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THE 1948 RADIOLOGICAL AND BIOLOGICAL SURVEY OF AREAS IN NEW MEXICO AFFECTED BY THE FIRST ATOMIC BOMB DETONATION

PART I

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SPECIFI [redacted] ED

Submitted by: Stafford L. Warren, M.D.
Director

Report Submitted: October 12, 1949
Report Issued: November 17, 1949

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ABSTRACT

The areas in New Mexico affected by the First Atomic Bomb Detonation have been surveyed from both radiological and biological aspects. The remaining radioactivity due to the fall-out has been outlined along a transect extending out northeast of the Crater for the first 100 miles with a detailed survey of the first thirty-two miles. For the most part, all activities outside the Crater are found in the upper two inches of soil. The activity is being spread by wind and water, particularly in the Trinity Region. Water deposits of coarse sand were found to have the greatest activity outside the Fenced Area. A study of soil profiles collected in 1947 and 1948 from the Crater indicate that a portion of the activity in thi area is neutron-induced.

From the radiological assays of 402 small animals collected during the survey it was found that activity, when present, was associated with the digestive tract. No substantial indication of tissue accumulation has been found. No significant differences in activities could be found between 519 samples of tissues from 8 cows from the Chupadera Mesa and 64 comparable samples of tissues purchased in the Los Angeles Area from civilian sources.

Within the fence of the Trinity Region, the activity in the plants exceeded the level of 5.0 dis./sec./gm. of ash. Other regions showing plants with activities above 5.0 dis./sec./gm. of ash include the Chupadera Mesa where the maximum uptake of activity outside the Crater was found and some localities beyond in the direction of the drift. No significant differences in activity could be found in crop plants from contaminated areas when compared to those from uncontaminated areas.

THE 1948 RADIOLOGICAL AND BIOLOGICAL SURVEY OF AREAS IN NEW MEXICO AFFECTED BY THE FIRST ATOMIC BOMB DETONATION

I. INTRODUCTION

THE 1948 RADIOLOGICAL AND BIOLOGICAL SURVEY OF AREAS IN NEW MEXICO AFFECTED BY THE FIRST ATOMIC BOMB DETONATION

I. INTRODUCTION

1.1 Immediately following the detonation of the First Atomic Bomb at Trinity, New Mexico, and during the months following, the Los Alamos Group made a large number of spot checks for radioactivity in the region downwind from point zero and accumulated a considerable quantity of radiochemical data. The extreme pressures of other assignments under war conditions prevented a more systematic study at that time. Many uncertainties remained regarding the precise distribution and amounts of radioactivity still present in the area in successive years, as well as possible effects on plants and animals constantly exposed to low-grade irradiation. Accordingly, in 1947 the Atomic Energy Commission authorized the Atomic Energy Project at the University of California at Los Angeles to conduct a systematic study of the area. The principal initial objective of this "Alamogordo Section" was to estimate the probability that hazards to man exist now or may arise in the future as a result of widespread, low grade radioactivity.

1.2 This over-all objective is broken down into more specific problems.

1. To what extent and degree are the Crater and fall-out areas contaminated by fission products and other radioactive materials?
2. What factors are affecting the distribution, both horizontal and vertical, as well as the fixation of activity in the soil?
3. To what extent are plants picking up radioactive materials and what factors are important in this process?
4. Do animals enter into a metabolic cycle whereby radioactive materials are picked up, either directly from the soil or indirectly through ingestion of plants as food, thus further concentrating the activity and increasing the biological hazard?

1.3 In addition to our principal tasks certain other objectives have been kept in mind.

1. The training of personnel.
2. The collection of data useful to Military and Defense organizations.
3. Repopulation of the devastated part of the Trinity Region.
4. Individual and population response to continuous exposure to low level beta-gamma irradiation.

1.4 The program was carried out by two groups, one in the field and the other in the laboratory as follows:

Laboratory Personnel:

1. Albert W. Bellamy, Chief, Alamogordo Section
2. James L. Leitch, Associate, Metabolic History
3. Kermit H. Larson, Assistant, Soils
4. David B. Dunn, Assistant, Botany
5. W.F. Dunn, Senior Laboratory Technician, Radiochemical Analysis
6. Margaret R. Lewis, Senior Laboratory Technician, Botany
7. Frances Koerner, Laboratory Technician, Metabolic History

Field Personnel: Kermit H. Larson, Field Director

Transect Party:

1. David B. Dunn, Supervisor
2. H. L. Lint, Consultant, Botany
3. D.S. Warren, Consultant, Electronics
4. W. Bixby, Consultant, Surveyor

Group 1:

1. R.B. Cowles, Consultant, Herpetology
2. K.S. Norris, Consultant, Herpetology
3. R.G. Zwiefel, Consultant, Herpetology

Group 2:

1. A.J. Van Rossem, Consultant, Ornithology
2. W.R. Dawson, Consultant, Mammalogy

Group 3:

1. Kermit H. Larson, Field Director
2. J.M. Blume, Consultant, Soils
3. W.F. Dunn, Soils

1.5 The data obtained from both the laboratory and field aspects of the 1948 Radiological and Biological Survey will be reported in subsequent sections of this report as follows:

2. Radiological Survey
3. Biological Survey - Animals
4. Biological Survey - Plants
5. General Discussion and Summary

1.6 All paragraphs in this report are numbered consecutively within each major section to facilitate cross-referencing. In addition, all tables, figures and plates are numbered consecutively for the whole report. It should be noted that the two principal maps of the report, Figures 2 and 3, are filed inside the back cover.

THE 1949 RADIOLOGICAL AND BIOLOGICAL SURVEY OF AREAS IN NEW MEXICO AFFECTED BY THE FIRST ATOMIC BOMB DETONATION

2. RADIOLOGICAL SURVEY

APPROVED FOR PUBLIC RELEASE

INTRODUCTION

2.1 The primary purpose of the 1948 Radiological Survey of the Trinity Area in New Mexico was to define the approximate remaining area of contamination and determine existing levels of remaining radioactivity due to the First Atomic Detonation, July 16, 1945 and subsequent fall-out of fission products and other active materials. Prior to the consideration of the observations and results obtained during this field survey, it is well to review the physical characteristics of the area. For convenience in description this area is divided into five regions, viz., the Trinity Area, the Red and Grey Hills Region, the Oscuro Mountains, the Chupadera Mesa and the Rolling Plains Region. Reference should be made to the following three maps:

Figure 1. Outline Map of Contaminated Area.
Figure 2. General Reconnaissance Map.(1)
Figure 3. Detailed Lateral Radiological Survey Map.(1)

2.2 Topography. The topography ranges from mountains with a maximum elevation of approximately 8000 feet to rolling plains of a minimum elevation of 4800 feet. There are many small basins and valleys surrounded by ridges and eroded hills with many deep arroyos formed by accelerated water erosion. These various features have a direct influence on any extrapolation made regarding the radioactive contamination and its fate. Therefore, each region should be given consideration as an entity.

2.3 The *Trinity Region* is defined as that area extending five miles to the north and east of the detonation site to the base of the Oscuro Mountains. This region is further subdivided into three areas as follows:

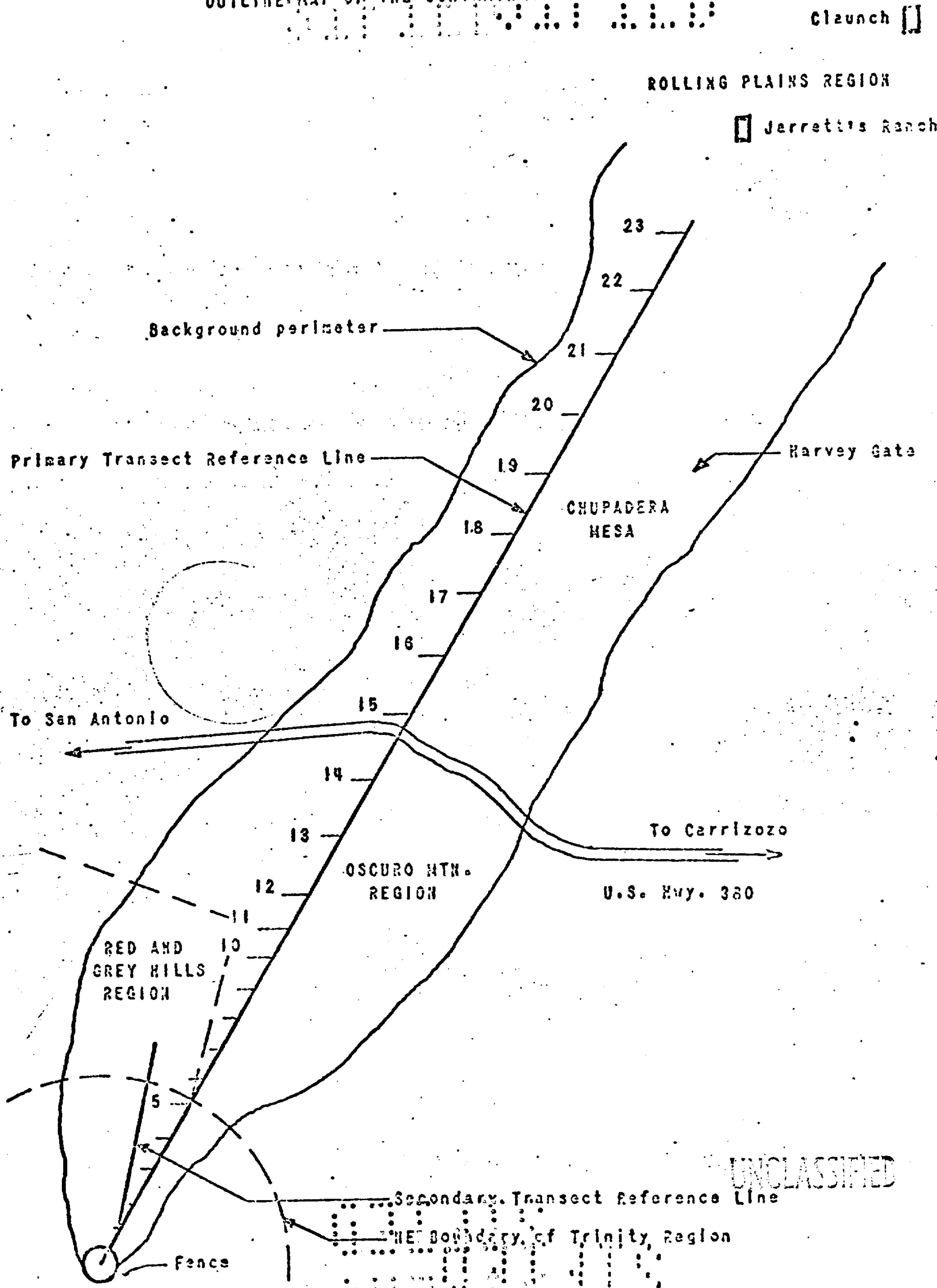
1. The Crater: The depressed area, some 600 feet in diameter, at the site of the detonation.
2. The Fenced Area: A fourteen-sided polygon, approximately 2800 feet in diameter around the Crater.
3. The Unfenced Area.

The average elevation in this region is approximately 5000 feet. The drainage system around the Fenced Area has its beginning at the base of the Oscuros, flows to the west and finally terminates in a playa west of the Fenced Area. Because of this feature the present diverting drainage ditches were constructed to prevent excessive flooding of the Crater. There are three large arroyos, more than ten feet deep and often twenty feet wide, north of the Fenced Area in the Trinity Region, which terminate in the above mentioned playa. Many smaller channels lead into these

(1) FIGURES 2 AND 3 ARE FILED INSIDE THE BACK COVER

Fig. 2

OUTLINE MAP OF THE CONTAMINATED AREA



[redacted]

principal arroyos, all contributing to the factor of water erosion of the general terrain. No important outcrops or elevations occur in this region. The general slope is to the west and southwest direction.

2.4 The Red and Grey Hills Region *(Figure 4)* is defined as that series of low hills beginning about 5.5 miles north of the Crater, extending approximately six miles in the northerly direction. The maximum elevation is approximately 6300 feet.

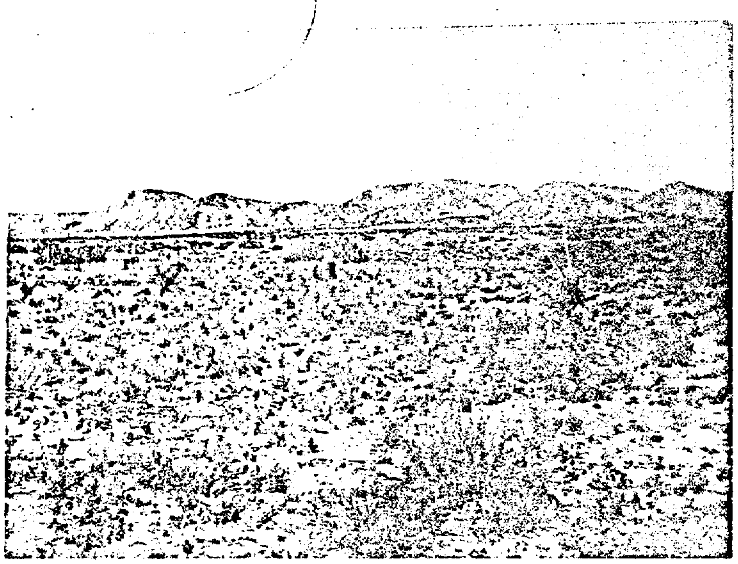


Figure 4
The Red and Grey Hills from the southeast

2.5 The northern half of the Oscuro Mountain Range, with a maximum elevation of approximately 7800 feet, is also included in this survey. The northern tip of the Oscuros is of the same composition and formation as the Red Hills. A principal drainage system, a network of arroyos, has been formed beginning on the east side of the northern tip of the Oscuros and flowing north. Because of the influence of the Chupadera Mesa this drainage system is finally forced to the west with the principal drainage channel cutting across the "flats" to the north of the Grey Hills and terminating west of the present Bursum Ranch Headquarters *(formerly the Hansomberg Ranch)*. The principal channel is over ten feet deep and twenty-five feet wide in many places. The alluvial deposits in this region are deep red in color. The vegetation is composed primarily of grasses.

2.6 The Chupadera Mesa is defined as that abrupt elevated limestone formation, beginning approximately four miles northeast of the northern

[redacted]

tip of the Oscuros, extending approximately twenty miles northeast into the Cibola National Forest. The elevation varies considerably with a maximum of approximately 7000 feet. Many of the hills within the mesa are very steep. The vegetation is characterized by juniper and pinyon pine covered hills and open grassy meadows. This is the principal grazing range of the locality.

2.7 Beyond the mesa is the *Rolling Plains Region* which extends beyond Vaughn and for approximately 100 miles northeast of the Crater. There are some outcrops of mesa-like formations throughout. The vegetation on the plains is very sparse, grasses for the most part. However, on the mesa-like formations, there are well defined areas of juniper and mesquite, depending on the soil. There are several small areas of cultivated crops in this region. North of Cedarvale there are some cultivated crops, principally corn, millet and oats. West, north and east of Claunch is another area of cultivation - the crops being oats, millet, beans and corn.

2.8 Soils of the Surveyed Area. Since the soil is the reservoir of the remaining contaminants, including plutonium, it will be helpful to review certain of the factors that affect soil characteristics as they now exist. It should be pointed out that any conclusions drawn from this survey will not necessarily apply in unmodified form to other regions where any one or all of the soil-forming factors differ from this area.

2.9 Soil is an end-product of five general soil-forming factors, namely: the combined actions of climate and organic matter on the parent material *(fragmented and partly or wholly weathered rocks and minerals)* as influenced by the topography and time. These factors are interdependent, each modifying the other. In the Yearbook of Agriculture, "Soil and Men" this summary is given regarding the inter-reactions of the various soil-forming factors, 'The character of the relief influences, through drainage and runoff, the effects of rainfall and time. The character of the parent material modifies the effects of rainfall and relief of a given area. The character of the vegetation is, in part, determined by temperature and rainfall and in turn modifies the effects of these, particularly of rainfall." (1) These soil-forming factors will be considered briefly in subsequent paragraphs with the exception of topography which has already been discussed *(paragraphs 2.2 through 2.7)* and time which does not require amplification.

(1) "Soil and Men." Yearbook of Agriculture, 1938, p. 949. U.S. Department of Agriculture, Washington, D.C.

2.10 Geology. Geologically, the area may be considered as consisting of three major types of terrain: (1) the western side and northern part of the Oscuro Mountains, (2) the northeastern tip of the Jornado del Muerto Basin and (3) the southern part of the Chupadera Mesa. *(See Detailed Lateral Radiological Survey Map, Figure 3, (inside cover) for exact location.)*

2.11 The older rocks of this area are masses of schist, gneiss and granite and may be considered a crystalline complex of the pre-Cambrian age. This complex is overlain by rock formations, called the Magdelena Group, *(of the Pennsylvanian age)* composed of limestone, sandstone and shale[1]. The Oscuro Mountains are included in this grouping with the crystalline complex being the west face of the outcrop. The schists are of igneous and sedimentary origin with large thicknesses of quartzite. These metamorphic rocks are intruded by igneous rocks, chiefly granite and granodiorite. Throughout the subsequent geological history, these rocks have been resistant to erosion and have formed highlands. From these resistant rocks smaller rocks and pebbles have been formed and are included in the more recent rocks. Today it is possible to find the older rocks in all stream beds and alluvial deposits of the area.

2.12 A sea invaded the area from the south during the early Paleozoic age. In this sea the early Palezoic rocks were laid down overlying the pre-Cambrian complex. The deposits in this sea were mostly limestone and shale. The Oscuro Mountains are the outcrops of these deposits, due to the uplifting and erosion that took place during the Upper Cambrian to the Upper Devonian periods. Finally, during the Permian age, the Permian rocks were formed consisting of the Abo sandstone and the complex called the Chupadera formation. The Abo sandstone is red sandstone and sandy shale. There are two such localities in the area surveyed, one on the northern and northeastern slope of the Oscuro Mountains while the other location referred to as "Red Hills" in this report is approximately five miles west of the northern peak of the Oscuros. These Red Hills are flanked on both sides by the "Grey Hills," which are of the Chupadera formation.

2.13 The Chupadera formation is composed of a complex consisting of limestone, gypsum and grey and red sandstones, varying in character from place to place. Its thickness in the surveyed area varies from less than 500 feet to perhaps over 1500 feet.[2] The mesa is a part of this formation.

(1) THE RIO GRANDE JOINT INVESTIGATION IN THE UPPER RIO GRANDE BASIN. PART IV - REGIONAL PLANNING VOL. 1. P. 201. 1938. NATIONAL RESOURCES COMMITTEE, WASHINGTON, D.C.

(2) THE RIO GRANDE JOINT INVESTIGATION IN THE UPPER RIO GRANDE BASIN. PART IV - REGIONAL PLANNING VOL. 1. P. 202. 1938. NATIONAL RESOURCES COMMITTEE, WASHINGTON, D.C.

[redacted]

The northern tip of the Jornada del Muerto Basin was part of the basin of the receding sea which invaded the area. Its present characteristics are the result of erosion and deposits from the Oscuro Mountains and the Red and Grey Hills during the Pleistocene and recent periods. Because of this the Basin is now highly calcareous and saline approaching what is commonly called "salt or alkali flats."

2.14 From this brief resume of the geologic characteristics of the area surveyed, it becomes evident that there are considerable differences in the composition of the basic or parent material from which the present soils of the fall-out area are being derived. In all the alluvial soil studied in the area, there has been considerable and varied degrees of mixing of the igneous and sedimentary weathered rocks from place to place.

2.15 Climate. In the Trinity Region, the climate is classified as Hot-Arid. The rainfall varies from year to year from an estimated 6 to 10 inches, mostly as gentle winter rains or snow and torrential midsummer thunderstorms. The summers are long and hot with the winters being short and sunny. Illustrative of this point are the climatic data given in the Yearbook of Agriculture, "Climate and Man" (1) for San Marcial (approximately thirty miles west of Trinity); Bingham, Claunch, Gran Quivira National Monument, which are all within the fall-out area; and the Jornada Experimental Range and Socorro. (2) The selected data are presented in Table I.

Table I
Weather Summary of Principal Stations
In and Near the Trinity Region

Station	Date	Elevation	Mean Temp.	Highest Temp.	Lowest Temp.	Precipitation	Greatest precipitation in 24 hrs.or mo.
Bingham	Aug.'47	5750'	74.9°	97°	57°	3.97"	1.10"
	Mean'47		---	100°	-1°	7.05"	Aug.
	Aug.'48		75.3°	---	54°	2.53"	0.95"
Claunch	Aug.'47	6400'	---	---	---	4.13"	1.30"
	Mean'47		---	---	---	8.83"	Aug.
	Aug.'48		---	---	---	1.51"	0.37"
Gran Quivira	Aug.'47	6620'	69.4°	92°	50°	4.76"	1.53"
Nat'l. Mon.	Mean'47		52.1°	97°	-6°	10.73"	Aug.
	Aug.'48		70.3°	91°	48	2.01"	1.26"

(1) "CLIMATE AND MAN." YEARBOOK OF AGRICULTURE, 1941, P. 1015. U.S. DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

(2) CLIMATALOGICAL DATA, SUMMARY 1947, NEW MEXICO SECTION, P. 99, VOL. LI, NO. 13, 1947. U.S. DEPARTMENT OF COMMERCE, WEATHER BUREAU WASHINGTON, D.C.

[redacted]

Table I (Cont'd.)
Weather Summary of Principal Stations
In and Near the Trinity Region

Station	Date	Elevation	Mean Temp.	Highest Temp.	Lowest Temp.	Precipitation	Greatest precipitation in 24 hrs. or mo.
Jornada	Aug.'47	4265'	77.9°	102°	60°	2.69"	0.72"
Exp'l Range	Mean'47		58.7°	104°	3°	7.06"	Aug.
	Aug.'48		79.2	---	---	---	---
San Marcial	40 year Mean	---	58.1°	113°	9°	8.31"	1.61" Jul.
Socorro	Aug.'47	4618	77.5°	100°	57°	2.67"	0.99"
	Aug.'48		78.5°	98°	49°	0.84"	0.21"

2.16 During the periods of survey of August, 1947 and the three months of the 1948 survey, only one "flash flood" was observed across the Crater. *(Noted in the Preliminary Report, 1947.)* However, rains did occur which filled the arroyos during both the surveys of 1947 and 1948. In all observations the runoff carried large amounts of red clay and sand. This means changes are occurring continually in this area due to water erosion and redeposition of clay, sand and particles of similar dimensions deposited by the bomb explosion and subsequent fall-out of fission products and plutonium.

2.17 Temperature has a direct bearing in the amount of rainfall which is available for leaching and percolation in soils. In this area the factor of evaporation exceeds precipitation. In Table II, it is seen that evaporation at the Jornada Experimental Range Weather Station, south of Trinity in the Jornada del Muerto Basin, far exceeds the rainfall.

Table II
Total Precipitation, Evaporation and Mean Temperature
Per Month for Jornada Experimental Range - 1947

Month	Total Precipitation Inches	Total Evaporation* Inches	Mean Temperature °F
January	0.74	2.335	36.7
February	0.05	4.392	43.7
March	0.36	7.096	50.2
April	0.00	11.352	57.6
May	0.33	12.977	68.6
June	0.51	15.131	74.8
July	0.87	15.407	80.6
August	2.69	10.523	77.9
September	0.00	9.300	72.0
October	0.16	7.712	61.4
November	0.80	3.291	44.4
December	0.55	1.919	37.0
Annual	7.06	103.32	46.9

* As measured by open pans under the prevailing climatic conditions.

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Further evidence for this excessive evaporation is obtained from the Soil Profile Studies *(see paragraphs 2.45, 50, 54)* in which there is no indication of downward leaching and therefore, no accumulation of soluble salts of radioactivity in the lower regions of a typical soil profile during the recent period. In addition, lime concretions are found near the surface, as well as in the lower region of the profiles examined. Salt accumulation may be observed in several locations on the surface of the soils, particularly so if no erosion has taken place. The variations in lime content are, in part, associated with the heterogenity of the parent material.

2.18 Hydrolysis, carbonization and other common processes of chemical weathering are very rapid in warm, humid regions, while in this very dry, hot area, dehydration is the most prominent process, thus, hydrolysis, hydration and carbonization proceed at a very slow rate. Thus, the normal processes of chemical weathering of soil and fission materials are slower in this area than they might be expected to be in more humid climates.

