

RD99-179  
DOE/CD-ETEC-4886 (revised)

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**DRAFT DOCKET**

**FOR THE RELEASE OF BUILDING 4886 AS PART OF  
THE  
ENERGY TECHNOLOGY ENGINEERING CENTER  
CLOSURE**

September 1999 (Revised March 2000)

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**U.S. DEPARTMENT OF ENERGY  
OAKLAND OPERATIONS OFFICE  
ENVIRONMENTAL RESTORATION**

## **FORWARD**

The purpose of this Docket is to document the successful decontamination & decommissioning of Facility 4886, also known as Former Sodium Disposal Facility (FSDF), operated by the former Energy Technology Engineering Center (ETEC) at the Santa Susana Field Laboratory (SSFL), Area IV; and that the facility is suitable for release for unrestricted use. The material in this Draft Docket consists of documents supporting the status that conditions at the former facility 4886 are in compliance with applicable DOE and proposed Environmental Protection Agency and Nuclear Regulatory Commission standards and criteria established to protect human health, safety, and the environment.

The Boeing Company  
Rocketdyne Propulsion & Power  
6633 Canoga Avenue  
P.O. Box 7922  
Canoga Park, CA 91309-7922

April 13, 2000  
In reply refer to 2000RC-1706

Mr. Michael E. Lopez  
US Department of Energy  
Oakland Operations Office  
1301 Clay Street  
Oakland, CA 94612-5208

Subject: DE-AC03-99SF21530, Environmental Restoration and Remediation of  
the former Energy Technology Engineering Center (ETEC) Site  
Reporting Requirements Checklist, Part III, Section J, B/4886 Draft  
Certification Docket (*Revised*)

Dear Mr. Lopez:

The Draft Certification Docket pertaining to the decontamination and decommissioning of Building 4886, which was located in Area IV of Rocketdyne's Santa Susana Field Laboratory, was submitted to you in September 1999. The draft docket was revised to replace the Facility Final Report (Exhibit 4) with the revised report. No other changes were made. The revised draft docket is enclosed herewith for your information and retention.

Should you have any questions concerning this transmittal, please contact the undersigned at (818) 586-5283.

Sincerely,



Majelle Lee  
Program Manager  
Environmental Programs

G.O. 97055

Encl.: RD99-179 (revised), Draft Docket for the Release of B/4886 as Part of ETEC Closure, 2 copies

cc: (w/attach) Office of Scientific and Technical Information, Department of Energy,  
175 Oak Ridge Turnpike, P.O. Box 62, Oak Ridge, TN 37831

RD99-179 (revised)



## REVISION

The revision of this draft docket consists of replacing the Final Report for D&D of FSDF (Exhibit IV) with its latest revision, Revision A.

## **CONTENTS**

- EXHIBIT I** Document (Letter, dated 10 March 1995, from DOE to ETEC removing RMMA designation for the facility) supporting the certification for the unrestricted use of Facility 4886 in Area IV at Santa Susana Field Laboratory (SSFL)
- EXHIBIT II** Sitewide release criteria for remediation of facilities at SSFL and associated documentation
- EXHIBIT III** Document from California Department of Health Services Releasing the Former Sodium Disposal Facility (4886) to unrestricted use
- EXHIBIT IV** Facility 4886 Final Report(s)
- EXHIBIT V** Final Documentation and Radiological Survey(s) of Facility 4886 after decontamination and decommissioning
- EXHIBIT VI** National Environmental Policy Act (NEPA) documentation for decontamination and decommissioning of Facility 4886

## **EXHIBIT I**

**DOCUMENT (LETTER, DATED 10 MARCH 1995, FROM DOE TO ETEC  
REMOVING RMMA DESIGNATION FOR THE FACILITY) SUPPORTING  
THE CERTIFICATION FOR THE UNRESTRICTED USE OF FACILITY  
4886 IN AREA IV AT SANTA SUSANA FIELD LABORATORY (SSFL)**



Department of Energy  
Oakland Operations Office  
1301 Clay Street  
Oakland, California 94612-5208

MAR 10 1995

Dr. D.C. Gibbs  
General Manager  
Energy Technology Engineering Center  
Rocketdyne Division  
Rockwell International Corporation  
P.O. Box 7930  
Canoga Park, CA 91309-7930

Subject: Removal of RMMA Designation for the Sodium Disposal Facility  
(Reference: 94EETEC-DRF-0048)

Dear Dr. Gibbs:

EETEC requested removal of designation of this facility as a Radiological Materials Management Area (RMMA) in the referenced letter. The survey results of EETEC's post-remediation gamma survey of the Sodium Disposal Facility, B886, show that radioactivity levels are indistinguishable from the surrounding area. EETEC is now authorized to remove the RMMA designation for the Sodium Disposal Facility.

Sincerely,

A handwritten signature in cursive script, appearing to read "James T. Davis".

James T. Davis  
Assistant Manager  
for Environmental  
Management and Support

**EXHIBIT II**

**SITEWIDE RELEASE CRITERIA FOR REMEDIATION OF FACILITIES  
AT SSFL AND ASSOCIATED DOCUMENTATION**

# memorandum

DATE: 0 5 SEP 1996  
REPLY TO  
ATTN OF: DOE Oakland Operations Office(ERD)  
SUBJECT: Radiological Site Release Criteria for ETEC  
  
TO: Sally Robison, EM-44

I am requesting the approval of the radiation site release criteria for the Energy Technology Engineering Center. The release criteria are a critical component in the DOE process for releasing facilities for unrestricted use. The California Department of Health Services has approved the site release criteria in a letter dated August 9 (see attachment 1).

The proposed limits were developed in the following way:

- 1) Annual exposure dose. Rocketdyne proposes to use a dose limit of 15 mrem/yr to comply with the 100 mrem plus ALARA as required by DOE 5400.5). This limit is also consistent with the anticipated rules of the NRC and EPA.
- 2) Ambient exposure rate. The proposed limit of  $5\mu\text{R/hr}$  above natural background complies with the limit of  $20\mu\text{R/hr}$ , plus ALARA, as stated in DOE Order 5400.5. This proposed limit is consistent with NRC limits for Rocketdyne facilities at the Santa Susana Field Laboratory. This limit would be imposed for accessible, or potentially accessible, structures and land.
- 3) Surface contamination. Surface contamination limits comply with DOE Order 5400.5 and specify the potential contaminants present in the Rocketdyne facilities.
- 4) Generic Limits for Soil and Water. The generic limits for soil and water were established using the DOE pathway analysis code RESRAD.

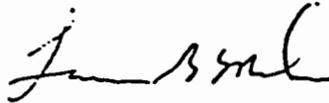
09/16/96  
[Signature]

Ms. Robison

2

The proposed site release criteria are included in "Proposed Sitewide Release Criteria for Remediation of Facilities at the SSFL", Revision A, N001SRR140127.

Your approval is requested by September 16, 1996.



Laurence McEwen  
Acting Director  
Environmental  
Restoration Division

Attachments

cc: R. Liddle, ESO  
M. Lopez, ERD  
D. Williams, EM-443

96-ER-095/

# memorandum



DATE: SEP 17, 1996

REPLY TO  
ATTN OF: EM-44 (D. Williams, 903-8173)

SUBJECT: Sitewide Limits for Release of Facilities Without Radiological Restriction

TO: R. Liddle, Oakland Operations Office

We have reviewed Rocketdyne's proposed sitewide limits for release of facilities at the Santa Susana Field Laboratory (SSFL) without radiological restriction and are satisfied that our previous concerns and comments have been addressed.

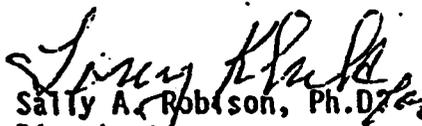
The proposed limits are consistent with the Department of Energy (DOE) Order 5400.5 requirement for a Total Effective Dose Equivalent limit of 100 mrem/yr plus As low As Reasonably Achievable (ALARA) for future occupants, the Nuclear Regulatory Commission proposed a radiological guideline of 15 mrem/yr ALARA, and the Environmental Protection Agency proposed a guideline of 15 mrem/yr for release of properties.

Corrective actions taken by Rocketdyne for the sampling and statistical approach to final survey data validation for DOE projects are now comparable to methodologies or standard practices used at other DOE sites and the requirements of Nuclear Regulatory Commission Nuclear Regulation (NUREG)/CR-5489 (Manual for Conducting Radiological Surveys in Support of License Termination).

We also received a copy of the letter from the California Department of Health Services stating concurrence with the proposed release guidelines and the intent to incorporate these guidelines into Rocketdyne's California Radioactive Material License.

Based upon the above information, the proposed sitewide release criteria for remediation of facilities at the SSFL are hereby approved for use.

If you have any questions, please call Mr. Don Williams of my staff at 301-903-8173.

  
Sally A. Robison, Ph.D.  
Director  
Office of Northwestern Area Programs  
Environmental Restoration

007857 RC





## DEPARTMENT OF HEALTH SERVICES

714/744 P STREET  
P.O. BOX 942732  
SACRAMENTO, CA 94234-7320

96ETEC-DRF-0455

(916) 323-2759

August 9, 1996

Ms. Majelle Lee, Program Manager  
Environmental Management  
Rocketdyne Division  
Rockwell International Corporation  
P. O. Box 7930  
Canoga Park, CA 91309-7930

Subject: Authorized Sitewide Radiological Guidelines for Release  
of Unrestricted Use

Dear Ms. Lee:

This letter is to acknowledge the receipt of your letter dated June 28, 1996 requesting concurrence of the above subject. The above mentioned letter and its attachments have been reviewed by the staff of this office. The Radiologic Health Branch (RHB) concurs that the proposed release guidelines provide adequate assurance for the release of the facilities and properties at Rocketdyne's Santa Susana Field Laboratory (SSFL) and DeSoto sites without further radiological restrictions. Your letter dated June 28, 1996 with attachments will be incorporated into Rocketdyne's California Radioactive Material License # 0015-70 upon receipt of a commitment letter signed by Mr. Phil Rutherford.

If you have any questions concerning this matter, please feel free to call Mr. Stephen Hsu of this office at (916) 322-4797.

Sincerely,

A handwritten signature in cursive script, appearing to read "Gerard Wong".

Gerard Wong, Ph.D., Chief  
Radioactive Material Licensing Section  
Radiologic Health Branch

GO NO. 90127	S/A NO.	PAGE 1 OF 28	TOTAL PAGES 28	REV. LTR/CHG. NO. New	NUMBER N001SRR140131
PROGRAM TITLE Radiation Safety					
DOCUMENT TITLE Approved Sitewide Release Criteria for Remediation of Radiological Facilities at the SSFL					
DOCUMENT TYPE Safety Review Report			RELATED DOCUMENTS		
ORIGINAL ISSUE DATE 12/18/98	RELEASE DATE <b>RELEASE</b> 3-18-99 E.M.	APPROVALS		DATE	
PREPARED BY/DATE <i>P. D. Rutherford</i> 12/14/98 P. D. Rutherford	DEPT. 641	MAIL ADDR T487	<i>P. D. Rutherford</i> P. D. Rutherford	<i>12/16/98</i> 12/16/98	<i>12/18/98</i> 12/18/98
IR&D PROGRAM? YES NO X IF YES, ENTER AUTHORIZATION NO.			<i>M. E. Lee</i> M. E. Lee	<i>J. Willenberg</i> J. Willenberg	
DISTRIBUTION			ABSTRACT		
* NAME	MAIL ADDR		<p>This document supersedes revision A of N001SRR140127, "Proposed Sitewide Release Criteria for Remediation of Facilities at the SSFL" issued August 22, 1996. N001SRR140127 was submitted to the Department of Energy (DOE) and the California Department of Health Services (DHS) who subsequently approved the use of these criteria for release of radiological facilities at Rocketdyne for unrestricted use.</p> <p>A complete set of release criteria for facilities at the SSFL has been developed, and are presented in this report. The various categories of release guidelines include; 1) annual expected dose, 2) soil and water concentration guidelines, 3) surface contamination guidelines, and 4) ambient gamma exposure rate. The guidelines were obtained from regulatory values where available. Where not available, for example for soil, guidelines were calculated by use of the DOE computer code, RESRAD. For these calculations, the annual dose limit is 15 mrem/year, which is consistent with proposed EPA and NRC guidelines and ALARA principles.</p>		
* P. D. Rutherford	T487				
* M. E. Lee	T038				
* P. H. Horton	T038				
* J. G. Barnes	T487				
* P. Liddy	T487				
* F. E. Dahl	T100				
* E. R. McGinnis	T487				
* S. R. Lafflam	T487				
* Radiation Safety Library	T487				
* COMPLETE DOCUMENT NO ASTERISK, TITLE PAGE/SUMMARY OF CHANGE PAGE ONLY.			RESERVED FOR PROPRIETARY/LEGAL NOTICES		

## TABLE OF CONTENTS

1. INTRODUCTION .....	3
2. ANNUAL DOSE LIMITATION.....	4
3. SOIL AND WATER GUIDELINES .....	5
3.1 Pathway Analysis.....	5
3.2 Property Usage Scenarios .....	6
3.3 RESRAD Input Parameters .....	6
3.4 Calculated Soil and Water Guidelines from RESRAD .....	10
3.5 Soil and Water Guidelines .....	11
4. SURFACE CONTAMINATION GUIDELINES.....	14
5. AMBIENT GAMMA EXPOSURE RATE .....	15
6. APPLICATION OF GUIDELINES .....	16
6.1 Soil Guidelines.....	16
6.2 Surface Contamination Guidelines .....	17
6.3 Ambient Gamma Exposure.....	18
6.4 Statistical Validation of Survey Data .....	19
7. REFERENCES .....	21
APPENDIX A. Input Parameters for RESRAD Calculations.....	23
APPENDIX B. Agency Approvals.....	26

## LIST OF TABLES

Table 1. Property Usage Conditions for Three Realistic Scenarios.....	6
Table 2. Gamma Shielding Factor Calculations for Typical SSFL Structure.....	8
Table 3. RESRAD-Calculated Single Isotope Guideline Values .....	11
Table 4. Soil and Water Guidelines for SSFL Facilities.....	12
Table 5. Surface Contamination Guidelines for SSFL Facilities.....	14

## 1. INTRODUCTION

*This document supersedes revision A of N001SRR140127, "Proposed Sitewide Release Criteria for Remediation of Facilities at the SSFL" issued August 22, 1996. N001SRR140127 was submitted to the Department of Energy (DOE) and the California Department of Health Services (DHS) who subsequently approved the use of these criteria for release of radiological facilities at Rocketdyne for unrestricted use. Copies of approval letters from DOE and DHS are included in Appendix B.*

At several locations at the Santa Susana Field Laboratory (SSFL), low levels of radiological contamination in buildings and in soil have occurred and have been or will be cleaned up for eventual release for use without radiological restrictions. The DOE requirements for allowable residual radioactivity in sites suitable for release without radiological restrictions ("unrestricted release") are established in DOE Order 5400.5 (Ref. 1). Specific guidelines are given in 5400.5 for surface contamination and for direct gamma exposure. However, except for radium and thorium in soil, no specific guidelines are provided for residual contamination in soil or water. It became clear that a set of DOE-authorized limits for the SSFL would greatly facilitate the process of determining that a facility is acceptably clean, and verifying this with a confirmatory survey. Approval of such a set of authorized limits is provided for in DOE Order 5400.5, Chapter IV, Section 5, and in draft 10 CFR 834.301(c).

The purpose of this report is to document the set of approved guideline values for the release without radiological restriction of DOE facilities at the SSFL. The various categories of release guidelines include; 1) annual expected dose, 2) soil and water concentration guidelines, 3) surface contamination guidelines, and 4) ambient gamma exposure rate. The guidelines presented in this report are for residual radioactivity above background. When feasible, the local background activity of the suspect radionuclides should be determined and these background values subtracted from the measured release survey data.

The goal for these limits is to provide assurance that reasonable future uses of the property will not result in individual doses exceeding 15 millirem per year. This is consistent with current EPA and NRC guidance, and is supported by a generic cost-benefit analysis presented in Reference 2.

## 2. ANNUAL DOSE LIMITATION

DOE Order 5400.5 specifies a base Total Effective Dose Equivalent (TEDE) limit of 100 millirem per year for any potential future occupant of a remediated site. The Order also requires the use of the As Low As Reasonably Achievable (ALARA) principle to establish Authorized Limits at a level that is below the base limit. Rocketdyne will apply a value of 15 millirem per year for the calculation of derived limits for the cleanup of DOE sites at the SSFL, consistent with EPA and NRC guidance. A limit of 15 millirem per year (mrem/year) is adopted to assure that future uses will contribute small doses compared to natural background doses, which are in the range of 250-400 mrem/year (Ref. 3). This limit is considered to be as low as reasonably achievable below the basic DOE dose limit of 100 mrem/year. The 15 mrem/year value corresponds to a calculated increased lifetime cancer risk to a potential future user of the site of  $3 \times 10^{-4}$ .

For any reasonable assigned cost per person-rem, further reduction of anticipated dose due to exposure to residual radioactivity at the site is difficult to justify. For example, the EPA proposed TEDE of 15 mrem/year was arrived at after extensive ALARA analysis of cleanup costs and benefits at sixteen "Reference Sites" representing a wide range of conditions found at contaminated sites throughout the United States. Their analyses assumed a residential use of the decontaminated sites, and their conclusions were that the 15 mrem/year limit represented the most effective value considering all the technical and socio-political issues involved.

Furthermore, at the SSFL, conservative choices in the development, measurement, and interpretation of limits and final surveys provide a firm bias towards overestimation of the remaining risk. These include, 1) a conservative residential scenario for the pathway analyses, 2) use of calibration sources that tend to underestimate the detector efficiency for the likely contaminants, and 3) both qualitative and quantitative tests that provide assurance that the decommissioned facility is suitable for release without radiological restrictions.

### 3. SOIL AND WATER GUIDELINES

Since there are no federal or state regulatory limits for soil contamination for many of the potential or actual radionuclides of concern at SSFL, site-specific guidelines must be developed. This development is done, as required by the DOE Order, by use of a "pathways" analysis program, which estimates the radiological dose (total effective dose equivalent) that a future user of the property might receive, considering the residual radioactivity and various conditions of use. An effort is made to make these use conditions as reasonable for the use and the local area as can be achieved, without greatly over-estimating or under-estimating potential doses.

To establish these guidelines for cleanup operations at SSFL, the pathways analysis program RESRAD (Ref. 4), developed at Argonne National Laboratory (ANL) for use by DOE, has been used to calculate single radionuclide guidelines for the radionuclides of potential concern at SSFL.

For soil, a dose limit of 15 millirem per year is used. For consideration of radiological contamination in water, which may be collected from wells, sumps, below-grade seepage, or surface water, concentration guidelines were calculated from the Dose Conversion Factors (DCFs) in RESRAD, using the EPA limit of 4 millirem per year for ingested drinking water (Ref. 5), and the EPA assumed intake of water, 2 liters per day. These limits are more restrictive than those imposed on releases from operating facilities, as provided by DOE Order 5400.5 (Ref. 1), NRC (Ref. 6), the State of California (Ref. 7), and EPA for uranium mines and mills (Ref. 8).

#### 3.1 Pathway Analysis

Pathways analysis involves calculating the doses received by a person through several pathways: direct radiation exposure; inhalation of airborne radioactivity; drinking water containing radioactivity; eating foods that have accumulated radioactivity, through uptake of water with radioactivity from the soil, or with airborne radioactivity deposited on the foliage; and ingestion of small amounts of contaminated soil.

The pathways analysis program RESRAD, was developed in the late 1980's for DOE by Argonne National Laboratory for the purpose of performing pathways analysis for a broad range of applications. Considerable flexibility is provided in the program for representing the site-specific conditions of exposure, to permit making the calculation as reasonable for the application as is possible.

Four general types of use may be considered for land for the purpose of calculating dose, other than the obvious zero-dose case of non-use. These may be identified as the industrial scenario, the wilderness scenario (or recreational, such as a park or golf course), the residential scenario, and the family farm scenario. Within these general use scenarios, choices are made for occupancy time (indoors and outdoors), water use, and food sources. Further choices are made to represent the contamination situation, geology, and hydrology. The program comes with a

complete set of generally conservative default values, and these may be changed as appropriate to reflect local reality in terms of usage practices and physical conditions, to produce a realistic pathways analysis for the specific site. The default values and the values actually used by the program in the analysis are listed in the output for each calculation, so departures from the default set are well recorded. The printed results from the calculations described in this report are stored in the Radiation Safety library file.

The family farm, on which family members spend 100% of their time, drinking water from the surface or from wells, eating vegetables and fruit grown on the land and irrigated with the same water, raising their meat, milk, and fish on that land, is not a reasonable scenario for the site. Although commercial farming is practiced in low-lying valley and coastal areas west of the facility, the rugged nature and topography of the SSFL, combined with poor soil quality, would reasonably preclude a family farm activity on the site. Further, recent land use trends in the area have been to conversion of previous farming property to other non-farming uses. Thus, the industrial, wilderness, and residential scenarios are all perhaps equally probable for the future of the site, and should be the scenarios considered.

### 3.2 Property Usage Scenarios

The basic usage conditions (per year) modeled in these calculations, for each of the three realistic scenarios, are summarized in Table 1. A complete listing of all RESRAD input data, for the three scenarios, is given in Appendix A. Discussion on specific RESRAD input parameters is given below in Section 3.3

**Table 1. Property Usage Conditions for Three Realistic Scenarios**

	<b>Industrial</b>	<b>Wilderness</b>	<b>Residential</b>
Occupancy, indoors (hours/year)	1752	0	4380
Occupancy, outdoors (hours/year)	350	876	2190
Occupancy, off site (hours/year)	6664	7890	2190
Drinking water (liters/year)	0	0	510
Fruit, vegetables, grain (kg/year)	1.6	1.6	16
Leafy vegetables (kg/year)	0	0	1.4
Cover thickness (meters)	0	0	0
Contamination area (m <sup>2</sup> )	10000	10000	10000
Contamination thickness (meters)	1	1	1
Depth to water table (meters)	5	5	5

### 3.3 RESRAD Input Parameters

Default values provided in RESRAD are considered to be conservative estimates intended for use when no site-specific information is available. Users of the program are encouraged, however, to use input data that most closely reflects actual conditions existing on their site. As

part of several earlier efforts at the SSFL, a number of screening evaluations were performed using the RESRAD code to determine which of the approximately 80 input parameters required by RESRAD were of significance to the general SSFL area. These screening evaluations also were useful in determining conservative site-specific values for input to the code, when the default values were not used. In general, changes to most of the parameters were found to have a negligible effect on the final results because certain dose pathways were either not applicable or negligible for the given scenarios.

Contaminated Zone Parameters: Default values for the area of contamination (10,000 m<sup>2</sup>) and the length parallel to aquifer flow (100 m) were assumed. For the depth of contamination, a conservative value of 1 meter is assumed. Measurements conducted at the site have indicated historical maximum values ranging from about 0.4 to 0.6 m for this parameter.

Occupancy Parameters: The default RESRAD values for occupancy of a residence on an affected site are 50% of the time spent indoors and 25% of the time spent outdoors, on the site. Thus, 25% of the time the occupancy is assumed to be off site. For the residential scenario, assuming 8,760 hours in a year, this translates into 4,380 hours spent indoors, 2,190 hours spent outdoors on the site, and 2,190 hours spent off site. For the industrial scenario, the corresponding percentages are assumed to be 20%, 4%, and 76% respectively. For the wilderness scenario, the corresponding percentages are 0%, 10%, and 90%.

Shielding Factors: The annual dose estimates calculated by RESRAD from either direct exposure or by inhalation (dust) are functions of two "structural" shielding parameters and the fraction of time an individual is assumed to spend inside a structure built on the site. Both shielding factors range from 0 to 1, and may be changed by the user to more appropriately match actual site conditions. For inhalation, the RESRAD default is 0.4, and this value is assumed for the present evaluations. For direct gamma exposure, the RESRAD default is 0.7, which is a rather conservative estimate of gamma shielding by a structure. For the present calculations, this latter value was adjusted from the default, for both the industrial and residential scenarios, to account for local construction practice which dictate a minimum 4-inch (0.1 m) concrete slab under the structure.

The gamma shielding factor used as input to RESRAD was calculated by modeling a typical two-story residential structure, and a single story industrial structure using the computer code MicroShield<sup>1</sup>. MicroShield is a point-kernel gamma shielding code developed for IBM-compatible personal computers, based on the mainframe code ISOSHLD. For the residential structure, a conservative lower bound footprint (area) value of 93 m<sup>2</sup> (1,000 ft<sup>2</sup>) was assumed. For the industrial structure, a 186 m<sup>2</sup> (2,000 ft<sup>2</sup>) area was assumed. A circular area was used with MicroShield to obtain maximum code accuracy with minimum computational time. Screening

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<sup>1</sup> MicroShield, Version 4.0, Grove Engineering, Inc., 15215 Shady Grove Road, Suite 200, Rockville, MD 20850.

calculations indicated no significant differences between the results for circular and square areas of the same volume.

In all cases the contaminated soil was assumed to have a density of  $1.5 \text{ g/cm}^3$ , and a thickness of 1 meter. Dose calculations were performed for two vertical distances (1m for the ground floor and 3.6 m for the second story) and for three radial distances (center, midpoint, and edge of structure). The isotopic mix input to MicroShield was the same as that used for the present RESRAD calculations, with a concentration of 1 pCi/g for each isotope. Resulting gamma energy groups for this isotope mix ranged from 0.1 to 1.5 MeV. A factor of 0.89 was used to account for gamma shielding from a typical structural wall composed of approximately 1 inch of stucco and 5/8 inch of drywall, and a window area of approximately 10% of the wall area.

Effective gamma shielding factors obtained from the MicroShield calculations are given in Appendix A. For the residential scenario (the most credible), it is assumed that 12 hours are spent inside the structure per day. If it is further assumed that 8 of these hours are spent upstairs in a bedroom, 4 hours are spent downstairs in a family room, and that a person (on average) is located at the midpoint between the center and the edge of the structure, then the effective gamma shielding factor would be:  $(0.67)(0.61) + (0.33)(0.31) = 0.51$ . For the industrial scenario, the value is 0.25, which is the shielding value at the midpoint location for the single story structure.

**Table 2. Gamma Shielding Factor Calculations  
for Typical SSFL Structure**

Radial Location	Gamma Shielding Factor	
	1st Floor	2nd Floor
<b>Residential Structure (93 m<sup>2</sup> footprint, two story)</b>		
Center	0.27	0.57
Midpoint <sup>a</sup>	0.31	0.61
Perimeter <sup>b</sup>	0.57	0.71
<b>Industrial Structure (186 m<sup>2</sup> footprint, single story)</b>		
Center	0.22	-
Midpoint <sup>a</sup>	0.25	-
Perimeter <sup>b</sup>	0.58	-

<sup>a</sup>Midpoint between the center and the perimeter of the structure

<sup>b</sup>Edge of the structure.

It should be noted, that these values do not take into account any out-structures such as garages and patios, both of which would result in additional gamma shielding, and both of which would almost certainly be part of any residences built on the site.

**Dietary Parameters:** Default RESRAD input values for food and water consumption are based on the family farm scenario, where a significant portion of the diet is grown or raised on the site. For the three credible scenarios considered here, these parameters were adjusted as follows: for the residential scenario, it is conservatively assumed that a small fraction (10% of that grown on a family farm) of the fruit and leafy vegetables consumption would be from material grown on site. The values used are 16 kg/year per person and 1.4 kg/year per person, respectively. It was further assumed that water for the residence would be obtained from a well on the site (510 liters/year per person).

For the industrial and wilderness scenarios, it was assumed that no water would be used that was taken from the site; thus, all water pathways were suppressed with the exception of a secondary pathway via plant ingestion. In the industrial case, bottled drinking water is supplied. Since essentially all surface water at present is a result of the current industrial operations, no surface water would be available in the wilderness scenario. It is also assumed that perhaps 1% of the family farm fruit consumption value might be collected from wild sources, thus, 0.14 kg/year is used for these scenarios.

**Contaminated Zone Hydrology Data:** The SSFL facility is located in the Simi Hills in eastern Ventura County, California. The Simi Hills are in the northern part of the Transverse Range geomorphic province, and are composed primarily of exposures of the Upper Cretaceous Chatsworth Formation. This formation is a marine turbidite sequence of sandstone with interbedded siltstone/mudstone and minor conglomeratic lenses. The Chatsworth Formation is at least 1,800 m thick in locations east and north of the Facility.

The principal geologic units at the SSFL are the Chatsworth Formation and the shallow alluvium which overlies the Chatsworth Formation in some parts of the Facility, notably in Area IV of the SSFL where the decommissioning and decontamination of nuclear sites is taking place. This layer is Quaternary alluvium consisting of mixtures of unconsolidated sand, silt, and clay, and would include the contaminated zone. Drill holes indicate that the layer may be as thick as 6 meters in some locations.

The density of this alluvium layer is approximately  $1.5 \text{ g/cm}^3$ . The total and effective porosity of the contaminated zone are assumed to be 0.43 and 0.20 based on the average of data for sand, silt, and clay as given in the RESRAD manual. Precipitation at the facility is measured annually by a rain gauge located in the northeastern portion of the SSFL (Ventura County Rain Gauge Number 249). Based on measured data since 1959, the mean annual precipitation at the SSFL is approximately 18.6 inch, or 0.47 meters. In general, the majority of the precipitation occurs during the months of January through March.

**Saturated Zone Hydrology Data:** There are two groundwater systems at the SSFL: 1) a shallow system in the surficial alluvium and the underlying zones of weathered sandstone and siltstone/claystone, and isolated shallow fracture systems; and 2) a deeper regional system in the fractured Chatsworth Formation. The shallow zone is discontinuous, with depths to groundwater ranging from land surface to over 9 m. For the present study, we assume that this shallow region most conservatively represents the saturated zone, with an average depth to the water table of about 5 m. Hydraulic conductivity in the saturated zone generally ranges from about 30 to 3,000 m/year. Here, the higher value has been assumed.

Typical pumping rates for deep wells in the Chatsworth Formation (rock) range from 60 to 70 m<sup>3</sup>/year up to a maximum of about 300 m<sup>3</sup>/year. For the shallow (alluvium) region, however, pumping rates are significantly lower, typically about 35 m<sup>3</sup>/year. Further, in the shallow region, many wells would be dry for a good fraction of the year as the replenishment rate is generally low. Water table drop rates, therefore, would range up to 10 m as a result of on-site pumping. Without pumping, however, no data is available on any inherent lowering of the water table. For conservatism, therefore, the default value of 0.001 m/year has been assumed.

**Radon Pathway:** Two default values were modified for the radon pathway. The thickness of the foundation was set at 0.1 m (4 inches) to correspond to the gamma shielding calculations discussed above. Also, the depth below ground surface was also set at 0.1 m, as basement structures are not typical for the local area.

### 3.4 Calculated Soil and Water Guidelines from RESRAD

The guidelines calculated from the RESRAD code for various single radionuclides are listed in Table 3 for comparison of the three scenarios. Values for each of the scenarios were determined from separate RESRAD calculation runs using the input parameters given in Appendix A. Water guideline values in Table 3 were calculated from the dose conversion factors used in RESRAD for ingestion, using an EPA value of 2 liters/day total water consumption (per person) from the site, and an EPA dose limit of 4 mrem/year (Ref. 5).

For radionuclides specifically regulated by the EPA (and the State of California), the Safe Drinking Water Act (and CCR Title 22) limits were used. These are (in pCi/l):

H-3 .....	20,000
Combined Ra-226 and Ra-228.....	5
Sr-90 .....	8
Gross alpha (not including radon and uranium) .....	15
Gross beta .....	50
Uranium (U-234 + U-235 + U-238).....	20

For U-234, U-235, and U-238, DOE imposes the EPA regulations in 40 CFR 192 (and parts 190 and 440). Similarly, for Ra-226, Th-228 and Th-232, DOE imposes the limits in DOE Order 5400.5.

### 3.5 Soil and Water Guidelines

Based on the data in Table 3, conservative guidelines, consistent with the several applicable regulations governing residual radioactivity discussed above, are listed in Table 4. With the exception of uranium, radium, and thorium, the soil guidelines are those calculated from RESRAD for the residential use scenario. For uranium, the guidelines are those adopted by the NRC (30, 30, and 35 pCi/g for U-234, U-235, and U-238, respectively, see Ref. 9). For

**Table 3. RESRAD-Calculated Single Isotope Guideline Values**

Radionuclide	Soil Guidelines (pCi/g)			Water (pCi/l) <sup>a</sup>
	Industrial	Wilderness	Residential	
Am-241	120	162	5.44	1.50
Co-60	10.9	9.83	1.94	204
Cs-134	18.7	16.9	3.33	74.7
Cs-137	51.9	46.7	9.20	110
Eu-152	25.3	22.8	4.51	845
Eu-154	23.0	20.7	4.11	573
Fe-55	2,370,000	4,780,000	629,000	9,020
H-3	129,000	129,000	31,900	85,600 <sup>b</sup>
K-40	162	147	27.6	294
Mn-54	34.4	30.9	6.11	1,980
Na-22	13.0	11.7	2.31	476
Ni-59	1,390,000	1,560,000	151,000	26,100
Ni-63	511,000	572,000	55,300	9,490
Pu-238	140	192	37.2	1.71
Pu-239	127	175	33.9	1.55
Pu-240	127	175	33.9	1.55
Pu-241	4,740	6,430	230	79.9
Pu-242	133	183	35.5	1.63
Ra-226	0.520	13.6	0.199	4.12 <sup>b</sup>
Sr-90	370	376	36.0	35.8 <sup>b</sup>
Th-228	14.8	14.7	2.81	6.78
Th-232	7.94	7.98	1.53	2.01
U-234	519	647	106	19.3 <sup>b</sup>
U-235	163	160	32.1	20.5 <sup>b</sup>
U-238	399	445	90.9	20.4 <sup>b</sup>

<sup>a</sup>Water guidelines calculated from RESRAD ingestion dose conversion factors, assuming the EPA dose limit of 4 mrem/year (see text).

<sup>b</sup>For these radionuclides, the EPA Safe Drinking Water Act or the State of California CCR Title 22 limits should be used (see Table 4).

**Table 4. Soil and Water Guidelines for SSFL Facilities**

<b>Radionuclide</b>	<b>Soil Guidelines (pCi/g)</b>	<b>Water (pCi/l)</b>
Am-241	5.44	1.5
Co-60	1.94	200
Cs-134	3.33	75
Cs-137	9.20	110
Eu-152	4.51	840
Eu-154	4.11	570
Fe-55	629,000	9,000
H-3	31,900	20,000 <sup>a</sup>
K-40	27.6	290
Mn-54	6.11	2,000
Na-22	2.31	480
Ni-59	151,000	26,000
Ni-63	55,300	9,500
Pu-238	37.2	1.7
Pu-239	33.9	1.6
Pu-240	33.9	1.6
Pu-241	230	80
Pu-242	35.5	1.6
Ra-226	5 <sup>c</sup> and 15 <sup>c</sup>	4.1
Sr-90	36.0	8 <sup>a</sup>
Th-228	5 <sup>c</sup> and 15 <sup>c</sup>	6.8
Th-232	5 <sup>c</sup> and 15 <sup>c</sup>	2.0
U-234	30 <sup>b</sup>	
U-235	30 <sup>b</sup>	total uranium 20 <sup>a</sup>
U-238	35 <sup>b</sup>	
Gross alpha (not including radon and uranium)		15 <sup>a</sup>
Gross beta		50 <sup>a</sup>

<sup>a</sup>State of California Maximum Contaminant Levels, CCR Title 22

<sup>b</sup>Generally more conservative NRC limits for uranium isotopes are used.

<sup>c</sup>DOE Order 5400.5 limits are used (5 pCi/g averaged over first 15 cm of soil depth and 15 pCi/g averaged over 15 cm layers below the top 15 cm).

radium and thorium, DOE Order 5400.5 limits are used (5 pCi/g averaged over first 15 cm of soil depth and 15 pCi/g averaged over 15 cm layers below the top 15 cm, see Ref. 1). Guidelines established from the residential use scenario are the most restrictive of the three scenarios considered.

The choice of a basic dose limit of 15 mrem/year for all pathways combined leads to lower limits than would result from the use of the dose limits established by the EPA for the uranium fuel cycle (Ref. 10) and by DOE for unrestricted release of contaminated property (Ref. 1). The water guidelines are those calculated from the RESRAD dose conversion factors, using the EPA values for the basic dose limit and daily water intake, with the Maximum Contaminant Levels (MCL) specified for certain radionuclides by the State of California (Ref. 11).

#### 4. SURFACE CONTAMINATION GUIDELINES

Surface contamination limits are specified in Figure IV-1 of Chapter IV in DOE Order 5400.5. For SSFL facilities, these limits have been modified by specifying the potential contaminants present in the Rocketdyne facilities, and eliminating those that are not pertinent. The proposed guidelines are given in Table 5. As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

**Table 5. Surface Contamination Guidelines for SSFL Facilities**

Radionuclide	Average over 1 m <sup>2</sup> (dpm/100 cm <sup>2</sup> )	Maximum in 100 cm <sup>2</sup> (dpm/100 cm <sup>2</sup> )	Removable (dpm/100 cm <sup>2</sup> )
Plutonium, Radium	100	300	20
Thorium	1,000	3,000	200
Uranium	5,000	15,000	1,000
Mixed fission products	5,000	15,000	1,000
Activation products	5,000	15,000	1,000
Tritium	-	-	10,000

As included in Table 5, Pu, Ra, U, Th, mixed fission products, and activation products, refer to those forms of radioactive material that comprise the residual activity at the SSFL. Plutonium is predominately Pu-239; Radium is Ra-226. It is assumed that thorium is sufficiently aged that all daughters are in equilibrium, Th-natural. Uranium will occur in depleted, normal, or enriched forms; U-233 is not present. Mixed fission products include Sr-90 and Cs-137 as components of the mixture. Possible activation products include Co-60, Fe-55, Mn-54, Eu-152, Eu-154, Al-26, and similar radionuclides.

Tritium contamination limits are based on interim guidelines for removable surface contamination (Ref. 12). This level of removable contamination insures that any non-removable or volumetric contamination will not cause unacceptable exposures.

These guidelines will be imposed for accessible (or potentially accessible) surfaces and structures.

## 5. AMBIENT GAMMA EXPOSURE RATE

A guideline of 5  $\mu\text{R/hr}$  above natural background, measured at 1 meter above the surface, is used. This value has been imposed by the NRC for decommissioning research reactors (Ref. 13). It is as low as reasonably measurable, due to variations in background, and is significantly lower than the guideline of 20  $\mu\text{R/hr}$  stated in DOE Order 5400.5, Chapter IV, Section 4.c. This guideline is imposed for accessible (or potentially accessible) structures and land. Our experience has been that this level can be achieved and verified in facilities that would be suitable for continued use.

## 6. APPLICATION OF GUIDELINES

*Note: The survey protocols described below were those employed at the time of issue of N001SRR140127 and have been in use up until the end of 1998. As of the beginning of 1999, MARSSIM protocols will be employed (Reference 19) utilizing the guidelines developed in this report as the DCGL<sub>w</sub>s (derived concentration guideline limits).*

The guidelines presented above should be used in planning any decontamination effort at the SSFL. Analytical capability for detection of each radionuclide should be, if possible, less than one-tenth of the guideline values. That is, the Minimum Detectable Activity (MDA, our LLD) should be less than 0.1 x guideline. Field measurements used to direct removal of contaminated soil should be capable of practical measurements below the guideline value. Survey measurements and sample analyses should be corrected for the local background activity of each radionuclide.

### 6.1 Soil Guidelines

Sample analysis is necessary to demonstrate the successful decontamination of soil areas. A qualitative scan will be performed using gamma-sensitive and/or beta-sensitive detectors to identify any significant areas of residual contamination. Soil samples will be taken from locations based on a 3x3 meter master grid. One sample will be taken from within a 1x1 meter grid location in each 3x3-meter section, based either on the qualitative scan survey indications at the area of maximum readings or, if no noticeable readings were found, at the location most likely to have residual contamination, by the surveyor's judgment. This selection assures a reasonably uniform sampling of the ground areas, at a sample density of approximately 11 samples per 100 m<sup>2</sup>.

Results from individual samples will be compared with the limit for hotspots of 9-m<sup>2</sup> area, that is, 3.3 x the adopted concentration limit. Averages of adjacent samples, covering 100 m<sup>2</sup>, will be compared with the average limit. The overall average, assuming that the individual and 100-m<sup>2</sup> area averages satisfy the applicable limits, will be used for a RESRAD confirmatory calculation. This calculation will be performed to demonstrate that the maximum expected annual dose for the indicated reasonable use scenario for the facility *does not exceed* the proposed 15 mrem/year guideline value.

For mixtures of radionuclides in soil, the "Sum of Fractions" rule is used. The sum of the ratios of concentration of each radionuclide to the corresponding guideline must not exceed 1. This value must be satisfied when samples are averaged over each 100-m<sup>2</sup> region. For cases in which the relative concentrations are known or assumed, this method is used to generate combined radionuclide guidelines for each radionuclide in the mixture.

The guidelines are not intended to be spot limits, and should not be applied to individual measurements. If the specific sampling provides only (or fewer than) one measurement per 100-

m<sup>2</sup> area, each measurement becomes, by default, the "average" for that 100-m<sup>2</sup> area, and the guidelines have the effect of acting as spot limits. In cases where an individual sample exceeds the guideline value, additional samples should be taken from within the same 100-m<sup>2</sup> area, and used to define the average contamination in this area.

The maximum concentrations remaining as "hot spots" must have contamination less than that calculated by the hot-spot rule presented in DOE Order 5400.5, Chapter IV, page 4. The average contamination within any area not exceeding 25 m<sup>2</sup> shall not be greater than  $\sqrt{100/A}$  guideline, where A is the area in m<sup>2</sup>. Reasonable efforts shall be made to remove any soil with contamination that exceeds 30 x guideline (Ref. 4).

## 6.2 Surface Contamination Guidelines

The proposed surface contamination guidelines would be applied to all accessible surfaces and structures. This would include ceilings, floors, and walls, and other potentially accessible locations such as attics. Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the guidelines established for alpha- and beta-gamma-emitting radionuclides should apply independently. Measurements of average contamination are averaged over an area of 1 m<sup>2</sup>. For objects of less surface area, the average should be derived for each such object. The maximum contamination level applies to an area of not more than 100 cm<sup>2</sup>. Surfaces of facilities which are likely to be contaminated, but are inaccessible for purposes of measurement, shall be presumed to be contaminated in excess of the applicable limits.

Following a complete qualitative scan of the facility, quantitative surface contamination measurements will be made over a fraction of the structural surfaces, as determined by the designation of the area as affected or unaffected. Affected areas will be surveyed at a nominal fraction of 11%. Unaffected areas will be surveyed at lesser fractions. Locations for the quantitative survey measurements will be based on a 3x3 meter master grid. One sample will be taken from within a 1x1 meter grid location in each 3x3-meter section, based either on the qualitative scan survey indications at the area of maximum readings or, if no noticeable readings were found, at the location most likely to have residual contamination, by the surveyor's judgment. Results from individual locations will be compared with the applicable limits.

Total surface contamination is measured by use of detectors primarily or exclusively sensitive to alpha or beta-gamma radiation. After a qualitative survey of the surfaces of the entire subject area, quantitative measurements are made on 1-m<sup>2</sup> areas selected uniformly throughout the area. These measurements are made with the detectors connected to a scaler set to accumulate counts for a 5-minute period. The detector is slowly scanned over the 1-m<sup>2</sup> grid location and the numerical result, after correction for background, count time, and detector efficiency, yields the 1-m<sup>2</sup> average surface activity. These detectors are calibrated against Th-230 for alpha activity and Tc-99 for beta activity. The emission energies of these radionuclides is generally less than those radionuclides found as contamination at SSFL. This results in an

underestimate of the efficiency of the detectors for the actual contaminant radioactivity and hence an overestimate of the actual measurement.

The amount of removable activity per 100 cm<sup>2</sup> of surface area is determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wiping with an appropriate instrument of known efficiency. Typically at Rocketdyne, a low background gas flow proportional counter is used. When removable contamination on objects of surface area less than 100 cm<sup>2</sup> is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. It is not necessary to use wiping techniques to measure removable contamination levels if direct scan surveys indicate that the total residual surface contamination levels are within the guidelines for removable contamination.

Smear methods for tritium detection are similar to that described above, with the exception that a wet swipe or piece of Styrofoam should be used. If the property has been recently decontaminated, a follow-up measurement (smears) should be conducted to ensure that there is no build-up of contamination with time.

### 6.3 Ambient Gamma Exposure

Measurements of the ambient gamma exposure rate provides a useful determination of residual volumetric radioactivity that may not be as easily detected by surface measurements or sampling and analysis. For the purpose of demonstrating suitability for release, this measurement provides an additional test.

The DOE established a limit of 20  $\mu$ R/hr above natural background for screening radium-contaminated property. The NRC has imposed a 10 $\mu$ R/hr limit on the decommissioning of radioactive materials licensees, and a 5 $\mu$ R/hr limit on the decommissioning of research reactors. The 5  $\mu$ R/hr limit above natural background is proposed for use at Rocketdyne. Because of the variability and differences in natural background, the limit of 5  $\mu$ R/hr is about as low as can be reasonably implemented.

Quantitative measurements of the ambient gamma exposure rate will be made over a fraction of the structural surfaces, as determined by the designation of the area as affected or unaffected. Affected areas will be surveyed at a nominal fraction of 11%. Unaffected areas will be surveyed at lesser fractions. Locations for the quantitative survey measurements will be based on a 3x3-meter master grid. One measurement, covering one 1-m<sup>2</sup> grid location, will be made at each grid location chosen for the surface contamination measurements. Results from individual locations will be compared with the applicable limits.

At Rocketdyne, gamma exposure rate is generally measured by use of a 1x1 inch NaI(Tl) detector/photomultiplier probe, connected to a scaler to provide objective numerical values. The

detector is placed 1 meter above the local (ground or floor) surface. This instrument is calibrated by reference to a High Pressure Ion Chamber (HPIC) in a background area.

#### 6.4 Statistical Validation of Survey Data

The statistical approach employed at Rocketdyne/ETEC for establishing that survey data meets guideline values is a method referred to as Sampling Inspection by Variables (Ref. 14). This method has been widely applied in industry and the military and is essential where the lot size is impractically large. Application of this method to the remediation of contaminated sites has been discussed in detail elsewhere (see for example, Ref. 15).

In sampling inspection by variables, the number of data points on which measurements are obtained is first chosen to be large so that the parameters of the distribution are likely to have a normal distribution (i.e., Gaussian). The mean of the distribution,  $\bar{x}$ , and its standard deviation,  $s$ , are then related to a "test statistic", TS, as follows:

$$TS = \bar{x} + ks$$

where  $\bar{x}$  = average (arithmetic mean of measured values)  
 $s$  = observed sample standard deviation  
 $k$  = tolerance factor calculated from the number of samples to achieve the desired sensitivity for the test

TS and  $\bar{x}$  are then compared with an authorized acceptance limit,  $U$ , to determine acceptance or other plans of action, including rejection of the area as contaminated and requiring further remediation.

The sample mean and standard deviation are easily calculable quantities; the value of  $k$ , the tolerance factor, bears further discussion. Of the various criteria for selecting plans for acceptance sampling by variables, the most appropriate is the method of Lot Tolerance Percent Defective (LTPD), also referred to as the Rejectable Quality Level (RQL). The LTPD is defined as the poorest quality that should be accepted in an individual lot. Associated with the LTPD is a parameter referred to as consumer's risk ( $\beta$ ), the risk of accepting a lot of quality equal to or poorer than the LTPD (or 10%). NRC Regulatory Guide 6.6 (Ref. 16) states that the value for the consumer's risk should be 0.10. Conventionally, the value assigned to the LTPD has been 10%.

The State of California, Department of Radiological Health Branch, has stated that the consumer's risk of acceptance ( $\beta$ ) at 10% defective (LTPD) must be 0.1 (Ref. 17). For those choices of  $\beta$  and LTPD,  $K_\beta = K_2 = 1.282$ . The number of samples is  $n$ . Values of  $k$  for each sample size are calculated in accordance with the following equations:

$$k = \frac{K_2 + \sqrt{K_2^2 - ab}}{a}; \quad a = 1 - \frac{K_\beta}{2(n-1)}; \quad b = K_2^2 - \frac{K_\beta^2}{n}$$

- where
- $k$  = tolerance factor,
  - $K_p$  = the normal deviate exceeded with probability of  $\beta$ , 0.10 (from tables,  $K_2 = 1.282$ , see Ref. 18),
  - $K_2$  = the normal deviate exceeded with probability equal to the LTPD, 10% (from tables,  $K_p = 1.282$ , see Ref. 18)<sup>2</sup>, and
  - $n$  = number of samples.

The statistical criteria for acceptance of a remediated area are presented below.

- a) **Acceptance:** If the test statistic  $(\bar{x} + ks)$  is less than or equal to the guideline ( $U$ ), accept the area as clean. If any single measured value exceeds 80% of the limit, decontaminate that location to as near background as is possible, but do not change the value in the analysis.
- b) **Collect additional measurements:** If the test statistic  $(\bar{x} + ks)$  is greater than the limit ( $U$ ), but  $\bar{x}$  itself is less than  $U$ , independently resample and combine all measured values to determine if  $\bar{x} + ks \leq U$  for the combined set; if so, accept the area as clean. If not, the area is contaminated and must be remediated.
- c) **Rejection:** If the test statistic  $(\bar{x} + ks)$  is greater than the limit ( $U$ ) and  $\bar{x} > U$ , the region is contaminated and must be remediated.

Thus, based on sampling inspection, we are willing to accept the hypothesis that the probability of accepting an area as not being contaminated which is, in fact, 10% or more contaminated is 0.10. Or in other words, the final survey acceptance criteria corresponds to assuring with 90% confidence that 90% of an area has residual contamination below 100% (a 90/90/100 test) of the authorized limit.

## 7. REFERENCES

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18. MIL-STD-414, Sampling Procedures and Tables for Inspection by Variables for Percent Defective, June 11, 1957.
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## Appendix A

## Input Parameters for RESRAD Calculations (Sheet 1 of 3)

Parameter	Value Used for Scenario			RESRAD
	Industrial	Wilderness	Residential	Default
Area of contaminated zone (m <sup>2</sup> )	1.000E+04	1.000E+04	1.000E+04	1.000E+04
Thickness of contaminated zone (m)	1.000E+00	2.000E+00	1.000E+00	2.000E+00
Length parallel to aquifer flow (m)	1.000E+02	1.000E+02	1.000E+02	1.000E+02
Basic radiation dose limit (mrem/yr)	1.500E+01	1.500E+01	1.500E+01	3.000E+01
Time since placement of material (yr)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Times for calculations (yr)	1.000E+00	1.000E+00	1.000E+00	1.000E+00
Times for calculations (yr)	3.000E+00	3.000E+00	3.000E+00	3.000E+00
Times for calculations (yr)	1.000E+01	1.000E+01	1.000E+01	1.000E+01
Times for calculations (yr)	3.000E+01	3.000E+01	3.000E+01	3.000E+01
Times for calculations (yr)	1.000E+02	1.000E+02	1.000E+02	1.000E+02
Times for calculations (yr)	3.000E+02	3.000E+02	3.000E+02	3.000E+02
Times for calculations (yr)	1.000E+03	1.000E+03	1.000E+03	1.000E+03
Times for calculations (yr)	3.000E+03	0.000E+00	3.000E+03	0.000E+00
Times for calculations (yr)	1.000E+04	0.000E+00	1.000E+04	0.000E+00
Cover depth (m)	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Density of cover material (g/cm <sup>3</sup> )	not used	not used	not used	1.500E+00
Cover depth erosion rate (m/yr)	not used	not used	not used	1.000E-03
Density of contaminated zone (g/cm <sup>3</sup> )	1.500E+00	1.500E+00	1.500E+00	1.500E+00
Contaminated zone erosion rate (m/yr)	1.000E-03	1.000E-03	1.000E-03	1.000E-03
Contaminated zone total porosity	4.300E-01	4.300E-01	4.300E-01	4.000E-01
Contaminated zone effective porosity	2.000E-01	2.000E-01	2.000E-01	2.000E-01
Contaminated zone hydraulic conductivity (m/yr)	3.000E+03	3.000E+03	3.000E+03	1.000E+01
Contaminated zone b parameter	5.300E+00	5.300E+00	5.300E+00	5.300E+00
Humidity in air (g/cm <sup>3</sup> )	8.000E+00	8.000E+00	8.000E+00	8.000E+00
Evapotranspiration coefficient	5.000E-01	5.000E-01	5.000E-01	5.000E-01
Precipitation (m/yr)	4.700E-01	4.700E-01	4.700E-01	1.000E+00
Irrigation (m/yr)	2.000E-01	2.000E-01	2.000E-01	2.000E-01
Irrigation mode	overhead	overhead	overhead	overhead
Runoff coefficient	2.000E-01	2.000E-01	2.000E-01	2.000E-01
Watershed area for nearby stream or pond (m <sup>2</sup> )	1.000E+06	1.000E+06	1.000E+06	1.000E+06
Accuracy for water/soil computations	1.000E-03	1.000E-03	1.000E-03	1.000E-03
Density of saturated zone (g/cm <sup>3</sup> )	1.500E+00	1.500E+00	1.500E+00	1.500E+00
Saturated zone total porosity	4.300E-01	4.300E-01	4.300E-01	4.000E-01
Saturated zone effective porosity	2.000E-01	2.000E-01	2.000E-01	2.000E-01
Saturated zone hydraulic conductivity (m/yr)	3.000E+03	3.000E+03	3.000E+03	1.000E+02
Saturated zone hydraulic gradient	2.000E-02	2.000E-02	2.000E-02	2.000E-02
Saturated zone b parameter	5.300E+00	5.300E+00	5.300E+00	5.300E+00
Water table drop rate (m/yr)	1.000E-03	1.000E-03	1.000E-03	1.000E-03
Well pump intake depth (m below water table)	1.000E+01	1.000E+01	1.000E+01	1.000E+01

## Input Parameters for RESRAD Calculations (Sheet 2 of 3)

Parameter	Value Used for Scenario			RESRAD Default
	Industrial	Wilderness	Residential	
Model: Nondispersion (ND) or Mass-Balance (MB)	ND	ND	ND	ND
Well pumping rate (m <sup>3</sup> /yr)	not used	not used	7.000E+01	2.500E+02
Number of unsaturated zone strata	1	1	1	1
Unsat. zone 1, thickness (m)	4.000E+00	4.000E+00	4.000E+00	4.000E+00
Unsat. zone 1, soil density (g/cm <sup>3</sup> )	1.500E+00	1.500E+00	1.500E+00	1.500E+00
Unsat. zone 1, total porosity	4.300E-01	4.300E-01	4.300E-01	4.000E-01
Unsat. zone 1, effective porosity	2.000E-01	2.000E-01	2.000E-01	2.000E-01
Unsat. zone 1, soil-specific b parameter	5.300E+00	5.300E+00	5.300E+00	5.300E+00
Unsat. zone 1, hydraulic conductivity (m/yr)	3.000E+03	3.000E+03	3.000E+03	1.000E+01
Inhalation rate (m <sup>3</sup> /yr)	8.400E+03	8.400E+03	8.400E+03	8.400E+03
Mass loading for inhalation (g/m <sup>3</sup> )	2.000E-04	2.000E-04	2.000E-04	2.000E-04
Dilution length for airborne dust, inhalation (m)	3.000E+00	3.000E+00	3.000E+00	3.000E+00
Exposure duration	3.000E+01	3.000E+01	3.000E+01	3.000E+01
Shielding factor, inhalation	4.000E-01	4.000E-01	4.000E-01	4.000E-01
Shielding factor, external gamma	2.500E-01	7.000E-01	5.100E-01	7.000E-01
Fraction of time spent indoors	2.000E-01	0.000E+00	5.000E-01	5.000E-01
Fraction of time spent outdoors (on site)	4.000E-02	1.000E-01	2.500E-01	2.500E-01
Shape factor flag, external gamma	1.000E+00	1.000E+00	1.000E+00	1.000E+00
Fruits, vegetables and grain consumption (kg/yr)	1.600E+00	1.600E+00	1.600E+01	1.600E+02
Leafy vegetable consumption (kg/yr)	0.000E+00	0.000E+00	1.400E+00	1.400E+01
Milk consumption (L/yr)	not used	not used	not used	9.200E+01
Meat and poultry consumption (kg/yr)	not used	not used	not used	6.300E+01
Fish consumption (kg/yr)	not used	not used	not used	5.400E+00
Other seafood consumption (kg/yr)	not used	not used	not used	9.000E-01
Soil ingestion rate (g/yr)	3.650E+01	3.650E+01	3.650E+01	3.650E+01
Drinking water intake (L/yr)	not used	not used	5.100E+02	5.100E+02
Contamination fraction of drinking water	not used	not used	1.000E+00	1.000E+00
Contamination fraction of household water	1.000E+00	0.000E+00	1.000E+00	1.000E+00
Contamination fraction of livestock water	not used	0.000E+00	not used	1.000E+00
Contamination fraction of irrigation water	1.000E+00	1.000E+00	1.000E+00	1.000E+00
Contamination fraction of aquatic food	not used	not used	not used	5.000E-01
Contamination fraction of plant food	-1	-1	-1	-1
Contamination fraction of meat	not used	not used	not used	-1
Contamination fraction of milk	not used	not used	not used	-1
Livestock fodder intake for meat (kg/day)	not used	not used	not used	6.800E+01
Livestock fodder intake for milk (kg/day)	not used	not used	not used	5.500E+01
Livestock water intake for meat (L/day)	not used	not used	not used	5.000E+01
Livestock water intake for milk (L/day)	not used	not used	not used	1.600E+02
Livestock soil intake (kg/day)	not used	not used	not used	5.000E-01
Mass loading for foliar deposition (g/m <sup>3</sup> )	1.000E-04	1.000E-04	1.000E-04	1.000E-04
Depth of soil mixing layer (m)	1.500E-01	1.500E-01	1.500E-01	1.500E-01
Depth of roots (m)	9.000E-01	9.000E-01	9.000E-01	9.000E-01

## Input Parameters for RESRAD Calculations (Sheet 3 of 3)

Parameter	Value Used for Scenario			RESRAD
	Industrial	Wilderness	Residential	Default
Drinking water fraction from ground water	1.000E+00	1.000E+00	1.000E+00	1.000E+00
Household water fraction from ground water	not used	not used	1.000E+00	1.000E+00
Livestock water fraction from ground water	1.000E+00	1.000E+00	1.000E+00	1.000E+00
Irrigation fraction from ground water	not used	not used	not used	1.000E+00
C-12 concentration in water (g/cm <sup>3</sup> )	not used	not used	not used	2.000E-05
C-12 concentration in contaminated soil (g/g)	not used	not used	not used	3.000E-02
Fraction of vegetation carbon from soil	not used	not used	not used	2.000E-02
Fraction of vegetation carbon from air	not used	not used	not used	9.800E-01
C-14 evasion layer thickness in soil (m)	not used	not used	not used	3.000E-01
C-14 evasion flux rate from soil (1/sec)	not used	not used	not used	7.000E-07
C-12 evasion flux rate from soil (1/sec)	not used	not used	not used	1.000E-10
Fraction of grain in beef cattle feed	not used	not used	not used	8.000E-01
Fraction of grain in milk cow feed	not used	not used	not used	2.000E-01
Storage times of contaminated foodstuffs (days):				
Fruits, non-leafy vegetables, and grain	1.400E+01	1.400E+01	1.400E+01	1.400E+01
Leafy vegetables	1.000E+00	1.000E+00	1.000E+00	1.000E+00
Milk	not used	not used	not used	1.000E+00
Meat and poultry	not used	not used	not used	2.000E+01
Fish	not used	not used	not used	7.000E+00
Crustacea and mollusks	not used	not used	not used	7.000E+00
Well water	1.000E+00	1.000E+00	1.000E+00	1.000E+00
Surface water	1.000E+00	1.000E+00	1.000E+00	1.000E+00
Livestock fodder	not used	not used	not used	4.500E+01
Thickness of building foundation (m)	1.000E-01	not used	1.000E-01	1.500E-01
Bulk density of building foundation (g/cm)	2.400E+00	not used	2.400E+00	2.400E+00
Total porosity of the cover material	not used	not used	not used	4.000E-01
Total porosity of the building foundation	1.000E-01	not used	1.000E-01	1.000E-01
Volumetric water content of the cover material	not used	not used	not used	5.000E-02
Volumetric water content of the foundation	3.000E-02	not used	3.000E-02	3.000E-02
Diffusion coefficient for radon gas (m/sec):				
in cover material	not used	not used	not used	2.000E-06
in foundation material	3.000E-07	not used	3.000E-07	3.000E-07
in contaminated zone soil	2.000E-06	not used	2.000E-06	2.000E-06
Radon vertical dimension of mixing (m)	2.000E+00	not used	2.000E+00	2.000E+00
Average annual wind speed (m/sec)	2.000E+00	not used	2.000E+00	2.000E+00
Average building air exchange rate (1/hr)	5.000E-01	not used	5.000E-01	5.000E-01
Height of the building (room) (m)	2.500E+00	not used	2.500E+00	2.500E+00
Building interior area factor	0.000E+00	not used	0.000E+00	0.000E+00
Building depth below ground surface (m)	1.000E-01	not used	1.000E-01	-1.000E+00
Emanating power of Rn-222 gas	2.500E-01	not used	2.500E-01	2.500E-01
Emanating power of Rn-220 gas	not used	not used	not used	1.500E-01

**Appendix B**  
**Agency Approvals**

1. Letter from Gerard Wong (DHS) to Majelle Lee (Rocketdyne), "Authorized Sitewide Radiological Guidelines for Release for Unrestricted Use", 96ETEC-DRF-0455, August 9, 1996.
2. Memorandum from Sally A. Robison (DOE-ER) to Roger Liddle (DOE-OAK), "Sitewide Limits for Release of Facilities Without Radiological Restriction", 007857RC, September 17, 1996.

**EXHIBIT III**

**DOCUMENT FROM CALIFORNIA DEPARTMENT OF HEALTH  
SERVICES RELEASING THE FORMER SODIUM DISPOSAL FACILITY  
(4886) TO UNRESTRICTED USE**

## DEPARTMENT OF HEALTH SERVICES

714/744 P STREET  
P.O. BOX 942732  
SACRAMENTO, CA 94234-7320



(916) 445-0931

May 15, 1998

P.D. Rutherford, Manager  
Radiation Protection & Health Physics Services  
Boeing North America/Rocketdyne Division  
P.O. Box 7922, MS-T100  
6633 Canoga Avenue  
Canoga Park, CA 91309-7922

Dear Mr. Rutherford:

This letter is to confirm the release of Former Sodium Disposal Facility (FSDF) at the Rockwell International Santa Susana Field Laboratory. A final gamma radiation survey and a sampling of soil and rock demonstrated satisfactory removal of the radioactive contamination.

Amendment number 98 to California Radioactive Material License Number 0015-19 was issued on May 6, 1998 releasing the Former Sodium Disposal Facility (FSDF) to unrestricted use.

Sincerely,

A handwritten signature in cursive script that reads "Gerard Wong".

Gerard Wong, Ph.D., Chief  
Radioactive Material Licensing Section  
Radiologic Health Branch

003463 RC

05-20-98 A10:54 IN

**EXHIBIT IV**

FACILITY 4886 FINAL REPORT (REVISION A)



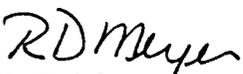
# Team Product Document

GO Number 97055	S/A Number 61000	Page 1 of 150	Total Pages 151	Rev. Ltr/Chg. No. See Summary of Chg. A	Number EID-04628
Program Title CLOSURE OF ETEC (R21-RF)					
Document Title FINAL REPORT FOR DECONTAMINATION & DECOMMISSIONING OF FORMER SODIUM DISPOSAL FACILITY (FSDF) - B/4886					
Document Type OPERATIONS (D&D) REPORT			Related Documents		
Original Issue Date 10-5-99		Release Date 11-17-99 <b>RELEASE</b> <i>son</i>		Approvals R. D. Meyer	
Prepared By/Date Alex Klein 9/29/99		Dept. 117	Mail/Addr T038	Date S. E. Reeder	
IR&D Program? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>			M. E. Lee		
If Yes, Enter Authorization No.					
Distribution			Abstract		
*	Name	Mail Addr.	This report documents the history and the activities and results of the decontamination and decommissioning of the Former Sodium Disposal Facility (FSDF), also known as B/4886.		
	Marshall, R. A.	T038			
	Lafflam, S. R.	T487			
	Lee, M. E.	T038			
*	Meyer, R. D. (2)	T038			
	Reeder, S. E.	T038			
*	Rutherford, P. D. (3)	T038			
*	Shah, S. N. (2)	T038			
*	Chung, D. H.	T487			
*	Dassler, D. W.	T487			
*	Sullivan, M.	T487			
*	Ervin III, Guy	T038			
	Hardy, R.	T038			
	Moore, R. M.	T038			
*	B. Bassat (2)	T038			
<ul style="list-style-type: none"> <li>Complete Document</li> <li>No Asterisk, Title Page/Summary or Change Page Only.</li> </ul>			Reserved for Proprietary/Legal Notice		

# Supporting Document Summary of Change

EID-04628

No.  
Page 1.1 of 150

Rev.	Summary of Change	Approvals and Date
A	This revision removed duplication of figures, and also made editorial corrections.	 S. N. Shah  R. D. Meyer  P. D. Rutherford  M. E. Lee

## TABLE OF CONTENTS

ABSTRACT.....	3
1.0 INTRODUCTION .....	5
2.0 EXECUTIVE SUMMARY .....	7
3.0 FACILITY BACKGROUND .....	9
4.0 CHRONOLOGICAL SUMMARY .....	12
4.1 BACKGROUND AND EARLY HISTORY .....	12
4.2 INITIATING ACTIVITIES-1990 & 1991 .....	12
4.3 PROJECT ACTIVITIES – Phase I, August 1991 to June 1993 .....	14
4.4 PROJECT ACTIVITIES – Phase II, June 1993 to October 1995 .....	24
4.5 PROJECT ACTIVITIES – Phase III, October 1995 to June 1999 .....	28
5.0 KEY TASKS AND RESULTS.....	36
6.0 ISSUES and LESSONS LEARNED .....	46
7.0 SCHEDULE AND COST SUMMARY .....	50
7.1 SCHEDULE.....	50
7.2 COSTS .....	51
8.0 WASTE VOLUMES GENERATED .....	57
9.0 PERSONNEL RADIATION EXPOSURES .....	64
10.0 CURRENT STATUS AND FUTURE WORK .....	66
11.0 APPENDICES .....	70
12.0 ABBREVIATIONS AND DEFINITIONS.....	75
13.0 FIGURES.....	77
14.0 REFERENCES .....	147

## ABSTRACT

This report documents the environmental remediation of the Former Sodium Disposal Facility (FSDF) and its current status. The radiological remediation work is complete, but chemical remediation and site restoration remain to be finished.

The facility was used during the 1960's and 1970's primarily to clean components that contained alkali metals. There was some limited disposal of chemical, industrial and construction wastes at this site before there were prohibitions in effect. A small amount of very low level radioactive waste was inadvertently disposed of at the site as well. Concerns about the quality of the groundwater below several facilities led to the selection of this site, in April 1991, for immediate remediation that was to be completed by December 31, 1992.

Although it was long known that contamination of various types existed at the facility, it became necessary to determine the specific nature and extent of all forms of contamination, to assure that a credible cleanup plan could be prepared. This involved the need for soil and groundwater sampling, geophysical examinations for subterranean objects, and surface radiation scanning. Based upon these site characterization efforts, it was expected that wastes of various categories would be generated: hazardous (chemical), radioactive, mixed (chemical and radiological), and conventional (non-hazardous). Each waste stream required identification of methods of classification, handling and a disposal destination. The nature of the work required that staff be specially trained and equipped with appropriate tools, hazard detection devices and personal protective equipment. The imposed schedule required multiple work shifts. The outdoor setting presented challenges in the performance of the work, management of the site during rain and in packaging of wastes for transportation.

The fundamental clean up strategy involved the excavation of contaminated soil, down to bedrock in certain areas, with limited excavation in others, demolition of unneeded structures, and removal of all objects that were detected below the surface. Following achievement of cleanliness levels, the site would be restored to that of the surrounding terrain, and a post closure monitoring activity would be conducted.

The proximity of the site to residential and recreational property heightened the public interest in this project, bringing intensive scrutiny and involvement by regulators. This participation by regulators has been the prime cause of the protracted schedule. Aside from procedural regulatory controls, the key issue preventing the project from reaching closure was setting acceptable levels of chemical cleanliness. Success in achieving radiological release without restrictions was accomplished in May 1998.

To date, the project has cost slightly over \$ 12,000,000 and has extended over a period of nearly eight years. Excavation and disposal of over 12,000 cubic yards of soil and 20,000 pounds of debris has been accomplished to date, and more is required. There have been no significant injuries, no uncontrolled releases of hazardous substances and there were no radioactive exposures of significance to the remediation workers.

There is no evidence that the FSDF cleanup project has made a contribution to the overall objective of improvement of the degraded groundwater at the laboratory. Although the contaminants of concern found in the groundwater (TCE and TCA) were found only in the lower pond region of the FSDF, the other contaminants found at the FSDF (mercury, PCBs, Cs-137) have not been found in the groundwater. A change in the TCE and TCA concentrations in the groundwater has not been detected following the FSDF cleanup. Clearly, however, the removal of contaminants from the site can only be considered a step in the right direction to prevent further potential migration of such substances into the environment.

This report is being issued at this time to support public awareness of the final phase of the project; that of removing the remaining contamination found after the prior remediation work, to be followed thereafter by site restoration. The cleanup actions at this facility are a portion of the remedial actions being carried out for the entire laboratory site

## 1.0 INTRODUCTION

The purpose of this report is to summarize the history, activities, results and current status of the Former Sodium Disposal Facility decontamination and decommissioning project.

### 1.1 GENERAL

Boeing North American's (BNA <sup>1</sup>) Rocketdyne Division operates a 2900-acre installation, located in the Santa Susana Mountains, approximately 30 miles northwest of the city of Los Angeles, in Ventura County. The complex is known as the Santa Susana Field Laboratory (SSFL). The Energy Technology Engineering Center (ETEC) is that portion of the SSFL operated for the Department of Energy (DOE), which performed testing of equipment, materials, and components for nuclear and energy-related programs. Contract work for the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), predecessor agencies to the DOE, began in the early 1950's. Specific programs conducted for AEC/ERDA/DOE involved the engineering, development, testing, and manufacturing operations of nuclear reactor systems and components <sup>2</sup>. Some activities were performed under license issued by the Nuclear Regulatory Commission (NRC) and the State of California Radiological Health Branch of the Department of Health Services.

Decontamination and decommissioning (D&D) of radiologically contaminated facilities began in the late 1960's and continues today, as all DOE nuclear program operations have been terminated.

The Former Sodium Disposal Facility (FSDF or 4886, formerly T886) is one of the facilities that was radiologically decontaminated and released. This report documents the history and operations relating to unrestricted radiological release of the site. However, there is ongoing remediation activity at the site directed toward chemical release.

This report discusses the cleanup of a region at the western edge of the SSFL, known as the Former Sodium Disposal Facility (FSDF). The facility was removed from service in the late 1970s, and had some limited cosmetic cleanup actions prior to this project.

The project was initiated as a result of findings of degraded groundwater on and off the premises of Boeing North American's (BNA)'s field laboratory, located in the Santa Susana Mountains. One of the locations at the field laboratory which was suspected to be a source of contamination, the Former Sodium Disposal Facility (FSDF) was identified

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<sup>1</sup> Boeing North American-This name was created in 1996 when the Boeing Company acquired portions of the Former Rockwell International Corporation. Those portions were related to the former North American Aviation Company. The use of BNA throughout this document includes the entities of Rockwell, Rocketdyne, and ETEC (Energy Technology Engineering Center-a subdivision of Rocketdyne). This choice avoids the complication of multiple names. References, photos and other documents, however will carry the designations given to them at the time of creation.

<sup>2</sup> An excellent summary of the entire ETEC site history is available for the interested reader in "Technical Site Description of the ETEC" GEN-AT-0027, BNA Staff, August 1991

for immediate remediation by the Regional (Los Angeles Region) Water Quality Control Board (RWQCB).

The DOE (and predecessor agencies) was the primary sponsor of the research which utilized the disposal facility, and has accepted financial responsibility for the cleanup project. Environmental management of DOE contaminated properties continues under the current contract (DE-AC03-99SF21530) entered into between DOE and Boeing North American effective January 1<sup>st</sup>, 1999, to complete remediation of all liabilities associated with former DOE activities at the site. Adherence to this contract assures compliance with federal requirements for protection of the environment, and the health and safety of workers and the community.

## **1.2 ARRANGEMENT OF THE REPORT**

This report is intended for a general audience, but attempts to be sufficiently complete to enable an understanding of the project in a single document.

The abstract allows researchers to find this report and understand the nature and scope of the project.

This introduction (Section 1) sets the context of the project and explains what information is provided in the report.

An executive summary (Section 2) is provided for the casual reader, and presents a highly condensed summary of the project.

The background (Section 3) provides the historical context, physical characteristics of the site and the prior usage of the facility.

The chronological summary (Section 4) is the heart of the report. The project history is presented by a discussion of the key activities that took place, and makes continuous reference to the formal correspondence to explain the then current issues.

There are a series of topics that are worthy of detailed discussion, which are presented in the key tasks and results (Section 5).

Some major issues are discussed (Section 6), together with lessons learned in regard to the issues.

Schedules and costs are discussed in Section 7.

The waste volumes that were generated are presented in Section 8.

Personnel exposure to radiation is summarized in Section 9.

The current status and planned future actions are discussed briefly in Section 10.

Section 11 contains two Appendices; a discussion of the nature of and locations of formal records, and a listing of formally released documents.

Section 12 provides a glossary of abbreviations and definitions.

Section 13 contains all of the figures cited throughout the body of the report.

Section 14 is a list of references cited throughout the body of the report.

## 2.0 EXECUTIVE SUMMARY

The Former Sodium Disposal Facility (T886) at Boeing North American's Santa Susana Field Laboratory was used primarily for cleaning alkali metal system components (e.g. pipes, valves, tanks, instruments) and for disposal of scrap sodium by reaction with water. However, during its use from the early 1950's through the late 1970s, small quantities of a variety of other materials were disposed of at the site, at a time when this was an acceptable practice. Some radioactive materials were inadvertently placed there. As a result, small amounts of radioactive contamination became dispersed in the cleaning submergence pit, and in the upper and lower basin areas.

The finding of chemically contaminated groundwater at some locations led regulators to the selection of a portion of this facility, in April 1991, for immediate remediation that was required to be completed by December 31, 1992. The designated portion of the facility was remediated by the specified date.

The concrete cleaning pit, related structures, all the soil in the lower basin and a considerable amount of soil from adjacent areas was removed during a remediation effort conducted from 1991 through 1994. At the completion of this effort, a final gamma radiation survey, and a sampling of soil and rock were performed to demonstrate the satisfactory removal of the radioactive contamination. However, the results of soil and sediment sampling and analysis showed residual levels of chemical substances that were evaluated to pose a threat to the environment.

Based on six independent rounds of radiological surveys and soil sample investigations, the Sodium Disposal Facility has been found to be free of radioactive contamination that could result in any exposure or risk to any current or future user. In May of 1998 the facility was removed from the list of licensed areas and released for (radiologically) unrestricted use. Today there is no requirement to radiologically monitor, sample or screen any soil taken from the Sodium Disposal Facility during any future activity.

An assessment of the risks of allowing the residual chemical contaminants to remain at the site resulted in a plan for additional soil and sediment removal. Obtaining regulatory approval for the remaining cleanup and site restoration has consumed all of the time from October 1995 to the present.

Final closure of the facility will not be accomplished individually, as the entire site cleanup plan is being finalized. The remaining facility work, defined as an Interim Measure published in a public notice dated July 1999, "...entails the following activities: 1) removal and off-site disposal of approximately 3,200 cubic yards of PCBs, dioxin and mercury contaminated soil; 2) the replacement of excavated material with clean soil from an on-site source; and 3) the planting of native vegetation where soil has been excavated." These actions are planned for late 1999, subject to final approval by the California Department of Toxic Substance Control.

The Former Sodium Disposal Facility cleanup project has had an exceptionally large amount of regulatory scrutiny and public involvement, incurring a considerable cost and schedule impact. The contribution towards improvement of the degraded

groundwater associated with the FDSF cleanup remains to be determined. Clearly, however, the removal of contaminants from the site can only be considered a step in the right direction to prevent further migration of such substances into the environment.

### **3.0 FACILITY BACKGROUND**

#### **3.1 FACILITY LOCATION AND PHYSICAL SETTING**

The facility is located in Southern California, about 30 miles northwest of Los Angeles City center, see Figure 1. It is at the western edge of BNA's laboratory situated in the Santa Susana Mountains, just inside of Ventura County. The laboratory is adjacent to high value, residential and recreational property. There is a vocal, concerned citizenry who are environmentally sensitive. This brought the remediation project into high visibility by the public, by regulators and by BNA management.

The former sodium disposal facility is an outdoor setting, lies on a gentle downslope at the western extreme of the SSFL site, Figure 2. It is an approximate 3-acre site, characterized by rugged sandstone layers that are overburdened with thin layers of alluvial soil. The triangular site shape is defined by the eastern and western exposed rock outcroppings as shown in the April 1991 photo of Figure 3. The upslope region to the south of the access road is a level, treeless meadow (today) and the area to the north is typified by rugged terrain and natural watercourses which drain to neighboring private property. Surface water disappears from the site quickly as a result of the site slope and the percolation that occurs rapidly into the fractured bedrock.

This region of Southern California receives on average, less than 20 inches of rain per year and the depth to groundwater is approximately 250 feet at its shallowest, in the vicinity of the FSDF. Details about the geology of the site may be found in Reference 1. The upslope region to the south previously had a security department practice shooting range and to its west a sodium/water reaction test facility, both of which were demolished in the early 1990s. Remaining underground utility features from these facilities were detected in the geophysical surveys. There was another shooting range, downslope to the north that was demolished in the 1960's.

#### **3.2 FACILITY USAGE**

The site has been used primarily for cleaning and disposal of components containing residual alkali metals and their oxides. Alkali metals (predominantly sodium, but including potassium and sodium/potassium mixtures [NaK]) were used as the heat transfer media in nuclear reactor systems. These metals and their oxides are not radioactive. Since these alkali metals are highly chemically reactive with water and steam, the process for cleaning components involved the use of submergence in a water filled "pool" and/or a high pressure steam jet. The site was also used for disposal of "Santo-wax" which was an organic compound also used as a heat transfer medium in nuclear reactors. This non-radioactive material was combusted at the site. The site was used for these purposes during the 1960's and 1970's.

Components to be cleaned were placed on the slab, opened to expose the reactive alkali compounds, and then washed off with water and/or steam jet cleaned. The water reacted with the alkali metal compounds to generate hydrogen, which often burned in the air (hence the name 'burn pit'). The washed items, which were to be scrapped were then placed into the pit, where the reaction with water continued, and then removed from the pit and placed into one of the water filled basins, where they were allowed to remain until

any residual material was reacted. They were then retrieved and disposed of off-site as solid waste, or in many cases allowed to sink to the bottom.

It is likely that the site was used for other waste disposal, based upon the findings of conventional and construction wastes and debris. Mercury and TCE have been found at the facility, but there are no records as to when their disposal occurred. In the early 70s, use of the facility as a disposal was terminated and in the late 70's an effort was made to clean up the site. Due to funding limitations, only superficial cleanup activities were performed in the 70's and 80's and were comprised of removal of surface (visible) scrap, and limited removal of radioactive material was accomplished in the lower pond (Reference 2).

Examination of drawings (Reference 3) made at the time of installation of the cleaning pad and concrete submergence pit note the existence of two "earth" pits; one at the area defined as the western region and the other south of the access road.

The submergence pit also was connected to the former ESADA facility (B814, located upslope and removed in 1991) by underground piping and presumably received wastes from sodium/water reaction experiments performed at that facility.

The existence of both chemical and radiological materials at the site was noted in a report, "CERCLA Program Phase II-Site Characterization" May 1987 (Reference 4). The source of the chemical materials is a result of the site usage. The source of the radiological materials is unknown; but is believed to have occurred by error or oversight-given the extremely low activity level of the materials. It was never a practice to dispose of radiological materials on the SSFL site.

### **3.3 FACILITY WORK AREAS**

For purposes of site remediation, the FSDF has been subdivided into four work areas as depicted in Figure 4. The division of the FSDF into these areas was based upon the structures, topography and previous activities at the site. The major characteristics of each area, and the future plans are briefly described below:

#### **FSDF-1**

FSDF-1 encompasses an area of approximately 40 feet by 250 feet south of the access road that traverses the site. There is little information about this region of the site beyond a circa 1950's drawing which depicts the area and suggests a burial site for wastes. Characterization of the site for radiological, chemical and physical properties included this region. No remediation of this area of 5 to 10-foot thick soil overburden was found to be necessary, beyond extraction of subterranean objects that were located by a geophysical survey conducted in late June of 1995.

#### **FSDF-2**

FSDF-2 is located north of the access road, and includes the former cleaning pad area, the upper pond and an area to the west of the upper pond. The cleaning area included an asphalt pad that contained a small building which housed the steam production and handling equipment, and a covered, concrete lined submergence pit. The upper pond was a manmade region formed by earthen berms to contain water into which scrap components were "tossed" to react and then sink. After the pond dried out, and an

excessive amount of scrap was accumulated, the scrap was bulldozed out to the west for staging for disposal. When the next cleaning activity was needed, the earthen bermed pond was re-created.

These areas were found to be moderately contaminated, and have been partially remediated. The majority of the remaining work will be to remove the balance of soils in the upper pond, to bedrock, with some scarification of the rock to remove staining and accessible contamination. Additional soils will also be removed from the western area to achieve the cleanup objectives.

### **FSDF-3**

FSDF-3 is the lower pond, which was also used for disposal of scrap. It is not known why two regions were used. The cleanup order for the FSDF site identified the lower pond as the target for immediate remediation. The shallow soil depth, small area and the nature of the contamination formed the basis for removal of all soils down to bedrock. No additional remediation is required for this region.

### **FSDF-4**

FSDF-4 is the region comprised of the two drainage systems. There are two naturally occurring drainage channels, designated A (westerly) and B (easterly). The terrain slopes downward in a northerly direction to the former BNA property boundary. The new boundary is approximately 500 feet north, such that channel C is on BNA property. Figure 5 illustrate the channel arrangements and an estimate of the new boundary is indicated. The lengths of channels A and B are approximately 400 and 625 feet, respectively. Channel C has been designated as the continuations of both channels, but further subdivided. Channel C1 is the continuation of channel A and channel C2 is the continuation of channel B. Channels C1 and C2 converge and continue down slope as channel C-3 until another drainage channel enters the path.

The soils and sediments in the drainage channels were found to contain residual chemical contamination, and removal of sedimentary material is planned.

#### **4.0 CHRONOLOGICAL SUMMARY**

Considering the protracted timespan of this project, a chronological summary is offered as a framework for presentation. It shows that, in spite of the obstacles, the limited objective of compliance with the initial remediation order was achieved on time; and the facility was radiologically released for unlimited use. It also shows that the greater objective - full remediation of the facility - is not yet achieved due to the difficulties of reaching agreement upon what constitutes a satisfactory cleaned up chemical condition and delays in the regulatory decision making process.

#### **4.1 BACKGROUND AND EARLY HISTORY**

The Sodium Disposal Facility (originally called the Sodium Burn Pit) was built in the early 1960's to clean alkali metals containing components. It was also used for disposal of organic substances. Some disposal of other wastes took place, including unintentional disposal of radioactive materials.

The Sodium Disposal facility was operated from 1956 to 1978. In the late 70's a concrete channel was installed across the southern edge and extended into the upstream end of the western drainage channel to deflect run-on rainfall and minimize erosion and possible material dispersion.

The Sodium Disposal Facility was never intended for use or disposal of radioactive materials, however it is clear that controls in place at the time were not adequate to prevent some contaminated equipment from being taken to the facility and treated as described above.

Following termination of operations at the Sodium Disposal Facility in 1978, when new facilities built expressly for that purpose were opened, some limited cleanup and removal of equipment and debris was performed (Reference 2) in the late 1970s and 1980s.

Periodic radiation surveys and soils sampling performed between 1978 and 1983 indicated that low levels of radioactive contamination existed principally in the lower pond, some in the upper pond, and was principally cesium-137. No radiological contamination was identified in the areas outside the ponds.

A chemical survey (CERCLA Phase II) was conducted in March 1987 (Reference 4). Known areas of radiological contamination were avoided during this survey. An aerial view of the site showing the sampling trenches can be seen in Figure 6.

Following the CERCLA survey, a comprehensive radiological survey was performed in 1987-88, in areas surrounding the two open pits (Reference 5). Again, no evidence of radiological contamination was found in surrounding areas or drainage channels.

#### **4.2 INITIATING ACTIVITIES-1990 & 1991**

The key initiating activity for this project occurred in April 1990 when a directive was received from the Regional (Los Angeles) Water Quality Control Board (RWQCB) to characterize the lower water impoundment at the T886 facility. This action was taken under RWQCB's authority provided in the California Code of Regulations (Reference 6),

as a consequence of findings of halogenated solvents in groundwater at various locations of the overall field laboratory. Rocketdyne commissioned a hydrogeological study that resulted in a physical characterization of the site that focused upon contamination of the soils and groundwater. In June of 1990, the study (Reference 1) concluded that there is "a reasonable likelihood that hazardous waste constituents, primarily F001 [chemical] volatile organic constituents, could continue to migrate into the Vadose Zone and the underlying groundwater systems", and the study was forwarded to RWQCB.

## 1991

Nine months later, in March 1991, RWQCB provided their comments (Reference 7) to the hydrogeological study, requesting that a corrective action (closure) plan be prepared for the site.

On April 30, 1991, RWQCB issued "Cleanup and Abatement Order No.91-061" to BNA (Reference 8) to close the lower pond impoundment, and to investigate and cleanup soil and groundwater contamination resulting from activities at the site (FSDF). The order called for:

- Completion of the remediation of the lower pond by 31 December 1992
- Issuance of quarterly progress reports
- A post closure plan showing this area to be included in a sitewide groundwater cleanup activity
- Civil liabilities for failure to comply

In late May, BNA issued a plan (Reference 9) to DOE for the proposed FSDF assessment, (which was the proposed response to the RWQCB Order) and requested that DOE funds be used for the activity.

On July 31, 1991, BNA submitted (Reference 10) a closure plan for the FSDF in response to the closure order, and requested a 30-day approval to enable achievement of the 31 December 1992 schedule. The plan was prepared by EBASCO under contract to BNA. The RWQCB order limited itself to remediation of the lower pond because of the contamination found at that location. However, on the basis of the prior CERCLA II investigations (Reference 4), it was known that there was contamination in the upper pond and the western area, and BNA planned the cleanup scope to include the entire FSDF facility site.

Unrelated to the FSDF project, but which had costly ramifications, DOE (in July 1991) placed a nationwide moratorium on shipping hazardous wastes that originated within a radioactive materials area, and set guidelines for release of the moratorium. This action was taken because of an erroneous shipment of hazardous waste containing radioactive materials was sent to an unlicensed site (not a BNA project). All DOE contractors were subsequently required to develop procedures to obtain the lifting of the moratorium at their respective sites.

### 4.3 PROJECT ACTIVITIES – Phase I, August 1991 to June 1993

In August 1991 BNA assembled a team and began preparations in earnest. A budgetary request was submitted to DOE detailing cleanup of the entire site, which assumed an optimistic 15-month work schedule and a cost of less than \$5M.

In early September RWQCB informally notified BNA (Reference 11) that the closure plan was unacceptable because it proposed unnecessary additional characterization but insufficient cleanup activity. RWQCB directed that BNA submit a [revised] plan (by May 1, 1992) to remediate the surface impoundment (lower pond), and include plans for remediation of the surrounding areas (upper pond and the area to the west), and capture and properly dispose of storm runoff which enters the impoundment. This response was basically disapproval of the plan.

Involvement in the project by California-EPA, Department of Toxic Substance Control (DTSC) occurred as a result of BNA's intention to consolidate regulatory oversight. A sitewide RCRA investigation was in progress, and included the FSDF as an area of interest. California DTSC was expected to be involved in the activities sooner or later and early coordination with RWQCB was thought to be beneficial, which was the reason that all correspondence was distributed to both agencies, although conflicting directions were to become an issue.

To date, all activity related to remediation of the FSDF had been conducted within the Environmental Control department of BNA. The application of substantial DOE funding required that a formal project be developed. In September 1991, a project manager was assigned from the ETEC department of BNA. Project management planning and procedure preparation got underway; and staffing and training activities began.

DOE was required, in compliance with NEPA, to make an environmental impact assessment of all projects—basically to assure that mitigation steps are being taken to minimize or avert negative impacts. The analysis is to result in a determination as to what actions, if any are required by the project. BNA recommended (Reference 12) to DOE, that the FSDF project would have a positive environmental impact, by its very nature as a cleanup activity. BNA recommended that a categorical exclusion be applied to the activity. This classification precluded the need for preparation of separate environmental impact analysis and documentation, noting that the closure plan, when approved, would address the issues.

By mid-September BNA defined (Reference 13) the criteria and locations at the SSFL laboratory to which the waste disposal moratorium applied, and the FSDF facility was included. Of specific concern to DOE was the assurance that any hazardous wastes removed from the area were adequately shown (documented) to be free of radioactive components before shipment to a non-radioactive hazardous waste disposal site.

In late October 1991, DOE informed BNA (Reference 14) that the waste shipping moratorium was still in effect, and the guidelines for approval were now more advanced. Administrative controls would have to be developed before any wastes would be approved for shipment if they originated within a radioactive materials area. The impact

of this reminder was not fully appreciated until later, when the delay in approval of the procedures by DOE precluded shipping the accumulated wastes, in conflict with other regulations that required that the wastes be shipped within 90 days of generation.

On November 1, 1991, a combined (RWQCB and DTSC) formal response to the Closure plan was received (Reference 15) which provided that if the list of 38 identified items was complied with, approval would be granted. The items requested ranged from providing detailed plans and procedures, to performing remedial actions themselves. BNA launched an intensive effort to prepare the documents requested and develop appropriate detail plans for the other actions. Most of what was requested is standard operating practice to produce, but is generally not available at the planning stages.

The first issue of a project management plan (Reference 16) was released in November 1991. The plan identified the project objectives, general work scope, organizational responsibilities, schedules, a budgetary cost estimate and the governing rules and regulations to which the project must comply. It further defined, in general terms, the need for preparation of subtier documents including a Health and Safety Plan, a Quality Assurance Plan, process procedures, procurement plans etc.

By mid-November, site mobilization activities began. Temporary buildings were identified, weeds cleared, utilities ordered, roads graded and fencing was repaired. Training of approximately 30 future field workers began, which required completion of a 40-hour hazardous waste worker class and a 24-hour on the job training, including facility and project familiarization. Supervisory staff also completed this training plus an 8-hour supplement. Baseline medical examinations of all site workers were conducted. Purchase orders for materials, waste handling and storage containers were issued, leases for rental machinery were placed and specifications for competitive bidding for support services (waste hauling, laboratories, etc.) were initiated.

BNA issued the first release of the project Health and Safety Plan (Reference 17) in early December 1991, and forwarded it to DOE and to RWQCB/DTSC.

By mid-December, specifications and requirements were completed for key subcontracts: groundwater monitoring and installation of new wells, geophysical survey of the site, a chemistry lab for analysis of non-radioactive wastes (soil, debris, water) and a radio-chemistry lab for analysis of radioactive wastes (soil, debris, water).

Site development was completed by 15 December. This included; installing temporary buildings for office space and decontamination facilities for workers (Figure 7) radiological equipment storage, fencing, utilities and establishment of a 10 foot coordinate grid system for location and control. The grid system was documented on maps (Figure 8 from Reference 18) to which all future fieldwork was referenced. Figure 9 shows the site prior to the beginning of excavation, and rainwater has accumulated in the upper pond. A careful examination of the photograph will show the grid markers.

## 1992

Top level plans and policies were completed by 1 Jan 1992. This included compliance with California regulations, DOE Orders, ETEC requirements, and BNA requirements. Detailed management plans, staff training plans, health and safety plans, waste handling plans, quality assurance plans were in production as were procedures for

radiation surveying, soil and object excavation, waste classification, handling, storage and disposal.

On 3 January 1992, BNA submitted (Reference 19) responses to each of the 38 items specified in the RWQCB/DTSC closure plan approval. In many cases, documents requested were included, in others, discussions of what was to be prepared was given. BNA requested an expedited review and meeting to enhance the approvals to proceed.

On January 7, 1992, rain began at the site, and pumping of water accumulation into storage tanks was accomplished as required in the closure order. This was the beginning of what turned out to be some of the heaviest recorded storms of the century.

A routine analysis of rain runoff from the site showed 2.4 ppb of Hg, compared to the drinking water standard of 2.0 ppb. Monitoring of off site drainage is conducted under the site wide NPDES permit. This was the first finding of a contaminant and an unplanned occurrence report was written.

On February 2, 1992, an updated revision to the Health and Safety plan was issued (Reference 17), and the site work procedures were ready. Fieldwork could have begun, weather permitting, had all approvals been in place.

The staff completed an informal geophysical examination of the facility, in an attempt to accomplish some productive work while waiting for weather and approvals. There were sufficient findings to justify a specialist's investigation. Further, regions could not be claimed to be free of subterranean objects without a more sophisticated survey.

A meeting with RWQCB/DTSC on February 5<sup>th</sup> resulted in conditional agreement to proceed with limited cleanup, concurrent with issuance of additional material from BNA. The buried object removal procedure was forwarded to RWQCB/DTSC on February 7<sup>th</sup> (Reference 20).

On February 11, 1992 DTSC sent (Reference 21) additional requirements necessary to obtain agency approval of the closure plan. Some of the new items included:

- Implement a characterization plan (recall RWQCB's opposition to further characterization)
- Develop and initiate a public participation plan
- Set preliminary cleanup targets for each hazardous constituent

The other items requested were already planned in one form or another. DTSC approval was issued conditioned upon implementation of the actions specified.

On the same day, RWQCB provided (Reference 22) its approval of the closure plan, with some additional new requirements. The key items were:

- A pilot demonstration of the effectiveness of the planned remediation process will be conducted in a region of the lower pond specified by RWQCB. This was intended to expedite the start of field cleanup.
- Verification of cleanliness would take place prior to backfilling.

- Fieldwork may not begin until the DTSC public participation fact sheet is issued and the pilot region defined.

RWQCB noted that the completion date specified in the closure order (issued almost a year ago) remains unchanged. The involvement by DTSC imposing new and sometimes conflicting requirements, the addition of new requirements by RWQCB, and the delays in arriving at a fieldwork go ahead did not warrant a completion schedule delay in the view of the RWQCB.

February 15 Heavy rainfall was falling and threatened to delay start of field work (surveys and excavation). Staff and procedures were ready and conditional approval to proceed was in place.

BNA accepted (References. 23 and 24) the companion DTSC/RWQCB conditional approval letters as notices to proceed, subject to the identification of the pilot demonstration zone in the lower pond. A request was made that the zone be the entire pond in order to enhance schedules, but was subsequently denied.

On February 20<sup>th</sup>, DOE disapproved of BNA's method for confirmation that hazardous (chemically) wastes are free of radioactivity (concerned about sending radioactive material to hazardous waste sites). Additional administrative detail was required to be included. This presented the first impediment to excavation because there was a 90-day limit (EPA regulation) in effect for on-site storage of hazardous wastes.

On February 24, 1992 RWQCB visited the site and defined (Reference 25) the pilot excavation demonstration area in the lower pond to be about one-third of the total volume (about 550 cubic yards) encompassing the region identified as being the most chemically and radiologically contaminated. The only constraints to proceeding with excavation were the weather and the notice required to be given to the RWQCB representative who wanted to be on site for the start of work, verbal approval of the DOE NEPA determination had been provided.

On February 26, 1992 - The pre-remediation site gamma survey was started. This was intended to confirm that the radioactively contaminated areas have not changed.

On March 4, 1992 DTSC issues the project fact sheet (that was drafted by BNA) for public information.

DOE issued (Reference 26) its NEPA determination and authorized BNA to proceed with the project. A categorical exclusion was granted because the project is a positive impact environmental action.

On March 9, 1992 - The first soil is excavated (manually, due to wet conditions) and placed in barrels, awaiting delivery of larger waste containers. Figure 10 shows this first excavation activity being conducted with shovels. Note the presence of health and safety representatives who are monitoring the soil for hazardous vapors. Visible elemental mercury was found in the soil, as can be seen in Figure 11.

On March 10, 1992, DTSC issued a letter (Reference 27) reiterating its prior conditions, but emphasized its insistence upon soil removal in layers. This was neither feasible, nor practical with the relatively small pilot area surface and shallow depth.

March 10, 1992 - Excavation of subterranean objects was begun using informal data from in-house scanning, while awaiting the results of commercial geophysical survey. Examples of some of the exhumed debris are shown in Figure 13 and Figure 14.

At the first shovel full of hazardous wastes, which started a 90-day on-site storage limit clock, and the DOE moratorium on shipping of hazardous, BNA was placed in a potentially non-compliant position. The option of not extracting the waste was in violation of the cleanup order, while storage (beyond 90 days) of the wastes produced would violate EPA regulations, and shipping of the wastes would violate DOE's orders. BNA, (Reference 28) requested relief from the 90 day storage limit on the basis that this was a cleanup project, and not a continuous waste generating operation and that the DOE moratorium issue was being aggressively worked, but may not meet the current schedule needs.

March 14, 1992 - The baseline radiation survey of the site was completed. The findings confirmed the prior knowledge base. There was no migration of contamination and there were no unexpected findings. Elevated radiation levels were found in the lower pond (the highest being 27.5  $\mu\text{R/hr}$ , or approximately twice natural background levels), and the upper pond slightly above background. This examination included measurement of ambient gamma radiation at a distance of 1 meter from the surface, using sodium iodide detectors as shown in Figure 15; and at the ground surface with "pancake" beta-gamma detectors as shown in Figure 16. The results of the survey were factored into the site cleanup strategy and procedures. The formal report was issued later (Reference 29)

On March 27 and 31, 1992 TCE was reported in storm water runoff from rainfall events. Findings of 6 and 18 ppb (reporting threshold is 5 ppb) required an occurrence report to be issued. Additionally, this sampling gave the first detection of mercury at this location and was assumed to be a result of the disturbed earth from excavations.

On April 6, DTSC approved (Reference 30) BNA's request for a storage extension of hazardous wastes, beyond the 90 statutory limit. No explicit limit was identified, but was tied to DOE's lifting of the shipping moratorium.

April 15 - Heavy rains continue to prevent site remediation. Attempts were made to capture and divert shallow groundwater which was flowing downslope and onto the site. Diversion trenches dug to the south of the access road exposed a strong odor of kerosene in the southeast region, prompting extension of this area for examination and remediation if required.

April 22 - Excavation at the site resumed (manually, while awaiting receipt of a soil handling machine which was late in delivery) in the designated area of the lower pond, while extraction of subterranean objects proceeded sitewide. Two crews were put on to enhance schedule compliance.

On April 24, 1992 DTSC issued a comprehensive review and critique (Reference 31) of the project Health and Safety Plan document (Reference 17). DTSC requested numerous changes, substantially intending the document to be a stand alone project plan. DTSC ignored the existence of the companion documents that provided the information requested. The issuance of the critique occurred six weeks after approvals to start work

were received, however no requirement to stop work or to resubmit revised documents was imposed.

On April 27, 1992, the initial geophysical survey was completed and an advance map issued (see Figure 17) for buried object removal. The survey was conducted by ICF Kaiser (Reference 32) over the entire site north of the access road, except for both ponds which was going to be excavated to bedrock and the information would be of little value. This survey formed the plan for object removal and the basis for improved volumetric estimation of excavation quantities. The site was generally found to contain buried objects in the expected areas, and the soil thickness ranged from 0 to 15 feet. The results identified objects throughout the site. It is known that scrap was abandoned and, over the course of time, become covered by the effects of weather, and that scrap was buried in trenches north of the lower pond (Reference 33). Figure 18 shows technicians *performing the geophysical survey.*

On May 6, 1992 BNA was informed (Reference 34) of DOE's policy regarding the generation of regulated wastes for which land disposal was no longer acceptable. BNA was directed to cease generation by May 8, 1992. This was an entirely new restriction, not related to the hazardous waste shipping moratorium. Another impediment to remediation of the site was now identified. This order applied to both hazardous and mixed wastes, both of which are produced in the lower pond cleanup zone. The presence of mercury in the soil rendered it hazardous. The order basically prohibits the generation of wastes that cannot be land disposed, or for which there is no known treatment that complied with the disposal restriction requirements. All excavation, which potentially would generate wastes with RCRA hazardous components, was stopped. Meanwhile, excavation of buried objects in non-radioactive areas was continued.

On May 10, 1992 it was determined that hand screening of soils to remove the radioactive components was not sufficiently effective to enable classification of the remaining soil as non-radioactive. There were dispersed radionuclides that were not physically separable by sorting techniques. Development of an alternate method became the top priority task.

On May 11, 1992 DTSC clarified (Reference 35) its position on the issue of waste storage beyond the 90-day limit. It was not clear whether the prior approval was reversed or not! DTSC reiterated the need for closed containers (no soil piles) and no excavation in areas other than those specified by RWQCB. DTSC added two new requirements: screening (no specification for size or what is wanted) and examination of the ground where storage containers would be located.

At this point, BNA responded (Reference 36) to the DTSC review of the HASP by pointing out where the information requested was currently available, and agreeing to improve the HASP in areas suggested by DTSC.

On May 22, 1992 DTSC revised and approved (Reference 37) the public participation document by imposing more new requirements; chief among them was that areas surrounding the ponds would be characterized and if they are above cleanup levels, they will also be excavated. This commitment for BNA was made unilaterally by DTSC and had not been agreed to by BNA or by DOE, the funding agency.

On May 22, 1992 BNA issued a letter (Reference 38) to DOE/RWQCB/DTSC stating that the excavation work has been stopped at the FSDF due to the conflict of regulations and that a joint meeting should be held to seek methods to resolve the impasse.

On June 5, 1992 DTSC issued a letter (Reference 39) summarizing a series of documentary exchanges pertaining to the cleanup plan. The letter explicitly provided approval to proceed with site cleanup outside of the RWQCB designated zones, conditioned upon BNA implementing the requirements contained in the series of referenced documents. The letter further went on to require that BNA demonstrate, via a health based risk assessment (HBRA), that all clean up standards have been met. It should be noted that a single, stand-alone document defining the cleanup plan had not been prepared, issued and approved. The continuing discussions, negotiations, exchanges and urgency of fieldwork precluded the preparation of such a document.

On June 11, 1992, BNA issued a letter (Reference 40) summarizing agreements that had been reached at a joint meeting of federal and state regulators convened to review the issues of conflicting requirements, concluding that no excavation would be performed until a federal agency authorized work. Mixed waste generation had been suspended since May 7, 1992.

BNA received a letter (Reference 41) from EPA which agreed that BNA is caught in a regulatory conflict, and offered to set low priority on civil enforcement of regulations [by EPA], given that certain actions are taken. The requested actions were well within the planned management procedures already in effect, thereby imposing no new requirements. The key feature of the correspondence was that if a method for mixed waste treatment were shown to be available and effective, the creation of mixed wastes would no longer be a violation. BNA chose to avoid the specter of federal prosecution by placing a stop on the excavation of mixed wastes and aggressively began a search for mixed waste treatments.

On June 30, BNA (Reference 42) requested RWQCB to extend the time for compliance with the closure order, given the federal and state legal "catch 22" that precludes continued excavation.

On August 2, 1992, after considerable investigations into alternative approaches and an industry survey, a study effort was initiated at Clemson Technical Center to treat mixed waste soils. The treatment would produce two waste streams, neither of which are restricted wastes. Successful demonstration of such a technique would allow site remediation to resume in the radioactive area.

In response to BNA's informal submittal (in early August 1992) of a sampling plan for verifying site cleanliness, DTSC responded (Reference 43) by proposing criteria that require that the site be at the prevailing background levels (for metals, volatile organic compounds and petroleum hydrocarbons). If the findings are above background (or the limits of detection), that further excavation/disposal be accomplished until such limits are achieved.

Since the excavation had been suspended in areas where hazardous waste generation was possible, the only productive use of the staff was to demolish the non-hazardous

structures and equipment, and dispose of the conventional wastes. Demolition of the asphalt pad, concrete pit and scrap hardware was used for fill-in work until the lower pond work could be resumed. Figure 19 shows the pit before demolition began and Figure 20 shows it during demolition.

On September 1, 1992, a key breakthrough occurred when a successful demonstration was conducted showing that mixed wastes could be treated to produce non-mixed waste streams (Reference 44) in a commercial process. This enabled the moratorium to be lifted from excavation in radioactive areas. See the key tasks and results section for a discussion about the treatment process.

In early September 1992, a site restoration-grading permit was issued (Reference 45) by Ventura County. It has been renewed annually ever since.

On September 3, 1992, excavation of soils in the radioactive areas was resumed on a multiple crew, multiple shift basis. Four calendar months remained to remove the contaminated soil from the lower pond to comply with the closure order.

Aggressive pursuit of the implementation of the mixed waste treatment system was initiated in early September. Transport of mixed wastes to an off site location for treatment was determined to be non-feasible (costs, permits, risks and approvals). Purchase or lease of the waste treatment equipment system to be located at an on site location was selected, and aggressive contracting and permitting actions were initiated.

As of September 14, 1992, no wastes from the FSDF project had left the site, because of the shipping restrictions. The cost of waste container demurrage was considerable. The waste inventory included:

450 cubic yards of non-radioactive soil (chemical content not yet determined).  
Figure 21 illustrates the accumulation of covered roll-on/roll-off containers.

83 cubic yards of radioactive soil (chemical content not yet determined). Figure 22 illustrates the accumulation of radioactive wastes in B-12 containers.

Many pallets of exhumed debris (conventional wastes) see Figure 13 and Figure 14.

On September 20, 1992 the first shipment of wastes left the site –approximately 40 tons of conventional concrete, asphalt and debris were sent to a class 3 landfill. Waste disposal costs were determined by weight and transport vehicles were weighed coming in and going out. Some of the transportation elements are shown in Figure 23, Figure 24, and Figure 25.

On October 2, 1992, BNA requested (Reference 46) RWQCB to accept the methods and procedures used to date in the pilot study zone of the lower pond, and release the balance of the site for cleanup. This would enable more crews to be put to work to achieve the closure order.

RWQCB approved (Reference 47) the plan for closure of the balance of the lower pond only! Backfilling is to be held pending verification of site cleanliness. Agreements were reached on the sampling and analysis verification plan intended to be performed after cleanup is completed

On October 10, 1992, the first shipment of hazardous soil wastes were sent to a Class 1 site-Chemical Waste Management's Kettleman City, CA. These were soils verified to contain RCRA constituents, but which did not originate in a radioactive materials management area.

In early November, DOE's Hanford waste disposal site agreed to accept the low-level radioactive wastes from the project. The radioactive wastes can be from treated mixed wastes (radioactive components only) or as classified as radioactive only. The costs to the project were projected to be very high.

On November 10, 1992 the first shipment of hazardous wastes which originated in an RMMA (and verified to be non-radioactive) were shipped to the Kettleman City disposal site. DOE provided an exception (Reference 48) to the moratorium on RMMA wastes because of the 90-day limit for on site storage, and their confidence in BNA's methods of verification of the absence of added radioactivity. The approval was conditioned upon future receipt of certifications of cleanliness, and will continue on a case-by-case basis

By December 1, 1992 the excavation of all soils down to bedrock was completed in the lower pond. Approximately 6500 cubic-yards of soil were excavated compared with original estimate of 1830 cubic-yards. Figure 26 shows the as cleaned condition of the lower pond. The photo was taken after the wells were installed however.

On December 7th, rain begins-excavations have been covered with tarps, storage tanks and pumps mobilized to capture water that appears below tarps. Figure 27 illustrates the site prepared for rain, and Figure 28 shows the water accumulation during rain.

On December 8th, the first samples of candidate mixed wastes were taken for analysis. Delay in sampling had been caused by difficulty in securing a chemistry lab licensed to handle radioactive materials.

In mid-December 1992, RWQCB verbally declared that BNA has complied with the order to remove the contaminated soil and debris, and that upon submission of data and a satisfactory post-closure plan document, RWQCB would issue a notice of compliance. Figure 29 shows the RWQCB representative (Mr. Ross in the vest) on site.

