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Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area

Los Alamos
NATIONAL LABORATORY

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GEOLOGIC AND HYDROLOGIC RECORDS OF OBSERVATION WELLS, TEST HOLES, TEST WELLS, SUPPLY WELLS, SPRINGS, AND SURFACE WATER STATIONS IN THE LOS ALAMOS AREA

by

W. D. Purtymun

ABSTRACT

Hundreds of holes have been drilled into the Pajarito Plateau and surrounding test areas of the Los Alamos National Laboratory since the end of World War II. They range in depth from a few feet to more than 14 000 ft. The holes were drilled to provide geologic, hydrologic, and engineering information related to development of a water supply, to provide data on the likelihood or presence of subsurface contamination from hazardous and nuclear materials, and for engineering design for construction. The data contained in this report provide a basis for further investigations into the consequences of our past, present, and future interactions with the environment.

I. INTRODUCTION

Studies for the development of water supply, for the monitoring of the release of liquid wastes, for the disposal and storage of industrial wastes, and engineering investigations have resulted in a large number of reports. These reports have required the drilling of supply wells, test holes, test wells, and observation wells for water supply and for geologic and hydrologic information. Other test holes have been drilled for various experiments related to waste disposal and storage. Surface water investigations have been conducted to help determine the hydrology of the area. In addition, a number of stations have been established to monitor the quality of both the surface and ground water.

A. Purpose and Scope

The purpose of this report is to compile geologic logs, construction records, and locations of supply wells, observation wells, test wells, test holes and monitoring stations (both surface and ground water stations). The geology and hydrology are presented to provide a framework for understanding the geologic units that relate to the movement of surface and ground water. The original sources of the data presented in each section are referenced at the end of each section.

This report is similar to the two reports, "Records of Wells, Test Wells, Springs and Surface-Water Stations in the Los Alamos Area," by E. C. John, E. Enyart, and W. D. Purtymun, U.S. Geological Survey Open-File Report (1966) and "Geohydrology of the Pajarito Plateau with Reference to the Quality of Water 1949–1972," by W. D. Purtymun, Los Alamos Scientific Laboratory, internal EM-8 document, 1975. This document incorporates data from those documents and presents additional data collected through 1992.

Katherine D. Bennett's "Annotated Bibliography of Geologic, Hydrologic and Environmental Studies Related to Solid Waste Management Units at Los Alamos National Laboratory" Los Alamos National Laboratory document LA-UR-90-3216 presents a complete reference to geologic, hydrologic, and environmental reports available at the Environmental Community Reading Room located at 1450 Central Ave. Suite 101, Los Alamos, New Mexico. The reading room is maintained by the Laboratory as part of the operating permit granted to the Laboratory by the U.S. Environmental Protection Agency (EPA). All reports referenced in this report should be available at the reading room.

This report includes geologic logs and construction data for the following:

(1) observation wells or test holes completed in the shallow alluvial aquifers
(2) wells or test holes constructed for special studies
(3) moisture-access holes (cased with 2-in.-diam plastic or aluminum pipe and used in conjunction with a moisture/density gauge to determine moisture and density of material adjacent to the core hole)
(4) wells or test holes completed into the main aquifer, or into perched aquifers below the alluvial aquifer and above the main aquifer
(5) supply wells completed into the main aquifer
(6) springs
(7) holes drilled for specific engineering purposes
(8) holes used for facility construction
(9) surface water data related to seepage measurements
(10) the monitoring of surface and ground water in and adjacent to the Laboratory
(11) preliminary studies and support activities such as water supply and water quality monitoring at the Fenton Hill geothermal experimental site.

In this paper we have sometimes used internal or unpublished reports or memos that relate to holes drilled for small, specific, geologic or hydrologic studies. These papers can be found in Los Alamos National Laboratory report LA-12733-MS. This report is entitled "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990."

B. Locations of Test Holes, Wells, and Monitoring Stations

Two methods are used for the location of test holes, wells, and monitoring stations in this report: (1) the North American Datum 1927 coordinate system (NAD 1927) and (2) the Los Alamos National Laboratory coordinate system (LANLC). The NAD 1927 system is preferred; however, in some cases sites where the wells or stations have been originally surveyed in the LANLC, this system has been used to document the location. Each section of the report contains a reference map showing the general loca-

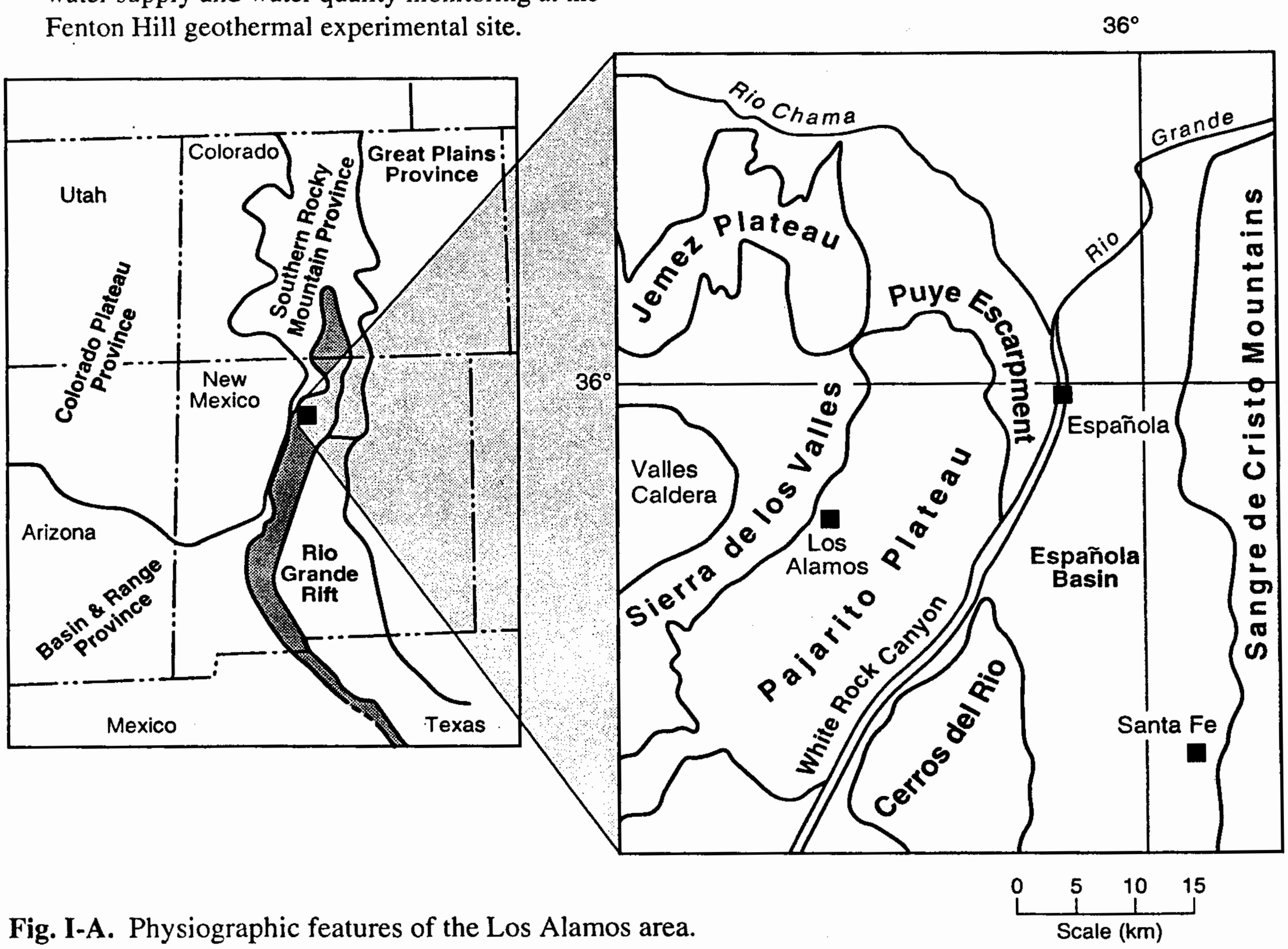

Fig. I-A. Physiographic features of the Los Alamos area.

tion for the wells, test holes, or monitoring stations.

C. Topography

The facilities of Los Alamos National Laboratory and the communities of Los Alamos and White Rock are located on the Pajarito Plateau. The Pajarito Plateau forms an apron 8 to 16 miles wide and 30 to 40 miles long around the eastern flanks of the Sierra de los Valles (Fig. I-A). The surface of the plateau slopes gently eastward from an elevation of about 7800 ft along the flanks of the mountains to about 6200 ft along the eastern edge, where it terminates along the Puye Escarpment and White Rock Canyon (Fig. I-B). The plateau is drained by southeast- and eastward-trending streams that have cut deep canyons. These canyons dissect the plateau into narrow east- to southeast-trending mesas.

The Rio Grande lies along the eastern edge of the plateau. It drops from an elevation of about 5500 ft at Otowi (at the mouth of Los Alamos Canyon) to about 5360 ft at its junction with Frijoles Canyon. North of Otowi the Rio Grande lies in a broad valley, whereas to the south the river is confined in a deep narrow canyon (White Rock Canyon).

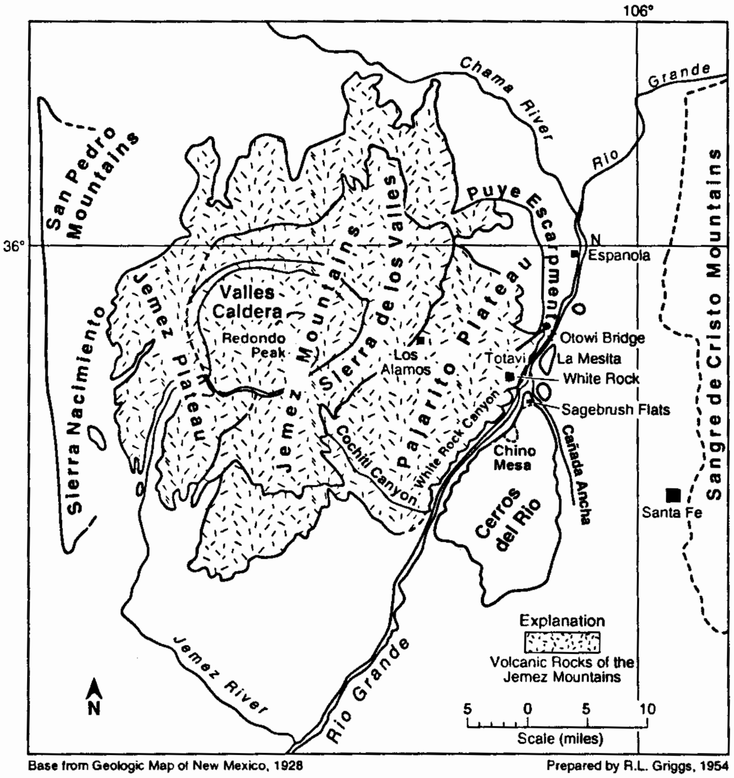

Fig. I-B. Topographic features in the Los Alamos area and their relation to the volcanic rocks (shaded) of the Jemez Mountains.

The mountain peaks of the Sierra de los Valles rise to an elevation of about 11 500 ft near the head of Santa Clara Canyon to the north and to an elevation of about 10 200 ft near the head of Frijoles Canyon to the south. The crest of the north/south range of peaks and ridges forms a surface water divide. Streams originating on the eastern slopes and the Pajarito Plateau flow directly into the Rio Grande. Streams originating on the western slopes flow into the Valles Caldera, an intermountain basin, which is drained mainly by the Jemez River. The Jemez enters the Rio Grande 75 miles to the south.

D. Geology

The geologic nomenclature of the rock units has evolved over the years. An effort has been made to incorporate these changes into this report. The geologic and geophysical logs of deep test holes or wells penetrating the Puye Conglomerate and Santa Fe Group have been revised to reflect these changes. The major change is the separation of the coarse gravels, cobbles, and boulders that represent a deposition of volcanic debris from the west and granitic and metamorphic rocks from the east. These were previously logged as the upper part of the Tesuque Formation beneath the Pajarito Plateau. This unit (named the Chaquehui Formation of the Santa Fe Group) has allowed the development of a high-yield water supply on the plateau. The Chamita Formation which overlies the Tesuque Formation (and which was previously included in the early descriptions of the Tesuque Formation) is also described separately where it can be identified. There are different terminologies used in the nomenclature of the volcanic rocks of the Jemez Mountains and the Basaltic Rocks of Chino Mesa. The stratigraphic units used in this report are shown in Fig. I-C.

The drainage areas or streams that head on the flanks of the mountains cut into the rocks of the Tschicoma Formation. Canyons on the plateau cut into and are underlain by the Bandelier Tuff. Along the eastern edge of the plateau the channels cut into

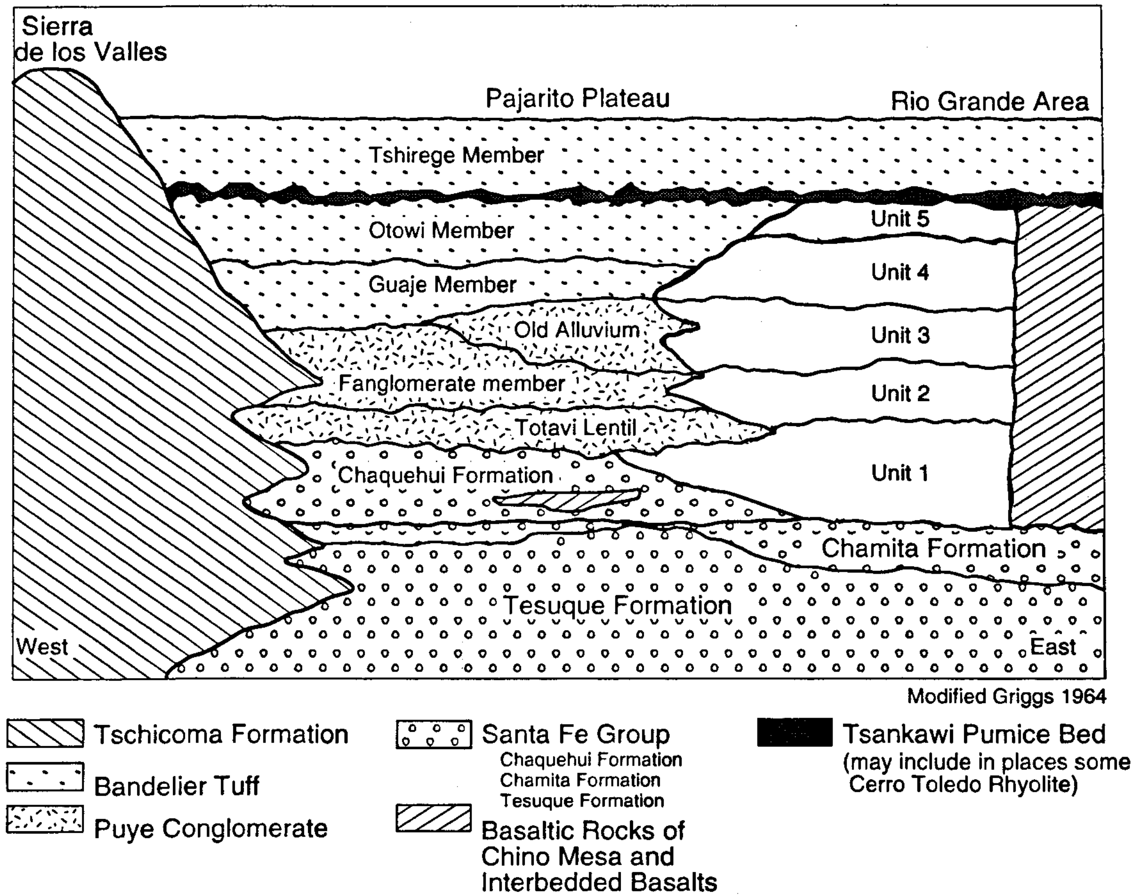

Fig. I-C. Diagram of stratigraphic units used in this report.

the Basaltic Rocks of Chino Mesa (part of the Cerros del Rio basalts) and the sediments of the Puye Conglomerate and the Santa Fe Group. These sediments floor the valley north of Otowi on the Rio Grande and form the lower canyon walls along the Rio Grande in White Rock Canyon. The Basaltic Rocks of Chino Mesa are interbedded with the sediments of the Puye Conglomerate along White Rock Canyon and beneath the Pajarito Plateau
(Fig. I-D).

The rock units, described from the oldest to the youngest, are the Santa Fe Group, Puye Conglomerate, and the Basaltic Rocks of Chino Mesa. The volcanic rocks of the Jemez Mountains include the Tschicoma Formation and the Bandelier Tuff (which includes the Cerro Toledo Rhyolites and Tsankawi Pumice Bed). A diagrammatic section of geologic units beneath the Pajarito Plateau is shown on Fig. I-F.

1. Santa Fe Group. The Santa Fe Group underlies the Puye Conglomerate and outcrops along the eastern edge of the plateau along the Rio Grande. The stratigraphic nomenclature of the Santa Fe Group and Puye Conglomerate has evolved over the past 50 years as shown in Fig. I-E. The nomenclature used in this report is shown on the right side of the figure.

The Santa Fe Group is composed of three formations in the area. The oldest is the Tesuque Formation which underlies the Chamita Formation.

The name Tesuque Formation was first used by Spiegel and Baldwin (1963) to describe the sediments at the southern end of the Española valley including the exposures in the vicinity of Otowi Bridge and along White Rock Canyon on the Rio Grande. Baltz et al. (1963) extended the name into the Los Alamos area in 1960 on the basis of lithology and stratigraphic location. Galusha and Blick (1971) split the younger

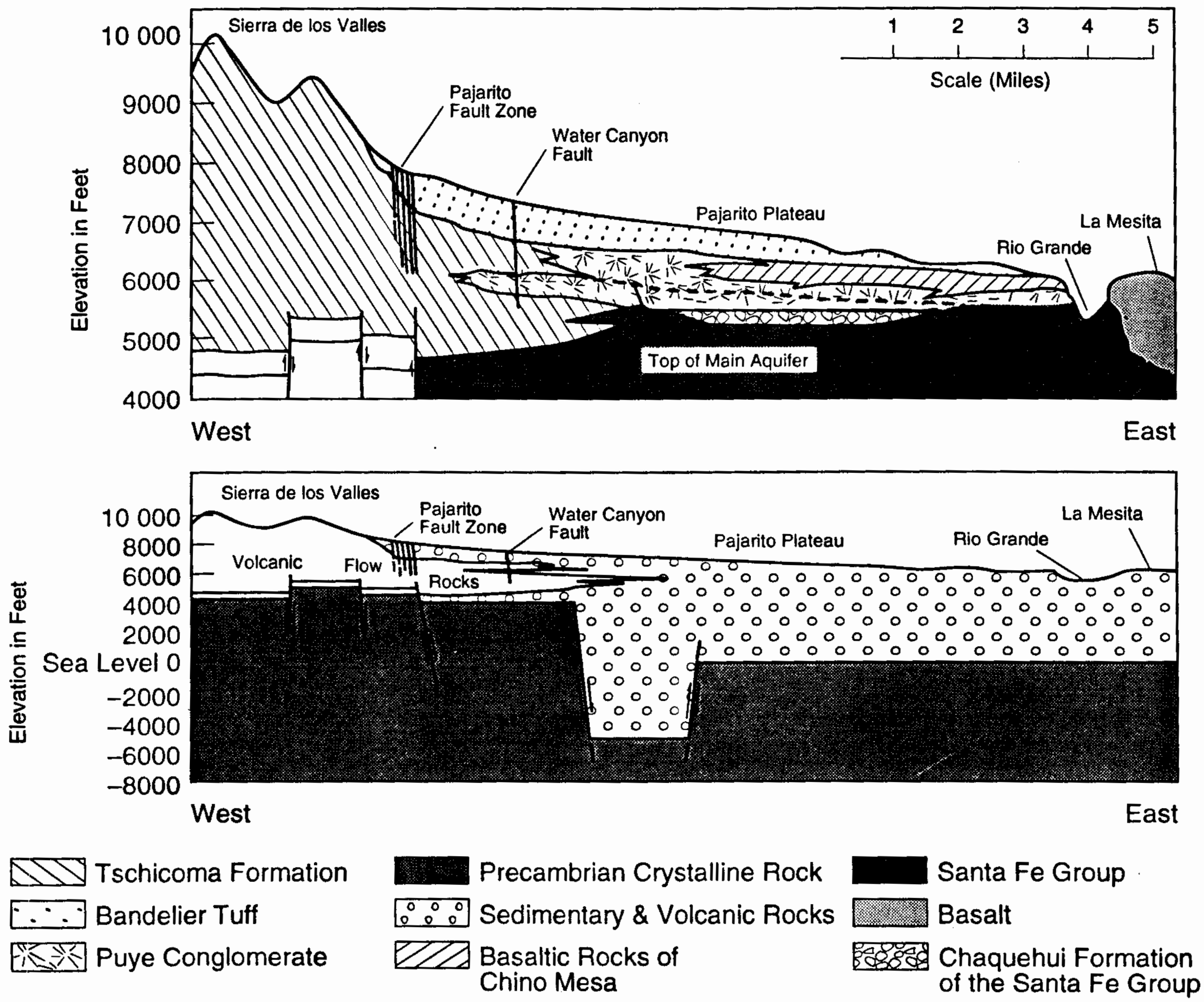

Fig. I-D. Geologic sections showing the stratigraphy and structure from the Sierra de los Valles across the Pajarito Plateau to the Rio Grande (modified Purtymun 1968).