2.19 Wind erosion is an important factor in the desert. Winds pick up fine particles of soil and transport them from areas that are barren or have scant vegetation to nearby areas where vegetation is more dense, thus holding the particles of soil in place. There is evidence of such wind erosion in the Trinity Area, as observed in the area of mesquite holding large dunes a short distance west of Bingham. Wind-blown dust from the Crater was collected from a guard shack about 100 feet west of the crater fence. The radioactivity of this dust is the greatest found in any sample of such particle size collected outside the fence in 1948. *(See paragraph 2.40)*.

2.20 Organic Matter. Some desert soils contain only a small fraction of one per cent of organic matter. A primary source of organic matter is decaying vegetation and modifies the color of practically all soils. Desert vegetation is usually scanty and contributes little organic matter to the soil. Examination reveals that there is little or no evidence of any organic accumulation in the soil profiles made. A discussion of the vegetation of the fall-out area will be found in the Plant Section of this report.

2.21 The above summary gives a brief description of the area still contaminated from the first atomic bomb explosion. The various general soil-forming factors have been indicated, namely: the several important features of the physical terrain or topography, geological or parent material, climate *(including temperature, evaporation and rainfall)*, and organic matter. All these factors may have had important effects on the existing contamination through such phenomena as (1) redistribution of activity due to wind and water erosion, (2) the original deposition of fission products and plutonium particles during the fall-out, (3) fixation of fission products

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and their subsequent release to vegetation and (4) the rate of migration and/or diffusion of the fission products in the soil particle-soil solution relationships.

EXPERIMENTAL PROCEDURES

2.22 Survey Instruments and Procedures. In both the General Reconnaissance Survey and the Detailed Lateral Survey, all measurements were made with the Victoreen Survey Meter, Model 263A. All readings were taken with the G.M. tube held in the operator's hand, approximately one inch above the soil surface or other sources of radiation as illustrated in Figure 5. The instruments were calibrated by the operators before starting the survey, as well as at the end of the survey, using a Standard 1.09 mg. Radium Source. The initial calibration was also an indoctrination for operators. In the field Navy Radium Door Marker Buttons mounted on standard tube holders were provided each operator for instrument sensitivity checks. These sensitivity checks were made on each of the three ranges: x0.2, x2.0 and x20.0 on the survey meter at the beginning and end of each day's operation. The total radiation (beta and gamma) as measured by the several instruments is expressed in milliroentgens per hour (mr./hr.).

A

Figure 5

Technique of Measurement

A - Illustrates method of obtaining the reading in a grass tuft.

[redacted]

B
Figure 5
Technique of Measurement

B - A side view of obtaining a reading on a grass tuft.

2.23 Survey Instrument Background. The instrument background was determined as frequently as necessary to assure the operator that the probe was not contaminated. Background readings were taken with the tube shield closed. The instrument background in New Mexico was approximately twice that observed in Los Angeles, due primarily to the increase in cosmic radiation with elevation.

2.24 Soil Background. Soil background was taken to be twice the observed instrument background reading, a reading which was arbitrarily selected as the most practical point at which to terminate the radiological survey of each lateral. Some of the reasons for this selection were: the variations in the sensitivity in the instruments, differences in the operator's estimation and judgment of the dial readings in obtaining a background reading and the differences between instruments due to the effect of temperature.

2.25 General Reconnaissance Survey. As a practical approach to surveying the estimated area of contamination a general reconnaissance was made followed by a detailed survey of the more significant regions. For the general reconnaissance, two groups of two individuals each were assigned the general survey. Group one covered the area north and east of Socorro, using Highways 85 and 60 with Vaughn as the eastern terminus. Group two

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covered the area from Socorro to Carrizozo along Highway 380, north to Vaughn and back to Bingham. Readings were taken at least every mile, particularly in the more contaminated areas. All readings obtained on this general survey are recorded on the General Reconnaissance Map, Figure 2, *(inside back cover)*.

2.26 Detailed Lateral Survey. The first thirty-two miles of the fall-out were surved in detail. A Primary Transect Reference Line was established 34° 56' east of north by a licensed civil engineer, Mr. William Bixby. This line started at the Section Marker [1] within the crater fence, extending through the North Oscuro Peak Triangulation Point into the Cibola National Forest. Other triangulation points used were the Little Burro Point *(approximately ten miles south of the Crater)* and the Bursum Point *(approximately 9.5 miles north of the Crater)*. At every 4930 feet, reference points were marked for the first eleven points. From Point 12, the reference points were marked every 9000 feet. From this Primary Transect Reference Line, laterals were extended 90° right and left with a minimum of three readings *(mr./hr., total beta and gamma radiation)* being taken at least every 0.2 mile whenever possible. These readings were taken on at least three of the following: coarse sand water deposits, silt deposits, grass tufts, under junipers and on normal soil. It should be pointed out, however, that some arroyos and washouts prevented a routine reading at every 0.2 mile. In these cases detours were necessary and on the line distances were estimated. In the cases of Laterals 9 right, 10 right and 12 right, the available trails back of the escarpment were used, thereby affording a reasonable and practical estimate of the background contour. Refer to Figure 3, Detailed Lateral Radiological Survey Map *(inside back cover)*.

2.27 After a preliminary map of the detailed survey had been prepared in the field, it was decided that a Secondary Transect Reference Line should be established through the more active area just north of the Fenced Area. The Secondary Transect Reference Line *(see Figure 1)* was started at Lateral Reference Point 1 and extended 13° east of north for a distance of 6.5 miles.

2.28 Counting Equipment. The equipment used for the radiological assay of all samples was as follows:

1. Scalers:
   a. Potter Decade Scaling Unit, A.E.C. Model CGM-14A. A/N Modification.

(1) $25 \left| \frac{30}{31} \right.$ TOWNSHIP 7, SOUTH BETWEEN RANGES 4 EAST AND 5 EAST, AS SURVEYED BY THE U.S. GENERAL LAND OFFICE SURVEY, 1936.

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[redacted]

b. I.D.L. G.M. Proportional Scalers, A.E.C. Models CGP-1A and CGP-7A.

2. Lead Shield: A.E.C. Catalogue No. A1-14A.

3. Tube: Victoreen, Model VG-10 with 2-3 mg./cm.^{2} window.

4. Standard: U_3O_8 with a decay rate of 251.5 dis./sec.

2.29 General Counting Procedure. Since several thousand samples had to be assayed for radioactivity as rapidly as possible, all samples were screened in the project laboratory by counting for 500 seconds or for 1000 counts, whichever occurred first. Modifications of this screening procedure were employed as determined by the importance of the materials being analyzed. Such modifications are reported in subsequent paragrphs of this report. At all times the effective geometry of the counting systems was determined using the uranium oxide beta standard which was prepared in a dish identical with those used for sample assay. All results are reported in terms of disintegrations per second per gram (dis./sec./gm.). Self-absorption data were determined on representative samples of soils so that activity data could be corrected to zero-mass.

2.30 Counting Procedures for Soil Samples. In soil chemistry, it is well known that the soil particle of clay dimension is a principal source of the mineral nutrition of plants. This fact is based, in part, on the phenomenon of base exchange with the clay particles serving as the anions. Cations which exist in the water phase associated with the soil *(soil solution)* may be attracted to so-called "exchange spots" on the clay. Substitutions by other cations are common and these reactions are called exchange reactions. This is due to the characteristic properties of the clay; its crystalline structure and unbalanced valence bonds. It is, therefore, conceivable that if any fission products were or are soluble, an exchange between the ions originally fixed on the clay and the fission products could take place.

2.31 With this in mind it was necessary to develop a method for determining the amount of radioactivity associated with or on the soil particle. Preliminary work indicated that one gram replicates of the total sample material collected gave unreliable results due to the particles identified as trinitite. Observed counting rates of ten 1.000 gram replicates from a total sample varied from 0.1 counts per second per gram *(c./s./gm.)*, to 21.0 c./s./gm. To illustrate the effect of trinitite, one sample originally assayed 78.0 c./s./gm. but by removing three particles thought to be trinitite, it then assayed 0.4 c./s./gm. The use of the radioautograph technique on two other fractionated soils *(250-150 microns)* indicated that some activity is associated with individual particles rather than being uniformly distributed. In comparing the results of fractionation with respect to radioactivity, the particle size of 230 microns and less was the most consistent.

[redacted]

[redacted]

The maximum percentage of soil from a typical field sample was also obtained using this fraction. Therefore, all assays of samples collected outside the crater fence were made on the particle size fraction of 250 microns and less.

2.32 The following is the procedure used for preparation and assaying of surface and profile samples outside the Fenced Area.

(1) The total field sample was dried at 110° C for 16 hours and fractionated into two parts: greater than, and less than 250 microns by suitable screening.

(2) Three 1.000-gram samples were weighed out from the less than 250-micron fraction and the beta and gamma activity determined for 1000 counts or 500 seconds, whichever occurred first.

2.33 The following modifications were made in the above procedure for samples collected in the Fenced Area.

(1) The entire dried-field sample was fractionated into four particle-size ranges: 150 microns and less, 150-250 microns, 250-840 microns and greater than 840 microns.

(2) Three 1.000-gram samples were prepared from each of the three smaller particle-size ranges.

2:34 Determination of Soil Background Activity. In order to determine more accurately the extent of radiocontamination due to fall-out in the Trinity soils sampled, it became necessary to determine the amount of naturally-occurring radioactivity in soils. Since there is no available record of this work having been done before the bomb detonation, it is only possible to approximate the value of natural radioactivity of the area. This was done by collecting similar soils from different areas known not to have been contaminated by fall-out. Eighteen samples of soil were collected from the Los Angeles area - from San Dimas to Thousand Palms. The disintegration rate varied from 0.45 dis./sec./gm. to 1.27 dis./sec./gm. Eight samples were collected from east of Las Cruces, New Mexico. These samples varied from a minimum of 0.32 dis./sec./gm. to a maximum of 1.28 dis./sec./gm. Eleven samples were collected from the area around Deming, New Mexico which varied from 0.5 dis./sec./gm. to 1.17 dis./sec./gm. Forty-four other samples were collected for these background studies from various other locations in New Mexico.

2.35 These soil samples were processed in the same manner as those from outside the Fenced Area, with the exception that only one 1.000-gram counting sample was prepared and counted for one hour. The average of the 81 "background" soils thus far assayed is 0.71 dis./sec./gm. This average value was deducted from all results obtained in an effort to determine the radioactive contamination due to fall-out.

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2.36 Extent of Contamination. The total area surveyed by the Reconnaissance and Detailed Survey Methods is estimated as 1130 square miles. The area of the Detailed Lateral Survey, which includes the first thirty-two miles northeast of the Crater, has been arbitrarily divided on the basis of activity levels into four areas as given in Table III. This grouping of activities is summarized as contours with the appropriate area in color on a grid map, scale 1 inch = 1 mile, as Figure 3, see Detailed Radiological Survey Map *(filed inside back cover)*. The remaining 845 square miles in which activity readings of less than 0.1 mr./hr. were obtained are recorded in Figure 2, the General Reconnaissance Map, scale 0.5 inch = 1 mile *(filed inside back cover)*. It is emphasized that this area represents the remaining activities in the path of the initial maximum fall-out.

Table III

Extent and Degree of Activity found by the Detailed Lateral Radiological Survey

Total Beta and Gamma Activity mr./hr.	Square Miles
Bkg. - 0.3	241
0.3 - 0.6	38
0.6 - 0.9	2.1
0.9 - 6.4	3.7

2.37 Confirmatory samples of soils and plants were collected at the terminal points of the laterals where the 263A Survey Meter gave readings twice the normal field background values.

Table IV

Confirmatory Soil Samples Collected at the Terminals of Laterals

Lateral Reference Point	Distance and Direction from Reference Point	Disintegrations Per Second Per Gram Zero-Mass	Beta and Gamma milli-roentgens Per Hour
1	0.8 miles, right	none	Background
2	0.4 " "	0.90	"
3	0.4 " "	none	"
4	1.2 " "	"	"
5	1.8 " "	1.43	"
6	2.4 " "	0.60	"
7	2.8 " "	1.43	"
8	3.8 " "	1.04	"
9	Terrain too difficult to cross		
10	Terrain too difficult to cross		
11	4.4 miles, right	No sample	Background
12	Terrain too difficult to cross		
13	6.9 miles, right	none	Background

[redacted]

[redacted]

Table IV (Cont'd.)

Confirmatory Soil Samples Collected at the Terminals of Laterals

Lateral Reference Point	Distance and Direction from Reference Point	Disintegrations Per Second Per Gram Zero-Mass	Beta and Gamma milli-roentgens Per Hour
14	5.0 miles, right	No sample	Background
15	5.2 " "	none	"
16	5.2 " "	"	"
17	6.4 " "	"	"
18	6.4 " "	"	0.011
19	6.4 " "	"	Background
20	6.5 " "	1.60	"
21	7.2 " "	0.74	0.013
22	6.9 " "	1.72	Background
23	6.6 " "	1.14	0.018
1	1.9 miles, left	none	Background
2	2.9 " "	"	0.016
3	3.5 " "	"	Background
4	3.5 " "	0.51	0.028
5	3.[illegible] " "	4.45	Background
6	5.[illegible] " "	none	0.012
7	4.4 " "	0.67	0.016
8	5.0 " "	0.48	Background
9	5.0 " "	0.67	"
10	6.0 " "	none	0.012
11	6.0 " "	"	Background
12	5.8 " "	"	"
13	5.1 " "	"	0.010
14	3.8 " "	1.55	Background
15	2.7 " "	0.94	0.010
16	3.2 " "	0.46	0.017
17	2.4 " "	0.57	0.020
18	1.4 " "	1.55	Background
19	1.6 " "	0.46	0.010
20	2.4 " "	0.77	Background
21	3.0 " "	0.31	0.009
22	3.6 " "	0.46	Background
23	4.3 " "	3.72	0.013

Table IV summarizes the data obtained on these soil samples expressed as disintegrations per second per gram after deducting the average soil background *(see paragraphs 2.34 and 2.35)* and correcting to zero-mass.

2.38 Activity in the Fenced Area. The Crater and that portion of the Trinity Region *(see paragraph 2.3)* enclosed within the fence was surveyed along the four principal radials in the same manner as in 1947. The resulting readings in mr./hr. are summarized in Table V. No apparent differences in appearance of the trinitite could be observed between 1947 and 1948, although in some instances the gamma activity level for 1948 is slightly lower than that obtained in 1947. Some slight changes in distribution of activity are apparently occurring at the present time.

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Table V

Comparison of the Beta Plus Gamma Activities
In mr./hr., 1948 vs. 1947 in the Fenced Area
Along the Four Principal Transects Established in 1947

Distance to and from Center	All activities Expressed as mr./hr.			
	Beta and Gamma		Gamma	
	1948	1947	1948	1947
T-180-1400'	0.25	0.19	0.046	0.14
T-180-1200'	0.93	0.88	0.048	0.11
T-180-1000'	2.10	3.00	0.13	0.20
T-180- 800'	O.S.*	7.60	1.10	0.58
T-180- 600'	O.S.	O.S.*	1.50	1.70
T-180- 500'	21.8	O.S.	1.60	3.40
T-180- 400'	O.S.	O.S.	2.20	5.20
T-180- 300'	O.S.	O.S.	4.30	7.00
T-180- 225'	14.8	---	5.40	---
T-180- 175'	12.5	---	5.60	---
T-180- 125'	O.S.	---	13.5	---
T-180- 100'	O.S.	O.S.	14.6	10.3
T-180- 75'	O.S.	O.S.	O.S.*	10.3
T-180- 50'	O.S.	O.S.	O.S.	10.5
T-180- 25'	O.S.	O.S.	14.9	O.S.
Center 0'	---	---	15.8	10.5
T- 0- 25'	O.S.	O.S.	17.9	20.1
T- 0- 50'	O.S.	O.S.	O.S.	O.S.
T- 0- 75'	O.S.	O.S.	O.S.	20.1
T- 0- 100'	O.S.	O.S.	O.S.	10.3
T- 0- 125'	O.S.	---	17.9	---
T- 0- 175'	O.S.	---	11.7	---
T- 0- 225'	O.S.	---	7.7	---
T- 0- 300'	O.S.	O.S.	14.6	3.8
T- 0- 400'	13.9	O.S.	2.5	2.6
T- 0- 500'	O.S.	O.S.	1.9	2.6
T- 0- 600'	O.S.	O.S.	1.4	2.2
T- 0- 800'	[illegible].9	---	0.57	---
T- 0-1000'	1.06	4.40	0.15	0.3
T- 0-1200'	1.9	3.00	0.13	0.16
T- 0-1400'	4.2	4.00	0.16	0.4
T-270-1400'	0.[illegible]4	---	0.13	---
T-270-1200'	6.1	5.2	0.24	0.26
T-270-1000'	10.4	10.4	0.65	0.58
T-270- 800'	O.S.*	O.S.*	1.1	1.30
T-270- 600'	O.S.	O.S.	1.5	4.80
T-270- 500'	O.S.	O.S.	2.1	4.00
T-270- 400'	O.S.	O.S.	2.8	5.20
T-270- 300'	O.S.	O.S.	5.0	8.00
T-270- 225'	O.S.	---	9.3	---
T-270- 175'	O.S.	---	14.4	---
T-270- 125'	O.S.	---	13.3	---
T-270- 100'	O.S.	O.S.	O.S.*	O.S.*
T-270- 75'	O.S.	O.S.	O.S.	O.S.
T-270- 50'	O.S.	O.S.	O.S.	O.S.
T-270- 25'	O.S.	O.S.	14.[illegible]	10.6

[redacted]

Table V (cont'd.)

Comparison of the Beta Plus Gamma Activities
In mr./hr., 1948 vs. 1947 in the Fenced Area
Along the Four Principal Transects Established in 1947

Distance to and from Center	All activities Expressed as mr./hr.			
	Beta and Gamma		Gamma	
	1948	1947	1948	1947
Center 0	O.S.	O.S.	15.8	10.8
T- 90- 25'	17.6	---	11.4	---
T- 90- 50'	O.S.	O.S.	18.6	O.S.
T- 90- 75'	O.S.	O.S.	21.1	O.S.
T- 90- 100'	O.S.	O.S.	21.4	O.S.
T- 90- 125'	O.S.	O.S.	16.9	O.S
T- 90- 175'	O.S.	---	16.5	---
T- 90- 225'	O.S.	---	8.1	---
T- 90- 300'	15.3	O.S.	4.7	8.0
T- 90- 400'	11.2	O.S.	2.1	5.2
T- 90- 500'	10.5	O.S.	1.4	2.9
T- 90- 600'	19.1	O.S.	1.3	2.2
T- 90- 800'	17.1	O.S.	0.69	1.9
T- 90-1000'	3.6	10.0	0.23	0.54
T- 90-1200'	0.13	6.0	0.030	0.20
T- 90-1400'	0.033	2.6	0.007	0.14

*O.S. - No dial reading possible on the least sensitive range due to too high intensity of radiation.

2.39 The study of the effect of erosion on trinitite is still under consideration. Plate 1 is an aerial photograph taken of the Trinity Region the day after the detonation showing a continuous layer of trinitite *(black area)* deposited or formed in a definite blast pattern. Plate 2 is another aerial photograph taken approximately a year later after the guard fence had been constructed but before the wood shelter protecting an area of trinitite was constructed. In this picture, the erosional factors, particularly water, have taken effect. The initial continuous layer of trinitite has become broken particularly on the eastern section. More recent pictures indicate even more breakup of the initial layer of trinitite.

2.40 The influence of wind in eroding and its subsequent action in spreading the weathered trinitite is also hard to evaluate. However, in 1948 wind-blown radioactive dust was collected from the table tops and floor of a guard shack located adjacent to the crater fence, a short distance north of the west guard road. Figure 6 shows the accumulation of dust on the floor of the guard shack. The activities found in these samples vary from 5.3 to 34.3 dis./sec./gm. zero-mass, beta and gamma activity and approximately 1.2 counts per minute per gram, alpha activity.

Plate I

ORIGINAL BLAST PATTERN OF TRINITITE DEPOSITION

Photograph courtesy of
Los Alamos Photo Laboratory

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Plate 2

EFFECTS OF EROSIONAL FACTORS
ON ORIGINAL TRINITITE DEPOSITION

Photograph taken approximately one year after detonation.

Photograph courtesy of
Los Alamos Photo Laboratory

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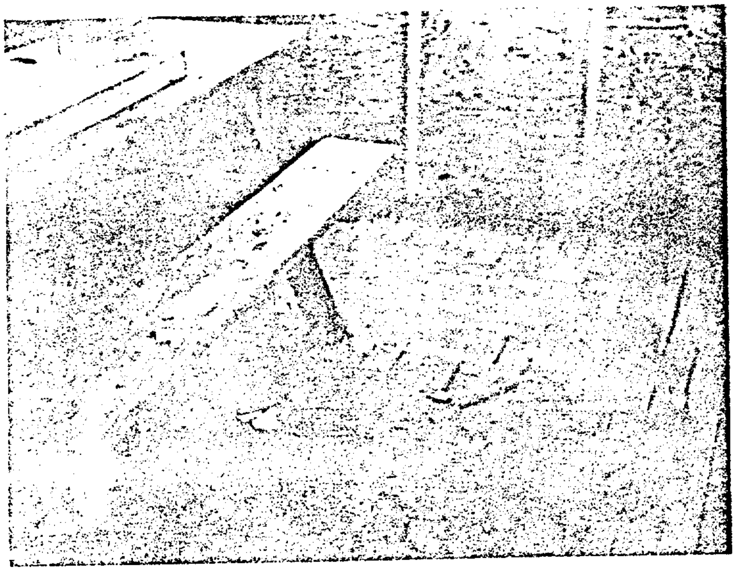


Figure 6
Accumulation of Dust
on Floor of Guard Shack

2.41 It is apparent from these observations and results that the trinitite and contaminated soil is being transported outside the crater fence. As this weathering process continues, more of the trinitite will become of such a particle size that it will be more easily transported by wind and water. This will cause a spreading of the activity but, at the same time, a dilution which will tend to lessen the contamination per unit area. The activity just outside the crater fence as determined in September, 1948, is summarized in Figure 7.