On December 20th, results of soils in crevices and bedrock samples from the lower pond indicated residual chemical contamination at 50% of the sample sites. Found PCBs, hydrocarbons, VOCs and Mercury. This condition has been assessed to be acceptable and the pond will be backfilled when the other portions of the site are backfilled.

On December 22, BNA submitted (Reference 49) its interim plan for activities to be conducted after site closure (post-closure). A post-closure plan was required by the cleanup order.

On December 29, 1992 RWQCB issued a letter (Reference 50) stating that "...all Board requirements have been met for closure of this facility". It confirmed the requirement to manage water that enters the site and stated that it had no further regulatory interest in this site, deferring to DTSC for future guidance.

## 1993

By January 1993, the excavations at the site included the entire lower pond, a substantial portion of the upper pond, the submergence pit and associated structures; and a good deal of the soil due west of the lower pond, as shown in Figure 30.

In mid-January, 1993, DTSC asserts its authority over the mixed waste treatment that BNA has proposed to perform at its on-site radioactive materials disposal facility (RMDF, subsequently renamed to RMHF-handling versus disposal). A request for information, potentially leading to a permitting action was requested in the communication (Reference 51). Although the RMHF was currently licensed to store and treat radioactive wastes, this issue promised to further complicate and delay the project completion. By default, DTSC also became the sole regulatory agency for the site cleanup, except that radioactive materials control and radioactive release of the site remained the purview of the DHS.

Another breakthrough occurred on January 19, 1993 when DOE lifted the moratorium on shipment of hazardous wastes from the RMMA at the FSDF (Reference 52). The appropriate documentation is still required, but individual shipment approvals were no longer required. Sitewide lifting of the moratorium was not to be granted until August of 1993.

BNA issued a letter to DTSC on February 17, 1993 (Reference 53), which requested an extension of the period for storage of mixed wastes. The wastes were being stored at the permitted RMDF facility as shown in Figure 31.

Pursuant to DTSC's request for information about mixed waste treatment at the RMDF, BNA provided (Reference 54) some information and stated its belief that the Federal EPA permit was in effect and that it governed the planned work.

On February 24, 1993, BNA furnished (Reference 55) more of the information requested by DTSC, believing that DTSC's concerns were more than adequately addressed in DOE's requirements for control of hazardous wastes. Additional information was sent on March 3, 1993 (Reference 56).

On March 24, RWQCB sampled the lower pond to determine the post-remediation conditions of contamination. Traces of chemical contamination was confirmed, and agreed to be below concern. No additional remediation is required in the lower pond. Further, all sample analyses indicated that only background levels of radioisotopes remained (Reference 57), also below regulatory concern.

On April 1, 1993, DTSC notified BNA of its determination that a separate permit would be required to be issued by DTSC for the mixed waste treatment at the Radioactive Materials Handling Facility (RMDH, formerly the RMDF). Further, demonstration of the adequacy (repeatability, reliability, scalability, maintainability and other features) of the treatment process shall be provided as part of the permit application. DTSC also provided a list of [out of state] locations where mixed wastes might be sent, as an alternative to treatment at the RMHF. DTSC's resistance to mixed waste treatment motivated BNA to aggressively seek other solutions. BNA began to lobby DOE strongly

for its receptivity to off site disposal, irrespective of the costs. Investigations into locations where mixed wastes could be sent were initiated.

In early May, the treatment and disposal of objects removed from the FSDF that were likely to contain alkali components began at the Hazardous Waste Treatment Facility (T133). All materials were verified to be non-radioactive prior to removal from the FSDF perimeter.

On May 19, 1993, BNA documented (Reference 58) its perspectives on the permit issues raised by DTSC and questioned the nature of, and who should be the applicant for the permit (facility owner or treatment process equipment owner). DTSC was also reminded about responding to the storage extension request made 4 months previously.

DTSC granted (Reference 59) BNA a one-year extension of the storage period for mixed wastes, detailing the storage conditions—all of which were already in effect.

On June 10, 1993, the DHS took eight additional soil samples from the lower pond and the recently excavated upper pond (Reference 60). Again, no radioactive contamination above background was found.

By the end of June 1993, BNA determined that no further excavation was to be undertaken, pending the results of the site cleanliness verification study. It was known that some residual contamination was present, but its potential for migration was unknown, pending the health based risk assessment to be performed at the completion of the cleanliness verification study.

In late June, construction of the wells in the lower pond commenced. Figure 32 shows well cluster RD-54 being drilled in the lower pond. Note the capture of the well tailings, which were disposed of as waste to an off site disposal.

#### **4.4 PROJECT ACTIVITIES – Phase II, June 1993 to October 1995**

No additional site remediation had been performed since June 1993, except for some limited excavations of subterranean objects in August 1996. The next phase of the project was occupied with establishing the requirements for site closure, and the disposal of accumulated wastes.

On June 22, 1993, the California Department of Health Services (DHS) notified (Reference 61) BNA of its investigation into an alleged violation of its radioactive materials license. The matter related to controls that assure that no radioactive materials enter a non-radioactive licensed disposal site. The DHS findings denied the allegation, but requested that BNA issue new documentation to support the methods used. This was identical to DOE's original concerns about the same potential problem, which caused the moratorium to be placed, then lifted when the assurances were put into place. On the same date, DHS issued a letter to DOE stating that had DOE submitted documents to DHS prior to allowing BNA to make shipments of wastes, that DHS would have avoided the effort and expense of investigating the allegations.

On July 12, 1993 BNA issued a response (Reference 62) to DHS' letters about the soil shipments, and their not being sufficiently informed about them. The response stated BNA's belief that DHS' involvement in cleanup plan reviews, participation in joint

agency status meetings and site visits was sufficient to keep DHS informed of the activities. Further, the controls upon waste shipments imposed by DOE are more restrictive than the DHS cited regulations, and that DHS was in possession of the procedures. The response agreed with DHS that the allegations are false, and that further action by BNA is neither planned nor necessary.

On July 30, 1993 BNA requested that EPA acknowledge that the RMHF permit allows storage and treatment of mixed wastes; referring to a permit modification processed in July 1992 (in anticipation of mixed waste treatment).

On 6 August 1993, BNA requested (Reference 63) that senior management at DTSC provide assistance in resolving the oversight controversy of the mixed waste treatment process. A companion letter (Reference 64) which detailed the legal basis for Federal EPA jurisdiction, and the applicability of the current permit, was sent a week later supporting the position taken by BNA.

In September 1993, the selection of an independent contractor to perform the site cleanliness verification program was made, anticipating that the work would be completed early next spring. The scope included sampling, analysis and interpretation of results, and an assessment of the need for additional remediation.

In mid-September 1993, a contract was placed with Rust Remedial Services for lease of the "X-TRAX®" equipment for the treatment of mixed wastes. The plan was to operate the thermal separation process at the RWHF. This was the process previously shown to successfully demonstrate the effectiveness of waste separation.

In October 1993, DOE agreed (Reference 65) to pursue the disposal of mixed wastes off site. Other DOE contractors were doing it, it is considerably less costly than projected and then currently identified waste treatment process being developed, and it avoided the entire regulatory approvals for treatment permits, storage time extensions and many other complications. This was a key DOE decision.

In early December 1993, DHS issued its review comments (Reference 66) to the plan for verification of radioactivity removal from the FSDF. The review accepted the survey plan as adequate subject to review of some companion information and documents.

## 1994

In January 1994, a second geophysical survey was conducted at the FSDF (Norcal, Reference 67). The survey examined the unexcavated portion of the upper pond and the regions previously beneath the work pad and pit area. BNA anticipated that no further excavations would be needed, and determined that an object survey would be needed in unexcavated areas to verify freedom from subterranean objects. Some limited clusters of objects were detected, unearthed and disposed.

On January 27, 1994 BNA informed (Reference 68) DOE that the draft plan for site cleanliness verification (to be done by an independent contractor) was being distributed to a predetermined multi-agency review team.

In February 1994, DHS provided (Reference 69) the laboratory results of soil and rock sampling done in June and November of 1993. DHS observed that the results of the analysis "indicated insignificant concentrations of radioactive materials."

On April 15, 1994 a hydrogeological conditions report for the site was issued (Reference 70, which included information about the 4 wells that were newly installed (RS54 and RD 54abc) and summarized the data characterizing the groundwater following site remediation. See the tasks and results section of the report for the findings.

Decontamination of debris from the FSDF containing chemically reactive (but non-radioactive) material began at the T133 facility, and was completed by early May 1994.

On May 10, 1994, DOE approved a waiver to DOE Orders enabling the project to ship mixed wastes to a commercial (DOE Approved) site. All planning, preparations and contracts for on-site treatment were terminated.

Beginning on May 24, 1994 (and ending August 23, 1994) the shipment of mixed wastes commenced to the Envirocare facility in Tooele County, Utah. This shipment campaign involved 238 boxes of soil, which weighed approximately 775,000 lb. (net), equal to 425 cubic yards. Twenty-two truckloads carrying ten or eleven boxes per load were accomplished.

In July 1994, well after completion of all excavation, Rocketdyne performed a radiation exposure (ambient gamma) survey of the entire FSDF area, including all the drainage channels. This survey was documented (Reference 71) and submitted to the California DHS. Again no radiation anomalies were detected, showing that no residual radioactivity above prevailing background exists at the site. BNA submitted a request to DOE to remove the FSDF from the RMMA designation list, as a result of no detectable radioactivity above background.

In October 1994, a contractual issue arose with the contractor selected to perform the independent verification program. The issue related to increased costs for work not previously defined. BNA determined that rebid of the contract was the appropriate resolution. The efforts to develop better descriptions of the work of sampling, analysis, risk assessments and corrective measures plans consumed approximately 9 months.

## **1995**

On March 15, 1995 DOE declared (Reference 72) the FSDF site non-radioactive and the RMMA designation was removed.

On June 7, 1995 BNA requested that DTSC assign review priority to the FSDF site cleanliness sampling workplan, over other BNA projects. This was primarily due to funding availability issues at BNA for the FSDF project.

In June 1995, the (newly awarded) independent verification contractor (ICF Kaiser) issued a workplan for the site verification sampling and analysis (Reference 73). The prime objectives of the workplan were:

To characterize the site in its current remediated condition by evaluation of the concentrations of chemical contaminants, if any.

Assess the potential risk to human health and the environment associated with residual chemical concentrations, and finally

To define health-based cleanup level for additional work if necessary. Residual radiological contamination was to be investigated by others, with a similar objective.

Between June 26 and July 5, 1995 ICF Kaiser performed a limited geophysical survey (the third and last) in the region south of the road and reported (Reference 74) that some of the objects identified are known structures (Monitoring well RD-21 and former underground utility conduits), and several others may be subterranean objects. The balance of the site had been previously examined. Removal of the objects identified by the survey was delayed until late summer 1996 due to the availability of staff.

On June 29, 1995, the formal issuance of the sampling and analysis workplan document was accomplished (Reference 75).

On July 13, 1995 DTSC provided (Reference 76) its approval of the formal soil-sampling plan that had been prepared by ICF Kaiser, the independent examiner. Technical corrections and modifications were included in the review, and were to be incorporated as conditions for the approval.

The soil and bedrock sampling tasks were conducted in July 1995 by ICF Kaiser focusing on the FSDF on BNA property; while another contractor--McLaren-Hart Environmental Engineering Company - performed sampling adjacent to the FSDF, but off-site on private property. The specific locations, depths, sampling and analysis methods, parameters of interest and detailed results are presented in reports (References 77, 78 and 79). The general findings of the on-site chemical samples were:

- No volatile organic compounds (VOCs) were found, except for naturally occurring chemical from native plant species.
- High boiling point petroleum hydrocarbons were detected in all regions of the site. No low boiling hydrocarbons were found.
- Semi-volatile organic compounds were found only in the FSDF-2 area (upper pond and western area) which had received partial remediation prior to the sampling.
- Dioxin compounds (Total OCDD) were found in all regions
- The highest concentrations of PCBs were found in the upper region of channel B (nearest the lower pond)
- Metals found were comparable to naturally occurring backgrounds, except for mercury that was found in all regions, but does not occur naturally.
- PCBs were found in all regions.

Results by regions, including the off-site findings:

FSDF Area 1 (south of the access road) gave evidence of residual contamination with mercury, PCBs and dioxins/furans. This was somewhat unexpected, as the area was not known to have been used for waste storage or disposal.

FSDF Area 2 (upper pond and area to the west) gave evidence of residual contamination with mercury, PCBs and dioxins/furans. Most of the findings were in the western area, in shallow samples, not unexpected given the site history.

FSDF Area 3 (lower pond) gave evidence of residual contamination with mercury, PCBs and dioxins/furans. Most of the findings were in the area north of the excavated pond, although some bedrock samples showed residual contamination. This was not unexpected.

FSDF Area 4 (drainage channels A to the north and west of the lower pond, and channel B to the north and east of the lower pond) gave evidence of residual contamination with mercury, PCBs and dioxins/furans. The PCBs and dioxins/furans had not been previously observed in the drainage channels, and were suspected to have been liberated by the excavations.

Of the many samples taken by ICF Kaiser, the Oak Ridge Institute of Science and Education (ORISE) analyzed 78 samples for radioisotopes. The majority of the samples were determined to be at or below background levels. In the case where elevated levels were found, they were determined to be well below regulatory agency approved residential cleanup standards. A soil sample report (Reference 80) was subsequently prepared (April 1997) and submitted to the California DHS, with a request to release the facility for (radiologically) unrestricted use.

Beginning on August 29, 1995 (and ending September 19, 1995) the shipment of low level radioactive wastes commenced to the Envirocare facility in Tooele County, Utah. This shipment campaign involved 200 boxes of soil, which weighed approximately 555,000 lb. (net), equal to 300 cubic yards. Eighteen truckloads carrying ten or eleven boxes per load were accomplished, although there were a few loads involving larger containers and more volume, but fewer containers were shipped.

By early October 1995, the culmination of the site cleanliness verification activity resulted in the issuance of three draft documents relating to residual chemical contamination:

The on-site and off-site chemical survey results (Characterization) report (Reference 77) as summarized above.

An outline (Reference 81) of the methodology to be used to assess the impacts of the residual chemicals found (health based risk assessment-HBRA). The results of the assessment will be the cleanup levels to be achieved.

A plan for final closure of the site (Reference 82) which, at this time, merely discussed interim site management actions, awaiting the establishment of agreed upon cleanup levels. The document later came to be known as the interim remedial measures (IRM) workplan.

#### **4.5 PROJECT ACTIVITIES – Phase III, October 1995 to June 1999**

The finalization and acceptance of the cleanup levels for chemical contamination was the main activity during this phase. Radiological closure (release) of the project was accomplished during this period.

In mid-October 1995, BNA received the results of the chemical analyses performed by DTSC. The results were consistent with prior findings.

On December 1, 1995, DTSC issued a letter (Reference 83) acknowledging receipt of several documents (Draft Interim Remedial Measures Workplan, Draft Health Based Risk Assessment and the McLaren Hart off site sampling results). On the basis of the findings, DTSC directed that interim measures be taken which included tarping of the excavation zones, and the installation of sediment collection devices, both actions to prevent or mitigate contamination migration. DTSC further asserted its authority to regulate the site activities under the existing permit (under Reference 84) granted to BNA for hazardous waste treatment and storage [at another facility-- building 4133].

On December 20, 1995, BNA proposed (Reference 85) some interim actions to be carried out during the winter, to prevent or mitigate the effects of rain while the final remediation plans were being worked out. It was clear that no work would be completed before the winter. These actions included:

- A diversion ditch, similar to that previously installed, to prevent entry of water into the excavations
- Continuation of the tarping of excavated areas
- Weirs to capture migrant solids

## 1996

On January 17<sup>th</sup>, 1996, DTSC (Reference 86) acknowledged receipt of the BNA recommendations for site protection, and requested additional information and changes to the plan.

By mid-January 1996, New tarps and pumps were in place, and the sediment collection weirs were completed for the coming rainy season.

On January 31, 1996, BNA provided (Reference 87) the information requested by DTSC regarding the interim measures for site protection and presented the details and plans for monitoring of weirs, and agreed to all of the changes requested.

On February 10, 1996, a DTSC memo (Reference 88) was received that cited the unacceptable features of the HBRA outline. The general objections related to: selection of chemicals of concern, risks and hazards to all possible receptors, improper terminology, ambiguous nomenclature, models and criteria issues, and the plan should conform to DTSC and USEPA guidelines

On February 28, 1996, DTSC responded (Reference 89) to issues regarding the interim protective measures for the site. The letter acknowledged that most of the work had been completed, but additional conditions were now identified:

- Areas containing hazardous constituents must be tarped
- Preventive measures to prevent storm water run-on from upslope must be taken
- DTSC approval must be provided for reuse of excavated material

- Analysis of surface water (run-off and captured) shall include all contaminants detected at the site

On February 29, BNA forwarded (Reference 90) a response to each of DTSC's comments about the HBRA Workplan, defending the basis for the draft plan. Agreement to correct ambiguities and terminology was made. Agreement to furnish additional explanations and information was made. This letter began a stream of correspondence (verbal, written, meetings, etc.) which effectively precluded any further fieldwork from being performed. Repeated reviews, staff changes and the delays in reaching decisions by DTSC has substantially delayed the project and increased the costs, as can be seen by the following activities.

On March 20, 1996, DOE was informed (Reference 91) of the ongoing discussions between BNA and DTSC about the statistical methods used as the basis for completed sampling program. The validity of the conclusions, and their use in the draft Health Based Risk Assessment was at issue.

On April 23, 1996, DTSC (Reference 92) stated that there were only two outstanding issues (soil vapor sampling in unconsolidated materials and in bedrock) which impacted approvals of the HBRA. DTSC took the position that the conclusions about the absence of VOCs were not valid, because the methods of sampling were defective. DTSC asked that additional sampling be done, and the results included in the HBRA. Since this issue affected remediation plans, the matter had to be resolved prior to fieldwork. DTSC expressed its desire to resolve the issues and complete the site work before the next rainy season (winter 96). Ultimately, sampling for VOCs was agreed not to be meaningful and was not done.

Over known opposition by DTSC (to portions of the plan), BNA directed (in mid-May 1996) ICF Kaiser to proceed with the Health Based Risk Assessment (HBRA) task. This was intended to yield the cleanup target cleanup levels for residential and recreational use of the site, and set the basis for the remaining excavations. The issues of disagreement between BNA and DTSC were minor and further delays to the assessment task were not warranted, as shown by DTSC's subsequent acceptance.

On May 6, 1996 BNA forwarded (Reference 93) to DHS the results of radiological surveys, in support of an upcoming request for site release and removal from the radioactive materials license.

On May 16, 1996, BNA requested (Reference 94) DHS to release the FSDF for unrestricted use and to remove it from BNA's radioactive material license. Support data and analyses were furnished.

In June 26, 1996, DOE informed DTSC (Reference 95) that it had directed BNA to proceed with the HBRA workplan, soon to be followed by implementation of the remediation efforts resulting from the assessment.

On July 29, 1996, the California DHS visited SSFL and took soil samples from the Sodium Disposal Facility lower pond and drainage channels for radiological analysis. Results from this round of sampling again showed no radiological contamination above background (Reference 96).

In August 1996, the objects located in FSDF-1, as identified by the geophysical survey, were extracted and placed in storage containers for future decontamination and disposal.

In September 1996, preliminary results from the health based risk assessment indicated that a scope of excavation of approximately 3000 cubic yards of soils would be needed to remediate the PCB contaminants. Bids for the excavation and site restoration were under concurrent review.

On October 10, 1996, BNA summarized (Reference 97) in a letter to DTSC, the major accomplishments toward the [chemical] closure of the FSDF site, and requested a meeting to present the final closure action plan.

The results of the chemical sampling and analyses were evaluated using the outlines and review comments in the first HBRA, and in early November 1996, the draft assessment document (Reference 98) was submitted to DTSC. The risk assessment showed that although total cancer and non-cancer risks are within acceptable ranges, further risk reduction and elimination of potential "downstream" impacts can be achieved by removing PCBs and dioxin/furan contaminated soils and sediments from the FSDF and channels.

On November 18, 1996, BNA submitted (Reference 99) to DTSC a summary of the final interim measures proposed for closure of the FSDF site. It included excavation and removal of soils and sediments (approximately 3350 cubic yards) to achieve the cleanup levels derived from the health based risk assessment. It presented the risks computed for the various contaminants and briefly discussed methods used. It requested approval of the risk assessment, excavation plan and backfilling.

On December 11, 1996, DTSC responded (Reference 100) to both of the BNA submittals (Oct 10 and Nov 18) with the view that the plans were technically incomplete, inadequately described and do not conform to standards for closure. Further, DTSC requires that "an adequate cap must be designed with appropriate run-off and erosion control provisions and that vadose [geologically shallow-above the water table] zone monitoring for residual contaminants be performed...as a final remedy for the FSDF." The requests for approvals to perform excavations were denied.

## 1997

In mid-March 1997, DTSC provided (Reference 101) its review of the draft risk assessment document. Its general conclusion was "since risk and hazard estimates may be underestimated, this risk assessment must be resubmitted after all comments in this and previous memoranda have been adequately addressed".

On April 8, 1997, BNA issued the final soil sampling and analysis report (Reference 102) certifying that radiological cleanup standards have been met and that the site is suitable for release for unrestricted use.

On April 11, 1997, the installation, checkout and initiation of pumping wells RD-21 and RS-54 were accomplished. Pumping of less than 2 gpm is possible due to low infiltration rates which will not sustain a yield. The effluent is passed through activated

charcoal canisters, monitored for quality and then pumped into the site surface drainage system.

On April 11, 1997, BNA requested (Reference 103) DTSC assistance in resolving the issues cited in the rejection of the health based risk assessment. Responses to the issues were provided as attachments to the request.

At the end of April, BNA summarized (Reference 104) agreements reached regarding the risk assessment. The key points were that:

- Groundwater issues could be removed from the FSDF closure plan and included in the sitewide RFI program.
- DTSC will expedite its review of the other items

In May 1997, the objects exhumed from FSDF-1 in August 1996 were verified to be free of chemical contamination (and free of radioactivity) and released for size reduction and disposal as conventional wastes.

May 9, 1997-DTSC provided (Reference 105) its review of some risk assessment issues. Of concern was the basis for the development of the PCB/dioxin cleanup levels.

In later May, BNA provided (References. 106 and 107) DTSC with additional information relative to risk assessment issues. A key point of the response was that the planned excavations remove contaminants avoiding the need for or benefit of further characterization of the site, and noting that confirmatory samples will show that cleanup targets have been met.

On June 2, 1997, DTSC provided (Reference 108) a review of the ERA (ecological risk assessment) portion of the HBRA. The review indicated many deficiencies, but agreed with the conclusions that further exposure pathways should be examined and DTSC requested rework and resubmittal.

A BNA/DTSC meeting was held on July 24, 1997 (Reference 109) wherein several agreements were made:

- The ERA will be reworked and scope added
- The risk assessment document will only address PCBs and dioxins, omitting mercury from cleanup levels.
- Revised documents will be submitted no later than 10/2/97.

On August 7, 1997 DOE informed DTSC (Reference 110) of its intention to proceed with excavation and backfilling and directed BNA (Reference 111) to proceed because further delays are unacceptable.

On August 15, 1997, the findings of the on site chemical sampling and analysis activity were formally reported (Reference 112). The results were as stated above. These results were the same as those previously reported to DOE (Reference 113).

In late August 1997, it was reported (Reference 114) that DTSC issued a Cease and Desist order to DOE regarding DOE's instructions to BNA to proceed with cleanup.

On September 8, 1997, BNA submitted (Reference 115) a stand-alone, new version of an Interim Remedial Measures workplan to DTSC, and requesting an expedited review and approval. The characterization portion of the report had been removed and released independently.

On September 10, DOE withdrew its letter of intention to proceed, and committed (Reference 116) BNA to another submittal of an interim remedial measures (IRM) workplan document to DTSC. BNA had made the submittal a week prior. DOE requested that DTSC review and provide its approval to enable work to occur prior to the winter rainy season.

On September 16, 1997, DHS revisited the FSDF and took 25 soil samples at nine locations from the upper pond and western area. Both surface and sub-surface core samples to bedrock were taken. Results from this round of sampling again showed no radiological contamination above background (References. 117 and 118).

In a letter dated September 22, 1997 (Reference 119), DTSC explained that the prior approval given (Reference 39) to the site cleanup plan was invalid because it didn't (doesn't) meet current requirements. The approvals inferred from subsequent agreements relating to additional work at the site are non-existent. DTSC has rescinded all approvals and seeks to define an acceptable interim measures work plan. No work will be allowed until such a plan has been approved.

On October 3, 1997, DTSC (in a letter to DOE, Reference 120) stated that the remedial actions planned for the FSDF are subject to the public review aspects of the California Environmental Quality Act (CEQA), and that an assessment of the project is required. Further, DOE shall fund the costs of the actions, and the total cost will be determined when the actions are completed.

## 1998

On February 2, 1998, BNA received the results of sampling and analysis of soils and sediments collected during the prior winter months to evaluate rain induced migration. The results showed elevated (above background) concentrations of certain metals (as seen previously) but no evidence of PCBs. The proposed excavation plan includes collection of sediments from drainage channels.

Later in February, BNA sent (Reference 121) several reports to a contractor engaged by DTSC. The material related to the chemicals identified in the drainage channels from the FSDF site.

On May 6, 1998, the DHS removed the Sodium Disposal Facility from BNA's California Radioactive Materials License 0015-19 (Reference 122), and formally released the facility for (radiological) unrestricted use (Reference 123). These actions were based upon sampling and analysis data summarized thoroughly in a DHS memorandum (Reference 124). This action was the culmination of six independent investigations into the radiological condition of the site.

On May 15, 1998 BNA received a letter from DHS (Reference 125) which released the FSDF for unrestricted use, and referred to amendment #98 (Reference 126) to the license, wherein the FSDF was removed.

On May 18, 1998, a revised Interim Measures Workplan was submitted (Reference 127) to DTSC, incorporating the reviews and agreements since the submittal of the plan in September 1997 (Reference 115), eight months prior. This submittal removes the need for radiological screening because of the radiological site release. This submittal also committed to removing as much material as is necessary to achieve the cleanup levels. Finally, the issue of a "cap" was discussed and rejected by BNA on the basis that backfilling is satisfactory as an interim measure, and that the sitewide RCRA actions will address future groundwater issues.

On July 16, 1998, DTSC conditionally approved (Reference 128) the interim *remedial measure workplan*, subject to minor revisions to the transportation section and specifics regarding the backfill material quality. DTSC will be preparing an Initial Study document, required by CEQA. When the revised IMR workplan and the Initial study are complete, DTSC will place them into the public review process.

On July 23, 1998 BNA submitted (Reference 129) what it believed was the final Interim Measures Workplan, incorporating all comments received to date.

On October 5, 1998, DTSC (Reference 130) invited BNA to meet and finalize the IRM workplan, in an effort to expedite final approval and public review.

On October 26, 1998, more comments from DTSC were received, but determined to be minor. The CEQA public review period of 30 days cannot begin until DTSC accepts the Workplan.

A "Proposed Interim Measure and CEQA Negative Declaration for FSDF" fact sheet and the draft of the declaration were issued for Public Review and Comment during the period of October 20 through November 20, 1998 with a public hearing scheduled for November 7, 1998.

On October 23, DTSC forwarded (Reference 131) review comments that are still necessary for incorporation.

On November 2, 1998, DOE directed (Reference 132) BNA to cease all work on the FSDF project (except for precipitation controls at the site) until a solution to the DTSC approval process is in place.

## **1999**

On January 27, 1999, DOE authorized (Reference 133) BNA to resume activity on the FSDF interim remedial measures workplan preparation. DOE directed that the funds be used for planning only, not fieldwork.

On January 29, 1999 a new, dedicated staff was assigned to SSFL projects, and assurances given that the FSDF project would be a high priority.

On February 18 and 23, 1999, following inquiries by DTSC and DHS on the radiological status of the FSDF, DHS issued letters to DTSC (References 134 and 135) clarifying that the facility was released for unrestricted use, which meant that DHS does not require any monitoring of the soil that is removed from the FSDF.

On March 18, 1999, another revision to the interim measures remedial actions workplan for the site was issued (Reference 136). It reflected the continuing DTSC reviews.

On July 9, 1999 both the Draft Final interim remedial measures workplan (Reference 137) for site closure and the Draft Final Interim Measures Risk Assessment (Reference 138) documents were issued for approval.

On July 15, 1999 DTSC (Reference 139) approved the FSDF Interim Measures Workplan as complete and acceptable for public notice and review.

On July 15, 1999 DTSC (Reference 140) approved the FSDF Final Interim Measures Risk Assessment. The cleanup levels identified herein will be used for site remediation.

## **5.0 KEY TASKS AND RESULTS**

The following discussions provide an assessment of the utility and effectiveness of selected tasks and the results of their use for this project.

### **5.1 SITE PRE-CHARACTERIZATION MAP**

The data collected from several different chemical and radiological surveys of the site were composited onto a map (see Figure 36 taken from Reference 10) which gave a spatial indication of the types of contaminants to be expected in the wastes, and provided a logical pattern for excavation. The vertical concentrations were not defined. An excavation strategy, which would be likely to minimize the amount of material to be removed, would proceed from the most contaminated zones towards the least. The composite map showed regions where soils might be expected to be "mixed" (i.e. radioactive and chemically contaminated), hazardous only (chemical), radioactive only, and non-hazardous. At the beginning of the project, there was considerable discussion concerning the value of better defining the nature and the extent of contamination by performing more characterization. In retrospect, more characterization would have been quite costly and would not likely have had any beneficial affect upon the work done. It is not likely that any less material would have had to be removed. The use of the pre-characterization map proved to a useful tool for the development of strategies, but rather ineffective for quantitative assessments.

The map proved to be effective for understanding the work to be done, except it tended to convey the idea that the boundaries of contamination shown were the limits of excavation. In fact, the boundaries are yet to be determined and will be based on the cleanup levels to be achieved. The ongoing discussions with regulators relate to how much excavation will be required to reach the cleanup levels.

### **5.2 SITE COORDINATE GRID**

The composite contamination map suggested that a coordinate grid system be established over the site, and used as a reference system. The use of a grid system is commonplace in radioactive decontamination projects. Its application to a large site proved to be very useful as all activity was referenced to a common system and definitions of locations was easily and precisely achieved. All contractors working on the site were required to utilize the grid system. The 10-ft by 10-ft grid system was surveyed onto the site and referenced to benchmarks established by the California Coordinate System. Figure 8 illustrates the grid system, taken from Ref. 141. The grid subdivision size was easily emplaced, referenced and restored when needed. There was no need for any higher resolution (smaller grid elements) for the work being done.

### **5.3 BURIED OBJECT LOCATION**

Subterranean objects were expected throughout the site as a result of the usage history of burial of waste and scrap, and the natural sinking of objects more dense than soil. It was obvious that in order to claim that the site was free of contaminants, confirmation was needed that no residual objects existed. Geophysical surveys were performed over the areas that were not going to be excavated. The site was highly

amenable to the standard geophysical techniques because the soil was shallow and the expected objects were metallic. The results of the surveys were maps that enabled unknown objects to be extracted with precision. An example of such a map is shown in Figure 17, taken from Reference 32. It further confirmed the existence of known objects, including underground utility conduits and well features.

The use of geophysical techniques was very effective for this project. The results were shown to be excellent tools for selected excavations, and for validating that a region was free of "significant" subterranean objects.

#### 5.4 RADIOLOGICAL CRITERIA FOR SEGREGATION OF EXCAVATED SOILS

Two sets of radiological criteria were relevant to the project. One pertains to the release of land for unrestricted use and the other pertains to disposal of wastes (were they radioactive or not?).

The release of land is based upon the potential for exposure to occupants that may use the site in the future. The criteria are prescribed in the regulations promulgated by both federal and state agencies. These criteria are shown in Table 1 below, while the details of the methods and basis for the criteria are presented in Reference 142. The values were applied to multiple surveys of the site leading to its radiological release for unrestricted use.

For materials to be disposed of as non-radioactive wastes, the DOE criterion of "no detectable activity above background" was applied. This provides the assurance that radioactive materials will not pose a future risk. The issue here is subtle, in that soil which is a waste from this project and removed as such, could be reused in the future should the receiving waste site be reclaimed (similarly for waste water or other wastes). Additionally, there was the need to assure that objects and containers leaving the site did not have surface contamination, hence the surface cleanliness criteria.

**Table 1 Radioactivity Criteria**

Criteria for releasing land for use without radiological restriction			
The ambient gamma field limit is based on NRC and State of California guidelines: $\leq 5 \mu\text{R/hr}$ (gamma) above background at 1 meter from the surface, and The annual dose limit is based on DOE Order 5400.5, Chapter IV, release limits: $\leq 15 \text{ mrem/yr.}$ based on RESRAD code and identified radionuclide constituents			
Criteria for characterizing material as not radioactive (or mixed) waste			
The following are based on DOE performance objectives for identification of mixed wastes			
1. Surface contamination	5400.5 surface contamination limit (with in-house limits for ALARA)	<u>Alpha</u>	<u>Beta</u>
	<u>In-house limits</u>	( dpm/100 cm <sup>2</sup> )	
	Removable	$\leq 20$	$\leq 100$
	Total	bkgd	bkgd
2. Volumetric contamination	Less than detectable levels above background activity inherent in the material		

The volumetric criteria were developed from measurements of background soils. The background samples were collected from sites geologically similar to the FSDF but uncontaminated by research and development activities. The soils were placed in a special container equipped with a central hollow tube, Figure 38, and a sodium iodide detector was lowered into the tube (Figure 40), and the output "counted" for one minute (Figure 41). Sufficient data was collected to establish the background soil statistics. Gamma spectroscopic and other isotope specific soil samples from the background soil verified that only primordial isotopes and typical fallout levels existed. A 95% confidence level was applied to the background data against which an excavated soil sample's count could be compared. If an excavated sample exceeded the statistically significant activity level, it was deemed radioactive.

These waste classification criteria were established before excavations began and applied to each and every increment (approximately 1 cubic-yard) of soil excavated.

The California Department of Health Services (DHS) which is responsible for radiological oversight, and which released the site for unrestricted use accepted these methods, procedures and the criteria established for the remediation.

## **5.5 WASTE SEGREGATION**

The single most important field task of this project was the proper classification of wastes. This bore directly upon the final disposal destination of the wastes, but was important to field worker safety, waste packaging, labeling, storage and shipping. Compliance with DOE's mandate for waste volume minimization was also achieved through the process that was developed. The known presence of hazardous (RCRA) constituents, radioactivity, unreacted materials, and hidden objects created a need for a rigorously controlled process. There was also a requirement that all potentially hazardous wastes be placed into containers (vs. creating piles) immediately upon excavation, which placed emphasis upon successfully segregating wastes of like type into the containers. Reference 143 was the procedure developed for this purpose, and a schematic diagram of the process is presented in Figure 39. The details of this procedure follow:

It was intended that the excavation processes move from the most contaminated area to the least. Figure 39 shows a small figure in the upper left, which shows the pre-established contamination zones at the site, which were derived from the sampling studies conducted in years past.

Zone 1, in the lower pond was where the most severe chemical contamination was collocated with radioactivity, potentially yielding a mixed waste stream.

Zone 2, in both the upper and lower ponds was the region of radioactivity only, potentially yielding a low-level radioactive waste stream.

Zone 3, in both the upper and lower ponds was the region of neither hazardous, nor radioactive soil, potentially yielding conventional wastes

Zone 4, to the west of the ponds was a region of only chemical contamination, potentially yielding a hazardous waste stream.

Using these zones for a preliminary classification, soils were first excavated from zone 1. A complicating factor was the potential presence of hazardous substances that posed a risk for field workers. Technicians were assigned the task of monitoring the excavation site for hazardous chemical vapors or liquids using special instrumentation, and for radioactivity using gamma-beta detectors. Further, the presence of subterranean objects (which could contain hazardous or reactive substances) had to be anticipated with each “shovel-full”. These precautions prevented the use of large, bulk handling excavation equipment and slowed the process to a maximum of about 75 cubic yards per day.

Therefore, the first excavation step was the determination whether the quantity excavated was indeed hazardous or not. Note that this was only a preliminary categorization, as all soils would be sampled and analyzed for chemical contamination. The objective was to avoid placing a shovel-full of definitely contaminated soil into a container of possibly uncontaminated soil and contaminating it. Keep in mind the principle that a small amount of contaminant added to clean material will render the whole quantity as hazardous, whereas a small amount of clean soil will not change the classification of a batch of hazardous waste—the idea was to minimize the amount of hazardous waste.

If the soil was definitely hazardous (or very likely to be, based on vapors, color or texture), it was passed through a coarse then finer screen to remove objects. The soil was then placed into a one-yard container (Intermediate transfer container-ITC) and evaluated for radioactivity. See the discussion above.

If the soil was determined to be radioactive (and likely hazardous), it was placed into an approved radioactive storage container (2 cubic-yard B-12 box) and classified as “mixed” waste, pending analysis and labeled accordingly.

If the soil was not believed to be hazardous, and was determined to be radioactive, it was also placed in a B-12 box but classified as “low-level radwaste”, pending analysis, and labeled accordingly.

If the soil was definitely hazardous (or very likely to be), it was processed as above, and if not radioactive, placed into a DOT approved storage container (15 cubic yard roll-on/roll-off (R/O)) and marked as “hazardous”, pending analysis and labeled accordingly.

If the soil was neither hazardous, nor radioactive, it was placed in a roll-on/roll-off container and labeled as “conventional”, pending analysis.

The results of these field segregation processes were 4 distinct waste streams: 1) mixed, 2) low-level radwaste 3) hazardous and 4) conventional. These were preliminary classifications in respect to chemical contamination only. The radioactivity determination was made once, at this time, and not repeated.

To determine the final waste category, a sampling and chemical analysis program was performed, as discussed below.

Objects that were screened out of the soil were essentially classified the same way, except the possibility existed that closed containers held unreacted or harmful substances. After determining that the containers were free of radioactivity, they were sent to a

specialized facility (T133) designed for treatment of hazardous wastes. Following the cleaning, the debris was disposed of as conventional waste and the hazardous waste products disposed of accordingly.

The process involved a crew of about 8 persons to perform the excavation, transporting, sorting, classifying and packaging tasks. The area of excavation was selected, cordoned off and identified as an exclusion zone, with access limited to certified hazardous waste workers. The backhoe operator would excavate a scoop of soil and the health and safety technicians would examine the material, and the excavation cavity for evidence of hazardous materials, objects or radioactivity. The scoop of soil was taken to the soil sorting and handling machine (see Figure 34) and dumped onto the coarse (4") grid. The hopper with the coarse grating was where excavated materials entered the machine. Large objects (>4") were removed by hand at this location. Soil fell into the hopper and onto the belt that conveyed it to the elevated end. At this location was a screen (1/2") which allowed the fines to fall through into an intermediate transfer container (ITC). The remaining coarse soils passed into another ITC. Note the plastic coverings, which limited dust migration. Any objects found during excavation or removed at the screen were placed in storage receptacles for later examination in detail. The fine screen was sized at 1/2" in order to enable removal of what was originally expected to be the discrete radioactive wastes. Although removal of the radioactivity was not possible by this method, the screening process did effectively enable removal of most non-soil debris.

The finer soils fell through the screen into a one-yard container (ITC), Figure 41, which was equipped to enable the radioactivity evaluation to be performed. The soil was "counted" for activity and placed into the appropriate storage container as discussed above. Soils that did not pass through the fine screen (clods) moved across the screen and dropped into other ITCs, and were similarly counted. When it was apparent that the fine screen was not effective for the purpose intended, the screen was removed and soils were sent to two ITCs simultaneously, somewhat improving the material flowrate.

Figure 35 shows the soil segregation in process. Note the operators examining the soil with the hazardous vapor detection devices. The photo was taken at a time when soils were being extracted from a radioactive zone; hence the radioactive waste container standing ready.

This overall process was found to be effective in assuring that all of the necessary aspects of the work were accomplished and documented. See the section titled Wastes Generated in this report for specific details concerning the wastes. This procedure, though tedious and time consuming, achieved the waste minimization objectives defined by DOE.

## **5.6 FINAL WASTE CLASSIFICATION**

A requirement of all waste disposal sites is the certification by the originator of the wastes as to their content. A chemical analysis was required to both classify the waste and establish the contaminant content (species and concentration). Each of the waste streams was analyzed accordingly. A tradeoff study was performed to optimize the amount of waste to be collectivized for classification. Classifying each B-12 box or R/O bin would be prohibitively expensive, while sampling too few risked sending larger

quantities of wastes to potentially the “wrong” site. A procedure for sampling the wastes was prepared (Ref. 144) and featured the following:

For the radioactive wastes, a random sample was taken from each of six (a batch) B-12 boxes and the samples composited to form a single sample. Since the samples were radioactive, only a licensed radiochemistry laboratory could be used for the analysis. The analysis of this sample formed the basis for the batch characterization. Both radionuclide and hazardous constituents were determined, and the results of this analysis established the 12 cubic-yard batch to be either

- Low-level radioactive waste (LSA-low specific activity), or
- Mixed wastes.

The containers were then documented and labeled accordingly, and stored properly awaiting shipment to the disposal site.

For the non-radioactive wastes, random samples were taken from each R/O bin and the samples from 5 bins composited to form a single sample. The analysis of these samples were performed by a conventional chemistry laboratory, and formed the basis for the final batch characterization. Only hazardous constituents were determined. The results of this analysis specified the 75 cubic-yard batch to be either:

- RCRA hazardous waste or some lesser category for controlled constituents, or
- Conventional waste.

The containers were then documented and labeled accordingly, and stored properly awaiting shipment to the disposal site.

A similar procedure was applied to the evaluation of debris and wastewater.

This process was found to be costly and time consuming as well, but complemented the waste minimization objectives and provided reasonable assurance of the correct final disposition of the wastes generated. Additional details concerning the waste specifics can be found the Wastes Generated section.

## **5.7 RADIOACTIVE MATERIALS MANAGEMENT AREA (RMMA)**

As a result of issues at other DOE sites, a nationwide moratorium was placed upon the shipment of wastes to a hazardous disposal site, if the wastes originated from a location that could have radiologically contaminated the wastes. Such locations were identified as Radioactive Material Management Areas (RMMA). The FSDF was one of a series of facilities at SSFL placed upon a list of RMMAs, which then required special identification of the work areas and the imposition of special administrative controls, as detailed in reference 145.

A special administrative procedure was then developed (Ref. 146) for the FSDF wastes that satisfied DOE that the hazardous wastes contained “no DOE-added radioactivity.” The FSDF project was the first project to have the moratorium lifted. The procedure controls how the absence of radioactive content was ascertained.

DOE's objectives, which mandated the RMMA process, were successfully accomplished on the FSDF project, which set the pattern for disposal of DOE wastes at other projects at the SSFL site.

The implementation of the RMMA program imposed by DOE required formulation for some procedures that were standard practice, but not fully documented.

## **5.8 RADIOLOGICAL REMEDIATION**

As a result of removal of the soils from the lower pond, and portions of the upper pond, all detectable radioactive materials have been removed from the site. Based upon six independent rounds of surveys and soil sample investigations, the FSDF has been found to be free of radioactive contamination that could result in any exposure or risk to any current or future user. The FSDF has been removed from the requirements of the license [to possess radioactive materials] and released for unrestricted use.

The final survey report (Ref.71) concluded: "the remediated areas are statistically indistinguishable from background readings elsewhere in SSFL Area IV. The entire site averaged 15.6  $\mu\text{R/hr}$  with maximum readings up to 21.4  $\mu\text{R/hr}$  occurring next to or on the surrounding rock formations, which is consistent with...[data from the balance of the site]".

Any future work or usage at the site need not consider its radiological history. There is no requirement for radiological examination of any materials, and no requirement for posting or monitoring.

The result of this task was the successful, if protracted, release of the site for unrestricted use.

## **5.9 CHEMICAL REMEDIATION**

As a result of removal of soils from the lower pond, portions of the upper pond and portions of the western area, it has been determined by DTSC that additional remediation is required to reduce the potential for health risks. The chemical results of the ICF Kaiser on site soil sampling and analysis task (Ref.78) and the McLaren-Hart off site sampling and analysis task (Ref.79) conducted in June/July 1995 were:

- "The statistical analysis of the FSDF chemical analytical results identified that concentrations of mercury and dioxin/furan compounds are present at levels greater than background concentrations".
- "The statistical analysis of the FSDF chemical analytical results also supports the conclusion that detections of mercury and dioxin/furan compounds are elevated in regions FSDF-2 (partially excavated upper pond and area to the west), and FSDF-4 (drainage channels); relative to regions FSDF-1 (south of the access road) and FSDF-3 (excavated lower pond).

The results by regions, including the off-site areas:

FSDF-1 (south of the access road) gave evidence of residual contamination with mercury, PCBs and dioxins/furans. This was somewhat unexpected, as the area was not known to be used for waste storage or disposal.

FSDf-2 (upper pond and area to the west) gave evidence of residual contamination with mercury, PCBs and dioxins/furans. Most of the findings were in the western area, in shallow samples, not unexpected given the site history.

FSDf-3 (lower pond) gave evidence of residual contamination with mercury, PCBs and dioxins/furans. Most of the findings were in the area north of the excavated pond, although some bedrock samples showed residual contamination. This was not unexpected.

FSDf-4 (drainage channels A to the north and west of the lower pond, and channel B to the north and east of the lower pond, see Figure 5) gave evidence of residual contamination in the sediments with mercury, PCBs and dioxins/furans. These substances had not been observed before the major excavations occurred at the site, very likely liberating them.

Since the site has not yet been fully chemically remediated, the only comment that can be made is that the process for chemical remediation needs to be improved.

## **5.10 GROUNDWATER REMEDIATION**

The origin of this project arose from a finding of degraded groundwater. Although the ultimate objective is the remediation of groundwater, a specific effort to achieve this was beyond the scope of the FSDf cleanup project, except for the limited ongoing treatment of water being pumped at two wells that are on the site proper. Obviously, removal of the source of contaminants is a necessary step toward final remediation.

A hydrogeological assessment (Ref.70) was made following the remediation efforts of 1992 and 1993, and reported:

- “Analytical data indicates that much of the SSFL Facility, including the B/886 [FSDf] area is [still] underlain by degraded groundwater. The most prevalent contaminant is TCE.”
- “Degraded groundwater is present in both the Shallow Zone and Chatsworth Formation (upper zone) under the B/886 area.”
- “However, degraded groundwater has not been detected in [recently installed] deeper wells RD54b [379 to 437 ft] or RD54c [558 to 638 ft]....”
- “At the B/886 site, primary drinking water limits were exceeded for a series of .....[volatile organic compounds] “.
- “Data indicates that degraded groundwater beneath the B/886 is limited to the upper 100 feet of the saturated portion of the Chatsworth Formation. Beneath the immediate B/886 site, degraded groundwater appears to be limited to a depth of about 300 to 350 feet.”

The conditions reported above are similar to those reported prior to the remediation (Reference 1), except for the data from the wells installed after the remediation work was completed.

The effectiveness of the FSDf remediation upon groundwater quality will probably not be known until long-term quality trends are observed.

### **5.11 CLEANUP AND ABATEMENT ORDER**

Although the specific order was limited to abating only the lower pond by 31 December 1992, it was intended during the planning stages that all contamination sources would be removed from the facility. The order was complied with by an intensive effort that focused only upon the lower pond.

Although the milestone was achieved, considerable work remained to be done after that date, considerable work remains to be done today.

### **5.12 WASTE MINIMIZATION**

A key DOE objective for remediation projects was waste minimization. Development of a method for measuring radioactivity in small batches resulted in producing the least amount of radioactive wastes. It may have less costly to combine all wastes from the radioactive areas and send them to a mixed waste site, however, this would have been contrary to DOE's waste minimization objectives. Analysis of batches of non-radioactive soils for chemical content resulted in higher costs than might have occurred had they all been classified as hazardous wastes and disposed of accordingly, however, again counter to DOE's objectives. Minimization of waste quantities was accomplished.

### **5.13 MIXED WASTE DISPOSAL**

At the beginning of the project, an assumption was made that the radioactive components were discrete objects that could be "screened" out of the excavated soil, yielding small quantities of only low level radioactive wastes and non-radioactive wastes. This assumption led to the purchase of the soil handling (and screening) machine and the omission of plans for disposal of mixed waste soils. The regulatory issues of hazardous waste generation restrictions, restricted land disposal, moratoria on shipping, storage and treatment permits/approvals and RMMA matters notwithstanding, the disposal of the mixed wastes became a major technical problem.

The primary approach was treatment of the wastes that would yield waste streams that could be handled by conventional procedures at practical costs. This was pursued in order to overcome the other restrictions in effect at the time when compliance with the cleanup and abatement order was considered inviolate. Some of the aspects of this approach included:

- The volatile nature of the hazardous constituents of the mixed waste was found to be amenable to a commercially available thermal treatment. A process, X-TRAX®, was shown to be able to remove the mercury and organics from the soil, leaving the soil as low level waste and the condensate, which was removed from the soil, free of radioactivity. A pilot level demonstration was successfully performed by the vendor of the equipment, enabling the site excavations to resume. This was followed by placement of a contract for lease of the equipment and an operating staff to set up a processing system at BNA's radioactive materials handling facility.

- BNA believed that the EPA permit for the facility was licensed to perform such tasks, but after considerable discussion, DTSC mandated that a new permit would be required. Actions to secure the new permit were initiated.
- The cost of this method was comparatively high, due to the multiple handling of the wastes, the fuel costs for the thermal treatment, and the fees for the leased services. And, following the treatments, the residual waste stream disposal costs still applied.

The next solution was bulk disposal at DOE's Hanford site. Some of the factors to this approach were:

- The costs were very high (Upwards of \$75 per cubic foot for the buried volume of the container)-Potentially a burial cost of \$ 1 M, excluding the costs of containers, shipping and analysis.
- The concentration of hazardous constituents could not exceed Washington State regulations.

The solution that was chosen was bulk disposal at a commercial site (Envirocare Inc.) in Utah.

- DOE had standing orders that DOE wastes could only be disposed of at DOE site, which required that DOE waive its own requirements (which was done).
- Other DOE laboratories were found to be using the site.
- DOE agreed that FSDF mixed wastes could be sent to Envirocare under the auspices of the DOE-Oak Ridge commercial contract with Envirocare.
- This option has the least costs, and was the most palatable to California regulators.
- Parenthetically, the low-level radwaste was sent to Envirocare also, because of the low disposal costs.

Mixed waste disposal was the most difficult task of the project. It was not adequately anticipated at the beginning, and it seemed to be adversely affected by every rule and regulation change.

## **6.0 ISSUES and LESSONS LEARNED**

### **6.1 DO IT INHOUSE OR OUTSOURCE?**

It was determined that the project would be planned, staffed and executed utilizing in house staff, for the most part, versus subcontracting the work. This determination was based upon the following factors:

The professional staff was technically competent and could be made available for the work, and re-assigned during periods of inactivity. The work was within the scope of the bargaining unit's contracts.

Definition of the work scope to permit competitive bidding would have been unfeasible given the approval process by regulatory bodies. Long periods of inactivity awaiting approvals would have been extremely costly, and non-productive.

Costs of execution were estimated to be 100% greater if subcontracted due to labor rates, mobilization/demobilization costs and field construction rates.

Management of radioactive materials requires licensing and specialty staffing; and a limited field of bidders was available.

The imposed schedule for implementation had no slack time for bid/award/negotiation and contract approvals.

At the time of the presumed completion of the fieldwork (1994), the decision to perform the work in-house was well founded. Instances of weather delays, waste shipping delays due to uncontrollable causes, changes in direction, and holds by agencies for approvals would have caused exorbitant cost adds, had a contractor been doing the work. A down side aspect of "doing it ourselves" was the need for special hazardous waste worker training (HAZWOPER), to which no regular staff workers had been qualified. This presumes, of course, that contractors have staffs fully trained and available for the job, which is speculative.

Performance of some tasks for which in-house capability existed (chemistry) were out-sourced due to public perceptions relating to conflicts of interest and independence of bias from the analysis results.

Performance of the site cleanliness verification was mandated to be by independent investigators. Upon release of the investigation results, a decision was taken to utilize the independent verification investigator to complete the work at the site. That decision was based upon:

The contractor's having a thorough knowledge of the site, regulatory environment, and ability to perform the work. In some cases, the tasks require skills not available in house (e.g. risk assessments, impact studies).

In house staff reductions reduced the available labor pool

The lesson learned is that a project which has substantial uncertainties of scope, schedule and weather can be accomplished at a reduced cost by in-house forces provided alternate assignments can be made during unscheduled interruptions.

## **6.2 MAKE SURE IT WORKS BEFORE YOU ARE COMMITTED TO IT !**

The initial strategy for the project was based upon the belief that the significant radioactive components were discrete objects that could be detected and removed from the excavated soils, and the balance was of sufficiently low activity as to be of no concern. Several zirconium-hydride "slugs" had been found at the site and were easily identified as radioactive, and would be reasonably easy to segregate during excavation. This strategy proved ineffective as the soils were subsequently found to have elevated (by DOE criteria) radioactivity caused by radionuclides dispersed in the soil, without the presence of discrete objects.

The failure of this initial strategy resulted in the generation of mixed wastes, which became a complex issue, as discussed in section 5

The lesson learned is to demonstrate (on a pilot scale) that the planned process achieves the results needed. Further, it should be accomplished before the budgets, schedules, training and mobilization activity has progressed to a point where major impacts will result.

## **6.3 PACKAGE THE WASTE DISPOSAL FUNCTIONS**

It was recognized early in the project that various elements associated with waste disposal were needed (containers, transportation, treatment, and disposal). The approach taken was to contract for rental of containers, contract for transportation, and pay posted prices for treatment and disposal. Functionally, this gave the most flexibility to the project, but was considerably more expensive and complex than necessary. It was later learned that private arrangements are often made by waste disposal site operators with transporters, container suppliers and related functions, to provide a fully packaged service to the client.

Allowing vendors to bid on packaged work (properly defined) enables much better prices and schedules to result. A contract to dispose of \_\_\_ cubic yards of \_\_\_\_\_ type wastes over a period of \_\_\_\_\_ months, at a price of \$\_\_\_/ cubic yard enables the vendors to assemble packages that are less costly and less complex than coordinating the details on a day to day basis. This lesson may be applicable to other contracted efforts where there may be economies of packaging.

## **6.4 DEFINE THE CLEANLINESS CRITERIA (IF YOU CAN)**

The imposition of the cleanup and abatement order to this site was presumably within the regulatory agency's authority. The order explicitly stated that "verification sampling shall be conducted to ensure all contaminated soil and debris is removed". The order required that a [closure] plan for accomplishing the decontamination be provided for approval. The plan that was approved, called for removal of all soil to bedrock— followed by sampling of the exposed surfaces. The absence of the criteria for what the sampling was to show has prevented constructive site work from October 1995 to the

present. A denial by the governing regulator (DTSC) in September 1997, that it had previously approved a closure plan, brought the basic problem into sharp focus—perhaps agreement cannot be reached!

The question of “how clean is clean” cannot be asked *too soon on a remediation project*. Notably, the standards and guidelines for declaring this formerly radioactively contaminated site to be clean were not difficult to define, to verify against, to demonstrate compliance and to obtain agreement for closure. *The chemical cleanliness target is believed to be in hand, but approval to proceed with final remediation has not been provided.*

The lesson to be learned is that asking how “clean is clean?” before starting the work, is not sufficient. Getting an agreed upon target may be the best strategy to take before committing to the activity, if this is possible. It is likely that an attempt to establish agreed-upon standards at the outset of this project would have been highly contentious, but may have significantly limited activities that continue to the present. The existence of Federal and State standards for radiological release made it possible to achieve that objective in a straightforward, although lengthy, way.

## **6.5 WORRY ABOUT THE WEATHER**

It is obvious in retrospect that rain would be a factor to contend with, both as a medium for transporting and spreading contamination, and a physical impediment to excavation. Consideration was given to tenting the site to minimize interruptions due to rain. Wet soil (mud) cannot be examined and classified. Design and availability of a wind resistant covering for a large site was determined to be not feasible, plus the complications of managing vehicular exhaust. The application of tarps was necessary, as was the management of the water that collected on top and below the tarps.

Advance detailed planning is required to anticipate the effects of weather at all *stages of an outdoor remediation project*. To the extent schedules can be made amenable to seasons, they should be.

## **6.6 WHO ARE YOUR REGULATORS & WHO IS IN CHARGE?**

The original agency that ordered the site cleanup was the Regional Water Quality Control Board (RWQCB). It specified what was to be done and required pre-approval for the implementation plan. Other portions of the laboratory site were being examined by California EPA (DTSC) and Federal EPA. Soon DTSC became the governing regulator when RWQCB declared itself satisfied with the excavation of the lower pond. Interactions with DOE (as the cleanup project sponsor), California Department of Health Services (for radiological issues) and other agencies for various activities became more and more complex. A joint activity was achieved for part of the project through an AIP (agreement in principle) involving some agencies, but not all, and not consistently throughout the project.

The concept of a lead agency for a particular activity has an attractive ring to it, but the relinquishing of authority by one regulator to another is unlikely to take place.

A strategy to consider is the convening of a committee of the regulatory agencies. To the extent that a coordinated overview by all of the pertinent authorities can be

*accomplished in joint meetings or committees, a major administrative gain will result. Identification of and contact with all of the appropriate regulatory functions is recommended as early in the project cycle as possible.*

## 7.0 SCHEDULE AND COST SUMMARY

### 7.1 SCHEDULE

The FSDF project had originally been projected to be performed during the 15-month period of October 1991 through December 1992. This optimistic plan was based upon the arbitrary completion date imposed by the RWQCB closure order. It further, naively, assumed all necessary approvals, permits and funding would be obtained in a timely fashion, and that weather would not be a limiting factor. The key milestones are listed on Table 2. A detailed discussion of schedule is not provided because Section 4.0 of this report is a chronological summary.

**Table 2 Key Milestones**

1	April 1990	BNA ordered to characterize the lower impoundment at building 4886
2	June 1990	Found that impoundment may be a source of groundwater contamination
3	April 1991	BNA ordered to remediate the lower impoundment, be done 12/31/92
4	July 1991	DOE issues nationwide moratorium on disposal of wastes from radioactive areas
5	September 1991	DOE accepts the responsibility for cleanup, creates and funds project.
6	November 1991	RWQCB/DTSC rejects cleanup plan
7	December 1991	Mobilization of remediation facilities begins at the site
8	February 1992	RWQCB/DTSC issue conditional approval to demonstrate remedial actions
9	March 9, 1992	First shovel full of contaminated soil excavated, began extraction of buried objects
10	March 14, 1992	Ambient gamma survey complete, no new findings
11	May 7, 1992	DOE stops cleanup, prohibits generating wastes from radioactive area.
12	September 1, 1992	BNA demonstrates that mixed wastes can be treated-overcomes DOE ban
13	September 20, 1992	First shipment of wastes left the site (conventional debris)
14	October 10, 1992	First shipment of hazardous wastes (not from radioactive area)
15	November 10, 1992	First shipment of hazardous wastes (from rad area) DOE case exception granted
16	October 9, 1992	RWQCB approves remediation process for balance of lower impoundment
17	December 1, 1992	Lower impoundment excavated to bedrock
18	December 29, 1992	RWQCB declares that closure order has been complied with.
19	January 19, 1993	DOE lifts shipping moratorium from project
20	March 24, 1993	RWQCB confirmed lower impoundment to be at radiological background
21	June 10, 1993	DHS confirms lower impoundment is at radiological background
22	September 1993	Independent site cleanliness verification contractor selected
23	February 1994	DHS summarizes results of radiological sampling-findings are negative
24	May 10, 1994	DOE approves disposal of mixed wastes at Utah commercial site.
25	May 24, 1994	Mixed waste shipments to Utah begin
26	June 24, 1994	Site excavations, demolitions and buried object removal completed.
27	July 1994	Site gamma survey shows site is free of radioactivity above background
28	March 15, 1995	DOE removes facility from list of radiologically controlled areas for wastes
29	July 1995	On and off site cleanliness verification sampling completed
30	August 15, 1995	Residual chemical contamination found (PCBs, dioxins, Mercury)
31	September 1995	No radioactivity in samples above background
32	August 29, 1995	Low level radioactive wastes shipped to Utah (begin)
33	December 1, 1995	Proposed plan for risk assessment and limited additional cleanup
34	July 29, 1996	DHS samples in lower pond and drainage channels-negative findings.
35	April 8, 1997	BNA issues final radiological survey report-site is suitable for release
36	September, 16, 1997	DHS samples upper pond and western area-confirms absence of rad contamination
37	May 6, 1998	DHS removes the facility from the radioactive materials license-full site release.

The dominant schedule problem has been and continues to be obtaining approvals from regulators. Whether it was for excavation plans and procedures, sampling plans, analysis results or anything that affected performance of a subsequent task, the times have been extremely long. Close examination of the chronology in Section 4 will clearly show how long specific issues and approvals took to be accomplished. An early warning of these problems should have been sensed in the arbitrary imposition of the [short] fieldwork completion schedule by a regulator, who immediately failed to respond to the workplan submittals in a timely fashion.

Weather was a problem to which any outdoor activity is subject. The low productivity of fully suited up hazardous waste workers in mid-summer was not fully appreciated, nor was the loss of time due to rain anticipated. The winters of 1991/1992 and 1992/1993 were record breakers (El Nino conditions) for the site.

Another schedule factor that was unanticipated was the imposition of moratoria upon waste generation, storage, shipping and disposal. The DOE restriction upon shipping hazardous wastes from a radioactive management area would not have been especially difficult had there not been a restriction on the amount of time the wastes can be stored. Further, EPA imposed a requirement that generation of certain hazardous wastes (for which there was no available land disposal capacity) was illegal. BNA imposed its own excavation schedule interruption, choosing to violate the closure order (and not remediate the site on the imposed schedule) rather than risk federal civil law violations by illegally generating and storing banned wastes.

Finally, funding from DOE generally needed to be identified two years in advance, and often was not capable of being carried over to another year if not used. Accurately projecting how much and when funds would be used was not possible with the regulatory review processes discussed above, and some years had insufficient funds to be fully productive.

As of this writing, the entire period from August 1995 until the present has been occupied with attempting to reach agreement with DTSC on what work shall be conducted to close the site. The results of the cleanliness verification task were presented in August 1995, and showed some residual contamination. Only two choices were possible--clean up some more or leave the residual contamination in place. The decision for the action to be taken has not been made.

## **7.2 COSTS**

The FSDF project had originally been projected to be performed during the 15-month period of October 1991 through December 1992 and was estimated to cost approximately \$8,275,000. This estimate was for the complete project including site restoration. The major area where the estimate was inadequate was the quantities of waste to be excavated and disposed of, especially the mixed wastes.

There was six times as much soil removed as estimated; the amount of radioactive waste was twice, and the unit costs of disposal were nowhere near the original estimates. The overall project schedule will likely be eight (plus) years, but not due to the

excavation quantities. The costs associated with obtaining regulator approval for the closure actions are continuing to mount, and the scope of restoration will of course be much greater than originally estimated.

The current accumulated cost, from inception through 30 June 1999 (94 months), is \$12,040,284. Not all of these costs were paid through BNA. In some cases, DOE funded other entities directly for support to this project and those costs have been included. There are substantial costs yet to be expended (roughly estimated to be \$ 2 M): for additional site remediation, for sampling and analysis to verify cleanliness, and for restoration of the site terrain. Although the project will be completed when the site is restored, the ongoing general sitewide environmental monitoring program will continue and will include this region.

The following discussion provides an overview of the costs accumulated by work task categories, including some generalized cost parameters derived from detailed costs. Table 3 presents the overall costs, which are briefly discussed below.

**Table 3 Summary of Costs**

Task	Cost \$ (000)	Percent
Site preparation & maintenance	\$ 211	2 %
Project management	\$ 1,491	12 %
Engineering & technical support	\$ 522	4 %
Assessments	\$ 2,110	18 %
Groundwater work	\$ 650	5 %
Site restoration	\$ 50	Nil
Waste disposal	\$ 3,842	32 %
Excavation	\$ 3,164	26 %
<b>Total</b>	<b>\$ 12,040</b>	

### **Site Preparation and Maintenance**

This task included the establishment of offices, fences, roads, surveying and related efforts needed to support the on-site work. Following the majority of the on-site work, continuing site maintenance costs were incurred for coverage tarpaulins, site housekeeping and management of rainwater. This activity was mostly an in-house staff effort and site maintenance continues. Costs allocated to this category are \$211 K (~2% of the total). Of this amount, \$ 172K was for maintenance materials and supplies over the duration of the project, about \$ 2 K per month.

The site mobilization costs were minimal due to the availability of portable structures at no cost. The protracted schedule incurred the annual costs of purchasing and installing tarps, and rainfall management. The temporary facilities were demobilized in 1995 when the site work was thought to be complete.

### **Project Management**

This task included the preparation of top level plans, coordination with regulators, project controls, procurement actions, and administrative functions, prior to active remediation. During site cleanup, direction and control of all activities was performed. Following the completion of the excavation, a low level continuing management effort was required for coordination with contractors, regulators and staff. Project management actions continue. This activity is entirely an in-house staff effort. Costs allocated to this category are \$1,491 K (~12% of the total). Of this amount, \$ 200K was for fees charged by regulators for their work.

Typical construction projects can be expected to cost about 10% for management, which is borne out here. Fees by regulatory agencies began to be applied late in the program (beginning in GFY97) and are significant enough to warrant budgeting for them.

### **Engineering and Technical Support**

This task included the development of technical approaches, preparation of detailed procedures, evaluation of work strategies and technical management of subcontractor efforts. This task was performed before and during the excavation work, and performed by in house staff. Any further required technical work will be performed by subcontractors. Costs allocated to this category are \$522 K (~4% of the total).

It is difficult to define a rule of thumb for technical costs for a project because it varies according to the technical challenges. A conventional cleanup/demolition project can be expected to be very low (3% or less), assuming the technology and procedures are well defined prior to the start of work. Due to the very high total costs, the technical work represented a small cost percentage, but the absolute costs of \$500 K plus are significant. For this project, considerable effort was expended towards developing (unsuccessfully) in house treatment of mixed wastes, development (unsuccessfully) of rapid, reliable chemical analysis of soils in the field. A key successful technical development was the process for surveying small batches of soil for radioactivity, discussed elsewhere.

The continuing costs of development of risk assessments, and site remediation plans/procedures are not being accumulated in this category. There was a decision taken to have such work performed by contractors, and the costs are included in the assessment category below.

### **Assessments**

This broad category included all characterization efforts for the project. It included the initial site cleanup plan (which was predominately a characterization plan), site geophysical surveys both before and after cleanup, radiological surveying of the site, sampling and (laboratory) analyses for waste characterization and post cleanup assessments of the site for cleanliness. This work was performed by in house staff and subcontractors. As a result of findings of residual contaminants, further cleanup will be required (in the cleanup category), but final verification assessments will be very likely be conducted by subcontractors. Costs allocated to this category are \$2,110 K (~18%

of the total). Of this amount, \$ 1,162 K was for examination and evaluation of the site after the FY92/93 cleanup campaign, and for preparation of additional work plans.

The major costs for the project since 1995 (Approximately \$ 1,450,000) have been for the preparation of assessments and remediation plans ( \$ 665 K) and regulatory fees (\$ 200 K). The balance has been spent for site maintenance and in house project management.

Some of the key unit costs derived from the assessment task area were:

- Chemical analyses of (non-radioactive) soils for hazardous constituents cost \$ 1,200 each (175 samples). The use of impartial, certified laboratories is discussed in the lessons learned. The costs are a direct function of the number, species, methods selected and detection levels of the constituents of interest.
- Standard chemical analysis of radioactive soils for hazardous constituents cost \$ 2,900 each (75 samples). The limited availability of certified chemistry labs with radiological licenses contributed to this high cost. Similarly, these costs were driven by the constituents sought.
- Sampling of soils from waste containers and from the site: 5.5 person hours (approximately \$320 per sample, for several hundred samples). The need for special equipment, procedural controls and personnel protection issues contribute to this figure.

#### **Groundwater**

All work related to monitoring of groundwater, installation of wells and related subjects is included in this category, and was performed by specialist subcontractors. This work continues for surveillance. Costs allocated to this category are \$650 K (~5% of the total). Of this amount, \$230 K was for installation of monitoring wells. The use of a single contractor (Groundwater Resources Consultants) at the SSFL had the advantages of historical knowledge and on-site presence; however the inability to competitively bid the work may have resulted in higher costs. The unit costs to this project were the contractor's standard pricing.

#### **Site Restoration**

This task is self-explanatory. Definition of the requirements for site restoration (backfilling, grading and revegetation) has been accomplished. The costs to date are \$ 50 K (less than 1 % of the total). The implementation will follow the acceptance of the site as clean.

#### **Waste Disposal**

This category included the costs of rental of waste storage containers, purchase of radioactive waste shipping and burial containers, waste transportation, waste site treatment and disposal cost. There was considerable labor effort in waste manifesting, labeling, handling, classification and sampling. Costs allocated to this category are \$ 3,842 K (~32% of the total). Of this amount, \$ 2,590 K was for disposal of non-radioactive wastes and \$ 1,120 K was for disposal of radioactive (mixed and non-mixed)

wastes. The balance of the costs was for disposal of conventional wastes (solid and liquid), and for associated labor.

Some of the key unit costs derived from the disposal task area were:

- Hazardous (RCRA) waste (not requiring treatment at the disposal site) cost about \$ 200 per ton for 8,460 tons. This included rental of storage/shipping containers, transportation and disposal fees. The fees at the disposal site were \$ 134/ton (1/1/93).
- Radioactive (mixed and low-level) waste cost about \$ 1,700 per ton for 660 tons. This included purchase of storage boxes, transportation and disposal at DOE's contracted site in Utah. This is to be compared with a projected cost of \$ 2,750 per ton to perform the treatment of mixed wastes to yield two waste streams, which would then have to be disposed of. The fee for the mixed waste was \$1,280 per ton at the Tooele County, Utah site. The balance of costs was for containers and shipping.
- Conventional wastes (debris and non-hazardous soil excavated) cost about \$65 per ton for 1750 tons. This included storage containers, transportation and disposal to approved landfills.
- Non-hazardous liquid wastes (primarily water pumped from the excavation areas) cost about 25 cents per gallon for 46,000 gallons including transportation and disposal.

### **Excavation**

This category includes the costs of the site crew labor for excavation and waste handling. Costs of health and safety staff, health physics staff, quality assurance, field supervision and leased earth handling equipment were included. It is emphasized that the excavation was very labor intensive due to the small quantities being extracted for radioactive surveying, and the crew suit-up requirements. To date, this work was performed by in house staff; but all of the planned future work will be done by subcontract. Costs allocated to this category are \$ 3,164 K (~26% of the total). Of this amount, \$ 2,794 K was for crew labor and \$380 K was for supporting equipment and supplies. The quantities of waste generated yielded the following experience:

- A cost indicator (although skewed to the high side) was that excavation, surveying, documenting and packaging waste soils cost approximately \$ 265 per cubic yard. Excavation of buried objects, demolition of the concrete pit and other structures inflated this cost indicator. The activity included excavation, sorting, radioactivity surveying (1 cubic yard at a time), documenting, packaging and labeling of wastes. Excluding the effects of the demolition tasks, an indicator of \$ 200 per cubic yard is offered.
- A production indicator, when the equipment and staff were fully trained and efficient, is about 75 cubic yards per 8-hour shift. Wet weather and buried objects affect this figure dramatically.

There were a series of costs incurred by DOE to support the project, but which were not funded through the BNA contract with DOE. These costs have been distributed into the appropriate categories above, but are not observable in the BNA code of accounts.

BNA Capital Funds-purchase of the soil handling machine	\$ 85,456
DOE Direct Funding to Oak Ridge National Laboratory, for disposal of mixed radioactive wastes at Envirocare-Utah	\$ 500,000
DOE Direct Funding to Oak Ridge National Laboratory for disposal of low-level radioactive wastes at Envirocare-Utah	\$ 358,600
DOE Direct Funding to Oak Ridge National Laboratory for ORISE analysis of soil samples	\$ 40,600

## **8.0 WASTE VOLUMES GENERATED**

### **8.1 GENERAL**

The cleanup of the FSDF involved the generation of wastes from several activities. Of particular concern were wastes that required special handling due to their hazardous content. These "regulated" wastes contained RCRA listed chemical substances and/or radioactivity in varying quantities. The fundamental objective of this project was to remove these materials from the site.

Classification of wastes, as they were generated, was a regulatory requirement involving categorization, labeling, packaging and storing. A detailed procedure for classification of wastes was developed and implemented to assure compliance with these regulatory requirements.

Figure 42 illustrates the various solid waste streams as discussed in detail below.

### **8.2 WASTE SOURCES**

#### **Contaminated soils and sediments**

Excavation of contaminated soils in the lower pond and portions of the upper pond were expected to result in wastes containing chemical and radionuclide substances. The species, concentrations and volumes were not well predicted. Most of the wastes generated originated from this activity, because this was the purpose of the project. The total excavated soil wastes generated were 11,876 cubic yards (10,864 tons) prior to the site cleanliness verification activities conducted in 1995. Additional excavation of soils and sediments from the drainage channels is planned for final remediation.

#### **Subterranean objects**

The past burial of scrap materials and abandonment of scrap objects at the site was known to be the cause of subterranean objects. The possibility that these objects were sources of contamination or hazards to the workers during soil excavation deemed it necessary to remove them. Since not all of the soils were intended to be removed, a method for locating such objects was employed. Geophysical surveying was found to be effective because the soils were shallow and the objects of concern likely to be metal. An exhumation of objects defined by the geophysical maps yielded a considerable mass of scrap.

The objects that were determined to be potentially hazardous (chemically) were sent to the Hazardous Waste Treatment Facility (building 4133) for decontamination. Since the cleaned objects were confirmed to not be regulated wastes, no effort was made to quantify and further characterize it. This material and the non-hazardous material from structures and equipment demolition yielded approximately 5 tons of scrap metal, all conventional wastes.

#### **Structures, building and equipment**

The site was used for cleaning of alkali bearing components. The process involved steam cleaning and submergence of the components in a concrete pit, and was performed

at an asphalt work pad near the entrance to the site. The cleaning equipment, storage and operating buildings, the pit and the asphalt pad were fully demolished yielding conventional wastes. It was later determined that an existing runoff diversion channel needed to be removed, also yielding conventional steel and concrete wastes. These wastes together with the cleaned scrap objects mentioned above, were approximately 240 tons of concrete and asphalt and 5 tons of scrap metal.

#### **Rinsewater from equipment and personnel decontamination**

Water was used to decontaminate equipment and for personnel hygiene. The wastewater was collected, analyzed and classified according to content. Most of the water collected was determined not to require hazardous disposal. All of the wastewater was transported off site for disposal.

#### **Water collected from contaminated regions**

A condition of the site remediation order was to collect and remove water which may have become contaminated or which could percolate through contaminated soils and reach groundwater. The excavations were covered by tarps and water collected from beneath the tarps was pumped into contains. Similarly, most of the water collected was found to not require hazardous disposal, but was transported off-site. The water that was found to be hazardous was disposed of at a commercial regulated treatment facility. None was radioactive. Most of the water was from rainfall that penetrated the tarps or which flowed underground from upslope. Water was collected over seven rainy seasons, and collection continues.

#### **Well construction wastes**

Cluster well number 54 was drilled at the low point of the lower pond. It was determined that since the area was contaminated, the well drilling wastes should be collected, classified and disposed of accordingly. Less than 5 cubic yards of non-hazardous cuttings were accumulated, and sent for off site disposal.

#### **Well water wastes**

Two wells (RD-21 just south of the access road, and RS-54c in the lower pond) are being operated in an extraction mode, pumping less than 5 gpm each. The discharge wastewater is routed through activated charcoal filter canisters, then piped into sitewide surface drains. Analysis of the extraction pump discharge is regularly performed, as is the total site drainage. The low extraction capacity of the wells and the solar driven pumps, limit the total amount of waste water generated to less than 5000 gallons since pumping began in April 1997.

### **8.3 WASTE STREAMS**

#### **Radioactive Wastes**

In all, only about 720 cubic yards (6% of the soil excavated) was found to be radioactive waste. All radioactive soil was sampled and analyzed for radiological and chemical constituents. Eighty composite soil samples were taken from the 720 cubic yards of soil and analyzed by an independent laboratory for gamma emitters (gamma spectroscopy), Sr-90, H-3, isotopic uranium, isotopic thorium and isotopic plutonium.

Based on the concentration results, a total quantity of 6 millicuries of Cs-137 and 1 millicurie of Sr-90 was identified as contamination.

Cs-137 concentrations ranged from 0.09 to 52 picocuries per gram of soil (pCi/gm) with an average of 8 pCi/gm, while Sr-90 concentrations ranged from 0.11 to 38 pCi/gm with an average of 1.6 pCi/gm. Quantities of all other isotopes including uranium and thorium and their decay products were equal or less than that expected in clean soil.

All of the radiologically contaminated soil was sent to Envirocare Inc., Utah, a licensed, commercial low level radioactive waste site approved by DOE, and by state and federal regulating agencies.

Although the soils were shipped to a radioactive waste disposal facility, the level of contamination in the soil was so low that Department of Transportation (DOT) regulations did not require the shipments to be classified as a radioactive waste shipment, and did not require the shipping trucks to be placarded with "radioactive material" signs.

The radionuclide composition of the radioactive wastes are shown in Figure 43.

### **Mixed Wastes**

The waste stream of greatest concern was material containing both radioactivity and RCRA listed chemicals. It was a DOE objective to minimize wastes in general and minimize wastes for which treatment and disposal options were limited. Mixed wastes fell into this category. During the course of the project, there was a prohibition placed upon the generation of mixed wastes because there were no disposal processes available or acceptable disposal sites. Ultimately, a specific treatment was developed and demonstrated which enabled the remediation project to continue, but was not used when a DOE approved commercial disposal site became available.

The excavation strategy involved small batches of soil which were examined for radioactivity. This check determined once and for all whether the batch was radioactive or not. Had this not been done and wholesale excavation performed, the quantity of radioactively classified (mixed and low-level) soil would have been substantially greater. The details of the soil classification process are discussed in Section 5.

The mixed waste generated on the project was all in the form of soil. A few radioactively contaminated objects were found but they did not also contain hazardous constituents. Following chemical sampling and analysis of the waste soils (previously determined to be radioactive) that soil which contained RCRA constituents above regulated levels was classified as mixed. Mercury was the driving hazardous constituent (> 8 ppm) found at regulatory levels, although some samples showed PCBs. Mercury ranged from 8 ppm to a maximum of 126 ppm, while PCBs occurred infrequently from detection level up to 5.3 ppm. The elevated radionuclides were cesium-137 and strontium-90.

All of the mixed wastes were placed in steel boxes approved for storage, shipping and disposal. The details of the container sizes, weights, serial numbers and radioactive content are in the files maintained at the Radioactive Materials Handling Facility (RMHF).

All of the waste classification data (sampling procedures, measurements, laboratory analysis and interpretations) are stored in project records.

There were 238 boxes of mixed soil wastes shipped to Envirocare Inc., located in Tooele County, Utah. The soils were shipped under mixed waste profile number EC-6005, during the period of May 24, 1994 through August 23, 1994. A total of 773,480 pounds of soils (422.6 cubic yards) was shipped. This quantity was approximately 60 % of the radioactive soil excavated.

#### **Hazardous waste soils**

The next waste stream of concern was soils containing RCRA listed chemicals above regulated concentrations. The list of contaminants can be found in the RCRA legislation documents, and was used as the laboratory analysis screen. The groupings are: volatile organic compounds (VOCs), semi volatile organics, (SVOCs), heavy metals, PCBs, and dioxins. Soils extracted from areas previously known to be contaminated were immediately classified as hazardous, pending analysis. Following analysis, a final classification was made. Several categories were possible, each of which had different costs for disposal.

There were no significant quantities of soils that required treatment prior to disposal. Most of the wastes were determined to be California regulated (more stringent) than Federally regulated. The results of the chemical analyses of the wastes from the lower pond are shown in Figure 44 through Figure 49.

During the course of the project, a DOE prohibition was placed upon the shipping of hazardous wastes that originated in an area where radioactive contamination of the wastes was possible. This area was designated as a Radioactive Materials Management Area (RMMA). DOE required that an administrative control process be imposed to preclude hazardous wastes from being sent to non-radiologically licensed disposal sites with radioactive components in it. Ultimately, the verification process was satisfactory to DOE and shipping was allowed.

The hazardous wastes generated by the project were primarily in the form of soil (except for a small amount of rinse water that was found to be hazardous). The few objects that contained hazardous reactive materials were treated, rendering them non-hazardous. The hazardous waste soils were placed in steel roll-on, roll-off containers approved for storage, shipping and disposal. The details of the container sizes, weights, serial numbers and chemical content (manifests) are in the files maintained by the Safety, Health and Environmental staff. Following chemical sampling and analysis of the waste soils, final classifications were applied. Two categories of hazardous wastes resulted:

Wastes containing hazardous components at a level below RCRA concern, but which were California regulated and requiring disposal at a class 1 site. The waste was profiled as BF 6840, requiring EPA manifests (see Figure 50) for administrative control and payment of state disposal taxes.

Wastes containing hazardous components below California regulatory attention, but above sanitary land fill standards. The waste was profiled as AM 7335. These wastes were sent to a Class 1 site because there were no approved Class 2 sites available at the

time. Subsequently, a Class 2 site was found and the remaining wastes were routed there at a lesser cost. Administrative control data was collected for this waste stream also (Figure 51).

Due to the various constraints placed upon shipping of wastes, many filled containers were accumulated and were stored near the site. When the shipping releases finally occurred, an intensive shipping campaign was accomplished as follows:

Approximately 90 containers (1100 tons, 1202 cubic yards) of hazardous wastes were disposed of as class 1 waste at Chemical Waste Management's, Kettleman City, California facility. The soils were shipped under hazardous waste profile number KHF-BF 6840, during the period of November 3, 1992 through February 2, 1993.

Approximately 600 containers (7360 tons, 8042 cubic yards) of non-hazardous wastes were disposed of at Chemical Waste Management's, Kettleman City, California facility. The soils were shipped under waste profile number KHF-AM 7335, during the period of September 28, 1992 through June 17, 1993.

Approximately 140 containers (1749 tons, 1911 cubic yards) of non-hazardous wastes were disposed of at TPS Technology's, Class 2 waste disposal facility at Adelanto, California. The soils were shipped under waste profile number TPS 01122, during the period of October 15, 1993 through January 15, 1994. This was the same classification of wastes as KHF-AM7335 but the costs were 40% less for site disposal and shipping to a closer site, but which was not available prior to late 1993.

The hazardous wastes were the stream commanding the most attention due to regulatory concerns. To illustrate the matter, the following process had to be implemented before release of the waste load (the documents are extracted from various procedures governing the work execution):

- A checklist of all documents had to be completed and bought off (see Figure 52).
- A form certifying conformance to DOE objectives (see Figure 53).
- A form documenting the basis for the waste chemical classification (see Figure 54).
- A shipping data form (Figure 51) documenting the load, carrier and destination.
- A Radioactive survey report (Figure 55) recording the gamma spectrometer readings of each "scoop" of soil, and also used for clearing objects.
- A departing vehicle inspection report (Figure 56) recording the vehicle and driver identifications and safety features.
- An Intermediate Lot Follower (Figure 57) recording the details of each scoopful of soil and receiving container.
- A California land disposal restriction form (Figure 58) certifying that wastes conforms to regulations.

- A waste profile (Figure 59) certifying the maximum concentration of contaminants in waste stream. Profile BF6840 shown for hazardous wastes for illustration.
- A copy of the DOE approval (Figure 60) to make the shipment, issued on a case-by-case exception to the shipment moratorium.
- A typical container label (Figure 61) required by law to show contents.

Supporting information was needed to make waste classification determinations. These included:

- Sampling Guide (Figure 62) which randomly determined the locations for the samples to be used to characterize the shipment batch. The locations from 5 roll-on/roll-off bins are shown.
- Chemical sample analysis request forms (Figure 63-side one and Figure 64-side two) define sample information and analytical methods to be performed, and is a part of the chain of custody process.
- Chemical sample analysis reports (Figure 65 through Figure 68) show the results of the analyses. These are illustrative examples only.

A similar process, but involving somewhat less documentation, was followed for all waste streams. The documents generated are stored in project files.

#### **Other Hazardous Wastes**

A considerable quantity of elemental mercury was found during the excavations of the lower pond and the western areas. Approximately 650 pounds of mercury saturated soils were sent to Bethlehem Apparatus Co., in Pennsylvania for recycling.

Some water was collected from equipment rinsing and from beneath the tarps that covered excavated areas. A small amount was found to contain regulated contaminants and shipped off site for treatment and disposal. The quantity was less than 1000 gallons.

#### **Low Level Radioactive Wastes**

The soils that were found to be radioactive upon excavation, then subsequently determined to not be mixed (below hazardous chemical action levels) were classified as low level wastes (LLW). It was planned that they be shipped to DOE's Hanford, Washington site, but DOE's acceptance of the Envirocare, Inc. Utah site for mixed wastes, and the associated lower cost changed the plan for the LLW wastes.

There were 202 boxes of low level radioactive soil wastes shipped to Envirocare Inc., located in Tooele County, Utah. The soils were shipped under LLW profile number EC-2031, during the period of August 29, 1995 through September 19, 1995. A total of 554,740 pounds of soils (303 cubic yards) was shipped. This quantity was approximately 40 % of the total radioactive soil excavated; while the total radioactive soil was approximately 6% of the total soil excavated.

### **Conventional Wastes**

The conventional debris (concrete from the pit and asphalt from the pad) was sent to the Chiquita Canyon, Valencia California Class 3 disposal facility. It was estimated that there was 240 tons of this material.

Unearthed objects (mostly metallic scrap) were confirmed to be non-hazardous when found, or sent to building 4133 for cleaning. An estimated 5 tons of this type of conventional scrap was shipped off site.

A considerable quantity of water was pumped from beneath the tarps over the course of seven winters. It is roughly estimated to have exceeded 400,000 gallons. This water has never been found to meet the definition of hazardous waste. It is sent off site because the water is not clean enough to manage through the SSFL surface water system.

## **9.0 PERSONNEL RADIATION EXPOSURES**

Approximately seventy persons were authorized entry into the controlled work area at the FSDF during the cleanup associated with potential radioactive exposure. All of these persons, including personnel from third-party contractors, were issued film badges, given the appropriate training and issued personnel protective equipment. Additionally, specialist radiation technicians were part of the excavation crew and they were responsible for radiation surveys of all materials and for radiation safety of all persons. The site was fenced and posted in accordance with regulations, and procedures for control of contamination were imposed.

Personnel exposure to radioactivity was related to the nature and duration of the work assignments at the site. The tasks discussed below collectively occurred during the period of October 1991 through March of 1993, when the last load of radioactive waste was shipped from the site to the Radioactive Waste Handling Facility.

Four personnel from the Radiation Safety department participated in the project as follows:

- Surveys of the site for activity levels
- Collection of samples and laboratory analysis for species detection and activity levels
- Survey of individual lots of soil during excavation for activity levels.
- Survey of waste containers and transport vehicles.

Seven personnel from the Health and Safety department participated in the project as follows:

- Survey of individual lots of soil during excavation for hazardous chemical levels.
- Surveillance of the work site.
- Forty-six personnel from the DOE Site Restoration department participated in the project as follows:
  - Excavation of objects, demolition of structures, sorting and handling of all wastes
  - Packaging and handling of waste containers
  - Site housekeeping and maintenance

Personnel from other departments, or from contractor organizations were involved to various extents, as follows:

- Four quality assurance department employees for oversight and inspection
- One employee from facilities engineering to perform the grid survey
- Three persons from contracted organizations for health and safety officer duties and a geophysical surveying task.

Many of the staff personnel were assigned to other projects during the course of the FSDF cleanup, and detailed data records of their exposures specifically received at the FSDF were not made. Examination of film badges occurred quarterly, and any indications of cumulative exposure (above the detection sensitivity) would be cause for a graded investigation and, where indicated, corrective action. There were no instances of exposures greater than 50 mrem to any person as a consequence of working at the FSDF cleanup project. In addition, quarterly bioassay was conducted on the participating personnel. No significant intakes of radioactive material were noted.

## **10.0 CURRENT STATUS AND FUTURE WORK**

### **10.1 CURRENT PHYSICAL STATUS**

The following activities are being conducted in compliance with direction from regulators:

- The excavated areas are covered with nylon reinforced, polyvinyl tarps to limit water percolation into the ground and minimize fugitive migration of loose materials. Water above the tarps is diverted into the site drainage channels, while water collected beneath the tarps is pumped into containers for off site disposal, after analysis for contaminants.
- Two wells (RD-21 just south of the access road, and RS-54c in the lower pond) are being operated in an extraction mode, pumping less than 5 gpm each. The purpose of the pumping is to mitigate, if possible, further migration of contaminants and to monitor changes in the groundwater adjacent to the remediated site. The discharge water is routed through activated charcoal filter canisters and into surface drainages. Analysis of the discharge is regularly performed.
- Sampling and analysis of site drainage from rainfall events is accomplished at water sampling stations and weir stations located in both of the drainage channels. The purpose of this activity is to determine if any residual contamination may be migrating.
- Sitewide quarterly monitoring of groundwater wells is being conducted, and includes wells in the vicinity of FSDF. Four additional wells were installed in the FSDF area as a part of the site remediation project and continue to serve as monitoring stations, or extraction pumps as discussed above.

### **10.2 PLANNED REMAINING WORK**

#### **Contamination Remediation Targets and Cleanup Plan**

The scope of the remaining site remediation effort is based upon regulatory acceptance of the levels of cleanliness to be achieved.

As a result of findings of residual chemical contaminants, a health based risk assessment (reference 147) was performed to evaluate the consequences of taking no further action at the site. The conclusions were that additional remedial cleanup is required to reduce the potential health risks due to contact with PCBs and dioxins, all other species of contaminants were evaluated to be within acceptable risk ranges. The risk-based cleanup levels were developed for PCBs and dioxins based on residential and recreational exposures and are 600  $\mu\text{g}/\text{kg}$  and 13.1  $\text{pg}/\text{g}$  respectively. The residual mercury was not found to be a health risk.

IT Corporation has prepared an interim remediation workplan document, reference 148, and submitted it to DTSC for review and approval. This plan specifies in detail the planned remaining work, as discussed below.

#### **Excavation and Waste Disposal:**

Excavation and disposal of soil to bedrock in the upper pond and western areas will take place as necessary to achieve projected residual levels 600 µg/kg for PCBs or 13.1 pg/g dioxins. Sampling and analysis data will be collected following the excavations.

Excavation and disposal of sediments from drainage channels A and B, above the weirs, will be performed as necessary to achieve the above levels.

Excavation and disposal of all soils and sediments in channels A, B & C downstream of the weirs will be performed.

It is expected that the presence of mercury in some of the excavations will require disposal of those wastes as hazardous, even though the mercury concentrations themselves are not at sufficient levels to pose a health risk if left in place.

The estimated quantity of wastes is 3140 cy (4710 tons) of which: 325 cy are expected to contain mercury, requiring disposal as hazardous waste, and 2800 cy are expected to contain low levels of contaminants allowing disposal as conventional wastes.

Radiological release of the site for unrestricted use occurred in May 1998, therefore radiological monitoring of the site, or of wastes or samples taken from it, is not required.

#### **Backfilling and Contouring**

Clean soil will be imported (source location has not yet been finalized) and placed in the excavations of the lower pond, upper pond, western area and channel B. The backfilling incorporates the requirements of the Ventura County grading permit (reference 45) for compaction and final contouring for erosion control. Storm water control features will be installed.

#### **Revegetation and irrigation.**

A specific requirement of the abatement and cleanup order was to restore the site to prevailing conditions. This was interpreted to mean restoring the site to natural contours, thereby limiting erosion, and revegetation to native species. A study performed by Envicom (reference 149) characterized the surrounding terrain and recommended restorative measures. The workplan has incorporated the recommendations for import soils and revegetation, the type and source of vegetative materials and the application of special features (irrigation), and an erosion control plan that incorporates drainage channels and swales.

Revegetation consists of placing retentive material into drainage swale(s) and planting of container plants. Seeding of the entire site and installation of drip irrigation will then be accomplished.

### **Groundwater Monitoring**

The sitewide quarterly groundwater monitoring program includes the four newly installed wells at the Former Sodium Disposal Facility, satisfying a portion of the “post-closure” monitoring plan.

### **Site Closure**

It is not clear how formal release (closure) of the FSDF site for unrestricted use (from a chemical perspective) will occur. The original closure order (reference 8) specified a series of actions, which presumably when taken and accepted by regulators constitutes closure, but no procedural mechanisms are known to exist. The current understanding is that the RCRA corrective actions that are underway for the entire laboratory will include the FSDF.

### **Post-Closure Monitoring**

Remediation of the FSDF requires a “post-closure” monitoring plan. That plan includes continuous monitoring of surface and groundwater, physical verification of erosion controls, and support for revegetation. The Interim Measures Workplan discusses the annual operation and maintenance of the site, which addresses drainage channel weirs, the vegetation condition and irrigation, and the monitoring wells.

Post closure maintenance planning includes analysis of sediments collected behind weirs to support collection and disposal. This will occur at least annually, but as frequently as necessary to prevent overflow. Regular examination of the general site for evidence of soil erosion or material migration is performed, and repairs effected as necessary. The plan also includes maintenance and repair of the revegetation and associated irrigation systems.

### **10.3 CURRENT ADMINISTRATIVE STATUS**

The Interim Measure Workplan (reference 148) has been through many review actions and is currently under final review by the State of California, Environmental Protection Agency (CAL-EPA), Department of Toxic Substance Control (DTSC), which has jurisdiction over the site cleanup.

DTSC has issued (reference 150) a draft of a Negative Declaration for the Interim Measure Workplan, meaning that an environmental impact analysis of the cleanup project is not needed. Final issuance of the Negative Declaration constitutes approval to proceed with the interim measure workplan.

The current plan is to continue with IT Corporation (formerly ICF Kaiser) acting as the general contractor for the balance of the project, with the exception of the groundwater monitoring activity, currently contracted to Groundwater Resources Consultants, Inc.

The workplan has been placed into the public domain for review and comment, under the requirements of CEQA.

Implementation of the plan will achieve closure of the site provided the cleanup criteria have been met. Start of site work is planned for the fall of 1999.

A large-scale groundwater cleanup and monitoring effort continues at the field laboratory site, of which the FSDF is a small part. A comprehensive RCRA corrective action process is ongoing for the field laboratory site and includes the FSDF.

## **11.0 APPENDICES**

### **APPENDIX A - FORMAL RECORDS**

The following items are groups of data collected during the course of the project. As of this writing, the data and records are stored in file cabinets and boxes located in building 4057 at the Santa Susana facility site.

#### **Data & Records**

A considerable amount of data and records were accumulated during this project. The following discussion is provided to familiarize the reader with the nature of and the content of the data and records.

#### **Personnel Training Records**

All personnel who were authorized to work in the controlled areas were required (by reference 886-AN-0001) to have specific training. The records contain the evidence of that training.

#### **Sign-In/Sign-out Logs**

All personnel who entered the work site, but who were not authorized workers were required to sign-in and sign out. This provided a means of control and coverage for identification of personnel in the event of an emergency evacuation. Site supervisory staff was responsible for the safety of sign-in visitors.

#### **Site Logbooks**

All projects are required to maintain activity logs, in addition to any forms required by procedures. These are intended to inform readers about unusual occurrences, general activity. It is also a means to inform the subsequent shifts about the activities of prior ones.

#### **Industrial Hygienists Records**

The health and safety plan (886-ZR-00010) required the use of specific devices for monitoring the safety of the workplace and for collection of data about the devices and personnel.

#### **Radiation Survey Records**

In addition to the data collected for determination of the ambient radiation fields, each and every item which was intended to leave the controlled work area was surveyed and a record made. This included debris, waste in containers, equipment and instruments and wastes that were not in containers. This is part and parcel of contamination control. Soil lots and water survey records are discussed below.

### **Sample Analysis Log**

Upon the identification of material as a waste, a sample was needed for confirmation. A log was kept which recorded the taking of the sample and the final classification of the waste. This assured that wastes were not released from the site until the final determination was made and recorded.

### **Hazardous Waste Shipping Documents**

Wastes containing RCRA designated constituents were classified as hazardous wastes. Internal procedures required the preparation of shipping documents. Additionally, wastes were manifested on forms required by the state where the wastes were to be disposed of. These records were created at the time of waste dispatch. Subsequently, after the wastes were disposed of at the disposal site, a certification of disposal was provided to the sender. These records are on hand.

### **Non-hazardous Waste Shipping Documents**

Wastes containing RCRA designated constituents but below levels of concern, were classified as non-hazardous wastes. Internal procedures required the preparation of shipping documents. These records were created at the time of waste dispatch. Subsequently, after the wastes were disposed of at the disposal site, a certification of disposal was provided to the sender. These records are on hand.

### **Conventional Waste Shipping Documents**

Wastes not containing RCRA designated constituents were classified as conventional. Internal procedures required the preparation of shipping documents. These records were created at the time of waste dispatch. These records are on hand.

### **Soil Analysis Documents**

Soils, collected in one cubic yard lots, were surveyed for radioactivity and visual indications of chemical content. The results of the survey, and data concerning the location of origin of the soil were recorded as part of the pre-classification of waste category. The pre-classification determined which primary container in which to place the soil. These records, known as intermediate lot followers, are preserved.

Containers that held larger quantities of soils were sampled and the results analyzed by contracted laboratories. The results and the associated classifications of wastes were recorded and preserved.

### **Water Analysis Documents**

Waste water, collected from beneath the protective tarps and from decontamination/cleaning containers and sanitary wastes were analysis for waste disposal categorization also. These records are preserved.

### **Waste Profiles**

Disposal sites typically require the shipper to characterize the waste stream. This requires the specification of the maximum concentrations of constituents and other features of the wastes. It forms the basis of how and where the disposal site will handle the waste and is the basis for setting the disposal price. A series of waste profiles were generated and referred to in each shipment. These profiles are recorded as records.

### **Injury Reports**

Personnel injury reports were issued in accordance with procedures. The records of these reports are preserved. There were twenty reports issued; they ranged in severity from a wrenched shoulder to a heat rash. There were no serious traumas, no broken bones, and no emergency evacuations.

### **Tailgate Meeting Notes**

Shift workers attended regular meetings to learn about work assignments, project status, safety information and general information. Records of these meetings were preserved.

## APPENDIX B - FORMALLY RELEASED DOCUMENTS

The following documents were formally released for use on this project. Original copies of the documents may be found in the BNA documents vault.

