DEPARTMENT OF THE AIR FORCE

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

ENTERED

22 JAN 93

JAN 1993
RECEIVED
HAZARDOUS WASTE
PROGRAM

27 FW CC
100 S DL Ingram Blvd Suite 100
Cannon AFB NM 88103-5214

Ms Barbara Hoditschek Manager
RCRA Permit Program
State of New Mexico Environment Department
Hazardous & Radioactive Materials Bureau
PO Box 26110
Santa Fe NM 87502

Re: Notice of Deficiency - Melrose Air Force Base Range - RCRA Permit Application

Dear Ms Hoditschek

Concerning the telephone conversation from Mr. Tom Tatkin to Ms. Vera Wood on 21 Jan 93, we were informed by Mr. Tatkin that the above subject matter is due to your office no later than 22 Jan 93. Our incoming correspondence log reflects that a staff member signed for the Notice of Deficiency (NOD) on 4 January 1993 and this is the beginning of the thirty day time frame to respond to your notice; therefore, I understand that the requested information must be in the mail posted no later than 2 Feb 93.

We are submitting a copy of the Work Plan and Sampling and Analysis Plan for the Open Burn/Open Detonation Thermal Treatment Facility as provided by our contract with US Geological Survey. Once you have reviewed the package and find that the Sampling and Analysis Plan are acceptable, we will proceed with the characterization of the OB/OD site.

U.S.Geological Survey will have a crew at Melrose Air Force Range next week, barring inclement weather, to begin working on the 100 Year Flood Plain Plan.

The wing senior leadership at Cannon Air Force Base is expediting issues addressed in the NOD through all available sources internally and externally and will have a package for your review by 2 Feb 93.

Your cooperation and assistance in this matter are greatly appreciated. If you have any questions concerning this response, please contact Mr. Jim Richards at 784-4639 or Ms. Vera Wood at 784-2739.

Sincerely

RICHARD N. GODDARD
Brigadier General, USAF
Commander

2 Atch
1. Melrose AFR 100 Year Flood Plain Study
2. MAFR Sample & Analysis Plan

cc: HQ ACC/CEVCM

Global Power for America

[redacted]

United States Air Force

[redacted]

WORK PLAN
AND
SAMPLING AND ANALYSIS PLAN

OPEN BURN/OPEN DETONATION THERMAL TREATMENT FACILITY

Melrose Air Force Range
New Mexico

January 1993

Atch 16

RCRA SUBPART X PART B APPLICATION
OPEN BURN/OPEN DETONATION THERMAL TREATMENT FACILITY
MELROSE AIR FORCE RANGE

January 1993

WORK PLAN

PREPARED FOR

27 CES/CEV
Environmental Management Flight
Cannon Air Force Base, New Mexico 88103
505-784-4639

PREPARED BY

U.S. Geological Survey, Water Resources Division
4501 Indian School Road NE, Suite 200
Albuquerque, New Mexico 87110
505-262-5342

NOTICE

This report has been prepared for Cannon Air Force Base by the U.S. Geological Survey, Water Resources Division, New Mexico District for the purpose of providing technical information for completion of their Resource Conservation Recovery Act (RCRA) Subpart X Part B operating permit at Melrose Air Force Range. As the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the baseline study for the permit application, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report because subsequent facts may become known that may make this report premature or inaccurate. Acceptance of this report in performance of the contract under which it is prepared does not mean that the Air Force adopts the conclusions, recommendations, or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the United States Air Force.

PREFACE

The purpose of this investigation is to determine if soils have become contaminated in or immediately adjacent to the Open Burn/Open Detonation Thermal Treatment Facility on the Melrose Air Force Range, New Mexico, where contaminants may have released from the operation of the Open Burn/Open Detonation Thermal Treatment Facility.

Project Chief of this investigation is Jerry Larson. Technical support is provided by employees of the New Mexico District of the U.S. Geological Survey, Water Resources Division. Text and illustrations were prepared by the Publications Unit of the New Mexico District. Chemical analyses will be performed by Rocky Mountain Analytical Laboratory, a Division of Enseco, Arvada, Colorado. Drilling will be performed by the U.S. Geological Survey.

Appreciation is extended to the base points of contact--Mr. Jimmie N. Richards and Ms. Vera Wood, Environmental Management, Cannon Air Force Base. The assistance and cooperation of all involved in the investigation at Melrose Air Force Range are greatly appreciated.

This work will be performed between February and August 1993. Mr. Jimmie N. Richards, Environmental Manager, Cannon Air Force Base, is the Technical Project Manager for this investigation.

Approved:

Russell K. Livingston
District Chief, New Mexico
U.S. Geological Survey

Mr. Jimmie N. Richards
Technical Project Manager
Cannon AFB, New Mexico

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1

1.1 Description of the Melrose Air Force Range Subpart X Part B Permit Application 1
1.2 History of Past Work at the Installation 1

1.2.1 Previous investigative activities and documentation 1

1.3 Installation Description 2
1.4 Description of Study Area 2

1.4.1 Project objectives 2
1.4.2 Scoping documents 6

2.0 SUMMARY OF EXISTING INFORMATION 6

2.1 Installation Environmental Setting 6

2.1.1 Geographic setting 6
2.1.2 Geology 6
2.1.3 Soils 7
2.1.4 Ground water 7
2.1.5 Surface water 7
2.1.6 Climate 7
2.1.7 Biology 8
2.1.8 Demographics 8

2.2 Site-Specific Environmental Setting 8

2.2.1 Site 1 Open Burn/Open Detonation Thermal Treatment Facility 12

2.3 Action Levels 14

3.0 RCRA BASELINE STUDY TASKS 14

3.1 Site Objectives 14
3.2 Field Investigation 14

3.2.1 Field tasks 14

3.2.1.1 Soil boring and hand augering 16
3.2.1.2 Land surveying 16

3.2.2 Sampling and analysis activities 16

3.2.2.1 Soil samples 16
3.2.2.2 Field quality control (QC) samples 16

3.3 Record Keeping 18
3.4 Data Assessment 19

TABLE OF CONTENTS--Concluded

		Page
4.0	REPORTING REQUIREMENTS	20
	4.1 Technical Report	20
	4.2 Special Notification	20
5.0	PROJECT SCHEDULE	20
6.0	REFERENCES	22
7.0	APPENDICES	A-1

LIST OF FIGURES

Figure 1.3.1	Map showing location of Melrose Air Force Range, New Mexico	3
Figure 1.3.2	Map showing facilities on Melrose Air Force Range	4
Figure 1.4.1	Map showing configuration of Open Burn/Open Detonation Thermal Treatment Facility	5
Figure 2.2.1.1	Map showing Phase 1 sampling locations at Open Burn/ Open Detonation Thermal Treatment Facility	13
Figure 2.2.1.2	Map showing Phase 2 approximate sampling locations at Open Burn/Open Detonation Thermal Treatment Facility	15
Figure 5.1	Diagram showing proposed schedule for the Open Burn/ Open Detonation Thermal Treatment Facility investigation	21

LIST OF TABLES

Table 3.2.2.1	Summary of the number of soil analyses by analytical method for OB/OD	17
Table 3.2.2.2.1	Summary of the number of field QC samples by analytical method	17

WORK PLAN
RCRA SUBPART X PART B APPLICATION
OPEN BURN/OPEN DETONATION THERMAL TREATMENT FACILITY
MELROSE AIR FORCE RANGE, NEW MEXICO

1.0 INTRODUCTION

1.1 Description of the Melrose Air Force Range Subpart X Part B Permit Application

The U.S. Air Force (USAF), in performing its primary mission of defense of the United States, has frequently engaged in operations that deal with toxic and hazardous materials. Cannon Air Force Base has applied for a RCRA Subpart X Part B Permit to treat reactive material in expended ordnance. This baseline study will identify the constituents of past toxic and hazardous materials burned or detonated at the Open Burn/Open Detonation site to control hazards to public health and the environment. The DOD issued Defense Environmental Quality Program Policy Memorandum (DEQPPM) 80-6 in June 1980, which mandated that hazardous waste material sites on DOD installations be identified. The USAF implemented DEQPPM 80-6 in December 1980. The current policy is contained in DEQPPM 81-5, dated December 11, 1981, and was implemented by U.S. Air Force Message 211807Z in January 1982.

DOD policy is to identify and evaluate suspected problems associated with past hazardous contamination and to control hazards to the public health and welfare. This baseline study will be conducted in accordance with the basis for response actions on USAF installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, the Superfund Amendment and Reauthorization Act (SARA) of 1986, the Resource Conservation and Recovery Act (RCRA) of 1976, the Hazardous and Solid Waste Amendments (HSWA) of 1984, and Executive Order 12316.

This current study of the Open Burn/Open Detonation Thermal Treatment Facility (hereafter referred to as OB/OD) on Melrose Air Force Range is a baseline RCRA Investigation.

1.2 History of Past Work at the Installation

1.2.1 Previous investigative activities and documentation

No previous investigations have been performed at this installation. An Environmental Impact Statement was completed on October 17, 1989, by Science Applications International Corporation (SAIC) for the Melrose Air Force Range (MAFR).

1.3 Installation Description

Melrose Air Force Range is located approximately 10 miles southwest of Melrose and approximately 30 miles west-southwest of Clovis in east-central New Mexico (fig. 1.3.1). The Range consists of 77,120 acres in Roosevelt County, New Mexico. The Air Force has 15,680 acres of restrictive easement of the total acreage, which can be used for cattle grazing or gas/oil exploration or extraction. Some crops are grown in the northern sections of the Range but the primary use is for cattle grazing. A Range support facility near the center of the Range houses a fire station, maintenance area, TV camera station for monitoring ordnance practices, and other support facilities (fig. 1.3.2). The basic mission of MAFR is to support bombing and air-to-ground gunnery training missions by Air Force, Air Force Reserve, Air National Guard, Navy, and Marine units. The Range consists of a composite day/night simulated special and conventional weapon delivery range and a day/night tactical range.

1.4 Description of Study Area

The OB/OD is located approximately 1.2 miles south of the Range support facility as shown on figure 1.3.2. The site is an approximately 700-foot-diameter circular area with a burn area in the center (fig. 1.4.1). Surrounding the burn area is a 200-foot area used for detonations. Detonations were performed by digging trenches and exploding the ordnance within the trench. The burn area was used infrequently and consisted of burning material with the aid of unused diesel fuel.

1.4.1 Project objectives

In this project the Geological Survey will investigate the OB/OD on MAFR for possible hazardous materials in the soil.

The objective of this effort is to conduct a facility investigation of the OB/OD on MAFR and to identify and characterize past releases that may have occurred. The amount of information presently available concerning the site use, history, and type of waste is minimal. This investigation will result in the collection of data to determine the type of wastes and extent of contamination at the site. This site is remote and there are few people (receptors) near the sites who would come in contact with airborne contaminants released from the sites. The receptors of most concern are humans working on the base who come in contact with surface water or ground water from supply wells or residents of the area who could come in contact with ground water or surface water that has moved off the base. The pathways for contaminant release are through air, surface water, and ground water. No perennial streams are on base so transport of contaminants in surface water would occur during the rare times when runoff occurs resulting from precipitation. The pathway of greatest potential is the release of contaminants to the ground water. The depth of ground water on base is generally large so an important consideration in this study is to determine if contamination is moving through the unsaturated zone toward the ground water.

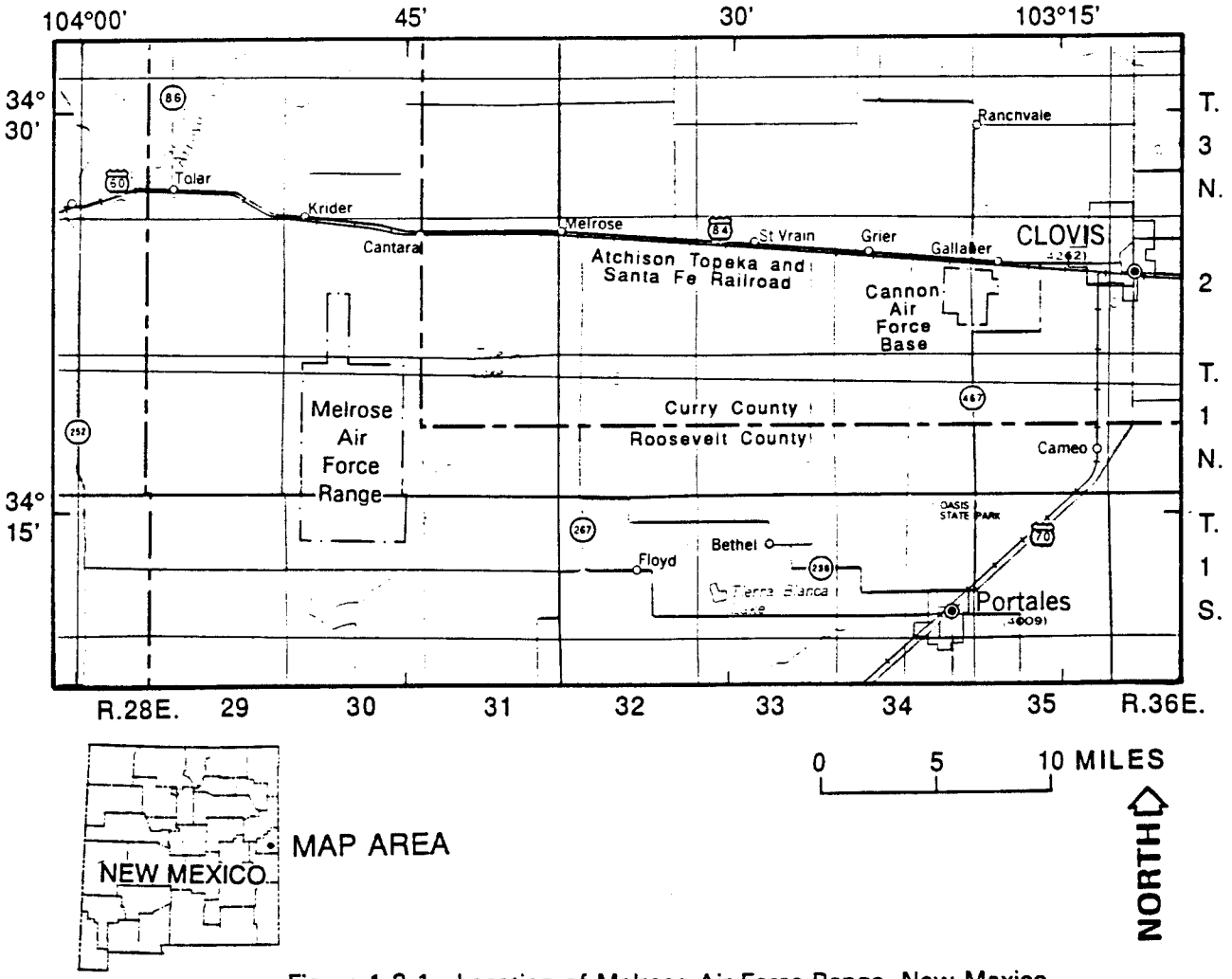


Figure 1.3.1.--Location of Melrose Air Force Range, New Mexico.

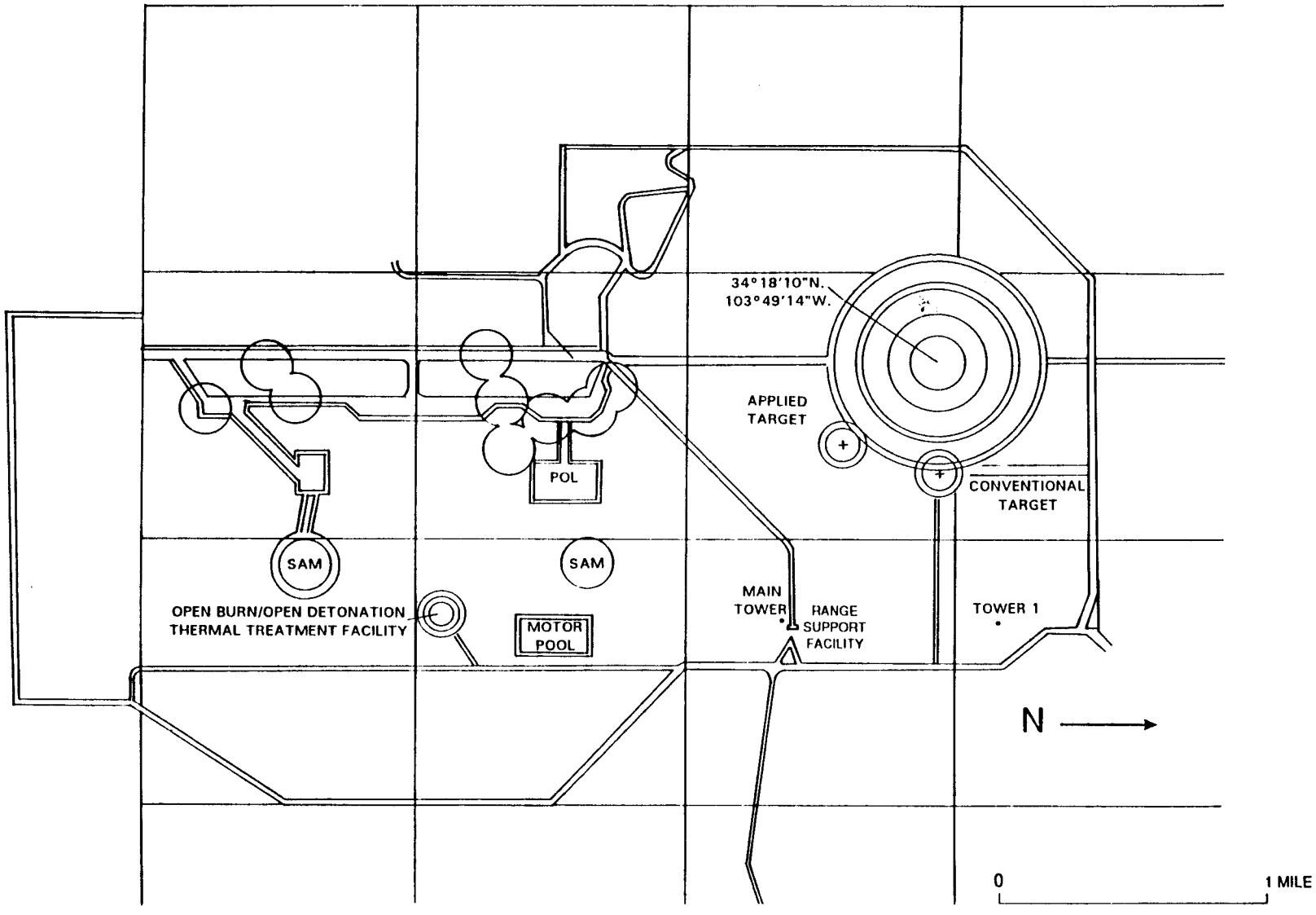


Figure 1.3.2.--Facilities on Melrose Air Force Range.

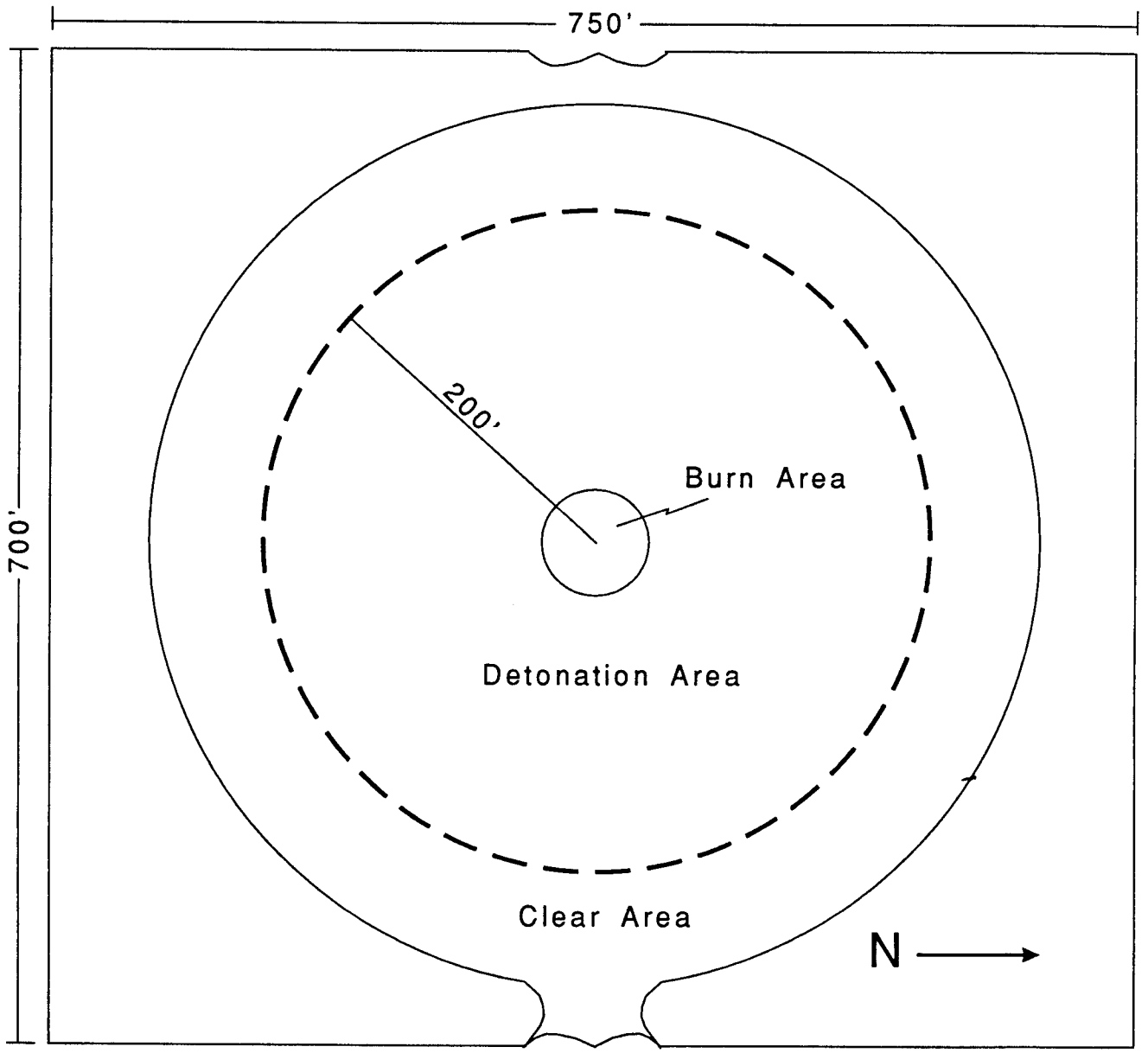


Figure 1.4.1.--Configuration of the Open Burn/Open Detonation Thermal Treatment Facility.

1.4.2 Scoping documents

The following scoping documents will be prepared for the OB/OD investigation at MAFR in addition to this document.

SAMPLING AND ANALYSIS PLAN (SAP) - The SAP will address the quality assurance/quality control (QA/QC) objectives of the study. All facets of the study such as sampling, laboratory analysis, field analysis, and chain-of-custody procedures will be addressed. The SAP will be prepared consistent with the requirements set forth in the U.S. Environmental Protection Agency (USEPA) document Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans (U.S. Environmental Protection Agency, 1980).

2.0 SUMMARY OF EXISTING INFORMATION

2.1 Installation Environmental Setting

A summary of the available information on the environmental setting of MAFR is discussed in the following sections. This includes the geographic setting, geology, soils, ground water, surface water, climate, biology, and demographics.

2.1.1 Geographic setting

Melrose AFR is located in the High Plains section of the Great Plains physiographic province. The region is essentially a plateau, bounded on the north by the Canadian River and on the east and west by prominent escarpments rising as much as 300 or more feet above the lower lands.

The surface of the plains is remarkably flat throughout much of the area and gently undulating in the remainder. An exception to the flat surface is the Portales Valley, which is the drainage for much of MAFR. This valley is as much as 30 miles wide and drains eastward-southeastward into Texas. The drainage on MAFR is predominantly to the northeast toward the Portales Valley and altitudes range from about 4,620 feet on the mesa on the southwest edge of the Range to 4,218 feet on the northeast corner of the Range.

2.1.2 Geology

The Melrose AFR lies on the western edge of the Ogallala Formation and is defined as a stratigraphic unit of Pliocene age. The Ogallala in the MAFR area includes the valley-fill deposits of Quaternary age. The Ogallala Formation consists of clay, silt, fine- to coarse-grained sand, gravel, and caliche. Lithology varies within short distances, both vertically and horizontally, and individual beds or lenses are not continuous over wide areas.

Most of the Ogallala is unconsolidated, although near the top and locally within the formation the sediments have been cemented, chiefly by calcium carbonate, to form beds of caliche. The degree of cementation varies greatly from well cemented to partially cemented. The caliche occurs in single or multiple layers in the uppermost part of the formation throughout the area.

The Ogallala Formation overlies an erosional surface cut into Triassic rocks on the MAFR. The slope of the Triassic rocks is to the east-southeast.

2.1.3 Soils

Surface soils, as described by Ross and Bailey (1967), constitute generally the first 5 feet of unconsolidated material below land surface. The soils on MAFR are generally of the Amarillo-Clovis loams and Amarillo-Clovis fine sandy loams association, and the soils on OB/OD are further subdivided as being Olton loam. The Olton loam consists of about 4 inches of brown to dark-brown loam that has strong granular structure and is noncalcareous. The subsoil is noncalcareous clay loam. It is about 24 inches thick and has a subangular blocky structure. This layer overlies a strongly calcareous layer that is 18 to 20 inches thick, light reddish brown in color, and massive. The Olton loam is characterized by moderate runoff and slow internal drainage. Puddling is common following a hard rain and wind erosion is a slight or moderate hazard.

2.1.4 Ground Water

The principal source of ground water on MAFR is the underlying Ogallala aquifer. The Quaternary alluvium of the Portales Valley is considered part of the Ogallala aquifer. Ground water in the Ogallala is unconfined and is contained in the pore spaces of the unconsolidated or partially consolidated sediments. The saturated thickness of Ogallala aquifer material is estimated to be less than 100 feet on the Range due to its proximity to the western edge of the aquifer.

Depth to water varies from 41 feet below land surface along the Cañada del Tule on the southeast corner of the Range to 128 feet along the east-central part of the Range boundary. Ground water on the Range flows in a northeasterly direction toward the Portales Valley.

2.1.5 Surface Water

Melrose AFR has no permanent surface water. During intense precipitation, flow is present in the normally dry stream channels and as overland flow. Lakes were present during pluvial periods of the PleistoceneL but declining water tables during the Holocene led to the drying up of these lakes. Presently, ephemeral lakes form in playa basins after heavy rainfall.

2.1.6 Climate

The climate for MAFR is classified as semiarid. The average annual rainfall as recorded at Cannon AFB is 15.2 inches and the majority occurs during the summer months as thundershowers. Monthly averages vary from 0.4 inch in the winter months to 2.5 and 2.7 inches in July and August, respectively. The maximum monthly rainfall is 11.4 inches in July and the maximum daily rainfall is 4.8 inches. Annual snowfall for this region is 10 to 13 inches and the record snowfall is 19 inches.

Average monthly temperatures range from the mid-30's in January to the upper 70's in July. Occasional days of temperature more than 100 degrees occasionally occur in the summer; the highest recorded temperature is 106 degrees. Minimum temperatures range from the low 20's in January to the mid-60's in July; the lowest temperature on record is 11 degrees.

Winds on the MAFR are often gusty and can average 19 miles per hour (mph) or greater. The prevailing surface wind direction is from the west. These west winds occur primarily from October to May. During the remainder of the year, winds tend to be from the south. Monthly wind averages range from 6 to 10 mph; the maximum recorded wind gust is 84 mph.

2.1.7 Biology

The vegetation of MAFR is classified as grassland. Grassland is dominated by various grasses but may also contain low shrubs. No fishing streams or lakes are on the Range and wildlife is sparse. Burrowing rodents are the most common form of wildlife. Several species of endangered wildlife may exist within the area but have not been sighted on the Range. These include the Southern Bald Eagle, the American Peregrine Falcon, and the Black-Footed Ferret.

2.1.8 Demographics

No major population centers are near MAFR. The nearest community is Melrose, which is about 10 miles north of the Range. Clovis and Portales are about 30 miles east of the Range. The nearest inhabitants are about 4.5 miles east of MAFR on the road into the Range.

2.2 Site-Specific Environmental Setting

To design a technically sound investigation of the presence or absence of contaminant release from the OB/OD, a conceptual model of contaminant movement from the site has been developed. This conceptual model has been developed using the existing information available on the nature of the site, stratigraphy, and hydrology of the MAFR area, and pertinent literature on the movement of contaminants in the unsaturated zone.

The OB/OD on MAFR overlies the Holocene alluvium and the Ogallala Formation. The Holocene alluvium generally consists of a thin veneer (less than 50 feet thick) of clay, sand, and gravel on top of the Ogallala.

The lithology of the Holocene alluvium and the Ogallala Formation varies considerably in short vertical distances. Lithology ranges from clay to gravel and cobbles. Caliche or buried soil zones are penetrated at several locations at various depths. Many of these caliche zones contain considerable amounts of calcareous cemented sediments, and in some cases root casts were evident. The relatively large changes in dominant grain size and sorting in small vertical distances indicate that the vertical and lateral permeabilities of the alluvium and Ogallala vary considerably in small vertical distances. The dominant grain size of the sediments on the Range also may considerably vary laterally in short distances. No detailed geologic mapping has been done on the Range.

Hydrologic factors that are important for the conceptual model are the large thickness of the unsaturated zone (to as much as 200 feet) over a large area of the base and the amount and location of recharge. Most of the wastes that are in OB/OD are located on land surface or in shallow trenches near the land surface so release of contaminants to the ground water would require the contaminants to move downward through the unsaturated zone. Recharge to the ground-water system occurs as the result of infiltration of surface water entering the basin in arroyos and of infiltration of overland flow. This suggests a minimal, natural flux of water downward through the unsaturated zone throughout most of the Range area. A downward flux of water would occur, however, in the unsaturated zone beneath arroyos on the base. The OB/OD is not located in an arroyo so movement of water downward in the unsaturated zone would not be significant in the displacement or dissolution of contaminants downward to the ground-water system.

If there is no downward flux of water, the downward movement of fluids would be the result of fluid derived from the OB/OD. If there is a small downward flux of water due to small amounts of infiltrating water (future recharge), the rate of movement of water and contaminants would be expected to be slow because of the small flux of water. However, short-term recharge pulses could move contaminants to the water table. In addition, a high permeability zone may short-circuit the normal path that water or contaminants would take. Several researchers have published articles discussing the movement of fluids and gases in the unsaturated zone (Baehr, 1987; Baehr and Corapcioglu, 1987; Corapcioglu and Baehr, 1987; Mantoglou and Gelhar, 1987; and Mendoza and Frind, 1990a, b). The following discussion is a summary of the important principles that apply to the conceptual model of contaminant movement through the unsaturated zone.

In the unsaturated zone, contaminants can be transported as solutes dissolved in the water phase, as vapors in the gas phase, and as the unaltered contaminant in the liquid phase. Contaminants can move through the unsaturated zone by advection, dispersion, and molecular diffusion. The movement of any particular contaminant in any of the three states discussed above is in part dependent on the chemical properties of the constituent such as volatility, solubility in water (octanol-water partition coefficient), density, dynamic viscosity, bulk diffusion coefficients (molecular diffusion coefficients), and the activity coefficient (Corapcioglu and Baehr, 1987). For example, dense nonaqueous phase liquids, such as trichloroethylene (TCE), are expected to move rapidly through sand and clay lenses into the ground water due to high density and low viscosity properties. TCE may move in any direction through the unsaturated and saturated zones and may move down to the bottom of the aquifer or to a confining layer. Light nonaqueous phase liquids, such as JP-4 jet fuel, are not expected to move as rapidly as the dense liquids, and these light liquids will spread out on the water surface if the saturated zone is penetrated (Nielsen, 1991). Adsorption and chemical and biological reactions can also affect the movement of contaminants in the unsaturated zone. The rate and movement of contaminant transport in the unsaturated zone are affected by horizontal and vertical intrinsic permeability, moisture content, longitudinal and transverse dispersivity, and spatial variation (Corapcioglu and Baehr, 1987; Mantoglou and Gelhar, 1987). Thus, the movement of contaminants in the unsaturated zone is complex and dependent on many properties of the individual contaminants, the porous media, and the flux of water and contaminants.

Contaminants in the unsaturated zone can move by transport in the liquid phase or the gas phase (Mendoza and Frind, 1990a). In the liquid phase, the fluid (dissolved in water or unaltered) will move downward as the result of advection and spread out vertically and laterally as the result of mechanical dispersion. The rate of vertical movement is a function of the pressures of the water and the contaminant, vertical intrinsic permeability, density, dynamic viscosity, mechanical dispersivities, soil moisture, and variations in local soil properties. As the contaminant (dissolved in water or unaltered) moves downward, part of the contaminant is left behind as residual saturation because of capillary forces. The amount of this contaminant is dependent on the physical and chemical properties of the contaminant and the soil. This residual contaminant can be displaced by an additional flux of contaminant or water. In most cases the contaminant will not be completely flushed from the unsaturated zone, but may change to the gas phase and be transported by gaseous diffusion (Mendoza and Frind, 1990a, b). Some of the contaminant may also be adsorbed to the mineral grains or organic particles in the soil zone, which can result in the retardation of contaminant movement. Contaminants may also be chemically transformed, which will result in decreases in the contaminant concentrations. Biologically mediated chemical reactions may be important in the chemical transformation of a contaminant to innocuous compounds (Jamison and others, 1976).

In the gas phase, contaminants can move upward or downward (depending on the density of the resultant gas) by advection and can also move in almost any direction as the result of gas diffusion (Baehr and Corapcioglu, 1987; Corapcioglu and Baehr, 1987; Mendoza and Frind, 1990a, Mendoza and Frind, 1990b). This movement of contaminants in the gas phase can result in significant lateral spreading of the contaminant and is an important aspect of contaminant movement in the unsaturated zone. The amount of contaminant that partitions into the gas phase from the liquid phase is related to the concentration of the contaminant in the gas and liquid phase and its volatility. The importance of gas-phase transport of contaminants is in part contaminant-dependent. Mendoza and Frind (1990) have found that the lateral spreading of contaminants may be significant due to the combination of advection-dispersion and diffusion. They have also confirmed that part of the contaminant diffuses upward and into the atmosphere. Baehr (1987) has shown that the diffusive transport of contaminants is dependent on the contaminants and that the lateral spreading of contaminants increases with decreasing moisture content in the soil. Baehr (1987) has also shown that the lateral migration of contaminants resulting from diffusive transport can be significant.

Baehr and Corapcioglu (1987) and Corapcioglu and Baehr (1987) simulated the combined effects of advective-dispersive transport of the liquid phase and diffusive transport of the gas phase of several contaminants with different physical properties in one dimension. Baehr and Corapcioglu (1987) found that the amount of diffusive transport of a particular contaminant was sensitive to the tortuosity factor of the porous media, the ground-surface boundary condition (impermeable cap at land surface or no cap), and the rate of recharge or flux of water through the unsaturated zone. Small recharge rates and large tortuosity factors of the porous media resulted in less of a particular contaminant transported to the ground water and more of that contaminant transported upward to the atmosphere. Mantoglou and Gelhar (1987) discussed the effects of stratification in the soil and evaluated the effect of variations in the local soil properties (vertical variations in effective hydraulic conductivity) on the lateral transport of contaminants. Mantoglou and Gelhar (1987) have shown that the capillary forces in fine-grained material can result in significant lateral migration of contaminants in areas having small recharge rates that are not predicted by classical deterministic models, which generally use averages of local soil properties. Mantoglou and Gelhar (1987) cited results of several field investigations where the lateral spreading of contaminants was significant. In one case where the depth to water was approximately 400 feet, lateral spreading of the contaminant was greater than 6,500 feet around the source (a surface pond) (Mantoglou and Gelhar, 1987, p. 65).

On the basis of the above summary of the geology, hydrology, and physics of unsaturated flow, a knowledge of the movement of contaminants in the unsaturated zone is important in understanding the ultimate fate of the release of contaminants from the OB/OD.

Contaminants may be restricted to the unsaturated zone and not be moving downward because of the relatively small soil moisture observed in the sediments on the Range, the large thickness of the unsaturated zone, and thus the amount of contaminant that can be stored as residual saturation. Furthermore, contaminants may occur primarily in the unsaturated zone if the amount of recharge or flux of water that moves through the unsaturated zone is minimal and does not dissolve or displace the contaminants and move them downward to the water table. The volume of liquid contaminants that would be required to be released to account for residual saturation in 200 feet of the unsaturated zone would be considerable and not significant unless large pools of contaminants existed for a long period of time.

Transport of contaminants upward, downward, or laterally in the gas phase could be important also. As discussed earlier, the transport of contaminants in the unsaturated zone by gas diffusion and advective transport may be significant.

The lateral movement of contaminants released from a site could be considerable, and releases from a small area should spread laterally and be detectable over a relatively large area. This statement is based on the principle that dispersion and gaseous diffusion are important processes that would occur in the area of the Range because of the relatively small soil moistures, the absence of or small flux of water (recharge) in the area, and the large variation in local soil properties.

The approach and scale of the investigation at the OB/OD will be based on the above discussion and on the nature of the site and wastes or contaminants that may have been placed in the site.

2.2.1 Site 1 Open Burn/Open Detonation Thermal Treatment Facility

The OB/OD site is located in the south-central part of Melrose Air Force Range in section 27, Township 1 North, Range 30 East. The site is about 1 mile south of the main observation tower and command post for the Range.

Pathways for contaminants include the air, dust, surface water, and ground water. Air pathways may result from contaminants that have a large volatility or have been blown into the air during detonations. Dust pathways can result from winds that erode surface materials that may be contaminated. Surface-water pathways are likely only during precipitation from storms that result in runoff over and through the site and eastward. Ground-water pathways may result from migration of contamination through the unsaturated zone to ground water. Receptors include site workers and base employees who work on or near the site.

The focus of the investigation at OB/OD will be to determine if contamination exists in the unsaturated zone at the site. The investigation will be a phased approach. The first phase will evaluate whether past burns or detonations have contributed contaminants to the soils around the site. The second phase will consist of random soil sampling immediately after a detonation at the site to characterize the short-term effects of this practice on the soils. The third phase will assess the long-term and short-term effects on the soils and determine whether practices at the site are introducing contaminants in the environment.

In the first phase the upper unsaturated zone will be investigated using 10-foot soil borings and surface sampling. The 10-foot samples will be located within the detonation area as shown on figure 2.2.1.1. Three additional 10-foot borings will be drilled 200 feet west of the outer perimeter of the site to determine background. The rationale for the background samples at the locations shown is the predominantly westerly wind and the eastward-dipping alluvial sediments at this location. The 10-foot borings will be sampled at 0, 5, and 10 feet for metals and explosive residue. Additional surface samples will be collected at sites shown on figure 2.2.1.1 and analyzed for metals and explosive residue.

To better define the near-surface geology, three of the borings will be continuously cored to a maximum of 20 feet. These cores will be selected on the basis of providing a good cross-sectional look at the site. If thick caliche zones are penetrated, coring may be restricted to less than 20 feet.