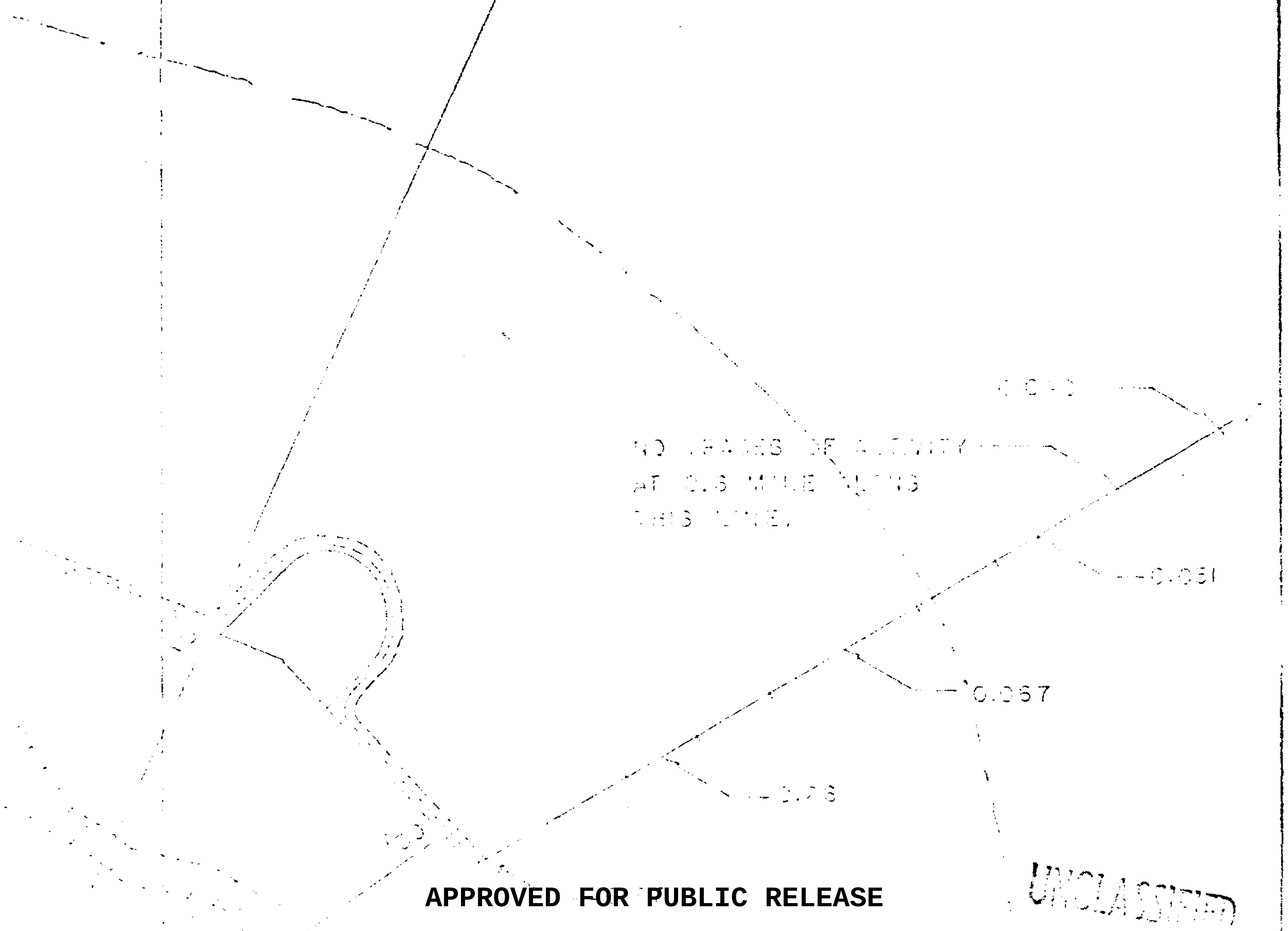
2.42 Profiles in the Fenced Area. Table VI is a comparison of beta and gamma activity, zero-mass, with respect to depth in twelve profiles collected along the four main Radials established in the Fenced Area at 200, 600, and 1000 feet from Zero. The distribution of radioactivity in the profiles collected at 200 feet from Zero does not follow a definite pattern with respect to depth. From the data and observations made at this location in the Crater, it appears the soil while in momentary suspension during the explosion was mixed with the fission porducts. Therefore, the beta and gamma activity reported is probably the result of this mixing effect and, in addition, neutron-induced activity.

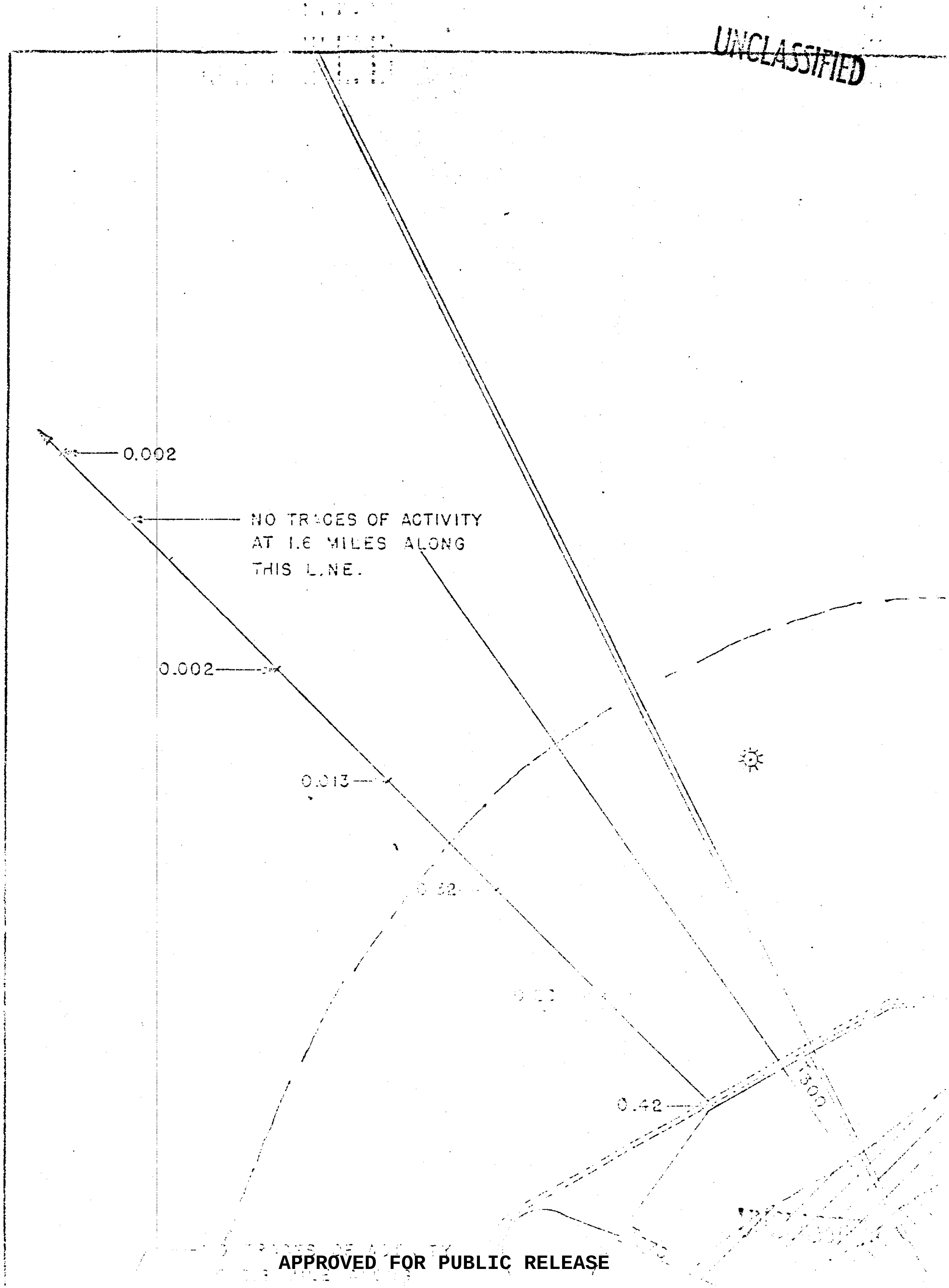
[redacted]

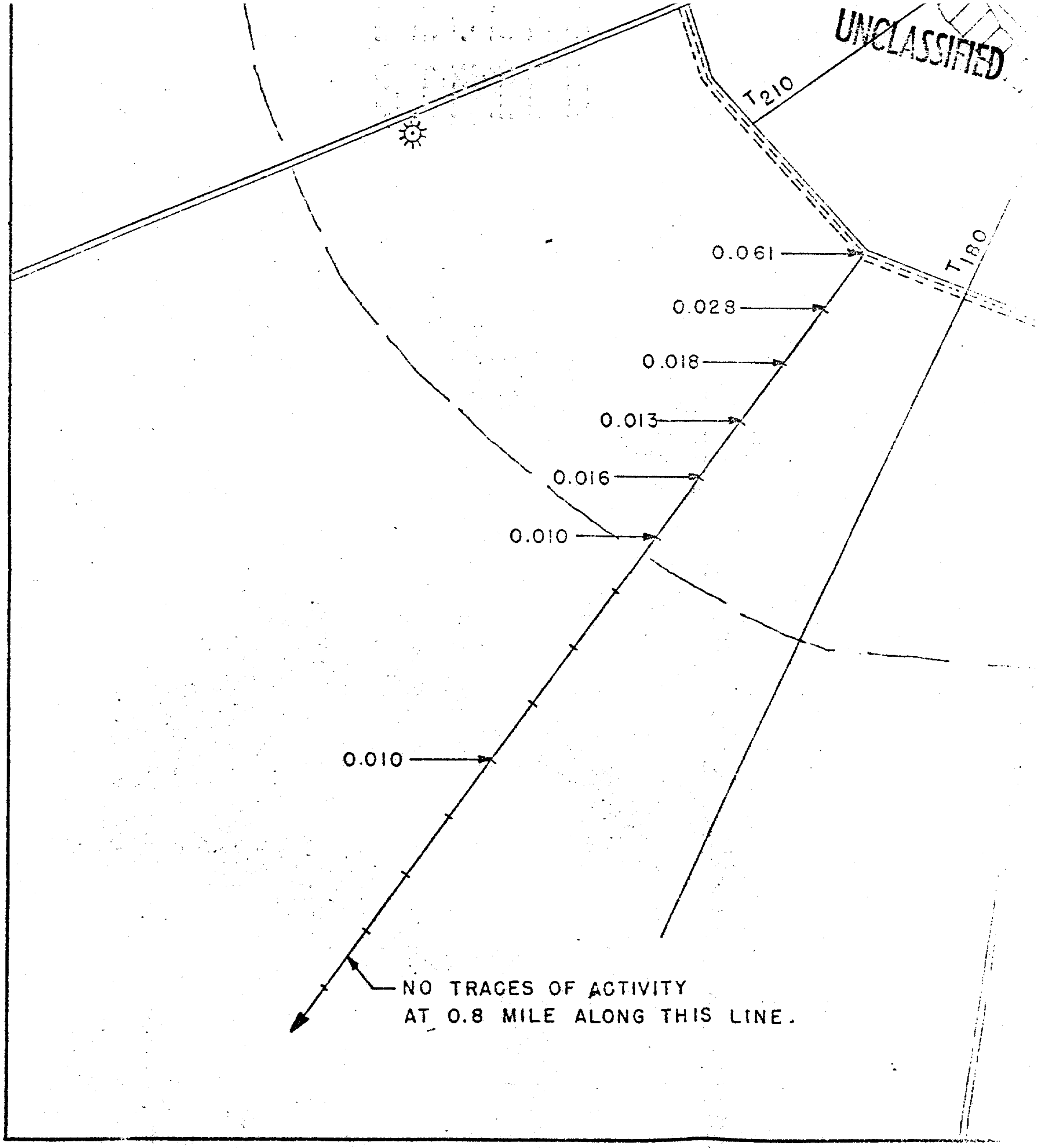
READINGS OF BETA PLUS GAMMA ACTIVITY ALONG THE REFERENCE LINES OUTSIDE THE CRATER FENCE AS INDICATED.

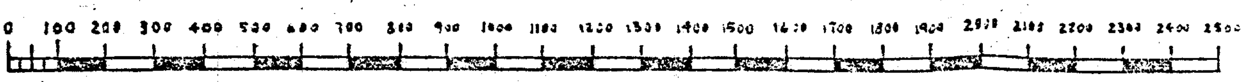
ALL RESULTS REPORTED IN MR/HR. AS OBTAINED ON MODEL 263 A–VICTOREEN SURVEY METERS.

DATE: SEPT. 1948.




0.002
NO TRACES OF ACTIVITY
AT 1.6 MILES ALONG
THIS LINE.
0.002
0.013
0.42
1300

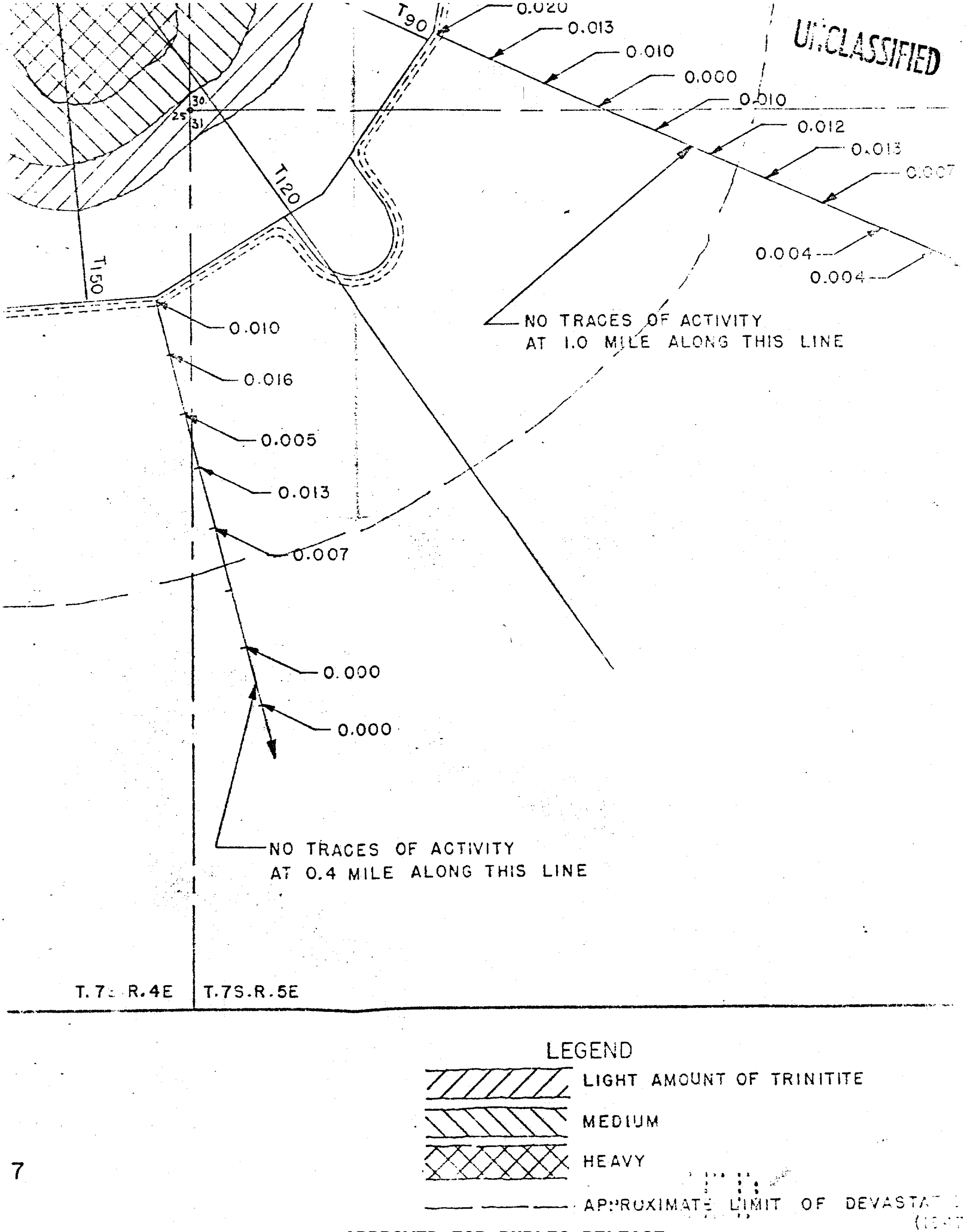




SCALE 1" = 400'

A1 ASPHALT PROFILE 204 FEET FROM CENTER
A2 193
A3 135
} COLLECTED 1947

T_{30}, T_{60} ETC., SAMPLE TRANSECT LINES RELATIVE
TO APPROXIMATE LINE OF DRIFT, T_0
} ESTABLISHED 1947


UNCLASSIFIED
T90
T120
T150
0.020
0.013
0.010
0.000
0.010
0.012
0.013
0.007
0.004
0.004
NO TRACES OF ACTIVITY
AT 1.0 MILE ALONG THIS LINE
30
25
31
0.010
0.016
0.005
0.013
0.007
0.000
0.000
NO TRACES OF ACTIVITY
AT 0.4 MILE ALONG THIS LINE
T.7S.R.5E
LEGEND
LIGHT AMOUNT OF TRINITITE
MEDIUM
HEAVY

[redacted]

Table VI

Beta and Gamma Activity in 12 Profiles Collected from the Fenced Area in the Fraction 150 Microns and Less

Profile Number and Distance from Zero

Activity Expressed as Disintegrations per Second per Gram, Zero-Mass

Depth In Inches	T-0 1000 Ft.	T-0 600 Ft.	T-0 200 Ft.	T-180 200 Ft.	T-180 600 Ft.	T-180 1000 Ft.
0-1	9.60	34.4	97.4	18.5	17.8	5.82
1-2	0.57	12.3	98.6	18.2	7.65	1.41
2-3	0.91	11.5	87.0	21.6	7.24	0.74
3-4	none	8.84	87.0	23.6	7.10	none
4-6	none	8.37	82.0	41.2	4.72	---
6-8	none	7.50	65.2	104.	3.21	none
8-10	none	4.25	46.8	99.3	1.21	---
10-12	none	2.98	18.8	66.7	0.51	none
12-14	none	2.92	9.54	43.8	---	none
Depth In Inches	**T-90 1000 Ft.**	**T-90 600 Ft.**	**T-90 200 Ft.**	**T-270 200 Ft.**	**T-270 600 Ft.**	**T-270 1000 Ft.**
0-1	8.44	13.1	562.	203.	23.9	21.2
1-2	1.72	10.2	488.	72.4	9.37	2.02
2-3	1.21	9.92	1358.	59.7	7.57	1.95
3-4	1.89	8.60	400.	59.7	6.50	1.32
4-6	0.23	8.33	360.	57.5	5.80	1.04
6-8	0.91	7.35	46.0	58.0	4.02	0.64
8-10	0.40	6.20	22.4	39.2	2.25	0.23
10-12	0.23	4.65	21.4	28.1	1.61	none
12-14	0.51	4.18	13.5	---	none	none

2.43 The profile samples collected at 600 feet from Zero along the four Radials have a similarity in the pattern of distribution of activity with respect to depth. The surface sample in all cases has the greatest amount of beta and gamma activity with the deeper samples containing progressively less activity. On a theoretical basis, the activity in the deeper samples at this distance is probably still neutron-induced.

2.44 The profile samples collected at 1000 feet from Zero along the four Radials approach the distribution pattern of beta and gamma activity found in the so-called "normal contaminated profile" in the fall-out area. *(See paragraphs 2.49, 50, 54.)* In other words, the activity is in the first three inches. This is particularly true of the profiles T-0 - T-180; the radials approximating the line of drift and fall-out. The profile T-90 - 1000 feet is atypical and wanting of an explanation at this time. It is hoped that when data are available on the isotopes responsible for the activities at various depths some explanation for this atypical distribution will be possible.

2.45 Neutron-induced Activity in the Crater. Evidence for neutron-induced activity is found in three profiles taken from under unbroken asphalt.

[redacted]

[redacted]

This asphalt was laid down previous to the explosion. The area selected was at least a square yard in dimension. The asphalt layer was carefully stripped and the profiles taken in the center of this cleared area. Table VII gives the distribution of beta and gamma activity with respect to depth of the three profiles taken at 135, 193 and 204 feet from Zero along Radial T-O.

Table VII

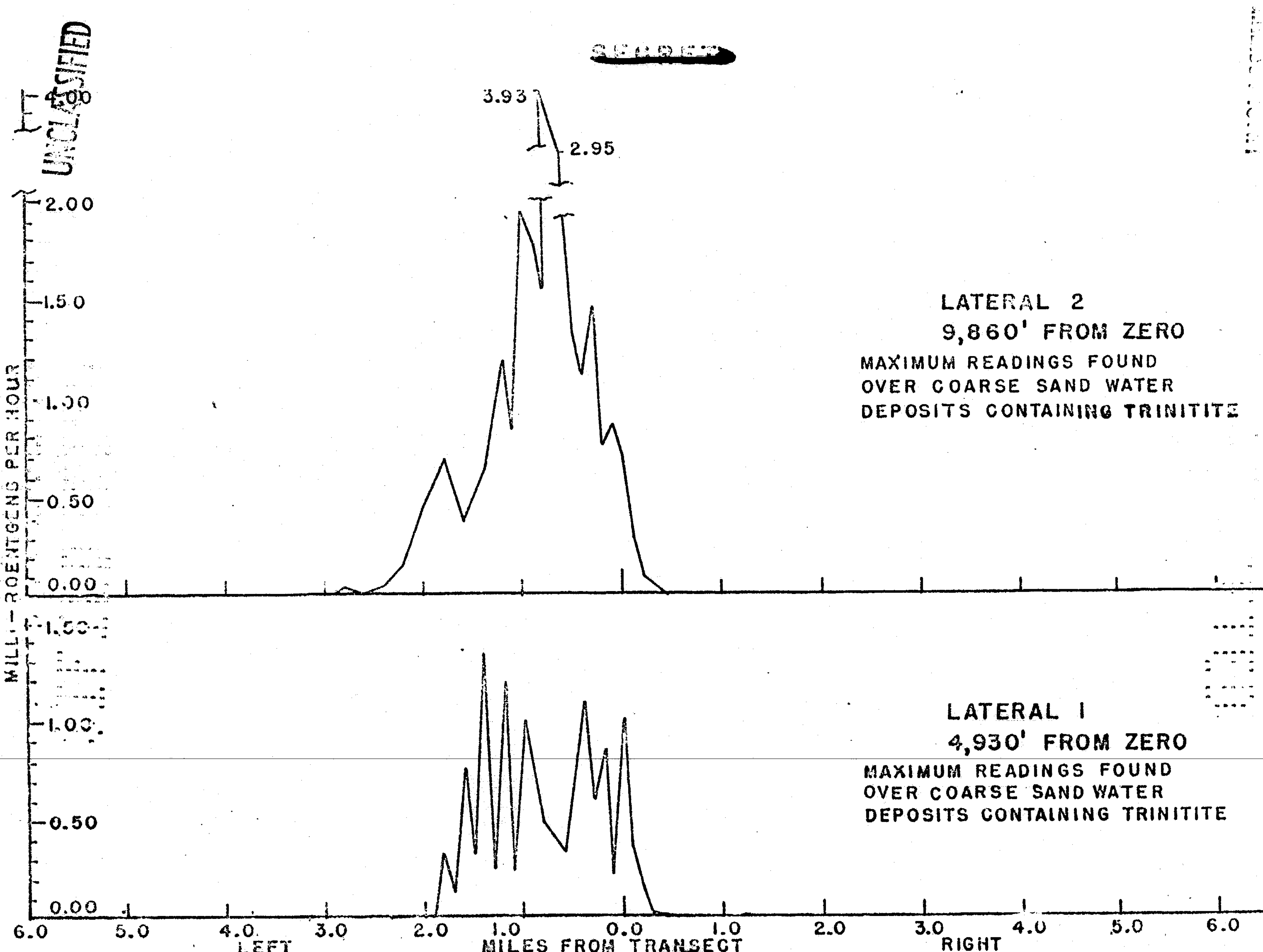
Residual Neutron-Induced Activity as Beta and Gamma Found in Soil Profiles Taken from under Asphalt Layers

Depth In Inches	A.S.P.-135' d./s./g.-Zero-mass	Depth In Inches	A.S.P.-193' d./s./g. - Zero-mass	A.S.P.-204' d./s./g. - Zero-mass
0-2	149	0-2	84.7	82.7
2-4	127	2-4	84.7	78.0
4-6	92.5	4-6	70.7	71.8
6-8	59.5	6-9	36.9	45.5
8-10	24.3	9-12	18.0	13.9
10-12	18.7			

The identification of the isotope responsible for the beta and gamma activity reported as neutron-induced activity will be presented in a later report when the data is accumulated.

2.46 Trinity Region. The maximum activities of the total surveyed area outside the Crater are found in this region. Trinitite fragments are found throughout, on the surface or accumulated in the coarse sand water deposits in the existing small washes. Another source of maximum activity found in this region is glass beads which are abundant up to Lateral 3. These beads are dark green to black in color, very hard and of various sizes, usually spherical in shape. Figures 8 and 9 represent the average mr./hr., total beta and gamma radiation, of all readings taken per location on Laterals 1, 2, 3, 4, 5, and 6. This pattern of distribution is evidence of how the effect of physical terrain, climate and vegetation will continually cause a spread of radioactive particles. More specifically, the spread is principally dependent on the amount of water erosion.

2.47 Plate 3 is an aerial photograph showing the physical characteristics of this terrain. The principal arroyos and the alluvial fans are clearly shown. Plate 4 shows the playa west of the Crater. The drainage of the area represented by the first five laterals all terminate in this playa. It is in this playa that the activity, now present in the Crater and especially the trinitite to the north, may eventually be deposited. The dilution factor may be many fold. However, at this time no estimates can be given as to the rate at which this spreading of activity will be brought into an equilibrium.