Document Number	Originator	Issue Date	Title
886-SP-0002	ETEC	12/3/92	SDFC-Excavation, sorting, segregation and classification of soils
886-SP-0003	ETEC	9/8/92	SDFC-Locating & excavating buried objects
886-SP-0004	ETEC	2/15/93	SDFC-Sampling of soils for analysis
886-SP-0005	ETEC	12/3/92	SDFC-Packaging, labeling, classification & disposal of wastes
886-SP-0006	ETEC	4/2/93	SDFC-Groundwater & surface water sampling
886-OI-001	ETEC	1/20/93	SDFC-Asphalt pad, concrete pit & concrete drainage ditch demolition
886-OI-002	ETEC	1/20/93	SDFC-Instructions for relocating waste containers outside of site
886-ZR-0001	ETEC	8/10/92	SDFC-Health & Safety Plan
886-ZN-0002	ETEC	12/9/91	Assessment Plan for SDF
886-ZB-0003	ETEC	2/20/92	Preliminary beta/gamma radiologic survey procedure
886-ZR-0004	ETEC	3/9/92	Safety analysis for SDF closure
886-ZR-0005	ETEC	3/6/92	Independent review of safety analysis
886-ZB-0006	ETEC	7/30/93	Final radiologic sampling and gamma survey procedure
886-ZR-0007	ETEC	1/5/95	Post remedial ambient gamma survey report
886-ZR-0008	ETEC	10/30/95	Bio-geochemical probe study
886-ZR-0009	ETEC	4/2/97	Post remediation soil sampling and analysis ambient gamma survey report
886-XT-0001	ETEC	2/1/93	Radiological acceptance criteria for soil segregation
886-XT-0002	ETEC	12/3/92	Bases for determination of no DOE added radioactivity
886-XT-0003	ETEC	7/8/94	SDFC-Closure
886-CN-0001	ETEC	1/10/92	Sodium Burn Pit Grid layout
886-CX-0002	ETEC	4/23/92	FSDF-Remediation site layout

886-AN-0001	ETEC	3/5/92	SDFC-Project Management plan
886-AN-0002	ETEC	4/6/92	SDFC-Training plan
886-AN-0003	ETEC	10/12/92	SDFC-Familiarization training
886-AN-0004	ETEC	2/5/93	Interim post-closure plan for lower pond
03.0601846.001.001	McLaren-Hart	6/21/95	FSD-Draft offsite drainage characterization work plan, and HASP
none	EBASCO	10/25/91	FSD-Closure Plan (July 1991)
8640M-174	GWRC	6/19/92	Health and Safety Plan
8640M-176	GWRC	9/1/92	Results/comparisons of geophysical and video camera logging of RD-21,-22 & -23
8640M-216	GWRC	4/25/94	Hydrogeological conditions
8640M-186	GWRC	12/17/93	Groundwater monitoring plan
04994-001-00	ICF-Kaiser	6/30/92	Geophysical survey report
none	ICF-Kaiser	4/23/92	Health & Safety plan(geophysical)
SSFL-95-01	ICF-Kaiser	7/21/95	Sampling and Analysis work plan
SSFL-95-02	ICF-Kaiser	7/21/95	Health & Safety plan
none	NORCAL	2/17/94	Geophysic survey report
92-003	Clemson	11/1/92	Mixed waste treatability study
ER-SP-0001	ETEC	10/22/91	Control of wastes from RMMA
M000-80599	ETEC	9/14/92	SDFC-Grading plan
089QPP000001	ETEC	10/30/92	R/A matl pkg/ship QA plan
094QAP-00	ETEC	9/7/90	Insp. Reqts-R/A materials
GEN-QAP-0001	ETEC	10/11/91	QAP for hazwaste shipping
N001DWP00009	ETEC	10/3/84	R/A enviro monitoring program QA plan
N704SRR990034	ETEC	8/10/92	Baseline rad survey of SDF
173OP000002	ETEC		On-site R/A transport procedure
N001OP000034	ETEC	8/26/91	Surv/Release of non-R/A wastes
N001SRR140119	ETEC	1/15/93	Anal of hazwaste for R/A
N001TI000343	ETEC	12/18/92	Rad survey/release criteria
N001TI000339	ETEC	9/4/91	Def & Designation of RMMAs
N001OP000002	ETEC	5/6/85	R/A Material, pkg,ship and transport plan
8664	Ventura	9/8/92	County grading permit
552621	OSHA	7/31/92	Excavation/trenching permit
0015-70	California		R/A Material License
CA000629972	EPA		Haz Waste Dispos Facility
CA3890090001	EPA	7/9/92	RCRA treatment/store permit

**12.0 ABBREVIATIONS AND DEFINITIONS**

886	Building 886-Former Sodium Disposal Facility
4057	Building 057-Temporary document warehouse
4133	Building 133-Hazardous waste treatment facility
4886	Area IV, Building 886-same as 886
AEC	Atomic Energy Commission
ALARA	As low as reasonable achievable
B/886	Building 886-same as 886
B-12	Approved container for radioactive materials
BNA	Boeing North American
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
Cs-137	cesium-137, a radionuclide
CWM	Chemical Waste Management Inc.
cy	Cubic yards
D&D	Decontamination and decommissioning
DHS	California Department of Health Services
DOE	United States Department of Energy
dpm	Disintegrations per minute
DTSC	Department of Toxic Substance Control-California
EBASCO	A commercial architect-engineering firm
El Nino	A periodic weather condition producing heavy rains
EPA	Environmental Protection Agency (Federal)
ERA	Ecological risk assessment
ERDA	Energy Research and Development Administration
ESADA	Empire State Atomic Development Agency
ETEC	Energy Technology Engineering Center
FSDf	Former Sodium Disposal Facility
H-3	Tritium, a radionuclide
hazardous (waste)	Waste which is corrosive (pH <2 or >12.25), ignitable (Flashpoint ,140F), reactive (explosive or chemically active), or toxic LD50 < 5,000mg/kg; or listed in the California Administrative Code, Title 22, Article 9, Section 66680.
HAZWOPER	hazardous waste worker training, an OSHA requirement
HBRA	Health based risk assessment
ILF	Intermediate lot follower-waste identification document
IMPACTS-BRC	An NRC computer code for dosage analysis
IT	A commercial architect-engineering firm-formerly ICF-Kaiser
ITC	Intermediate transfer container
LLW	Low level waste
LSA	Low specific activity
mcl	Maximum contaminant level

mixed (waste)	Waste that contains both a RCRA hazardous waste component, regulated under subtitle C or RCRA, and a radioactive component consisting of source, special nuclear, or by-product material regulated under the AEA.
mrem	Millirem
NaK	Sodium and potassium mixture
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OCDD	Dioxins
ORISE	Oak Ridge Institute of Science and Education
OSHA	Occupational safety and health act-Federal
PCB	Polychlorinated Biphenyls
pCi/gm	Pico-curies per gram, an amount of radioactivity
pg/g	Pico-gram/gram, 1 x E-12, or ppt, parts per trillion
ppb	Parts per billion
ppm	Parts per million
R	Roentgen
radionuclide	A radioactive substance
RCRA	Resource Conservation and Recovery Act
RD	Rocketdyne-deep
RESRAD	A DOE computer code for pathway analysis
RFI	RCRA Field Investigation
RMDF	Radioactive Materials Disposal Facility
RMMA	Radioactive Materials Management Area
RO/RO	Roll-on, roll-off containers
RS	Rocketdyne-shallow
RWHF	Radioactive waste handling facility - Former RMDF
RWQCB	Regional (Los Angeles Region) Water Quality Control Board
Sr-90	strontium-90, a radionuclide
SSFL	Santa Susana Field Laboratory
SVOC	Semi-volatile organic compounds
T133	Building 133-Hazardous waste treatment facility
T886	Building 886-same as 886
TCA	Trichloroethane
TCE	Trichloroethylene
TPCA	Toxic Pits Cleanup Act-California
TPS	A commercial waste disposal site
USEPA	Same as EPA
VOC	Volatile Organic Compounds
X-TRAX	Trade name for thermal extraction process

## 13.0 FIGURES

Figure 1-Location of Rocketdyne Field Laboratory .....	79
Figure 2-Santa Susana Field Laboratory (SSFL).....	80
Figure 3-Former Sodium Disposal Facility (1991).....	81
Figure 4-Designated Remediation Areas .....	82
Figure 5-Off-site drainage channels .....	83
Figure 6-Trenching for the CERCLA II study (3/87).....	84
Figure 7-Office and personnel hygiene trailers .....	85
Figure 8-Site coordinate grid.....	86
Figure 9 -Pre-remediation site condition (2/92).....	87
Figure 10-Excavation begins (3/92) .....	88
Figure 11-Elemental mercury is found .....	89
Figure 12-Excavation of subterranean objects.....	90
Figure 13-Exhumed debris .....	91
Figure 14-More exhumed debris .....	92
Figure 15-NaI Gamma detector instrument.....	93
Figure 16 - Beta-gamma detector .....	94
Figure 17-Geophysical map of buried objects.....	95
Figure 18-Geophysical surveying.....	96
Figure 19-Submergence pit .....	97
Figure 20-Demolition of pit.....	98
Figure 21-Filled hazardous containers (awaiting shipment).....	99
Figure 22-Radioactive waste containers (filled).....	100
Figure 23-On-loading of filled containers .....	101
Figure 24-Shipping of full containers.....	102
Figure 25-Vehicle weigh station.....	103
Figure 26-Bedrock exposed in lower pond.....	104
Figure 27-Tarps over excavations .....	105
Figure 28-Tarped site during rain .....	106
Figure 29-RWQCB Officer (in vest) on site.....	107
Figure 30-Site in February 1993 .....	108
Figure 31-Radioactive waste containers at RMDF .....	109
Figure 32-Drilling well cluster RD-54 in lower pond .....	110
Figure 33-Sorting and segregating non-hazardous soils .....	111
Figure 34-Soil sorting and handling machine.....	112
Figure 35-Soil segregation in process.....	113
Figure 36-Composite view of contamination types .....	114
Figure 37-"Sniffing potentially hazardous material .....	115
Figure 38-ITC with NaI probe receptacle.....	116
Figure 39-Excavation, segregation and classification process.....	117
Figure 40-NaI probe insertion into receptacle .....	118
Figure 41-ITC filled with soil being counted for radioactivity.....	119
Figure 42-Solid waste streams.....	120
Figure 43-Radionuclide content of radioactive and mixed wastes .....	121
Figure 44-Inorganic (metals) constituents of wastes from lower pond.....	122
Figure 45-SVOCs from lower pond (1 of 2).....	123
Figure 46-SVOCs from lower pond (2 of 2).....	124
Figure 47-VOCs from lower pond (1 of 2).....	125
Figure 48-VOCs from lower pond (2 of 2).....	126
Figure 49-Miscellaneous compounds from the lower pond.....	127
Figure 50-Hazardous waste manifest.....	128
Figure 51-Conventional waste shipper .....	129
Figure 52-Waste data checklist.....	130
Figure 53-Certificate of compliance with DOE objectives.....	131

Figure 54-Waste classification determination .....	132
Figure 55-Radioactivity survey report.....	133
Figure 56-Vehicle inspection report .....	134
Figure 57-Intermediate lot follower.....	135
Figure 58-California land disposal restriction form.....	136
Figure 59-Regulated waste profile.....	137
Figure 60-Case exception for DOE approval for shipment .....	138
Figure 61-Waste label.....	139
Figure 62-Random sampling of 5 R/O bins.....	140
Figure 63-Chemical sample request- (page 1 of 2).....	141
Figure 64-Chemical sample request (page 2 of 2) .....	142
Figure 65-Chemical analysis results (metals) .....	143
Figure 66-Chemical analysis results (PCBs) .....	144
Figure 67-Chemical analysis results (VOCs) .....	145
Figure 68-Chemical analysis results (SVOCs) .....	146

Figure 1-Location of Rocketdyne Field Laboratory

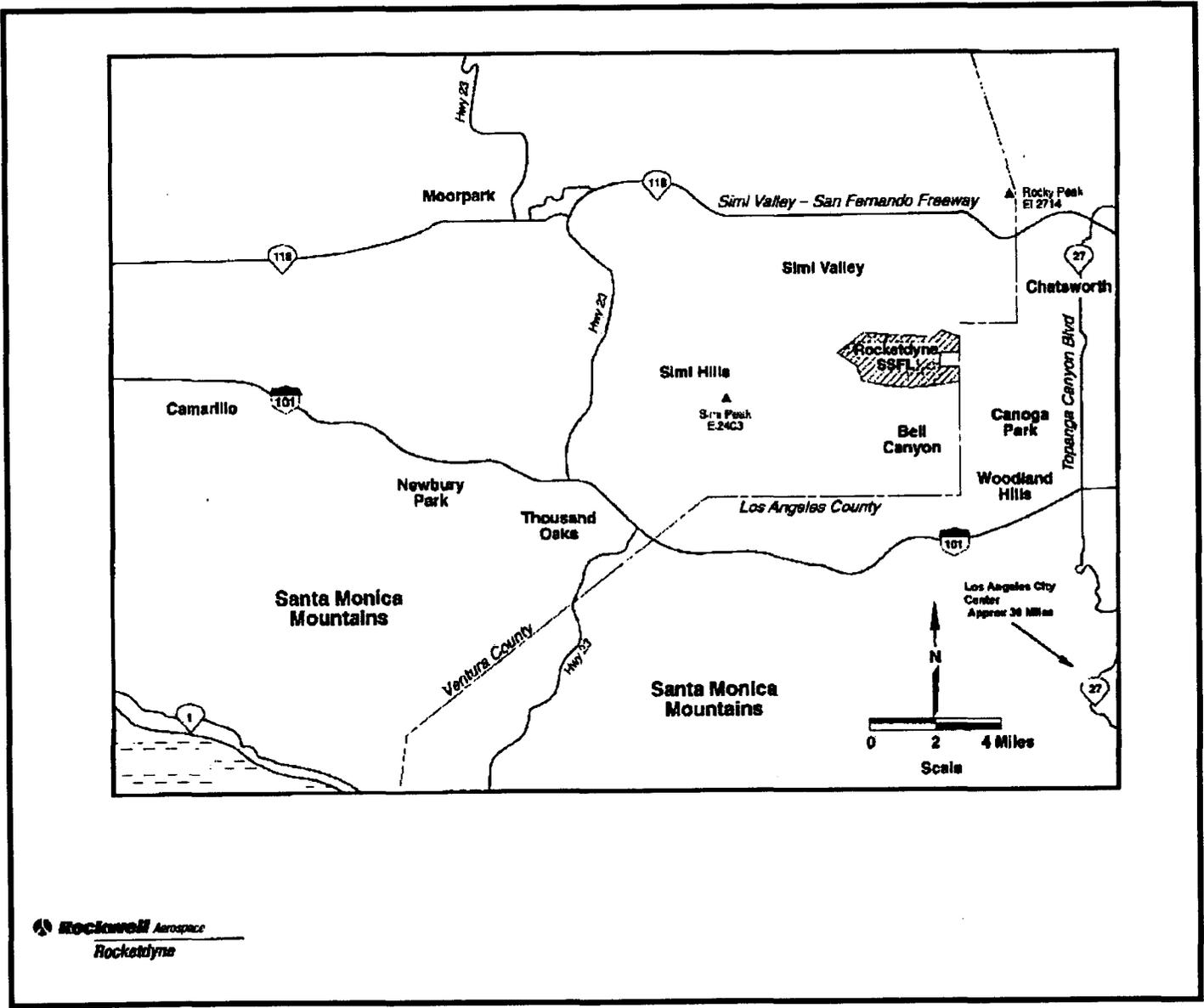
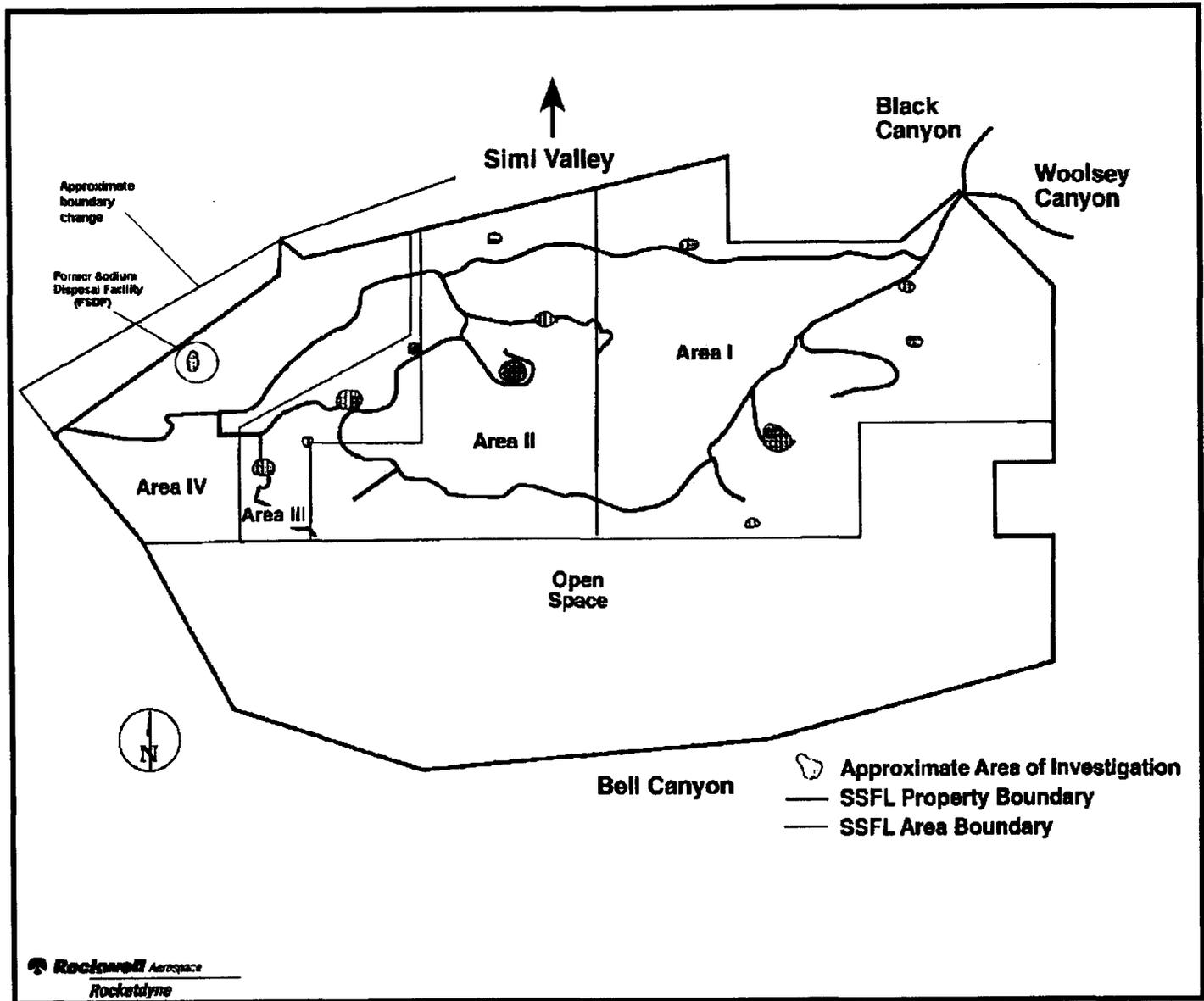


Figure 2-Santa Susana Field Laboratory (SSFL)





**Figure 3-Former Sodium Disposal Facility (1991)**



Figure 4-Designated Remediation Areas

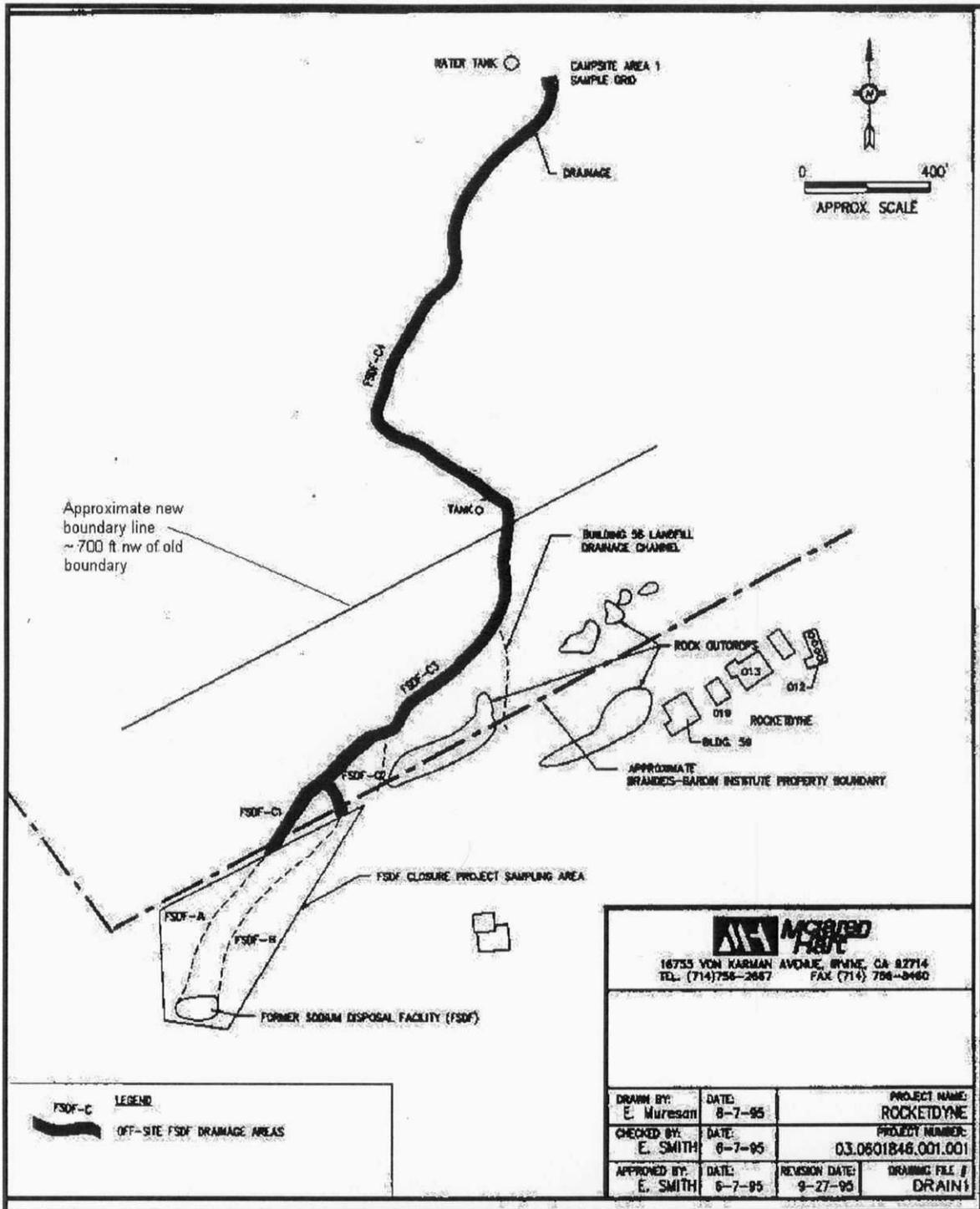


Figure 5-Off-site drainage channels



**Figure 6-Trenching for the CERCLA II study (3/87)**



**Figure 7-Office and personnel hygiene trailers**

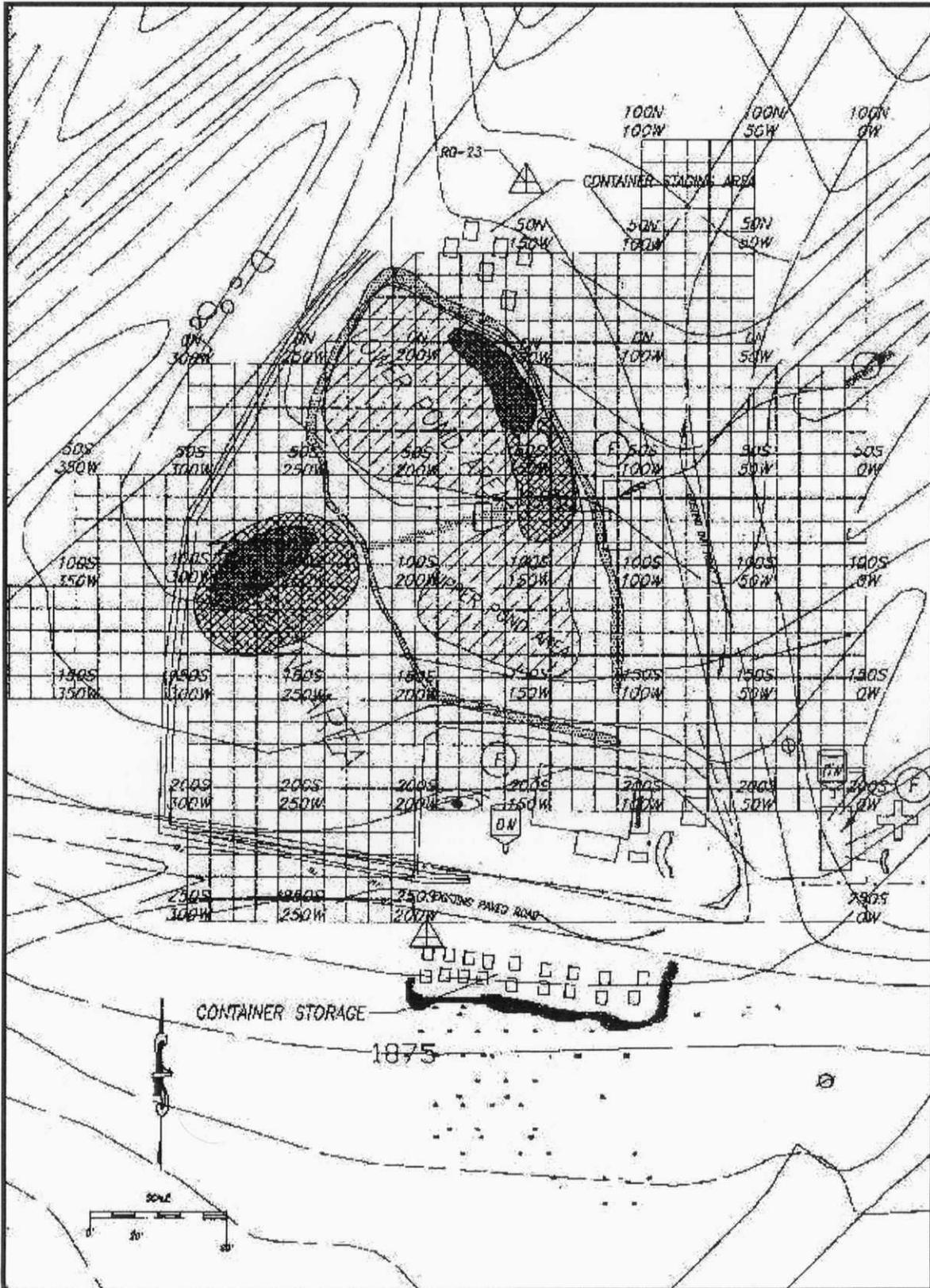
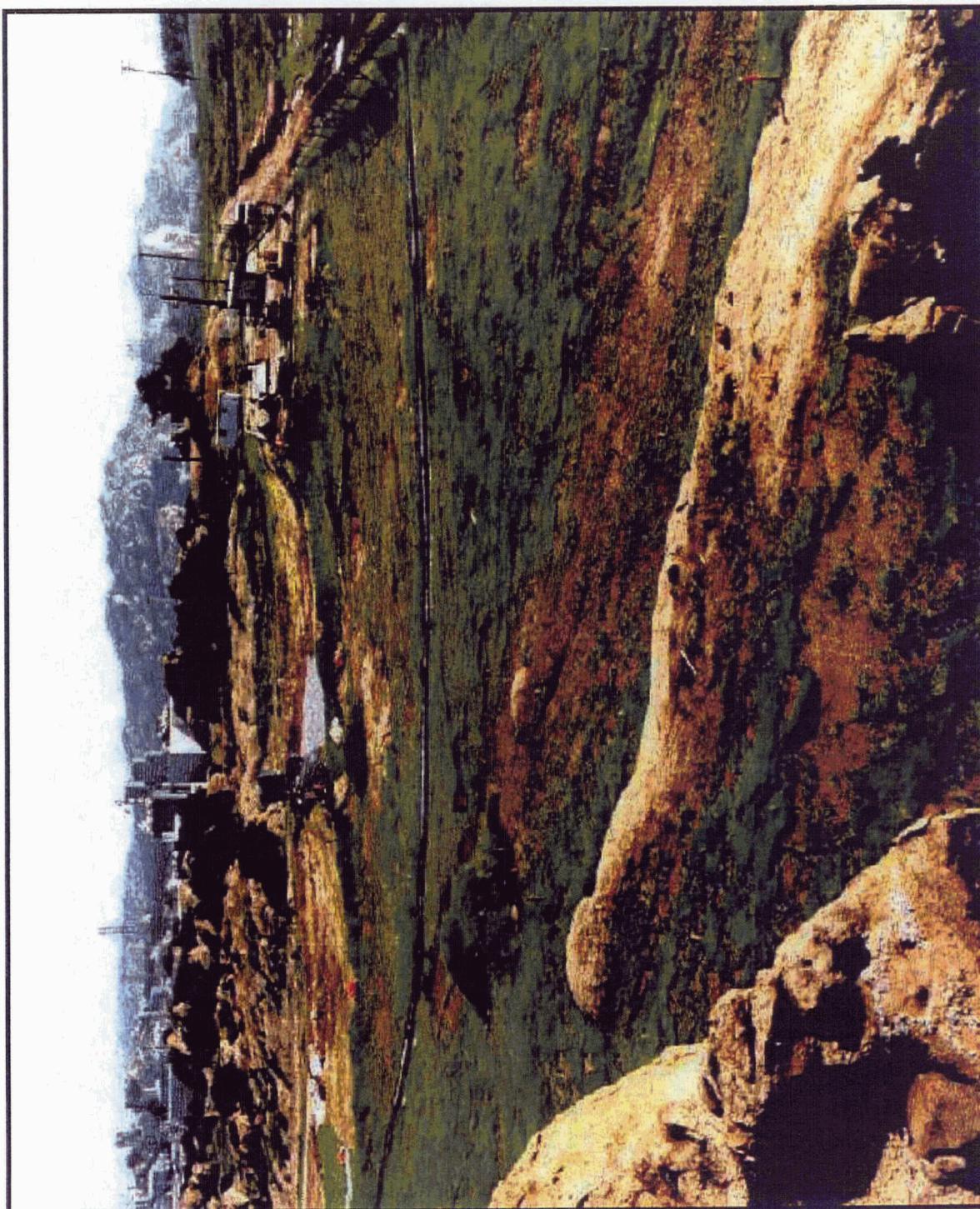


Figure 8-Site coordinate grid



**Figure 9 -Pre-remediation site condition (2/92)**

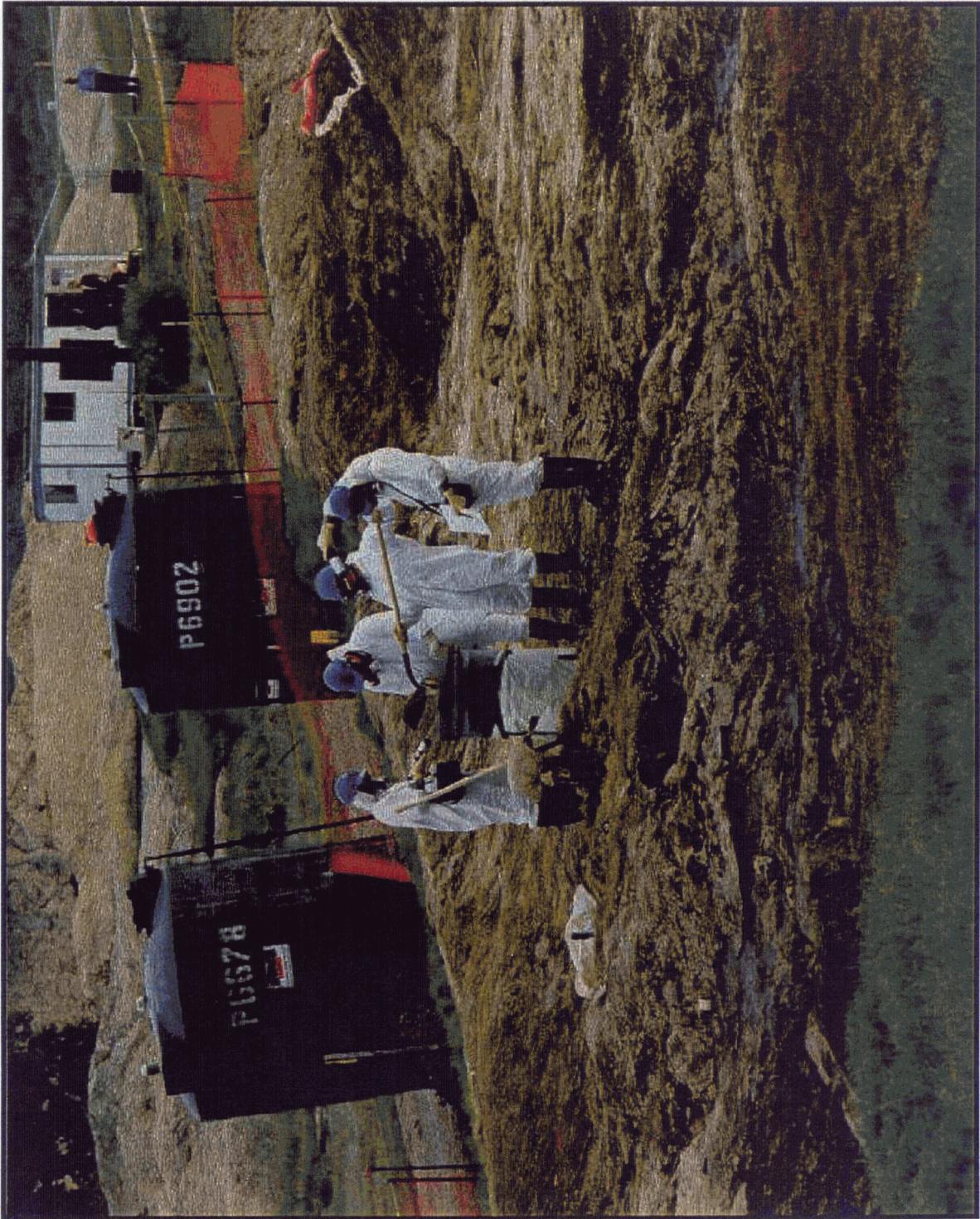


Figure 10-Excavation begins (3/92)



**Figure 11-Elemental mercury is found**

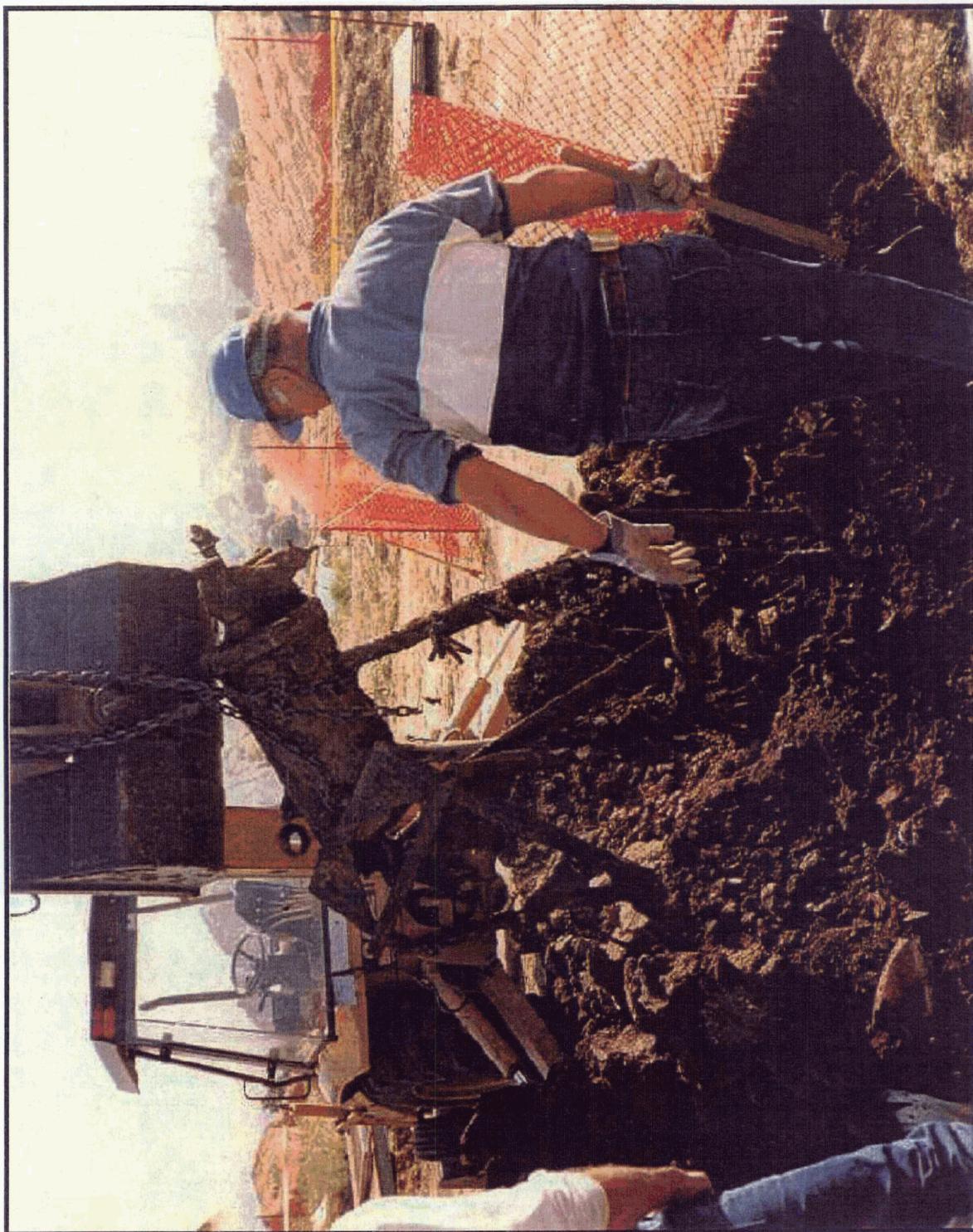


Figure 12-Excavation of subterranean objects

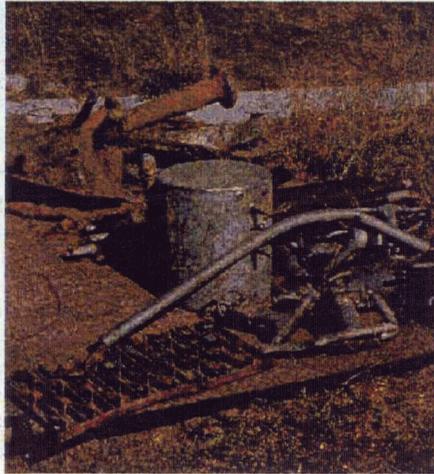


Figure 13-Exhumed debris



**Figure 14-More exhumed debris**



**Figure 15-NaI Gamma detector instrument**



Figure 16 - Beta-gamma detector

Figure 17-Geophysical map of buried objects

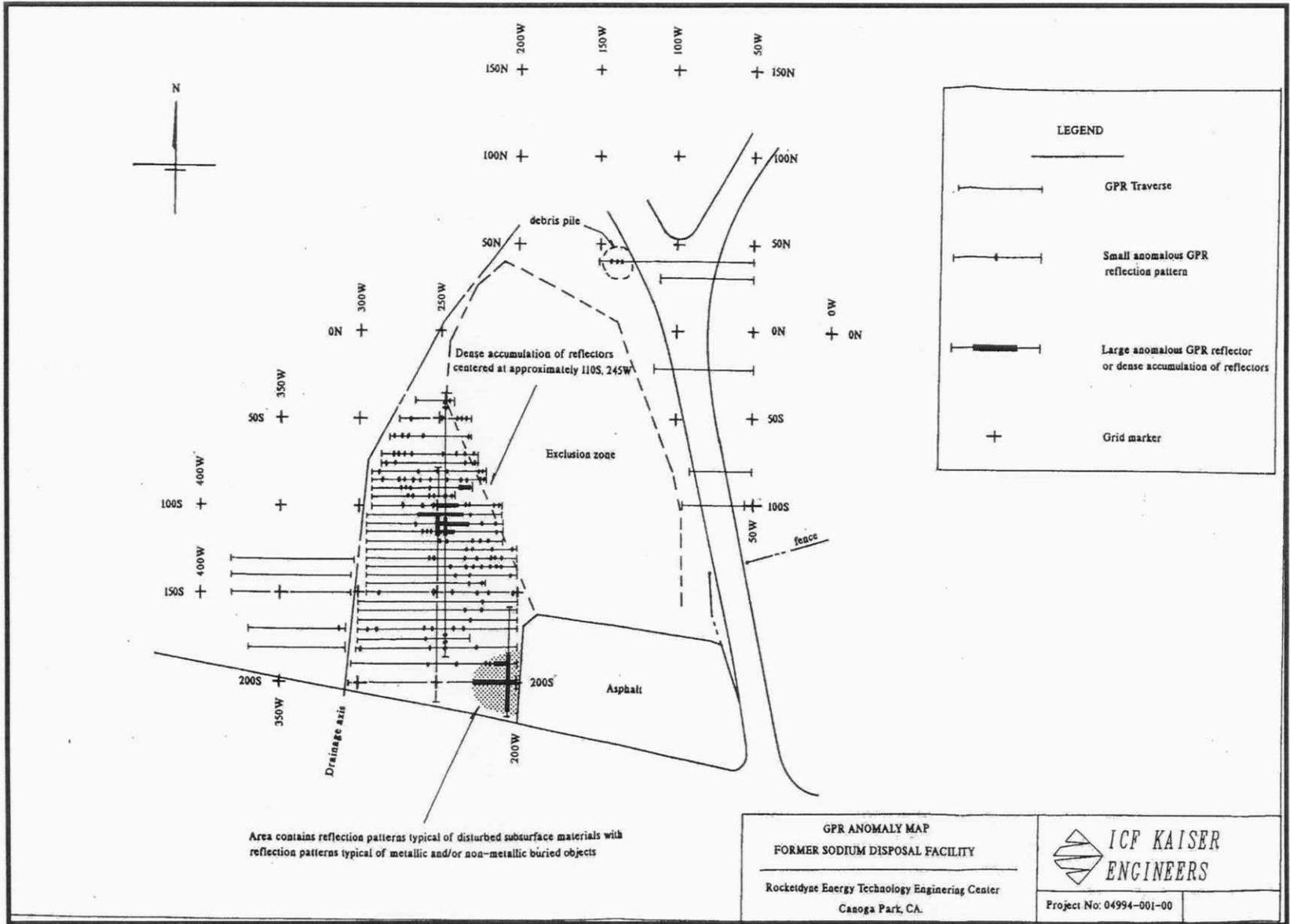




Figure 18-Geophysical surveying



Figure 19-Submergence pit



Figure 20-Demolition of pit



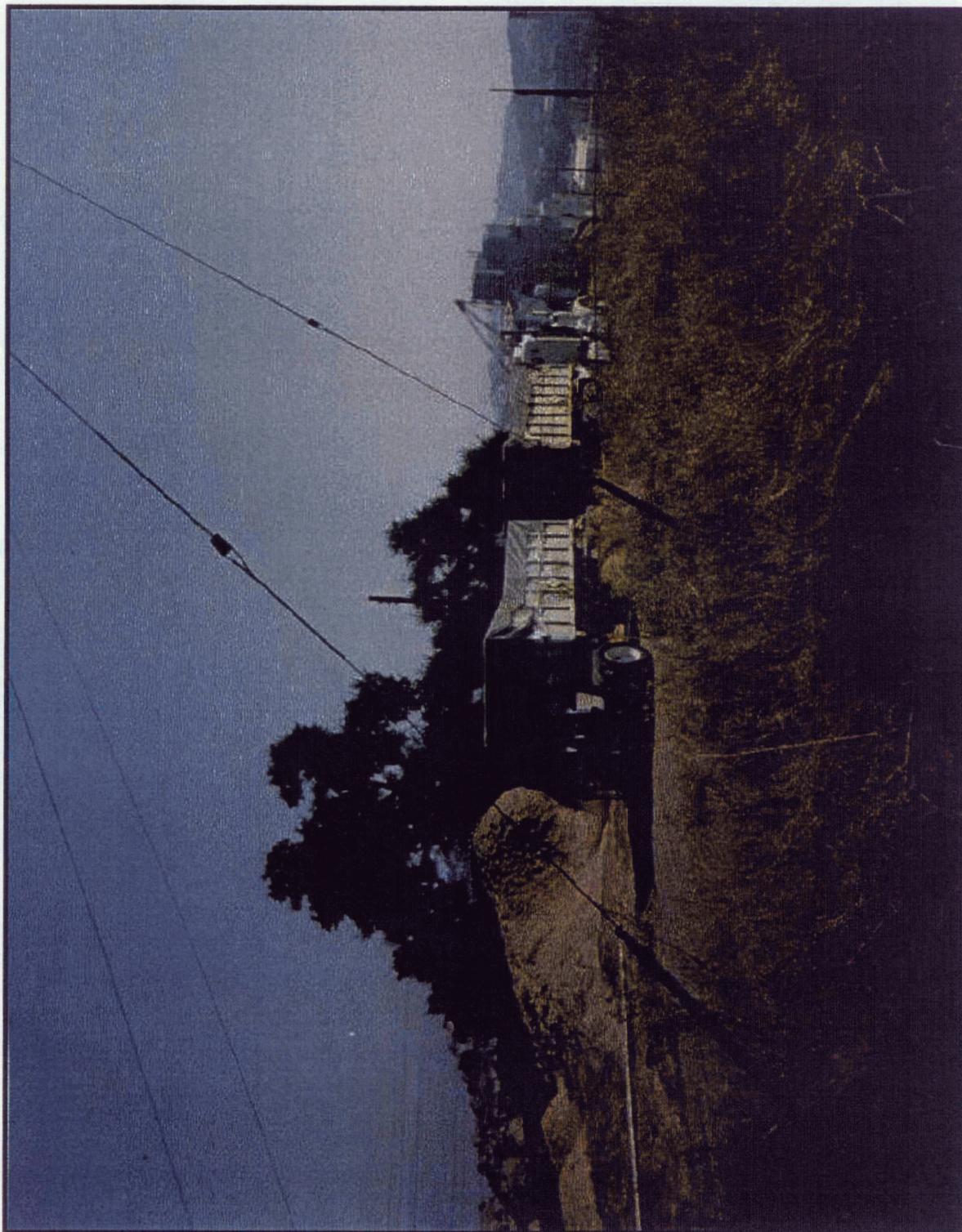
**Figure 21-Filled hazardous containers (awaiting shipment)**



**Figure 22-Radioactive waste containers (filled)**



Figure 23-On-loading of filled containers



**Figure 24-Shipping of full containers**

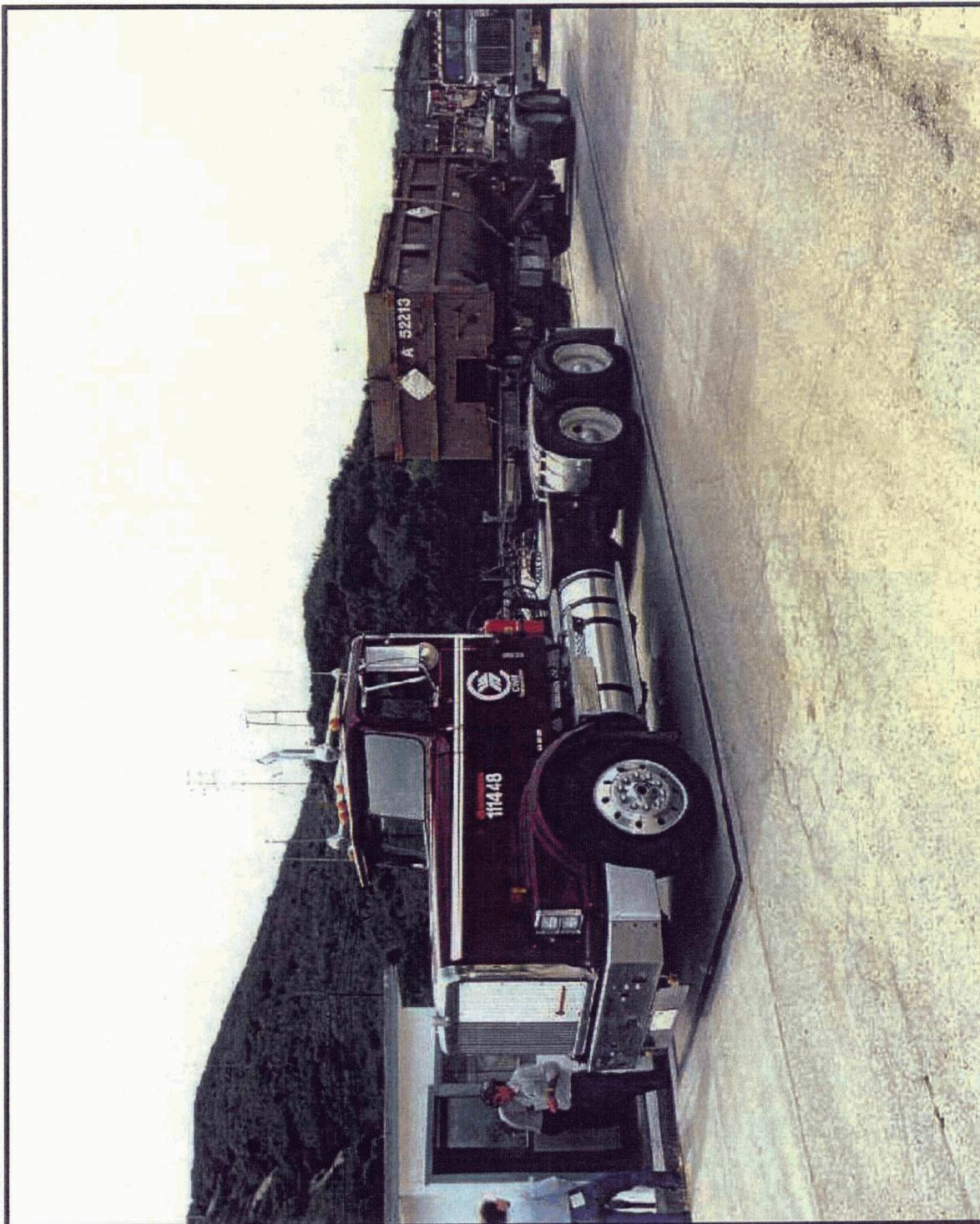


Figure 25-Vehicle weigh station



**Figure 26-Bedrock exposed in lower pond**



Figure 27-Tarps over excavations



**Figure 28-Tarped site during rain**



Figure 29-RWQCB Officer (in vest) on site



Figure 30-Site in February 1993

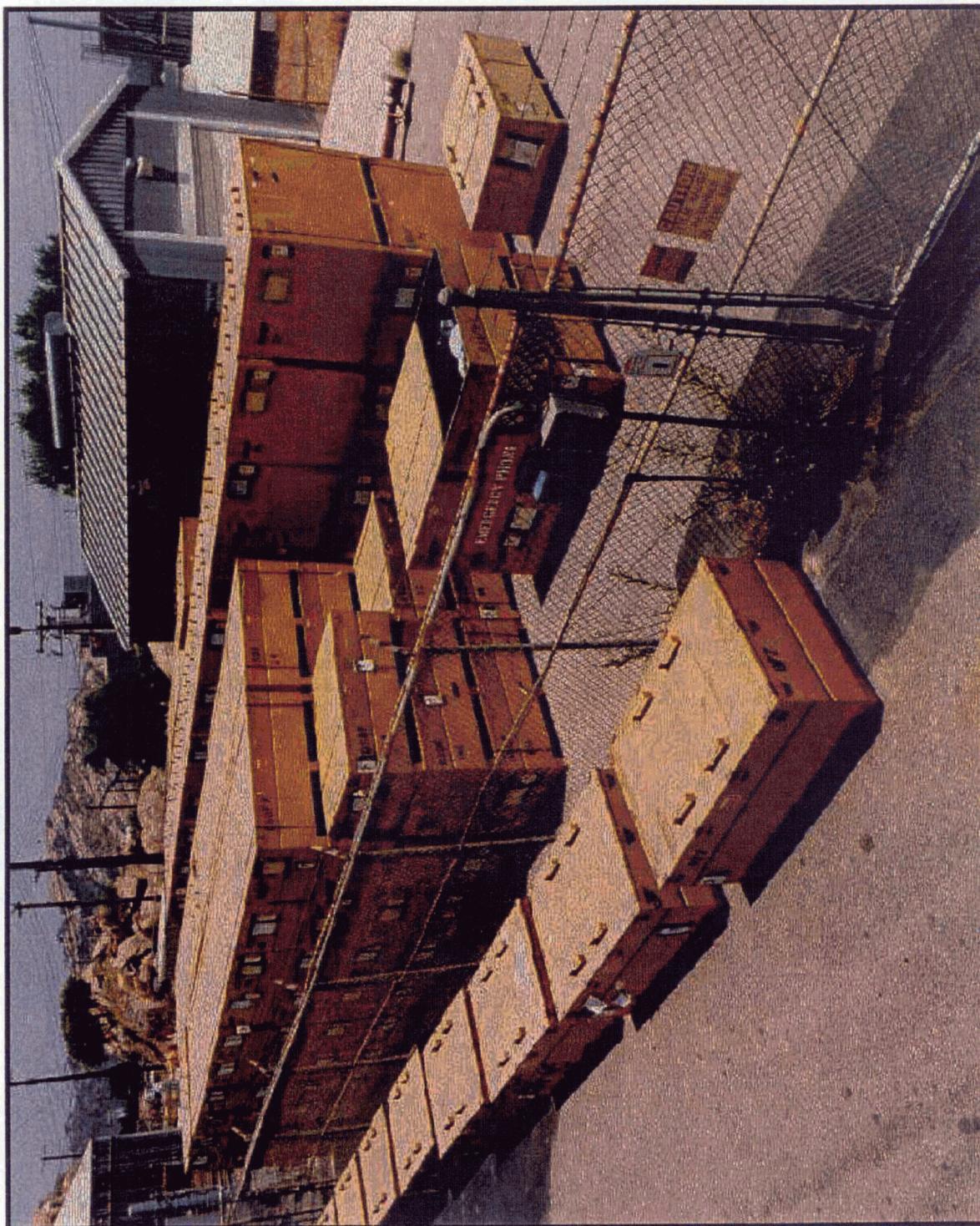
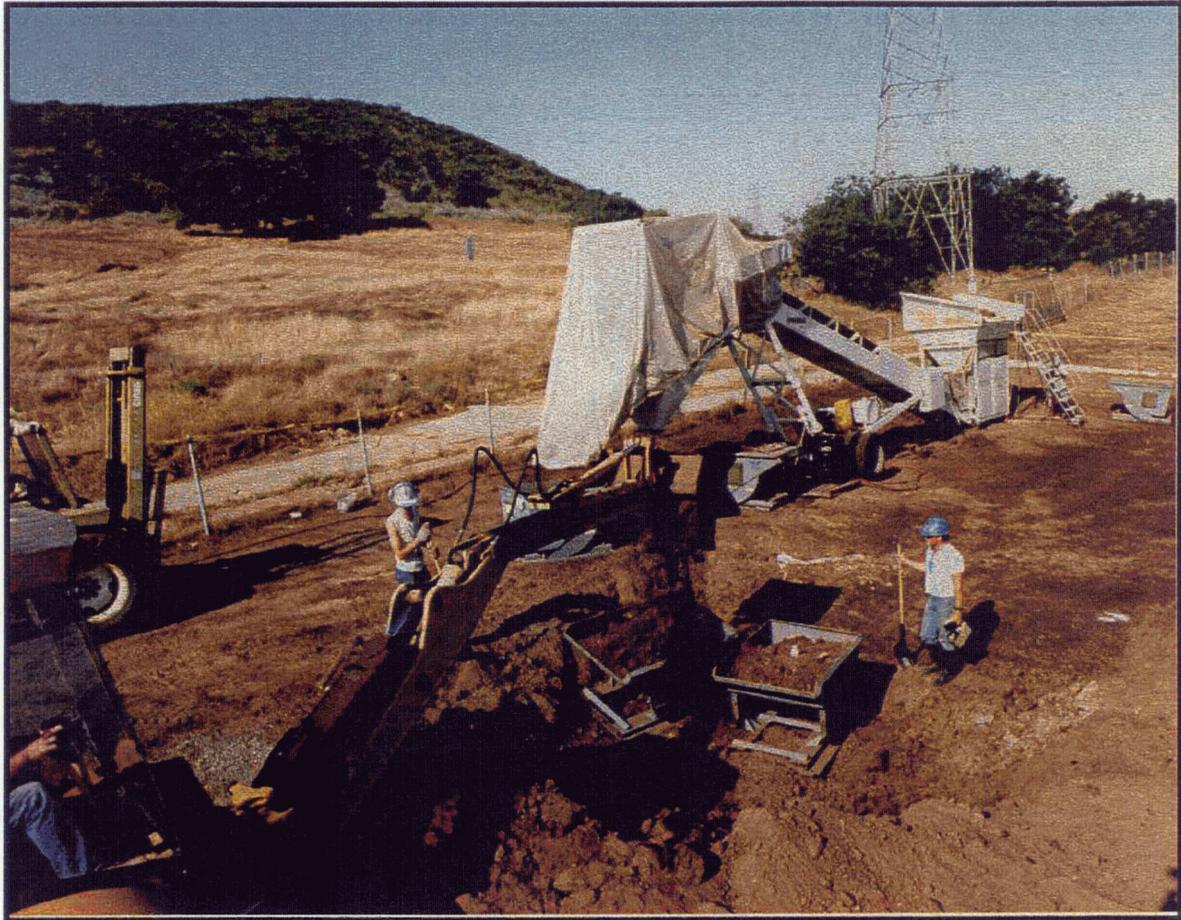


Figure 31-Radioactive waste containers at RMDF



**Figure 32-Drilling well cluster RD-54 in lower pond**



**Figure 33-Sorting and segregating non-hazardous soils**



**Figure 34-Soil sorting and handling machine**



Figure 35-Soil segregation in process

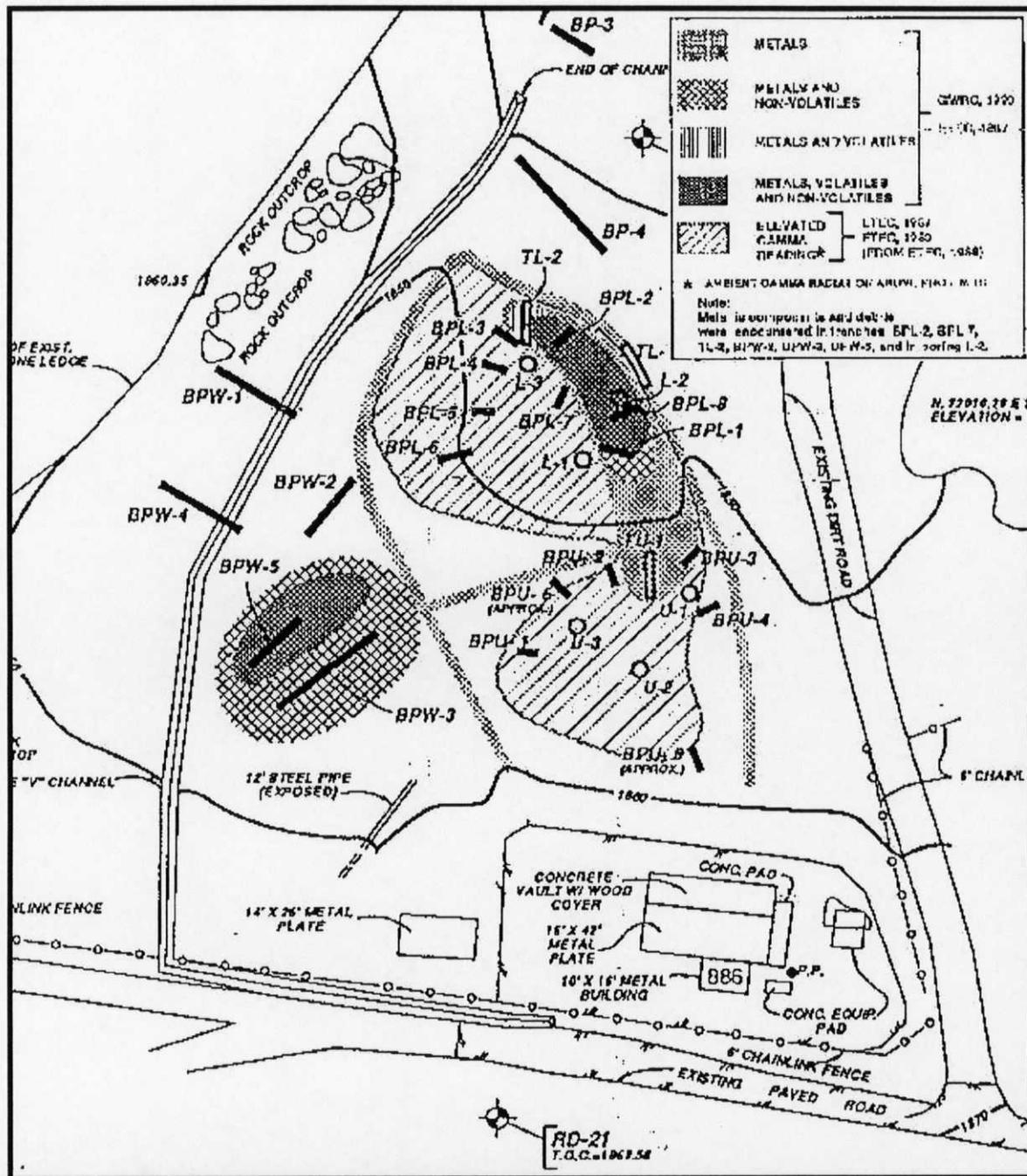


Figure 36-Composite view of contamination types



Figure 37.-“Sniffing potentially hazardous material

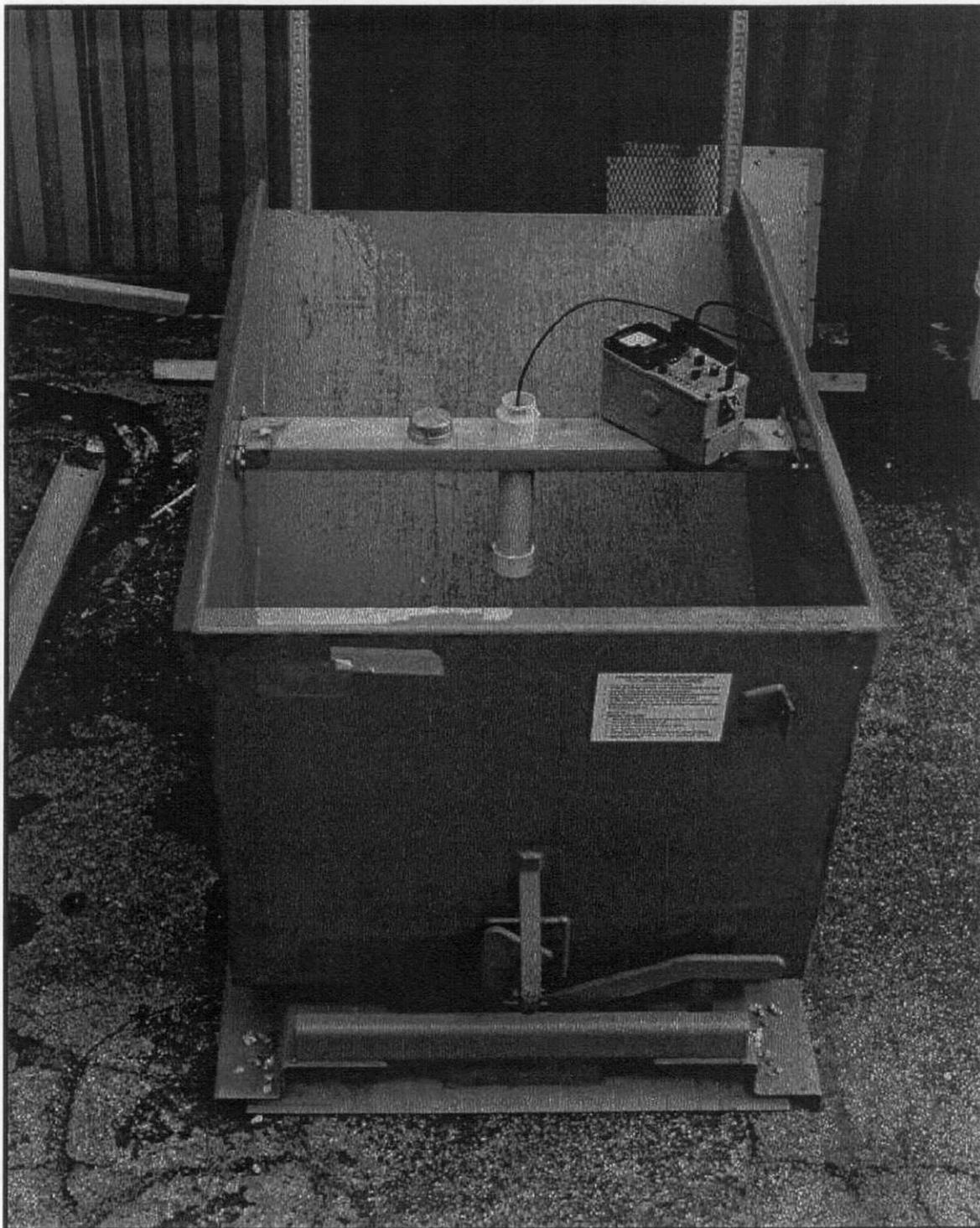


Figure 38-ITC with NaI probe receptacle

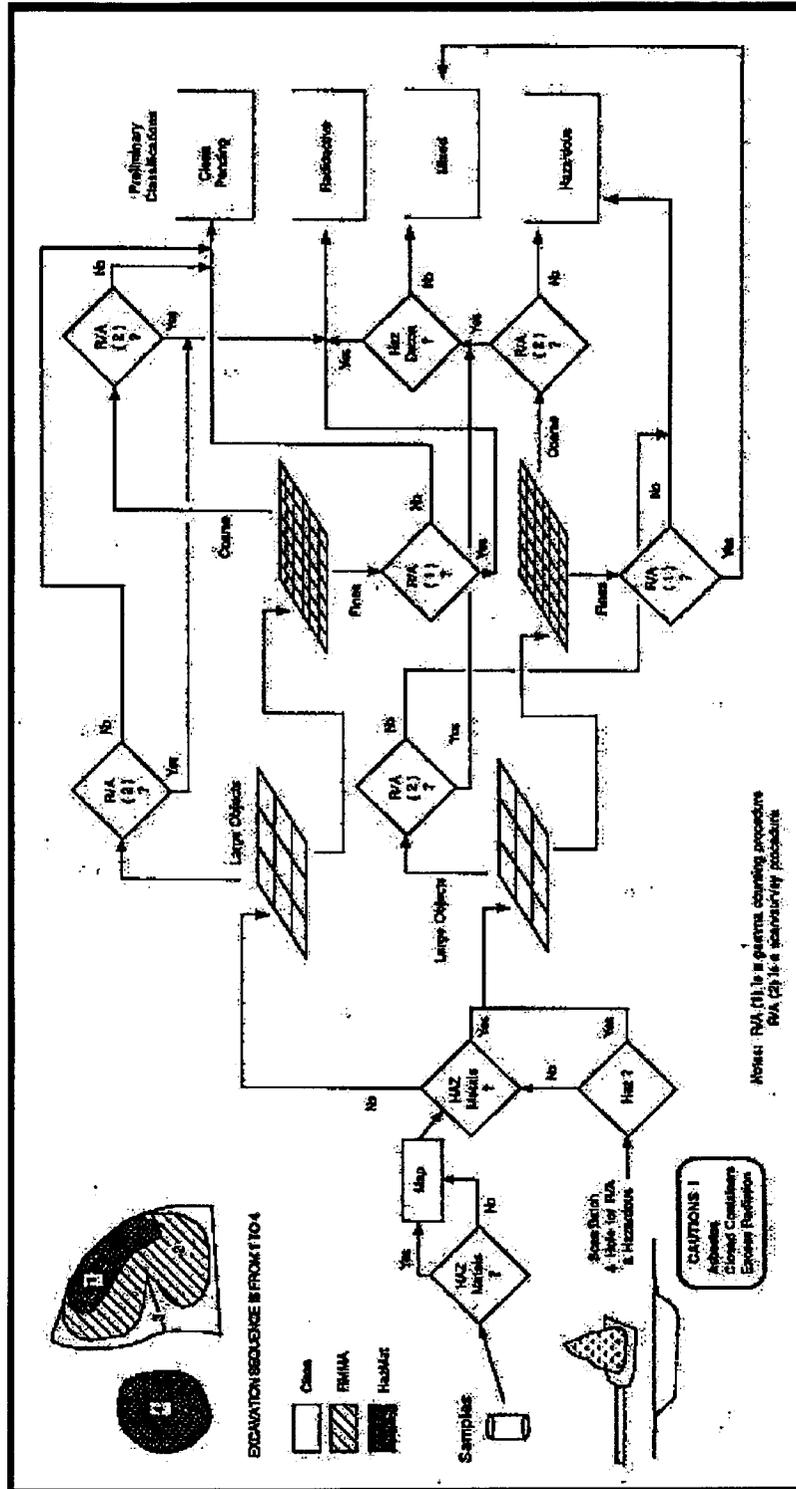
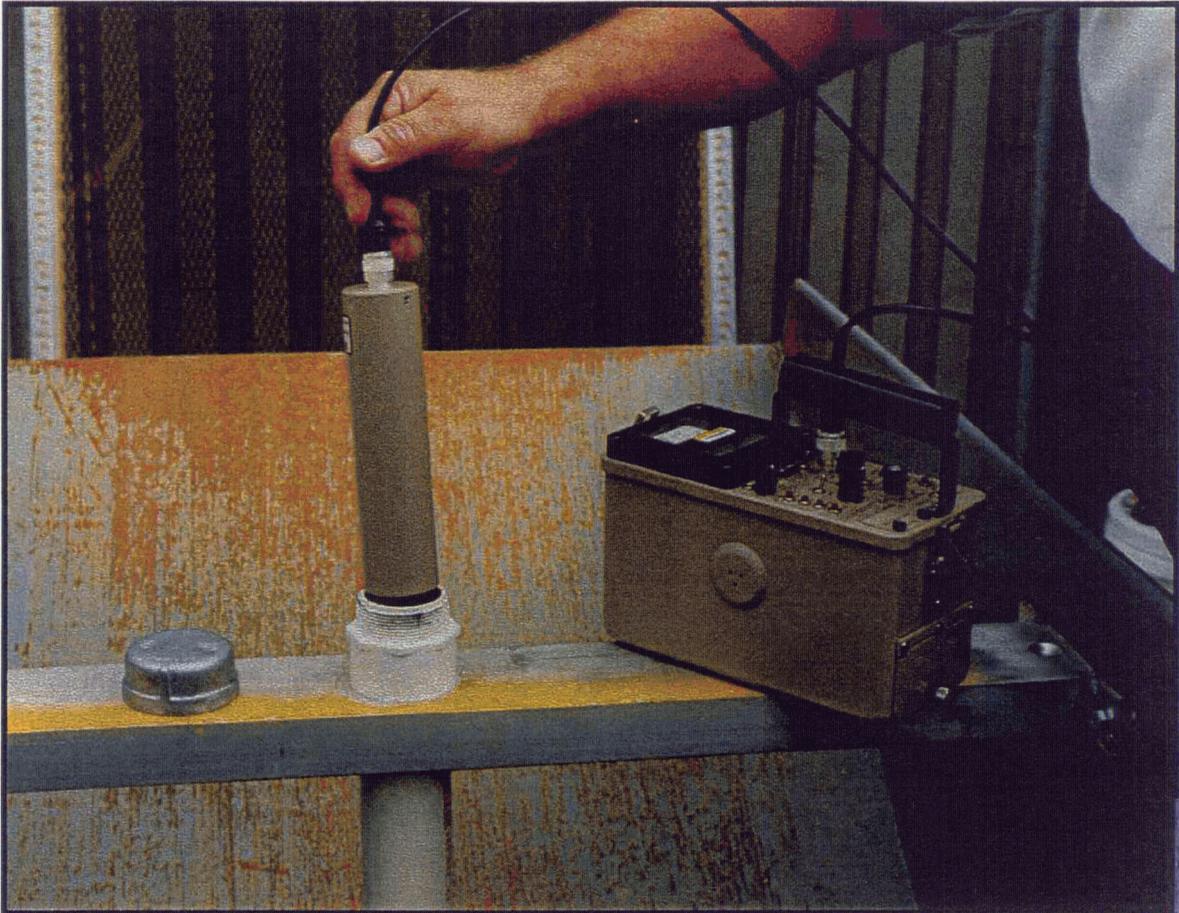


Figure 39-Excavation, segregation and classification process



**Figure 40-NaI probe insertion into receptacle**



**Figure 41-ITC filled with soil being counted for radioactivity**

## FORMER SODIUM DISPOSAL FACILITY - SOLID WASTES

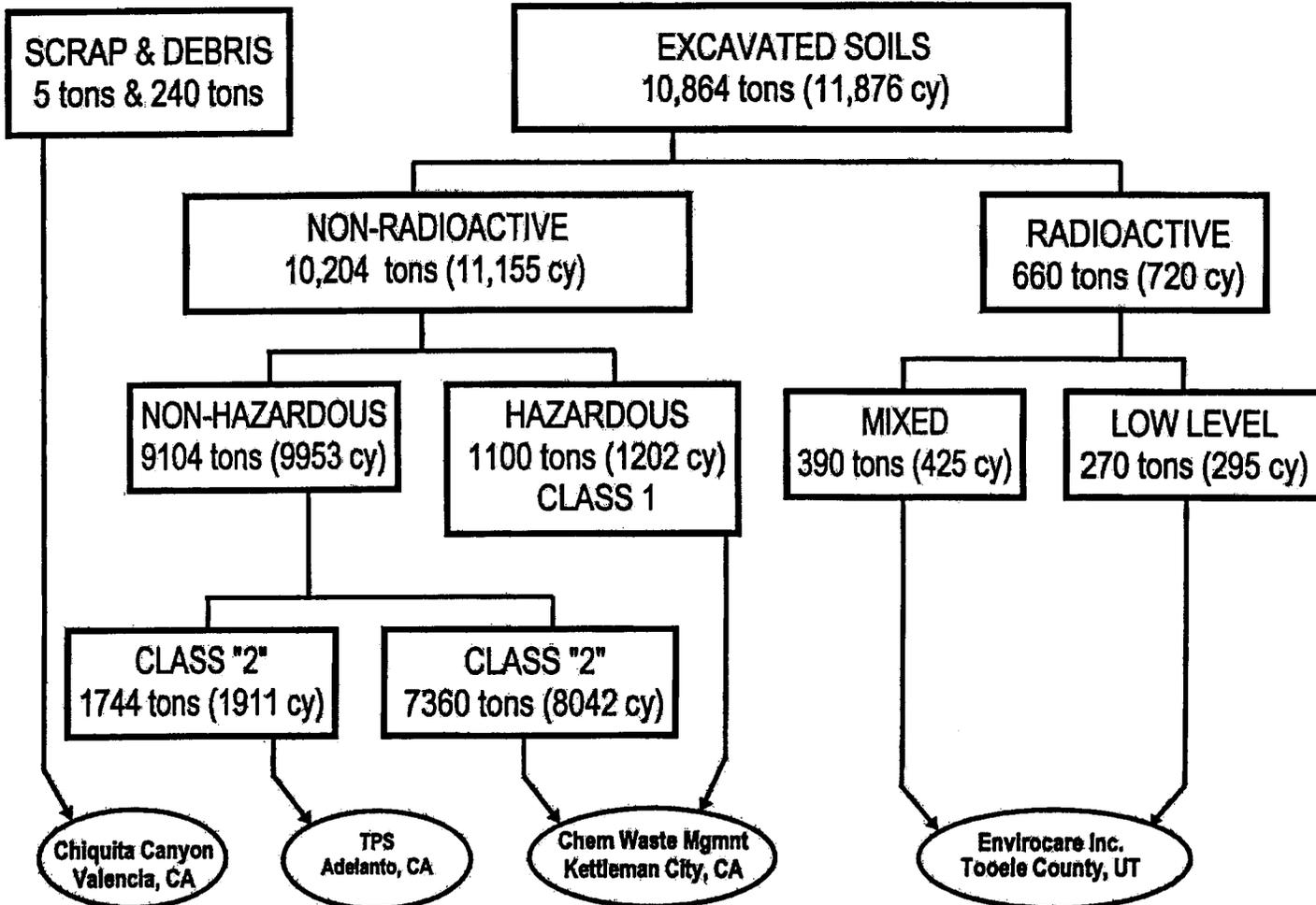


Figure 42-Solid waste streams

June 1995

## Attachment 1.

Radioisotope Activity (pCi/cm)

<u>Isotope</u>	<u>Minimum</u>	<u>Average</u>	<u>Maximum</u>
H-3	ND	0.04	0.6
K-40	11	18	26
Sr-90	ND	1.2	38
Cs-137	ND	8.4	52
Tl-208	0.1	1.0	1.6
Pb-212	0.12	1.3	1.9
Bi-214	0.07	0.74	1.1
Pb-214	0.08	0.68	1.0
Ra-226	0.07	0.69	1.2
Ac-228	ND	1.4	2.1
Th-228	ND	0.24	5.1
Th-230	ND	0.08	0.69
Th-232	ND	0.37	1.6
U-234	ND	1.4	9.5
U-235	ND	0.06	0.46
U-238	ND	0.99	8.4
Pu-238	ND	0.02	0.41
Pu-239	ND	0.005	0.08

ND Non-Detectable

Figure 43-Radionuclide content of radioactive and mixed wastes

Figure 44-Inorganic (metals) constituents of wastes from lower pond

**B/886 Former Sodium Disposal Facility  
Analytical Result Summary  
Lower Pond Excavated Soils  
Inorganics**

Waste Constituent	Analytical Result										Analytical Method		
	TLC			STLC			TCLP						
	Efforts	Findings	MDL	Low	High	MDL	Efforts	Findings	Low	High		MDL	
Antimony	81	0	32	0	0	0.32						6010/SW 846	
Arsenic	81	10	1.4	2.7	5.3	0	0.53			0.053		6010/SW 846	
Barium	107	107	44	130	0.2	0	0.02			0.002		6010/SW 846	
Beryllium	107	10	0.49	0.58	0.03	0	0.003					6010/SW 846	
Cadmium	107	88	0.4	7.5	0.4	0	0.04			0.004		6010/SW 846	
Chromium, total	107	98	4.7	66	0.7	0	0.07	1	0	0.007		6010/SW 846	
Cobalt	107	106	4.1	9.8	0.7	0	0.07					6010/SW 846	
Copper	107	105	8.2	78	0.6	0	0.06					6010/SW 846	
Lead	107	22	4.6	85	4.2	0	0.42			0.42		6010/SW 846	
Mercury	107	107	0.054	85	0.02	0	0.002	17	3	0.0034	0.13	0.0008	7471/SW 846
Molybdenum	81	4	1.1	1.8	0.8	0	0.08					6010/SW 846	
Nickel	107	86	4.4	240	1.5	0	0.15					6010/SW 846	
Selenium	107	0			7.5	0	0.75			0.075		6010/SW 846	
Silver	81	11	0.28	5	0.7	0	0.07			0.007		6010/SW 846	
Thallium	81	0			4.0	0	0.4					6010/SW 846	
Vanadium	107	105	21	41	0.8	0	0.08					6010/SW 846	
Zinc	107	105	29	1100	0.2	0	0.02					6010/SW 846	

Note: MDL - Typical Minimum Detection Limit. Shaded regions indicate where no TCLP analysis are performed.  
Summary includes all B/886 soils removed from the lower pond.

**B/886 Former Sodium Disposal Facility  
Analytical Result Summary  
Lower Pond Excavated Soils  
Semi Volatile Organic Compounds**

Page 1 of 2

Waste Constituent	Analytical Method SW 846 6270				
			Result Range		Typical MDL
	Efforts	Findings	Low	High	
			mg/Kg		
1,2,4-Trichlorobenzene	44	0			0.2
1,2-Dichlorobenzene	44	0			0.2
1,4-Dichlorobenzene	44	0			0.2
1,2-Diphenylhydrazine	44	0			0.2
1,3-Dichlorobenzene	44	0			0.2
1,4-Dichlorobenzene	44	0			0.2
2,4,5-Trichlorophenol	44	0			0.7
2,4,6-Trichlorophenol	44	0			0.2
2,4,6 Tribromophenol	44	14	2.6	3.33	TIC
2,4-Dichlorophenol	44	0			0.4
2,4-Dimethylphenol	44	0			0.4
2,4-Dinitrophenol	44	0			1.0
2,4-Dinitrotoluene	44	0			0.2
2,6-Dinitrotoluene	44	0			0.2
2-Chloronaphthalene	44	0			0.7
2-Chlorophenol	44	0			0.4
2-Fluorobiphenyl	44	14	1.01	1.67	TIC
2-Fluorophenol	44	14	2.58	3.33	TIC
2-Methyl-4,6-dinitrophenol	44	0			0.7
2-Methylnaphthalene	44	0			0.7
2-Methylphenol (o-Cresol)	44	0			0.2
2-Nitroaniline	44	0			2.0
2-Nitrophenol	44	0			0.4
3-3'-Dichlorobenzidine	44	0			0.4
3-Nitroaniline	44	0			0.4
4-Bromophenylphenylether	44	0			0.2
4-Chloro-3-methylphenol	44	0			0.2
4-Chloroaniline	44	0			0.4
4-Chlorophenylphenylether	44	0			0.2
4-Methylphenol	44	0			0.2
4-Nitroaniline	44	0			0.7
4-Nitrophenol	44	0			0.7
Acenaphthene	44	0			0.2
Acenaphthylene	44	0			0.2
Aniline	44	0			0.4

See page 2 for explanations.

Figure 45-SVOCs from lower pond (1 of 2)

**B/886 Former Sodium Disposal Facility  
Analytical Result Summary  
Lower Pond Excavated Soils  
Semi Volatile Organic Compounds (cont.)**

Waste Constituent	Analytical Method SW 846 8270				
	Efforts	Findings	Result Range		Typical MDL
			Low	High	
mg/Kg					
Anthracene	44	1	ND	0.65	0.2
Benzidine	44	0			7.0
Benzo(a)anthracene	44	1	ND	0.49	0.2
Benzo(a)pyrene	44	0			0.2
Benzo(b)fluoranthene	44	0			0.2
Benzo(g,h,i)perylene	44	0			0.2
Benzo(k)fluoranthene	44	0			0.2
Benzyl alcohol	44	0			0.2
Benzoic acid	44	0			2.0
Butylbenzylphthalate	44	0			0.2
Chrysene	44	14	0.43	3.2	0.2
Di-n-octylphthalate	44	0			0.2
Dibenzo(a,h)anthracene	44	0			0.2
Dibenzofuran	44	0			0.2
Dibutylphthalate	44	0			0.4
Diethylphthalate	44	1	ND	1.1	0.4
Dimethylphthalate	44	0			0.4
Fluoranthene	44	0			0.2
Fluorene	44	7	0.43	1.5	0.4
Hexachlorobenzene	44	0			0.2
Hexachlorobutadiene	44	0			0.2
Hexachlorocyclopentadiene	44	0			0.2
Hexachloroethane	44	0			0.2
Indeno(1,2,3-c,d)pyrene	44	0			0.4
Isophorone	44	0			0.2
N-Nitrosodimethylamine	44	0			0.2
N-Nitrosodiphenylamine	44	0			0.2
N-Nitrosodi-n-propylamine	44	0			0.7
Nitrobenzene	44	15	1.04	1.67	0.2
Napthalene	44	1	ND	0.31	0.2
Phenanthrene	44	17	0.22	13	0.2
Phenol	44	15	1.93	3.33	0.4
Pentachlorophenol	44	0			0.4
Pyrene	44	0			0.4
Terphenyl	44	15	0.913	1.67	TIC
Bis(2-chloroethoxy)methane	44	0			0.4
Bis(2-chloroethyl)ether	44	0			0.4
Bis(2-chloroisopropyl)ether	44	0			0.4
Bis(2-ethylhexyl)phthalate	44	10	0.35	2.2	0.4

Note: MDL = Minimum Detection Limit. Compounds identified by the laboratory as a "Tentatively Identified Compound" are labeled "TIC" in the MDL column. The TIC's minimum detection limits are unavailable.

Figure 46-SVOCs from lower pond (2 of 2)

**B/886 Former Sodium Disposal Facility  
Analytical Result Summary  
Lower Pond Excavated Soils  
Volatile Organic Compounds**

Page 1 of 2

Waste Constituent	Analytical Method SW 846.8240				
	Efforts	Findings	Result Range		MDL
			Low	High	
			ug/Kg		
1,1'-Oxybisbenzene	75	5	77	620	TIC
1,1,1-Trichloroethane	75	25	2.6	600	0.8
1,1,2,2-Tetrachloroethane	75	0			0.5
1,1,2-Trichloroethane	75	0			0.5
1,1-Dichloroethane	75	2	6.2	11	1.1
1,1-Dichloroethylene	75	3	7.8	70	0.8
1,2-Dichlorobenzene	75	0			0.6
1,2-Dichloroethane	75	0			0.2
1,2-Dichloroethylene (cis)	75	0			0.2
1,2-Dichloroethylene (trans)	75	0			0.4
1,2,3,4-Tetrahydronaphthalene	75	5	15	43	TIC
1,4-Dichloropropane	75	0			0.8
1,3-Dichlorobenzene	75	7	2.5	1300	0.6
1,3-Dichloropropene (cis)	75	6	10	410	0.6
1,3-Dichloropropene (trans)	75	0			0.5
1,4-Dichlorobenzene	75	3	2.2	5.5	1.0
Acetone	75	0			7.9
Alkyl substituted benzene isomer	75	1	ND	36	TIC
Benzene	75	0			0.7
Bromodichloromethane	75	0			0.6
Bromoform	75	0			0.5
Bromodichloromethane	75	0			1.0
Carbon Tetrachloride	75	0			0.5
Chloroethane	75	0			1.0
Chloroform	75	1	ND	4.1	0.8
Chloromethane	75	0			0.6
Dibromochloromethane	75	0			0.4
Dimethylcyclooctane	75	1	ND	22	TIC
Ethylbenzene	75	2	1.8	28	0.8
Freon 113	75	11	7.4	34	0.8
Methylene Chloride	75	0			2.9
Monochlorobenzene	75	0			0.6
Napthalene	75	1	ND	31	TIC
Polyaromatic hydrocarbon	75	7	5.5	4800	TIC
Polynuclear aromatic hydrocarbon	75	4	6.5	42	TIC

See Page 2 for explanations

Figure 47-VOCs from lower pond (1 of 2)

**B/886 Former Sodium Disposal Facility  
Analytical Result Summary  
Lower Pond Excavated Soils  
Volatile Organic Compounds (cont.)**

Page 2 of 2

Waste Constituent	Analytical Method SW 846 B240				
	Efforts	Findings	Result Range		MDL
			Low	High	
uc/Kg					
Saturated alipatic hydrocarbon	75	7	5.5	200	TIC
Tetrachloroethylene	75	10	4.1	610	0.8
Tetrachlorohexafluorobutane	75	1	ND	70	TIC
Tetramethylbenzene isomer	75	1	ND	6	TIC
Toluene	75	5	5.7	41	0.7
Thiobismethane	75	1	ND	18	TIC
Trichloroethylene (TCE)	75	46	3.4	1700	0.6
Trichlorofluoromethane	75	1	ND	1.4	0.8
Tridecane	75	1	ND	85	TIC
Trimethylbenzene isomer	75	5	7	42	TIC
Trimethylcyclohexane isomer	75	1	ND	40	TIC
Undecane	75	1	ND	110	TIC
Unknown aromatic hydrocarbon	75	2	7	63	TIC
Unknown hydrocarbon	75	37	4.7	490	TIC
Vinyl Chloride	75	0			0.4
Xylenes (Total)	75	9	3.9	97	1.4

Note: MDL = Minimum Detection Limit. Waste constituents identified by the laboratory as a "Tentatively Identified Compound" are labeled "TIC" in the MDL column. The TIC's minimum detection limits are unavailable.

**Figure 48-VOCs from lower pond (2 of 2)**

**B/886 Former Sodium Disposal Facility  
Analytical Result Summary  
Lower Pond Excavated Soils  
Miscellaneous Waste Constituents**

Waste Constituent	Results		Results Range			Analytical Method
	Efforts	Findings	Low	High	MDL	
pH	44	44	pH Units			SW846 9042
			6.9	10	DNA	
Polychlorinated Biphenyls	45	43	mg/Kg			SW846 8080
Total Petroleum Hydrocarbons	41	40	0.06	2	0.05	EPA 418.1
			10	7900	10	
TCLP Organics			ug/L			
Vinyl Chloride	1	0			50	8150/GCMS
1,1-Dichloroethylene	1	0			25	8150/GCMS
Chloroform	1	0			25	8150/GCMS
1,2-Dichloroethane	1	0			25	8150/GCMS
2-Butanone	1	0			50	8150/GCMS
Carbon tetrachloride	1	0			25	8150/GCMS
Trichloroethylene	1	0			25	8150/GCMS
Chlorobenzene	1	0			25	8150/GCMS
TCLP Semi Volatile Organics			ug/L			
o-Cresol	1	0			40	3550/8270
m+p Cresol	1	0			40	3550/8270
1,4-Dichloroethalene	1	0			40	3550/8270
2,4-Dinitrotoluene	1	0			40	3550/8270
Hexachlorobenzene	1	0			40	3550/8270
Hexachloro-1,3-butadiene	1	0			40	3550/8270
Hexachloroethane	1	0			40	3550/8270
Nitrobenzene	1	0			40	3550/8270
Pentachlorophenol	1	0			200	3550/8270
Pyridine	1	0			400	3550/8270
2,4,5-Trichlorophenol	1	0			200	3550/8270
2,4,6-Trichlorophenol	1	0			40	3550/8270
TCLP Pesticides			ug/L			
Lindane	1	0			1	3550/8270
Heptachlor	1	0			1	3550/8270
Heptachlor epoxide	1	0			1	3550/8270
Endrin	1	0			1	3550/8270
Methoxychlor	1	0			1	3550/8270
Chlorodane	1	0			4	3550/8270
Toxaphene	1	0			4	3550/8270
2,4-D	1	0			10	3550/8270
Stivex	1	0			10	3550/8270

Note: MDL - Minimum Detection Limit

Analysis summarized: 85a,c,84 \*\*

**Figure 49-Miscellaneous compounds from the lower pond**

State of California—Health and Welfare Agency  
Form Approved OMB No. 2060-0038 (Expires 9-30-91)  
Please print or type. (Form designed for use on site (12-point typewriter).)

See instructions on back of Page 6 and Front of Page 7  
Department of Health Services  
Toxic Substances Control Division  
Sacramento, California

**UNIFORM HAZARDOUS WASTE MANIFEST**

1. Generator's US EPA ID No. \_\_\_\_\_ Manifest Document No. \_\_\_\_\_ 2. Page 1 of \_\_\_\_\_ Information in the shaded areas is not required by Federal law.

3. Generator's Name and Mailing Address  
Rockwell International  
Rockledge Division - SBFL STEC, 6633 Canoga Avenue T44  
Canoga Park, CA 91304  
4. Generator's Phone (818) 700-6127

A. State Manifest Document Number  
**89861494**

B. State Generator's ID  
XXXXXXXXXXXX

5. Transporter 1 Company Name  
Chemical Waste Management  
6. US EPA ID Number  
CA10004611

C. State Transporter's ID  
J06203

D. Transporter's Phone  
(309) 386-9711

7. Transporter 2 Company Name  
\_\_\_\_\_  
8. US EPA ID Number  
\_\_\_\_\_  
E. State Transporter's ID  
\_\_\_\_\_  
F. Transporter's Phone  
\_\_\_\_\_

9. Designated Facility Name and Site Address  
Chemical Waste Management  
35251 Old Skyline Road  
Kettleman City, CA, 93239  
10. US EPA ID Number  
CA10004611

G. State Facility's ID  
CATC060417

H. Facility's Phone  
(209) 386-9711

11. US DOT Description (Including Proper Shipping Name, Hazard Class, and ID Number)	12. Containers No.	13. Total Quantity	14. Unit (L/WT/DR)	15. Waste No.	
				Waste No.	Waste No.
a. NON-RCRA HAZARDOUS WASTE SOLID. (Contaminated soil)	001 CM	27360		611 181	NONE
b.					
c.					
d.					

J. Additional Descriptions for Materials Listed Above  
a.) Contaminated soil **SR 6840.**

K. Handling Codes for Shaded Listed Above  
03

16. Special Handling Instructions and Additional Information  
Wear proper personal protective equipment when handling. Avoid contact or inhalation of soil or dust. \*\* 24 HOUR EMERGENCY TELEPHONE NUMBER: (818) 710-2531. CONTACT: BRIAN SUJATA. \*\* DOT ERG: A.) 31

17. GENERATOR'S CERTIFICATION: I hereby declare that the contents of this shipment are fully and accurately described above by proper shipping name and are classified, packed, marked, and labeled, and are in all respects in proper condition for transport by highway according to applicable international and national government regulations.  
If I am a large quantity generator, I certify that I have a program in place to reduce the volume and toxicity of waste generated to the degree I have determined to be economically practicable and that I have selected the practicable method of treatment, storage, or disposal currently available to me which minimizes the present and future threat to human health and the environment; OR, if I am a small quantity generator, I have made a good faith effort to minimize my waste generation and select the best waste management method that is available to me and that I can afford.

Printed/Typed Name: Brian D. Sujata For Rockwell Int. Corp. Signature: *Brian Sujata* Month Day Year: 11/03/92

17. Transporter 1 Acknowledgement of Receipt of Materials  
Printed/Typed Name: Glen Williams Signature: *Glen Williams* Month Day Year: 11/03/92

18. Transporter 2 Acknowledgement of Receipt of Materials  
Printed/Typed Name: \_\_\_\_\_ Signature: \_\_\_\_\_ Month Day Year: \_\_\_\_\_

18. Discrepancy Indication Space  
**OB**  
**(B) Prod. 30,160 lbs. Resolved w/ Brian Sujata 11/5/92**

19. Facility Owner or Operator Certification of receipt of hazardous materials covered by this manifest except as noted in item 18.  
Printed/Typed Name: *D. Gentry* Signature: *D. Gentry* Month Day Year: *11/03/92*

Do Not Write Below This Line

DHS 8022 A (1/88)  
EPA 8700-22  
(Rev. 9-85) Previous editions are obsolete.

While: TSDf SENDS THIS COPY TO DOHS WITHIN 30 DAYS  
To: P.O. Box 3000, Sacramento, CA 95812

89861494  
IN CASE OF AN EMERGENCY OR SPILL, CALL THE NATIONAL RESPONSE CENTER 1-800-424-9802; WITHIN CALIFORNIA, CALL 1-800-852-7690

Figure 50-Hazardous waste manifest

SHIPPING INFORMATION FOR CONVENTIONAL WASTES

1. Waste Disposal Site:

Name of Owner/Operator Chemical Waste Management - KHF  
EPA Permit No. CAT 000 046 117  
Address 35251 Old Skyline Road, Kettleman City, CA 93239

2. Waste Hauler:

Name of Company Chemical Waste Management  
Hauler's Permit No. CAD 003942718  
Permit Issued by CALIF

3. Shipper:

Rockwell International, Rocketdyne Division  
6633 Canoga Ave.  
Canoga Park, CA 91304  
Purchase Order Number B24 PTK 92033533

4. Shipping Information

Container ID No. 52114 Container ID No. 0  
Weight: Gross 64946 Tare 39990 Net 25040  
Waste Name: non-hazardous waste soil  
Profile Number /RWQCB Permit Number (if applicable) AM 7335

Date of Departure from Facility 6-7-95  
Name of Driver Glenn Hutton  
Signature of Driver [Signature]  
Name of Rockwell Representative Robert HAROY  
Signature of Rockwell Representative [Signature]

*Waste Control*  
*6/7/95*  
*26/12/95*

CHEMICAL WASTE MANAGEMENT, INC.  
KETTLEMAN HILLS DISPOSAL FACILITY  
P. O. BOX 471, 35251 OLD SKYLINE ROAD  
KETTLEMAN CITY, CA 93239

Figure 51-Conventional waste shipper

OFF-SITE SHIPMENT FOR  
HAZARDOUS (ONLY) WASTE QA CHECKLIST

Container No: 5700

Shipment Date: JAN 25 1993

Item No. +	Form No.	Description (title)	Inspection Verification				+
			1	2	3	4	
A	DHS8022A	Uniform Hazardous Waste Manifest	✓	✓	✓	✓	A
B	- -	Cert of No Detectable Activity	✓	✓	✓	✓	B
C	- -	Haz Determination Report by EP	✓	✓	✓	✓	C
D	- -	Shipping Data form for Haz Wastes	✓	✓	✓	✓	D
E	732-A	Radiation Survey Report	✓	✓	✓	✓	E
F	- -	Inspection Checklist for Vehicle	✓	✓	✓	✓	F
G	- -	Log Entries	✓	✓	✓	NR	G
H	- -	Intermediate Lot Followers	✓	✓	✓	NA	H
I	- -	Federal Notice Land Disposal Restriction	NR	✓	✓	✓	I
J	- -	California Notice & Cert Land Disposal Restriction	✓	✓	✓	✓	J
K	- -	DOE Approval	✓	✓	✓	✓	K
L	- -	Waste Profile & Haz Label	✓	✓	✓	NR	L
M	- -	Drivers Safety Awareness Sheet	NR	✓	✓	✓	M

VERIFICATION KEY

- 1 All Required Line Entries Completed. If entry is not required, enter NR.
- 2 Entry Information Legible
- 3 Required Signatures and Date
- 4 Copy of Completed form for QA Records

Shipment and QA Records

Approved Hazardous Waste Desposal Site: Kettleman Hills Ca

All operations on this checklist have been verified. Material is acceptable for transport.

 JAN 25 1993  
Stamp/Date

This checklist and a copy of completed forms (A thru M) are to be retained in the facility file and one forwarded to QA Engineering.

Figure 52-Waste data checklist

**CERTIFICATION OF "CONFORMANCE TO DOE OBJECTIVES"**

The undersigned certifies that the identified wastes contained within the container conforms to the performance objectives established by the DOE and based upon process knowledge, operational procedures and radiological analysis that this waste meets all release criteria established by the DOE

A copy of this certification, and the below cited attachments shall be affixed to any container so certified.

Container No. 5700

1. External Radiation Survey (form 732-A) D&P 11/19/92

2. Uniform Hazardous Waste Manifest No. (form DHS 8022A 1/88) 89861575  
(for Hazardous Wastes only)

Certification of meeting DOE performance objective

Daniel P. Mitchell (Health Physicist)  
Name

11/16/92  
Date

Figure 53-Certificate of compliance with DOE objectives

No. 886-SP-0005 Rev New  
Page 44 of 50  
Original Date: 06/08/92  
Rev Date: \_\_\_\_\_

APPENDIX H

The Energy Technology Engineering Center (ETEC) has supplied Environmental Protection (DS43) with all available laboratory analytical data for the following container(s):

1029, 5942, 5700, 0220, 0216  
(Bin, tank, roll-off, or box identification numbers)

The analysis was performed by the following laboratory, with the following identification numbers:

92-886-168  
Sample No. (B886 sample log)

Laboratory Name: SSFL, BCA

Laboratory Report Number: \_\_\_\_\_

Laboratory Sample Identification Number (s):

92110433  
92110434  
92110470

The data is attached, and has been reviewed by Environmental Protection. Based upon this review, the material has been determined to fall into the following category:

Non-hazardous- Clean

DS43  
(signature of reviewer)

Non-hazardous- Selectively Contaminated  
Acceptable for Class III disposal

DS43  
(signature of reviewer)

Non-hazardous- Contaminated above  
Class III disposal limits

DS43  
(signature of reviewer)

Hazardous- Non-RCRA-California Regulated

Berni [Signature] DS43  
(signature of reviewer)

Hazardous- RCRA not requiring treatment

DS43  
(signature of reviewer)

Hazardous- RCRA requiring treatment

DS43  
(signature of reviewer)

NOTE

Only a waste that was determined to contain less than detectable radioactivity may be categorized as any of the above categories (refer to Appendix B).

Chemical Evaluation of Wastes

Figure 54-Waste classification determination



5700  
5943

**MOTOR VEHICLE INSPECTION**

(SEE OVER FOR INFORMATION)

NAME OF CARRIER Enlow Disposal DATE OF INSPECTION 1-25-93  
 NAME OF DRIVER Richard Romero  
 DRIVER'S LICENSE NUMBER/STATE 03697309 CA  
 DRIVER'S LICENSE AUTHORIZATION'S \_\_\_\_\_  
 MEDICAL EXAM DATE 2-11-92  
 VEHICLE LICENSE PLATE NO BP52400 STATE CA TAG YR \_\_\_\_\_

	ACCEPTABLE	UNACCEPTABLE	REMARKS
GENERAL VEHICLE CONDITION	✓		
FIRE EXTINGUISHERS INSTALLED	✓		
TIRE CONDITIONS	✓		
HORN/LIGHTS/REFLECTORS	✓		
BRAKES	✓		
MIRRORS/WINDSHIELD	✓		
LOAD	✓		
MISCELLANEOUS	✓		

ACCEPTED BY Sam Leddy  
(NAME, TITLE)

Figure 56-Vehicle inspection report

ITC# <b>5822</b> INTERMEDIATE LOT FOLLOWER		Sign/Date
Grid Location <u>Lower Pond</u>	Material from RMMA? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	<u>[Signature]</u> 11/14/92
Hazardous		
Visual	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	
HNU	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	
HAZMXP	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	
Radioactivity		
Background Reading <u>4810</u> cpm		
$X = 6.01 \sqrt{B} =$ <u>5227</u>		
Direct Counts <u>4545</u>		
less Background Reading		
Compare to X: radioactive? <u>NO</u>		
Transfer to:		
Clean container No.		
Radioactive container No.		
Hazardous container No. <u>5700</u>		
Mixed Haz container No.		
Quality Assurance Verification:		
QA Inspector	Stamp	<u>[Signature]</u> 11/14/92 NOV 14 1992

Figure 57-Intermediate lot follower

## California Land Disposal Restriction Notice and Certification

Generator Name <u>Rockwell Int Corp, Rockledge, Fla 32955</u>	Manifest Number <u>89861575</u>
California Hazardous Waste Code(s) <u>181, 611</u>	CWM Profile Number <u>BF 6640</u>

This form is submitted to Chemical Waste Management, Inc. in accordance with the requirements of CCR Title 22, Chapter 18, Article 1 which restricts the land disposal of certain hazardous wastes. I have marked the appropriate box (boxes A. through D.) below to indicate how my waste must be managed to conform to the land disposal restrictions. A copy of all applicable treatment standards and waste analysis data, where available, is maintained at the Chemical Waste Management facility identified on the manifest referenced above. I have entered the appropriate California Waste Code and checked the appropriate box in the table below to indicate the applicable non-RCRA hazardous waste listing from 22 CCR § 66268.29.

	State of California Restricted Waste Description Listed in 22 CCR § 66268.29	Prohibition Effective Date	Corresponding Treatment Standard (from 22 CCR)
✓	1 Metal-containing aqueous waste identified in 22 CCR 66268.29(a).	1/29/90	66268.107(a)
	2 PCB wastes identified in section 66268.29(b).	1/27/90	66268.110
	3 Auto shredder waste identified in section 66268.29(c).	5/8/91	66268.106(a)(1)
	4 Nonwastewater solvent waste identified in section 66268.29(c).	5/8/91	66268.107(b)
	5 Hazardous waste foundry sand identified in section 66268.29(e).	1/1/91	66268.106(a)(2)
	6 (reserved for dry petroleum wastes)		
Ⓚ	7 Metal-containing solid waste identified in 66268.29(c).	5/8/92	66268.106(a)(3)
	8 Fly ash, bottom ash, retort ash or baghouse waste identified in 66268.29(h).	1/1/91	66268.106(a)(4)
	9 Baghouse waste from foundries identified in 66268.29(j).	1/1/91	66268.106(a)(5)
	10 Aqueous and liquid organic waste identified in 66268.29(i).	5/8/92	66268.112
	11 Solid waste containing organics identified in 66268.29(f).	5/8/92	66268.113

- A. RESTRICTED WASTE REQUIRES TREATMENT**  
I am the generator of the waste identified above which must be treated to meet the applicable treatment standards set forth in CCR Title 22, article 4 or article 11 of Chapter 18.
- B.1 RESTRICTED WASTE TREATED TO PERFORMANCE STANDARDS**  
I certify under penalty of law that I have personally examined and am familiar with the treatment technology and operation of the treatment process used to support this certification and that, based upon my inquiry of those individuals immediately responsible for obtaining this information, I believe that the treatment process has been operated and maintained properly so as to comply with the performance levels specified in article 4 and article 11 of chapter 18, division 4.5, Title 22, CCR and all applicable prohibitions set forth in section 66268.32 or RCRA section 3004(c) (42 U.S.C. section 6924(c)) without impermissible dilution of the prohibited waste. I am aware that there are significant penalties for submitting a false certification, including the possibility of a fine and imprisonment.
- C. RESTRICTED WASTE SUBJECT TO A VARIANCE**  
The waste identified above is subject to a capacity variance which expires on 1 January 1995.
- D. RESTRICTED WASTE CAN BE LAND DISPOSED WITHOUT FURTHER TREATMENT**  
I certify under penalty of law that I personally have examined and am familiar with the waste through analysis and testing or through knowledge of the waste to support this certification, that the waste complies with the treatment standards specified in CCR Title 22, division 4.5, chapter 18, article 4 and article 11 and all applicable prohibitions set forth in CCR Title 22, section 66268.32 or RCRA section 3004(c) (42 U.S.C. section 6924(c)). I am aware that there are significant penalties for submitting a false certification, including the possibility of a fine and imprisonment.

I hereby certify that all information submitted in this and all associated documents is complete and accurate to the best of my knowledge and information.

Signature <u>[Signature]</u>	Title <u>Member of Technical Staff</u>	Date <u>20 Jan 93</u>
------------------------------	--	-----------------------

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Figure 58-California land disposal restriction form



# Chemical Waste Management, Inc. BF 6840

## WASTE PROFILE

Profile 1

SHOULD BE SENT TO: BENTON COUNTY, OR

Check here if this is a Recertification

LOCATION OF ORIGINAL \_\_\_\_\_

**GENERAL INFORMATION**

1. GENERATOR NAME: Rockedyme, Inc. or Rockwell Int'l for U.S. Department of Energy Generator USEPA ID: CA3 890 090 001  
 2. Generator Address: 6633 Canoga Ave Canoga Park, CA 91303 Billing Address: the same  
 3. Technical Contact/Phone: BRUCE SUTHER 805 773 5426  
 4. Administrative Contact/Phone: Alex Klein 805 526 5726 Billing Contact/Phone: \_\_\_\_\_

**PROPERTIES AND COMPOSITION**

5. Process Generating Waste: Sodium Burn Pit Clean-out  
 6. Waste Name: Non-PCRA Sodium Burn pit waste  
 7A. Is this a USEPA hazardous waste (40 CFR Part 261)? Yes  No   
 B. Identify ALL USEPA listed and characteristic waste code numbers (E,F,K,P,U): \_\_\_\_\_

8. Physical State @ 70°F: A. Solid  Liquid  Both  B. Single Layer  Multi-layer  C. Free liquid range: to 0 %  
 9A. pH Range: \_\_\_\_\_ to \_\_\_\_\_ or (if applicable)  B. Strong Odor  describe: \_\_\_\_\_  
 10. Liquid Flash Point: < 75°F  75-99°F  100-139°F  140-199°F  ≥ 200°F  N/A  Closed Cup  Open Cup

11. CHEMICAL COMPOSITION: List ALL constituents (including halogenated organics) present in any concentration and (where available) analysis.

Constituents	Range	Units	Constituents	Range	Units
Chromium	0-2000	ppm	Heavy Organics	0-5	%
Mercury	0-5000	"	Plastic Solvents	0-5	%
Lead	0-400	"	Polychlorinated Biphenyls	0-10	ppm
Zinc	0-1000	"			
Pipes, Tank Fragments, Metal & Debris	0-5	%			

TOTAL COMPOSITION MUST EQUAL OR EXCEED 100%

12. OTHER: PCBs if yes, concentration \_\_\_\_\_ ppm; PCBs regulated by 40 CFR 791  Pyrophoric  Explosive  Radioactive   
 Benzene if yes, concentration \_\_\_\_\_ ppm: Shock Sensitive  Oxidizer  Carcinogen  Infectious  Other: \_\_\_\_\_  
 13. If the waste is subject to the land ban and meets the treatment standards, check here: \_\_\_\_\_ and supply analytical results where applicable.

**SHIPPING INFORMATION**  
 14. PACKAGING: Bulk Liquid  Bulk Liquid  Drum  Type/Size: \_\_\_\_\_ Other: \_\_\_\_\_  
 15. ANTICIPATED ANNUAL VOLUME: \_\_\_\_\_ Units: \_\_\_\_\_ Shipping Frequency: \_\_\_\_\_

**SAMPLING INFORMATION**  
 16a. Sample source (drum, lagoon, pond, tank, vat, etc.): Excavation  
 Date Sampled: 28 August 1992 Sampler's Name/Company: \_\_\_\_\_  
 16b. Generator's Agent Supervising Sampling: \_\_\_\_\_ 17.  No sample required (See Instructions)

**GENERATOR'S CERTIFICATION**  
 I hereby certify that all information submitted in this and all attached documents, contains true and accurate descriptions of this waste. Any sample submitted is representative as defined in 40 CFR 261. Appendix I for use of analytical methods. All relevant information regarding known or suspected hazards in the possession of the generator has been disclosed. I authorize CWM to obtain samples from this waste at a time for purposes of recertification.

Bruce Suther Bruce Suther 28 Aug 92  
 Signature Printed (or typed) name and date

Form 6840-1 (Rev. 10/88) is available from the following sources: CWM-6840, CWM-6840, CWM-6840 and CWM-6840

Figure 59-Regulated waste profile

DOE F 1374  
(10-80)  
GSA FPMR

United States Government

Department of Energy

# memorandum

RECEIVED

JAN 15 1993

ORF 0079

DATE  
REPLY TO  
ACTION OF  
EM-331

SUBJECT: Approval of Waste Shipment from the Energy Technology Engineering Center's Sodium Disposal Facility

TO: James T. Davis, SF

The December 11, 1992, memorandum from Alex Dong to Lee Stevens (attached), requesting to ship offsite all soils designated as nonradioactive wastes has been received and reviewed by this office. In consideration of the Energy Technology Engineering Center's (ETEC's) demonstrated knowledge of the waste, and procedures to assure that only those Sodium Disposal Facility (SDF) wastes showing no detectable activity will be designated as nonradioactive, this office believes that no Department of Energy (DOE)-added radiation is present in these wastes.

ETEC has to date, not provided information acceptable to lift the moratorium site-wide. For this request, the information submitted for the SDF wastes specified above is sufficient. This office concurs with your request to ship all SDF wastes found to have no DOE-added radiation offsite as nonradioactive. The moratorium remains in effect for all RCRA/TSCA wastes at ETEC, which are not specifically excavated soils from the remediation activity at the SDF.

*John E. Lytle*  
John E. Lytle  
Deputy Assistant Secretary  
for Waste Management  
Environmental Restoration and  
Waste Management

Attachment

cc: Joe Boda, EM-322  
Gordon Langlie, EM-322  
Hannibal Joma, DOE-SF  
Jonathan King, EM-351

Figure 60-Case exception for DOE approval for shipment

Figure 61-Waste Label

**HAZARDOUS WASTE** 5700  
**PENDING ANALYSIS**

---

Canoga 6633 Canoga Avenue Canoga Park, CA 91303  
 DeSoto 8900 DeSoto Avenue Canoga Park, CA 91304  
 SSFL End of Woolsey Canyon Road Simi Hills, CA 91311  
 Westlake 2825 Towngate Rd. Westlake, CA 91361  
 Plummer 21415 Plummer Ave. Chatsworth, CA 91311  
 Other

Date of Storage \_\_\_\_\_ FROM RMMA

Date of 1st Accum./Date Deemed to be a Waste 11-14-92

Department Number / Name 025/ETEC Area/Site 4/OSDF Bldg. No. BB6 Area Contact / Phone HARDY 5922

<u>Soil</u>	<u>99%</u>	Known Properties:	<input type="checkbox"/> Ignitability (F.P. < 140 °)	<input type="checkbox"/> Corrosivity (PH < 2 or > 12.5)	<input type="checkbox"/> Toxicity
<u>Misc. Contaminants</u>	<u>&lt;1%</u>		<input type="checkbox"/> Reactivity	<input type="checkbox"/> Other _____	
_____	____%	Known Physical State:	<input checked="" type="checkbox"/> Solid	<input type="checkbox"/> Liquid	<input type="checkbox"/> Sludge
_____	____%		<input type="checkbox"/> Gas	<input type="checkbox"/> Other _____	
_____	____%	Quantity in Container:	<u>10</u>	<input type="checkbox"/> gal.	<input type="checkbox"/> lbs.
_____	____%	Process Generating Waste	<u>OSDF CLOSURE</u>	<input checked="" type="checkbox"/> cu. yds.	
_____	____%				

Analysis Log No. 92886-168 Date Sampled 11-19-92

Rockwell International Corporation/Rocketdyne Division, 6633 Canoga Avenue, Canoga Park, CA 91303 818/710-5163

FORM 853-Y-000 NEW 11-88

92-886-168c

886 Random sample generator (1 sample, 5 bins)

BIN NO. 1           CONTAINER SERIAL NO. 1029

RANDOM NUMBER LIST

3

BIN NO. 2           CONTAINER SERIAL NO. 5942

RANDOM NUMBER LIST

6

BIN NO. 3           CONTAINER SERIAL NO. 5700

RANDOM NUMBER LIST

5

BIN NO. 4           CONTAINER SERIAL NO. 0220

RANDOM NUMBER LIST

1

BIN NO. 5           CONTAINER SERIAL NO. 0216

RANDOM NUMBER LIST

2

Figure 62-Random sampling of 5 R/O bins

**SAMPLE ANALYSIS REQUEST FORM**  
(Side 1)

Requester: Sodium Disposal Fac. Sampler: \_\_\_\_\_  
 Dept: 025 Mail: T886  
 Telephone: 2882-5922 Requested: \_\_\_\_\_  
 Completion Date: 11/27/88

Project Name: Sodium Disposal Facility Closure

Proj. Charge Number: 22841-96215-15300

Are these samples for Regulatory Compliance? N

To which agency are the results being reported? \_\_\_\_\_

MATRIX (check one)

Drinking Water: \_\_\_\_\_ Soil: P Oil: \_\_\_\_\_

Ground Water: \_\_\_\_\_ Sludge: \_\_\_\_\_ Solvent: \_\_\_\_\_

Waste Water: \_\_\_\_\_ Hazardous Waste: \_\_\_\_\_ Other: \_\_\_\_\_

COMMENTS

\_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

Sample Conditions			
For Lab Use Only			
Are the seals intact?	Y	N	N/A
Are labels present?	Y	N	N/A
Are samples Chain of Custody?	Y	N	N/A
Are Tags, Containers, and Chain of Custody in agreement?	Y	N	N/A
Are Samples Cold?	Y	N	N/A
Are samples Intact?	Y	N	N/A
Is there headspace?	Y	N	N/A
Is there sufficient Sample?	Y	N	N/A

Received By: \_\_\_\_\_ Date: \_\_\_\_\_ Time: \_\_\_\_\_

Figure 63-Chemical sample request- (page 1 of 2)

SAMPLE ANALYSIS REQUEST FORM  
(side 2)

Sampled By (Sign): [Signature] P. Pollock

Log Number	Sample #	Date	Time	Sample Description	Analysis
	92-886-168C1	11-9-92	0820	Bur 1029	Metals and pH Method 8240 Method 8270 Method 8080 EPA 418.1
	92-886-168C2	11-9-92	0824	Bur 5942	
	92-886-168C3	11-9-92	0829	Bur 5700	
	92-886-168C4	11-9-92	0832	Bur 0220	
	92-886-168C5	11-9-92	0835	Bur 0216	

Log Number	Sample #	Date	Time	Sample Description	Analysis
	92-886-168A	11-6-92	1629	BINS 1029, 5942,	Metals and pH Method 8240 Method 8270 Method 8080 EPA 418.1
	92-886-168B	11-6-92	1629	5700, 0220,	
				0216	
	92-886-168B	11-6-92	1629		
	92-886-168C1			BIN 1029	
	92-886-168C2			BIN 5942	
	92-886-168C3			BIN 5700	
	92-886-168C4			BIN 0220	
	92-886-168C5			BIN 0216	

CHAIN OF CUSTODY (For Environmental Samples)

Relinquished By (sign)	Date	Time	Received By (sign)
<u>[Signature]</u>	11-19-92	11:32	<u>[Signature]</u>

Figure 64-Chemical sample request (page 2 of 2)

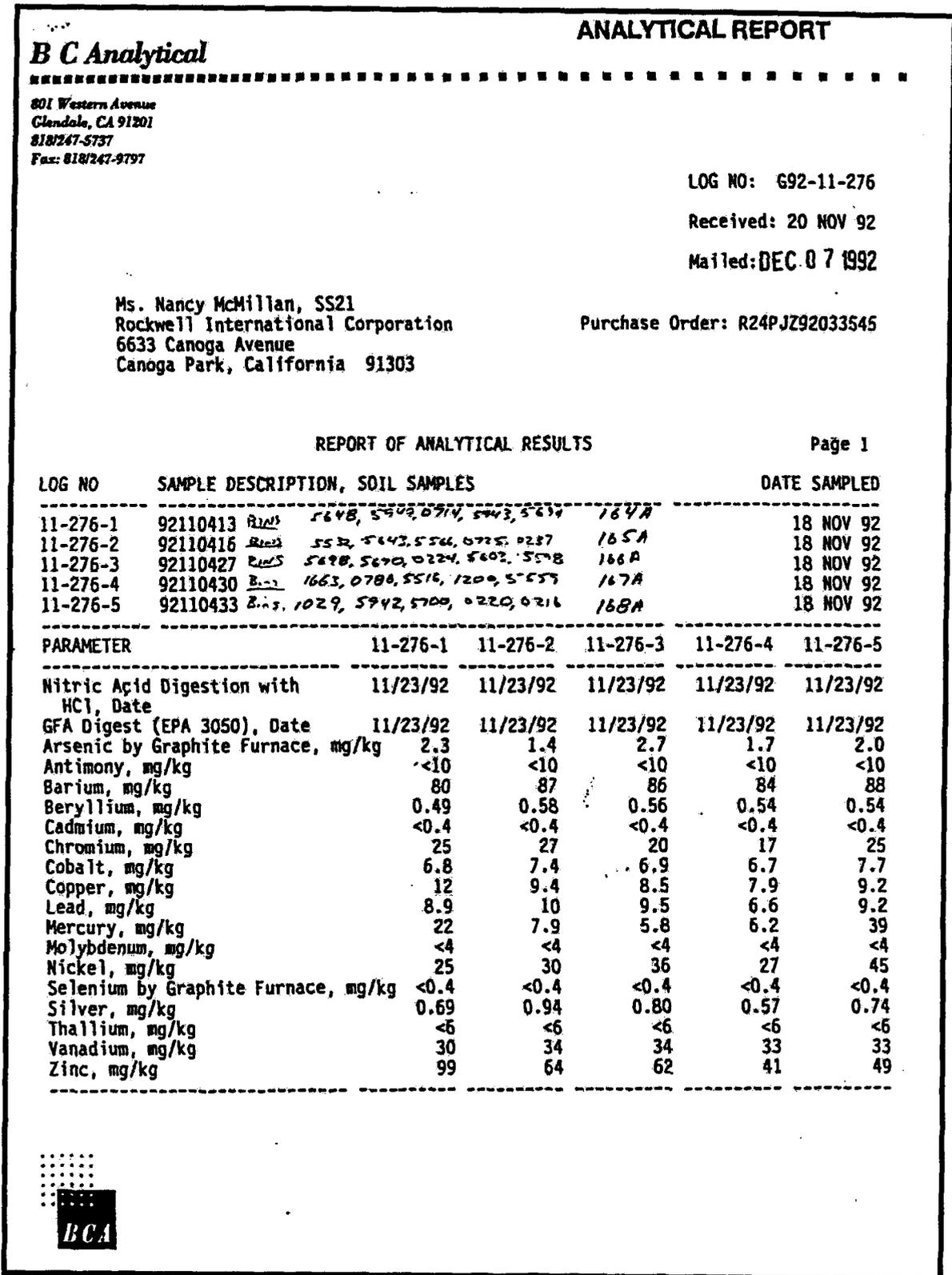


Figure 65-Chemical analysis results (metals)

**SSFL ANALYTICAL CHEMISTRY**

Rockwell International, Rocketdyne Div.  
(818) 586-5827 D/392 SS21

Log Number  
92110434

TO: Sodium Disposal Fac.

