 ft) below ground surface to assess the contents of each trench and 2) soil potentially affected by leachate migration below the bottom of the trenches, which extends from approximately 3.6 m (10 ft) below ground surface to approximately 8 m (25 ft) below ground surface. Appendix A presents the results of models that were run in order to help answer the question of how far leachate could potentially migrate below the trenches. Figure 3-2 presents a schematic cross-sectional view of the trenches; Figure 3-3 depicts a plan view of the trenches.

### 3.2.5 Development of Decision Rules

The results of the environmental laboratory analytical data will determine whether a decision is made for no further action, closure in place, or clean closure. If environmental sample analytical data indicate that analytes are not: 1) above TCLP and 100 mg/kg TPH criteria, 2) 100 times the MCL, or Subpart S criteria for other analytes, and 3) if no alpha/gamma radiation is detected above the criteria given in Section 3.1, then either no further action or closure in place will be recommended. If no further action is not a closure option, engineering studies will be used to determine whether closure in place or clean closure is the most appropriate strategy. After sampling, if it is determined that the groundwater may be impacted, the NDEP will be notified, the site rescoped, and the groundwater pathway investigated.

### 3.2.6 Specifications on Decision Error Limits

There are two types of decision errors possible in implementing this CAIP. These errors are described as a false positive, judging a clean area to be contaminated, and a false negative, judging a contaminated area to be clean. This CAIP is designed to minimize both types of errors.

The consequences of a false positive are:

- Remedial activities may encompass a greater quantity of media than is necessary.
- Media incorrectly judged to be contaminated may be disposed of as a regulated or mixed waste instead of solid waste.

Both of these consequences may lead to increased remediation and disposal costs.
The consequences of a false negative are:

- Regulated contaminants may not be appropriately addressed by remedial treatment activities.
- Contamination may continue to leach.
- Contaminated media may be disposed of improperly.

These consequences may lead to unacceptable risks to human health and the environment and to potential fines from regulatory agencies.

Decisions depend foremost on an accurate conceptual model as well as an accurate interpretation of the model (Section 3.1). Interpretation of the model dictates the sampling approach and, ultimately, the course of action that will be taken for a site. The current conceptual model postulates that the plume does not and will not reach groundwater. A consequence of error is that contamination has or will in the future impact groundwater and cause degradation to occur. However, by conducting vertical field screening and sampling until the extent of contamination is known, the model will be tested with regard to the possibility of groundwater impact.

If field screening and/or laboratory analysis indicates contamination is much more extensive than anticipated, an alternate conceptual model that may include the groundwater pathway will be considered. If the alternate conceptual model is found to be representative of site conditions, the site will be rescoped; the NDEP requirements for groundwater assessment will be complied with; the investigation will continue deeper, and the groundwater pathway will be investigated.

Statistical sampling is not appropriate for this type of investigation. When biased samples are collected in a vertical boring to determine the boundary of a potential plume, equation 8 of SW-846 does not apply (EPA, 1986). In lieu of a quantitative determination of sampling error, error will be minimized by the following actions. Two consecutive clean samples, confirmed clean through offsite laboratory analysis, should adequately define the lower limit of the affected soils, based on the type of soils expected (sands and gravels), and the properties of the contaminants (liquid phase, wetting the grains). If unexpected geologic conditions are encountered which affect the contaminant migration pathway, then NDEP will be notified, and a change to the investigation may be considered. The specific sampling approach to be followed at this site is described in Section 4.1.

### 3.2.7 Optimization of the Design for Obtaining Data

The sampling and analysis approach for the Cactus Spring Waste Trenches described in Section 4.0 of the CAIP was developed to optimize the design for obtaining data. If this approach results in insufficient data to support the decisions to be made, the NDEP will be notified, and the DQO process will be reevaluated.

# Appendix C

# Technical Changes

# RECORD OF TECHNICAL CHANGE

Technical Change No. 1 Page 1 of 1

Project/Job No. 764034 Date 08/26/96

Project/Job Name TTR-Cactus Spring Waste Trenches CAU

Phase/Task 03030100

The following technical changes (including justification) are requested by:

Kenneth C. Beach, Jr. (Name) Industrial Sites Project Manager (Title)

The changes in this Record of Technical Change apply to the Corrective Action Investigation Plan: Cactus Spring Waste Trenches-Revision 1.

