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OU 1132, Action, Parameters, Model

Abandon
Aboveground Tank
Absorption
Abstract
Accelerator
Access
Accident
Accumulation
Acid
Active
Administrative
ADS (Activity Data Sheet)
Adsorption
AEC (Atomic Energy Commission)
Aerial
Agenda
Agreement
Air
Alpha
Americium
Analysis
Analytical
AOC (Area of Concern)
Approval
Aquifer
ARAR (Applicable, Relevant, or Appropriate Requirements)
Archaeology
Archive
Area
Arsenic
Asbestos
Asphalt
Assessment
Audit

Backfill
Bacteria
Barium
Baseline
BCP (Baseline Change Proposal)
Beds
Bermed Area
Beryllium
Beta
Biology
Blank
Boiler
Boneyard
Bunker
Buried
Burn
Burn Site

Cadmium
Caisson
Calibration
Canyon
Capacitor
Caustic
CEARP (Comprehensive Environmental Assessment and Response Program)
Cement
CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act)
Certification
Cesium
Chain of Custody
Chamber
Change Control
Change Order
Charge
Chart
Checklist
Chemical
Chromium
Cleanup
Clearance
Closure
Clothing
CMI/RA (Corrective Measures Implementation/Remedial Action)
CMS/FS (Corrective Measures Study/ Feasibility Study)
Cobalt
Comment
Committee
Community Relations
Compliance
Compressed Gas
Computer Modeling
Computer Output
Concern
Concrete
Concurrence
Configuration
Construction
Container
Containment
Contaminant
Contract
Control
Controlled Distribution
Core
Corrective Action
Correspondence
Criteria
Cyanide

Data
Deadline
Debris
Decision Analysis
Decommission
Decontamination
Deficiency
Deliverable
Demolition
Description
Detection
Detonation
Development
Discharge
Disposal
Documentation
DOE (Department of Energy)
Dose
DQO (Data Quality Objectives)
Draft
Drainage
Drainline
Drawing
Drilling
Drop Tower
Drum
Dry Well
Dump
Duplicates

Ecology
Effluent
EIS (Environmental Impact Statement)
Emission
Engineering
Environmental
EPA (Environmental Protection Agency)
Equipment
ERDA (Energy Research and Development Administration)
Erosion
Error
ES&H (Environment, Safety, and Health)
Estimate
Evacuation
Evaluation
Evaporator
Excavation
Exclusion
Exhaust
Experiment
Explosive
Exposure
Extension
Extraction

Facility
Fallout
Farm
FAX
Fence
Field
Figure
Filter
FIMAD (Facility for Information Management, Analysis, and Display)
Finding
Fire
Firing Site
Fiscal
Fission
Five-Year Plan
Flow
Flow chart
Fluid
Form
Framework
Free
Fuel
Fume

Gamma
Gas
Generation
Generic
Geochemistry
Geology
Geophysics
Glass Beaker
Glove Box
Graph
Guidance
Gun

Handling
Hazardous
Health
HE (High Explosive)
History
Hole
Home Owner
Hood
HSWA (Hazardous and Solid Waste Amendments)
Hydrology
Hygiene

Impact
Implementation
Implosion
Impoundment
Inactive
Incident
Incinerator
Industrial
Infiltration
Injection Well
Injury
Inorganic
Inspection
Installation
Interim
Interim Action
Internal
Interview
Inventory
Investigation
IRM (Interim Remedial Measure)
Isotope
IWP (Installation Work Plan)

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GEOLOGIC AND HYDROLOGIC EVALUATION OF TECHNICAL AREA 49

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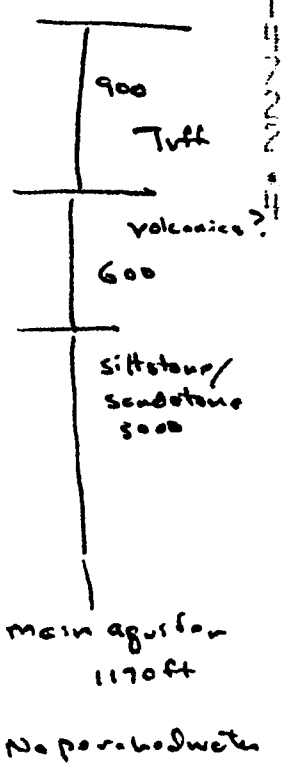
GEOLOGIC AND HYDROLOGIC EVALUATION OF TECHNICAL AREA 49

by

W. D. Purtymun and A. J. Ahlquist

ABSTRACT

Technical Area 49 is located on the Pajarito Plateau within the Laboratory boundary. The plateau is comprised of about 900 ft of Bandelier Tuff. The tuff is underlain by about 600 ft of volcanics and sediments that are, in turn, underlain by over 3,000 ft of siltstone and silty sandstone. Drainage from the mesa at TA-49 is northward into Water Canyon and east and south into Ancho Canyon. The stream flow in the canyons is intermittent from snowmelt runoff and from summer storms. The canyons are tributaries to the Rio Grande. The top of the main aquifer at TA-49 lies at a depth of about 1170 ft below the surface of the mesa. There is no perched water in the tuff or in volcanics and sediments below the surface of the mesa and the top of the main aquifer. Water in the top of the main aquifer is moving at a rate of 345 ft/yr toward the Rio Grande where part is discharged into the river through seeps and springs. Monitoring of surface water (intermittent runoff) and ground water in the main aquifer at TA-49 as well as water discharged through seeps and springs along the Rio Grande indicate no contamination from activities and experiments at TA-49. Surface sediments from three stations indicate contamination; however, the concentrations of contaminants are low, below remedial action levels. Some remedial action has been taken at the experimental areas to reduce possible transport of contaminants to the main aquifer. A risk analysis of possible transport is beyond the scope of this report. Hydrologic parameters for the analyses were compiled and are included for use by the health physicist who is to make the assessment.



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I. INTRODUCTION

This paper briefly describes the geohydrology of Technical Area 49 (TA-49). It also presents the monitoring, remedial actions, and parameters for a model to prepare a risk analysis.

The technical area is located on Frijoles Mesa in the south-central part of laboratory property (Fig. 1). It was used for experiments in late 1959 and early 1960 and consisted of six main areas: Areas 1, 2, 3, 4, 5, and 10 (Fig. 2). A preliminary study of the geology and hydrology of the area was performed by the U S Geological Survey before selection of the area. A major report by the USGS "Geology and Hydrology of Technical Area 49, Frijoles Mesa, Los Alamos County, New Mexico," (Wier 1962) was prepared from data collected during a two-year field investigation. The field investigation included drilling four shallow core holes (300 to 500 ft deep) and three test wells into the main aquifer (1420 to 1820 ft deep), geologic mapping, and collecting other geologic and hydrologic data. The geohydrology of this report summarizes the data from the latter USGS report (Wier 1962).

4 shallow core holes
3 test wells (1420 to 1820 ft)

II. GEOLOGY

Frijoles Mesa is part of the Pajarito Plateau. The plateau forms an apron around the Sierra de los Valles to the west and slopes gently eastward until it terminates along White Rock Canyon of the Rio Grande (Fig. 3). The plateau was formed by a series of ashfall and ashflow tuff underlain by volcanics and sediments (Griggs 1964). It is a part of the Rio Grande Rift, a structural depression stretching from southern Colorado through New Mexico and into Mexico. The rift is formed by a series of echelon faults that have formed a structural low area that constitutes the valley of

the Rio Grande. In the Los Alamos area, the thickness of the depression exceeds 12,000 ft. It is filled with sediment and volcanics (Kelley 1956).

The tuff that forms the upper surface of the Pajarito Plateau was emplaced about one million years ago. Frijoles Mesa is stable because mapping of the tuff at the site indicates no faults within the technical area. The nearest fault, the Water Canyon fault, lies about 1.5 miles west of TA-49 (Fig. 4).

The rock units at TA-49, from oldest to youngest, are the Tesuque Formation, Puye Conglomerate, Tschicoma Formation, basaltic rock of Chino Mesa, and the upper most Bandelier Tuff (Fig. 4).

The Tesuque Formation consists mainly of siltstone and silty sandstone with occasional thin sandstone or lenses of clay and pebbly conglomerate. The three deep test holes penetrated the top of the Tesuque Formation (Fig. 4). The thickness of the formation is over 3,000 ft based on logs of other test holes in the Los Alamos area (Cushman 1965).

The Tschicoma Formation consists of flows of latite, dacite, and rhyolite that are associated with the formation of the Sierra de Los Valles to the west. The basaltic rocks of Chino Mesa consist of basalt flows and interflow breccias. The Puye Conglomerate consists of the Totavi Lentil, a basal conglomerate of quartzite and granite debris, and the fanglomerate member comprised of angular volcanic rocks in a matrix of gravel, sand, and ash derived from the older Tschicoma Formation to the west (Fig. 4).

Two flow units of Tschicoma Formation, penetrated in test hole DT-5A, ranged in thickness from 26 to 126 ft. Test hole DT-10 penetrated about a 40-ft flow of the Tschicoma Formation. The basalt and interflow breccias were encountered in test holes DT-9 and DT-10. The flow thickness ranges from 240 to 270 ft. The Tschicoma and basaltic rocks of Chino Mesa are interbedded

with the Puye Conglomerate. The Totavi Lentil is about 50 ft thick but the fanglomerate member ranges from 230 ft in DT-10, 270 ft in DT-9, to 445 ft in DT-5A. These three units are shown together as sediments and volcanics in Fig. 4. The combined thickness ranges from about 500 ft in DT-9, 540 ft in DT-10, to 600 ft in DT-5A (Fig. 5).

The Bandelier Tuff, which forms Frijoles Mesa, consists of three members. They are, in ascending order, the Guaje Member, an ashfall of lump pumice; the Otowi Member, a massive ashfall of nonwelded tuff; and the Upper Tshirege Member, a series of ashflows and ashfalls of nonwelded to welded tuff. At Frijoles Mesa, the Tshirege Member has been broken down into seven units. The stratagraphic section of the Bandelier Tuff near Area 5 is as follow:

Tshirege Member	Thickness (ft)
Unit 6, Moderately Welded	70
Unit 5, Friable Sand	2
Unit 4, Moderately Welded	40
Unit 3, Non- to Moderately Welded	60
Unit 2, Welded	150
Unit 1A, Nonwelded	210
Unit 1, Nonwelded	150
Otowi Member	
Nonwelded	210
Gauje Member	
Pumice	40
TOTAL	∿ 930 ft

The tuff is rhyolitic and is composed of quartz, sandine crystals, crystal fragments, a few small rock fragments of pumice latite, and rhyolite in an ash matrix. The degree of welding of the tuff affects the physical and

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hydrologic characteristics of the tuff (Purtymun 1965). Some of the physical and hydrologic characteristics of the tuff are as follow:

Degree of Welding	Range: Porosity (% by Volume)	Range: Density (lbs/ft^3)
Nonwelded	40-60	65- 95
Moderately Welded	30-55	72-115
Welded	15-40	95-135

Unit and Degree of Welding	Porosity (Per Cent)	Specific Yield (Per Cent)	Specific Yield (Per Cent)	Hydrologic Conductivity (ft/day)
Unit 6, Moderately Welded	38-54	18-34	16-27	0.1-0.8
Unit 5, Sand	-----	-----	-----	4.5-7.8
Unit 4, Moderately Welded	33-54	11-43	12-22	0.4-1.7
Unit 3, Nonwelded	48	34	14	2.9
Unit 2, Welded	19-37	0.6-26	11-21	0.01-0.26
Unit 1B, Nonwelded	-----	-----	-----	1.6-6.9

Note: Hydrologic tests of tuff were made under saturated conditions; the tuff is not saturated.

tuff 850 ft

The thickness of the Bandelier Tuff ranges from 850 ft at DT-9, 865 ft at DT-10, to 930 ft at DT-5A (Fig. 5). The Bandelier Tuff is in the zone of aeration. It is not saturated.