Dept/Group: 025-000 MAIL: T886

PHONE: 382-5922

REPORT DATE: 12/04/92

**SAMPLE INFORMATION**

Sample Description: Soil, Bins: 1029, 5942, 5700, 0220, 0216  
Requested Analysis: 8080 Received: 11/19/92  
Sampler: B. Sujata Sampler ID#: 92-886-168B Sampled: 11/18/92 @ 16:29:00

ANALYTE	RESULT	UNITS	METHOD/SOURCE
PCB 1254 in soil	0.60	mg/ Kg	SU846, Method 8080

SPECIFICATION: (PCB analysis)

SPECIAL NOTES:

COMMENTS:

APPROVED: A.C. New Jan M.D. Redman  
Rocketdyne SSFL Analytical Chemistry

SIGNED: Eydie Schwartz  
Rocketdyne SSFL Analytical Chemistry

Figure 66-Chemical analysis results (PCBs)

**SSFL ANALYTICAL CHEMISTRY**  
Rockwell International, Rocketdyne Div.  
(818) 586-5827 D/392 5521

Log Number  
92110470

TO: Rocketdyne Environmental Protection  
Requester: Sodium Disposal Fac.  
Dept/Group: 025-000 MAIL: 1886 PHONE: 382-5922

REPORT DATE: 11/30/92  
DATE OF ANALYSIS: 11/25/92

SAMPLE INFORMATION

Sample Description: Soil, Bins: 1029, 5942, 5700, 0220, 0216  
Requested Analysis: 8240  
Sampler: F. Pollock  
Sampler ID#: 92-886-168C  
Received: 11/19/92  
Sampled: 11/19/92 @ 8:20:00

ANALYTE per SW-846, 88240	RESULT, ug/kg	MDL	MCL
Date Extracted	11/25/92		
1,1,1-Trichloroethane (TCA)	N.D.	0.8	**
1,1,2,2-Tetrachloroethane	N.D.	0.5	**
1,1,2-Trichloroethane	N.D.	0.5	**
1,1-Dichloroethane	N.D.	1.1	**
1,1-Dichloroethylene	N.D.	0.8	**
1,2-Dichlorobenzene	N.D.	0.6	**
1,2-Dichloroethane	N.D.	0.2	**
1,2-Dichloroethylene (cis)	N.D.	0.2	**
1,2-Dichloroethylene (trans)	N.D.	0.4	**
1,2-Dichloropropane	N.D.	0.8	**
1,3-Dichlorobenzene	N.D.	0.6	**
1,3-Dichloropropane (cis)	N.D.	0.6	**
1,3-Dichloropropane (trans)	N.D.	0.5	**
1,4-Dichlorobenzene	N.D.	1.0	**
Acetone	N.D.	7.9	**
Benzene	N.D.	0.7	**
Bromodichloromethane	N.D.	0.6	**
Bromoform	N.D.	0.5	**
Bromomethane	N.D.	1.0	**
Carbon Tetrachloride	N.D.	0.5	**
Chloroethane	N.D.	1.0	**
Chloroform	N.D.	0.8	**
Chloromethane	N.D.	0.6	**
Dibromochloromethane	N.D.	0.4	**
Ethylbenzene	N.D.	0.8	**
Freon 113	N.D.	0.8	**
Methylene Chloride	N.D.	2.9	**
Monochlorobenzene	N.D.	0.6	**
Tetrachloroethylene	N.D.	0.8	**
Toluene	N.D.	0.7	**
Trichloroethylene (TCE)	N.D.	0.6	**
Trichlorofluoromethane	N.D.	0.8	**
Unknown Hydrocarbon	** 15		
Vinyl Chloride	N.D.	0.4	**

Figure 67-Chemical analysis results (VOCs)

DATE OF ANALYSIS: 11/25/92

SAMPLE INFORMATION

Sample Description: Soil, Bins: 1029, 5942, 5700, 0220, 0216  
Requested Analysis: 8240  
Sampler: P. Pollock  
Sampler ID#: 92-886-168C  
Received: 11/19/92  
Sampled: 11/19/92 @ 8:20:00

ANALYTE per SW-846, 8240	RESULT, ug/kg	MDL	MCL
Xylenes (Total)	N.D.	1.4	**

SPECIFICATION: Title 22 (Soil for Method SW846 8240)

SPECIAL NOTES: \*\* Application not provided by requester, thus mcl is not specified.

COMMENTS: \*\*Tentatively identified compound. Semi-quantitated from nearest internal std.

APPROVED: *Saverly R. Kurt*  
Rocketdyne SSFL Analytical Chemistry

SIGNED: *Vonnie Douglas*  
Rocketdyne SSFL Analytical Chemistry

Figure 68-Chemical analysis results (SVOCs)

## 14.0 REFERENCES

- 1 8640M-95 "Hydrogeologic Assessment Report, Lower Pond B 886 SDF", Groundwater Resources Consultants Staff, 6/12/90.
- 2 Internal Letter, "Burn Pit Lower Pond", BNA Staff, Lang to McCurnin, 12/11/80
- 3 303-886-C1, Sodium & Flammable Liquid Disposal Facility-Site Plan and Concrete Pit Details", Atomics International, September 1960
- 4 GEN-ZR-0002, "CERCLA Program Phase II - Site Characterization," Rocketdyne Staff, 5/29/87
- 5 BNA GEN-ZR-0004, "Radiological Survey of the Sodium Disposal Facility - Building T886." 6/27/88
- 6 TOXIC PITS CLEANUP ACT (TPCA) Section 25208 of Article 9.5 , California Code of Regulations.
- 7 ETEC-DRF-2438 "Hydrogeological Assessment Report-Review thereof, RI-SSFL, File 04.003.00" J.E.Ross (Los Angeles Regional Water Quality Control Board), 3/5/91
- 8 ETEC-DRF-2439 "Clean Up and Abatement Order No. 91-061 (File No. 200.003)" Ghirelli (RWQCB), 4/30/91
- 9 90 ETEC-DRF-1145, "Assessment Plan for the FSDF..." BNA Staff, 5/25/91
- 10 91RC09556, "Former Sodium Disposal Facility (SSFL) Closure Plan", BNA Staff, 7/31/91
- 11 RWQCB DRAFT Letter, FSDF Closure Plan Approval, Ross, 9/9/91
- 12 ETEC-DRF-2192 "Request for NEPA Determination" Stone (BNA) 9/28/91
- 13 N001TI000339 "Definitions and Designation of Radioactive Materials Management Areas-RMMA)", Rocketdyne Staff 9/15/91.
- 14 ETEC-DRF-2418 "Revision to the Performance Objective [Waste Shipment Moratorium]", Nakahara (DOE-SF) to Gaylord (ETEC), 10/22/91
- 15 011775RC "FSDF Closure Plan [Deficiencies]" Ross (RWQCB) & Pearson (DTSC), 11/1/91
- 16 886-AN-0001 "Project Management Plan-Sodium Disposal Facility Closure", ETEC, 11/20/91
- 17 886-ZR-0001 "SDF Closure-Health and Safety Plan", ETEC Staff, 12/06/91
- 18 886-CX-0002 "FSDF Remediation Site Layout", Staff, 4/23/92
- 19 92RC00025 "Response to Recommendations on the Closure Plan for FSDF" Jensen (BNA), 1/3/92
- 20 92 RC01593 "SDF, Buried Object Removal Procedure" Lafflam 2/7/92
- 21 002077 "Closure Plan for FSDF", Pearson 2/11/92
- 22 002076RC "Closure Plan Approval" Ross 2/11/92
- 23 92RC02376 "Closure Plan for the FSDF" BNA, Jensen to Ross (RWQCB) 2/20/92
- 24 92RC02374 "Closure Plan for the FSDF" BNA Jensen to Pearson (DTSC), 2/20/92
- 25 IL, "SFDF Pilot Study Designations", Klein to Gaylord, 2/24/92
- 26 DRF 0390 "NEPA Approval for FSDF Remediation", Liddle (DOE), 3/5/92
- 27 DTSC Letter, "Closure Plan for FSDF" Pearson to Lafflam, 3/10/92.
- 28 92RC02624 "Request for Extension of Soil Storage at the FSDF", Jensen to Pearson (DTSC), 3/16/92
- 29 N704SRR990034 "Baseline Radiological Survey of the FSDF", Rocketdyne staff, 8/31/92
- 30 003854RC "Request for an Extension of the 90 day period for storage", DTSC, 4/6/92
- 31 004455RC "Health and Safety Plan Review", DTSC Staff, 4/24/92
- 32 04994-001-00 "Geophysical Survey of B-886, Former Sodium Disposal Facility", ICF Kaiser Engineers, M. Miele 5/92
- 33 Internal Letter, "Funding for Burn Pit Lower Pond", BNA Staff, McCurnin to Kittinger, 2/24/81
34. DRF-0839 "Land Disposal Restrictions-National Variance Deadline for Mixed Wastes", DOE Staff 5/6/92
- 35 005087 "Soil Cleanup and Storage", DTSC Staff, 5/11/92
- 36 92RC05537 "Response to HASP review for FSDF", Rocketdyne staff, 5/14/92
- 37 DRF-1090 "Public Information Document Review", DTSC Staff, 5/22/92
- 38 92RC05668 "B/886 FSDF" BNA Staff, 5/22/92
- 39 005871RC "Approval of Interim Measure Workplan...", DTSC Staff, 6/5/92
- 40 92RC06399 "B/886 FSDF" BNA Staff, 6/11/92
- 41 006001RC "Conflict of Applicable Regulations", Zelikson, EPA, 6/10/92
- 42 92RC07098 "Cleanup and Abatement Order", BNA Staff, 6/30/92
- 43 007980RC "Soil Boring and Excavation...", DTSC Staff, 8/10/92

- 
- 44 #92-003, "X\*TRAX and Stabilization Treatability Studies of Mercury Contaminated Soil, from SSFL",  
Clemson Technical Center, Chemical Waste Management Inc., 10/92. (011324 RC).
- 45 #8664 (CUP 248) Grading Permit, Ventura County, 9/8/92
- 46 92RC09932 "Pilot Study Report-B/886 FSDF" BNA Staff, 10/2/92
- 47 DRF-1806 "FSDF Final Closure Plan Approval), RWQCB Staff, 10/9/92
- 48 DOE Memorandum, "Clarification on Approval.....ETEC...", Stevens (HQ) to Davis (OAK), 10/29/92
- 49 92RC12948 "Submittal of Interim Post Closure Plan for the Lower Pond-FSDF", BNA Staff 12/22/92
- 50 DRF2280 "Closure of Surface Impoundment-FSDF", RWQCB Staff, 12/29/92
- 51 00588RC "Authority to Regulate Mixed Waste Treatment", DTSC Staff, 1/12/93
- 52 ETEC-DRF-0347 "Approval of Waste Shipment from FSDF" Dong (DOE-SF) 1/19/93
- 53 93RC02022 "Extension of Permit per Title 22" BNA Staff, 2/17/93
- 54 93 ETEC-DRF-0357 "Proposed Treatment Process for FSDF Mixed Waste" BNA Staff, 2/23/93
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**EXHIBIT V**

**FINAL DOCUMENTATION AND RADIOLOGICAL SURVEY(S) OF  
FACILITY 4886 AFTER DECONTAMINATION AND  
DECOMMISSIONING**

**ENERGY TECHNOLOGY ENGINEERING CENTER**

OPERATED FOR THE U.S. DEPARTMENT OF ENERGY  
ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL

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**TITLE: Post-Remediation Soil Sampling and Analysis  
for the Former Sodium Disposal Facility**

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# CONTENTS

	<b>Page</b>
<b>1. INTRODUCTION .....</b>	<b>3</b>
<b>2. SUMMARY AND CONCLUSIONS .....</b>	<b>3</b>
<b>3. SAMPLING.....</b>	<b>4</b>
<b>4. ANALYSIS.....</b>	<b>5</b>
<b>5. RESULTS.....</b>	<b>5</b>
<b>6. INTERPRETATION.....</b>	<b>5</b>
<b>7. QUALITY ASSURANCE .....</b>	<b>7</b>
<b>8. DOCUMENTATION.....</b>	<b>9</b>
<b>9. REFERENCES .....</b>	<b>9</b>
<b>10. APPENDIX A.....</b>	<b>51</b>
<b>11. APPENDIX B- INTERPRETATION OF RESULTS.....</b>	<b>57</b>

## 1. Introduction

The Former Sodium Disposal Facility (T886) at the Rockwell International Santa Susana Field Laboratory was used primarily for cleaning sodium heat transfer system components (pipes, valves, tanks) and for disposal of scrap sodium by reaction with water. However, during its use, small quantities of a variety of other materials were disposed of there, including radioactively contaminated components and material. As a result, small amounts of radioactive contamination became dispersed in the T886 pool, and in the lower basin and adjacent areas. The pool and related structure, and all the soil in the lower basin, were removed during a remediation project lasting from 1991 through 1994. At the completion of the radiological remediation, a final gamma radiation survey and a sampling of soil and rock were performed to demonstrate the satisfactory removal of the radioactive contamination. The gamma radiation survey was summarized in ETEC document number 886-ZR-0007 (Ref. 1).

Following removal of all potentially radioactively contaminated soil from the former Sodium Disposal Facility, the soil and rock samples were independently taken by ICF-Kaiser Environment and Energy Group. These samples were analyzed by Oak Ridge Institute for Science and Education (ORISE), and the results reported to the Radiation Protection and Health Physics Services Group (now Environmental Remediation) at Rocketdyne. This report summarizes those results and presents comparisons with local background values.

## 2. Summary and Conclusions

To confirm the satisfactory radiological remediation of this area, a sampling and analysis plan was developed by the Environment and Energy Group of ICF Kaiser Engineers (Ref. 2). ICF Kaiser personnel collected 63 soil samples and 15 rock samples for analysis according to this plan. Figure 1 shows the layout of the Former Sodium Disposal Facility and its subdivision into grids to provide a basis for the sampling. (Figures and Tables follow the text of this report.)

The ICF Kaiser samples were sent to ORISE where they were individually analyzed by gamma spectrometry, and analyzed by various radiochemistry procedures in composited groups. Sample material is available for confirmatory analyses by the State of California Department of Health Services - Radiologic Health Branch.

The gamma spectrometry showed low concentrations of Cs-137, the primary radioactive contaminant at the Former Sodium Disposal Facility, and normal amounts of natural K-40, and the thorium and uranium decay chains. The Cs-137 concentrations are similar to, though in some instances somewhat greater than, local background surface soil concentrations due to global fallout from nuclear weapon testing. The radiochemistry showed low concentrations of Sr-90, similar to the Cs-137 concentrations, and somewhat higher than local background surface soil concentrations. Radiochemistry with alpha spectrometry for thorium and uranium showed concentrations that agreed well with values expected for naturally occurring minerals, and in agreement with the daughter activities found by gamma spectrometry. This comparison shows that the thorium and uranium activities are a natural occurrence.

Gamma spectrometry of the rock samples showed natural concentrations of K-40 and the thorium and uranium decay chains, in agreement with the concentrations found in the soil, but no Cs-137. Radiochemistry showed natural equilibrium in the thorium chain but some

disequilibrium in the uranium chain, with the Th-230 activity (and its daughters) exceeding that expected from the parent uranium activities. This is commonly found in geological materials.

Radiochemistry with alpha spectrometry for plutonium (Pu-238, Pu-239/240) showed no concentrations in soil or in rock that differed statistically from zero.

The small amounts of Sr-90 and Cs-137, which may represent residue from the contaminated soil that was removed, are well below proposed guidelines for residual radioactivity in soil, for release without radiological restrictions (Ref. 3). No other indications of possible remaining contamination were found.

No samples indicated the presence of significant levels of radioactive contaminants. All results were well below proposed acceptable limits for radioactive contamination in soil. The results of this sampling and analysis program confirm that the area is acceptable for release for use without radiological restriction.

### 3. Sampling

For the purpose of providing a uniform basis for sampling the Former Sodium Disposal Facility area, four regions were established, relating to the history of the facility. These regions were subdivided into 50-foot square grids, and sample locations were selected within the grids by use of random numbers.

Surface soil samples were collected by hand, with a trowel, providing somewhat more than 1 kg of soil for each sample. Soil samples were placed in jars for transport to the ORISE laboratory. Subsurface samples were collected at a depth of about 4 feet below the surface by use of a hand auger. Bedrock samples were broken after core-drilling from the local rock.

Sample locations were identified, relative to the grid shown in Figure 1, by use of a 12-character code. The first digit indicates the region (1-4), the next 2 digits indicate the block number for that region, the next 2 digits give the distance in feet to the north from the southeast corner of the block, the next 2 digits give the distance in feet to the west from the same corner, and the next digit (0 or 1) indicates a surface sample (0) or a 4-foot subsurface sample (1). The type of sample is indicated by S for soil and B for bedrock. The samples taken for radionuclide analysis were further identified by RN. Scheduled samples, as distinct from QC samples, were identified by a final 0.

After the initial gamma spectrometry had been reported for all the individual samples, portions of selected samples were grouped together at the ORISE laboratory to form composite samples for the radiochemistry analyses. This was done to use the analytical funding as effectively as possible, since gamma spectrometry is relatively inexpensive, compared to analyses requiring chemical separation.

The composite groups were selected by first associating the gamma spectrometry results for each sample with the region, and then combining nearby samples with similar radiological characteristics, as determined from the gamma spectrometry. Some samples were kept separate for individual analysis. The sample groupings are shown on the layout map of the area in Figure 2.

## 4. Analysis

Samples were analyzed at ORISE in Oak Ridge, Tennessee, under contract to DOE/OAK. The gamma spectrometry used a high-purity germanium detector with a computer based multichannel analyzer. The standard Canberra software for interpretation of photopeaks was used. The uncertainties reported with the results are determined by the computer processing and are specified at the 2-sigma level.

Radiochemistry was done to quantify Sr-90 and the requested alpha emitters. Chemical separation provides a strontium precipitate, beta counting serves as the determination of the activity. Similarly chemical separation provides separate deposits for thorium, uranium, and plutonium. Alpha spectrometry is used to determine the individual isotopic activity for each element. Uncertainties for the radiochemical results are also reported at the 2-sigma level.

## 5. Results

The results of the ORISE analyses are listed in Tables 1A, 1B, and 1C. These tables provide the sample location code number, as described above, and the activity concentration and 2-sigma uncertainty, in pCi/g. All scheduled samples are included here, with the results for 3 field duplicate soil samples. Blank entries in the uncertainty (unc) column indicate that the activity for that radionuclide was not detected, and so one-half of the Minimum Detectable Activity (MDA) has been entered as the result for that sample. Table 1A lists all sample results obtained by gamma spectrometry. Table 1B lists the results obtained by radiochemistry. Table 1C lists the MDA values for all the radionuclide analyses that were performed.

The groups of individual samples that were composited for the radiochemistry analyses are listed in Table 2, with the associated Lab ID, Lab composite ID, and the designated composite number.

## 6. Interpretation

Individual results from the analysis of soil and rock are presented as cumulative probability plots in Figures 3a through 3q. In these plots, measured values are shown with a small or large error bar associated with the data symbol. The error bars indicate the 2-sigma uncertainty estimated for the result. Non-detected results, set to one-half the MDA, are shown without an error bar. In a cumulative probability plot, data with a normal (or Gaussian) distribution fall along a straight line. The plot shows, as a diagonal line, the theoretical Gaussian distribution calculated from the arithmetic mean and standard deviation of the dataset.

Most of the radionuclides detected show a distribution that is close to Gaussian. The distribution for Cs-137 in soil (Figure 3b) shows several values that are somewhat higher than expected, but not entirely outside the range of environmental fallout activity in surface soil. Only 3 samples, at 0.57, 0.30, and 0.30 pCi/g, are above the upper 95% bound for local background of 0.27 pCi/g. The highest value, 0.57, corresponded to the sample with the highest Sr-90 result. All results are well below the proposed SSFL site limit for Cs-137 in soil, 8.6 pCi/g (Ref. 3). This limit was determined by a pathways analysis using the DOE code RESRAD Version 5.61, for a maximum annual dose of 10 mrem in a residential setting.

The results for Sr-90 in soil (Figure 3i) also show some elevated values. Of the 19 composite sample analyses performed, 14 were reported at levels that were below the MDA. Only 4 composite soil samples, at 0.57, 0.49, 0.40, and 0.26 pCi/g, are above MDA for this analysis. The

highest value, 0.57, corresponded to the sample with the highest Cs-137 result, also 0.57 pCi/g. One composite rock sample, at 0.28 pCi/g, was above the MDA of 0.27. All results are well below the proposed SSFL site limit for Sr-90 in soil, 24 pCi/g. This limit was determined by the same pathways analysis.

The distribution for U-235, in both soil and rock (Figure 3h), as determined by gamma spectrometry, is distorted by the many non-detected values. There is no indication of contamination in these results, and higher quality values determined by radiochemistry with alpha spectrometry (Figure 3n) confirm this conclusion.

The analyses for plutonium, both Pu-238 and Pu-239 (including Pu-240), show no results that indicate contamination. While the analyses for Pu-238, which is found in global fallout, showed 6 (out of 19) results above the MDA, none of the analyses for Pu-239, a suspect SSFL contaminant, were above the MDA. The reported values result from random variability in the background of the analyses.

The determination of background distributions of the radionuclides reported here, for soil, is based on two sets of data covering large local areas. One collection is from the McLaren-Hart Multimedia Study of the Brandeis-Bardin Institute and Santa Monica Mountains Conservancy properties near SSFL (Ref. 4), as supplemented by some recent samples collected offsite by Rocketdyne. (This set is identified as "... in Background Soil".) The other consists of results from the Rocketdyne Area IV Radiological Characterization Study (Ref. 3), using only those results that are clearly unaffected by contamination. (This set is identified as "... in Area IV Soil (background)".) These measured background distributions, representative of the local area, are shown in Figures 4a through 4k.

For comparison, the average value and 2-sigma uncertainty for each radionuclide measured in soil from the Former Sodium Disposal Facility are listed below, with the corresponding values from the two background sets.

Radionuclide	Former Sodium Disposal Facility	Background Soil	Area IV Soil
K-40	21.7 ± 3.14	21.9 ± 3.44	19.0 ± 4.72
Sr-90	0.13 ± 0.29	0.047 ± 0.080	0.040 ± 0.080
Cs-137	0.069 ± 0.189	0.103 ± 0.166	0.079 ± 0.141
Th-228	1.43 ± 0.35	0.98 ± 0.95	1.00 ± 0.53
Th-230	1.21 ± 0.26	0.28 ± 0.57	0.82 ± 0.46
Th-232	1.34 ± 0.35	0.37 ± 0.83	0.99 ± 0.51
U-234	0.96 ± 0.27	0.35 ± 0.84	0.77 ± 0.35
U-235	0.044 ± 0.024	0.018 ± 0.045	0.042 ± 0.022
U-238	0.95 ± 0.26	0.36 ± 0.79	0.78 ± 0.33
Pu-238	0.027 ± 0.040	-----	0.0006 ± 0.0052
Pu-239	0.009 ± 0.043	-----	0.003 ± 0.007

While there are some variations from background, some above, some below, the averages look quite similar.

Further evidence that the thorium and uranium activity detected in the Former Sodium Disposal Facility soil is natural, can be seen in comparisons of the daughter activities. Thorium and uranium are naturally occurring radioactive elements that slowly decay to stable isotopes of lead. The sequence of radionuclides in the major decay chains is shown below, with those radionuclides that were detected by the present analyses shown in boldface:

thorium chain	---- uranium chain ---- (U-238)	(U-235)
<b>Th-232</b>	<b>U-238</b>	<b>U-235</b>
Ra-228	<b>Th-234</b>	Th-231
<b>Ac-228</b>	Pa-234	Pa-231
<b>Th-228</b>	<b>U-234</b>	Ac-227
Ra-224	<b>Th-230</b>	Th-227
Rn-220	Ra-226	Ra-223
Po-216	Rn-222	Rn-219
<b>Pb-212</b>	Po-218	Po-215
Bi-212	<b>Pb-214</b>	Pb-211
Po-212	<b>Bi-214</b>	Bi-211
Pb-208 (stable)	Po-214	Po-211
	Pb-210	Pb-207 (stable)
	Bi-210	
	Po-210	
	Pb-206 (stable)	

In each chain, one longer-lived radionuclide acts as a “bottleneck” to the development of equilibrium activity after chemical purification of the element. Ra-228, with a half-life of 5.76 years, delays full development of equilibrium activity in the thorium chain by about 25 years. Th-230, with a half-life of 75,000 years, delays development of the uranium chain by 300,000 years. Several of these daughters (and the U-235 “cousin” to U-238) were measured in the soil from the Former Sodium Disposal Facility. The activities detected are shown in Figure 5. The straight diagonal lines show the theoretical variation of the daughter activity with the parent. The good agreement of the measured values with the theoretical variation shows that these activities are natural.

## 7. Quality Assurance

Several sets of measurements were done to provide quality control checks on the analytical procedure. These measurements were directed towards demonstrating the precision and accuracy of the analytical results. The QC samples consisted of field duplicates (which were reported in the main section of this report, but are also discussed here), laboratory replicate analyses, matrix spikes (laboratory control samples), and blind spikes. The Data Quality Objectives are considered to be satisfied if the observed differences are less than 3 times the estimated standard deviation of the difference (Ref. 4). (Standard laboratory reporting provides the uncertainties (unc) as 2 times the estimated standard deviation of the result. For the QC comparisons, the derived uncertainty must be multiplied by 1.5 to obtain the 3-sigma value.)

Duplicate soil samples were made from 3 original samples: 21346220, 30113170, and 42455090. The original samples were individually mixed, and “split” samples were taken from

the bulk material. These samples then proceeded through the balance of the sampling and analysis as though they were independent samples. The results are compared in Table 3. These results show good agreement, with the differences between separate paired soil samples generally being less than the estimated uncertainty. Of 31 comparisons, 5 failed to satisfy the 3-sigma test. Of these, 4 were among the alpha spectrometry analyses, which are sensitive to non-uniformity in the soil.

Laboratory duplicate analyses were done extensively for the gamma spectrometry, less so for the more complicated radiochemistry analyses. These results are shown in Table 4. The comparison is made by calculating the relative difference between the results of the two analyses, and the estimated uncertainty for this relative difference. For a perfect comparison, the relative difference would be zero. Because of random variations, some deviations from zero will occur. These should generally be less than the uncertainty. Of 79 comparisons, 15 failed the 3-sigma test. Two of these failures were for uranium in one of the blind laboratory spike samples, and may have resulted from lack of homogeneity.

Laboratory matrix spikes were prepared for gamma spectrometry by adding a calibrated solution of Cs-137 to selected soil samples. These results are shown as the first 9 entries in Table 5A. A "recovery" value of 1.000 indicates perfect detection of the added spike activity. Of the 9 ORISE-spiked samples, all results are within the required range of 3 times the estimated standard deviation of the difference.

Blind spikes were obtained through a commercial laboratory, by adding calibrated solutions of Sr-90, Cs-137, Th, U, and Pu-239 to 3 selected soil samples. These results are shown as the last 3 entries for Table 5A and all the entries in Table 5B. (The calibration sheets for these blind spikes are presented in the Appendix.) Gamma spectrometry showed the required agreement for 2 of the 3 comparisons. The radiochemistry showed disagreement for 14 of the 32 comparisons. In some of these cases, the differences may reflect the difficulty in making a bulk sample that is adequately homogeneous on the small scale of the analytical aliquots. (Gamma spectrometry measures the radioactivity in a large sample, 600-1000 grams, averaging throughout its volume, while the radiochemical procedures use relatively small aliquots, 3-5 grams, for processing and analysis.)

The results of the QC tests are summarized below as percentages of comparisons satisfying the 3-sigma test.

	Field Duplicates	Lab Duplicates	Matrix Spikes	Blind Spikes	Aggregate Total
K-40	3/3	9/10	---	---	12/13
Sr-90	1/1	1/1	---	2/4	4/6
Cs-137	3/3	10/10	9/9	2/3	24/25
Pb-212	3/3	6/10	---	---	9/13
Pb-214	3/3	3/10	---	---	6/13
Bi-214	3/3	10/10	---	---	13/13
Ac-228	2/3	10/10	---	---	12/13
Th-228	0/1	1/1	---	2/4	3/6
Th-230	1/3	1/1	---	---	2/4
Th-232	0/1	1/1	---	2/4	3/6
Th-234	3/3	9/10	---	---	12/13
U-234	0/1	0/1	---	0/4	0/6
U-235	1/1	1/1	---	4/4	4/6
U-238	0/1	0/1	---	1/4	1/6
Pu-238	1/1	1/1	---	4/4	6/6
Pu-239	1/1	1/1	---	3/4	5/6

The overall score for these comparisons is 74%.

## **8. Documentation**

Backup documentation for this sampling and analysis project is stored in the Former Sodium Disposal Facility (T886) decommissioning file.

## **9. References**

1. "Post-Remediation Ambient Gamma Radiological Survey of the Former Sodium Disposal Facility", 886-ZR-0007, F. C. Dahl, 12/13/94.
2. "Sampling and Analysis Workplan -- Former Sodium Disposal Facility, Santa Susana Field Laboratory", SSFL 95-01, ICF Kaiser Engineers, Environment and Energy Group, June 29, 1995.
3. "Proposed Sitewide Release Criteria for Remediation of facilities at the SSFL", N001SRR140127, B. M. Oliver and R. J. Tuttle, 3/11/96.
4. "Area IV Radiological Characterization Survey, Draft Final Report", Volume 1, A4CM-ZR-0011, P. D. Rutherford, March 15, 1996.
5. "Multi-Media Sampling Report for the Brandeis-Bardin Institute and the Santa Monica Mountains Conservancy", McLaren/Hart Environmental Engineering Corporation, March 10, 1993.

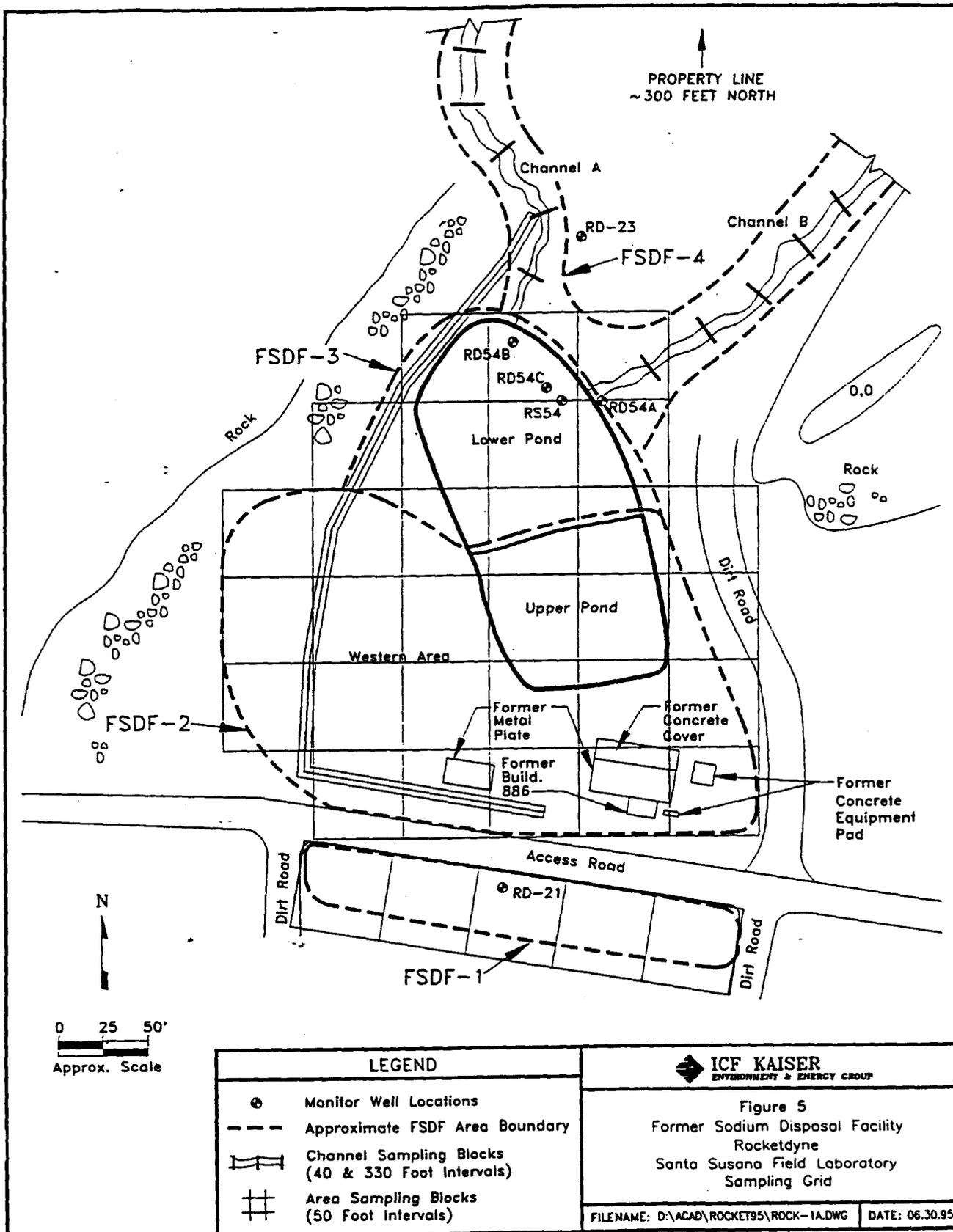


Figure 1. Layout of Former Sodium Disposal Facility for sampling.

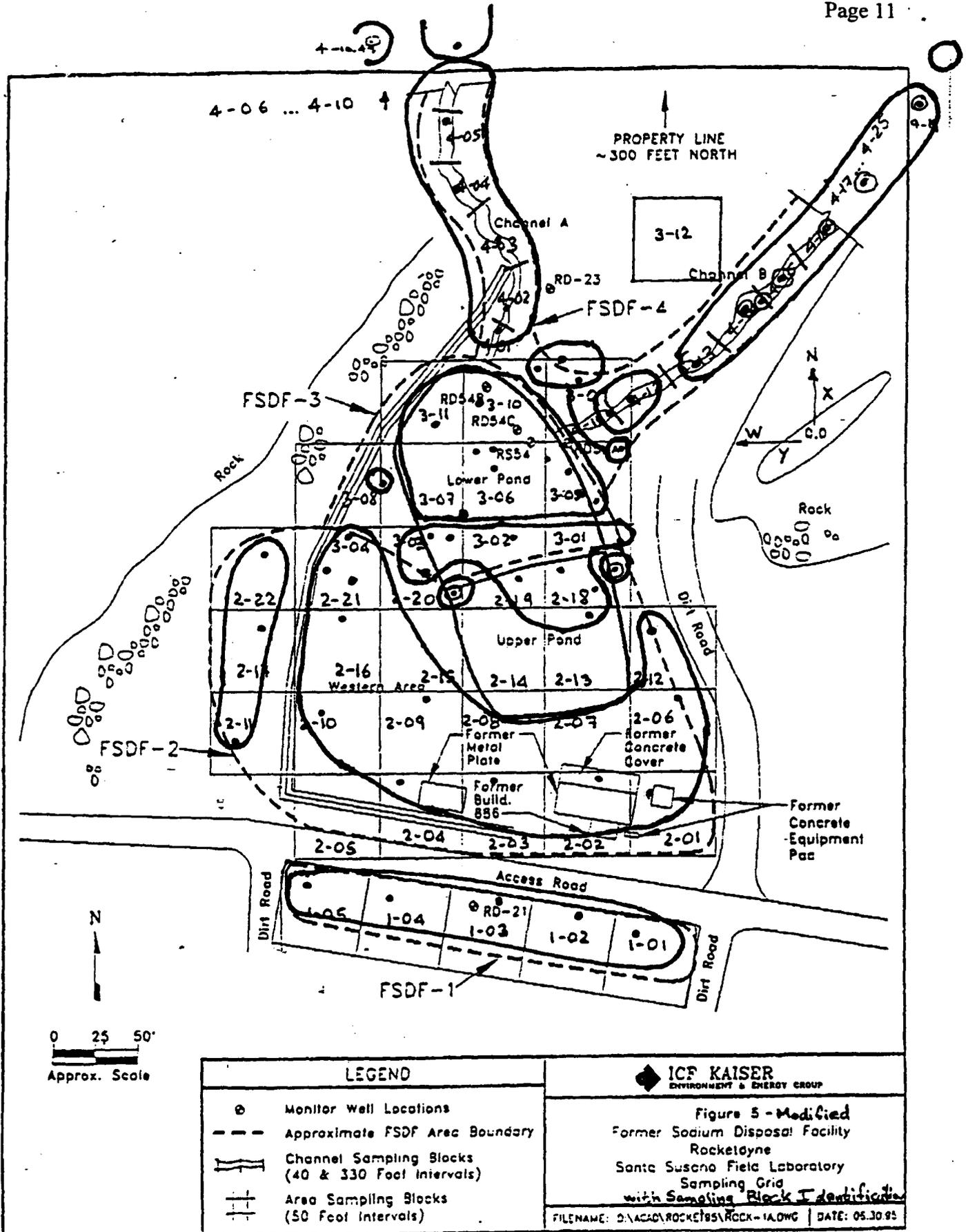
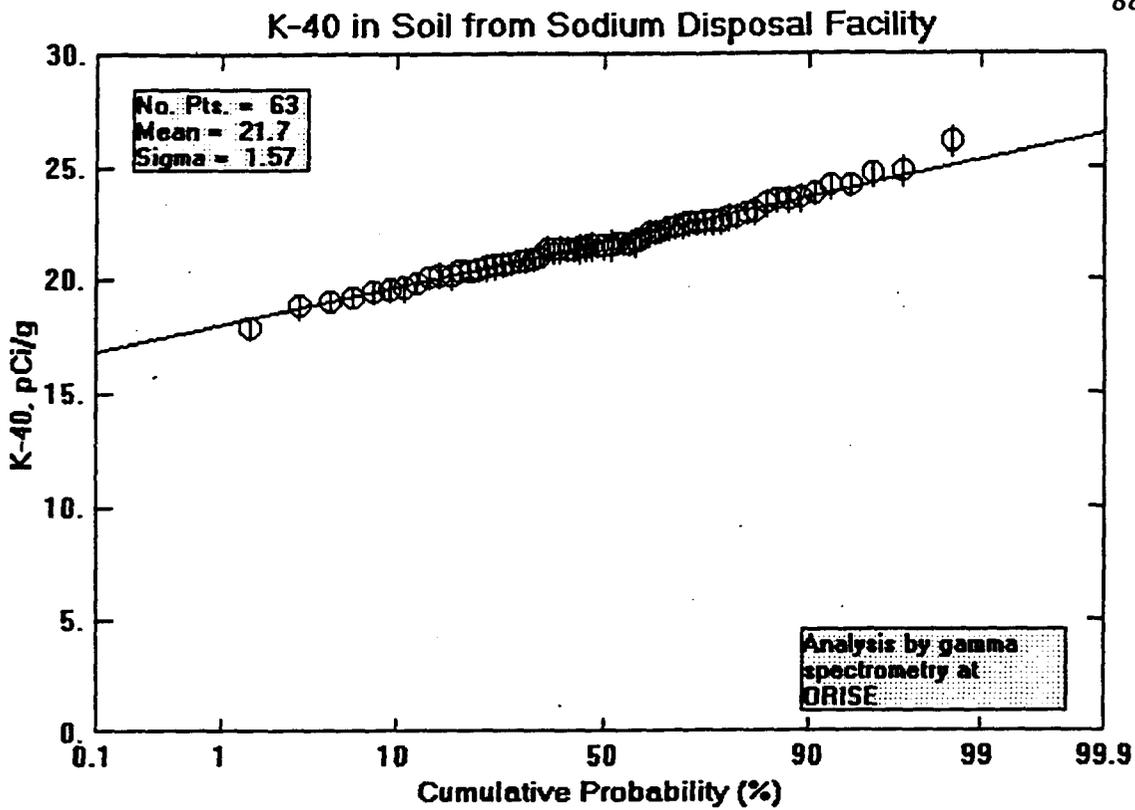
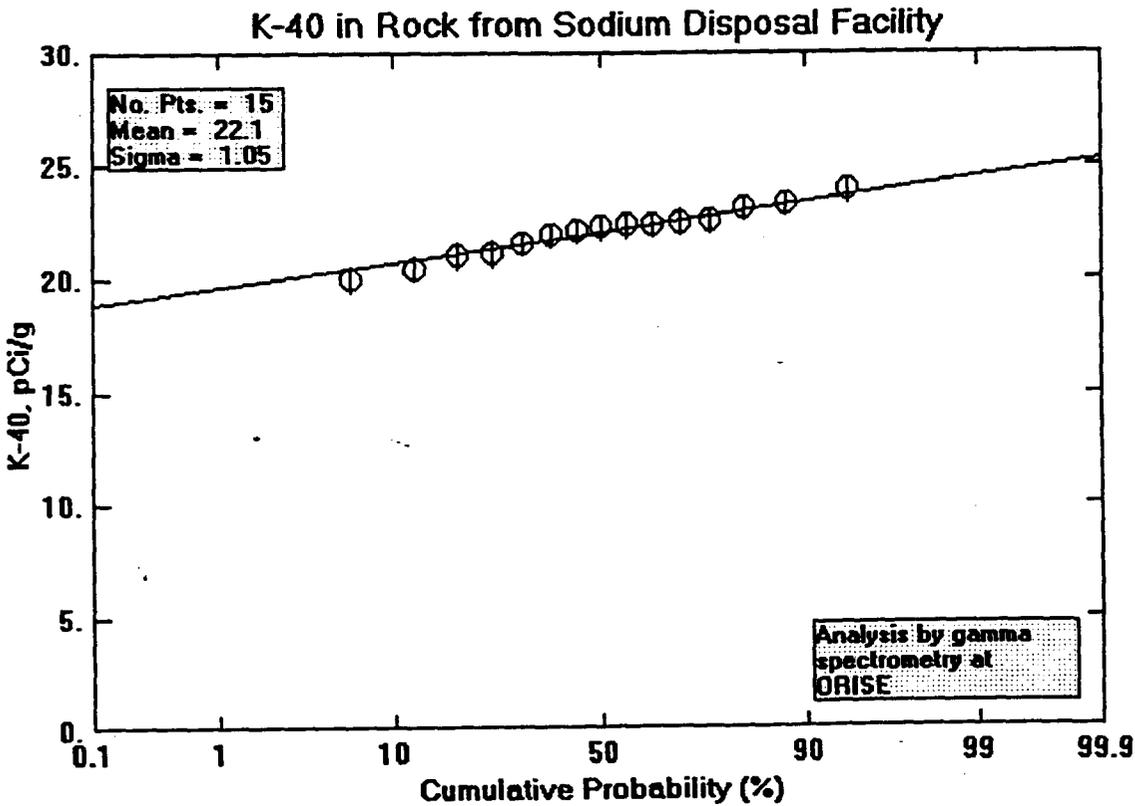


Figure 2. Locations of samples grouped for composite analysis.



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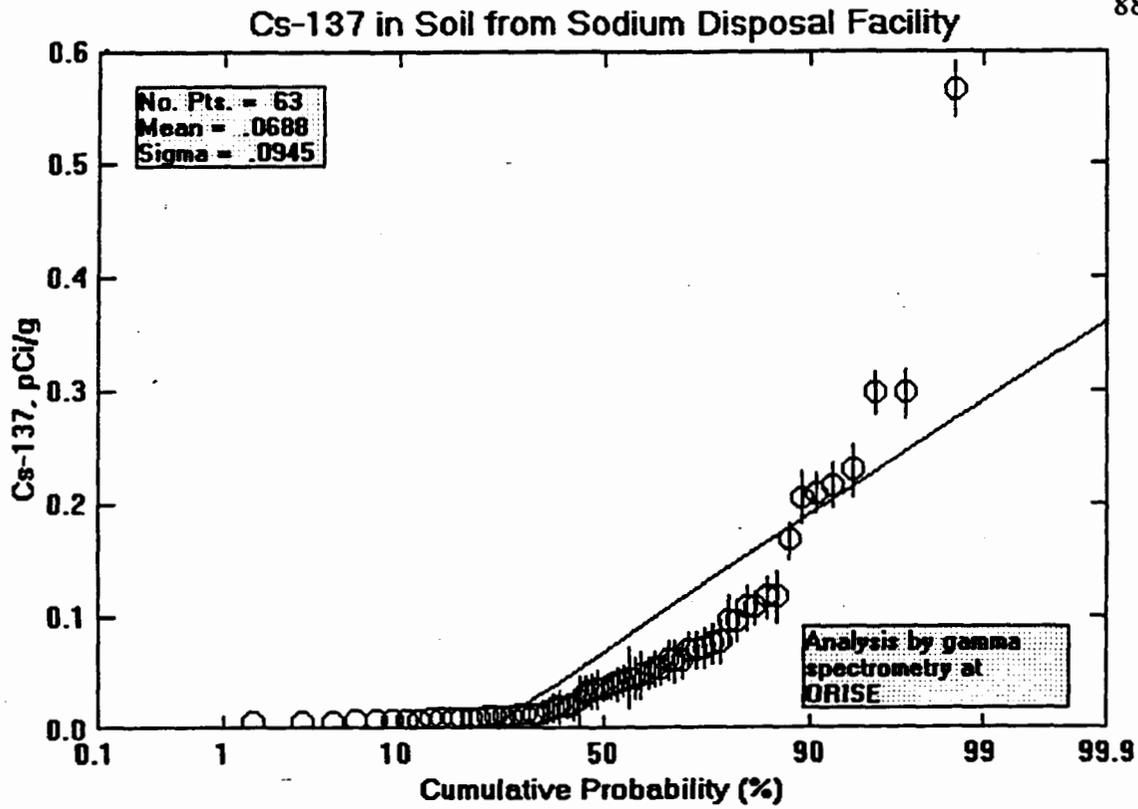
02-15-96



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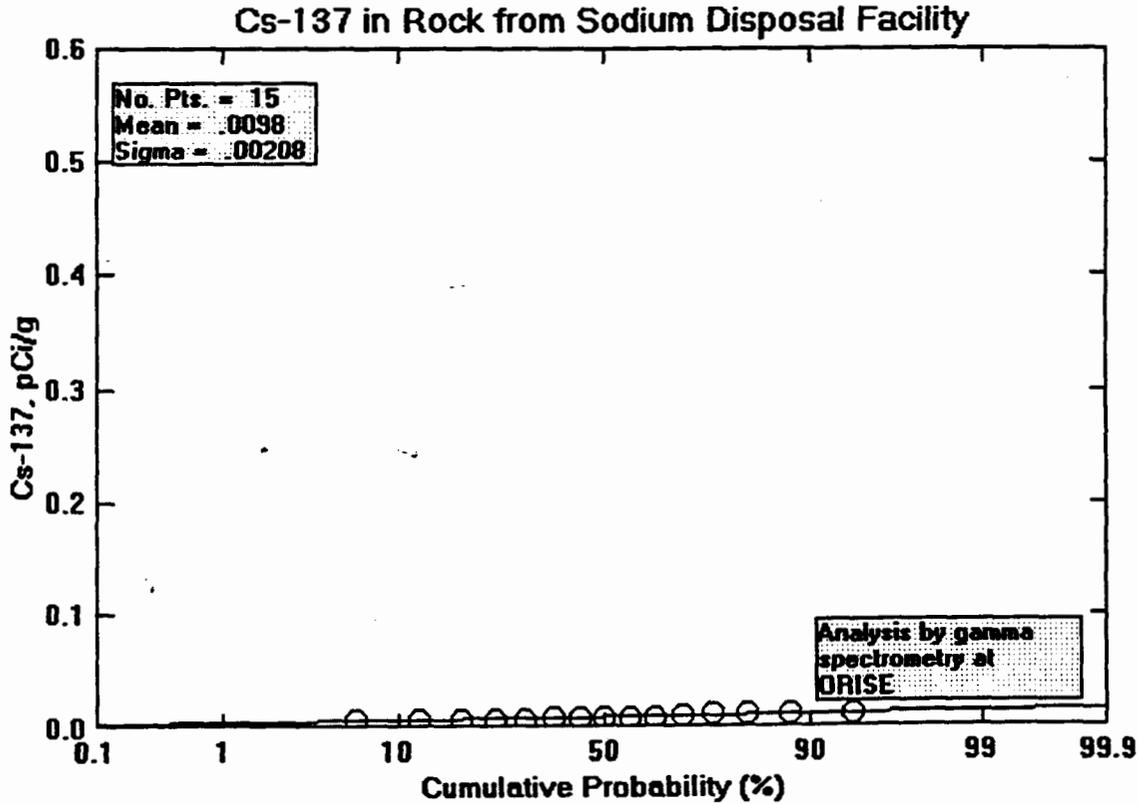
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Figure 3a. Distribution of K-40 in Soil and Rock at the Former Sodium Disposal Facility.



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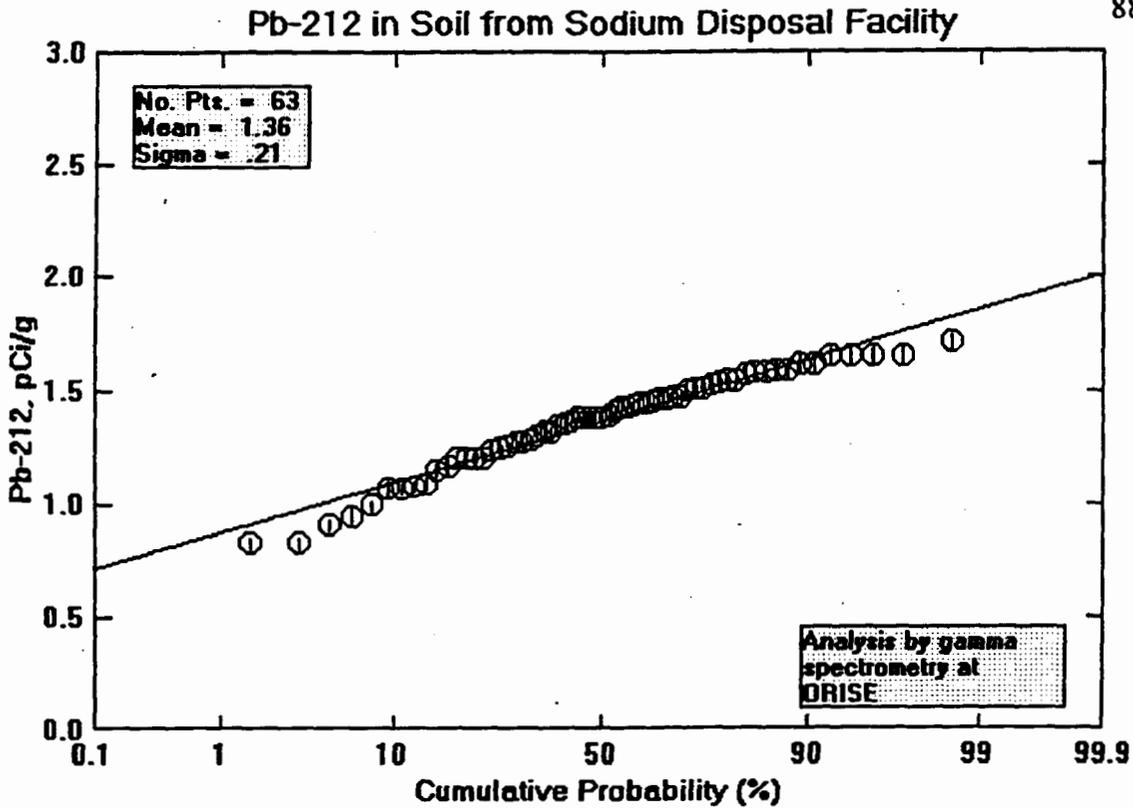
02-15-96



C:\CUMPLOT\T886R02.CMP

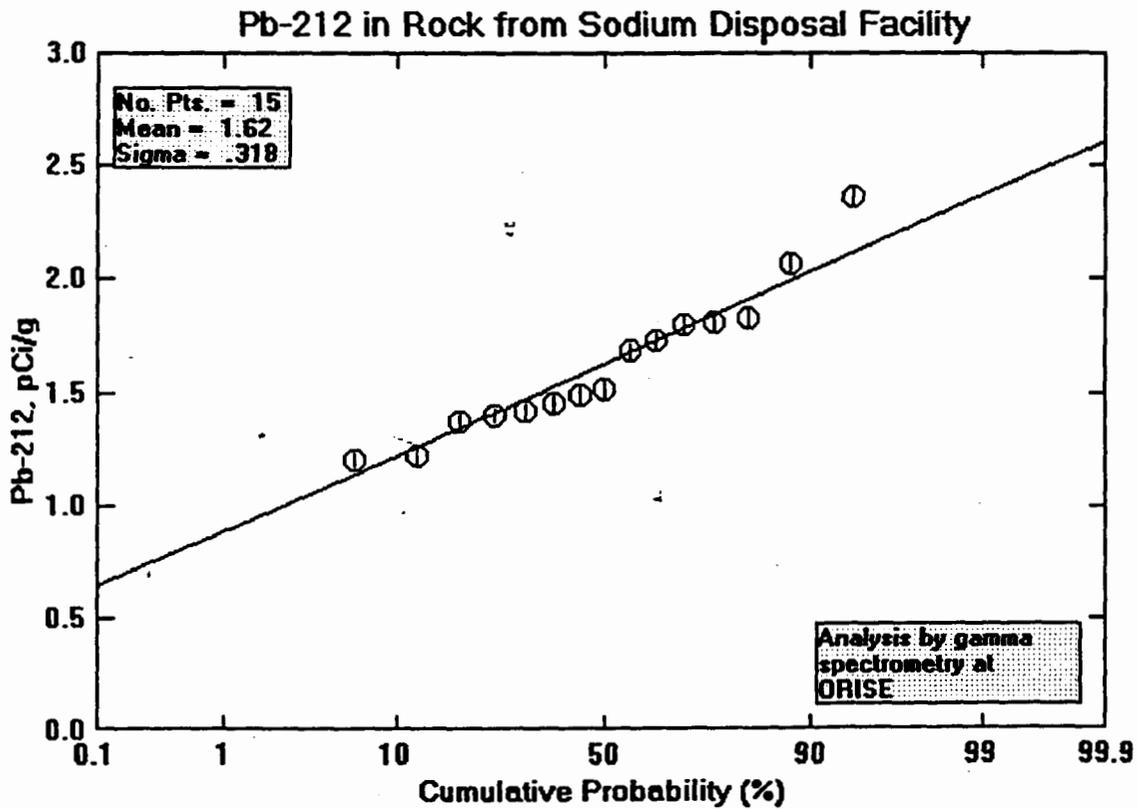
02-15-96

Figure 3b. Distribution of Cs-137 in Soil and Rock at the Former Sodium Disposal Facility.



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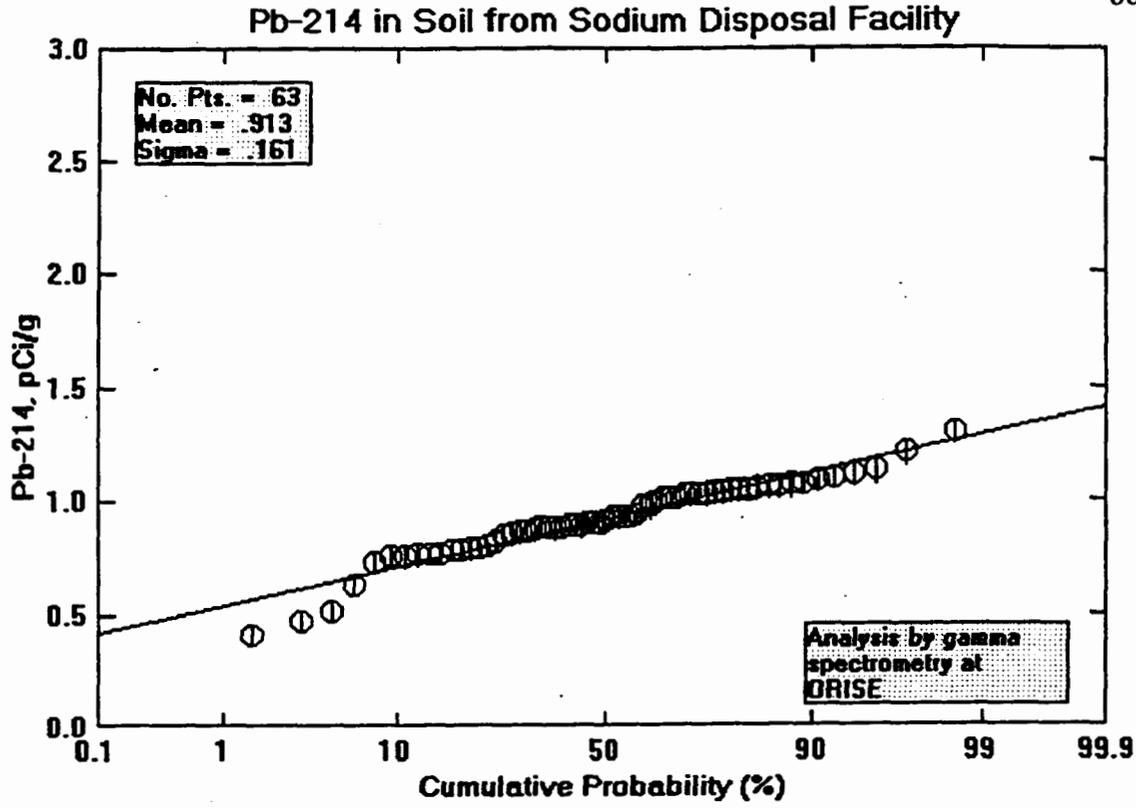
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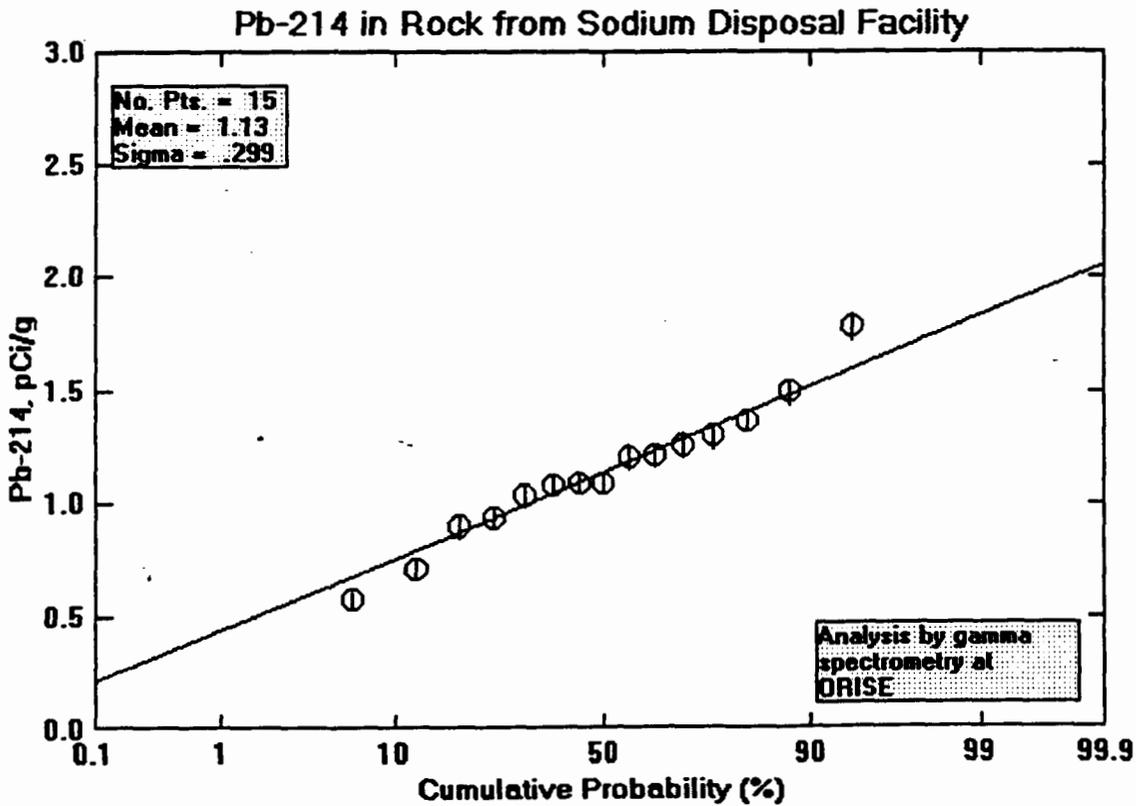
02-15-96

Figure 3c. Distribution of Pb-212 in Soil and Rock at the Former Sodium Disposal Facility.



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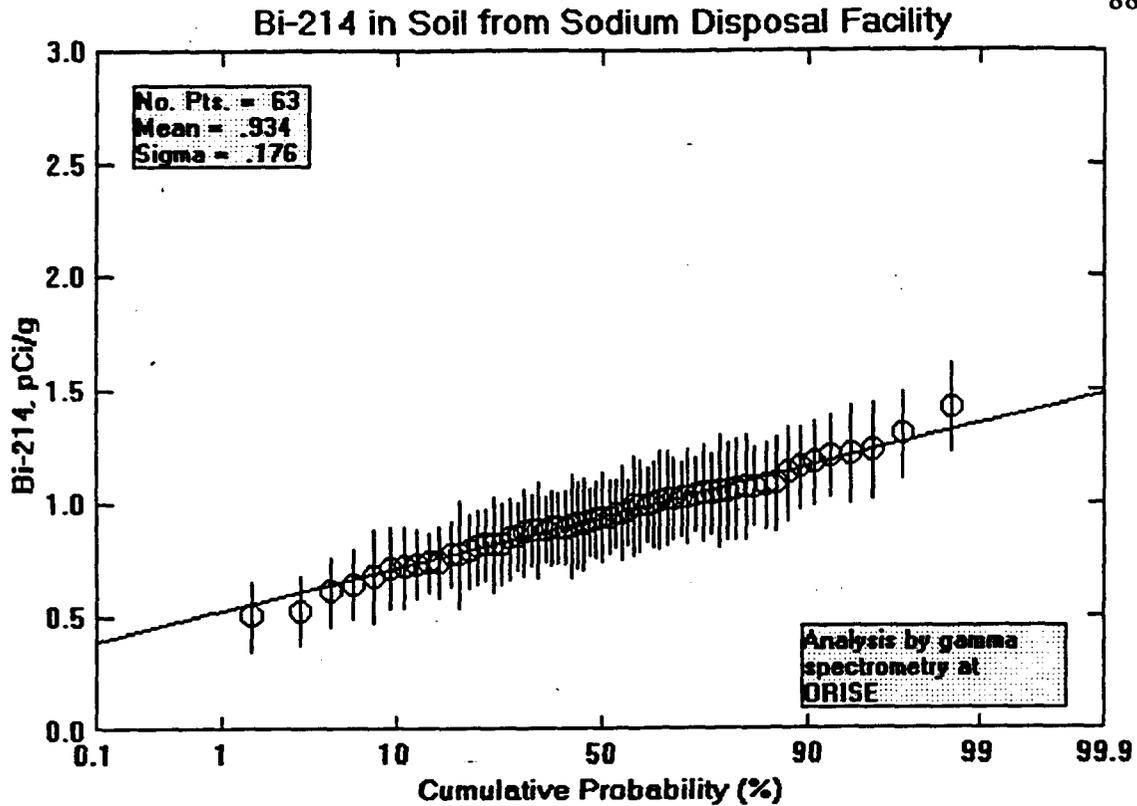
02-15-96



C:\CUMPLOT\T886R04.CMP

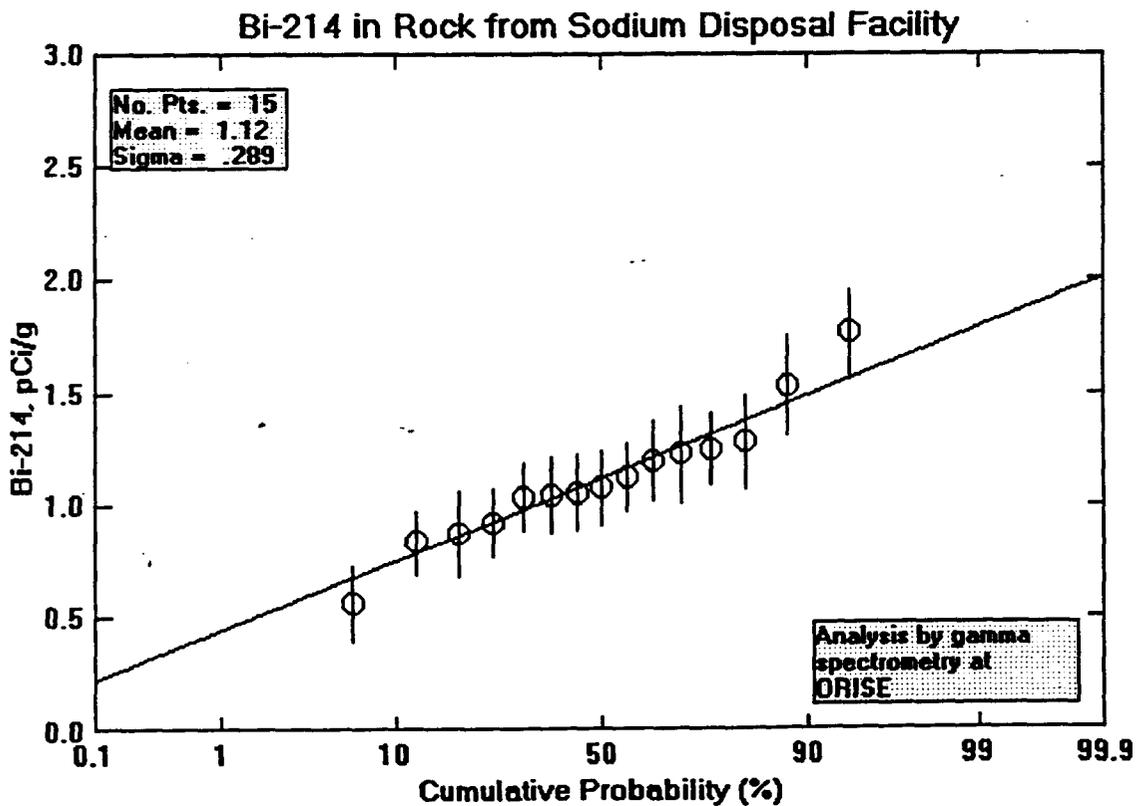
02-15-96

Figure 3d. Distribution of Pb-214 in Soil and Rock at the Former Sodium Disposal Facility.



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02-15-96

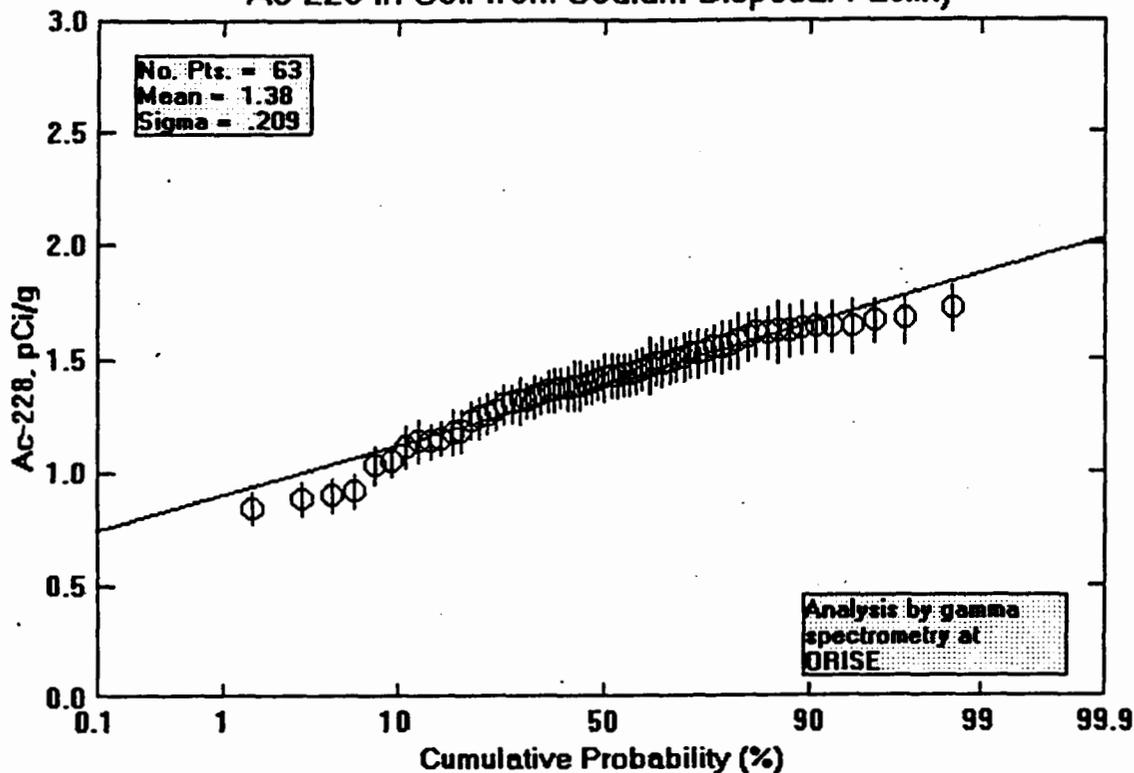


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02-15-96

Figure 3e. Distribution of Bi-214 in Soil and Rock at the Former Sodium Disposal Facility.

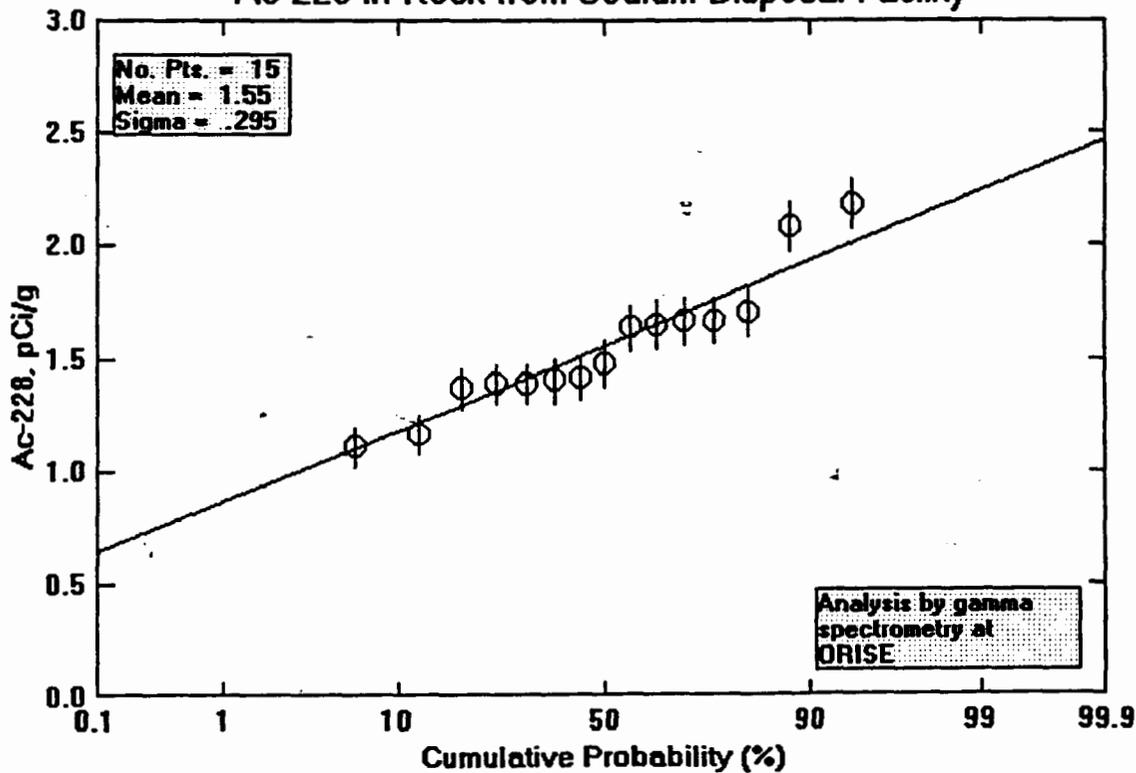
### Ac-228 in Soil from Sodium Disposal Facility



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02-15-96

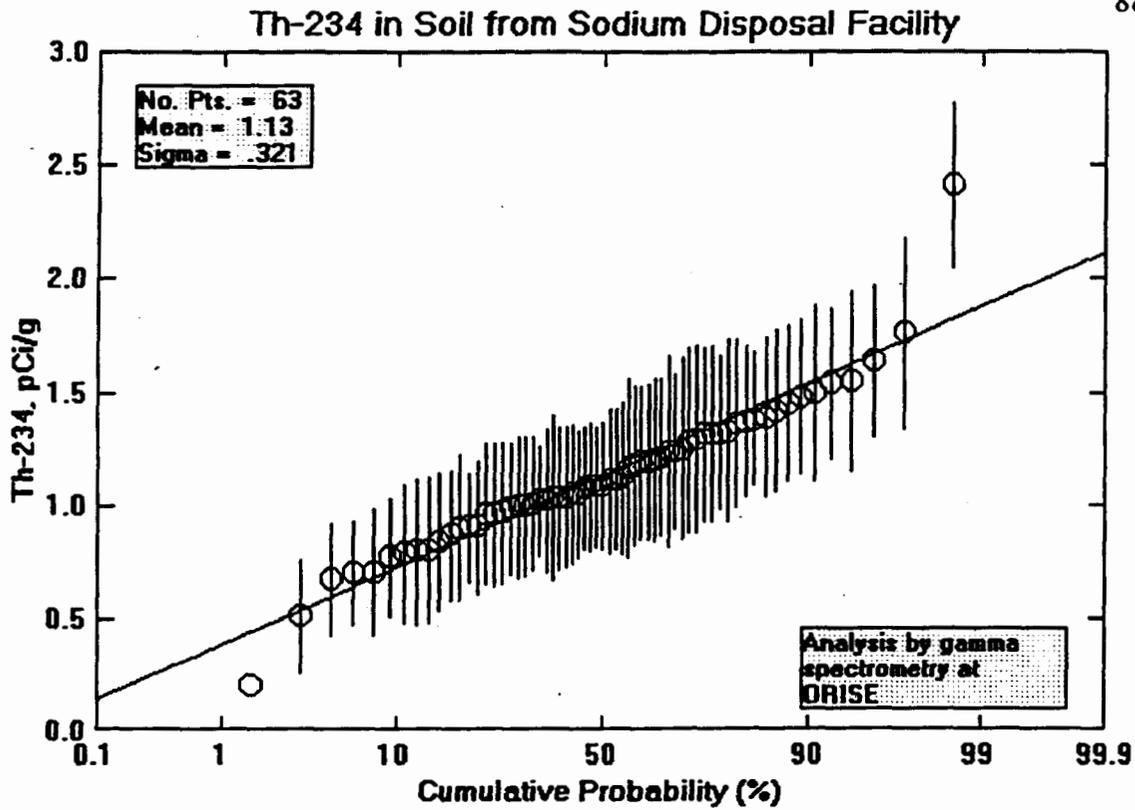
### Ac-228 in Rock from Sodium Disposal Facility



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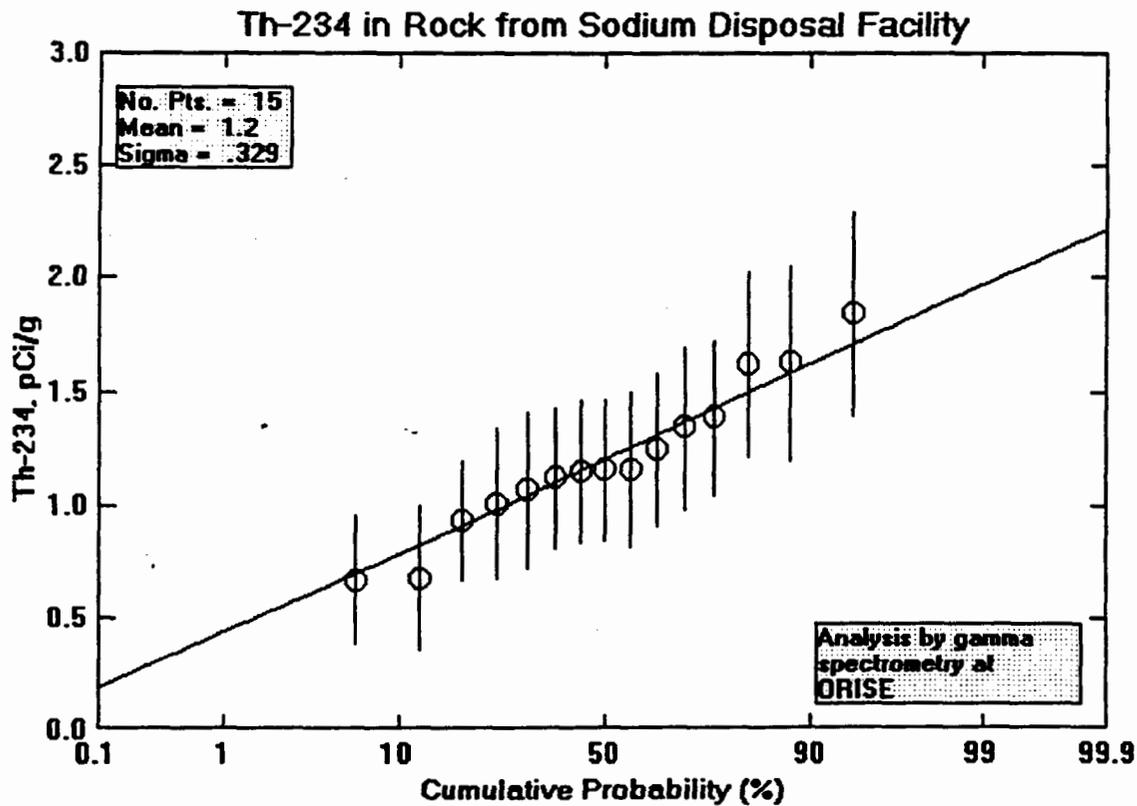
02-15-96

Figure 3f. Distribution of Ac-228 in Soil and Rock at the Former Sodium Disposal Facility.



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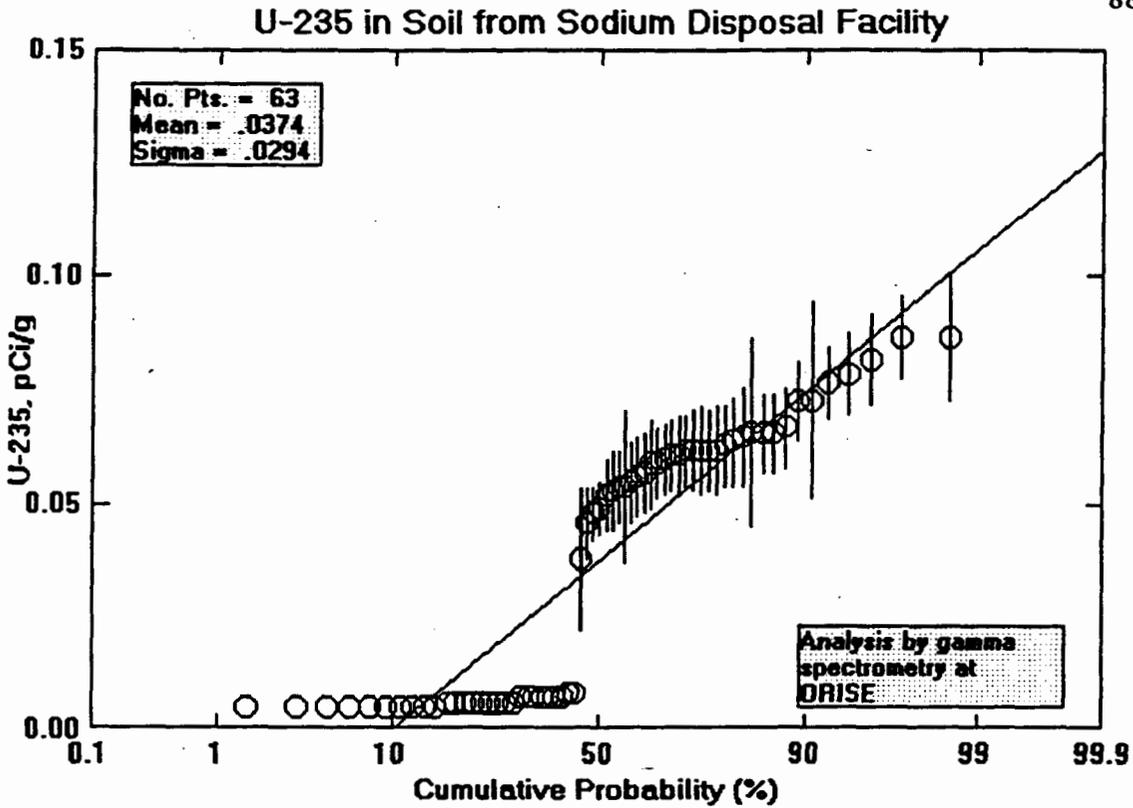
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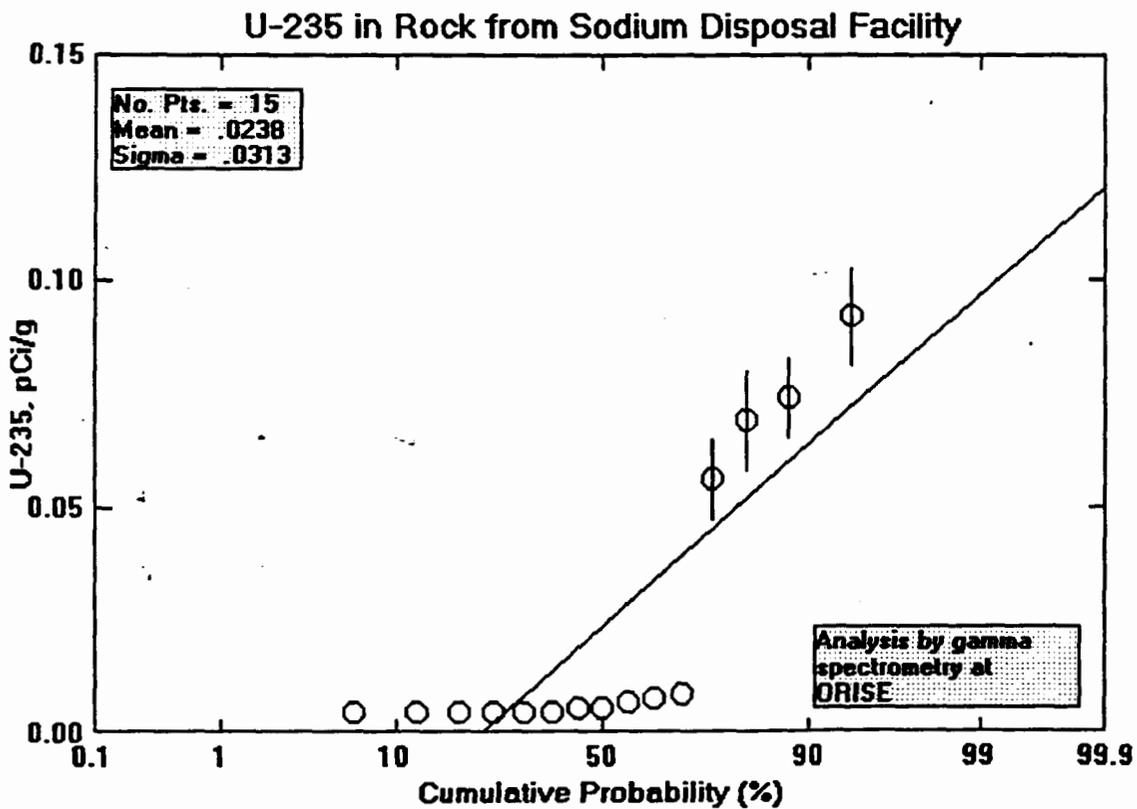
02-15-96

Figure 3g. Distribution of Th-234 in Soil and Rock at the Former Sodium Disposal Facility.



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02-15-96

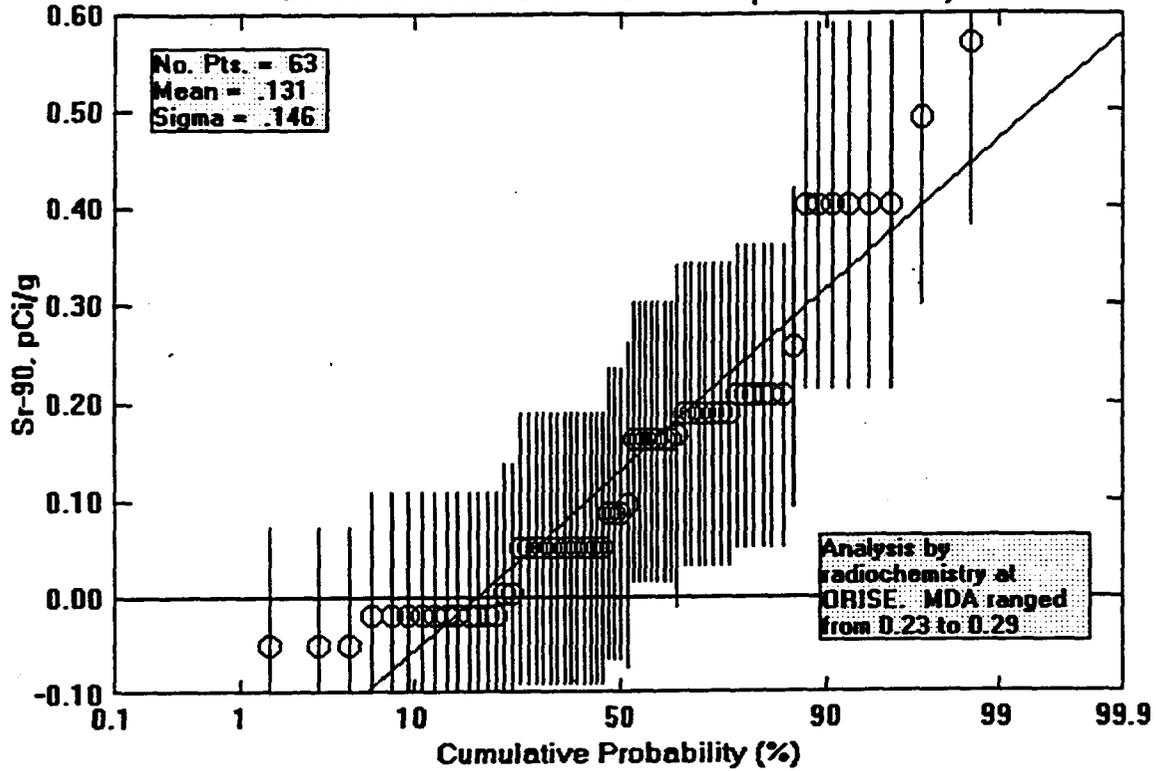


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02-15-96

Figure 3h. Distribution of U-235 in Soil and Rock at the Former Sodium Disposal Facility.

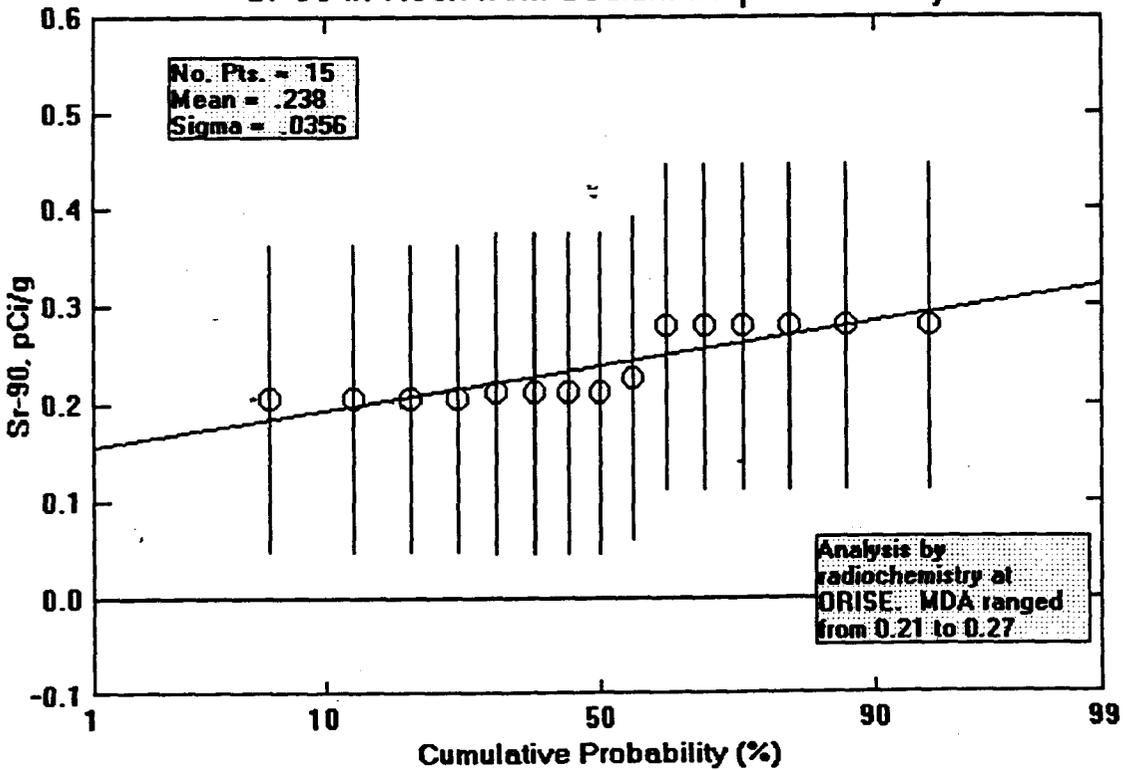
Sr-90 in Soil from Sodium Disposal Facility



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03-01-96

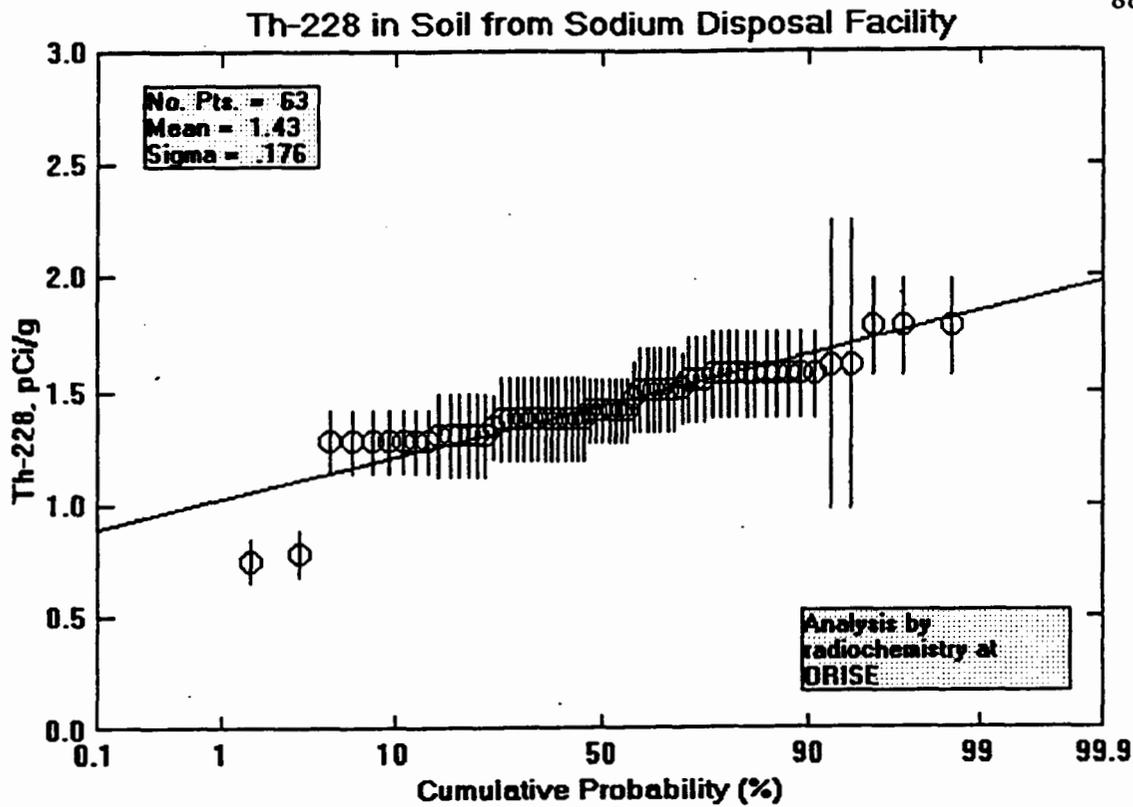
Sr-90 in Rock from Sodium Disposal Facility



C:\CUMPLOT\T886R09.CMP

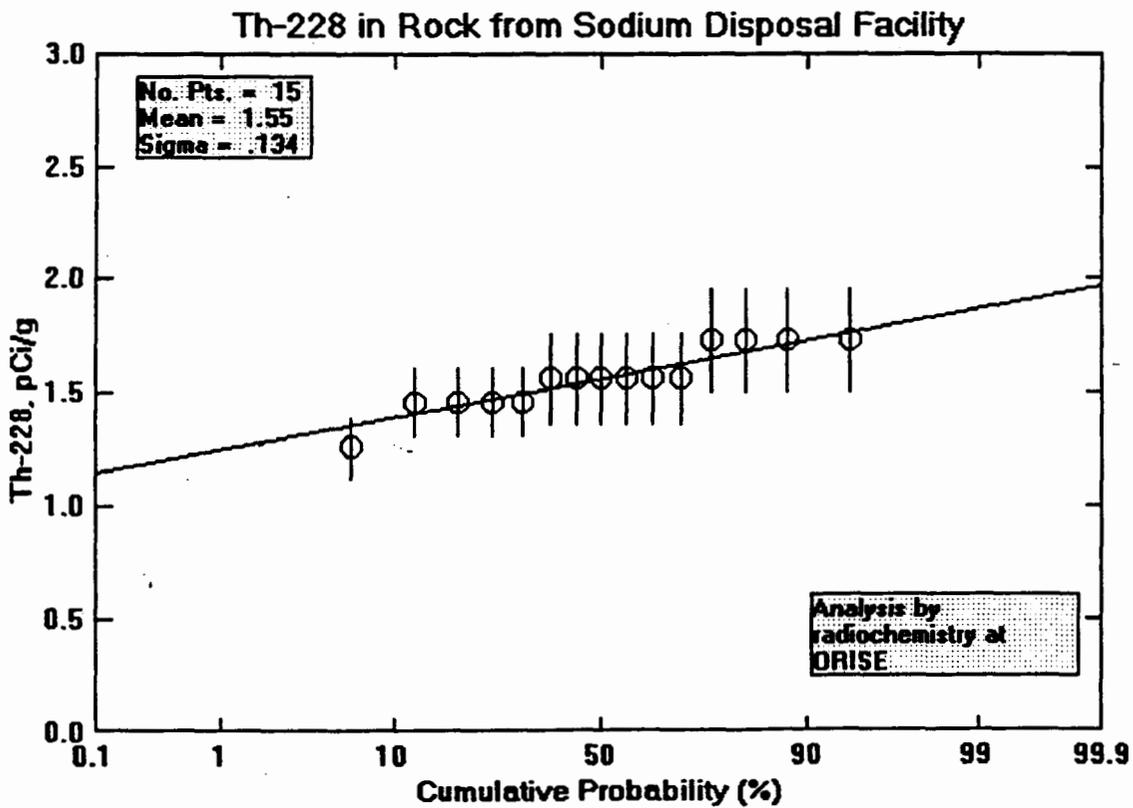
03-01-96

Figure 3i. Distribution of Sr-90 in Soil and Rock at the Former Sodium Disposal Facility.



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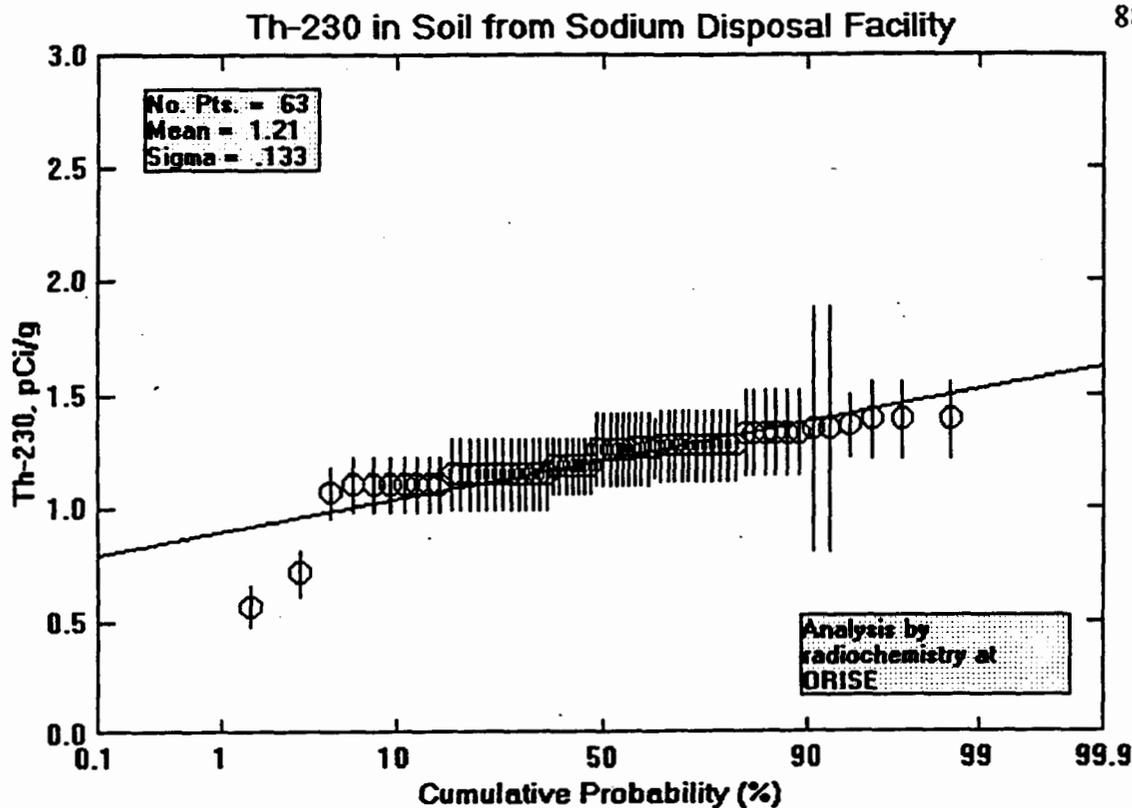
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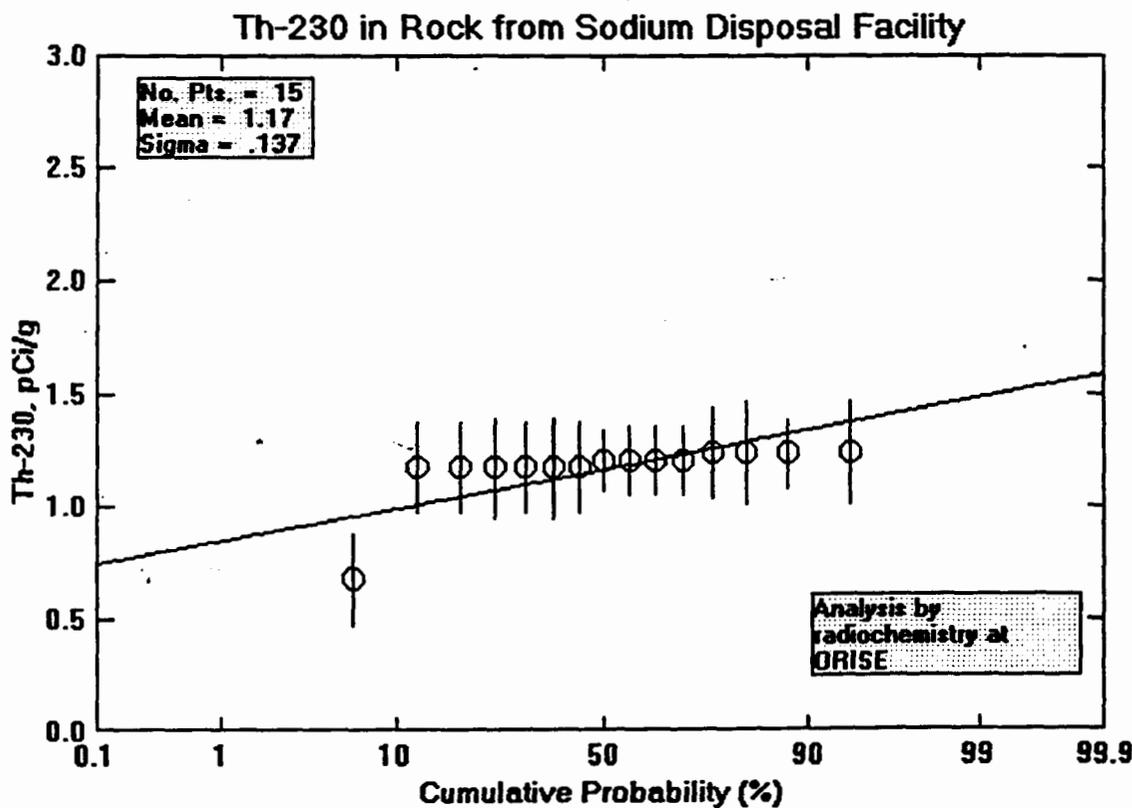
02-15-96

Figure 3j. Distribution of Th-228 in Soil and Rock at the Former Sodium Disposal Facility.



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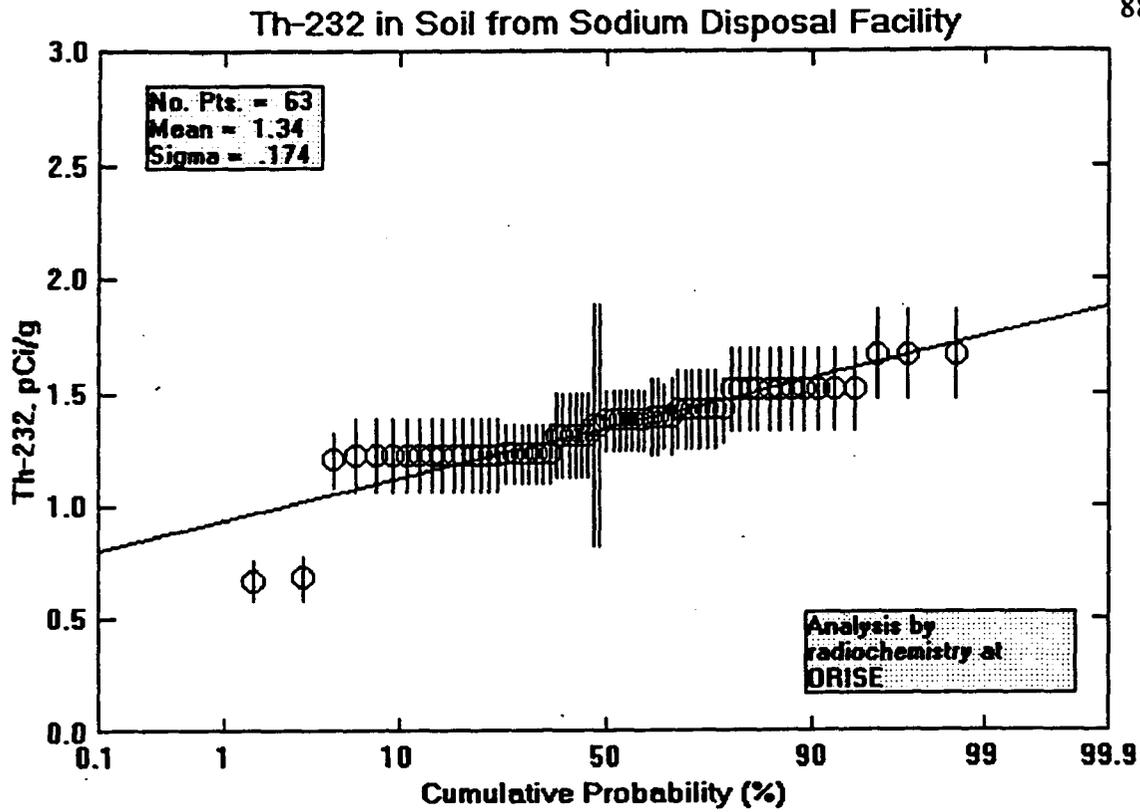
02-15-96



C:\CUMPLOT\T886R11.CMP

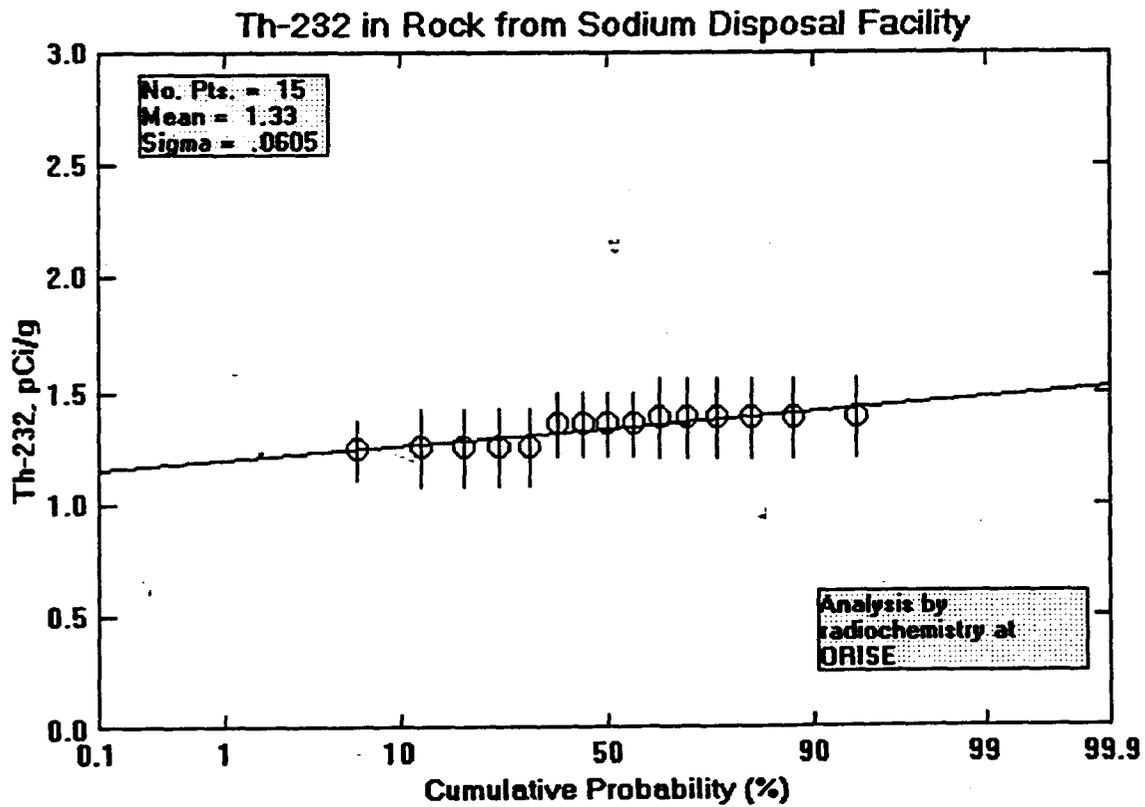
02-15-96

Figure 3k. Distribution of Th-230 in Soil and Rock at the Former Sodium Disposal Facility.