The first bullet on page 3-5 will be delated and rewritten as follows:

Resource Conservation and Recovery Act (RCRA) limits for VOCs, SVOCs, or metals (CFR, 1996)

The first full paragraph on page 3-7 will be deleted and rewritten as follows:

The available process knowledge for this site is mostly incomplete and/or highly subjective and is insufficient to determine if the waste is listed or characteristic. Management of all investigation-derived waste will be conducted in accordance with applicable RCRA and state of Nevada hazardous waste regulations. Waste will be managed as hazardous waste until shown to be nonhazardous through laboratory analyses. If total VOCs or SVOCs are discovered above laboratory detection limits, the waste will be assumed to be listed waste unless there is evidence to demonstrate that their presence is due to laboratory contamination.

Table 4-1 on page 4-4, fifth row, first column has been corrected to read as follows: Total Pesticides/PCBs

Table 5-1 on page 5-2, delete " Note" in its entirety

Paragraph 4 on page 5-3, third sentence: After "RCRA-regulated waste; delete : " (i.e. above toxicity characteristic or land-disposal restriction levels)"

The project time will be (Increased)(Decreased)**(Unchanged)** by approximately ______

Applicable Project-Specific Document(s):
(1) Corrective Action Investigation Plan: Cactus Spring Waste Trenches-Revision 1

CC:

Approved By: Sabine Curtis Date 9-9-96

Janet Appenzeller-Wing Date 9/19/96

# RECORD OF TECHNICAL CHANGE

Technical Change No. 2 | Page 1 of 1

Project/Job No. 764034 | Date 08/26/96

Project/Job Name TTR-Cactus Spring Waste Trenches CAU

Phase/Task 03030100

The following technical changes (including justification) are requested by:

Kenneth C. Beach, Jr. — Industrial Sites Project Manager
(Name) (Title)

IT Corp has identified the need to amend the Corrective Action Investigation Plan: Cactus Spring Waste Trenches-Revision 1 (CSWT/CAIP) to include the following scope: (1) an additional drill-hole designated as an exploratory hole; (2) additional sampling points in the characterization holes for geotechnical and hydrologic analysis. This record of technical change does not require any deletions to the current CSWT/CAIP.

1) Exploratory hole:

An exploratory hole will be advanced prior to drilling the planned trench characterization holes as a precautionary step to determine the hydrogeologic conditions at the site. Currently, the depth to groundwater and other hydrogeologic parameters remain unknown. Although not anticipated, the potential exists for encountering a perched aquifer while drilling the trench characterization holes, whereby creating an inadvertent pathway for contamination to impact groundwater. To reduce this risk, the hydrologic conditions will be investigated at a location outside the trench perimeter (see attached map for approximate location). The total depth of the hole will be determined in the field by the Site Supervisor and Principle Investigator based on either the first occurrence of groundwater or bedrock, or when approximately 50 feet is reached. The information from the hole will provide vertical guidance for the subsequent trench characterization drilling program, and significantly reduce the potential for introducing contamination encountered in the trenches to the groundwater.

The exploratory hole will be continuously cored in 10-ft intervals using the Sonic drilling method. The core intervals will be field screened under the same procedures as are currently presented in the CSWT/CAIP for the trench characterization holes. Sampling for laboratory analysis will be conducted for waste management purposes and to obtain background data. The sampling procedure, including the laboratory analytical suite, will be conducted in the same manner as is outlined in the current CSWT/CAIP.

Geotechnical and hydrologic samples will also be collected in the exploratory hole to provide data for possible future corrective action measures. The samples will be collected using a 2-ft Shelby tube driven ahead of the bit. The sample points will be determined by the Site Supervisor and Principle Investigator based primarily on field observations; optimally, the sample points should include 1 sample from approximately 5 ft, one sample from approximately 10 ft (representative of strata near the bottom of the trenches) and one from total depth. The geotechnical and hydrologic laboratory analytical suite is attached. At the conclusion of the drilling program, the exploratory hole will be plugged and abandoned in the same manner as the characterization holes.