UNCLASSIFIED
3.93
2.95
4.00
2.00
1.50
1.00
0.50
0.00
MILLI - ROENTGENS PER HOUR
LATERAL 2
9,860' FROM ZERO
MAXIMUM READINGS FOUND OVER COARSE SAND WATER DEPOSITS CONTAINING TRINITITE
LATERAL I
4,930' FROM ZERO
MAXIMUM READINGS FOUND OVER COARSE SAND WATER DEPOSITS CONTAINING TRINITITE
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
LEFT
MILES FROM TRANSECT
RIGHT

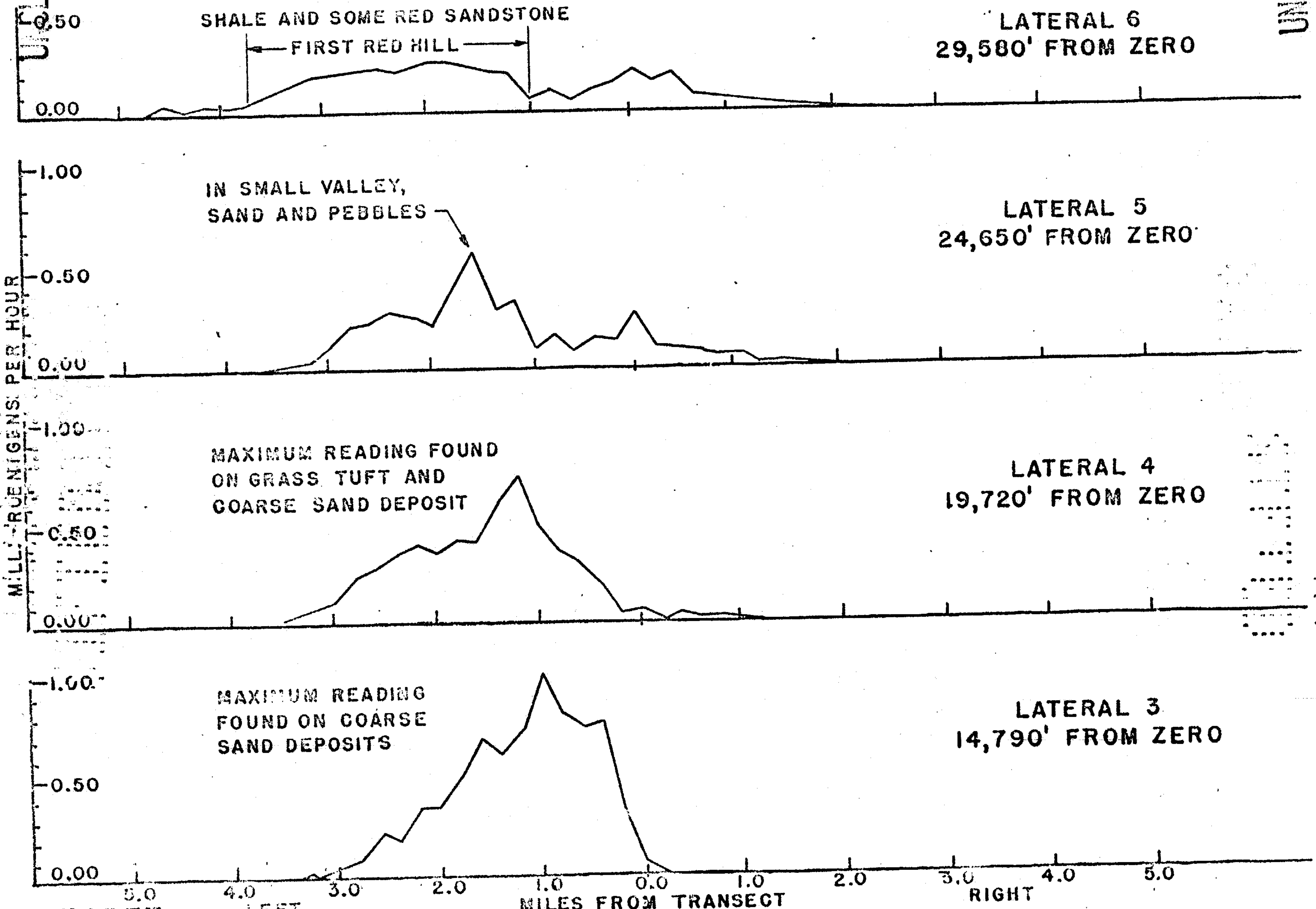

SHALE AND SOME RED SANDSTONE
FIRST RED HILL
LATERAL 6
29,580' FROM ZERO
IN SMALL VALLEY,
SAND AND PEBBLES
LATERAL 5
24,650' FROM ZERO
MAXIMUM READING FOUND
ON GRASS TUFT AND
COARSE SAND DEPOSIT
LATERAL 4
19,720' FROM ZERO
MAXIMUM READING
FOUND ON COARSE
SAND DEPOSITS
LATERAL 3
14,790' FROM ZERO
MILLI ROENTGENS PER HOUR
0.00
0.50
1.00
5.0
4.0
3.0
2.0
1.0
0.0
LEFT
RIGHT
MILES FROM TRANSECT

FIGURE 9

[redacted]

Plate 3

PHYSICAL CHARACTERISTICS
OF THE TERRAIN, EASTERN TRINITY REGION

Photograph courtesy of
Los Alamos Photo Laboratory

[redacted]

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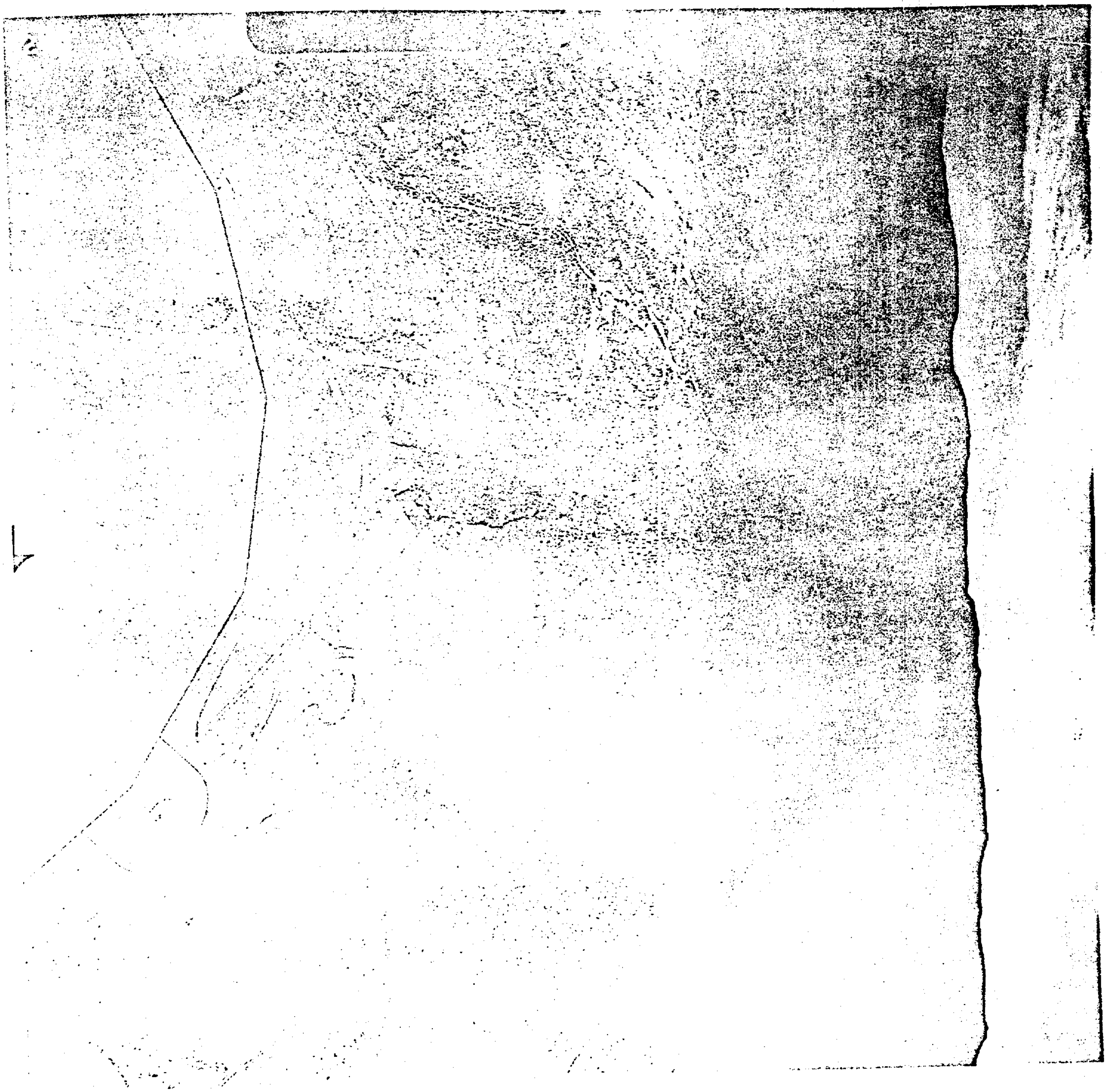

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Plate 4

PHYSICAL CHARACTERISTICS
OF THE TERRAIN, WESTERN TRINITY REGION

Photograph courtesy of
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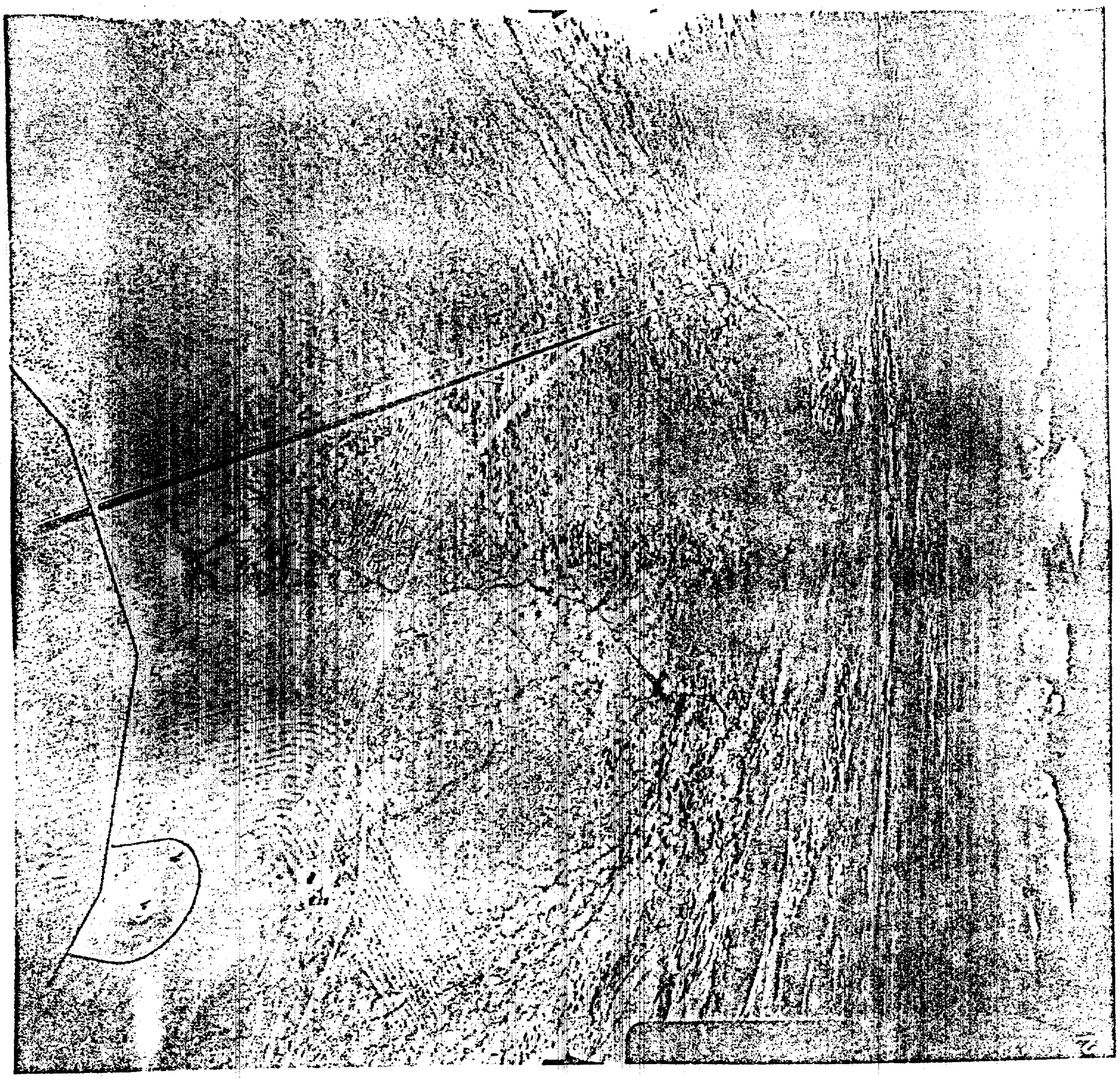

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2.48 In Table VIII is presented the results obtained on the surface samples collected along Lateral 2, left, approximately two miles north of the Crater.

Table VIII

Beta and Gamma Activity Found in the Surface Samples Collected Along Lateral 2, left

Distance in Miles from Lateral 2 Reference Point, Left	Disintegrations per Second per Gram
0.0	2.82
0.1	0.64
0.2	0.46
0.3	2.52
0.4	4.65
0.5	3.90
0.6	3.50
0.7	7.92
0.8	6.60
0.9	2.08
1.0	6.48
1.2	9.06
1.4	1.90
1.6	1.61
1.8	4.31
2.0	6.10
2.2	0.23
2.4	none
2.6	4.00

2.49 In Table IX is presented the results obtained on the profile samples collected on the same Lateral Reference 2, left.

Table IX

Beta and Gamma Activity in Soil Profiles Collected on Lateral Reference 2

Depth in Inches	Miles from Lateral Reference 2		
	0.0 Miles dis./sec./gm.	1.0 Miles dis./sec./gm.	2.0 Miles dis./sec./gm.
0-0.75	3.61	6.50	8.15
0.75-1.5	0.29	1.68	0.46
1.5 -3	none	none	none
3 -6	none	none	none
6 -9	none	none	none

2.50 Activity Along Secondary Transect Reference Line. *(See paragraph 2.27.)* So that additional data would be available through the more active regions in the Trinity Region *(see Figure 1)*, profile and surface samples were collected along a second transect starting at Lateral Reference Point 1 and extending 13° east of north. Table X gives the beta and gamma activity present with respect to depth expressed as dis./sec./gm.

[redacted]

Table X

Total Beta and Gamma Activity for Profile Samples
Along Second Transect Reference Line

Depth-Inches	0.0 Miles	1.0 Miles	2.0 Miles	3.0 Miles	4.0 Miles	6.5 Miles
0-0.75	2.24	6.14	0.70	1.72	13.5	6.26
0.75-1.5	0.18	none	none	0.81	1.55	4.10
1.5 -3	none	none	none	none	0.57	0.17
3 -6	none	none	none	0.53	none	none

The profiles taken at 4.0 miles and 6.5 miles are atypical with respect to soil development of this region with more limestone present and with a silt-like crust on the surface. Under the surface crust there were four to six inches of very loose, fine sand which is probably the explanation for the radioactivity found at the lower depths. The other profiles indicate what is known as a "normal contaminated distribution."

2.51 The activities in the surface samples collected along this same transect are summarized in Table XI.

Table XI

Total Beta and Gamma Activities of Surface Samples
Along the Second Transect From Lateral Reference Point 1

Distance in Miles from Lateral 2 Reference Point	Disintegrations per Second per Gram
0.5	1.27
1.5	7.52
2.5	6.27
3.5	12.9
4.2	22.8
4.5	31.0
5.9	38.9
7.0	11.1
7.5	8.95
8.0	5.52
8.5	25.2
9.0	11.7
9.5	20.3

The higher activities were found on samples of surface soil collected in locations of greater limestone content and water-borne silt deposits. The soil in these regions had a pH of 8.0-8.5 and a brown to red-brown color with lime concretions beginning at 10 inches.

2.52 Red and Grey Hills and the Oscuro Region. The radioactivity in these areas are of a low order. Figures 10 and 11 give the readings in mr./hr. obtained on Laterals 7, 8, 9, 10, 11, 12, 13 and 14. The terrain is very rough in most places due to either the arroyos or the Oscuro Mountains. There is no apparent correlation with respect to elevation and fall-out.

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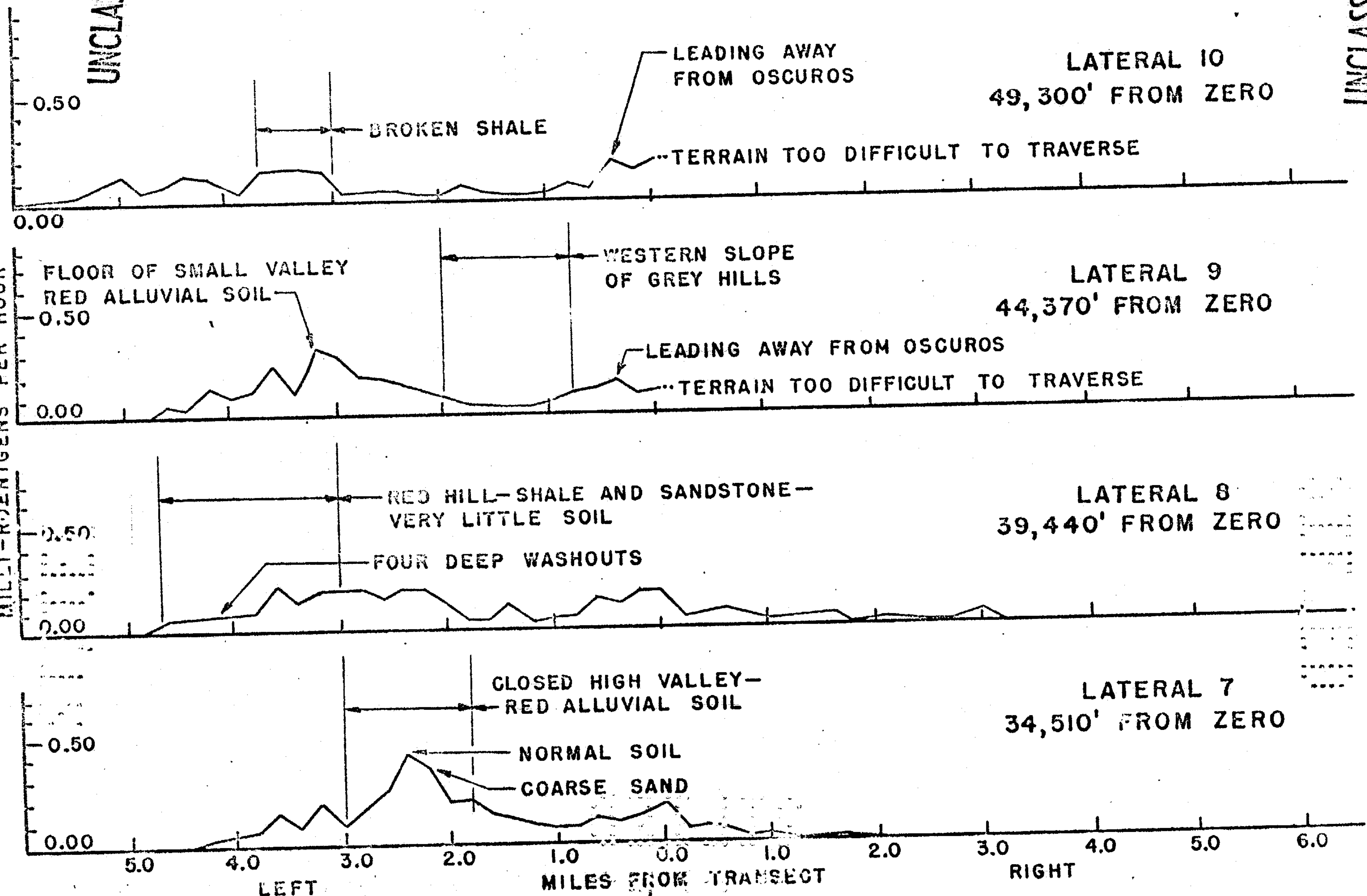
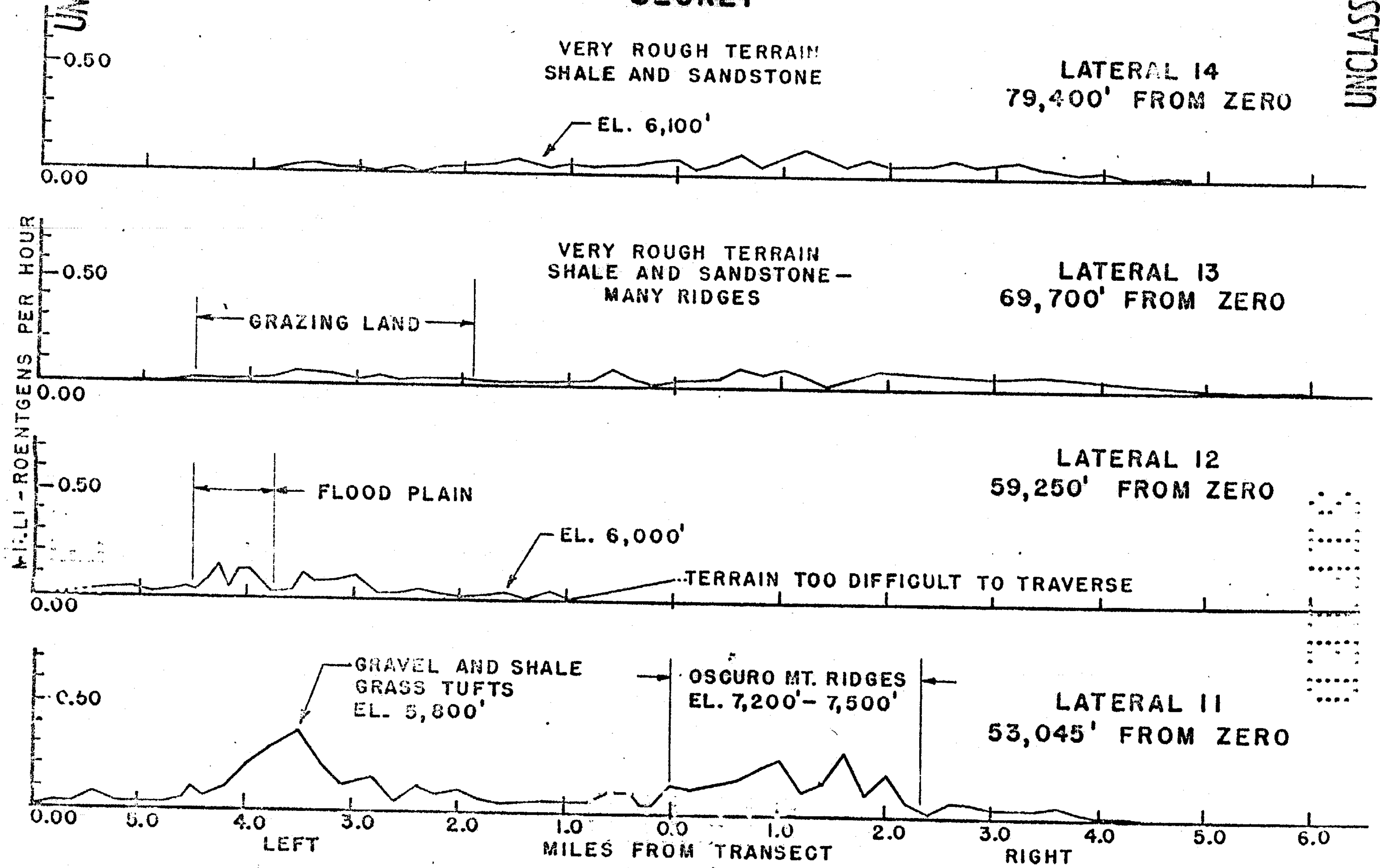


FIGURE 10


VERY ROUGH TERRAIN
SHALE AND SANDSTONE
LATERAL 14
79,400' FROM ZERO
EL. 6,100'
0.50
0.00
VERY ROUGH TERRAIN
SHALE AND SANDSTONE—
MANY RIDGES
LATERAL 13
69,700' FROM ZERO
GRAZING LAND
MILLI-ROENTGENS PER HOUR
LATERAL 12
59,250' FROM ZERO
FLOOD PLAIN
EL. 6,000'
TERRAIN TOO DIFFICULT TO TRAVERSE
GRAVEL AND SHALE
GRASS TUFTS
EL. 5,800'
OSCURO MT. RIDGES
EL. 7,200'– 7,500'
LATERAL 11
53,045' FROM ZERO
0.00
5.0
4.0
3.0
2.0
1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
LEFT
MILES FROM TRANSECT
RIGHT

[redacted]

However, a general trend is established which does indicate that the maximum fall-out occurred in the direction of 13° east of north for the first ten miles of drift. *(Refer to the Detailed Lateral Radiological Survey Map, Figure 3, inside back cover.)*

2.53 Chupadera Mesa. In this area, the radioactivity is higher than in the previous region. There are approximately 35 square miles of activity in the range of 0.3-0.6 mr./hr. in this region. It is a principal grazing area with four ranch owners controlling most of the land. The approximate average elevation is 6700 feet above swa level. Figures 12, 13 and 14 give the activities found in mr./hr. obtained on Laterals 15, 16, 17, 18, 19, 20, 21, 22 and 23. The area traversed by Lateral 21 is the most ative with a maximum of about 0.8 mr./hr.