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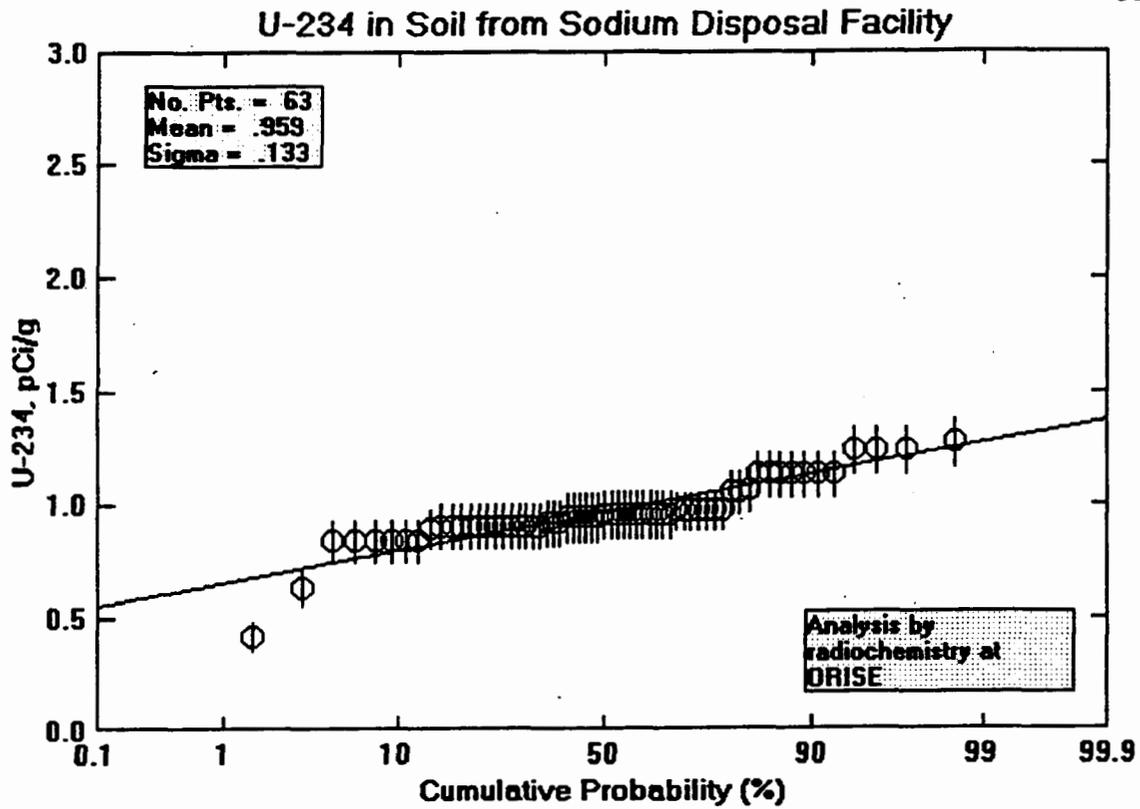
02-15-96



C:\CUMPLOT\T886R12.CMP

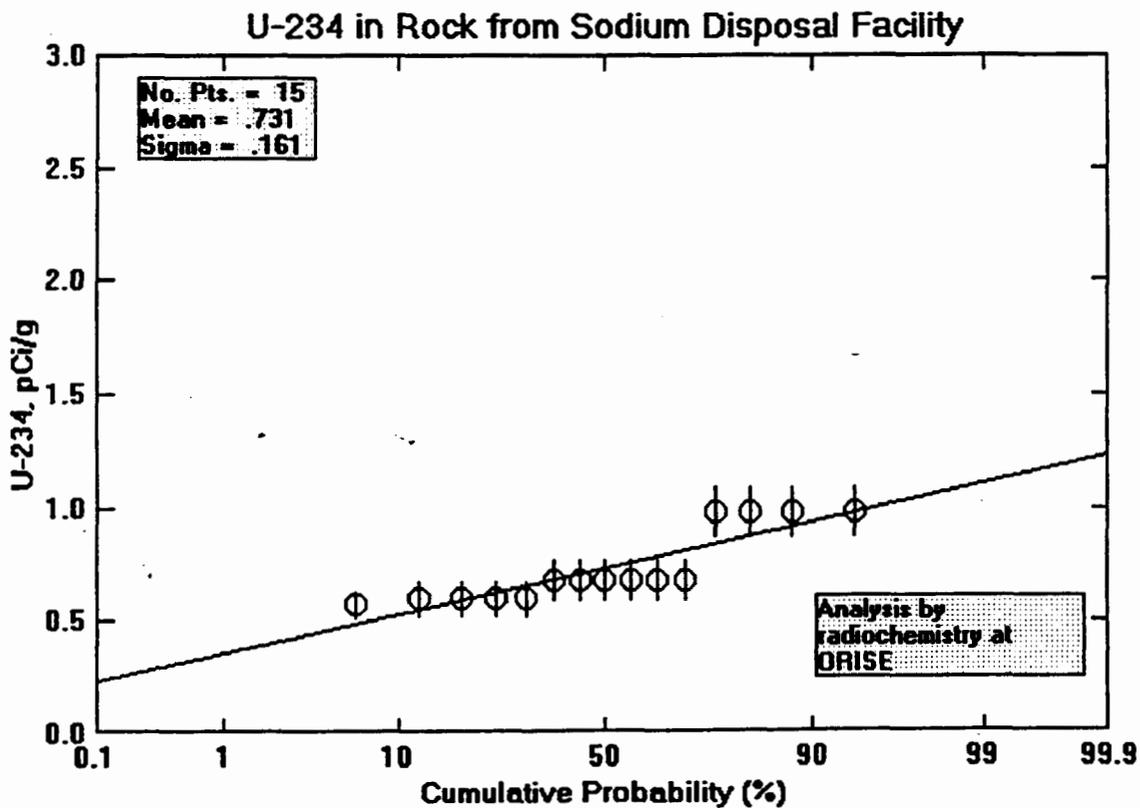
02-15-96

Figure 31. Distribution of Th-232 in Soil and Rock at the Former Sodium Disposal Facility.



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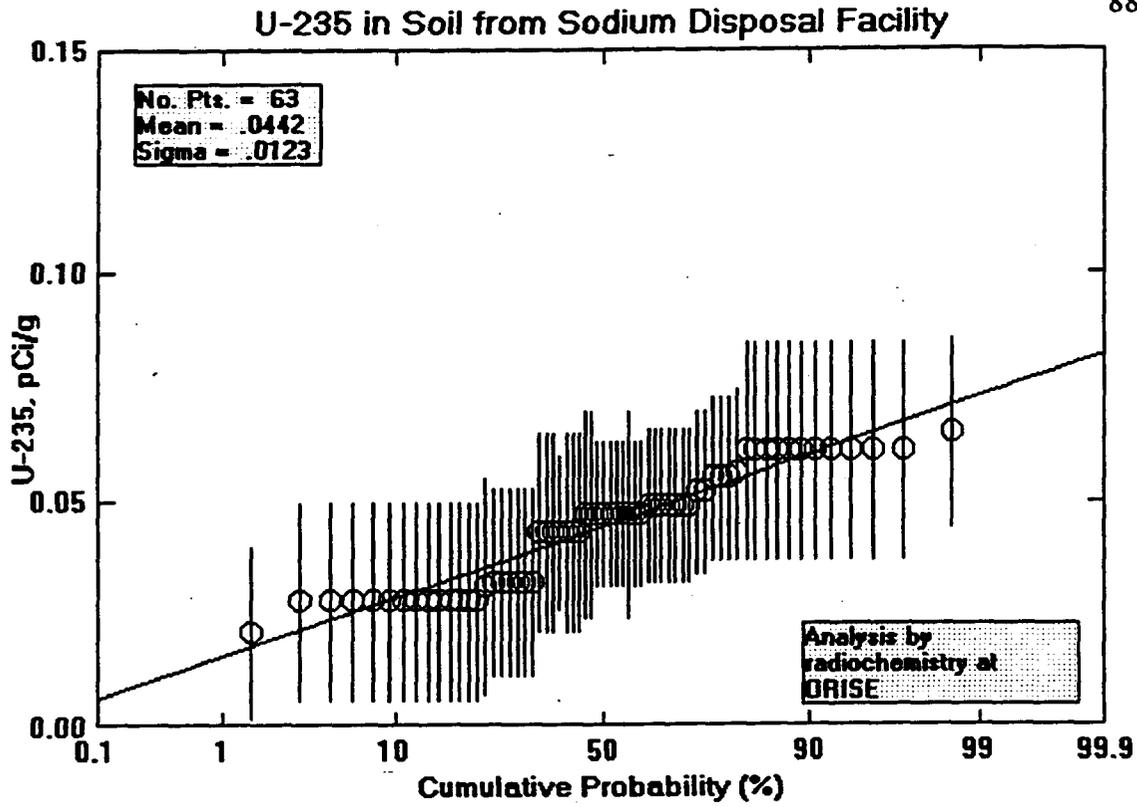
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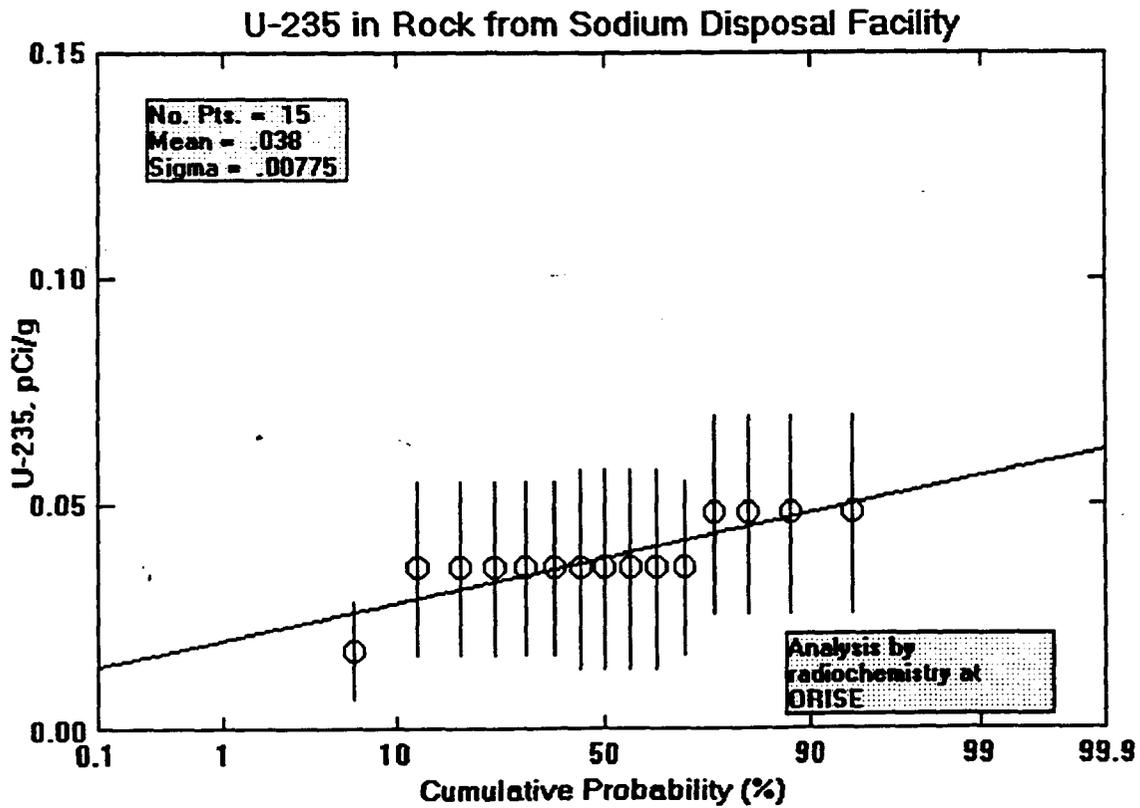
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Figure 3m. Distribution of U-234 in Soil and Rock at the Former Sodium Disposal Facility.



C:\CUMPLOT\T886S14.CMP

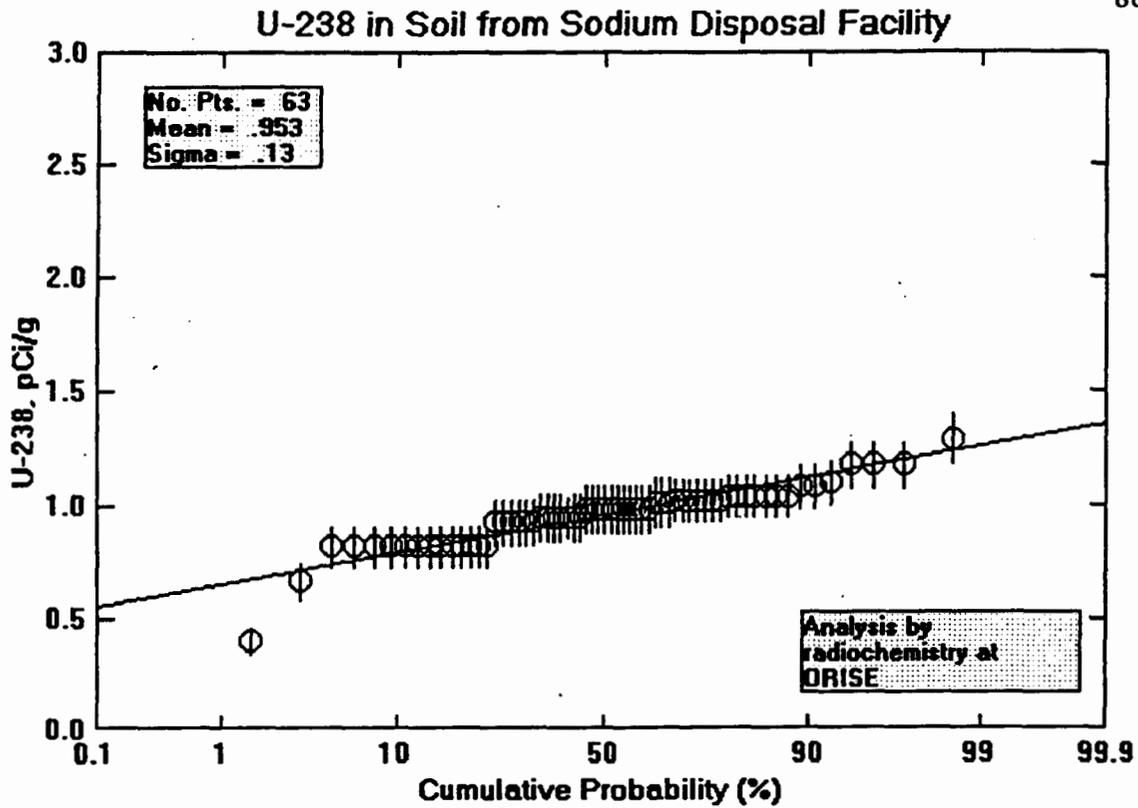
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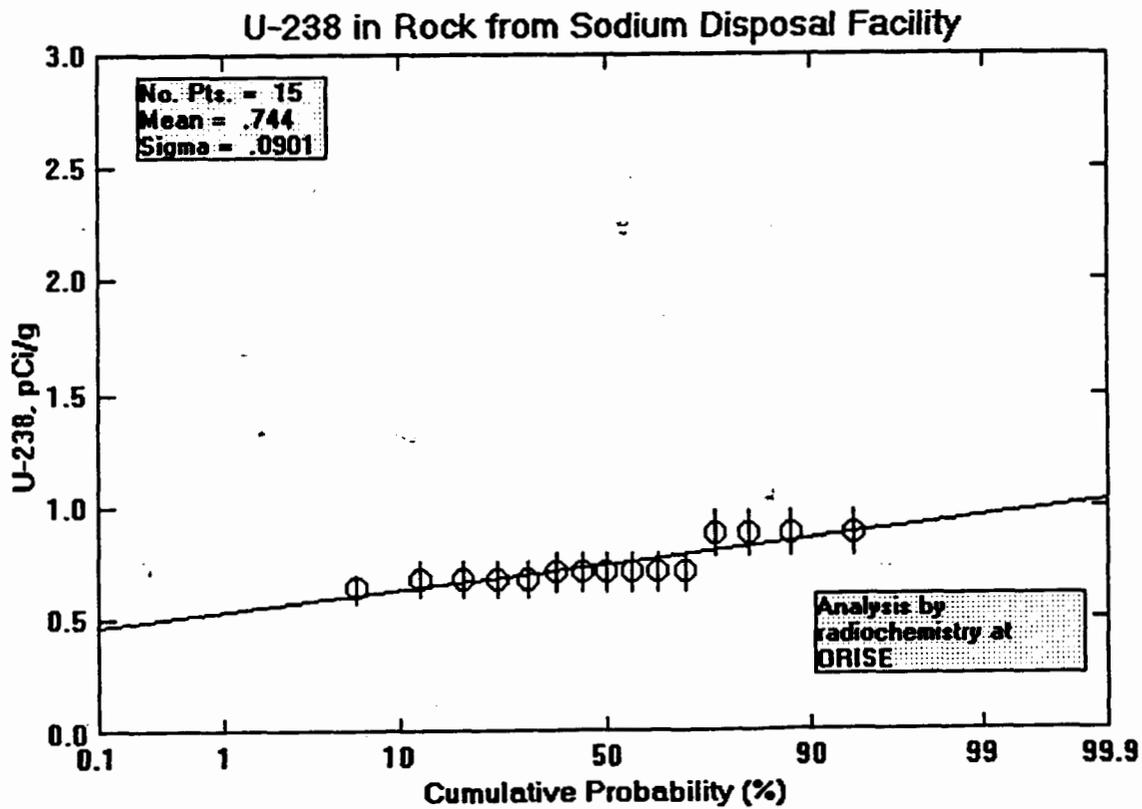
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Figure 3n. Distribution of U-235 in Soil and Rock at the Former Sodium Disposal Facility.



C:\CUMPLOT\T886S15.CMP

02-15-96

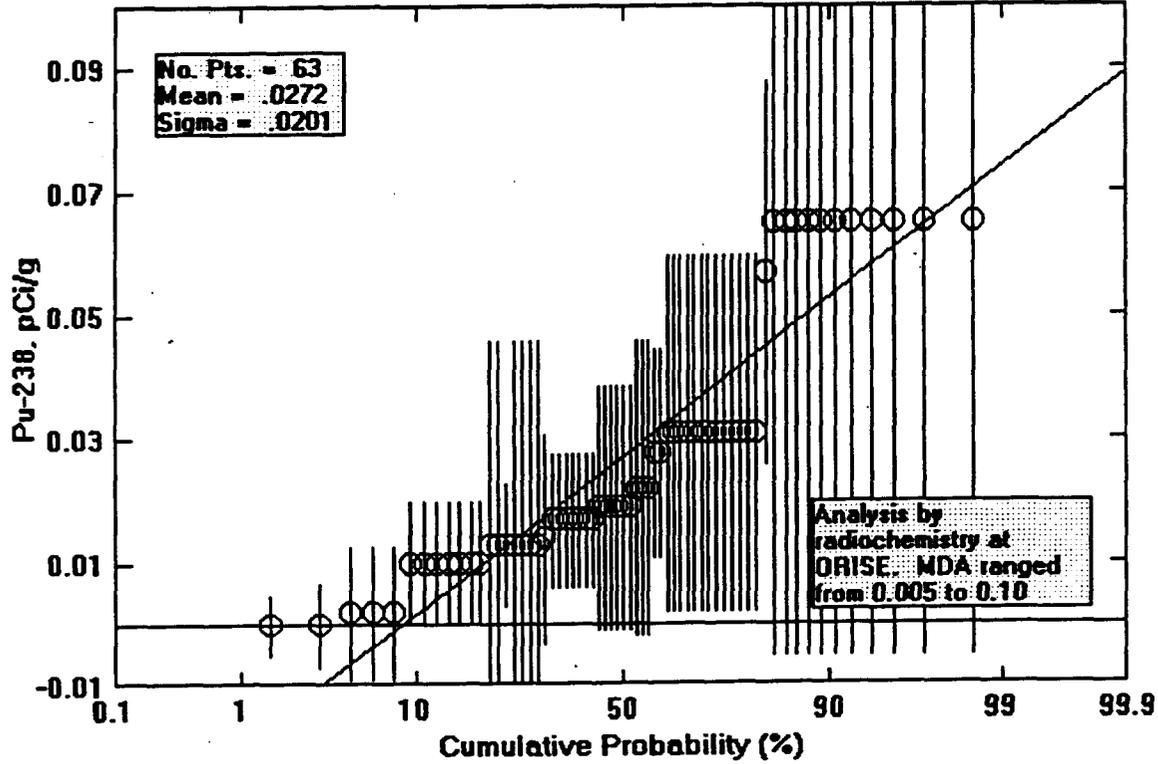


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02-15-96

Figure 3o. Distribution of U-238 in Soil and Rock at the Former Sodium Disposal Facility.

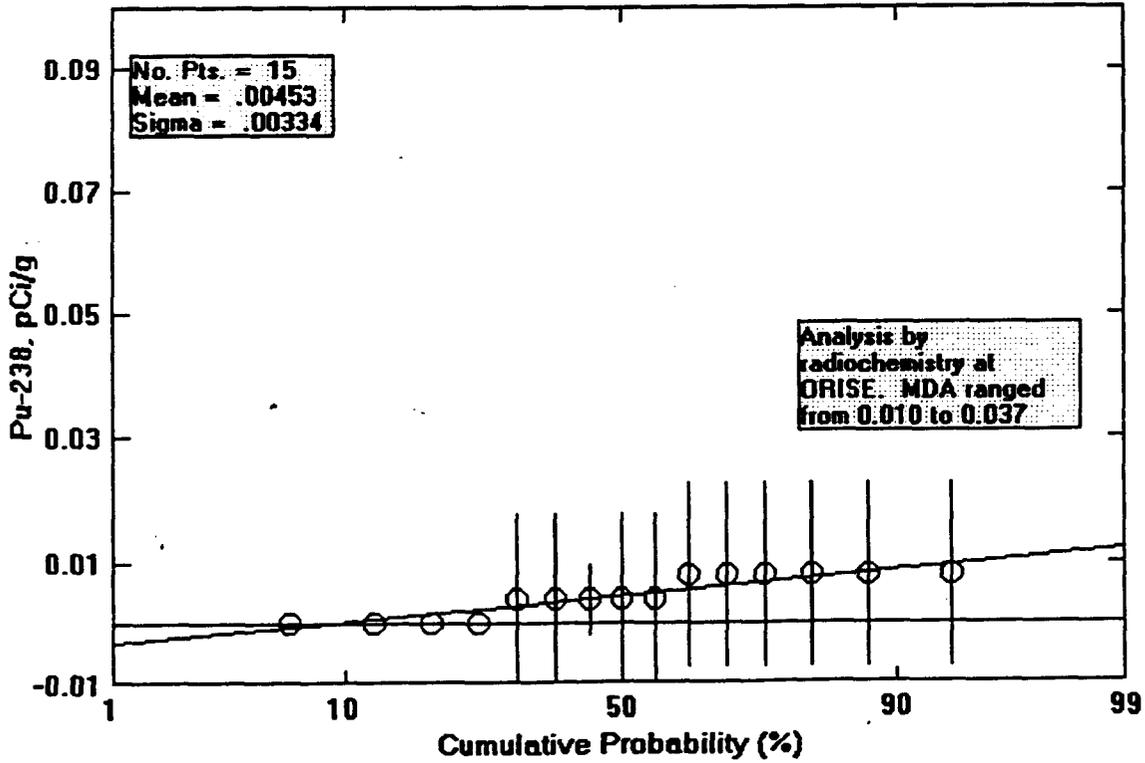
Pu-238 in Soil from Sodium Disposal Facility



C:\CUMPLOT\T886S16.CMP

03-01-96

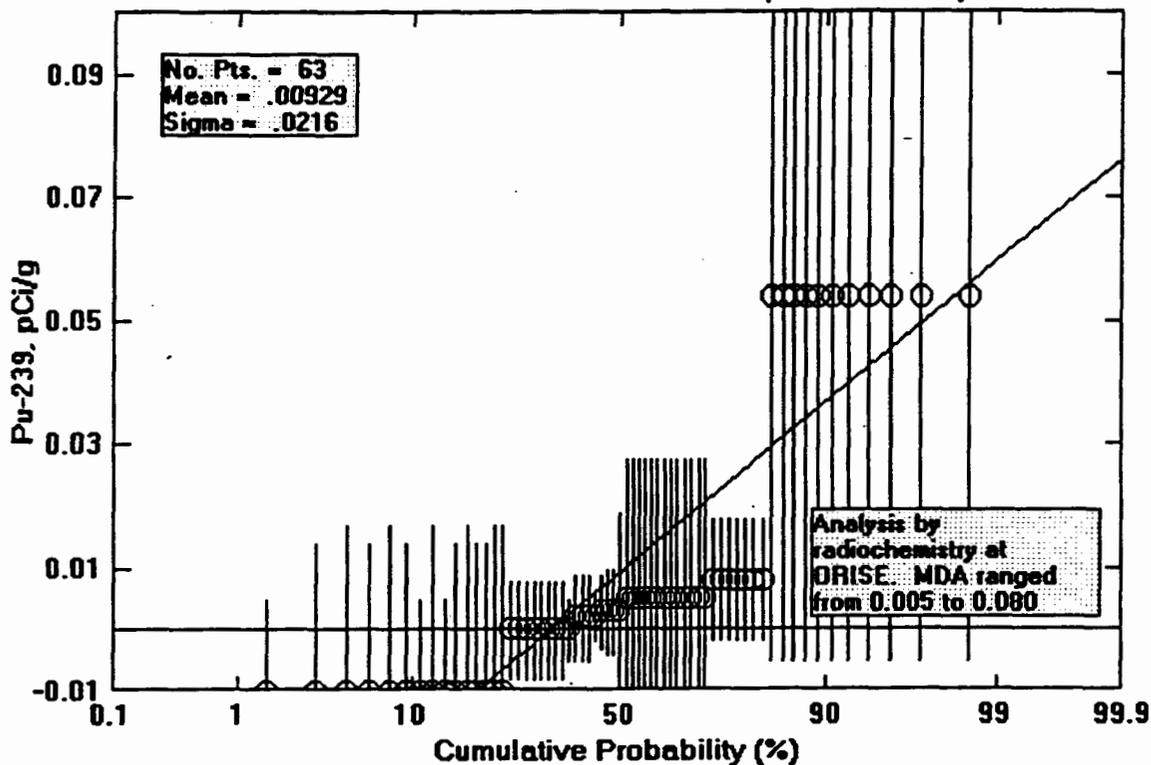
Pu-238 in Rock from Sodium Disposal Facility



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03-01-96

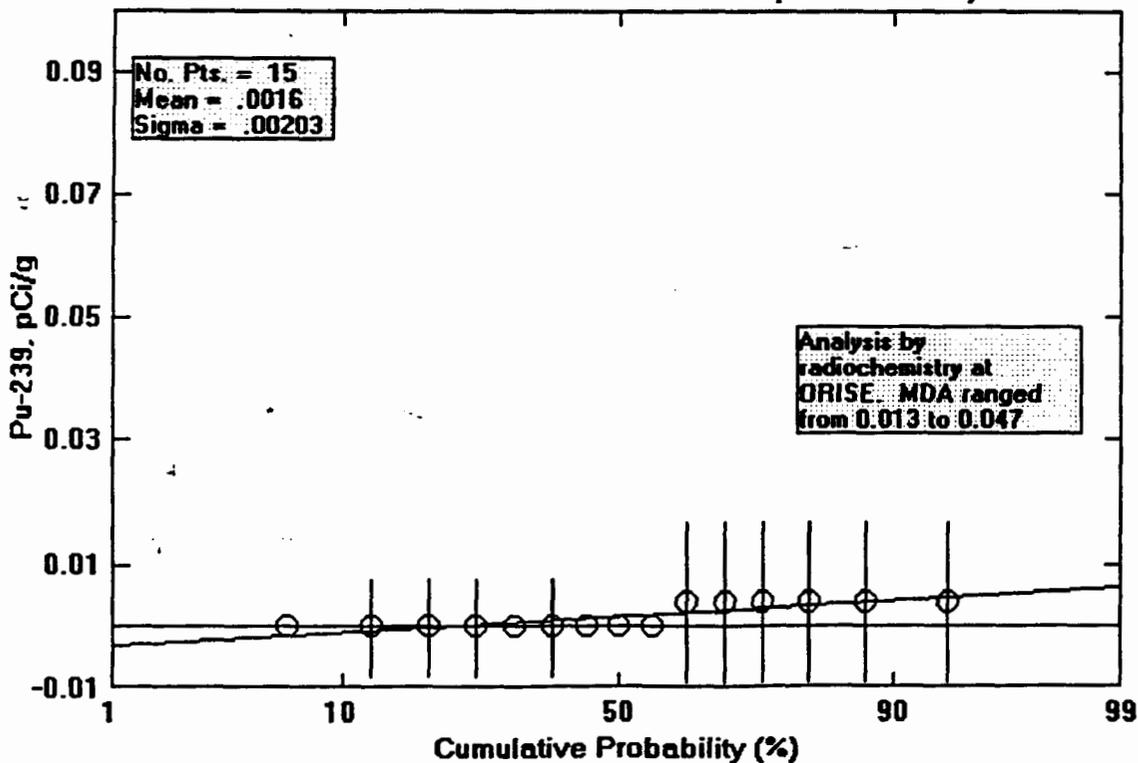
Figure 3p. Distribution of Pu-238 in Soil and Rock at the Former Sodium Disposal Facility.



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03-01-96

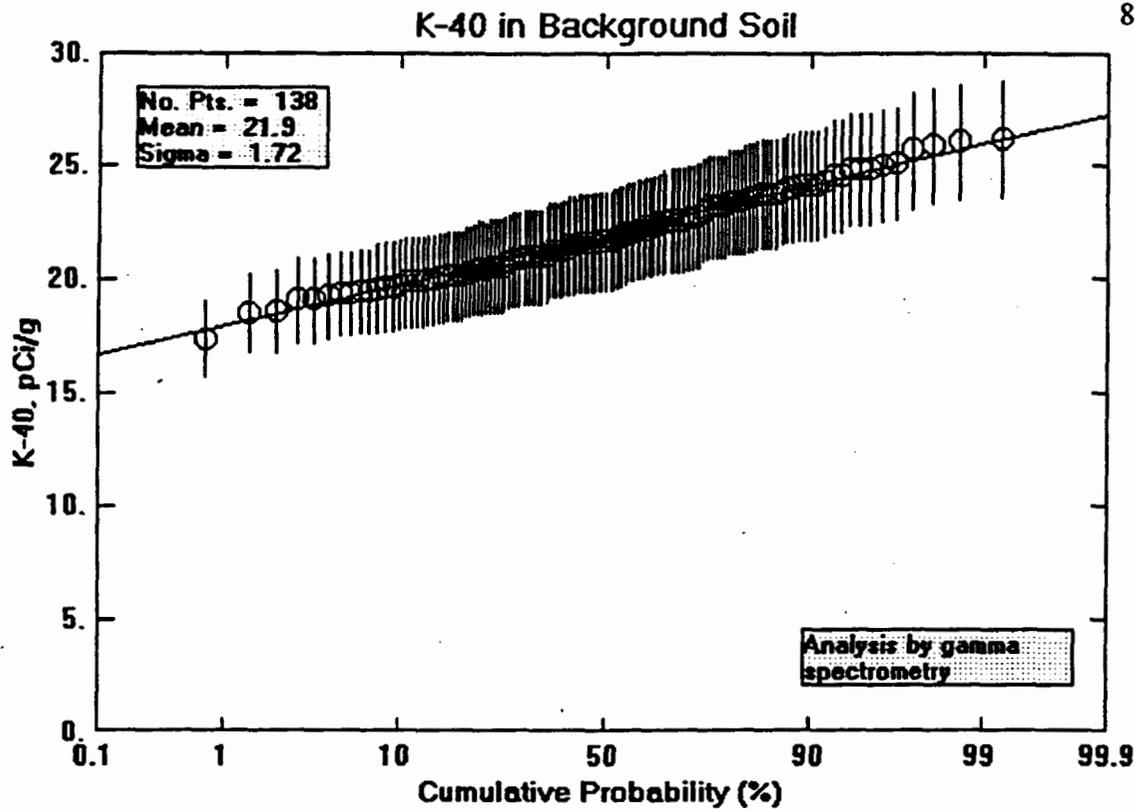
Pu-239 in Rock from Sodium Disposal Facility



C:\CUMPLOT\T886R17.CMP

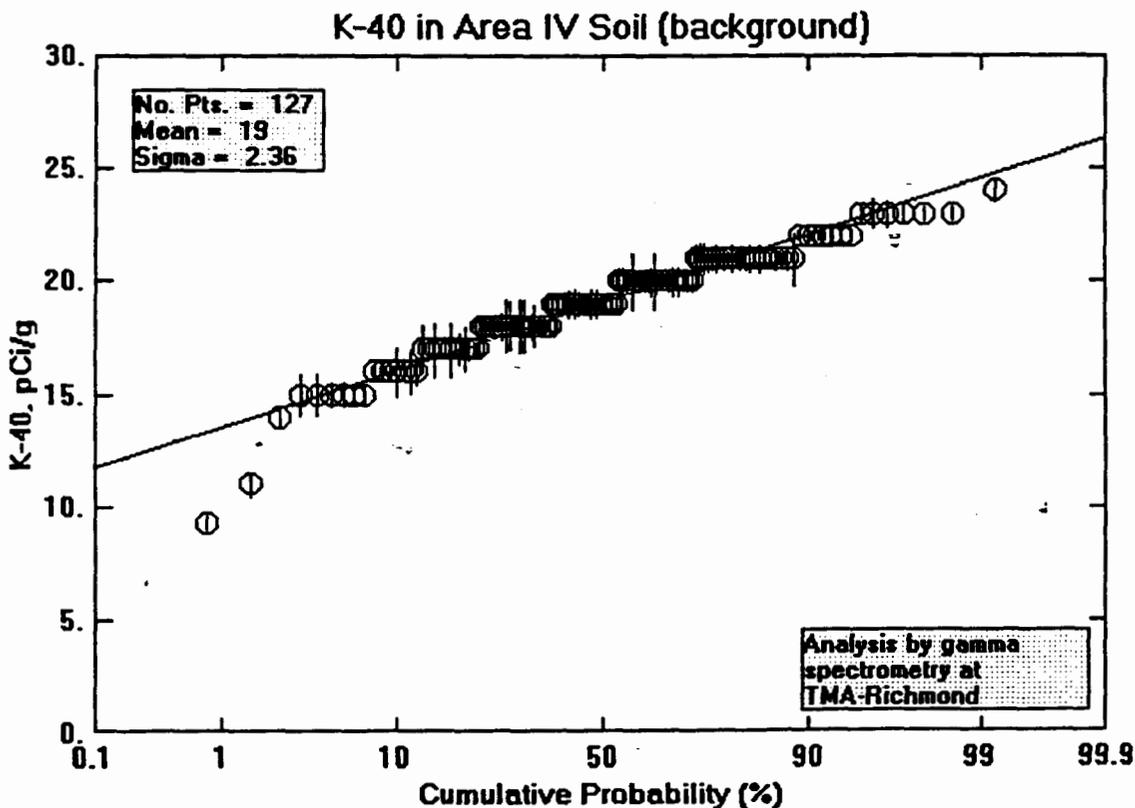
03-01-96

Figure 3q. Distribution of Pu-239 in Soil and Rock at the Former Sodium Disposal Facility.



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02-16-96

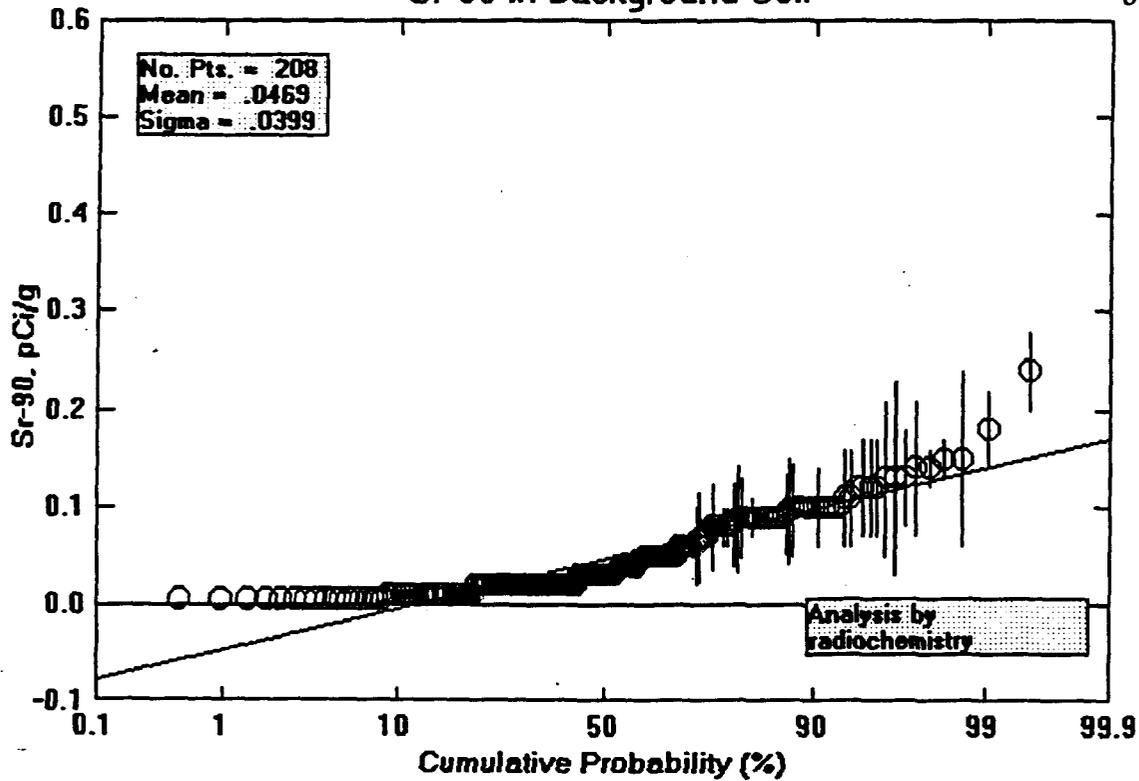


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02-16-96

Figure 4a. Distribution of K-40 in Background Soil.

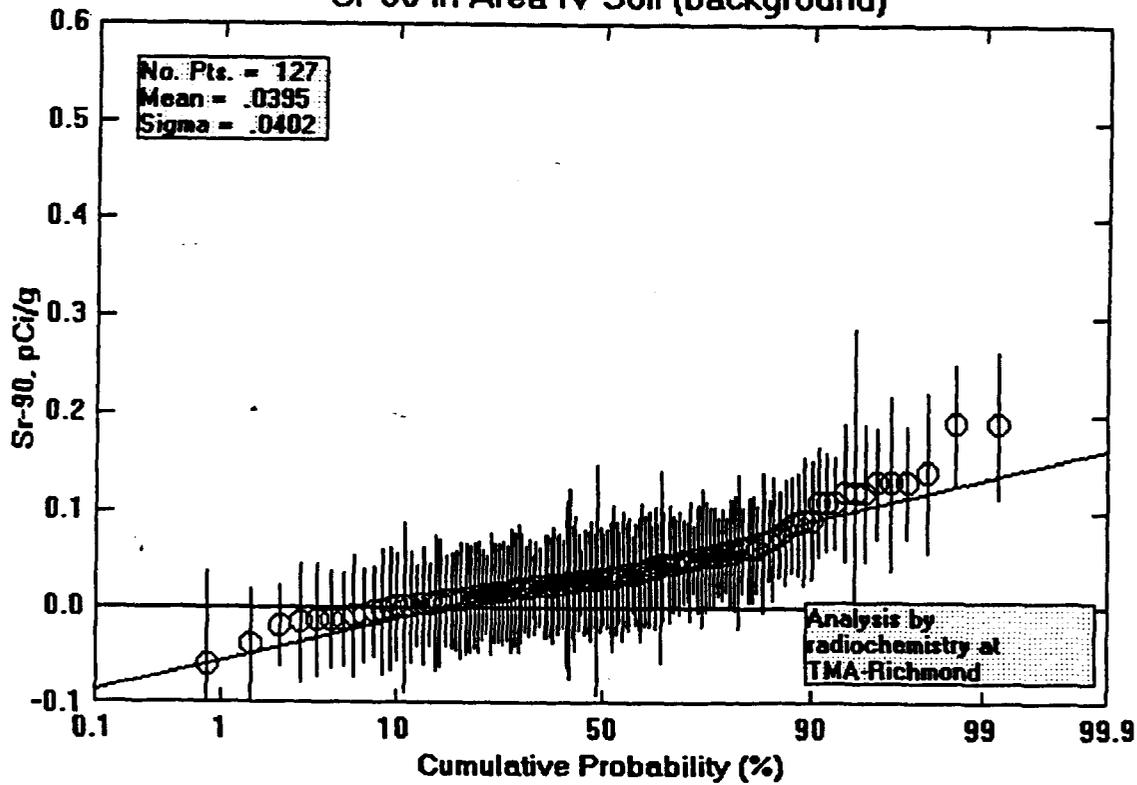
Sr-90 in Background Soil



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02-16-96

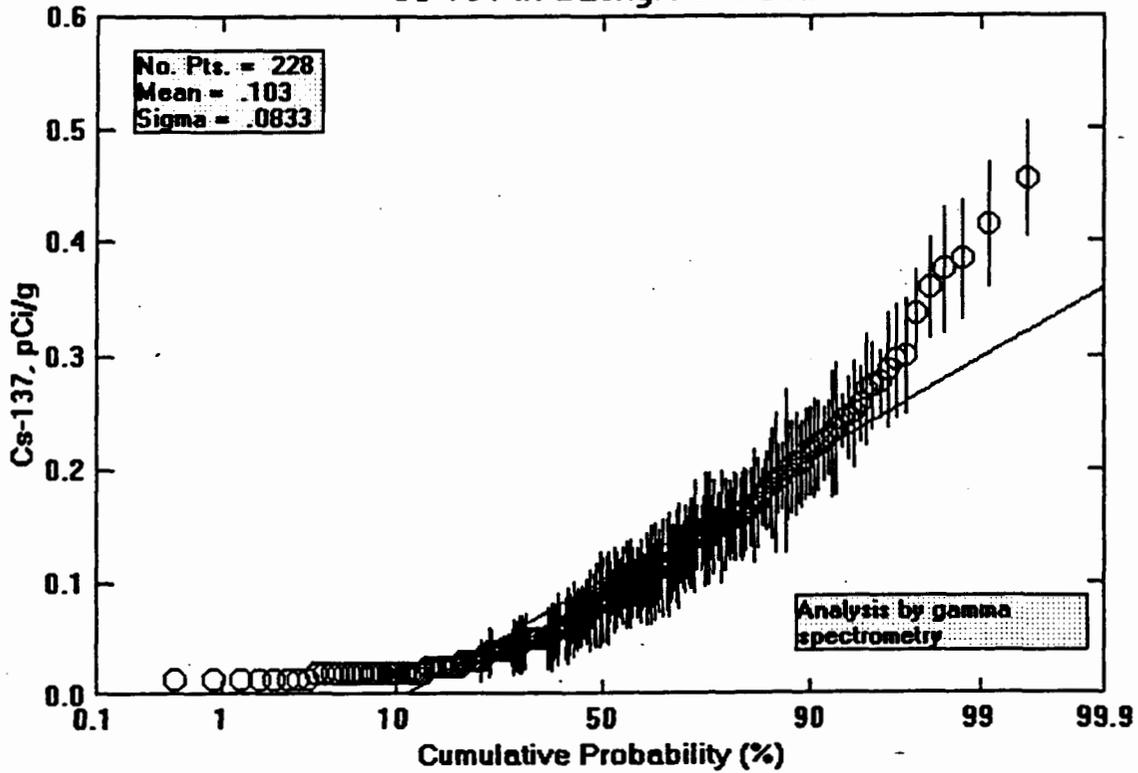
Sr-90 in Area IV Soil (background)



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02-16-96

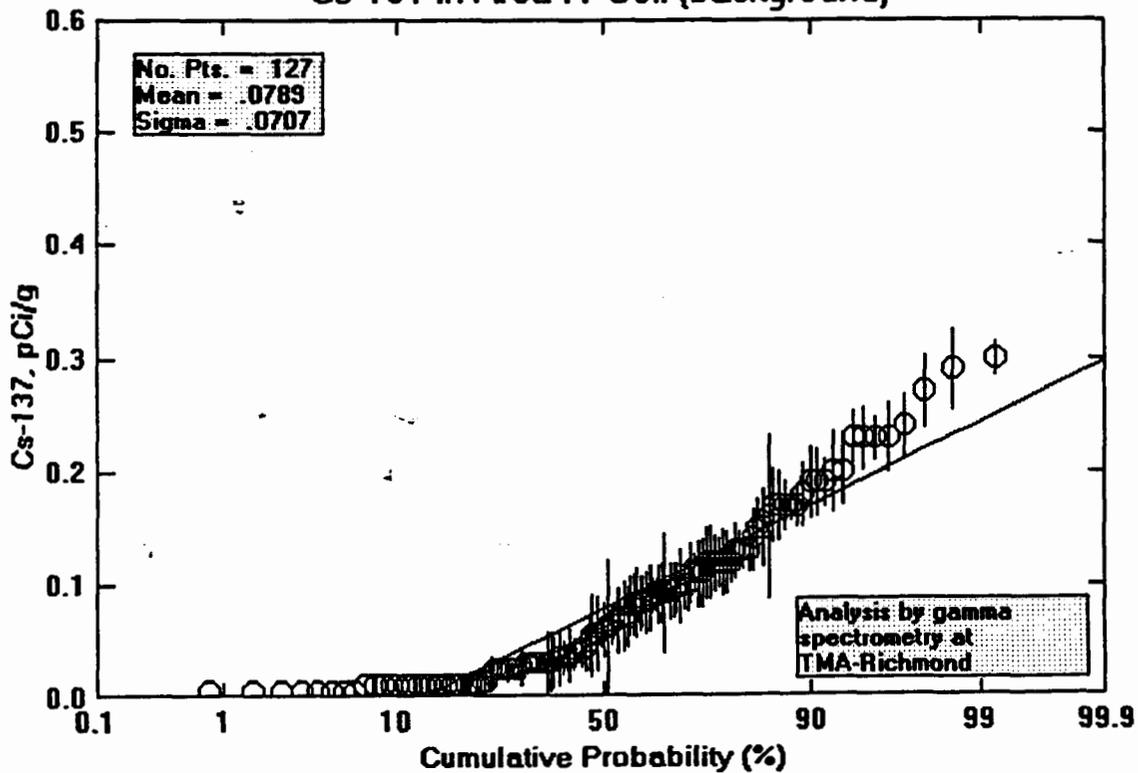
Figure 4b. Distribution of Sr-90 in Background Soil.



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Cs-137 in Area IV Soil (background)



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02-16-96

Figure 4c. Distribution of Cs-137 in Background Soil.

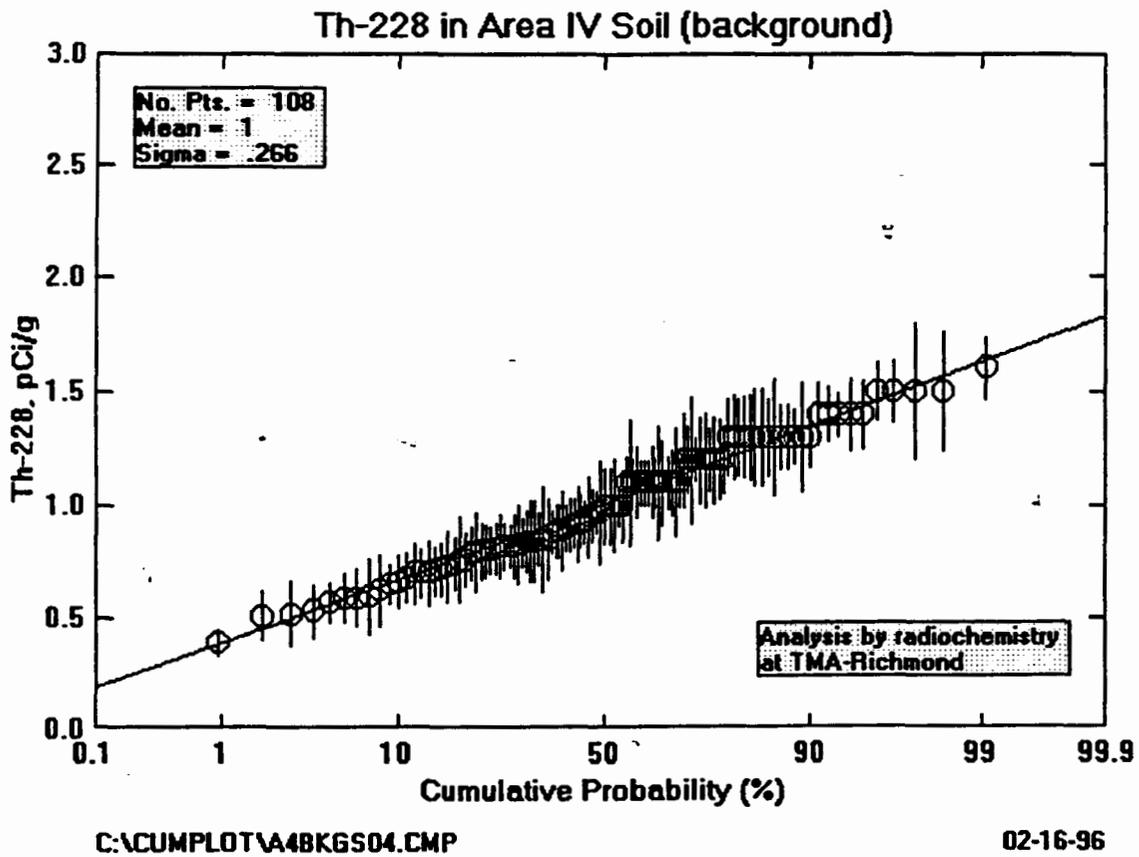
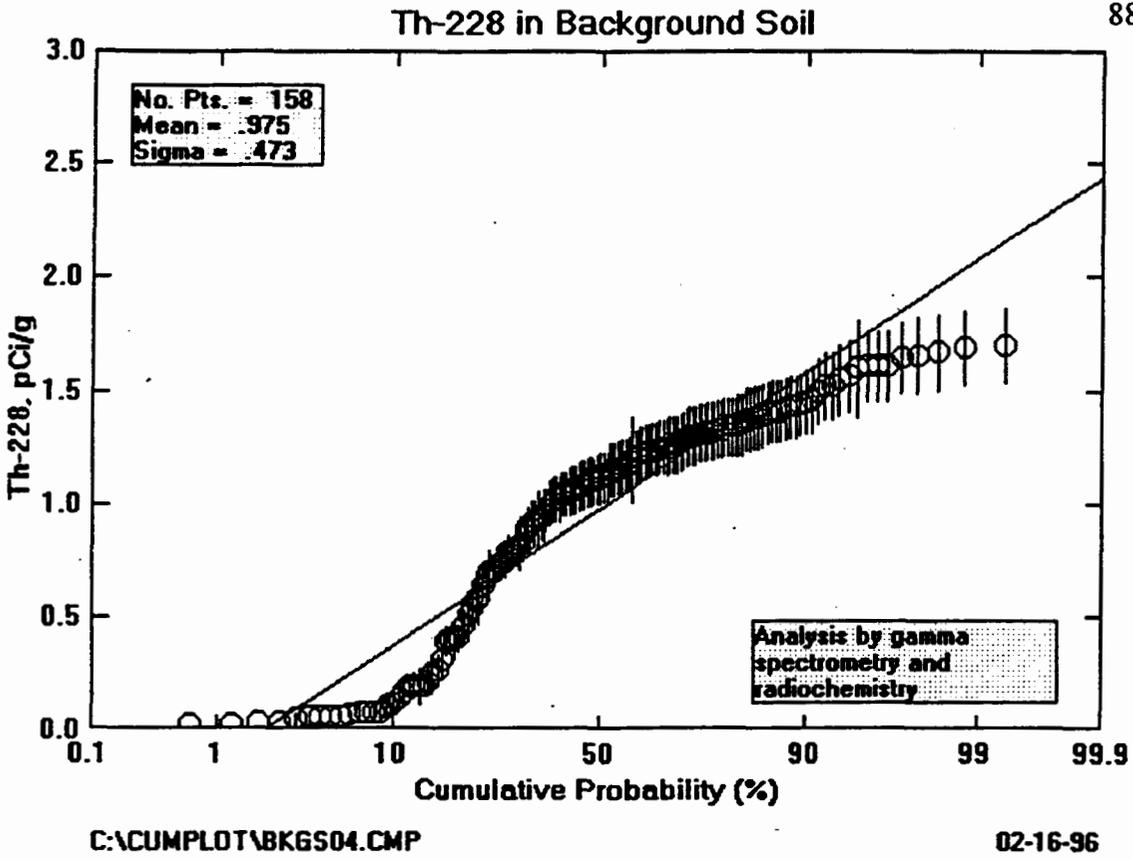


Figure 4d. Distribution of Th-228 in Background Soil.

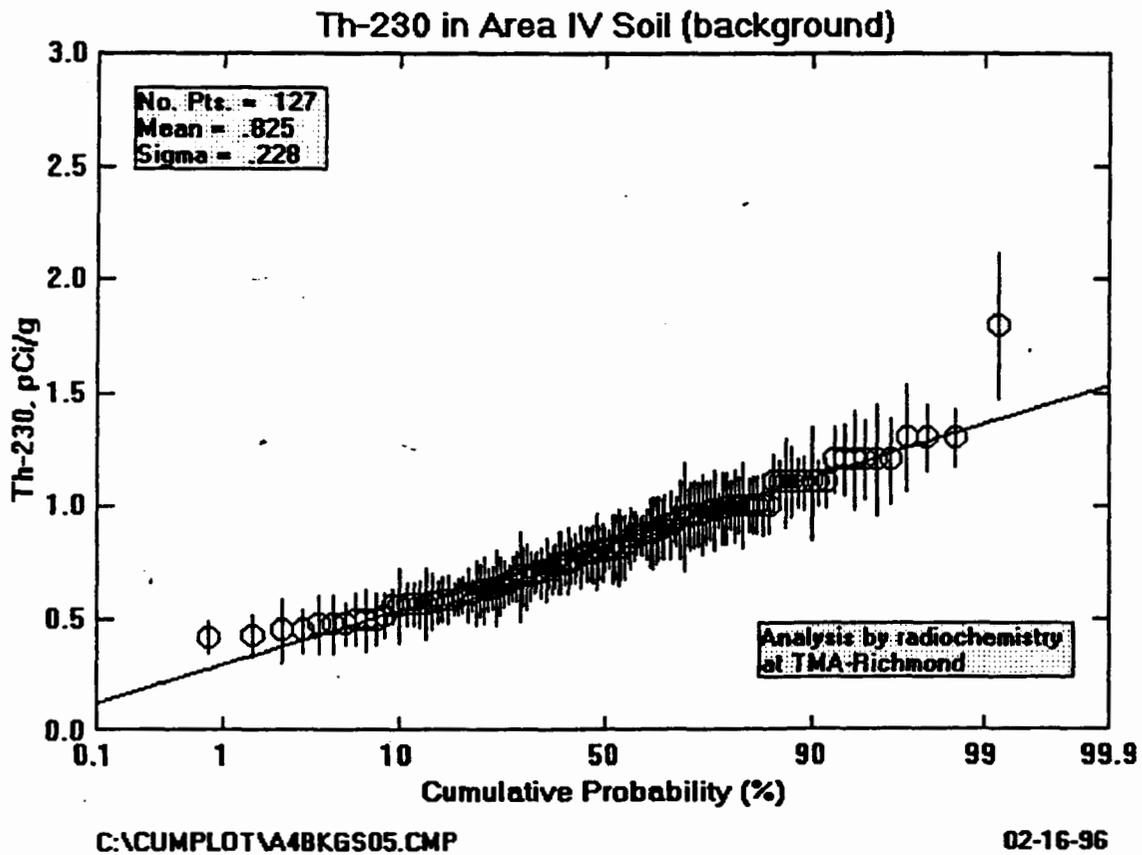
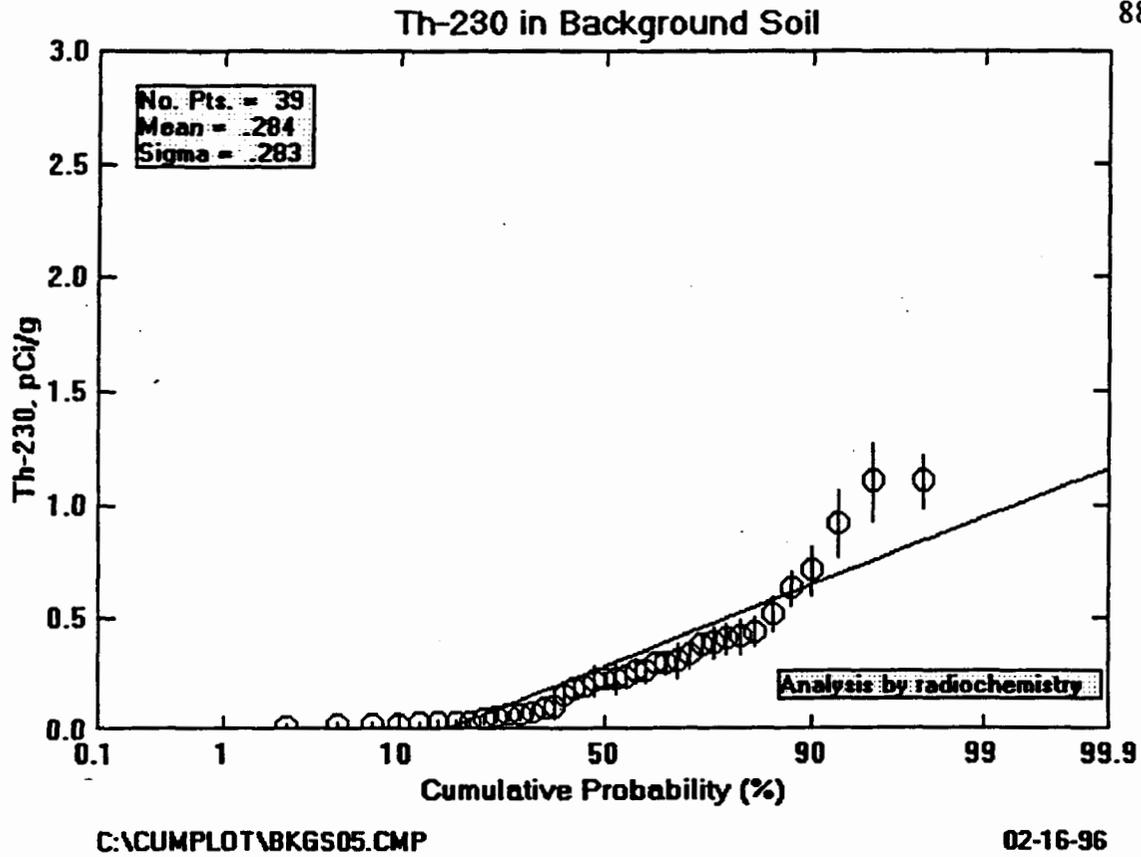
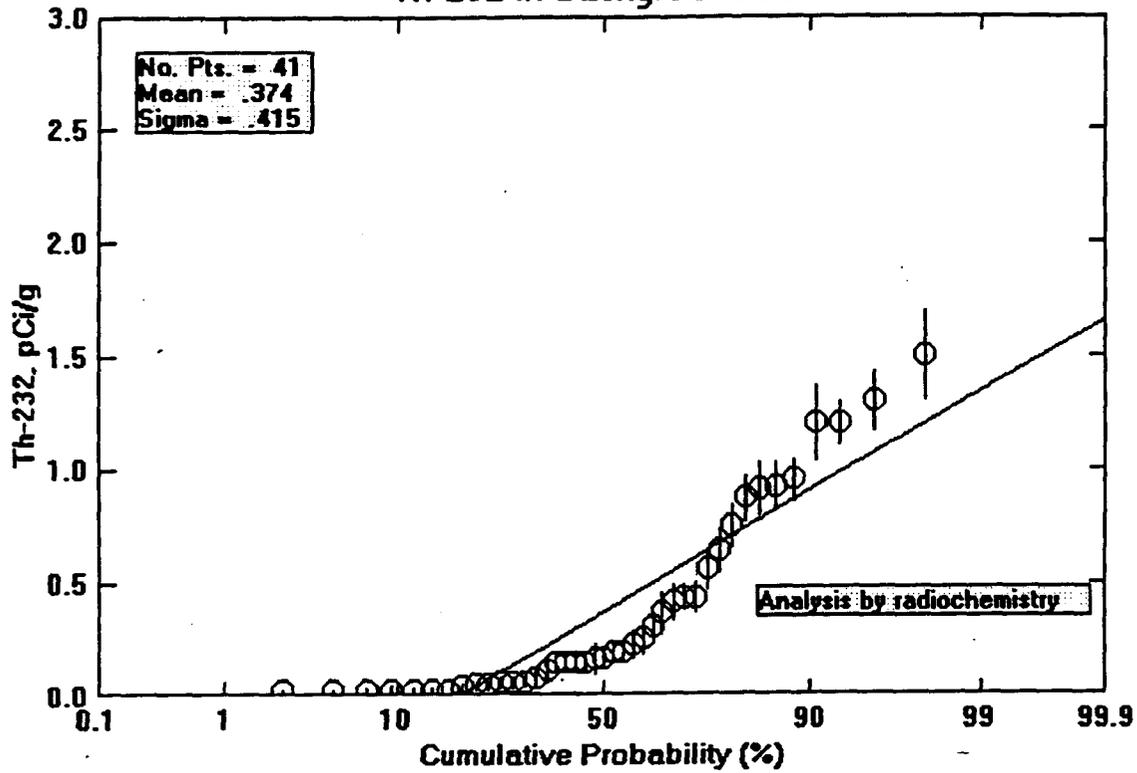


Figure 4e. Distribution of Th-230 in Background Soil.

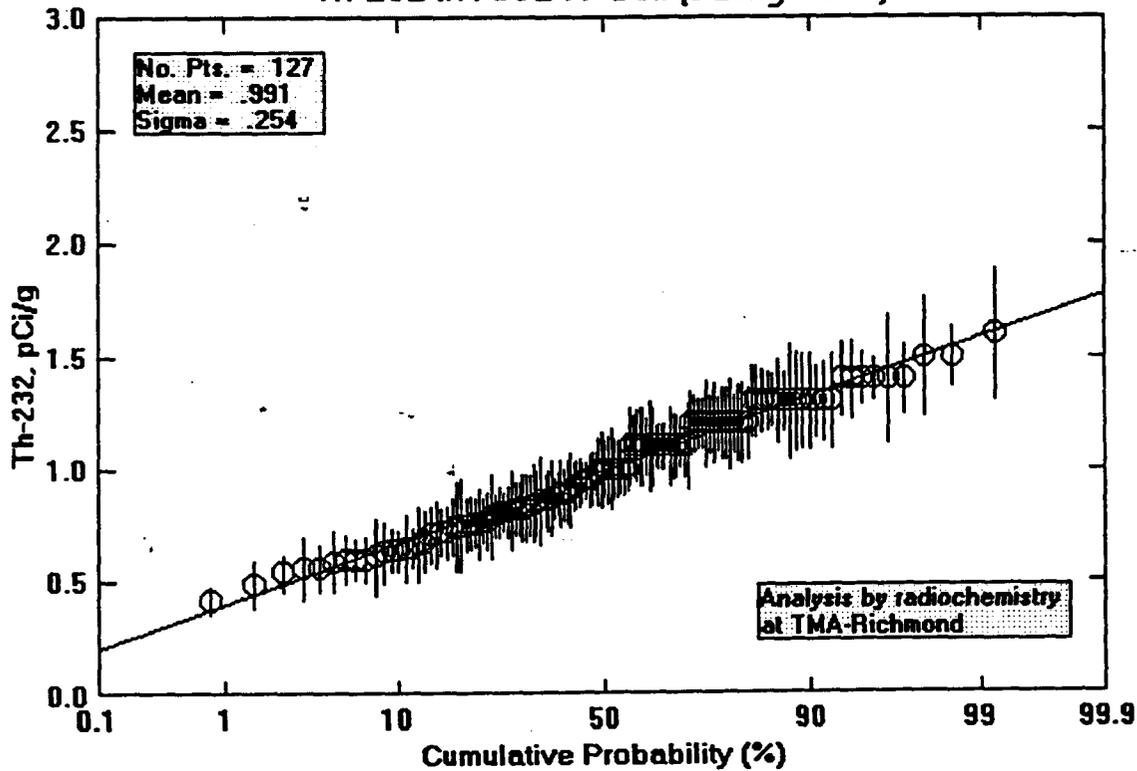
### Th-232 in Background Soil



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02-16-96

### Th-232 in Area IV Soil (background)

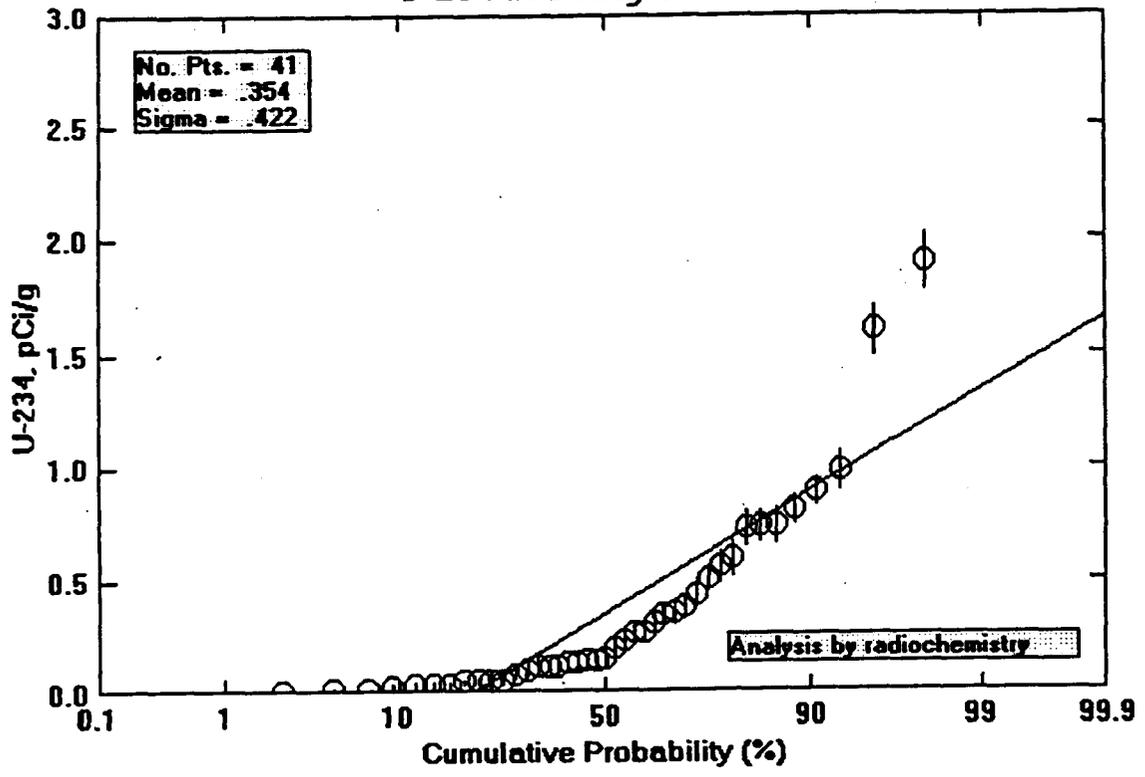


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Figure 4f. Distribution of Th-232 in Background Soil.

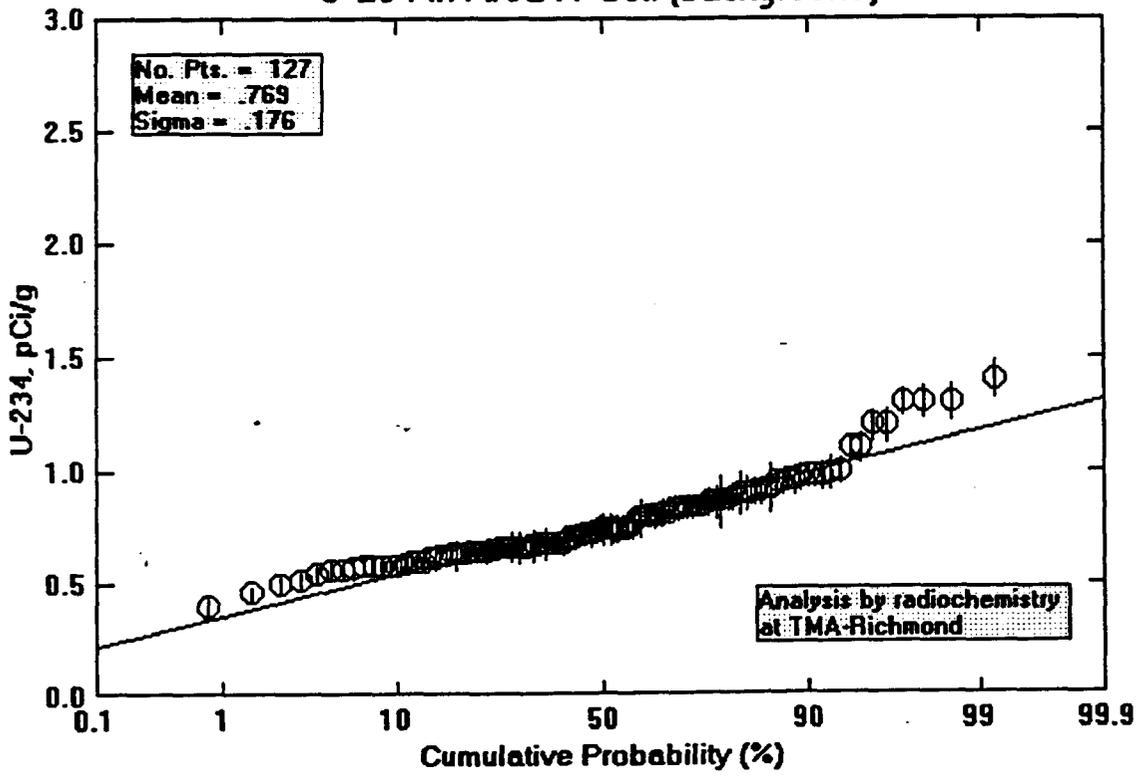
### U-234 in Background Soil



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02-16-96

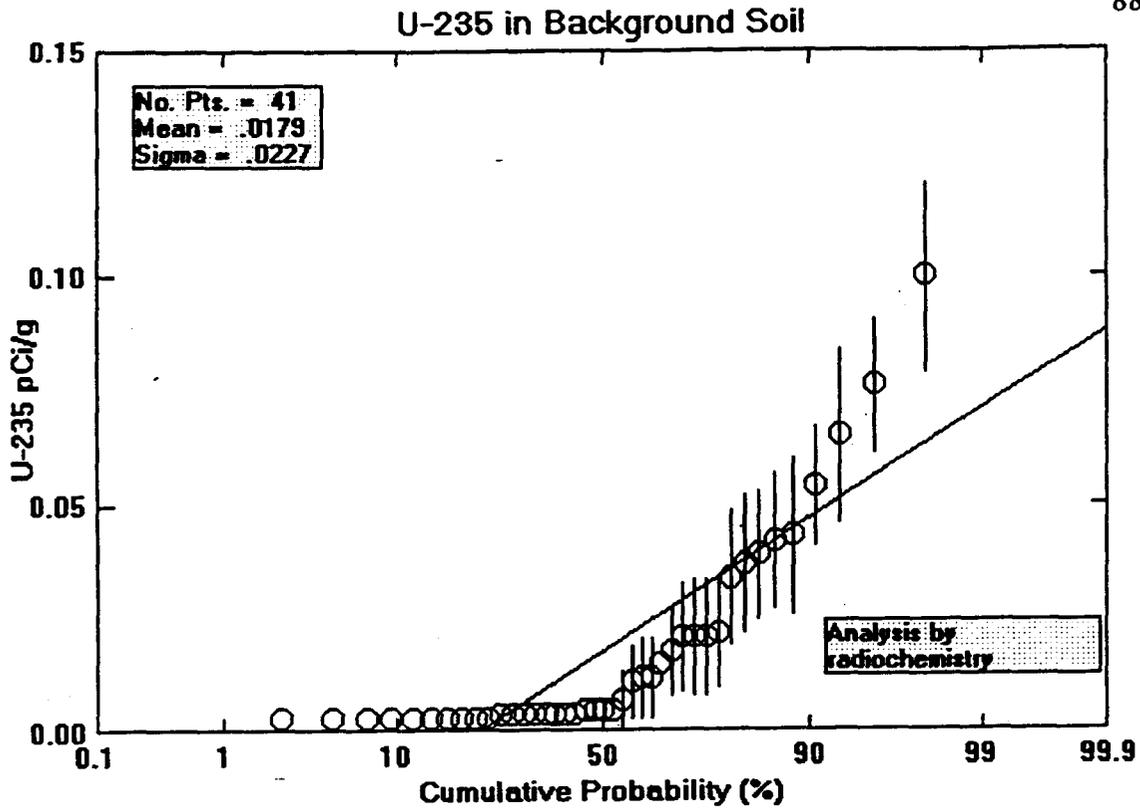
### U-234 in Area IV Soil (background)



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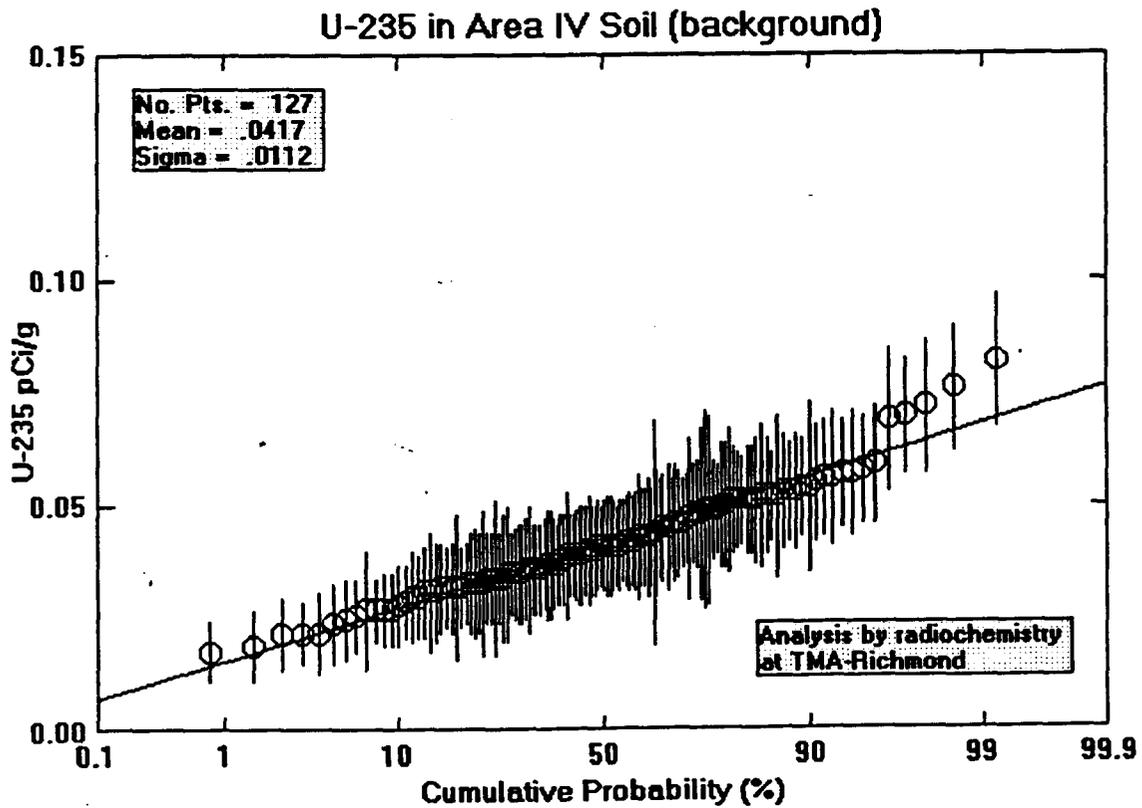
02-16-96

Figure 4g. Distribution of U-234 in Background Soil.



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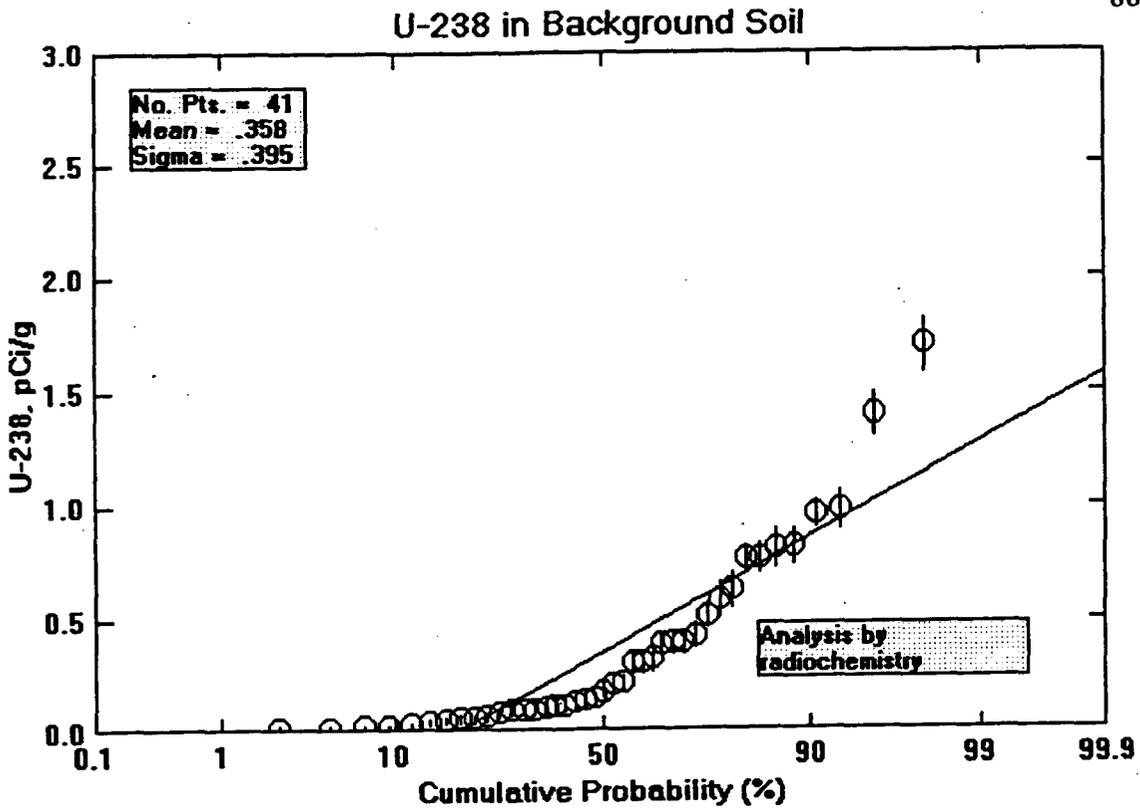
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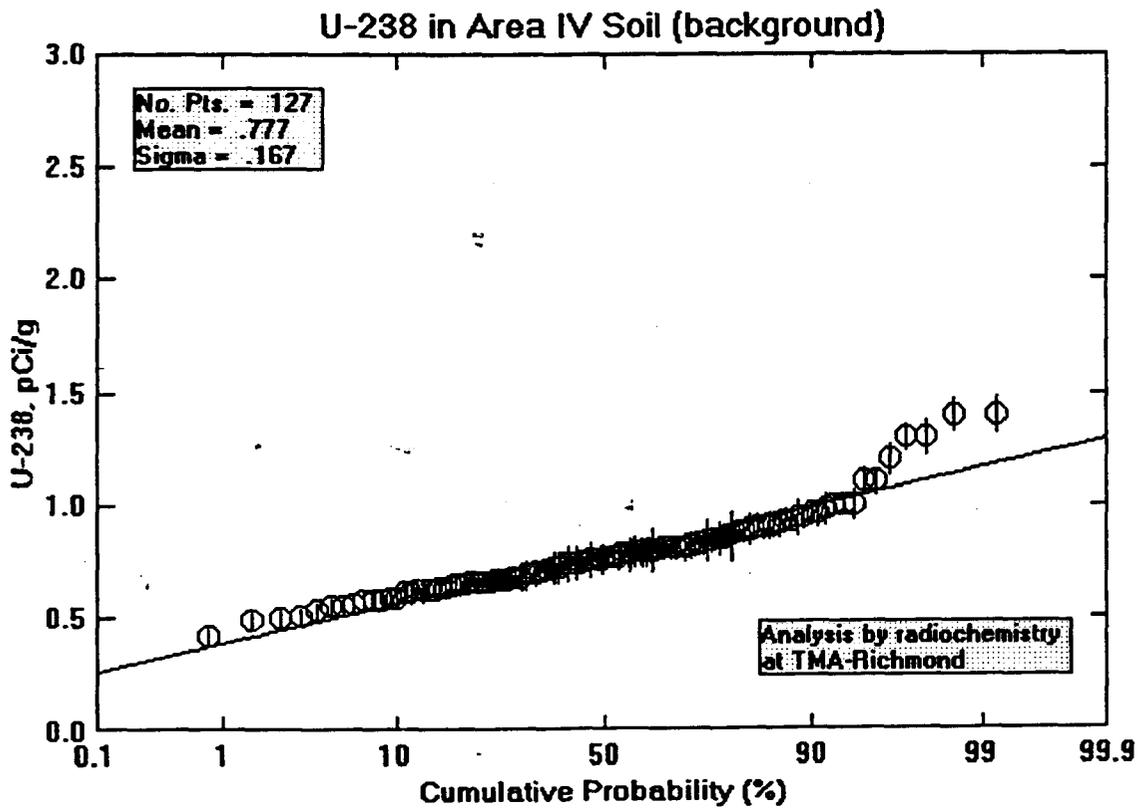
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Figure 4h. Distribution of U-235 in Background Soil.



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Figure 4i. Distribution of U-238 in Background Soil.

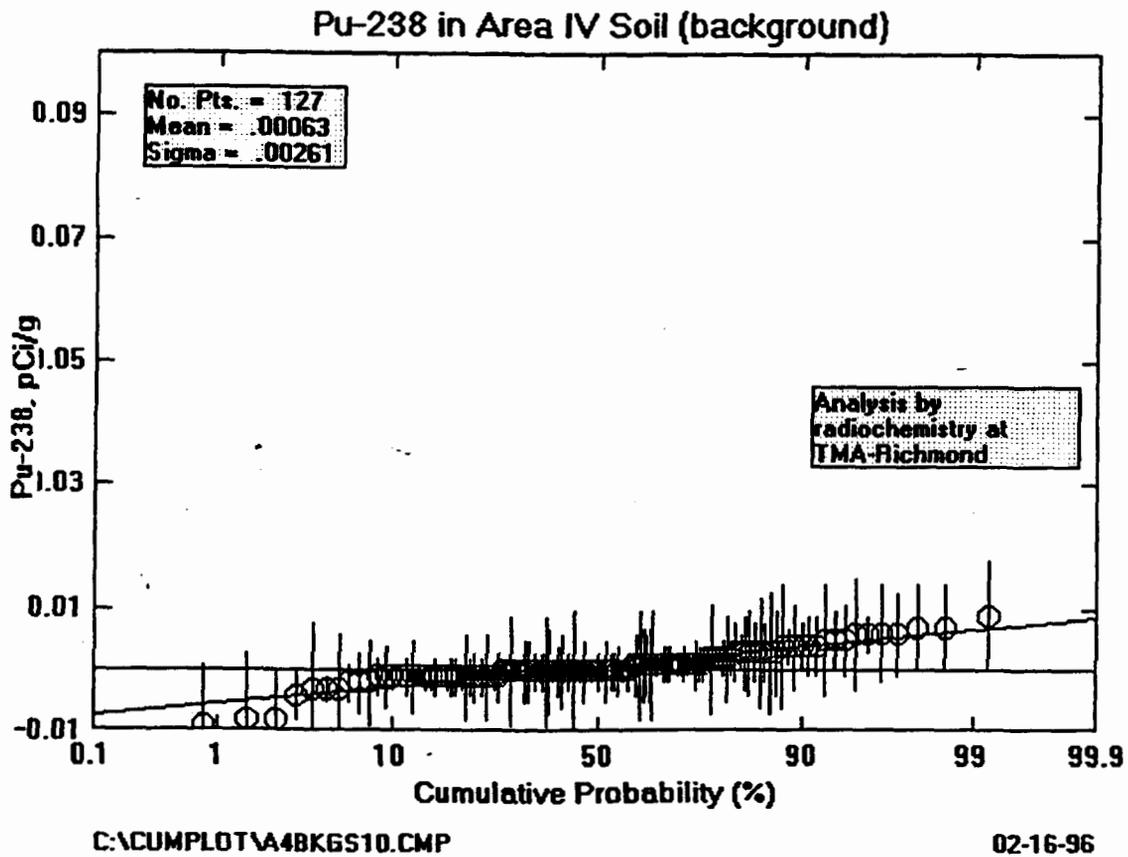


Figure 4j. Distribution of Pu-238 in Background Soil.

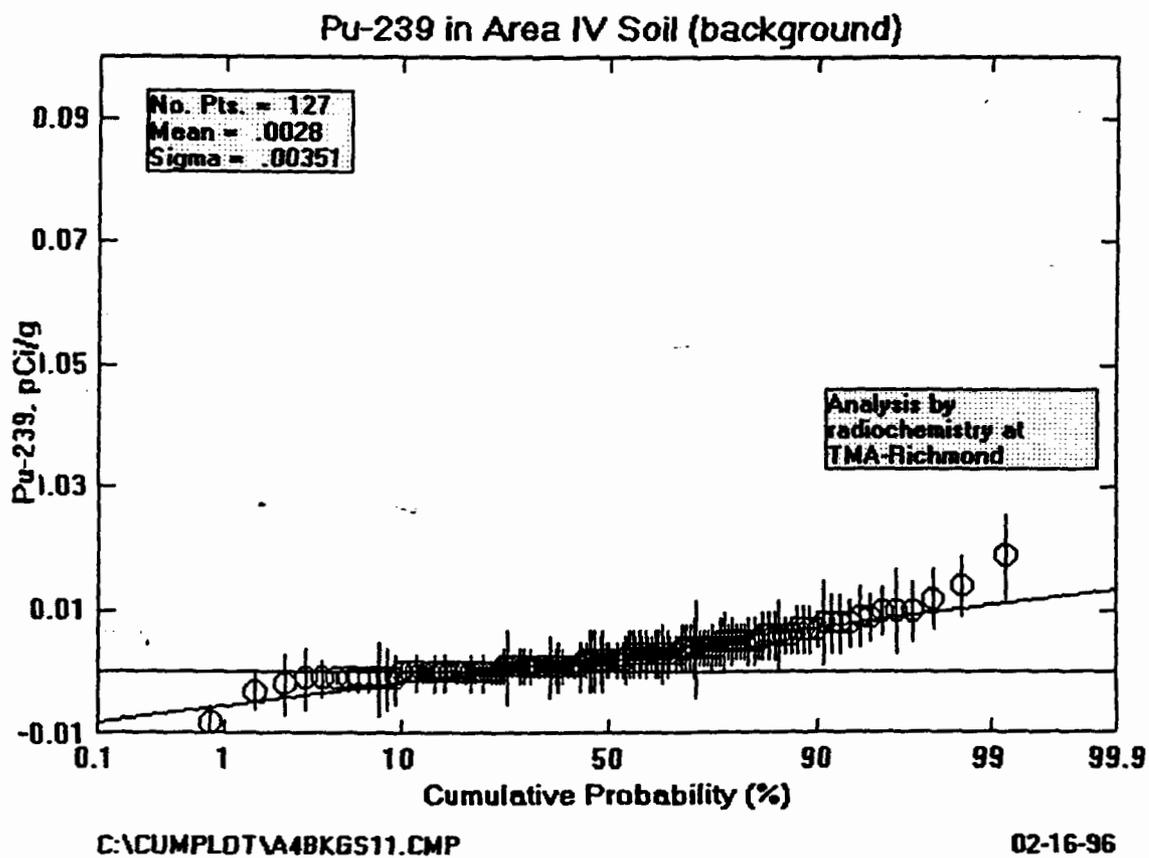
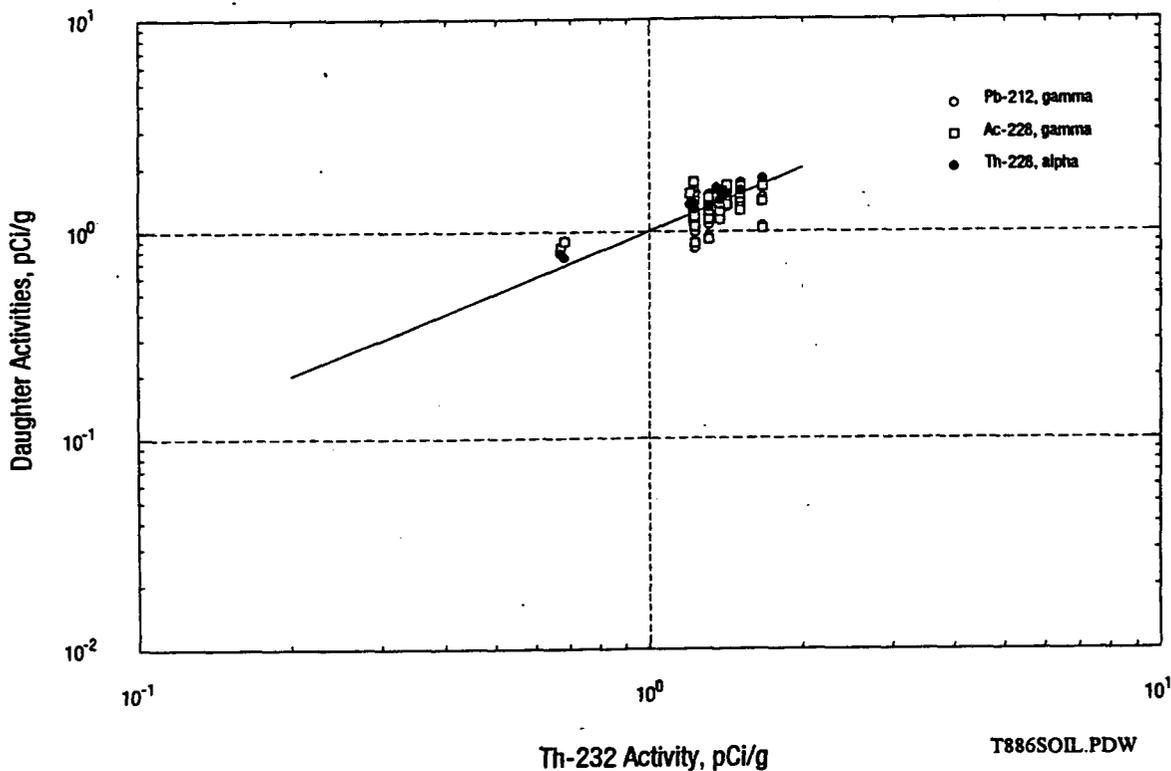


Figure 4k. Distribution of Pu-239 in Background Soil.

Comparison of Thorium Chain Activities for T886 Soil



Comparison of Uranium Chain Activities for T886 Soil

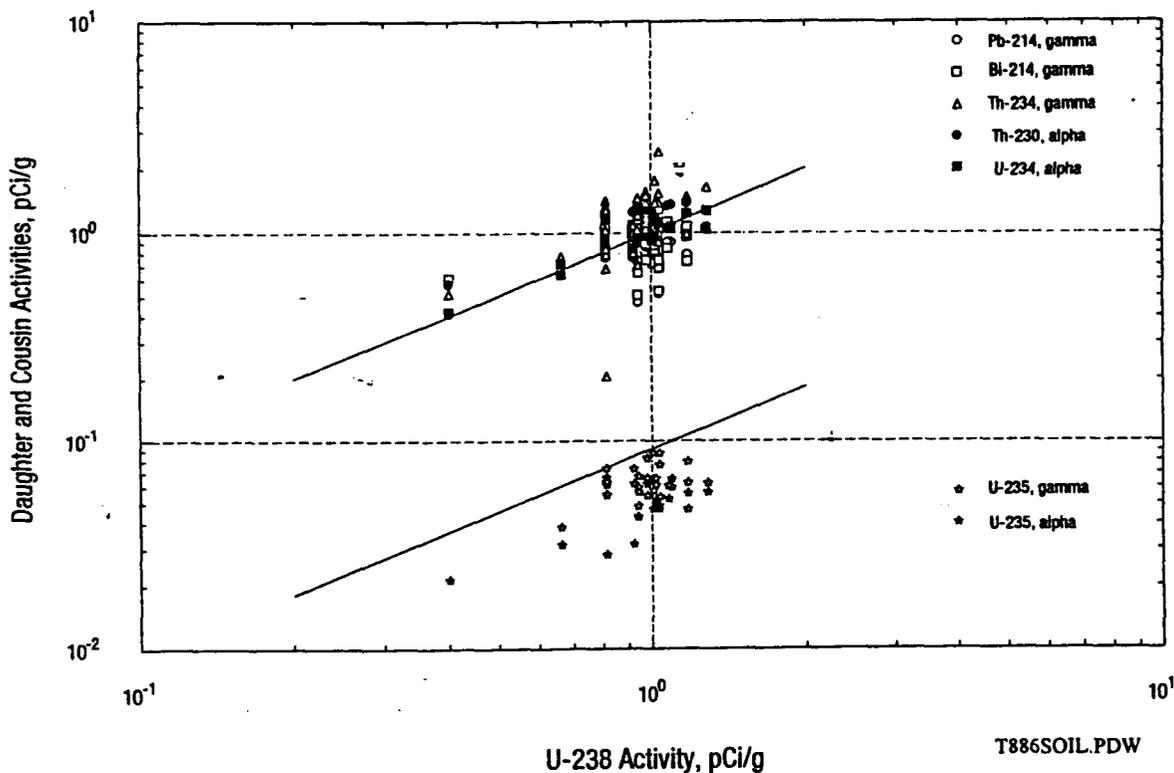


Figure 5. Decay chain daughter activities for soil from the Former Sodium Disposal Facility

Table 1A. Results of gamma spectrometry analyses of soil and rock samples.

Sample Location	K40		CS137		PB212		PB214		BI214		AC228		TH234		U235	
	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc
SOIL																
10130331SRNO	19.66	0.58	0.009		1.377	0.035	0.769	0.047	0.885	0.149	1.524	0.107	0.963	0.319	0.005	
10246220SRNO	21.43	0.61	0.021	0.016	1.450	0.037	0.878	0.045	1.017	0.211	1.416	0.103	0.966	0.320	0.062	0.010
10346220SRNO	21.37	0.62	0.052	0.014	1.381	0.038	0.763	0.052	0.778	0.241	1.383	0.111	0.800	0.325	0.007	
10430331SRNO	19.49	0.55	0.010		1.504	0.036	0.968	0.048	0.891	0.160	1.591	0.105	0.995	0.317	0.062	0.008
10530331SRNO	21.53	0.58	0.010		1.648	0.037	1.069	0.048	1.083	0.209	1.662	0.099	1.082	0.291	0.073	0.009
10530331SRN2	22.41	0.61	0.010		1.439	0.036	0.890	0.046	0.951	0.152	1.420	0.098	0.997	0.313	0.006	
20130331SRNO	17.85	0.52	0.009		1.166	0.032	0.793	0.043	0.939	0.167	1.429	0.091	1.416	0.361	0.005	
20246220SRNO	21.33	0.62	0.047	0.028	1.241	0.036	0.860	0.049	1.009	0.220	1.480	0.113	1.022	0.319	0.007	
20346310SRNO	23.59	0.58	0.078	0.020	1.365	0.034	0.890	0.047	0.851	0.152	1.427	0.098	0.804	0.326	0.062	0.009
20446370SRNO	21.40	0.54	0.073	0.018	1.203	0.031	0.765	0.040	0.889	0.172	1.113	0.097	0.788	0.303	0.005	
20646220SRNO	23.64	0.66	0.034	0.015	1.564	0.040	1.027	0.056	1.027	0.207	1.609	0.108	1.291	0.415	0.073	0.022
20730331SRNO	19.27	0.49	0.008		1.381	0.031	0.845	0.039	0.778	0.147	1.429	0.093	0.678	0.247	0.005	
20946220SRNO	22.37	0.58	0.044	0.014	1.428	0.035	1.128	0.056	1.017	0.181	1.362	0.095	1.035	0.369	0.061	0.009
21030331SRNO	20.50	0.52	0.009		1.532	0.034	0.901	0.045	0.925	0.166	1.530	0.095	0.869	0.289	0.054	0.017
21120331SRNO	22.11	0.60	0.012		1.277	0.035	0.790	0.047	0.718	0.183	1.316	0.104	1.052	0.284	0.057	0.009
21230331SRNO	21.54	0.70	0.014		1.581	0.044	0.977	0.062	1.215	0.216	1.616	0.137	1.168	0.402	0.066	0.021
21346220SRNO	22.59	0.61	0.062	0.018	1.467	0.037	1.026	0.050	0.992	0.167	1.553	0.116	1.037	0.316	0.006	
21346220SRN2	23.04	0.64	0.077	0.018	1.507	0.038	1.058	0.056	0.956	0.210	1.623	0.116	1.234	0.428	0.006	
21646220SRNO	22.83	0.59	0.055	0.016	1.439	0.035	1.004	0.050	1.053	0.212	1.547	0.104	0.838	0.306	0.063	0.009
21736220SRNO	24.80	0.71	0.014		1.462	0.042	0.874	0.059	1.052	0.249	1.467	0.124	1.314	0.388	0.065	0.011
21946220SRNO	22.07	0.66	0.096	0.023	1.541	0.042	1.029	0.053	1.067	0.232	1.613	0.114	1.316	0.394	0.064	0.010
22046220SRNO	21.65	0.55	0.108	0.021	1.314	0.032	0.922	0.047	0.883	0.213	1.405	0.088	1.110	0.323	0.066	0.009
22146220SRNO	23.38	0.62	0.010		1.380	0.036	0.984	0.051	0.820	0.212	1.486	0.101	0.205		0.055	0.009
22236220SRNO	26.17	0.72	0.026	0.023	1.578	0.043	1.116	0.056	1.060	0.219	1.572	0.124	1.321	0.346	0.087	0.014
30113170SRNO	20.58	0.65	0.014		1.614	0.043	1.039	0.055	1.226	0.212	1.641	0.125	1.549	0.397	0.008	
30113170SRN2	21.42	0.68	0.015		1.648	0.044	1.064	0.061	0.988	0.206	1.631	0.119	1.364	0.375	0.008	
30123080SRNO	23.56	0.59	0.229	0.024	1.582	0.036	1.043	0.050	1.154	0.185	1.558	0.108	1.189	0.344	0.067	0.009
30123380SRNO	21.79	0.54	0.055	0.014	1.347	0.033	0.867	0.046	0.738	0.157	1.305	0.085	1.195	0.348	0.054	0.008
30139040SRNO	21.50	0.64	0.037	0.018	1.645	0.041	1.086	0.056	1.204	0.183	1.671	0.110	1.492	0.392	0.006	
30219160SRNO	21.68	0.63	0.011		1.705	0.042	1.208	0.057	1.418	0.199	1.636	0.118	1.173	0.354	0.082	0.010
30309040SRNO	20.90	0.54	0.567	0.025	1.314	0.032	0.905	0.047	1.071	0.176	1.342	0.086	1.088	0.284	0.059	0.008
30315160SRNO	22.33	0.57	0.047	0.018	1.469	0.035	1.010	0.047	1.041	0.210	1.504	0.107	1.371	0.336	0.006	
30345110SRNO	21.34	0.58	0.063	0.016	1.377	0.037	0.855	0.050	0.880	0.163	1.257	0.095	1.250	0.403	0.007	
30413170SRNO	19.59	0.55	0.050	0.022	1.615	0.037	1.022	0.054	0.918	0.152	1.718	0.104	1.330	0.402	0.006	
30427300SRNO	20.67	0.58	0.013		1.352	0.037	0.922	0.053	0.789	0.163	1.360	0.092	1.284	0.416	0.007	
40102080SRNO	22.58	0.59	0.012		1.089	0.034	0.753	0.050	0.681	0.206	1.184	0.094	1.388	0.359	0.007	
40208080SRNO	24.18	0.55	0.009		1.201	0.032	0.818	0.044	0.806	0.164	1.151	0.077	0.962	0.316	0.053	0.009
40310080SRNO	22.80	0.59	0.010		0.827	0.030	0.515	0.039	0.528	0.157	0.877	0.080	0.906	0.299	0.006	
40414080SRNO	20.85	0.58	0.036	0.016	1.067	0.033	0.753	0.047	0.823	0.186	1.179	0.101	1.009	0.296	0.007	
40518080SRNO	24.71	0.59	0.072	0.015	1.537	0.037	1.296	0.054	1.297	0.195	1.475	0.092	1.536	0.334	0.077	0.008
40620580SRNO	21.63	0.54	0.041	0.013	1.403	0.033	1.022	0.049	1.036	0.167	1.398	0.094	2.413	0.365	0.087	0.009
40728080SRNO	24.25	0.53	0.020	0.013	0.826	0.025	0.631	0.036	0.715	0.185	0.841	0.073	0.773	0.262	0.038	0.016
40832080SRNO	21.05	0.49	0.022	0.012	0.993	0.026	0.803	0.037	0.737	0.133	1.050	0.072	0.904	0.246	0.049	0.006
40933580SRNO	20.63	0.60	0.062	0.019	1.643	0.040	1.042	0.053	1.073	0.191	1.636	0.113	1.480	0.343	0.079	0.009
41038580SRNO	22.58	0.55	0.108	0.015	1.460	0.035	1.010	0.045	0.957	0.151	1.391	0.091	1.237	0.345	0.062	0.009
41047580SRNO	23.86	0.56	0.038	0.012	1.069	0.030	0.786	0.038	0.733	0.153	1.035	0.090	0.986	0.295	0.046	0.008
41049080SRNO	20.22	0.60	0.205	0.024	1.518	0.040	1.052	0.059	1.043	0.177	1.518	0.103	1.638	0.339	0.062	0.010
41102090SRNO	22.97	0.53	0.009		1.579	0.036	1.095	0.044	1.128	0.211	1.495	0.095	1.051	0.313	0.066	
41206390SRNO	20.43	0.52	0.008		1.279	0.031	0.903	0.043	0.842	0.184	1.443	0.097	1.074	0.275	0.060	0.008
41310090SRNO	18.86	0.59	0.209	0.019	1.274	0.036	0.892	0.055	0.987	0.220	1.381	0.112	1.203	0.366	0.066	0.009
41414090SRNO	20.13	0.51	0.118	0.023	1.301	0.032	0.925	0.047	0.894	0.161	1.301	0.088	1.123	0.336	0.052	0.008
41430090SRNO	19.89	0.51	0.216	0.021	1.249	0.030	0.934	0.040	0.819	0.158	1.316	0.083	1.384	0.295	0.061	0.008
41518090SRNO	20.80	0.54	0.297	0.020	1.253	0.032	0.902	0.045	0.870	0.195	1.270	0.089	1.117	0.317	0.005	
41622090SRNO	19.07	0.50	0.167	0.017	1.150	0.030	0.884	0.044	0.938	0.201	1.232	0.086	1.082	0.268	0.005	
41726090SRNO	20.36	0.53	0.297	0.022	1.199	0.030	0.880	0.046	1.020	0.167	1.138	0.097	1.020	0.248	0.005	
41934090SRNO	22.49	0.57	0.117	0.019	1.435	0.035	1.029	0.050	1.177	0.189	1.370	0.095	1.763	0.427	0.006	
42038090SRNO	21.65	0.54	0.008		1.497	0.036	1.059	0.051	0.993	0.190	1.368	0.090	1.451	0.346	0.059	0.010
42142090SRNO	21.39	0.59	0.042	0.015	1.199	0.034	0.785	0.050	0.899	0.231	1.242	0.093	0.903	0.326	0.056	0.009
42246090SRNO	20.21	0.58	0.012		1.393	0.036	0.882	0.051	0.908	0.208	1.335	0.097	1.035	0.319	0.007	
42351990SRNO	20.74	0.54	0.097	0.019	1.426	0.033	0.926	0.044	0.906	0.192	1.453	0.093	1.215	0.353	0.005	
42455090SRN2	22.52	0.54	0.017	0.012	0.907	0.029	0.413	0.038	0.612	0.158	0.898	0.077	0.514	0.252	0.005	
42455090SRNO	22.18	0.55	0.023	0.014	0.945	0.030	0.468									

Sample Location	K40	CS137	PB212	PB214	BI214	AC228	TH234	U235
BEDROCK	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc
30511230BRNO	22.39 0.55	0.009	1.374 0.033	0.895 0.048	0.920 0.157	1.392 0.089	1.159 0.343	0.005
30515270BRNO	20.50 0.58	0.013	1.800 0.042	1.296 0.057	1.225 0.220	1.649 0.112	1.845 0.456	0.008 0.000
30530340BRNO	22.44 0.56	0.008	1.219 0.033	0.937 0.050	0.872 0.196	1.168 0.087	0.672 0.285	0.005
30540490BRNO	21.20 0.60	0.013	1.822 0.043	1.259 0.055	1.196 0.184	1.663 0.107	1.626 0.432	0.069 0.011
30547080BRNO	21.63 0.54	0.009	1.680 0.037	1.032 0.050	1.054 0.175	1.701 0.105	1.009 0.335	0.005
30604500BRNO	22.61 0.57	0.009	1.510 0.035	1.081 0.048	1.036 0.158	1.405 0.102	1.247 0.337	0.006
30630280BRNO	20.04 0.59	0.013	1.725 0.040	1.204 0.057	1.283 0.211	1.668 0.105	1.151 0.315	0.007
30648280BRNO	22.18 0.53	0.008	1.413 0.034	0.715 0.043	0.833 0.145	1.416 0.099	0.937 0.265	0.005
30648390BRNO	23.91 0.55	0.008	1.453 0.035	1.207 0.049	1.124 0.155	1.369 0.093	1.157 0.314	0.006
30724500BRNO	23.12 0.55	0.008	1.204 0.031	0.577 0.039	0.558 0.168	1.109 0.091	0.681 0.326	0.005
30940300BRNO	22.30 0.54	0.009	1.401 0.033	1.086 0.045	1.078 0.169	1.387 0.087	1.068 0.349	0.056 0.009
30950430BRNO	22.00 0.53	0.009	1.810 0.038	1.364 0.049	1.249 0.162	1.634 0.101	1.341 0.362	0.074 0.009
31027430BRNO	22.55 0.56	0.010	2.361 0.044	1.781 0.059	1.768 0.189	2.184 0.111	1.621 0.413	0.092 0.011
31044050BRNO	23.31 0.54	0.008	1.488 0.035	1.087 0.046	1.044 0.176	1.477 0.104	1.124 0.311	0.005
31111220BRNO	21.10 0.60	0.013	2.068 0.044	1.493 0.058	1.532 0.227	2.082 0.116	1.387 0.343	0.009
BEDROCK	K40	CS137	PB212	PB214	BI214	AC228	TH234	U235
	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc
number	15	15	15	15	15	15	15	15
maximum	23.91	0.013	2.361	1.781	1.768	2.184	1.845	0.092
mean	22.09 2.09	0.010 0.004	1.622 0.636	1.134 0.598	1.118 0.578	1.554 0.590	1.202 0.658	0.024 0.063
minimum	20.04	0.008	1.204	0.577	0.558	1.109	0.672	0.005

Table 1B. Results of radiochemistry analyses of soil and rock samples.