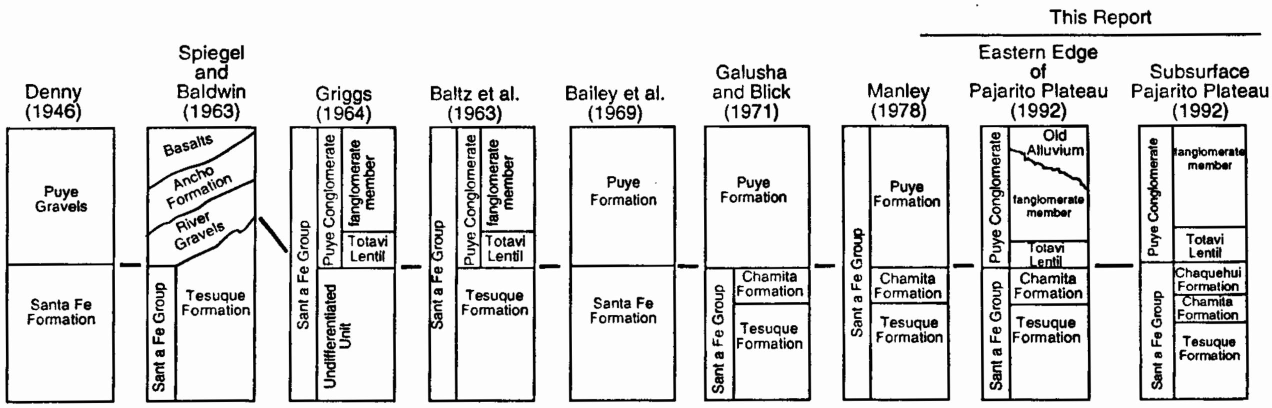

Fig. I-E. Stratigraphic nomenclature of the pre-Bandelier sediments.

Chamita Formation from the top units of the Tesuque Formation (Fig. I-E). Previous well logs considered the Chamita Formation as the upper part of the Tesuque Formation. This report separates out the Chamita Formation from the Tesuque Formation where it is present.

The Tesuque Formation is the oldest geologic formation to be considered in this report. It is a massive, thick unit consisting of arkosic sediments that are poorly to moderately cemented, light pink to buff siltstone, silty sandstone, and a few lenses of pebbly conglomerate and clay. The sand-sized particles are dominantly quartz and feldspar; minor amounts of biotite, muscovite, and magnetite are also present. Most of the beds are shallow stream or deltaic deposits with some minor amounts of wind-blown sand. Basalts older than the Basaltic Rocks of Chino Mesa were not encountered in the Tesuque Formation in the Pajarito Well Field; however, basalts older than the Chino Mesa basalts were encountered interbedded with the Tesuque Formation sediments in wells G-1, G-1A, and G-6 in the Guaje Field (Fig. I-F). A basalt sill at a depth of 2219 ft in Otowi Well O-1 was found to be 12 million years old (Laughtin et al. 1993).

South of Otowi, the Tesuque Formation forms the valley along the Rio Grande and outcrops in lower canyon walls cut into the eastern edge of the Pajarito Plateau. In this area the Tesuque is overlain by a thin section of the Totavi Lentil. North of Water Canyon the Tesuque plunges beneath the younger Chaquehui Formation of the Santa Fe Group.

The Chamita Formation consists of arkosic siltstones, sandstones, and pebbly conglomerate that contains two prominent beds of white ash. These ash beds were described in the logs of Pajarito Wells PM-1, PM-2, and PM-5, and Otowi Well 0-4. The formation is thickest in the northern part of the Española Basin and thins to less than 30 feet in the area north of Otowi. It is of localized extent. In the immediate Los Alamos area, it is absent in the supply wells in lower Los Alamos and Guaje Canyons, and only thin remnants are found in a few of the supply wells completed on the Pajarito Plateau (Fig. I-F). The bulk of the Chamita Formation has been stripped off by erosion or was not deposited in the area. The lithology and physical characteristics of the Chamita are similar to the Tesuque Formation, and thus do not contribute any measurable change to the hydrologic properties of the Santa Fe Group.

The Chaquehui Formation of the Santa Fe Group is composed of a mixture of volcanic debris from the Sierra de los Valles and arkosic and granitic debris from the highlands to the north and east. It contains the only aquifer in the Los Alamos area that is capable of providing a municipal and industrial water supply. The early basalt flows of the Cerros del Rio basalts formed a constriction at the southern end of the Española Basin, forcing the river west of the volcanic centers (Kelley 1948; Theis 1950). The volcanic debris mixed with granitic debris carried by the river and filled the basin. This deposition of coarse sediments was contemporaneous with the intrusion of basalts and basalt flows, which are interbedded with the sediments and are older than the Basaltic Rocks of Chino Mesa. In Otowi Well O-4

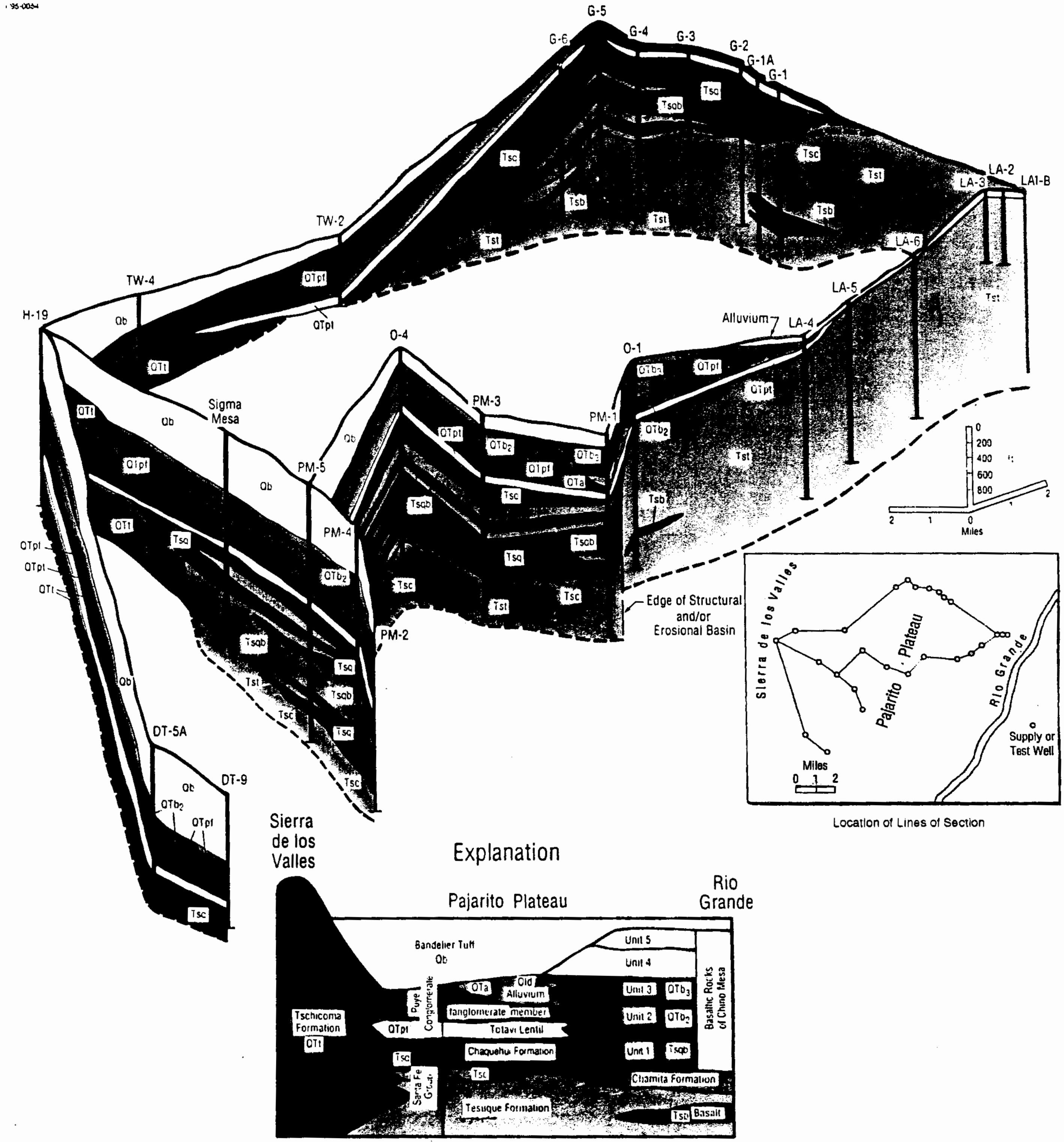

Fig. I-F. Diagrammatic section showing stratigraphy beneath the Pajarito Plateau.

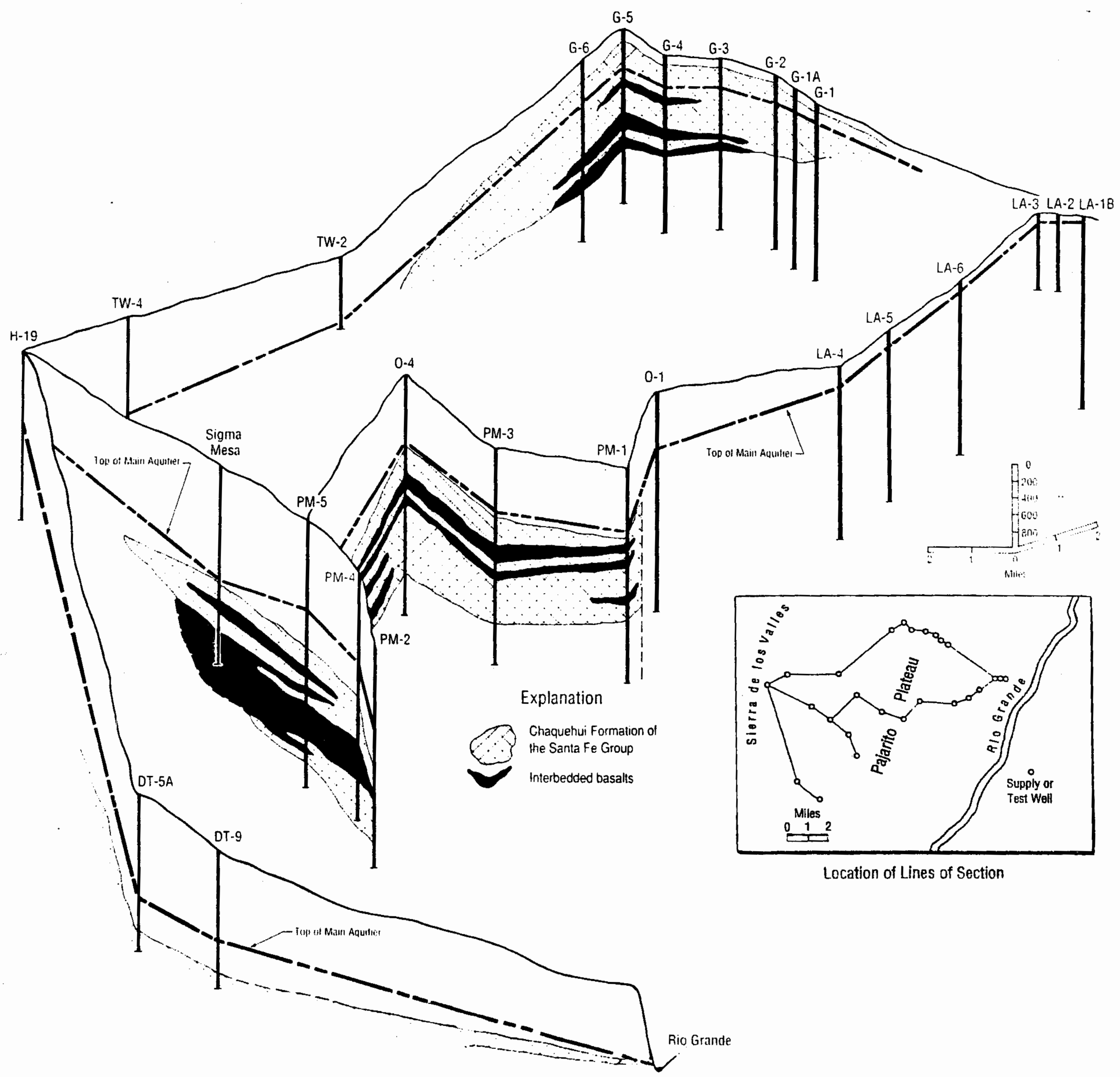

Fig. I-G. Diagrammatic section showing the distribution of the Chaquehui Formation of the Santa Fe Group and interbedded basalts beneath the Pajarito Plateau.

there are interbedded basalts between the depths of 1140 and 1392 ft that were dated as being 8 to 9 million years old (Laughtin et al. 1993), or about equivalent in age to the Chamita Formation. Several of the wells on the plateau show, however, that the Chamita Formation consistently underlies the Chaquehui Formation.

The coarse sediments of the Chaquehui Formation contain volcanic rock fragments of basalt, latite, rhyolite, tuff, and pumice derived from the west as well as rhyolite, gneiss, limestone, and quartzite derived from the highlands to the north and east. The formation is found in the subsurface beneath the plateau and outcrops in a thin section in White Rock Canyon (Fig. I-G). It is transitional between the rest of the Santa Fe Group (encompassing also the Chamita and Tesuque Formations) and the volcanic rocks of the Jemez Mountains. The presence of the coarse-grained sediments of the Chaquehui was first noted by Griggs (1964) as arkosic quartz sands, latite gravels, and volcanic debris derived from the east and west sources in the subsurface of the Guaje Well Field. He also noted their presence in White Rock Canyon to the south of Water Canyon. The formation is named after the small Chaquehui Canyon that drains into White Rock Canyon at the south end of the outcrop described by Griggs.

Overlying the Chaquehui Formation in White Rock Canyon are mixtures of sediments, quartzites, basalts, and volcanic sediments described as maar deposits (a mixture of sediments and volcanic material resulting from a volcanic eruption through an aquifer or shallow lake). Aubele (1978) noted Precambrian granitic and metamorphic chert, quartzite and granitic fragments interbedded with the basalts of the Cerros del Rio Volcanic Field. Heiken et al. (1989) also described the maar deposits in White Rock Canyon. However, these maar deposits are below the Totavi Lentil in Ancho Canyon and below the Unit 1 Basaltic Rocks of Chino Mesa (Figs. I-H and I-I). Dethier (in press 1994) indicated that the maar deposits at the mouth of Chaquehui Canyon are older than 2.6 million years, the age of the Basaltic Rocks of Chino Mesa. The maar deposits have not been dated and may be similar in age to the Chaquehui Formation (8 to 9 million years old).

Weir and Purtymun (1962) encountered the coarse-grained sediments of the Chaquehui Formation beneath the Totavi Lentil and recognized the potential of the formation for the development of a water supply. Based on aquifer tests at TA-49, Purtymun and Cushman (1961) located the first of the Pajarito wells on the eastern edge of the Pajarito Plateau, followed by Purtymun and John (1964) locating the second well near the center of the plateau. The coarse-grained cuttings encountered in both wells beneath the Totavi Lentil outlined a trough of coarse-grained sediments that would allow the development of high-yield wells (with yields greater than 1000 gpm). Five additional well-site locations were laid out by Purtymun and Cooper (1965). Three additional wells were drilled from 1966 to 1982 to complete the five wells in the Pajarito Field. Four of the five were high-yield wells while the fifth (the first well drilled) was limited in its production by its completed diameter rather than by its hydrologic characteristics. The other four wells in the field were completed with a larger diameter so as to accommodate high-yield pumps.

Purtymun and Stoker (1988) laid out locations for four wells in the Otowi Well Field. Two wells were completed in 1990. One well was a high-yield well penetrating more than 1500 ft of coarse sediments and basalts below the Totavi Lentil. In trying to get proper spacing between the wells in the field, the other well was located outside the area underlain by the Chaquehui Formation. This well penetrated only fine-grained sediments below the Totavi Lentil, and has a probable yield of less than 1000 gpm. Other wells with limited penetration of the coarse-grained sediments of the Santa Fe Group include the wells in the Guaje Well Field, test wells at TA-49, and Sigma Mesa Hole. Wells in the Los Alamos field also failed to penetrate the coarse-grained sediments.

Purtymun and Cooper (1969) indicated a facies change in the Santa Fe Group from fine-grained sediments in the east to coarse-grained sediments in the west beneath the Pajarito Plateau. Griggs (1964) called the Santa Fe Group the Undifferentiated Unit while Baltz (1963) referred to it as the Tesuque Formation. Geologic logs of the supply wells and test holes referred to the coarse-grained sediments underlying the Totavi Lentil as the Tesuque Formation. The thin section of the Chamita Formation described by Galusha and Blick (1971) was included in the Tesuque Formation. The development of the high-yield wells in the coarse-grained sediments beneath the plateau contrasts with the low-yield wells (less than 600 gpm) in the fine sediments in Los Alamos Canyon. There was only partial penetration

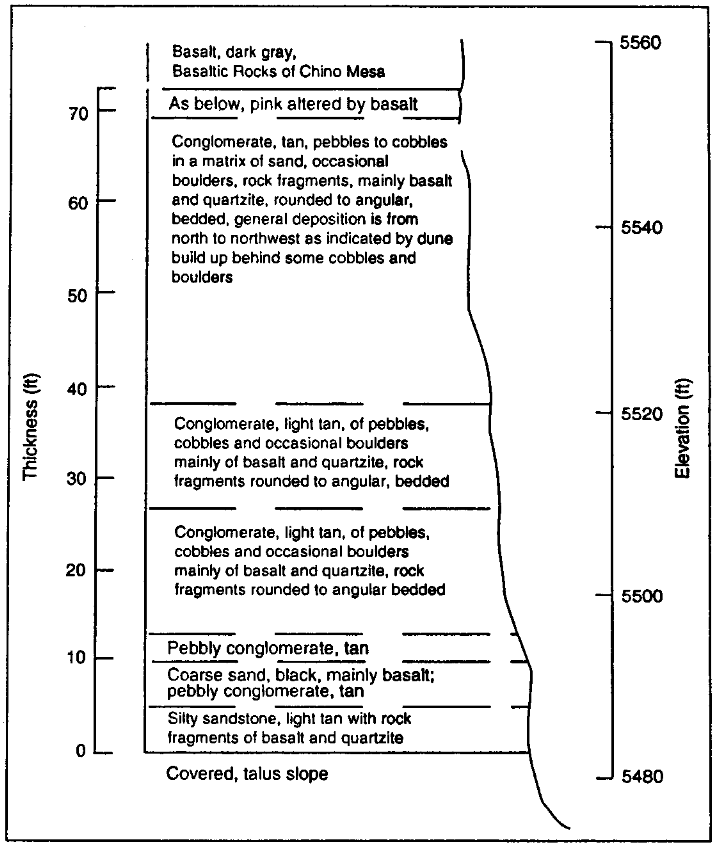

Fig. I-H. Type section of the maar sediments on the south wall of Chaquehui Canyon at the Rio Grande.