2.54 The soil is similar throughout the area surveyed. Five soil profile descriptions are presented to illustrate this conclusion. *(Figures 15 to 19 inclusive.)* The parent material is the same but varies in depth. The pH is the same. At the time these profile studies were made (*August 1947*) several rains had fallen. For this reason the moisture penetration is noted. During 1948 profile samples were collected along the northwestern side of Harvey Fence for radioactivity assay. Table XII gives the dis./sec./gm. obtained. The Harvey Ranch Gate is the reference point.

Table XII

Total Beta and Gamma Activities for Soil Profiles from the Harvey Fence

Depth	H.G. 0.3 mi.W. dis./sec./gm.	H.G. 0.0 mi. dis./sec./gm.	H.G. 0.2 mi.E. dis./sec./gm.	H.G. 0.9 mi.E. dis./sec./gm.
0-1"	14.6	18.5	9.72	8.22
1-2"	0.36	0.87	0.72	none
2-3"	none	none	0.17	none
3-5"	none	none	(?)	none
5-7"	none	none	0.23	none

The profile 0.2 mile east of Harvey Gate *(H.G. 0.2 mi. E.)* was collected on the side of a small knoll. The drainage is into a small valley. The soil is uniform, light red-brown in color and the texture is sandy to fine sand throughout the depth of 48 inches. A lime reaction was obtained throughout. In other words, this profile is normal with respect to the soil. Therefore, the reason as to why radioactivity should be at the lower depths is unknown as yet.

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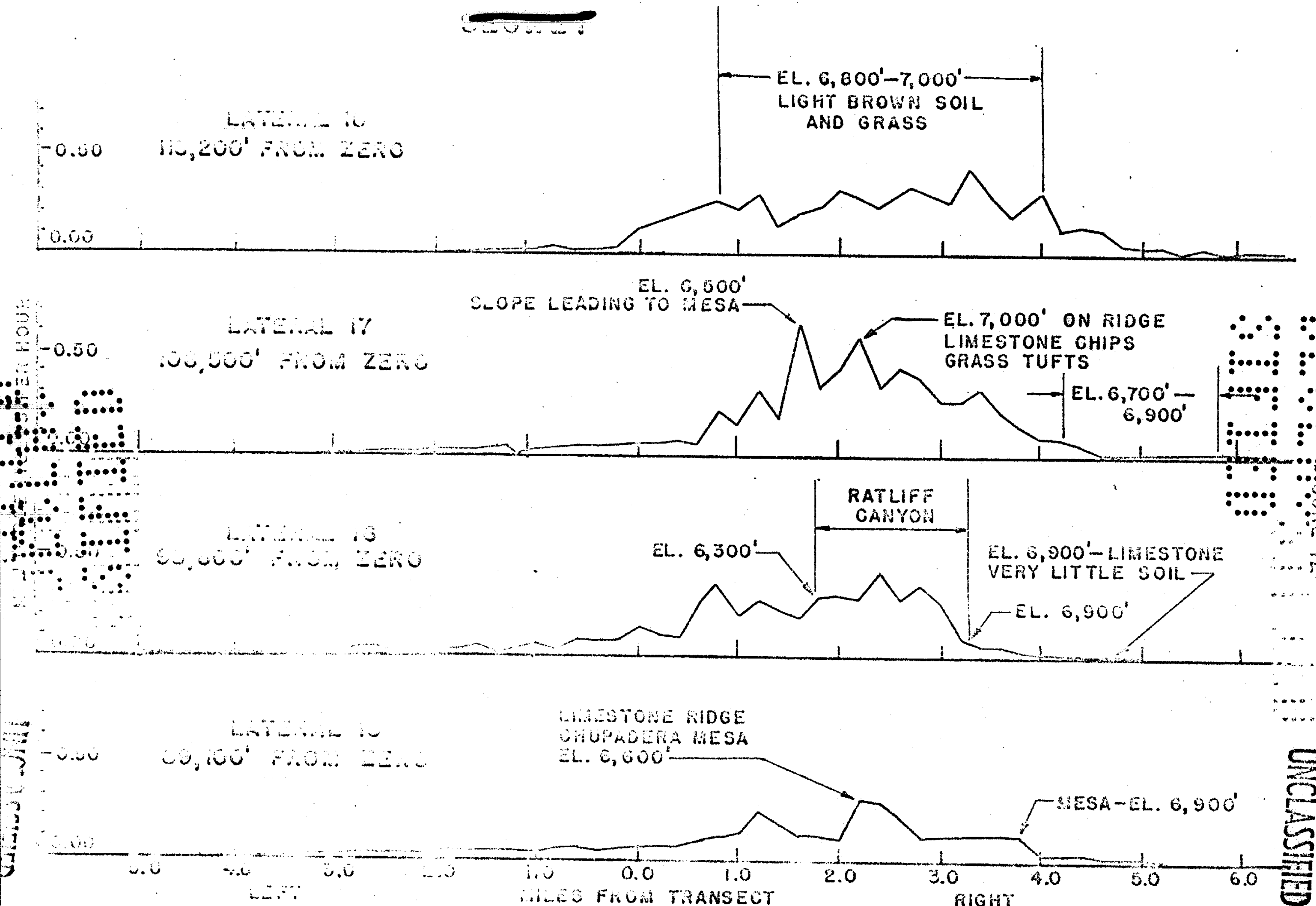

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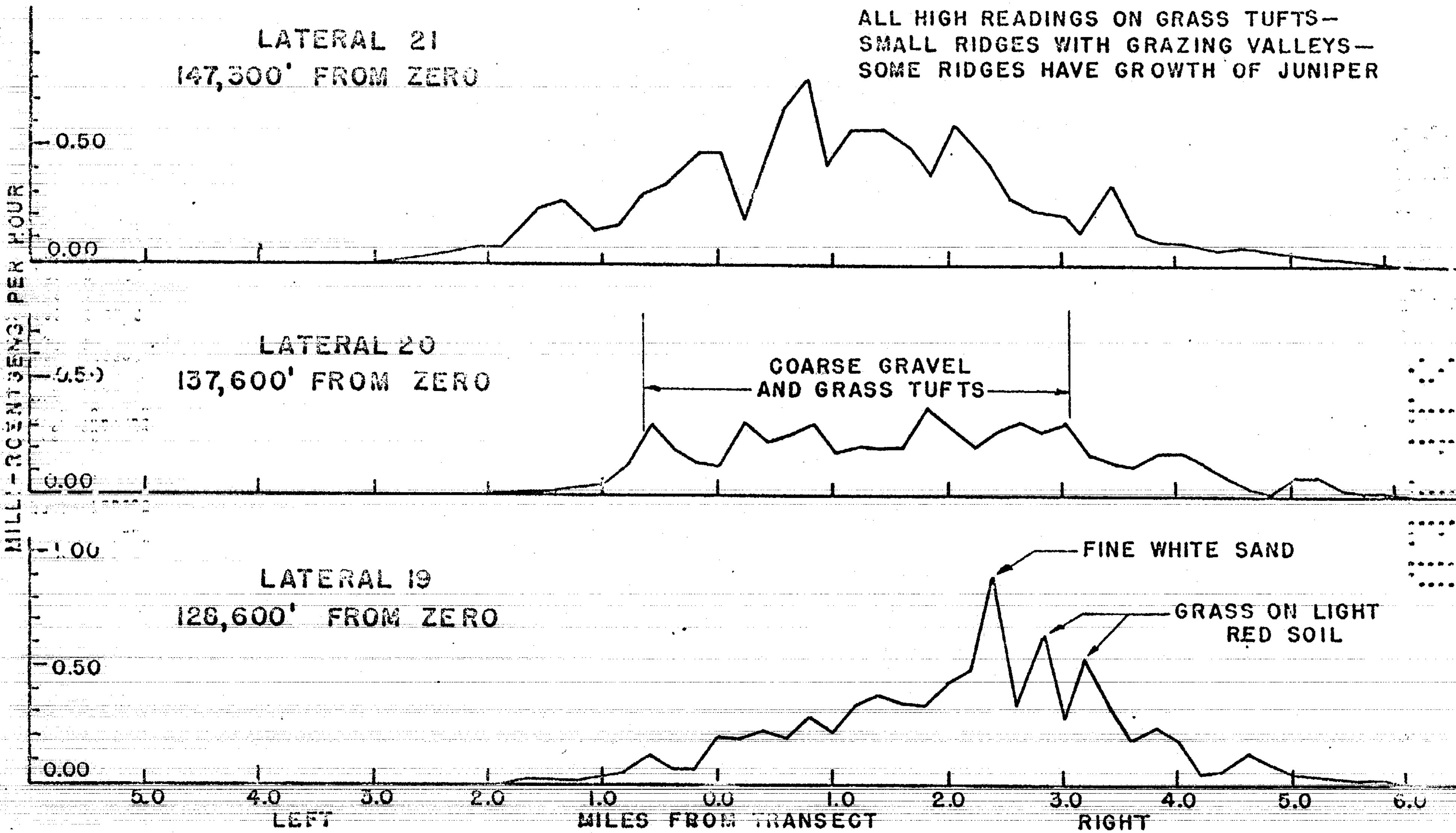

LATERAL 21
147,300' FROM ZERO
ALL HIGH READINGS ON GRASS TUFTS—
SMALL RIDGES WITH GRAZING VALLEYS—
SOME RIDGES HAVE GROWTH OF JUNIPER
0.50
0.00
LATERAL 20
137,600' FROM ZERO
COARSE GRAVEL
AND GRASS TUFTS
0.00
LATERAL 19
128,600' FROM ZERO
FINE WHITE SAND
GRASS ON LIGHT
RED SOIL
1.00
0.50
0.00
MILLI-ROENTGENS PER HOUR
5.0
4.0
3.0
2.0
1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
LEFT
MILES FROM TRANSECT
RIGHT

FIGURE 13

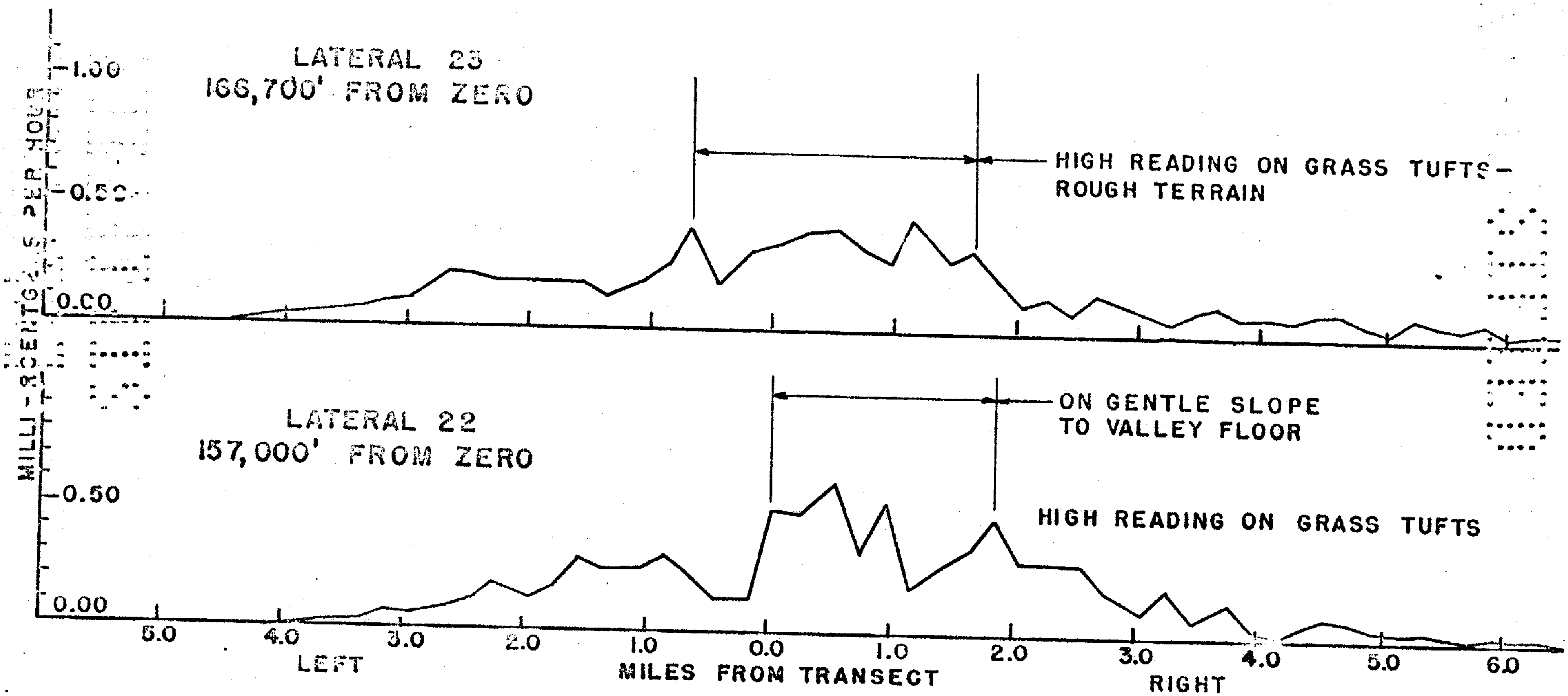

LATERAL 23
166,700' FROM ZERO
HIGH READING ON GRASS TUFTS—
ROUGH TERRAIN
LATERAL 22
157,000' FROM ZERO
ON GENTLE SLOPE
TO VALLEY FLOOR
HIGH READING ON GRASS TUFTS
MILLI-ROENTGENS PER HOUR
0.00
0.50
5.0
4.0
3.0
2.0
1.0
0.0
6.0
LEFT
MILES FROM TRANSECT
RIGHT

FIGURE 4

Fig. 15

RECORDED SOIL CHARACTERISTICS

Profile Description

PROFILE - No. 1.

LOCATION - 75' SSE Section marker 35|36 / 2|1 R.6 E. T.4 S / T.5 S

GEOGRAPHICAL LANDSCAPE - Old terrace or low upland - rolling.

ELEVATION - 5000'. SLOPE - 9-12%. EROSION - Moderate.

GROUNDWATER - Deep. DRAINAGE - Good to excessive. ALKALI - none.

MODE OF FORMATION - Primary. PARENT MATERIAL - Metamorphic rock.

CLIMATE - Semi-arid.

NATURAL COVER - Yucca, bunch grass. PRESENT USE - Grazing.

ORDER, CLASS, GREAT SOIL GROUP - Zonal - red desert.

Profile Sketch	Color	Texture	Structure	Compactness Density	Reaction	Miscellaneous Roots, Concretions Permeability, etc.
	Light brown	Gr. fine sandy loam	Light crumb	Friable	8.0	8" limit of moisture penetration. Moderate amount small fragments. Low organic matter content. Moderate amount disseminated lime.
6"	Very light brown	Gr. fine sandy loam	Massive	Friable	8.0	Moderate amount small fragments. Moderate amount disseminated lime.
15"	Light reddish brown	Gr. fine sandy loam	Massive	Friable	8.0	Large amount small fragments. Strong disseminated lime.
30"	Dark grey					Parent material: Fractured, partially weathered metamorphic rock. Fragments lime coated.

Fig. 16

RECORDED SOIL CHARACTERISTICS

Profile Description

PROFILE - No. 2.

LOCATION - Junction Cooper Well and Bingham Roads *(Cibola National Forest).*

GEOGRAPHICAL LANDSCAPE - Rolling - mesa top.

ELEVATION - 7000'. SLOPE - 9%. EROSION - Moderate.

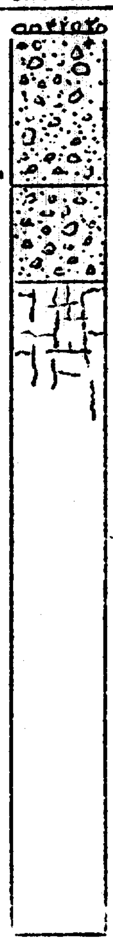
GROUNDWATER - Deep. DRAINAGE - Good. ALKALI - None.

MODE OF FORMATION - Primary. PARENT MATERIAL - Metamorphic rock.

CLIMATE - Semi-arid.

NATURAL COVER - Bunch grass, juniper, cactus. PRESENT USE - Grazing.

ORDER, CLASS, GREAT SOIL GROUP - Zonal - red desert.



Profile Sketch	Color	Texture	Structure	Compact-ness Density	Reaction	Miscellaneous Roots, Concretions Permeability, etc.
0–8"	Light brown or pale brown *(10 yr. 6/3)*	Gravelly loam	Soft crumb	Friable, loose	8.0	Moisture penetration to 6". Low organic matter content. Large amt. gravel, small fragments. Moder. amt. of disseminated lime.
8"–12"	Pale brown *(pinkish)*	Gravelly loam	Soft, small irrg.	Friable	8.0	Many small fragments. Strong disseminated lime.
	Dark grey					Parent material: Fractured, weathered metamorphic rock. Soil has fair moisture-holding capacity. May be some mixing of residual material with material deposited by washes draining higher ground. Root penetration: shallow.

[redacted]

Fig. 17

RECORDED SOIL CHARACTERISTICS

Profile Description

PROFILE - No. 3.

LOCATION - ½ mile north of Cooper Well.

GEOGRAPHICAL LANDSCAPE - Rolling to hilly mesa.

ELEVATION - 7000'. EROSION - Moderate.

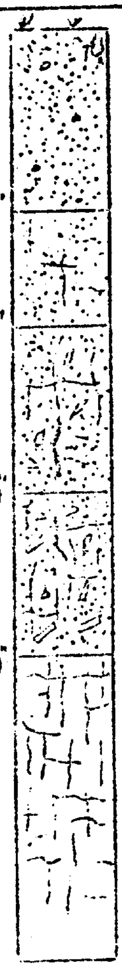
GROUNDWATER - Deep. DRAINAGE - Good - excessive. ALKALI - None.

MODE OF FORMATION - Primary. PARENT MATERIAL - Metamorphic rock.

CLIMATE - Semi-arid.

NATURAL COVER - Bunch grass, juniper, pinon. PRESENT USE - Grazing.

ORDER, CLASS, GREAT SOIL GROUP - Zonal - red desert.

Profile Sketch	Color	Texture	Structure	Compactness Density	Reaction	Miscellaneous Roots, Concretions Permeability, etc.
	Brown to pale brown	Loam	Loose crumb	Friable	8.0	Moisture penetration to 12". Low organic matter content. Moderate amount of disseminated lime. Root penetration to 12".
12"	Pale brown (pinkish)	Loam	Irregular soft blocky	Friable	8.0	Moderate amount of disseminated lime.
20"	Light brown (pinkish)	Loam	Irregular soft blocky	Friable	8.0	Moderate amount of segregated lime - soft chunks.
30"	Light brown (pinkish)	Loam	Irregular soft blocky	Friable	8.0	Large amount of segregated lime - soft chunks.
40"	Dark grey					Parent material: fractured, weathered metamorphic rock.

[redacted]

[redacted]

Fig. 18.

RECORDED SOIL CHARACTERISTICS

Profile Description

PROFILE - No. 5.

LOCATION - 1/4 mile NW of Ratliff Ranch Headquarters.

GEOGRAPHICAL LANDSCAPE - Stream flood plain *(Ratliff Canyon)*; gentle slope.

ELEVATION - 6500'. SLOPE - 3%. EROSION - Gully.

GROUNDWATER - Deep. DRAINAGE - Good. ALKALI - None.

MODE OF FORMATION - Secondary. PARENT MATERIAL - Mixed alluvium.

CLIMATE - Semi-arid.

NATURAL COVER - Bunch grass, cactus, juniper. PRESENT USE - Grazing.

ORDER, CLASS, GREAT SOIL GROUP - Azonal - alluvial.

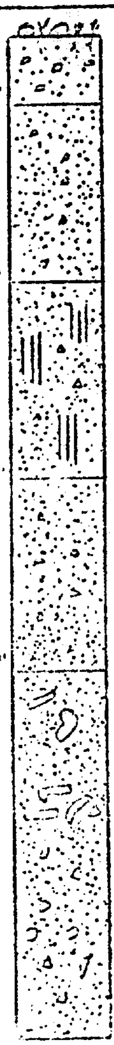
Profile Sketch	Color	Texture	Structure	Compact-ness Density	Reaction	Miscellaneous Roots, Concretions Permeability, etc.
	Rich brown	Light loam	Slightly cloddy	Friable	8.0	Moisture penetration to 6". Moderate amt. of disseminated lime. Few angular fragments. Low organic matter content.
6"	Pink Light brown (7.5 yr. 7/4)	Loam	Massive to small, soft granular	Friable	8.0	Moderate amount of disseminated lime. Occasional angular fragments. Root penetration: 12-18".
18"	Pink	Loam	Indistinct columnar	Friable slightly compact	8.0	Moderate to strong segregated lime. Occasional angular fragments.
30"	Pink	Loam	Massive	Firm moderate compaction	8.0	Moderate to strong disseminated lime. Occasional angular fragments.
42"	Pink	Heavy loam	Stratified	Friable	8.0	Moderate to strong disseminated lime. Large and small rock fragments.

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Fig. 16

RECORDED SOIL CHARACTERISTICS

Profile Description

PROFILE - No. 6.

LOCATION - 2 miles NW of Ratliff Ranch

GEOGRAPHICAL LANDSCAPE - Alluvial fan between low, rolling upland hills.

ELEVATION - 6500'. SLOPE - 2%. EROSION - Slight.

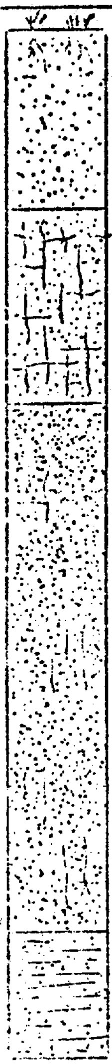
GROUNDWATER - DEEP. DRAINAGE - Good. ALKALI - None.

MODE OF FORMATION - Secondary. PARENT MATERIAL - Mixed alluvium.

CLIMATE - Semi-arid.

NATURAL COVER - Bunch grass, juniper, yucca. PRESENT USE - Grazing.

ORDER, CLASS, GREAT SOIL GROUP - Azonal - alluvial.

Profile Sketch	Color	Texture	Structure	Compactness Density	Reaction	Miscellaneous Roots, Concretions Permeability, etc.
	Brown	Loam	Small soft cloddy	Friable	8.0	Moisture penetration to 6". Moderate amount of disseminated lime.
12"	Brown	Loam	Soft Regular Blocky	Firm	8.0	Moderate amount of segregated lime.
24"	Greyish brown to brown	Light clay loam	Irregular blocky	Firm	8.0	Moderate amount of disseminated and segregated lime.
56"	Greyish brown	Loam	Platy	Firm	8.0	Large amount of segregated lime. Indeterminate depth.

[redacted]

[redacted]

2.55 The area of the remaining radioactivity due to fall-out from the First Atomic Bomb has been outlined along a transect extending out northeast of the Crater for the first 100 miles. The first thirty-two miles were surveyed in detail. A contour map has been prepared on the basis of the mr./hr. total beta and gamma radiation measurable during the summer of 1948.