Sample Location	SR90	TH228	TH230	TH232	U234	U235	U238	PU238	PU239
	pCi/g unc								
<b>SOIL</b>									
10130331SRN0	0.402 0.189	1.506 0.186	1.257 0.163	1.420 0.178	0.841 0.098	0.032 0.021	0.923 0.103	0.013 0.033	-0.01 0.027
10246220SRN0	0.402 0.189	1.506 0.186	1.257 0.163	1.420 0.178	0.841 0.098	0.032 0.021	0.923 0.103	0.013 0.033	-0.01 0.027
10346220SRN0	0.402 0.189	1.506 0.186	1.257 0.163	1.420 0.178	0.841 0.098	0.032 0.021	0.923 0.103	0.013 0.033	-0.01 0.027
10430331SRN0	0.402 0.189	1.506 0.186	1.257 0.163	1.420 0.178	0.841 0.098	0.032 0.021	0.923 0.103	0.013 0.033	-0.01 0.027
10530331SRN0	0.402 0.189	1.506 0.186	1.257 0.163	1.420 0.178	0.841 0.098	0.032 0.021	0.923 0.103	0.013 0.033	-0.01 0.027
10530331SRN2	0.402 0.189	1.506 0.186	1.257 0.163	1.420 0.178	0.841 0.098	0.032 0.021	0.923 0.103	0.013 0.033	-0.01 0.027
20130331SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
20246220SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
20346310SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
20446370SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
20646220SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
20730331SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
20946220SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
21030331SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
21120331SRN0	-0.05 0.124	1.549 0.191	1.262 0.164	1.391 0.174	0.915 0.104	0.047 0.023	1.008 0.110	0.022 0.024	-0.01 0.015
21230331SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
21346220SRN0	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
21346220SRN2	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
21646220SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
21736220SRN0	-0.05 0.124	1.549 0.191	1.262 0.164	1.391 0.174	0.915 0.104	0.047 0.023	1.008 0.110	0.022 0.024	-0.01 0.015
21946220SRN0	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
22046220SRN0	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
22146220SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
22236220SRN0	-0.05 0.124	1.549 0.191	1.262 0.164	1.391 0.174	0.915 0.104	0.047 0.023	1.008 0.110	0.022 0.024	-0.01 0.015
30113170SRN0	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
30113170SRN2	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
30123080SRN0	0.493 0.192	1.473 0.153	1.263 0.135	1.391 0.146	0.893 0.088	0.043 0.017	0.942 0.091	0.013 0.010	0.00 0.008
30123380SRN0	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
30139040SRN0	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
30219160SRN0	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
30309040SRN0	0.569 0.188	1.512 0.155	1.364 0.142	1.422 0.147	1.059 0.100	0.065 0.021	1.095 0.102	0.000 0.005	0.002 0.004
30315160SRN0	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
30345110SRN0	-0.02 0.130	1.572 0.193	1.272 0.163	1.511 0.186	0.953 0.104	0.061 0.024	0.978 0.106	0.065 0.070	0.054 0.059
30413170SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
30427300SRN0	0.051 0.140	1.380 0.184	1.149 0.162	1.222 0.166	0.903 0.100	0.028 0.022	0.815 0.093	0.031 0.029	0.005 0.023
40102080SRN0	0.188 0.156	1.279 0.141	1.106 0.125	1.230 0.136	1.128 0.100	0.047 0.016	1.037 0.093	0.010 0.010	0.00 0.008
40208080SRN0	0.188 0.156	1.279 0.141	1.106 0.125	1.230 0.136	1.128 0.100	0.047 0.016	1.037 0.093	0.010 0.010	0.00 0.008
40310080SRN0	0.188 0.156	1.279 0.141	1.106 0.125	1.230 0.136	1.128 0.100	0.047 0.016	1.037 0.093	0.010 0.010	0.00 0.008
40414080SRN0	0.188 0.156	1.279 0.141	1.106 0.125	1.230 0.136	1.128 0.100	0.047 0.016	1.037 0.093	0.010 0.010	0.00 0.008
40518080SRN0	0.188 0.156	1.279 0.141	1.106 0.125	1.230 0.136	1.128 0.100	0.047 0.016	1.037 0.093	0.010 0.010	0.00 0.008
40620580SRN0	0.188 0.156	1.279 0.141	1.106 0.125	1.230 0.136	1.128 0.100	0.047 0.016	1.037 0.093	0.010 0.010	0.00 0.008
40728080SRN0	0.096 0.168	0.782 0.108	0.718 0.102	0.672 0.097	0.634 0.084	0.031 0.024	0.664 0.084	0.057 0.031	0.003 0.016
40832080SRN0	0.188 0.156	1.279 0.141	1.106 0.125	1.230 0.136	1.128 0.100	0.047 0.016	1.037 0.093	0.010 0.010	0.00 0.008
40933580SRN0	0.086 0.150	1.782 0.213	1.387 0.172	1.667 0.201	1.238 0.106	0.055 0.018	1.174 0.102	0.002 0.011	0.002 0.007
41038580SRN0	0.086 0.150	1.782 0.213	1.387 0.172	1.667 0.201	1.238 0.106	0.055 0.018	1.174 0.102	0.002 0.011	0.002 0.007
41047580SRN0	0.086 0.150	1.782 0.213	1.387 0.172	1.667 0.201	1.238 0.106	0.055 0.018	1.174 0.102	0.002 0.011	0.002 0.007
41049080SRN0	0.258 0.164	1.347 0.141	1.066 0.117	1.201 0.128	1.269 0.112	0.056 0.019	1.284 0.113	0.000 0.007	0.000 0.005
41102090SRN0	0.004 0.135	1.614 0.634	1.343 0.546	1.356 0.538	1.054 0.098	0.052 0.018	1.079 0.100	0.028 0.017	0.003 0.007
41206390SRN0	0.004 0.135	1.614 0.634	1.343 0.546	1.356 0.538	1.054 0.098	0.052 0.018	1.079 0.100	0.028 0.017	0.003 0.007
41310090SRN0	0.161 0.145	1.414 0.142	1.184 0.123	1.377 0.139	0.967 0.087	0.049 0.017	1.019 0.091	0.017 0.011	0.008 0.010
41414090SRN0	0.161 0.145	1.414 0.142	1.184 0.123	1.377 0.139	0.967 0.087	0.049 0.017	1.019 0.091	0.017 0.011	0.008 0.010
41430090SRN0	0.161 0.145	1.414 0.142	1.184 0.123	1.377 0.139	0.967 0.087	0.049 0.017	1.019 0.091	0.017 0.011	0.008 0.010
41518090SRN0	0.161 0.145	1.414 0.142	1.184 0.123	1.377 0.139	0.967 0.087	0.049 0.017	1.019 0.091	0.017 0.011	0.008 0.010
41622090SRN0	0.161 0.145	1.414 0.142	1.184 0.123	1.377 0.139	0.967 0.087	0.049 0.017	1.019 0.091	0.017 0.011	0.008 0.010
41726090SRN0	0.161 0.145	1.414 0.142	1.184 0.123	1.377 0.139	0.967 0.087	0.049 0.017	1.019 0.091	0.017 0.011	0.008 0.010
41934090SRN0	0.161 0.145	1.414 0.142	1.184 0.123	1.377 0.139	0.967 0.087	0.049 0.017	1.019 0.091	0.017 0.011	0.008 0.010
42038090SRN0	0.207 0.156	1.307 0.189	1.330 0.191	1.312 0.188	0.942 0.110	0.043 0.022	0.942 0.109	0.019 0.020	-0.01 0.024
42142090SRN0	0.207 0.156	1.307 0.189	1.330 0.191	1.312 0.188	0.942 0.110	0.043 0.022	0.942 0.109	0.019 0.020	-0.01 0.024
42246090SRN0	0.207 0.156	1.307 0.189	1.330 0.191	1.312 0.188	0.942 0.110	0.043 0.022	0.942 0.109	0.019 0.020	-0.01 0.024
42351990SRN0	0.207 0.156	1.307 0.189	1.330 0.191	1.312 0.188	0.942 0.110	0.043 0.022	0.942 0.109	0.019 0.020	-0.01 0.024
42455090SRN2	0.166 0.176	0.752 0.106	0.574 0.090	0.682 0.099	0.421 0.065	0.021 0.019	0.401 0.062	0.014 0.017	0.003 0.006
42455090SRN0	0.207 0.156	1.307 0.189	1.330 0.191	1.312 0.188	0.942 0.110	0.043 0.022	0.942 0.109	0.019 0.020	-0.01 0.024
42559090SRN0	0.207 0.156	1.307 0.189	1.330 0.191	1.312 0.188	0.942 0.110	0.043 0.022	0.942 0.109	0.019 0.020	-0.01 0.024
<b>SOIL</b>									
	SR90	TH228	TH230	TH232	U234	U235	U238	PU238	PU239
	pCi/g unc								
number	63	63	62	63	63	62	63	63	63
maximum	0.569	1.782	1.387	1.667	1.269	0.065	1.284	0.065	0.054
mean	0.131 0.146	1.429 0.176	1.206 0.134	1.340 0.174	0.959 0.133	0.044 0.013	0.953 0.130	0.027 0.020	0.008 0.022
minimum	-0.05	0.752	0.574	0.672	0.421	0.021	0.401	0.000	-0.01

Sample Location	SR90	TH228	TH230	TH232	U234	U235	U238	PU238	PU239
<b>BEDROCK</b>	pCi/g unc								
30511230BRNO	0.211 0.166	1.452 0.155	1.205 0.135	1.361 0.147	0.981 0.110	0.048 0.022	0.885 0.102	0.000 0.000	0.000 0.000
30515270BRNO	0.211 0.166	1.452 0.155	1.205 0.135	1.361 0.147	0.981 0.110	0.048 0.022	0.885 0.102	0.000 0.000	0.000 0.000
30530340BRNO	0.211 0.166	1.452 0.155	1.205 0.135	1.361 0.147	0.981 0.110	0.048 0.022	0.885 0.102	0.000 0.000	0.000 0.000
30540490BRNO	0.211 0.166	1.452 0.155	1.205 0.135	1.361 0.147	0.981 0.110	0.048 0.022	0.885 0.102	0.000 0.000	0.000 0.000
30547080BRNO	0.206 0.159	1.728 0.229	1.236 0.178	1.255 0.178	0.596 0.081	0.036 0.022	0.680 0.088	0.004 0.014	0.00 0.008
30604500BRNO	0.280 0.168	1.555 0.204	1.172 0.165	1.385 0.186	0.681 0.090	0.036 0.019	0.711 0.091	0.008 0.015	0.004 0.013
30630280BRNO	0.280 0.168	1.555 0.204	1.172 0.165	1.385 0.186	0.681 0.090	0.036 0.019	0.711 0.091	0.008 0.015	0.004 0.013
30648280BRNO	0.280 0.168	1.555 0.204	1.172 0.165	1.385 0.186	0.681 0.090	0.036 0.019	0.711 0.091	0.008 0.015	0.004 0.013
30648390BRNO	0.280 0.168	1.555 0.204	1.172 0.165	1.385 0.186	0.681 0.090	0.036 0.019	0.711 0.091	0.008 0.015	0.004 0.013
30724500BRNO	0.227 0.167	1.254 0.139	0.679 0.087	1.246 0.138	0.567 0.063	0.018 0.011	0.638 0.068	0.004 0.006	0.000 0.000
30940300BRNO	0.206 0.159	1.728 0.229	1.236 0.178	1.255 0.178	0.596 0.081	0.036 0.022	0.680 0.088	0.004 0.014	0.00 0.008
30950430BRNO	0.206 0.159	1.728 0.229	1.236 0.178	1.255 0.178	0.596 0.081	0.036 0.022	0.680 0.088	0.004 0.014	0.00 0.008
31027430BRNO	0.280 0.168	1.555 0.204	1.172 0.165	1.385 0.186	0.681 0.090	0.036 0.019	0.711 0.091	0.008 0.015	0.004 0.013
31044050BRNO	0.206 0.159	1.728 0.229	1.236 0.178	1.255 0.178	0.596 0.081	0.036 0.022	0.680 0.088	0.004 0.014	0.00 0.008
31111220BRNO	0.280 0.168	1.555 0.204	1.172 0.165	1.385 0.186	0.681 0.090	0.036 0.019	0.711 0.091	0.008 0.015	0.004 0.013
<b>BEDROCK</b>	SR90	TH228	TH230	TH232	U234	U235	U238	PU238	PU239
	pCi/g unc								
number	15	15	15	15	15	15	15	15	15
maximum	0.280	1.728	1.236	1.385	0.981	0.048	0.885	0.008	0.004
mean	0.238 0.071	1.554 0.269	1.165 0.274	1.334 0.121	0.731 0.323	0.038 0.016	0.745 0.180	0.004 0.006	0.000 0.006
minimum	0.206	1.254	0.679	1.246	0.567	0.018	0.638	0.000	0.00

Table 1C. Minimum Detectable Activity

Sample Location	CO60	ZN65	SR90	SB125	CS134	CS137	CE144	EU152	EU154	TH228	TH230	TH232	U234	U235	U238	PU238	PU239
SOIL	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g							
10130331SRN0	0.034	0.062	0.256	0.057	0.018	0.023	0.110	0.058	0.100	0.022	0.010	0.004	0.016	0.010	0.003	0.014	0.021
10246220SRN0	0.024	0.044	0.256	0.040	0.014	0.018	0.083	0.041	0.072	0.022	0.010	0.004	0.016	0.010	0.003	0.014	0.021
10346220SRN0	0.034	0.060	0.256	0.050	0.018	0.020	0.100	0.052	0.099	0.022	0.010	0.004	0.016	0.010	0.003	0.014	0.021
10430331SRN0	0.034	0.062	0.256	0.057	0.019		0.112	0.058	0.105	0.022	0.010	0.004	0.016	0.010	0.003	0.014	0.021
10530331SRN0	0.025	0.044	0.256	0.046	0.015		0.097	0.047	0.081	0.022	0.010	0.004	0.016	0.010	0.003	0.014	0.021
10530331SRN2	0.024	0.046	0.256	0.044	0.015		0.091	0.043	0.082	0.022	0.010	0.004	0.016	0.010	0.003	0.014	0.021
20130331SRN0	0.020	0.037	0.256	0.035	0.012		0.074	0.035	0.063	0.022	0.010	0.004	0.016	0.010	0.003	0.014	0.021
20246220SRN0	0.037	0.067	0.256	0.063	0.021		0.126	0.066	0.115	0.022	0.020	0.014	0.015	0.012	0.010	0.022	0.015
20346310SRN0	0.025	0.045	0.256	0.042	0.014		0.090	0.044	0.074	0.022	0.020	0.014	0.015	0.012	0.010	0.022	0.015
20446370SRN0	0.024	0.043	0.256	0.041	0.014		0.087	0.041	0.071	0.022	0.020	0.014	0.015	0.012	0.010	0.022	0.015
20646220SRN0	0.024	0.044	0.241	0.042	0.014	0.018	0.093	0.045	0.076	0.226	0.239	0.111	0.016	0.010	0.008	0.019	0.013
20730331SRN0	0.022	0.042	0.241	0.041	0.014	0.017	0.084	0.041	0.077	0.226	0.239	0.111	0.016	0.010	0.008	0.019	0.013
20946220SRN0	0.034	0.064	0.238	0.060	0.020		0.118	0.059	0.109	0.009	0.016	0.003	0.008	0.012	0.008	0.010	0.015
21030331SRN0	0.024	0.044	0.238	0.043	0.013		0.087	0.042	0.079	0.009	0.016	0.003	0.008	0.012	0.008	0.010	0.015
21120331SRN0	0.022	0.042	0.238	0.040	0.013		0.082	0.040	0.070	0.009	0.016	0.003	0.008	0.012	0.008	0.010	0.015
21230331SRN0	0.025	0.045	0.238	0.043	0.014		0.087	0.043	0.078	0.009	0.016	0.003	0.008	0.012	0.008	0.010	0.015
21346220SRN0	0.022	0.043	0.238	0.040	0.013		0.081	0.040	0.075	0.009	0.016	0.003	0.008	0.012	0.008	0.010	0.015
21346220SRN2	0.023	0.040	0.238	0.040	0.014		0.081	0.041	0.073	0.009	0.016	0.003	0.008	0.012	0.008	0.010	0.015
21646220SRN0	0.026	0.047	0.238	0.044	0.014		0.098	0.046	0.086	0.009	0.016	0.003	0.008	0.012	0.008	0.010	0.015
21736220SRN0	0.023	0.038	0.252	0.042	0.014	0.017	0.085	0.044	0.079	0.046	0.049	0.030	0.037	0.019	0.019	0.013	0.058
21946220SRN0	0.033	0.064	0.252	0.057	0.019		0.116	0.055	0.104	0.046	0.049	0.030	0.037	0.019	0.019	0.013	0.058
22046220SRN0	0.032	0.061	0.252	0.058	0.021	0.025	0.117	0.058	0.112	0.046	0.049	0.030	0.037	0.019	0.019	0.013	0.058
22146220SRN0	0.026	0.045	0.252	0.045	0.015		0.090	0.042	0.083	0.046	0.049	0.030	0.037	0.019	0.019	0.013	0.058
22236220SRN0	0.030	0.058	0.252	0.050	0.016		0.100	0.050	0.090	0.046	0.049	0.030	0.037	0.019	0.019	0.013	0.058
30113170SRN0	0.023	0.041	0.252	0.037	0.013		0.075	0.037	0.068	0.046	0.049	0.030	0.037	0.019	0.019	0.013	0.058
30113170SRN2	0.024	0.043	0.243	0.042	0.014	0.018	0.088	0.041	0.076	0.045	0.065	0.025	0.037	0.030	0.029	0.031	0.048
30123080SRN0	0.035	0.066	0.243	0.059	0.021		0.121	0.059	0.120	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
30123380SRN0	0.025	0.048	0.243	0.045	0.015		0.094	0.046	0.081	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
30139040SRN0	0.025	0.045	0.243	0.041	0.014		0.085	0.042	0.075	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
30219160SRN0	0.031	0.052	0.243	0.052	0.018		0.104	0.055	0.096	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
30309040SRN0	0.022	0.041	0.243	0.037	0.013	0.016	0.083	0.039	0.073	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
30315160SRN0	0.028	0.048	0.243	0.045	0.015		0.098	0.047	0.088	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
30345110SRN0	0.023	0.043	0.243	0.040	0.015	0.018	0.087	0.042	0.078	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
30413170SRN0	0.041	0.074	0.243	0.071	0.024	0.029	0.133	0.073	0.136	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
30427300SRN0	0.027	0.047	0.243	0.045	0.015		0.090	0.047	0.086	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
40102080SRN0	0.027	0.050	0.243	0.046	0.016	0.021	0.094	0.047	0.082	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
40208080SRN0	0.025	0.045	0.243	0.046	0.016		0.100	0.046	0.082	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
40310080SRN0	0.033	0.061	0.243	0.060	0.020	0.026	0.121	0.061	0.115	0.045	0.065	0.025	0.037	0.030	0.029	0.038	0.048
40414080SRN0	0.034	0.065	0.228	0.055	0.019	0.024	0.114	0.058	0.113	0.044	0.057	0.027	0.028	0.022	0.020	0.033	0.048
40518080SRN0	0.041	0.075	0.228	0.066	0.024	0.028	0.131	0.070	0.134	0.044	0.057	0.027	0.028	0.022	0.020	0.033	0.048
40620580SRN0	0.040	0.081	0.228	0.073	0.023		0.137	0.068	0.138	0.044	0.057	0.027	0.028	0.022	0.020	0.033	0.048
40728080SRN0	0.027	0.049	0.234	0.045	0.016		0.091	0.046	0.089	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
40832080SRN0	0.027	0.051	0.234	0.049	0.016		0.101	0.049	0.093	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
40933580SRN0	0.039	0.075	0.234	0.067	0.024		0.133	0.069	0.131	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
41038580SRN0	0.026	0.048	0.234	0.044	0.014		0.089	0.044	0.077	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
41047580SRN0	0.038	0.071	0.234	0.067	0.023	0.028	0.129	0.069	0.129	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
41049080SRN0	0.038	0.073	0.234	0.070	0.024	0.030	0.137	0.069	0.141	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
41102090SRN0	0.024	0.042	0.234	0.043	0.014		0.086	0.043	0.077	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
41206390SRN0	0.031	0.049	0.234	0.053	0.017		0.104	0.053	0.100	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
41310090SRN0	0.029	0.054	0.234	0.052	0.018	0.022	0.103	0.052	0.097	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
41414090SRN0	0.027	0.048	0.234	0.047	0.015		0.098	0.048	0.082	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
41430090SRN0	0.033	0.061	0.234	0.058	0.019		0.117	0.060	0.103	0.036	0.031	0.007	0.017	0.006	0.020	0.100	0.080
41518090SRN0	0.024	0.042	0.289	0.044	0.015	0.019	0.089	0.044	0.086	0.019	0.033	0.019	0.040	0.027	0.030	0.062	0.072
41622090SRN0	0.028	0.048	0.289	0.048	0.016		0.093	0.048	0.091	0.019	0.033	0.019	0.040	0.027	0.030	0.062	0.072
41726090SRN0	0.036	0.066	0.289	0.062	0.021		0.121	0.063	0.113	0.019	0.033	0.019	0.040	0.027	0.030	0.062	0.072
41934090SRN0	0.024	0.046	0.289	0.044	0.016	0.019	0.094	0.046	0.085	0.019	0.033	0.019	0.040	0.027	0.030	0.062	0.072
42038090SRN0	0.026	0.047	0.289	0.049	0.016	0.020	0.095	0.047	0.088	0.019	0.033	0.019	0.040	0.027	0.030	0.062	0.072
42142090SRN0	0.026	0.049	0.289	0.047	0.016	0.020	0.092	0.046	0.087	0.019	0.033	0.019	0.040	0.027	0.030	0.062	0.072
42246090SRN0	0.026	0.047	0.285	0.047	0.016		0.094	0.048	0.089	0.012	0.020	0.012	0.024	0.015	0.012	0.005	0.018
42351990SRN0	0.022	0.044	0.269	0.044	0.014		0.087	0.043	0.075	0.019	0.020	0.009	0.023	0.013	0.015	0.013	0.005
42455090SRN2	0.035	0.067	0.260	0.063	0.022		0.127	0.064	0.119	0.010	0.017	0.004	0.022	0.015	0.012	0.017	0.014
42455090SRN0	0.030	0.055	0.293	0.045	0.016		0.098	0.047	0.092	0.025	0.036	0.030	0.029	0.026	0.018	0.026	0.008
42559090SRN0	0.023	0.042	0.288	0.036	0.012		0.080	0.037	0.068	0.021	0.021	0.017	0.050	0.034	0.038	0.032	0.032
SOIL	CO60	ZN65	SR90	SB125	CS134	CS137	CE144	EU152</									

Sample Location	CO60	ZN65	SR90	SB125	CS134	CS137	CE144	EU152	EU154	TH228	TH230	TH232	U234	U235	U238	PU238	PU239
<b>BEDROCK</b>	pCi/g																
30511230BRNO	0.024	0.048	0.266	0.042	0.014	0.017	0.092	0.042	0.075	0.020	0.030	0.025	0.029	0.007	0.018	0.037	0.047
30515270BRNO	0.033	0.063	0.266	0.062	0.022	0.025	0.132	0.065	0.120	0.020	0.030	0.025	0.029	0.007	0.018	0.037	0.047
30530340BRNO	0.026	0.045	0.266	0.043	0.015	0.017	0.092	0.043	0.077	0.020	0.030	0.025	0.029	0.007	0.018	0.037	0.047
30540490BRNO	0.035	0.065	0.266	0.063	0.021	0.025	0.133	0.067	0.122	0.020	0.030	0.025	0.029	0.007	0.018	0.037	0.047
30547080BRNO	0.025	0.045	0.257	0.045	0.016	0.019	0.098	0.045	0.080	0.046	0.063	0.040	0.015	0.024	0.006	0.029	0.029
30604500BRNO	0.027	0.048	0.266	0.044	0.015	0.018	0.098	0.047	0.084	0.041	0.044	0.035	0.033	0.007	0.006	0.028	0.028
30630280BRNO	0.033	0.066	0.266	0.064	0.021	0.025	0.133	0.064	0.120	0.041	0.044	0.035	0.033	0.007	0.006	0.028	0.028
30648280BRNO	0.023	0.041	0.266	0.041	0.013	0.016	0.086	0.042	0.071	0.041	0.044	0.035	0.033	0.007	0.006	0.028	0.028
30648390BRNO	0.023	0.042	0.266	0.044	0.014	0.016	0.093	0.046	0.078	0.041	0.044	0.035	0.033	0.007	0.006	0.028	0.028
30724500BRNO	0.024	0.045	0.269	0.041	0.014	0.016	0.088	0.040	0.074	1.254	0.679	0.011	0.019	0.018	0.638	0.010	0.013
30940300BRNO	0.025	0.046	0.257	0.045	0.014	0.017	0.095	0.044	0.077	0.046	0.063	0.040	0.015	0.024	0.006	0.029	0.029
30950430BRNO	0.022	0.046	0.206	0.047	0.014	0.018	0.098	0.049	0.081	0.046	0.063	0.040	0.015	0.024	0.006	0.029	0.029
31027430BRNO	0.025	0.049	0.266	0.051	0.016	0.019	0.113	0.054	0.091	0.041	0.044	0.035	0.033	0.007	0.006	0.028	0.028
31044050BRNO	0.024	0.044	0.257	0.043	0.014	0.017	0.090	0.045	0.074	0.046	0.063	0.040	0.015	0.024	0.006	0.029	0.029
31111220BRNO	0.035	0.067	0.266	0.069	0.024	0.026	0.139	0.070	0.128	0.041	0.044	0.035	0.033	0.007	0.006	0.028	0.028
<b>BEDROCK</b>	CO60	ZN65	SR90	SB125	CS134	CS137	CE144	EU152	EU154	TH228	TH230	TH232	U234	U235	U238	PU238	PU239
	pCi/g																
number	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
maximum	0.035	0.067	0.269	0.069	0.024	0.026	0.139	0.070	0.128	1.254	0.679	0.040	0.033	0.024	0.638	0.037	0.047
mean	0.027	0.051	0.260	0.050	0.016	0.019	0.105	0.051	0.090	0.118	0.088	0.032	0.026	0.012	0.051	0.029	0.032
minimum	0.022	0.041	0.206	0.041	0.013	0.016	0.086	0.040	0.071	0.020	0.030	0.011	0.015	0.007	0.006	0.010	0.013

Table 2. Grouping of samples for composite analyses.

COMPOSITE NUMBER	LAB COMPOSITE ID	LAB ID	Sample Location	COMPOSITE NUMBER	LAB COMPOSITE ID	LAB ID	Sample Location	
1	22494	22322	40310080SRNO	8	22501	22287	30113170SRN2	
1		22324	40208080SRNO	8		22290	30113170SRNO	
1		22325	40102080SRNO	8		22291	21946220SRNO	
1		22359	40728080SRNO	8		22292	21346220SRN2	
1		22360	40414080SRNO	8		22293	21346220SRNO	
1		22361	40620580SRNO	8		22288	30139040SRNO	
1		22362	40518080SRNO	8		22289	30219160SRNO	
1		22363	40832080SRNO	8		22330	22046220SRNO	
2		22495	22347	41047580SRNO		8	22334	30123380SRNO
2	22350		41038580SRNO	8	22335	30345110SRNO		
2	22351		40933580SRNO	8	22336	30315160SRNO		
3	22496	22331	41206390SRNO	9	22502	22271	10130331SRNO	
3		22348	41102090SRNO	9		22272	10246220SRNO	
4	22497	22342	41518090SRNO	9		22273	10346220SRNO	
4		22345	41622090SRNO	9		22274	10530331SRN2	
4		22349	41934090SRNO	9		22275	10430331SRNO	
4		22353	41414090SRNO	9		22281	10530331SRNO	
4		22354	41430090SRNO	10	22503	22295	30530340BRNO	
4		22355	41310090SRNO	10		22303	30540490BRNO	
4		22357	41726090SRNO	10		22304	30511230BRNO	
5	22498	22339	42038090SRNO	10		22306	30510270BRNO	
5		22340	42559090SRNO	11	22504	22297	31027430BRNO	
5		22341	42455090SRNO	11		22298	30604500BRNO	
5		22346	42246090SRNO	11		22299	30648280BRNO	
5		22352	42142090SRNO	11		22300	30630280BRNO	
5		22356	42351990SRNO	11		22302	30648390BRNO	
6	22499	22277	21646220SRNO	11		22309	31111220BRNO	
6		22278	22146220SRNO	12	22505	22294	30940300BRNO	
6		22282	21030331SRNO	12		22296	31044050BRNO	
6		22284	21230331SRNO	12		22305	30950430BRNO	
6		22285	20646220SRNO	12		22310	30547080BRNO	
6		22307	20946220SRNO	13	22506	22283	10546220WRN1	
6		22308	20730331SRNO	13		22326	21431330WRN1	
6		22323	20346310SRNO	13		22337	40414080WRN1	
6		22327	20130331SRNO	13		22338	30543090WRN1	
6		22329	30427300SRNO	14	22286	22286	30123080SRNO	
6		22332	20246220SRNO	15	22301	22301	30724500BRNO	
6		22333	30413170SRNO	16	22328	22328	30309040SRNO	
6		22344	20446370SRNO	17	22358	22358	41049080SRNO	
7		22500	22276	21120331SRNO	18	22343	22343	42455090SRN2
7			22279	31027430BRNO	19	22359	22359	40728080SRNO
7			22280	30604500BRNO				

end

Table 3A. Comparison of Field Duplicate Samples for Radionuclides, Gamma Spectrometry

Sample Location	K40	CS137	PB212	PB214	BI214	AC228	TH234	U235
<b>SOIL</b>	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc	pCi/g unc
10530331SRN0	21.53 0.58	0.010 0.010	1.648 0.037	1.069 0.048	1.083 0.209	1.662 0.099	1.082 0.291	0.073 0.009
10530331SRN2	22.41 0.61	0.010 0.010	1.439 0.036	0.890 0.046	0.951 0.152	1.420 0.098	0.997 0.313	0.006 0.006
30113170SRN0	20.58 0.65	0.014 0.014	1.614 0.043	1.039 0.055	1.226 0.212	1.641 0.125	1.549 0.397	0.008 0.008
30113170SRN2	21.42 0.68	0.015 0.015	1.648 0.044	1.064 0.061	0.988 0.206	1.631 0.119	1.364 0.375	0.008 0.008
42455090SRN0	22.18 0.55	0.023 0.014	0.945 0.030	0.468 0.039	0.503 0.158	0.915 0.081	0.704 0.281	0.005 0.005
42455090SRN2	22.52 0.54	0.017 0.012	0.907 0.029	0.413 0.038	0.612 0.158	0.898 0.077	0.514 0.252	0.005 0.005

Comparison, relative difference second/first

10530331SRN	0.040 0.038	0.000 1.414	-0.14 0.034	-0.18 0.067	-0.13 0.254	-0.16 0.090	-0.08 0.411	-1.71 0.276
30113170SRN	0.040 0.045	0.062 1.415	0.021 0.038	0.024 0.078	-0.22 0.267	-0.01 0.106	-0.13 0.375	0.034 1.414
42455090SRN	0.015 0.035	-0.29 0.910	-0.04 0.045	-0.12 0.125	0.196 0.400	-0.02 0.123	-0.31 0.619	0.017 1.414

SOIL	K40	CS137	PB212	PB214	BI214	AC228	TH234	U235
	diff unc							
number	3	3	3	3	3	3	3	3
maximum	0.040 0.045	0.062 0.910	0.021 0.038	0.024 0.078	0.196 0.400	-0.01 0.106	-0.08 0.411	0.034 0.411
mean	0.032 0.029	-0.08 0.910	-0.05 0.157	-0.09 0.213	-0.05 0.434	-0.06 0.168	-0.17 0.243	-0.55 2.006
minimum	0.015 0.035	-0.29 0.910	-0.14 0.034	-0.18 0.067	-0.22 0.267	-0.16 0.106	-0.31 0.619	-1.71 0.619

Table 3B. Comparison of Field Duplicate Samples for Radionuclides, Radiochemistry

Sample Location	SR90	TH228	TH230	TH232	U234	U235	U238	PU238	PU239
<b>SOIL</b>	pCi/g unc								
42455090SRN0	0.207 0.156	1.307 0.189	1.330 0.191	1.312 0.188	0.942 0.110	0.043 0.022	0.942 0.109	0.019 0.020	-0.01 0.024
42455090SRN2	0.166 0.176	0.752 0.106	0.574 0.090	0.682 0.099	0.421 0.065	0.021 0.019	0.401 0.062	0.014 0.017	0.003 0.006
10530331SRN0			1.257 0.163						
10530331SRN5			1.665 0.246						
42455090SRN0			1.330 0.191						
42455090SRN5			0.665 0.182						

Comparison, relative difference second/first

42455090SRN0	-0.22 1.261	-0.54 0.210	-0.79 0.222	-0.63 0.213	-0.76 0.188	-0.66 0.898	-0.81 0.187	-0.32 1.549	-3.62 7.087
10530331SRN0			0.746 0.202						
42455090SRN0			0.279 0.264						

Table 4A. Comparison of Laboratory Duplicate Analyses for Radionuclides, Gamma Spectrometry

Sample Location	K40		CS137		PB212		PB214		BI214		AC228		TH234		U235	
	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc	pCi/g	unc
10346220SRNO	21.37	0.62	0.052	0.014	1.381	0.038	0.763	0.052	0.778	0.241	1.383	0.111	0.800	0.325	0.007	0.007
10346220SRNO	21.63	0.56	0.046	0.015	1.400	0.034	1.043	0.047	1.089	0.188	1.373	0.100	0.748	0.271	0.005	0.005
21946220SRNO	22.07	0.66	0.096	0.023	1.541	0.042	1.029	0.053	1.067	0.232	1.613	0.114	1.316	0.394	0.064	0.010
21946220SRNO	21.69	0.61	0.124	0.022	1.509	0.038	1.274	0.055	1.180	0.202	1.514	0.097	1.255	0.342	0.068	0.009
22146220SRNO	23.38	0.62	0.010	0.010	1.380	0.036	0.984	0.051	0.820	0.212	1.486	0.101	0.850	0.330	0.055	0.009
22146220SRNO	23.73	0.68	0.015	0.015	1.481	0.041	1.178	0.063	1.106	0.214	1.466	0.120	1.426	0.305	0.010	0.010
30309040SRNO	20.90	0.54	0.567	0.025	1.314	0.032	0.905	0.047	1.071	0.176	1.342	0.086	1.088	0.284	0.059	0.008
30309040SRNO	21.62	0.56	0.561	0.028	1.460	0.035	1.098	0.049	1.167	0.187	1.369	0.099	1.275	0.276	0.005	0.005
30315160SRNO	22.33	0.57	0.047	0.018	1.469	0.035	1.010	0.047	1.041	0.210	1.504	0.107	1.371	0.336	0.006	0.006
30315160SRNO	22.76	0.58	0.048	0.017	1.488	0.036	1.165	0.051	1.153	0.190	1.446	0.107	1.426	0.380	0.005	0.005
30540490BRNO	21.20	0.60	0.013	0.013	1.822	0.043	1.259	0.055	1.196	0.184	1.663	0.107	1.626	0.432	0.069	0.011
30540490BRNO	22.34	0.57	0.010	0.010	1.865	0.039	1.373	0.051	1.500	0.216	1.818	0.110	1.576	0.366	0.070	0.009
30547080BRNO	21.63	0.54	0.009	0.009	1.680	0.037	1.032	0.050	1.054	0.175	1.701	0.105	1.009	0.335	0.005	0.005
30547080BRNO	21.18	0.53	0.010	0.010	1.797	0.038	1.104	0.051	1.067	0.201	1.671	0.104	1.023	0.317	0.005	0.005
30648280BRNO	22.18	0.53	0.008	0.008	1.413	0.034	0.715	0.043	0.833	0.145	1.416	0.099	0.937	0.265	0.005	0.005
30648280BRNO	20.87	0.57	0.010	0.010	1.381	0.037	0.676	0.045	0.680	0.182	1.249	0.098	0.984	0.342	0.005	0.005
42246090SRNO	20.21	0.58	0.012	0.012	1.393	0.036	0.882	0.051	0.908	0.208	1.335	0.097	1.035	0.319	0.007	0.007
42246090SRNO	19.99	0.56	0.015	0.015	1.362	0.036	0.990	0.050	1.006	0.203	1.399	0.101	1.553	0.394	0.060	0.010
42351990SRNO	20.74	0.54	0.097	0.019	1.426	0.033	0.926	0.044	0.906	0.192	1.453	0.093	1.215	0.353	0.005	0.005
42351990SRNO	21.29	0.54	0.083	0.018	1.436	0.033	0.947	0.044	0.985	0.153	1.484	0.096	1.003	0.321	0.005	0.005

Comparison, relative difference second/first

10346220SRNO	0.012	0.039	-0.11	0.416	0.014	0.037	0.311	0.077	0.333	0.328	-0.01	0.109	-0.07	0.547	-0.36	1.436
21946220SRNO	-0.02	0.041	0.257	0.289	-0.02	0.037	0.213	0.066	0.101	0.274	-0.06	0.096	-0.05	0.406	0.065	0.210
22146220SRNO	0.015	0.039	0.373	1.439	0.071	0.038	0.179	0.075	0.297	0.313	-0.01	0.106	-1.22	0.736	-1.38	0.408
30309040SRNO	0.034	0.037	-0.01	0.066	0.105	0.034	0.193	0.068	0.086	0.229	0.020	0.096	0.158	0.335	-1.69	0.303
30315160SRNO	0.019	0.036	0.019	0.514	0.013	0.034	0.143	0.064	0.102	0.258	-0.04	0.103	0.039	0.363	-0.14	1.418
30540490BRNO	0.052	0.038	-0.24	1.424	0.023	0.032	0.087	0.057	0.226	0.211	0.089	0.088	-0.03	0.353	0.013	0.205
30547080BRNO	-0.02	0.035	0.061	1.415	0.067	0.030	0.067	0.066	0.012	0.252	-0.02	0.087	0.014	0.454	0.000	1.414
30648280BRNO	-0.06	0.036	0.239	1.424	-0.02	0.036	-0.06	0.089	-0.20	0.308	-0.13	0.105	0.049	0.451	0.000	1.414
42246090SRNO	-0.01	0.040	0.196	1.421	-0.02	0.037	0.116	0.077	0.102	0.304	0.047	0.102	0.400	0.392	1.573	0.366
42351990SRNO	0.026	0.037	-0.16	0.284	0.007	0.033	0.023	0.066	0.083	0.259	0.021	0.091	-0.19	0.430	0.000	1.414

	K40		CS137		PB212		PB214		BI214		AC228		TH234		U235	
	diff	unc														
number	10		10		10		10		10		10		10		10	
maximum	0.052	0.038	0.373	0.289	0.105	0.034	0.311	0.077	0.333	0.328	0.089	0.088	0.400	0.392	1.573	0.210
mean	0.005	0.065	0.064	0.398	0.023	0.088	0.127	0.209	0.114	0.303	-0.01	0.119	-0.09	0.856	-0.19	1.767
minimum	-0.06	0.036	-0.24	0.284	-0.02	0.036	-0.06	0.089	-0.20	0.308	-0.13	0.105	-1.22	0.430	-1.69	0.205

Table 4B. Comparison of Laboratory Duplicate Analyses for Radionuclides, Radiochemistry

Sample Location	SR90		TH228		TH230		TH232		U234		U235		U238		PU238		PU239	
	pCi/g	unc																
IPL-506-2-3	6.248	0.389	7.716	0.801	1.696	0.258	7.519	0.782	3.594	0.359	0.241	0.085	3.839	0.375	0.122	0.087	2.903	0.524
IPL-506-2-3D	6.743	0.408	9.266	1.054	1.741	0.299	9.116	1.037	7.082	0.629	0.311	0.107	7.103	0.627	0.018	0.051	2.698	0.446

Comparison, relative difference second/first

IPL-506-2-3	0.076	0.087	0.183	0.156	0.026	0.230	0.192	0.156	0.653	0.136	0.254	0.495	0.597	0.134	-1.49	1.441	-0.07	0.246
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Table 5A. Comparison of Laboratory Matrix Spike Analyses for Radionuclides, Gamma Spectrometry

Sample	Location	pct/g unc	AVERAGE	Recovery	1.025 0.064
10530331SM2		pct/g unc	Added	2.000 0.090	
			Measured	2.240 0.130	
			Recovery	1.120 0.082	
20446370SRNO			Added	2.000 0.080	
			Measured	2.040 0.120	
			Recovery	1.020 0.073	
21030331SRNO			Added	1.990 0.090	
			Measured	1.990 0.120	
			Recovery	1.000 0.075	
30113170SRNO			Added	1.970 0.090	
			Measured	2.020 0.150	
			Recovery	1.025 0.089	
30309040SRNO			Added	2.010 0.080	
			Measured	2.020 0.110	
			Recovery	1.005 0.068	
30345110SRNO			Added	2.010 0.080	
			Measured	2.010 0.130	
			Recovery	1.000 0.076	
30511230BRNO			Added	2.010 0.080	
			Measured	2.160 0.110	
			Recovery	1.075 0.069	
30540490BRNO			Added	2.000 0.080	
			Measured	1.900 0.130	
			Recovery	0.950 0.075	
41726090SRNO			Added	2.000 0.080	
			Measured	1.970 0.110	
			Recovery	0.985 0.068	
10530331SRMS			Added	5.260 0.050	
			Measured	5.420 0.170	
			Recovery	1.030 0.034	
10530331SRMS			Added	4.560 0.050	
			Measured	4.880 0.140	
			Recovery	1.070 0.033	
10530331SRMS			Added	5.460 0.050	
			Measured	5.560 0.150	
			Recovery	1.018 0.029	
10530331SRMS			Added	2.830 0.062	
			Measured	2.383 0.153	
			Recovery	0.837 0.054	
10530331SRMS			Added	2.526 0.280	
			Measured	8.872 0.865	
			Recovery	1.031 0.117	
10530331SRMS			Added	2.240 0.049	
			Measured	6.970 0.568	
			Recovery	0.665 0.182	
10530331SRMS			Added	2.193 0.267	
			Measured	4.028 0.267	
			Recovery	0.979 0.121	
42455090SRMS			Added	2.830 0.062	
			Measured	6.248 0.389	
			Recovery	2.208 0.146	
10530331SRMS			Added	2.830 0.062	
			Measured	9.090 0.327	
			Recovery	0.849 0.093	
20646220SRMS			Added	6.248 0.389	
			Measured	7.716 0.801	
			Recovery	1.696 0.258	
10530331SRMS			Added	9.090 0.327	
			Measured	9.116 1.037	
			Recovery	1.003 0.120	
10530331SRMS			Added	2.830 0.062	
			Measured	7.082 0.629	
			Recovery	0.311 0.107	
10530331SRMS			Added	2.830 0.062	
			Measured	5.376 0.194	
			Recovery	0.244 0.009	
10530331SRMS			Added	2.830 0.062	
			Measured	7.103 0.627	
			Recovery	0.012 0.012	
10530331SRMS			Added	2.830 0.062	
			Measured	10.25 7.312	
			Recovery	0.956 0.174	
10530331SRMS			Added	2.830 0.062	
			Measured	3.037 0.064	
			Recovery	2.903 0.524	
10530331SRMS			Added	2.830 0.062	
			Measured	7.103 0.627	
			Recovery	0.012 0.012	
10530331SRMS			Added	2.830 0.062	
			Measured	10.25 7.312	
			Recovery	0.956 0.174	
10530331SRMS			Added	2.830 0.062	
			Measured	3.037 0.064	
			Recovery	2.903 0.524	
10530331SRMS			Added	2.830 0.062	
			Measured	7.103 0.627	
			Recovery	0.012 0.012	
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10530331SRMS			Added	2.830 0.062	
			Measured	7.103 0.627	

## **10. Appendix A**

The Certificates of Calibration for the blind spike samples prepared by Isotope Product Laboratories are presented here. The activity values, uncertainties, and isotopic fractions stated on these sheets have been used in the intercomparisons discussed in this report.

# CERTIFICATE OF CALIBRATION MULTINUCLIDE STANDARD SOURCE

Customer: ROCKWELL INTL/ROCKETDYNE P.O.No.: R54PJO-95162004  
 Catalog No.: EG-0075 Reference Date: September 1 1995 12:00 PST.  
 Source No.: 506-2-1 Total Radioactivity: 28.9 nCi.  
 Total Radioactivity: 1,068 Bq.

### Description of Source

- a. Capsule type: Customer supplied bottle  
 b. Nature of active deposit: SrCl<sub>2</sub>, CsCl, Th(NO<sub>3</sub>)<sub>4</sub>, UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>, and Pu(NO<sub>3</sub>)<sub>3</sub> dispersed in a sand matrix  
 c. Active diameter/volume: Approximately 1.0 L (Mass of sand = 1,125.60 g)  
 d. Backing: Glass  
 e. Cover: Glass

Nuclide	Half-life	Activity. (nCi)	Concentration (pCi/g)	Systematic Uncert.	Random Uncert.	Total Uncert.
Sr-90	28.5 ± 0.2 years	2.76	2.45	2.0%	0.9%	2.2%
Cs-137	30.17 ± 0.16 years	5.92	5.26	1.0%	0.7%	1.2%
Th-232	(1.405 ± 0.006) x 10 <sup>10</sup> years	9.05	8.04	3.0%	2.0%	3.6%
U-238	(4.468 ± 0.005) x 10 <sup>9</sup> years	7.87	6.99	3.0%	2.0%	3.6%
Pu-239	24,110 ± 30 years	3.26	2.90	2.1%	0.3%	2.1%

### Method of Calibration

This source was prepared from weighed aliquots of solutions whose concentrations, in nCi/g, were determined as follows: 1) for Sr-90 and Pu-239 by a liquid scintillation counter, 2) for Cs-137 by a well type ionization chamber, and 3) for Th-232 and U-238 by specific activity and mass calculations. Sr-90 has a daughter (Y-90) in equilibrium. U-238 and Pu-239 have attached technical data sheets for impurities and daughters.

### Daughter decay scheme for Th-232

Ra-228 → Ac-228 → Th-228 → Ra-224 → Rn-220 → Po-216 → Pb-212 → Bi-212 → Po-212 → Tl-208 → Pb-208

### NIST Traceability

This calibration is implicitly traceable to the National Institute of Standards and Technology.

### Leak Test(s)

See reverse side for Leak Test(s) applied to this source.

### Notes

- IPL participates in an NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Overall uncertainty is calculated at the 95.5% confidence level.



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*Ann H. Kim*  
QUALITY CONTROL

14 Sep 1995

Date Signed

IPL Ref No. 506-2-1

# CERTIFICATE OF CALIBRATION MULTINUCLIDE STANDARD SOURCE

Customer: ROCKWELL INTL/ROCKETDYNE	P.O.No.: RS4PJO-95162004	
Catalog No.: EG-0075	Reference Date: September 1 1995	12:00 PST.
Source No.: 506-2-2	Total Radioactivity: 28.3	nCi.
	Total Radioactivity: 1,048	Bq.

**Description of Source**

- a. Capsule type: Customer supplied bottle
- b. Nature of active deposit: SrCl<sub>2</sub>, CsCl, Th(NO<sub>3</sub>)<sub>4</sub>, UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>, and Pu(NO<sub>3</sub>)<sub>3</sub> dispersed in a sand matrix
- c. Active diameter/volume: Approximately 1.0 L. (Mass of sand - 1,283.96 g)
- d. Backing: Glass
- e. Cover: Glass

Nuclide	Half-life	Activity. (nCi)	Concentration (pCi/g)	Systematic Uncert.	Random Uncert.	Total Uncert.
Sr-90	28.5 ± 0.2 years	2.88	2.24	2.0%	0.9%	2.2%
Cs-137	30.17 ± 0.16 years	5.86	4.56	1.0%	0.7%	1.2%
Th-232	(1.405 ± 0.006) x 10 <sup>10</sup> years	8.95	6.97	3.0%	2.0%	3.6%
U-238	(4.468 ± 0.005) x 10 <sup>9</sup> years	7.81	6.09	3.0%	2.0%	3.6%
Pu-239	24,110 ± 30 years	2.83	2.26	2.1%	0.3%	2.1%

**Method of Calibration**

This source was prepared from weighed aliquots of solutions whose concentrations, in nCi/g, were determined as follows: 1) for Sr-90 and Pu-239 by a liquid scintillation counter, 2) for Cs-137 by a well type ionization chamber, and 3) for Th-232 and U-238 by specific activity and mass calculations. Sr-90 has a daughter (Y-90) in equilibrium. U-238 and Pu-239 have attached technical data sheets for impurities and daughters.

**Daughter decay scheme for Th-232**

Ra-228 -> Ac-228 -> Th-228 -> Ra-224 -> Rn-220 -> Po-216 -> Pb-212 -> Bi-212 -> Po-212 -> Tl-208 -> Pb-208

**NIST Traceability**

This calibration is implicitly traceable to the National Institute of Standards and Technology.

**Leak Test(s)**

See reverse side for Leak Test(s) applied to this source.

**Notes**

1. IPL participates in an NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
2. Overall uncertainty is calculated at the 95.5% confidence level.



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QUALITY CONTROL

14 Sep 1995  
\_\_\_\_\_  
Date Signed

IPL Ref No. 506-2-2

# CERTIFICATE OF CALIBRATION MULTINUCLIDE STANDARD SOURCE

Customer: ROCKWELL INTL/ROCKETDYNE	P.O.No.: R54PJO-95162004	
Catalog No.: EG-0075	Reference Date: September 1 1995	12:00 PST
Source No.: 506-2-3	Total Radioactivity: 25.3	nCi.
	Total Radioactivity: 938	Hq.

### Description of Source

- a. Capsule type: Customer supplied bottle
- b. Nature of active deposit: SrCl<sub>2</sub>, CsCl, Th(NO<sub>3</sub>)<sub>4</sub>, UO<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>, and Pu(NO<sub>3</sub>)<sub>3</sub> dispersed in a sand matrix
- c. Active diameter/volume: Approximately 1.0 L (Mass of sand = 995.76g)
- d. Backing: Glass
- e. Cover: Glass

Nuclide	Half-life	Activity. (nCi)	Concentration (pCi/g)	Systematic Uncert.	Random Uncert.	Total Uncert.
Sr-90	28.5 ± 0.2 years	2.82	2.83	2.0%	0.9%	2.2%
Cs-137	30.17 ± 0.16 years	5.44	5.46	1.0%	0.7%	1.2%
Th-232	(1.405 ± 0.006) x 10 <sup>10</sup> years	9.05	9.09	3.0%	2.0%	3.6%
U-238	(4.468 ± 0.005) x 10 <sup>9</sup> years	5.22	5.24	3.0%	2.0%	3.6%
Pu-239	24,110 ± 30 years	2.81	2.82	2.1%	0.3%	2.1%

### Method of Calibration

This source was prepared from weighed aliquots of solutions whose concentrations, in nCi/g, were determined as follows: 1) for Sr-90 and Pu-239 by a liquid scintillation counter, 2) for Cs-137 by a well type ionization chamber, and 3) for Th-232 and U-238 by specific activity and mass calculations. Sr-90 has a daughter (Y-90) in equilibrium. U-238 and Pu-239 have attached technical data sheets for impurities and daughters.

### Daughter decay scheme for Th-232

Ra-228 → Ac-228 → Th-228 → Ra-224 → Rn-220 → Po-216 → Pb-212 → Bi-212 → Po-212 → Tl-208 → Pb-208

### NIST Traceability

This calibration is implicitly traceable to the National Institute of Standards and Technology.

### Leak Test(s)

See reverse side for Leak Test(s) applied to this source.

### Notes

- IPL participates in an NIST measurement assurance program to establish and maintain implicit traceability for a number of nuclides, based on the blind assay (and later NIST certification) of Standard Reference Materials (As in NRC Regulatory Guide 4.15).
- Overall uncertainty is calculated at the 95.5% confidence level.



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QUALITY CONTROL

14 Sep 1995  
Date Signed

IPL Ref No. 506-2-3



## U-238 TECHNICAL DATA

The U-238 used to prepare your order was taken from Isotope Products Laboratories Lot #6794 and had the following composition as of June 1, 1994.

### Corporate Offices

3017 N. San Fernando Blvd.  
Burbank, California  
91504

### NUCLIDE

### ATOM%

### ACTIVITY%

U-232

N/D

U-233

N/D

U-234

0.005

49.501

### Main Laboratory

1800 N. Keystone Street  
Burbank, California  
91504

U-235

0.720

2.250

U-236

N/D

U-238

99.274

48.249

Isotopic composition provided by Oak Ridge National Laboratory.

818-843-7000

Fax 818-843-6168

If you have any questions, please contact Technical Service.

(818)843-7000



## Pu-239 TECHNICAL DATA

The Pu-239 used to prepare your order was taken from Isotope Products Laboratories Lot #6617-1 and had the following composition as of October 1, 1994.

<i>Corporate Offices</i>	<u>NUCLIDE</u>	<u>ATOM%</u>	<u>ACTIVITY%</u>	<u>TOTAL <math>\alpha</math> ACTIVITY %</u>
3017 N. San Fernando Blvd.				
Burbank, California	Pu-238	0.002	0.337	0.388
91504	Pu-239	97.933	79.717	91.887
	Pu-240	2.056	6.124	7.058
<i>Main Laboratory</i>	Pu-241	0.010	13.241	N/A
1800 N. Keystone Street	Pu-242	0.001	0.000	0.000
Burbank, California				
91504	Am-241	-----	0.582	0.671

Note: Pu-241 is beta active.

818-843-7000

Fax 818-843-6168

Isotopic composition provided by New Brunswick Laboratory.

If you have any questions, please contact Technical Service.

## 11. Appendix B - Interpretation of Results

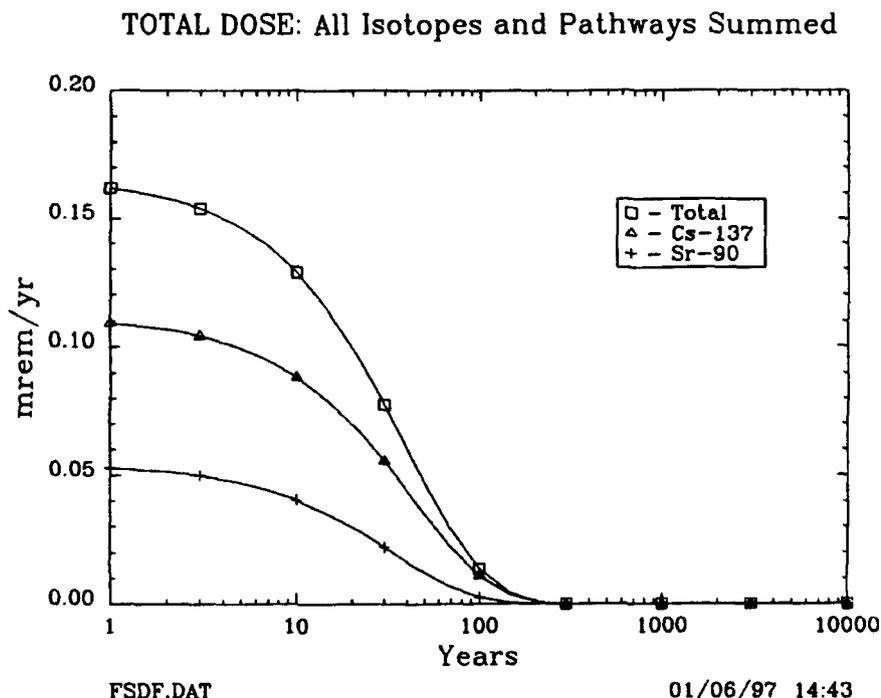
All soil sample analytical results are well below the approved limits for release of land areas for use without radiological restrictions (see "Proposed Sitewide Release Criteria for Remediation of Facilities at the SSFL", B. M. Oliver and R. J. Tuttle, Rocketdyne Document N001SRR140127, 8/22/96). That document provided single-isotope limits for all radionuclides that are possible contaminants at SSFL, and those limits were approved by the Department of Energy, Oakland Operations Office, and by the State of California Department of Health Services, Radiologic Health Branch. Potential doses to future users of the site, for residential, industrial, and wilderness use situations were considered, and concentrations were calculated that provided a Total Effective Dose Equivalent (TEDE) equal to the limit of 15 mrem/year recommended by the EPA. For the two radionuclides detected in the soil sampling survey, Sr-90 and Cs-137, the limits are 36.0 and 9.2 pCi/g, respectively. All analytical results were well below these limits. The maximum value for Sr-90 was 0.569 pCi/g, or 1.58% of the single-isotope limit. The maximum value for Cs-137 was 0.567 pCi/g, or 6.16% of the single-isotope limit. Combining these two percentages to test for the combined sum of fractions rule, results in a percentage of 7.74%, far below the allowable 100%.

To demonstrate the satisfactory condition of the radiologically remediated Former Sodium Disposal Facility, a pathways analysis was performed to estimate potential dose to a hypothetical resident of the area. This analysis used the pathways code, RESRAD (version 5.61), with the same parameters that were used in establishing the generic limits on radioactivity in soil at SSFL. The Former Sodium Disposal Facility was represented as a slightly smaller area, 8,200 m<sup>2</sup>, than the generic reference case, 10,000 m<sup>2</sup>.

The residual contamination of the site was assumed to be equal to the average of the measured values, for Sr-90 and Cs-137, the only contaminants detected in the radiometric analyses. These values were, respectively, 0.131 pCi/g for Sr-90 and 0.069 pCi/g for Cs-137. Residual contamination was assumed to be uniformly distributed through the upper 1 meter of the soil. (This is a conservative assumption, since much of the area was excavated down to bedrock and only a very thin residual layer of soil remains. For this calculation the top 1 meter of the site is considered to be soil. Studies of the depth distribution of the original contamination showed that the radioactivity, which had initially been deposited on the surface of the soil, had not penetrated beyond about 18 inches.)

RESRAD calculates the dose from a variety of exposure pathways. The only significant pathways were direct radiation from the ground for the Cs-137, and plant uptake (in vegetables) for the Sr-90. If the Former Sodium Disposal Facility had been occupied in a residential manner immediately after completion of the soil sampling, that is, in August 1995, the first-year dose is calculated to be 0.166 mrem. This is small compared to the recommended limit of 15 mrem per year, established by the EPA, and trivial compared to the natural dose from "clean" soil approximately 80 mrem/year. The estimated dose declines with time into the future. This is

shown in Figure A. 1, where the dose becomes essentially zero after 100 years.



**Figure A-1. Calculated potential dose to resident of remediated Former Sodium Disposal Facility.**

The average values assumed for contamination are comparable to the fallout background found in surface soil in this region. Subtraction of background activities is not suitable in this case, however, because many of the samples are from deep below the original surface of the soil where the background activity of these radionuclides is essentially zero. Therefore, a comparison calculation was performed, representing an undisturbed plot of land with the same characteristics and usage as proposed for the Former Sodium Disposal Facility, except that the residual contamination was replaced by the values of activity found for the surrounding, unaffected, terrain. These background values were derived from the Area IV Characterization Survey results, by excluding all samples that were suggestive of possible contamination, and the deliberately selected offsite (background) soil sample results. (See "Area IV Radiological Characterization Survey - Final Report", ETEC Document A4CM-ZR-0011, Revision A, Volumes I-IV, August 15, 1996.) For unaffected soil, contaminated only by fallout activity, the activity was assumed to be limited to the upper 10 cm of the soil (4 inches). This calculation shows that the dose on unaffected, and unremediated, land would be 0.171 mrem in the first year, slightly more than for the remediated Former Sodium Disposal Facility. When naturally occurring concentrations of potassium-40, uranium (plus daughters) and thorium (plus daughters) are included in the "clean" soil, a similar RESRAD calculation yields 81.74 mrem/year, as an additional, natural dose from the natural radioactivity alone.

As a further demonstration of the conservatism in the cleanup conducted here, a RESRAD calculation was also done with the assumption that the entire site was contaminated at the level found in the single most contaminated sample, that is, the sample taken at location 3030904, in the former Lower Pond. (All soil had been removed from the Lower Pond, so that only bedrock remains.) This calculation showed that these greater amounts of Sr-90 (0.569 pCi/g) and Cs-137

(0.567 pCi/g) would produce only 1.157 mrem/year in the first year, still far below the limit of 15 mrem/year and the natural dose of 81.74 mrem/year.

**This study shows that the Former Sodium Disposal Facility is in compliance with the recommended acceptance limit of 15 mrem per year for radiological exposure, and is essentially no different, radiologically, from any similar unaffected plot of land.**

DER 25490 MO

**ENERGY TECHNOLOGY ENGINEERING CENTER**

OPERATED FOR THE U.S. DEPARTMENT OF ENERGY  
ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL

No. 886-ZR-0007 Rev. NC  
Page 1 of 66  
Orig. Date 12/13/94  
Rev. Date \_\_\_\_\_

**TITLE: POST-REMEDATION AMBIENT GAMMA RADIOLOGICAL SURVEY OF THE FORMER SODIUM DISPOSAL FACILITY (T886)**

- APPROVALS -

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REV. LTR.	REVISION	APPROVAL/DATE
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**CONTENTS**

	<b>Page</b>
1.0 Introduction . . . . .	8
2.0 Summary and Conclusions . . . . .	9
3.0 Background . . . . .	12
3.1 Location . . . . .	12
3.2 Topography and Site Characterization . . . . .	12
3.3 Remediation Activities . . . . .	12
4.0 Survey Results . . . . .	16
4.1 Overview . . . . .	16
4.2 Survey Procedures . . . . .	16

## FIGURES

	Page
1. Data Analysis Results Summary . . . . .	11
2. Location of SSFL in Relation to Los Angeles and Vicinity	13
3. Map of Neighboring SSFL Communities . . . . .	14
4. Santa Susana Field Laboratory (SSFL) Area IV . . . . .	15
5. Sodium Disposal Facility Plan View . . . . .	17
6. Sodium Disposal Facility Post-Remediation Survey Grid Map . . . . .	18
7. All Survey Areas Combined Ambient Gamma Exposure Rate .	21
8. Lower and Upper Pond Basins Ambient Gamma Exposure Rate	22
9. Ambient Gamma Exposure Rate Excluding the Lower and Upper Pond Basins . . . . .	23
10. Upper Pond Basin Ambient Gamma Exposure Rate . . . . .	24
11. Lower Pond Basin Ambient Gamma Exposure Rate . . . . .	25
12. Grid Locator Map for Survey Results . . . . .	26
13. Grid #1 Ambient Gamma Exposure Rate . . . . .	27
14. Grid #2 Ambient Gamma Exposure Rate . . . . .	28
15. Grid #4 Ambient Gamma Exposure Rate . . . . .	29
16. Grid #5 Ambient Gamma Exposure Rate . . . . .	30
17. Grid #6 Ambient Gamma Exposure Rate . . . . .	31
18. Grid #7 Plot View . . . . .	32
19. Grid #8 Ambient Gamma Exposure Rate . . . . .	33
20. Grid #9 Ambient Gamma Exposure Rate . . . . .	34
21. Grid #10 Ambient Gamma Exposure Rate . . . . .	35
22. Grid #11 Ambient Gamma Exposure Rate . . . . .	36
23. Grid #13 Ambient Gamma Exposure Rate . . . . .	37
24. Grid #14 Ambient Gamma Exposure Rate . . . . .	38
25. Grid #15 Ambient Gamma Exposure Rate . . . . .	39
26. Grid #16 Ambient Gamma Exposure Rate . . . . .	40
27. Grid #17 Ambient Gamma Exposure Rate . . . . .	41
28. Grid #21 Ambient Gamma Exposure Rate . . . . .	42
29. Grid #22 Ambient Gamma Exposure Rate . . . . .	43
30. Grid #23 Ambient Gamma Exposure Rate . . . . .	44
31. Grid #24 Ambient Gamma Exposure Rate . . . . .	45

## FIGURES

	Page
32. Grid #29 Ambient Gamma Exposure Rate . . . . .	46
33. Grid #30 Ambient Gamma Exposure Rate . . . . .	47
34. Grid #31 Ambient Gamma Exposure Rate . . . . .	48
35. Grid #32 Ambient Gamma Exposure Rate . . . . .	49
36. Grid #33 Ambient Gamma Exposure Rate . . . . .	50
37. Grid #36 Ambient Gamma Exposure Rate . . . . .	51
38. Grid #37 Ambient Gamma Exposure Rate . . . . .	52
39. Grid #38 Ambient Gamma Exposure Rate . . . . .	53
40. Grid #39 Ambient Gamma Exposure Rate . . . . .	54
41. Grid #40 Ambient Gamma Exposure Rate . . . . .	55
42. Grid #41 Ambient Gamma Exposure Rate . . . . .	56
43. Grid #43 Ambient Gamma Exposure Rate . . . . .	57
44. Grid #44 Ambient Gamma Exposure Rate . . . . .	58
45. Grid #45 Ambient Gamma Exposure Rate . . . . .	59
46. Grid #46 Ambient Gamma Exposure Rate . . . . .	60
47. Grid #47 Ambient Gamma Exposure Rate . . . . .	61
48. Grid #48 Ambient Gamma Exposure Rate . . . . .	62
49. Grid #52 Ambient Gamma Exposure Rate . . . . .	63
50. Grid #53 Ambient Gamma Exposure Rate . . . . .	64
51. Grid #54 Ambient Gamma Exposure Rate . . . . .	65
52. Grid #55 Ambient Gamma Exposure Rate . . . . .	66

**TABLES**

	Page
1. Data Analysis Results Summary . . . . .	11

**ABSTRACT**

A comprehensive baseline radiological survey for ambient gamma exposure rate was conducted in 1991 (Reference 3) just prior to the site remediation of the former Sodium Disposal Facility (SDF) (T886). That survey covered the lower and upper pond areas of the SDF and was used as a guide in beginning remediation (i.e., excavation). After the remedial efforts were completed (which included numerous operational gamma surveys) the stage was set for the post-remedial ambient gamma exposure survey. This survey covered the lower and upper pond areas as well as adjacent land.

Results of this survey show the ambient gamma exposure rates of the former SDF and surrounding land to be indistinguishable from each other. These results presented here along with the planned soil sampling by an outside contractor will serve as a basis to release the SDF for use without radiological controls. This document represents the ambient gamma survey as performed in accordance with Reference 1.

## REFERENCES

1. J. J. Collins, "Final Radiological Sampling and Gamma Survey Procedures to Follow Site Remediation of the Former T886 Sodium Disposal Facility, ETEC, 886-ZR-0006 (July 20, 1993)
2. J. Chapman, "Radiological Survey of the Sodium Disposal Facility Bldg T886," ETEC, GEN-ZR-0004 (June 3, 1988)
3. J. J. Collins, "Baseline Radiological Survey of the Sodium Disposal Facility (T886)," Rockwell International, Rocketdyne Division, N704SRR990034 (August 31, 1992)
4. "Radiological Soil Sampling and Pathways Dose Analysis for the Sodium Disposal Facility (T886)" to be published
5. L. Mountford, "Interim Report (March - May 1994), Area IV, Radiological Characterization Study," A4CM-ZR-0008, June 28, 1994
6. L. Mountford, "Interim Report (June - August 1994), Area IV, Radiological Characterization Study," A4CM-ZR-0009, October 6, 1994
7. "Additional Soil and Water Sampling at the Brandeis-Bardin Institute and Santa Monica Mountains Conservancy," draft, November 18, 1994

1.0

INTRODUCTION

This report documents the post-remediation radiological ambient gamma survey of the former Sodium Disposal Facility (SDF) (T886) and subsequent data analyses. The post-remediation ambient gamma survey was undertaken to evaluate the radiological conditions after the completion of the site remediation. The surveyed areas included the remediated lower and upper pond basins, the surrounding land, and the site drainage pathways. The ambient gamma exposure rate results used in conjunction with the soil sampling analyses as outlined in Reference 1 will serve as a basis to quantitatively release the SDF from radiological controls. This document represents the gamma survey as performed in accordance with Reference 1.

## 2.0 SUMMARY AND CONCLUSIONS

Analyses of the ambient gamma exposure rates show the remediated areas are statistically indistinguishable from background readings elsewhere in SSFL Area IV. The entire site averaged 15.6  $\mu\text{R/hr}$  with maximum readings up to 21.4  $\mu\text{R/hr}$  occurring next to or on the surrounding rock formations, which is consistent with data and results from References 2 and 3, data being accumulated in the Area IV radiological characterization survey (References 5 and 6) and EPA measurements taken during the off-site multimedia sampling program (Reference 7). Table 1 provides the summarized data from the survey.

Table 1. Data Analysis Results Summary

Location	No. of Data Points	Mean ( $\mu\text{R/hr}$ )	Std. Dev. ( $\mu\text{R/hr}$ )	$\mu\text{R/hr}$		Ref. Fig. No.	Page No.
				Min	Max		
All areas	2316	15.6	1.5	10.4	21.0	7	21
Lower & upper pond basins	419	14.6	0.9	12.2	17.2	8	22
Lower & upper pond basins excluded	1897	15.7	1.5	10.4	21.0	9	23
Upper pond basin	244	14.2	0.7	12.2	15.8	10	24
Lower pond basin	175	15.3	0.7	13.2	17.2	11	25
Grid #1	16	17.0	0.6	16.3	18.6	13	27
Grid #2	17	17.0	0.4	16.2	17.6	14	28
Grid #4	51	16.7	0.8	15.2	19.0	15	29
Grid #5	112	16.6	0.6	15.5	18.6	16	30
Grid #6	70	17.2	0.4	16.1	18.2	17	31
Grid #7	Inaccessible or not in survey scope					18	32
Grid #8	50	18.7	0.9	17.2	21.4	19	33
Grid #9	82	16.6	0.9	15.1	21.4	20	34
Grid #10	103	15.2	0.8	11.3	16.8	21	35
Grid #11	37	16.0	0.4	14.9	16.8	22	36
Grid #13	20	18.4	0.7	17.8	19.6	23	37
Grid #14	61	17.0	1.1	15.2	19.6	24	38
Grid #15	110	17.1	1.1	14.9	19.7	25	39
Grid #16	113	16.3	0.4	15.5	17.2	26	40
Grid #17	31	16	0.4	15.3	16.9	27	41

Table 1. Data Analysis Results Summary

Location	No. of Data Points	Mean ( $\mu\text{R/hr}$ )	Std. Dev. ( $\mu\text{R/hr}$ )	$\mu\text{R/hr}$		Ref. Fig. No.	Page No.
				Min	Max		
Grid #21	13	17.2	1.0	15.8	18.6	28	42
Grid #22	118	15.6	0.7	13.9	18.4	29	43
Grid #23	115	14.7	0.7	13.3	16.6	30	44
Grid #24	61	16.0	0.3	15.1	16.7	31	45
Grid #29	90	16.1	0.9	14.9	19.4	32	46
Grid #30	121	15.2	0.6	13.7	17.6	33	47
Grid #31	96	14.3	0.7	12.0	15.6	34	48
Grid #32	10	16.2	0.4	15.7	16.8	35	49
Grid #33	33	16.8	0.4	16.2	18.1	36	50
Grid #36	75	16.4	1.1	14.5	19.8	37	51
Grid #37	121	15.6	0.6	14.5	17.4	38	52
Grid #38	121	14.6	0.7	13.2	17.2	39	53
Grid #39	86	14.2	0.7	12.5	15.4	40	54
Grid #40	48	17.3	0.7	16.2	18.8	41	55
Grid #41	22	17.0	0.6	15.2	18.4	42	56
Grid #43	64	16.8	1.2	14.7	19.9	43	57
Grid #44	120	15.1	1.0	13.5	17.9	44	58
Grid #45	121	14.4	0.6	13.0	15.6	45	59
Grid #46	121	13.8	0.5	12.6	15.5	46	60
Grid #47	104	13.2	1.1	10.4	15.4	47	61
Grid #48	40	16.5	0.8	15.1	18.7	48	62
Grid #52	14	14.7	0.2	14.1	15.0	49	63
Grid #53	44	14.0	0.9	10.4	15.3	50	64
Grid #54	66	14.3	0.6	13.1	16.1	51	65
Grid #55	66	13.7	1.0	10.9	15.0	52	66
Grid #3, 12, 18, 19, 20, 25, 26, 27, 28, 34, 35, 42, 49, 50, 51, 56, 57, 58	Inaccessible areas or outside the survey scope					12	26

Figure 1 demonstrates the homogeneity of the results from the survey. The remediated areas averaged lower exposure rate readings than the rock formations as expected and the standard deviation of the entire data set was only  $1.5 \mu\text{R/hr}$

In conclusion, the post-remediation ambient gamma exposure rate survey results show that the SDF site and surroundings to be indistinguishable from one another and from other referenced gamma survey reports.

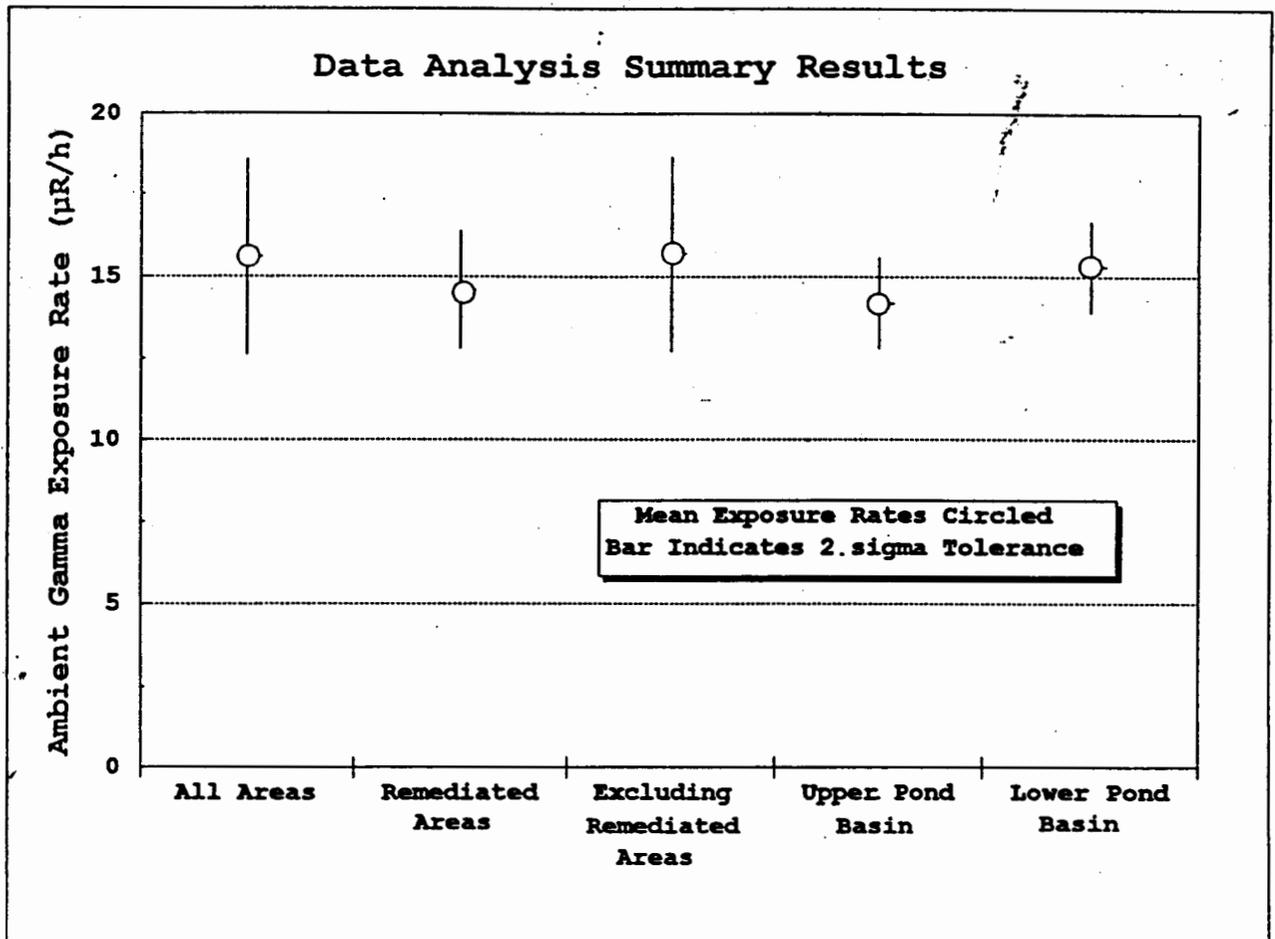


Figure 1. Data Analysis Summary Results

### 3.0 BACKGROUND

#### 3.1 Location

The Sodium Disposal Facility (SDF) is located within Rockwell International's Santa Susana Field Laboratory (SSFL) in the Simi Hills of southeastern Ventura County, California, adjacent to the Los Angeles County line and approximately 29 miles northwest of downtown Los Angeles, directly south of the City of Simi Valley. Location of the SSFL relative to the Los Angeles and vicinities is shown in Figure 1. An enlarged map of neighboring SSFL communicate is shown in Figure 2. Figure 3 is a plot plan of the western portion of SSFL known as Area IV, where the SDF is located. A drawing (plan view) of the SDF and its adjoining areas is shown in Figure 4. The SDF is located on Rockwell-owned land.

#### 3.2 Topography and Site Characteristics

The SDF is located at the west end of Rockwell International's SSFL. The SDF is commonly called the "Old Sodium Burn Pit," and is designated as SSFL site T886. The facility occupies the high ground of an alluvial flat that is roughly triangular in shape, and about two acres in area. The site is bordered by siltstone rock formations on two sides, which come together at the north end of the site to form a blunted apex to the triangle. Site drainage is through the siltstone narrows to the northwest.

The SDF was once used as a disposal site for sodium and sodium-potassium alloys, and combustible materials from US DOE/AEC nuclear programs. The disposal activity was mostly confined to a concrete pool, and two open-field pits that are referred to as the Upper Pond Basin and the Lower Pond Basin. Previous radiological survey and decontamination work have been done at the site. A more detailed description of the site's physical location, its relevant operational history, and a discussion of previous survey and decontamination efforts can be found in Reference 2.

#### 3.3 Remediation Activities

A total of 12,000 cubic yards of soil were excavated from the lower pond basin and portions of the upper pond basin. Field gamma surveys of each cubic yard of soil resulted in approximately 750 cubic yards (~6%) being declared radioactively contaminated. Eighty composite soil samples were taken from the 750 cubic yards of soil and analyzed by an independent laboratory for gamma emitters (gamma spectroscopy), Sr-90, H-3, isotopic uranium, isotopic thorium and isotopic plutonium. Based on the concentration results, a total quantity of 6 millicuries of Cs-137 and

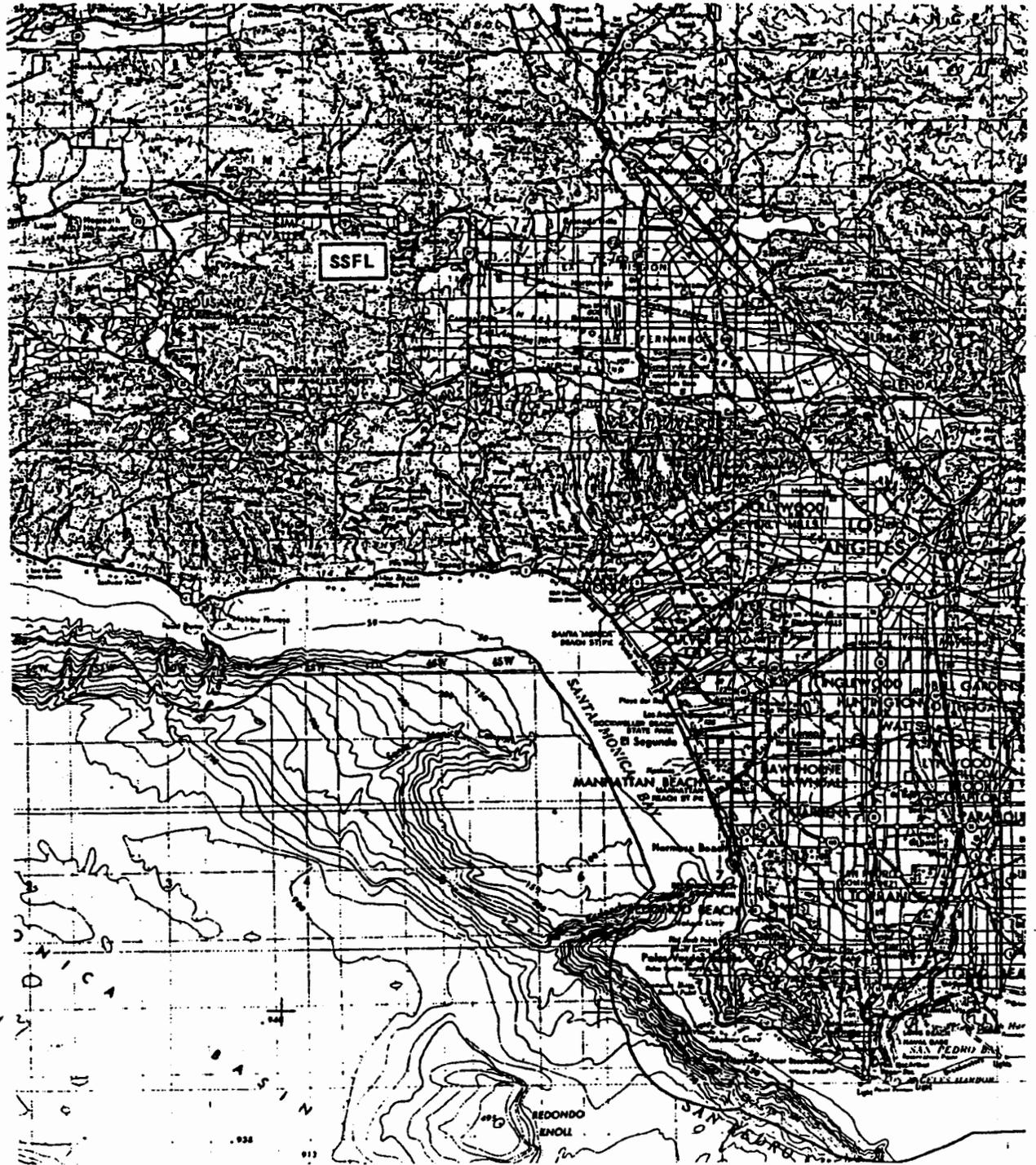


Figure 2. Location of SSFL in Relation to Los Angeles and Vicinity



Figure 3. Map of Neighboring SSFL Communities

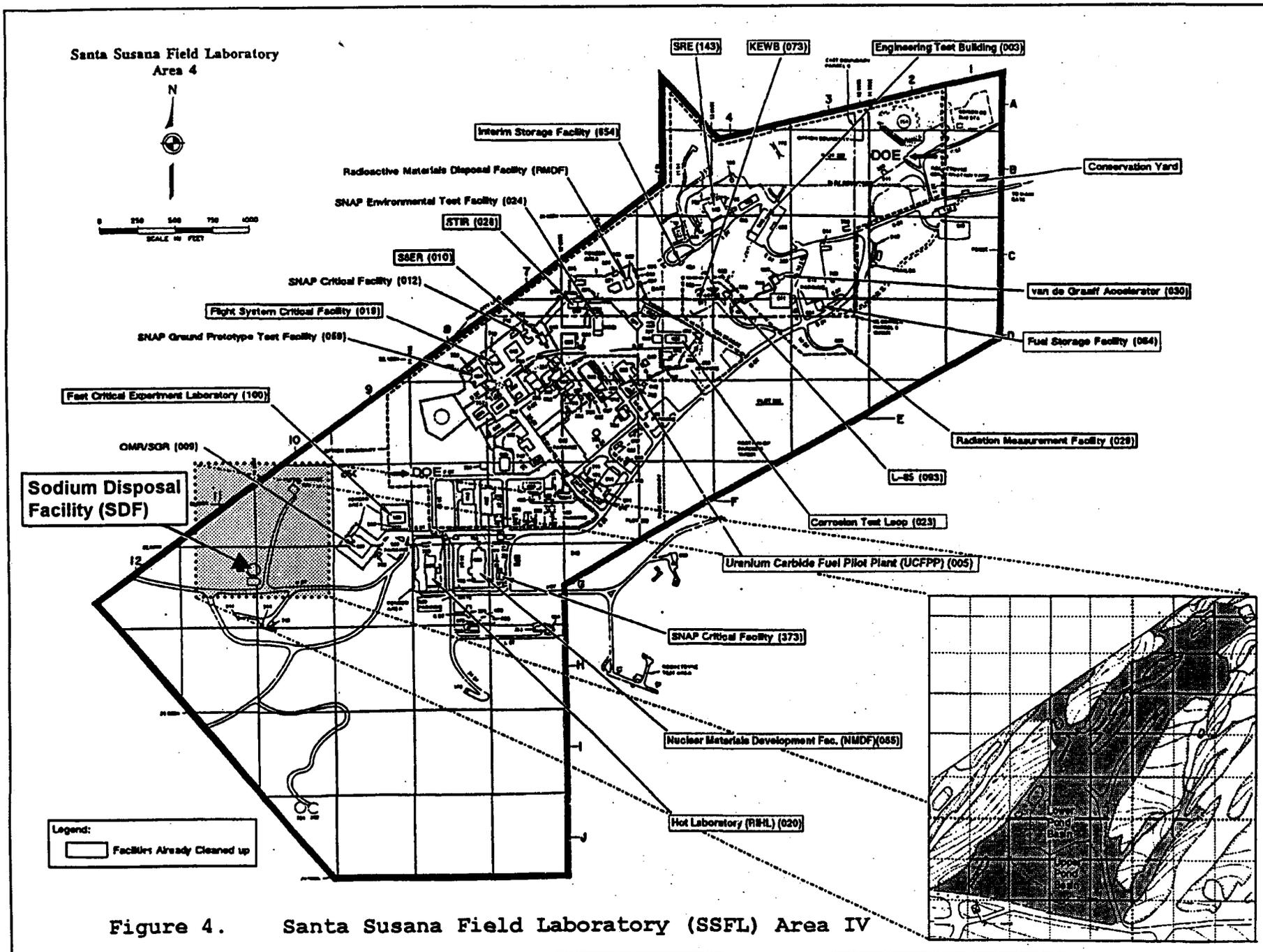


Figure 4. Santa Susana Field Laboratory (SSFL) Area IV

1 millicurie of Sr-90 was identified as contamination. Cs-137 concentrations ranged from 0.09 - 52 picocuries per gram of soil (pCi/gm) with an average of 8 pCi/gm, while Sr-90 concentrations ranged from 0.11 to 38 pCi/gm with an average of 1.6 pCi/gm. Of this radiologically contaminated soil, the mixed waste portion was disposed of to Envirocare in Utah while the radwaste portion is to be shipped to Hanford, Washington.

#### 4.0 SURVEY RESULTS

##### 4.1 Overview

The radiological survey of this report was performed to establish a post-remedial ambient gamma exposure rate comparison between the remedial areas (Upper and Lower Basins, see Figure 5) and the surrounding adjacent land. The previous baseline survey of Reference 3 had clearly shown residual radioactivity present in an enclosed 10' x 10' area. Subsequent soil excavation and removal along with numerous operational surveys indicated remediation was complete. This document will serve as one of the checks for completeness (soil sampling and RESRAD analyses will be documented in Reference 4).

##### 4.2 Survey Procedures

The survey procedures are detailed in Reference 1 and are essentially the same as the survey of Reference 3. The zero-zero (0,0) coordinate for both surveys is the same, however, and the SDF site was again overlaid by a 10-ft (spacing intervals) north/south, east/west grid. Wood stakes were placed at the intersection of the 200-ft grid lines and survey measurement taken every 10-ft intersection at 1-meter height. For data analyses and interpretation, 100-ft by 100-ft grid squares were analyzed as one statistical distribution. Additional analyses of the site compared the affected areas (Upper and Lower Pond Basins) separately and together. Figure 6 shows the pond basins and locations of the grid squares.

The survey consisted of measurements of detected activity counts during a 1-minute time interval. All measurements were made with paired sets of independent survey instruments--two 1-inch NaI gamma detectors at 1-meter height. To insure precision in reproducing the 1-meter height at each location, the two gamma detectors were mounted on a fixture made from a PVC pole and assorted PVC fittings. Details about the fixtures can be found in Reference 1.

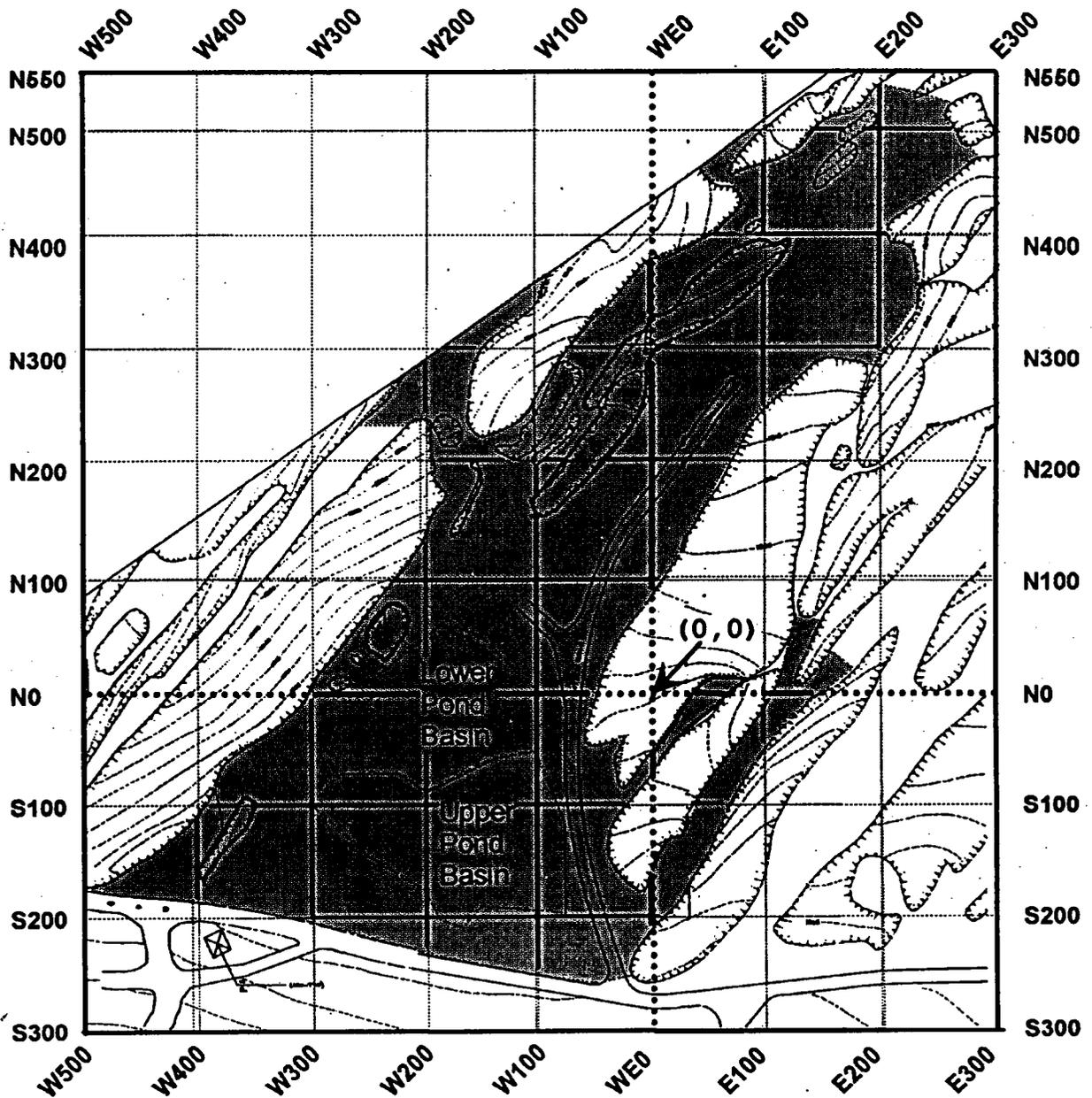


Figure 5. Sodium Disposal Facility Plan View

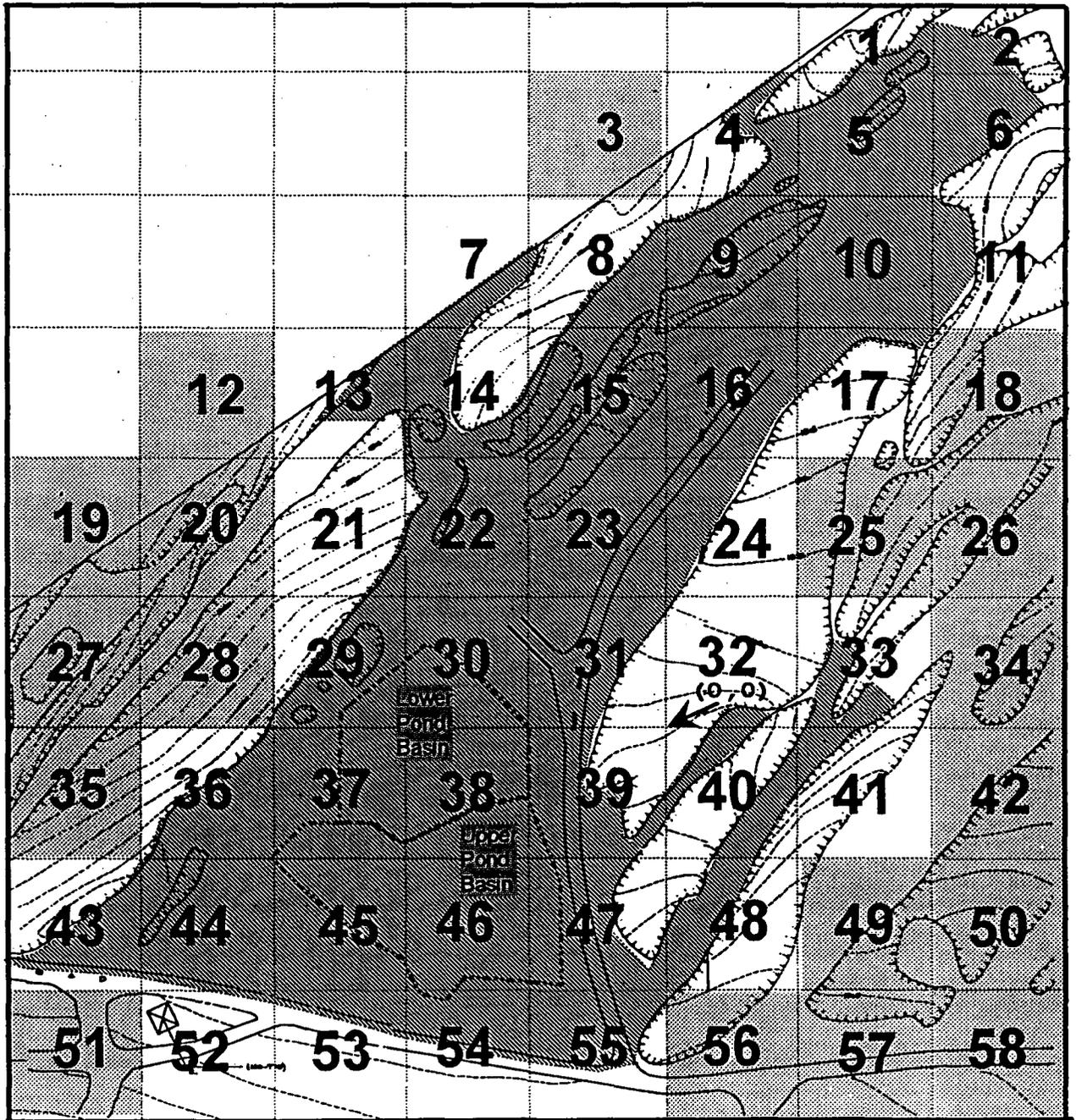


Figure 6. Sodium Disposal Facility Post-remediation Survey Grid Map

During the survey, the readings from the independent instrument pairs were compared for consistency and reasonableness. Anomalous or disparate readings at any time caused the survey team to interrupt the survey to check for instrument malfunctions and to retake the measurements if needed. All of the data (2 instruments averaged) from each location were ultimately used in analyses. Some data points are missing from the location plots of the data; however, the missing plots correspond to inaccessible locations (e.g., rock, heavy growth, poison oak, etc.).

Instrument performance was monitored throughout the survey by regular checks at a designated location which remained unchanged throughout the survey. The performance checks included measuring the instrument response to the ambient background radiation level, as read from a calibrated Reuter-Stokes meter, and measuring the instrument and Reuter-Stokes response to a 5  $\mu\text{Ci}$  Cs-137 check source at 1 meter. The performance checks for the instruments were recorded three times daily. The 3-point average Reuter-Stokes information was used to determine the efficiency conversion factor to convert the recorded counts per minute (cpm) to  $\mu\text{R/hr}$  for data comparison. Specific details about the instrument check sources, and the hardware used for the performance checks are given in Reference 1.

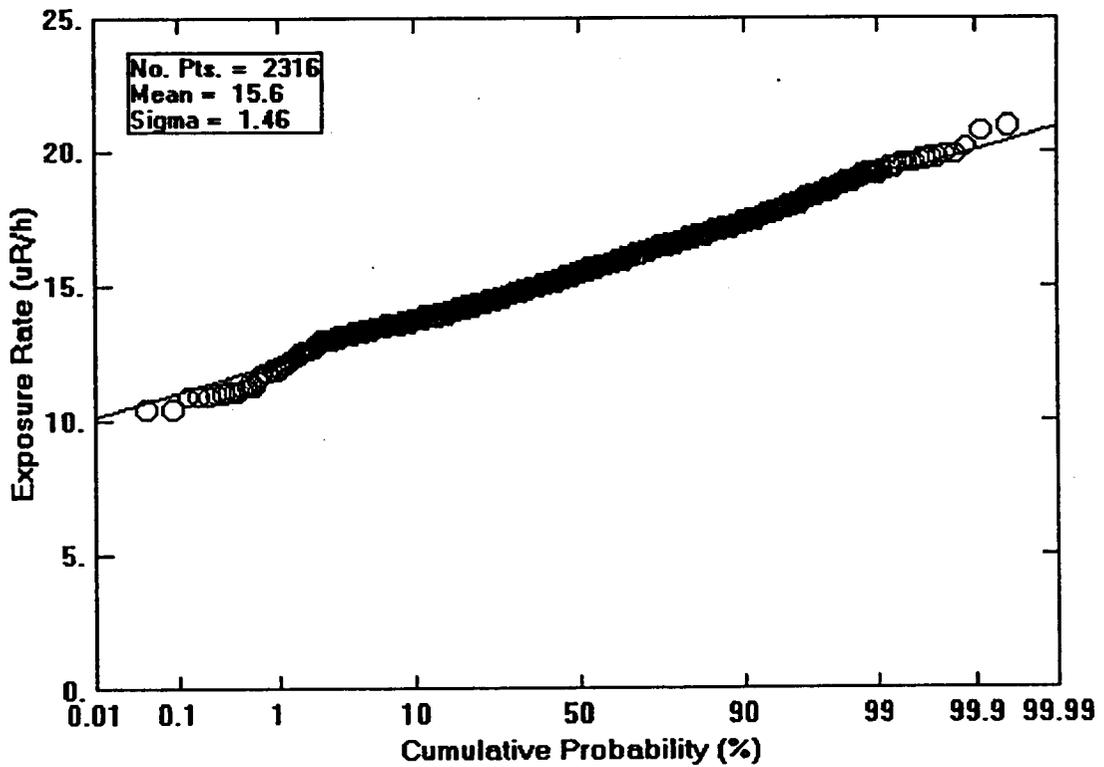
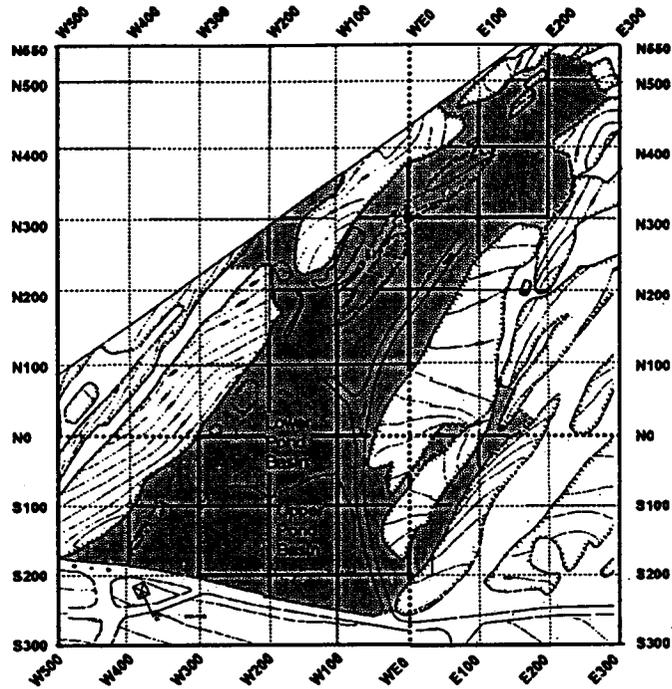
#### 4.3 Data Analyses and Results

All of the raw data were entered into a Microsoft Excel spreadsheet as counts per minute (cpm) along with the grid coordinates and calibration factors from the survey data sheets. The data was then converted into exposure rate ( $\mu\text{R/hr}$ ) from the daily Reuter-Stokes calibration data. Since each 10-ft grid point measurement was performed by an instrument pair, the exposure rate analyses on the following plots and graphs are for the average of the paired data. Statistical analyses of the data to determine the mean exposure rate and standard deviation was plotted on a cumulative probability distribution graph. When this type of graph is used, the x-axis is a Gaussian distribution function, so that a perfect fit of the data set to a Gaussian (bell) curve would plot along a straight line and the slope of the line would be greater for a larger standard deviation value of the data set.

The survey data was analyzed in several ways. First, the entire site with all areas combined was graphed. Figure 7 represents the 2316 data points for each separate 10-ft grid point surveyed. The mean site exposure rate which included the remediated areas and surrounding land was 15.6  $\mu\text{R/hr}$  with a standard deviation of 1.46  $\mu\text{R/hr}$  (9%).

Second, the remediated areas (the lower and upper pond basins) data was compared separately from the entire area surveyed. The results are shown in Figure 8. The remediated areas show a mean exposure rate of 14.6  $\mu\text{R/hr}$  (std. dev. = 0.897  $\mu\text{R/hr}$ ) for 419 grid points. Figure 9 represents the mean exposure rate excluding the upper and lower pond basins. Figure 10 shows the upper pond basin mean exposure rate analysis and Figure 11 shows the lower pond basin mean exposure rate analysis. Lastly, each 100-ft by 100-ft grid square was given a numbering system to locate the data as shown in Figure 12. Each grid square's data is shown along with the resulting statistical analysis graph and is given in Figures 13-52. These figures also show the minimum and maximum exposure rate (used in Table 1) in larger typeface.

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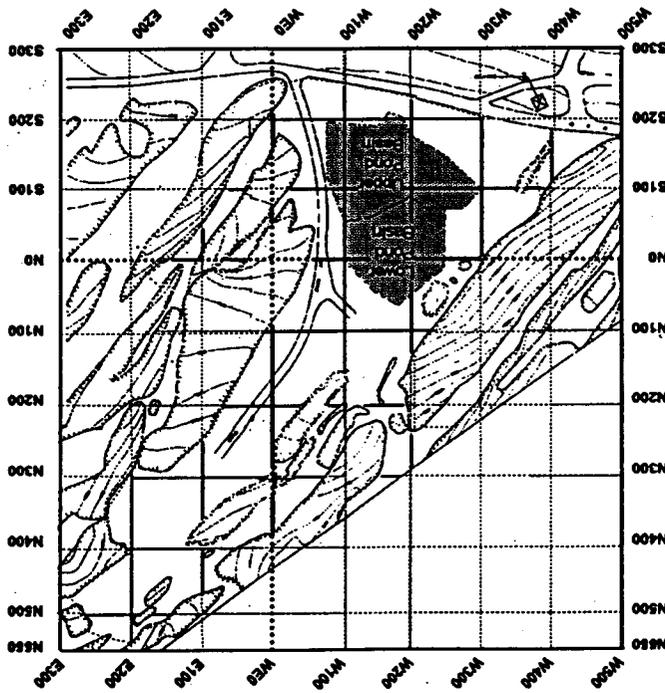
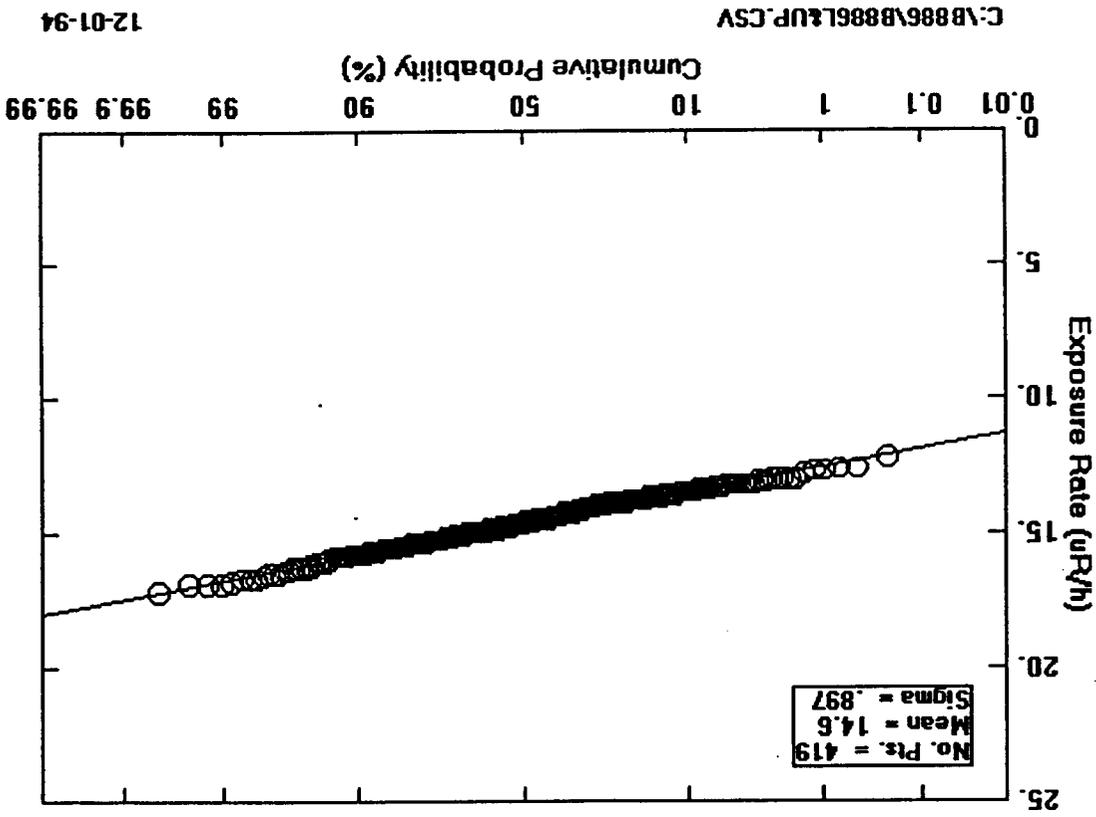


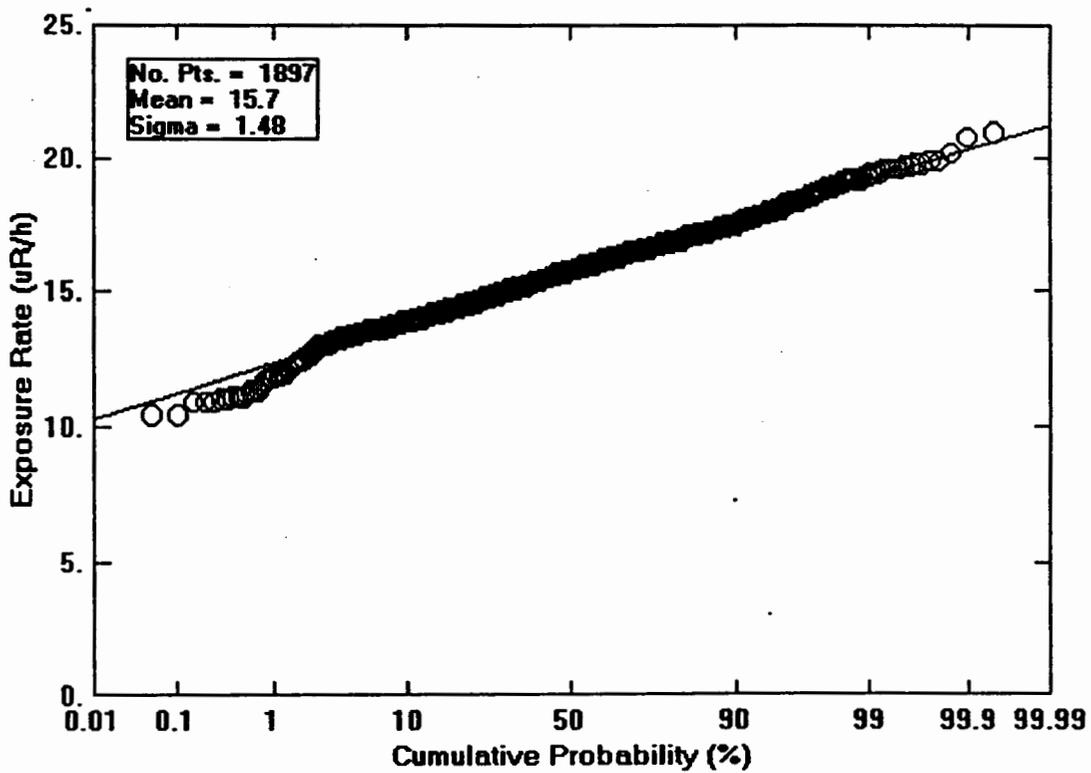
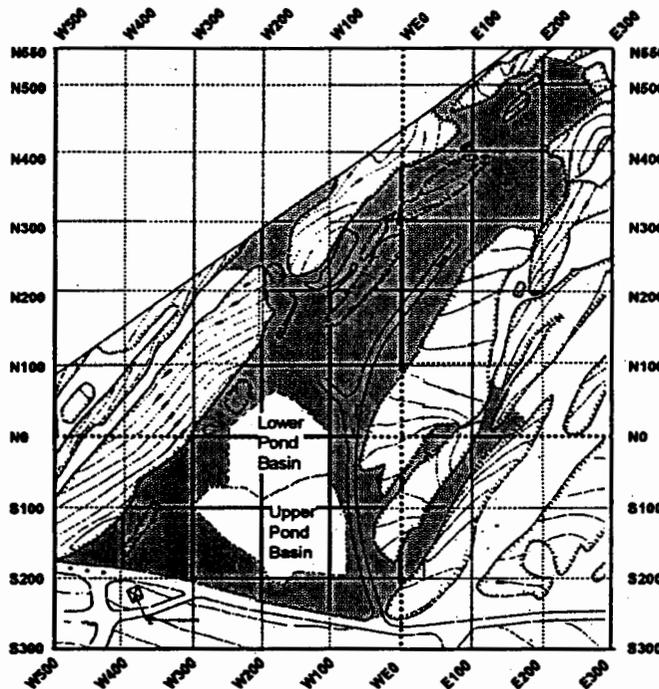
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Figure 7. All Areas Combined Ambient Gamma Exposure Rate.