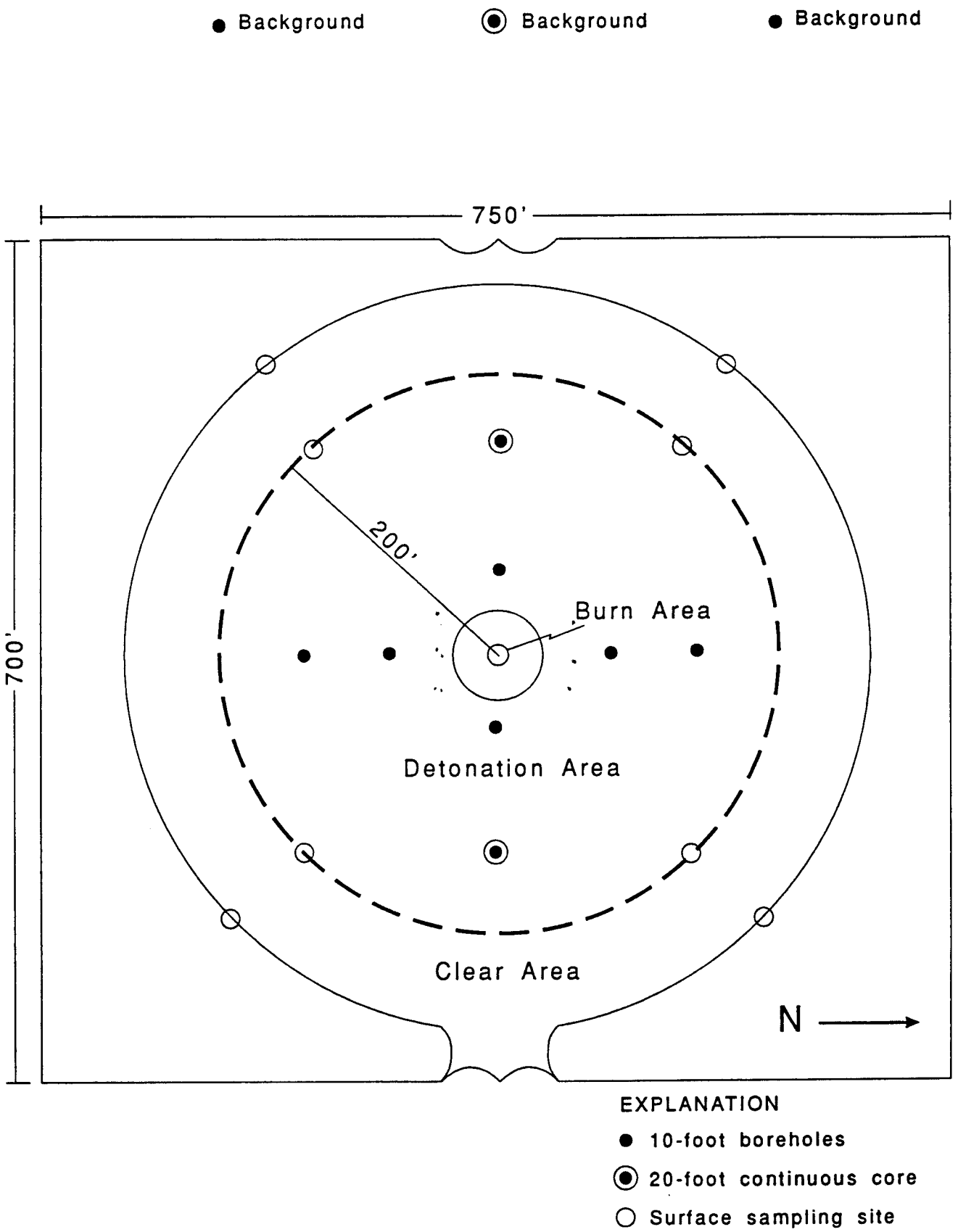


Figure 2.2.1.1.--Phase 1 sampling locations at Open Burn/Open Detonation Thermal Treatment Facility.

The second phase of the study will involve soil sampling immediately after a detonation to determine the short-term effects of a detonation on the surroundings. This sampling will consist of collection of one soil sample in the bottom of the detonation trench, one sample in the sidewall of the detonation trench, and six samples downwind of the detonation site in a grid between the prior sites sampled. Figure 2.2.1.2 shows a conceptual sampling grid for this phase.

The third phase of the study will involve assessing the data, filling data gaps, and proposing any future work at the site. Continued sampling of soils after detonations may be required for a period of time. If contamination is found, future work would involve a feasibility study and cleanup.

2.3 Action Levels

RCRA action levels for soil and air have been adopted for this investigation, and are given in Appendix A.

3.0 RCRA BASELINE STUDY TASKS

This section will describe in general terms the tasks to be performed during the preliminary baseline study at OB/OD. How these activities will be accomplished and the details of each field task are addressed in detail in the Sampling and Analysis Plan.

3.1 Site Objectives

The tasks to be performed in this study will be used to identify and better characterize the site so that a feasibility study can be accomplished, if necessary in a later stage, on the basis of the results of the investigation. The baseline study will collect and interpret information to develop site conceptual models at the OB/OD. The primary goal of the tasks presented in this work plan is to determine if contamination exists within the OB/OD site. Determining the extent and magnitude of contamination will be performed after this investigation. The pathway having greatest potential is the release of contaminants to ground water. This investigation will focus on the unsaturated zone.

3.2 Field Investigation

3.2.1 Field tasks

The following subsections briefly describe the purpose of the field tasks that will be conducted. The soil sampling plan for work to be conducted by the Geological Survey is described in this section.

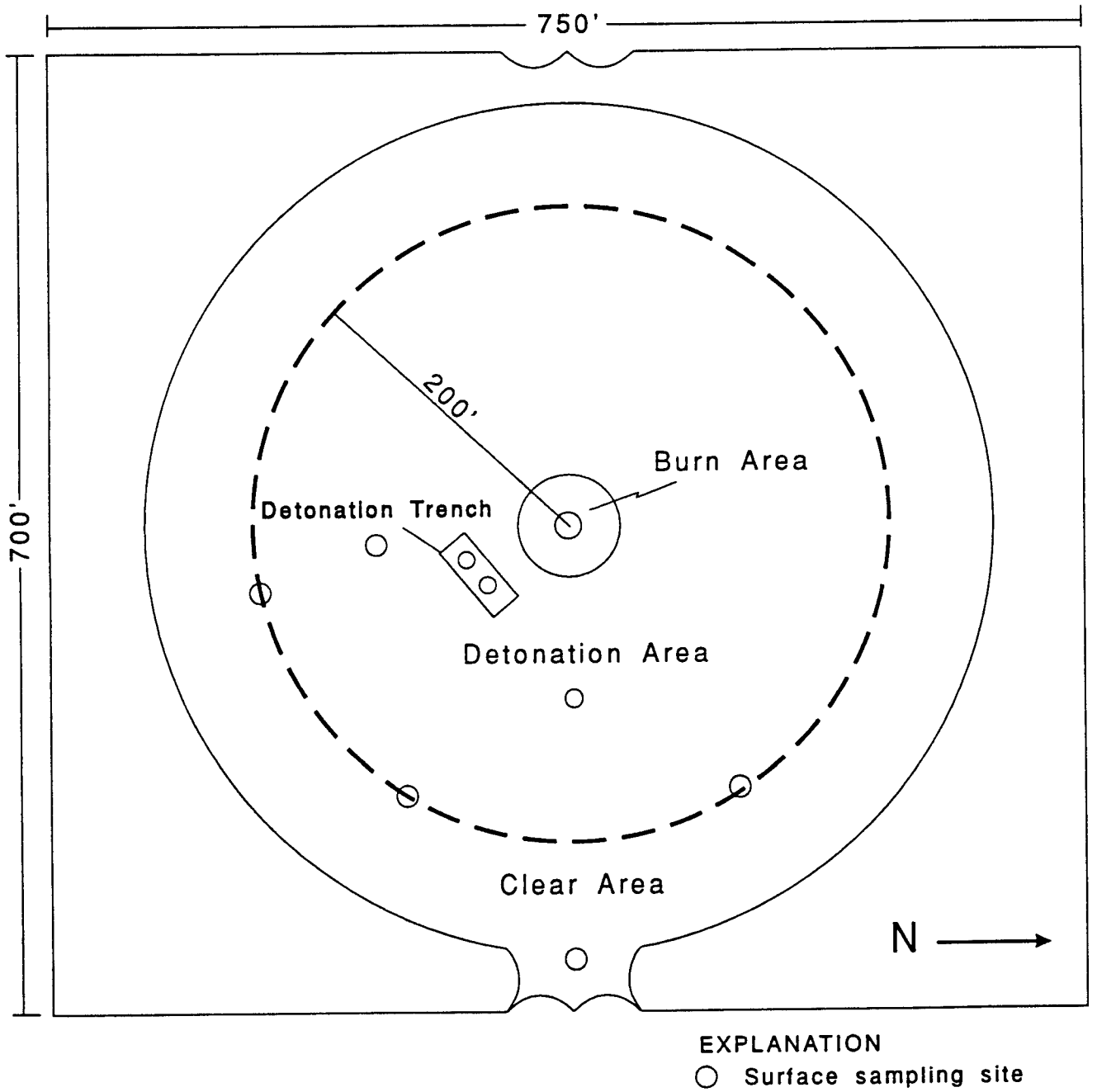


Figure 2.2.1.2.--Phase 2 approximate sampling locations at Open Burn/Open Detonation Thermal Treatment Facility.

3.2.1.1 Soil boring and hand augering

Soil borings will be collected with a driven-hole (Geoprobe) coring system. Soil samples will be collected using a driven sample tube. The purpose of the soil borings is to collect soil samples at various depths to determine the extent and magnitude of soil contamination.

Shallow hand-auger borings and surface samples will be collected with a 4-inch-diameter stainless-steel hand auger. One soil sample will be collected from each hand auger. The purpose of the hand-auger samples is to determine the extent and magnitude of shallow soil contamination.

Because of the thick vadose zone, it is more economically feasible to obtain initial site contamination information by collecting soil samples in the shallow subsurface. Therefore, at most sites, soil samples will be collected from either soil borings or hand augers to identify and characterize contamination in the unsaturated, unconsolidated soil.

3.2.1.2 Land surveying

A land surveyor will survey the elevations (vertical) and horizontal locations of all newly completed soil borings and other sampling points at all sites. Horizontal locational surveys are used to properly locate the sampling point with respect to other features at the site.

3.2.2 Sampling and analysis activities

Table 3.2.2.1 presents a summary of the number of samples to be collected at the site during phases 1 and 2. The following subsections briefly describe the rationale for the soil sample types and field quality control samples.

3.2.2.1 Soil samples

Three types of soil samples will be collected for the purposes of determining the extent and magnitude of soil contamination. Surficial soil samples will be collected using a stainless-steel scoop or hand auger. Soil-boring samples will be collected using a drive tube sampler at sites at various depths in the soil borings. Hand-auger samples will be collected at depths to as much as 3 feet deep at sites using a 4-inch-diameter stainless-steel hand auger.

3.2.2.2 Field quality control (QC) samples

Field QC samples will be collected and analyzed as part of all field sampling activities. The numbers of field QC samples to be collected are summarized in table 3.2.2.2.1. The protocols listed below will be followed for collection of field QC samples.

Equipment blanks will be collected one per day of soil sampling and analyzed for the same parameters as the soils. These samples will be collected by pouring ASTM Type II reagent water through the sampling device (e.g., hand auger) and into the appropriate sampling container.

Table 3.2.2.1.--Summary of the number of soil analyses by analytical method for OB/OD

Method[1] number	Parameter	Number of analyses Phase 1	Phase 2	Total
SW3050/SW6010	ICP metals	41	8	49
SW3050/SW7041	Antimony	41	8	49
SW3050/SW7740	Selenium	41	8	49
USATHAMA	Explosives	41	8	49

[1]Method numbers preceded by SW are from U.S. Environmental Protection Agency (1986). Method numbers preceded by USATHAMA are methods provided by the U.S. Army Toxic and Hazardous Materials Agency, Assessment Division, Aberdeen Proving Grounds, Maryland 21010.

Table 3.2.2.2.1.--Summary of the number of field QC samples by analytical method

Method[1] number	Parameter	Number of analyses	Equipment blanks	Duplicate/ replicate	Matrix spike/ matrix spike duplicates	Total
SW3050/ SW6010	ICP Metals	49	10	5	3	67
SW3050/ SW7041	Antimony	49	10	5	3	67
SW3050/ SW7740	Selenium	49	10	5	3	67
USATHAMA	Explosives	49	10	5	3	67

[1]Method numbers preceded by SW are from U.S. Environmental Protection Agency (1986). Method numbers preceded by USATHAMA are methods provided by the U.S. Army Toxic and Hazardous Materials Agency, Assessment Division, Aberdeen Proving Grounds, Maryland 21010.

Field replicates will be collected for soil samples. The number of field replicates will be equal to 10 percent of the total number of samples. Replicates will be collected by placing the soil in a stainless-steel tray and dividing the soil into two equal parts with a stainless-steel trowel. One-half of the soil is placed in the appropriate jars labeled for the soil sample, and the other half is placed in the appropriate jars labeled for the replicate sample.

Matrix spike/matrix spike duplicates (MS/MSD's) will be collected for soil samples. One MS/MSD will be collected per 20 samples collected. MS/MSD's will be collected in the same manner as the field replicates.

3.3 Record Keeping

Field records that are sufficient to recreate all sampling and measurement activities will be maintained. This information will be recorded in either a permanently bound daily logbook or on preprinted forms designed exclusively for recording information of a particular task. Examples of these forms are included in the Sampling and Analysis Plan.

The following information shall be recorded for all field activities:

Location.
Date and time.
Identity of people taking measurements or collecting samples.
Numerical value of each measurement.
Calibration records for each field instrument.
Weather conditions.

The following additional information shall be recorded for all sampling activities.

Sample type and sampling method.
Identity of each sample.
Amount of each sample.
Sample description (e.g., color, odor, clarity).
Identification of sampling devices.
Identification of conditions that might affect the sample.

The ENSECO-RMAL laboratory maintains records of sufficient quality to recreate each analytical event conducted. Details of analytical and QC protocols are contained in SOP's (Standard Operating Procedures). SOP's are documents that contain detailed information on the requirements for the correct performance of a laboratory procedure. The laboratory has four categories of SOP's:

* SOP's for Performance of an Analytical Method;
* SOP's for Preparation of Standards and Reagents;
* SOP's for Equipment Operation, Calibration, and Maintenance; and
* SOP's for General Laboratory Procedures.

The laboratory relies on a customized Laboratory Information Management System (LIMS) as the primary data base. Client information, sample results, and QC results are all stored in the LIMS. Reports are generated directly from the data base to eliminate transcription errors. The most recent 2 to 3 months of analytical data are kept on-line. All other data are archived on magnetic tape or optical disk.

Laboratory bench sheets are used to document information from routine laboratory operations, including sample preparation and analysis. Bench sheets ensure that the information is recorded in a complete and organized manner and that the analysis can be reconstructed, if necessary. Portions of information from the bench sheet are also stored in the LIMS.

Laboratory notebooks are used to document information that cannot easily be recorded in the LIMS. Information typically recorded in laboratory notebooks includes unusual observations or occurrences in the analysis of samples or methods-development information. Each page in a laboratory notebook is initialed and dated as information is entered.

A project file is created for each project handled within the laboratory. The project file contains all documents associated with the project, including correspondence from the client, chain-of-custody records, raw data, copies of laboratory notebook entries pertaining to the project, and a copy of the final report. When a project is complete, all records are passed to the Document Custodian who inventories the file, checks for completeness, and puts the file into document archive.

3.4 Data Assessment

Field records and analytical data will be reviewed for accuracy and validity to ensure that the environmental conditions interpreted for a particular site are technically sound. Data generated under the laboratory and field QA/QC program will be used to evaluate the analytical results assembled for each site and to formulate conclusions and recommendations pertaining to the need for additional site investigations. This data quality assessment will be presented in the appropriate sections of the Technical Report for OB/OD.

Field records will be evaluated for completeness to ensure that all requirements have been fulfilled and that the procedures documented in the SAP have been implemented. Environmental data associated with poor or incorrect field work will be identified to detect problems affecting the representativeness of environmental samples. Anomalous field data will also be identified and explained to the extent possible.

Laboratory data completeness will be reviewed to ensure that all samples and analyses required have been processed, that complete records exist for each analysis and the associated QC samples, and that the procedures specified in the Work Plan and SAP have been implemented. Analytical control and detection limits will be assessed, and control limits outside of the acceptable range as specified in the SAP will be identified along with any trends or problems with the data. Any detection limits that exceed the limits in the SAP will also be identified. Sample holding times will be compared with those in the SAP; if exceeded additional samples will be collected and analyzed.

After valid data are obtained through the assessment of field records and laboratory data, the environmental data from field duplicates, field and laboratory blanks, and sample matrix effects will be evaluated. Precise field duplicate results indicate reproducible sampling techniques and precise laboratory analysis. Field duplicate results not within control limits could indicate a heterogeneous sample medium, poor sampling technique, or a lack of analytical precision. Results from the analysis of blanks will be assessed to determine sources of contamination and the impact of any contamination on the analytical results for the environmental samples. Potential matrix effects identified through laboratory tests or field records will be identified and their impact on results for the environmental samples described in the Technical Report.

Data that are not representative of environmental conditions and are generated through poor field or laboratory practices will not be used in the evaluation process. This determination will be made using the professional judgment of a multidisciplinary team of geologists, hydrologist, chemists, and other personnel having direct experience with the data collection effort. This coordination is essential for the identification of valid data and the proper evaluation of those data.

4.0 REPORTING REQUIREMENTS

4.1 Technical Report

The results of the investigation of OB/OD on MAFR will be incorporated into the Technical Report. The Technical Report will address the following areas.

1. Introduction (includes base environmental setting)
2. Project activities
3. OB/OD investigation results
4. Conclusions and recommendations
5. Appendices

4.2 Special Notification

Any data or results generated during this investigation that may indicate an imminent health risk will be immediately reported to the Environmental Manager, Cannon AFB, via telephone. The telephone notification will be followed with a written notice within three (3) days, and a copy of the raw laboratory data (e.g., chromatograms, standards used for calibration, etc. will be attached).

5.0 PROJECT SCHEDULE

The proposed schedule for the OB/OD investigation and reports is shown in figure 5.1. The exact dates of the drilling and sampling will depend in part on weather conditions, availability of drilling equipment, and notification by the New Mexico Environment Department and Cannon AFB to proceed with the work.

	1992		1993								
Work item	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Scoping document											
Work plan		XXXXXX									
Analysis plan		XXXXXX									
Drill and sample phase 1				XXXXXXX							
Drill and sample phase 2					XXXXXXXXXXXXX						
Technical Report											
Draft 1								XXXXXXX			
Draft 2										XXXXXX	
Final											XX
Meetings				X		X		X			X

Figure 5.1--Proposed schedule for the Open Burn/Open Detonation Thermal Treatment Facility investigation.

6.0 REFERENCES

Baehr, A.L., 1987, Selective transport of hydrocarbons in the unsaturated zone due to aqueous and vapor phase partitioning: Water Resources Research, vol. 23, no. 10, p. 1926-1938.

Baehr, A.L., and Corapcioglu, M.Y., 1987, A compositional multiphase model for groundwater contamination by petroleum products--2. Numerical solution: Water Resources Research, v. 23, no. 1, p. 201-213.

Corapcioglu, M.Y., and Baehr, A.L., 1987, A compositional multiphase model for groundwater contamination by petroleum products--1. Theoretical considerations: Water Resources Research, v. 23, no. 1, p. 191-200.

Dane, C.H., and Bachman, G.O., 1965, Geologic map of New Mexico: U.S. Geological Survey, scale 1:500,000, 2 sheets.

Jamison, V.W., Raymond, R.L., and Hudson, J.O., 1976, Biodegradation of high octane gasoline, in Proceedings: Third International Biodegradation Symposium, Englewood, N.J., Applied Science Publishers, p. 187-196.

Mantoglou, Aristotelis, and Gelhar, L.W., 1987, Effective hydraulic conductivities of transient unsaturated flow in stratified soils: Water Resources Research, vol. 23, no. 1, p. 57-67.

Mendoza, C.A., and Frind, E.O., 1990a, Advective-dispersive transport of dense organic vapors in the unsaturated zone--1. Model development: Water Resources Research, v. 26, no. 3, p. 379-387.

Mendoza, C.A., and Frind, E.O., 1990b, Advective-dispersive transport of dense organic vapors in the unsaturated zone--2. Sensitivity analysis: Water Resources Research, v. 26, no. 3, p. 388-398.

Nielsen, D.M., ed., 1991, Practical handbook of ground-water monitoring: Lewis Publishers, 717 p.

Ross, W. James, and Bailey, Oran F., 1967, Soil Survey of Roosevelt County, New Mexico: U.S. Department of Agriculture, Soil Conservation Service.

U.S. Air Force Occupational and Environmental Health Laboratory Technical Services Division, 1989, Handbook to support the Installation Restoration Program statements of work for remedial investigation/feasibility studies, version 3.0: U.S. Air Force Human Systems Division HSD/YAQ, Brooks Air Force Base, Tex.

U.S. Environmental Protection Agency, 1980, Interim guidelines and specifications for preparing quality assurance project plans: U.S. Environmental Protection Agency Office of Research and Development, QAMS-005/80.

U.S. Environmental Protection Agency, 1986, Test methods for evaluating solid waste, Physical/chemical methods, SW-846: U.S. Environmental Protection Agency, third ed.

APPENDIX A.—EXAMPLES OF CONCENTRATIONS MEETING CRITERIA FOR ACTION LEVELS

[Section 264.521(a)(2)(i-iv)]

Constituent name	Class	Air(ug/m^3)	Water (mg/L)	Soils (mg/kg)
Acetone	D		4E−00	8E+03
Acetonitrile	D		2E−01	5E+02
Acetophenone	D	2E−01	4E−00	8E+03
Acrylamide	B2	8E−04	8E−08	2E−01
Acrylonitrile	B1	1E−02	6E−05	1E−00
Aldicarb	D		5E−02	1E+02
Aldrin	B2	2E−04	2E−08	4E−02
Allyl alcohol	D		2E−01	4E+02
Aluminum phosphide	D		1E−02	3E+01
Aniline	B2		6E−03	1E+02
Antimony	D		1E−02	3E+01
Arsenic	A	7E−05	(1)	8E+01
Asbestos (2)	A	2E−02		
Barium cyanide	D		2E−00	6E+03
Barium, ionic	D	4E−01	(1)	4E+03
Benzidine	A	2E−05	2E−07	3E−03
Beryllium	B2	4E−04	8E−08	2E−01
Bis(2-ethylhexyl)phthlate	B2		3E−03	5E+01
Bis(chloroethyl)ether	B2	3E−03	3E−05	6E-01
Bromodichloromethane (3)	B2		3E−05	5E−01
Bromoform (3)	D		7E−01	2E+03
Bromomethane	D	3E+01	5E−02	1E+02
Butyl benzyl phthalate	C		7E−00	2E+04

APPENDIX A.—EXAMPLES OF CONCENTRATIONS MEETING CRITERIA FOR ACTION LEVELS—Continued

[Section 264.521(a)(2)(i-iv)]

Constituent name	Class	Air(ug/m^3)	Water (mg/L)	Soils (mg/kg)
Cadmium	B1	8E-04	(1)	4E+01
Calcium cyanide	D		1E-00	3E+03
Carbon disulfide	D		4E-00	8E+03
Carbon tetrachloride	B2	3E-02	3E-04	5E-00
Chloral	D		7E-02	2E+02
Chlordane	B2	3E-03	3E-05	5E-01
Chlorine cyanide	D		2E-00	4E+03
Chlorobenzene	D	2E+01	7E-01	2E+03
Chloroform (3)	B2	4E-02	6E-03	1E+02
2-Chlorophenol	D		2E-01	4E+02
Chromium (VI)	A	9E-05	(1)	4E+02
Copper cyanide	D		2E-01	4E+02
m-Cresol	D		2E-00	4E+03
o-Cresol	D		2E-00	4E+03
p-Cresol	D		2E-00	40+03
Cyanide	D		7E-01	2E+03
Cyanogen	D		1E-00	3E+03
Cyanogen bromide	D		3E-00	7E+03
DDD	B2		1E-04	3E-00
DDE	B2		1E-04	2E-00
DDT	B2	1E-02	1E-04	2E-00
Dibutyl phthalate	D		4E-00	8E+03
Dibutylnitrosamine	B2	6E-04	6E-06	1E-01
3,3'-Dichlorobenzidine	B2		8E-05	2E-00
Dichlorodifluoromethane	D	2E+02	7E-00	2E+04
1,2-Dichloroethane	B2	4E-02	(1)	8E-00
1,1-Dichloroethylene	C	3E-02	(1)	1E+01
2,4-Dichlorophenol	D		1E-01	2E+02
2,4-Dichlorophenoxyacetic acid	D		4E-01	8E+02
1,3-Dichloropropene	B2		1E-02	2E+01
Dieldrin	B2	2E-04	2E-06	4E-02
Diethyl phthalate	D		3E+01	6E+04
Diethylnitrosamine	B2	2E-05	2E-07	5E-03
Dimethoate	D		7E-01	2E+03
Dimethylnitrosamine	B2	7E-05	7E-07	1E-02
m-Dinitrobenzene	D		4E-03	8E-00
2,4-Dinitrophenol	D		7E-02	2E+02
2,3-Dinitrotoluene (and 2,6-, mixture)	B2		5E-05	1E-00
1,4-Dioxane	B2		3E-03	6E+01
Diphenylamine	D		9E-01	2E+03
1,2-Diphenylhydrazine	B2	4E-03	4E-05	9E-01
Disulfoton	D		1E-03	3E-00
Endosulfan	D		2E-03	4E-00
Endothall	D		7E-01	2E+03
Endrin	D		(1)	2E+01
Epichlorohydrin	B2	8E-01	4E-03	7E+01
Ethylbenzene	D		4E-00	8E+03
Ethylene dibromide	B2	5E-03	4E-07	8E-03
Formaldehyde	B1	8E-02		
Formic acid	D		7E+01	2E+05
Glycidylaldehyde	D		1E-02	3E+01
Heptachlor	B2	8E-04	8E-06	2E-01
Heptachlor epoxide	B2	4E-04	4E-06	8E-02
Hexachlorodibenzo-p-dioxin	B2	6E-07	1E-08	1E-04
Hexachlorobutadiene	C	4E-01	4E-03	8E+01
alpha-Hexachlorocyclohexane	B2	6E-04	6E-06	1E-01
beta-Hexachlorocyclohexane	C	2E-02	2E-04	4E-00
Hexachlorocyclopentadiene	D	7E-02	2E-01	6E+02
Hexachloroethane	C	3E-00	3E-02	8E+01
Hexachlorophene	D		1E-02	2E+01
Hydrazine	B2	2E-04	1E-05	2E-01
Hydrogen cyanide	D		7E-01	2E+03
Hydrogen sulfite	D		1E-01	2E+02
Isobutyl alcohol	D		1E+01	2E+04
Isophorone	C		9E-02	2E+03
Lead	B2		(1)	
Lindane (gamma-hexachlorocyclohexane)	B2/C		(1)	8E-01
m-Phenylenediamine	D		2E-01	5E+02
Maleic anhydride	D		4E-00	8E+03
Maleic hydrazide	D		2E+01	4E+04
Mercury (inorganic)	D		(1)	2E+01
Methacrylonitrile	D	7E-01	4E-03	8E-00
Methomyl	D		8E-01	2E+03
Methyl chlorocarbonate	D			
Methyl ethyl ketone	D	3E+02	2E-00	4E+03
Methyl isobutyl ketone	D	7E+01	2E-00	4E+03
Methyl parathion	D		9E-03	2E+01

APPENDIX A.—EXAMPLES OF CONCENTRATIONS MEETING CRITERIA FOR ACTION LEVELS—Continued

[Section 264.521(a)(2)(i-iv)]

Constituent name	Class	Air(ug/m^3)	Water (mg/L)	Soils (mg/kg)
Methylene chloride	B	3E−01	5E−03	9E+01
n-Nitroso-di-n-butylamine	B2	6E−04	6E−06	1E−01
n-Nitroso-n-ethylurea	B			
n-Nitroso-n-methylethylamine	B2		2E−06	3E−02
n-Nitrosodi-n-propylamine	B2		5E−06	1E−01
n-Nitrosodiethanolamine	B2		1E−05	3E−01
n-Nitrosodiphenylamine	B2		7E−03	1E+02
n-Nitrosopyrrolidine	B2	2E−03	2E−05	3E−01
Nickel	D		7E−01	2E+03
Nickel refinery dust	A	4E−03		
Nitric oxide	D		4E−00	6E+03
Nitrobenzene	D	2E−00	2E−02	4E+01
Nitrogen dioxide	D		4E+01	8E+04
Osmium tetroxide	D		4E−04	6E−01
Parathion	C		2E−01	5E+02
Pentachlorobenzene	D		3E−02	6E+01
Pentachloronitrobenzene	C	1E−01	1E−01	2E+02
Pentachlorophenol	D		1E−00	2E+03
Phenol	D		2E+01	5E+04
Phenyl mercuric acetate	D		3E−03	6E−00
Phosphine	D		1E−02	2E+01
Phthalic anhydride	D		7E+01	2E+05
Polychlorinated biphenyls	B2		5E−06	9E−02
Potassium cyanide	D		2E−00	4E+03
Potassium silver cyanide	D		7E−00	2E+04
Pronamide	D		3E−00	6E+03
Pyridine	D		4E−02	8E+01
Selenious acid	D		1E−01	2E+02
Selenoures	D		2E−01	4E+02
Silver	D		(1)	2E+02
Silver cyanide	D		4E−00	8E+03
Sodium cyanide	D		1E−00	3E+03
Strychnine	D		1E−02	2E+01
Styrene	C		7E−00	2E+04
1,1,1,2-Tetrachloroethane	C	1E−00	1E−02	3E+02
1,2,4,5-Tetrachlorobenzene	D		1E−02	2E+01
1,1,1,2-Tetrachloroethane	C	1E−00	1E−02	3E+02
1,1,2,2-Tetrachloroethane	C	2E−01	2E−03	4E+01
Tetrachloroethylene	B2	1E−00	7E−04	1E+01
2,3,4,6-Tetrachlorophenol	D		1E−00	2E+03
Tetraethyl lead	D		4E−06	8E−03
Tetraethyldithiopyrophosphate	D		2E−02	4E+01
Thallic oxide	D		2E−03	6E−00
Thallium acetate	D		3E−03	7E−00
Thallium carbonate	D		3E−03	6E−00
Thallium chloride	D		3E−03	6E−00
Thallium nitrate	D		3E−03	7E−00
Thallium sulfate	D		3E−03	6E−00
Thiosemicarbazide	D		2E−01	5E+02
Thiram	D		2E−01	4E+02
Toluene	D	7E+03	1E+01	2E+04
Toxaphene	B2	3E−03	(1)	6E−01
1,2,4-Trichlorobenzene	D	1E+01	7E−01	2E+03
1,1,1-Trichloroethane	D	1E+03	3E−00	7E+03
1,1,2-Trichloroethane	C	6E−01	6E−03	1E+02
Trichloroethylene	B2		(1)	6E+01
Trichloromonofluoromethane	D	7E+02	1E+01	2E+04
2,4,5-Trichlorophenol	D		4E−00	8E+03
2,4,6-Trichlorophenol	B2	2E−01	2E−03	4E+01
2,4,5-Trichlorophenoxyacetic acid	D		(1)	8E+02
1,2,3-Trichloropropane	D		2E−01	5E+02
Vanadium pentoxide	D		3E−01	7E+02
Xylenes	D	1E+03	7E+01	2E+05
Zinc cyanide	D		2E−00	4E+03
Zinc phosphide	D		1E−02	2E+01

(1) MCL available; see appendix B.

(2) The air action level for asbestos is measured in units of fibers/milliliters.

(3) There is an MCL for total trihalomethanes, which includes four constituents: bromoform, bromodichloromethane, chloroform, and dibromochloromethane.

Concentration derived using exposure assumptions in appendix D and reference doses for systemic toxicants and verified risk-specific doses at 10−6 for Class A and B carcinogens and 10−5 for Class C carcinogens (see section VI.F.2.6 for further discussion).

A, B and C represents class A, B and C carcinogens, respectively; D represents a systemic toxicant.

NOTICE

This report has been prepared for Cannon Air Force Base by the U.S. Geological Survey, Water Resources Division, New Mexico District for the purpose of providing technical information for completion of their Resource Conservation Recovery Act (RCRA) Subpart X Part B operating permit at Melrose Air Force Range. As the report relates to actual or possible releases of potentially hazardous substances, its release prior to an Air Force final decision on remedial action may be in the public's interest. The limited objectives of this report and the ongoing nature of the baseline study for the permit application, along with the evolving knowledge of site conditions and chemical effects on the environment and health, must be considered when evaluating this report, since subsequent facts may become known which may make this report premature or inaccurate. Acceptance of this report in performance of the contract under which it is prepared does not mean that the US Air Force adopts the conclusions, recommendations or other views expressed herein, which are those of the contractor only and do not necessarily reflect the official position of the United States Air Force.

RCRA SUBPART X PART B PERMIT APPLICATION

SAMPLING AND ANALYSIS PLAN

FOR

Open Burn/Open Detonation Thermal Treatment Facility

Melrose Force Range, New Mexico

27 CES/CEV
Environmental Management Flight
Cannon Air Force Base, New Mexico 88103

January 1993

PREPARED BY

U.S. Geological Survey, Water Resources Division
(USGS-WRD)
4501 Indian School Rd. NE, Suite 200
Albuquerque, New Mexico 87110

Russell K. Livingston
USGS
District Chief

Gary Torf
Laboratory QA
Officer, Enseco Incorporated

Kim Ong
USGS
QA Officer

Jimmie N. Richards
Technical Project
Manager

Jimmie N. Richards
PROJECT MANAGER
CANNON AIR FORCE BASE

PREFACE

The purpose of this investigation was to determine if contamination has occurred in soils immediately on or adjacent to the Open Burn/Open Detonation Thermal Treatment Facility site on Melrose Air Force Range where contaminants were disposed of by burning and detonation..

Project Chief of this investigation is Jerry Larson. Technical support is provided by employees of the New Mexico District of the U.S. Geological Survey, Water Resources Division. Editorial and typing support for this report was provided by Petra Dickey, Mary Montaño, and Cindy Shattuck. Illustrations were prepared by Darla Straka. Chemical analyses will be performed by Rocky Mountain Analytical Laboratory, a Division of Enseco, Arvada, Colorado. Drilling will be performed by the U.S. Geological Survey. Appreciation is extended to the Base Point of Contact, Mr. Jimmie N. Richards, and Ms. Vera Wood, Environmental Management at Cannon Air Force Base. The assistance and cooperation of the entire Cannon Air Force Base is greatly appreciated.

Approved:

Russell K. Livingston
District Chief
U.S. Geological Survey

Jimmie N. Richards
Technical Project Manager
Cannon AFB, New Mexico

TABLE OF CONTENTS

Section	Title	Page
1.0	QUALITY ASSURANCE PROJECT PLAN (QAPP)	
1.1	INTRODUCTION	1
1.1.1	The Melrose Air Force Range Subpart X Part B Permit Application	1
1.1.2	Purpose and scope	1
1.2	PROJECT DESCRIPTION	2
1.2.1	Project background	2
1.2.2	Project objectives	6
1.2.3	Identification of subcontractors and their tasks	7
1.3	PROJECT ORGANIZATION AND RESPONSIBILITY	7
1.4	QA OBJECTIVES FOR MEASUREMENT DATA	10
1.4.1	Definition of Criteria	10
1.4.2	Goals	15
1.5	SAMPLING PROCEDURES	16
1.5.1	Sampling protocols	16
1.5.2	Sample Handling	17
1.6	SAMPLE CUSTODY	19
1.6.1	Field operations	19
1.6.2	Laboratory operations	19
1.6.2.1	Sample handling and custody	19
1.6.2.2	Sample identification	19
1.7	CALIBRATION PROCEDURES AND FREQUENCY FOR FIELD TEST EQUIPMENT	21
1.8	ANALYTICAL PROCEDURES	21
1.8.1	Identification of methods	21
1.8.2	Detection limits and quantification criteria	21
1.8.3	Method calibration	24
1.9	DATA REDUCTION, VALIDATION, AND REPORTING	29
1.9.1	Data management	29
1.9.2	Data reduction	31
1.9.3	Data quality assessment	31
1.9.4	Reporting	32

TABLE OF CONTENTS--Continued

Section	Title	Page
	1.10 INTERNAL QUALITY CONTROL CHECKS FOR FIELD AND LABORATORY OPERATIONS	33
	1.10.1 Field quality control	33
	1.10.2 Laboratory quality control	33
	1.10.3 Control limits	37
	1.11 PERFORMANCE AND SYSTEM AUDIT	38
	1.12 PREVENTATIVE MAINTENANCE	39
	1.12.1 Procedures	39
	1.12.2 Schedule	39
	1.12.3 List of critical spare parts	39
	1.13 FIELD AND LABORATORY PROCEDURES FOR ASSESSING DATA PRECISION, ACCURACY, AND COMPLETENESS	40
	1.13.1 Formulas	40
	1.13.2 Control limits	41
	1.13.3 Data quality assessment	43
	1.13.4 Documentation	43
	1.14 CORRECTIVE ACTION	45
	1.14.1 Response	45
	1.14.2 Reestablishment of control	46
	1.14.3 Documentation	46
	1.15 QUALITY ASSURANCE REPORTS	48
	1.15.1 Reporting procedure	48
	1.15.2 Report content	48
2.0	FIELD SAMPLING PLAN	
	2.1 FIELD OPERATIONS	49
	2.1.1 Site reconnaissance, preparation and restoration procedures	49
	2.1.2 Borehole construction	50
	2.1.3 Surveying	53
	2.1.4 Equipment decontamination	53
	2.1.5 Waste handling	54
	2.1.6 Summary of field activities	54

TABLE OF CONTENTS--Concluded

Section	Title	Page
2.2	ENVIRONMENTAL SAMPLING	55
	2.2.1 Procedures	55
	2.2.1.1 Soil samples	55
	2.2.2 Samples handling	56
	2.2.3 Sample custody	56
	2.2.4 QC samples	60
	2.2.5 Sample analyses summary	60
2.3	FIELD MEASUREMENTS	62
	2.3.1 Parameters	62
	2.3.2 Equipment calibration	62
	2.3.3 Equipment maintenance	62
2.4	FIELD QA/QC PROGRAM	62
	2.4.1 Control parameters	62
	2.4.2 Control limits	63
	2.4.3 Corrective action	63
2.5	RECORD KEEPING	65
2.6	SITE MANAGEMENT	65
2.7	REFERENCES	67

LIST OF FIGURES

		Page
Figure 1.2.1.1	Map showing location of Melrose Air Force Range, New Mexico	3
Figure 1.2.1.2	Map showing facilities on Melrose AFR	4
Figure 1.2.1.3	Map showing configuration of the Open Burn/Open Detonation Thermal Treatment Facility site on Melrose AFR	5
Figure 1.3.1	Organizational chart for OB/OD study on Melrose AFR	8
Figure 1.3.2	Enseco quality assurance organizational chart	9
Figure 1.6.2.1.1	Laboratory sample processing flow chart	20
Figure 1.9.1.1	Laboratory data management flow chart	30
Figure 1.14.3.1	RMAL's warning/out-of-control form	47
Figure 2.1.4.1	Borehole log form	51
Figure 2.2.3.1	Example of completed sample label	58
Figure 2.2.3.2	Analytical services request and chain-of-custody record form	59

LIST OF TABLES

		Page
Table 1.5.2.1	Required volume, preservation, and analytical holding time by method for water and soil samples.....	18
Table 1.8.1.1	Analytical methods and sources.....	22
Table 1.8.2.1	Project detection limits.....	23
Table 1.8.3.1	Summary of internal quality control procedures.....	25
Table 1.13.2.1	Laboratory control limits for matrix spikes, matrix spike duplicates, and surrogate spikes.....	42
Table 2.2.5.1	Summary of the number of analyses by method for each site.....	61
Table 2.2.5.2	Summary of the field QA/QC analyses and the total number of analyses by method.....	61

SAMPLING AND ANALYSIS PLAN
OPEN BURN/OPEN DETONATION THERMAL TREATMENT FACILITY
MELROSE AFR, NEW MEXICO

1.0 QUALITY ASSURANCE PROJECT PLAN

1.1 INTRODUCTION

1.1.1 The Melrose Air Force Range Subpart X Part B Permit Application

Under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, the Superfund Amendments and Reauthorization Act of 1986 (SARA), the Resource Conservation and Recovery Act of 1976 (RCRA), and Executive Order 12316, Cannon Air Force Base has applied for a RCRA Subpart X Part B Permit to treat reactive material in expended ordnance. Data collected in this phase of the study will be used to determine the impacts, if any, of past waste disposal at the Open Burn/Open Detonation Thermal Treatment Facility (OB/OD) on Melrose Air Force Range (MAFR). The data also will be used to determine if any standards are being violated and to help determine if site cleanup is necessary, and in the selection of remedial technology.