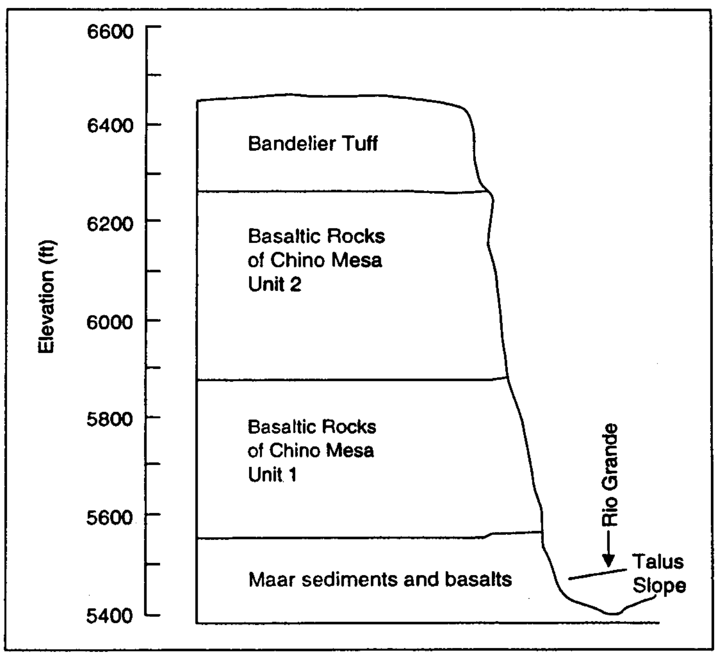

Fig. I-I. Generalized geologic section on the south wall of Chaquehui Canyon at the Rio Grande showing the maar sediments and basalts overlain by the Basaltic Rocks of Chino Mesa and Bandelier Tuff.

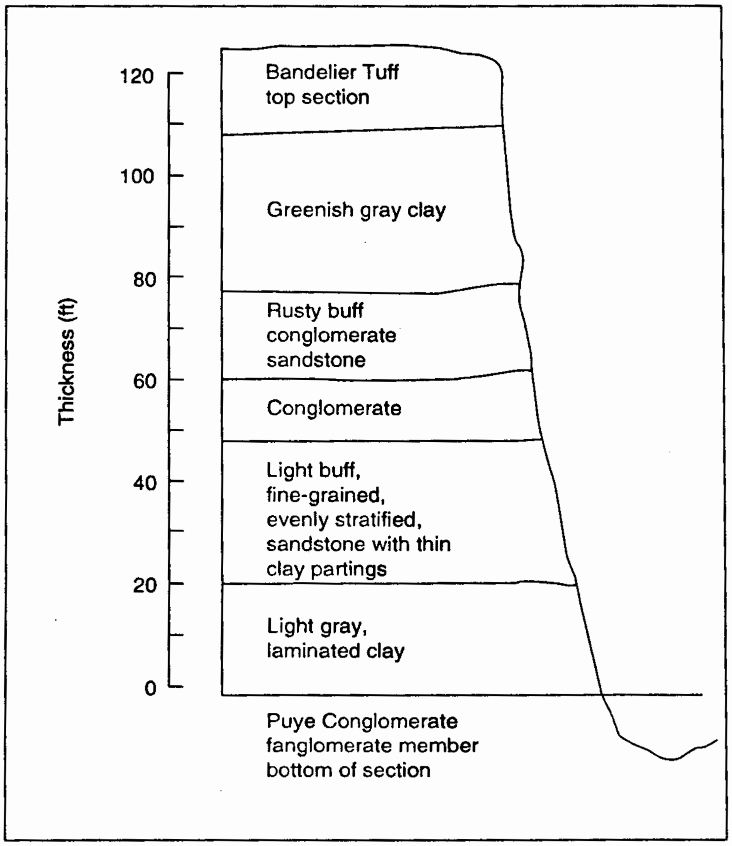

Fig. I-J. Generalized section showing the thickness of Old Alluvium in road cut near Totavi.

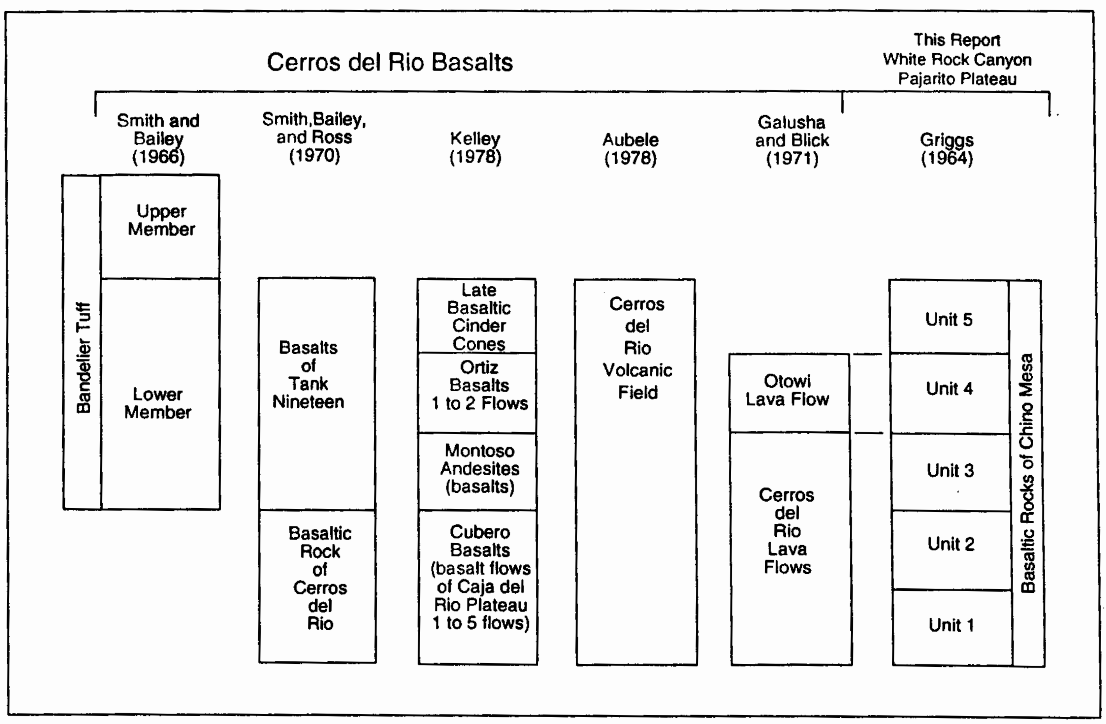

Fig. I-K. Stratigraphic nomenclature of the Cerros del Rio basalts.

of coarse sediments in the upper saturated section of the wells in Guaje Canyon. This indicated a major lithologic change, a change that was noted in the cuttings, geophysical logs, and geologic logs of wells drilled on the Pajarito Plateau.

A review was made of the geophysical and geologic logs to separate out the Chamita Formation and the overlying Chaquehui Formation (with its coarse-grained sediments) from the Tesuque Formation. The Chamita Formation was identified through the prominent white ash beds in four of the wells in the Pajarito Field. The Chaquehui Formation is a mappable unit that occurs in the subsurface beneath the plateau. It is a trough filled with coarse sediments as much as 1500 ft thick, 3 to 4 miles wide, and extending 7 to 8 miles from the northeast to the southwest.

It is an important formation, containing the main aquifer of the Los Alamos area, the only aquifer capable of municipal and industrial supply. The saturated section of the Chaquehui Formation can support the development of high-yield wells. The drilling of test holes and water supply wells which penetrate the main aquifer should be performed so as to prevent contamination of this crucial resource.

2. Puye Conglomerate. The sediments of the Santa Fe Group are overlain by the Puye Conglomerate. The Puye is composed of three members or units: the Totavi Lentil, the Old Alluvium, and the upper fanglomerate member. The past stratigraphic nomenclature and the nomenclature used in this report are shown on Fig. I-E.

Overlying the Chaquehui Formation of the Santa Fe Group in the subsurface beneath the Pajarito Plateau is the Totavi Lentil. It consists of a poorly consolidated, channel-fill deposit of granitic debris, quartzite, gneiss, and occasional schist, and boulders to cobbles in a matrix of sand. The lentil is about 50 ft thick. The lentil is overlain by the fanglomerate member of the Puye Conglomerate. The Totavi outcrops along the eastern edge of the Pajarito Plateau between the Santa Fe Group and the overlying fanglomerate member of the Puye Conglomerate. South of Water Canyon the Totavi Lentil is underlain by the Chaquehui Formation and wedges out between the Basaltic Rocks of Chino Mesa Unit 2 and the Chaquehui Formation south of Ancho Canyon.

The fanglomerate member of the Puye Conglomerate overlies the Totavi Lentil. It is volcanic debris composed of latite, quartzite latite, rhyolite, tuff, dacite, and pumice cobbles to boulders in a matrix of silts, clays, and sands. The cobbles to boulders are angular to subangular. Lenses of silt, clay, and pumice are common. The fanglomerate was derived from the volcanic pile to the west and is interbedded with the younger flow rocks of the Tschicoma Formation beneath the western edge of the plateau. The volcanic debris is also interbedded with Unit 2 of the Basaltic Rocks of Chino Mesa from the east. The fanglomerate is widespread in the subsurface beneath the plateau and forms the bold cliffs that occur along the Rio Grande north of Otowi.

The Old Alluvium of Griggs (1964) is composed of lake clays and gravels deposited in ancient stream channels cut into the fanglomerate member. Unit 3 of the Basaltic Rocks of Chino Mesa flowed into these channels, forming lakes that accumulated sediments (Figs. I-F and I-J). The lake clays and gravels outcrop in lower Los Alamos Canyon and extend northward in discontinuous outcrops for several miles. They are of limited extent beneath the plateau as they were identified in only one well (PM-1) near the eastern edge of the plateau.

3. Basaltic Rocks of Chino Mesa. The Basaltic Rocks of Chino Mesa represent a small number of basalt flows from the Cerros del Rio Volcanic Field located east of the Rio Grande. They extend from Otowi to the upper headwaters of Cochiti Reservoir, a distance of more than 15 miles.

The stratigraphic nomenclature of the Cerros del Rio Volcanic Field has varied with different workers (Figs. I-C and I-K). Smith, Bailey, and Ross (1970) mapped two units of the Cerros del Rio basalts, the older Basaltic Rocks of Cerros del Rio and the younger basalts of Tank Nineteen. The Tank Nineteen basalts are 1 million to 1.5 million years old and overlie the Otowi Member of the Bandelier Tuff. Through the use of aerial photographs, Kelley (1978) mapped four different units of the Cerros del Rio basalts, one of which (the Cubero Basalts) includes the five units of the Chino Mesa Basalts of Griggs (1964). According to Laughtin et al. (1993) they range in age from 2.5 million to 4 million years old. Aubele (1978) describes the basalts of the Cerros del Rio field as did Galusha and Blick (1971). The Otowi lava flows of Galusha and Blick are equivalent to the

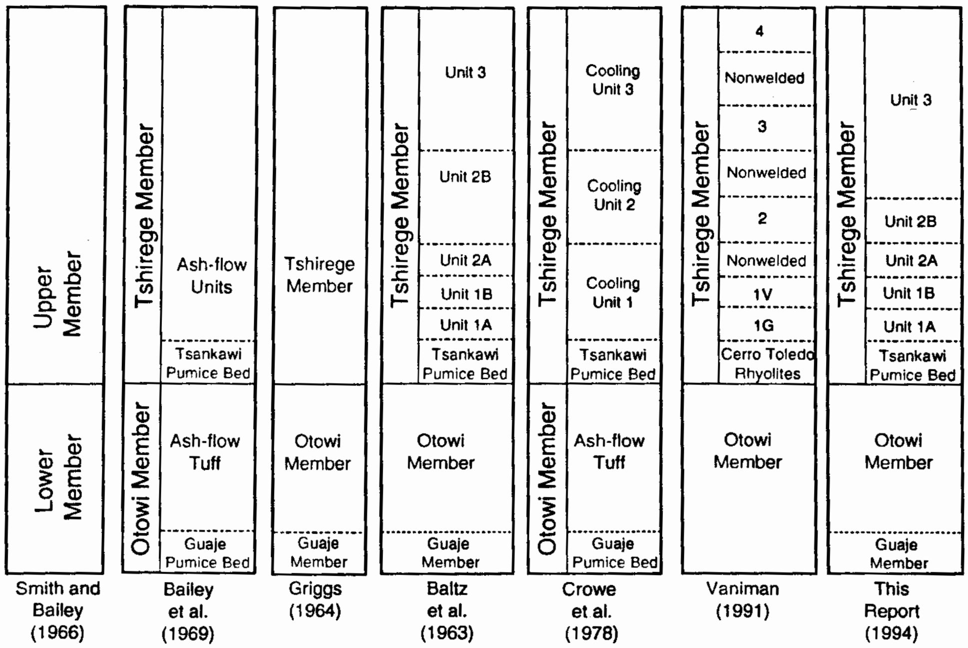

Fig. I-L. Stratigraphic nomenclature of the Bandelier Tuff.

Unit 4 Basaltic Rocks of Chino Mesa of Griggs (1964).

The nomenclature of the basalts used by Griggs (1964) is most appropriate to describe the relationship of the basalts and volcanic sediments in the subsurface of the Pajarito Plateau and adjacent White Rock Canyon (Figs. I-C and I-K).

The Basaltic Rocks of Chino Mesa consist of a thick sequence of basaltic to andesite rocks and interflow breccias. These flowed from vents in the vicinity of Chino Mesa, which is located east of the Rio Grande opposite Chaquehui and Ancho Canyons. The Chino Mesa basalts flowed north along the Rio Grande, and northwest and west into the area of the Pajarito Plateau, where they are found in the subsurface interbedded with the Chaquehui Formation of the Santa Fe Group and the fanglomerate member of the Puye Conglomerate. Though some of the basalts found in the subsurface may not have originated from vents in the vicinity of Chino Mesa, they are equivalent in age. The Basaltic Rocks of Chino Mesa consist of five mappable units in the Los Alamos area (Fig. I-C).

The lower unit, Unit 1, outcrops in the lower wall of White Rock Canyon (Figs. I-G and I-I). The basalts are dark gray to black, porphyritic, and contain small phenocrysts of olivine which may be as long as 1/4 in.

Unit 2 overlies Unit 1 and forms the main cliffs along White Rock Canyon (Fig. I-I). The unit is composed of a series of flows and interflow breccias that thins to the west and northwest in the subsurface beneath the plateau where it interdigitates with the fanglomerate member of the Puye Conglomerate. It ranges in color from gray to dark gray and is generally lighter in color than the underlying unit. The flows contain small phenocrysts of olivine.

Unit 3 consists of a series of flows deposited in an old river channel, and crops out in lower Los Alamos, Sandia, and Mortandad Canyons west of the Rio Grande. It is a series of flows of dark gray basalt containing large to small phenocrysts of olivine and some of plagioclase. It is up to 120 ft thick in lower Los Alamos Canyon where it blocked the ancient stream channel and formed a lake. This led to the deposition of the Old Alluvium lake clays and gravels.

Unit 4 consists of two flows that cap the mesa south of Los Alamos Canyon where they overlie the Puye Conglomerate and Tesuque Formation. The basalt is dark gray and contains some phenocrysts of olivine, with some small quartz (generally with radiating crystals of augite). The combined thickness of the two flows can range up to 240 ft.

Unit 5 consists of cinder cones and local basalt

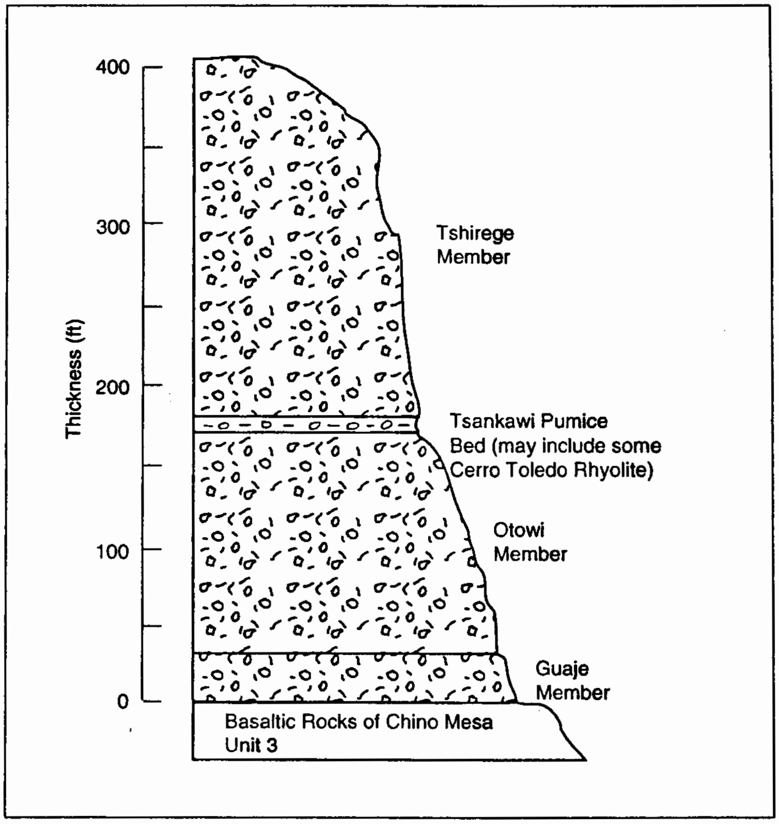

Fig. I-M. Type section showing the thickness of members of the Bandelier Tuff near the junction of State Roads 4 and 502.

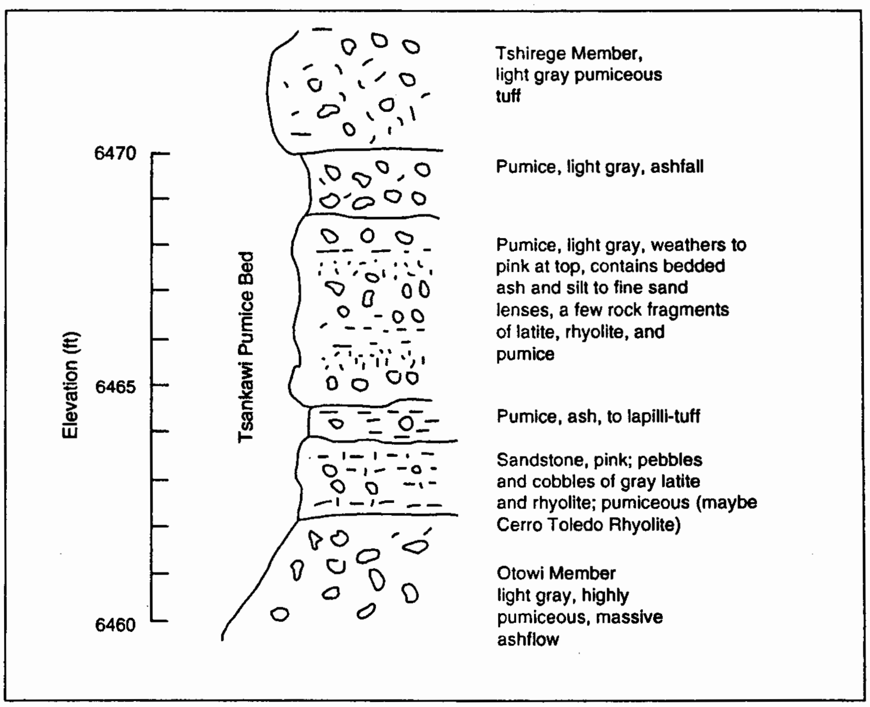

Fig. I-N. Geologic section of the Tsankawi Pumice Bed near the junction of State Roads 4 and 502.

flows on Chino Mesa and on the mesa between lower Ancho Canyon and Chaquehui Canyon. The rocks of the flows and cinder cones are black and are slightly vesicular. They contain tiny phenocrysts of olivine and labradorite.

4. Volcanic Rocks of the Jemez Mountains. The volcanic rocks of the Jemez Mountains consist of the older Tschicoma Formation and the Bandelier Tuff.

The flow of the Tschicoma Formation forms the mountain mass of the Sierra de los Valles. The flows are composed of undifferentiated latites, quartz latites, and dacites, which are in places highly fractured and jointed. The flows range from gray to dark gray and some range to reddish brown. These rocks form the Sierra de los Valles that separates the interbasin caldera and the plateau (Fig. I-B). Some of these latite flows interdigitate to the west beneath the plateau within the gravels of the fanglomerate member of the Puye Conglomerate. The fanglomerate is made up of the older Tschicoma rocks that eroded from the mountain mass as it was building.

The Bandelier Tuff is composed chiefly of ashfalls and ashflows of rhyolite tuff with some thin beds of water-laid sediments and some surge beds of blast-laid volcanics and sediments.