Figure 8. Lower and Upper Pond Basins Ambient Gamma Exposure Rate.

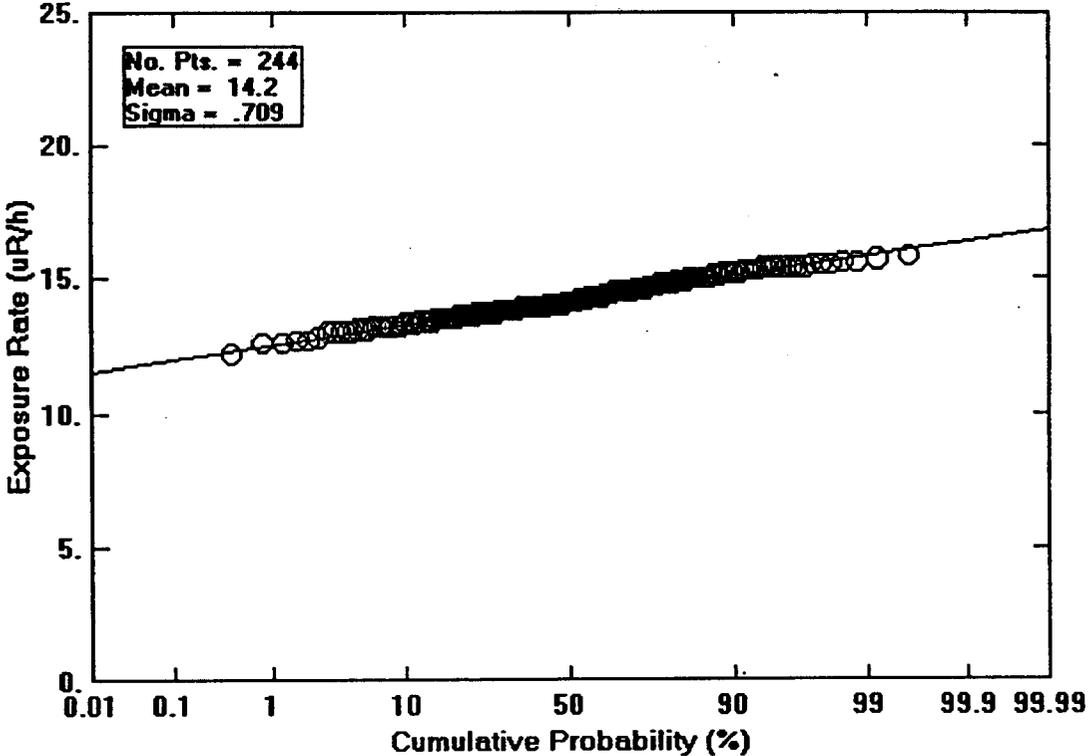
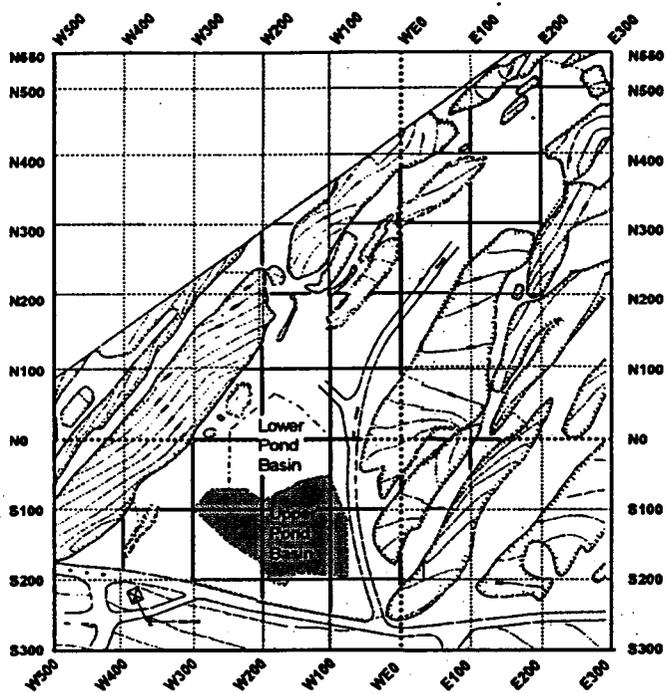




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Figure 9. Ambient Gamma Exposure Rate Excluding the Lower and Upper Pond Basins.

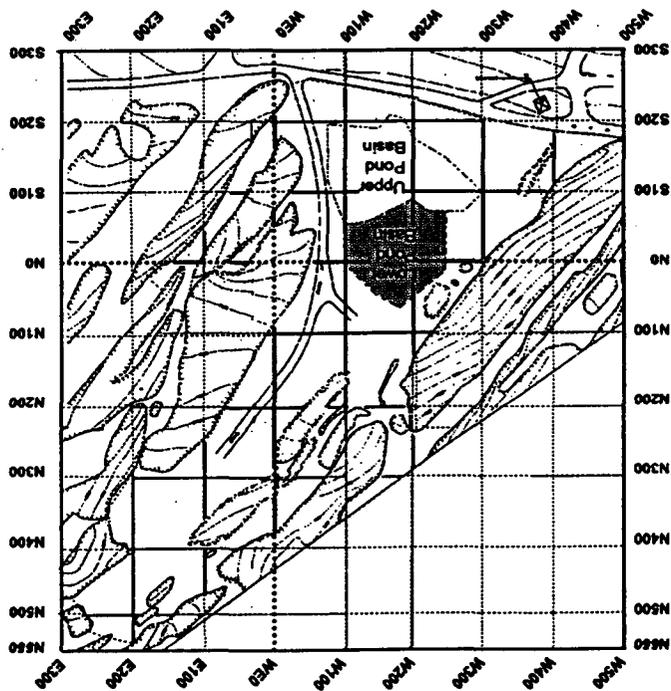
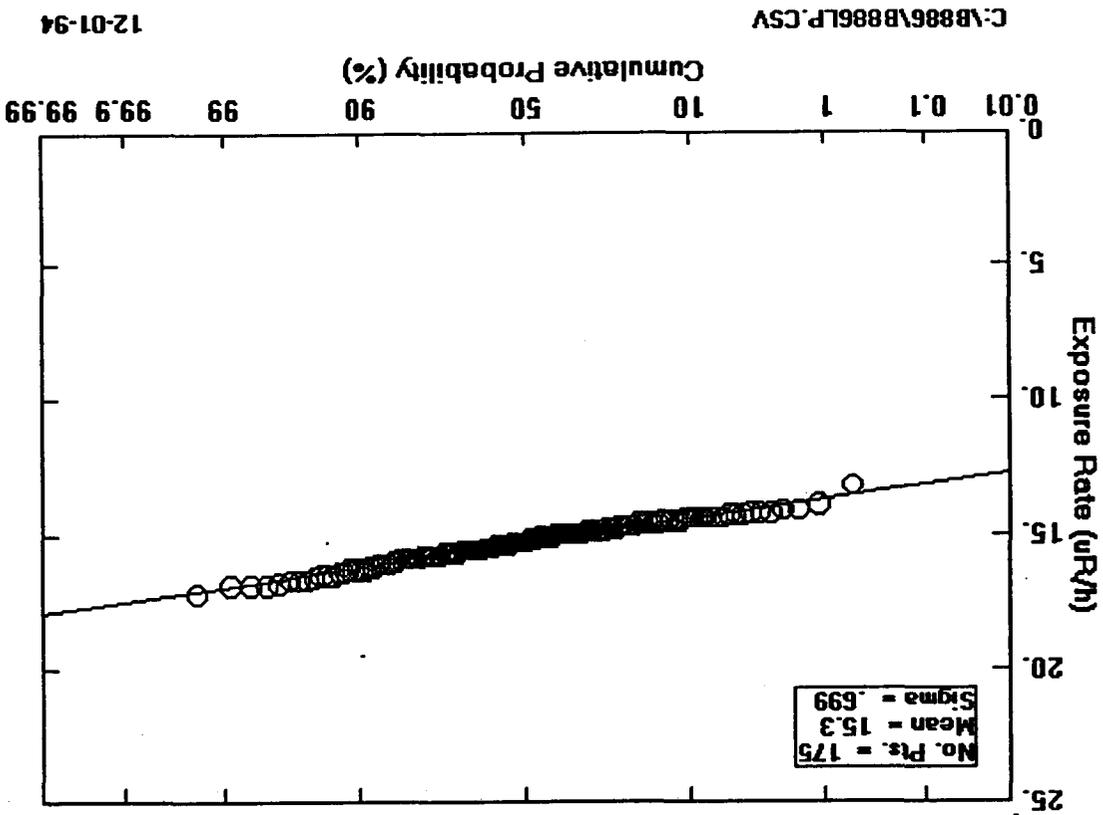


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Figure 10. Upper Pond Basin Ambient Gamma Exposure Rate.

Figure 11. Lower Pond Basin Ambient Gamma Exposure Rate.



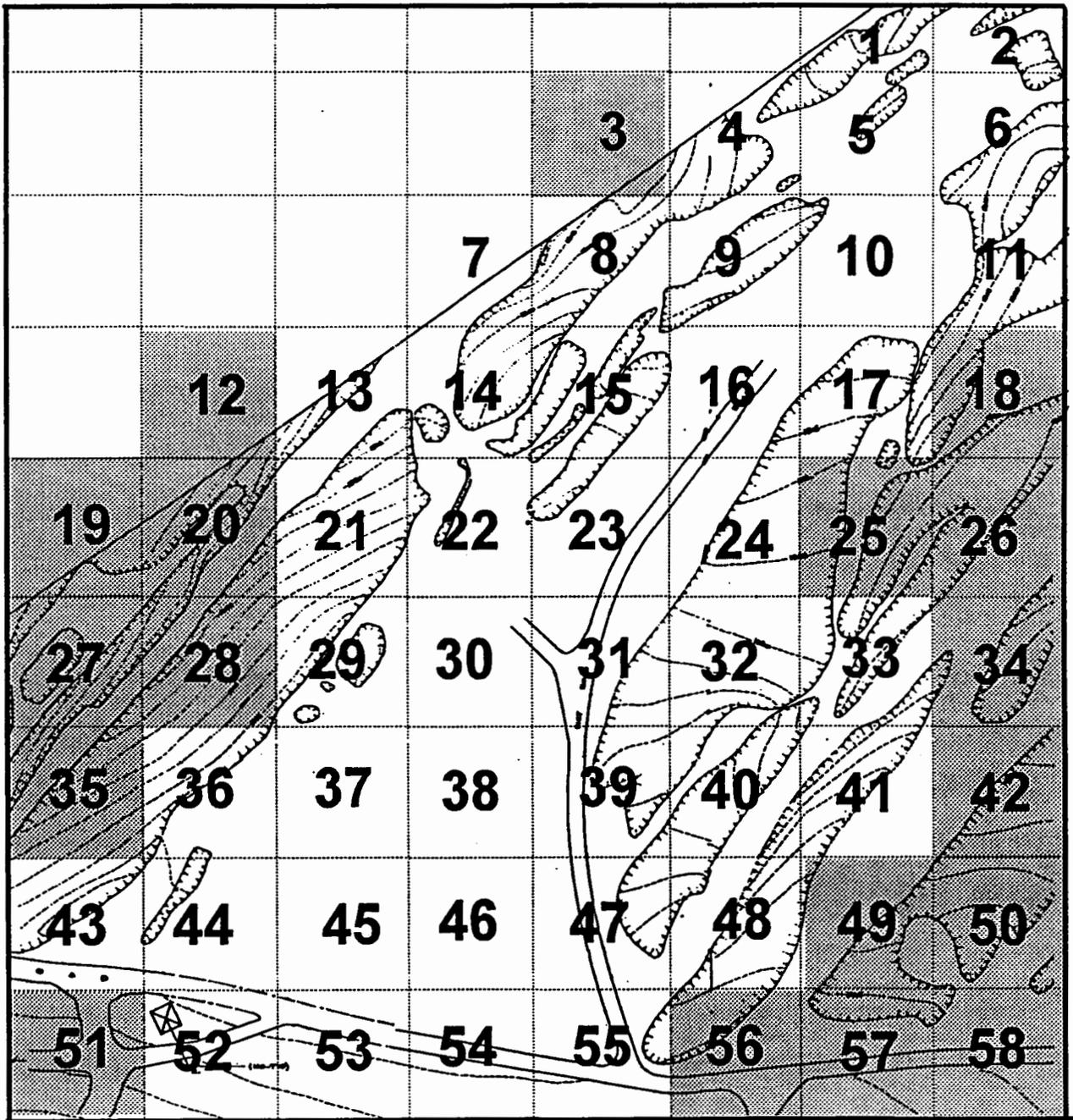
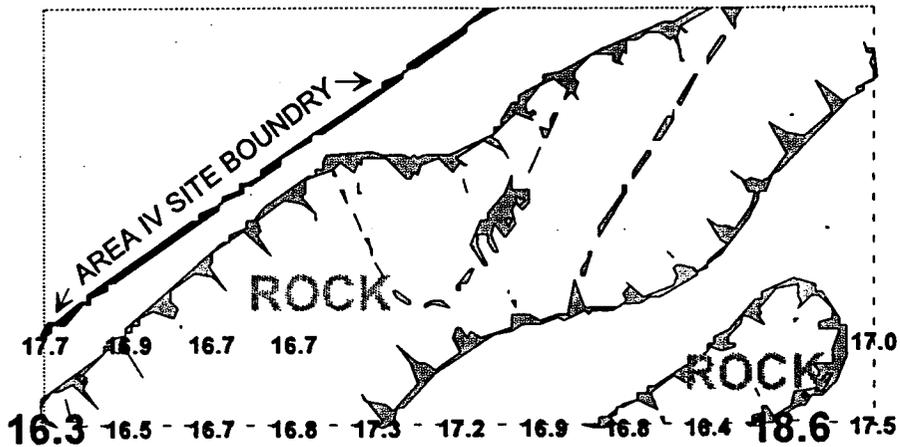


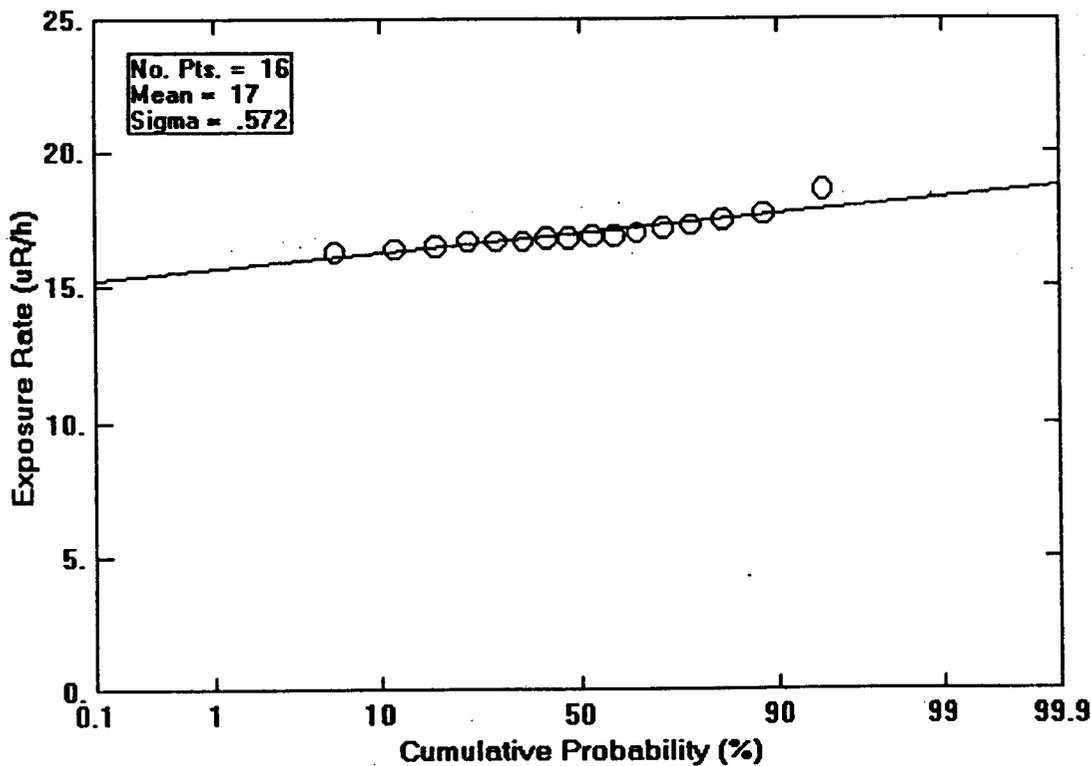
Figure 12. Grid Locator Map for Survey Results



Grid #1

N500ft - 550ft

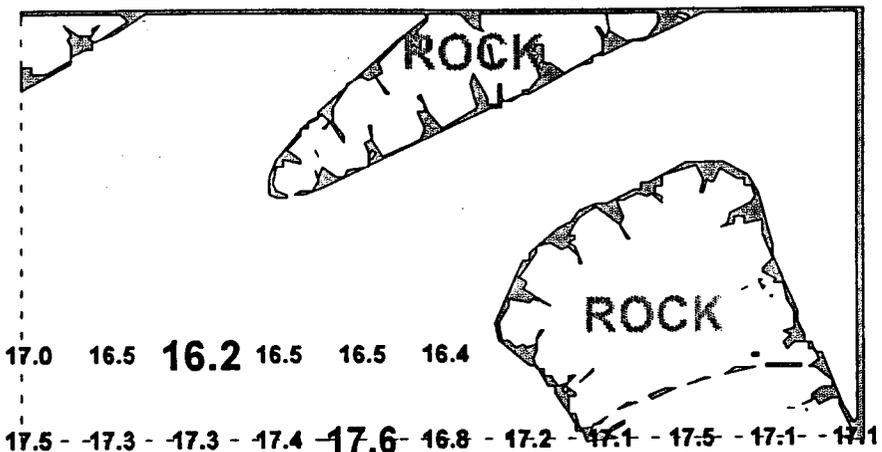
E100ft - 200ft



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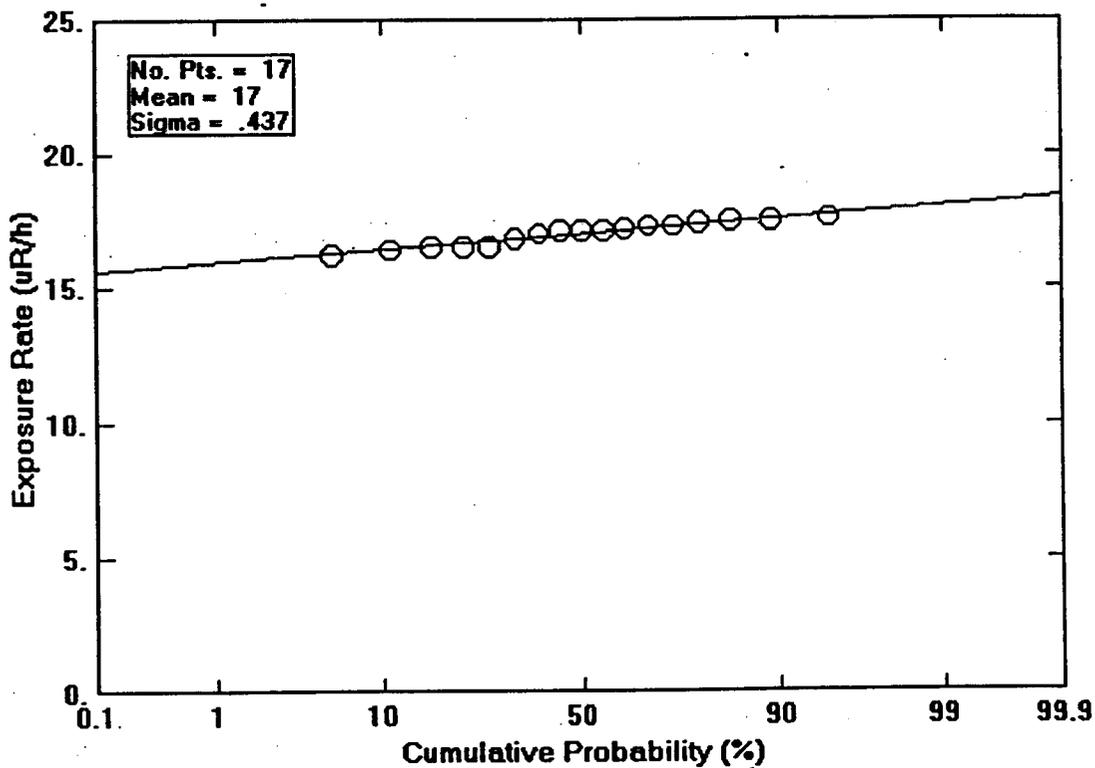
Figure 13. Grid #1 Ambient Gamma Exposure Rate.



Grid #2

N500ft - 550ft

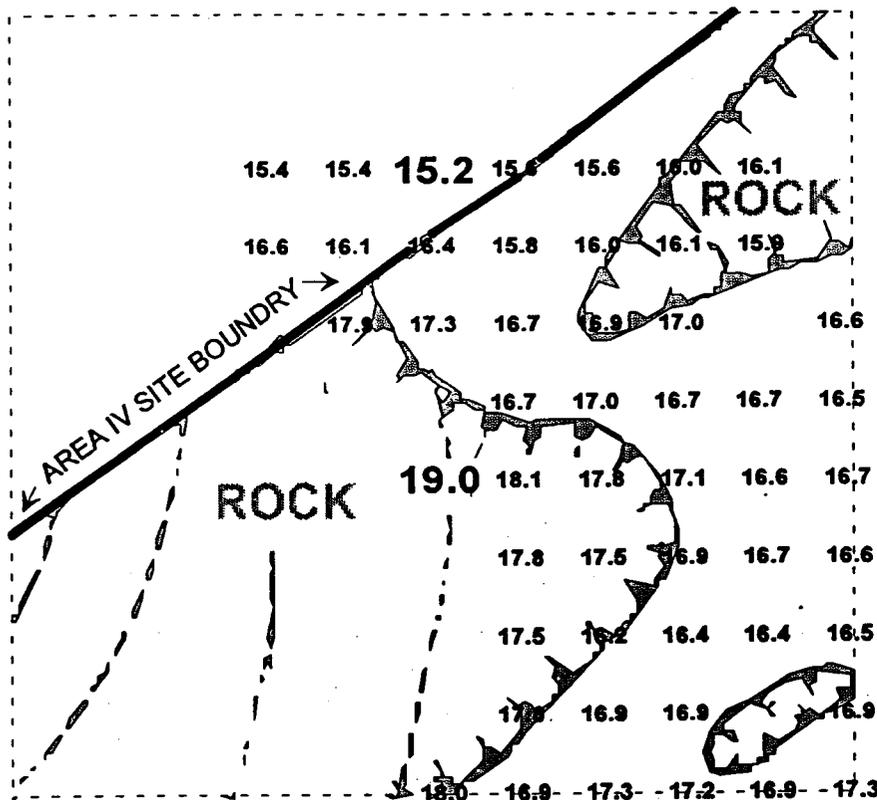
E200ft - 300ft



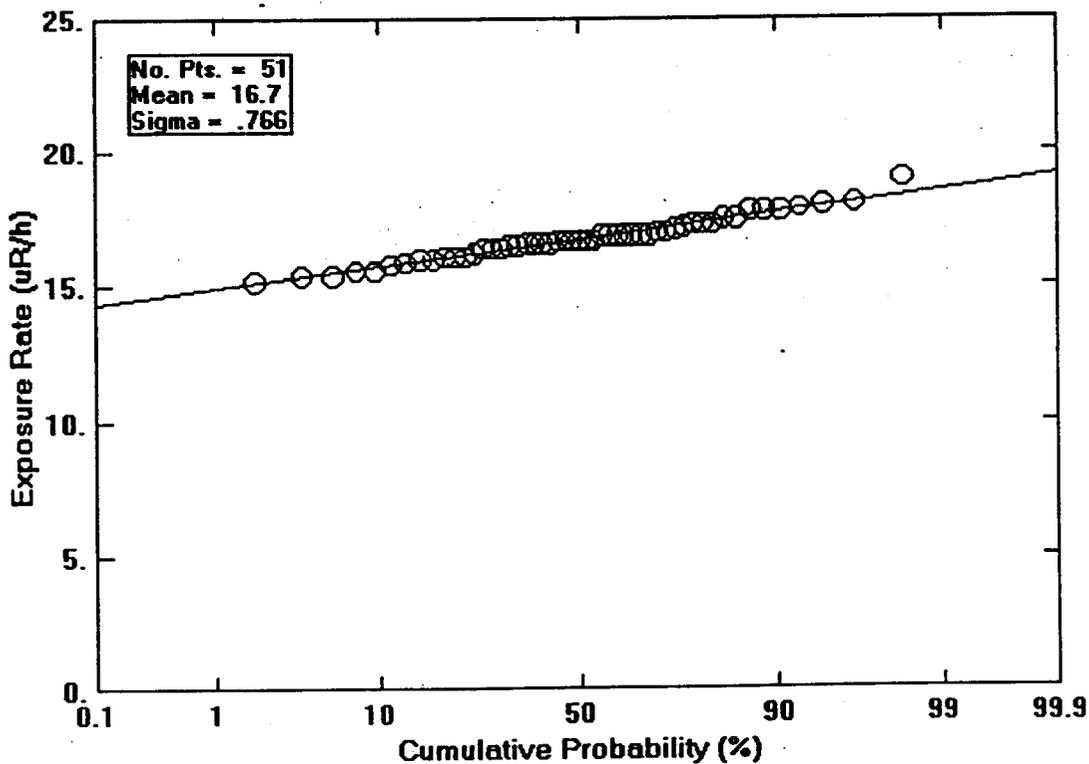
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Figure 14. Grid #2 Ambient Gamma Exposure Rate.



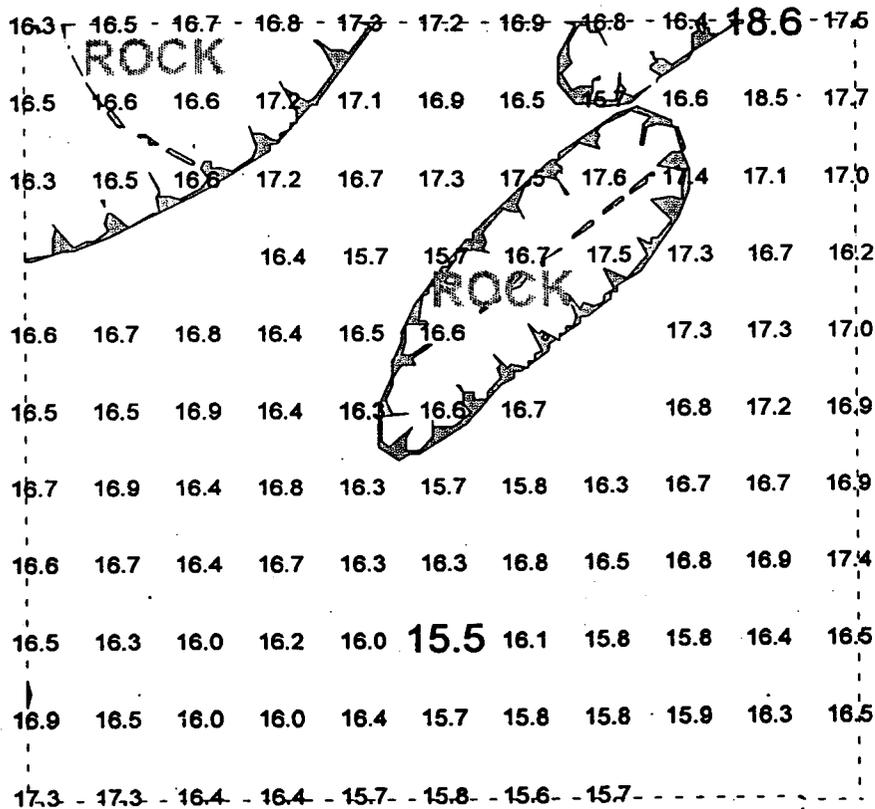
**Grid #4**  
N400ft - 500ft  
E000ft - 100ft



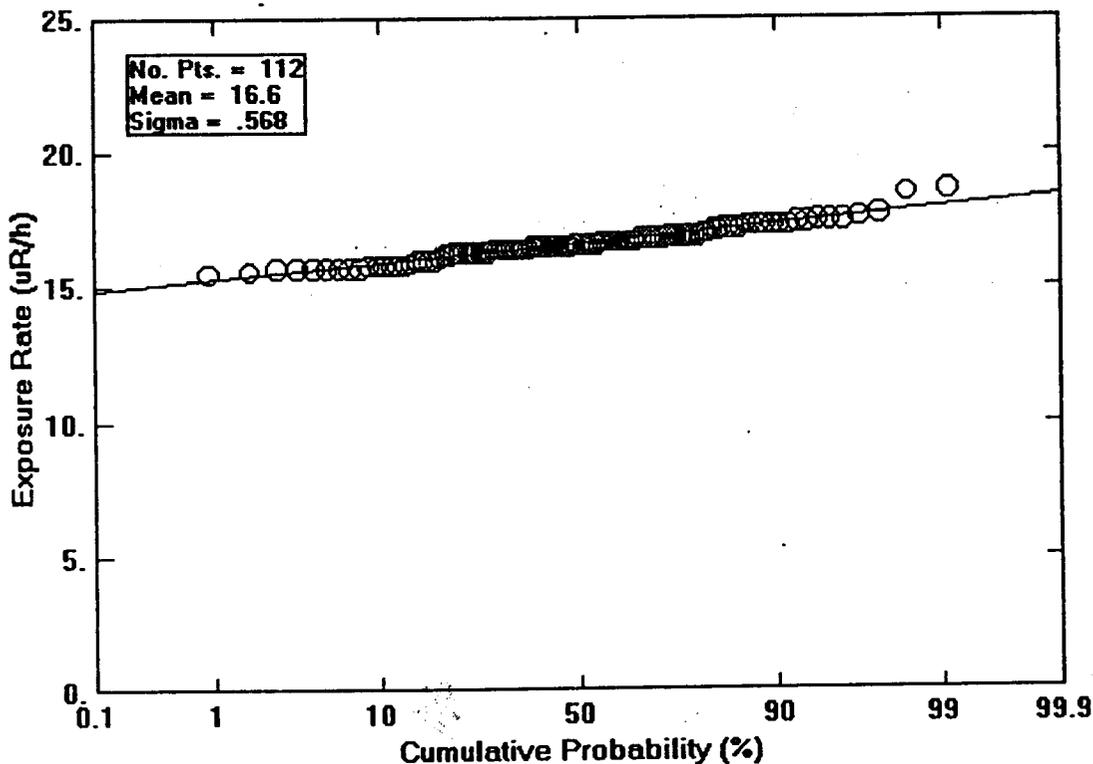
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Figure 15. Grid #4 Ambient Gamma Exposure Rate.



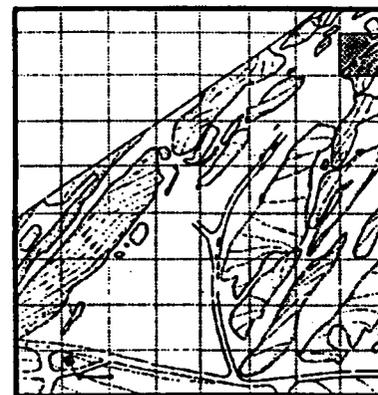
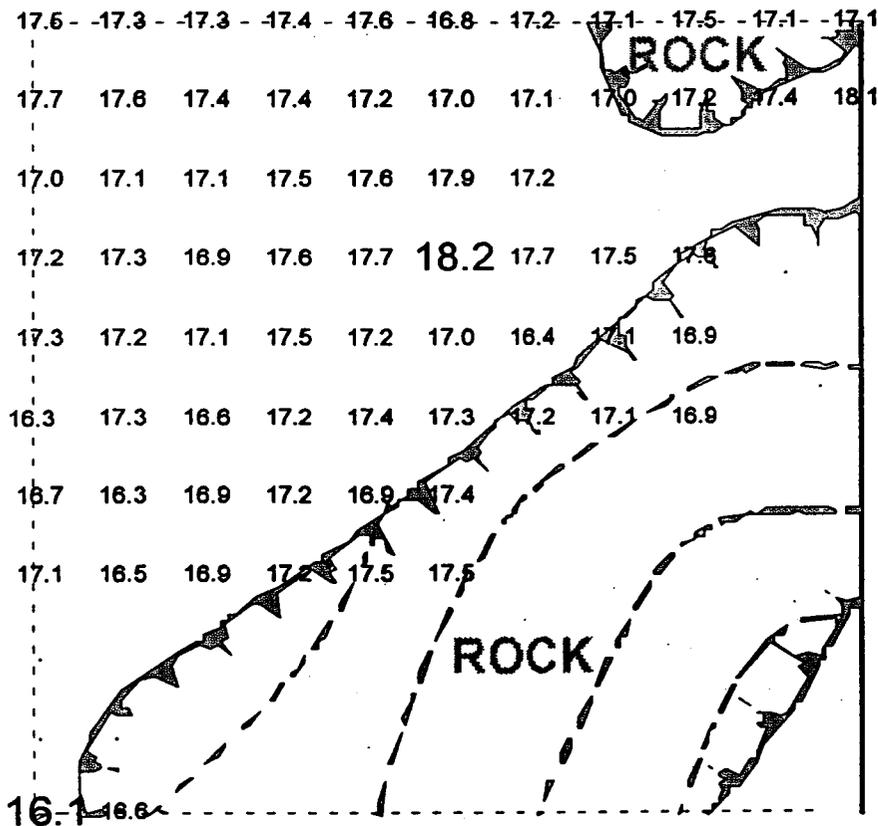
**Grid #5**  
N400ft - 500ft  
E100ft - 200ft



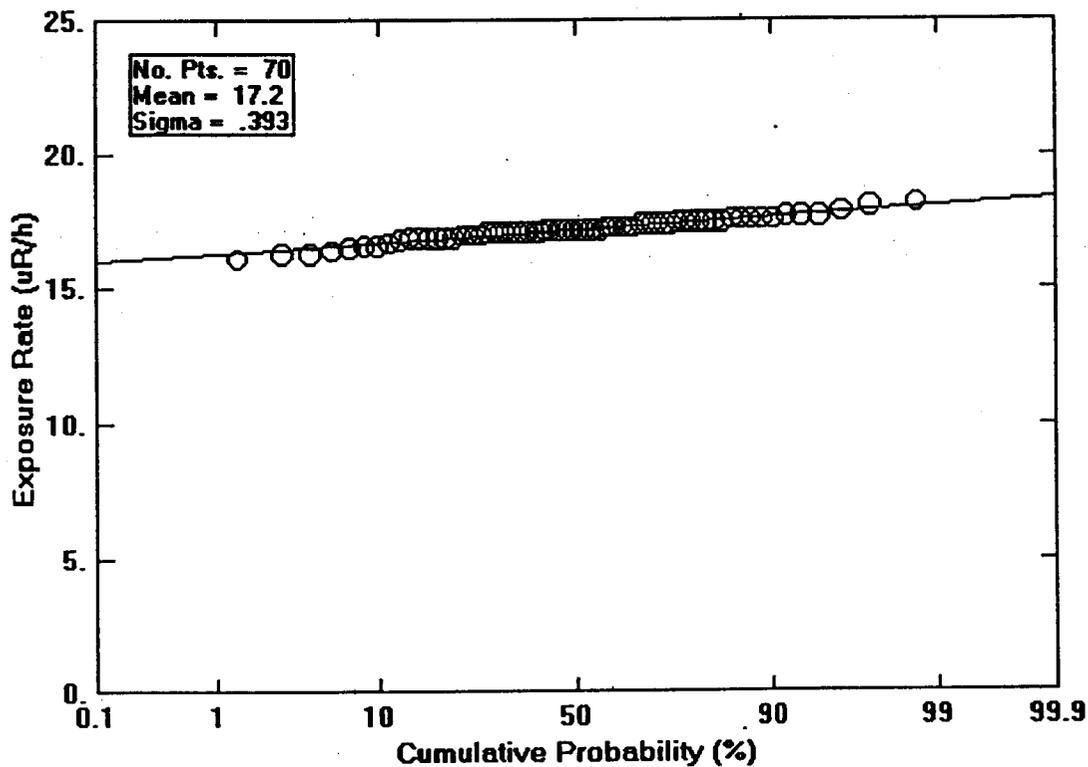
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Figure 16. Grid #5 Ambient Gamma Exposure Rate.



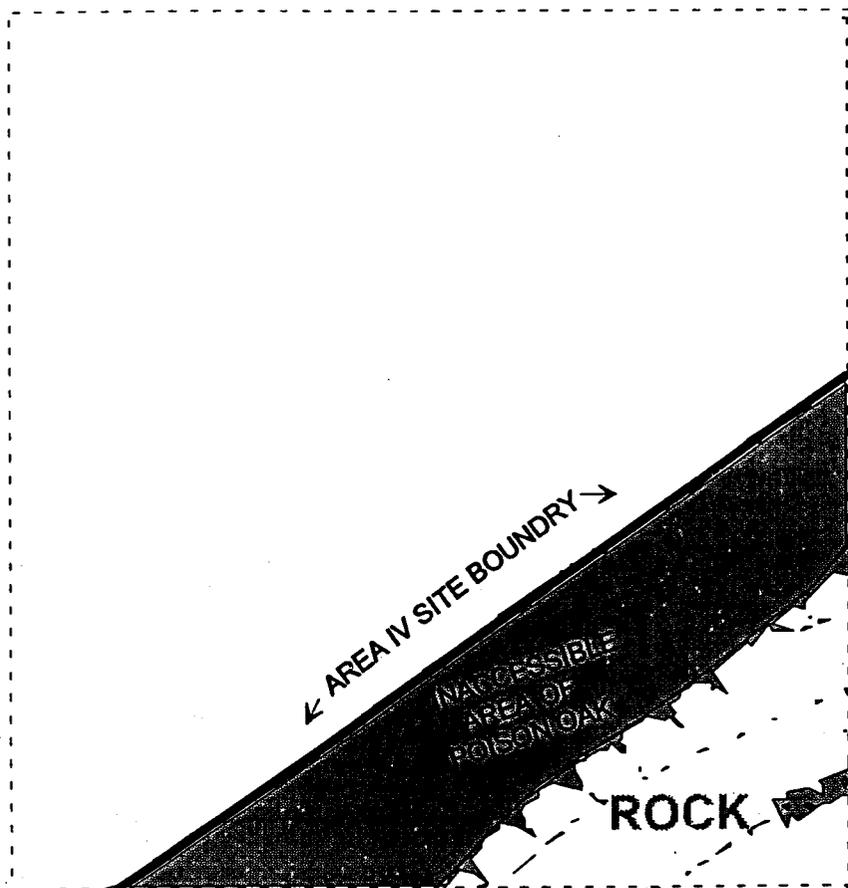
Grid #6  
N400ft - 500ft  
E200ft - 300ft



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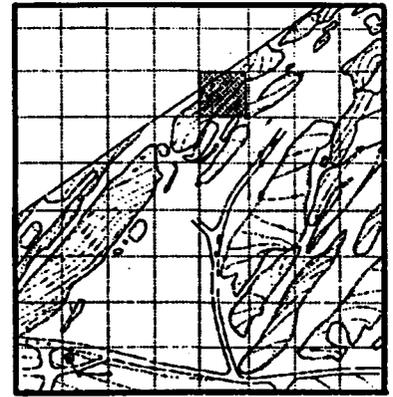
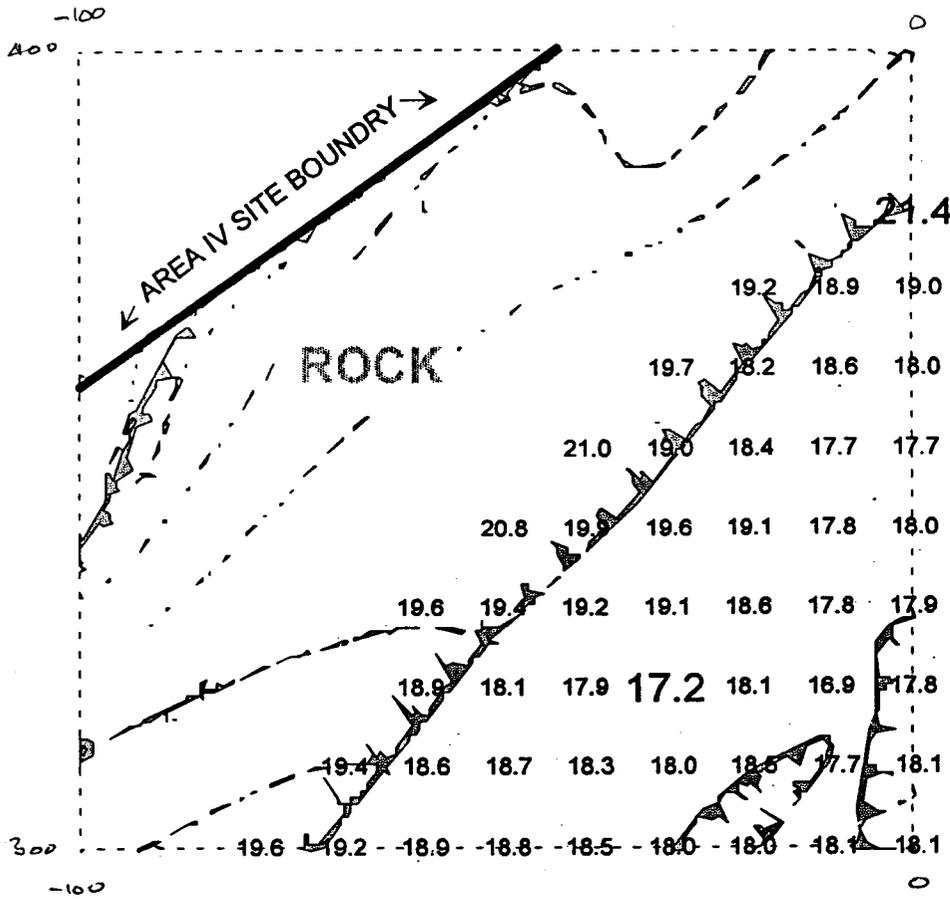
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Figure 17. Grid #6 Ambient Gamma Exposure Rate.

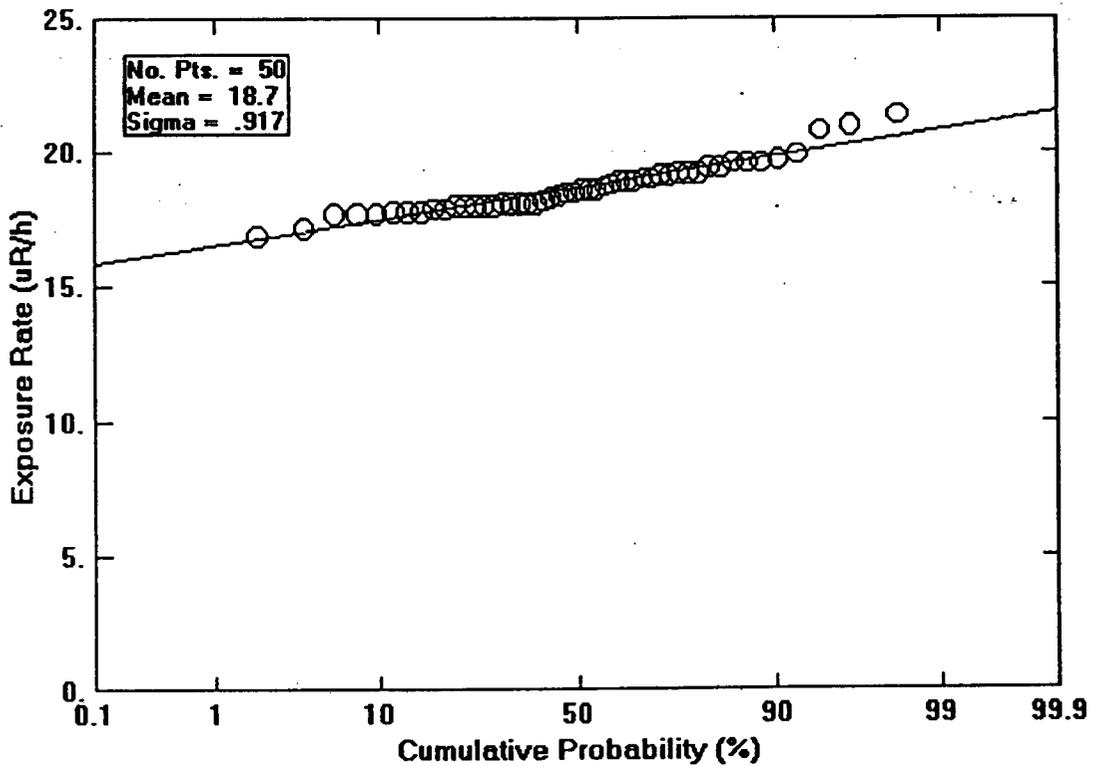


**Grid #7**  
N300ft - 400ft  
W200ft - 100ft

Figure 18. Grid #7 Plotview - Inaccessible area



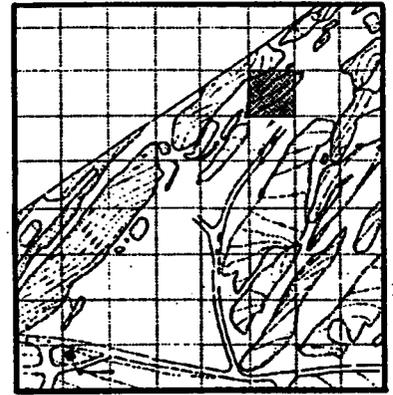
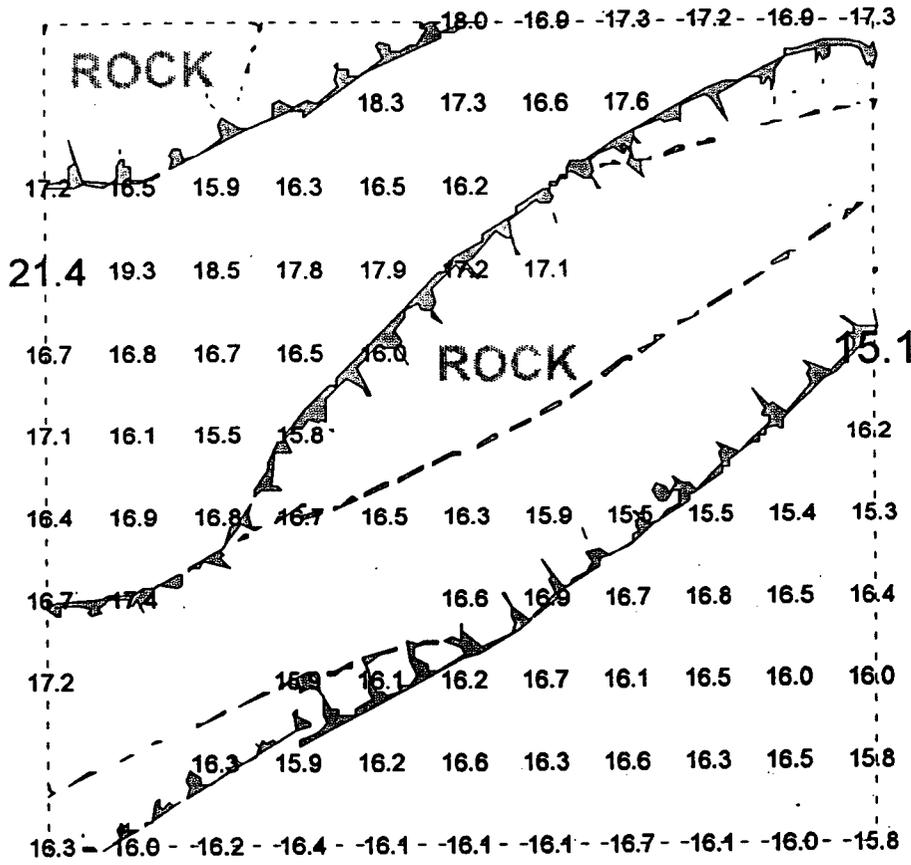
**Grid #8**  
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 W100ft - 0ft



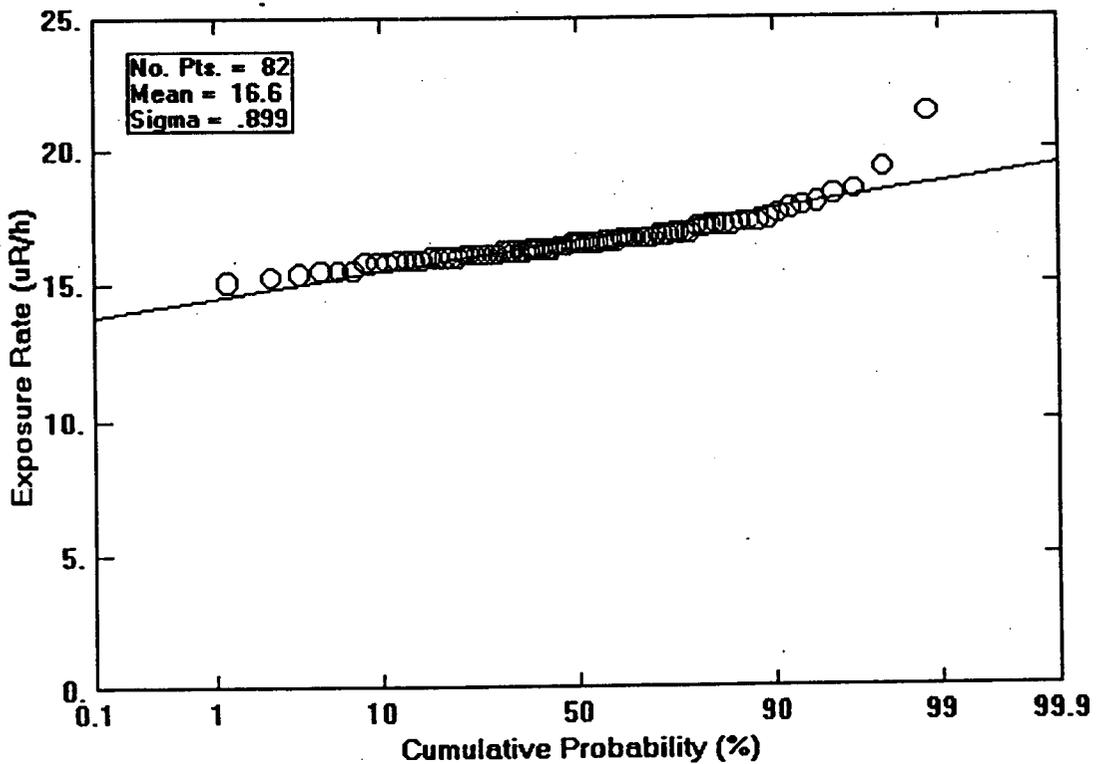
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Figure 19. Grid #8 Ambient Gamma Exposure Rate.



**Grid #9**  
 N300ft - 400ft  
 E 0ft - 100ft



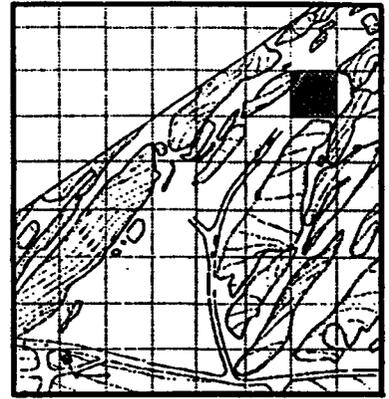
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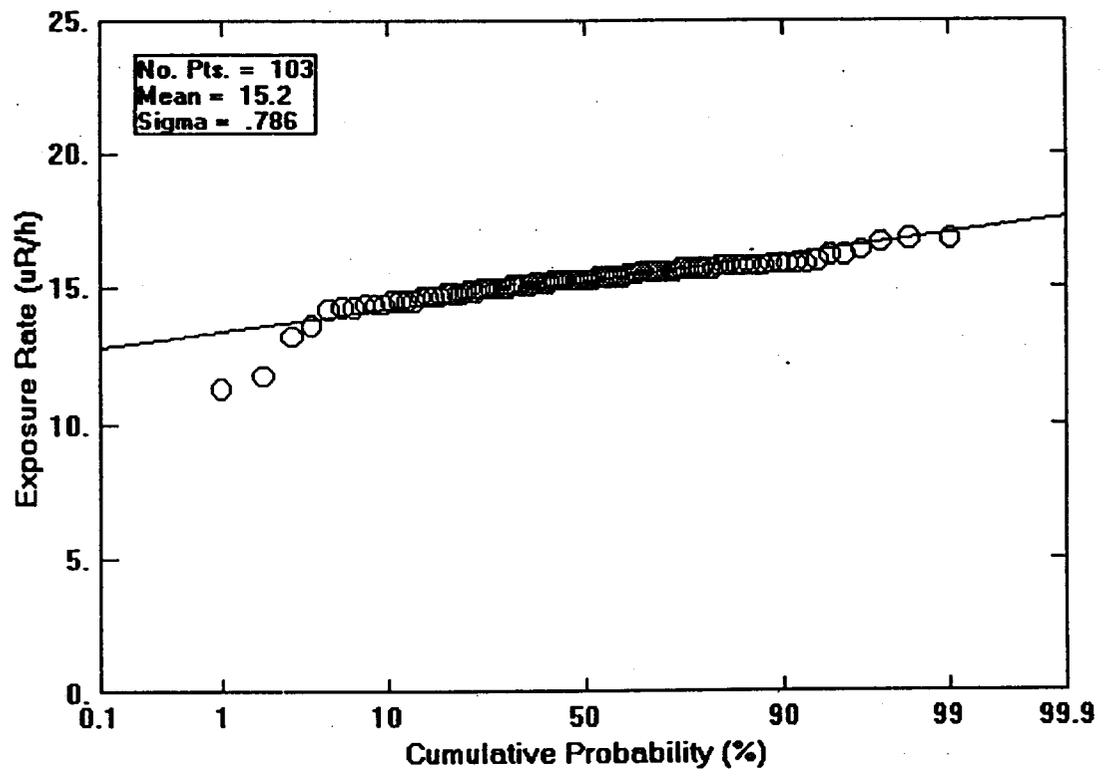
Figure 20. Grid #9 Ambient Gamma Exposure Rate.

16.8	16.8	15.9	15.9	15.3	15.4	15.1	15.2			
								15.8	15.9	16.7
								15.6	15.3	
								14.8	14.5	15.0
								14.5	14.8	14.3
								14.4	14.2	14.3
								15.9	15.8	16.0
								15.7	15.4	14.7
								14.7	14.4	
15.1	14.7	14.9	15.0	15.0	14.8	15.3	15.1	14.7	14.5	15.1
16.2	15.2	15.0	15.0	15.8	15.3	15.6	15.8	15.5	15.7	15.6
15.3	15.6		15.0	15.3	15.4	15.0	15.7	15.8		
16.4	15.8	15.2	15.5	15.4	15.7	15.5	15.6	15.7	15.3	15.5
15.7	14.9	14.5	14.9	14.7	15.1	15.3	14.4	13.2	14.8	15.7
15.8	15.6	15.4	15.2	15.4	15.6	15.3	13.6	11.3	11.8	15.2
15.8	15.6	15.7	15.3	15.4	15.9	15.6	15.3	15.4	15.3	16.2

886-ZR-0007  
Page 35  
12/13/94



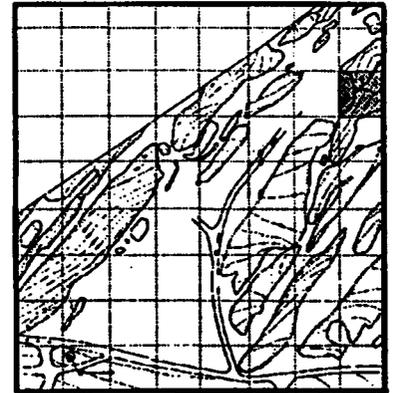
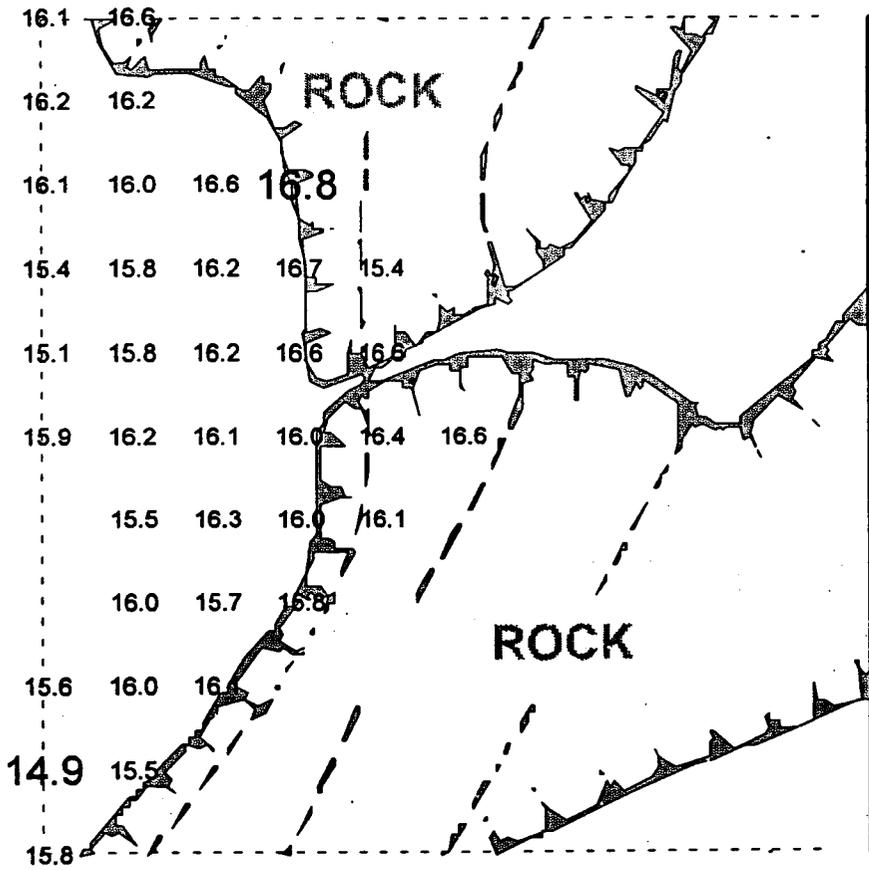
**Grid #10**  
**N300ft - 400ft**  
**E100ft - 200ft**



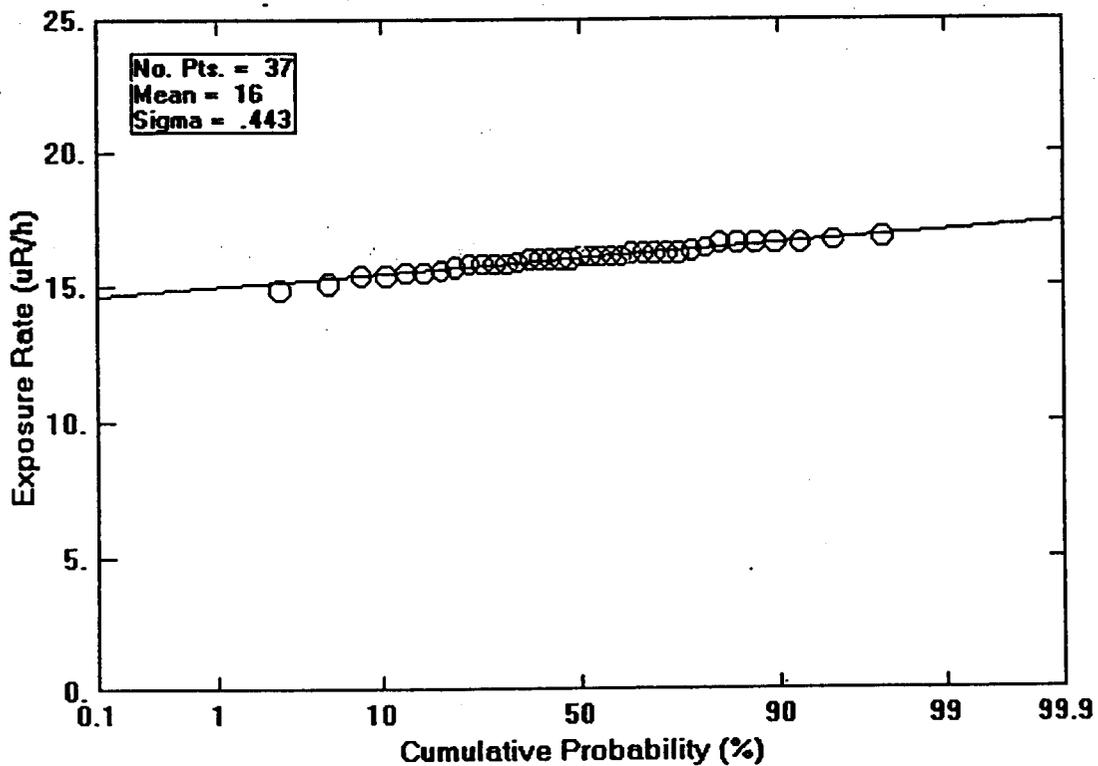
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11-28-94

Figure 21. Grid #10 Ambient Gamma Exposure Rate.



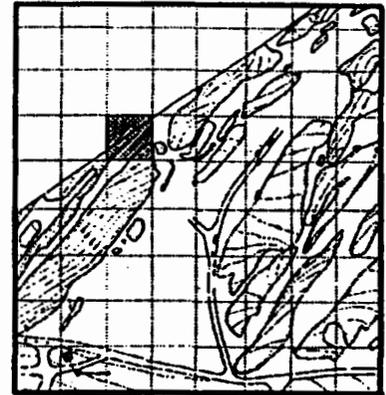
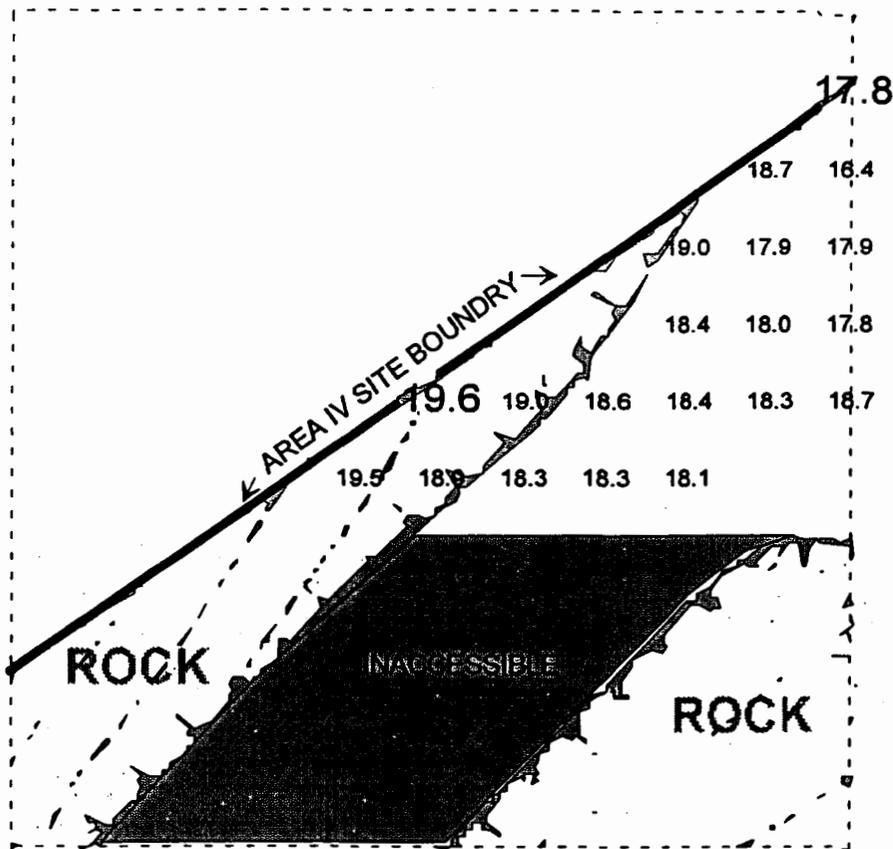
Grid #11  
N300ft - 400ft  
E200ft - 300ft



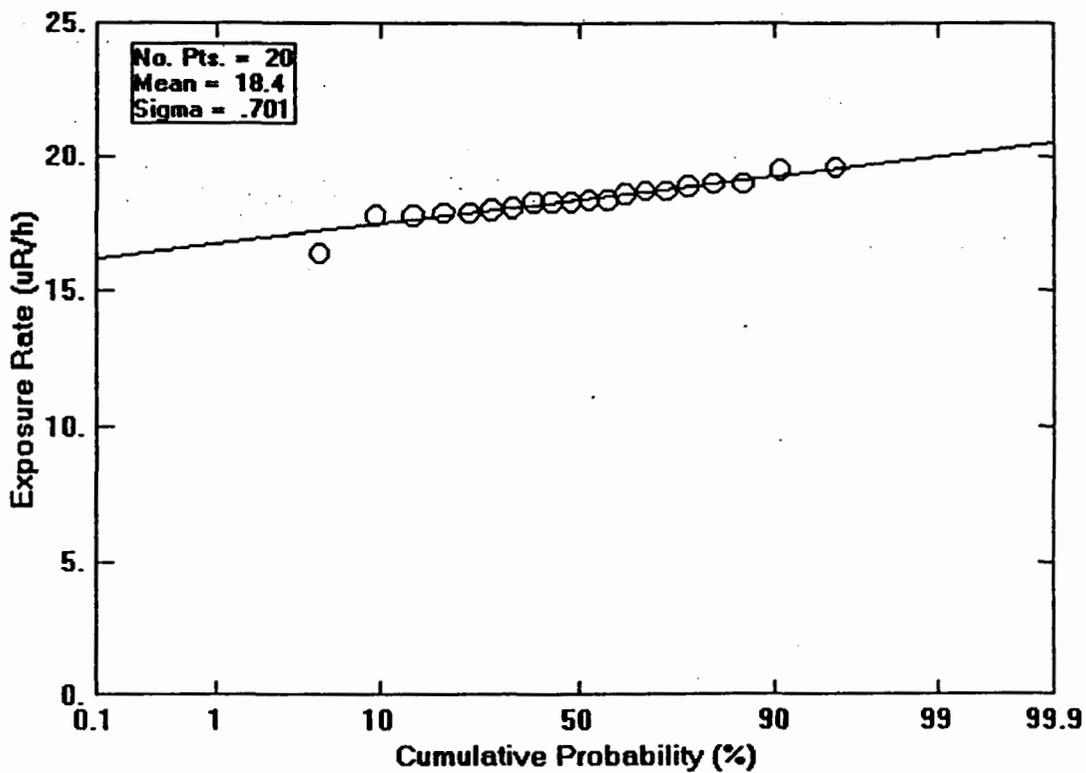
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11-28-94

Figure 22. Grid #11 Ambient Gamma Exposure Rate.



**Grid #13**  
 N200ft - 300ft  
 W300ft - 200ft

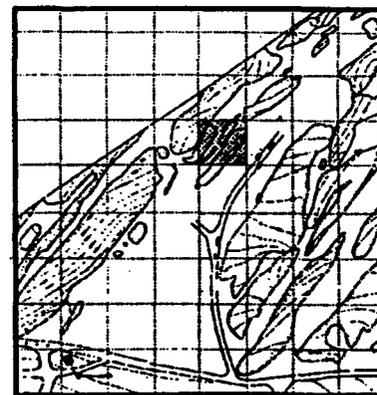
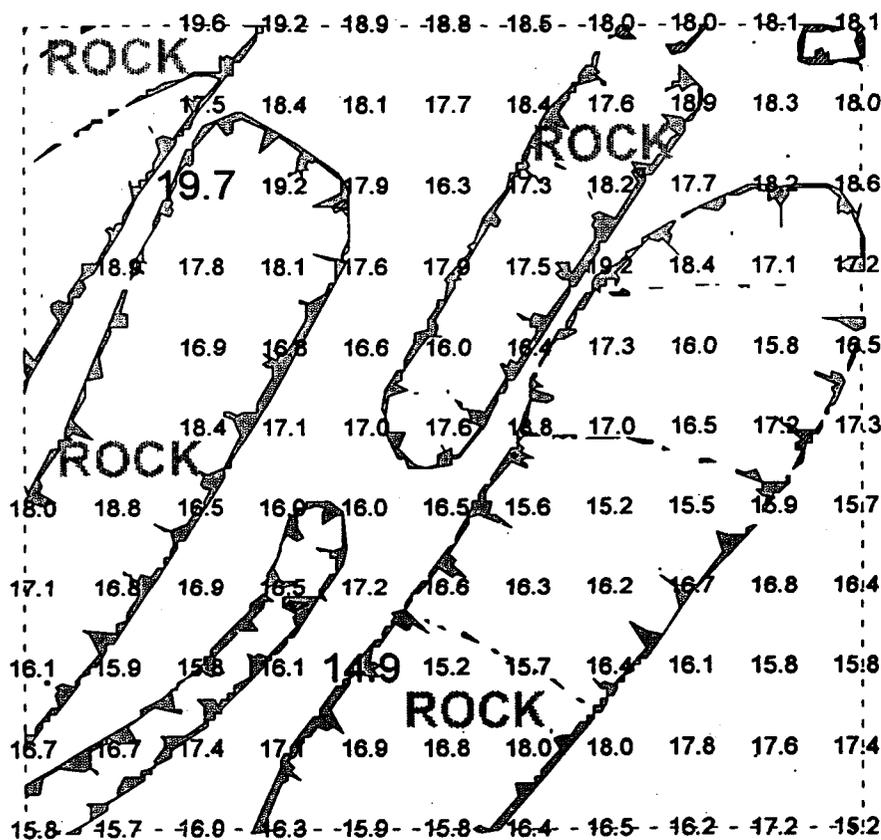


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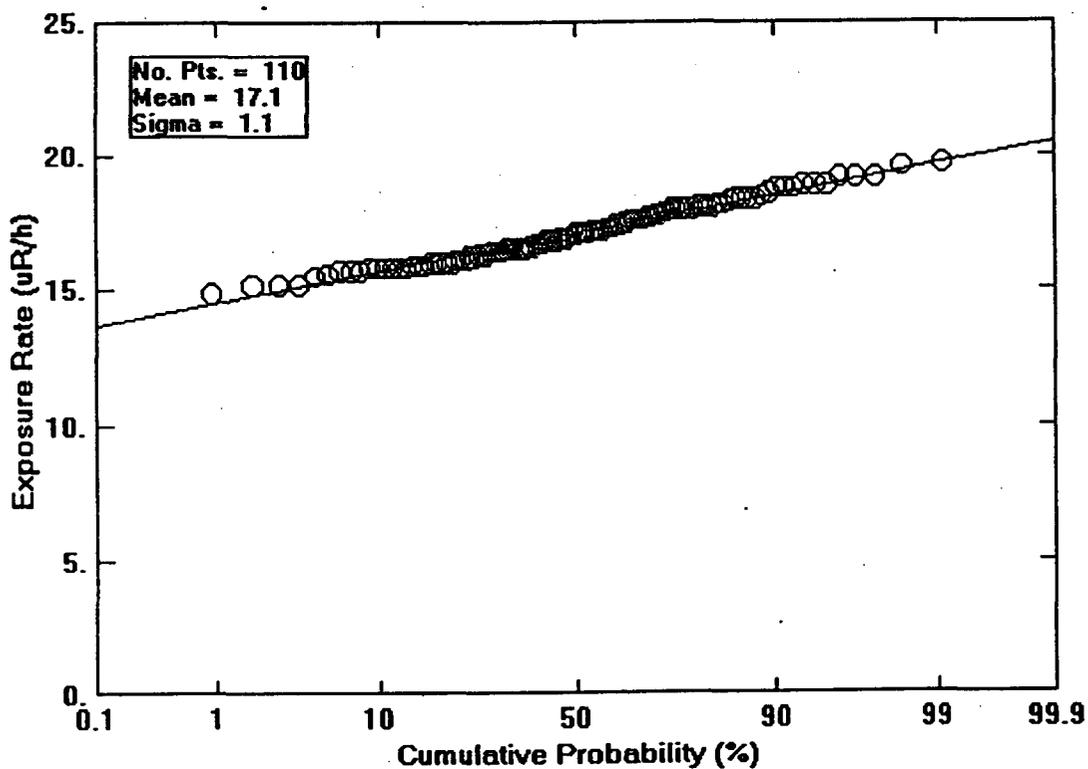
11-28-94

Figure 23. Grid #13 Ambient Gamma Exposure Rate.





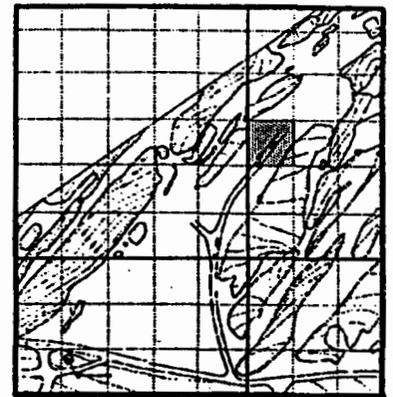
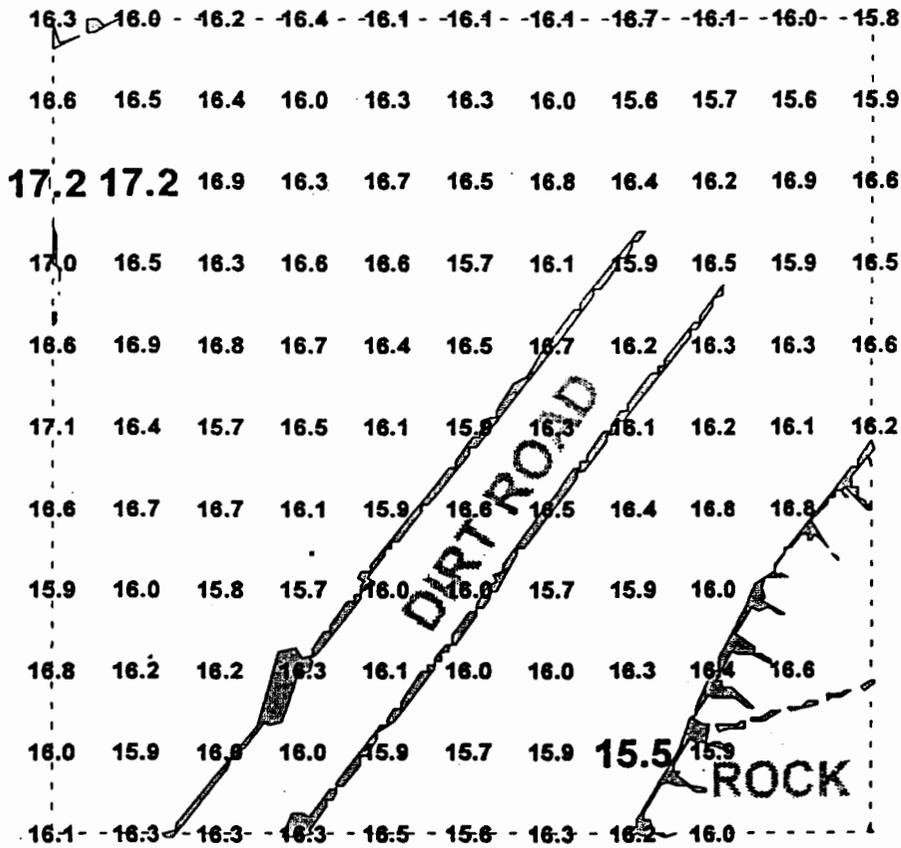
**Grid #15**  
**N200ft - 300ft**  
**W100ft - 0ft**



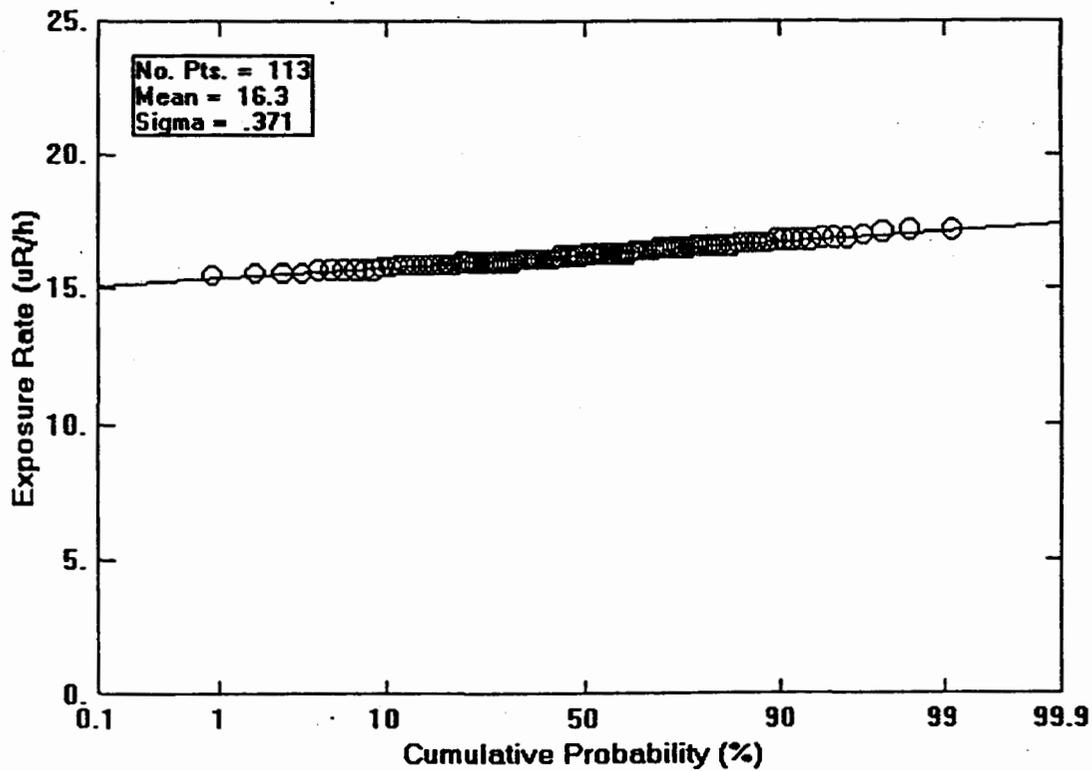
C:\B886\N2W1.CMP

11-28-94

Figure 25. Grid #15 Ambient Gamma Exposure Rate.



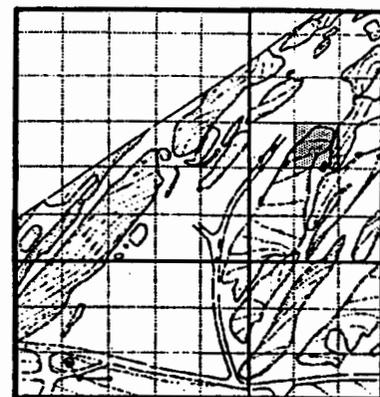
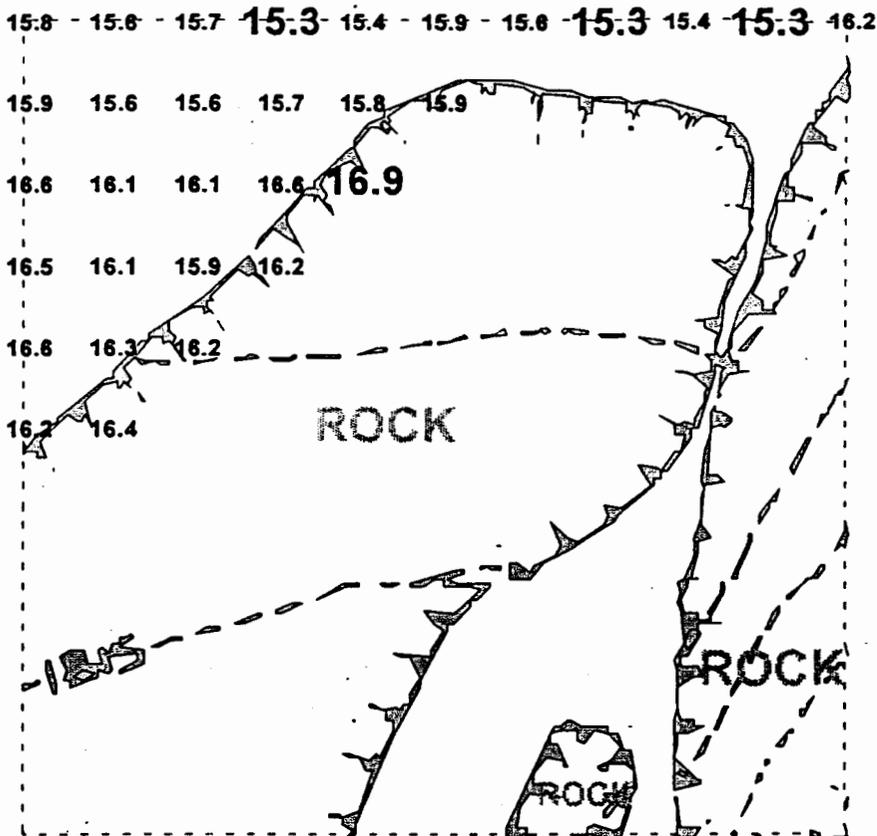
Grid #16  
N200ft - 300ft  
E 0ft - 100ft



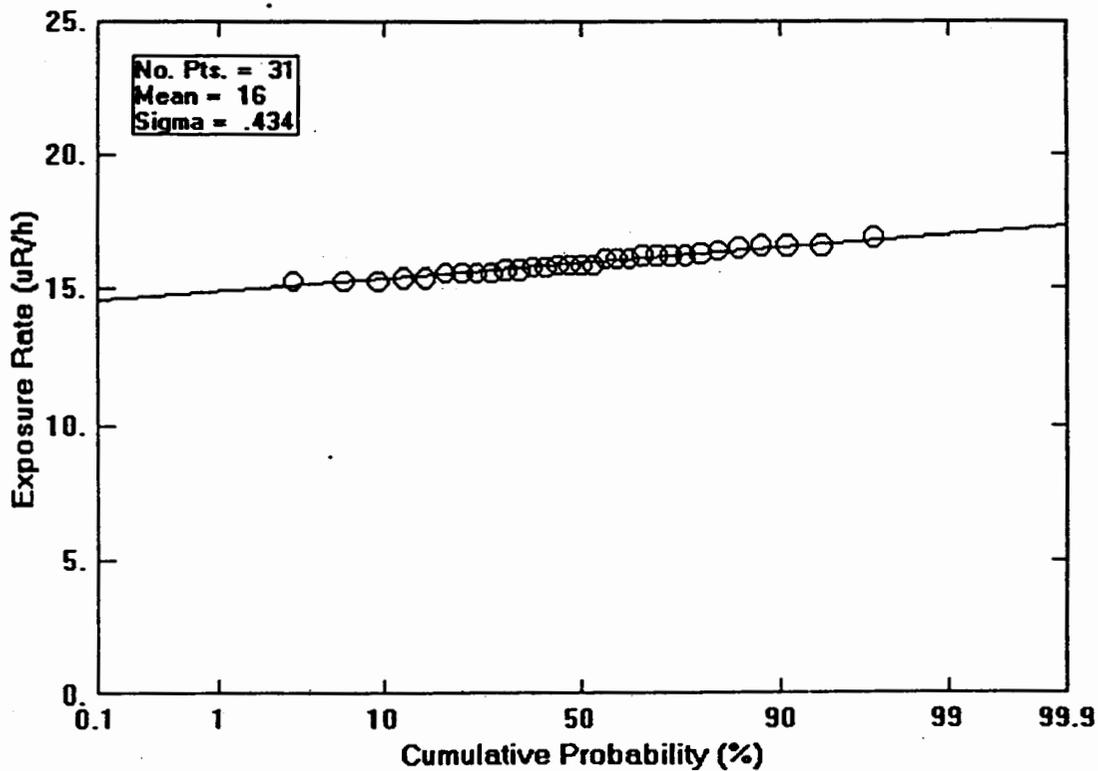
C:\B886\N2E0.CMP

11-28-94

Figure 26. Grid #16 Ambient Gamma Exposure Rate.



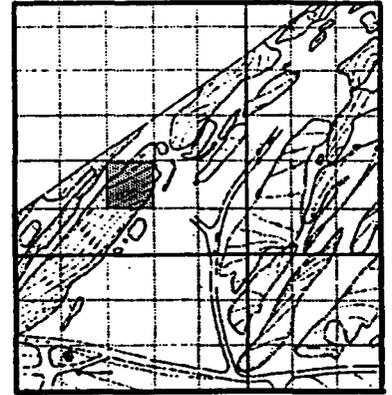
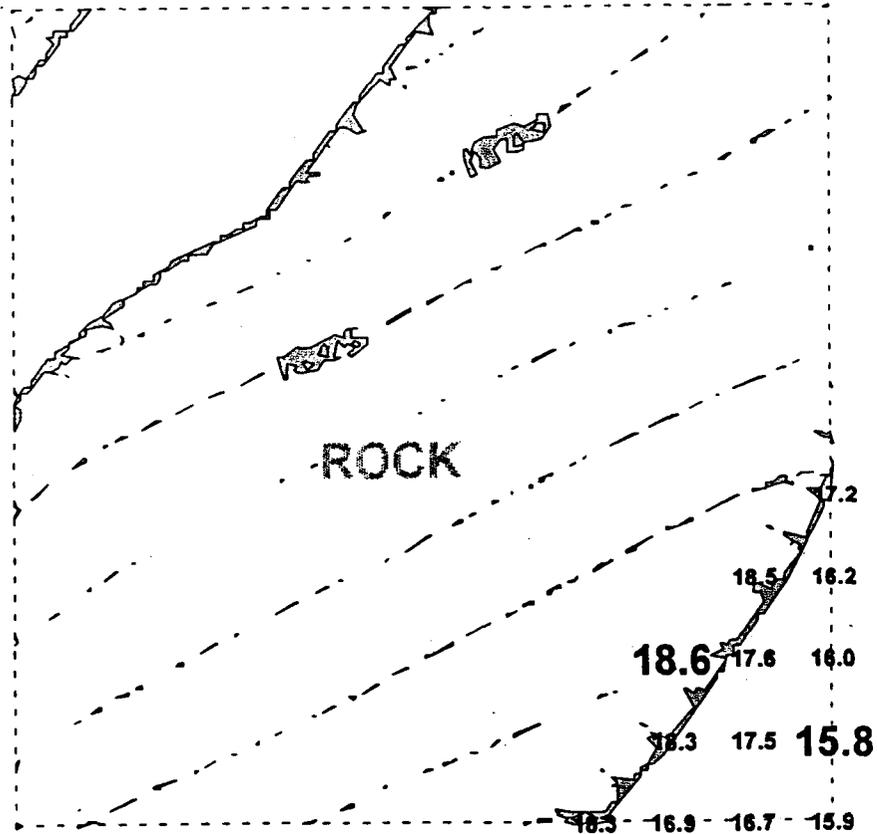
**Grid #17**  
N200ft - 300ft  
E100ft - 200ft



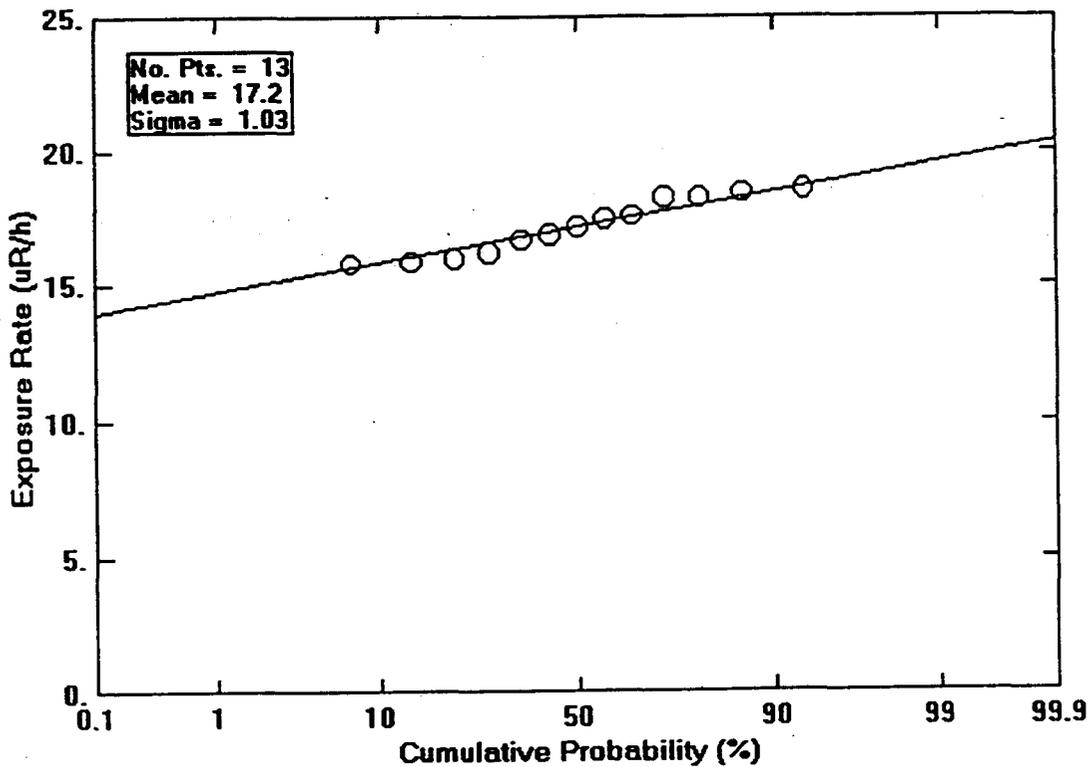
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11-28-94

Figure 27. Grid #17 Ambient Gamma Exposure Rate.



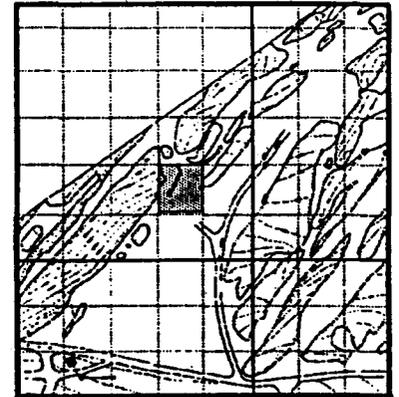
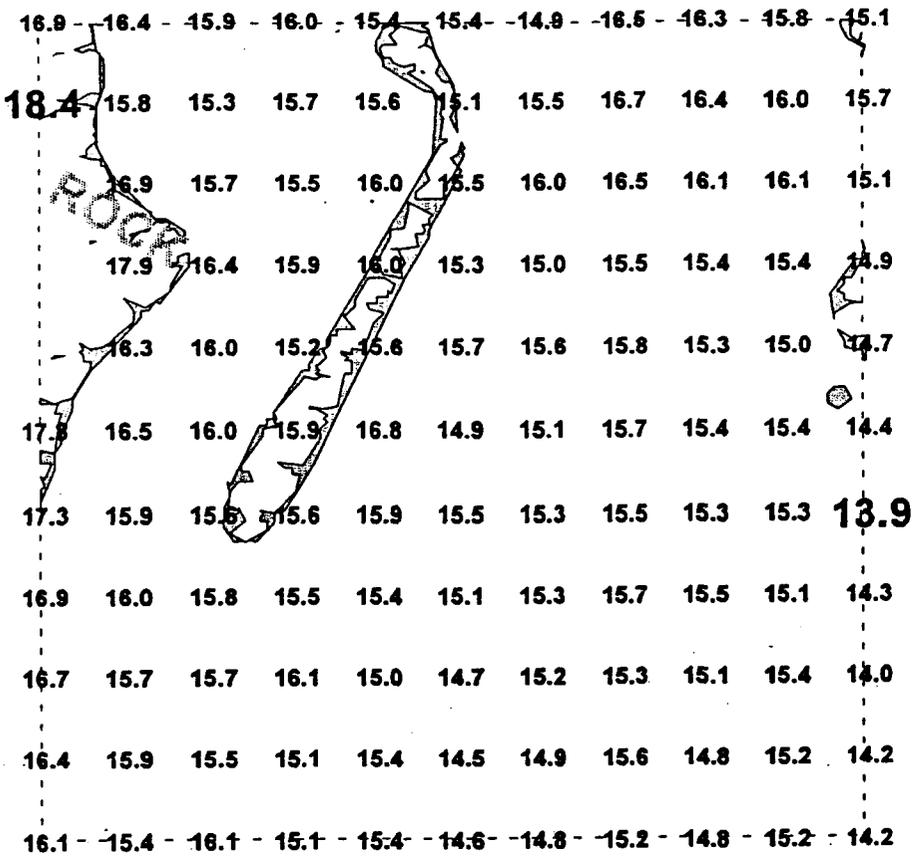
**Grid #21**  
N100ft - 200ft  
W300ft - 200ft



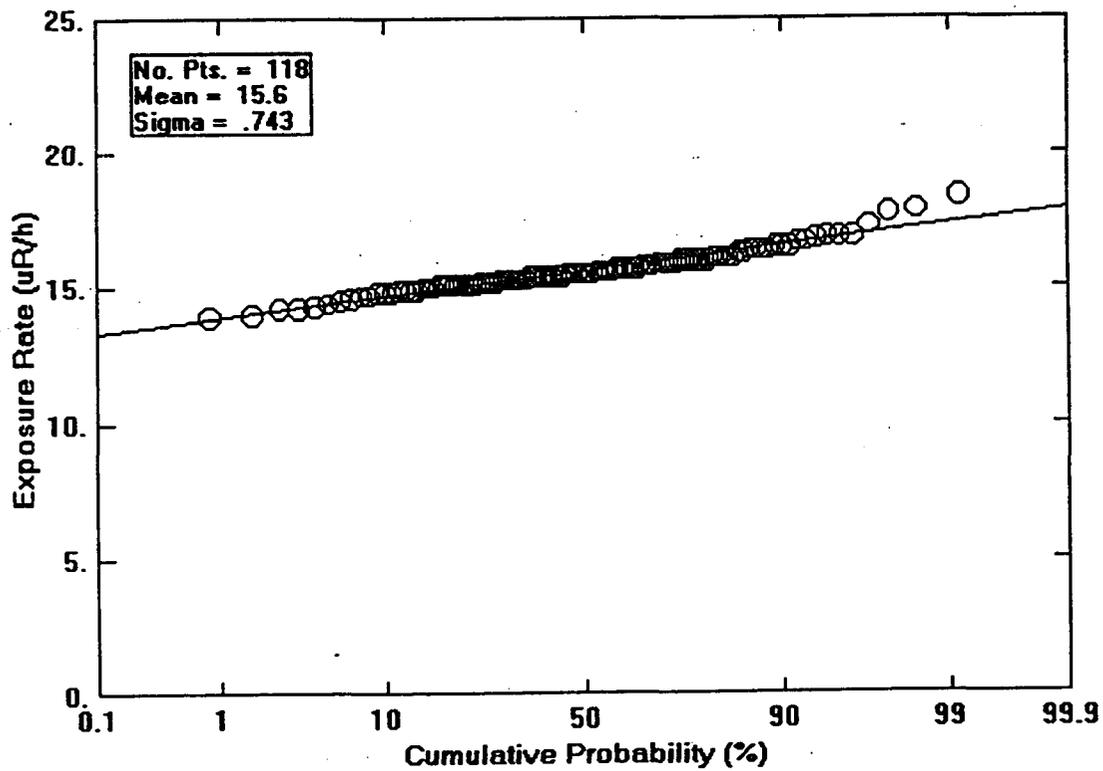
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11-28-94

Figure 28. Grid #21 Ambient Gamma Exposure Rate.



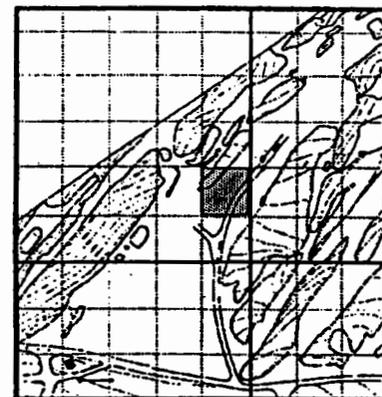
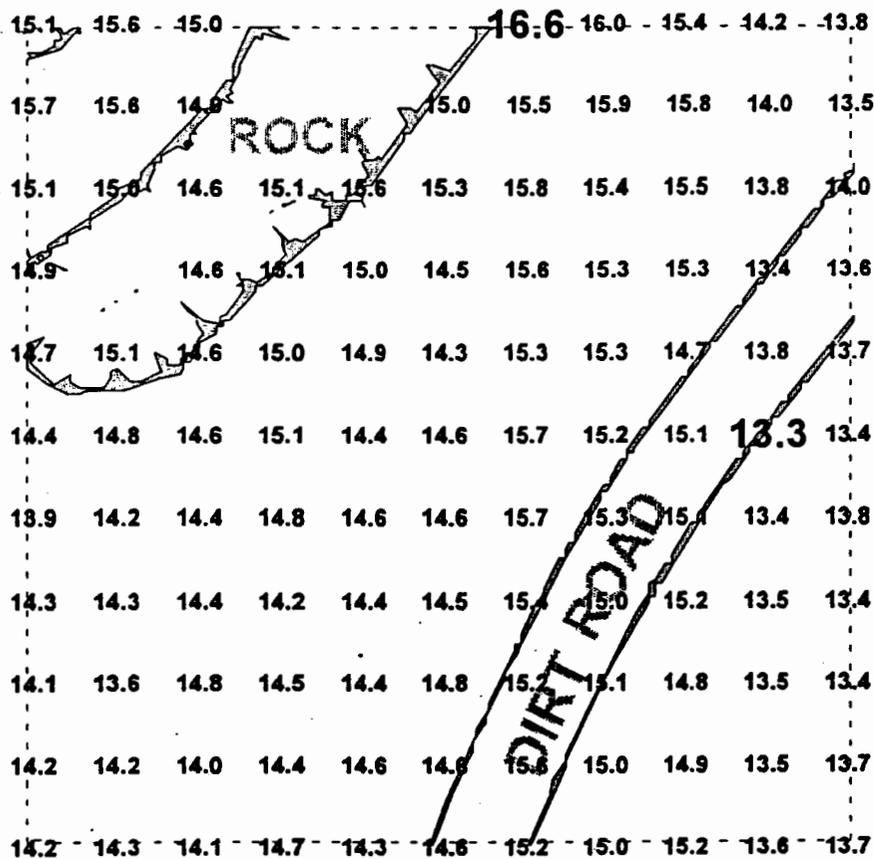
**Grid #22**  
**N100ft - 200ft**  
**W200ft - 100ft**



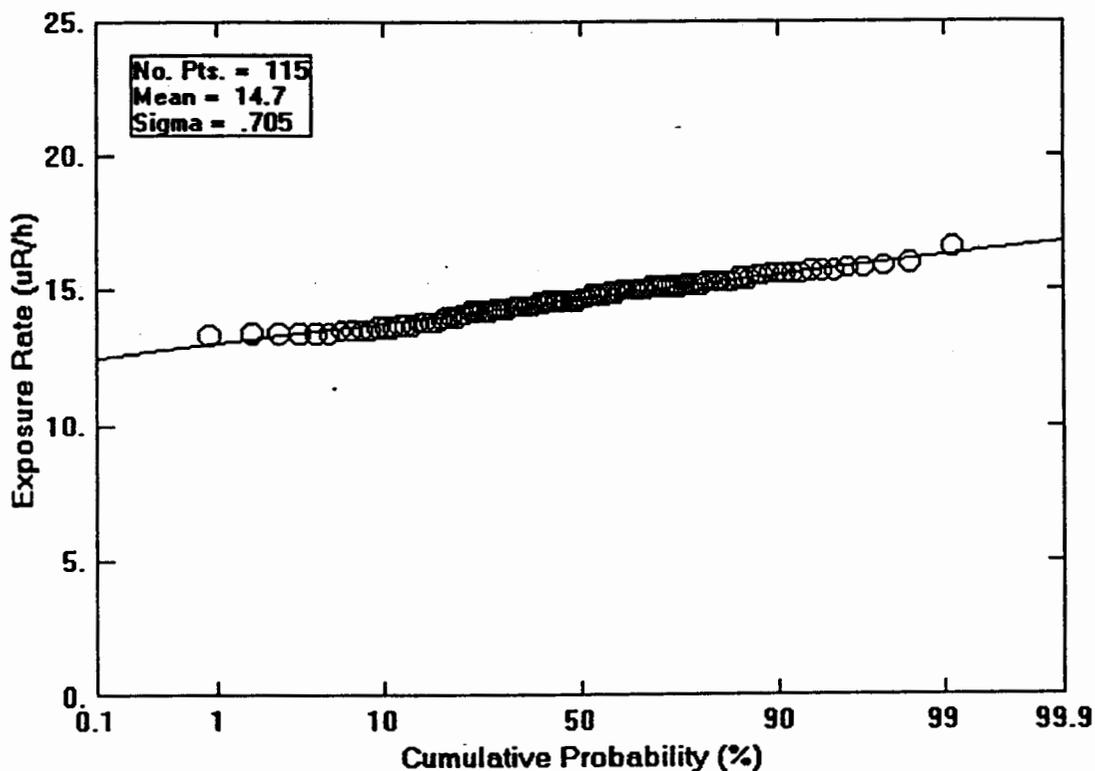
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11-28-94

Figure 29. Grid #22 Ambient Gamma Exposure Rate.



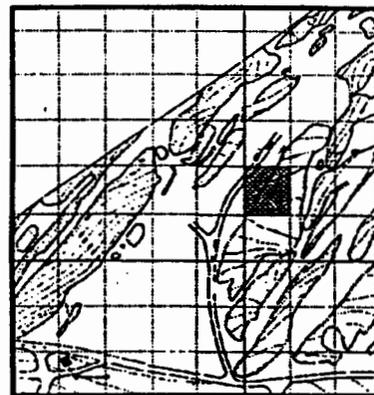
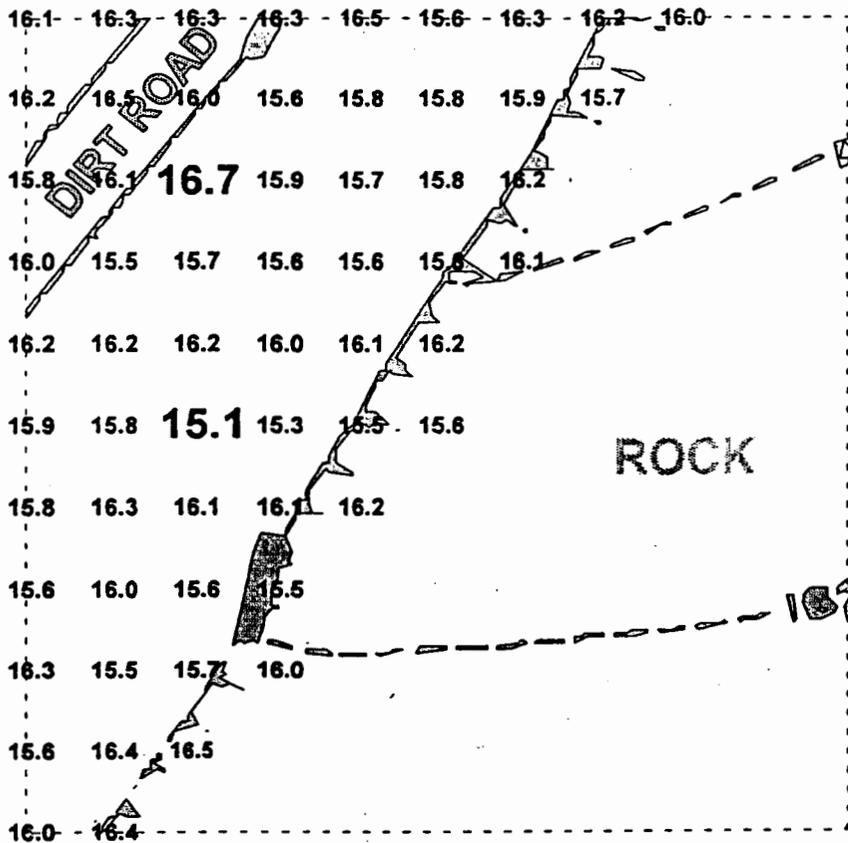
**Grid #23**  
 N100ft - 200ft  
 W100ft - 0ft



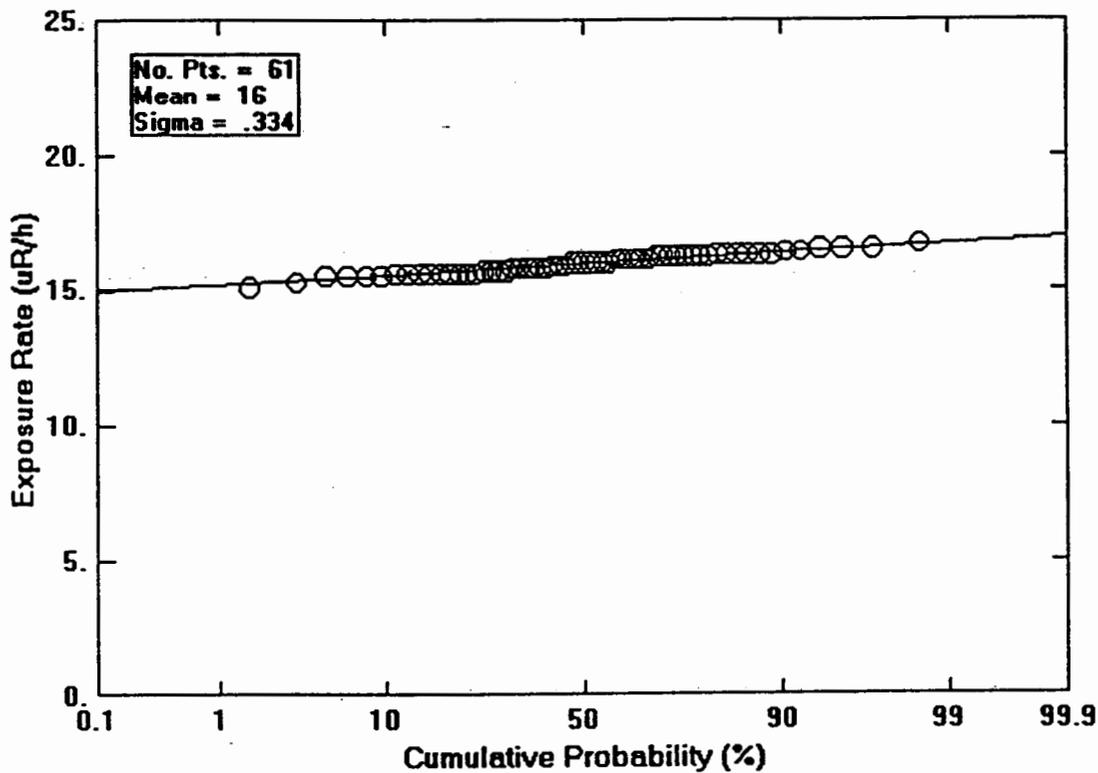
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11-28-94

Figure 30. Grid #23 Ambient Gamma Exposure Rate.