The surface of the mesa is covered with a clayey soil, which ranges in thickness up to about 4 ft. The greatest thickness occurs along the axis of the mesa and thins at the edges of the canyon where the tuff is exposed. At Areas 2 and 10 a thin section up to 4 ft of well-sorted water-laid pumice rests on the tuff and is overlain by the clayey soil.

III. HYDROLOGY

Surface water runoff from Frijoles Mesa is into Water Canyon to the north, an un-named tributary canyon to Ancho Canyon to the east, and into Ancho Canyon to the south. Water and Ancho Canyons drain into the Rio Grande in White Rock Canyon about 5 miles to the east. Stream flow in the canyons is intermittent and occurs in the spring from snowmelt and summer and early fall from heavy thunder showers.

Coring of the four core holes and drilling of three deep test wells into the main aquifer indicated no perched water occurred in the tuff and underlying sediments and volcanics above the main aquifer. The main aquifer of the Los Alamos area is the only aquifer capable of municipal and industrial supplies (Theis 1962, Cushman 1965). The upper surface of the aquifer rises westward from the Rio Grande through the Tesuque Formation, into the lower part of the volcanics and sediments beneath the central and western part of the Pajarito Plateau (Fig. 4). The water in the aquifer moves from the major recharge area in the Valles Caldera eastward toward the Rio Grande, where a part is discharged into the river through seeps and springs (Purtymun 1980). There is little if any recharge through the mesas to the main aquifer (Cushman 1965, Purtymun 1965a).

The gradient on the upper surface of the aquifer is about 40 to 60 ft/mile beneath the western and central part of the plateau in the volcanic sedimentary portion and steepens to 80 to 120 ft/mile as the aquifer moves into less permeable sediments of the Tesuque Formation (Purtymun 1984). Movement of water in the aquifer is perpendicular to the contours (shown in Fig 6., regional; and Fig. 7 at TA-49).

Test wells DT-5A, DT-9, and DT-10 were drilled in the early 1960's to evaluate the hydrologic conditions of the main aquifer. Aquifer tests were

performed on each well and the following table presents the data. Figure 8 presents average hydrologic characteristics of test and supply wells on the Pajarito Plateau.

	Well		
	DT-5A	DT-9	DT-10
Depth (ft)	1,821	1,501	1,409
Depth to Water (ft)	1,178	1,006	1,091
Saturated Thickness (ft)	643	498	324
Rate (gpm)	81	88	78
Specific Capacity (gpm/ft)	5.7	22	16
Transmissivity (gpd/ft)	11,000	61,000	36,100
Field Coefficient of Permeability $(gpd/ft)^2$	17	122	111

The average water velocity in the upper 490 ft of the aquifer at TA-49 (calculated on average thickness and coefficient of permeability values) is about 345 ft/yr. Movement is in the lower part of the volcanics and sediments and upper part of the siltstone and silty sandstone (Fig. 9).

Water-level measurements at DT-5A from 1960 to 1964 indicated a water-level decline of about 4 ft or about 0.8 ft/yr (Fig. 10). The well was equipped with a pump in 1970 to facilitate collection of water samples for chemical and radiochemical analyses.

Well DT-9 is about 0.75 miles south of DT-10 and 1.25 miles southeast of well DT-5A. Small amounts of water pumped from these wells (DT-5A and DT-10) will not affect the water levels in DT-9. The well was equipped with a water-stage recorder from 1960 to 1968 and from 1970 to 1982. A continuous water-level record was obtained for a 20-yr period. This reflects the normal water-level trend for the region. Water levels in the well declined about 3

ft from 1003 ft in 1960 to 1006 ft in 1982 or at an average rate of about 0.1 ft/yr (Fig. 10).

At well DT-10, the water level declined about 0.5 ft/yr from 1960 to 1967. The well was equipped with a pump in 1979 to facilitate taking water samples for analyses.

The water-level declines, measured before putting pumps in the wells, is normal (declining recharge to the aquifer) and not the result of pumping.

Water from wells DT-5A, DT-9, and DT-10 is of a sodium-bicarbonate type. The quality of the water is quite similar to all three test wells. The water is soft, ranging from 35 to 42 mg/l. The concentrations of total dissolved solids (TDS) range from 124 to 142 mg/l with chloride concentrations of 4 mg/l or less and fluoride concentrations of 0.3 mg/l. Figure 11 presents a graphic comparison of average concentrations of constituents with other wells on Pajarito Plateau. Radiochemical analyses of water, 1960 through 1985, indicate no radioactive contamination.

IV. MONITORING

Radioactive contaminants are buried in shafts in the tuff in Areas 1, 2, and 4 at depths of 58 and 100 ft below the surface of the mesa. The major means of transport of the radionuclides would be in the hydrologic cycle, i.e., infiltration of water from precipitation and carrying the contaminants downward to the main aquifer that lies 1,000 to 1,200 ft below the surface of the mesa. Thus, monitoring of the area began with completion of the first test holes into the main aquifer with subsequent monitoring of the soil and sediments subject to surface transport by surface runoff. An initial study was made to determine the distribution of moisture in the soil and tuff. The monitoring section of this report will present results of the above study in

the water, soil, and sediments section. An internal document that relates to monitoring of TA-49 has been prepared annually or biannually.

A. Distribution of Moisture in Soil and Tuff

Neutron access tubes

Twenty-three moisture access holes, ranging from 9 to 50 ft in depth, were constructed at TA-49 in February and March of 1960 to determine the distribution of moisture in the soil and tuff (Fig. 12). These holes were located in or near test areas, roadside drainage ditches, and arroyos.

The moisture contents of the soil and tuff adjacent to these access tubes were measured with a neutron-scattering neutron probe and scaler. The study was made over a 2-year period (Purtymun 1962, Abrahams 1961).

Moisture content of tuff not changing

The conclusion made after a 2-year period of observations indicated that water from precipitation rarely infiltrates the undisturbed soil cover into the underlying tuff. The study also indicated the moisture content of the soil and transition zone above the tuff varied due to weather conditions. The moisture content of the tuff remained the same, varied due to weather conditions, or increased slightly in the upper few feet in 21 of the moisture access holes. The moisture content in two of the holes near Area 1 increased in moisture content from 13 to 18% by volume up to a depth of 16 ft, indicating infiltration of water. The two holes were located adjacent to an arroyo that was dammed by construction allowing water to pond for short periods of time (two weeks). Conclusions: There is little if any recharge to the main aquifer through the mesa (Abrahams 1961, Cushman 1965, Kennedy 1971).

B. Quality of Surface and Ground Water

The following data on quality of water related to TA-49 is published annually as part of the Laboratory-wide environmental surveillance program. The chemical and radiochemical quality of water data are reported. There is no mention of TA-49 in the report (ESG 1984, ESG 1985).

Surface transport by storm runoff is remote because the wastes are buried in the tuff; however, four surface water stations are sampled. Base flow of Ancho Canyon is ground water discharge from the main aquifer. Water Canyon effluent release from the S-Site area and base flow of Frijoles from spring discharge west of TA-49. There is no hydrologic connection with ground water at TA-49. The 1984 data are presented in Table I and show analytical results and dates the first samples were collected. Numbers in parentheses are in reference to location shown in Fig. 13. There is no indication of contamination in surface water.

Three deep test wells at TA-49 have been sampled since 1960. Two wells (DT-5A and DT-10) are equipped with pumps in order to obtain the best representative samples from the aquifer. Well DT-9 has been used to collect water-level data from the main aquifer. Samples are bailed from the well. Anlayses of samples from the wells indicate no contamination of ground water at TA-49 (Table I).

Twelve springs located in White Rock Canyon of the Rio Grande from Water Canyon to Frijoles Canyon are sampled annually. These springs discharge from the main aquifer. The springs are located in an area that would receive ground water moving from beneath TA-49. There is no indication of contamination of water from the springs (Table I).

Transport of radionuclides in intermittent stream channels can occur with spring snowmelt or heavy summer thunder-storm runoff. During 1978 and 1979, snowmelt runoff was collected from Water and Ancho Canyons at State Road 4. The runoff was analyzed for radionuclides in solution and in suspended sediments. There is no indication of contamination from TA-49 either in solution or in the suspended sediments (Table II).

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C. Soil and Sediments

Soil (two stations) and sediments (six stations) are collected for anlaysis and results are published annually as a part of the Laboratory-wide environmental surveillance program. Sediments (twelve stations) in TA-49 are collected annually for analysis and results are reported in an internal document. Any soil and sediment contamination would have to be surface contamination left after the test area was closed.

Soil samples collected near TA-49 outside the area and near DT-9 within the area indicate only world-wide fallout concentrations of plutonium.

The four sediment samples collected in Water and Ancho Canyons, downgrade from TA-49, contain only traces of plutonium at or below limits of detection. There is no indication of contamination from TA-49.

Results from the two sediment samples from Frijoles Canyon at Bandelier and at the Rio Grande are included as background concentrations to compare with the analyses from Water and Ancho Canyons. The concentrations are at or below limits of detection or reflect world-wide fallout concentrations.

In 1975, a sediment sampling program was started where samples were collected annually from stream channels draining the experimental areas (Fig. 14). Eleven stations were established in 1975. Clearing a fire break in 1979 changed the drainage from Areas 2 and 10 slightly and another station (4A) was added. The monitoring of sediments reflects only the surface contamination in the area and not the contaminants in shafts. The annual monitoring for the past ten years indicates contaminates are transported from Area 1 and 2 (stations A-1, A-2, and A-3). The highest concentrations are consistently found at station A-3 (Table III). The sediments from station A-3 are from the former site of the radiochemistry laboratory (removed) and Area 2. Surface contamination occurred at Area 2 in 1960 and was cleaned up

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(see "Remedial Action"). Only trace amounts remain. The concentration of 3.1 pCi/g of $^{239,240}Pu$ is about 100 times world-wide fallout levels. The 3.1 pCi/g concentration is below remedial action (cleanup) guidelines of the Environmental Protection Agency of 17 pCi/g (USEPA 1977) and well below 100 pCi/g value proposed by Healy (1979).

V. REMEDIAL ACTION AT TA-49

The technical area for the experiments was chosen for the favorable geologic and hydrologic conditions that would contain any contamination left in the tuff. The shafts were excavated in the tuff with a bucket auger. Depth ranged from 50 to 125 ft. Most experiments were carried out at about 60 ft. Shaft diameters ranged from 3 to 6 ft with most shafts excavated with a 6-ft diameter.

Areas 1, 2, 3, and 4 were laid out with shafts located on 25-ft centers, 5 shafts wide and 5 shafts long or in about 100-ft squares (Fig. 15). Not all the shafts in an area were excavated.