The stratigraphic nomenclature of the Bandelier Tuff has varied according to different workers in the area as shown in Fig. I-L. The division similar to Griggs (1964) and further subdivision of the Tshirege Member by Baltz et al. (1963) are most appropriate for this report as they have similar lithology, degrees of welding, and stratigraphic position.

The Bandelier Tuff has been divided into three members: Guaje, Otowi, and Tshirege Members from oldest to youngest (Fig. I-C). The Bandelier Tuff forms the upper surface of the Pajarito Plateau, lapping onto the Tschicoma Formation along the western margin of the plateau and truncated by erosion at the eastern edge along the rim of White Rock Canyon (Fig. I-M). Included in the Bandelier Tuff are the Tsankawi Pumice Bed (in some places) and the cobbles and boulders of the Cerro Toledo Rhyolites. The Tsankawi and Cerro Toledo Rhyolites lie between the Tshirege Member and the underlying Otowi Member.

The Guaje Member of the Bandelier Tuff is an ashfall of pumice with some water-laid or surge-bed pumiceous tuff that rests unconformably on older rocks. The base of the unit contains gray lump-pumice fragments as much as 2 in. long. Glass shards and crystals of quartz and sanidine are present in the cellular structure of the partly devitrified pumice. Rounded, pebble-sized fragments of light red rhyolite are present near the top of the member.

The Otowi Member of the Bandelier Tuff is a light gray, nonwelded, pumiceous rhyolite tuff that weathers to a gentle slope; it is conformable with the underlying Guaje. Quartz and sanidine crystals and crystal fragments, glass shards, minor amounts of mafic minerals, along with varying amounts of rock fragments of latite, rhyolite, quartz latite, and pumice fragments are found in a fine-grained ash matrix. The Otowi may consist of several ashflows laid down in rapid succession.

The Tsankawi Pumice Bed (Bailey et al. 1969) is a thin pumice fall with some surge deposits and possibly water-laid material of latite and rock fragments with an abundance of quartz and sanidine crystals in an ash matrix. It is deposited between the lower Otowi Member and the overlying Tshirege Member (Fig. I-N). The Tsankawi may include a thin section of blast-laid debris of rock fragments of latite, rhyolite, and pumice of the Cerro Toledo Rhyolites.

The Tsankawi Pumice bed and the Cerro Toledo Rhyolites in general are quite thin, absent in places, and may thicken in others to as much as 30 ft. They are probably present in deep test holes or wells drilled on the Pajarito Plateau but were not identified in the cuttings (these wells and test holes were not cored) and are not included in the older geologic logs. In some areas such as the middle reaches of Los Alamos Canyon, Sandia Canyon and Mortandad Canyon, the Tsankawi Pumice may include some gravels, cobbles, and boulders of the Cerro Toledo Rhyolites. In other areas such as in the upper and middle reaches of Cañada del Buey and Ancho Canyon only a thin section of the pumice and no apparent gravels of the Cerro Toledo Rhyolites are evident.

The Tshirege Member of the Bandelier Tuff forms the upper surface of the Pajarito Plateau. It consists of a series of nonwelded to welded ashflows and ashfalls that are composed of quartz and sanidine crystals and crystal fragments, a few rock fragments of dacite, latite, rhyolite, and pumice in a gray to dark gray ash matrix. The ashflows vary in amounts and size of the minerals and rock fragments and as to the degree of welding. Blast debris, sand, gravel, and boulders may be found between the flows (Weir and

Purtymun 1962).

The Tshirege Member, as a series of ashflows and ashfalls of rhyolite tuff, has been classified according to degrees of welding (i.e., as nonwelded, moderately welded, and welded). The nonwelded tuff has a high porosity, only light cohesion, little deformation of glassy fragments, and crumbly fracture. The moderately welded tuff has less porosity, moderate cohesion, slight deformation of glassy fragments, and somewhat brittle fracture. The welded tuff has low porosity, good cohesion, a high degree of deformation by flattening of glassy fragments, and brittle fracture. Most if not all of the pores are capillary in size. There can be a considerable overlay in porosity range in each classification (Purtymun and Kennedy 1971).

Degree of Welding	Range of Porosity (volume %)
Nonwelded tuff	40 to 60
Moderately welded tuff	30 to 55
Welded tuff	15 to 40

The degree of welding can change in a vertical section of an ashflow (zone of denser welding, lower porosity near the middle of the flow) and distance from source (denser near caldera and becoming progressively less dense, with higher porosity, further from the caldera). The degree of welding is an important determinant of the hydrologic characteristics and engineering properties of the tuff. Only slight changes in welding can drastically change the hydrologic characteristics or engineering properties of the tuff (Weir and Purtymun 1962; Abrahams 1963; Purtymun and Koopman 1965; Purtymun 1966a; Keller 1968; Purtymun et al. 1974; Purtymun et al. 1989; Stoker et al. 1991; and Purtymun 1994 chapter 31).

Working with Weir and Purtymun in 1962, Baltz divided the Tshirege Member at TA-49 into seven units, 1A, 1B, 2, 3, 4, 5, and 6 (see Section IX). After additional work in Mortandad Canyon Baltz revised the nomenclature to correspond to his observations in Mortandad Canyon. He believed the Mortandad Canyon nomenclature best represented the units that make up the Tshirege Member. Other workers in the area have used different terminology in describing the Bandelier Tuff (Fig. I-L). Baltz's terminology is used throughout this report; where a difference occurs, it is discussed in that section. The descriptions of the units that follow are from a type section in Mortandad Canyon as described by Baltz. The units can be followed across the Pajarito Plateau; however, as previously stated the degree of welding and the thickness of the units will vary across the plateau (from the source area in the west to the east along White Rock Canyon on the Rio Grande).

Unit 1 consists of two ledge-forming subunits of pumiceous tuff breccia that are generally similar in lithology but are slightly different in color and weathering characteristics.

The lower layer, Unit 1A, is a massive, orange-weathering, pumiceous tuff breccia that forms a low ledge above the alluvium in Mortandad Canyon and is a widespread unit that persists over most of the plateau. The unit is composed of pink to light salmon colored fragments of pumice ranging from 1/8 in. to 6 in. in length. The pumice fragments with tiny subhedral quartz crystals and some rock fragments of obsidian and rhyolite are in a matrix of fine glassy ash. The unit is non- to moderately welded. Unit 1A is probably an explosive volcanic breccia laid down as an ashflow. The outer 1 to 3 in. of the unit weathers to a hard rind that protects the unweathered rock from erosion. In Mortandad Canyon, Unit 1A thins as one moves eastward from about 105 ft at test well TW-8 to about 10 ft (Baltz et al. 1963) near State Road 4 (SR 4).

Unit 1B rests conformably on Unit 1A and weathers to dull grayish brown, pink, and light orange. The unit is a tuff breccia with a fine-grained pink ash matrix similar to 1A; however, the pumice fragments are smaller, and 15 to 20% of the unit consists of quartz crystal fragments and rock fragments of rhyolite and latite in an ash matrix. The unit is moderately welded. In most places the unit has slightly less resistance to erosion than Unit 1A, and forms a rounded ledge set back from the top of Unit 1A, while at other places the two units form a nearly vertical cliff. The units are then separated by a slight notch in the cliff. In Mortandad Canyon Unit 1B is fairly uniform in thickness, ranging from 18 to 20 ft thick.

Unit 2 of the Tshirege Member of the Bandelier Tuff rests conformably on Unit 1B and seems to be transitional into it. Unit 2 consists of two units, 2A and overlying 2B, that are separated by an erosional unconformity or surge bed. In the eastern part of the plateau these two units are moderately welded;

however, westward across the plateau toward the source of the ashflows the degree of welding increases, so that in the western third of the plateau the two units become densely welded and appear as a single unit.

The lower Unit 2A is a light gray, pumiceous tuff. The tuff consists of slightly welded pumiceous ash containing angular rock fragments of pumice, dense rhyolite and latite as much as 4 in. long. The ash matrix also contains quartz and sanidine crystals and crystal fragments. The unit weathers to dull gray and grayish brown with a hard rind several inches thick and with rounded slopes set back from Unit 1B. In Mortandad Canyon, Unit 2A is about 80 ft thick near test well TW-8 and thins eastward to about 55 ft near SR-4.

The overlying Unit 2B is a tan- to brown-weathering tuff composed of crystal and crystal fragments of quartz and sanidine with rock fragments of pumice, rhyolite, and latite. The unit is probably composed of several ashflows, separated by blast-laid or surge deposits of reworked tuff (sands and gravels) and rock fragments of rhyolite and latite. The unit is resistant to erosion and forms ledges and benches above the more rounded slopes of Unit 2A. In Mortandad Canyon the unit is about 40 ft thick near test well TW-8 and thins eastward to about 20 ft near SR-4 as its top is eroded off.

Unit 3 rests conformably on Unit 2B. Unit 3 consists of mainly light gray, light tan, pink, and white moderately welded pumiceous rhyolite tuff breccia. The unit is composed of crystal and crystal fragments of quartz and sanidine, rock fragments of pumice, latite, and rhyolite in an ash matrix of fine pumice fragments and glassy shards. Rock fragments range in size from granules to cobbles. The unit weathers to form soft slopes and benches. The upper part of the unit is resistant to erosion and forms cliffs along the upper part of the plateau. The unit may consist of several ashflows. In the eastern two-thirds of the plateau Unit 3 is stratigraphically the highest part of the Bandelier Tuff. In Mortandad Canyon the unit is about 110 ft thick near test well TW-8 and thins eastward toward SR-4 as the unit is eroded off (Fig. I-O).

5. Alluvium and Soil. Alluvium derived from weathering and erosion of the rocks that form the Sierra de los Valles and the Pajarito Plateau has been deposited in the canyons of the plateau. The south-east-trending canyons have cut deeply into the plateau. Near the heads of the canyons and on the flanks of the Sierra de los Valles bedrock is generally exposed. Along the western edge of the plateau the canyons deepen and are narrow with thin alluvium. The alluvium thickens as one moves eastward, and along the eastern edge of the plateau the canyons widen and canyon walls generally decrease in height. Along the eastern edge of the plateau all stream channels cut down to the top of the Basaltic Rocks of Chino Mesa, to Unit 3 in Pueblo and Los Alamos Canyons and to Unit 2 in the remainder of the canyons. The thickness of the alluvium varies, but is generally less than 20 ft in most canyons. The thickest section observed is 76 ft, penetrated by test holes in Mortandad Canyon.

Test holes and observation wells have been drilled into or through the alluvium in a number of canyons, generally for water quality or hydrologic studies (Fig. I-P). Based on test holes or observation wells, illustrations showing sections of the stream channel have been prepared to show: the thickness of the alluvium and underlying volcanic sediments or basalt; the gradient of the stream channel; the drainage area west of the most eastern control point (usually SR-4); and whether the drainage area extends to the mountains (Sierra de los Valles) or heads on the plateau. The thickness of the alluvium shown in the figures is that adjacent to the stream channel, not that of the terrace or coalluvium in the canyons. These sections have been developed for segments of the following canyons: Pueblo (Fig. I-Q), Los Alamos (Fig. I-R), Sandia (Fig. I-S), Mortandad (Fig. I-T), Cañada del Buey (Fig. I-U), Pajarito (Fig.I -V), Potrillo (Fig. I-W), Fence (Fig. I-X), Water (Fig. I-Y), and Ancho (Fig. I-Z).

The alluvium in the canyons heading on the flanks of the Sierra de los Valles contains cobbles and boulders of dacite, latite, and rhyolite with accompanying clay, silt, sand, and gravel derived from the Tschicoma Formation and the Bandelier Tuff. The alluvium in the canyons heading on the Pajarito Plateau contains clay, silt, sand, and gravel derived from the Bandelier Tuff. The alluvium contains some water in the larger canyons; however, the amount is insufficient for water supply.

Clayey soil derived from weathering of the Bandelier Tuff covers most of the finger-like mesas of the Pajarito Plateau. The soil is thickest along the axis

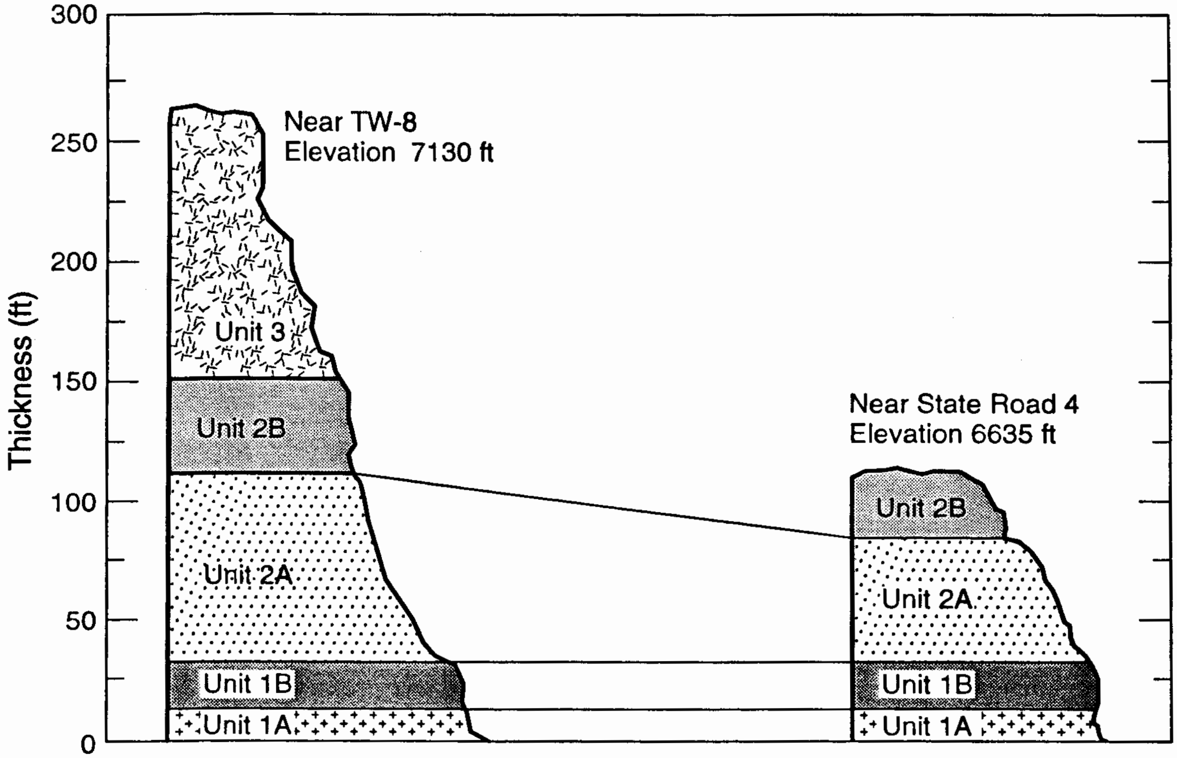

Fig. I-O. Type section of units in the Tshirege Member of the Bandelier Tuff in Mortandad Canyon.

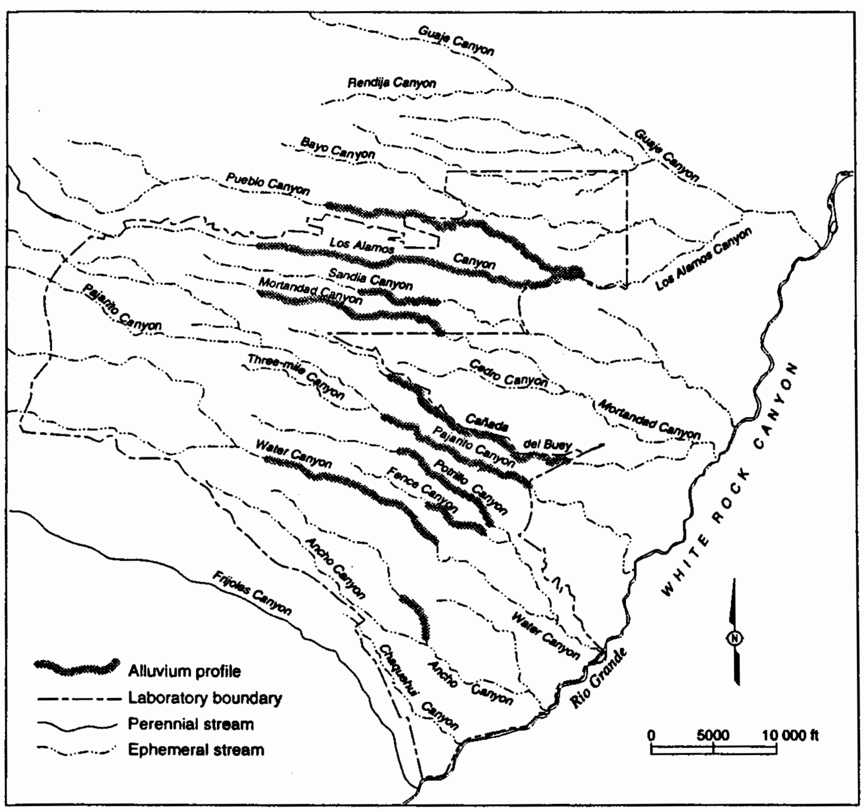

Fig. I-P. Locations of diagrammatic sections of alluvium in major canyons.

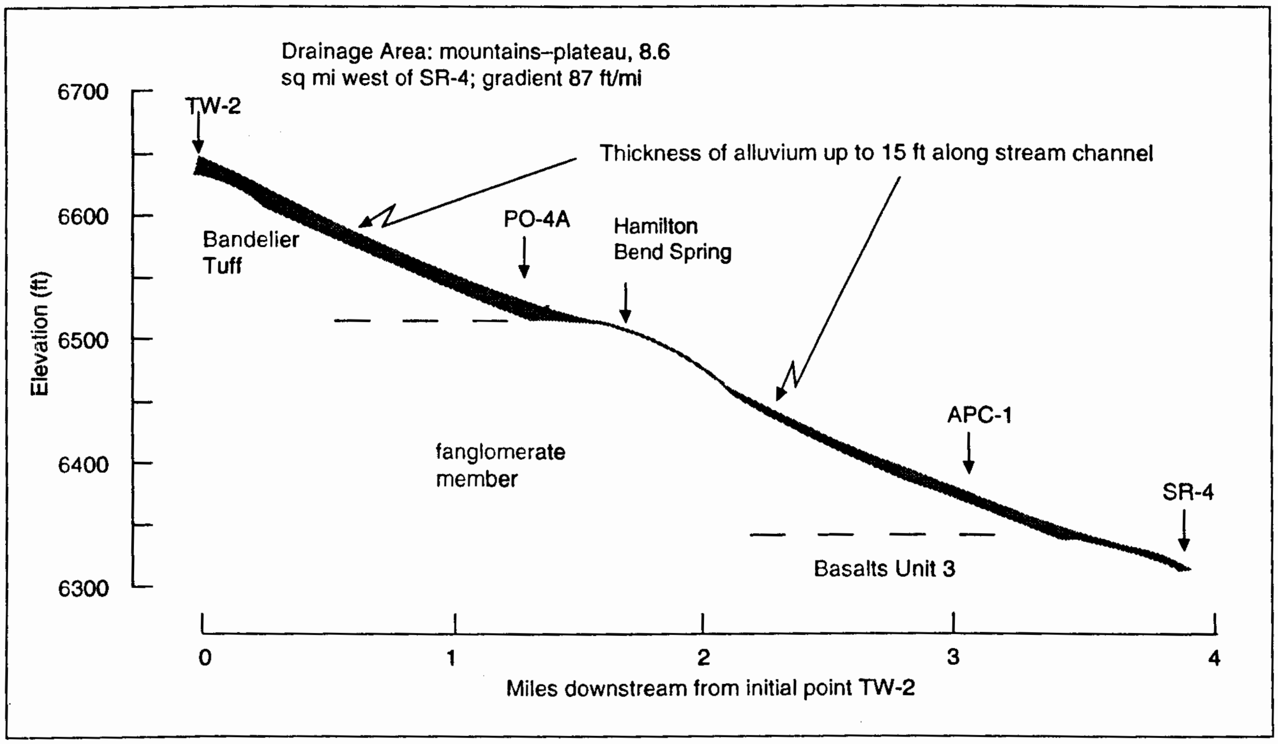

Fig. I-Q. Diagrammatic section showing rocks underlying alluvium in lower Pueblo Canyon.