1.1.2 Purpose and scope

The purpose of this Sampling and Analysis Plan (SAP) is to ensure that data collected for this investigation are of adequate quality for the purposes of the permit application. The SAP describes the procedures which will be used to document and report precision, accuracy, and completeness of environmental measurements of the RCRA baseline investigation.

1.2 PROJECT DESCRIPTION

1.2.1 Project background

The U.S. Geological Survey (USGS) New Mexico District has been contracted to perform a baseline study at Melrose Air Force Range, New Mexico for Cannon Air Force Base.

Melrose Air Force Range is located approximately 10 miles southwest of Melrose and approximately 30 miles west southwest of Clovis in east central New Mexico (fig 1.2.1.1.). The Range consists of 77,120 acres in Roosevelt and Curry Counties, New Mexico. The Air Force has 15,680 acres of restrictive easement exploration or extraction. Some crops are grown in the northern sections of the range but the primary use is for cattle grazing. There is a range support facility near the center of the Range that houses a fire station, Maintenance area, TV camera station for monitoring ordnance practices, and other support facilities (fig. 1.2.1.2.). The basic mission of MAFR is to support bombing and air-to-ground gunnery training missions by Air Force, Air Force Reserve, Air National Guard, Navy, and marine units. The Range consists of a composite day and night simulated special and conventional weapon delivery range and a day/night tactical range.

The OB/OD is located approximately 1.2 miles south of the range support facility as shown on figure 1.2.1.2. The site is an approximately 700 foot diameter circular area with a burn area in the center (fig. 1.2.1.3.). Surrounding the burn area is a 200 foot are used for detonations. Detonations were performed by digging trenches and exploding the ordnance with the trench. The burn are has been used infrequently and consisted of burning material with the aid of unused diesel fuel.

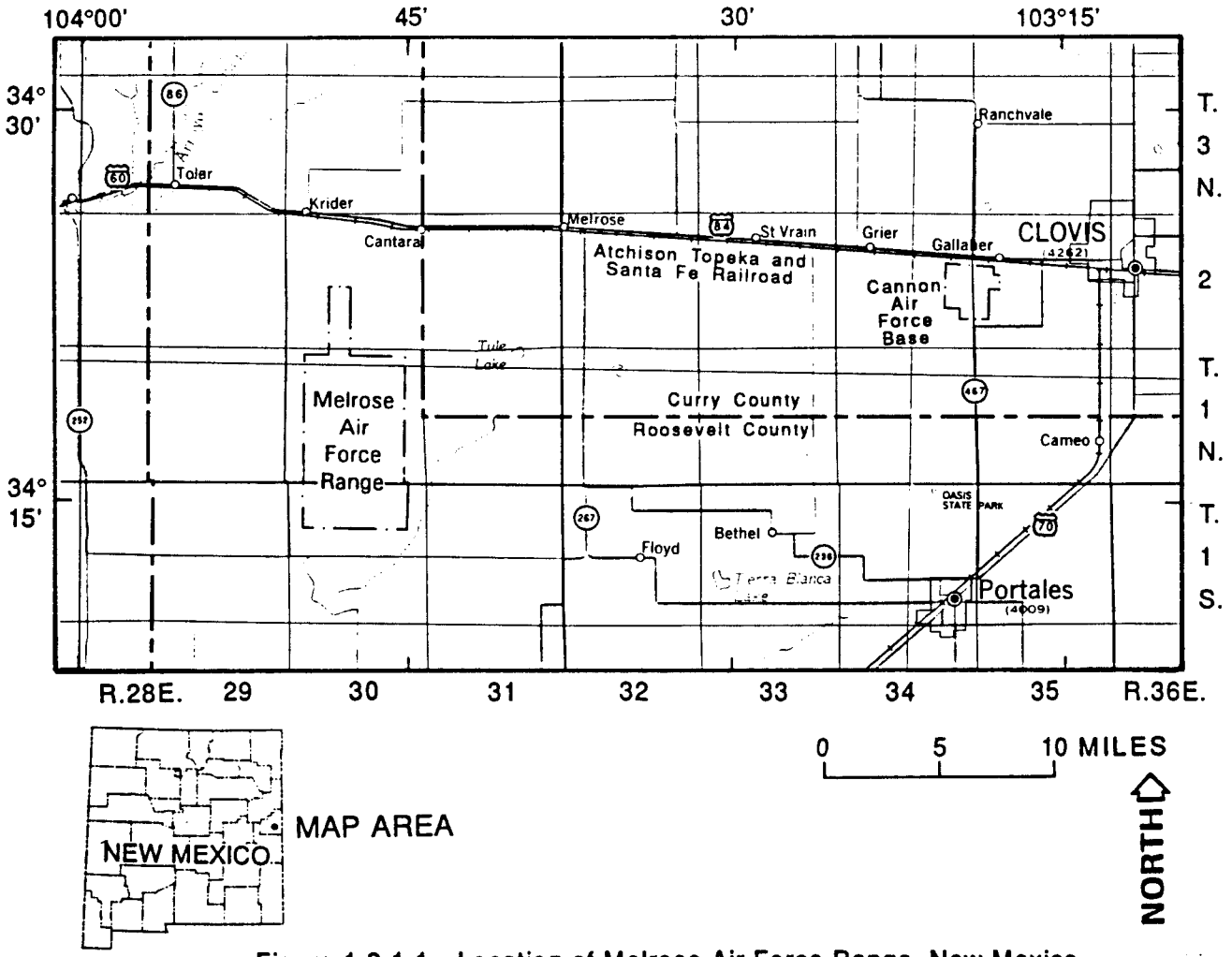


Figure 1.2.1.1.--Location of Melrose Air Force Range, New Mexico.

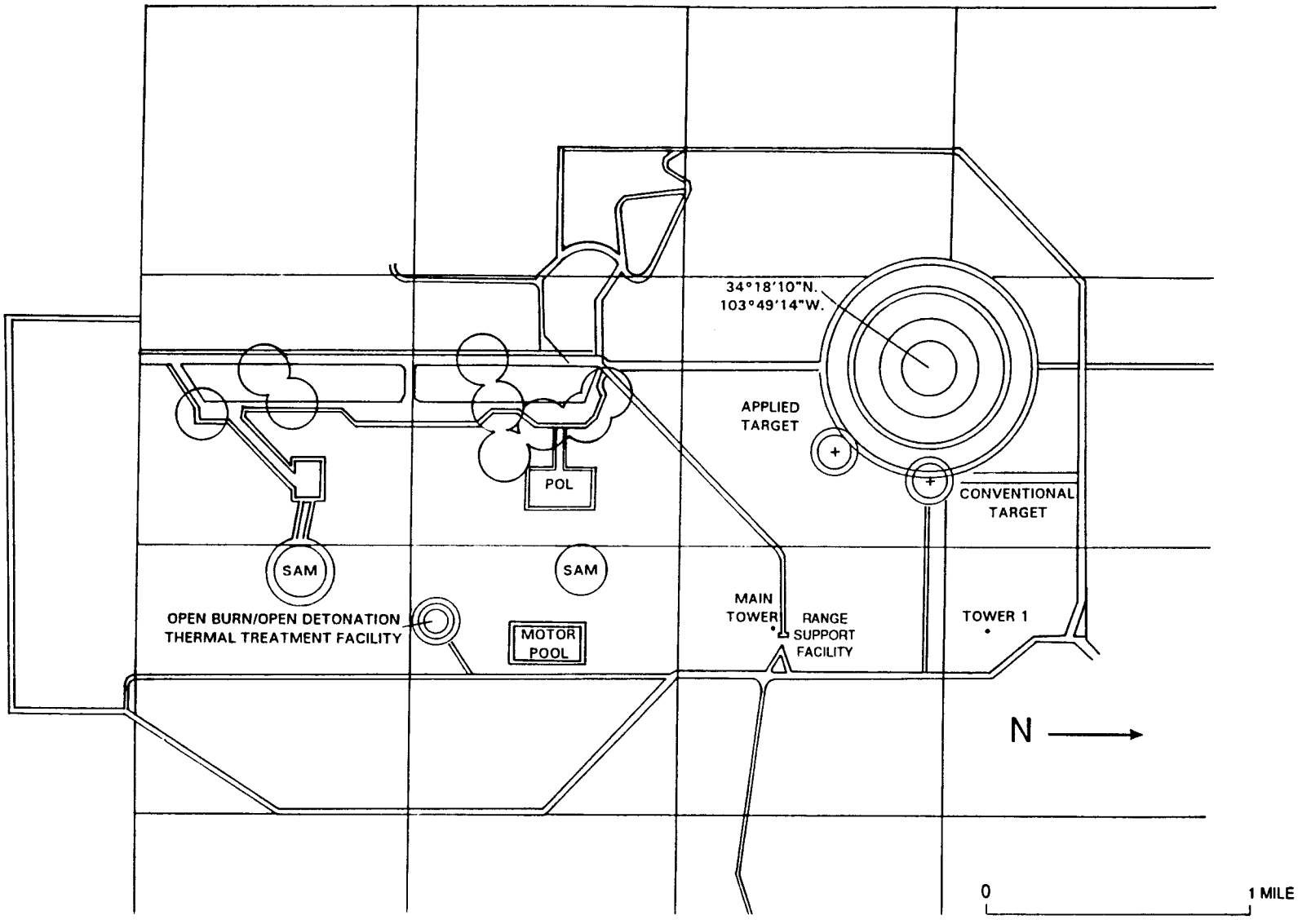


Figure 1.2.1.2.--Facilities on Melrose Air Force Range.

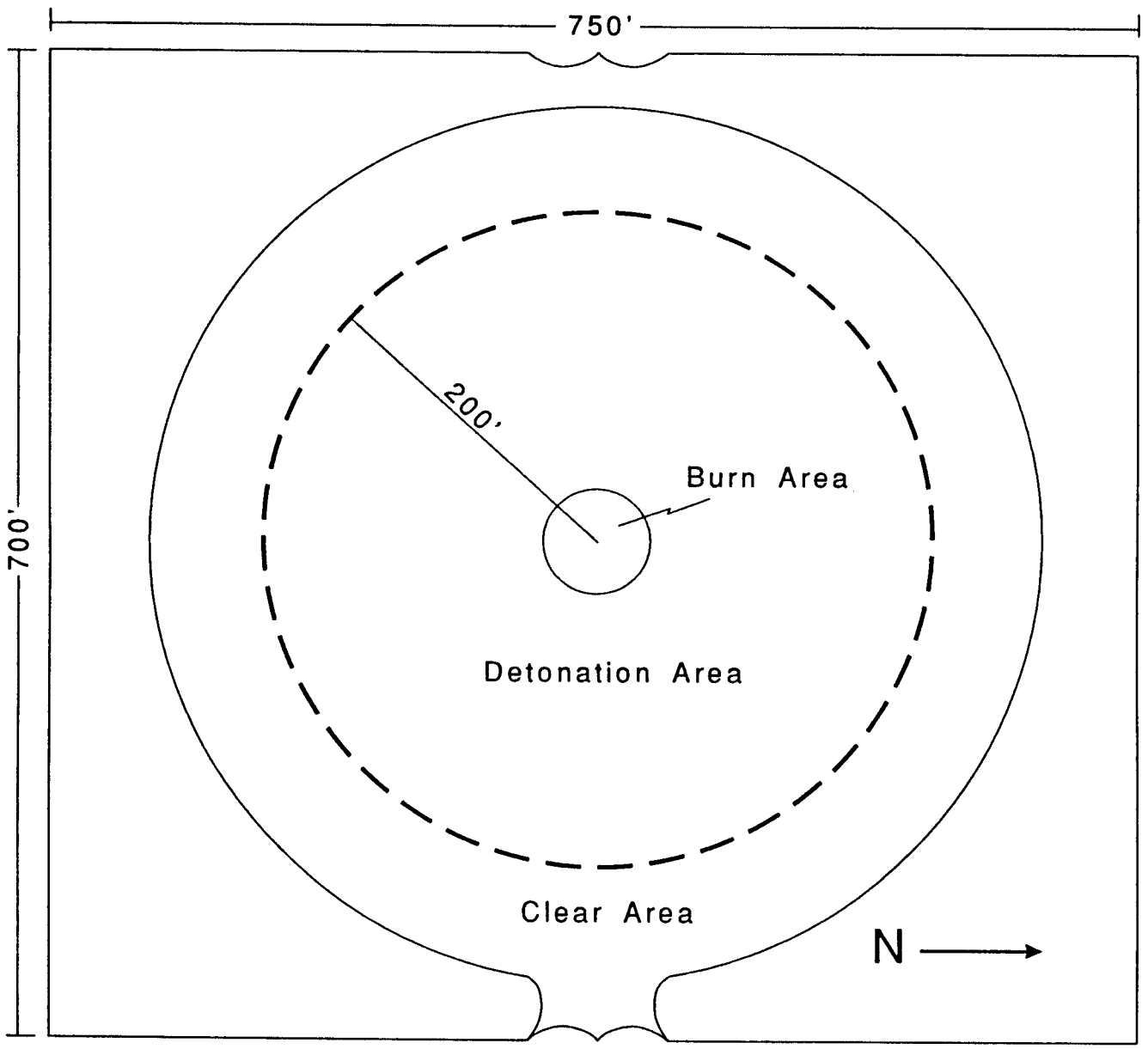


Figure 1.2.1.3.--Configuration of the Open Burn/Open Detonation Thermal Treatment Facility.

1.2.2 Project objectives

The objective of this effort is to conduct a baseline investigation of the OB/OD. The first phase of this work will include drilling of ten foot borings plus three background borings and surface sampling sites. The second phase will be to collect surface samples immediately after a detonation event on the site. This work is intended to identify and characterize past releases that may have occurred at OB/OD. This includes developing a conceptual site model. Conceptual site models consist of a description of the site use, history, and boundaries, identification of the receptors and pathways to the receptors, description of the geology and hydrology of the site, and determination if contaminant releases have occurred. The amount of information presently available concerning the site use, history, and type of waste at the site minimal. This investigation will result in the collection of data to determine the type of wastes and extent of contamination at the site. This site is remote and there are not many people (receptors) near the site that would come in contact with airborne contaminants released from the sites. The receptors of most concern are humans working on the range that contact dust or soil from the site, or residents of the area that could come in contact with ground water or surface water that has moved off the base. The pathways for contaminant release are through air, surface water and ground water. There are no perennial streams on base so transport of contaminants in surface water would occur during the rare times when runoff due to precipitation occurs. The pathway of greatest potential is the release of contaminants to the ground water. The depth of ground water on base is generally large so an important consideration in this study is to determine if contamination is moving through the unsaturated zone towards the ground water.

1.2.3 Identification of subcontractors and their tasks

1. Rocky Mountain Analytical Laboratory (RMAL), a division of ENSECO, Inc., Denver, Colorado--chemical analyses of soils in laboratory facilities.

2. (To-be-selected) licensed surveyor--surveying of soil boring and soil sampling locations..

1.3 PROJECT ORGANIZATION AND RESPONSIBILITY

The project organizational chart for this study is shown in figure 1.3.1 Major responsibilities for the project's activities will be carried by the following individuals or laboratory:

District Chief of the New Mexico District,
Water Resources Division, U.S. Geological Survey,
Albuquerque, New Mexico.....Russell Livingston

Project Supervisor .....Rodger Ferreira

Project Quality Assurance Manager.....Kim Ong

Project Chief of the OB/OD site,.....Jerry Larson

Project Safety Officer for assessing
the safety of field operations.....Fred Gebhardt

U.S. Geological Survey National Water Quality Lab
Contract Officer's Representative provides technical
support for contract services.....Dorothy Walker

Analytical Laboratory QA, Rocky Mountain Analytical Laboratory
(RMAL), a division of ENSECO, Inc.....(see fig. 1.3.2)

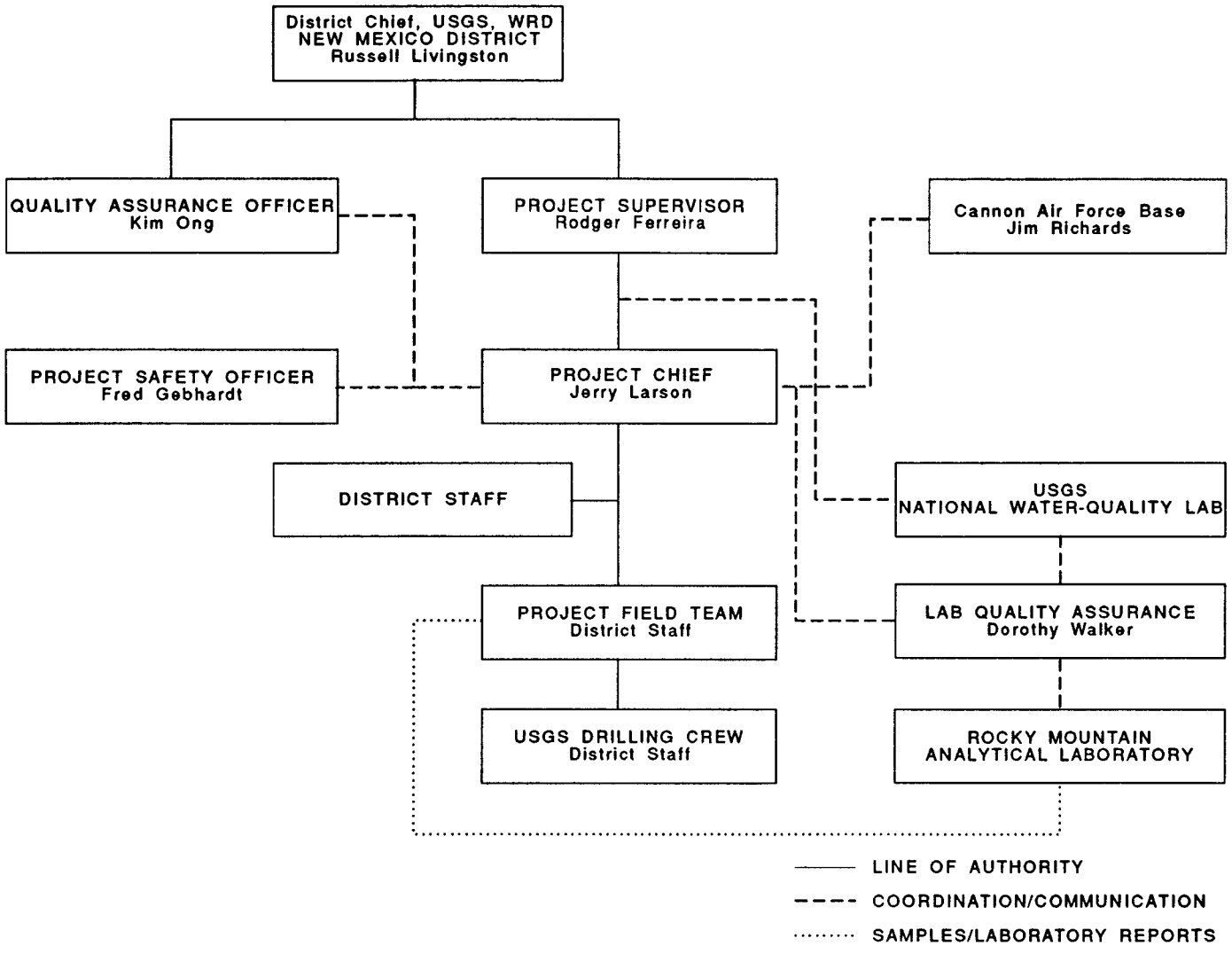


Figure 1.3.1.--Organization chart for Open Burn/Open Detonation Study on Melrose Air Force Range.

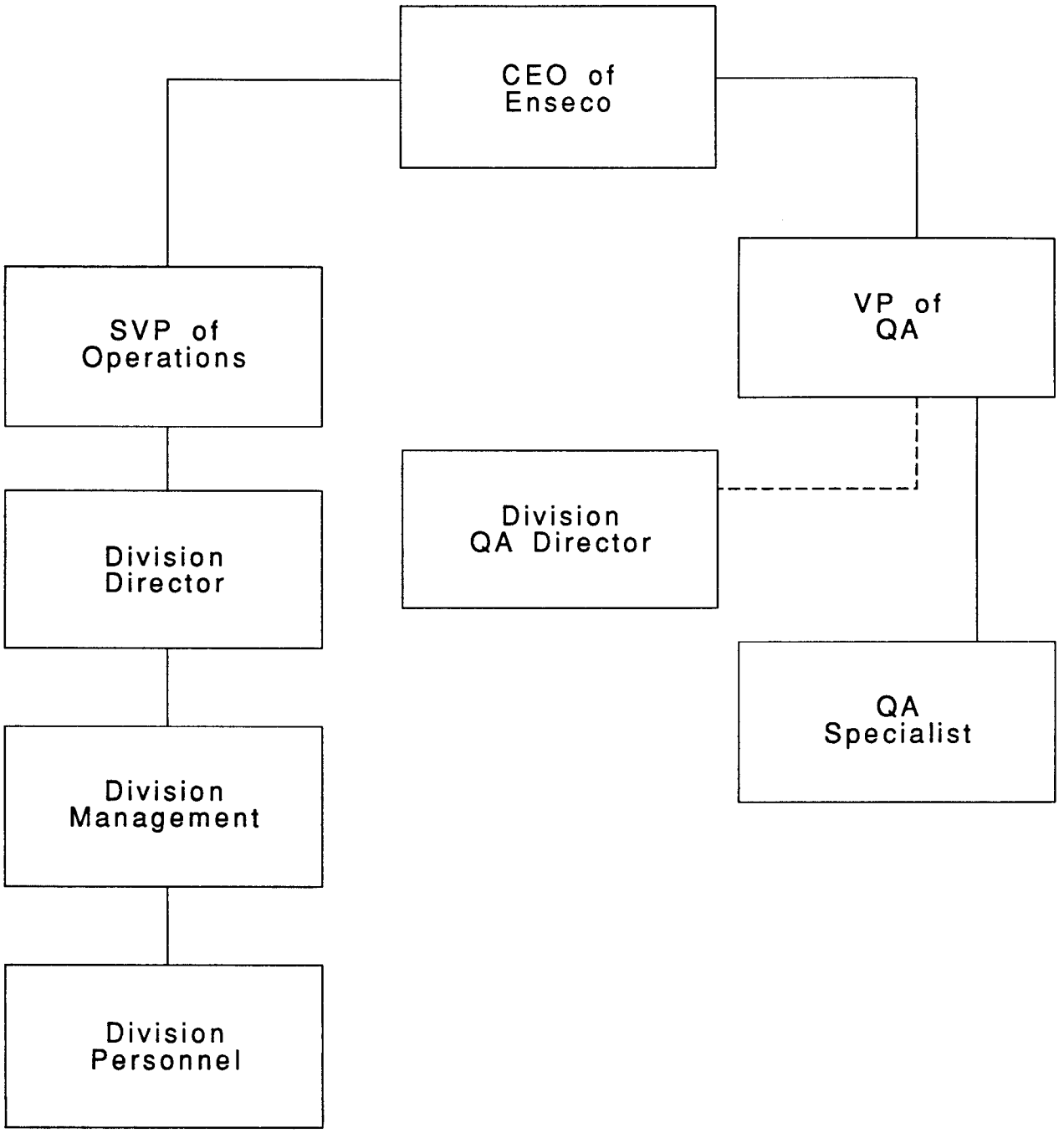


Figure 1.3.2.--Enseco quality assurance organizational chart.

1.4 QA OBJECTIVES FOR MEASUREMENT DATA

The objective of the Quality Assurance/Quality Control (QA/QC) plan is to monitor the overall program for all environmentally related data collection and analyses to ensure that all data generated are suitable for evaluation and interpretation of hazardous waste sites at MAFR. The QA/QC plan is divided into two major parts; overall program QA/QC and laboratory QA/QC. Oversight of the overall program QA/QC is the responsibility of the Project Quality Assurance Manager. Lab QA/QC is the responsibility of the Lab QA/QC manager and the USGS Contract Officer Representative. This section defines the recommended QA objectives or goals for accuracy, precision, completeness, representativeness, and comparability. These goals present the acceptable standards that field and laboratory teams must plan to meet before sampling begins. Because the effectiveness of a quality assurance program generally is measured by the quality of data generated by the laboratory, much of what is presented in this Sampling and Analyses Plan (SAP) applies to laboratory operations. Although specific procedures to be used in the field are also described.

Quality assurance efforts on this project will be emphasized and will be carried out conscientiously by following procedures in this SAP that will prevent the introduction of contaminants into soil samples and that will chemically stabilize any samples before laboratory analyses. Field instruments will be calibrated frequently and checked against concentration standards. Laboratory data will be examined relative to QA/QC sample data.

1.4.1 Definition of Criteria

The effectiveness of a QA program is measured by the quality of data generated. Data quality is judged in terms of its accuracy, precision, completeness, representativeness, and comparability. These terms are described as follows:

Accuracy - the degree of agreement of a measurement with an accepted reference or true value, usually expressed as the difference between the two values, or the difference as a percentage of the reference or true value. Accuracy is a measure of the bias in a system.

Accuracy of field measurements will be evaluated by:

(a) standard methods - methods of measurement shall be used which, whenever possible, are recognized and considered as standard by the scientific community.

(b) calibration and calibration checks of field instruments and equipment shall be performed at a frequency that will insure each measurement is accurate.

Accuracy of laboratory analytical data will be evaluated by:

(a) standard methods - methods of analysis shall be used which, whenever possible, are recognized and considered as standard by the scientific community. EPA methods, generally, shall be used.

(b) calibration standards - primary standards shall be obtained from NIST (National Institute of Standards and Technology, formerly the National Bureau of Standards) EPA repository, or other reliable commercial sources.

(c) audit samples - laboratory performance on EPA Water Supply and Water Pollution audit samples must be such that EPA certification is maintained.

(d) surrogate spikes - recovery of organic surrogate analytes shall be within three standard deviations of the laboratory-established average recovery of the surrogate analyte.

(e) known laboratory control samples - recovery of analytes shall be within three standard deviations of the laboratory-established average recovery of the analyte. For multi-analyte samples, 80 percent of the analytes must be within control limits. In-house control limits will be used.

(f) recovery of analytes shall be within three standard deviations of the laboratory-established average recovery of the analyte. For multi-analyte method, 95 percent of the analytes must be within control limits.

The determination of the accuracy of a measurement requires a knowledge of the true or accepted value for the signal being measured. Accuracy may be calculated in terms of percent recovery as follows:

$$\text{Percent Recovery} = \frac{X}{T} \times 100$$

where: X = the observed value of measurement
T = "true" value

Precision-the degree to which the measurement is reproducible. Precision is a measure of mutual agreement among individual measurements of the same property, usually under prescribed similar conditions. Precision is best expressed in terms of the standard deviation. Standard deviation (S) is calculated as follows:

$$S = \frac{1}{n-1} \sum_{i=1}^{n} (x_1 - \bar{x})^2$$

where a quantity "x" (e.g., a concentration) is measured "n" times.

Precision of field measurements will be evaluated by laboratory analytical results of samples collected in duplicate.

Precision of laboratory analytical data will be evaluated by:

(a) duplicate control samples (DCS) - replicate analyses of analytes shall be within laboratory established control limits. (See table 1.13.2.1).

(b) matrix spike duplicates - agreement between duplicate analyses of organic spiked analytes shall be within the relative percent difference (RPD) limits specified in SW 846, Third Edition (USEPA, 1986a) unless otherwise specified.

(c) matrix (sample) duplicates - agreement between duplicate analyses of environmental samples shall be within 20 to 40 relative percent difference.

In the case of duplicates, the RPD between the two samples may be used to estimate precision.

$$RPD = \frac{D_1 - D_2}{(D_1 + D_2)/2} \times 100$$

where: RPD = relative percent difference
D1 = first sample value
D2 = second sample value (duplicate)

Completeness - a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. At least 95 percent of the analytical batches will be associated with acceptable QC results. At least 95 percent of the analytical methods must be in control and at least 95 percent of the analytes must be in control for a method to be in control.

The percent completeness for each set of samples is calculated as follows:

$$\text{Completeness} = \frac{\text{valid data obtained}}{\text{total data planned}} \times 100$$

Completeness of field data will be evaluated by:

(a) all measurements and observations shall be recorded in a notebook and reviewed in terms of stated goals.

(b) all deviations from SOP shall be recorded and documented.

Completeness of laboratory analytical data will be evaluated by:

(a) each data set (batch) shall contain all QC check analyses verifying precision and accuracy for the analytical protocol.

(b) each data set (batch) shall contain all field and trip blank analysis.

(c) all pertinent dates are recorded (dates received, extracted, analyzed, etc.).

(d) all requested analyses shall be performed or documentation provided as to the reason for non-performance.

Representativeness - the degree to which data accurately and precisely represents a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

Representativeness of field data will be evaluated by:

(a) use of standard methods of measurement and sample collection.

(b) collection of sufficient size or amount of sample.

(c) documentation of reasons for use of non-standard techniques.

(d) adherence to chain-of-custody procedures.

Representativeness of laboratory analytical data will be evaluated by:

(a) use of preservation techniques (including chilling during shipment) to minimize sample degradation which may occur between sample collection and sample analysis.

(b) holding times prescribed in 40 CFR 136 shall be adhered to by the analytical laboratory.

(c) field and laboratory blank analyses will be used to determine if samples have been contaminated.

(d) matrix spikes will be used to determine the presence of matrix effects.

Comparability - expresses the confidence with which one data set can be compared to another data set measuring the same property.

Comparability of field measurements will be evaluated by:

(a) standard methods - methods of measurement shall be used which, whenever possible, are recognized and considered as standard by the scientific community.

(b) reporting units - data shall be consistently reported in units recognized and considered as standard by the scientific community.

Comparability of laboratory analytical data will be evaluated by:

(a) standard methods - methods of analysis shall be used which, whenever possible, are recognized and considered as standard by the scientific community. In general, EPA methods are used.

(b) reporting units - data shall be consistently reported in units recognized and considered as standard by the scientific community.

(c) the use of traceable materials for calibration and quality control (QC).

1.4.2 Goals

The numerical QA goals for measured data are as follows:

PARAMETER	ACCURACY	PRECISION	COMPLETENESS
Analytes (laboratory) for soil and water	+ or - 3 standard deviations (sigmas) of known standard concentrations	RPD generally	90%

Failure to achieve there criteria shall require resampling and reanalyses.

1.5 SAMPLING PROCEDURES

1.5.1 Sampling protocols

Specific sampling procedures that will be followed for the collection of soil samples are described in Section 2.0 of this SAP. General sampling procedures follow methods described in the technical documents referenced below.

SOIL SAMPLING:

Boomer, Erickson, Swanson, Kelso, Cos, and Schultz, 1985, Verification of PCB spill cleanup by sampling and analysis: U.S. Environmental Protection Agency, EPA-560/5-85-026, 68 p.

Dunlap, McNabb, Scalf, and Cosby, 1977, Sampling for organic chemicals and microorganisms in the subsurface: U.S. Environmental Protection Agency, EPA-600/2-77-176, 26 p.

Other applicable guidelines and reference documents that will be followed are:

CODE OF FEDERAL REGULATIONS:

40 CFR Part 136. 3A	Guidelines for Establishing Test Procedures for the Analysis of Pollutants
40 CFR Parts 136,3E,	Required containers, preservation Table II Techniques, and Holding times
40 CFR Parts 300.61	National Contingency Plan to 300.81 (Subpart F)

ENVIRONMENTAL PROTECTION AGENCY MANUALS AND DOCUMENTS:

EPA-330/9-S1-002	NEIC Manual for Groundwater/Subsurface Investigations at Hazardous Wastes Sites
EPA-600/4-79-020	Methods for Chemical Analysis of Water and Wastes (1983)
SW-846	Test Methods for Evaluating Solid Waste, Third Edition (1986a)
EPA-540/G-89-004	Guidance for conducting Remedial Investigations and Feasibility Studies under CERCLA (1986a)
EPA-540/P-87-001	A Compendium of Superfund Field Operations Methods (1988b)

AMERICAN PUBLIC HEALTH ASSOCIATION (APHA, AWWA, & WPCF) MANUAL:

16th Edition	Standard Methods for the Examination of Water and Wastes, 1985

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM) STANDARDS:

D-1452	Soil Investigation and Sampling by Auger Boring
D-1586	Penetration Test and Split-Barrel Sampling of Soils
D-2488	Recommended Practices for Visual-Manual Description of Soils

Annual Book of ASTM Section 11, Water and Environmental Technology Standards

1.5.2 Sampling handling

The required sample volume, preservation, and analytical holding times by method for soil samples are presented in Table 1.5.2.1.

Table 1.5.2.1.--Required volume, preservation, and analytical holding times for soil samples.

Method (1)	Parameter	Volume (grams)	Preservation Code (2a)	Holding time (3) (days after collection)
SW3050/SW6010	ICPAES	100	BGC	180
SW3050/SW7041	Antimony	100	BGC	180
SW3050/SW7740	Selenium	100	BGC	180
USATHAMA	Explosives	100	BGC	7 for extraction 40 for analysis (3c)

Footnotes:

(1) Method numbers preceded by SW are from: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition (USEPA, 1986)

Method numbers preceded by USATHAMA are methods provided by the U.S. Army Toxic and Hazardous Materials Agency, Assessment Division, Aberdeen Proving Grounds, Maryland, 21010

(2) BGC Solid sample, glass container, chilled - 7 ounce to 1 quart wide-mouth jar, chilled and maintained at 4 degrees Celsius, no chemical preservative.

(a) All analyses requiring preservation code BGC can be performed with a single 1000 gram sample.

(3) Soil Sample holding times are as specified in SW-846, revision 1, December 1987, except when noted.

(b) Holding times as specified in SW-846, September, 1986.

1.6 SAMPLE CUSTODY

1.6.1 Field operations

Sample handling and custody procedures for the field investigation will be discussed in sections 2.2.2 and 2.2.3 of the field sampling plan (section 2.0 of this document).

1.6.2 Laboratory operations

Laboratory procedures for sample handling, sample identification and sample custody are discussed in the following subsections.

1.6.2.1 Sample handling and custody

Samples are received by the laboratory's Sample Control Group and are carefully checked for label identification, chain-of-custody, and any discrepancies. Photographs document the condition of samples and each sample is then assigned a unique laboratory identification number through a computerized Laboratory Information Management System (LIMS), which stores all identifications and essential information. The LIMS and internal chain-of-custody procedures track the sample from storage through the laboratory system until the analytical process is complete and the sample is back in the custody of Sample Control for disposal or return to the client. This process is summarized in figure 1.6.2.1.1. Access to the laboratory is restricted to prevent any unauthorized contact with samples, extracts or documentation.

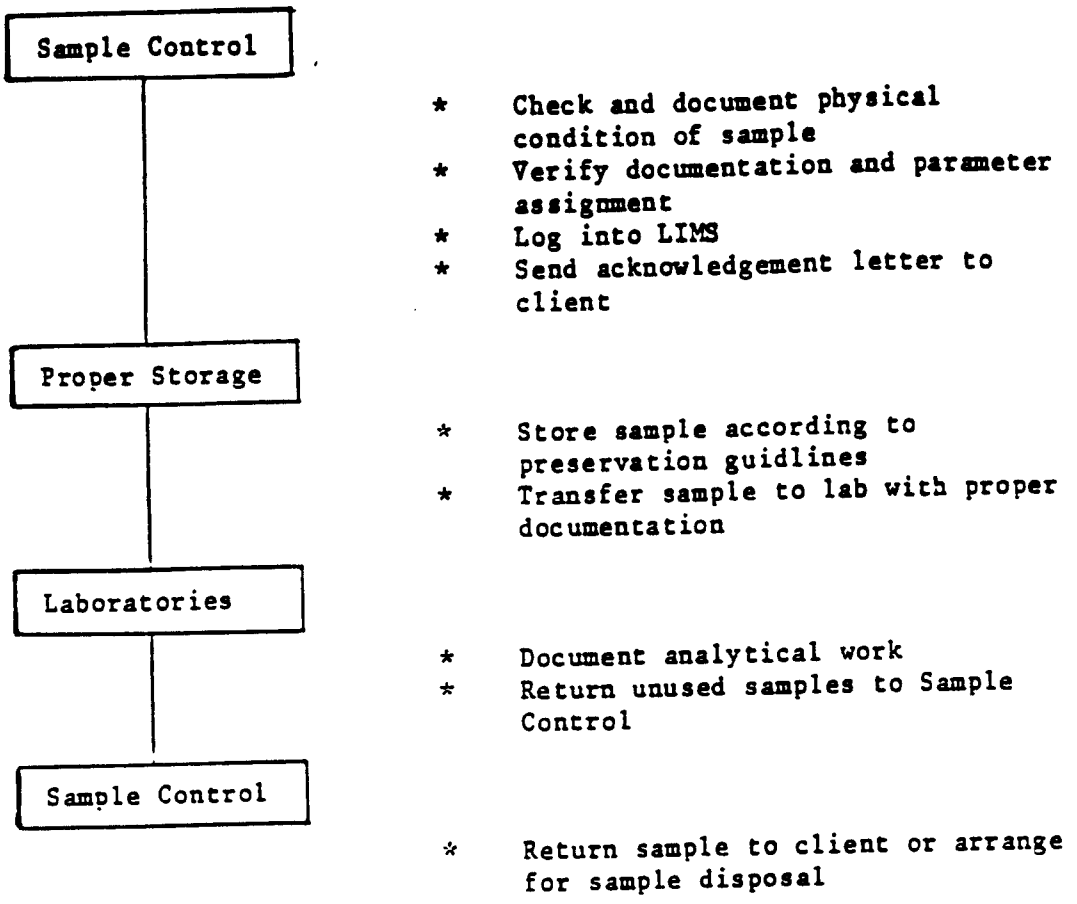
1.6.2.2 Sample identification

Each environmental sample collected is uniquely identified by both a field and a laboratory sample identification number. The field number is assigned by the Geological Survey sampling team using a 10-character string of letters and numbers. For example, the field sample identification number OBOD0103-0 signifies: OB/OD for Open Burn/Open Detonation Thermal Treatment Facility.