Near the centers of each area a core hole was drilled to determine the physical and hydrologic characteristics of the tuff. The tuff (Bandelier Tuff) was in excess of 900 ft thick in the four areas. The core holes range in depth of about 300 ft in Areas 3 and 5 to 500 ft in Areas 1 and 2. The core holes were cased with 2-inch galvanized pipe. Before setting pipe in core holes in Areas 1 and 2, the holes were filled with fluid (water, drilling mud, and lost circulation material) to allow geophysical logging.

Experiments in shafts in Area 2 were carried out from late 1959 to late 1960. During the excavation of shaft 2M in November 1960, the tuff excavated from the shaft was found to be contaminated. The shaft is adjacent to the core hole (Fig. 16). The contamination had been blown through open joints and

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fractures into the tuff adjacent to the shaft in which the experiment was being conducted. Shaft 2M encountered some of this contamination. The surface contamination was cleaned up and the shaft filled. It was customary that the experiments were stemmed to the surface with sand and then a cement cap was poured in the upper 2 ft of the hole after the experiment was completed. This cap was not poured at shaft 2M because the hole had not been used for an experiment.

The presence of some residual contamination at Area 2 resulted in remedial action. The area was abandoned and capped with 4 to 6 ft of compacted clay and gravel in the spring of 1961. The clay and gravel pad extend 12.5 ft beyond the outside shafts. The clay and gravel was then paved over with 4 to 6 inches of asphalt. Experiments were then done at two new areas, Area 2A west of Area 2, and Area 2B south of Area 2 (Fig. 16).

The sand and tuff used to fill shaft 2M compacted and the asphalt pad above the shaft collapsed forming a hole 3 to 4 ft deep, about 3 ft wide, and 6 ft long. This occurred in the fall of 1974 and was discovered in Februray 1975. The hole was filled and another 4 to 6 inches of asphalt was placed over the existing asphalt pad in September 1976.

The fluids (in core holes to facilitate geophysical logging) in the core hole in Area 2 gradually declined from 1960 to 1974; however, in the spring of 1975, the fluid level apparently rose to about 465 ft. It was probably due to precipitation entering the pad through holes at shaft 2M and, thus, entered the core hole. No action seemed necessary with the pad resurfaced.

A measurement in April 1979 indicated the fluid level in the core hole had risen to 348 ft below land surface and then declined about 1 ft from April 1979 to April 1980. In June 1980, the hole was bailed dry. Plutonium

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analysis was made of the fluid in solution and of the suspended sediments at different depths. Results were

Depth (ft)	Solution (pCi/ℓ)	Suspended Sediment (pCi/g)
350	2.5	0.54
420	0.1	0.72
495	5.5	0.55

It was evident that water in the core hole had come in contact with contamination in the shafts.

It was necessary to determine if water was still entering the test area that was capped or adjacent Areas 2A and 2B.

At the completion of the experiments in about 1961, shafts D and Y in Area 2A and shafts L, T, V, and Y had been excavated and were open. For safety, they were filled with sand. These sand-filled shafts were suspected of being recharge areas for water in core holes in Area 2. Moisture access tubes were installed in the sand of holes 2A-O, 2A-Y, and 2BY in the spring of 1980. The access tubes ranged in depth from 27 to 61 ft into the sand of the shafts. In addition, five test holes were drilled around Areas 2, 2A, and 2B to a depth of 123 ft. These holes penetrated the upper ashflow and thin sand unit at about 80 ft and were completed to the upper part of the lower ashflow. The result of neutron-moisture logging in the moisture access tubes in the sand-filled shafts of 2A-O, 2A-Y, and 2BY and five test holes around the areas indicated no recharge or movement of water into Area 2 had ever occurred adjacent to Areas 2, 2A, or 2B or from the sand-filled shafts of Areas 2A or 2B. The fluids in the core holes must have been induced from the collapse of the pad above shaft 2M. Water-level measurements since June 1980 through 1985 indicate the core hole remains dry. About 2 ft of sand was removed from the

sand-filled holes in Area 2A and 2B in 1981. A cap of concrete was poured to seal the upper part of the hole.

Remedial action to clean up all surface debris was carried out in February to April 1984. A few buildings were left in Area 5 and miscellaneous pipes, cable ways, cables, and other equipment left in the area when it ceased to be used for experiemnts. These wastes were buried in a trench dug next to the trash-burning area northeast of the main areas (Fig. 16). A forest fire in June 1977 swept the area. It burned out some of the buildings and some other structures. These remains were also removed to the trench. None of the material was contaminated. The trench was closed in the late spring of 1984.

VI. HYDROLOGIC PARAMETERS FOR A TRANSPORT MODEL

A model for risk analysis of shallow land burial of radioactive wastes was prepared by Hansen (1983). The model they developed for radioactive solid waste sites in the tuff is similar to the burial of contaminates in shafts. It can be used by changing a few of the parameters. The purpose of this section of the report is not to present a risk analysis, but to modify hydrologic conditions for the model that will be used by the health physicist who will prepare the risk anlysis.

A cross section showing the route of transport of contamination is presented in Fig. 18. The changes in ground water transport model and modification of parameters are discussed using the following table:

Groundwater Transport Conditions at Los Alamos for Modeling

		Change
I. Unsaturated Zone Conditions:		
Depth to Aquifer:	275 m (900 ft)	Yes
Seepage Velocity:	1.52×10^{-7} m/d (5×10^{-7} ft/d)	No
Moisture Flux:	120 mm/yr	No
Dispersivity:	2.01×10^{-4} m (6.6×10^{-4} ft)	No
Retardation Coefficients:		No
Pu = 150, Am = 1000,		
Th = 150, Ac = 150, Pa = 150,		
Ra = 150, U = 2.5		
II. Saturated Zone Conditions		
Distance to Well Discharge:		
(Rio Grande)	8.4×10^{4} m (28,500 ft) Water	Yes
(Velocity)	0.3 m/day (1 ft/day)	No
Dispersivity:	3.05 X 10 m (0.01 ft)	No
Well Pumping Rate:		
(Ground Water Discharge)	6.7×10^{6} m^3/g (17.8×10^{9} gal/yr)	Yes
Well Depth:	21.3 m (70 ft)	No
Porosity:	0.20	Yes
Retardation Coefficients:		No
Pu = 300, Am = 2000,		
Th = 300, Ac = 300, Pa = 300,		
Ra = 300, U = 5		

Changes made in the parameters of Unsaturated Zone Conditions are in the depth to water values (main aquifer) amount to about 900 ft (275 m). In the Saturated Zone, the distance from TA-49 site to the Rio Grande (discharge through springs and seeps to the river) is about 28,500 ft (8.4×10^{4} m). The discharge from the main aquifer west of the Rio Grande (ground water discharge boundary) is estimated at 17.8×10^{9} gal/yr (6.7×10^{6} m^3/yr). The porosity of the volcanics and sediments of the main aquifer is about 20%.

VII. SUMMARY AND CONCLUSIONS

Wastes or contaminants are buried in shafts that range from 50 to 120 ft in depth at TA-49. The shafts are underlain by about 1170 ft of unsaturated tuff, volcanics, and sediments above the main aquifer. The mesa is not a recharge area for the aquifer. The movement of water in the main aquifer is

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about 345 ft/yr eastward toward the Rio Grande where a part is discharged into the river through seeps and springs.

Major movement or transport of contaminants would be in the hydrologic cycle. Because there is little, if any, recharge through the mesa (unsaturated tuff, pumice, volcanics, and sediments) to the main aquifer, it is very remote that contamination could be transported to the main aquifer.

The analysis prepared from hydrologic characteristics of the site (unsaturated and saturated conditions) will assess the risk factor for possible transport of contaminants through the environment.

The site (TA-49) should not be considered low priority for continued investigations and studies, though the risk factor appears low from past monitoring and geologic and hydrologic studies. The large mass, toxicity, and long life of the wastes in the shafts at TA-49 pose a greater threat to the environment and to human health than the threat found in any or all waste disposal sites at Los Alamos combined. The material in shafts at TA-49 represents 80% of the Laboratory's inventory of transuranic waste. Monitoring, in conjunction with routine surveillance programs and specific site monitoring, should be continued.

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TABLE I

RADIOCHEMICAL QUALITY OF SURFACE AND GROUND WATER[1]

Surface Water	Sampled Since	^{238}Pu (pCi/l)	$^{239,240}Pu$ (pCi/l)	Total U (µg/l)
Ancho Canyon (36)	1967	0.005 ± 0.030	0.012 ± 0.024	0.7 ± 0.4
Water Canyon (48)	1967	-0.013 ± 0.018	0.027 ± 0.030	0.7 ± 0.4
Frijoles Park (9)	1952	0.006 ± 0.028	0.006 ± 0.072	6.0 ± 12
Frijoles, RG (37)	1967	-0.006 ± 0.024	0.019 ± 0.038	0.9 ± 0.6
Test Wells				
DT-5A (42)	1960	-0.006 ± 0.024	-0.011 ± 0.022	0.4 ± 0.4
DT-9 (44)	1960	-0.006 ± 0.014	-0.006 ± 0.018	1.1 ± 0.8
DT-10 (45)	1960	-0.011 ± 0.022	-0.011 ± 0.022	0.6 ± 0.4
Springs				
Spring 5A (22)	1964	0.005 ± 0.030	0.015 ± 0.022	2.6 ± 0.8
Spring 5AA (20)	1978	-0.006 ± 0.025	-0.022 ± 0.022	0.7 ± 0.4
Ancho Spring (21)	1964	-0.006 ± 0.024	0.008 ± 0.022	1.1 ± 0.6
Spring 6 (23)	1964	0.013 ± 0.026	0.013 ± 0.026	1.2 ± 0.6
Spring 6A (24)	1964	0.013 ± 0.026	0.020 ± 0.022	1.0 ± 0.6
Spring 7 (25)	1964	0.040 ± 0.049	0.000 ± 0.020	1.2 ± 0.6
Spring 8 (26)	1964	0.007 ± 0.031	0.007 ± 0.031	1.8 ± 0.8
Spring 8A (27)	1964	0.012 ± 0.024	0.000 ± 0.020	0.6 ± 0.4
Spring 9 (28)	1964	0.005 ± 0.022	0.015 ± 0.017	1.2 ± 0.6
Spring 9A (29)	1978	0.006 ± 0.022	0.000 ± 0.020	1.2 ± 0.4
Doe Spring (30)	1964	0.063 ± 0.047	0.006 ± 0.030	0.7 ± 0.4
Spring 10 (31)	1964	0.015 ± 0.017	0.006 ± 0.22	1.2 ± 0.6

Note: Sample DT-9 collected 1982, the ± value is twice the uncertainty term for the analysis. Number after station reference fig. 13.

[1] From "Environmental Surveillance at Los Alamos During 1984," Los Alamos National Laboratory report LA-10427-ENV (1985).

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TABLE II
RADIOCHEMICAL QUALITY OF SNOWMELT RUNOFF
1978 and 1979

Stations at State Road 4	Year	No. of Analyses	^{238}Pu (pCi/l)	$^{239,240}Pu$ (pCi/l)
Solution				
Water Canyon	1978	7	-0.008 ± 0.008	0.011 ± 0.003
Water Canyon	1979	8	-0.02 ± 0.09	-0.01 ± 0.12
Ancho Canyon	1978	7	-0.021 ± 0.034	-0.019 ± 0.029
Ancho Canyon	1979	7	0.00 ± 0.04	0.01 ± 0.05

Suspended Sediments	Year	No. of Analyses	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
Water Canyon	1978	[illegible]	0.00 ± 0.16	0.12 ± 0.03
Water Canyon	1979	8	0.00 ± 0.05	0.06 ± 0.06
Ancho Canyon	1978	7	0.00 ± 0.00	0.08 ± 0.06
Ancho Canyon	1979	7	0.00 ± 0.03	0.10 ± 0.17

Note: ± value is twice the standard deviation of the distribution of number of analyses.