2) Additional sampling points for geotechnical and hydrologic analysis:

Additional samples will be collected from the trench characterization holes to provide supplementary geotechnical and hydrologic data for possible future corrective action measures. The samples will be collected from the *in situ* soil situated beneath the trenches. Approximately one sample will be collected per trench by using a 2-ft Shelby tube driven ahead of the bit. The sample will be collected as near to the base of the trench as possible depending on the extent of possible contamination. If the soil at the base of the trench is found (by field screening) to be contaminated, then screening and environmental sampling will continue as per the CSWT/CAIP and the geotechnical/hydrologic sample will be taken at total depth. Additional geotechnical/hydrologic samples may also be collected based on the geologic conditions as determined by the Site Supervisor and Principle Investigator. All samples will be field screened for radiation before packaging. The samples will be analyzed at a laboratory for the parameters presented in the attached table.

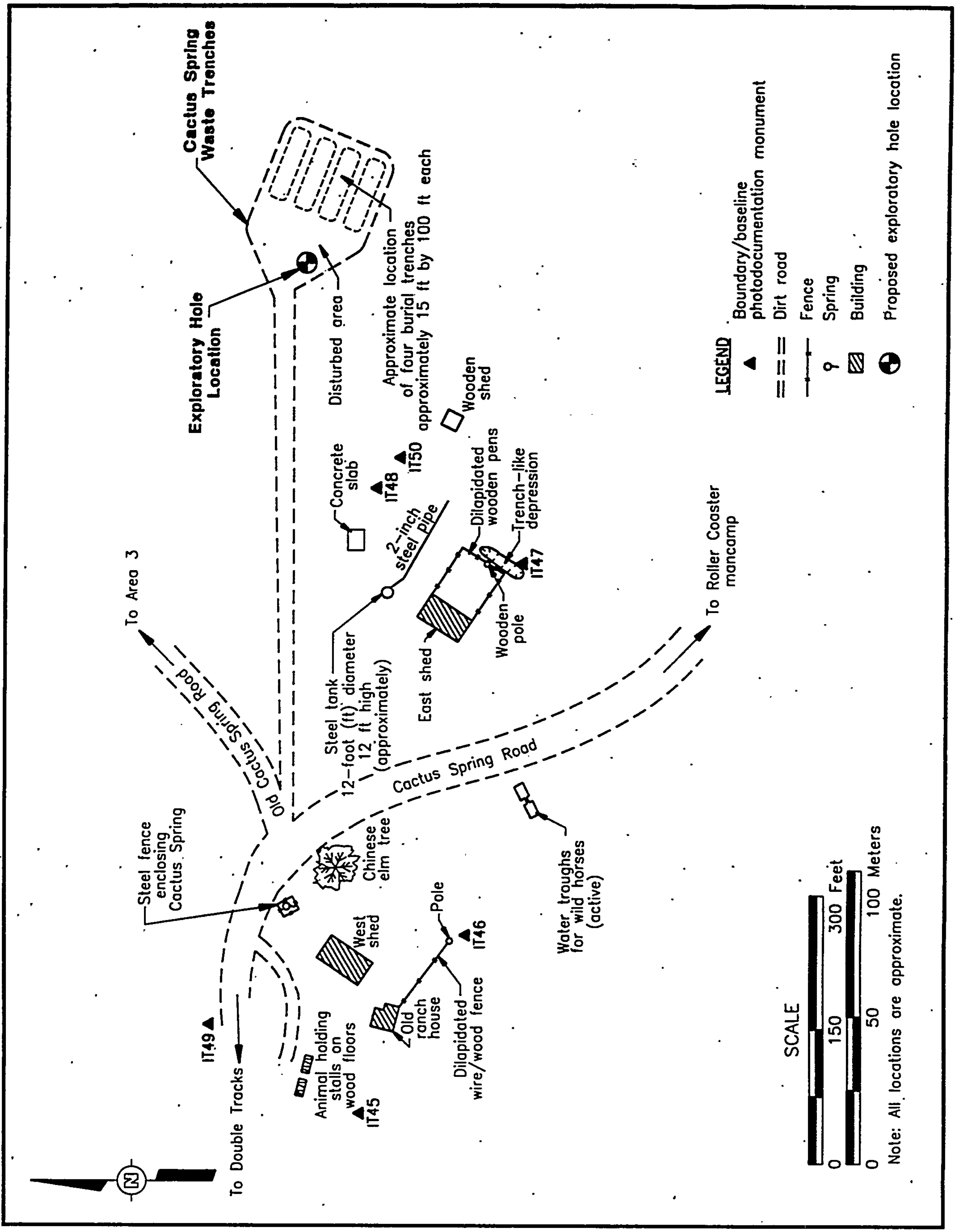
The project time will be (**Increased**)(Decreased)(Unchanged) by approximately 1.5 days