01 for borehole or surface sample number
03 for sample number (00 for no sample)
-0 for surface sample, -1 for 5 foot soil sample, -2 for 10 foot soil sample,

For the laboratory number, RMAL assigns a six-digit project number to each set of samples received in one day, and each sample is assigned a four-digit sample number in addition to the project number. For example, 001552-0001 is a unique sample number, where 001552 is the project number and 0001 is the sample number.

All samples analyzed concurrently by the same test are assigned the same QC lot number. Sample sets which contain numerous samples, analyzed over several days, may have multiple QC lot numbers associated with each test. QC lot numbers are identified uniquely using the date the samples were run (i.e. 21 May 90) followed by a letter (i.e.-B).



Source: ENSECO QA Program Plan, May 1989, p. 19

Figure 1.6.2.1.1.--Laboratory sample processing flow chart

USGS unique sample numbers and RMAL numbers for samples and QC lots are reported in analytical laboratory reports sent by RMAL to the USGS.

1.7 CALIBRATION PROCEDURES FOR FREQUENCY FOR FIELD TEST EQUIPMENT

Field equipment calibration procedures and frequency are discussed in section 2.3.2 of the Field Sampling Plan (Section 2.0 of this document).

1.8 ANALYTICAL PROCEDURES

1.8.1 Identification of methods

The analytical methods and sources that will be used for soil samples in this investigation are listed in table 1.8.1.1.

1.8.2 Detection limits and quantification criteria

The sensitivity of an analytical method is related to the detection limit which is the lowest concentration of an analyte that can be detected at a specific confidence level. Definitions and procedures for determining detection limits used in this investigation are presented below.

Instrument Detection Limit (IDL) is the smallest signal above background noise that an instrument can detect at a 99% confidence level. An IDL is measured by analyzing replicate blank samples. It is calculated by the mean plus two standard deviations for a normal distribution, or three standard deviations for data which does not describe a normal distribution.

Project Detection Limit (PDL) is the minimum signal level required to quantitatively identify a specific analyte by a specific procedure at a confidence level which is greater than 97%.

For organic analyses and graphite furnace atomic absorption analyses a PDL is measured by analyzing a minimum of seven replicates spiked at one to five times the expected method detection limit on three non-consecutive days. It is calculated by multiplying the standard deviation times the Student t-value at the desired confidence level.

PDL's for ICP methods, cold vapor atomic absorption method, and colorimetric methods are determined according to procedures outlined in the EPA Contract Laboratory Statement of Work.

RMAL determines the PDL for a routine method using a reagent water matrix and are performed approximately annually. Method Detection Limit Studies are generally not performed on soil samples. The PDL's used for this investigation are presented in Table 1.8.2.1.

Table 1.8.1.1--Analytical methods and sources

Parameter	Method number
ICP Screen (23 Metals, Exclude Boron and Silica	SW3050/SW6010
Antimony	SW3050/SW
Selenium	SW3050/SW7740
Explosives	USATHAMA, LW12 or Latest Method

Method Sources

"SW" Methods	Test Methods for Evaluation Solid Waste, Physical/Chemical Methods, SW-846, 3rd edition (U.S. Environmental Protection Agency, 1986a).
"USATHAMA" Methods	United States Army Toxic and Hazardous Materials Agency, Aberdeen Proving Ground, MD 21010-5401.

Table 1.8.2.1.--Project detection limits

[mg/kg, milligrams per kilogram]

Method	Parameter	Reporting units	Project detection limits Soil
SW3050/SW6010(s)		mg/kg	
	ICPAES		
	Aluminum		20
	Antimony		20
	Arsenic		30
	Barium		10
	Beryllium		.2
	Cadmium		2
	Calcium		500
	Chromium		4
	Cobalt		4
	Copper		3
	Iron		4
	Lead		20
	Magnesium		500
	Manganese		1
	Molybdenum		4
	Nickel		4
	Potassium		500
	Selenium		40
	Silver		3
	Sodium		500
	Thallium		200
	Vanadium		4
	Zinc		1
SW7740(s)	Selenium	mg/kg	.5
USATHAMA Nitroaromatics in Soil Samples		mg/kg	
	Nitrobenzene		.25
	2,4-Dinitrotoluene		.44
	2,6-Dinitrotoluene		.48
	1,3-dinitrobenzene		.51
	1,3,5-trinitrobenzene		.23
	2,4,6-trinitrotoluene		.49
	Tetryl		.5
	RDX		.5
	HMX		.5
	2-nitrotoluene		.25
	2-amino-4,6-dinitrotoluene		.25
	3-nitrotoluene		.25

Footnotes:

Method numbers preceded by SW are from: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition (USEPA, 1986).

Project Detection Limit studies are performed by the analytical laboratory approximately anually.

1.8.3 Method Calibration

All primary reference standards and standard solutions used by RMAL are obtained from the National Institute of Standards and Technology (formerly the National Bureau of Standards), the EPA Repository or other reliable commercial sources. Standards are validated prior to use. Validation procedures can range from a check for chromatographic purity to verification of the concentration of the standard using a standard prepared at a different time or obtained from a different source. Stock and working standards are checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change in concentration. Care is exercised in the proper storage and handling of standard solutions, and all containers are labeled as to compound, concentration, solvent, expiration date, and preparation data (initials of preparer/date of preparation).

Each instrument is calibrated with standard solutions appropriate to the type of instrument and the linear range established for the analytical method. The frequency of calibration and the concentration of calibration standards is determined by the manufacturer's guidelines, the analytical method, or the requirements of special programs. See table 1.8.3.1 for method-specific calibration procedures and acceptance criteria.

Chromatography systems - Each chromatographic system is calibrated prior to performance of analysis. Initial calibration consists of determining the linear range, establishing limits of detection, and establishing retention time windows as established in SW-846. The calibration is checked on a daily basis to ensure that the system remains within specifications. If the daily calibration check does not meet established criteria, the system is recalibrated and samples analyzed since the last acceptable calibration check are reanalyzed.

Table 1.8.3.1.--Summary of Internal Quality Control Procedures

Analytical method	Property or analyte	Quality-control check	Frequency	Acceptance criteria	Corrective action
SW6010 SW7041 SW7740	Metals, Antimony Selenium	Equipment blank	1 per day	Any compounds detected to be less than 3 times the PDL.	If compounds found in equipment blank are also found in samples at similar concentrations, determine cause, evaluate effect on samples, and qualify data or resample if necessary.
		Sampling duplicate	1 set per 10 samples	Within 30 percent RPD for water samples and within 40 percent for soils.	Use data to evaluate sample collection procedures. Resample if procedures found to be out of control.
		Calibration curve	Established daily, verified every 10 samples	Initial calibration verification check standard is within 10 percent of calibration curve.	1. Validate standard. If standard still exceeds acceptance criteria, obtain fresh, certified standards. 2. Recalibrate instrument. 3. Document actions taken.
		Interelement check sample	Daily	Concentration of analyte subject to potential spectral interference is within 20 percent of known value.	1. Recalibrate instrument and reanalyze interelement check sample. 2. Check interelement correction factors and update if necessary. 3. Document actions taken.

Table 1.8.3.1.--Summary of Internal Quality Control Procedures--Continued

Analytical method	Property or analyte	Quality-control check	Frequency	Acceptance criteria	Corrective action
		Method blank	1 per batch or 1 per 20 samples	Concentrations does not exceed two times the PDL of the analyte.	1. Determine if concentration levels in the sample exceed 10 times concentration levels in blank. If so, qualify data. 2. If not, reprepare blank, QC samples and affected samples. 3. Document actions taken.
		DCS	1 in duplicate per 20 samples	80 percent of values at within three SD of mean historical values or methodology control limits of precision and accuracy. Acceptance criteria are in Table QS.	1. Validate instrument parameters, sensitivity and linearity. Correct problems and document. 2. Validate standards. 3. Validate DCS preparation. 4. Reanalyze DCS and samples. 5. If repreparation of samples is not possible, qualify data. 6. Document actions taken.
		MS/MSD	1 per every 20 samples	Acceptance criteria are in Table QS.	1. Verify that the spike concentration is at least 50 per cent of the unspiked concentration. 2. Verify that correct spiking solutions and amounts were used. 3. Check method blanks and DCS recovery. 4. Reanalyze samples if laboratory error is suspected. 5. Document actions taken.

Table 1.8.3.1.--Summary of Internal Quality Control Procedures--Continued

Analytical method	Property or analyte	Quality-control check	Frequency	Acceptance criteria	Corrective action
USATHAMA	Explosives	Equipment blank (water only)	1 per day	Concentration of analyte is less than the PDL.	If analyte found in equipment blank is also found in samples at similar concentration, determine cause, evaluate effect on samples, and qualify data or resample if necessary.
		Sampling duplicate	1 set per 10 samples	Within 30 percent RPD for water samples and within 40 percent RPD for soils	Use data to evaluate sample collection procedures. Resample if procedures found to be out of control.
		Calibration curve	Established daily, verified every 10 samples	Verification check standard is within ten percent of the calibration curve.	1. Recalibrate instrument. 2. If criteria still exceeded, validate standards, reprepare, if necessary, recalibrate. 3. Document actions taken. 4. Reanalyze samples since last time criteria met.
		Method blank	1 per batch or 1 per 20 samples	Concentration is less than the PDL of the analyte.	1. If analytes in blank exceed PDL, reprepare all blanks and samples. 2. Reanalyze batch. 3. If samples cannot be reprepared, continue with analysis of batch and qualify data. 4. Document actions taken.
		DCS	1 in duplicate per 20 samples	Values are within three SD of mean historical values or methodology control limits. Acceptance criteria are in Table QS.	1. Analyze spiking solution. 2. If spiking solution results are acceptable, investigate possible error in preparation. 3. If no error detected, qualify data. 4. If error detected, reprepare and reanalyze samples and DCS. 5. Document action taken.

Metals analysis systems - Each ICP (inductively coupled argon plasma emission spectrometer) is calibrated prior to the analyses being performed using criteria prescribed in the CLP protocol. The calibration is then verified using standards from an independent source. The linear range of the instrument is established once every quarter using a linear range verification check standard. No values are reported above this upper concentration value without dilution. A calibration curve is established daily by analyzing a minimum of two standards, one of which is a calibration blank. The calibration is monitored throughout the day by analyzing a continuing calibration blank and a continuing calibration verification standard. The standard must meet established criteria or the system is recalibrated and all samples analyzed since the last acceptable calibration check are reanalyzed. An interelement check standard is analyzed at the beginning and end of each analytical run, and on a continuing basis, to verify that interelement and background correction factors have remained constant. Results outside of the established criteria trigger reanalysis of samples.

Other methods - Each system or method is calibrated prior to analysis being conducted. Calibration consists of defining the linear range by use of a series of standard solutions, establishing limits of detection, and identifying potential interferences. The calibration is checked on an ongoing basis to ensure that the system remains within specifications. If the ongoing calibration check does not meet established criteria, the system is recalibrated and all samples analyzed since the last acceptable calibration check are reanalyzed.

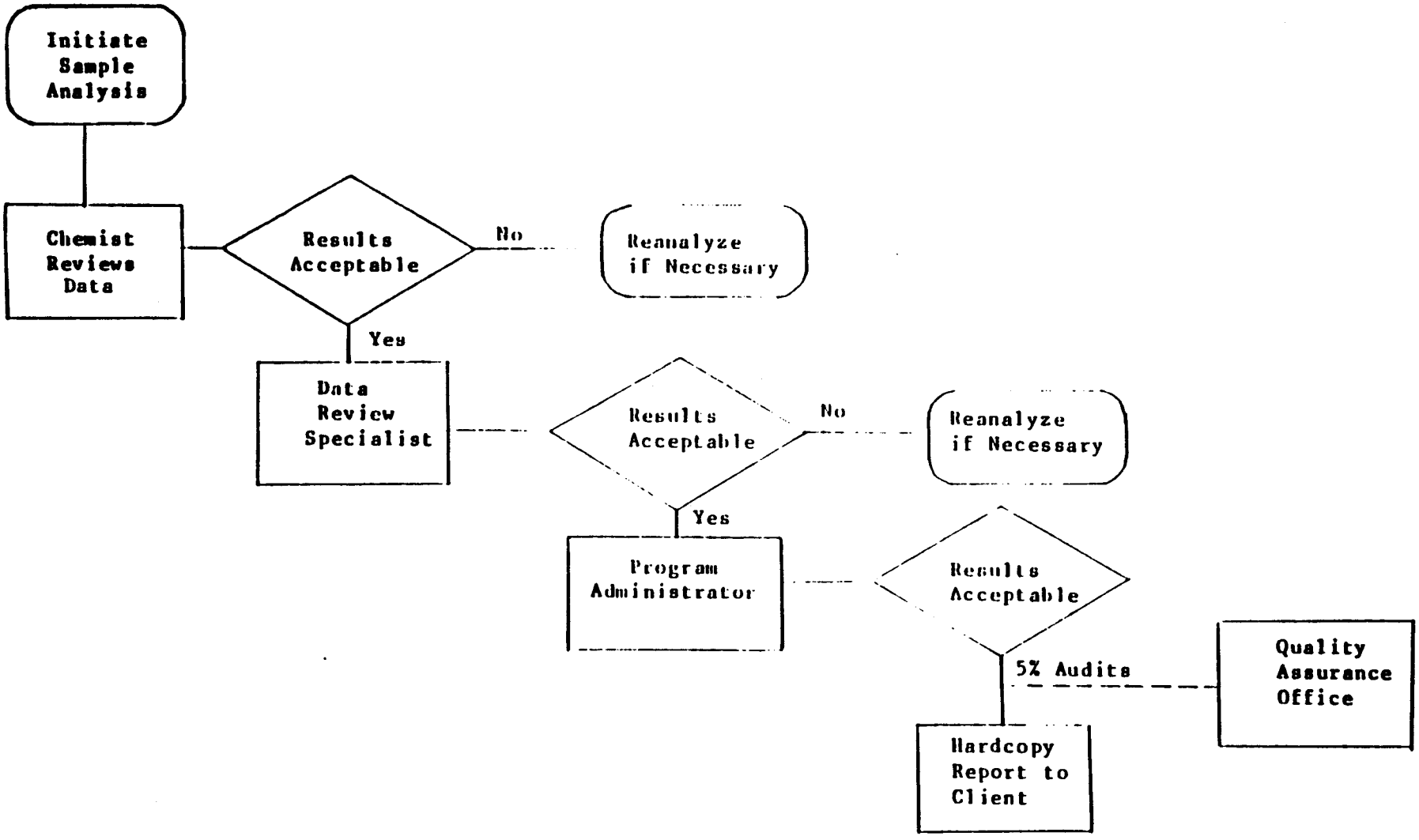
1.9 DATA REDUCTION, VALIDATION, AND REPORTING

1.9.1 Data management

The project's overall data management will move along the steps outlined below. The person, or laboratory, responsible for each step is listed. The Project Chief will delegate authority and responsibility for satisfactory completion of the data management steps under his supervision. Any corrections required will be returned to earlier steps. The data management steps are as follows:

	DATA MANAGEMENT STEP	BY
1.	Daily logbook entries and data collection schedule	Collector
2.	Field measurements and forms	Collector
3.	Sample collection and forms	Collector
4.	Daily QA/QC onsite review of field logbooks, measurements, sample collection forms leader	Field team
5.	Sample processing and shipment	Collector
6.	Weekly QA/QC on-site review of field logbooks, measurements and sample collections	Project QA Officer
7.	Laboratory analyses	RMAL
8.	Laboratory reports of results and QC/QA data	RMAL
9.	Laboratory reports review	Project lab QA Officer
10.	Data processing for IRP/IMS files	Project QA/QC Officer
11.	Data check and validation	Project QA/QC Officer
12.	Data collection progress review	Project Chief
13.	Data incorporation into final report	Project Chief
14.	Review and approval of final report	District Chief

The laboratory data management flow chart for samples submitted to RMAL is shown in figure 1.9.1.1.



Source; Enseco, 1989

Figure 1.9.1.1.--Laboratory data management flow chart.

1.9.2 Data reduction

Data produced by all field and laboratory activities will be reduced (generally to tabular form), checked for accuracy by the field personnel or laboratory analyst and a reviewer, and reported in computerized and hard copy formats. Data produced by field activities will be recorded in bound notebooks. Drilling data (lithology, organic vapor analysis results, completion depth, etc.) will be tabulated. Raw data resulting from analytical procedures and the equations used by the analyst to calculate reported concentrations are contained in the appropriate EPA or ASTM method.

1.9.3 Data quality assessment

The field team performing field measurements has the prime responsibility for entering data and observations into field notebooks. Each page will be initialed by the person recording the information. Another team member, on site, will inspect the entries for accuracy and adherence to standard procedures or documentation for non-standard procedures. The Project Chief or his designee will periodically review field notebooks for completeness and adherence to standard procedures. The Project Chief and Project QA officer review all data prior to entry into a computer data base to ensure that standard procedures were followed, all QA/QC checks were performed, anomalies were documented, and data packages are complete.

Three levels of review are performed in the laboratory. In level 1, the laboratory analyst generating the data has the prime responsibility for the correctness and completeness of the data. Each analyst reviews a data package to ensure that: Sample preparation information is correct and complete; Analysis information is correct and complete; The appropriate standard operating procedures have been followed; analytical results are correct and complete; QC samples are within established control limits; Blanks are within appropriate QC limits; special sample preparation and analytical requirements have been met; and documentation is complete (e.g., all anomalies have been reported, holding times have been reported, etc.). All calculations have been checked in level 1 review.

In level 2, an independent review of laboratory data is performed by laboratory personnel to ensure that: calibration data are scientifically sound, appropriate to the method, and completely documented; QC samples are within established guidelines; qualitative identification of sample components is correct; documentation is complete and correct; data are ready for incorporation into the final report; and data package is complete and ready for data archive.

In level 3, the laboratory client manager reviews the report to ensure that the data meet the overall objectives of the client, as understood by the client manager.

Environmental sample data will be compared to quality control data to ensure accurate and validated data. This determination shall be made using the professional judgement of a multidisciplinary team of geologists, hydrologist, chemists, quality assurance officers, and other personnel having direct experience with the data collection effort. Field duplicate results, field and laboratory blank results and sample matrix effects will be evaluated to identify valid data. Environmental data that are not representative of environmental conditions and were generated through poor field or laboratory practices shall not be used in the evaluation process.

Results from the analysis of blanks will be assessed to determine sources of contamination and the impact of any contamination on the analytical results for environmental samples.

Contamination proven to be a constant, low-level systematic error that cannot be eliminated will be noted in the technical report, and its impact on the analytical results for environmental samples will be evaluated. The results for environmental samples will not be "corrected" for blank contamination.

1.9.4 Reporting

Field and laboratory data will be provided in the final technical report. Laboratory data and some field data will also be provided in a computerized format using the IRP/IMS data loading Handbook.

1.10 INTERNAL QUALITY CONTROL CHECKS FOR FIELD AND LABORATORY OPERATIONS

1.10.1 Field quality control

A discussion of the field quality control program is presented in section 2.4 of the field sampling plan of this document.

1.10.2 Laboratory quality control

RMAL's QA/QC program consists of operational controls employed to ensure that the data generated meet pre-defined requirements for precision and accuracy, and that the system instituted documents the effectiveness of these controls. The QA/QC program has provisions to meet the following two objectives: 1) to monitor the laboratory's daily performance of an analytical method, and 2) to assess the effect of a specific sample matrix on the performance of the analytical method. Laboratory performance QC is based on the use of a standard, control matrix to generate precision and accuracy data that are compared, on a daily basis, to control limits. This information, in conjunction with method blank data, is used to assess daily laboratory performance. Matrix-specific QC is based on the use of actual environmental sample for precision and accuracy determinations and commonly relies on the analysis of matrix spikes, matrix duplicates, and matrix spike duplicates. This information, supplemented with field blank results, is used to assess the effect of the matrix and field conditions on analytical data. Another goal of the QA/QC program is to monitor long-term performance to detect trends or systematic error.

Laboratory performance QC is provided as a standard part of every routine RMAL analysis through the analysis of Laboratory Control Samples, which include Duplicate Control Samples (DCS), Single Control Samples (SCS), and method blanks. Laboratory Control Samples (LCS) are well-characterized, laboratory generated samples used to monitor the laboratory's day-to-day performance of routine analytical methods. Certain LCS are used to monitor the precision and accuracy of the analytical process, independent of matrix effects. Other LCS are used to identify any background interference or contamination of the analytical system which may lead to the reporting of elevated concentration levels or false positive data. The results of the LCS are compared to well-defined laboratory acceptance criteria to determine whether the laboratory system is "in control." Controlling lab operations with LCS (as opposed to matrix spike/matrix spike duplicate samples), offers the advantage of being able to differentiate low recoveries due to procedural errors from those due to matrix effects. Each of the three types of LCS are described below.

Duplicate Control Samples (DCS)

Duplicate Control Samples (DCS) are used to monitor the precision and accuracy of the analytical system on an on-going basis. Each DCS consists of a standard, control matrix that is spiked with a group of target compounds representative of the method analytes. A DCS pair is analyzed for every 20 samples processed by the method. DCS are analyzed with environmental samples to provide evidence that the laboratory is performing the method within accepted QC guidelines for accuracy and precision.

Accuracy (average recovery of each analyte in the DCS pair) and precision (Relative Percent Difference (RPD) between each analyte in the DCS pair) data are compared to control limits that have been established for each of the analytes contained in the DCS. Initially, control limits for analytes spiked into the DCS are taken directly from the CLP program. If CLP limits are not available, Enseco historical data are used to set the control limits. As sufficient laboratory data become available, the control limits are redefined based upon the most recent nine months of DCS data. Control limits for accuracy for each analyte are based on the historical average recovery (mean of the average recoveries of the DCS pairs) plus or minus three standard deviation units. Control limits for precision for each analyte are based on the historical RPD and range from zero (no difference between DCS results) to the average RPD plus three standard deviation units.

Analytical data that are generated with a DCS pair which falls within the established control limits are judged to be in control. Data generated with a DCS pair which falls outside of the control limits are considered suspect and are repeated or reported with qualifiers.

DCS have been established for each routine analytical method. The control matrix for solids samples is standard Ottawa sand, an ASTM approved material for use in highway construction, due to its fine degree of homogeneity. The DCS compounds are spiked into the Ottawa sand and carried through the appropriate steps of the analysis.

Single Control Samples (SCS)

As stated above, a DCS pair is analyzed with every 20 samples to measure the precision and accuracy of an analysis on an ongoing basis. However, samples are often analyzed in lots of less than 20, due to holding time or turn-around time requirements. Since it is necessary to have a measure of laboratory performance with each batch of sample processed, RMAL has instituted the SCS program.

As SCS consists of a control matrix that is spiked with surrogate compounds appropriate to the method being used. In cases where no surrogate is available, (e.g., metals or conventional analyses) a single DCS serves as the control sample. An SCS is prepared for each sample lot for which the DCS pair are not analyzed. Recovery data generated from the SCS are compared to control limits that have been established for each of the compounds being monitored. Initially, CLP control limits or ENSECO historical data are used to set the control limits. When sufficient SCS data are available, control limits are redefined based on the most recent nine months of data. Control limits for SCS components are based on the historical average recovery in the SCS plus or minus three standard deviation units.

Analytical data that are generated with an SCS which falls within the control limits are judged to be in control. Data that are generated with an SCS which falls outside of acceptance criteria are considered suspect and are reanalyzed or reported with qualifiers. The protocols for evaluating SCS are identical to those established for DCS.

DCS precision and accuracy and SCS recovery (accuracy) data are archived in the LIMS. In addition, the associated DCS and SCS data are reported with each set of sample results to enable the investigator to make a quality assessment of the data.

Method Blank

Method blanks, also known as reagent, analytical, or preparation blanks, are analyzed to assess the level of background interference or contamination which exists in the analytical system and which might lead to the reporting of evaluated concentration levels or false positive data.

As part of the standard laboratory QC program, a method blank is analyzed with every batch of samples processed. A method blank consists of reagents specific to the method which are carried through every aspect of the procedure, including preparation, clean-up, and analysis. The results of the method blank analysis are evaluated, in conjunction with other QC information, to determine the acceptability of the data generated for that batch of samples.

Ideally, the concentration of target analytes in the blank should be below the Reporting Limit for that analyte. In practice, however, some common laboratory solvents and metals are difficult to eliminate to the parts-per-billion levels commonly reported in environmental analyses. Therefore, criteria for determining blank acceptability must be based on consideration of the analytical techniques used, analytes reported, and Reporting Limits required.

For metals analysis, where the Reporting Limits are typically near the Instrument Detection Limit (IDL) and background levels for certain metals are difficult to completely eliminate, the policy is that the concentration of the target analytes in the blank must be below two times the Reporting Limit. If the blank value for a target analyte lies below the Reporting Limit, the Reporting Limit for that analyte in the associated samples is unaffected. If the blank value lies between the Reporting Limit and two times the Reporting Limit, the Reporting Limit for that analyte in the associated samples is raised to the level found in the blank. A blank containing an analyte(s) above two times the Reporting Limit is considered unacceptable unless the lowest concentration of the analyte in the associated samples is at least ten time the blank concentration (as per CLP protocol).

For conventional inorganic tests, the method SOP directs how the blank is treated. Generally, a reagent blank is used both to zero the equipment and as one of the calibration standards. If a preparation step is required for the analysis, then a prep blank is also analyzed to determine the extent of contamination or background interference. Blanks have no application or significance for some conventional inorganic parameters (e.g. pH).

If the blank does not meet acceptance criteria, the source of contamination must be investigated and appropriate corrective action must be taken and documented. Investigation includes an evaluation of the data to determine the extent and effect of the contamination on the sample results. Corrective actions may include reanalysis of the blank, and/or repreparation and reanalysis of the blank and all associated samples.

For organic and metals analyses, and selected conventional inorganic tests, method blank results are reported with each set of sample results. Sample results are not corrected for blank contamination. Occasionally, due to limited sample volume or other constraints, the laboratory reports data associated with an unacceptable blank. In these cases, the Reporting Limit for the each analyte contained in the blank is raised to the level found in the blank.

Matrix-Specific QC

Matrix-Specific QC is used to assess the effects of a sample matrix on the analytical data. The main elements of Matrix-Specific QC in this investigation are: The analysis of matrix spikes, and matrix spike duplicates and monitoring the recovery of surrogate compounds from environmental samples.

Matrix Spikes, and Matrix Spike Duplicates

A Matrix Spike (MS) is an environmental sample to which known concentrations of analytes have been added in the laboratory. The MS is taken through the entire analytical procedure and the recovery of the analytes is calculated. Results are expressed as percent recovery. The MS is used to evaluate the effect of the sample matrix on the accuracy of the analysis.

A Matrix Spike Duplicate (MSD) is an environmental sample that is divided into two separate aliquots, each of which is spiked with known concentrations of analytes. The two spiked aliquots are processed separately and the results compared to determine the effects of the matrix on the precision and accuracy of the analysis. Results are expressed as RPD and percent recovery.

Surrogate Recoveries

Surrogates are organic compounds which are similar to the analytes of interest in chemical behavior, but which are not normally found in environmental samples. Surrogates are added to samples to monitor the effect of the matrix on the accuracy of the analysis. Results are reported in terms of percent recovery.

RMAL adds surrogates to samples requiring GC/MS analysis and reports these surrogate recoveries in the sample data packages. The laboratory does not control its operations based on surrogate recoveries in environmental samples. As discussed earlier in this section, RMAL controls its operations based on the results of Laboratory Control Samples. The surrogate recoveries are primarily used by the laboratory to assess matrix effects. However, obvious problems with sample preparation and analysis (e.g. evaporation to dryness, leaking septum, etc.) which can lead to poor surrogate spike recoveries must be ruled out prior to attributing low surrogate recoveries to matrix effects.

Sources for the internal laboratory QC has been previously discussed in section 1.8.3.

1.10.3 Control limits

A summary of internal quality control procedures is presented in table 1.8.3.1.

1.11 PERFORMANCE AND SYSTEM AUDIT

A quality assurance (QA) audit is an independent assessment of a measurement system. The auditor or audit team must be functionally independent of the sampling/analytical teams to insure that an objective audit is conducted.

Field audits will be conducted periodically in the field by the Project Chief and QA Officer. The first audit will be conducted during the first two weeks of field activity and then at least once during each field session. The auditor or audit team will observe field work in progress and determine if prescribed procedures are being followed by the field team, check and verify instrument calibration records, check and verify that field notebooks are properly maintained and complete, check and verify proper shipping and handling procedures, identify and correct any weaknesses or omissions in the system, and assess the effectiveness of QC procedures and modify as necessary.

The laboratory participates in external audits to ensure that sample control, analysis, data and documentation meet stringent regulatory requirements and the procedures comply with good laboratory practices. As a minimum the laboratory must be certified by the USEPA to perform environmental analysis and participate in semiannual performance audits.

In addition to external audits, internal audits are regularly performed. Quarterly system audits are conducted by the laboratory's divisional Quality Assurance Director. Laboratory QC check samples are analyzed at a rate of approximately ten percent of the total sample workload. Control charts are maintained and monitored daily by QC personnel to determine out-of-control situations or detect undesirable trends. Periodic (at least yearly) audits are conducted by the Corporate QA Office. Special audits are conducted by the Divisional QA Director or Corporate QA Office when a problem is suspected. All Enseco laboratories participate in the analyses of EPA check samples provided under the Water Supply (WS) and Water Pollution (WP) Performance Evaluation Studies. The results of these PE samples are tabulated by the Corporate QA Office to identify performance trends within the Enseco laboratories. RMAL is a CLP lab and thus analyzes organic and/or inorganic CLP (PE) samples on a quarterly basis. The results of these analyses are also tabulated and evaluated by the Corporate QA Office. The laboratories participate in multiple state certification program (including New York, New Jersey and California) which require that PE samples be analyzed periodically. Blind check samples from an independent commercial firm are sent to the laboratories periodically by the Corporate QA Office. The frequency and type of samples sent is based on problem areas identified by evaluation of tabulated PE results. The results of these check samples are used to identify areas where additional training is needed or clarification of procedures is required.

1.12 PREVENTATIVE MAINTENANCE

1.12.1 Procedures

In the laboratory, preventative maintenance is routinely performed on each analytical instrument. Designated laboratory personnel are factory-trained in the routine maintenance procedures for all major instrumentation. When repairs are necessary, they are performed by either trained staff or trained service engineers employed by the instrument manufacturer. The laboratory is required to maintain detailed logbooks of maintenance and repairs for each analytical instrument. The preventative maintenance schedules are specific to each type of analytical instrumentation and manufacturer and are available as Standard Operating Procedures (SOP's). Instrument performance is typically checked by monitoring the instruments performance criteria for known standards. Logbooks are audited quarterly by the laboratory QA Officer.

1.12.2 Schedule

See section 1.12.1 above.

1.12.3 List of critical spare parts

A list of critical spare parts for field instruments and a spare parts inventory will be maintained by a designated project team member.

Spare parts inventories are maintained by RMAL. Any critical spare parts used will be reordered immediately from suppliers if an inventory check requires it.

1.13 FIELD AND LABORATORY PROCEDURES FOR ASSESSING DATA PRECISION, ACCURACY, AND COMPLETENESS

1.13.1 Formulas

The formulas explained below are for assessing precision, accuracy, and completeness. They will be used primarily for assessing laboratory data because a larger number of values will be generated for laboratory data. They will be used for field data if the number of values becomes statistically significant for QA assessment.

Precision assessment:

Replicated samples will comprise at least 10 percent of the samples analyzed.

The mean concentration, C(mean), of a series of replicate measurements can be calculated by the equation:

$$C(mean) = (C(1) + C(2) + \ldots\ldots + C(n))/n$$

where C(1) = the resulting concentration for replicate 1;
C(2) = the resulting concentration for replicate 2;
C(n) = the resulting concentration for replicate n; and
n = the number of replicate measurements.

Precision is estimated for a series of measurements as the coefficient of variation (CV) or relative standard deviation (RSD):

$$CV = \text{square root } (SUM(C(i)-C(mean))squared/(n-1))/C(mean)$$

where C(i) = the concentration of the sample;
C(mean) = the mean concentration; and
n = the number of samples.

The precision estimate for duplicate measurements, C(1) and C(2), can be expressed as the relative percent difference (RPD):

$$RPD = ((C(1)-C(2))/C(mean)) \times 100$$

The CV and RPD values will be compared to respective data quality goals identified in section 1.4.2. The acceptance criteria for evaluating QC samples is summarized in table 1.8.3.1.

Accuracy assessment:

Accuracy is measured via standards, matrix-spiked samples, and standard reference samples.

The control limits for accuracy will be monitored from spikes and surrogate recoveries. The spike and recovery data are used to determine the control limits for measuring the acceptability of the analytical data.

The percent recovery is determined as follows:

$$P = \frac{\text{(amount found in spiked sample - amount found in unspiked sample)}}{\text{amount added to spiked sample}}$$

The average percent recovery and the standard deviation of the percent recovery for each constituent are then calculated from a large number of spike and surrogate recovery analyses. The control limits are based on the average recovery of the analyte plus or minus three standard deviations.

Completeness assessment:

Completeness is estimated for each set of data by dividing the number of valid analyses (those meeting the data quality goals) by the number of samples analyzed. The definitions for completeness and valid data are given in section 1.4.1. The percent completeness can be described as:

$$\text{Percent completeness} = (N(\text{valid})/N(\text{total})) \times 100$$

where N(valid) = the number of valid analyses; and
N(total) = the total number of samples analyzed.

1.13.2 Control limits

A summary of the laboratory control limits for matrix spikes, matrix spike duplication and surrogate spikes is presented in Table 1.13.2.1.

Table 1.13.2.1.--Laboratory control limits for matrix spikes, matrix spike duplicates and surrogate spikes

[µg/L, micrograms per liter; mg/L, milligrams per liter; %, percent; <, less than]

Analytical method	Spiking compounds	Spike Concentration Water (µg/L)	Spike Concentration Soil (mg/kg)	Laboratory established control limits % Recovery Water	% Recovery Soil	Relative % difference Water	Relative % difference Soil
SW6010 Inductively coupled plasma atomic emission spectroscopy							
	Matrix spike: (mg/L)						
	Aluminum	2.0	200	75-125	75-125	<20	<20
	Antimony	.5	50	75-125	75-125	<20	<20
	Arsenic	.5	50	75-125	75-125	<20	<20
	Barium	2.0	200	75-125	75-125	<20	<20
	Beryllium	.05	5	75-125	75-125	<20	<20
	Cadmium	.05	5	75-125	75-125	<20	<20
	Calcium	100	10000	75-125	75-125	<20	<20
	Chromium	.2	20	75-125	75-125	<20	<20
	Cobalt	.5	50	75-125	75-125	<20	<20
	Copper	.25	25	75-125	75-125	<20	<20
	Iron	1.0	100	75-125	75-125	<20	<20
	Lead	.5	50	75-125	75-125	<20	<20
	Magnesium	50	5000	75-125	75-125	<20	<20
	Manganese	.5	50	75-125	75-125	<20	<20
	Nickel	.5	50	75-125	75-125	<20	<20
	Potassium	50	5000	75-125	75-125	<20	<20
	Silver	.05	5	75-125	75-125	<20	<20
	Sodium	100	10000	75-125	75-125	<20	<20
	Vanadium	.5	50	75-125	75-125	<20	<20
	Zinc	.5	50	75-125	75-125	<20	<20
SW7740 Selenium							
	Matrix spike: (mg/L)						
	Selenium	.01	1	75-125	75-125	<20	<20
SW7041 Antimony							
	Matrix spike: (mg/L)						
	Antimony	.5	50	75-125	75-125	<20	<20

1.13.3 Data quality assessment

If five consecutive data points are within control limits, and if they indicate a trend in one direction, whether increasing or decreasing, a warning of a condition possibly moving out of control will be issued in a warning/out-of-control document. The document will be given to the responsible field or laboratory person for corrective actions. Similarly, five consecutive data points above or below the mean would indicate a condition possibly moving out of control, and a warning document would be issued.

1.13.4 Documentation

Complete and accurate documentation of analytical and procedural information is an important part of the QA program. The following describes different types of documentation used in RMAL.

SOPs

Details of analytical and QC protocols are contained in SOPs (Standard Operating Procedures). SOPs are documents that contain detailed information on the requirements for the correct performance of a laboratory procedure. RMAL has four categories of laboratory SOPs:

* SOPs for Performance of an Analytical Method:
* SOPs for Preparation of Standard and Reagents:
* SOPs for Equipment Operation, Calibration, and Maintenance; and
* SOPs for General Laboratory Procedures.

All SOP's are approved by the QA Department before being implemented. The distribution of current SOP's and archiving of outdated ones is controlled through the QA Department.

LIMS

RMAL relies on a customized Laboratory Information Management System (LIMS) as the primary database. Client information, sample results, and QC results are all stored in the LIMS. Reports are generated directly from the database to eliminate transcription errors. A tiered security system is in place to control the ability of lab personnel to change results, and the system is designed with an audit trail that identifies when information has been changed and who changed it. The most recent two to three months of analytical data are kept online. All other data are archived on magnetic tape or optical disk.

Laboratory Bench Sheets

Laboratory bench sheets are used to document information from routine laboratory operations, including sample preparation and analysis. Bench sheets are used to ensure that the information is recorded in a complete and organized manner and that the analysis can be reconstructed, if necessary. Portions of information from the bench sheet are also stored in the LIMS.

Laboratory Notebooks

Laboratory notebooks are used to document information that cannot easily be recorded in the LIMS. Information typically recorded in laboratory notebooks includes unusual observations or occurrences in the analysis of samples, or methods development information. Each page in a laboratory notebook is initialed and dated as information is entered.

Control Charts

RMAL uses control charts, generated directly from the LIMS, to visually track the LCS precision and accuracy data. These control charts are used to identify trends in the analyses which may indicate a problem with the analytical procedure. When an adverse trend is detected, as specified in the SOP for generating and interpreting control charts, analysis is stopped and corrective action undertaken.

Anomaly Forms

Any situation which is outside of the normal scope of operations, as described in the laboratory SOPs, is documented on an Anomaly Form.

Examples of anomalous situation include: formation of a precipitate in an extract; formation of an emulsion during an extraction step; or missed holding times. These situations are thoroughly documented to enable a thorough review of the data to occur.