2.56 In the Detailed Survey 240 square miles were found to have the range of activity from background to 0.3 mr./hr., 38 square miles having the range of activity of 0.3 - 0.6 mr./hr., 2.14 square miles having the range of activity of 0.6 -0.9 mr./hr. with 3.7 square miles being the most active outside the crater fence - 0.9 -6.4 mr./hr. In the remainder of the 1130 square miles surveyd all activities were 0.1 mr./hr. or less.

2.57 For the most part, all activities outside the crater fence are found in the upper two inches. Some atypical profile samples were collected having activities existing at lower depths. These are indicated and discussed.

2.58 The activity is being spread by wind and water, particularly in the Trinity Region. Wind-blown dust collected from table tops and the floor in a guard shack does have considerable activity associated with it. Water deposits of coarse sand were found to have the greatest activity outside the Fenced Area.

2.59 A study of the soil profiles collected in 1947 and 1948 from the Crater indicate a portion of the present activity is due to neutron-induction.

2.60 Trinitite within the crater fence gives an average activity of 1185 dis./sec./gm. The weathering of trinitite is progressing - the large fragments are disintegrating.

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Division: Diversified Problems — Division Chief: Stafford L. Warren

Section: Alamogordo — Section Chief: Albert W. Bellamy

THE 1948 RADIOLOGICAL AND BIOLOGICAL SURVEY OF AREAS IN NEW MEXICO AFFECTED BY THE FIRST ATOMIC BOMB DETONATION

PART 2

91811

Submitted by: Stafford L. Warren, M.D.
Director

Report Submitted: October 12, 1949
Report Issued: November 17, 1949

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Part 2

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THE 1948 RADIOLOGICAL AND BIOLOGICAL SURVEY OF
AREAS IN NEW MEXICO AFFECTED BY THE
FIRST ATOMIC BOMB DETONATION

3. BIOLOGICAL SURVEY - ANIMALS

[redacted]

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INTRODUCTION

3.1 The primary objective of the 1948 Alamogordo Field Survey was to determine the degree and extent of contamination in the fall-out area of the First Atomic Bomb. Following the completion of that phase the consultants[1] undertook the animal investigations of the summer's program which included three different phases, as follows:

1. External Evidence of Radiation Damage.
2. Ecological Aspects of Survey.
3. Radiological Assay of Animal Samples.

Some information will be included from material collected during the 1947 Alamogordo Field Survey since these data have not been reported previously.

EXPERIMENTAL PROCEDURES

3.2 **Collection of Small Animals.** With the exception of the cattle *(see paragraphs 3.3 and 4)*, all specimens were collected by the consultants of the Alamogordo Section while in the Trinity and fall-out areas. After shooting or trapping, the specimens were either air-dried or preserved in ten per cent formalin for shipment to the project laboratory for analysis. All locality data are given with reference to the Detailed Radiological Survey Map *(see Figure 3, inside back cover)* and primarily with respect to the twenty-three Lateral Reference Points accurately surveyed in the Primary Transect Reference Line.

3.3 **Cattle.** Seven cows and one calf were purchased from T. R. Coker, Bingham, New Mexico, whose ranch lies within the southern section of the Cibola National Forest in the general region of Lateral Reference Point Numbers 18 and 19.[2] Since these cattle had been grazing for varying periods of time over open range country and in the forest, some areas contaminated and some not, it is not possible to arrive at any conclusions concerning their actual exposure time in contaminated areas of the fall-out. The only suggestive evidence along this line is the fact that cows 2 and 6 *(see Table I)*. showed typical patches of grey *(bleached)* hair on the

(1) THE CONSULTANTS WHO CARRIED OUT THE FIELD ASPECTS OF THESE INVESTIGATIONS WERE AS FOLLOWS:

PROF. R.B. COWLES, HERPETOLOGIST
DR. A.J. VAN ROSSEM, ORNITHOLOGIST
MR. W.R. DAWSON, MAMMALOGIST
MR. K.S. NORRIS, HERPETOLOGIST
MR. R.G. ZWEIFEL, HERPETOLOGIST

(2) FOR DETAILS SEE THE DETAILED LATERAL RADIOLOGICAL SURVEY MAP, FIGURE 3, FILED INSIDE BACK COVER.

[redacted]

[redacted]

dorsal and lateral surfaces apparently comparable to the condition described for cattle studied several months after the test. In an oral communication *(October 29, 1948)*, Mr. T. H. Coker told the senior author that these two cows had been "in the forest" during each annual grazing season. In view of these and other uncertainties all data with respect to the cattle must be considered in light of unpredictable and variable exposure, either external or internal, to radioactive contamination.

Table I

General Data on the Eight Cows

Number	Age (1)	Live Weight lb.	Dressed Weight lb. (2)
1	4-6 years	935	437
2	4-6 years	1035	511
3	Yearling	610	309
4	Yearling	615	323
5	Yearling	565	262
6	5-6 years	935	470
7	4-5 months	210	158 (3)
8	2-3 years	570	297

(1) Estimated by inspectors and personnel of the Schwartzman Packing Company, New Mexico.
(2) "Hot weights" taken immediately after slaughtering.
(3) Calf was not skinned.

3.4 The cattle were trucked from the Coker Ranch to the Schwartzman Packing Company, Albuquerque, New Mexico, on the morning of November 1, 1948. After weighing, all cattle were inspected for brands and distinguishing markings as given on the original bill of sale. Prior to and during slaughtering that afternoon, each cow was inspected in detail by Dr. Harry Klauber, D.V., Chief City Meat Inspector, Department of Sanitation, City of Albuquerque, New Mexico. No evidence of gross pathology either externally or internally was found and Dr. Klauber informed the project representative at that time that the meat of all the cattle would be acceptable for public consumption. Slaughtering was carried out by the usual procedure of the Schwartzman Packing Company, each organ or tissue being inspected in detail by Dr. Harry Klauber and by the project representative before being packed in half-pint packages *(containing a maximum of 300 to 400 grams)* for deep freezing. When the size of the organ or tissue permitted, duplicate or triplicate samples were removed. All samples were packed in dry-ice, shipped by Air Express to the project and the samples stored in deep-freeze lockers until ashed as described below.

3.5 Radiological Assay of Samples. In the laboratory the various samples *(tissues, organs or carcasses)* were transferred to weighed containers

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(porcelain dishes or pyrex beakers), dried overnight at 105-110° C, and finally placed in the muffle furnace and ashed overnight at a temperature of 550-600° C. After cooling to room temperature the containers plus ash samples were reweighed and weight of ash determined by difference. Samples ashed in the porcelain dishes were counted without transfer while material ashed in pyrex beakers were ground up and a sample, not exceeding one gram of ash, was weighed out accurately into a tin lid, 1-5/8" in diameter and 3/8" deep, for counting.

3.6 All counting was carried out with the equipment and by the procedure previously described *(see paragraphs 2.28 and 29)*. All results are reported in terms of disintegrations per second per gram of ash. No correction to zero-mass was practical for the animal specimens because of the very low activities involved. Only those data are considered as significant from the small animals which were equal to or greater than twice the background level. This level of significance was decided upon because of (1) the observed variations between different scaler units and between repeated counts of a sample on the same scaler unit and (2) comparable analyses on samples from the project's animal colony showing counts not exceeding twice background in the majority of cases. For the samples from the cattle all data are reported which exceeded the average background so that data would be available with regard to the actual magnitude of this low level of activity. However, duplicate or triplicate counts were made on all samples showing activities equal to or greater than twice the background level.

RESULTS OF RADIOLOGICAL ASSAYS

3.7 The results of the radiological assays of all animal specimens collected during the 1948 Alamogordo Field Survey, together with some data from material collected during 1947, are summarized in a series of seven tables as follows:

Table II	Birds
Table III	Small Mammals
Table IV	Reptiles
Table V	Soft Tissues of Cows
Table VI	Bones and Bone Marrows of Cows
Table VII	Miscellaneous Biological Samples

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Table II

Summary of Data of Total Beta and Gamma Activities for Birds Collected During the 1948 Biological Survey

Locality	Activity Above Soil mr./hr.	Total No. Collected	No. Showing Significant Activity	Data on Birds Showing Significant Activity: Name	Activity in Disintegrations/Second /Gram Ash: Digestive Tract	Other Viscera	Carcass (1)
NE side of crater fence	4.0	13	3	*Spizella passerina*	---	---	17.5
				Calamospiza melanocorys	NS (2)	---	3.67
				Chlorura chlorura	24.8	---	NS
1 mile north of crater fence	1.0-4.0	13	5	[illegible] *Otocoris alpestris*	374.0	NS	NS
					73.6	NS	NS
					603.0	NS	NS
					20.6	NS	5.25
					61.0	NS	NS
0.5 mile left of #8 Lateral Reference Point	0.15	6	0	---	---	---	---
South side of crater fence	0.20	1	1	*Lanius ludovicianus*	9.95	NS	NS
2.5 miles SE of crater	Background	1	0	---	---	---	---
Exact center of crater	More than 30.0	1	1	*Chondestes grammacus*	295.0	NS	10.1
At #7 Lateral Reference Point	0.16	1	0	---	---	---	---
Cooper Well	0.1-0.3	6	4	*Zenaidura macroura*	10.4 (3)	NS	NS
					20.0 (4)	NS	NS
					10.8 (3)	NS	NS
					12.5 (3)	NS	NS

(1) The term "Carcass" is used to indicate either the entire animal or that portion thereof after the digestive tract and other viscera have been removed.

(2) NS = not significant. *(Observed counts less than twice background.)*

(3) Value for crop only.

(4) Value for intestine only.

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Table IV

Summary of Data on Total Beta and Gamma Activities in Reptiles Collected During the 1948 Field Survey

Locality	Activity Above Soil mr./hr.	Total Number collected	Number showing Activity	Name	Activity in Carcass d./s./g. Ash	Stomach (1)
Lateral 2 left, 0.8 mile west	0.7-2.5	4	0	*Cnemidophorus* (juveniles)	NS(2)	NS
Lateral 3 left, 0.6 mile NW	0.5-0.7	2	1	*Cnemidophorus* (juveniles)	NS	1190
Lateral 4 left, 1 mile NW	0.5-0.7	7	0	*Cnemidophorus* (juveniles)	NS	NS
Socorro, New Mexico	Back-ground	4	0	*Cnemidophorus* (adults)	NS	---
Northwest of crater	0.1-2.5	11	2	*Cnemidophorus* (adults)	5.9 3.8	---
1/2 mile S of Little Red Tank near Lateral Reference Point #4	0.5-0.7	15	0	*Uta stansburiana*	NS	NS
At Lateral Reference Point #6	0.1-0.3	3	0	*Uta stansburiana*	NS	NS
Crater fence at Guard Shack Road	0.7-2.5	4	0	*Uta stansburiana*	NS	NS
East side of crater fence	0.1-0.3	6	0	*Uta stansburiana*	NS	NS
0.8 mile west on Lateral 2, left	0.7-2.5	9	0	*Uta stansburiana*	NS	NS
1.2 mile west on Lateral 2, left	0.7-2.5	[illegible]	1	*Uta stansburiana*	4390	NS
Outside crater fence	0.1-0.7	5	0	*Uta stansburiana*	NS	---
Inside crater fence	0.2-7.0	7	0	*Uta stansburiana*	NS	---
Outside crater fence	0.1-0.7	4	0	*Phrynosoma*	NS	---
Inside crater fence	7.0	1	1	*Phrynosoma*	8.2	---

(1) Stomachs of these reptiles were not analyzed individually but combined from each locality.

(2) NS=not significant *(observed counts less than twice background).*

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Table II

Summary of Data on Total Beta and Gamma Activities for Small Mammals from the 1947 and 1948 Biological Surveys

Locality	Activity Above Soil mr./hr.	Total Number Collected	No. Showing Significant Activity	Data on Animals Showing Significant Activities: Name	Activity in Disintegrations/Second/Gram Ash: Digestive Tract	Other Viscera	Carcass (1)
Lateral 1, left 0.4 mile pt.	0.98	10	0	---	---	---	---
Lateral 2, left 0.6 mile pt.	2.46	10	0	---	---	---	---
Lateral 2, left 0.7 mile pt.	2.46	1	0	---	---	---	---
Lateral 2, left 0.8 mile pt.	0.69	9	0	---	---	---	---
Outside crater fence between NE and SE mounds	0.77	17	1	*Lepus*	4.77	---	Not rec'd. for analysis
Outside crater fence except NE section	0.01 to 0.62	12	2	*Sylvilagus*	24.5(2) 19.3(3) 7.95(4)	NS(6)	NS
				Lepus	3.66(5)	NS	NS
Inside crater fence, 1948	0.01 to 25	45	7	*Peromyscus*	25.2	NS	NS
				Dipodomys	NS	NS	5.40
				Perognathus	---	---	16.1
				Perognathus	---	---	25.2
				Dipodomys	37.7	NS	NS
				Dipodomys	32.5	NS	NS
				Peromyscus	---	---	6.91
Outside crater fence, 1947	?	[illegible]	6	*Peromyscus*	52.5	---	NS
				Peromyscus	31.1	---	NS
				Peromyscus	19.8	---	NS
				Dipodomys	19.7	---	NS
				Peromyscus	132.	---	23.8
				Perognathus	---	---	18.2
Inside crater fence, 1947	?	42	4	Unidentified	19.2	---	NS
				Unidentified	132.	---	NS
				Unidentified	57.4	-	NS
				Peromyscus	107.	---	NS

(1) The term "Carcass" is used to indicate either the entire animal or that portion thereof after the digestive tract and other viscera have been removed.
(2) Value for stomach.
(3) Value for small intestine.
(4) Value for large intestine and caecum.
(5) Value for caecum.
(6) NS = not significant (observed activity less than twice background).

[redacted]

Table V

Summary of Data on Total Beta and Gamma Activities in the Soft Tissues of the Cows

Activity in Terms of Disintegrations Per Second Per Gram Ash (1)

Sample	Cow #1 4-6 yr. old	Cow #2 4-5 yr. old	Cow #3 Yearling	Cow #4 Yearling	Cow #5 Yearling	Cow #6 5-6 yr. old	Cow #7 4-5 mo. old	Cow #8 2-3 yr. old
Skin	2.21 3.25 2.09	NS(2) NS 1.19	1.88* NS 2.29	4.85* NS 2.66	2.94 2.49 NS	3.05* 3.64* 3.54*	2.74 0.97 1.26	1.27 0.69 1.58
Blood	0.10 NS	1.25 0.41	0.42 2.09	0.25 0.31	0.73 0.72	0.25 NS	0.51 NS	NS 1.56
Heart	4.03 4.33* 5.25*	4.20* 6.25*	5.44* 5.06*	3.61*	4.55* 4.84*	1.99	1.61	2.9[illegible] 5.8[illegible]
Cervical Lymph nodes	7.39	2.67	4.62	3.24	2.19	2.93 5.44	5.46	4.35
Lung	3.55* 3.80 4.95*	3.33 4.85* 4.76*	4.91* 4.66* 6.47*	4.45*	2.79 4.22* 5.69*	6.56* 8.83*	3.64 2.60	5.06 3.55* 5.06*
Liver	3.84* 5.80 4.10	4.13* 3.44 3.73* 1.25	4.94* 6.40*	1.77 5.00	5.71* 5.30*	3.26 2.45 5.81*	3.96 0.55 4.00*	5.41* 4.03 5.60*
Gall Bladder & Bile	0.57	2.13	4.34*	NS	0.82	0.92	0.50	---
Rumen	2.57 2.60 2.96	2.99 5.94* 5.85*	5.90* 6.12* 5.14* 6.09*	4.45* 3.12 7.37*	3.45* 4.55* 5.09*	1.55	3.64* 2.53 5.74* 3.79* 3.36 5.50*	2.17* 2.95* 2.96
Duodenum	4.65* 4.93*	4.95* 3.70	3.80*	4.15* 2.82	2.00	3.77*	4.75*	3.55* 4.22*
Ileum	---	---	---	---	---	---	5.10	---
Caecum	1.65	1.61 5.00*	4.26*	7.46*	4.62* 4.90	4.20* 3.30	---	5.04* 6.05*
Caecum contents	3.46*	2.27*	1.43	4.27*	3.57 3.16	2.76 2.82*	1.90	---
Colon	4.43* 4.76* 4.87*	5.54* 4.57* 7.22*	3.90* 4.03 4.23	5.00* 5.25* 5.04* 4.85*	1.65 5.37* 5.19	3.34 4.55*	4.85* 5.33*	1.04 4.95* 3.85*
Spleen	4.[illegible]* 2.39*	3.64* 3.[illegible]4*	2.77*	1.[illegible]*	2.19	4.75	3.25	---
Pancreas	5.78*	2.[illegible]6 4.39*	5.86	1.[illegible]1	2.[illegible]6	---	---	4.54

[redacted]

[redacted]

Table V (cont'd.)

Summary of Data on Total Beta and Gamma Activities in the Soft Tissues of the Cows

Activity in Terms of Disintegrations Per Second Per Gram Ash (1)

Sample	Cow #1 4-6 yr. old	Cow #2 4-6 yr. old	Cow #3 Yearling	Cow #4 Yearling	Cow #5 Yearling	Cow #6 5-6 yr. old	Cow #7 4-5 mo. old	Cow #8 2-3 yr. old
Kidney	3.97* 2.87* 3.73*	3.36* 4.51* 3.96* 3.88*	3.74* 2.56* 3.28*	1.63 8.89* 4.15*	4.67* 4.39* 2.17	4.93* 4.10* 3.02	4.50* 3.35	5.42* 3.9[illegible]* 4.35*
Adrenal	3.19	---	6.30*	8.43	---	---	5.73	5.82
Ovary	6.70	NS	2.17	4.36	5.92	1.98	---	---
Uterus	6.40	3.72* 2.54	2.19	5.93	4.58	---	---	3.69
Embryo	1.42	---	---	3.06	1.19	1.73	---	2.15
Muscle	5.15* 3.33*	1.96 5.25* 4.55* 3.79*	6.58* 3.86 3.62* 6.38*	2.08 0.95	4.44* 2.00	2.02 6.21* 1.18	2.39*	5.71* 6.81*

(1) Activities marked with an asterisk are based on observed counts which were greater than twice background.

(2) In this table, the symbol, NS, indicates that observed counts were within the limits observed for the background determinations.

[redacted]

[redacted]

Table VI

Summary of Data on Total Beta and Gamma Activities in the Bones and Bone Marrows of Cows

Activity in Terms of Disintegrations Per Second Per Gram Ash (1)

Sample	Cow #1 4-6 yr. old	Cow #2 4-6 yr. old	Cow #3 Yearling	Cow #4 Yearling	Cow #5 Yearling	Cow #6 5-6 yr. old	Cow #7 4-5 mo. old	Cow #8 2-3 yr. old
Ulnar	NS(1) 0.52 0.52 0.21 0.10	NS 0.41 NS 0.20	NS NS NS NS	NS 0.21 NS 0.10	NS NS 0.37 0.55	0.50 NS 0.21 0.81	0.10 0.30	NS 0.64 0.53 NS 0.42 NS 0.43
Carpals	NS 0.27 0.27 0.27	NS NS NS NS	NS 0.41 NS NS	NS 0.27 NS 0.46	0.41 0.10 0.41 0.61	0.41 NS 0.65 0.31	0.31 0.52	0.42 0.83 0.10 0.11
Proximal end of Radius	0.41 0.21 0.09 NS	1.12 0.31 0.20 0.41	NS NS NS NS	0.10 0.41 NS	0.28 NS NS 0.28	NS 0.24 NS NS	0.21 0.30	0.10 NS 0.53
Shaft of Radius	NS NS NS 0.41 NS	0.10 NS 0.51 NS	NS NS 0.21 NS	0.66 NS NS NS	0.09 NS NS NS	NS 0.16 NS NS	NS NS NS NS	0.53 0.11 NS 0.53
Distal end of Radius	0.37 0.37 0.42 0.31	NS NS 0.41 0.31	0.10 NS NS NS	0.46 NS NS NS	0.18 0.20 0.51 NS	NS 0.10 0.20 0.21	0.21 0.31	0.62 0.42 0.72 0.74
Vertebra, Thoracic	NS	NS	NS	NS	0.48	0.50	0.19	NS
Rib	NS NS	NS 0.20	NS 0.33	NS 0.36	NS NS	NS 1.18	NS 0.46	NS 0.34
Ilium, crest	NS	NS	0.39	0.14	3.47	NS	NS	0.17
Ilium, Posterior Spine	NS	0.30	0.31	NS	NS	NS	NS	0.63
Ilium, Ischium Junction	0.55	0.76	0.56	NS	NS	NS	NS	NS
Femur, Head of	NS	0.20	NS	NS	1.07	0.29	0.46	0.35
Acetabulum	NS	NS NS	0.49	NS	1.28	0.10	NS	0.29
Pubic Bone	NS	NS	NS	NS	NS	NS	NS	NS
Coccyx	0.78	---	NS	NS	0.10	NS	0.40	NS
Bone Marrow	0.99	1.10	NS	NS	NS	0.44	3.34	5.19

(1) In this table, the symbol, NS, indicates that observed counts were within the limits observed for the background determinations.

[redacted]

[redacted]

Table VII

Summary of Data of Total Beta and Gamma Activities for Miscellaneous Biological Samples

Type of Samples	Locality	Observed Activity Above Soil mr./hr.	Activity in Sample Dis-integrations/sec./gram ash
Antelope pellets	On asphalt road 1 mile west of Crater	Background	0.62
Cow dung	At Lateral Reference Point #17	0.058	1.33
	Base Camp at Trinity	0.015	5.77(1)
	5 miles south of Negra	0.018	2.00
	Harvey Gate	0.3-0.6	12.5 (1)
Deer pellets	Backside of North Oscuro Peak (Lateral Reference Point #11)	0.148	1.93
	Little Burro Ridge	---	2.28
	Slope of North Oscuro, 6600 feet elevation	0.148	1.19
	North slope of North Oscuro Peak	0.148	2.41
Deer or Elk pellets	175,800 feet on Transect, south of Game Refuge Fence	0.27	4.39 (1)
Dove crop contents	15.1 miles south of Gran Quivira	---	0.37
Horse dung	Nelda Headquarters	Bkg.0.3	3.55
Rabbit stomach contents	1.5 mile south of 4 miles south-west of Duran	0.025	4.17 (1)
Rabbit pellets	5 miles south of Vaughn-Corona road junction	0.035	7.84 (1)
Sheep pellets	North Oscuro Peak	0.148	5.4
Sheep and antelope pellets	Story Tank	0.02	2.48

(1) These values calculated on observed counts more than twice the observed background count.

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DISCUSSION

3.8 Accuracy of Counting Data. Before discussing the results obtained in the radiological assay of the animal samples, it will be necessary to consider the accuracy of counting data close to the background level. For this purpose, reference was made to the report of Jarrett[1] using the following equation:

$$Q = K \sqrt{\frac{N_s}{t_s} + \frac{N_b}{t_b}}$$

where: Q = Error in terms of counts per second.

K = Constant equal to 1.645 for a 0.90 level of significance.

N_s = Counting rate in counts per second for sample plus background.

N_b = Counting rate in counts per second for background.

t_s = Time of counting sample plus background, equal to 500 seconds in these experiments.

t_b = Time of counting background, equal to 500 seconds in these experiments.

3.9 The errors calculated by the above equation for low levels of counting by the procedure used in these experiments are summarized in Table VIII.

Table VIII

Errors in Low Level Counting for the 0.90 Level of Significance

Sample Count Above Background c./sec.	Error Q c./sec.	Error as Per Cent of Sample Count
0.02	0.058	260
0.05	0.059	118
0.10	0.061	61
0.20	0.066	33
0.30	0.070	23
0.60	0.081	13.5
0.90	0.090	10

From the data in Table VIII, it can be seen that the error of counting is quite large for counts *(after correcting for background)* below 0.3 c./sec. which includes over 90 per cent of all animal samples analyzed. However, since control samples also fall within this level, no advantage would ac-

(1) JARRETT, R.A.: STATISTICAL METHODS USED IN THE MEASUREMENTS OF RADIOACTIVITY. JUNE 17, 1946: MON P 126.

crue from reducing this error by increasing the time of counting. The remainder of the data above the level of 0.3 c./sec. can be considered has having an average error of approximately 0.08 c./sec. which is roughly equivalent to a variation of ±15%. These limitations of the data must be kept in mind throughout all future discussions.

3.10 Activities in Small Animals. Since it was decided *(see paragraph 3.6)* that only those observed activities equal to or greater than twice the average background of the counters would be considered as significant, the results of the radiological analyses made on the small animals as given in detail in Tables II, III and IV may be summarized as given in Table IX.