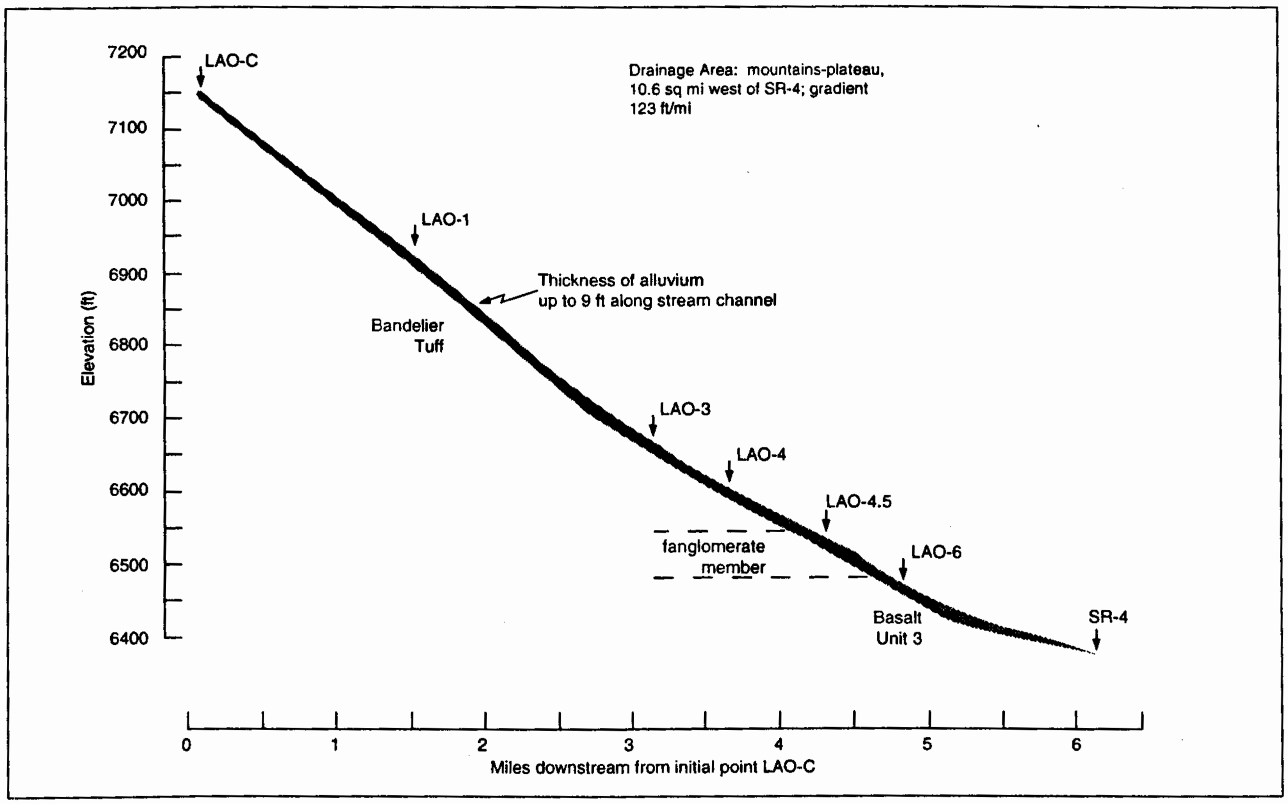

Fig. I-R. Diagrammatic section showing rocks underlying alluvium in Los Alamos Canyon.

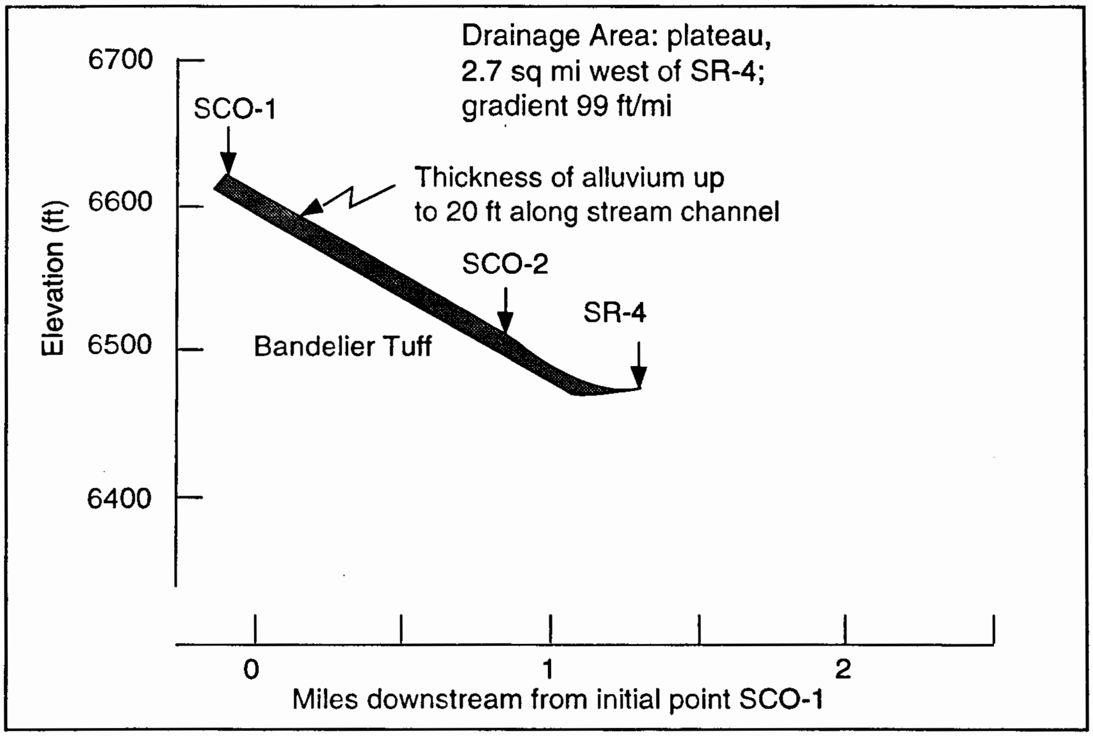

Fig. I-S. Diagrammatic section showing rocks underlying alluvium in lower Sandia Canyon.

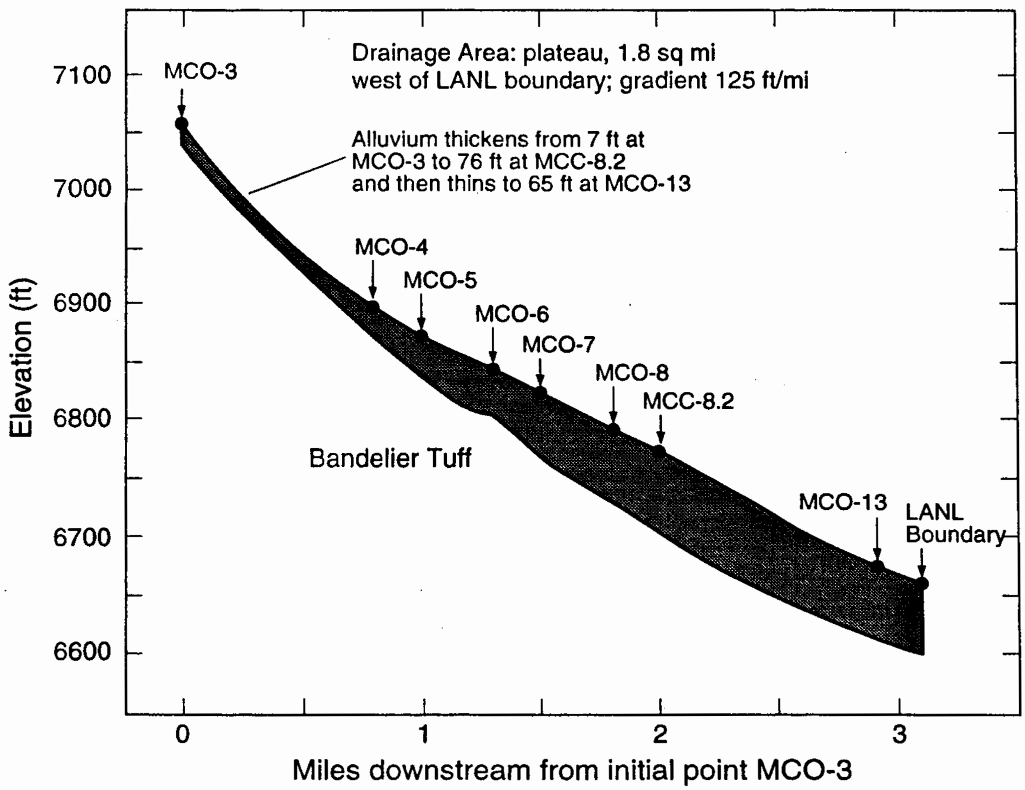

Fig. I-T. Diagrammatic section showing rocks underlying alluvium in Mortandad Canyon.

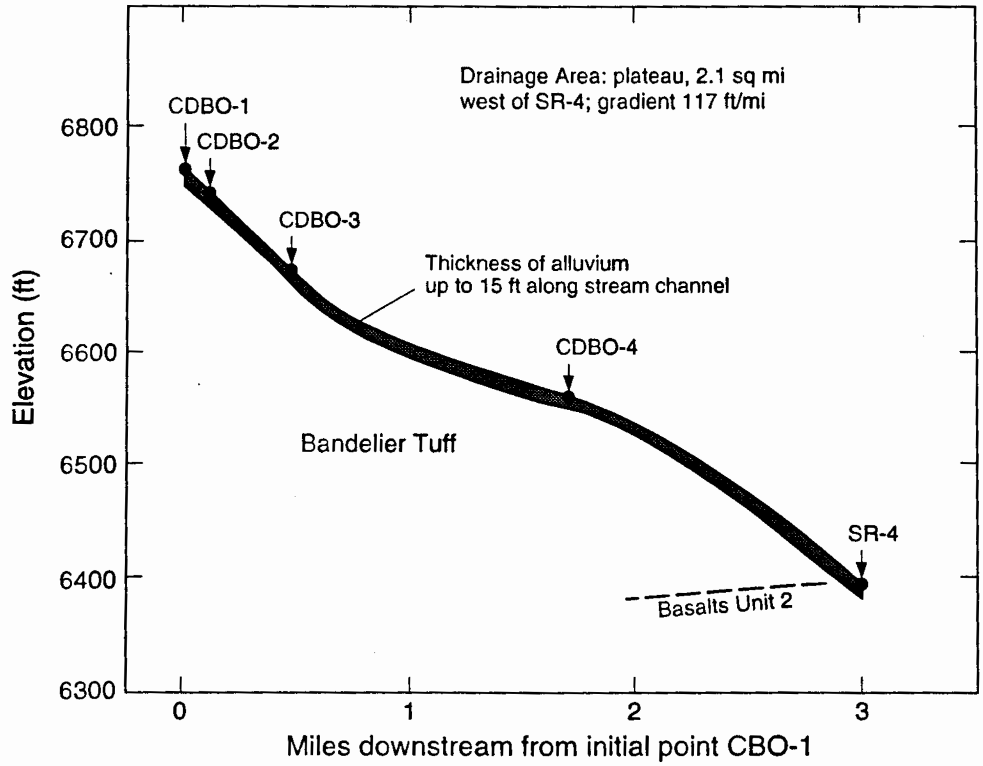

Fig. I-U. Diagrammatic section showing rocks underlying alluvium in lower Cañada del Buey.

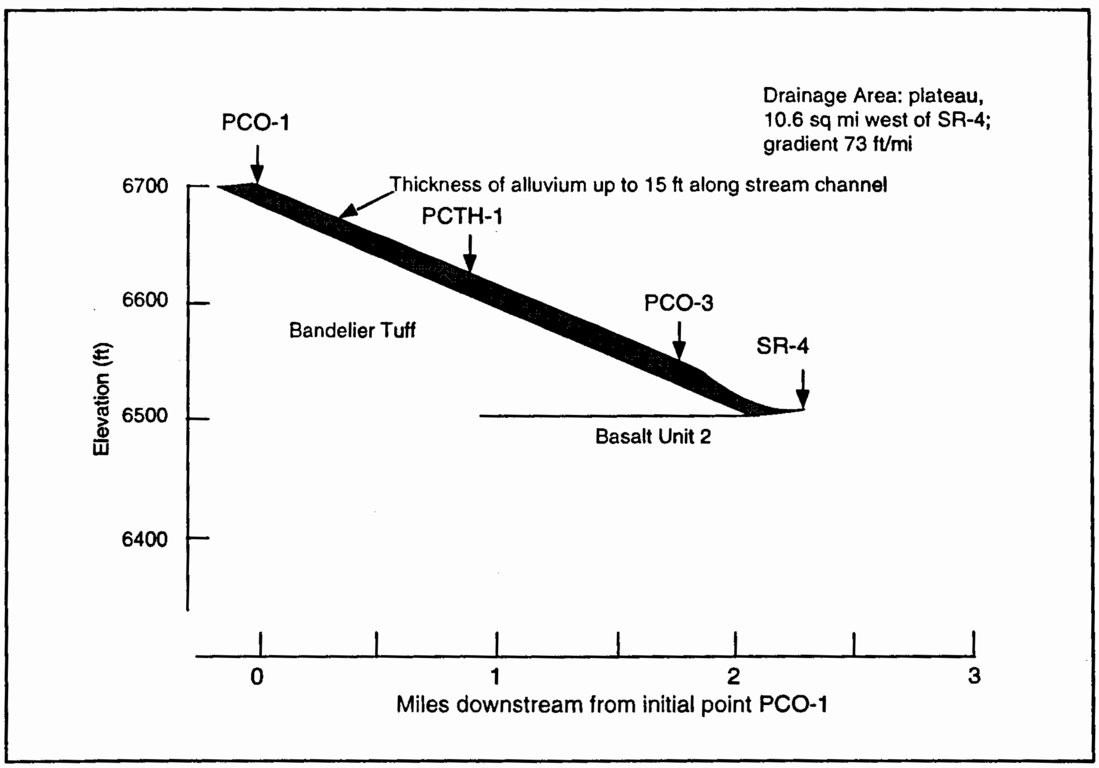

Fig. I-V. Diagrammatic section showing rocks underlying alluvium in lower Pajarito Canyon.

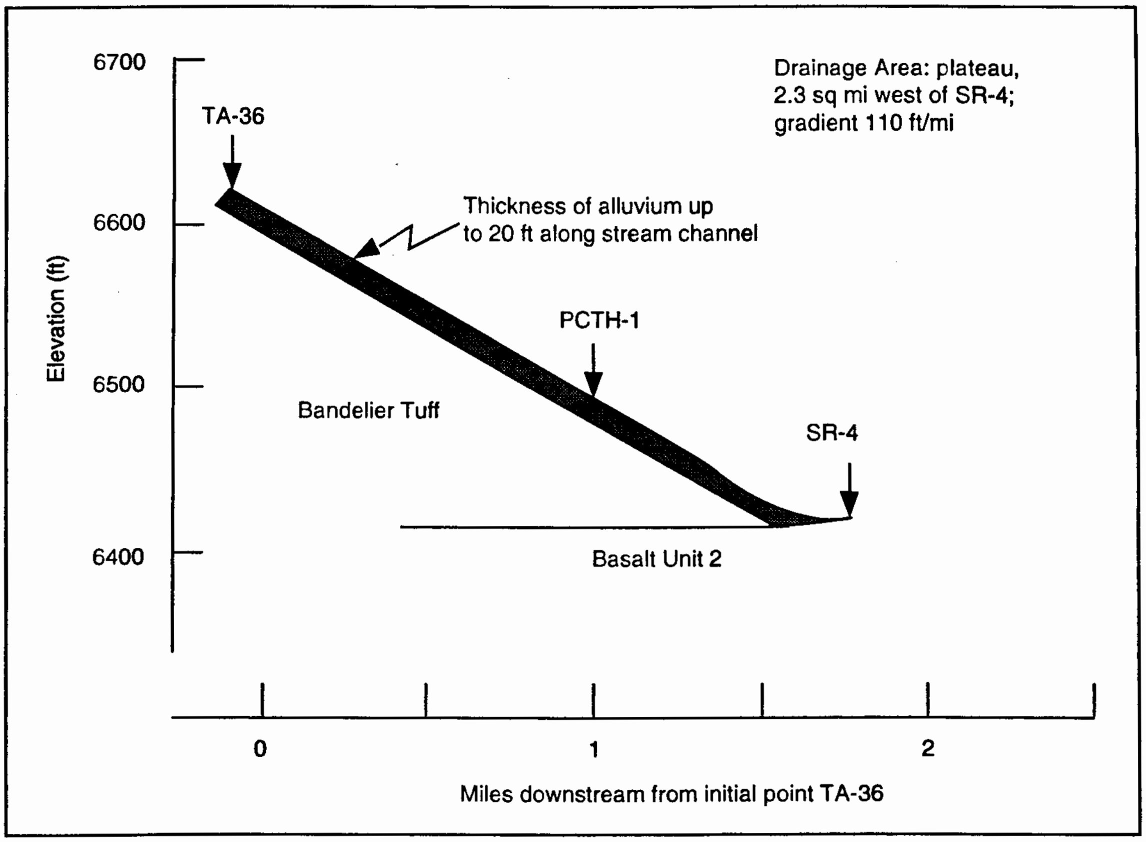

Fig. I-W. Diagrammatic section showing rocks underlying alluvium in lower Potrillo Canyon.

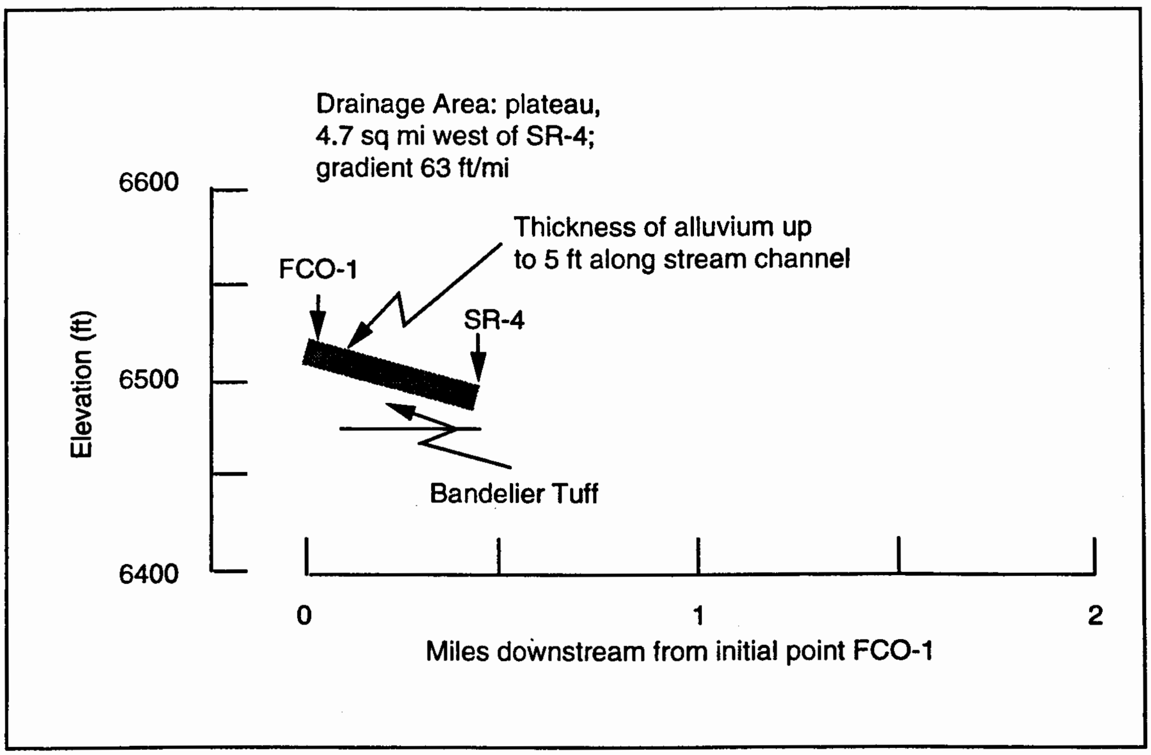

Fig. I-X. Diagrammatic section showing rocks underlying alluvium in lower Fence Canyon.