Out-of-Control situations are also documented on Anomaly Forms. An Out-of-Control situation occurs when QC data fall outside of established control limits. The documentation associated with and Out-of-Control situation is reviewed by the supervisor and the QA Department. Out-of-Control situations trigger Corrective Action. Corrective Actions taken are also documented on the Anomaly Form.

Project Files

A project file is created for each project handled within the laboratory. The project file contains all documents associated with the project. This includes correspondence from the client, chain-of-custody records, raw data, copies of laboratory notebook entries pertaining to the project, and a copy of the final report. When a project is complete, all records are passed to the Document Custodian who inventories the file, checks for completeness, and puts the file into document archive.

1.14 CORRECTIVE ACTION

1.14.1 Response

When errors, deficiencies, or out-of-control situations exist, the QA program provides systematic procedures, called "corrective actions," to resolved problems and restore proper functioning to the analytical system.

Laboratory personnel are alerted that corrective actions may be necessary if:

* QC data are outside the acceptable windows for precision and accuracy;
* Blanks, DCS or SCS contain contaminants above acceptable levels;
* Adverse trends (out of control for more than one batch of samples) are detected in spike recoveries or RPD between duplicates;
* There are changes in detection limits;
* Deficiencies are detected by the QA department during internal or external audits or from the results of performance evaluation samples; or
* Inquiries concerning data quality are received from clients.

Corrective actions are of two kinds: (1) immediate, to correct or repair nonconforming data or equipment; and (2) long term, to eliminate causes of nonconformance. Steps comprising a closed-loop corrective action system are as follows:

1. Define the problem.
2. Assign responsibility for investigating the problem.
3. Investigate and determine the cause of the problem.
4. Determine a corrective action to eliminate the problem,
5. Assign and accept responsibility for implementing the corrective action.
6. Establish effectiveness of the corrective action and implement the correction.
7. Verify that the corrective action has eliminated the problem.
8. Document action taken.

1.14.2 Reestablishment of control

When internal laboratory QC fails, the source of the problem is determined; standards, instrumentation, sample preparation, etc.

Corrective action procedures are often handled at the bench level by the analyst. Instrument operational settings, sensitivity, and linearity are validated. If a problem is detected, it is corrected, and QC samples are reanalyzed. If QC samples are still out of control, then the analytical standards are checked. If the standards are a problem, new or different standards are used and QC samples reanalyzed. If QC data are still outside of limits, the sample preparation is checked for anomalies. If no anomalies are found, the samples are re-prepared. If samples cannot be re-prepared, the samples are analyzed and the data reported with qualifying information. If sufficient sample remains, but holding times have expired, the sample is re-prepared and analyzed and the data reported with qualifying information. If preparation problems apply only to the QC samples, the samples are analyzed and the data reported with no qualifies. If preparation problems could have potentially affected all samples, all samples are re-prepared and analyzed. The entire process is documented including reasons supporting the final decision. If the problem persists or cannot be identified, the matter is referred to the laboratory supervisor, manager and/or QA department for further investigation.

1.14.3 Documentation

Full documentation of the corrective action procedure is filed with the QA department using RMAL's warning/out-of-control form (fig.1.14.3.1).

The laboratory QA Officer also documents problems encountered and corrective actions taken in extensive quarterly QA reports to RMAL's corporate managers. Corrective action documentation is routinely reviewed by the vice president of QA. Either form can be used, depending on the nature of the event, the type of information which must be recorded, and the judgement of the laboratory personnel.

Enseco - RMAL

Warning/Out of Control Form

Problem
(Briefly describe problem and QC Lot involved)

Analyst: Date:

Analyst Response
(Describe corrective actions taken and results)

Analyst: Date:

Supervisor Comments
(Comments on corrective actions taken. If necessary describe further actions to be taken)

Supervisor: Date:

Quality Assurance Approval

QC: Date:

Figure 1.14.3.1.—RMAL's warning/out-of-control form

1.15 QUALITY ASSURANCE REPORTS

1.15.1 Reporting procedure

The U.S. Geological Survey, New Mexico District, will hold monthly or weekly reviews of this study project at which the District Chief, Project Supervisor, Project Chief, and QA Officers will review progress, report problems including QA-related problems that are encountered, and recommend actions to resolve those problems. The Project Chief will review the field daily logbooks for progress or problems in field activities.

The Project Chief will be responsible for monthly activity reports, and the Project QA/QC Officer will prepare data reports that will include QA/QC information. The Project Laboratory QA Officer will be responsible for preparing any QA reports related to chemical measurements and sampling in the field, including audit reports.

Laboratory QA reports serve as an instrument for evaluating the program design, identifying problems and trends, and planning for future needs. Divisional QA Directors submit extensive monthly reports to the VP of QA and the Divisional Director. The VP of QA submits weekly reports to the CEO and regularly reports on the status of the QA Program to the Enseco Management Committee and each Divisional Director. These reports summarize the information gathered through the laboratory reporting system and contain a thorough review and evaluation of laboratory operations throughout Enseco.

1.15.2 Report Content

Written quarterly activities reports will be prepared by the Project Chief. The QA/QC part of the reports will address the following:

1. Summary of field activities
2. Laboratory reports and significant findings
3. Summary of QA/QC activities, including field audits
4. Out-of-control events and other problems, if any
5. Corrective actions taken or recommended
6. Personnel and budget status
7. Coordination with the Technical Program Manager (TPM) and base Point-of-Contact (POC)
8. Reports completed or reports in preparation
9. Plans for next quarter

The Laboratory Divisional QA Directors monthly reports include:

* The results of internal system audits including any corrective actions taken;
* Performance evaluation scores and commentaries;
* Results of site visits and audits by regulatory agencies and clients;
* Performance on major contracts, (including CLP);
* Problems encountered and corrective actions taken:
* Holding time violations;
* Comments and recommendations; and
* A summary of the 5% QA data audits conducted.

2.0 FIELD SAMPLING PLAN (FSP)

2.1 Field Operations

This section provides the requirements and procedures for the different field methodologies to be employed during the OB/OD study. Appropriate field methodologies will be undertaken to identify and characterize contaminants at the study site. Methodologies include hand augering, soil borings, hydrologic and geologic data acquisition.

2.1.1 Site reconnaissance, preparation and restoration procedures

Most of the field work will be performed within the boundaries of OB/OD. Access to OB/OD is limited to Air Force military and civilian personnel, dependents, and authorized visitors. Travel within range boundaries is restricted to authorized personnel. During actual field operations, access to working areas will be limited to Geological Survey and subcontractor personnel and visitors authorized by the Point of Contact (POC). All visitors will be requested to keep clear of field activities.

All water for field operations (except where ASTM Type II reagent water is specified) will be obtained from on-base drinking water sources to be specified by the POC.

Decontamination of drilling and sampling equipment will be performed either on the site or in the centralized decontamination area to be designated by the base POC, whichever is logistically and technically appropriate.

All uncontaminated borehole cuttings will be disposed of per direction of base POC. The general area will be cleaned following the completion of each borehole. If approved by the base POC, uncontaminated cuttings may be spread over the general area in the vicinity of the borehole or trucked to more suitable area for disposal. Cuttings suspected to be hazardous will be containerized in new, unused drums. These drums will be transported to an accumulation point within the installation boundary designated by the base POC. Base personal are responsible for ultimate disposal of contaminated soils using base resources.

2.1.2 Borehole construction

Shallow hand-auger borings (maximum of 3 feet each) will be accomplished with a 4-inch diameter stainless-steel hand auger. The location will be permanently marked with rod and flagging, surveyed and recorded on a site map. The hand auger will be decontaminated according to methods described in section 2.1.9.

All soil borings (10 feet) will be advanced with a driven-hole (geoprobe) coring system. Soil samples will be collected using the driven sample tube (0.96-inch-diameter core) at 5-foot intervals. With this technique, described in section 2.2.1.3, the sampler is pushed into the undisturbed material, withdrawn, opened, described, and subsampled for analysis as needed. Monitoring for vapors during augering, odor, and visual descriptions of the material will be used to determine evidence of contamination for immediate handling of materials.

A hydrogeologist/geologist log of the soil borings and well drilling activities will be completed for each borehole. The lithologic descriptions used will be a modified version of ASTM method D2488. The drill cuttings will be described as often as necessary to indicate significant changes in lithology. All split-spoon samples will be lithologically described and monitored with an OVA.

The borehole log will contain the information listed on the borehole log-form (fig. 2.1.4.1) which includes, but is not limited to:

1. Date and time (daily start and stop times and daily progress)
2. Location of well and number
3. Altitude of land-surface datum (from topographic map with 20-foot. contour interval). Wells will be surveyed in at later date.
4. Lithologic log of well or boring describing the materials penetrated.
5. Description of drill action (rate, method, and driller's comments on material being penetrated)
6. Drilling crew members and borehole logger
7. OVA and gas meter readings
8. Total depth of borehole
9. Diameter of hole
10. Drilling method
11. Sampling method(s)

Borehole Log

Project name:_____ Sheet of
Project number:_____ Site:_____
Borehole number: _____ Location:_____ Elevation:_____
Drilling Company:_____ Drilling crew:_____
Date started:_____ Date completed:_____ Total Depth:_____
Drilling method:_____ Drilling Fluid:_____
Borehole diameter:_____
Drilling equipment:_____
Logged by:_____ Sample type:_____

Date	Time	Depth(ft)	Lithology and Remarks

Figure 2.1.4.1--Borehole log form

FIELD BORING LOG INFORMATION

General

- Project name
- * Hole name/number
- * Date started and finished
- * Geologist's name
- * Driller's name
- Sheet number
- * Hole location: map and elevation
- * Rig type bit size/auger size
- * Petrologic lithologic classification scheme used (Wentworth, unified soil classification System)

Information Columns

- * Depth
- * Sample location/number
- Blow counts and advance rate
- * Percent sample recovery
- * Narrative description
- * Depth to saturation

Narrative Description

Geologic Observations:

- * soil/rock type
- * color and stain
- * gross petrology
- friability
- * moisture content
- * degree of weathering
- * presence of carbonate
- * fractures
- * solution cavities
- * bedding
- * discontinuities: e.g. foliation
- * water-bearing zones
- * formational strike and dip
- * fossils
- * depositional structures
- * organic content
- * odor
- * suspected contaminant

Drilling Observations:

- loss of circulation
- * advance rates
- rig chatter
- * water levels
- amount of air used, air pressure
- * drilling difficulties
- * changes in drilling method or equipment
- * readings from detective equipment, if any
- * amount of water yield or loss during drilling at different depths
- * amounts and types of any liquids used
- * running sands
- * caving/hole stability
- * drilling mud weight

Other Remarks:

- equipment failures
- * possible contamination
- * deviations from drilling plan
- * weather

*Indicates items that the Owner/Operator should record, at a minimum.

Figure 2.1.4.1 (Continued)--Borehole log form

2.1.3 Surveying

A certified land surveyor (to be selected) will survey the elevations and horizontal locations of all newly installed soil borings and other sampling points. This will be a third-order survey. The borehole elevation will be notched on the riser casing. The surveyed locations will be established with brass tablets at each sampling location. The surveyed locations will be referenced to U.S. Geological Survey (USGS) benchmarks or National Geodetic Survey (NGS) triangulation stations.

2.1.4 Equipment decontamination

Sampling equipment such as drill rods, drill rig, and hand augers including internal components will be decontaminated prior to use and between samples, to avoid cross-contamination. The following procedures will be used:

1. Wash equipment with a solution of potable water and Alconox or an equivalent laboratory-grade detergent
2. Rinse with potable water
3. Rinse with equivalent to ASTM Type II reagent water (reagent grade water is produced by U.S. Geological Survey personnel in Albuquerque, NM by using a series of Culligan filters - ion exchange resin, polisher and granular activated carbon; herein referred to as "ASTM Type II water")
4. Rinse with pesticide free-grade methanol
5. Rinse with pesticide free-grade hexane
6. Air-dry equipment on a clean non-plastic surface, in a well ventilated, uncontaminated environment. If the sampling device is not going to be used immediately, wrap it in aluminum foil (shiny side out) and place it in a plastic bag for storage.

Reagent grade water, methanol, and hexane shall be purchased, stored and dispensed only in glass, stainless steel, or Teflon containers. These containers shall have Teflon caps or cap liners.

2.1.5 Waste handling

If organic vapor analyzer concentrations are 5 ppm above background, or if there is other evidence of anomalous material (abnormal discoloration or odor), then drill cuttings will be assumed to be contaminated. If it is determined that the cuttings and drilling fluids from the soil borings are contaminated, they will be containerized in new, unused 55-gallon steel drums. The contaminated material and drums will be transported to an accumulation point on base as directed by the base POC. Base personnel are responsible for ultimate disposal of contaminated material using base resources.

2.1.6 Summary of field activities

Field activities for OB/OD include: hand-auger sampling of surficial material, 10-foot soil borings to obtain samples at 0, 5, and 10 feet, and 20-foot continuous core holes to describe the surficial geology.

2.2 ENVIRONMENTAL SAMPLING

2.2.1 Procedures

Detailed descriptions of the specific methods and procedures to be used for characterizing environmental conditions by collecting environmental samples from soils are discussed in this section.

2.2.1.1 Soil samples

Soil samples from soil borings will be obtained from inside the driven sample tube detailed in ASTM method 01586. This method allows collection of representative samples in unconsolidated geologic formations. Only soil borings from 10 feet deep or less will be obtained.

The sample probe is made of stainless steel and is 1.625 inches outside diameter (0.96 inch inside diameter). The samples will be collected from a 2-foot interval that brackets the selected sampling depths, the sampling depths generally will be 0, 5, and 10 feet for the 10-foot boreholes. Sample may be collected at intervals other than above based on odor, discoloration or OVA readings.

Collecting a soil sample using the Geoprobe coring system is accomplished as follows:

1. Drive the borehole to the desired sampling depth.
2. Attach the tube sampler with an inner brass sleeve (California brass ring or equivalent as approved by the TPM) onto the probe and drive it 18 to 21 inches into the undisturbed formation by a hammer drop system as described in ASTM method D1586.
3. Retrieve the tube sampler from the borehole and and place the probe in a lateral position. Remove the brass sleeve from the tube sampler and separate it into four 6-inch-long pieces by removing the outer plastic cover..
4. Transfer the samples to the containers using decontaminated scoops or spatulas of stainless steel. Completely fill the containers to minimize headspace, seal tightly, and label.
5. Decontaminate sampler prior to next sample as described in section 2.1.9.

Shallow soil samples may be collected with a hand auger. The augered location will be positioned to exclude twigs, vegetation, large rocks, and debris. The hand auger is made of stainless steel and is 4 inches in diameter. The hand auger will be augered into the ground to a maximum of 3 feet.

All soil samples will be lithologically described, monitored with an OVA, and placed in the appropriate sample container. All soil sampling equipment will be decontaminated prior to use and between samples as outlined in section 2.1.4.

Soil replicates, when needed, will be obtained by extruding the soil sample from driven tube, hand auger, or scoop onto a clean surface, composited, divided into two equal parts, then placed into the sample containers.

2.2.2 Sample handling

Refer to table 1.5.2.1 for the types of sample containers, sample volumes, methods of preservation, and sample holding times. Section 1.6.2.2 described site sample identification number system.

All sample containers will be clearly identified with the sample information. Completed on a sample label. Most of the samples will be chilled by ice during shipment to the laboratory. The sample bottles will be sealed in plastic "zip lock" bags to protect the labels from water damage and placed in ice chests for shipping. The samples will be placed in the shipping containers in such a manner as to minimize tipping, spilling, or breakage. The ice will be frozen inside containers and will be spaced in the ice chest to maintain chilled samples. The associated chain-of-custody forms will be placed in the ice chest in a sealed plastic bag at the time the samples are placed in the ice chest.

Shipping containers for chilled samples will be metal or high-impact plastic ice chests. Shipping containers for samples not requiring chilling will meet Geological Survey and U.S. Department of Transportation requirements for the shipment of such materials.

The chain-of-custody forms contained on the inside of each shipping container will clearly identify the contents and destination. The outside of the shipping container will be clearly marked with the origin and destination of the shipment. A shipping custody seal will be glued across the lid of the shipping ice chest. The seal will be a band of glue-backed paper with a project stamp. Information on special handling of chilled water and soil samples in glass containers of any sample shipment will be clearly identified on the outside of each container. Overnight shipment via commercial air carriers will be scheduled.

2.2.3 Sample custody

Sample custody is important for ensuring that samples are collected, protected, stored, handled, analyzed, and disposed of properly by authorized personnel. The person who collects the sample in the field will be the person with initial custody of the samples. That person will document the field data associated with the sample and will label the sampled container. Procedures for handling, packaging, and shipping samples will be followed, and the chain-of-custody procedure will be followed when custody is transferred to the laboratory after shipment of the samples.

A sample is in your custody if:

1. It is in your possession
2. It is in your view after being in possession
3. It was in your possession and you locked it up
4. It is in a designated secure area

Samples in containers will be identified using adhesive-backed sample labels (see fig. 2.2.3.1). Sample labels will be attached to the sample containers immediately after filling the containers. The following information will be entered, as a minimum, with waterproof ink on the sample label:

1. Field sample ID number (station number on label)
2. Location
3. Date
4. Time
5. Sampled by (collector)
6. Sample type
7. Analytical methods requested
8. Preservative

The analytical services request form includes the chain-of-custody record. This form will be filled out for each sample set at the time of sampling. The analytical services request and chain-of-custody record form is shown in figure 2.2.3.2. The form is a self-carbon type. The sampler will keep one copy and place the other copy in the sample shipping container with the samples.

An analytical services request and chain-of-custody record form will accompany the labeled samples to the laboratory. The transfer of custody will be recorded in the signature block of the chain-of-custody form.

At the completion of analysis the laboratory will return a completed copy of the form showing the chain-of-custody record within the laboratory.

USGS-WRD, NEW MEXICO DISTRICT
LOCATION: MELROSE AFR, NEW MEXICO
SAMPLE ID: 08DD0103-b
DATE: 3-10-93 TIME: 0830 COLLECTOR: Larson
SAMPLE TYPE: ICP METALS
METHOD: SW3050/SW6010

Figure 2.2.3.1.--Example of completed sample label.

ENSECO ANALYTICAL SERVICES REQUEST FORM

Special Handling (Circle as appropriate and explain in record 5)

Hazardous material

Site Type (circle one)

SW - Surface Water
GW - Ground Water
ME - Meteorological
LK - Lake
ES - Estuary
SP - Spring
SS - Special Source

Field ID

Station Name | Field Office | Project | Collector | Phone (FTS)

File Deposition* (Circle one)

Q - WATSTORE
X - Lab File

For Laboratory Use Only

Sample identification

Station ID or Unique Number* | Project Account #

Year* | Month* | Day* | Time* (Begin Date) | Month | Day | Time (Composite End Date) | State Code* | District/ User Code* | County Code

Analysis level codes and schedules

H or 9

Sample Medium** | Geologic Unit | Analysis Status** | Analysis Source** | Hydrologic Condition** | Sample Type** | Hydrologic Event**

Schedule #1 | Schedule #2 | Schedule #3 | Schedule #4 | Schedule #5

Laboratory codes to be added to (A) or deleted from (D) above schedules

Code	A/D	Code	A/D	Code	A/D	Code	A/D	Code	A/D	Code	A/D	Code	A/D	Code	A/D
Code	A/D	Code	A/D	Code	A/D	Code	A/D	Code	A/D	Code	A/D	Code	A/D	Code	A/D

Chain-of-Custody Record

PROJECT NAME_____ PROJECT NO._____ P.O. NO._____

Relinquished by: *(Signature)*	Received by: *(Signature)*	Date	Time
Relinquished by: *(Signature)*	Received by: *(Signature)*	Date	Time
Relinquished by: *(Signature)*	Received at lab by: *(Signature)*	Date	Time
Relinquished from lab by: *(Signature)*	Received by: *(Signature)*	Date	Time

Comments (Only 50 characters stored in NWIS)

Record 5

Record 6

Total number of sample bottles for this request: _____

SHIP TO:

Enseco-Rocky Mountain Analytical
4955 Yarrow Street
Arvada, CO 80002
(303) 421-6611

ATTENTION: _____

SS-034

Figure 2.2.3.2.--Analytical services request and chain-of-custody record form

2.2.4 QC samples

Field QA/QC samples will be collected and analyzed as part of all field sampling activities for soils. The number of field QA/QC samples to be collected are detailed in section 2.2.5 and table 2.2.5.2. The following protocols will be followed for collection of QA/QC samples.

One equipment blank will be collected per every other day for existing boreholes and analyzed for the same parameters as the groundwater. These samples will be collected by pouring ASTM Type II reagent water through the sampling device (e.g., hand Auger) and into the appropriate sampling container. Equipment blanks for soluble metals will be run through a filtering apparatus.

Field replicates will be collected for soil samples. The number of field replicates will be equal to 10 percent of the total number of samples. Replicates will be collected by placing the soil in a stainless steel tray and dividing the soil into two equal parts with a stainless steel trowel. One-half of the soil is placed in the appropriate jars labeled for the soil sample, and the other half is placed in the appropriate jars labeled for the replicate sample. Replicate and duplicate samples will be assigned different field sample identification numbers to aid in disguising them as replicates or duplicates during laboratory processing.

2.2.5 Sample analyses summary

A summary of the number of analyses by method is presented in table 2.2.5.1. A summary of the field QA/QC analyses and the total number of analyses by method for OB/OD is presented in table 2.2.5.2.

Table 2.2.5.1.--Summary of the number of soil analyses by analytical method for OB/OD

Method[1] number	Parameter	Number of analyses Phase 1	Phase 2	Total
SW3050/SW6010	ICP metals	41	8	49
SW3050/SW7041	Antimony	41	8	49
SW3050/SW7740	Selenium	41	8	49
USATHAMA	Explosives	41	8	49

[1]Method numbers preceded by SW are from U.S. Environmental Protection Agency (1986). Method numbers preceded by USATHAMA are methods provided by the U.S. Army Toxic and Hazardous Materials Agency, Assessment Division, Aberdeen Proving Grounds, Maryland 21010.

Table 2.2.5.2.--Summary of the number of field QC samples by analytical method

Method[1] number	Parameter	Number of analyses	Equipment blanks	Duplicate/ replicate	Matrix spike/ matrix spike duplicates	Total
SW3050/ SW6010	ICP Metals	49	10	5	3	67
SW3050/ SW7041	Antimony	49	10	5	3	67
SW3050/ SW7740	Selenium	49	10	5	3	67
USATHAMA	Explosives	49	10	5	3	67

[1]Method numbers preceded by SW are from U.S. Environmental Protection Agency (1986). Method numbers preceded by USATHAMA are methods provided by the U.S. Army Toxic and Hazardous Materials Agency, Assessment Division, Aberdeen Proving Grounds, Maryland 21010.

2.3 FIELD MEASUREMENTS

2.3.1 Parameters

Several parameters will be tested in the field as part of the analytical protocol for samples. Soil samples will be monitored for total volatile organic concentrations with an organic vapor analyzer (OVA).

2.3.2 Equipment calibration

The calibration procedures are as follows for field test equipment:

Organic vapor analyzer (portable HNU photoionization analyzer, Model PI-101)--The instrument is rented from the USGS Hydrologic Instrumentation Facility which calibrates the instrument with a standard gas of known methane concentration.

2.3.3 Equipment maintenance

The following maintenance checks will be made on the equipment used in the field.

Organic vapor analyzer - the battery charge level, gas content, probe, and connectors will checked daily prior to any field operation. The meter will be adjusted to a reading of zero for background before use.

2.4 FIELD QA/QC PROGRAM

2.4.1 Control parameters

The quality assurance effort for a field investigation program is developed to ensure and validate that inconsistencies in protocols or the field protocols themselves do not introduce error into the data collection process. Field quality control checks have been introduced into the sample collection procedures in order to minimize (and identify if it occurs) the potential for interference or introduction of nonenvironmental contaminant during samples collection, storage, transport, and/or equipment decontamination. These checks are provided through collection of field quality control samples.

Duplicate or replicate samples and equipment blanks, will be collected, prepared, and sent to the laboratory for analysis. The analytical results will be evaluated to determine the adequacy of sample collection techniques. A description of these field QC samples and their frequency have been previously discussed in section 2.2.4.

2.4.2 Control limits

The acceptance criteria for the field QC samples by analytical method has been previously presented in table 1.8.3.1.

2.4.3 Corrective Action

Out-of-control events that could occur in the field is any event that would require deviation from the standard operating procedure. The objective of a corrective action is to perform an alternate procedure and fully document that action in sufficient detail to result in defensible data. An out-of-control event may involve the following:

1. Malfunctioning instruments (erratic response or no response to calibration standards or samples)
2. Accidental loss of equipment while sampling (time lost until replacement results in loss of data)
3. Hydrologic conditions such that standard operating procedure is inadequate.

The Project Chief will determine whether other anomalous events are out of control and could possibly affect the QC of any data being collected. Occurrences of out-of-control events in the field will be recorded in the daily logbooks.

When, as a result of field observations or internal performance audits, conditions in sampling and/or analysis systems are shown to be in error or in any way unsatisfactory, a corrective action system will be employed. The objective is to select an alternate method and document that method in sufficient detail to result in the data meeting the Data Quality Objectives (DQO's).

For the field out-of-control events described above, the field team member performing the field work will initiate corrective action, which would include troubleshooting instruments, using and replacing spare equipment, immediate purging of potentially contaminated instruments, recalibrating instruments, discarding containers. The Project Chief will assess each situation for proper response for the QA of the data being gathered.

Corrective actions are of two kinds: (1) immediate, to correct or repair nonconforming data or equipment; and (2) long term, to eliminate causes of nonconformance. Steps comprising a closed-loop corrective action system are as follows:

1. Define the problem.
2. Assign responsibility for investigating the problem.
3. Investigate and determine the cause of the problem.
4. Determine a corrective action to eliminate the problem,
5. Assign and accept responsibility for implementing the corrective action.
6. Establish effectiveness of the corrective action and implement the correction.
7. Verify that the corrective action has eliminated the problem.
8. Document action taken.

Implementation of the corrective action is the responsibility of the Project Chief. The occurrence of the problem, the corrective action employed, and the verification that the problem has been eliminated will be documented in the daily logbooks.

Out-of-control events and corrective actions for the soil sampling field task is defined below:

task: Soil sampling from bore holes.
criteria: Collect 18 to 24 inches of undisturbed formation material in a split-spoon sampler at depths.
corrective action:
(A) Collect samples at designated depths.
(B) If formation material consists of gravel or larger clastics at these depths the split-spoon sampler probably will not retain a sample. If no sample is recovered record nature of borehole material at this depth. Determine if hole should be abandoned, or if the sample will be taken at a greater depth.
(C) Document actions taken.

The laboratory will be alerted of any field problems. Response to out-of-control events at RMAL are diagrammed on RMAL's sample flow chart shown in figure 1.9.1.1.

2.5 RECORD KEEPING

Field data and sampling information will be recorded in ink in bound daily logbooks (GPO Federal Supply Service 7530-00-222-3525). The site identification, date, time of collection, and the type of sample will be recorded in the logbook by the collector. This information will uniquely identify any sample. Any corrections to recorded information will be lined out and initialed by the collector. Photographs will be taken for this study and will be labeled with the site identification, the date photographed, and a brief description of the photograph.

Soil samples collected from augerings will be recorded in the daily logbooks and also on the borehole log form (fig. 2.1.4.1). Augered samples will be monitored for the presence or absence of large concentrations of VOC's in the soil by using the OVA. Detection levels of VOC's greater than 5 ppm methane will indicate contamination levels. The vapor level readings, time, and depths will be recorded in the appropriate daily field logbook and the borehole log form.

The documentation for out-of-control events in the field will be recorded in the field daily logbooks with a description of the problem and the appropriate corrective action taken. Resolution and verification of any out-of-control events also will be reached in the daily logbooks.

2.6 SITE MANAGEMENT

For this study project, the Cannon AFB point-of-contact (POC) and Technical Program Manager (TPM) will be:

Mr. Jim Richards
ABW/EM
Cannon AFB, NM 87117-5000
(505) 784-4639

The project chief will be responsible for coordinating with the POC for locating and avoiding underground utilities and for coordinating issuance of digging permits.

The TPM will approve of all study sites and any field sampling techniques that are used.

The study sites will not be accessed until clearance has been gained by the POC from the base engineer. All field work will be performed within or adjacent to OB/OD. The site is in the open and fenced areas that are away from buildings and overhead utility lines. The site is near roads with little or no traffic. Before any drilling or digging begins, the POC will obtain clearance from the base engineer so that underground utility lines will be avoided during drilling.

The base will provide the following support to accomplish the OB/OD study:

1. Provide Geological Survey personnel with an initial facility tour to familiarize the personnel with the facility and sites.
2. Locate underground utilities and issue digging or other appropriate permits prior to the commencement of digging or drilling operations.
3. Assign accumulation points within the installation to which field personnel can deliver any drill cuttings or well installation/development fluids generated from the field work which are suspected to be hazardous. The Geological Survey is responsible for providing all necessary containers (55-gallon drums) and for transporting the containerized material to the accumulation point.
4. Take custody of any drill cuttings or well installation/development fluids suspected to be hazardous and properly dispose of the material according to applicable State and/or Federal regulations.
5. Provide the Geological Survey with existing engineering plans, drawings, etc., to facilitate evaluation of the site under investigation.
6. Arrange for, and have available prior to the start-up of field work, the following services, materials, work space, and items of equipment to support the Geological Survey during the investigation:

    a. Personnel identification badges, vehicles passes and/or entry permits and security escorts.
    b. A secure staging area (approximately 1000 square feet) for storing equipment and supplies.
    c. A supply (e.g., fire hydrant, stand pipe, etc) of potable water for borehole flushing, equipment cleaning, etc.
    d. A temporary storage area which is heated for storage of drilling and sampling equipment.

In the event that circumstances arise during the field activities that could endanger personnel on site, the site will be evacuated and both the Project Chief and the base POC notified immediately. In an emergency, all personnel will be evacuated to the nearest point of safety. If other contingencies arise, such as restriction of access because of military operations, the Project Chief will maintain open communications with the base POC for information on lifting of restrictions. The Geological Survey will immediately report to the TPM or his supervisor, via telephone, any data or results generated during this investigation which may indicate an imminent health risk. The telephone notification will be followed with a written notice within three (3) days with a copy of the raw laboratory data (e.g., chromatograms, standards used for calibration, etc) attached.

2.7 REFERENCES

American Public Health Association and others, 1985, Standard methods for the examination of water and wastewater, (16th ed.): Washington, D.C., American Public Health Association, 1268 p.

American Society for Testing Materials, 1984, 1984 Annual book of ASTM standards, vol. 04.08, soil and rock; building stones: Philadelphia, Pennsylvania, American Society for Testing Materials, 830 p.

Dunlap, McNabb, Scalf, and Cosby, 1977, Sampling for organic chemicals and microorganisms in the subsurface: U.S. Environmental Protectional Agency, EPA-600/2-77-176, 26 p.

Enseco, 1989, Enseco Incorporated quality assurance program plan for environmental chemical monitoring, revision 3.3, Enseco Incorporated, Somerset, New Jersey, 58 p.

U.S. Air Force Occupational and Environmental Health Laboratory Technical Division, 1989, Handbook to support the Installation Restoration Program statements of work for remedial investigation/feasibility studies, version 3.0: U.S. Air Force Human Systems Division, HSD/YAQ, Brooks Air Force Base, Texas.

U.S. Environmental Protection Agency, 1982, Handbook for sampling and sample preservation of water and wastewater, Office of Research and Development, U.S. Environmental Protection Agency, 600/4-82-029, 402 p.

_____1983, Methods for chemical analysis of water and wastes: U.S. Environmental Protection Agency 600/4-79-020.

_____1986a, Test methods for evaluating solid waste, physical/chemical methods, SW-846 (3d ed.): U.S. Environmental Protection Agency.

_____1986b, RCRA Groundwater monitoring technical enforcement guidance document, Office of Solid Waste and Emergency Response, 9950.1.

_____1986c, Methods for organic chemical analysis of municipal and industrial wastewater: Federal Register, 40 CFR 136, App. A, July 1, 1986.

_____1987, EP toxicity test procedures: Federal Register, 40 CFR 261, App. II, July 7, 1987.

_____1988a, Guidance for conducting remedial investigations and feasibility studies under CERCLA, interim final, Office of Emergency and Remedial Response, U.S. Environmental Protection Agency 540/G-89/004.

_____1988b, A compendium of Superfund field operations methods, Office of Solid Waste and Emergency Response 540/p-87/001.

United States Air Force

RCRA Subpart X Part B Application

100-Year Flood Plain Study

Open Burn/Open Detonation Thermal Treatment Facility

Melrose Air Force Range
New Mexico

February 1993

UNNAMED ARROYO NEAR FLOYD, NM

RIO GRANDE BASIN

Part 8 UNGAGED SITE

100-YEAR FLOOD PLAIN STUDY

TYPE OF MEASUREMENT. --Flood hydrograph and water surface profile determination for a ungaged site. The techniques for this flood plain analysis are accomplished using the SCS unit hydrograph approach in computer program package of HEC-1. Water surface profile computations are accomplished using computer program WSPRO.

LOCATION. --Lat. 34 16 43, long. 103 47 23, in SE NW SW, sec. 27, T.1 N., R. 30 E., 14.5 miles southwest of Melrose and 13 miles west-northwest of Floyd, in Roosevelt county. Study reach starts about 300 feet above Open burn/Open Detonation unit situated on the Melrose Bombing Range and ends about 350 feet below the unit. Site altitude is 4,380 feet from topographic map.

SURVEY OF SITE. --The drainage basin was determined for the unit location and a corresponding stream reach traversing the unit, for the 100 year flood boundary determination. The channel geometry was surveyed on January 25-26, 1993 by Ben Phillips and Scott Waltemeyer. Instrument W453551 was found correct by double rodding between two hubs and closed on the RP 1 at -0.05 ft. closure. The instrument for the surveying is a Total Station and the radial traversing function is used for the cross-section stationing.

DRAINAGE AREA. --7.3 square miles. U.S. Geological Survey 7.5 minute quadrangle maps: Tolar, SE and Gammil Well, NE was used for the drainage basin delineation. The basin was divided into a overland flow subbasin on top of the mesa and gullied subbasin below the escarpment. The following basin measurements are:

Subbasin	Drainage area (square miles)	Flow length (feet)	Altitude-high (feet)	Altitude-low (feet)	H
Overland	3.71	7,550	4,690	4,640	50
Gullied	3.57	19,960	4,600	4,400	200

FIELD CONDITIONS. --A reach was surveyed for 5,430 ft. The reach is straight with some contraction on the most downstream section. The channel is defined in the vicinity of the OB/OD unit, but the topography is disturbed below. Roads and a motor pool parking area exist below. Cross sections 5, 6, 7, and 8 are not used for the analysis because a flow channel is not defined. Channel material consists of grass, firm earth and some sand in the channel bottom. Roughness coefficients using Mannings n values:

Section	n value Sub area 1 and 2	
1	0.022	0.024
2	0.022	0.024
3	0.022	0.024
4	0.022	0.024
5	propagated from section 4	
6	"	
7	"	
8	"	

Two photographs were made from 35mm color slides.

HYDROLOGY. --The 100 year peak discharge is determined from unit hydrograph method of the U.S. Soil Conservation Service, known as SCS TR-20 computer program. The U.S. Army Corps of Engineers computer package known as Hydrologic Engineering Center HEC-1 also includes the SCS TR-20 method. The HEC-1 Flood Hydrograph Package is used for this analysis beginning on page 4.

Precipitation Component: A synthetic storm from depth-duration data is used for the hypothetical 100 year 24 hour storm. NOAA precipitation station CN 1838 Clovis-North. The 24 hour precipitation for the basin is 5.40 inches and a NOAA Atlas II rainfall distribution is used for the analysis. The NOAA Atlas II for New Mexico was used for the 5-minute, 15-minute, 60-minute, 2-hour, 3-hour, 6-hour, 12-hour, and 24-hour rainfall distribution. The precipitation depth values are listed on the HEC-1 computer input and output. The following model parameters determined are as follows:

Subbasin	SCS lag hours	hours	Subbasin slope percent	v fps	CN	Impervious area percent
Overland	1.57	2.62	0.7	0.8	74	10.4
Gullied	0.90	1.50	1.0	--	74	4.5

The overland flow Tc is computed with the following equation:

$$Tc = L/3600 * V$$

where L is flow length in feet;
V is velocity in feet per second, from figure 2.3 of SCS chapter 2 manual for New Mexico. The overland flow hydrograph is shown on page 11.

$$\text{SCS lag} = Tc * 0.6$$

The gullied flow Tc is computed from figure 2.2 using Kirpicks relation with flow length and altitude fall. SCS lag as above. A hydrograph of the gullied or channel flow is shown on page 16. A 100-year peak discharge of 5,550 cubic feet per second is determined for this site from the above method. A hydrograph of the combined overland and gullied flow is shown on page 17.

HYDRAULICS. --Water surface profiles are obtained by computer program WSPRO developed by the Federal Highway Administration/ U.S. Geological Survey beginning on page 19. The method referred to as the standard step method for balancing the Energy Equation also known as step-backwater analysis is common to this computer package and the Hydrologic Engineering Center HEC-2 Water Surface Profiles package. Both computer packages produce the same calculations for open channel flow. The WSPRO package provides for improved hydraulic equations for flow through contractions or bridges, which does not apply to this study. The discharge of 5,550 cubic feet second is used for these water surface profile calculations. The flow regime was super critical and very uniform with a slight expansion indicated by the conveyance and Froude numbers. Cross sections 1, 2, 3, and 4 and propagated sections 5, 6, 7, and 8 are used for the water surface profile determinations. The propagated sections are based on section 4 and the valley slope between section 3 and 4. The propagated sections are used to obtain convergence of the computed profiles.

EVALUATION OF RESULTS. --Theoretical step-backwater analysis is rated good based upon comparison with the two slope areas. Fall, reach length, fall versus velocity head and conveyance ratios all are within acceptable limits. A U.S. Geological Survey streamflow gaging station (crest-stage gage) is about 3 miles

east of this Unnamed Arroyo. The station number is 08079300 Blackwater Draw near Floyd, NM. The predicted 100 year peak discharge for this basin is 8,710 cubic feet per second and has a drainage area of about 10 square miles. The maximum discharge for the period of record which began in 1963 is 3,400 cubic feet per second occurring September 1, 1969. Regional regression techniques are also applied to this site as presented by Waltemeyer, 1986. A 100-year peak discharge is determined at 3,280 cubic feet per second. Based upon the nearby gaging station record and the regional regression approach, the 100-year peak discharge of 5,550 cubic feet per second from the SCS method is very reasonable.

The plan view (page 45) shows the encroachment of the flood boundary on the open burn and open detonation pit. The northwest ground elevation from this survey showed a assumed elevation of 103.8 feet and the flood elevation is 102.98 feet. The south west corner ground elevation is 104.9 feet and the flood elevation is 105.25 feet at the right edge of water of section 1. Section 1 is located about mid distance between the north west and south west corner of the fence. The existing berm would need to be raised about 1 foot to contain this design 100 year flood discharge.