Applicable Project-Specific Document(s):
(1) Corrective Action Investigation Plan: Cactus Spring Waste Trenches-Revision 1

CC:

Approved By: [signature] Date 9/10/96

[signature] Date 9/10/96




**Site Location Map of the Cactus Spring Waste Trenches with Exploratory Hole Location**

## Possible Physical Analytical Methods and Container Requirements for Characterization Samples

| Analytical Parameter | Analytical Methods | Soil Containers[a] |
|---|---|---|
| Hydrologic Analyses | | |
| Initial moisture content | ASTM[b] D 2216-92/D 4643-93 | Two 2 x 6-inch sample tubes |
| Dry bulk density | ASTM D 2937-94/MOSA[c] Chapter 13 | |
| Calculated porosity | MOSA Chapter 18 | |
| Saturated hydraulic conductivity | ASTM D 2434-68(94) | |
| Unsaturated hydraulic conductivity | SSSAJ[d], 1980 | |
| Particle size distribution | ASTM D 422-63(90) | |
| Moisture retention characteristics | MOSA Chapter 26<br>ASTM D 2325-68(94)/MOSA Chapter 26<br>SSSAJ, 1984<br>MOSA Chapter 24<br>SSSAJ, 1982<br>ASTM D 3152<br>MOSA Chapter 23 | |
| Geotechnical Analyses* | | |
| Shrink/swell | ASTM D 4943-89 | Two 2 x 6-inch sample tubes |
| Specific gravity | ASTM D 854-92 | |

*Some or all of the geotechnical analyses may be eliminated prior to the beginning of the field work.

[a] One container per analysis or group of analyses
[b] American Society for Testing and Matenals
[c] *Methods of Soil Analysis* (American Society of Agronomy, 1986)
[d] *Soil Science Society of America Journal*

**Distribution List**


| | Copies |
|---|---|
| Ms. Janet Appenzeller-Wing,<br>Acting Industrial Sites Subproject Manager<br>DOE/Nevada Operations Office | 1 (uncontrolled) |
| Mr. Kevin J. Cabble, TTR Project Manager<br>DOE/Nevada Operations Office | 1 |
| Mr. Chuck Bulick<br>Nevada Division of Environmental Protection<br>Las Vegas, Nevada | 1 |
| Ms. Karen Beckley<br>Nevada Division of Environmental Protection<br>Carson City, Nevada | 1 |
| DOE/Nevada Operations Office<br>Technical Information Resource Center<br>Post Office Box 98518<br>Las Vegas, NV 89193-8518 | 2 (uncontrolled) |
| U.S. Department of Energy<br>Office of Scientific and Technical Information<br>175 Oak Ridge Turnpike<br>P.O. Box 62<br>Oak Ridge, Tennessee 37831 | 2 (uncontrolled) |
| Environmental Restoration Division Record Center<br>DOE/Nevada Operations Office | 1 |
| Mr. Paul J. Liebendorfer<br>Bureau of Federal Facilities<br>Nevada Division of Environmental Protection<br>333 W. Nye Lane<br>Carson City, NV 89710 | 2 |
| FFACO<br>Reading Room<br>Las Vegas, Nevada | 1 |

**Distribution List**
(Page 2 of 2)

| | Copies |
|---|---|
| Mr. Ken Beach, Project Manager<br>IT Corporation<br>Las Vegas, NV 89103 | 1 (uncontrolled) |
| Mr. Brad Schier<br>IT Corporation<br>Las Vegas, NV 89103 | 1 (uncontrolled) |
| Mr. Richard A. Dubiskas, Technical Lead<br>IT Corporation<br>Las Vegas, NV 89103 | 1 (uncontrolled) |
| Ms. Angelica Russell<br>IT Corporation<br>Las Vegas, NV 89103 | 1 |
| Ms. Jeanne Wightman<br>IT Corporation<br>Las Vegas, NV 89103 | 1 |
| Ms. Rosa Silver, CCCR<br>IT Corporation<br>Las Vegas, Nevada | 2 |
| Central Files<br>IT Corporation<br>Las Vegas, Nevada | 1 (uncontrolled) |