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TABLE III
RADIOCHEMICAL ANALYSES OF SOIL AND SEDIMENTS

	Year	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
Soils			
Near TA-49	1984	0.000 ± 0.002	0.024 ± 0.006
Near DT-9	1984	-0.006 ± 0.010	0.035 ± 0.010
Sediments			
Water Canyon at State Road 4	1984	0.002 ± 0.003	0.003 ± 0.004
Water Canyon at Rio Grande	1984	-0.001 ± 0.002	0.001 ± 0.002
Ancho Canyon at State Road 4	1984	0.003 ± 0.003	0.008 ± 0.004
Ancho Canyon at Rio Grande	1983	-0.003 ± 0.006	-0.001 ± 0.004
Frijoles at Bandelier	1983	0.001 ± 0.000	0.011 ± 0.000
Frijoles at Rio Grande	1984	-0.002 ± 0.004	-0.003 ± 0.004
Sediments in TA-49			
Station 1	1983	0.004 ± 0.002	0.175 ± 0.016
Station 2	1983	0.008 ± 0.002	0.356 ± 0.036
Station 3	1983	0.006 ± 0.014	3.10 ± 0.240
Station 4	1983	0.001 ± 0.002	0.004 ± 0.002
Station 4A	1983	0.003 ± 0.002	0.009 ± 0.004
Station 5	1983	0.002 ± 0.002	0.041 ± 0.010
Station 6	1983	0.000 ± 0.002	0.018 ± 0.008
Station 7	1983	0.000 ± 0.000	0.000 ± 0.000
Station 8	1983	0.005 ± 0.004	0.007 ± 0.008
Station 9	1983	0.005 ± 0.004	0.071 ± 0.017
Station 10	1983	0.003 ± 0.002	0.005 ± 0.004
Station 11	1983	-0.005 ± 0.002	0.017 ± 0.008
Station 1	1984	-0.001 ± 0.004	0.003 ± 0.005
Station 2	1984	-0.003 ± 0.004	0.009 ± 0.005
Station 3	1984	0.017 ± 0.006	0.535 ± 0.062
Station 4	1984	-0.002 ± 0.036	0.007 ± 0.007
Station 4A	1984	0.000 ± 0.001	0.078 ± 0.017
Station 5	1984	0.001 ± 0.004	0.013 ± 0.007
Station 6	1984	-0.001 ± 0.004	-0.002 ± 0.004
Station 7	1984	0.002 ± 0.005	0.006 ± 0.006
Station 8	1984	0.001 ± 0.005	0.077 ± 0.010
Station 9	1984	-0.001 ± 0.003	0.001 ± 0.004
Station 10	1984	-0.001 ± 0.003	-0.004 ± 0.002
Station 11	1984	-0.004 ± 0.004	0.008 ± 0.009
Regional Background	1978-1981	0.005	0.036

Note: ± value represents twice the uncertainty term for that analysis. The soil and sediment data 1983 from LA-10100-ENV. The 1984 data from LA-10821. Sediment in TA-49 data from internal document.

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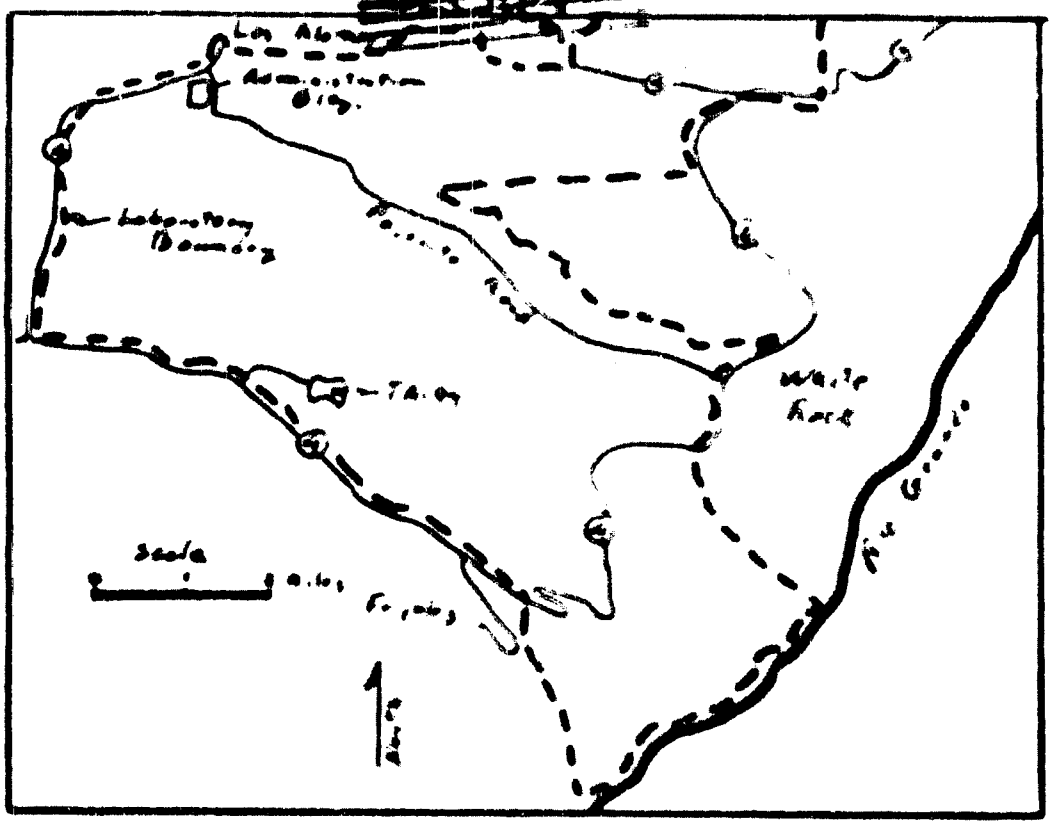

Fig. 1. Map showing location of TA-49 in the south central part of the Laboratory

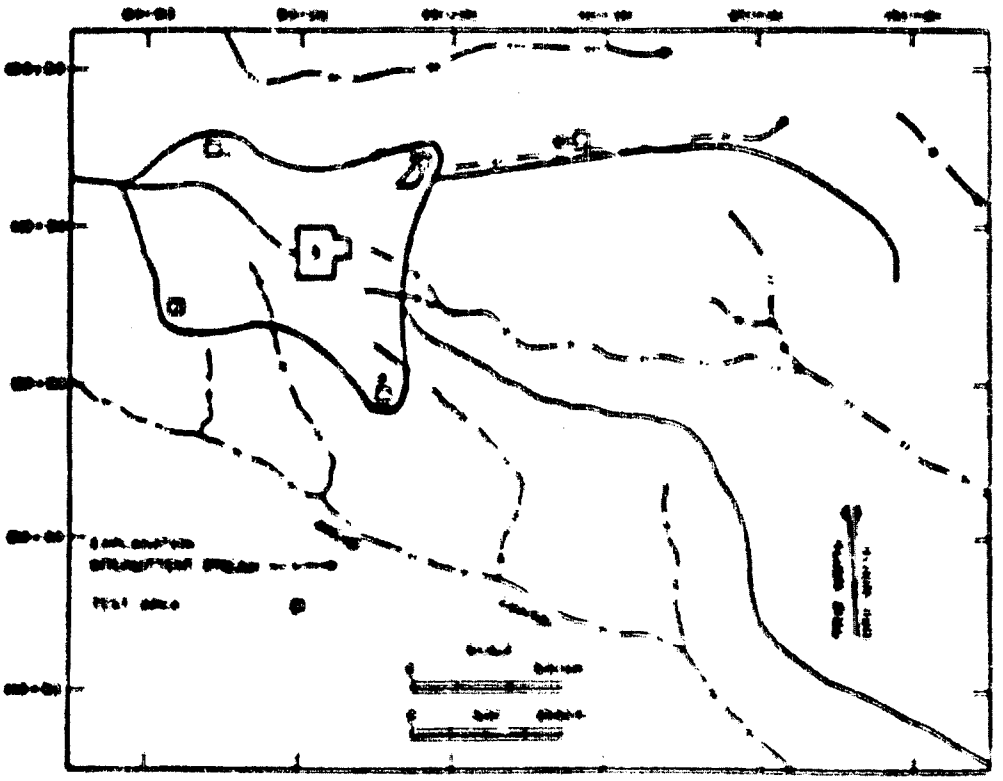

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Fig. 2. Map showing location of areas [illegible], 2, 3, 4, 5, and 10 in TA-49

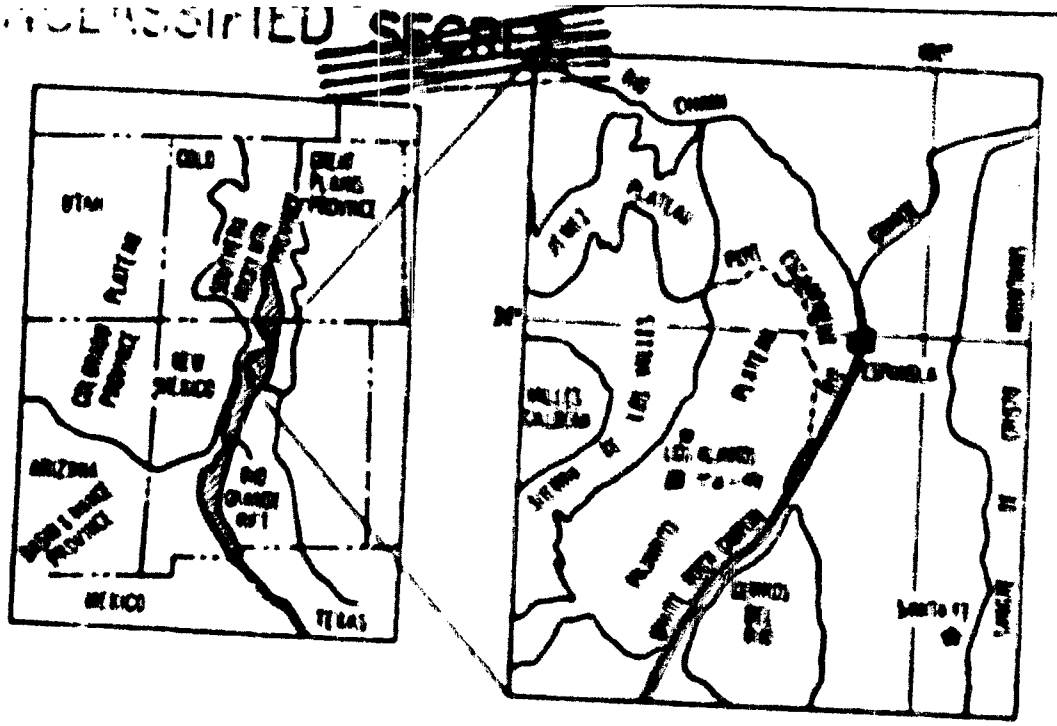


Fig. 3. Maps showing Rio Grande Rift in New Mexico and location of TA-49 on the Pajarito Plateau