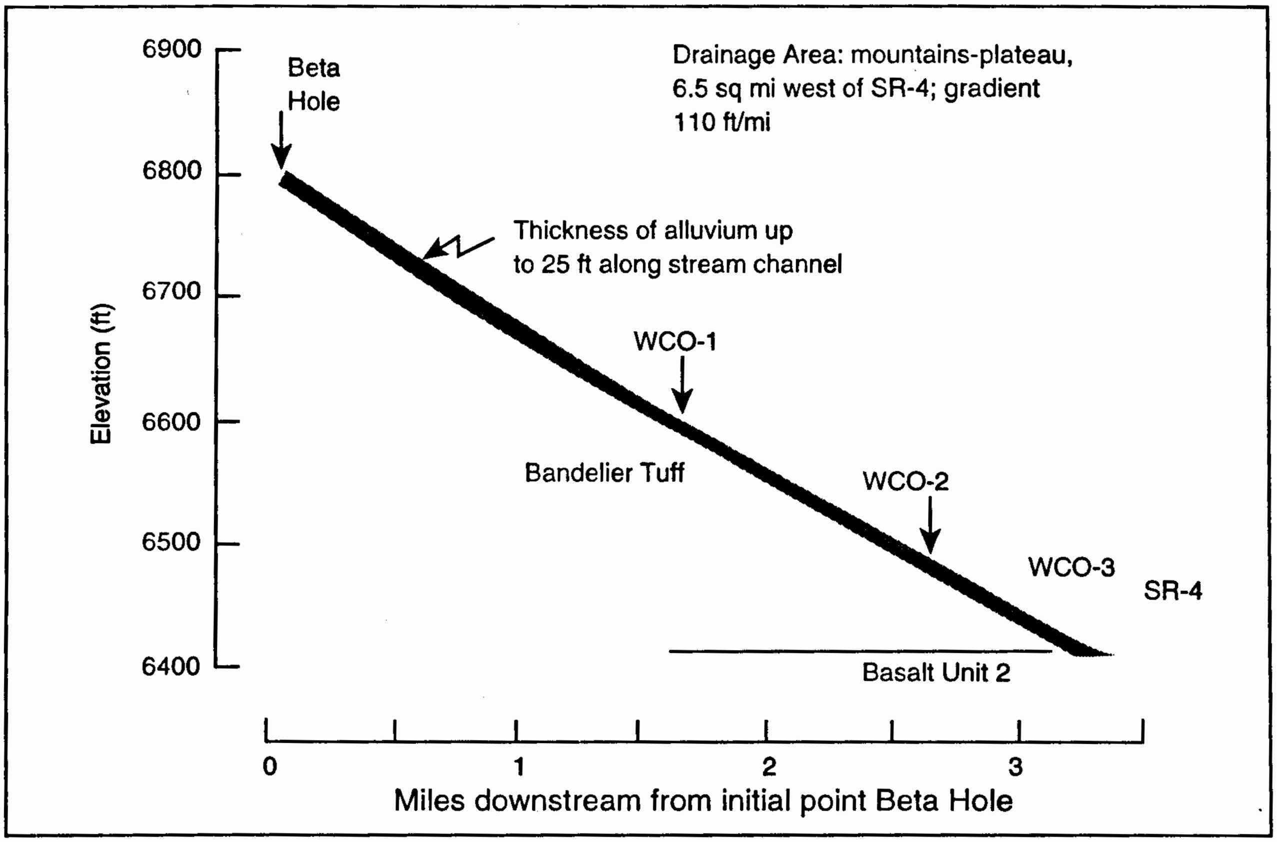

Fig. I-Y. Diagrammatic section showing rocks underlying alluvium in Water Canyon.

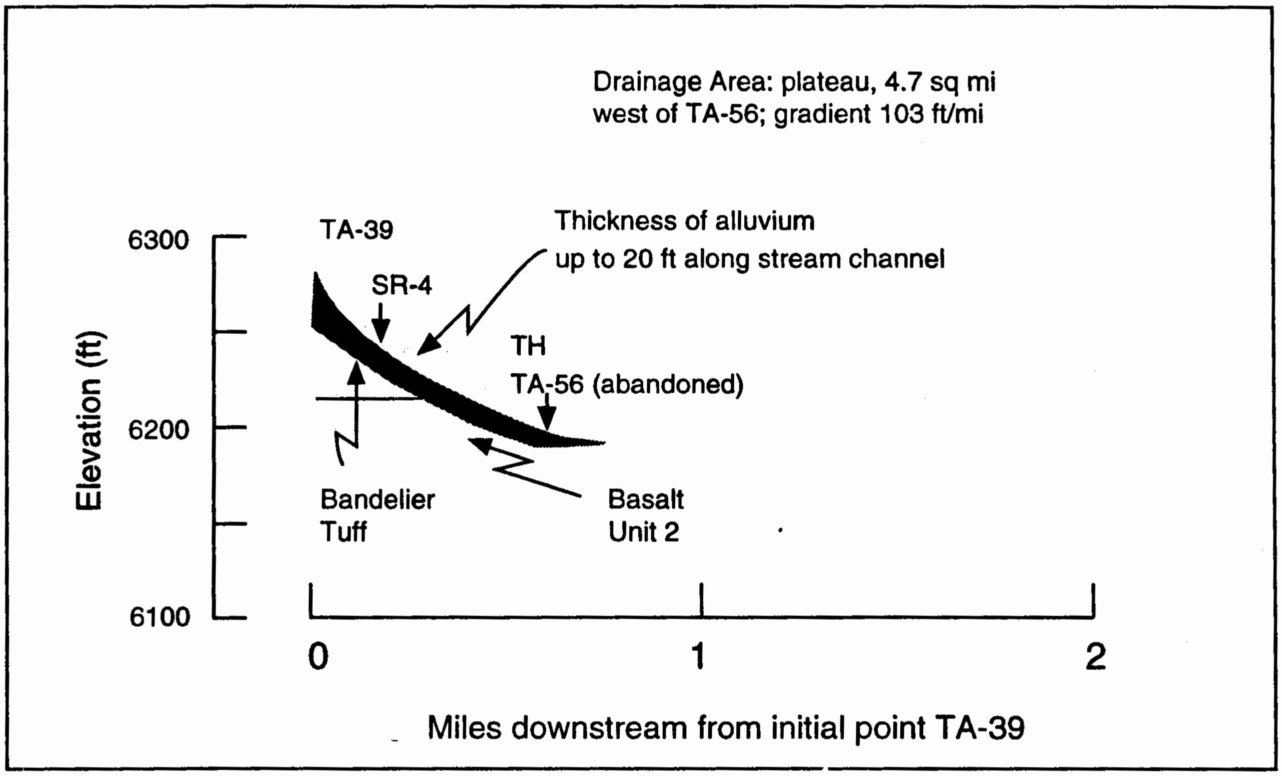

Fig. I-Z. Diagrammatic section showing rocks underlying alluvium in part of Ancho Canyon.

of the mesa and thins to the edges of the canyons where the tuff is exposed. The soil on the western edge of the plateau, and extending short distances eastward, is underlain by white ashfall pumice, a part of the El Cajate Pumice Fall. The pumice is thin, generally less than 3 ft. Along the fault scarp of the Pajarito Fault, the pumice attains a greater thickness. A detailed soil map of the Laboratory has been prepared by Nyhan et al. (1979).

E. Hydrology

The Rio Grande is the master stream in north-central New Mexico. All surface water drainage from the plateau and ground water discharge is into the Rio Grande. The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 14 300 sq mi in southern Colorado and northern New Mexico. The discharge for the period of record has ranged from a minimum of 60 cubic ft/sec (cfs) in 1902 to 24 400 cfs in 1920. The river transports about one million tons of suspended sediments past Otowi annually (Purtymun 1975).

Ground water occurs in three modes in the Los Alamos area: (1) water in shallow alluvium in some of the larger canyons, (2) perched water (a ground water body above an impermeable layer that separates it from the underlying main body of ground water by an unsaturated zone), and (3) the main aquifer of the Los Alamos area.

1. Surface Water. Los Alamos surface water occurs primarily as intermittent streams. Springs on the flanks of the Sierra de los Valles supply base flow into upper reaches of some of the canyons (Guaje, Los Alamos, Pajarito, Canyon de Valle and Water Canyon), but the amount is insufficient to maintain surface flow across the plateau before it is depleted by evaporation, transpiration, and infiltration. Runoff from heavy thunderstorms or heavy snowmelt reaches the Rio Grande several times a year in some drainages. Effluents from sanitary sewage, industrial waste treatment plants, and cooling-tower blowdown are released into some canyons at rates sufficient to maintain surface flow for short distances on the Pajarito Plateau (Purtymun 1975).

Spring discharge in lower Pajarito and Ancho Canyons is of sufficient volume to support perennial flow into White Rock Canyon and the Rio Grande.

2. Ground Water in the Alluvium. Intermittent stream flow in canyons of the plateau has deposited alluvium that ranges from less than 3 ft in thickness to as much as 76 ft. The alluvium is more permeable than the underlying volcanic tuff and sediments. The natural runoff and release of waste water, sanitary effluents, and industrial effluents infiltrate the alluvium until the downward movement of the water is impeded by the less permeable tuff and volcanic sediments. This results in a shallow ground water body that moves down the gradient within the alluvium. As the water in the alluvium moves down-gradient, it is depleted by evapotranspiration and movement into the underlying tuff.

Two of the best examples of alluvial aquifers are in Los Alamos and Mortandad Canyons. The alluvium in Los Alamos Canyon is composed of sands, gravels, pebbles, cobbles, and boulders derived from the Tschicoma Formation on the flanks of the mountains, and clay, silt, sand, and gravel from the Bandelier Tuff of the plateau. The alluvium in Mortandad Canyon consists mainly of clay, silt, sand, and gravel derived from the Bandelier Tuff on the plateau.

Sufficient observation wells and test holes have been drilled in the canyons to outline the aquifer in the alluvium in both canyons (Figs. I-AA, I-AB). Water levels fluctuate rapidly in Los Alamos Canyon due to varying amounts of natural recharge. The large drainage area on the flanks of the mountains provides snowmelt runoff in the spring and thunderstorm runoff in the summer. In general the water levels in the alluvium in Los Alamos Canyon are highest in the spring due to snowmelt runoff and in the early fall due to summer runoff.

Mortandad Canyon heads on the plateau. Its major source of recharge to water in the alluvium is industrial effluent. As a result the water level fluctuations are not as great as in Los Alamos Canyon. The movement of water in the alluvial aquifer was determined using tracers. The movement in the sand unit of the aquifer was about 60 ft/day, in a silty clay unit about 14 ft/day, and in a clay unit about 7 ft/day (Purtymun 1974). From 1967 through 1978 the maximum amount of water in transit storage in the aquifer was about 8 million gallons in 1967 and the minimum in transit storage was about 4 million gallons in 1977 (Purtymun et al. 1983).

The alluvium in many of the other canyons contains water, especially in the western part of the plateau. The amount of water in the alluvium in the canyons of the plateau is small and not dependable, and thus is not a viable source of water supply to the Laboratory or community (Purtymun 1984).

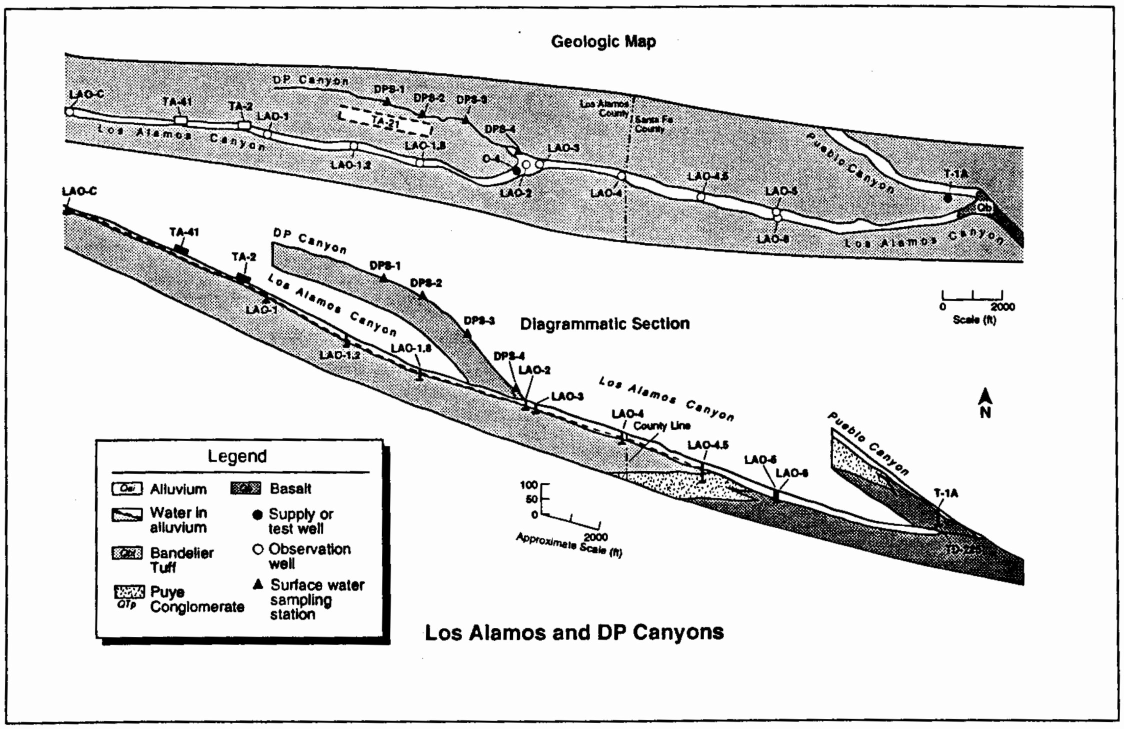

Fig. I-AA. Map showing shallow ground water in alluvium of Los Alamos and DP Canyons (Purtymun 1975).

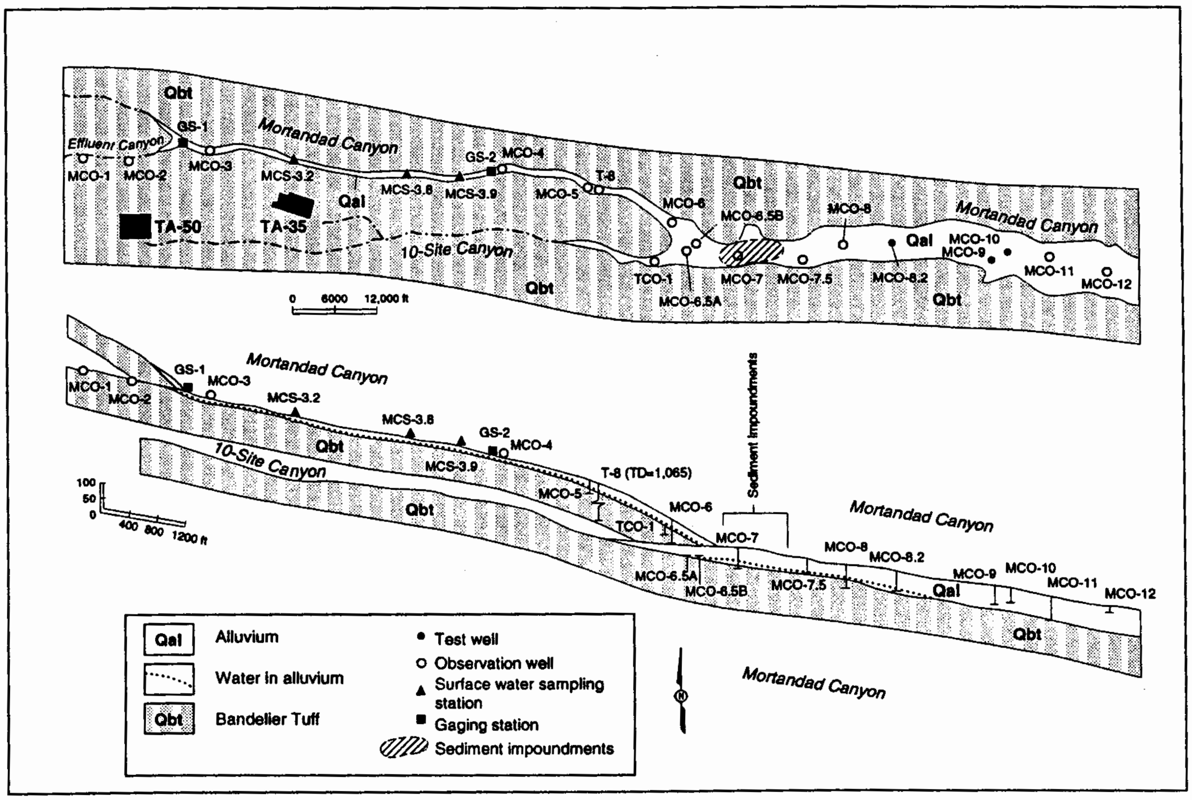

Fig. I-AB. Map showing shallow ground water in alluvium of Mortandad Canyon (Purtymun 1975).

3. Perched Water in Volcanic Sediments and Basalts. Perched water occurs in the volcanic sediments of the Puye Conglomerate in the midreach of Pueblo Canyon. The perched aquifer is at a depth of about 120 ft (TW-2A) and is of limited extent as determined by testing (Fig. I-AC). Water in the aquifer is depleted after about an hour pumping at 2 to 3 gpm. The perched water is recharged from the stream and lies in a clay lens in the fanglomerate member. The main aquifer in this area is at a depth of about 789 ft. (Weir et al. 1963; Purtymun 1982)

A second perched aquifer occurs in the midreach of Los Alamos Canyon. The perched aquifer was encountered during drilling of supply well O-4. The aquifer is perched in the volcanic sediments of the fanglomerate member of the Puye Conglomerate at a depth of 253 ft. The aquifer is in gravels underlain by a lens of silt and clay. The aquifer is also of limited extent as it was not recognized during the drilling of test well 3 about 300 ft east of O-4. Test well 3 was drilled with a cable tool and encountered no water at that depth (Stoker et al. 1992). The top of the main aquifer in this area is at a depth of about 760 ft.

The recharge to the perched aquifers in the Puye Conglomerate (fanglomerate member) in the midreach of Pueblo (TW-2A) and Los Alamos Canyons (O-4) is probably from the intermittent stream flow in the canyons. The perched aquifers are of limited extent beneath the canyon and do not extend beneath the mesas (Purtymun 1975).

A third perched water zone occurs in the lower reach of Pueblo Canyon and its junction with Los Alamos Canyon. Perched water was encountered in the drilling of supply well O-1 in the lower reach of Pueblo Canyon at a depth of about 183 ft in the fanglomerate member of the Puye Conglomerate. The gravels of the Puye Conglomerate are about 17 ft above Unit 2 of the Basaltic Rocks of Chino Mesa. At test well TW-1A about 400 ft to the east the same aquifer was encountered at a depth of about 180 ft in Unit 2. To the south in Sandia Canyon, supply well PM-1 encountered perched water at a depth of about 450 ft in Unit 3 of the Basaltic Rocks of Chino Mesa (Purtymun et al. 1993). Unit 3 is a series of basalt flows that flowed into a river channel, producing a dam that collected lake sediments and gravels (Old Alluvium). This third perched aquifer discharges to the east in Los Alamos Canyon at Basalt Spring along the base of Unit 3, the channel-fill basalt (Fig. I-AD). The discharge ranges from 15 to 40 gpm. South of Pueble Canyon movement of the water in the aquifer is to the southwest, where a part of the water is discharged in the Sandia Spring seep area. Discharge into the channel increases from 10 to 30 gpm as one moves eastward in the canyon.

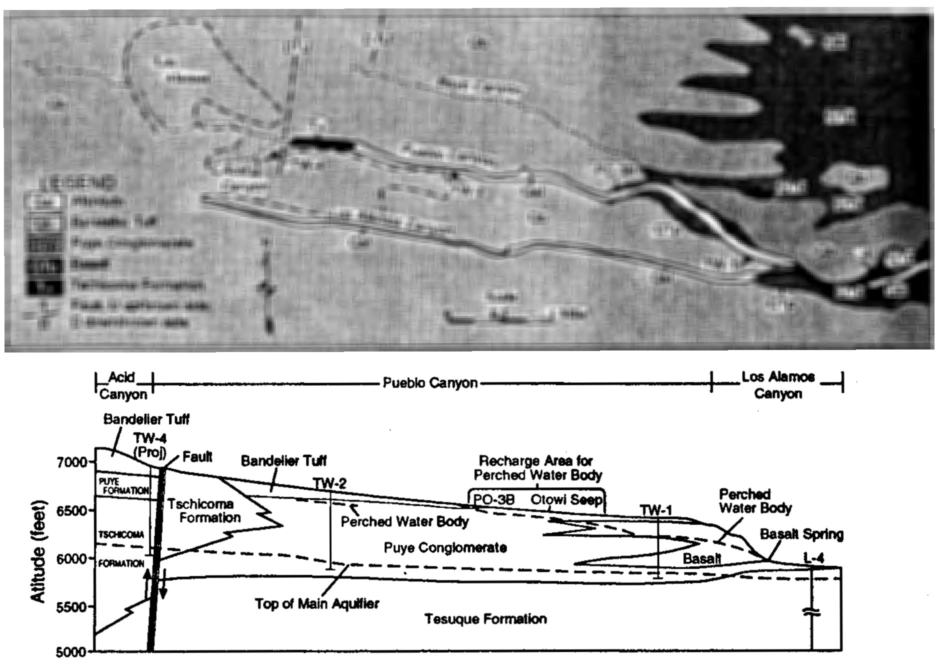

Fig. I-AC. Map with cross section along Pueblo Canyon showing perched water in volcanic sediments in the middle and lower reaches of Pueblo Canyon.