Table IX

Summary of Significant Data on the Total Beta and Gamma Activities found in the Small Animals Collected During the 1947 and 1948 Alamogordo Field Surveys

Type	Total number analyzed	No. showing significant activities	No. with higher activity in GI tract than in carcass	No. with lower activity in GI tract than in carcass	No. in which GI tract not analyzed separately from carcass
Birds	42	14	12	1	1
Mammals	274	20 (1)	14	1	4
Reptiles	86	4	(2)	(2)	(2)
Totals	402 (3)	38	26	2	5

(1) Gastrointestinal tract of one mammal analyzed but corresponding carcass not received for analysis.

(2) Analysis of reptile data not possible since the stomachs of these animals were analyzed as a group from each locality while the animals were analyzed individually.

(3) For these 402 specimens, a total of approximately 1500 determinations were carried out.

3.11 The data in Table IX indicate that of the 28 animals for which separate analyses of gastrointestinal tract and carcass are available, 26 showed higher activities in the former. In fact, inspection of the detailed data in Tables II, III and IV indicate that for 23 of these 26 animals, no significant activity could be detected in the carcasses. These data point very strongly to the fact that active material of some type is passing through the digestive tracts of some of the specimens with little or no evidence for absorption of active materials into the tissues and organs of the animals. Sufficient active material from the digestive tracts of these animals could not be obtained for a definite identification. However, the absence of absorption into the tissues would suggest a very insoluble material which might be either small particles of trinitite or soil particles on which radioactive materials had been fixed. The slight activities found in some of the fecal samples reported in Table VII may be considered as additional evidence for the passage of active materials through the digestive tracts of some of the animals.

[redacted]

3.12 The cases in which some activity was detected in the carcasses can not be considered as positive evidence of storage of radioactive materials in the tissues as there is no way of ascertaining if this material might not be due to contamination. The general procedure of collecting, trapping and shooting might permit some contamination of the carcasses with radioactive materials from the adjacent soil without the material being actually involved in any metabolic process. Great care was taken to prevent as much accidental contamination as was practical in the field.

3.13 From the data in Table IX the frequency of occurrence of animals with significant activities for each of the three groups was found to be:

Birds	33.3%
Mammals	7.3%
Reptiles	4.7%

The high value for birds may be explained on the basis of their normal habit of picking up small particles of sand which is retained in the gizzard. For the mammals a frequency of only 15.5% is found if the calculations are limited to those animals collected within the crater fence. Although some high activities are found in reptiles, external contamination must be considered because of their habitat in close contact with the contaminated soil.

3.14 Activities in Cattle. The detailed data on all samples from the cows as reported in Tables V and VI are summarized in Table X, together with comparable data from 64 samples purchased in the Los Angeles Area from the open market. The observed values are so low that all observed counts greater than the average background are reported. On the basis of data given in Table VIII, the low values *(near background)* for these cow samples may be subject to counting errors of as much as 200 per cent. These errors apply to both experimental and control samples. It may be concluded, Table X, that there are apparently no significant differences between the total beta and gamma activities of these two groups, one from the desert area and one from the Los Angeles open market. Furthermore, no significant differences could be observed from the detailed data of Tables V and VI between the activities of the cattle of different ages.

3.15 The data on the cattle indicate no accumulation of radioactive materials. This may be interpreted in one of four ways:

1. The cattle were never exposed to contaminated material from the fall-out since they were at all times in uncontaminated regions of the Chupadera Mesa. *(See paragraphs 3.3 and 4.)* In the case of Cows #2 and #6 this would not apply.

2. Although the cattle may have been in contaminated regions, they did not ingest or inhale significant amounts of radioactive materials.

Table X

Summary of Range and Average Total Beta and Gamma Activities in Tissues of Cows from Alamogordo and in Comparable Control Samples

Type of Sample	Alamogordo Samples No.	Range	Average	Control Samples (1) No.	Range	Average
	Activity in Disintegrations per second per gram ash					
Skin	24	0-4.85	1.86	-	---	---
Blood	16	0-2.09	0.54	-	---	---
Heart	14	1.61-6.25	4.28	7	4.27-6.89	5.51
Lymph node	9	2.19-7.39	4.25	-	---	---
Lung	20	2.79-8.89	4.69	-	---	---
Liver	22	0.55-6.40	4.11	6	0-6.15	3.39
Gall Bladder and Bile	7	0-4.34	1.34	-	---	---
Rumen	26	1.55-7.37	4.20	8	0-7.22	3.21
Duodenum	12	2.00-4.83	3.93	-	---	---
Ileum	1	---	6.10	-	---	---
Caecum	11	1.05-7.46	4.41	-	---	---
Caecum Contents	9	1.43-4.27	2.84	-	---	---
Colon	23	1.04-7.22	4.57	5	3.19-6.01	.74
Spleen	9	1.98-4.75	3.23	6	4.13-6.21	4.98
Pancreas	7	1.91-5.86	3.87	1	---	4.75
Kidney	24	1.63-8.29	3.97	6	2.82-7.17	4.31
Adrenal	5	3.19-8.43	5.89	-	---	---
Ovary	6	0-6.70	3.52	-	---	---
Uterus	7	2.19-6.40	4.15	-	---	---
Embryo	5	1.19-3.06	1.91	-	---	---
Muscle	20	0.95-6.31	3.91	7(2)	2.24-9.20	5.04
Bone	234	0-3.47	2.01	13	0-2.44	0.27
Bone Marrow	8	0-5.19	1.39	5	0-17.3	4.99

(1) These samples were purchased on the open market in the Los Angeles Area.

(2) These values are for samples of hamburger.

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3. If radioactive materials were ingested or inhaled by the cattle it was in such a form as to be unavailable for assimilation, a condition already suggested for the small mammals. (See paragraph 3.2)

4. Exposure was essentially a single exposure phenomenon, so that excretion was able to eliminate all but the traces found.

3.16 At the present time no data are available which would permit drawing any conclusions concerning which of the above four explanations are applicable. The survey in effect says only that these cattle are not contaminated with significant amounts of fission materials. It is hoped that additional data obtained from future investigations on small mammals may throw some light on this problem. Additional work on cattle with respect to the accumulation of radioactive materials does not seem justified at this time but should be postponed until such a time as soil and plant studies indicate that active materials are readily available for assimilation by animals.

3.17 Since it is known that animal and plant tissues all contain potassium, some of the observed activities must be due to the presence of the radioactive isotope of this element. Furthermore, radium and radioactive carbon, have recently been reported (1) as normal constituents of animal tissues. It would also seem likely that the normal radioactivity of living matter might also be due to the presence of radioactive isotopes of uranium and of the thorium series. It is quite possible that the activities observed in the animals and plants from the Trinity Area may be accounted for in part, or even entirely, by this naturally occurring activity. Additional work which is now in progress will have to be completed before this factor can be satisfactorily evaluated. Further work is also required to determine whether or not some radioactivity is lost by the ashing methods used in these experiments. The extent to which plutonium is present in these samples is not known at this time.

3.18 Relationship between Contamination and Activities in Animals. Only the data for the small animals can be discussed in relation to the degree of contamination. The data as given in Tables II, III and IV indicate the majority of animals showing significant activities were collected from one of three localities which are those of highest activity:

1. The area within the crater fence.
2. The area outside of but adjacent to the crater fence.
3. The area on Lateral 2, approximately 0.5 to 1.5 miles to the west of this reference point from the transect.

Some of the birds (*especially those from Cooper Wells*) were collected at a

(1) GROSSE, A.V. AND W.F. LIBBY: COSMIC RADIOCARBON AND NATURAL RADIOACTIVITY OF LIVING MATTER. SCIENCE, VOLUME 105, 88-89 (1947).

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distance from all of the above areas. These exceptions may be due to the more extended range of birds in comparison to those of the small mammals and reptiles.

3.19 Although significant activities in the small animals are apparently associated with regions of greatest contaminations, only a small proportion of the animals collected in any one region show significant activities. In no case did all the animals collected in any one locality, irrespective of the degree of contamination, show significant levels of activities. This suggests that the animal uptake of radioactive materials involves the purely chance periodic surface contamination of food and cannot be attributed to the continuous ingestion of food in which active materials were incorporated. In the latter case one would expect to find some activity, even though slight, in all animals. It is probable that all animals in the contaminated areas would show at some time the presence of active materials in the digestive tract.

3.20 Evidence of Radiation Damage. From a study of a total of 402 small animals collected during the 1947 and 1948 Alamogordo Field Surveys, no gross evidence has been obtained that would indicate radiation damage. We have not yet, however, undertaken detailed histological studies of materials preserved for this purpose.

3.21 Ecological Aspects of Survey. Although a large number of animals were studied in the field, collections were spread out over a number of localities. As a result only a few animals, usually ten or less including representatives of several genera, were collected in any one area, a number insufficient to permit any conclusions as to the population changes. This phase of the survey was also handicapped by the paucity of collections from uncontaminated control areas. In the devastated area within the crater fence, reinvasion by small animals is taking place apparently controlled by the reestablishment of plant cover and plant food. It is possible that after several years' study of the Trinity Area some data of significance with respect to the ecology of the region might be obtained.

3.22 Evidence for Biological Hazards. Available evidence indicates that some insoluble radioactive materials are passing through the digestive tracts of some of the small animals. However, this does not seem to be a continuous process but rather one that occurs at undetermined intervals. The maximum values in the digestive tract are equivalent to approximately 6.5×10^{-3} microcuries for one specimen of *Otocoris alpestris* collected one mile north of the crater fence and 1.4×10^{-3} microcuries for one specimen of *Sylvilagus* collected at the hut near the northwest crater fence. It should also be mentioned in this regard that the lizard, *Uta stansburiana*, collected 1.2 miles west of Lateral 2, [illegible], contained a total of 6.7×10^{-3}

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microcuries for the entire animal.

3.23 From the above data there arises the question of the biological hazards arising from the intermittent passage through the digestive tract of less than 0.01 microcuries of insoluble radioactive materials. In the absence of data relative to the frequency and duration of occurrence of this process, no estimate can be made as to the total internal radiation exposure of any animals collected in the Alamogordo Area. Furthermore, no specific information is available concerning which isotopes are involved. Therefore, until detailed laboratory investigations can be completed involving continued exposure of animals to low levels of activity comparable to those found for field animals, the question of probable biological hazards must remain unanswered.

SUMMARY

3.24 Of a total of 402 small animals collected during the 1947 and 1948 Alamogordo Field Surveys, only 38 showed significant values for total beta and gamma activities all of these under twenty times the background level. Evidence accumulated thus far indicates that activity when present in the small animals was associated almost exclusively with the digestive tract. We have no substantial indication of tissue accumulation. Furtheremore, the maximum activities were always very low, failing to reach a maximum equivalent to 0.01 microcuries per animal.

3.26 Although active animals were collected primarily from areas of relatively high soil activity, in no case did all of the animals from any one region show significant levels of activity.

3.27 Animal contamination apparently involves the intermittent passage of insoluble radioactive materials through the digestive tract. The frequency and duration of this process cannot be determined on the basis of available data.

3.28 No significant differences in activities could be found between 519 samples of tissues from the 8 cows from the Chupadera Mesa and 64 comparable samples of tissues purchased in the Los Angeles Area from civilian sources.

3.29 Due to the low levels of activities found in the animals from the Alamogordo Area and the absence of controlled laboratory data for such activity levels, no conclusion can be reached at this time concerning the presence or absence of biological hazards in the contaminated areas.

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THE 1948 RADIOLOGICAL AND BIOLOGICAL SURVEY OF
AREAS IN NEW MEXICO AFFECTED BY THE
FIRST ATOMIC BOMB DETONATION

4. BIOLOGICAL SURVEY - PLANTS

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INTRODUCTION

4.1 This section of the Biological Survey had as its primary function the determination of the extent to which plants were accumulating radioactive materials and the factors influencing this process. In addition to the above primary objective of the plant group, the following secondary problems were also investigated:

1. Evidence of direct irradiation damage in plants in the Trinity Region or appearing in their descendents.

2. Factors influencing the reinvasion of the devastated part of the Trinity Region.

3. Role of plants in the metabolic cycling of contaminants to the animals.

EXPERIMENTAL PROCEDURES

4.2 Field Sampling. Plant and soil samples were collected for radiological assay at each site so that a comparison of their radioactivity could be readily made. In addition, plants were collected for classification and preparation as herbarium specimens.

4.3 Field Localities. All plant specimens can be located with respect to one of the eight regions given below (1):

1. General Reconnaissance Series *(see paragraph 2.25)*: Samples were collected at intervals on the General Reconnaissance Survey for confirmation of comparable soil and survey data.

2. Perimeter Series *(see paragraph 2.37 and Table IV)*: Samples were collected at the end of each Lateral so that confirmation of the background level could be obtained.

3. Crater and Fenced Area of Trinity Region *(see paragraph 2.3)*: Plants were collected along two transects across the Crater at right angles to one another at 0, 25, 50, 75, 100, 125, 175, 225, 300, 400, 500, 600, 800, 1000, 1200 and 1400 feet from the center.

4. Primary Transect Reference Line *(see paragraph 2.26)*: The soil and grass samples were collected at intervals of 4930 feet for the entire length of the transect.

5. Lateral 2, Left *(see paragraph 2.26 and 49 and Figure 8)*: Grass samples were taken at 0.1-mile intervals for the first mile and then every 0.2 mile to a distance of 2.6 miles northwest of the Primary Transect Ref-

(1) REFERENCE SHOULD BE MADE TO FIGURES 1, 2 AND 3 IN THE RADIOLOGICAL SECTION, PART 1, OF THIS REPORT FOR DETAILS CONCERNING THESE LOCALITIES.

erence Line.

6. Harvey Gate Series *(see paragraph 2.54 and Table XII)*: Using the gate on the north side of Harvey's Ranch as a reference point a series of soil profiles was taken. Within a 15- to 20-foot radius of each of these profiles, samples of all of the grass, shrub and tree species were collected.

7. Claunch Agricultural Area *(see paragraph 2.7)*: Crop plants were collected along the roads running north, south and west of Claunch.

8. Control Region: These plants were collected from a number of localities which are reported in subsequent paragraphs of this report.

4.4 Sample Preparation: In an attempt to determine whether or not radioactive materials were localized in specific parts of the grass samples, they were divided into the following fractions:

1. Tops: the green upper portion and the inflorescence.
2. New stubs: the leaf sheaths and the basal portions from which the tops had been cut.
3. New roots:
4. Old stubs: old dead stems and leaves from previous years' growth
5. Old roots: any roots attached to the old dead stems or rhizomes.

Other plants were also divided into fractions as indicated in subsequent paragraphs.

4.5 Preliminary experiments indicated that some of the soil particles adhering to the plant surface might contribute to the observed activity. To reduce this contaminating factor to a minimum, all plant materials were washed with agitation and scrubbing in a dilute detergent solution *("Aerosol")* until all visible soil particles were removed. After thorough washing in distilled water, the fractions were dried overnight at 80°C, ground in a Wiley mill and finally ashed at 600°C for twelve hours. For counting, 0.500-gram samples were weighed out into metal cups.

4.6 Radiological Assay of Samples: All samples were counted in duplicate using the equipment and general procedure previously described *(see paragraphs 2.28 and 29)*. This procedure was modified for samples from outside the Crater by increasing the counting time to 3000 or 4000 seconds for increased accuracy. All data are reported in terms of disintegrations per second per gram of plant ash *(dis./sec./gm.)*. The data have not been corrected to zero-mass because of the low level of the activity and of the absence of data on the isotopes responsible for the observed activities.

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RESULTS OF RADIOLOGICAL ASSAYS

4.7 The results of the radiological assays of plant materials are summarized in nine tables as follows:

Table XI: Total beta and gamma activity in the plants from uncontaminated control areas.

Table XII: Total beta and gamma activity in the plants from the General Reconnaissance.

Table XIII: Total beta and gamma activity in plants from the terminals of the Laterals.

Table XIV: Total beta and gamma activity in the ash of *Corispermum nitidum* within the fence of the Trinity Region along radii T-0 and T-180.

Table XV: Total beta and gamma activity in the ash of *Corispermum nitidum* within the fence of the Trinity Region along radii T-90 and T-270.

Table XVI: Total beta and gamma activity in grasses from the Primary Transect Reference Line.

Table XVII: Total beta and gamma activity in the plants along Lateral 2, left.

Table XVIII: Total beta and gamma activity in the trees and shrubs of the Harvey Gate Series.

Table XIX: Total beta and gamma activity in crop plants.

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Table XI

TOTAL BETA AND GAMMA ACTIVITY
IN THE PLANTS FROM UNCONTAMINATED, CONTROL AREAS

Agricultural Crops:

Locality	Plants	Miscellaneous Type	Miscellaneous Activity	Leaves	Stems	Seeds	Roots
			Activity in dis./sec./gm. ash				
Las Cruces, N.M.	Cotton	Fibers	Bkg.	---	---	6.83	---
Deming, N.M.	Cotton	Fibers	4.05	2.82	7.53	7.13	9.20
9 miles SW of Crater (1)	Peas	Pods	7.69	1.26	3.07	7.9	4.52
	Wheat	Chaff	1.36	3.00	5.2	5.74	2.41
Covina, Calif.	Oats (young plants)				9.87(2)	---	4.65
	Brassica campestris				7.94(2)	---	8.02
San Dimas, Calif.	Oats (young plants)				10.3 (2)	---	3.75
	Brassica campestris				7.93(2)	---	9.52
7.7 miles E of Cabazon, Calif.	Oats (young plants)				10.02(2)	---	3.61
5 miles SW of Banning, Calif.	Wheat	Chaff	4.0	9.75	9.65	5.72	5.12
	Barley	Chaff	2.14	2.91	9.67	5.68	3.87
Los Angeles, Calif.	Peas	Pods	8.19	5.45	5.6	9.46	11.1
	Cauliflower			5.23	6.64	---	4.45
	Lettuce			8.41	7.15	---	1.78
	Wheat	Chaff	3.85	3.72	7.59	7.4	1.36
Uncultivated Plants:							
Mohave Desert, Calif.	Juniper	Berries	8.73	---	---	---	---
		Bark	0.97	---	---	---	---
		New leaves & branchlets	3.36	---	---	---	---
		Old leaves & branchlets	3.12	---	---	---	---
		Wood	2.42	---	---	---	---
Barstow, Calif.	*Salsola pestifer*	Entire plant	5.84				

(1) Peas and wheat were grown at the project in soil collected at this locality.

(2) These data are for leaves and stems combined as a single sample.

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Table XII

TOTAL BETA AND GAMMA ACTIVITY
IN THE PLANTS FROM THE GENERAL RECONNAISSANCE

Number of Samples	Reference Point	Activity Range dis./sec./gm. of ash
5	7 to 27 miles east of San Antonio on U.S. 380	Background to 6.7
13	2 to 35 miles east of Bingham on U.S. 380	0.10 to 11.6
10	5 to 50 miles north of Carrizozo on U.S. 54	1.69 to 10.75
15	5 to 44 miles west of Corona *(Junction of U.S. 54 and N.M. 42)*	1.00 to 9.34
22	5 to 33 miles west of Claunch *(west on N.M. 42 and south from Claunch)*	2.8 to 10.2
3	1 to 2.5 miles east of 7 miles west and 7 miles south of Claunch on N.M. 161	4.66 to 10.16
10	0.1 to 46 miles east of Palma	Background to 5.0
7	1.3 to 26 miles north of Vaughn	1.2 to 7.0
10	within 15 miles to west and south of Vaughn	2.1 to 9.3
7	11 to 25 miles south of Gran Quivira	2.29 to 18.6
3	Gallinas Peak Area	3.62 to 12.0

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Table XIII

TOTAL BETA AND GAMMA ACTIVITY
IN PLANTS FROM THE TERMINALS OF THE LATERALS

Lateral Reference Point	Distance and Directions from Reference Point	Grass Species	Disintegrations per second per gram of ash: Tops	Bottoms	Whole Plant
1	1.9 miles left	*Sporobolus airoides*	4.95	1.11	
2	2.9 " "	*Triodia pulchella*	4.92	9.24	
3	3.5 " "	*Sporobolus airoides*			9.94
3A	3.5 " "	*Aristida Fendleriana*	4.8	3.43	
4		No sample			
5	3.6 " "	*Triodia pulchella*	2.16	1.58	
6	5.0 " "	*Sporobolus airoides*	5.15	6.5	
7	4.4 " "	*Sporobolus airoides*	4.34	1.65	
8	5.0 " "	*Aristida Fendleriana*	2.19	1.2	
9	5.0 " "	*Aristida Fendleriana*	3.25	3.91	
10	6.0 " "	*Aristida Fendleriana*	2.22	1.55	
11		No sample			
12	5.8 " "	*Sporobolus cryptandrus*	4.9	2.96	
13	5.1 " "	*Aristida Fendleriana*	3.6	1.63	
14	3.8 " "	*Hilaria Jamesii*	3.33	2.48	
15	2.7 " "	*Hilaria Jamesii*	2.53	1.54	
16	3.2 " "	*Aristida purpurea*	3.31	2.58	
17	2.4 " "	*Hilaria Jamesii*	3.32	1.54	
18	1.4 " "	*Bouteloua gracilis*	3.35	2.37	
19	1.6 " "	*Muhlenbergia Torreyi*	3.74	1.57	
20	2.4 " "	*Bouteloua gracilis*	10.9	1.75	
21	3.0 " "	*Aristida Fendleriana*	5.1	10.5	
22	3.8 " "	*Aristida purpurea*	2.47	1.81	
23	4.3 " "	*Aristida purpurea*	Bkg.	Bkg.	
1	0.8 " right	*Sporobolus Nealleyi*	4.26	1.9	
2	0.5 " "	*Triodia pulchella*			1.59
3A	0.2 " "	*Triodia pulchella*			5.68
3	0.4 " "	*Sporobolus airoides*			1.18
4	1.2 " "	*Bouteloua eriopoda*	2.22	0.938	
5	1.8 " "	*Muhlenbergia Torreyi*			1.38
6	2.4 " "	*Bouteloua eriopoda*			3.56
7	1.0 " SE of Story Well	*Sporobolus cryptandrus*	4.74	1.97	
8	3.8 miles right	*Bouteloua gracilis*	5.5	8.1	
9		No sample			
10	1.0 " SE of Oscuro Ridge	*Stipa lobata*			1.75
11	3.0 miles from Bruton Tank	*Bouteloua eriopoda*	1.27	14.5	
12		No sample			
13	6.9 miles right	*Aristida Fendleriana*	3.14	3.82	
14	5.0 " "	*Bouteloua gracilis*	6.25	1.16	
15	5.2 " "	*Bouteloua gracilis*	3.51	1.23	
16	5.2 " "	*Muhlenbergia setifolia*	1.04	0.92	
17	6.4 " "	*Muhlenbergia Torreyi*			1.73

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Table XI.. (cont'd)

TOTAL BETA AND GAMMA ACTIVITY
IN PLANTS FROM THE TERMINALS OF THE LATERALS

Lateral Reference Point	Distance and Directions from Reference Point		Grass Species	Disintegrations per second per gram of ash		
				Tops	Bottoms	Whole Plant
18	6.4 miles	right	*Bouteloua gracilis*			1.51
19	6.4 "	"	*Muhlenbergia setifolia*	2.07	7.76	
20	6.5 "	"	*Aristida Fendleriana*	4.2	3.16	
21	5.8 "	"	*Muhlenbergia Torreyi*	3.18	1.48	
22	7.1 "	"	*Muhlenbergia Torreyi*			1.84
23	6.6 "	"	*Sporobolus sp.*	6.69	3.83	
23A	6.6 "	"	*Aristida Fendleriana*			2.78

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Table XIV

TOTAL BETA AND GAMMA ACTIVITY IN THE ASH OF *CORISPERMUM NITIDUM* WITHIN THE FENCE OF THE TRINITY REGION ALONG RADII T-0 AND T-180