REFERENCES. --Miller, J.R., Frederick, R.H., and Tracy, R.J., 1973, Precipitation-frequency atlas of the western United States, volume Iv--New Mexico: National Oceanic and Atmospheric Administration NOAA Atlas 2, 43 p.

U.S. Army Corps of Engineers, 1990, HEC-1 Flood hydrograph package user's manual: Hydrologic Engineering Center, Davis, California, CPD-la, 283 p.

U.S. Soil Conservation Service, 1985, Peak rates of discharge for small watersheds: U.S. Department of Agriculture, Albuquerque, New Mexico, Engineering Field manual for Conservation Practices, 33p.

Waltemeyer, S.D., 1986, Techniques for estimating flood-flow frequency for unregulated streams in New Mexico: U.S. Geological Survey Water-Resources Investigations 86-4104, 56 p.

HYDROLOGIST. --Scott D. Waltemeyer composed this analysis. 1-30-1993.

```
ID      MELROSE SUBBASIN:OVERLAND AND GULLIED
ID      CN 1838   NM209, CLOVIS-NORTH
ID      100 YEAR - 24 HOUR, RAINFALL EVENT
ID
I       RAINFALL DISTRIBUTION: BALANCED STORM
ID      RAINFALL DATA: NOAA ATLAS NO. 2, VOLUME IV-NEW MEXICO
ID      COMPUTATION INTERVAL: 5 MINUTE
IT     5       0       0     288
IO     0       2       0
KK    O1  OVERLAND BASIN
KO     0       0       0
BA   3.7
KM        100 YR. - 24 HR. EVENT
PH                 0.91    1.79    3.15    3.68    4.07    4.70    5.40    6.10
KM  SCS RUNOFF
LS            74    10.4
UD   1.57
KK    G1  GULLEY BASIN
BA   3.6
KM        100 YR. - 24 HR. EVENT
PH                 0.91    1.79    3.15    3.68    4.07    4.70    5.40    6.10
LS            74     4.5
UD   0.90
KK    G2  BASIN OUTLET
KO     4
KM      COMBINE HYDROGRAPHS OF SUBBAINS
HC     2
Z
```

```
*                                    *                                                    *                                    *
*                                    *                                                    *                                    *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1) *                                                    *   U.S. ARMY CORPS OF ENGINEERS     *
*           SEPTEMBER 1990           *                                                    *   HYDROLOGIC ENGINEERING CENTER    *
*            VERSION 4.0             *                                                    *         609 SECONC STREET          *
*                                    *                                                    *      DAVIS, CALIFCRNIA 95616       *
*  RUN DATE  01/21/1993  TIME  17:45:23 *                                                 *          (916) 756-1104            *
*                                    *                                                    *                                    *
**************************************                                                    **************************************

                                                X     X  XXXXXXX   XXXXX           X
                                                X     X  X        X     X         XX
                                                X     X  X        X               X
                                                XXXXXXX  XXXX     X        XXXXX  X
                                                X     X  X        X               X
                                                X     X  X        X     X         X
                                                X     X  XXXXXXX   XXXXX         XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

HEC-1 INPUT

```
LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

  1           ID        MELROSE SUBBASIN:OVERLAND AND GULLIED
  2           ID        CN 1838   NM209, CLOVIS-NORTH
  3           ID        100 YEAR - 24 HOUR, RAINFALL EVENT
  4           ID
  5           ID        RAINFALL DISTRIBUTION: BALANCED STORM
  6           ID        RAINFALL DATA: NOAA ATLAS NO. 2, VOLUME IV-NEW MEXICO
  7           ID        COMPUTATION INTERVAL: 5 MINUTE
  8           IT       5       0       0     288
  9           IO       0       2       0
 10           KK      01  OVERLAND BASIN
 11           KO       0       0       0
 12           BA     3.7
 13           KM           100 YR. - 24 HR. EVENT
 14           PH                   0.91    1.79    3.15    3.68    4.07    4.70    5.40    6.10
 15           KM    SCS RUNOFF
 16           LS              74    10.4
 17           UD     1.57
 18           KK      G1  GULLEY BASIN
 19           BA     3.6
 20           KM           100 YR. - 24 HR. EVENT
 21           PH                   0.91    1.79    3.15    3.68    4.07    4.70    5.40    6.10
 22           LS              74     4.5
 23           UD     0.90
 24           KK      G2  BASIN OUTLET
 25           KO       4
 26           KM        COMBINE HYDROGRAPHS OF SUB-BASINS
 27           HC       2
 28           ZZ
```

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*            SEPTEMBER 1990             *
*             VERSION 4.0               *
*                                       *
*  RUN DATE  01/21/1993  TIME  17:45:23 *
*                                       *
*****************************************
```

```
*****************************************
*                                       *
*    U.S. ARMY CORPS OF ENGINEERS       *
*    HYDROLOGIC ENGINEERING CENTER      *
*          609 SECOND STREET            *
*       DAVIS, CALIFORNIA 95616         *
*           (916) 756-1104              *
*                                       *
*****************************************
```

```
                              UNNAMED ARROYO ON MELROSE AIR FORCE RANGE
                              MELROSE SUBBASIN:OVERLAND AND GULLIED
                              CN 1838   NM209, CLOVIS-NORTH
                              100 YEAR - 24 HOUR, RAINFALL EVENT

                              RAINFALL DISTRIBUTION: BALANCED STORM
                              RAINFALL DATA: NOAA ATLAS NO. 2, VOLUME IV-NEW MEXICO
                              COMPUTATION INTERVAL: 5 MINUTE

  9 IO          OUTPUT CONTROL VARIABLES
                      IPRNT          0  PRINT CONTROL
                      IPLOT          2  PLOT CONTROL
                      QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT          HYDROGRAPH TIME DATA
                       NMIN          5  MINUTES IN COMPUTATION INTERVAL
                      IDATE      1   0  STARTING DATE
                      ITIME       0000  STARTING TIME
                         NQ        288  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE      1   0  ENDING DATE
                     NDTIME       2355  ENDING TIME
                      ICENT         19  CENTURY MARK

                 COMPUTATION INTERVAL     .08 HOURS
                      TOTAL TIME BASE   23.92 HOURS

          ENGLISH UNITS
               DRAINAGE AREA          SQUARE MILES
               PRECIPITATION DEPTH    INCHES
               LENGTH, ELEVATION      FEET
               FLOW                   CUBIC FEET PER SECOND
               STORAGE VOLUME         ACRE-FEET
               SURFACE AREA           ACRES
               TEMPERATURE            DEGREES FAHRENHEIT

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

```
                **************
                *            *
10 KK           *     01     *        OVERLAND BASIN
                *            *
                **************

11 KO              OUTPUT CONTROL VARIABLES
                         IPRNT          0  PRINT CONTROL
                         IPLOT          2  PLOT CONTROL
                         QSCAL         0.  HYDROGRAPH PLOT SCALE
                                   100 YR. - 24 HR. EVENT
                              SCS RUNOFF

                 SUBBASIN RUNOFF DATA

12 BA              SUBBASIN CHARACTERISTICS
                         TAREA       3.70  SUBBASIN AREA

                   PRECIPITATION DATA

14 PH                                   DEPTHS FOR   0-PERCENT HYPOTHETICAL STORM
                   ..... HYDRO-35 ......   ............... TP-40 ...............   ........... TP-49 ...........
                   5-MIN  15-MIN  60-MIN    2-HR    3-HR    6-HR   12-HR   24-HR   2-DAY   4-DAY   7-DAY  10-DAY
                     .91    1.79    3.15    3.68    4.07    4.70    5.40    6.10     .00     .00     .00     .00

                                                  STORM AREA =    3.70

16 LS              SCS LOSS RATE
                         STRTL        .70  INITIAL ABSTRACTION
                        CRVNBR      74.00  CURVE NUMBER
                         RTIMP      10.40  PERCENT IMPERVIOUS AREA

17 UD              SCS DIMENSIONLESS UNITGRAPH
                          TLAG       1.50  LAG

                                                   ***

                                                UNIT HYDROGRAPH
                                            92 END-OF-PERIOD ORDINATES
                 19.      41.      85.     133.     189.     254.     329.     420.     520.     634.
                753.     855.     954.    1023.    1086.    1123.    1150.    1156.    1156.    1150.
               1123.    1086.    1043.     999.     949.     898.     835.     769.     694.     624.
                561.     509.     465.     426.     388.     356.     325.     302.     279.     256.
                234.     216.     197.     178.     163.     150.     138.     125.     116.     106.
                 97.      88.      81.      74.      67.      61.      57.      52.      47.      44.
                 40.      37.      33.      31.      28.      26.      24.      22.      20.      18.
                 17.      15.      14.      13.      12.      11.      10.      10.       9.       8.
                  7.       7.       6.       5.       5.       4.       3.       3.       2.       2.
                  1.       0.
```

HYDROGRAPH AT STATION 01

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		1200	145	.89	.27	.61	258.
1		0005	2	.00	.00	.00	0.	1		1205	146	.35	.09	.26	321.
1		0010	3	.00	.00	.00	0.	1		1210	147	.21	.05	.16	405.
1		0015	4	.00	.00	.00	0.	1		1215	148	.14	.03	.11	504.
1		0020	5	.00	.00	.00	0.	1		1220	149	.12	.03	.09	620.
1		0025	6	.00	.00	.00	0.	1		1225	150	.10	.02	.08	754.
1		0030	7	.00	.00	.00	0.	1		1230	151	.06	.01	.05	905.
1		0035	8	.00	.00	.00	0.	1		1235	152	.05	.01	.04	1075.
1		0040	9	.00	.00	.00	1.	1		1240	153	.05	.01	.04	1261.
1		0045	10	.00	.00	.00	1.	1		1245	154	.04	.01	.03	1459.
1		0050	11	.00	.00	.00	1.	1		1250	155	.04	.01	.03	1660.
1		0055	12	.00	.00	.00	1.	1		1255	156	.04	.01	.03	1850.
1		0100	13	.00	.00	.00	2.	1		1300	157	.04	.01	.03	2025.
1		0105	14	.00	.00	.00	2.	1		1305	158	.04	.01	.03	2175.
1		0110	15	.00	.00	.00	2.	1		1310	159	.03	.01	.03	2304.
1		0115	16	.00	.00	.00	3.	1		1315	160	.03	.01	.03	2404.
1		0120	17	.00	.00	.00	3.	1		1320	161	.03	.01	.03	2480.
1		0125	18	.00	.00	.00	4.	1		1325	162	.03	.01	.02	2529.
1		0130	19	.00	.00	.00	4.	1		1330	163	.02	.00	.02	2557.
1		0135	20	.00	.00	.00	5.	1		1335	164	.02	.00	.02	2566.
1		0140	21	.00	.00	.00	5.	1		1340	165	.02	.00	.02	2550.
1		0145	22	.00	.00	.00	6.	1		1345	166	.02	.00	.02	2515.
1		0150	23	.00	.00	.00	6.	1		1350	167	.02	.00	.02	2465.
1		0155	24	.00	.00	.00	7.	1		1355	168	.02	.00	.02	2403.
1		0200	25	.00	.00	.00	7.	1		1400	169	.02	.00	.02	2330.
1		0205	26	.00	.00	.00	8.	1		1405	170	.02	.00	.01	2245.
1		0210	27	.00	.00	.00	8.	1		1410	171	.02	.00	.01	2149.
1		0215	28	.00	.00	.00	8.	1		1415	172	.02	.00	.01	2043.
1		0220	29	.00	.00	.00	9.	1		1420	173	.02	.00	.01	1929.
1		0225	30	.00	.00	.00	9.	1		1425	174	.02	.00	.01	1816.
1		0230	31	.00	.00	.00	9.	1		1430	175	.02	.00	.01	1708.
1		0235	32	.00	.00	.00	10.	1		1435	176	.02	.00	.01	1609.
1		0240	33	.00	.00	.00	10.	1		1440	177	.01	.00	.01	1519.
1		0245	34	.00	.00	.00	10.	1		1445	178	.01	.00	.01	1434.
1		0250	35	.00	.00	.00	10.	1		1450	179	.01	.00	.01	1355.
1		0255	36	.00	.00	.00	11.	1		1455	180	.01	.00	.01	1282.
1		0300	37	.00	.00	.00	11.	1		1500	181	.01	.00	.01	1215.
1		0305	38	.00	.00	.00	11.	1		1505	182	.01	.00	.01	1154.
1		0310	39	.00	.00	.00	11.	1		1510	183	.01	.00	.01	1096.
1		0315	40	.00	.00	.00	11.	1		1515	184	.01	.00	.01	1041.
1		0320	41	.00	.00	.00	12.	1		1520	185	.01	.00	.01	988.
1		0325	42	.00	.00	.00	12.	1		1525	186	.01	.00	.01	939.
1		0330	43	.01	.00	.00	12.	1		1530	187	.01	.00	.01	892.
1		0335	44	.01	.00	.00	12.	1		1535	188	.01	.00	.01	847.
1		0340	45	.01	.00	.00	12.	1		1540	189	.01	.00	.01	806.
1		0345	46	.01	.00	.00	12.	1		1545	190	.01	.00	.01	768.
1		0350	47	.01	.00	.00	12.	1		1550	191	.01	.00	.01	732.

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0355	48	.01	.00	.00	13.	*	1		1555	192	.01	.00	.01	698.
1		0400	49	.01	.00	.00	13.	*	1		1600	193	.01	.00	.01	667.
1		0405	50	.01	.00	.00	13.	*	1		1605	194	.01	.00	.01	638.
1		0410	51	.01	.00	.00	13.	*	1		1610	195	.01	.00	.01	610.
1		0415	52	.01	.00	.00	13.	*	1		1615	196	.01	.00	.01	584.
1		0420	53	.01	.00	.00	13.	*	1		1620	197	.01	.00	.01	560.
1		0425	54	.01	.00	.00	13.	*	1		1625	198	.01	.00	.01	537.
1		0430	55	.01	.00	.00	14.	*	1		1630	199	.01	.00	.01	515.
1		0435	56	.01	.01	.00	14.	*	1		1635	200	.01	.00	.01	495.
1		0440	57	.01	.01	.00	14.	*	1		1640	201	.01	.00	.01	477.
1		0445	58	.01	.01	.00	14.	*	1		1645	202	.01	.00	.01	459.
1		0450	59	.01	.01	.00	14.	*	1		1650	203	.01	.00	.01	443.
1		0455	60	.01	.01	.00	14.	*	1		1655	204	.01	.00	.01	427.
1		0500	61	.01	.01	.00	14.	*	1		1700	205	.01	.00	.01	413.
1		0505	62	.01	.01	.00	14.	*	1		1705	206	.01	.00	.01	399.
1		0510	63	.01	.01	.00	15.	*	1		1710	207	.01	.00	.01	386.
1		0515	64	.01	.01	.00	15.	*	1		1715	208	.01	.00	.01	374.
1		0520	65	.01	.01	.00	15.	*	1		1720	209	.01	.00	.01	363.
1		0525	66	.01	.01	.00	15.	*	1		1725	210	.01	.00	.01	352.
1		0530	67	.01	.01	.00	15.	*	1		1730	211	.01	.00	.01	342.
1		0535	68	.01	.01	.00	15.	*	1		1735	212	.01	.00	.01	332.
1		0540	69	.01	.01	.00	15.	*	1		1740	213	.01	.00	.01	323.
1		0545	70	.01	.01	.00	16.	*	1		1745	214	.01	.00	.01	315.
1		0550	71	.01	.01	.00	16.	*	1		1750	215	.01	.00	.01	307.
1		0555	72	.01	.01	.00	16.	*	1		1755	216	.01	.00	.01	299.
1		0600	73	.01	.01	.00	16.	*	1		1800	217	.01	.00	.01	292.
1		0605	74	.01	.01	.00	16.	*	1		1805	218	.01	.00	.01	285.
1		0610	75	.01	.01	.00	16.	*	1		1810	219	.01	.00	.01	279.
1		0615	76	.01	.01	.00	16.	*	1		1815	220	.01	.00	.01	273.
1		0620	77	.01	.01	.00	17.	*	1		1820	221	.01	.00	.01	267.
1		0625	78	.01	.01	.00	17.	*	1		1825	222	.01	.00	.01	262.
1		0630	79	.01	.01	.00	17.	*	1		1830	223	.01	.00	.01	256.
1		0635	80	.01	.01	.00	17.	*	1		1835	224	.01	.00	.01	251.
1		0640	81	.01	.01	.00	17.	*	1		1840	225	.01	.00	.01	245.
1		0645	82	.01	.01	.00	18.	*	1		1845	226	.01	.00	.01	240.
1		0650	83	.01	.01	.00	18.	*	1		1850	227	.01	.00	.01	234.
1		0655	84	.01	.01	.00	18.	*	1		1855	228	.01	.00	.01	229.
1		0700	85	.01	.01	.00	18.	*	1		1900	229	.01	.00	.00	224.
1		0705	86	.01	.01	.00	19.	*	1		1905	230	.01	.00	.00	219.
1		0710	87	.01	.01	.00	19.	*	1		1910	231	.01	.00	.00	214.
1		0715	88	.01	.01	.00	19.	*	1		1915	232	.01	.00	.00	209.
1		0720	89	.01	.01	.00	20.	*	1		1920	233	.01	.00	.00	204.
1		0725	90	.01	.01	.00	20.	*	1		1925	234	.01	.00	.00	200.
1		0730	91	.01	.01	.00	20.	*	1		1930	235	.01	.00	.00	195.
1		0735	92	.01	.01	.00	21.	*	1		1935	236	.01	.00	.00	191.
1		0740	93	.01	.01	.00	21.	*	1		1940	237	.01	.00	.00	187.
1		0745	94	.01	.01	.00	21.	*	1		1945	238	.01	.00	.00	184.
1		0750	95	.01	.01	.00	22.	*	1		1950	239	.01	.00	.00	180.
1		0755	96	.01	.01	.00	22.	*	1		1955	240	.01	.00	.00	177.
1		0800	97	.01	.01	.00	22.	*	1		2000	241	.01	.00	.00	174.
1		0805	98	.01	.01	.00	23.	*	1		2005	242	.01	.00	.00	171.
1		0810	99	.01	.01	.00	23.	*	1		2010	243	.01	.00	.00	168.
1		0815	100	.01	.01	.00	24.	*	1		2015	244	.01	.00	.00	166.
1		0820	101	.01	.01	.00	24.	*	1		2020	245	.01	.00	.00	163.

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0825	102	.01	.01	.00	24.	1		2025	246	.01	.00	.00	161.
1		0830	103	.01	.01	.00	25.	1		2030	247	.00	.00	.00	159.
1		0835	104	.01	.01	.00	25.	1		2035	248	.00	.00	.00	157.
1		0840	105	.01	.01	.00	25.	1		2040	249	.00	.00	.00	155.
1		0845	106	.01	.01	.00	26.	1		2045	250	.00	.00	.00	153.
1		0850	107	.01	.01	.00	26.	1		2050	251	.00	.00	.00	151.
1		0855	108	.01	.01	.00	27.	1		2055	252	.00	.00	.00	149.
1		0900	109	.01	.01	.00	27.	1		2100	253	.00	.00	.00	147.
1		0905	110	.01	.01	.00	28.	1		2105	254	.00	.00	.00	145.
1		0910	111	.01	.01	.00	28.	1		2110	255	.00	.00	.00	144.
1		0915	112	.01	.01	.00	28.	1		2115	256	.00	.00	.00	142.
1		0920	113	.02	.01	.00	29.	1		2120	257	.00	.00	.00	141.
1		0925	114	.02	.01	.00	30.	1		2125	258	.00	.00	.00	139.
1		0930	115	.02	.01	.00	30.	1		2130	259	.00	.00	.00	138.
1		0935	116	.02	.01	.00	31.	1		2135	260	.00	.00	.00	136.
1		0940	117	.02	.01	.00	32.	1		2140	261	.00	.00	.00	135.
1		0945	118	.02	.01	.00	32.	1		2145	262	.00	.00	.00	134.
1		0950	119	.02	.01	.00	33.	1		2150	263	.00	.00	.00	132.
1		0955	120	.02	.01	.00	34.	1		2155	264	.00	.00	.00	131.
1		1000	121	.02	.02	.00	36.	1		2200	265	.00	.00	.00	130.
1		1005	122	.02	.02	.00	37.	1		2205	266	.00	.00	.00	129.
1		1010	123	.02	.02	.00	39.	1		2210	267	.00	.00	.00	127.
1		1015	124	.02	.02	.00	40.	1		2215	268	.00	.00	.00	126.
1		1020	125	.02	.02	.01	42.	1		2220	269	.00	.00	.00	125.
1		1025	126	.02	.02	.01	45.	1		2225	270	.00	.00	.00	124.
1		1030	127	.03	.02	.01	47.	1		2230	271	.00	.00	.00	123.
1		1035	128	.03	.02	.01	50.	1		2235	272	.00	.00	.00	122.
1		1040	129	.03	.02	.01	53.	1		2240	273	.00	.00	.00	121.
1		1045	130	.03	.02	.01	56.	1		2245	274	.00	.00	.00	120.
1		1050	131	.03	.02	.01	60.	1		2250	275	.00	.00	.00	119.
1		1055	132	.04	.03	.01	65.	1		2255	276	.00	.00	.00	118.
1		1100	133	.04	.02	.01	70.	1		2300	277	.00	.00	.00	117.
1		1105	134	.04	.03	.01	75.	1		2305	278	.00	.00	.00	116.
1		1110	135	.04	.03	.01	82.	1		2310	279	.00	.00	.00	115.
1		1115	136	.04	.03	.02	89.	1		2315	280	.00	.00	.00	115.
1		1120	137	.05	.03	.02	96.	1		2320	281	.00	.00	.00	114.
1		1125	138	.05	.03	.02	105.	1		2325	282	.00	.00	.00	113.
1		1130	139	.10	.06	.04	115.	1		2330	283	.00	.00	.00	112.
1		1135	140	.11	.06	.05	127.	1		2335	284	.00	.00	.00	111.
1		1140	141	.13	.07	.06	141.	1		2340	285	.00	.00	.00	110.
1		1145	142	.19	.10	.10	158.	1		2345	286	.00	.00	.00	110.
1		1150	143	.24	.11	.13	180.	1		2350	287	.00	.00	.00	109.
1		1155	144	.51	.20	.31	210.	1		2355	288	.00	.00	.00	108.

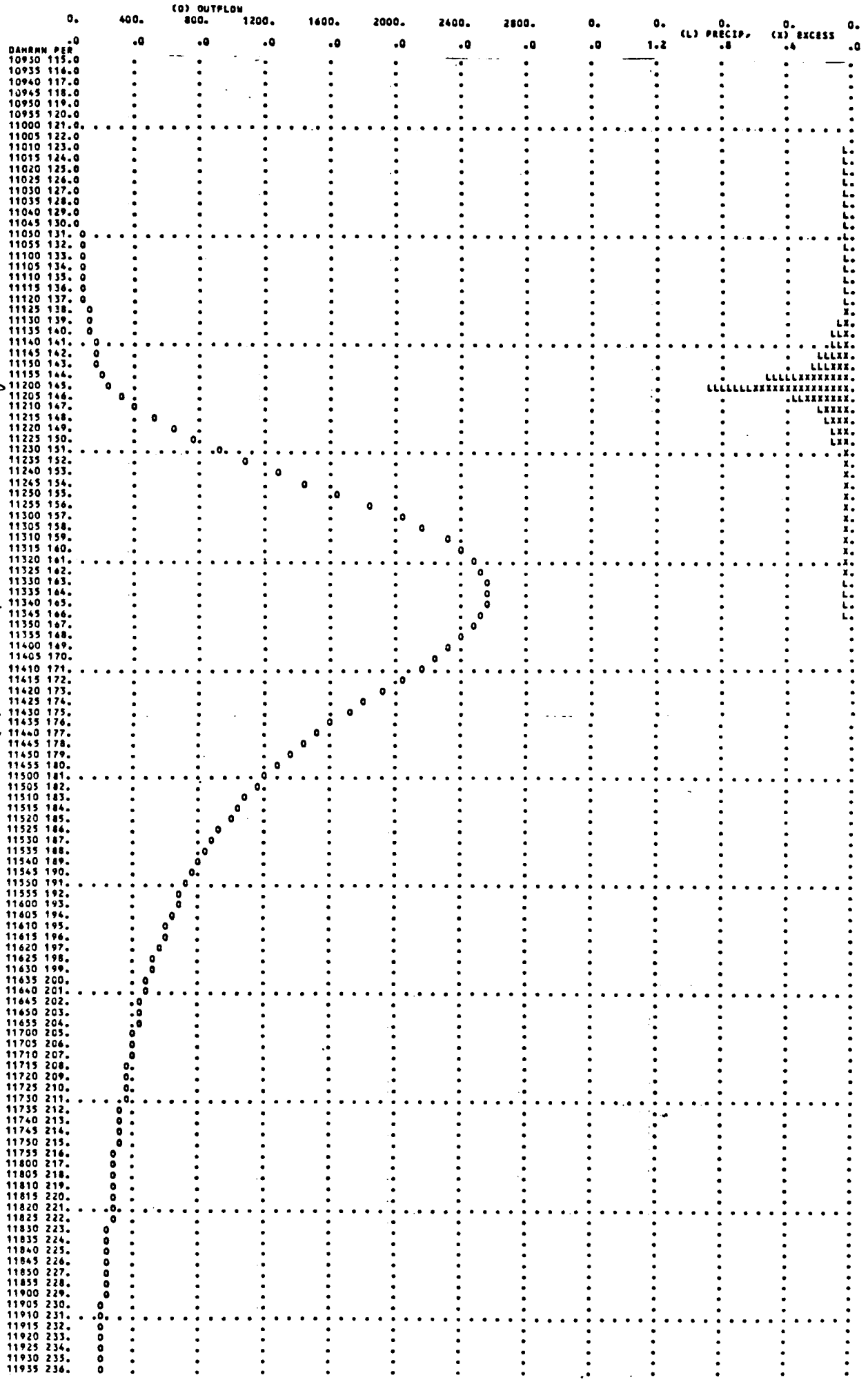
****

TOTAL RAINFALL = 6.07, TOTAL LOSS = 2.53, TOTAL EXCESS = 3.53

PEAK FLOW	TIME		MAXIMUM AVERAGE FLOW			
			6-HR	24-HR	72-HR	23.92-HR
+ (CFS)	(HR)					
		(CFS)				
+ 2566.	13.58		1157.	345.	345.	345.
		(INCHES)	2.906	3.451	3.451	3.451
		(AC-FT)	574.	681.	681.	681.

CUMULATIVE AREA = 3.70 SQ MI

STATION II 01



Unnamed arroyo - Melrose Air Force Range
Overland flow Hydrograph

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

            **************
            *            *
 18 KK      *     G1     *      GULLEY BASIN
            *            *
            **************
                                100 YR. - 24 HR. EVENT

              SUBBASIN RUNOFF DATA

 19 BA          SUBBASIN CHARACTERISTICS
                      TAREA        3.60  SUBBASIN AREA

                PRECIPITATION DATA

 21 PH                                DEPTHS FOR   0-PERCENT HYPOTHETICAL STORM
                ..... HYDRO-35 .....   ............... TP-40 ...............   ........... TP-49 ...........
                5-MIN  15-MIN  60-MIN    2-HR    3-HR    6-HR   12-HR   24-HR   2-DAY   4-DAY   7-DAY  10-DAY
                  .91    1.79    3.15    3.68    4.07    4.70    5.40    6.10     .00     .00     .00     .00

                                                STORM AREA =    3.60

 22 LS          SCS LOSS RATE
                      STRTL         .70  INITIAL ABSTRACTION
                     CRVNBR       74.00  CURVE NUMBER
                      RTIMP        4.50  PERCENT IMPERVIOUS AREA

 23 UD          SCS DIMENSIONLESS UNITGRAPH
                       TLAG         .90  LAG

                                                        ***

                                                   UNIT HYDROGRAPH
                                              56 END-OF-PERIOD ORDINATES
              49.      155.      293.      470.      698.      976.     1276.     1530.     1710.     1811.
            1841.     1835.     1772.     1667.     1547.     1411.     1246.     1050.      884.      759.
             655.      566.      493.      433.      375.      326.      277.      243.      210.      182.
             158.      136.      118.      100.       88.       76.       66.       57.       50.       43.
              37.       32.       27.       24.       21.       19.       17.       15.       13.       11.
               9.        7.        6.        4.        2.        1.
```

HYDROGRAPH AT STATION G1

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0000	1	.00	.00	.00	0.	1		1200	145	.89	.29	.60	502.
1		0005	2	.00	.00	.00	0.	1		1205	146	.35	.09	.26	694.
1		0010	3	.00	.00	.00	0.	1		1210	147	.21	.05	.16	942.
1		0015	4	.00	.00	.00	0.	1		1215	148	.14	.03	.11	1247.
1		0020	5	.00	.00	.00	0.	1		1220	149	.12	.03	.09	1610.
1		0025	6	.00	.00	.00	0.	1		1225	150	.10	.02	.08	2018.
1		0030	7	.00	.00	.00	0.	1		1230	151	.06	.01	.05	2435.
1		0035	8	.00	.00	.00	1.	1		1235	152	.05	.01	.04	2812.
1		0040	9	.00	.00	.00	1.	1		1240	153	.05	.01	.04	3114.
1		0045	10	.00	.00	.00	1.	1		1245	154	.04	.01	.03	3327.
1		0050	11	.00	.00	.00	2.	1		1250	155	.04	.01	.03	3453.
1		0055	12	.00	.00	.00	2.	1		1255	156	.04	.01	.03	3501.
1		0100	13	.00	.00	.00	2.	1		1300	157	.04	.01	.03	3472.
1		0105	14	.00	.00	.00	3.	1		1305	158	.04	.01	.03	3376.
1		0110	15	.00	.00	.00	3.	1		1310	159	.03	.01	.03	3234.
1		0115	16	.00	.00	.00	3.	1		1315	160	.03	.01	.03	3052.
1		0120	17	.00	.00	.00	3.	1		1320	161	.03	.01	.02	2832.
1		0125	18	.00	.00	.00	4.	1		1325	162	.03	.01	.02	2589.
1		0130	19	.00	.00	.00	4.	1		1330	163	.02	.00	.02	2358.
1		0135	20	.00	.00	.00	4.	1		1335	164	.02	.00	.02	2152.
1		0140	21	.00	.00	.00	4.	1		1340	165	.02	.00	.02	1969.
1		0145	22	.00	.00	.00	4.	1		1345	166	.02	.00	.02	1804.
1		0150	23	.00	.00	.00	4.	1		1350	167	.02	.00	.02	1659.
1		0155	24	.00	.00	.00	4.	1		1355	168	.02	.00	.02	1529.
1		0200	25	.00	.00	.00	5.	1		1400	169	.02	.00	.02	1410.
1		0205	26	.00	.00	.00	5.	1		1405	170	.02	.00	.01	1301.
1		0210	27	.00	.00	.00	5.	1		1410	171	.02	.00	.01	1200.
1		0215	28	.00	.00	.00	5.	1		1415	172	.02	.00	.01	1111.
1		0220	29	.00	.00	.00	5.	1		1420	173	.02	.00	.01	1030.
1		0225	30	.00	.00	.00	5.	1		1425	174	.02	.00	.01	956.
1		0230	31	.00	.00	.00	5.	1		1430	175	.02	.00	.01	889.
1		0235	32	.00	.00	.00	5.	1		1435	176	.02	.00	.01	828.
1		0240	33	.00	.00	.00	5.	1		1440	177	.01	.00	.01	773.
1		0245	34	.00	.00	.00	5.	1		1445	178	.01	.00	.01	723.
1		0250	35	.00	.00	.00	5.	1		1450	179	.01	.00	.01	679.
1		0255	36	.00	.00	.00	5.	1		1455	180	.01	.00	.01	639.
1		0300	37	.00	.00	.00	5.	1		1500	181	.01	.00	.01	604.
1		0305	38	.00	.00	.00	5.	1		1505	182	.01	.00	.01	572.
1		0310	39	.00	.00	.00	5.	1		1510	183	.01	.00	.01	543.
1		0315	40	.00	.00	.00	6.	1		1515	184	.01	.00	.01	516.
1		0320	41	.00	.00	.00	6.	1		1520	185	.01	.00	.01	492.
1		0325	42	.00	.00	.00	6.	1		1525	186	.01	.00	.01	470.
1		0330	43	.01	.00	.00	6.	1		1530	187	.01	.00	.01	449.
1		0335	44	.01	.00	.00	6.	1		1535	188	.01	.00	.01	431.
1		0340	45	.01	.00	.00	6.	1		1540	189	.01	.00	.01	414.
1		0345	46	.01	.00	.00	6.	1		1545	190	.01	.00	.01	398.
1		0350	47	.01	.00	.00	6.	1		1550	191	.01	.00	.01	384.
1		0355	48	.01	.00	.00	6.	1		1555	192	.01	.00	.01	370.
1		0400	49	.01	.01	.00	6.	1		1600	193	.01	.00	.01	358.
1		0405	50	.01	.01	.00	6.	1		1605	194	.01	.00	.01	346.
1		0410	51	.01	.01	.00	6.	1		1610	195	.01	.00	.01	334.

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0415	52	.01	.01	.00	6.	*	1		1615	196	.01	.00	.01	324.
1		0420	53	.01	.01	.00	6.	*	1		1620	197	.01	.00	.01	313.
1		0425	54	.01	.01	.00	6.	*	1		1625	198	.01	.00	.01	304.
1		0430	55	.01	.01	.00	6.	*	1		1630	199	.01	.00	.01	295.
1		0435	56	.01	.01	.00	6.	*	1		1635	200	.01	.00	.01	286.
1		0440	57	.01	.01	.00	6.	*	1		1640	201	.01	.00	.01	279.
1		0445	58	.01	.01	.00	6.	*	1		1645	202	.01	.00	.01	273.
1		0450	59	.01	.01	.00	6.	*	1		1650	203	.01	.00	.01	267.
1		0455	60	.01	.01	.00	6.	*	1		1655	204	.01	.00	.01	261.
1		0500	61	.01	.01	.00	7.	*	1		1700	205	.01	.00	.01	256.
1		0505	62	.01	.01	.00	7.	*	1		1705	206	.01	.00	.01	251.
1		0510	63	.01	.01	.00	7.	*	1		1710	207	.01	.00	.01	247.
1		0515	64	.01	.01	.00	7.	*	1		1715	208	.01	.00	.01	243.
1		0520	65	.01	.01	.00	7.	*	1		1720	209	.01	.00	.01	238.
1		0525	66	.01	.01	.00	7.	*	1		1725	210	.01	.00	.01	234.
1		0530	67	.01	.01	.00	7.	*	1		1730	211	.01	.00	.01	231.
1		0535	68	.01	.01	.00	7.	*	1		1735	212	.01	.00	.01	227.
1		0540	69	.01	.01	.00	7.	*	1		1740	213	.01	.00	.01	224.
1		0545	70	.01	.01	.00	7.	*	1		1745	214	.01	.00	.01	220.
1		0550	71	.01	.01	.00	7.	*	1		1750	215	.01	.00	.01	217.
1		0555	72	.01	.01	.00	7.	*	1		1755	216	.01	.00	.01	214.
1		0600	73	.01	.01	.00	7.	*	1		1800	217	.01	.00	.01	211.
1		0605	74	.01	.01	.00	7.	*	1		1805	218	.01	.00	.01	208.
1		0610	75	.01	.01	.00	7.	*	1		1810	219	.01	.00	.01	205.
1		0615	76	.01	.01	.00	8.	*	1		1815	220	.01	.00	.01	202.
1		0620	77	.01	.01	.00	8.	*	1		1820	221	.01	.00	.01	199.
1		0625	78	.01	.01	.00	8.	*	1		1825	222	.01	.00	.01	195.
1		0630	79	.01	.01	.00	8.	*	1		1830	223	.01	.00	.01	192.
1		0635	80	.01	.01	.00	8.	*	1		1835	224	.01	.00	.01	188.
1		0640	81	.01	.01	.00	8.	*	1		1840	225	.01	.00	.01	185.
1		0645	82	.01	.01	.00	8.	*	1		1845	226	.01	.00	.01	181.
1		0650	83	.01	.01	.00	9.	*	1		1850	227	.01	.00	.01	178.
1		0655	84	.01	.01	.00	9.	*	1		1855	228	.01	.00	.00	174.
1		0700	85	.01	.01	.00	9.	*	1		1900	229	.01	.00	.00	171.
1		0705	86	.01	.01	.00	9.	*	1		1905	230	.01	.00	.00	167.
1		0710	87	.01	.01	.00	9.	*	1		1910	231	.01	.00	.00	164.
1		0715	88	.01	.01	.00	9.	*	1		1915	232	.01	.00	.00	161.
1		0720	89	.01	.01	.00	10.	*	1		1920	233	.01	.00	.00	159.
1		0725	90	.01	.01	.00	10.	*	1		1925	234	.01	.00	.00	156.
1		0730	91	.01	.01	.00	10.	*	1		1930	235	.01	.00	.00	154.
1		0735	92	.01	.01	.00	10.	*	1		1935	236	.01	.00	.00	151.
1		0740	93	.01	.01	.00	10.	*	1		1940	237	.01	.00	.00	149.
1		0745	94	.01	.01	.00	10.	*	1		1945	238	.01	.00	.00	147.
1		0750	95	.01	.01	.00	11.	*	1		1950	239	.01	.00	.00	146.
1		0755	96	.01	.01	.00	11.	*	1		1955	240	.01	.00	.00	144.
1		0800	97	.01	.01	.00	11.	*	1		2000	241	.01	.00	.00	142.
1		0805	98	.01	.01	.00	11.	*	1		2005	242	.01	.00	.00	140.
1		0810	99	.01	.01	.00	11.	*	1		2010	243	.01	.00	.00	139.
1		0815	100	.01	.01	.00	11.	*	1		2015	244	.01	.00	.00	137.
1		0820	101	.01	.01	.00	11.	*	1		2020	245	.01	.00	.00	136.
1		0825	102	.01	.01	.00	12.	*	1		2025	246	.01	.00	.00	134.
1		0830	103	.01	.01	.00	12.	*	1		2030	247	.00	.00	.00	133.
1		0835	104	.01	.01	.00	12.	*	1		2035	248	.00	.00	.00	132.
1		0840	105	.01	.01	.00	12.	*	1		2040	249	.00	.00	.00	130.
1		0845	106	.01	.01	.00	12.	*	1		2045	250	.00	.00	.00	129.
1		0850	107	.01	.01	.00	13.	*	1		2050	251	.00	.00	.00	128.

DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q	*	DA	MON	HRMN	ORD	RAIN	LOSS	EXCESS	COMP Q
1		0855	108	.01	.01	.00	13.	*	1		2055	252	.00	.00	.00	127.
1		0900	109	.01	.01	.00	13.	*	1		2100	253	.00	.00	.00	126.
1		0905	110	.01	.01	.00	13.	*	1		2105	254	.00	.00	.00	125.
1		0910	111	.01	.01	.00	14.	*	1		2110	255	.00	.00	.00	124.
1		0915	112	.01	.01	.00	14.	*	1		2115	256	.00	.00	.00	122.
1		0920	113	.02	.01	.00	14.	*	1		2120	257	.00	.00	.00	121.
1		0925	114	.02	.01	.00	15.	*	1		2125	258	.00	.00	.00	120.
1		0930	115	.02	.01	.00	15.	*	1		2130	259	.00	.00	.00	119.
1		0935	116	.02	.01	.00	16.	*	1		2135	260	.00	.00	.00	118.
1		0940	117	.02	.01	.00	17.	*	1		2140	261	.00	.00	.00	118.
1		0945	118	.02	.02	.00	19.	*	1		2145	262	.00	.00	.00	117.
1		0950	119	.02	.02	.00	20.	*	1		2150	263	.00	.00	.00	116.
1		0955	120	.02	.02	.00	22.	*	1		2155	264	.00	.00	.00	115.
1		1000	121	.02	.02	.00	24.	*	1		2200	265	.00	.00	.00	114.
1		1005	122	.02	.02	.00	27.	*	1		2205	266	.00	.00	.00	113.
1		1010	123	.02	.02	.00	29.	*	1		2210	267	.00	.00	.00	112.
1		1015	124	.02	.02	.00	32.	*	1		2215	268	.00	.00	.00	111.
1		1020	125	.02	.02	.00	36.	*	1		2220	269	.00	.00	.00	111.
1		1025	126	.02	.02	.00	40.	*	1		2225	270	.00	.00	.00	110.
1		1030	127	.03	.02	.01	44.	*	1		2230	271	.00	.00	.00	109.
1		1035	128	.03	.02	.01	49.	*	1		2235	272	.00	.00	.00	108.
1		1040	129	.03	.02	.01	54.	*	1		2240	273	.00	.00	.00	107.
1		1045	130	.03	.03	.01	60.	*	1		2245	274	.00	.00	.00	107.
1		1050	131	.03	.03	.01	67.	*	1		2250	275	.00	.00	.00	106.
1		1055	132	.04	.03	.01	75.	*	1		2255	276	.00	.00	.00	105.
1		1100	133	.04	.03	.01	84.	*	1		2300	277	.00	.00	.00	104.
1		1105	134	.04	.03	.01	94.	*	1		2305	278	.00	.00	.00	104.
1		1110	135	.04	.03	.01	105.	*	1		2310	279	.00	.00	.00	103.
1		1115	136	.04	.03	.01	117.	*	1		2315	280	.00	.00	.00	102.
1		1120	137	.05	.03	.02	131.	*	1		2320	281	.00	.00	.00	102.
1		1125	138	.05	.04	.02	146.	*	1		2325	282	.00	.00	.00	101.
1		1130	139	.10	.06	.04	164.	*	1		2330	283	.00	.00	.00	100.
1		1135	140	.11	.07	.04	185.	*	1		2335	284	.00	.00	.00	100.
1		1140	141	.13	.07	.06	212.	*	1		2340	285	.00	.00	.00	99.
1		1145	142	.19	.10	.09	248.	*	1		2345	286	.00	.00	.00	98.
1		1150	143	.24	.12	.13	297.	*	1		2350	287	.00	.00	.00	98.
1		1155	144	.51	.21	.29	373.	*	1		2355	288	.00	.00	.00	97.

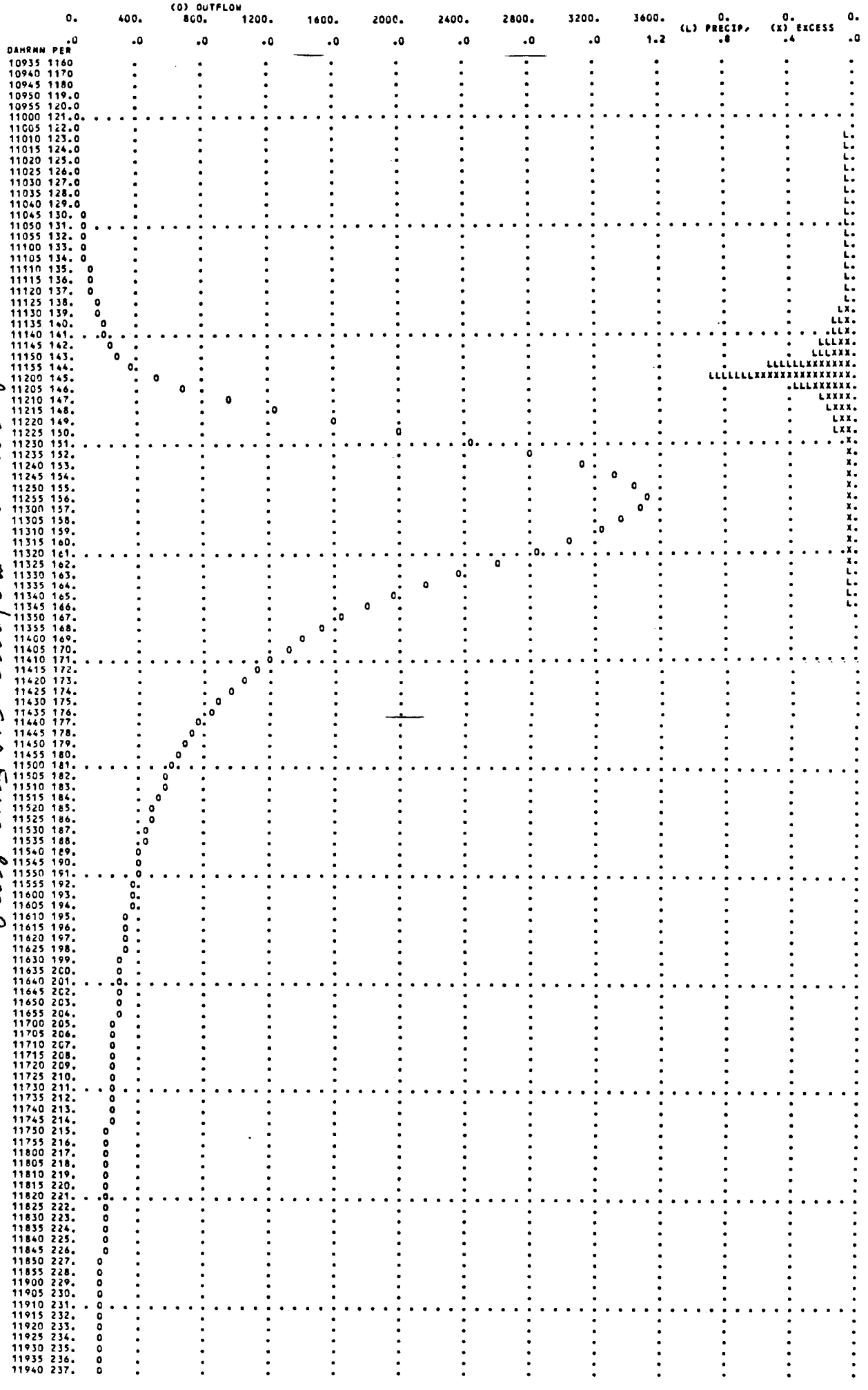
****

TOTAL RAINFALL = 6.07, TOTAL LOSS = 2.70, TOTAL EXCESS = 3.37

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	23.92-HR
		(CFS)	1105.	323.	323.	323.
3501.	12.92	(INCHES)	2.854	3.321	3.321	3.321
		(AC-FT)	548.	638.	638.	638.

CUMULATIVE AREA = 3.60 SQ MI

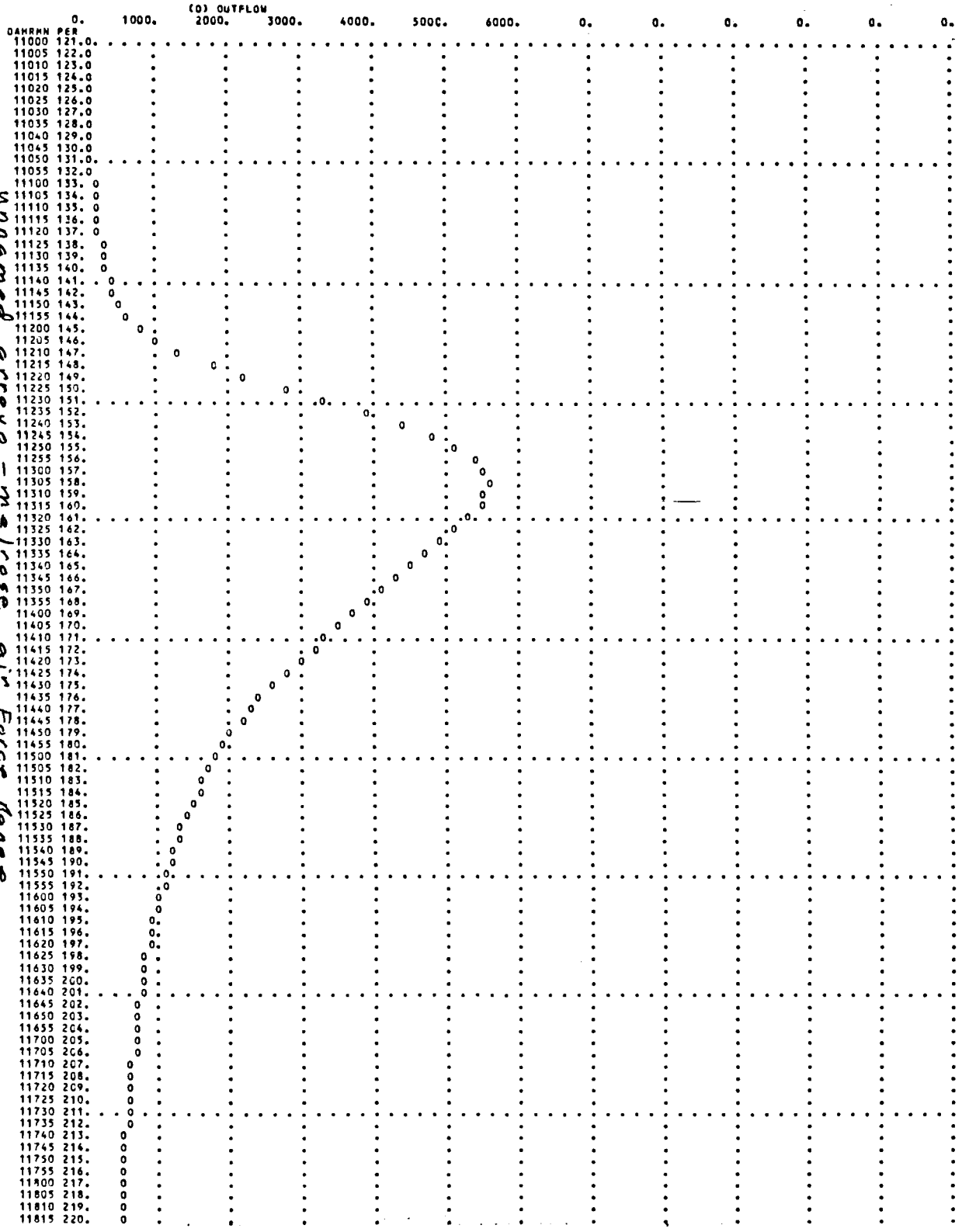
STATION G1


(O) OUTFLOW
0. 400. 800. 1200. 1600. 2000. 2400. 2800. 3200. 3600.
(L) PRECIP. 0. .8
(X) EXCESS 0. .4
DAHRMN PER
Unnamed Arroyo - Melrose Air Force Range
Channel or gully flow hydrograph

```
                 *************
                 *           *
24 KK            *     G2    *        BASIN OUTLET
                 *           *
                 *************

25 KO            OUTPUT CONTROL VARIABLES
                       IPRNT          4  PRINT CONTROL
                       IPLOT          2  PLOT CONTROL
                       QSCAL         0.  HYDROGRAPH PLOT SCALE
                             COMBINE HYDROGRAPHS OF SUBBAINS

27 HC            HYDROGRAPH COMBINATION
                       ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE
```

***
STATION G2

(O) OUTFLOW



unnamed arroyo - melrose air Force Range
overland flow plus channel flow hydrograph

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

	OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
+	HYDROGRAPH AT	01	2566.	13.58	1157.	345.	345.	3.70		
+	HYDROGRAPH AT	G1	3501.	12.92	1105.	323.	323.	3.60		
+	2 COMBINED AT	G2	5552.	13.08	2258.	667.	667.	7.30		

*** NORMAL END OF HEC-1 ***

```
T1          UNNAMED ARROYO (MELROSE BOMBING RANGE)
J1          0.05,.10,.02,1.0
J3          3 23 26 6 16 17 5 28 27 29 30 14 15 13  *
*
D           5550
SK           .002
XT    4     1940 * * * .009
GR          0,101.6 50,101.1 262,97.9 296,95.2 334,97.8 503,98.3 743,97.6
N           .022
XS    8     3300 * * * .009
GT          -12.8
N           .022
XS    7     2960  * * * .009
GT          -9.6
N           .022
XS    6     2620 * * * .009
GT          -6.4
N           .022
XS    5     2280 * * * .009
GT          -3.2
N           .022
XS    4     1940
GT
N           .022
XS    3     1600
GR          0,105.4 230,102.1 380,101.1 556,99.7 672,99.5 723,98.4 821,101.1
GR          975,102.4 1084,102.3 2000,102.6
N           .022,.024
SA          1000
XS    2     1090
GR          0,106.4 67,105.7 257,104.1 387,102.0 482,98.9 552,99.8 690,104.0
GR          803,103.9 1009,103.4 2000,104.2
N           .022, .024
SA          700
XS    1     485
GR          0,110.6 243,109.2 448,106.9 536,105.1 613,99.9 673,101.8 864,107.3
GR          1036,107.0 1252,105.7 1482,104.8 2000,106.2
N           .022, .024
SA          865
PX    1
PX    2
PX    3
PX    4
PX    5
PX    6
PX    7
PX    8
EX          1
ER
```

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

           *** RUN DATE & TIME: 01-29-93  13:03

  T1        UNNAMED ARROYO (MELROSE BOMBING RANGE)
  J1        0.05,.10,.02,1.0

J1 RECORD PARAMETERS:
DELTAY = 0.05   YTOL = 0.10   QTOL = 0.02   FNTEST = 1.00   IHFNOJ = -1

  J3        3 23 26 6 16 17 5 28 27 29 30 14 15 13  *
  *
  Q         5550
*** Q-DATA FOR SEC-ID, ISEQ =            1
  SK          .002
```

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

*** START PROCESSING CROSS SECTION - "4     "
  XT   4     1940 * * * .009
+++014 WARNING:  EXCESS DATA ITEMS IGNORED.
  GR         0,101.6 50,101.1 262,97.9 296,95.2 334,97.8 503,98.3 743,97.6
  N          .022

*** FINISH PROCESSING CROSS SECTION - "4     "
*** TEMPLATE CROSS SECTION "4     " SAVED INTERNALLY.
```

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

*** START PROCESSING CROSS SECTION - "8     "
  XS   8    3300 * * * .009
  GT        -12.8
  N         .022

*** FINISH PROCESSING CROSS SECTION - "8     "
*** CROSS SECTION "8     " WRITTEN TO DISK, RECORD NO. =  1

--- DATA SUMMARY FOR SECID "8     " AT SRD =   3300.  ERR-CODE =      0

     SKEW      IHFNO     VSLOPE        EK        CK
      0.0        0.     0.0090      0.50      0.00

X-Y COORDINATE PAIRS  (NGP =   7):
       X       Y          X       Y          X       Y          X       Y
     0.0   88.80       50.0   88.30      262.0   85.10      296.0   82.40
   334.0   85.00      503.0   85.50      743.0   84.80

 X-Y MAX-MIN POINTS:
    XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
     0.0   88.80      296.0   82.40      743.0   84.80        0.0   88.80

ROUGHNESS COEFFICIENTS (NSA =  1):
        0.022
```

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

*** START PROCESSING CROSS SECTION - "7     "
  XS   7     2960  * * * .009
  GT         -9.6
  N          .022

*** FINISH PROCESSING CROSS SECTION - "7     "
*** CROSS SECTION "7     " WRITTEN TO DISK, RECORD NO. =  2

--- DATA SUMMARY FOR SECID "7     " AT SRD =   2960.  ERR-CODE =      0

     SKEW      IHFNO     VSLOPE        EK        CK
      0.0        0.     0.0090      0.50      0.00

X-Y COORDINATE PAIRS  (NGP =   7):
       X       Y          X       Y          X       Y          X       Y
     0.0   92.00       50.0   91.50      262.0   88.30      296.0   85.60
   334.0   88.20      503.0   88.70      743.0   88.00

 X-   .AX-MIN POINTS:
     XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
      0.0   92.00      296.0   85.60      743.0   88.00        0.0   92.00

ROUGHNESS COEFFICIENTS (NSA =  1):
        0.022
```

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

*** START PROCESSING CROSS SECTION - "6     "
  XS   6     2620 * * * .009
  GT         -6.4
  N          .022

*** FINISH PROCESSING CROSS SECTION - "6     "
*** CROSS SECTION "6     " WRITTEN TO DISK, RECORD NO. =  3

--- DATA SUMMARY FOR SECID "6     " AT SRD =   2620.  ERR-CODE =      0

     SKEW      IHFNO     VSLOPE        EK        CK
      0.0        0.     0.0090      0.50      0.00

X-Y COORDINATE PAIRS  (NGP =   7):
       X       Y          X       Y          X       Y          X       Y
      0.0   95.20       50.0   94.70      262.0   91.50      296.0   88.80
    334.0   91.40      503.0   91.90      743.0   91.20

 X-Y  AX-MIN POINTS:
     MIN       Y          X    YMIN       XMAX       Y          X    YMAX
      0.0   95.20      296.0   88.80      743.0   91.20        0.0   95.20

ROUGHNESS COEFFICIENTS (NSA =  1):
        0.022
```

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

*** START PROCESSING CROSS SECTION - "5    "
  XS   5    2280 * * * .009
  GT         -3.2
  N           .022

*** FINISH PROCESSING CROSS SECTION - "5    "
*** CROSS SECTION "5    " WRITTEN TO DISK, RECORD NO. =  4

--- DATA SUMMARY FOR SECID "5    " AT SRD =   2280.  ERR-CODE =      0

     SKEW      IHFNO     VSLOPE        EK        CK
      0.0        0.     0.0090      0.50      0.00

X-Y COORDINATE PAIRS  (NGP =   7):
       X       Y          X       Y          X       Y          X       Y
      0.0   98.40       50.0   97.90      262.0   94.70      296.0   92.00
    334.0   94.60      503.0   95.10      743.0   94.40

 X-   AX-MIN POINTS:
     XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
      0.0   98.40      296.0   92.00      743.0   94.40        0.0   98.40

ROUGHNESS COEFFICIENTS (NSA =  1):
        0.022
```

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

*** START PROCESSING CROSS SECTION - "4     "
  XS   4     1940
  GT
  N          .022

*** FINISH PROCESSING CROSS SECTION - "4     "
*** CROSS SECTION "4     " WRITTEN TO DISK, RECORD NO. =  5

--- DATA SUMMARY FOR SECID "4     " AT SRD =   1940.  ERR-CODE =      0

     SKEW      IHFNO     VSLOPE        EK        CK
      0.0        0.     0.0090      0.50      0.00

X-Y COORDINATE PAIRS  (NGP =   7):
       X       Y          X       Y          X       Y          X       Y
      0.0  101.60      50.0  101.10     262.0   97.90     296.0   95.20
    334.0   97.80     503.0   98.30     743.0   97.60

 X-Y  \X-MIN POINTS:
     XMIN       Y          X    YMIN      XMAX       Y          X    YMAX
      0.0  101.60     296.0   95.20     743.0   97.60        0.0  101.60

ROUGHNESS COEFFICIENTS (NSA =  1):
        0.022
```

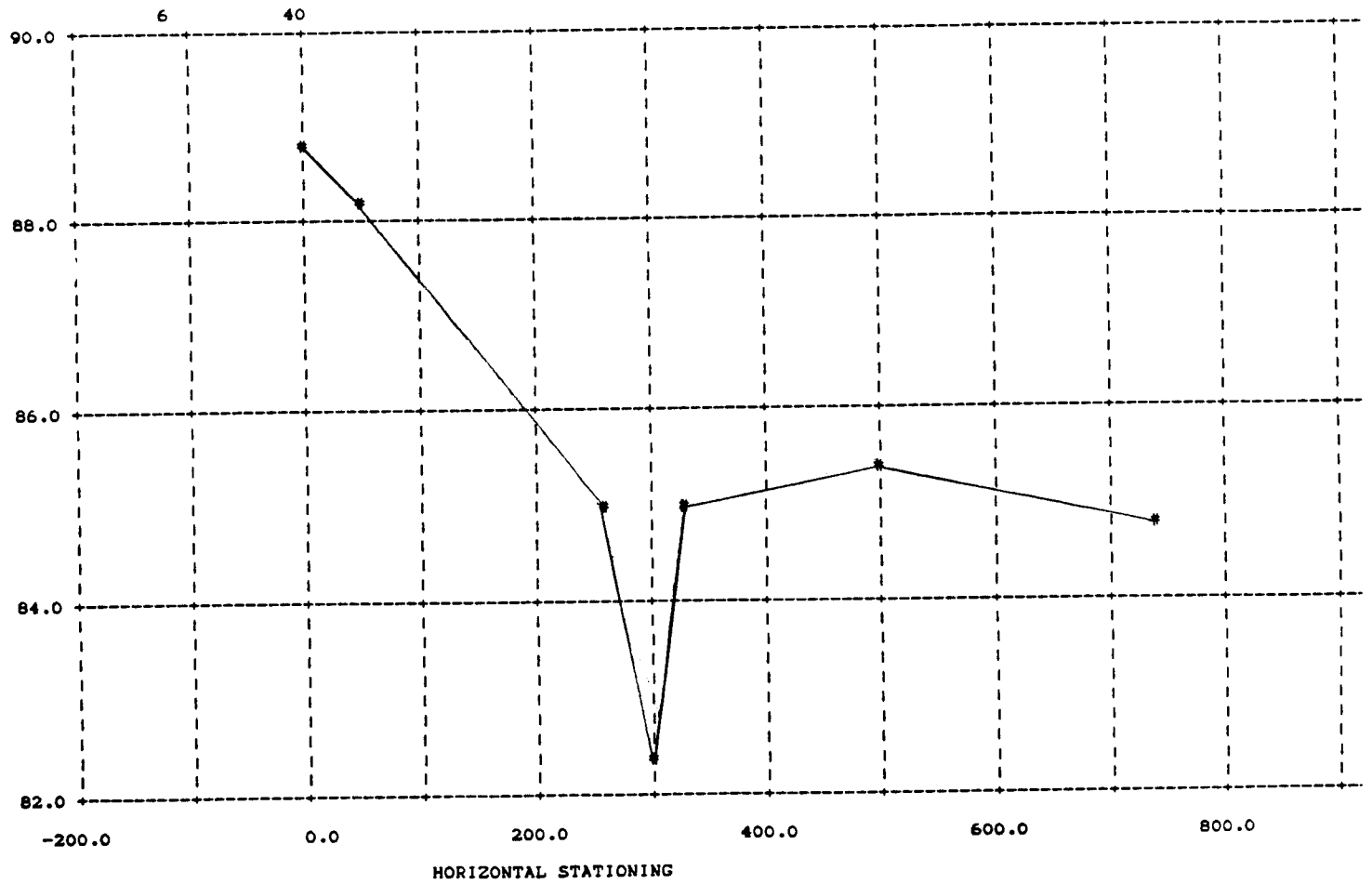
```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

*** START PROCESSING CROSS SECTION - "3     "
  XS   3     1600
  GR         0,105.4 230,102.1 380,101.1 556,99.7 672,99.5 723,98.4 821,101.1
  GR         975,102.4 1084,102.3 2000,102.6
  N          .022,.024
  SA         1000

*** FINISH PROCESSING CROSS SECTION - "3     "
*** CROSS SECTION "3     " WRITTEN TO DISK, RECORD NO. =  6

--- DATA SUMMARY FOR SECID "3     " AT SRD =   1600.  ERR-CODE =      0

     SKEW      IHFNO     VSLOPE        EK        CK
      0.0        0.     0.0090      0.50      0.00

X-Y COORDINATE PAIRS  (NGP =  10):
       X       Y          X       Y          X       Y          X       Y
     0.0  105.40      230.0  102.10      380.0  101.10      556.0   99.70
     2.0   99.50      723.0   98.40      821.0  101.10      975.0  102.40
    4.0  102.30     2000.0  102.60

 X-Y MAX-MIN POINTS:
     XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
      0.0  105.40      723.0   98.40     2000.0  102.60        0.0  105.40

SUBAREA BREAKPOINTS (NSA =  2):
       1000.

ROUGHNESS COEFFICIENTS (NSA =  2):
        0.022   0.024
```

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

*** START PROCESSING CROSS SECTION - "2     "
  XS   2     1090
  GR         0,106.4 67,105.7 257,104.1 387,102.0 482,98.9 552,99.8 690,104.0
  GR         803,103.9 1009,103.4 2000,104.2
  N          .022, .024
  SA         700

*** FINISH PROCESSING CROSS SECTION - "2     "
*** CROSS SECTION "2     " WRITTEN TO DISK, RECORD NO. =  7

--- DATA SUMMARY FOR SECID "2     " AT SRD =   1090.  ERR-CODE =       0

     SKEW      IHFNO     VSLOPE        EK        CK
      0.0        0.     0.0090      0.50      0.00

X-Y COORDINATE PAIRS  (NGP =  10):
       X       Y          X       Y          X       Y          X       Y
     0.0  106.40       67.0  105.70      257.0  104.10      387.0  102.00
     `2.0   98.90      552.0   99.80      690.0  104.00      803.0  103.90
   . ,9.0  103.40     2000.0  104.20

 X-Y MAX-MIN POINTS:
     XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
      0.0  106.40      482.0   98.90     2000.0  104.20        0.0  106.40

 SUBAREA BREAKPOINTS (NSA =  2):
        700.

 ROUGHNESS COEFFICIENTS (NSA =  2):
        0.022   0.024
```

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

*** START PROCESSING CROSS SECTION - "1     "
  XS   1     485
  GR         0,110.6 243,109.2 448,106.9 536,105.1 613,99.9 673,101.8 864,107.3
  GR         1036,107.0 1252,105.7 1482,104.8 2000,106.2
  N          .022, .024
  SA         865
  PX   1

*** FINISH PROCESSING CROSS SECTION - "1     "
*** CROSS SECTION "1     " WRITTEN TO DISK, RECORD NO. =  8

--- DATA SUMMARY FOR SECID "1     " AT SRD =    485.  ERR-CODE =       0

     SKEW      IHFNO     VSLOPE        EK        CK
      0.0        0.     0.0090      0.50      0.00

X-Y COORDINATE PAIRS  (NGP =  11):
       X       Y          X       Y          X       Y          X       Y
     0.0  110.60      243.0  109.20      448.0  106.90      536.0  105.10
     3.0   99.90      673.0  101.80      864.0  107.30     1036.0  107.00
  1252.0  105.70     1482.0  104.80     2000.0  106.20

 X-Y MAX-MIN POINTS:
     XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
     0.0  110.60      613.0   99.90     2000.0  106.20        0.0  110.60

SUBAREA BREAKPOINTS (NSA =  2):
        865.