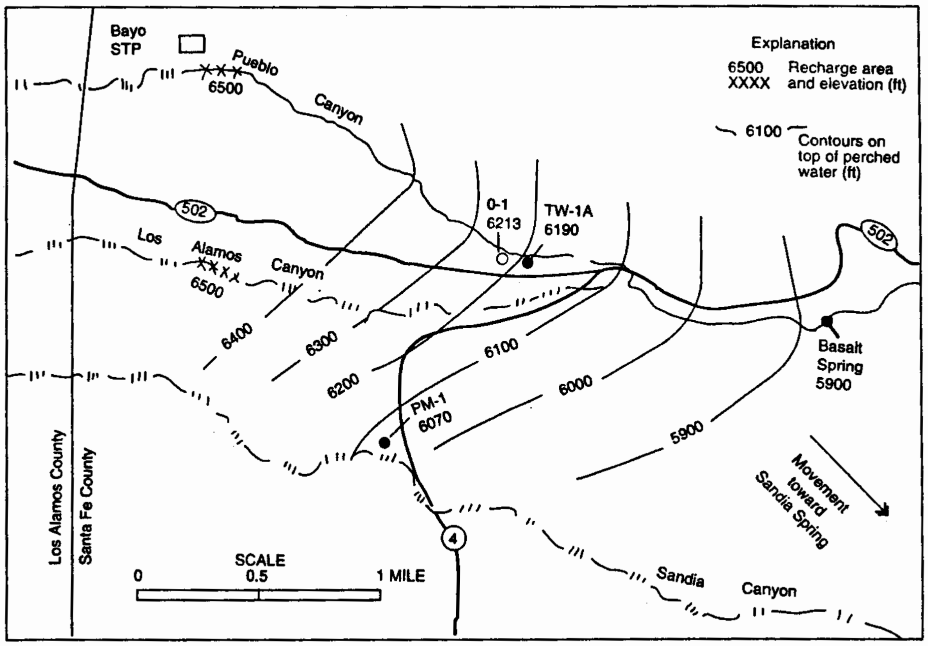

Fig. I-AD. Water level contours of the top of the perched aquifer in volcanic sediments and basalts in lower Pueblo Canyon and the midreach of Los Alamos Canyon.

The major recharge to this aquifer occurs in Pueblo Canyon where the channel cuts through the Bandelier Tuff and is underlain by the fanglomerate member of the Puye Conglomerate in the vicinity of Hamilton Bend Spring at an elevation of about 6500 ft (Fig. I-AD and I-Q). Surface water losses into the fanglomerate increase east of Hamilton Bend. There is and has been a large amount of water (sanitary effluent and storm runoff) available in this part of the canyon for the past 40 years (Purtymun 1975).

A minor area of recharge to this aquifer is in Los Alamos Canyon where the channel cuts through the Bandelier Tuff and is underlain by a thin section of fanglomerate which is underlain by the Unit 2 Basaltic Rocks of Chino Mesa. During the spring and late fall when the alluvium in the canyon is saturated or near saturation, stream flow returns to the surface in this area for a short distance, indicating thinning of the alluvium over the fanglomerate and basalts (Figs. I-AD and I-R). The elevation is about the same as in Pueblo Canyon (about 6500 ft). There is probably a minor amount of recharge to the aquifer from the alluvium in Sandia Canyon.

Based on the chemical quality of the water, which is similar to the quality of the sanitary effluent in Pueblo Canyon, and water level fluctuations in test well TW-1A, the rate of movement in the aquifer has been estimated to be about 60 ft/day or about 6 months from recharge to discharge (Weir et al. 1963; Purtymun 1975).

4. Main Aquifer of the Los Alamos Area. The main aquifer of the Los Alamos area is the only aquifer in the area that is capable of municipal water supply. The surface of the aquifer rises westward from the Rio Grande within the Santa Fe Group into the lower part of the Puye Conglomerate beneath the central and western part of the plateau. Depth of the aquifer decreases from about 1200 ft along the western margin of the plateau to about 600 ft at the eastern margin (Fig. I-AE). The main aquifer is separated from the water in the alluvium and perched water in the volcanics by 350 to 620 ft of tuff and volcanic sediments. There appears to be little if any hydrologic connection between the water in the alluvium and the main aquifer.

The water in the main aquifer is under water-table conditions in the western and central part of the plateau and under artesian and semiartesian conditions in the eastern part along the Rio Grande. The gradient on the piezometric surface of the main aquifer across the plateau indicates a recharge area to the west. The recharge is considered to be from the flanks of the Sierra de los Valles or canyons cut into the western edge of the plateau (Theis 1950; Theis and Conover 1962; Griggs 1964; and Cushman 1965). There is a possibility that there is some

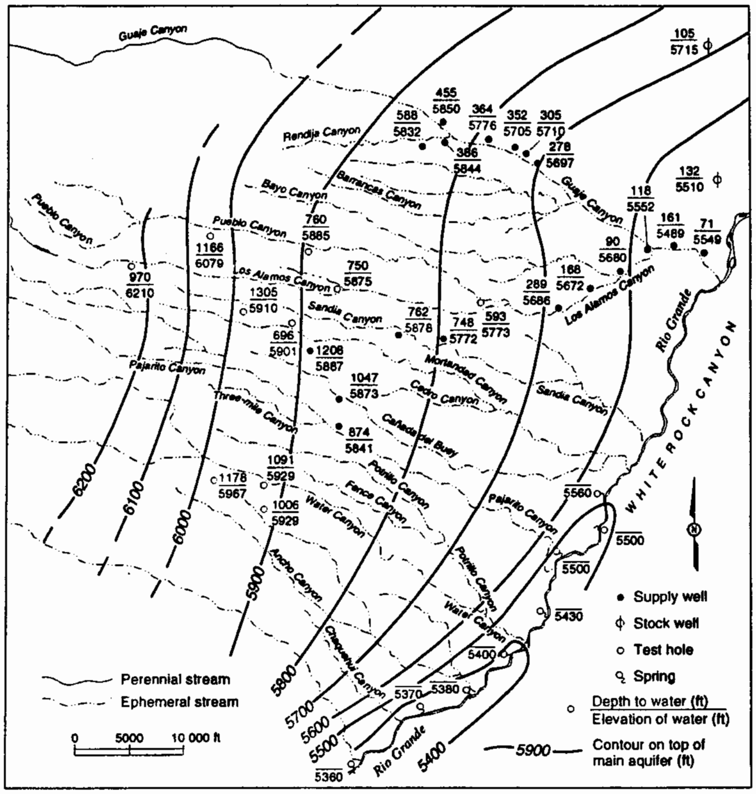

Fig. I-AE. Generalized water-level contours of the top of the main aquifer (Purtymun 1984).

recharge from intermountain basins such as the Valle Grande (Purtymun 1984).

Goff and Sayer (1980) indicated through deuterium and oxygen-18 ratios that deep supply wells LA-1B and LA-6 in the Los Alamos well field may be recharged from the east on the mountain slopes of the Sangre de Cristos. Additional investigations using isotope ratios were in progress in 1992.

Preliminary results based on low-level tritium and carbon-14 measurements indicate the age of the water in the main aquifer ranges from a few thousand years old to more than 40 000 years old. Youngest water occurs to the west, near the Sierra de los Valles and the oldest was found to the east near the Rio Grande. This is compatible with the direction of ground water flow based on water level contours on the top of the main aquifer (Stoker et al. 1993).

The movement of the water in the main aquifer is from the recharge area in the west to the east and southeast, where a part is discharged through seeps and springs into White Rock Canyon on the Rio Grande (Fig. I-AF). The 11-mile reach of the Rio Grande in White Rock Canyon from Otowi to Frijoles Canyon receives an estimated 5500 acre-ft annual discharge from the main aquifer through these springs (Purtymun 1966, Purtymun et al. 1980).

There were 21 supply wells and 10 test wells completed into the main aquifer on or adjacent to the Pajarito Plateau. The 21 supply wells are in four well fields. The Los Alamos field is no longer being used for water supply. It contained 7 wells, all of which are now either plugged or maintained as observation wells. The Guaje field contains 7 wells, the Pajarito field 5, and the Otowi field 2 wells. Not all wells are operational. Well G-3 in the Guaje field is now used for observation. Of the test wells 8 are equipped with pumps and are used for monitoring purposes while the remaining 2 wells are abandoned (H-19 and Sigma Mesa). Hydrologic characteristics of the main aquifer were determined at all of the supply wells and 8 of the test wells (Table I-A).

The hydrologic characteristics of the aquifer in the wells and test wells in the various fields differ due to the lithology of the aquifer and the thickness of the penetrated geologic section. The poorest wells are completed in the lower part of the Santa Fe Group, mainly the Tesuque Formation. The best-producing wells are completed in the sediments and interbedded basalts of the Chaquehui Formation (Purtymun and Stoker 1988).

TABLE I-A. Hydrologic Characteristics of Supply and Test Wells Completed in Main Aquifer

	Year	Saturated Thickness: Puye Conglomerate (ft)	Saturated Thickness: Chaquehui Formation (ft)	Saturated Thickness: Chamita and Tesuque Formations (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft of drawdown)	Transmissivity × 10³ (gpd/ft)	Field Coefficient of Permeability (gpd/ft²)
Los Alamos Field									
LA-1	1950	0	0	830	366	203	0.8	—	—
LA-1B	1982	0	0	1680	486	109	4.5	15.7	9.3
LA-2	1982	0	0	710	269	187	1.4	2.5	3.5
LA-3	1982	0	0	750	247	128	1.9	2.5	3.3
LA-4	1981	0	0	1680	579	104	5.6	9.6	5.7
LA-5	1982	0	0	1580	467	136	3.4	4.8	3.0
LA-6	1981	0	0	1700	580	57	10.2	15.5	9.1
Average				1275			4.0	8.4	5.6
Guaje Field									
G-1	1982	0	400	1420	313	165	1.9	12.0	7.0
G-1A	1982	0	560	1210	505	42	12.0	11.0	9.1
G-2	1982	0	570	1080	476	47	10.1	15.0	9.1
G-3	1982	0	720	910	239	112	2.1	7.5	5.3
G-4	1982	0	770	850	297	192	1.5	17.5	11.3
G-5	1982	0	750	790	522	55	9.5	12.0	8.7
G-6	1982	0	880	535	281	81	3.5	6.3	6.7
Average			660 (40%)	970 (60%)			5.8	11.6	8.2
Pajarito Field									
PM-1	1982	20	1030	700	589	22	26.8	55.0	31
PM-2	1982	540	960	230	1386	60	23.1	40.0	28
PM-3	1982	255	1045	490	1402	23	60.9	320.0	179
PM-4	1982	370	1500	0	1473	40	36.8	44.0	24
PM-5	1982	340	1230	340	1225	144	8.5	10.0	5.3
Average		305 (17%)	1153 (64%)	352 (19%)			31.2	93.8	53.4
Otowi Field									
O-1	1990	65	0	1755	1000	123	8.1	9.0	4.7
O-4	1990	110	1530	200	1500	33	46.2	62.0	30
Test Well									
DT-5A (TA-49)	1960	349	294	0	81	14	6	11.0	17
DT-9 (TA-49)	1960	354	144	0	88	4	22	61.0	122
DT-10 (TA-49)	1960	317	7	0	78	5	16	36.1	111
TW-1	1951	49	0	0	2.4	39	<1.0	0.2	4.0
TW-2	1951	30	0	0	6.7	7	1.0	7.0	241
TW-3	1951	65	0	0	6.6	15	0.5	7.8	120
TW-4	1951	0	0	0	2.8	5	0.6	0.7	19
TW-8	1960	95	0	0	16	8	2.0	2.4	25
H-19	1949	—		—	—	—	—	—	—
Sigma Mesa	1979	—		—	—	—	—	—	—

The average saturated thickness of the aquifer in the wells in the Los Alamos field is about 1275 ft in the Tesuque Formation of the Santa Fe Group. The aquifer consists of mainly siltstone and sandy siltstone; thus, the hydrologic characteristics of the aquifer are low. The average specific capacity is about 4 gpm/ft of drawdown, transmissivity is 8400 gallons per day (gpd)/ft, and the field coefficient of permeability is 5.6 gpd/ft^2 (Purtymun 1977, 1984).

The average saturated thickness of the aquifer in the Guaje field is about 1630 ft; however, of the saturated section about 660 ft or about 40% is within the Chaquehui Formation and associated basalts. The lower 970 ft or 60% is within the Tesuque Formation. The hydrologic characteristics of the aquifer in the Guaje field are slightly greater than in the Los Alamos field, with an average specific capacity of 5.8 gpm/ft and a field coefficient of permeability of 8.2 gpd/ft^2 (Griggs 1964).

The most productive wells are located in the Pajarito field where wells penetrated large thicknesses of the Chaquehui Formation and associated basalts. The average saturated thickness of the aquifer is 1810 ft. About 1153 ft or 64% of the saturated thickness is the Chaquehui Formation and basalts and 352 ft or 19% is within the Chamita and Tesuque Formations. The average specific capacity of the field is about 31.2 gpm/ft of drawdown, transmissivity 93 800 gpd/ft, with a field coefficient of permeability of 53.4 gpd/ft^2.

Four of the test wells are completed into the top of the main aquifer within the Puye Conglomerate while three others are completed within the Puye Conglomerate and the Chaquehui Formation. The hydrologic characteristics vary with the depth of penetration of the saturated section (Table I-A). Test well 4 was completed into the Tschicoma Formation. The hydrologic characteristics were not determined for test wells H-19 and Sigma Mesa.

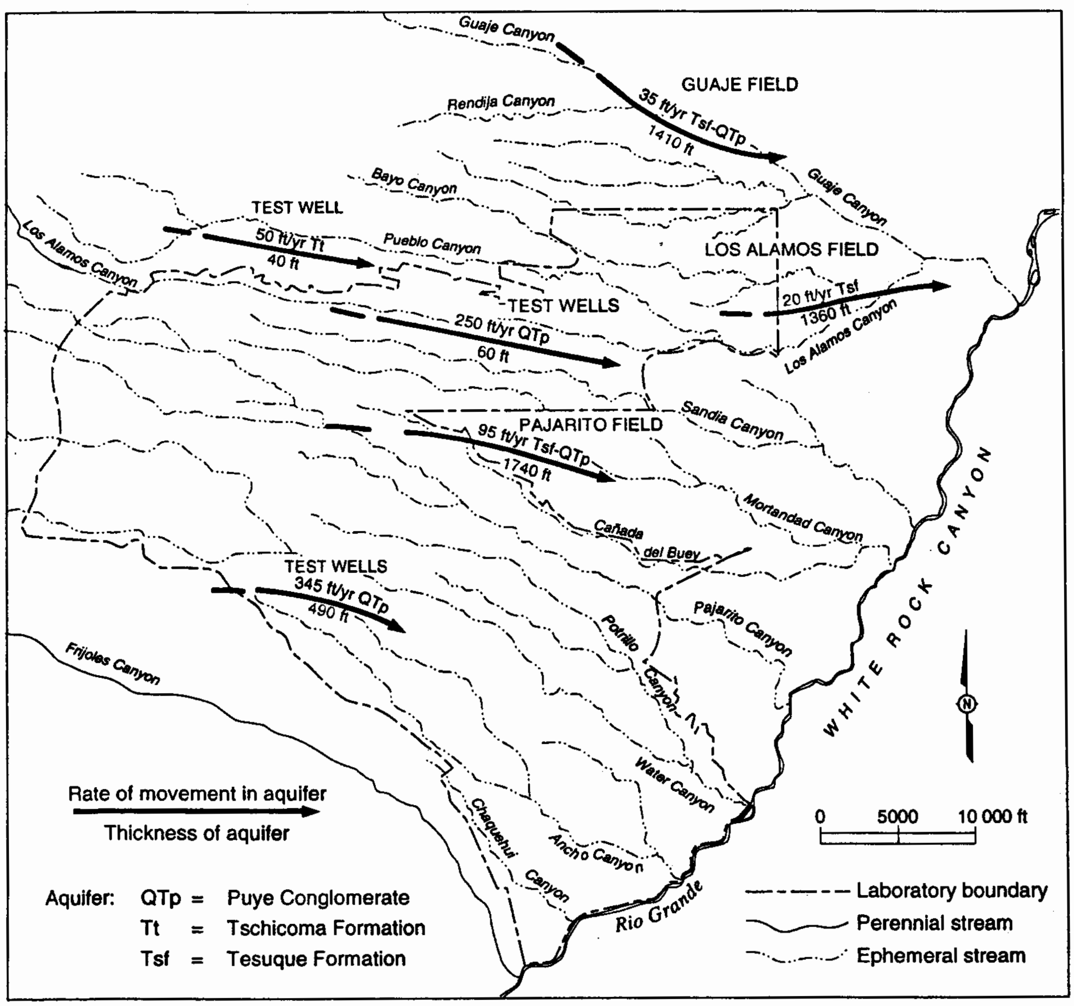

Fig. I-AF. Rate of movement of water in the main aquifer (Purtymun 1984).

The hydrologic characteristics of the supply and test wells were used to determine the rate of movement in the top of the main aquifer (Fig. I-AF). The rates of movement ranged from 20 ft/year in the Tesuque Formation to as much as 345 ft/yr in the Puye Conglomerate (Purtymun 1984).

Water-level measurements in the supply and test wells have been compiled indicating general water-level declines in the area (Table I-B). The amount of water-level decline related to production is indicative of the hydrologic characteristics of the aquifer. The lower permeability and porosity of the Tesuque

TABLE I-B. Water Levels in Supply and Test Wells

Los Alamos Field	Water Level at Completion	Completion	Most Recently Recorded Water Level	Year
LA-1	flowing	(1946)	10	(1991)
LA-1B	flowing	(1960)	55	(1991)
LA-2	flowing	(1946)	123	(1991)
LA-3	flowing	(1947)	112	(1991)
LA-4	189	(1948)	244	(1991)
LA-5	71	(1948)	158	(1991)
LA-6	3	(1948)	96	(1991)
Average	38		114	
Guaje Field				
G-1	192	(1951)	282	(1991)
G-1A	265	(1955)	325	(1991)
G-2	279	(1952)	369	(1991)
G-3	310	(1952)	347	(1991)
G-4	357	(1952)	382	(1991)
G-5	417	(1952)	487	(1991)
G-6	570	(1964)	591	(1991)
Average	342		398	
Pajarito Field				
PM-1	746	(1965)	752	(1991)
PM-2	826	(1966)	855	(1991)
PM-3	743	(1968)	768	(1991)
PM-4	1050	(1982)	1081	(1991)
PM-5	1208	(1982)	1239	(1991)
Average	915		939	
Test Well				
DT-5A (TA-49)	1173	(1960)	1178	(1964)
DT-9 (TA-49)	1003	(1960)	1006	(1982)
DT-10 (TA-49)	1085	(1960)	1089	(1962)
TW-1	585	(1950)	535	(1992)
TW-2	759	(1950)	792	(1992)
TW-3	743	(1949)	778	(1992)
TW-4	1171	(1950)	1173	(1992)
TW-8	968	(1960)	992	(1992)
H-19	970	(1949)	—	
Sigma Mesa	1330	(1979)	—	

Source: Purtymun et al. 1984.

Formation in the Los Alamos field has resulted in the greatest water-level decline. As the hydrologic characteristics improve, the amount of production per foot of water-level decline increases.Water level fluctuation in the main aquifer occurs during diurnal pressure changes, changes in atmospheric pressure, seismic events (earthquakes), and earth tides (Purtymun et al. 1974). Test holes, test wells, and supply wells that penetrate the tuff or volcanic sediments and basalt above the main aquifer draw in or expel air in response to atmospheric pressure changes.