	Radius T-0		Radius T-180	
Feet from center	Per cent ash	Activity dis./sec./gm.	Per cent ash	Activity dis./sec./gm.
0	10.9	42.1	---	---
25	11.6	44.7	15.0	57.7
50	13.5	47.8	15.4	35.5
75	---	30.18	12.4	41.7
100	11.7	36.1	13.7	23.7
125	12.6	35.5	11.1	26.6
175	15.5	27.9	11.5	18.0
225	11.7	23.2	12.5	15.4
300	12.2	14.6	11.1	11.0
400	10.6	10.5	13.3	11.0
500	14.1	8.4	15.0	7.19
600	13.1	10.5	9.9	8.25
800	10.4	7.32	10.8	8.25
1000	12.1	7.52	13.0	7.82
1200	9.5	4.95	10.5	6.34
1400	---	8.61	12.0	6.34

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Table XV

TOTAL BETA AND GAMMA ACTIVITY IN THE ASH OF *CORISPERMUM NITIDUM* WITHIN THE FENCE OF THE TRINITY REGION ALONG RADII T-90 AND T-270

	Radius T-90		Radius T-270	
Feet from Center	Per cent ash	Activity dis./sec./gm.	Per cent ash	Activity dis./sec./gm.
0	10.9	42.1	---	---
25	10.0	95.2	11.7	68.6
50	11.9	38.8	14.1	45.5
75	10.8	51.1	10.2	128.7
100	14.0	82.1	14.6	36.3
125	13.2	19.0	11.7	37.8
175	16.0	19.2	11.9	26.8
225	13.6	16.57	12.3	21.2
300	14.9	13.2	13.5	11.9
400	10.5	9.44	12.2	9.04
500	13.3	9.37	10.2	9.44
600	12.8	6.49	10.4	10.05
800	13.1	8.65	10.4	12.45
1000	10.5	9.08	9.8	7.5
1200	12.3	7.79	12.4	7.73
1400	10.8	6.49	10.8	8.16

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Table XVI

TOTAL BETA AND GAMMA ACTIVITY IN GRASSES FROM THE PRIMARY TRANSECT REFERENCE LINE

Reference Point	Distance From Zero Feet	Grass Species	Activity in dis./sec./gm. of ash Tops	New stubs	New Roots	Old Stubs	Old Roots
1	4,930	*Sporobolus airoides*	5.19	3.9	---	77.4	5.23*
2	9,860	*Sporobolus airoides*	4.48	3.13	2.41	10.08	5.32
3	14,790	*Sporobolus airoides*	4.22	2.94	---	3.24	1.78*
4	19,720	*Sporobolus airoides*	4.21	2.66	4.47	1.64	2.53
5	24,650	*Sporobolus airoides*	5.02	2.69	4.88	2.42	4.59
5		*Muhlenbergia arenacea*	5.36	4.34**	---	---	6.4 *
6	29,580	*Sporobolus airoides*	4.42	2.66	---	5.89	8.72*
6		*Triodia pulchella*	4.1	3.78	---	7.32	5.88*
7	34,510	*Bouteloua gracilis*	4.32	4.62	6.58	4.91	3.96
7		*Sporobolus contractus*	3.69	3.46	---	4.56	7.85*
8	39,440	*Bouteloua gracilis*	3.84	4.46	8.26	5.19	4.48
9	44,370	*Bouteloua gracilis*	2.17	2.62	4.17	4.85	5.71
9		*Muhlenbergia Torreyi*	2.4	2.44	4.35	44.1	2.34
10	49,300	*Bouteloua eriopoda*	2.32	5.06	5.88	6.21	7.8
11	54,230	*Bouteloua gracilis*	3.92	2.62	4.46	6.04	1.47
12	59,160	*Bouteloua gracilis*	1.26	2.18	5.07	2.97	3.04
13	68,160	*Sporobolus Wrightii*	5.17	3.22	3.04	3.52	1.2
13		*Bouteloua eriopoda*	3.67	2.99	---	3.88	0.476*
13A	72,660	*Aristida arizonica*	3.62	2.66	---	4.41	5.56*
13A		*Muhlenbergia setifolia*	3.77	2.59	---	4.24	---
14	77,160	*Bouteloua eriopoda*	3.45	4.9	---	6.6	1.78*
14A	81,660	*Aristida Fendleriana*	1.95	1.34	---	3.36	0.385*
15	86,160	*Bouteloua gracilis*	4.32	2.6	6.26	7.08	3.84
15A	90,660	*Bouteloua gracilis*	3.33	2.98	---	3.99	4.88*
16	95,160	*Sporobolus nealleyi*	4.83	8.53	---	8.91	7.62*
16A	99,660	*Aristida Fendleriana*	5.54	3.4	---	10.37	10.73*
17	104,160	*Bouteloua eriopoda*	7.4	7.0	6.71	9.62	3.71
17A	108,660	*Muhlenbergia Torreyi*	5.39	5.64	---	10.38	9.63*
18	113,160	*Bouteloua eriopoda*	5.37	12.61	10.72	23.5	9.07
18A	117,660	*Aristida glauca*	14.34	14.58	14.73	22.23	33.01
18A		*Muhlenbergia setifolia*	12.34	10.79	3.01	18.03	8.34
19	122,160	*Muhlenbergia setifolia*	17.31	16.39	5.92	31.72	10.03
19A	126,660	*Aristida arizonica*	13.46	13.00	8.94	27.60	4.62
20	131,160	*Bouteloua gracilis*	13.08	16.56	---	42.40	26.25*
20A	135,660	*Muhlenbergia setifolia*	24.80	30.65	---	49.70	10.77*
21	140,160	*Muhlenbergia setifolia*	16.05	30.00	12.3	63.00	7.08
21A	144,660	*Muhlenbergia setifolia*	10.41	27.07	9.65	47.30	9.50
22	149,160	*Muhlenbergia setifolia*	9.39	21.34	9.59	38.4	10.33
22A	153,660	*Muhlenbergia Torreyi*	8.11	5.26	9.94	26.20	11.16
22A		*Aristida glauca*	10.29	10.34	---	28.2	9.12*
23	158,160	*Bouteloua gracilis*	9.42	16.63	14.37	17.07	24.65
23A	162,660	*Bouteloua gracilis*	5.74	5.96	10.45	20.44	13.30

* New and old roots combined.

** New and old stubs combined.

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Table XVII

TOTAL BETA AND GAMMA ACTIVITY
IN THE PLANTS ALONG LATERAL 2, LEFT

Reference Point	Species	Activity in dis./sec./gm. of ash: Tops	New Stubs	Old Stubs	Roots
0.0	*Aristida glauca*	2.75	2.52	2.37	2.91
0.1	*Sporobolus airoides*	4.64	2.61	2.33	3.90
0.2	*Sporobolus airoides*	2.67	5.02	91.2	1.64
0.3	*Aristida glauca*	4.15	---	3.98	5.5
0.4	*Scleropogon brevifolius*	3.38	5.04	7.34	7.15
0.5	*Bouteloua eriopoda*	4.13	6.9 *	---	4.57
0.6	*Sporobolus airoides*	10.75	5.92*	---	3.13
	Bouteloua eriopoda	6.18	9.98*	---	9.0
0.7	*Sporobolus airoides*	5.19	5.86	8.47	10.57
	Scleropogon brevifolius	9.1 **	---	---	---
0.8	*Sporobolus airoides*	4.3	3.44*	---	2.64
	Aristida glauca	3.26	---	6.51	1.75
0.9	*Sporobolus Nealleyi*	0.83	5.07	8.53	9.88
	Triodia pulchella	7.32**	---	---	---
1.0	*Sporobolus Nealleyi*	6.01	---	9.8	13.2
1.2	*Sporobolus airoides*	6.52	3.5 *	---	17.27
	Muhlenbergia Porteri	8.64	---	12.37	12.8
1.4	*Sporobolus airoides*	4.07	---	4.43	9.33
	Aristida glauca	5.42**	---	---	---
1.6	*Aristida glauca*	4.62	---	5.21	22.2
1.8	*Sporobolus airoides*	7.01	4.16	4.46	7.64
2.0	*Sporobolus airoides*	6.46	4.62	4.52	3.34
2.2	*Sporobolus airoides*	3.9 **	---	---	---
	Aristida glauca	3.54**	---	---	---
2.4	*Sporobolus airoides*	3.10**	---	---	---
	Aristida glauca	3.82	---	2.1	2.59
2.6	*Aristida longiseta*	1.71	1.81***	---	---

* Includes old stubs.

** Entire plant.

*** Includes old stubs and roots.

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Table XVIII

TOTAL BETA AND GAMMA ACTIVITY
IN THE TREES AND SHRUBS OF THE HARVEY GATE SERIES

	Activity in dis./sec./gm. of ash			
Plant	0.3 mi. W.	0.0 Gate	0.2 mi. E.	0.9 mi. E.
Juniperus monosperma				
Berries	---	9.69	---	6.9
New growth	9.55	11.1	7.06	7.3
Recent growth	13.2	15.4	8.3	13.93
Older growth	31.7	13.7	11.93	17.75
Bark	79.0	65.1	16.6	62.6
Duff	41.6	44.8	52.6	30.2
Eurotia lanata				
Young stems and leaves	14.35	18.25	16.35	
Older stems	40.99	32.2	20.3	
Woody base	7.11	43.8	27.8	
Roots	20.55	29.3	28.7	
Atriplex canescens				
Leaves		10.89		8.63
Young stems		7.21		9.8
Older stems		18.25		1[illegible].08
Roots		62.0		
Pinus edulis				
Needles				12.7
Bark				47.7
Coldenia hispidissima				
Young stems and leaves.				51.0
Older stems				52.3
Woody base and roots				70.4
Senecio spartioides				
Leaves and fruit				9.35
Young stems				6.12
Older stems				17.8
Woody base				46.8

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Table XIX

TOTAL BETA AND GAMMA ACTIVITY
IN CROP PLANTS

Locality	Plant	Soil Activity d./s./g.	Miscellaneous Type	Miscellaneous Activity	Leaves	Stems	Seeds	Roots
Jarretts, 2.0 mi. S	Corn	1.2	Corn & cob	9.07	5.29	8.95	---	6.26
			Tassel	4.52				
	Beans				1.97	1.67	7.50	1.35
Jarretts, 2.0 mi. S & 1.3 mi. E	Sorghum	1.1			3.62	8.6	2.66	3.03
2.0 mi. S & 1.8 mi. E	Sorghum			1.1	1.34	7.6	1.93	2.95
2.0 mi. S & 2.0 mi. E	Milo	0.49			2.15	7.03	4.08	5.35
Claunch,								
3.5 mi. W	Beans	0.35			4.44	0.55	7.8	2.03
1.8 mi. W	Corn	0.05	Tassel	3.0	3.36	7.4	6.45	4.43
0.9 mi. S	Corn	0.46			2.69	8.45	8.75	4.76
0.7 mi. N	Beans	Bkg.			2.10	1.98	7.35	2.94
1.1 mi. N	Oats	Bkg.			4.94	7.07	1.44	5.0
2.2 mi. "	Sudan	0.10			2.41	7.35	1.51	2.18
2.2 mi. N	Kaffir	0.23			2.69	6.22	3.38	3.46
3.3 mi. N	Barley	0.12			3.43	7.95	2.99	5.16
4.9 mi. N	Sudan	0.58			2.53	9.2	3.25	1.94
4.9 mi. N	Corn	0.58	Tassel	0.59	3.48	7.57	5.35	2.58
5.4 mi. N	Beans	0.97			3.22	1.36	7.05	---
San Antonio,								
0.3 mi. E	Kaffir	Bkg.			2.14	11.65	5.15	8.2
0.3 mi. E	Beans				4.83	6.35	6.97	Bkg.

4.8 Plant Background. Before considering the radioactivity found in plants collected from areas known to have been contaminated from the fall-out of the First Atomic Bomb Detonation, it will be necessary to discuss the activity levels found in plants from other areas not affected by the bomb. These data have been summarized in Table XI. These data have been first considered with respect to crop plants *(with two samples of Brassica)* which were grown in cultivated areas in which fertilization, as well as proper spacing of plants miminizing competition for the available minerals, are factors that may increase among other nutrients, potassium in the soil. If so, the proportional increase in K^{40} would tend to increase the plant background. There is also the possibility that traces of the elements of the thorium series may also contribute to this plant background.

4.9 Various parts from these cultivated plants show an increase of activity by a factor of two or three over uncontaminated plants from Barstow and the Mojave Desert in California, with the exception of the juniper berries, a fruiting structure. The samples from Covina, San Dimas and Cabazon were young plants in a flush of growth and contained activities of approximately 10 dis./sec./gm. of ash. The various other mature crop plants, in which samples of all of the parts are shown, show a considerable transfer of activity to the seed or fruiting structure. This shift in activity parallels the movement of potassium as shown by Hartt.[1] Miller[2] cites a series of authors who have demonstrated the location and amount of potassium in plants. They found concentrations in the meristem and leaves and later shifting to the fruit.

4.10 It is evident that all plants will show some activity due to K^{40} and perhaps other radioactive materials. In evaluating the data on the activity of plants collected from contaminated soil we are forced to use, for the time being, activity data on plants from the perimeter of the contaminated area, Table XIII, which may not have been background. From these data we have taken, more or less arbitrarily, the figure of 5.0 dis./sec./gm. of ash as the normal plant background. While this figure is based on grasses and should err somewhat on the high side it furnishes a basis for estimating the extent to which plants in the contaminated area have picked up radioactivity.

(1) HARTT, C.E., SOME EFFECTS OF POTASSIUM UPON THE GROWTH OF SUGAR CANE AND UPON THE ABSORPTION AND MIGRATION OF ASH CONSTITUENTS, PLANT PHYSIOL., 9:399-451. (1934).

(2) MILLER, E.C., PLANT PHYSIOLOGY, MCGRAW - HILL BOOK CO. INC., NEW YORK. (1938).

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4.11 Agricultural crops and other plants growing on fertilized or fallow soil probably will show a higher background *(see Table XI)*. Young, vigorously growing plant parts with a higher protein content and considerable merismatic tissue, as well as fruits of various types, may be expected to show a higher natural background. These values for plant background may be modified as more data becomes available by any one or more of the following points:

1. It may have to be lowered, particularly for mature vegetative tissues.

2. An additional factor to be considered is that naturally-occurring radioactive isotopes in plants may be replaced or exchanged or a portion of their normal uptake suppressed, by the presence of available radioactive materials from the fall-out. Since in the majority of the plants of this area the ash represents approximately ten per cent of the dry weight, the above estimated activity level of 5.0 dis./sec./gm. of ash is equivalent to about 0.5 dis./sec./gm. of dry plant.

4.12 Grasses from the General Reconnaissance. In the General Reconnaissance *(see paragraph* 2.25) an attempt was made to get a general idea of the extent of contamination which would require a more detailed radiological survey. In addition to the readings made with the survey meter over the soil, plant samples were also collected for radiological analysis. The results of these analyses have been summarized in Table XII. A detailed mapping of the data has not been shown, but the majority of the plant ash samples gave activities below the level of 5.0 dis./sec./gm. of ash. Some samples, particularly in the Bingham Region, in the Gran Quivira Region as well as in other areas along the line of drift, show activities above this level. These values will be reported and discussed in greater detail after a more detailed study of background material has been completed.

4.13 Plants from the Terminals of the Laterals. In paragraphs 2.36 and 37, the extent of contamination was discussed on the basis of the detailed survey of the 23 Laterals using the radiological survey instruments. Since it was thought that plants growing in soil of background activity might accumulate activity above this observed level, plants were collected at the terminals of the Laterals to obtain confirmatory data on the background perimeter. The activities in terms of dis./sec./gm. of ash as summarized for these plants in Table XIII show only a few values that indicate some accumulation. It therefore appears safe to conclude that the background perimeter as indicated on the Detailed Lateral Radiological Survey Map *(see Figure 3, filed inside the back cover, Part 1,)* is essentially a true picture of the extent of contamination, with some slight extensions being suggested on the Laterals showing a value above 5.0 dis./sec./gm. of ash. This again may require some modifica-

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tion pending a more detailed study of background values.

4.14 Plants within the Fence of the Trinity Region. Since the Radiological Survey has shown *(see Table V)* that the area within the fence in the Trinity Region has the highest activity as measured by survey instruments, plants from this area might be expected to show significant uptake of activity. The results of the radiological analyses of representative plants along four radii have been summarized in Tables XIV and XV. It is at once apparent that all plants farther than 300 feet from the center and therefore, outside of the actual Crater, while showing activities well below those within the Crater, are still above the level of 5.0 dis./sec./gm. of ash. Within the Crater, the activities tend, in general, to increase as the center is approached. Final interpretation of these results can not be made until these values have been corrected for the concentration of the naturally-occurring radioactive materials in the plant ash.

4.15 Grasses from the Primary Transect Reference Line. The grasses collected along the Primary Transect Reference Line were subdivided into five parts as previously described *(see paragraph 4.4)*. All radiological assays for these samples are given in detail in Table XVI. These data may be further summarized as follows:

1. Reference Points 1 to 17A. Most of the samples from these points are below or near the level of 5.0 dis./sec./gm. of ash. Two samples with exceptionally high activities of the old stubs were found at Reference Points 1 and 9. These high values could quite easily be accounted for by the presence of one small piece of active material trapped in the sample.

2. Reference Points 18 to 23A. In general the activities in the samples from these points were well above the level of 5.0 dis./sec./gm. of ash. The final interpretation must await additional data.

4.16 The results obtained for the individual parts of the grass samples also vary widely. A tendency for the highest values to be associated with the old stubs and old roots is indicated in many instances. These parts are estimated to be from 5 to 15 years of age and hence, were present and dead at the time of the fall-out of the radioactive material. The amount of activity, thus, indicates the radioactive material that was embedded in or fixed to these plant parts during the fall-out and resisted the washing techniques. The plant growth since the time of the fall-out, however, suggests that there is also some uptake of radioactivity.

4.17 Plants Along Lateral 2, Left. Although the Radiological Survey showed that Lateral 2, left, gave the highest activity readings over the soil *(see Figure 8)*, only the plant samples from the central part of this lateral, as indicated by the data in Table XVII, gave activities above the level of

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5.0 dis./sec./gm. of ash. As in previous plant groups, the high value for the old stubs from 0.2 miles left may well be due to an active particle fixed to the old dead material.

4.18 Trees and Shrubs of the Harvey Gate Series. The data of Table XVIII indicate that activity well above the level of 5.0 dis./sec./gm. of ash was found in the majority of the samples analyzed from this region. Furthermore, the older growth and bark usually shows more activity than the younger growth. The evidence suggests that the larger the branch, the more bark surface available for contamination at the time of the fall-out, as well as since then by wind. The evidence also bears out the adherence of radioactive material to the plant material present at the time of the fall-out.

4.19 Crop Plants. A comparison of the data for crop plants from uncontaminated, control areas *(Table XI)* with that from crops from the Claunch and Jarrett Regions *(Table XIX)* shows that there is no significant difference in the results of radiological assay of these two groups of plants. Furthermore, there is no relationship between the activity found in the soil and that found in the plants.

SUMMARY

4.20 On the basis of the plants so far assayed for activity the data may be summarized as follows:

1. The activity found in plants from the General Reconnaissance and from the terminals of the Laterals is comparable to that found in the few plants from uncontaminated areas in the majority of the samples. Others suggest some activity above the natural background but these values cannot be adequately evaluated until a more detailed study of background samples has been made.

2. Within the fence of the Trinity Region, the activity in the plants exceeded the level of 5.0 dis./sec./gm. of ash over the entire area sampled with the highest values within 300 feet of the center.

3. Along the Primary Transect Reference Line, activities exceeding 5.0 dis./sec./gm. of ash from the living parts of the grasses were exceptional prior to the Chupadera Mesa where the maximum values were found.

4. Trees and shrubs contain more radioactivity on the bark but the new growth of shrubs contains activity comparable to that of the living parts of the grass.

5. No significant differences in activity could be observed in crop plants from contaminated agricultural areas when compared to those from uncontaminated areas.

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6. Further interpretation of these data may be possible when data are available permitting correction of all activity data for the presence of the naturally-occurring radioactive materials.

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THE 1948 RADIOLOGICAL AND BIOLOGICAL SURVEY OF
AREAS IN NEW MEXICO AFFECTED BY THE
FIRST ATOMIC BOMB DETONATION

5. GENERAL SUMMARY

GENERAL SUMMARY

5.1 Easily measurable amounts of radioactive fall-out remaining from the first atom bomb detonation are still found in an area some ten miles wide and extending roughly northeast for more than a hundred miles across the deserts of south-central New Mexico. The amounts of radioactive fission products to be found in any one place throughout this area are relatively small except at and near the detonation point. Here, enough radioactivity is still present to create a strong presumption of hazard to living things that remain continuously in the area. For this reason a fence enclosing about 145 acres permits access only by plants and smaller animals.

5.2 The line of drift runs northeastward and in general, with a few exceptions, the beta-gamma activity diminishes steadily in this direction until the Chupadera Mesa is reached, some 20 miles from the detonation point. Over this grazing area there is a larger amount of radioactivity than in any other place except near the Crater. The fall-out is somewhat spotty and readings of activity vary from less than 0.1 milli-roentgen per hour to as much as 6.5 milli-roentgens per hour in a few places.

5.3 It is not unreasonable to attribute the increased accumulation of fall-out over the Chupadera Mesa to such variables as increased elevation, vagaries of air currents, showers over or near the area during the afternoon and evening following the detonation and higher dew points at night during the fall-out period. Certainly there was enough radioactive material that settled out over this area to produce superficial skin "burns" on cattle grazing there, resulting in spots of white hair over the back and rump.

5.4 This report includes data indicating that the present concentrations of radioactive fission products are not great enough anywhere in the contaminated region, and especially outside the fenced-in part of the Crater Area, to present a significant immediate hazard to man or his domestic animals from total body exposure to beta-gamma irradiation. This finding is gratifying indeed, but it would be rash to conclude, in the absence of specific information, that now, no hazards associated with products of the bomb detonation exist in this area, the harmful effects of which may not appear for a number of years.

5.5 We now know; 1) that a human being would have to go to some trouble to expose himself to the minimum permissible daily dose of beta-gamma irradiation; 2) that over most of the area the active materials detectable with present equipment are still near the surface and for the most part inaccessible to plant roots; 3) that in the Crater Region and on the Chupadera Mesa some of the plants have radioactive materials in their tissues; 4) that the

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gut contents of many of the animals in the contaminated area are radioactive while their tissues are not; 5) that there is some plutonium in the area and presumably part of the wind-blown dust; 6) that because of low rainfall and soil conditions peculiar to the area, it may be a number of years before the remaining long-life fission products reach the plant-root zones; 7) that the active materials are being re-distributed by wind and water with dilution in some places and concentration in others.

5.6 We do not yet know very much about the physical and chemical states of the fission products responsible for the remaining activity and next to nothing about the relationship between soil characteristics and the rates at which the fission products will percolate downward in the soil. We do not know what amounts of plutonium are present or where it is distributed or at what rates it may accumulate in the tissues of animals and man living where they are exposed to the considerable amounts of wind-blown dust. We have no information as yet on the metabolic history of the radioactive contaminants present in the environment of all of the plants and animals of a large area. We are aware of the conditions peculiar to this desert area and the reader will be equally mindful of the fact that the metabolic history of fission products may well be very different in lush agricultural areas.

5.7 In addition to our principal tasks, certain other objectives have been kept in mind.

1. The training of personnel.
2. The collection of data useful to Military and Defense organizations, as well as to the Atomic Energy Commission.
3. Study the repopulation of the devastated part of the Crater Region by plants and animals.
4. Individual and population response to continuous exposure to low level beta-gamma irradiation.

5.8 It will be apparent from this report that a considerable amount of the data essential to the interpretation of what has been found in the field, and especially for estimating long-range hazards that can follow the contamination of large agricultural areas with radioactive materials, must come from the laboratory. Significant problems requiring specialized laboratory facilities include:

1. What are the tolerance limits to soil radioactivity due to bomb products for the survival and propagation of a variety of forage and crop plants?
2. Will any soil concentration of radioactivity within tolerance limits affect mutation rate in plants?
3. What are the up-take and concentration (storage) rates of radioactive bomb products in plants and the soil and other factors which influence

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these rates?

4. Will radioactive materials accumulated in plants in various chemical complexes transfer to animal tissues? What tissues and in what amounts?

5. Fixation of certain fissionable materials, as well as products of secondary neutron reactions by various soil types, including a study of the release of these materials from the various soil types by ion-exchange reactions.

6. Leaching of radioactive soils as a decontamination method.

7. Determination of the chemical and physical properties of trinitite.

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