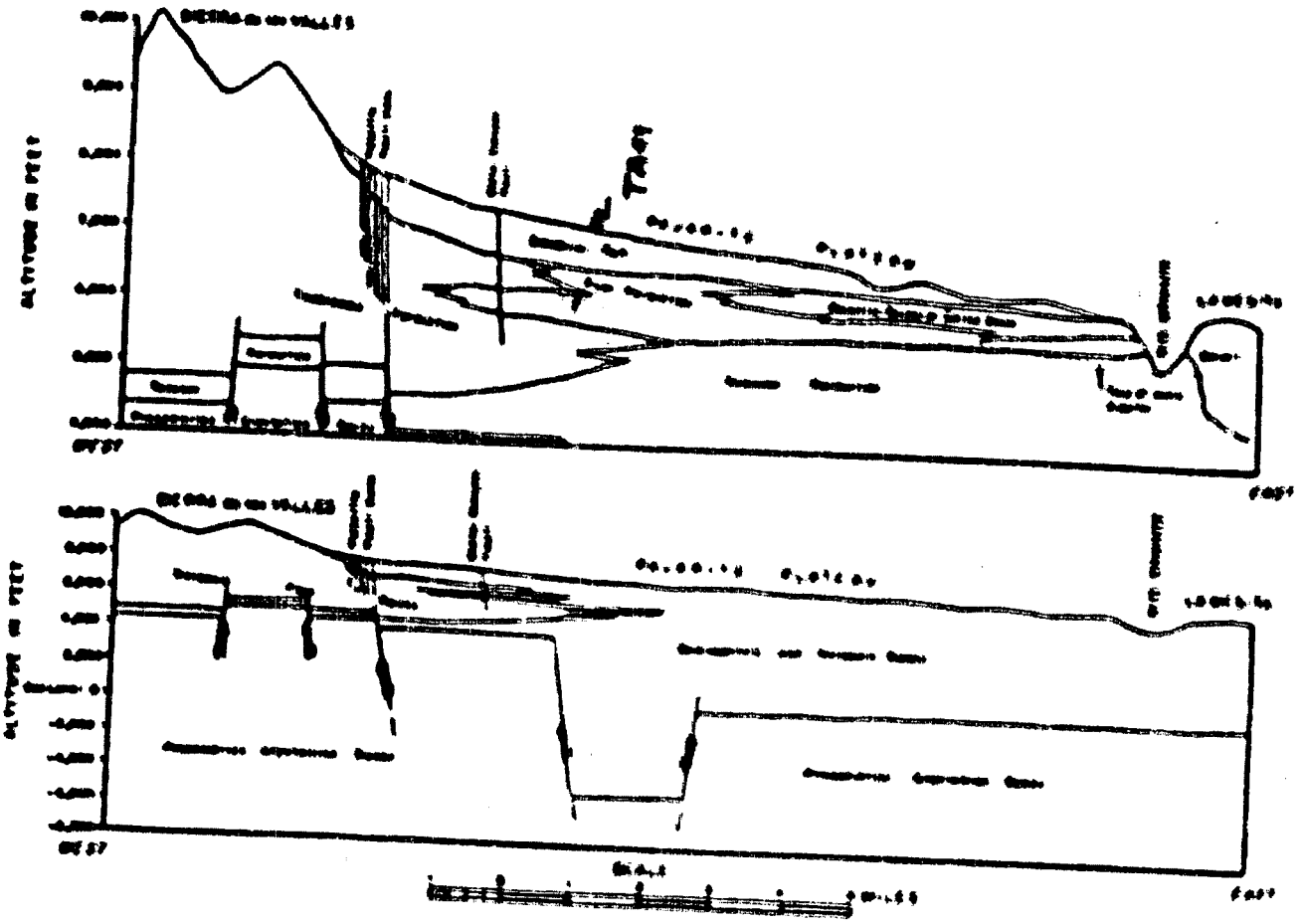
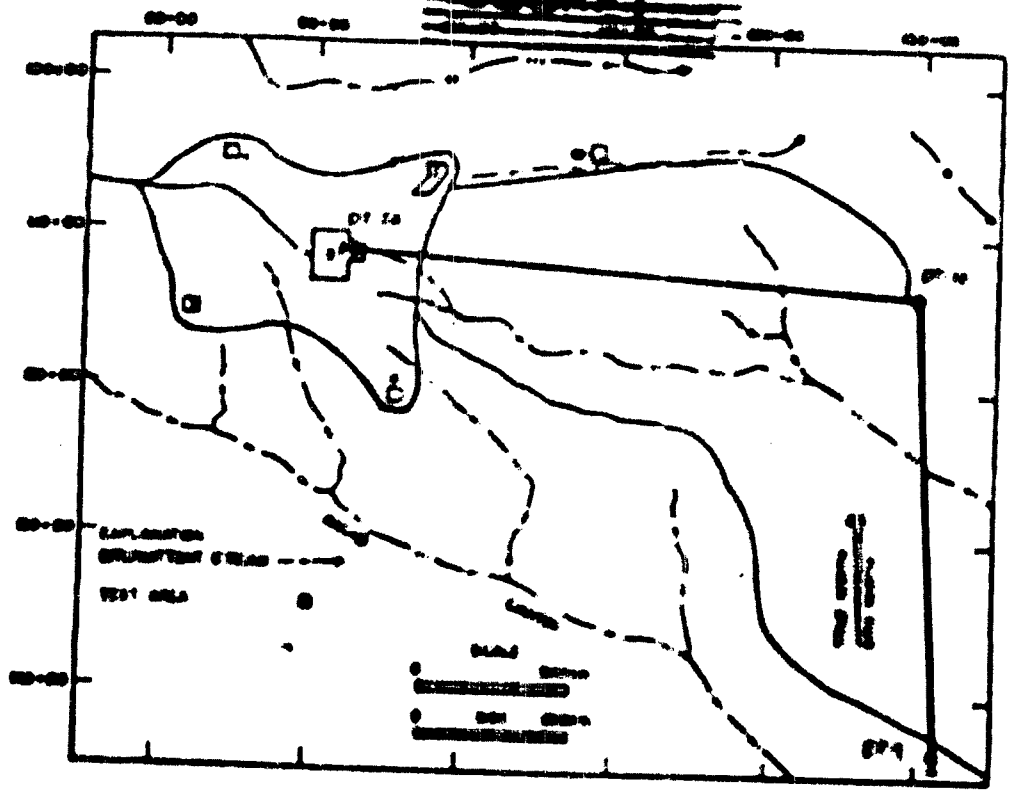
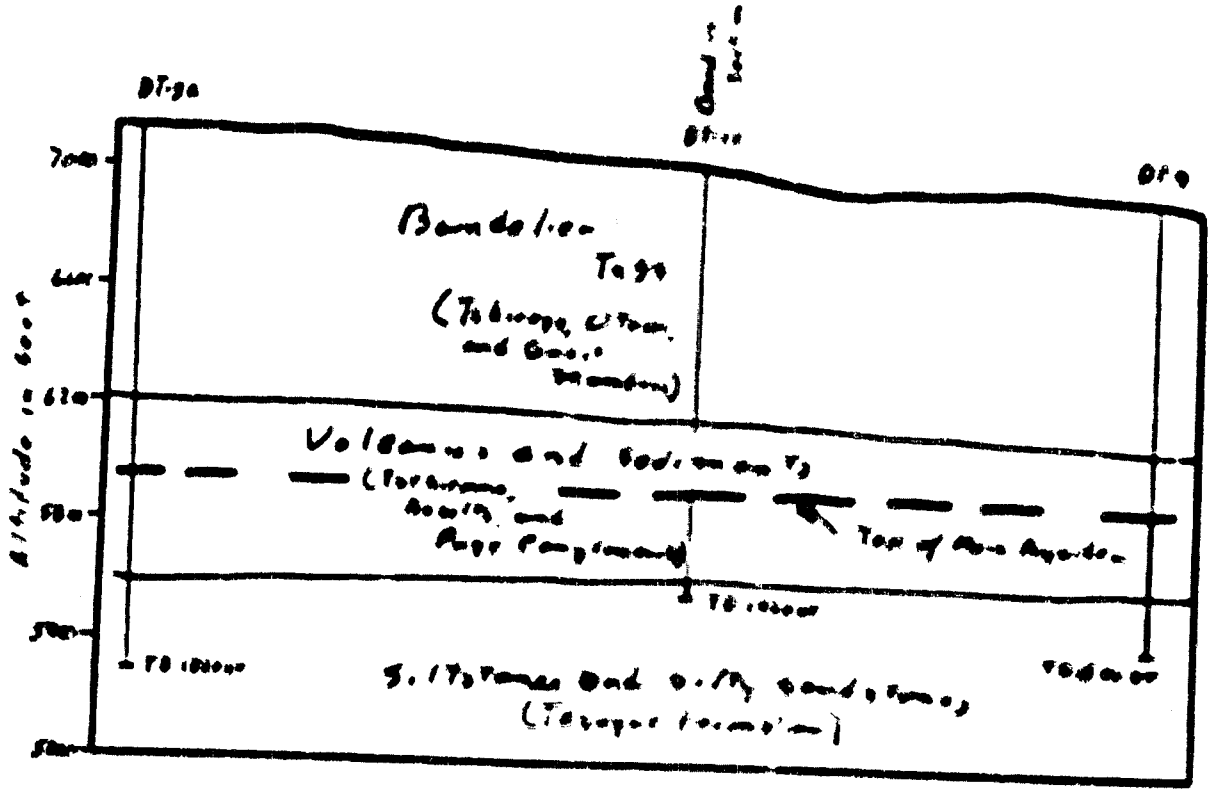


Fig. 4. Upper section showing stratigraphic relationship of geologic units, lower section showing geologic structure



Map showing line for geologic section below


DT-9a
DT-9
Bandelier
Tb3
Volcanics and Sediments
Top of Main Aquifer
Tb1
Tb1
Tb1

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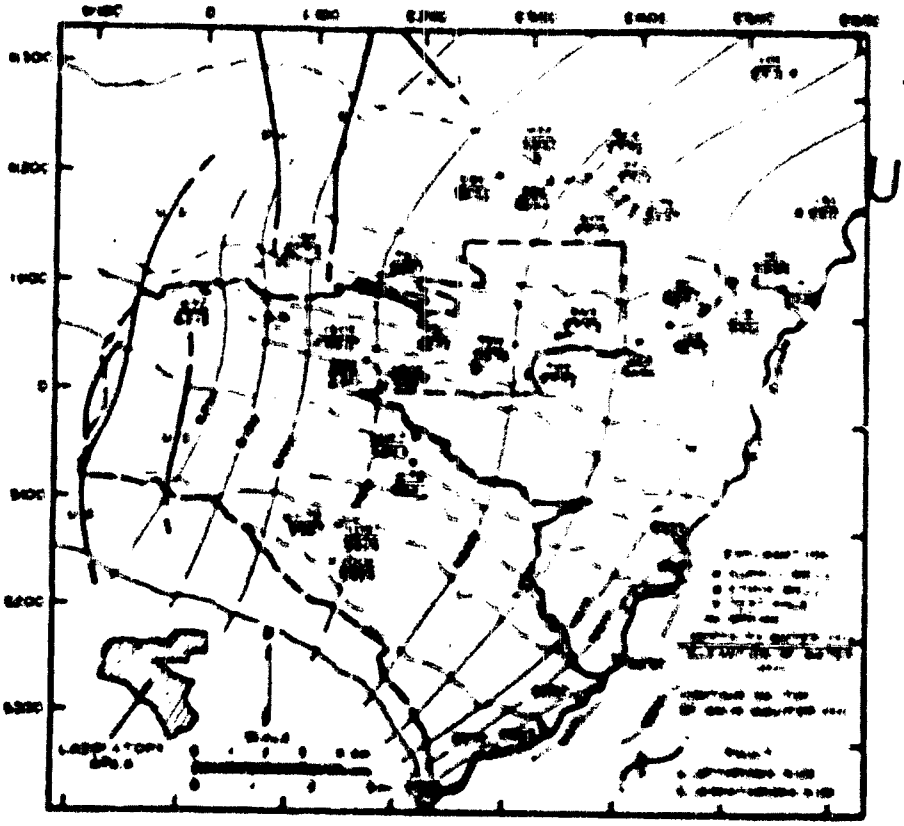