ROUGHNESS COEFFICIENTS (NSA =  2):
        0.022   0.024
```

unnamed Arroyo - Melrose Air Force Range

--- CROSS SECTION OUTLINE PLOT --- SEQ-NOB = 1 SEC-REF-DIST = 3300.0 SECID = '8 '

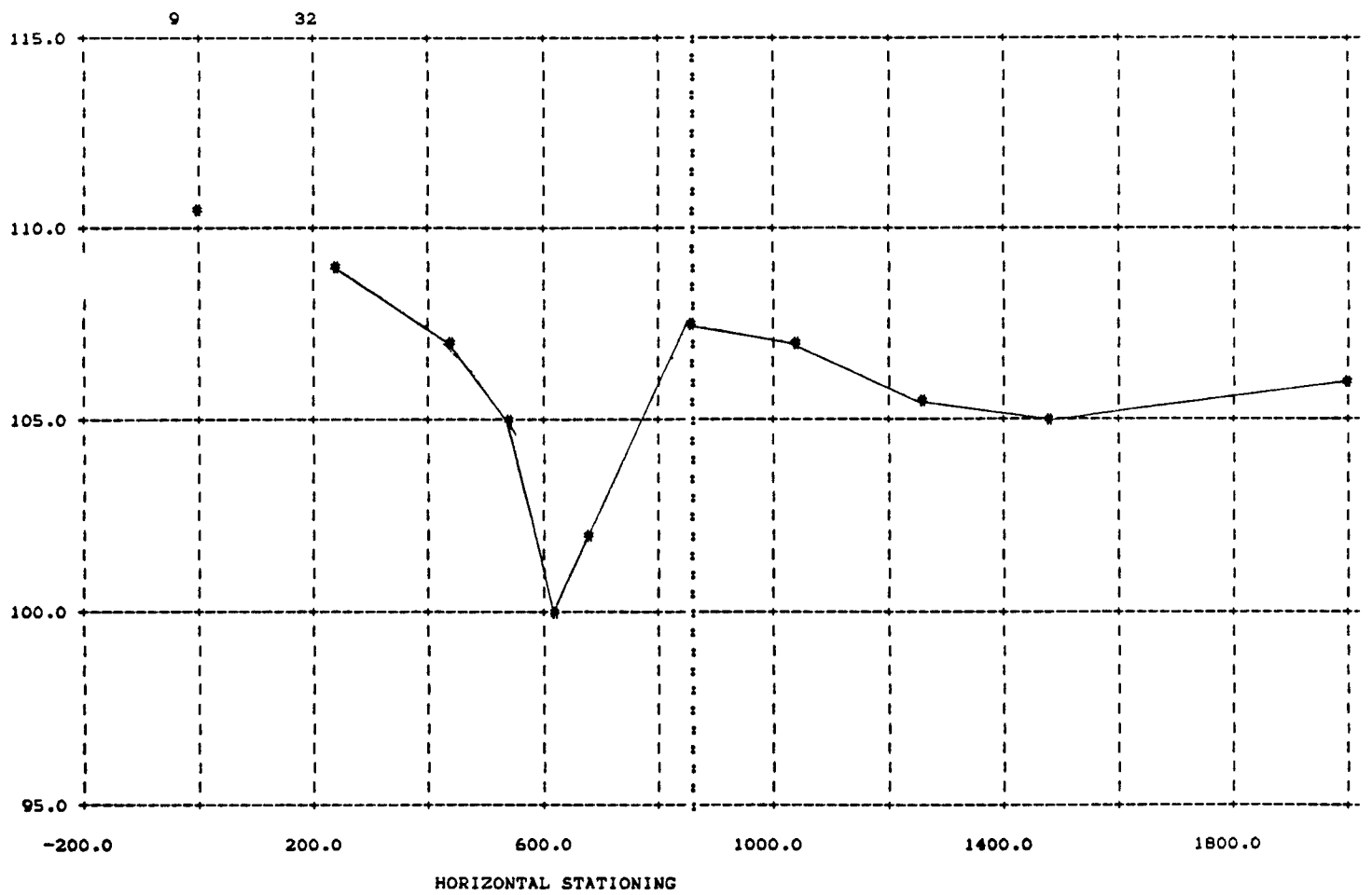


EX 1

+++ BEGINNING PROFILE CALCULATIONS -- 1

unnamed arroyo - Melrose Air Force Range

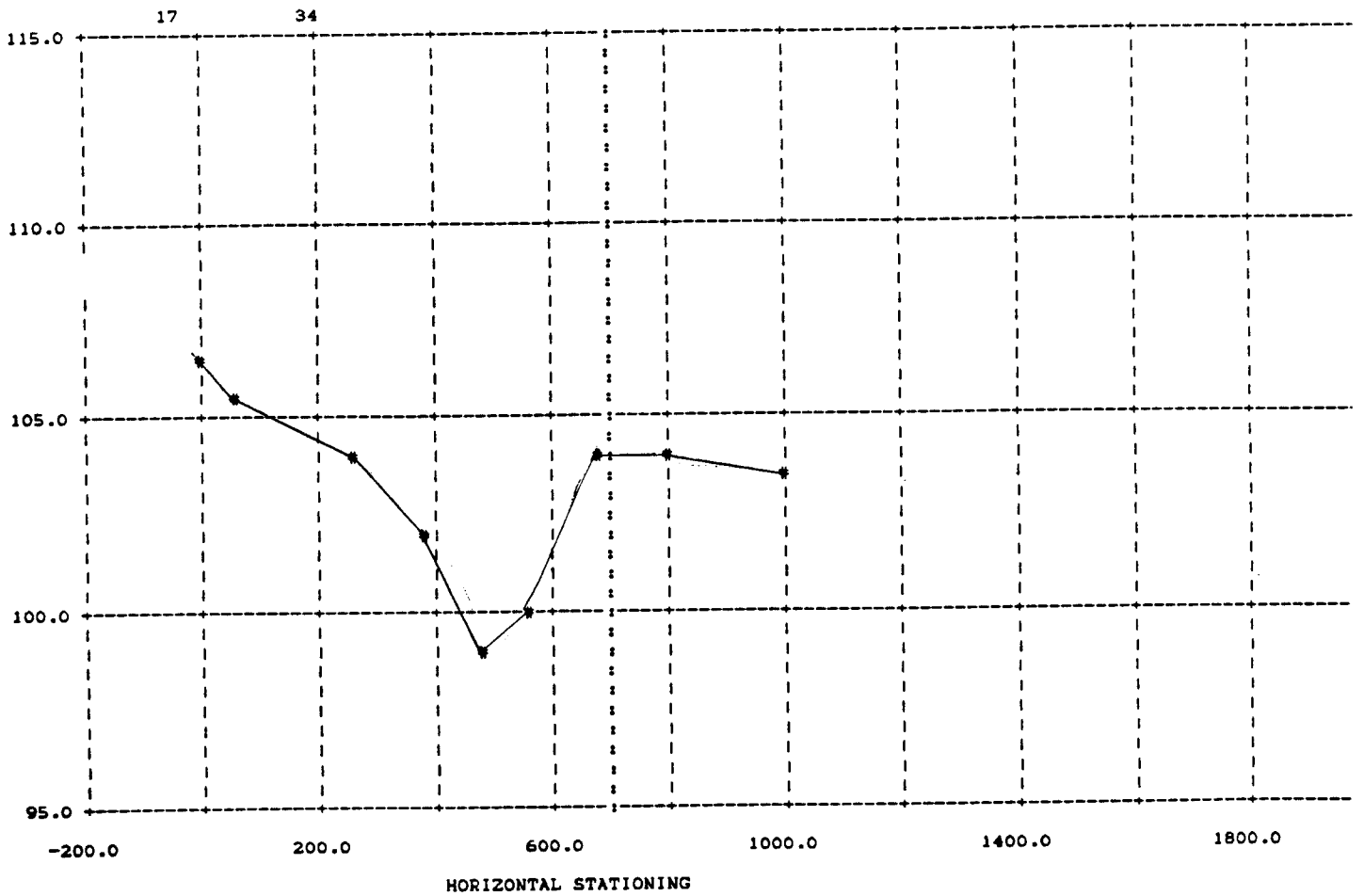
--- CROSS SECTION OUTLINE PLOT --- SEQ-NOB = 8 SEC-REF-DIST = 485.0 SECID = '1 '



PX 2

unnamed Arroyo - Melrose Air Force Range

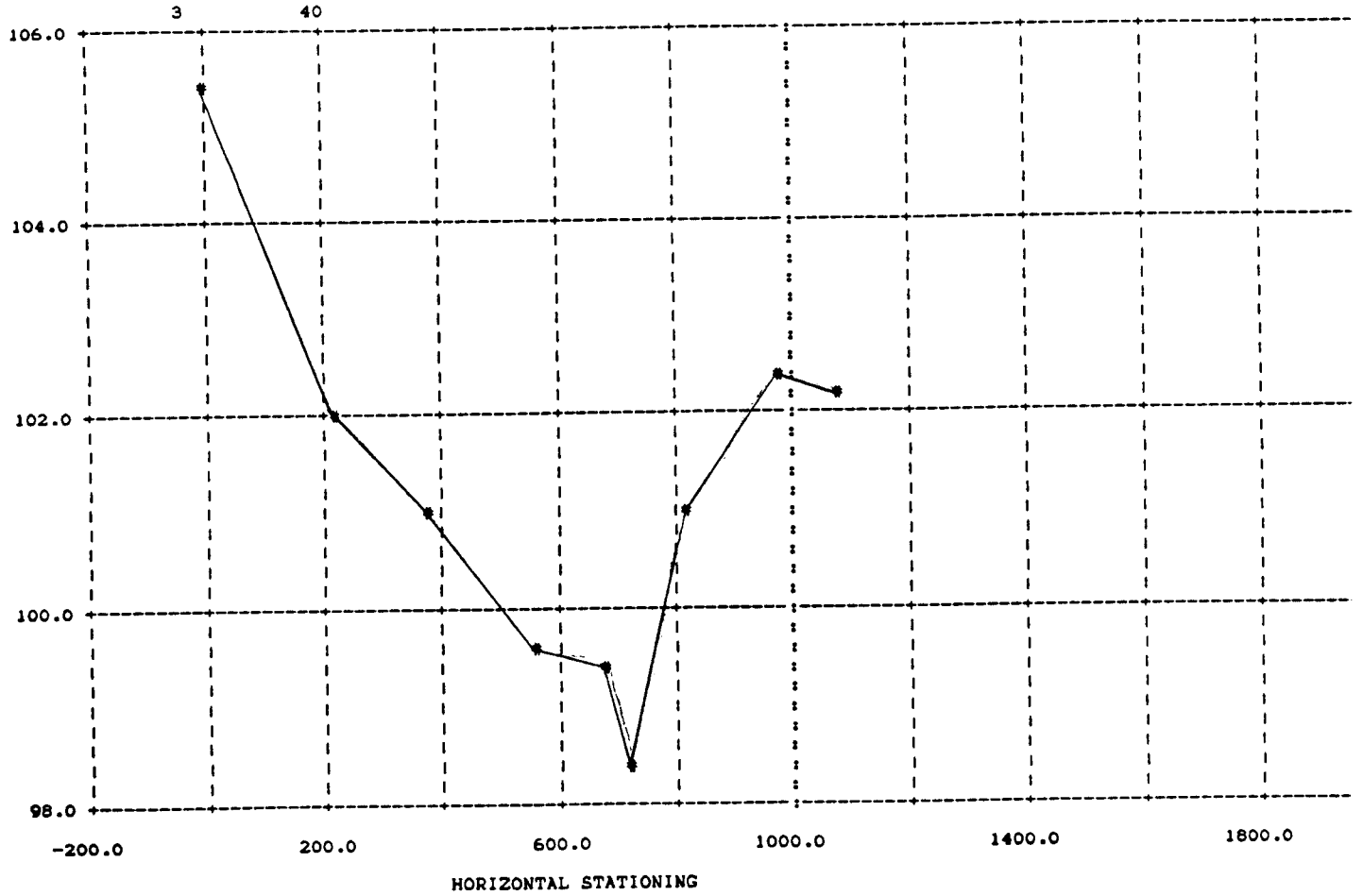
--- CROSS SECTION OUTLINE PLOT --- SEQ-NOB = 7 SEC-REF-DIST = 1090.0 SECID = '2



PX 3

unnamed arroyo - Melrose Air Force Range

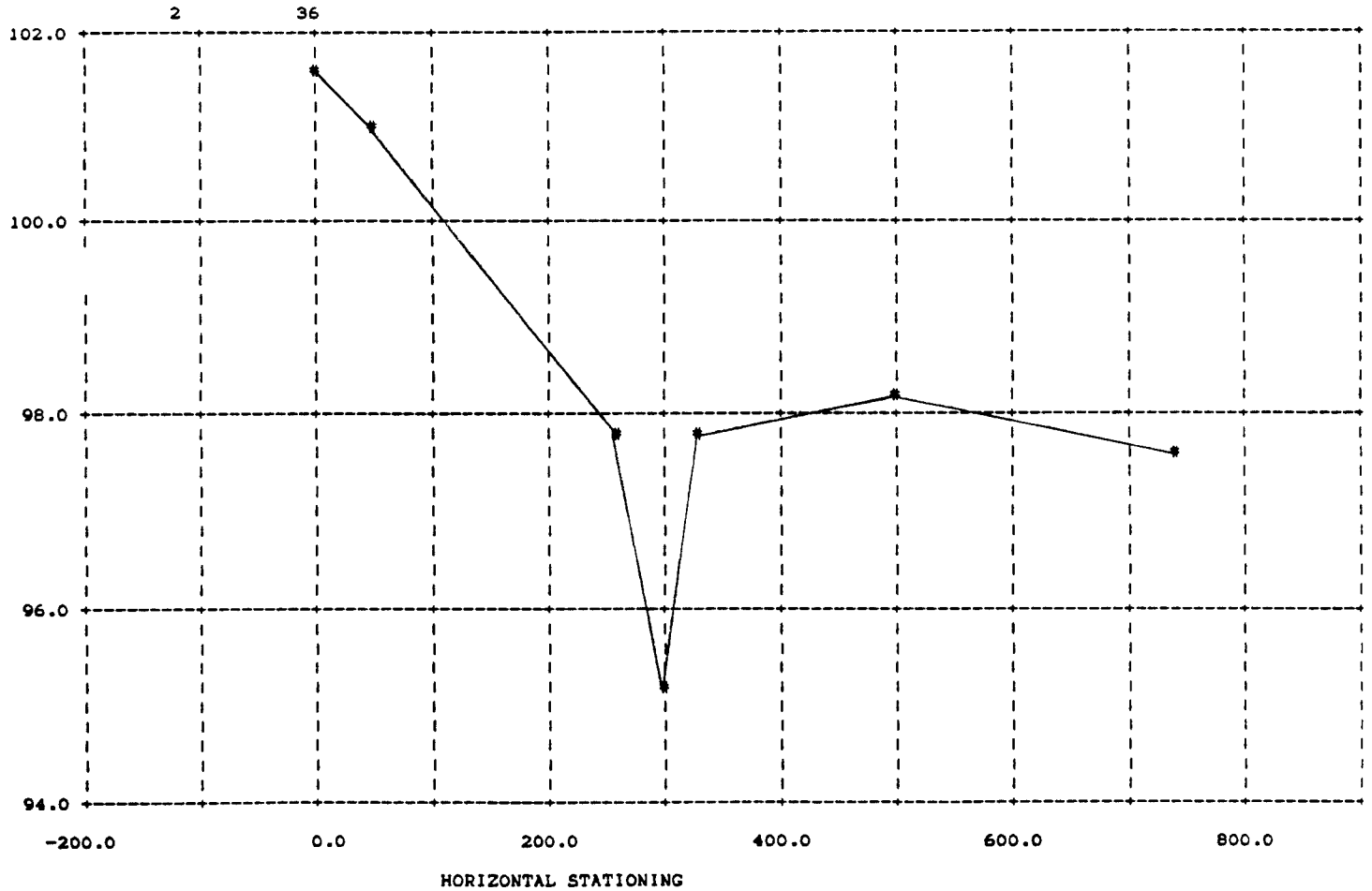
--- CROSS SECTION OUTLINE PLOT --- SEQ-NOB = 6 SEC-REF-DIST = 1600.0 SECID = '3



PX 4

unnamed arroyo – Melrose Air Force Range

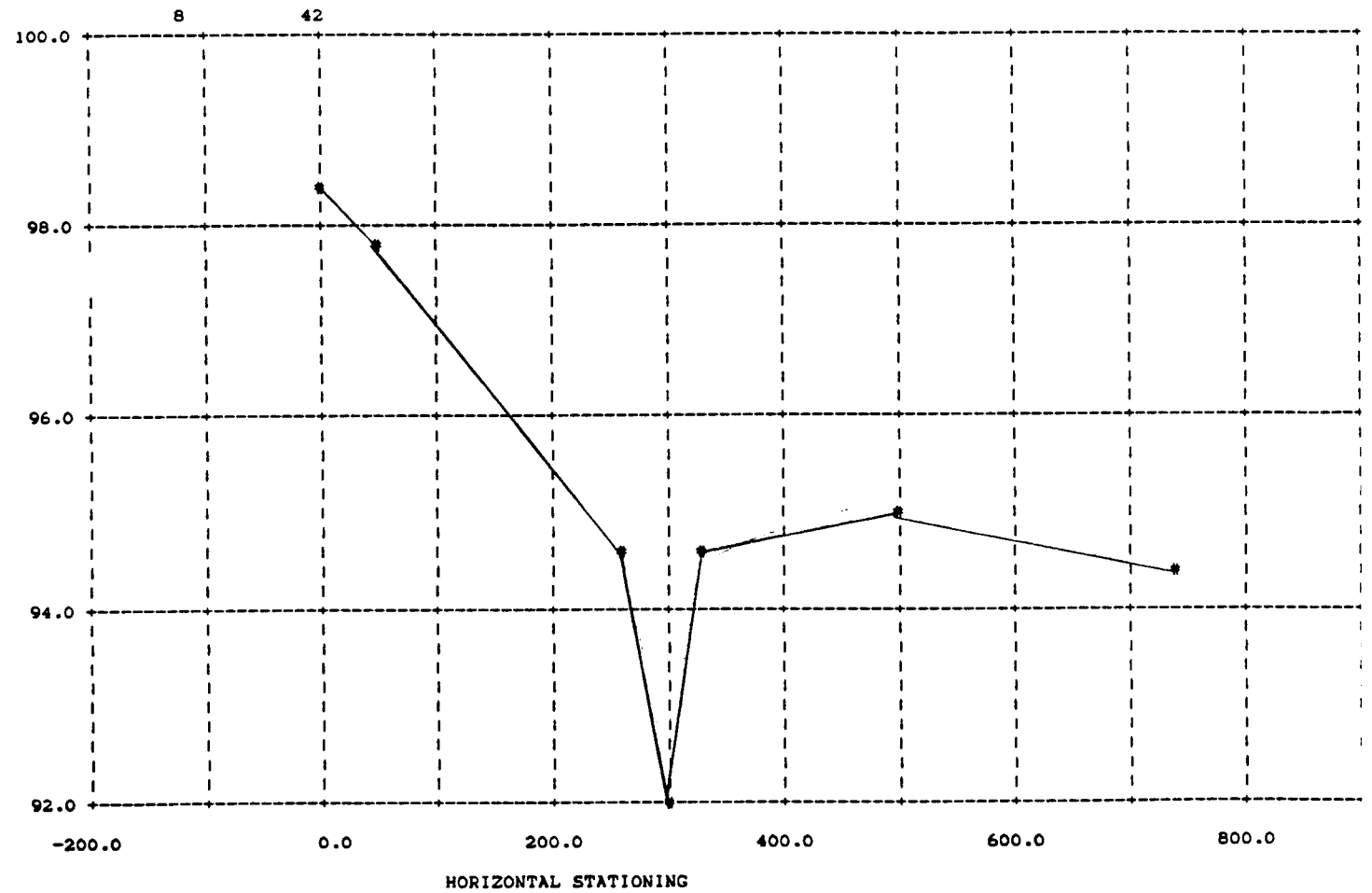
--- CROSS SECTION OUTLINE PLOT --- SEQ-NOB = 5 SEC-REF-DIST = 1940.0 SECID = '4 '



PX 5

Unnamed arroyo - Melrose Air Force Range

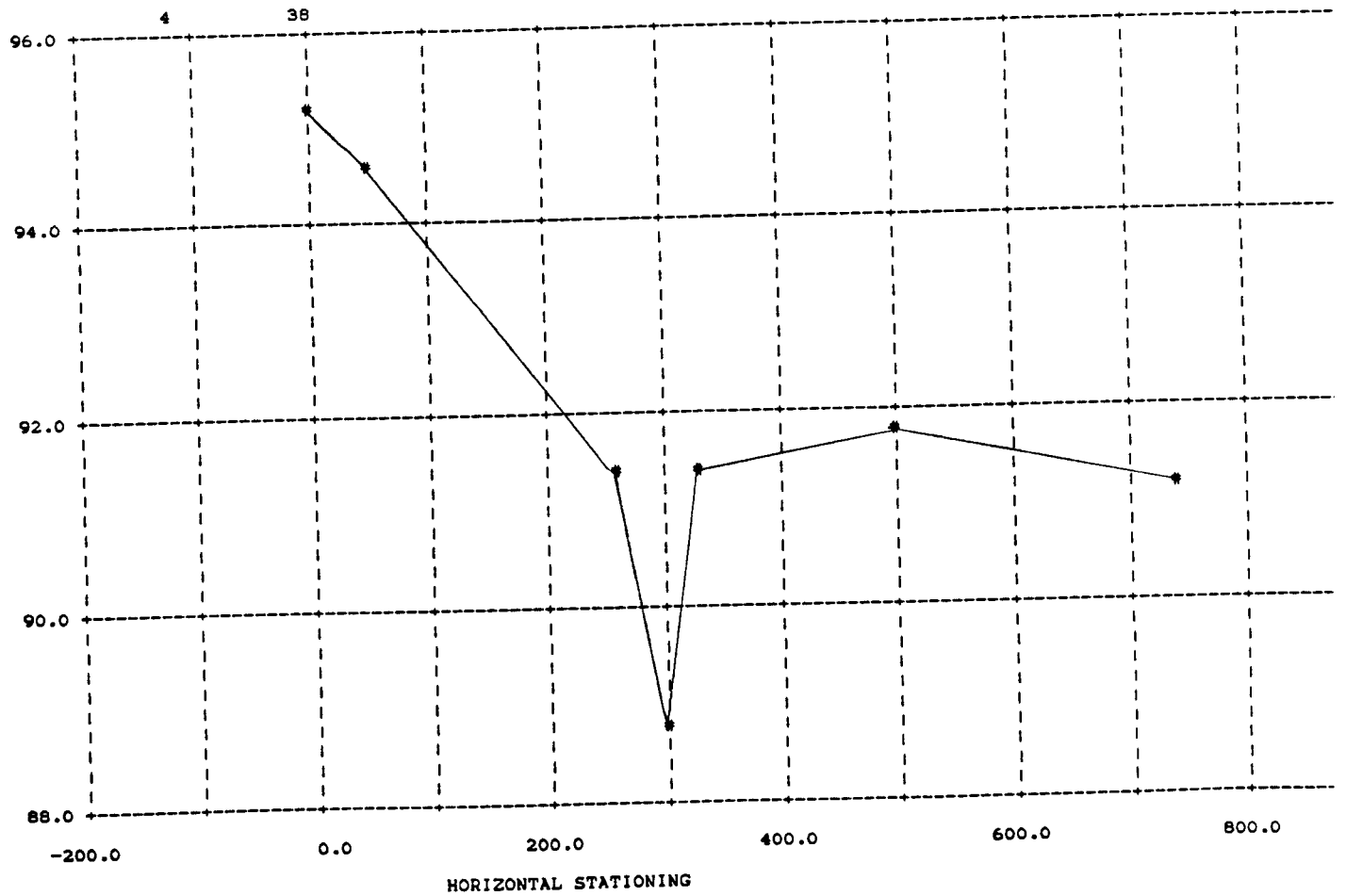
--- CROSS SECTION OUTLINE PLOT --- SEQ-NOB = 4 SEC-REF-DIST = 2280.0 SECID = '5 '



PX 6

unnamed arroyo - Melrose Air Force Range

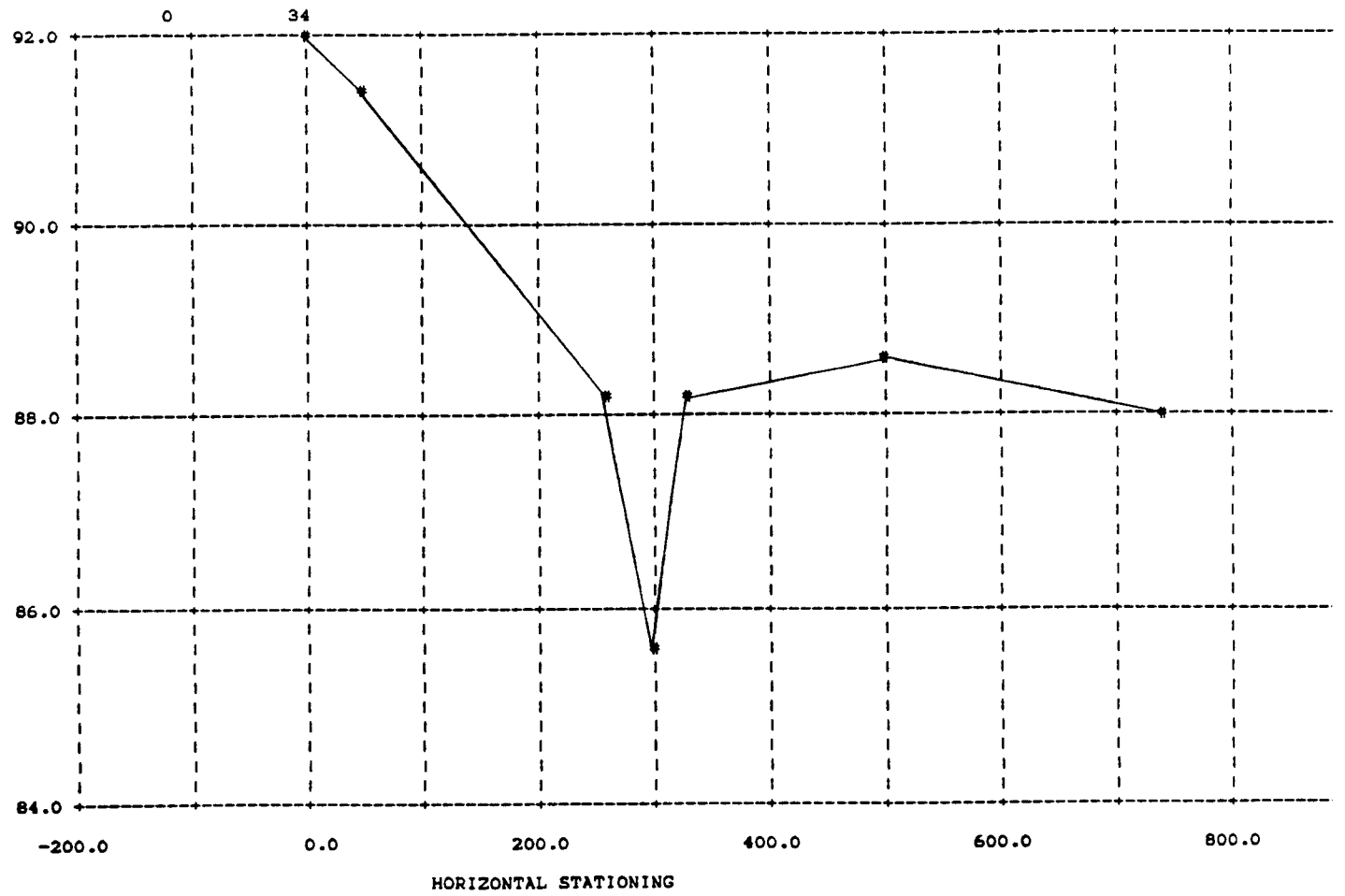
--- CROSS SECTION OUTLINE PLOT --- SEQ-NOB = 3 SEC-REF-DIST = 2620.0 SECID = '6



PX 7

Unnamed arroyo – Melrose Air Force Range

--- CROSS SECTION OUTLINE PLOT --- SEQ-NOB = 2 SEC-REF-DIST = 2960.0 SECID = '7



PX B

```
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        UNNAMED ARROYO (MELROSE BOMBING RANGE)
           *** RUN DATE & TIME: 01-29-93  13:03

 ===015 WSI IN WRONG FLOW REGIME AT SECID "1     ":  USED WSI = CRWS.
                                WSI,CRWS =   105.81      105.25

 XSID:CODE   SRDL    LEW      AREA   VHD     HF      EGL     CRWS        Q     WSEL
       SRD   FLEN    REW         K  ALPH     HO      ERR      FR#      VEL

1     :XS   ******   528.      749.  0.97 *****  106.23   105.25    5550.  105.25
      485. ******  1650.    88764.  1.14 ***** *******     1.19     7.41

 ===110 WSEL NOT FOUND AT SECID "2     ":  REDUCED DELTAY.
                     WSLIM1,WSLIM2,DELTAY =   102.98       99.10    -0.02

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "2     "
                     WSBEG,WSEND,CRWS =   102.98       99.10     102.98

2     :XS     605.   326.      692.  1.00 *****  103.99   102.98    5550.  102.98
     1090.    605.   657.    76647.  1.00 ***** *******     0.98     8.02

 ===110 WSEL NOT FOUND AT SECID "3     ":  REDUCED DELTAY.
                     WSLIM1,WSLIM2,DELTAY =   101.68       98.60    -0.02

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "3     "
                     WSBEG,WSEND,CRWS =   101.68       98.60     101.68

3     :XS     510.   293.      840.  0.68 *****  102.36   101.68    5550.  101.68
     1600.    510.   890.    71450.  1.00 ***** *******     0.98     6.61

 ===140 AT SECID "4     ":  END OF CROSS SECTION EXTENDED VERTICALLY.
                                WSEL,YLT,YRT =    99.26      101.60      97.60

4     :XS     340.   172.      777.  0.79  2.27  100.05    99.31    5550.   99.26
     1940.    340.   743.    64482.  1.00  0.00    0.03     1.08     7.14

 ===140 AT SECID "5     ":  END OF CROSS SECTION EXTENDED VERTICALLY.
                                WSEL,YLT,YRT =    95.88       98.40      94.40

5     :XS     340.   184.      677.  1.04  3.12   96.93    96.11    5550.   95.88
     2280.    340.   743.    52023.  1.00  0.00    0.00     1.31     8.19

 ===140 AT SECID "6     ":  END OF CROSS SECTION EXTENDED VERTICALLY.
                                WSEL,YLT,YRT =    92.86       95.20      91.20

6     :XS     340.   172.      777.  0.79  3.12   93.65    92.91    5550.   92.86
     2620.    340.   743.    64482.  1.00  0.13    0.03     1.08     7.14

 ===140 AT SECID "7     ":  END OF CROSS SECTION EXTENDED VERTICALLY.
                                WSEL,YLT,YRT =    89.48       92.00      88.00

7     :XS     340.   184.      677.  1.04  3.12   90.53    89.71    5550.   89.48
     2960.    340.   743.    52023.  1.00  0.00    0.00     1.31     8.19

 ===140 AT SECID "8     ":  END OF CROSS SECTION EXTENDED VERTICALLY.
                                WSEL,YLT,YRT =    86.46       88.80      84.80
```

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS

UNNAMED ARROYO (MELROSE BOMBING RANGE)
*** RUN DATE & TIME: 01-29-93 13:03
FIRST USER DEFINED TABLE.

XSID	:CODE	WSEL	YMIN	SKEW	SRD	K	AREA	Q	XSTW	XSWP	LEW	REW	FR#	CRWS
8	:XS	86.46	82.40	0.	3300.	64482.	777.	5550.	571.	573.	172.	743.	1.08	86.51
7	:XS	89.48	85.60	0.	2960.	52023.	677.	5550.	559.	561.	184.	743.	1.31	89.71
6	:XS	92.86	88.80	0.	2620.	64482.	777.	5550.	571.	573.	172.	743.	1.08	92.91
5	:XS	95.88	92.00	0.	2280.	52023.	677.	5550.	559.	561.	184.	743.	1.31	96.11
4	:XS	99.26	95.20	0.	1940.	64482.	777.	5550.	571.	573.	172.	743.	1.08	99.31
3	:XS	101.68	98.40	0.	1600.	71450.	840.	5550.	597.	597.	293.	890.	0.98	101.68
2	:XS	102.98	98.90	0.	1090.	76647.	692.	5550.	331.	331.	326.	657.	0.98	102.98
1	:XS	105.25	99.90	0.	485.	88764.	749.	5550.	549.	549.	528.	1650.	1.19	105.25

ER

9-230

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

File No. { Washington ..... District .....

Unnamed Arroyo – Melrose Air Force Range

Section 1 STA	Section 1 ELEV		Section 2 STA	Section 2 Elev		Section 3 STA	Section 3 Elev		Section 4 STA	Section 4 Elev	
0	110.6		0	106.4		0	105.4		0	101.6	
243	109.2		67	105.7		230	102.1		50	101.1	
448	106.5		257	104.1		380	101.1		262	97.9	
536	105.1		387	102.0		556	99.7		296	95.2	←
613	95.5	←	482	98.9	←	672	99.5		334	97.8	
673	101.8		552	99.8		723	98.4	←	503	98.3	
864	107.3		690	124.0		821	101.1		743	97.6	
1036	107.0		803	103.9		975	102.4				
1252	105.7		1009	103.4		1084	102.3				
1482	104.8					1347	100.3				

Section 5 STA	Section 5 Elev		Section 6 STA	Section 6 Elev		Station 7 STA	Station 7 Elev		Section 8 STA	Section 8 Elev	
0	83.4		0	90.7		0	79.6		0	77.6	
442	87.3		142	89.9		175	79.3		230	70.4	
927	89.6		316	88.2		262	79.4		488	69.2	
1199	91.6		324	87.0	←	411	77.4		686	68.2	
1312	101.6		332	88.3		567	78.9		848	67.7	
1444	92.6		355	88.4		745	79.2		1031	67.9	
1549	92.5	←	500	88.8		816	79.0		1134	68.6	
1672	92.6					830	77.8	←	1304	68.2	
1653	91.3					842	79.0		1491	67.8	
1788	92.9					1158	79.1		1710	68.3	
2692	93.3		Y min	FALL	SRD	1544	78.7		1907	67.8	
		1	99.9	0	485	1801	78.0		2115	67.6	←
		2	98.9	1.0	1090				2357	68.0	
		3	98.4	0.5	1600				2599	66.8	
		4	95.2	3.2	1940				2804	67.0	
		5	92.5	2.7	3090				2986	66.9	
		6	87.0	5.5	3540						
		7	77.8	9.2	4210						
		8	67.6	10.2	5430						

U.S. GOVERNMENT PRINTING OFFICE: 1965—O-763-759 857-606

EDM FIELD NOTES FOR INDIRECT DISCHARGE MEASUREMENT

Site: Unnamed Arroyo - Melrose Air Force Range

Flood date: _____

Survey Party: Phillips & Waltemeyer II Survey Date: 1-25-98

Instrument no.: _____ Date of two peg test: _____

Weather: _____

Hub 1 @ _____

Elevation of Hub: 92.18

Measure-up: 4.70

HI computation

100	+	8.30-5.18	+		=	96.88
	+		+		=	
	+		+		=	

HI = 96.88

low rod = 5.18 high rod = 8.83

Station	Azimuth Degree	Min	Sec	Distance (at hub 1)	Rod	Elev	Remarks
RP 1	190	02	55	1592	+8.30	100.00	-assumed
hub 2	246	46	45	644	+6.73	98.43	
	A Section						section parallel rod with towers
1.00	351	42	40	1625	-8.27	83.43	
442	350	58	50	1183	-4.44	87.26	
485	350	53	00	698	-2.06	89.64	
272	350	14	25	426	-.09	91.61	
113	349	26	35	314	+.49	101.57	
132	348	11	45	182	+.91	92.61	
105	347	13	40	77	+.79	92.49	
73	346	32	25	55	+.95	92.65	
31	343	08	45	23	-.33	91.31	
135	160	28	55	111	+1.24	92.94	
904	167	24	10	1014	+1.60	93.30	
R							
	B Section						Proceeding downstream
R 0	58	14	00	452	-2.87	88.83	
145	39	29	55	426	-3.32	88.38	
23	36	38	45	418	-3.44	88.26	
8	35	30	40	420	-4.68	87.02	
8	34	26	00	419	-3.47	88.23	
174	10	56	10	434	-1.71	89.99	
L 142	354	15	15	485	-1.00	90.70	
	C SECTION						
L	18	21	55	1407	-12.11	79.59	
175	75	24	45	1370	-12.39	79.31	
87	29	02	00	1361	-12.35	79.35	

Sheet 1 of ___ sheets computed: SDW checked: _____ rpt88NM

EDM FIELD NOTES FOR INDIRECT DISCHARGE MEASUREMENT

Site: Unnamed Arroyo - Melrose Air Force Range

Flood date: _____

Survey Party: _____ Survey Date: 1-25-93

Instrument no.: _____ Date of two peg test: _____

Weather: _____

Hub 3 @ _____

Elevation of Hub: _____

Measure-up: ③ 5.02

HI - 96.88

HI computation

_____ + _____ + _____ - _____

_____ + _____ + _____ - _____

_____ + _____ + _____ - _____

low rod - _____ high rod - _____

Station	Azimuth Degree	Min	Sec	Distance	Rod	Elev	Remarks
149	29	39	00	1360	-14.33	77.37	
156	30	18	50	1358	-12.77	78.93	
178	37	50	25	1332	-12.49	79.21	
71	40	30	55	1341	-12.65	79.05	
14	41	26	25	1342	-13.93	77.77	
12	41	36	55	1343	-12.69	79.01	
316	55	14	15	1375	-12.60	79.10	
386	65	33	00	1516	-13.04	78.66	
R 257	77	41	20	1642	-13.65	78.05	
⊡3	44	13	55	1501	-13.21	78.49	10' NE of Fence outside range HI = 92.18 + (-8.54) = 83.64 HI = 78.49 + 5.02 = 83.51
	↗ @ ⊡3			HI = 83.56			
⊡1	224	13	55	1501	+13.22	92.10	
	D SECTION						
L 0	330	33	05	1411	-3.82	77.56	
230	339	48	20	1354	-7.94	70.44	
258	349	40	20	1220	-9.14	69.24	
198	358	13	10	1127	-10.19	68.19	
162	6	12	30	1074	-10.68	67.70	
183	15	39	50	1012	-10.50	67.88	
103	21	19	25	980	-9.26	68.62	
170	31	17	50	970	-10.16	68.22	
187	42	16	30	990	-10.52	67.86	
219	54	07	45	1051	-10.11	68.27	
197	63	22	30	1139	-10.57	67.81	
208	71	21	00	1263	-10.81	67.57	
242	79	46	00	1406	-10.36	68.02	
242	86	09	00	1583	-11.55	66.79	

Sheet 2 of ____ sheets computed: SDW checked: _____ rpt88NM

EDM FIELD NOTES FOR INDIRECT DISCHARGE MEASUREMENT

Site: Unnamed Arroyo - Melrose Air Force Range

Flood date: _____

Survey Party: _____ Survey Date: 1-25-26-93

Instrument no.: _____ Date of two peg test: _____

Weather: _____

Hub ___ @ _____

Elevation of Hub: _____

Measure-up: _____

From page 2

HI = 83.56

HI computation

① 100.00 + 3.86 + 5.18 + _____ = 109.04

_____ + _____ + _____ = _____

_____ + _____ + _____ = _____

low rod = 5.18 high rod = 8.83

Station	Azimuth Degree	Min	Sec	Distance	Rod	Elev	Remarks
205	90	11	05	1751	-11.33	67.05	
182	83	29	40	1898	-11.51	66.87	
R 0							
⊡ 4	17	30	45	1486	-14.01	64.37	
	01-26-93				① HI	109.04	
RP 1	84	28	30	744	-9.86	100.00	Given
⊡ 2	19	04	35	1479	-5.45	98.41	by yellow truck
	E SECTION						
L 0	277	42	00	1390	+6.74	110.60	
243	273	17	40	1167	+5.38	109.24	
205	268	45	10	980	+3.00	106.86	
88	266	50	00	898	+1.24	105.10	
77	264	13	05	831	-.32	99.89	
60	264	05	30	771	+1.63	101.84	
191	256	02	20	606	+3.47	107.33	Norm L
172	244	09	20	475	+3.13	106.99	
216	223	42	55	307	+1.85	105.71	
230	175	23	00	216	+0.94	104.80	
R							
	F SECTION						
R 0	26	21	05	33	-0.42	103.44	
206	319	20	40	217	+.06	103.92	
113	319	03	15	330	+.18	104.04	
138	315	57	00	466	-4.04	99.82	
70	315	24	30	536	-4.92	98.94	
95	315	45	35	631	-1.82	102.04	
130	316	02	35	760	~~+0.28~~ +0.28	104.14	

Sheet 3 of ___ sheets computed: SDW checked: _____ rpt88NM

EDM FIELD NOTES FOR INDIRECT DISCHARGE MEASUREMENT

Site: Unnamed arroyo - Melrose Air Force Range

Flood date: _____

Survey Party: _____ Survey Date: 1-26-93

Instrument no.: _____ Date of two peg test: _____

Weather: _____

Hub ___ @ _____

Elevation of Hub: _____

Measure-up: _____

HI computation

_____ + _____ + _____ = _____

_____ + _____ + _____ = _____

_____ + _____ + _____ = _____

HI = 109.04

low rod = 5.18 high rod = 8.83 41

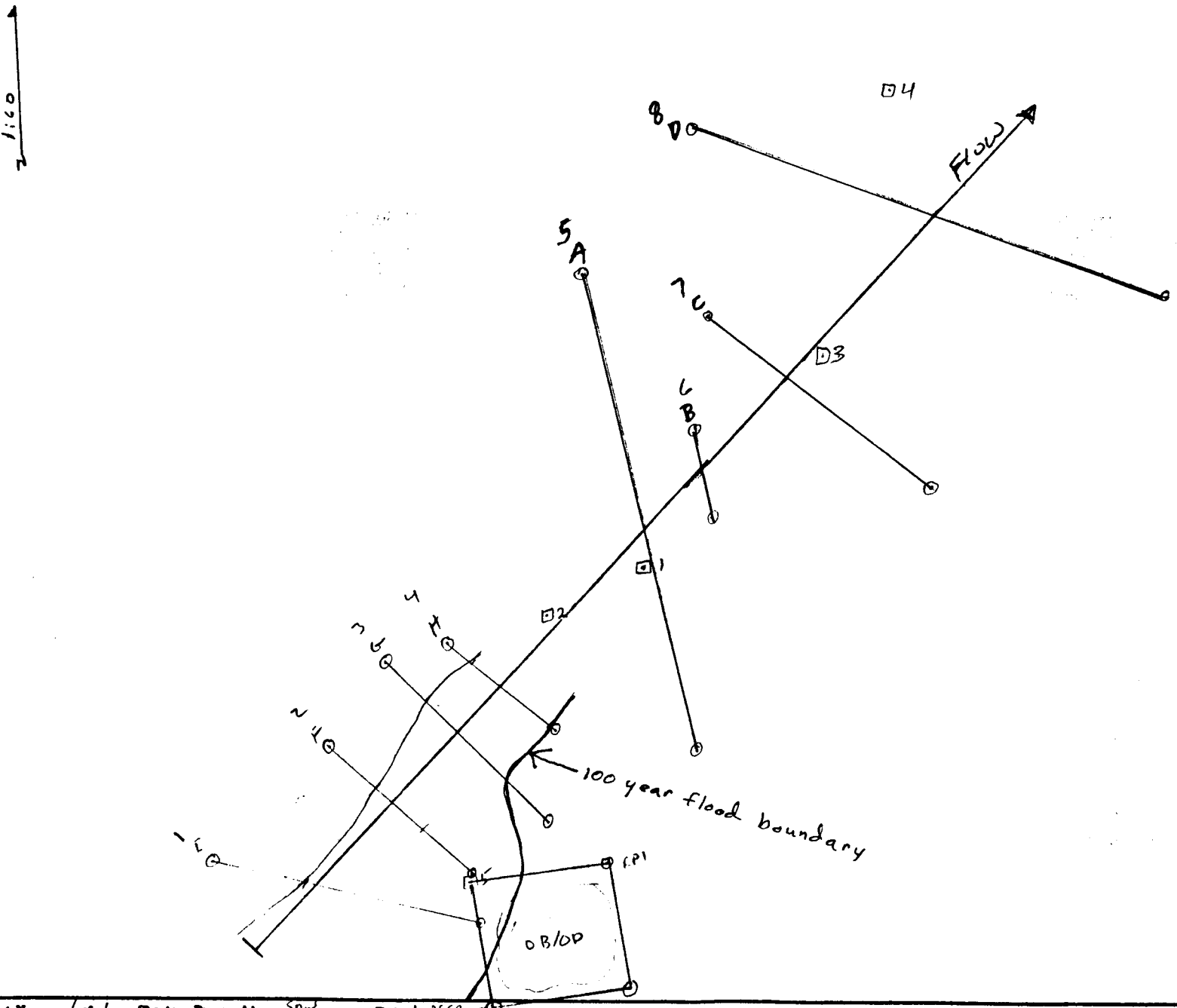
	Station	Azimuth Degree	Min	Sec	Distance	Rod	Elev	Remarks
	190	315	15	30	950	+1.87	105.73	
	67	315	19	45	1017	+2.52	106.38	
	L							
			G	SECTION				
	LO	342	01	05	1266	+1.54	105.40	
	230	346	58	55	1059	-1.72	102.14	
	150	348	16	05	910	-2.72	101.14	
	176	350	47	30	739	-4.15	99.71	
	116	353	01	30	626	-4.35	99.51	
	51	353	44	35	575	-5.50	98.36	
	98	356	46	40	482	-2.76	101.10	
	154	11	25	15	371	-1.51	102.35	
	109	28	22	20	342	-1.53	102.33	
R	263	56	56	55	506	-3.60	100.26	
			H	SECTION				
	RO	32	38	55	917	-6.31	97.55	
	240	18	23	25	970	-5.55	98.31	
	169	9	21	20	1037	-6.00	97.86	
	38	7	51	00	1058	-8.69	95.17	
	34	6	36	00	1083	-5.94	97.92	
	212	358	59	10	1230	-2.74	101.12	
LO	50	357	29	10	1267	-2.21	101.65	
Pit	NW	200	35	40	10	-.03	103.83	
Pit	700	174	20	20	709	+1.07	104.93	
Pit	749	127	42	45	1030	-5.05	98.81	
RPI	706	84	28	30	743	-3.91	99.95	

Sheet 4 of ___ sheets computed: SDW checked: _____ rpt88NM

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File .....

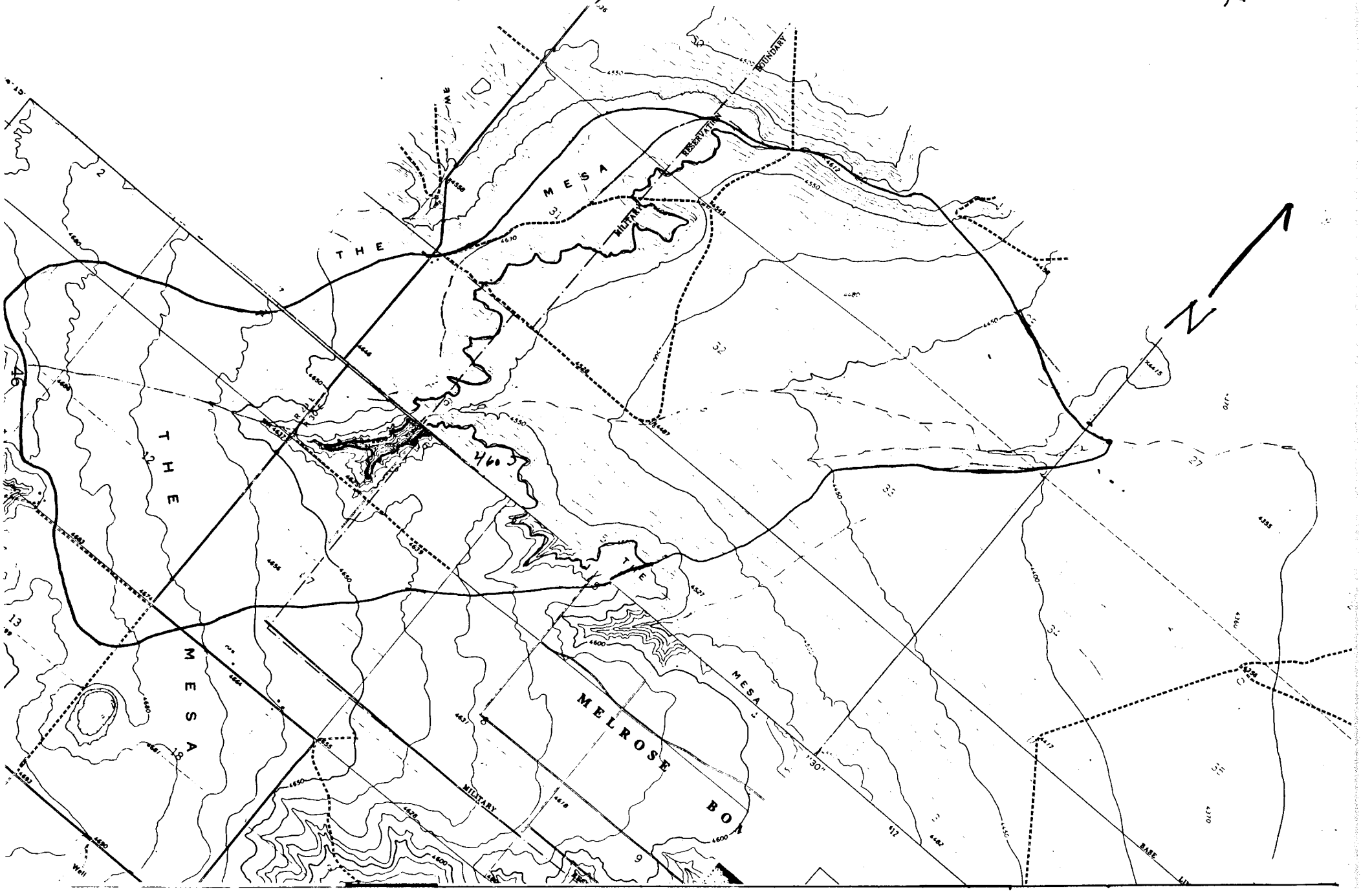
UNNAMED ARROYO (MELROSE BOMBING RANGE)



Section	SRD-feet
1	485
2	1090
3	1600
4	1940
5	3090
6	3540
7	4210
8	5430

Sheet No. 1 of 1 Sheets. Prepared by SPJ Date 1-28-53 Checked by ..... Date .....

FOLD

GPO : 1978 O - 270-903

Map showing unnamed Arroyo on Melrose Air Force Range