**Grid #24**  
N100ft - 200ft  
E 0ft - 100ft



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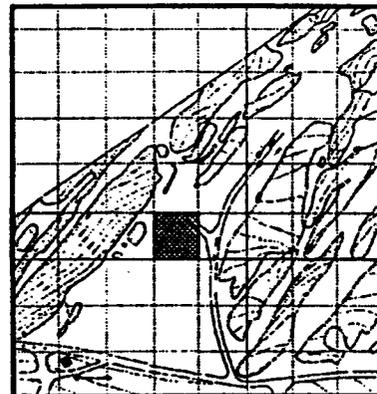
11-28-94

Figure 31. Grid #24 Ambient Gamma Exposure Rate.

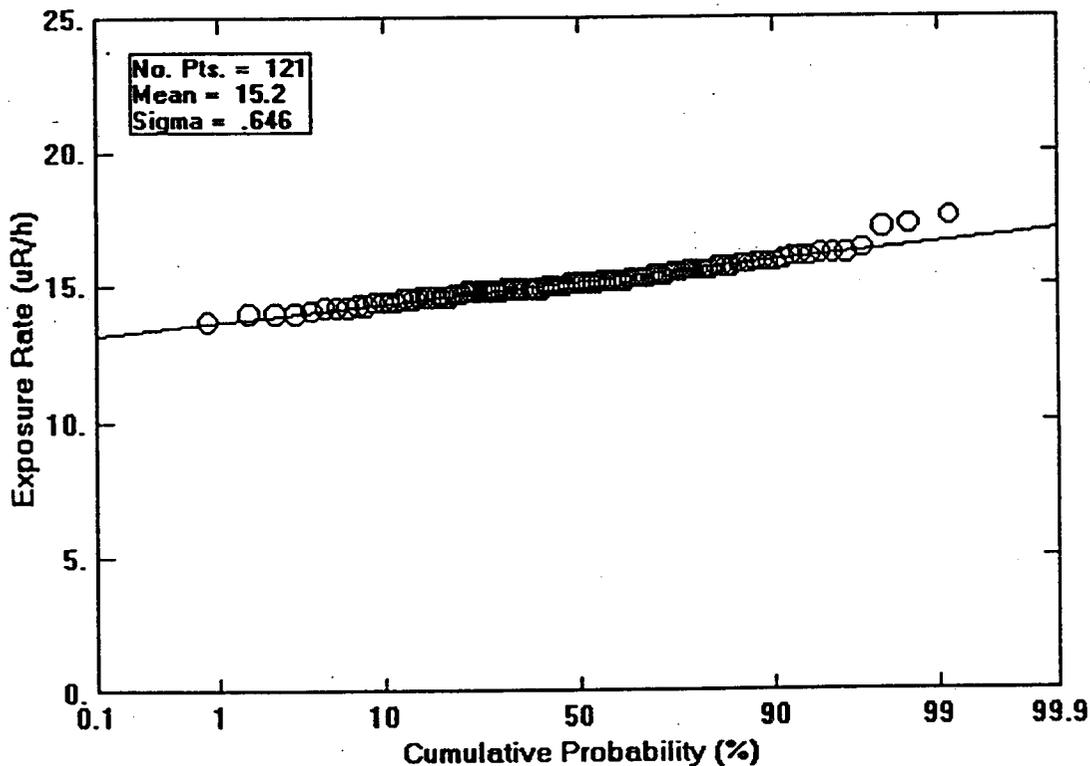


16.1	15.4	16.1	15.1	15.5	14.6	14.8	15.2	14.8	15.2	14.2
16.2	15.2	16.1	15.1	14.9	14.4	15.1	14.9	15.0	14.8	14.0
15.7	15.5	15.1	15.6	14.9	14.0	14.8	14.7	14.9	14.9	14.2
16.0	15.8	15.2	16.2	15.3	14.8	14.9	15.3	14.6	14.6	14.3
15.7	15.3	15.1	15.9	14.9	14.4	14.8	14.8	14.7	15.1	13.7
15.9	15.1	15.3	15.6	15.4	14.6	14.4	14.6	14.6	14.8	14.1
16.4	15.3	15.8	15.3	15.5	15.9	15.0	15.2	14.9	14.9	14.2
15.7	15.6	15.6	15.0	15.6	14.8	15.0	15.2	15.0	15.2	14.0
17.6	15.7	15.4	14.9	15.1	14.5	15.0	15.8	15.2	14.7	14.4
17.3	15.5	15.6	14.6	15.1	14.8	15.1	15.6	15.0	14.9	14.3
17.2	15.3	14.6	15.0	15.2	15.9	14.9	16.2	15.4	15.4	14.5

DIRT ROAD



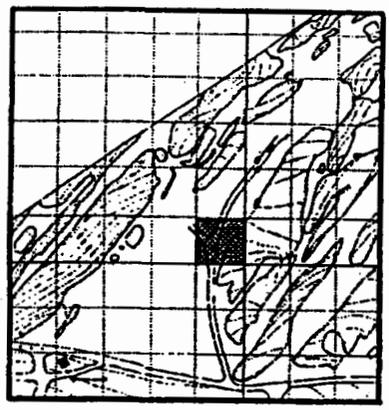
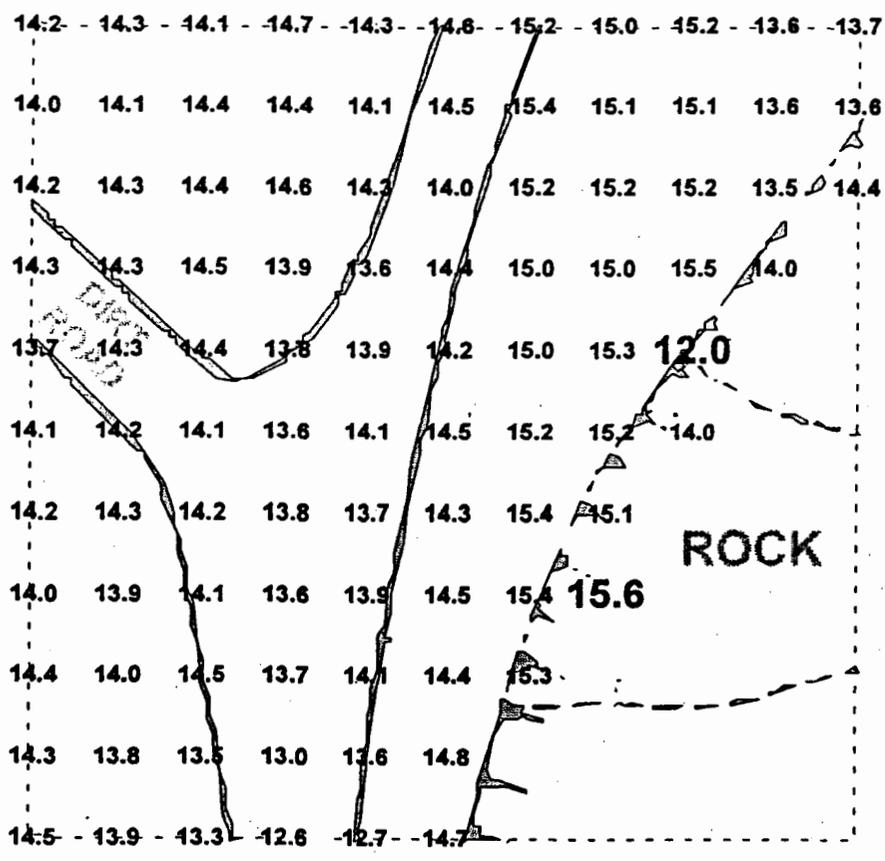
Grid #30  
N 0ft - 100ft  
W200ft - 100ft



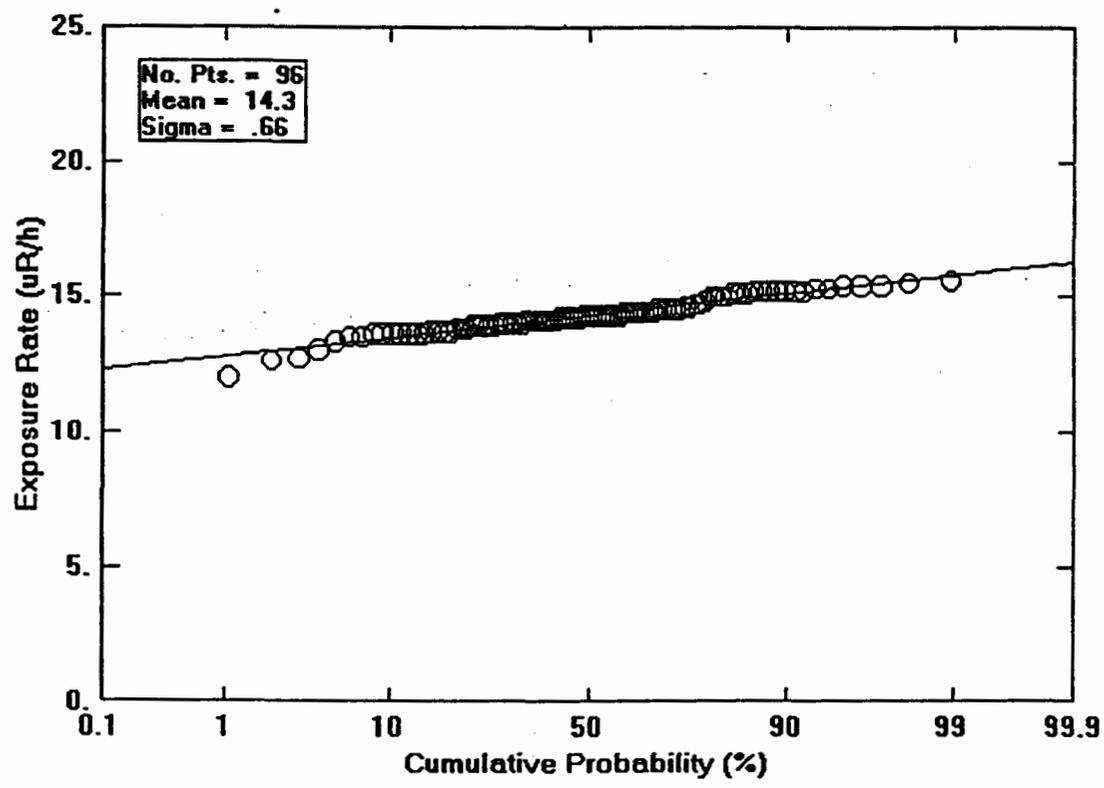
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11-28-94

Figure 33. Grid #30 Ambient Gamma Exposure Rate.



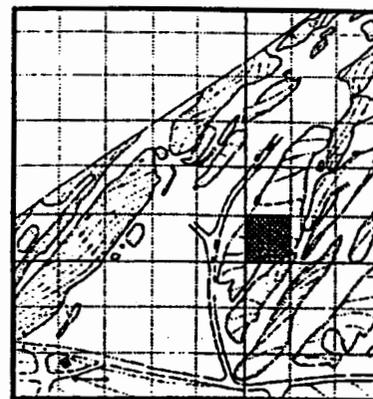
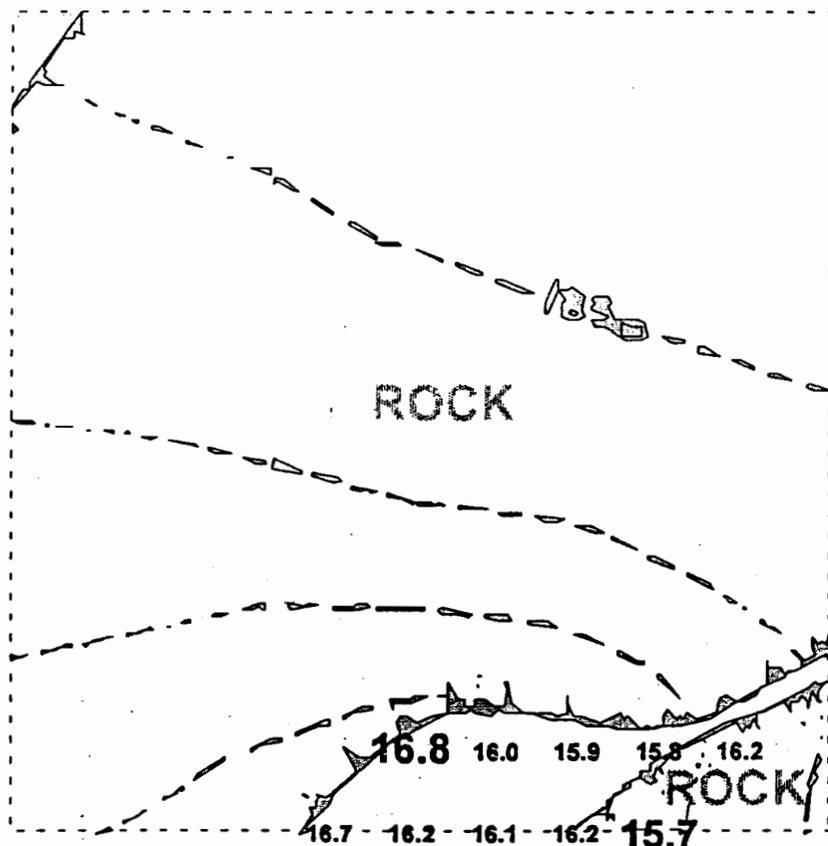
Grid #31  
 N 0ft - 100ft  
 W 100ft - 0ft



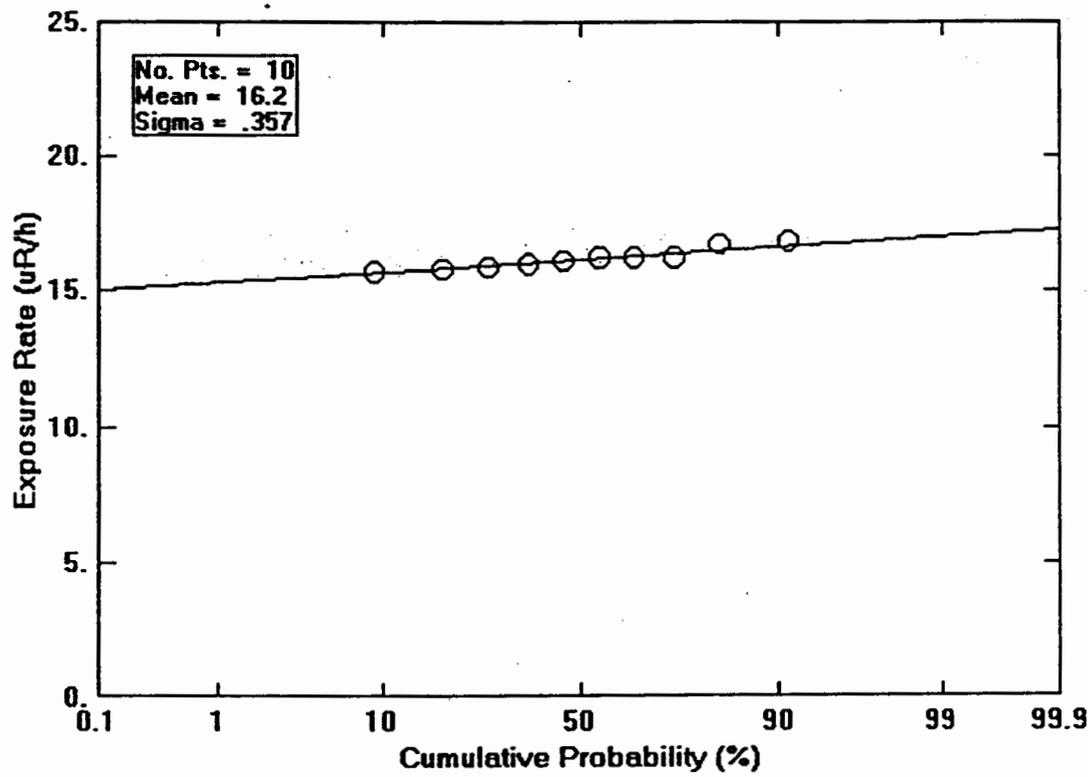
C:\B886\NOW1.CMP

11-28-94

Figure 34. Grid #31 Ambient Gamma Exposure Rate.



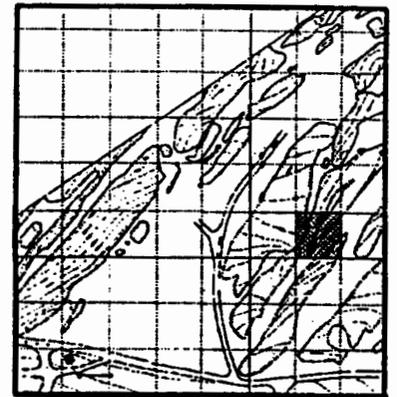
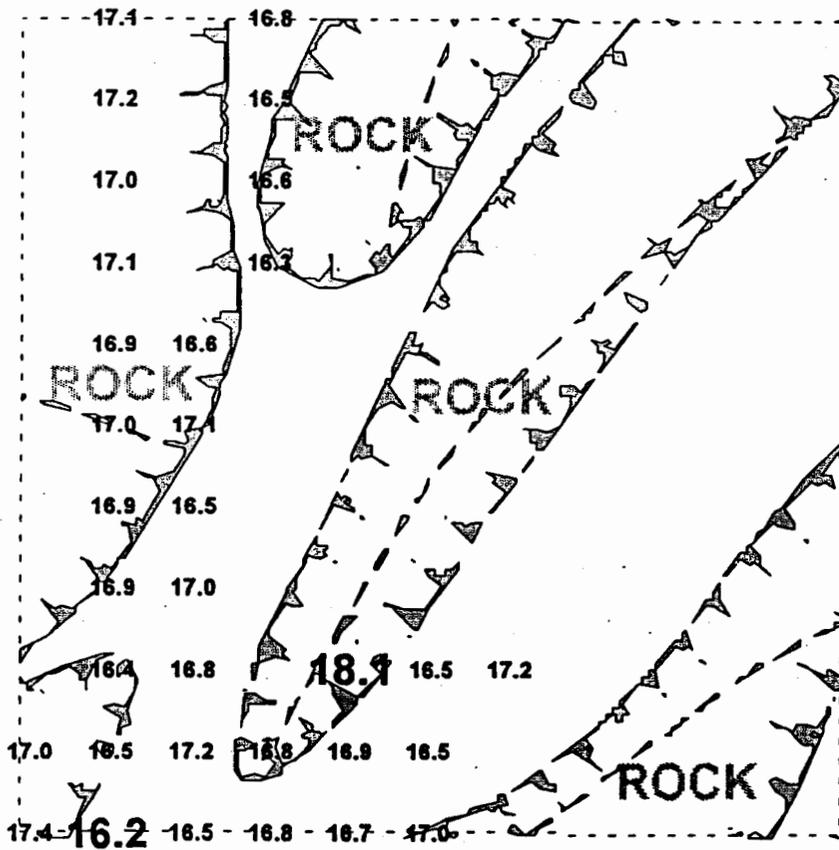
**Grid #32**  
N 0ft - 100ft  
E 0ft - 100ft



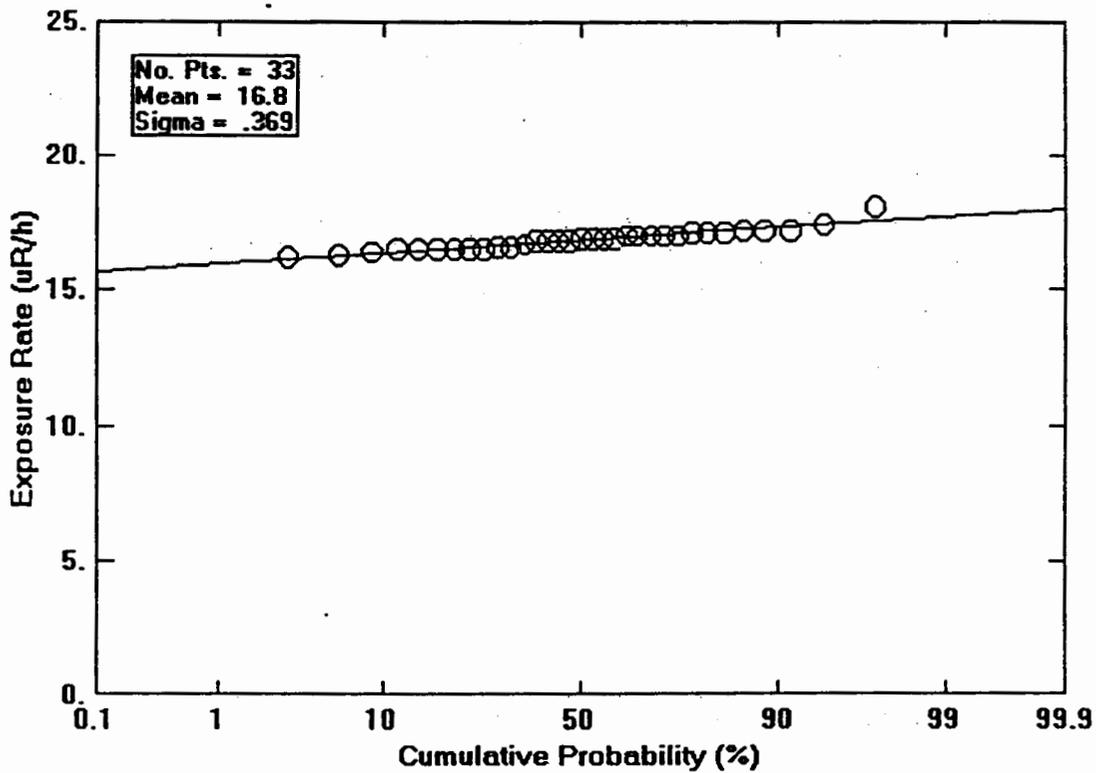
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11-28-94

Figure 35. Grid #32 Ambient Gamma Exposure Rate.



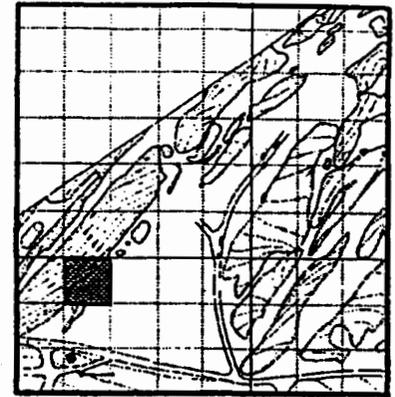
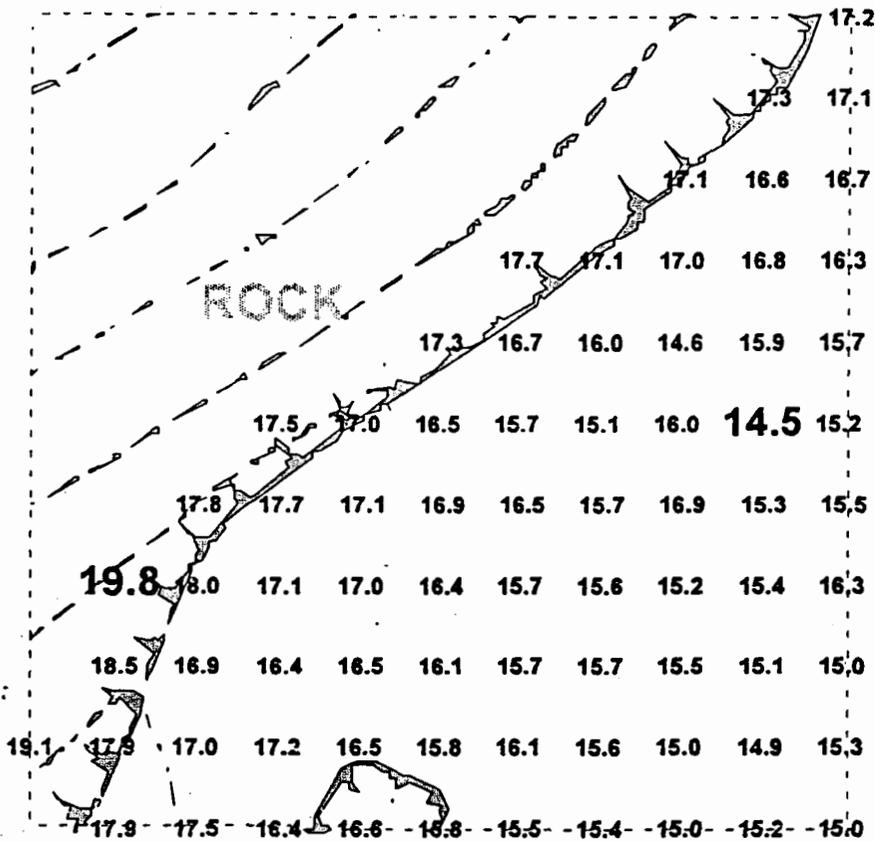
**Grid #33**  
 N 0ft - 100ft  
 E 100ft - 200ft



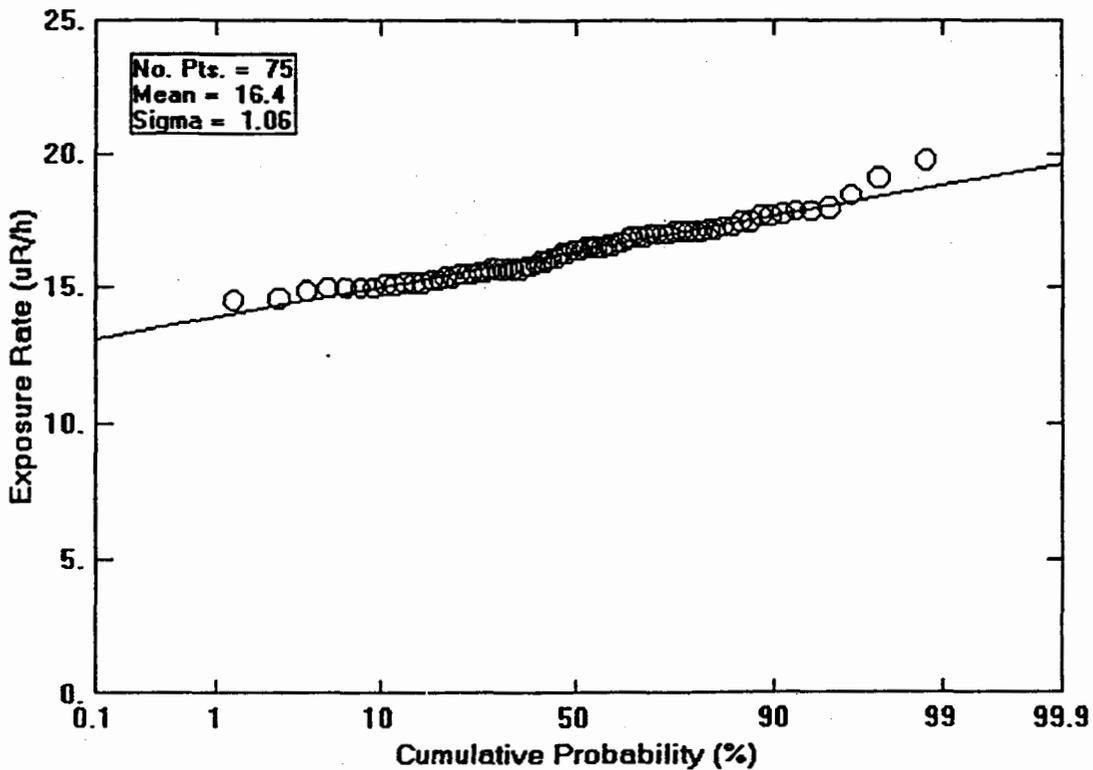
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11-28-94

Figure 36. Grid #33 Ambient Gamma Exposure Rate.



Grid #36  
 S 0ft - 100ft  
 W400ft - 300ft



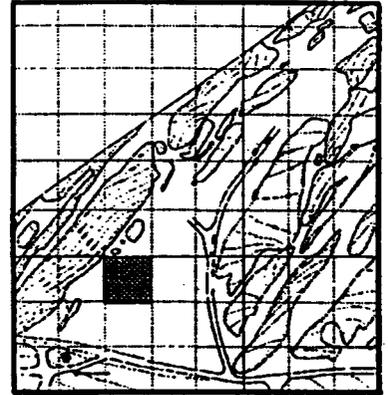
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11-28-94

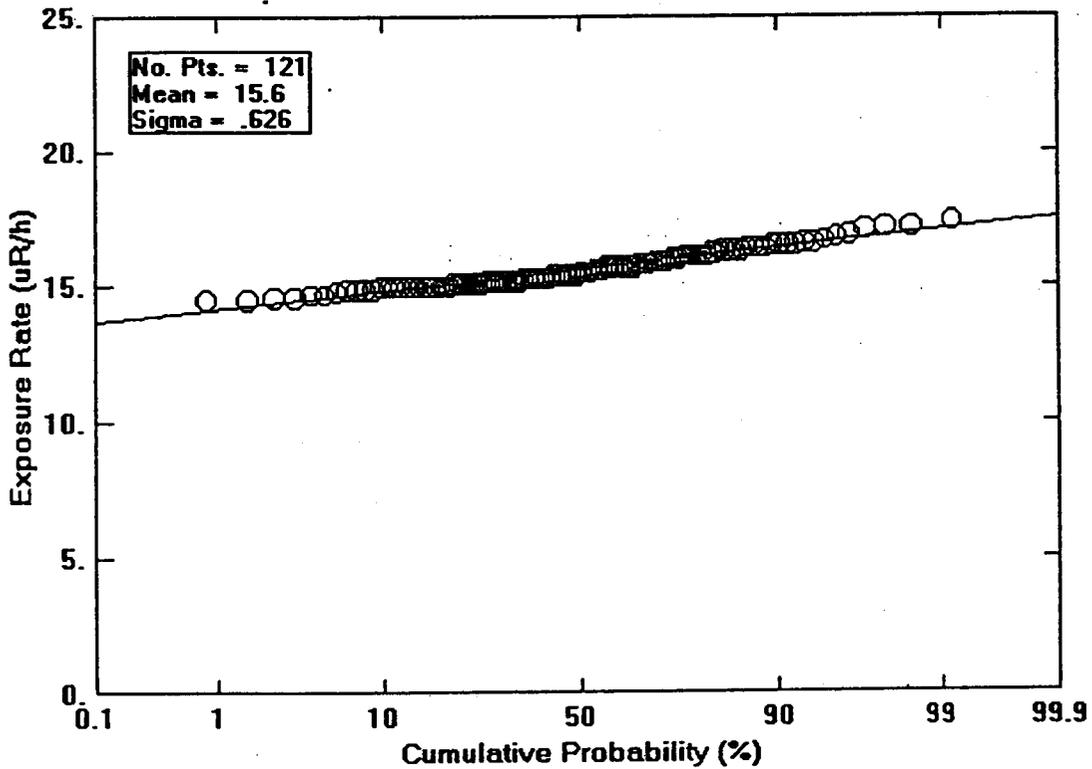
Figure 37.. Grid #36 Ambient Gamma Exposure Rate.

17.2	<b>17.4</b>	16.6	16.4	16.2	16.1	15.9	16.5	15.6	15.7	16.1
17.1	16.5	16.4	16.0	15.3	15.3	16.0	16.5	15.8	15.9	15.9
16.7	15.8	16.3	15.6	15.6	16.8	17.2	16.5	16.4	16.1	15.5
16.3	15.7	15.2	15.3	14.9	15.7	15.7	16.4	16.3	15.7	15.3
15.7	15.7	15.2	15.4	15.2	14.9	15.4	15.8	16.1	15.7	16.1
15.2	15.2	15.0	15.1	15.1	15.1	15.0	16.1	16.6	15.7	15.4
15.5	15.0	15.0	15.2	15.1	15.4	15.1	15.8	16.3	16.9	16.0
16.3	15.1	15.3	15.0	15.4	15.7	16.1	15.6	16.2	15.9	15.9
15.0	15.1	14.7	<b>14.5</b>	15.0	15.5	15.3	15.5	15.0	15.0	15.1
15.3	14.6	15.2	14.6	<b>14.5</b>	14.8	15.4	15.4	15.0	15.4	14.7
15.0	15.0	14.9	14.9	15.2	15.3	15.3	15.4	15.2	15.0	16.2

886-ZR-0007  
Page 52  
12/13/94



**Grid #37**  
S 0ft - 100ft  
W300ft - 200ft



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11-28-94

Figure 38. Grid #37 Ambient Gamma Exposure Rate.

17.2 - 15.3 - 14.6 - 15.0 - 15.2 - 15.9 - 14.9 - 16.2 - 15.4 - 15.4 - 14.5

15.7 15.3 16.0 16.7 16.7 15.6 14.9 15.0 15.5 15.5 14.1

15.1 15.3 15.2 14.4 15.4 15.0 14.7 14.7 15.0 14.7 14.4

14.9 14.9 14.2 14.6 14.7 14.4 14.2 14.4 14.8 14.9 14.2

15.0 14.4 14.4 15.0 14.8 14.6 14.4 14.7 15.0 14.4 13.9

14.9 14.6 14.6 14.8 14.9 14.9 15.0 14.6 14.3 14.5 13.2

15.3 15.0 14.7 14.5 14.3 14.5 14.1 14.5 14.3 14.0 13.7

15.0 14.6 14.4 14.7 14.1 14.3 14.0 13.7 13.8 13.5 13.4

14.2 14.3 14.5 14.1 13.9 14.0 14.0 14.5 14.3 14.2 14.0

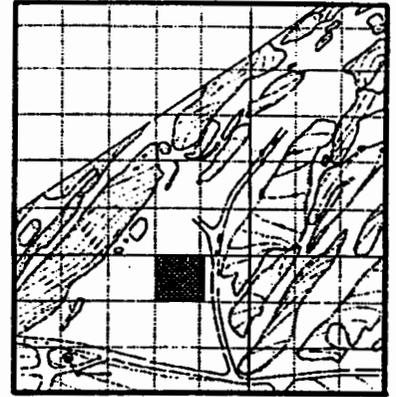
14.3 14.1 13.9 13.9 14.3 13.7 13.6 13.9 14.0 14.0 13.9

14.7 - 14.0 - 14.1 - 14.3 - 14.4 - 13.8 - 13.6 - 14.1 - 13.8 - 13.8 - 14.2

886-ZR-0007

Page 53

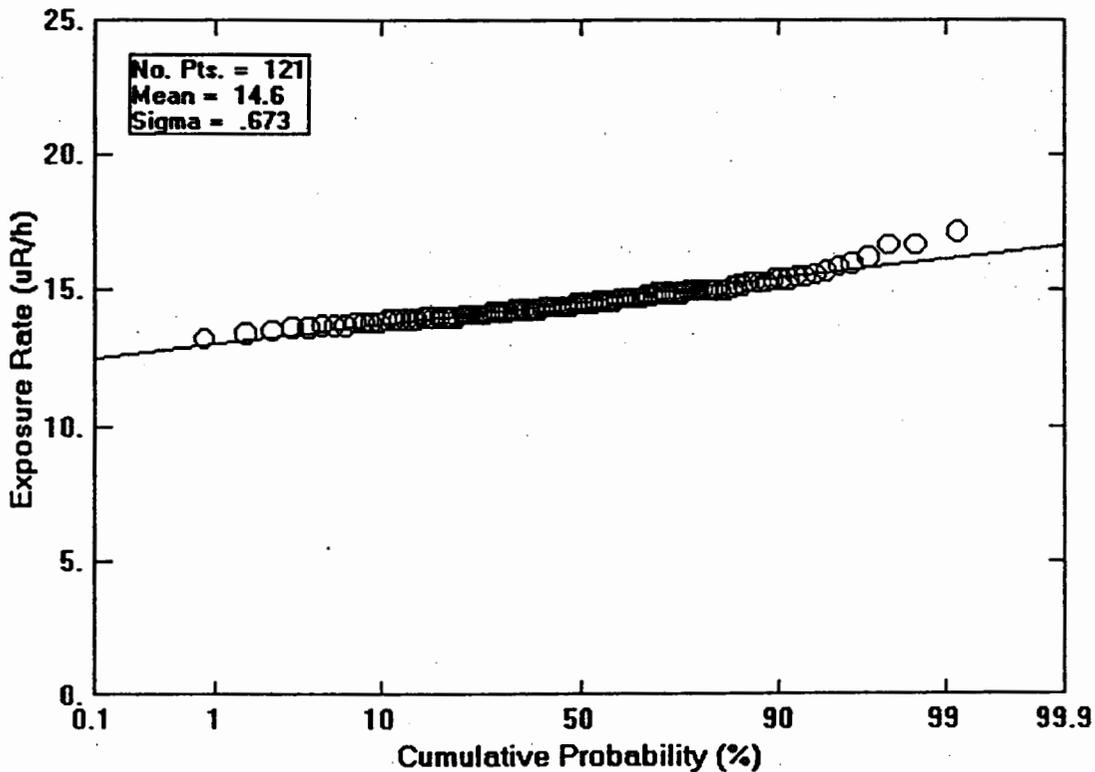
12/13/94



Grid #38

S 0ft - 100ft

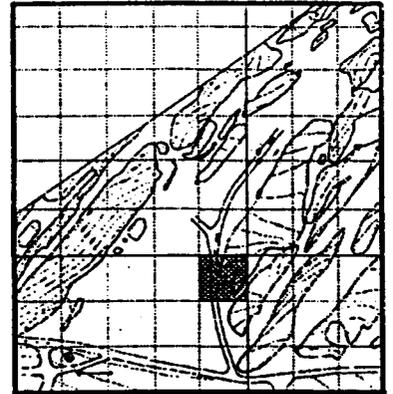
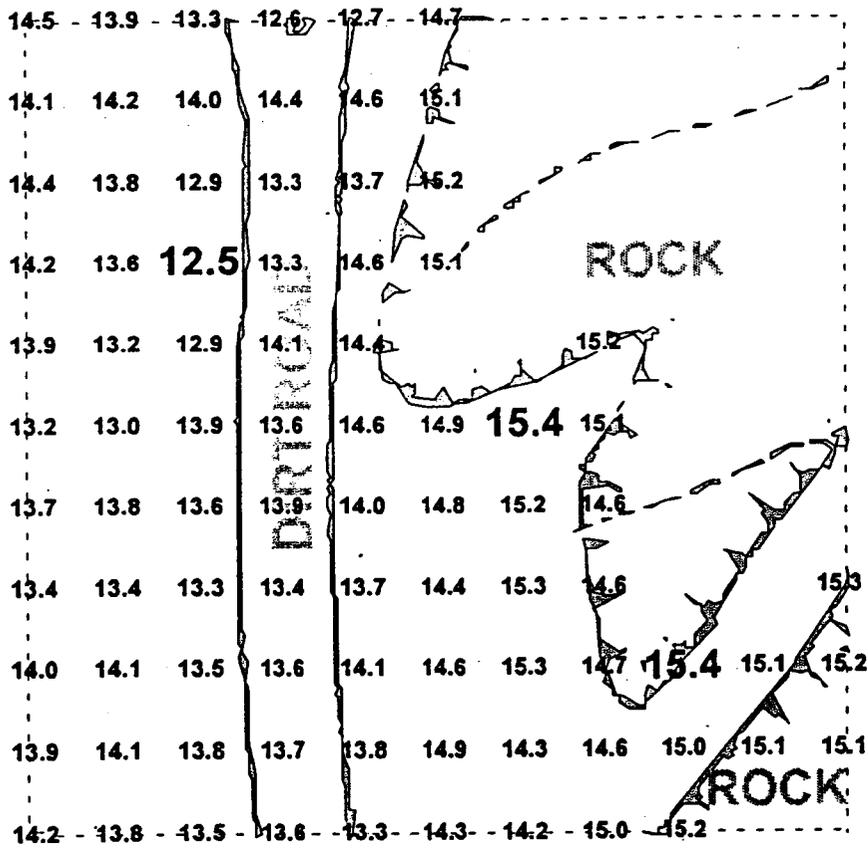
W200ft - 100ft



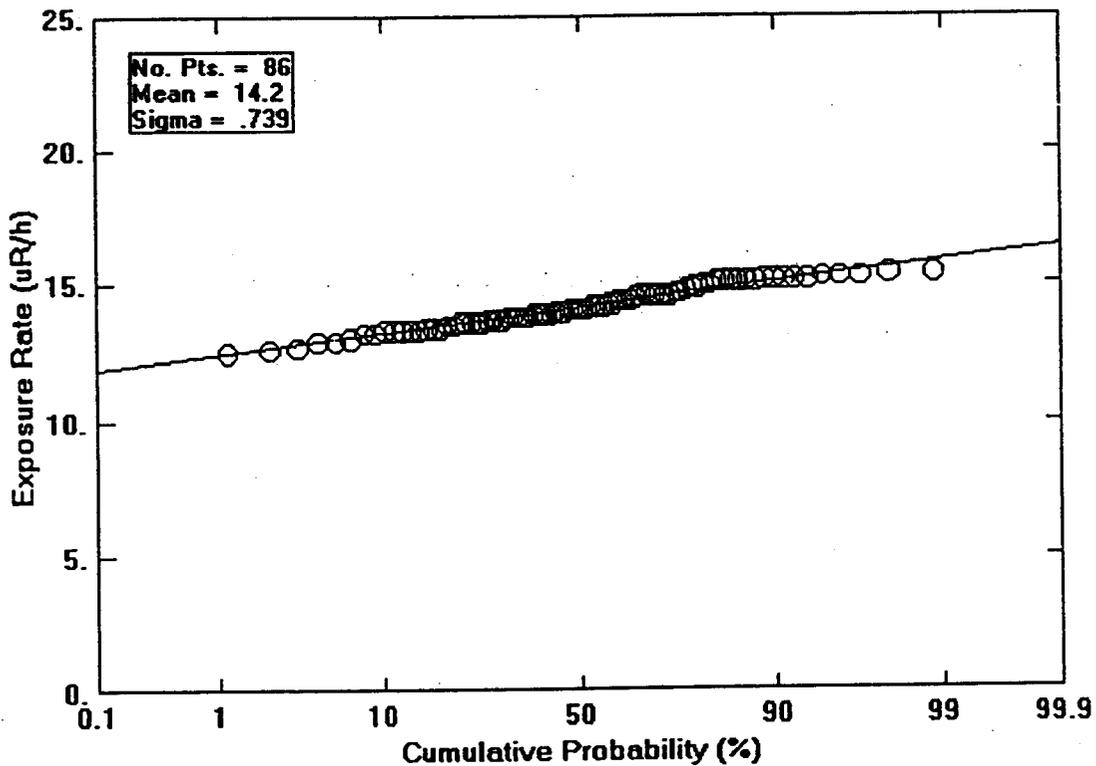
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11-28-94

Figure 39. Grid #38 Ambient Gamma Exposure Rate.



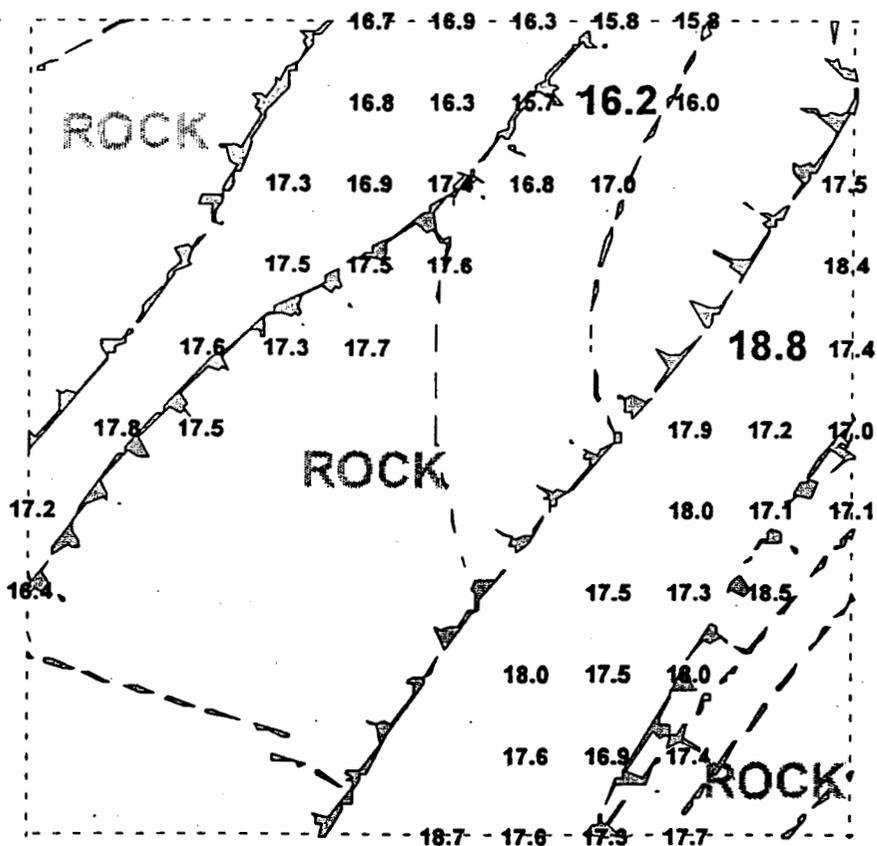
**Grid #39**  
S Off - 100ft  
W100ft - 0ft



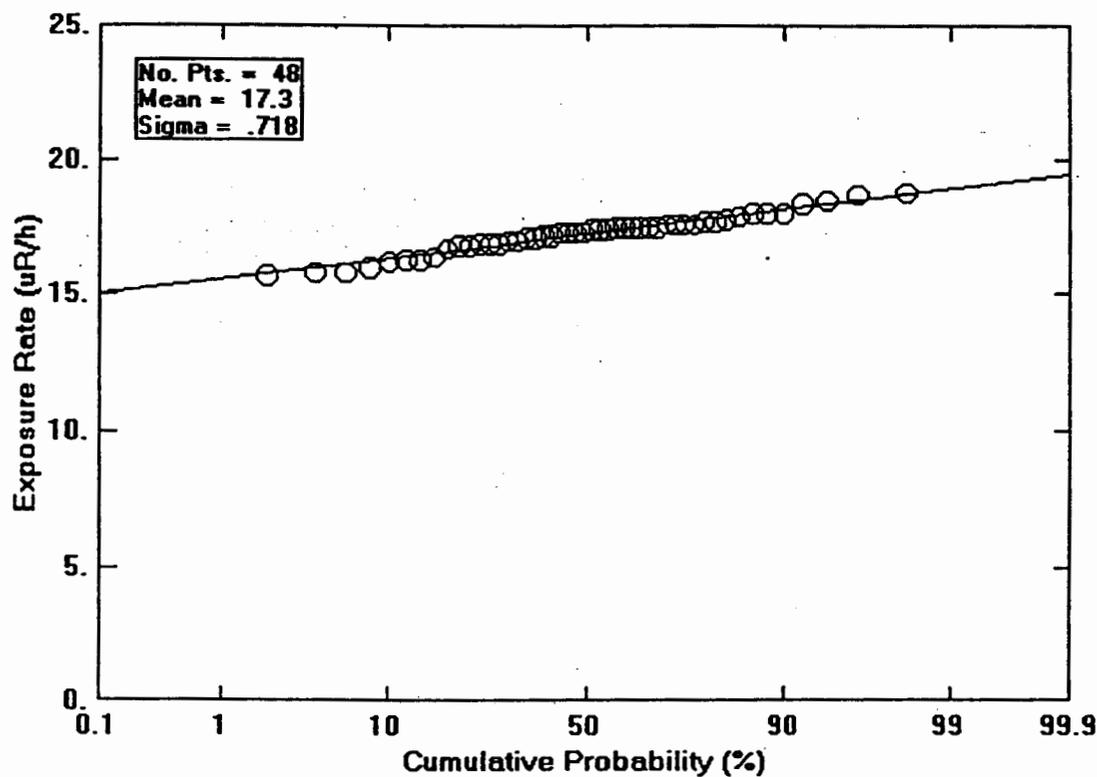
C:\B886\S1W1.CMP

11-28-94

Figure 40. Grid #39 Ambient Gamma Exposure Rate.



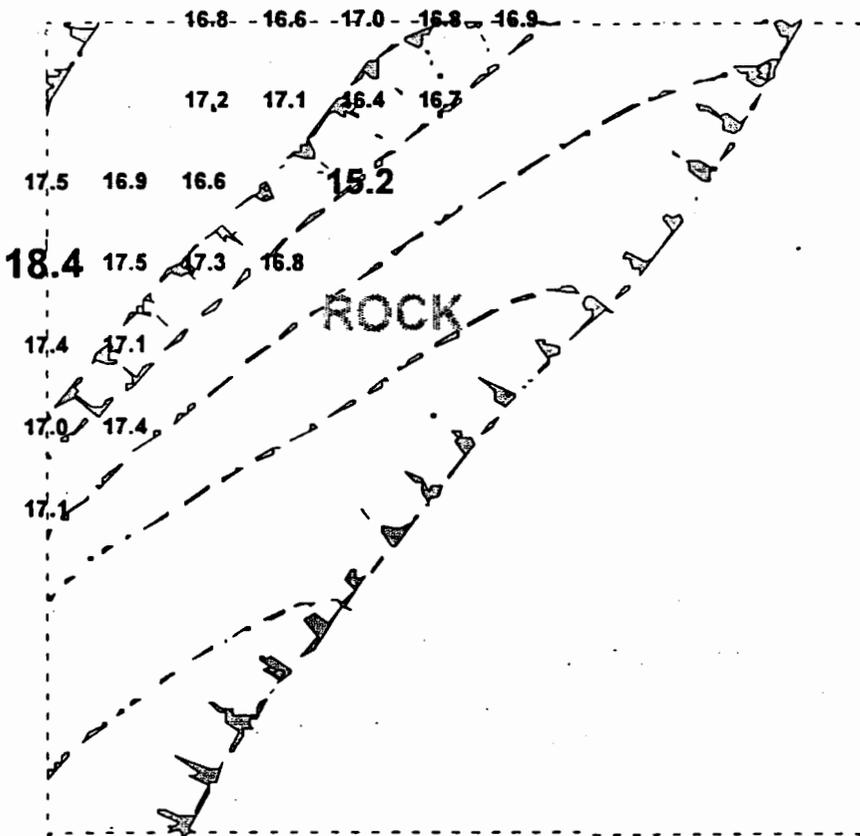
**Grid #40**  
 S 0ft - 100ft  
 E 0ft - 100ft



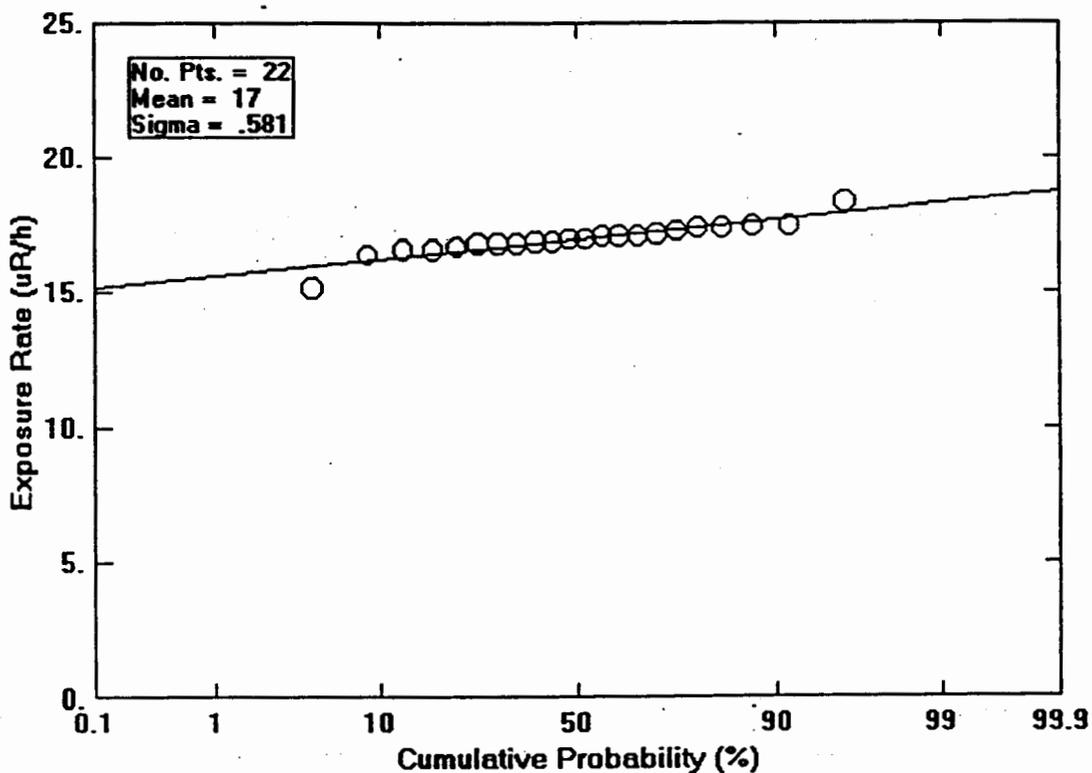
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11-28-94

Figure 41. Grid #40 Ambient Gamma Exposure Rate.



**Grid #41**  
S 0ft - 100ft  
E 100ft - 200ft

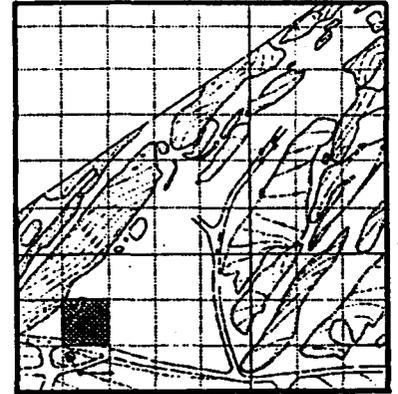
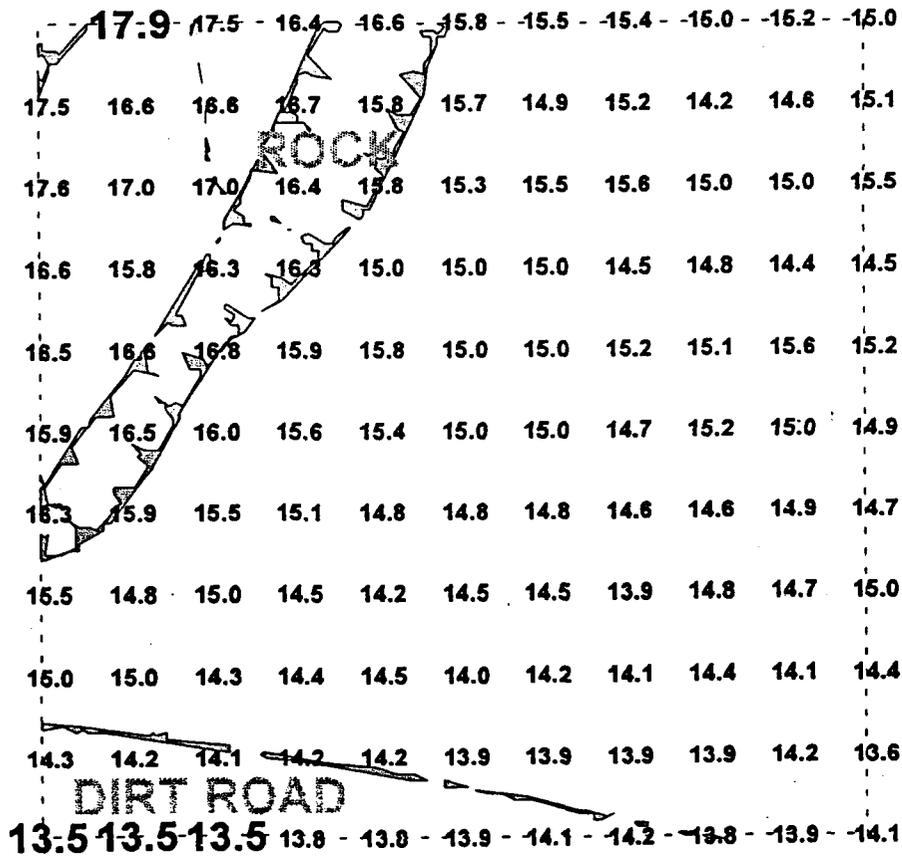


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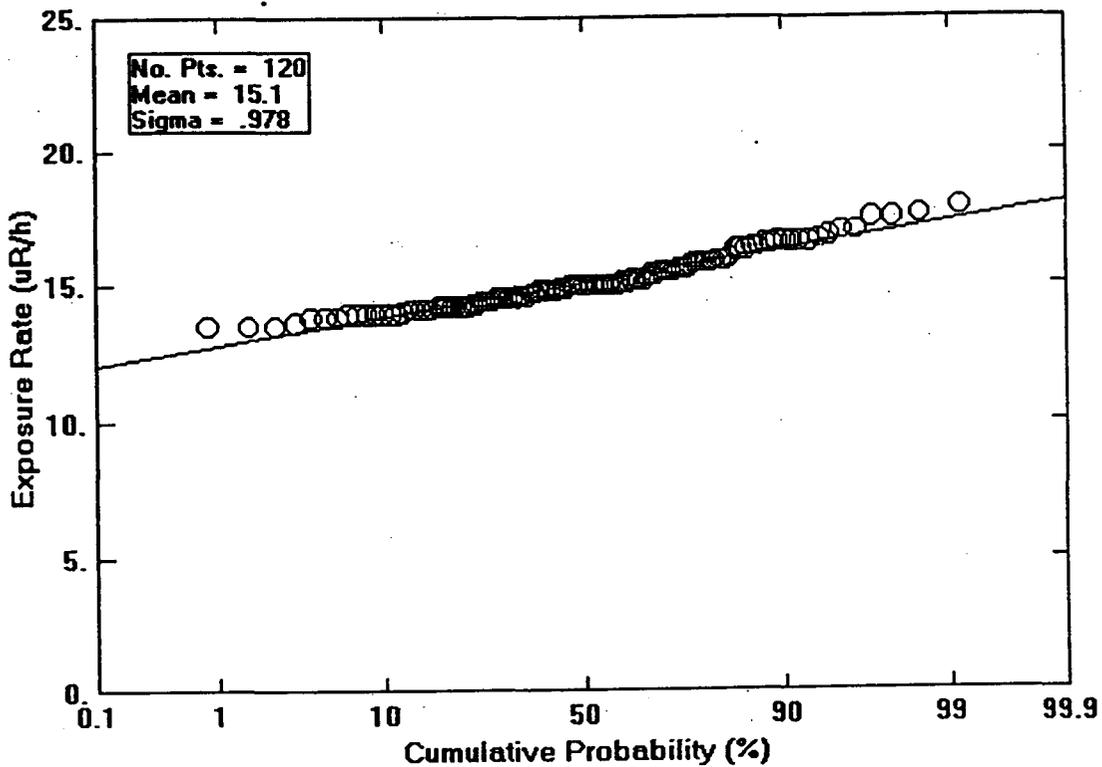
11-28-94

Figure 42. Grid #41 Ambient Gamma Exposure Rate.





**Grid #44**  
**S100ft - 200ft**  
**E400ft - 300ft**

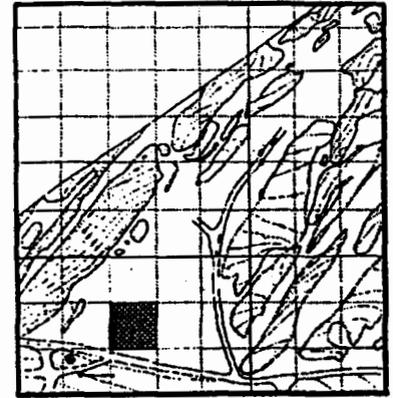


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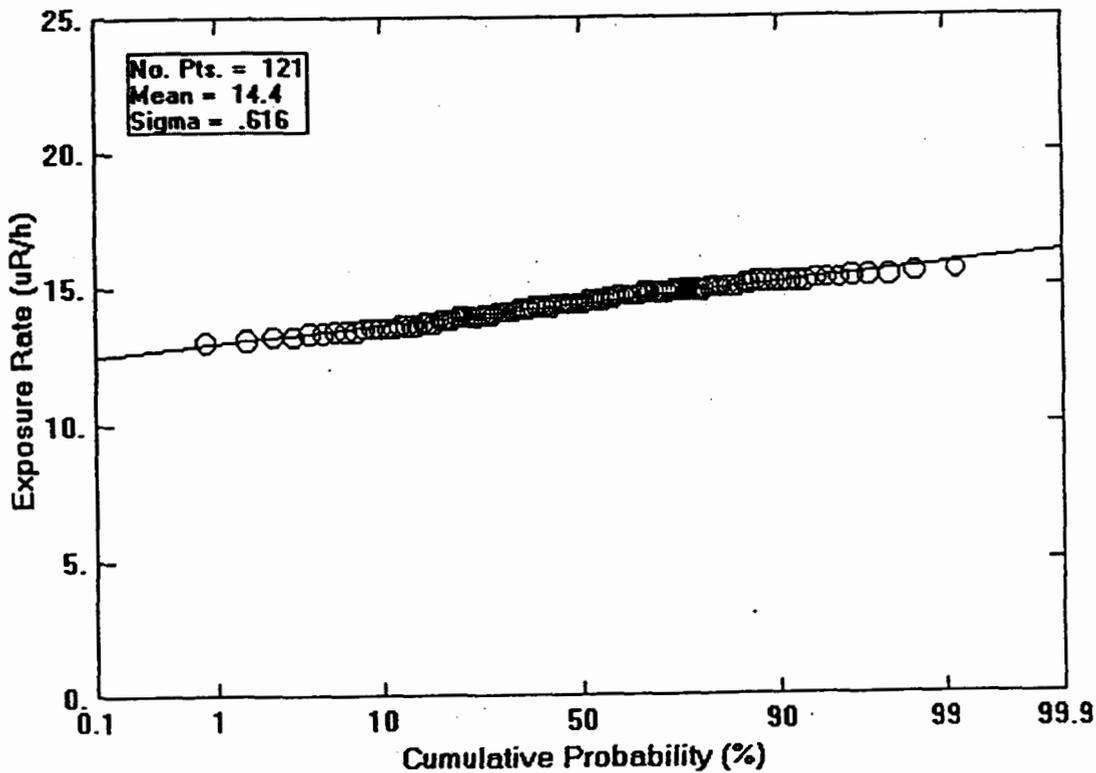
11-28-94

Figure 44. Grid #44 Ambient Gamma Exposure Rate.

15.0	15.0	14.9	14.9	15.2	15.3	15.3	15.4	15.2	15.0	15.2
15.1	14.9	14.7	14.6	14.9	14.4	14.4	14.8	14.7	14.7	14.5
15.5	15.2	14.8	14.8	15.3	15.4	<b>15.6</b>	15.0	15.1	15.0	15.4
14.5	14.1	13.8	14.1	14.1	14.0	14.8	14.3	14.5	14.5	14.3
15.2	14.9	14.3	14.4	14.5	14.8	14.8	14.2	15.2	14.7	14.9
14.9	14.6	14.6	14.3	14.4	14.4	15.2	14.4	14.3	14.8	14.7
14.7	14.9	14.4	14.3	14.2	14.7	14.8	14.9	14.7	15.0	15.2
15.0	14.5	14.0	13.7	14.1	<b>13.0</b>	14.4	13.9	14.4	13.5	13.5
14.4	13.9	14.0	13.9	14.1	13.5	13.8	13.9	13.6	13.1	13.2
13.6	14.2	13.2	14.0	13.7	13.4	13.9	13.5	13.7	13.6	13.8
14.1	14.3	14.2	13.8	13.9	13.3	13.3	13.5	13.4	13.4	13.6



**Grid #45**  
**S100ft - 200ft**  
**W300ft - 200ft**

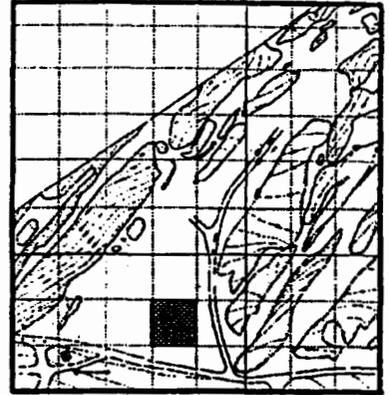


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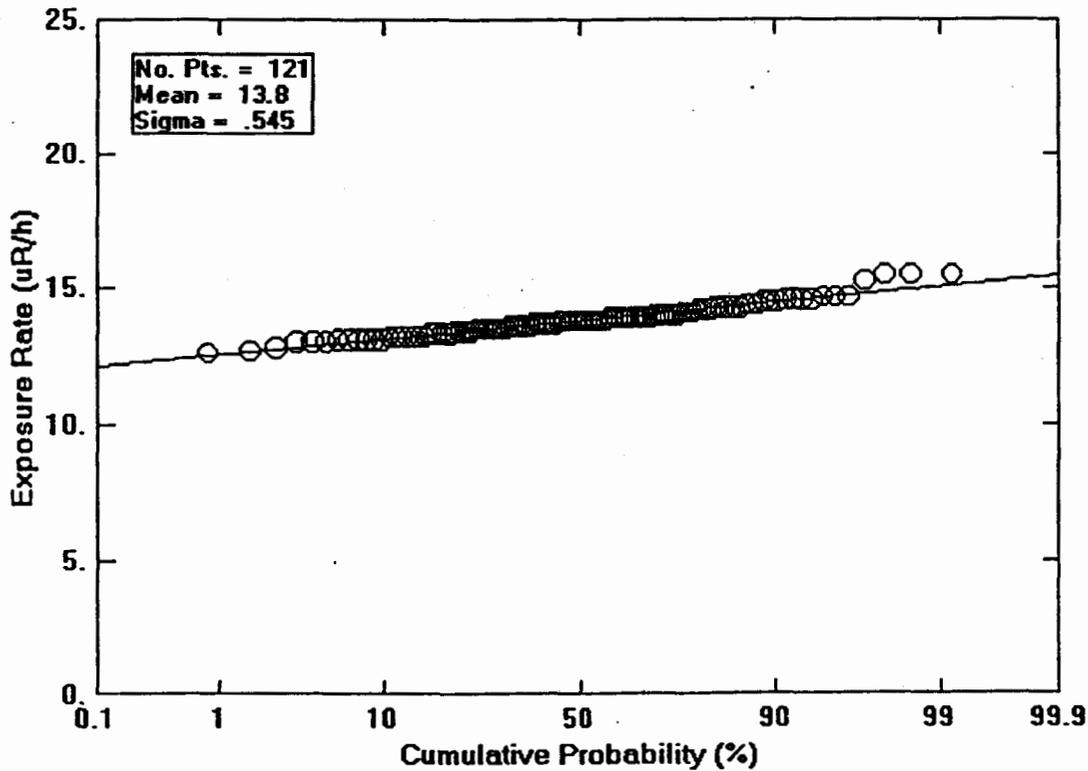
11-28-94

Figure 45. Grid #45 Ambient Gamma Exposure Rate.

14.7	14.0	14.1	14.3	14.4	13.8	13.6	14.1	13.8	13.8	14.2
14.4	13.9	14.2	14.2	14.0	13.9	13.5	13.9	13.7	13.8	13.1
13.8	13.9	13.9	13.9	14.3	13.9	13.9	13.9	13.7	13.4	14.0
14.0	14.1	13.8	13.3	13.8	13.2	13.6	13.8	13.0	13.4	13.4
14.0	14.1	14.2	13.5	13.9	13.9	13.7	13.9	13.7	13.3	13.2
13.4	13.6	13.7	13.7	14.3	13.8	13.5	13.2	13.3	13.4	13.5
13.8	13.8	13.6	13.5	13.6	13.2	13.2	<b>12.6</b>	13.0	13.2	13.3
13.9	14.3	14.6	14.4	14.3	13.8	13.5	13.1	13.3	13.8	13.8
13.5	14.7	14.6	14.6	14.3	14.0	13.5	12.7	13.1	12.8	13.8
14.0	14.5	14.7	14.6	14.5	14.5	13.9	13.5	13.0	13.7	13.7
13.8	<b>15.5</b>	15.3	<b>15.5</b>	<b>15.5</b>	13.1	13.1	13.1	13.2	13.8	13.6



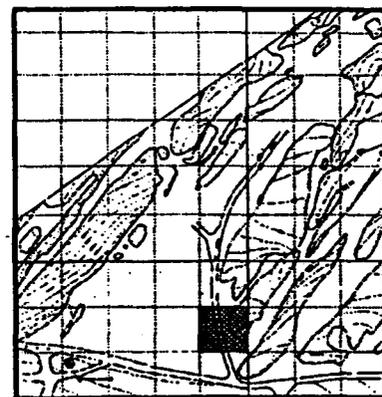
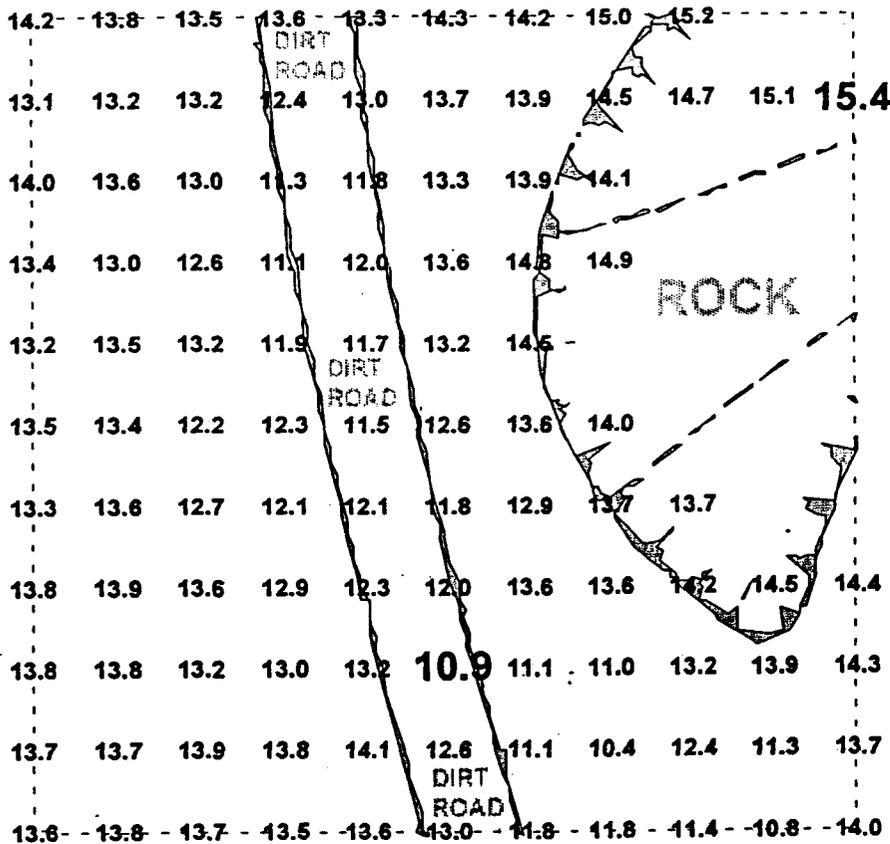
**Grid #46**  
**S100ft - 200ft**  
**W200ft - 100ft**



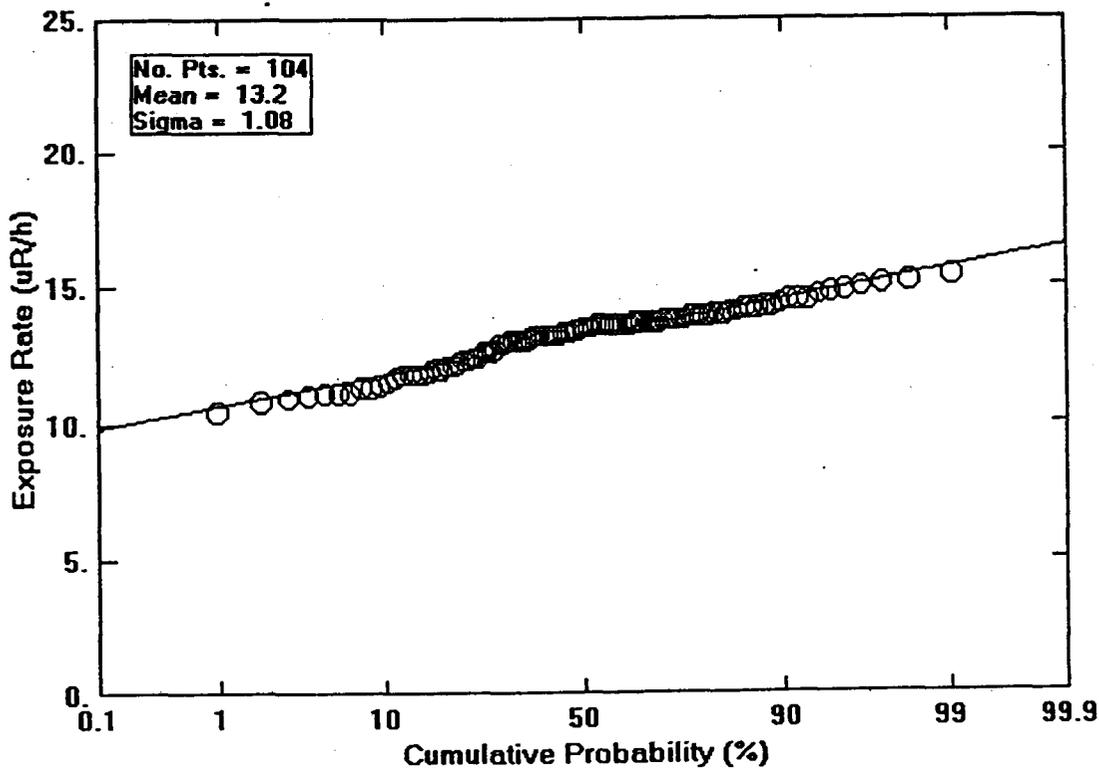
C:\B886\S2W2.CMP

11-28-94

Figure 46.. Grid #46 Ambient Gamma Exposure Rate.



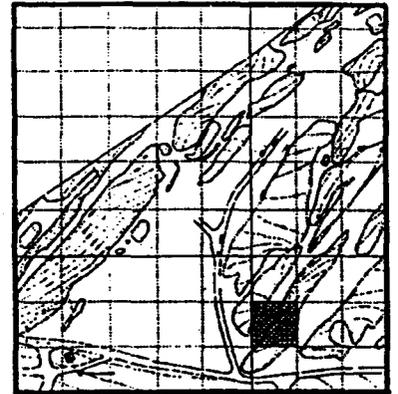
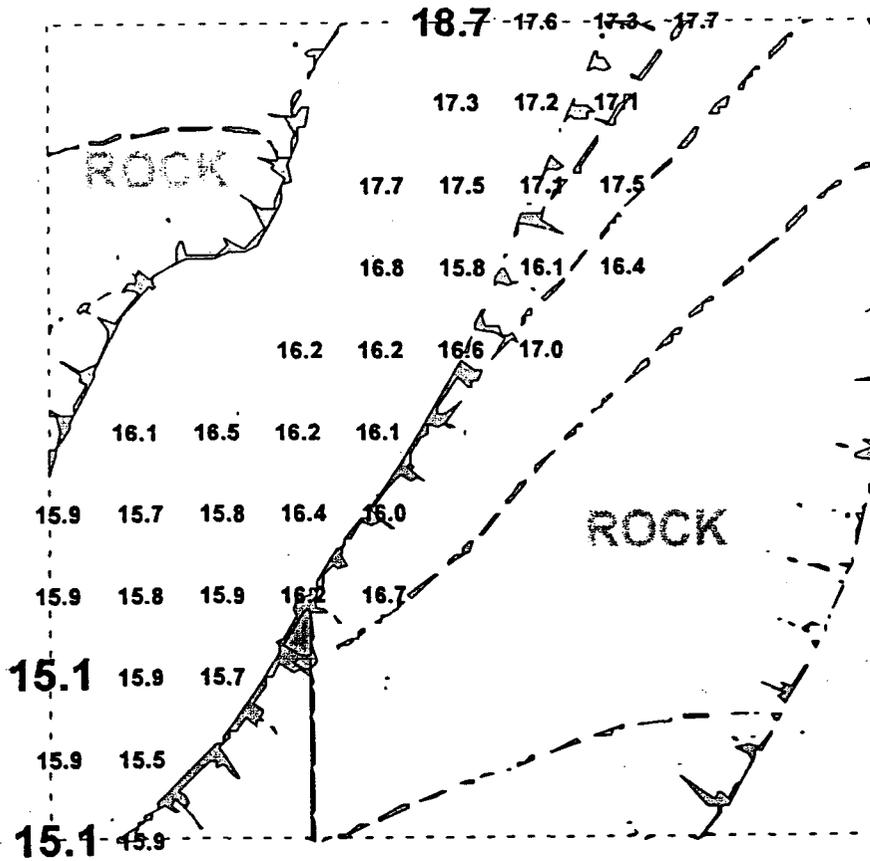
**Grid #47**  
**S100ft - 200ft**  
**W100ft - 0ft**



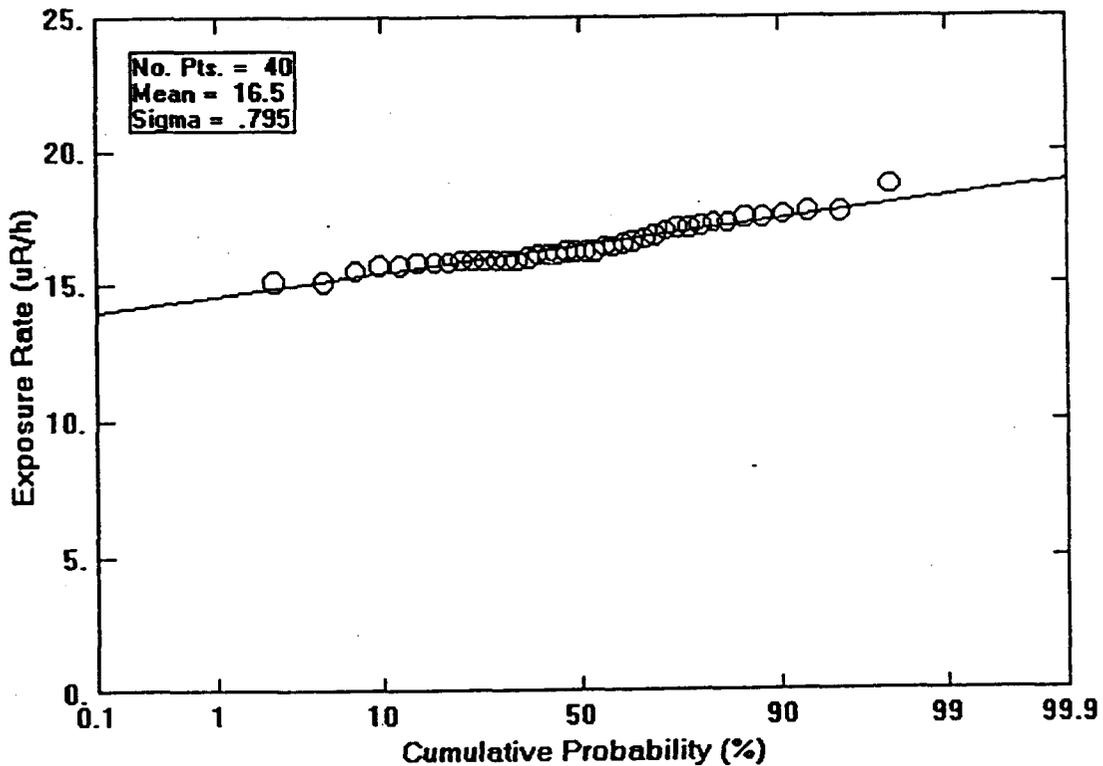
C:\B886\S2W1.CMP

11-28-94

Figure 47. Grid #47 Ambient Gamma Exposure Rate.



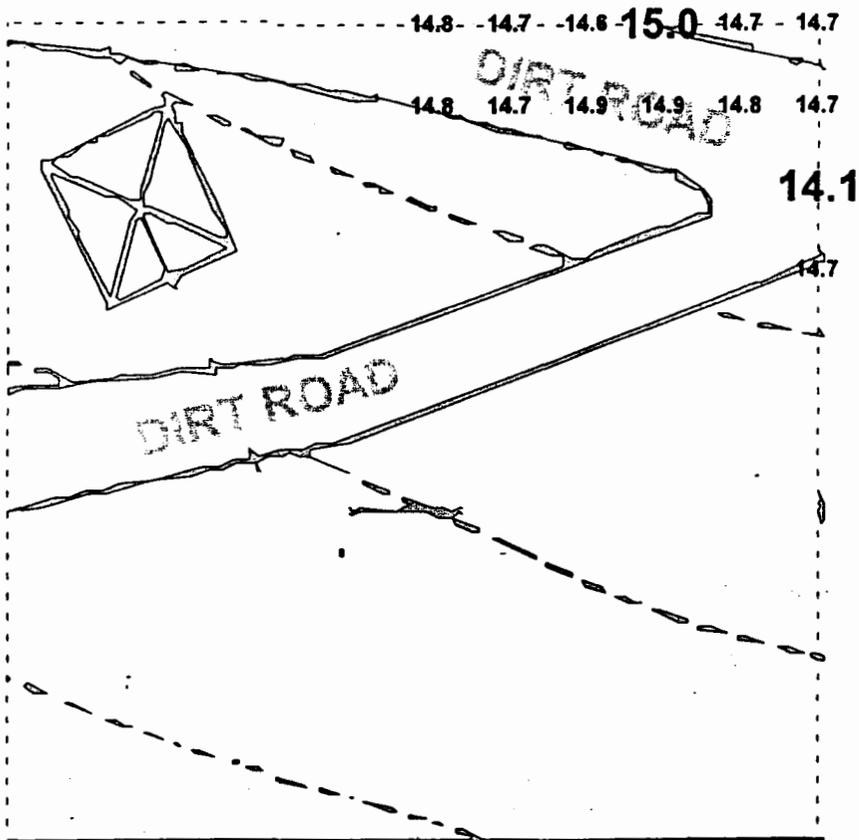
**Grid #48**  
 S100ft - 200ft  
 E 0ft - 100ft



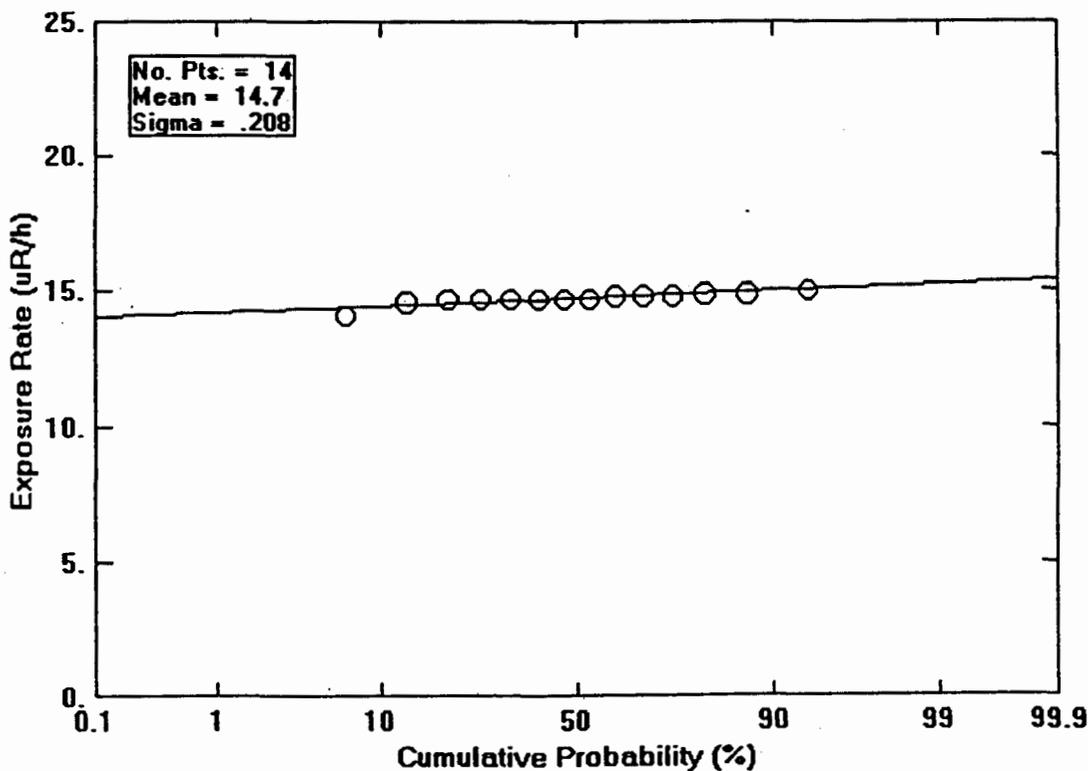
C:\B886\S2E0.CMP

11-28-94

Figure 48. Grid #48 Ambient Gamma Exposure Rate.



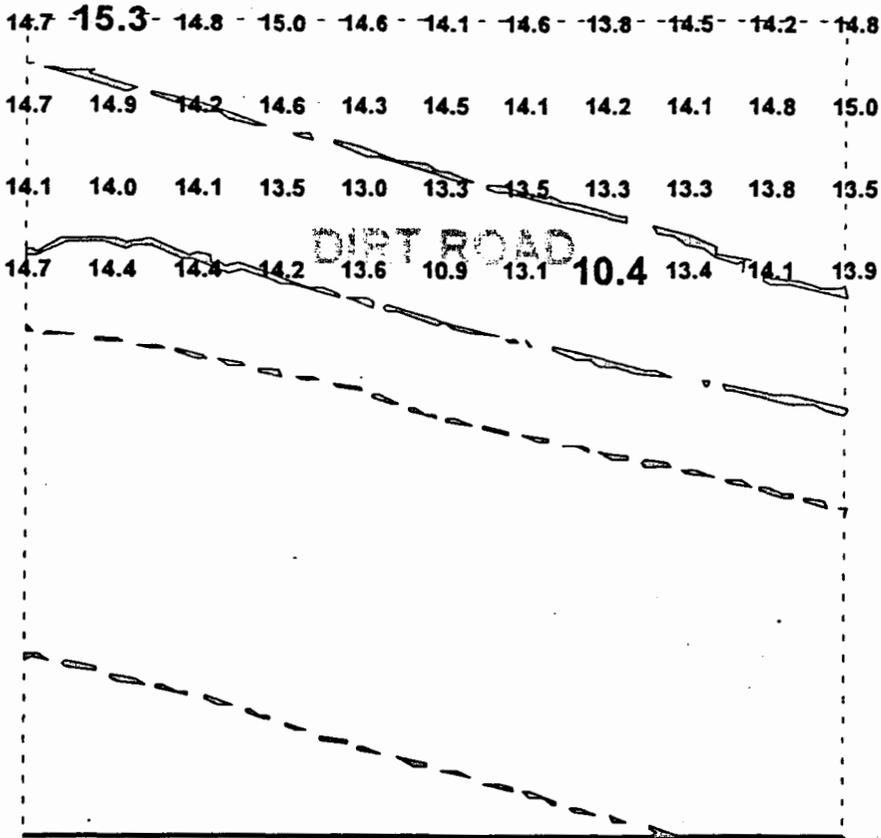
**Grid #52**  
 S200ft - 300ft  
 W400ft - 300ft



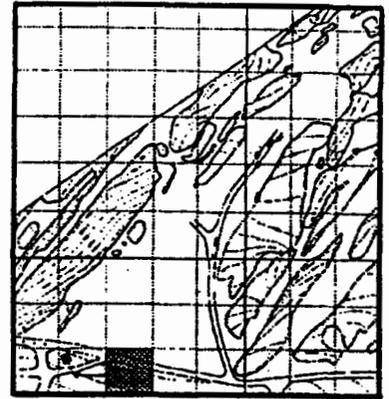
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11-28-94

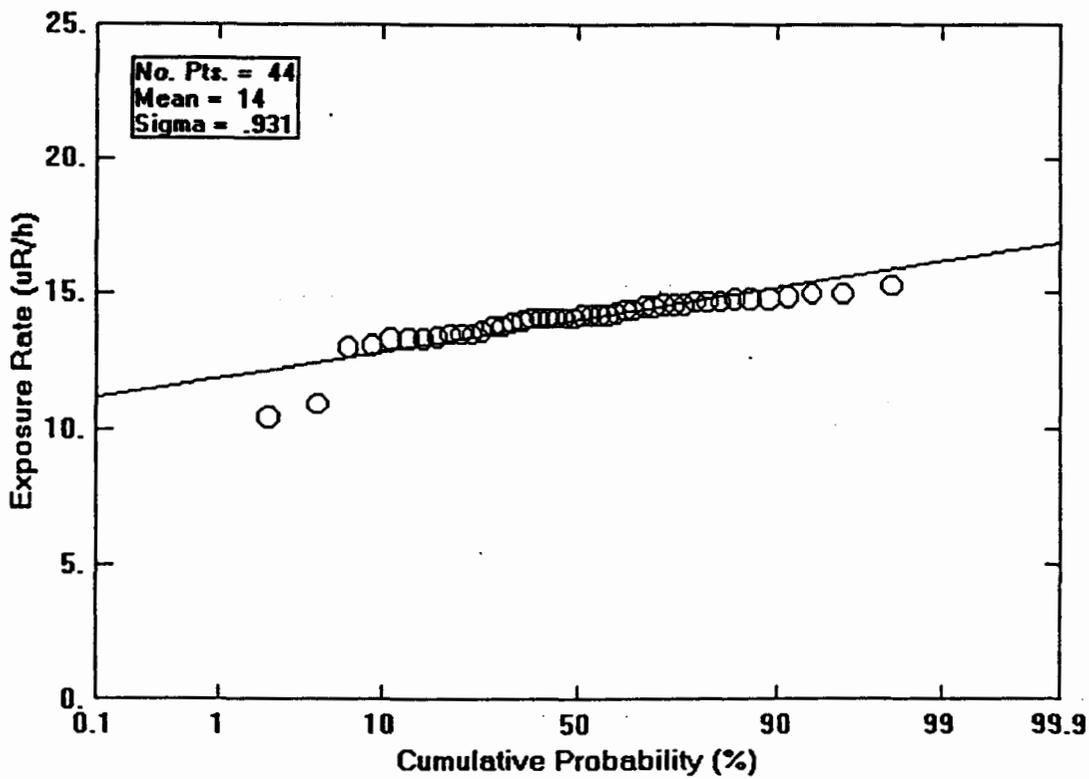
Figure 49. Grid #52 Ambient Gamma Exposure Rate.



886-ZR-0007  
 Page 64  
 12/13/94



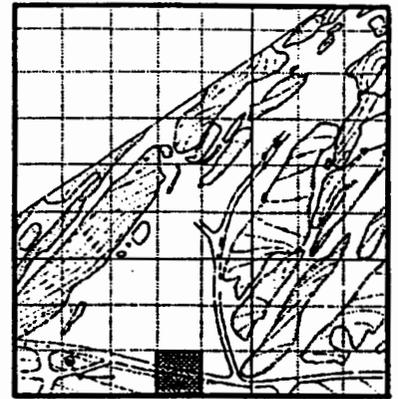
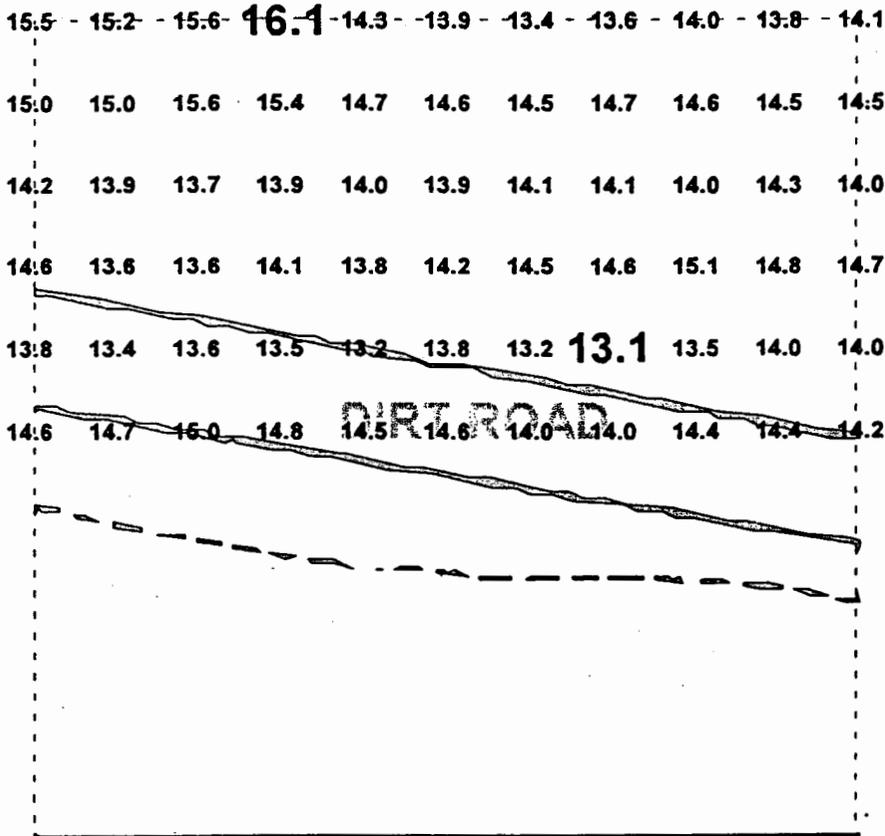
Grid #53  
 S200ft - 300ft  
 W300ft - 200ft



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11-28-94

Figure 50. Grid #53 Ambient Gamma Exposure Rate.



Grid #54  
S200ft - 300ft  
W200ft - 100ft

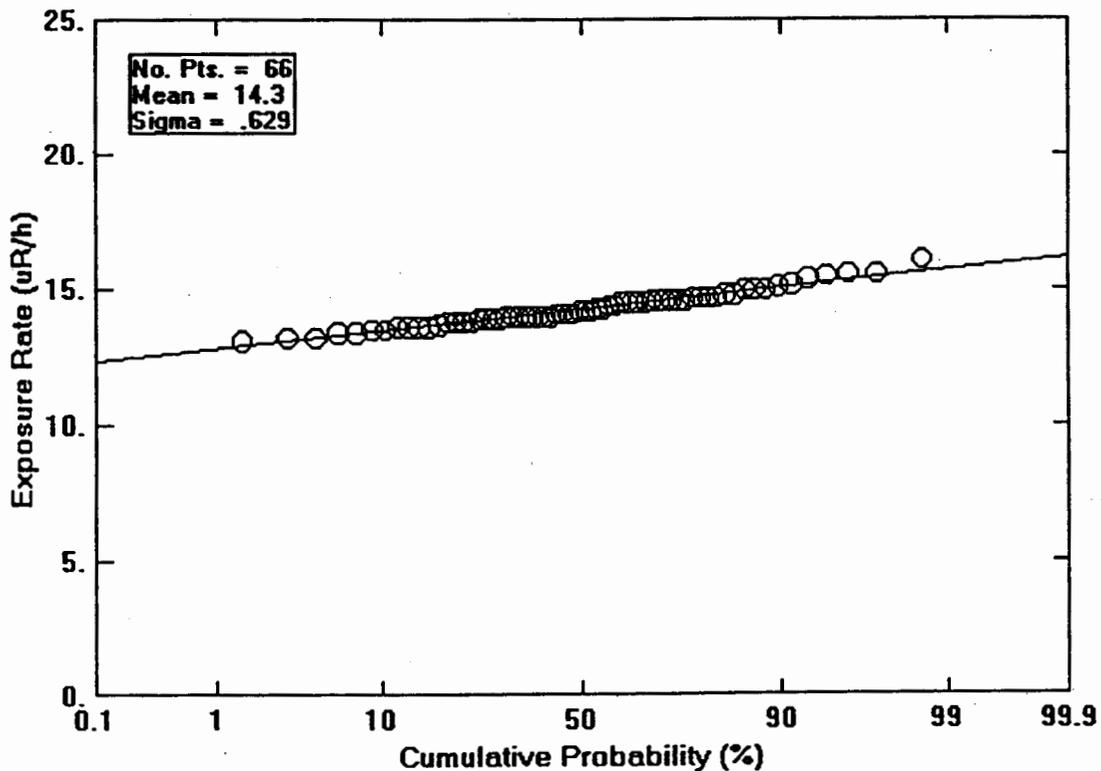
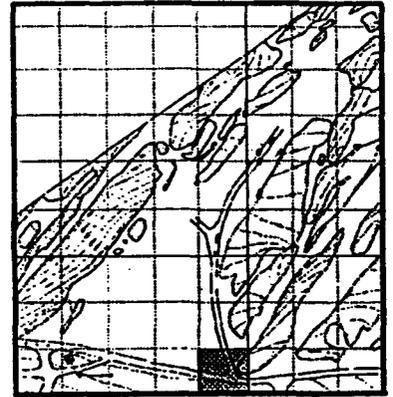
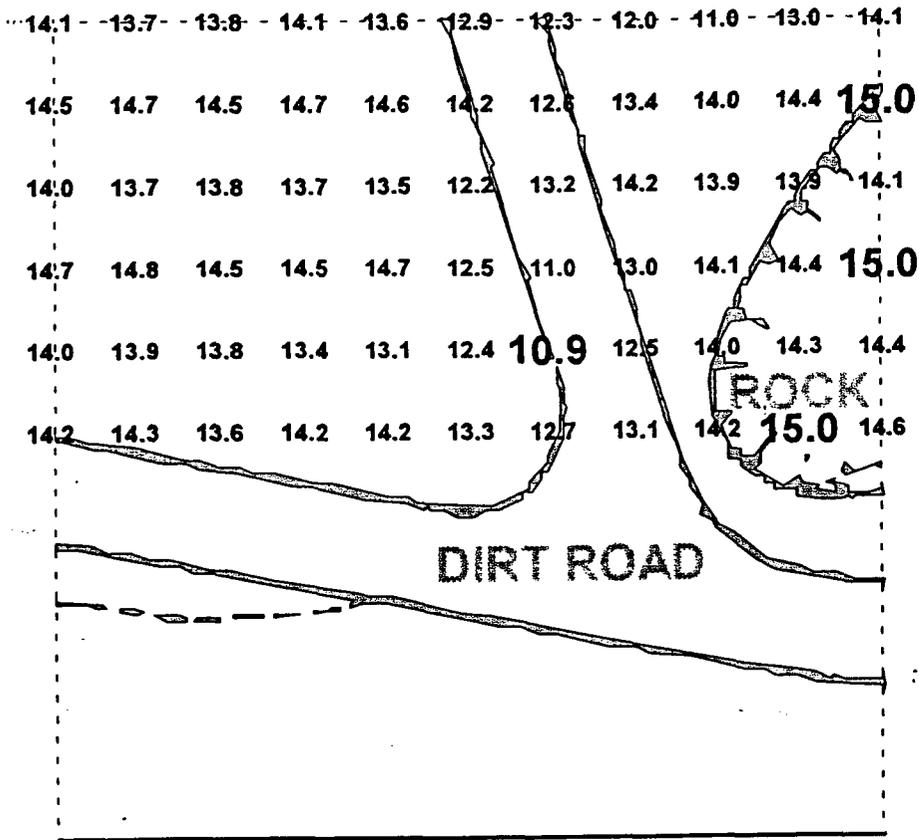
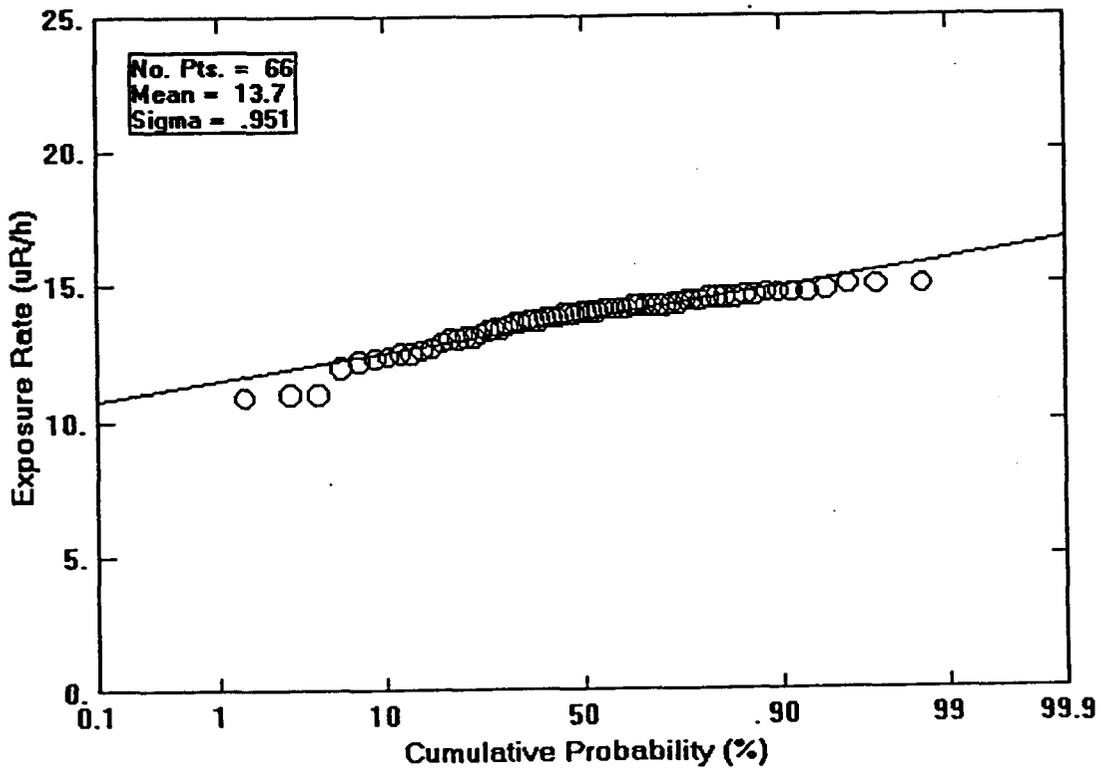


Figure 51. Grid #54 Ambient Gamma Exposure Rate.



Grid #55  
S200ft - 300ft  
W100ft - 0ft



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11-28-94

Figure 52. Grid #55 Ambient Gamma Exposure Rate.

**EXHIBIT VI**

**NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)  
DOCUMENTATION FOR DECONTAMINATION AND  
DECOMMISSIONING OF FACILITY 4886**



Department of Energy  
Energy Technology Engineering Center Project Office  
P.O. Box 1446  
Canoga Park, CA 91304

RECEIVED

FEB 28 1991

DRF0637

25 February 1991

Dr. D. Clark Gibbs  
General Manager  
Energy Technology Engineering Center  
Rockwell International  
P.O. Box 1449  
Canoga Park, CA 91304

Subj: Transmittal of Sodium Disposal Facility Assessment NEPA Determination

Dear Dr. Gibbs:

A copy of the NEPA determination (categorical exclusion) for assessment of the Sodium Disposal Facility's contamination is attached. This constitutes approval for the project relative to environmental considerations.

A handwritten signature in cursive script, appearing to read "Robert LeChevalier".

Robert LeChevalier  
Acting Site Manager,  
Energy Technology Engineering Center

cc:  
J. Semko, NE-47

CATEGORICAL EXCLUSION (CX) DETERMINATION

Proposed Action: Assessment of Sodium Disposal Facility Contamination

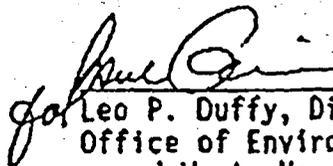
Location: Santa Susana Field Laboratory, Ventura County, California

Description Of Proposed Action: Assessment and characterization of soil contamination from a possible release at the Sodium Disposal Facility according to the requirements of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Activities will include soil boring, sampling, and analyses, a detailed radiological survey, and a geophysical survey. The total land area involved is approximately 4 acres.

Categorical Exclusion (CX) To Be Applied: (Section D, Department of Energy (DOE) National Environmental Policy Act (NEPA) Guidelines): CX as identified in Federal Register Volume 55, Number 174, dated September 7, 1990, for "3. Site characterization and environmental monitoring . . . under CERCLA or Resource Conservation Recovery Act (RCRA) . . . Activities covered include but are not limited to: . . . h. Sampling and characterization of water, rocks, soils and contaminants." The assessment activities will not introduce or spread hazardous substances and will not affect environmentally sensitive areas. Samples will be handled and disposed of in accordance with DOE and EPA requirements.

I have determined that the proposed action meets the requirements for the CX referenced above. Therefore, I have determined that the proposed action may be categorically excluded from further NEPA review and documentation.

APPROVAL:

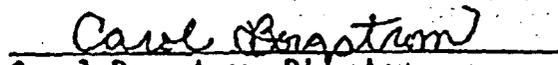


Leo P. Duffy, Director  
Office of Environmental Restoration  
and Waste Management, EM-1

DATE:

12/4/90

CONCURRENCE:

  
Carol Borgstrom, Director  
Office of NEPA Oversight

DATE:

12/18/90



Department of Energy  
San Francisco Field Office  
1333 Broadway  
Oakland, California 94612

RECEIVED

MAR 09 1992

DRF 0390

March 5, 1992

TO: G.G. Gaylord, ETEC

RE: NEPA Approval for Sodium Disposal Facility Remediation

This memo is to confirm that it is my understanding that EM-1 has approved the Categorical Exclusion for the Sodium Disposal Facility Remediation Project, and the proscribed time for EH comments has been made available. I will provide a copy of the approval to the site as soon as possible.

This memo authorizes you to proceed with the project.

A handwritten signature in cursive script, appearing to read "Roger H. Liddle".

Roger H. Liddle  
DOE/SAN/ERWM

CC: Bob LeChevalier, ETEC-SO  
Manny Tessier, ETEC

# Internal Letter



Rockwell International

Date: August 19, 1992

No: 92-021-01-100

TO: (Name, Organization, Internal Address)

FROM: (Name, Organization, Internal Address, Phone)

.. Alex Klein  
.. ETEC  
.. D/026 055-T009

.. L. R. Stone  
.. ETEC  
.. D/021 055-T039  
.. X5497

Subject: NEPA Status: Former B/886 Sodium Burn Pit

Reference 1: 91ETEC-DRF-2192, L. Stone (ETEC) to R. Liddle (DOE), "Sodium Disposal Facility Closure: National Environmental Policy Act (NEPA) Determination," dated September 28, 1991

2: DOE Letter R. H. Liddle (DOE/SAN/ERWM) to G. Gaylord (ETEC), "NEPA Approval for Sodium Disposal Facility Remediation," dated March 5, 1992 (DRF-0390)

A meeting was held on August 10, 1992 between R. Liddle (DOE/SFFO), G. Gaylord and the undersigned for the purpose of reviewing NEPA compliance status with regard to the proposed expanded earth excavation and replacement in the former B/886 Sodium Burn Pit. The NEPA submittal includes the California Regional Water Quality Control Board - Los Angeles Region Clean-Up and Abatement Order No. 91-061 dated April 30, 1991. There-in is the requirement to "...clean-up any soil and/or groundwater contamination..." This requirement provides sufficient latitude to increase the earth removal and replacement from an initial 4,000 Cu. Yards to a current 28,500 Cu. Yards.

It is not necessary to request any addition NEPA compliance reviews from the DOE at this time.

Loren Stone  
ES&H Coordinator  
Energy Technology Engineering Center

Roger Liddle  
Environmental Restoration  
U. S. Department of Energy

LRS:05dg65

cc: R. Le Chevalier, DOE/ETEC  
D. Spencer, DOE/ETEC  
G. Gaylord, 622-T038

M. Tessier, 021-T038  
T. Venable, 453-T039