Fig. 6. Generalized contours on the surface of the main aquifer

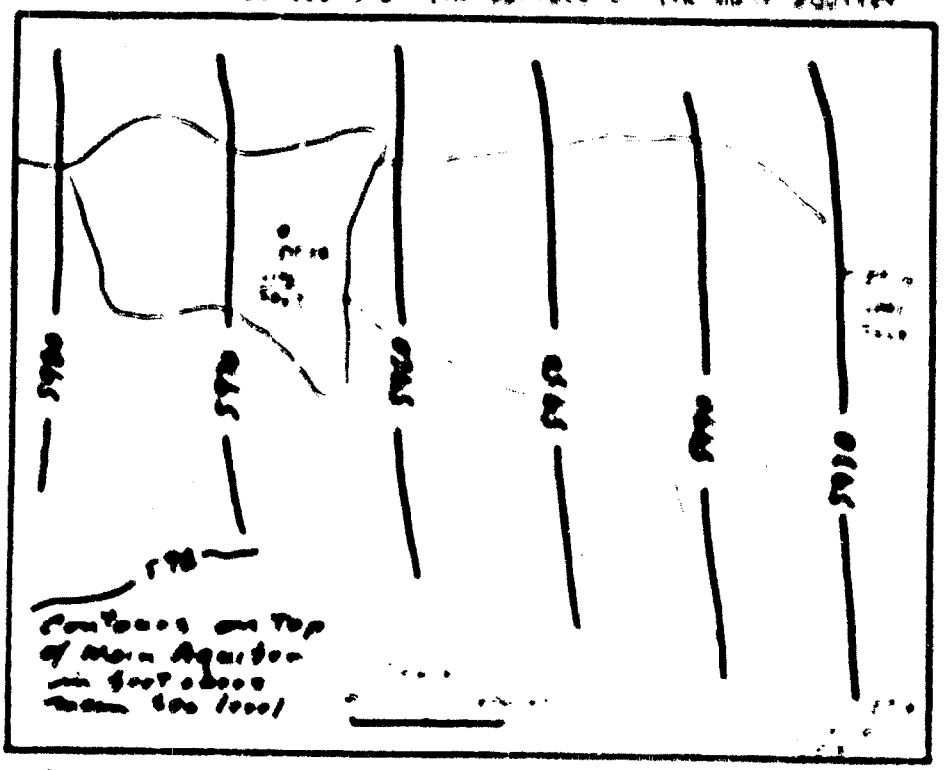

Fig 7. Contours on the surface of the main aquifer at 76-69

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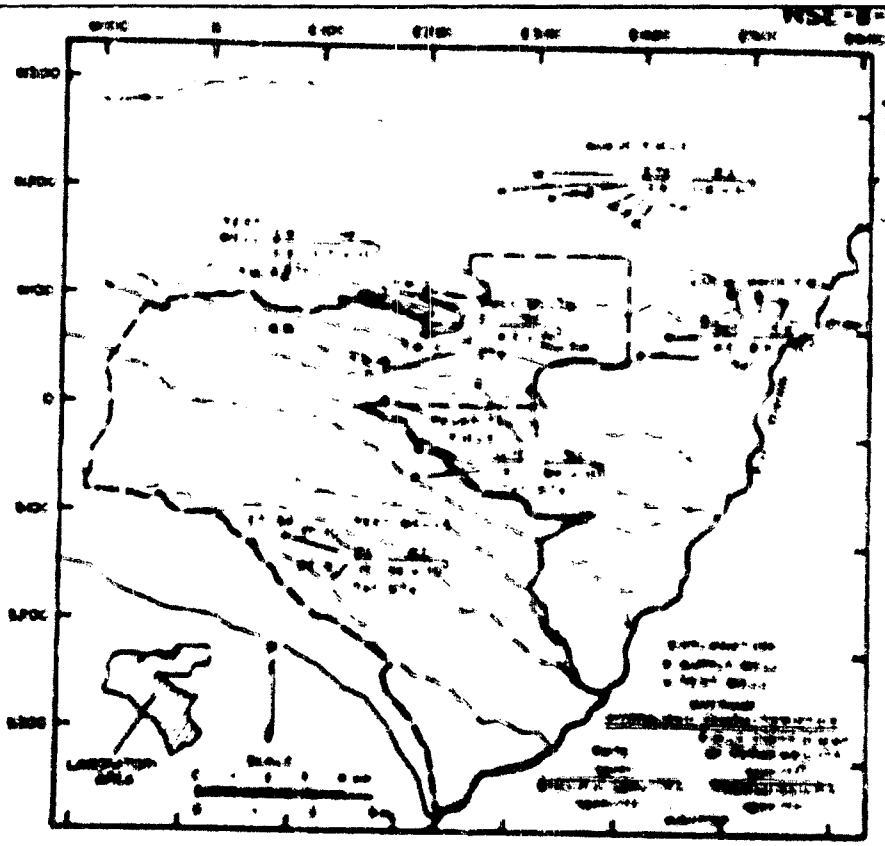

Fig. 8. Hydrologic characteristics of the main aquifer

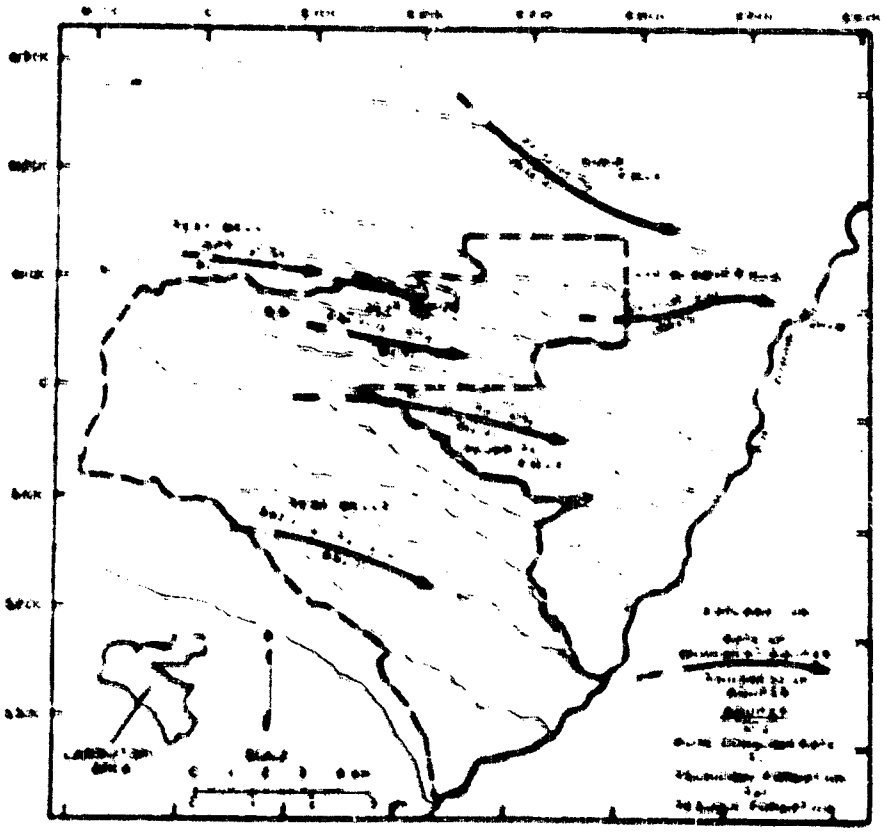

Fig. 9 Rate of movement of water in the main aquifer

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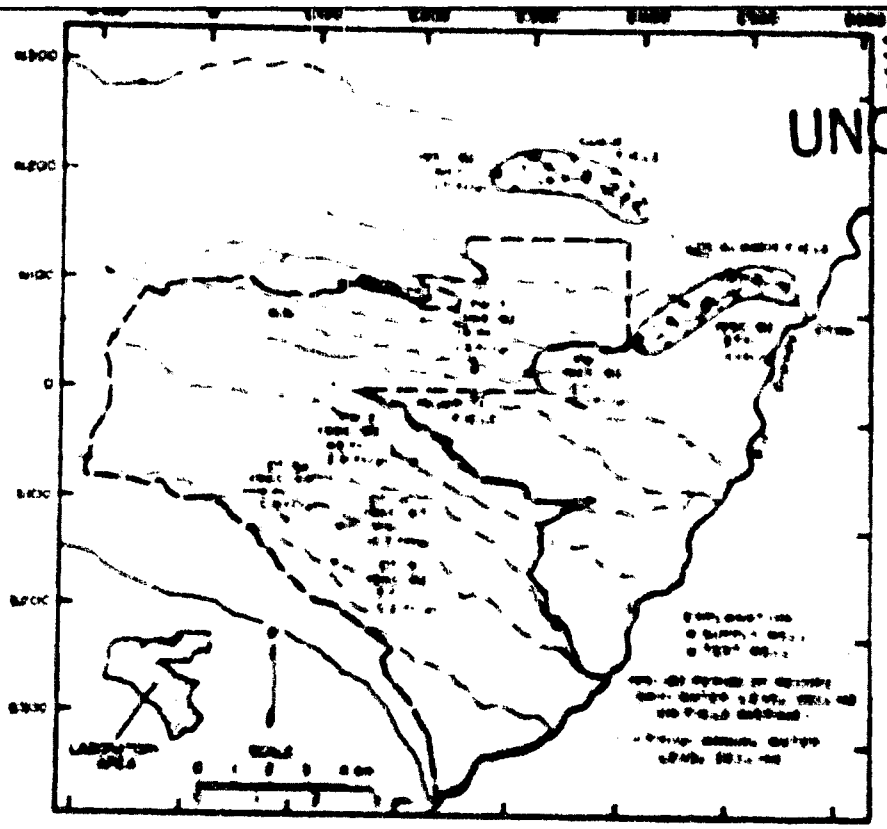

Fig. 10. Water-level declines in well fields and supply and test wells

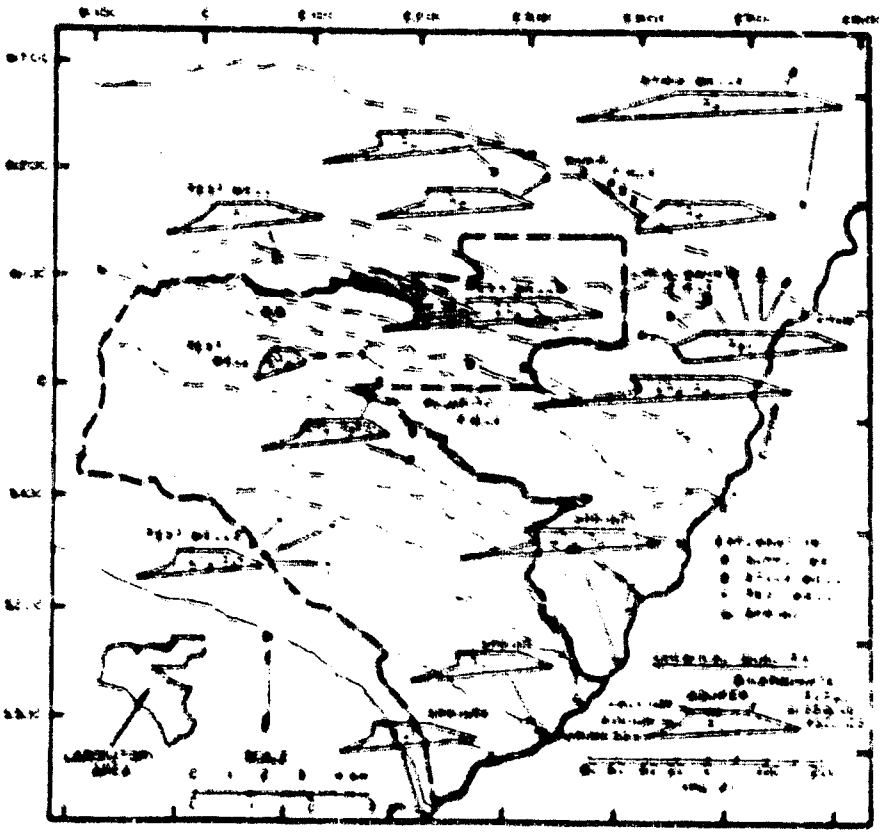

Fig. 11. Graphic comparison of chemical constituents in water from supply, test, and stock wells

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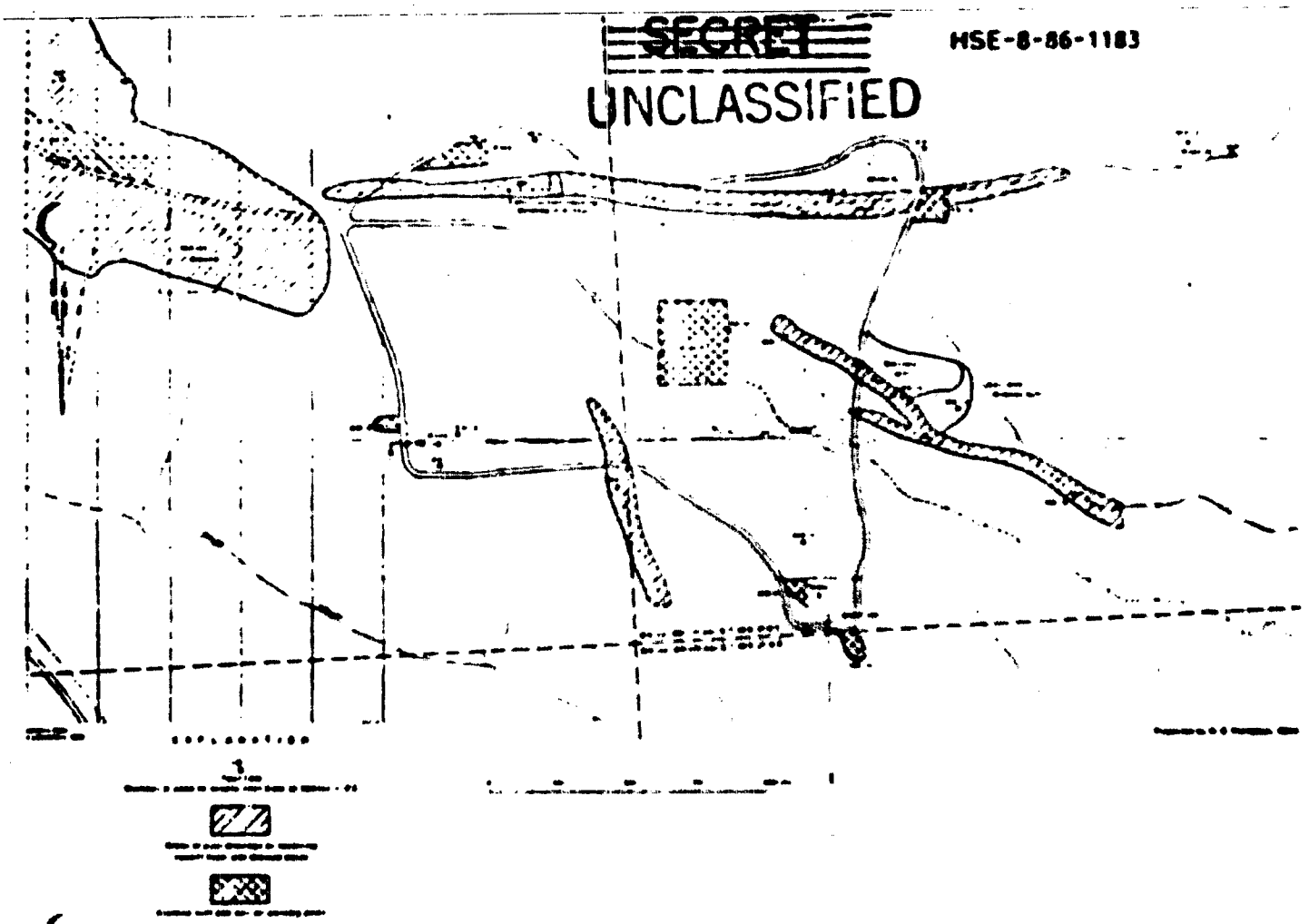

Fig. 12. Location of 23 moisture access tubes used to study the distribution of moisture in the soil and tuff.

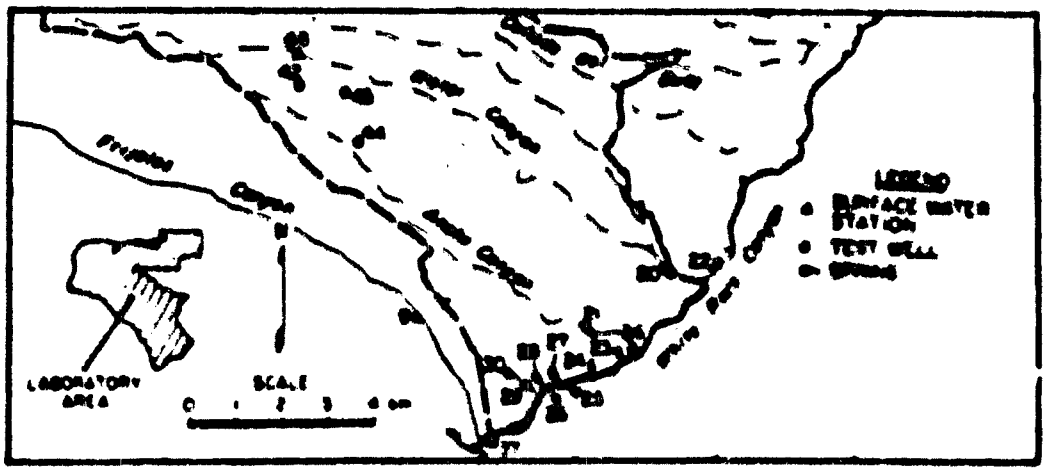

Fig. 13. Surface and groundwater sampling stations in and below TA-49, numbers reference to Table 1.

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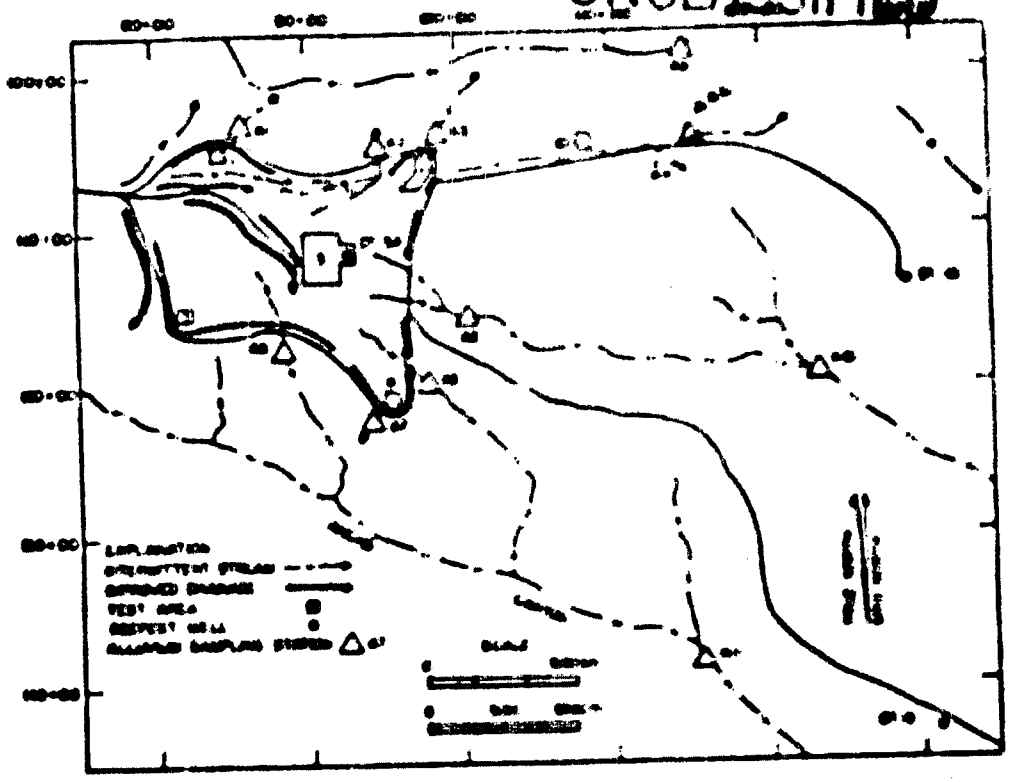

Fig. 14. Location of alluvium (sediment) sampling stations in 1A-49

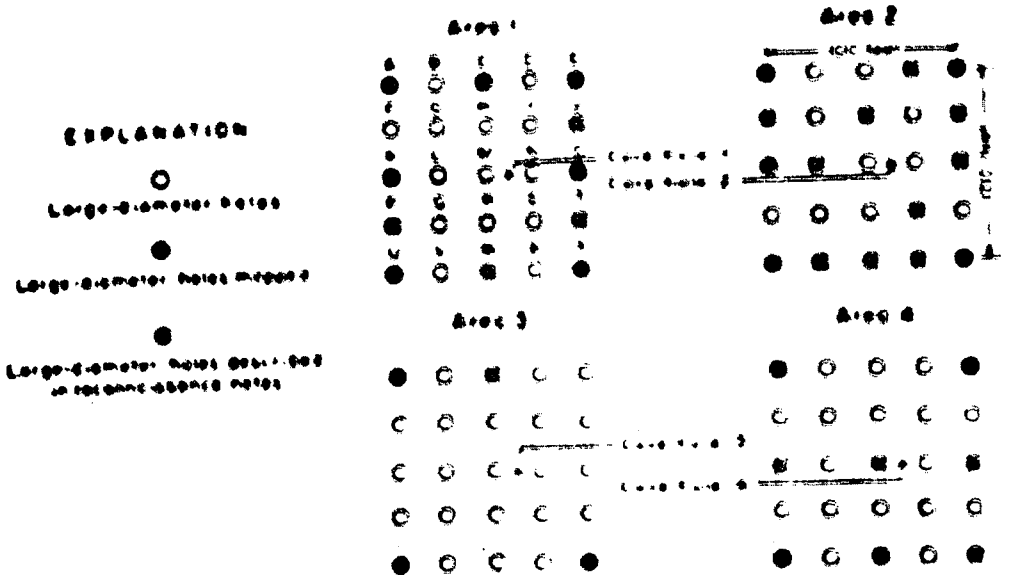

Fig. 15. Layout of shafts (large-diameter holes) in Areas 1, 2, 3, and 4, not all shafts excavated

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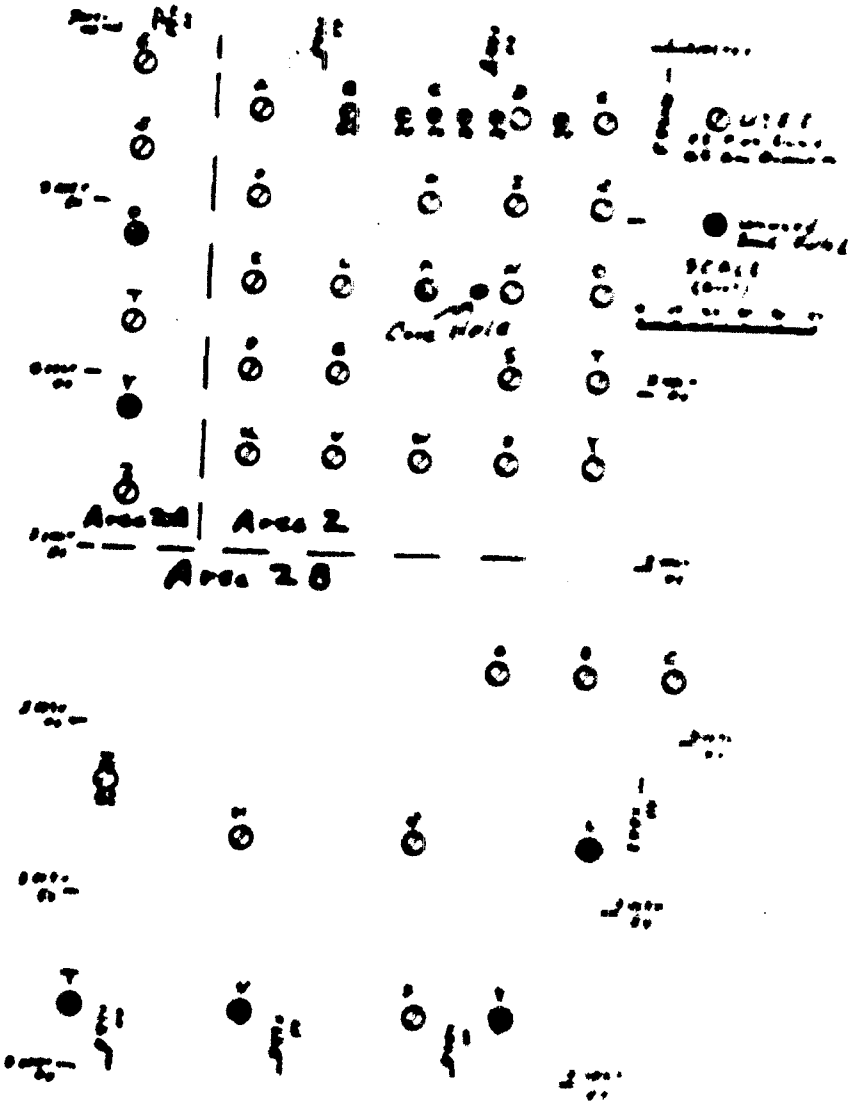

Fig. 16. Layout of shafts in Areas 1, 2A, and 2B

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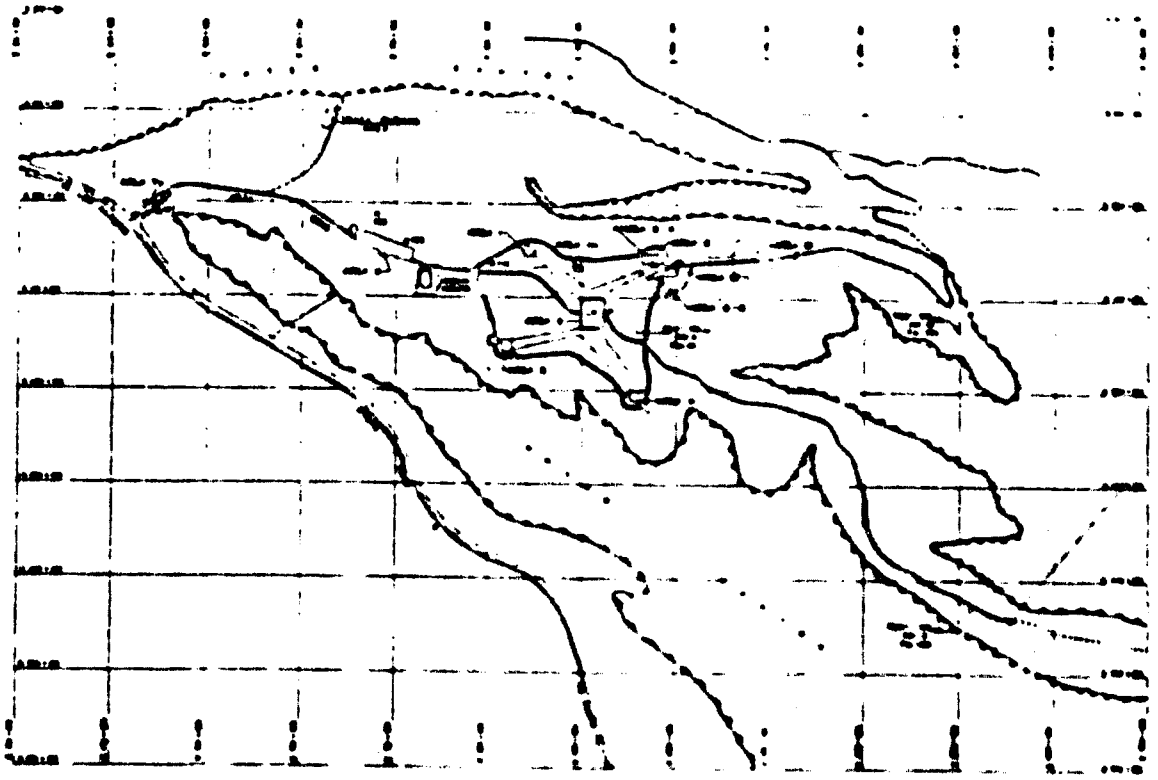

Fig. 17. Engineering drawing showing location of Areas and relation to trash-burning area at TA-49.

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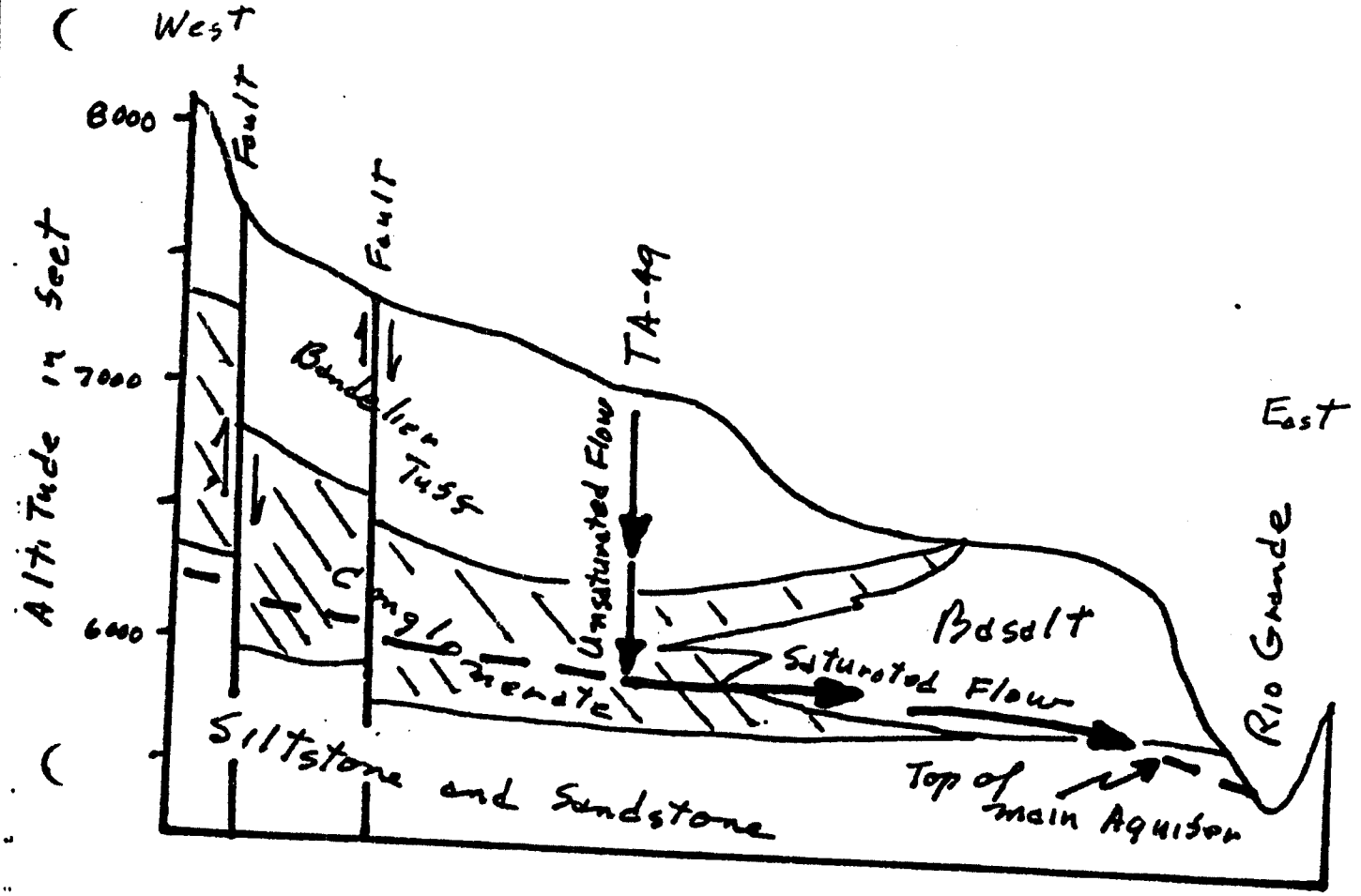

Fig. 18. Geologic cross section showing flow path (unsaturated and saturated) of contaminants from TA-49 to the Rio Grande as used in risk analyses (not to scale).

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