The average water-level decline in the Los Alamos field has been about 76 ft (Table I-B). The production from the field from 1947 through 1991 has been about 16.4 billion gallons or about 220 million gallons per foot of water-level decline for the period.

The average water-level decline in the Guaje field has been 56 ft from 1965 through 1991, while the production from the field has been about 19.2 billion gallons or about 340 million gallons per foot of water-level decline.

The average water-level decline in the Pajarito field has been about 24 ft from 1965 through 1991 while the production from the field has been 18.8 billion gallons or about 780 million gallons per foot of water-level decline.

Most of the test wells are removed beyond the influence of pumping in the well fields; however, all show water-level declines that indicate a regional water-level decline on the plateau (Table I-B).

The rate of movement of water in the upper section of the aquifer varies, dependent on the aquifer materials (Purtymun 1984). Aquifer tests indicate that the movement ranges from 20 ft/yr in the Tesuque Formation to 345 ft/yr in the more permeable Puye Conglomerate and Chaquehui Formation (Fig. I-AF).

The Chaquehui Formation of the Santa Fe Group beneath the Pajarito Plateau is an important part of the main aquifer in the development of water supply at Los Alamos. The coarse volcanic and granitic debris within the Chaquehui Formation yields water readily to wells and in part allows the development of high-yield, low-drawdown wells in the area. The formation attains its greatest thickness in a north-south trending basin beneath the central part of the plateau as shown in Figs. I-F and I-G. The location of future wells in this basin should be chosen carefully because wells located too far west will encounter volcanic rocks of the Tschicoma Formation and wells located too far to the east will encounter rocks of the Tesuque Formation that do not yield water as readily as the coarser sediments of the Chaquehui Formation (Figs. I-F and I-AG).

Two supply wells, Otowi 1 and Otowi 4, were drilled in the fall of 1989 and were tested by the late summer of 1990. The main completion of Otowi 4 was in the Chaquehui Formation, while Otowi 1 lay at the edge of the Chaquehui coarse-sediment basin and was completed in the Tesuque Formation (Table I-A). A comparison of the yields of the two wells indicate that Otowi 4, completed in the Chaquehui Formation, is a high-yield well at 1500 gpm (Stoker et al. 1992). Otowi 1, completed in the Tesuque, is a marginal high-yield well at 1000 gpm (Fig. I-AH).

The quality of water from the main aquifer is monitored from the supply and test wells and from the springs that discharge from the aquifer in White Rock Canyon. The quality of water from a well or spring depends on the lithology of the aquifer and the amount of yield from the individual beds within the aquifer. The quality of water from the individual wells and springs varies because of local conditions within the same aquifer. The variation in the general chemical quality of water from wells and springs is presented in graphic form (Figs. I-AI, I-AJ, and I-AK) showing the concentrations of calcium, sodium, hardness, bicarbonate, and total dissolved solids (concentrations in mg/L). Hardness is dissolved calcium-magnesium, with a hardness classification 1 to 60 mg/L rated soft; 61 to 120 mg/L moderately hard; and 121 to 180 mg/L hard. Predominant chemicals in the water are calcium or sodium with bicarbonate; thus, the waters are of either calcium-bicarbonate or sodium-bicarbonate types.

Graphic comparison of average chemical constituents in water from the main aquifer in the Los Alamos field, the Guaje field, and the Pajarito field shows gross differences in the concentration of constituents due to the lithology of the the aquifer. All of the yield from the Los Alamos field is from the Tesuque Formation; the yield from the Guaje field is partly from the Tesuque Formation and partly from the Chaquehui Formation; and most of the yield from the Pajarito field is from the Chaquehui

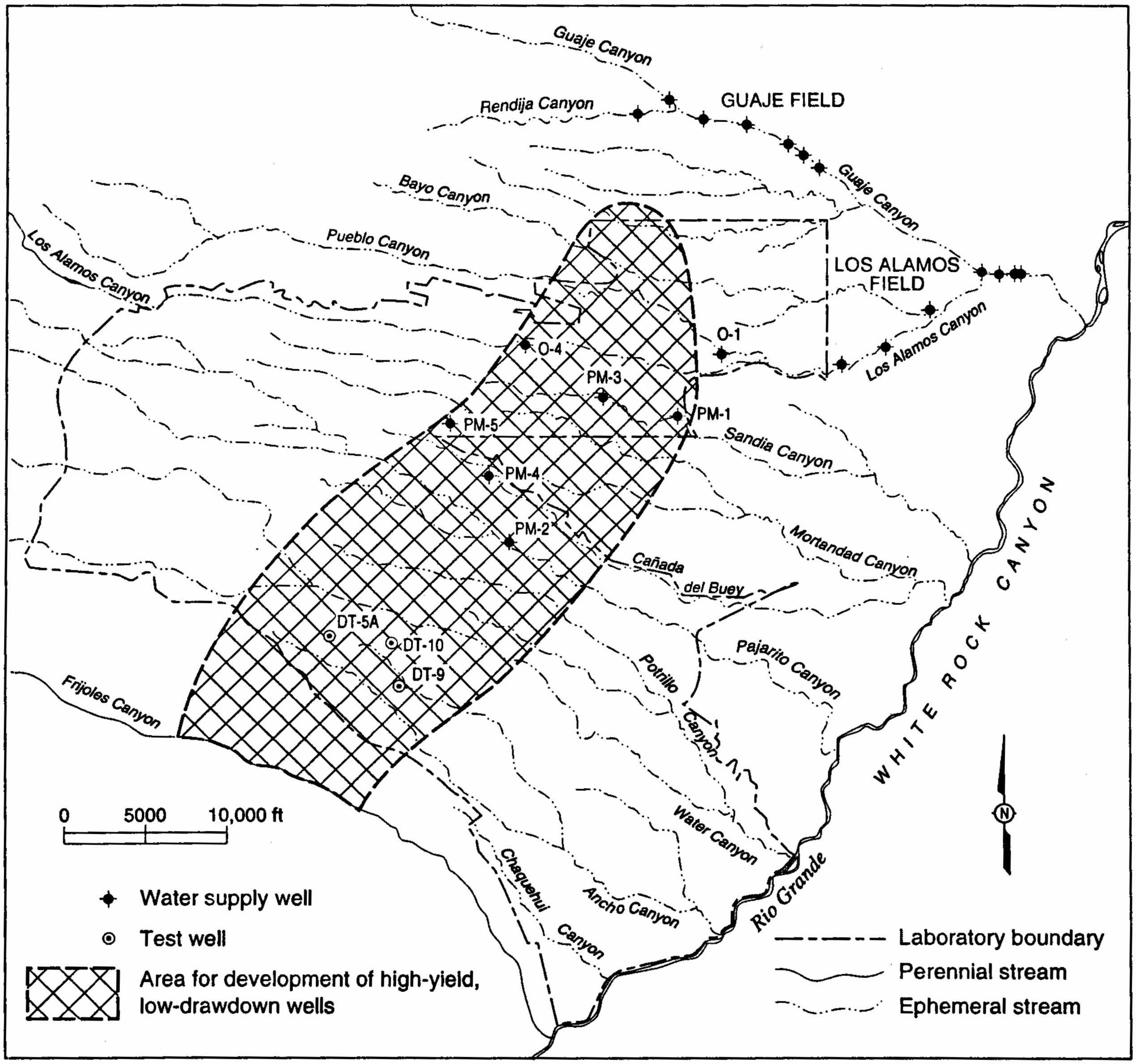

Fig. I-AG. Proposed locations for additional supply wells and area for the development of high-yield, low-drawdown wells (Purtymun 1984).

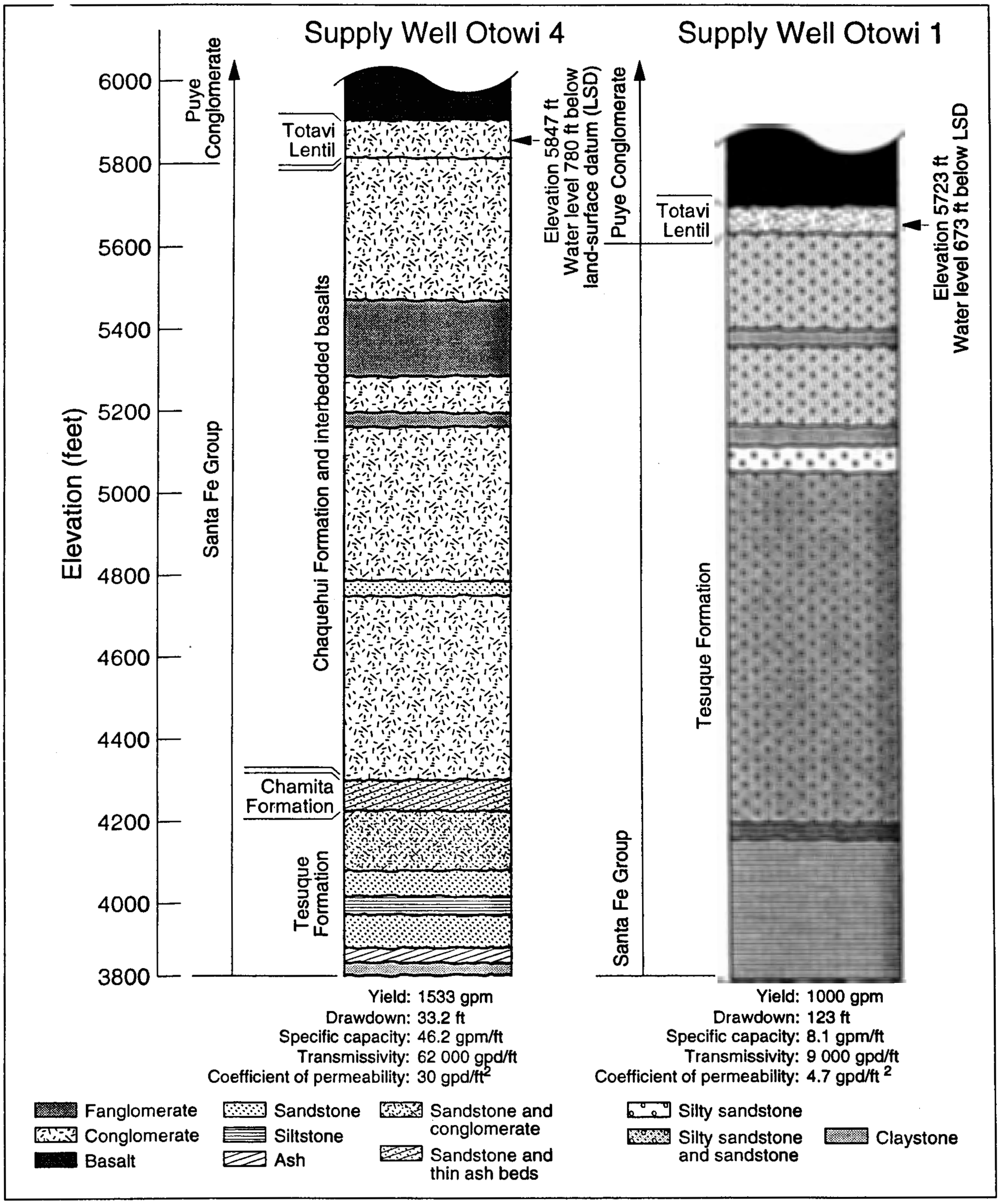

Fig. I-AH. Partial geologic logs of supply wells Otowi 1 and 4 showing equivalent saturated sections (main aquifer) in the Puye Conglomerate and Santa Fe Group and a comparison of their hydrologic characteristics (Purtymun 1993). See Figs. XXI-T and XXI-U for complete logs.

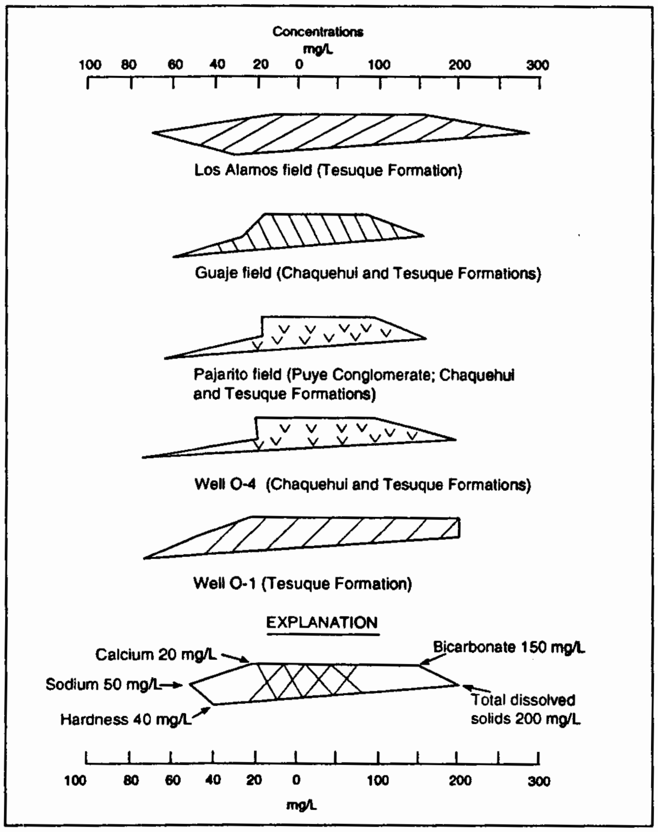

Fig. I-AI. Graphic comparsion of average chemical constituents in water in supply wells from the main aquifer (Purtymun 1993, Purtymun et al. 1994).

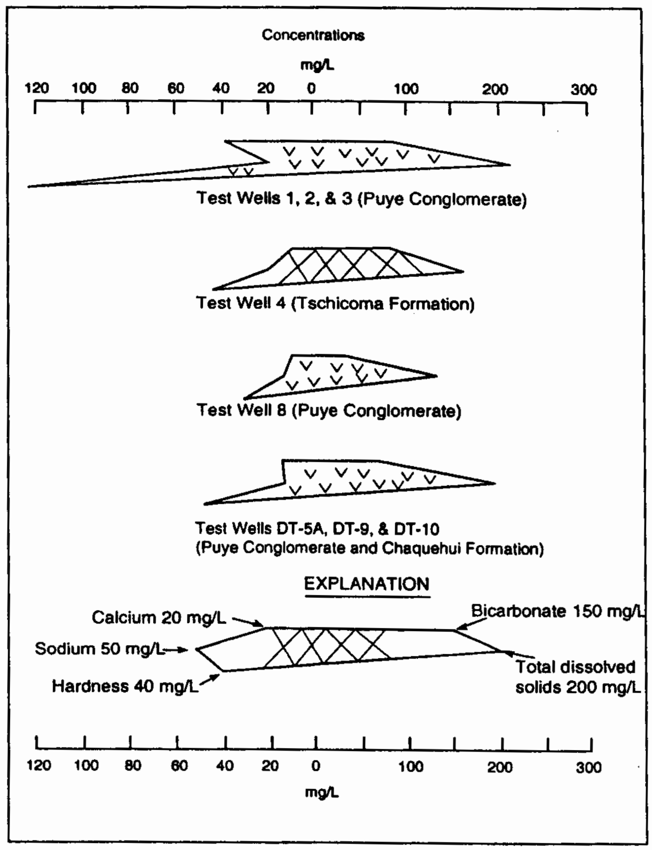

Fig. I-AJ. Graphic comparsion of average chemical constituents in water in test wells from the main aquifer (Purtymun 1993).

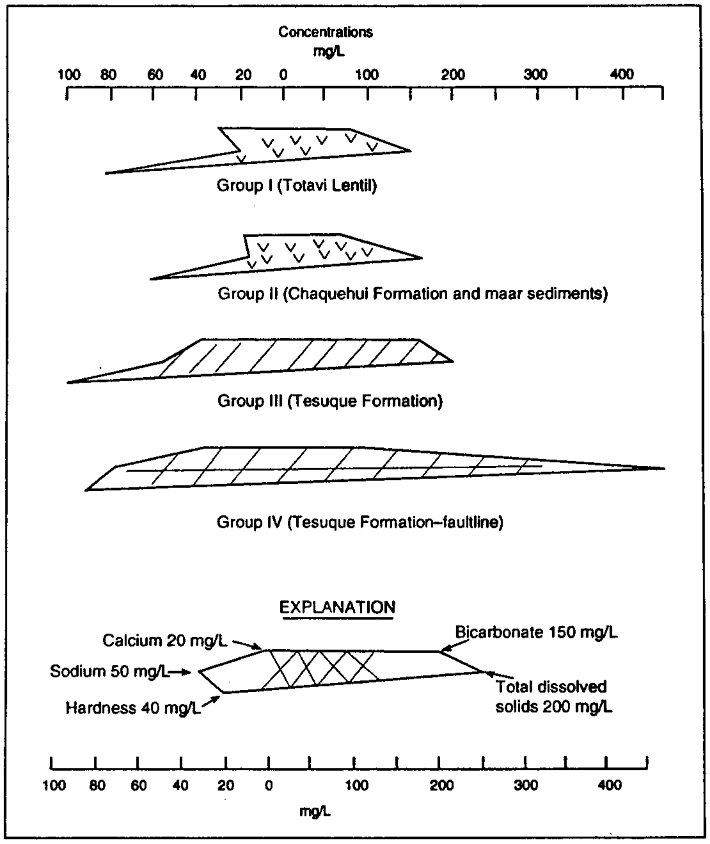

Fig. I-AK. Graphic comparison of average chemical constituents in water from the main aquifer in springs, in and adjacent to White Rock Canyon (Purtymun 1966, Purtymun et al. 1980, Purtymun 1993).

Formation (Fig. I-AI). A graphic comparison of chemical constituents from the wells in the Otowi field, O-1 and O-4, shows the difference due to the yield from the Chaquehui Formation (O-4) and the Tesuque Formation (O-1).

Graphic comparison of the average chemical constituents in water from the main aquifer in test wells shows large differences in the concentrations of constituents in the Puye Conglomerate (Fig. I-AJ). This is probably due in part to the differences in the saturated thickness penetrated by the test well and in part to the changes in lithology of the conglomerate on the plateau. Test well 4 was completed in the Tschicoma Formation (Purtymun 1993; Purtymun et al. 1994).

Graphic comparison of the average chemical constituents in water from springs that discharge from the main aquifer in and adjacent to White Rock Canyon shows slight varations in the concentrations of chemical constituents due to the lithology of the aquifer. The average concentration of constituents in the water from the Group I and II springs differs, depending upon whether the water discharges from the Totavi Lentil or the Chaquehui Formation. The 7 Group I springs contain water from the Totavi Lentil, while the 11 Group II springs discharge from the Chaquehui Formation and in some cases are associated with the maar sediments (Fig. I-AK). The agreement of concentrations within each group is significantly greater than between the groups, although the concentrations of the constituents of all 18 springs are similar. Also shown on the figure are the average concentrations of constituents from three Group III springs that discharge from the fine-grained Tesuque Formation of the Santa Fe Group as well as four Group IV springs that discharge from along probable faults in the fine-grained sediments of the Tesuque Formation (Purtymun 1966; Purtymun et al. 1980, Purtymun et al. 1993).

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II. BAYO CANYON

Bayo Canyon heads on the Pajarito Plateau at an elevation of 6680 ft with a drainage area of about 3.7 sq mi. Because the canyon heads on the plateau, the alluvium consists mainly of sand and gravel derived from the weathering of the tuff. The stream flow in the canyon is intermittent, with the largest percentage of runoff occurring during the summer from heavy thunderstorms. This runoff is of short duration, usually lasting less than two hours. There is no effluent discharge into the canyon. Before 1965 a technical area (TA-10) used for testing was located in the canyon. Water was hauled to the site. The site was abandoned and the area cleaned up in 1965. Additional cleanup has been performed in the canyon since 1965 (Environmental Surveillance Group 1979) and remediators are currently investigating the site to see if additional work is needed.

Four test holes were augered in the canyon in 1961 to determine if water occurred in the alluvium or tuff at the Puye Conglomerate contact (Fig. II-A and Tables II-A and II-B). The test holes were dry with no indication of water in the alluvium or tuff at the Puye contact. In 1973 three holes were augered to collect samples. These holes were also dry (Ferenbaugh et al. 1982; FBD Inc. 1981; Purtymun 1994).

The top of the main aquifer lies at a depth of about 780 ft near the center of the former site (Environmental Surveillance Group 1979).

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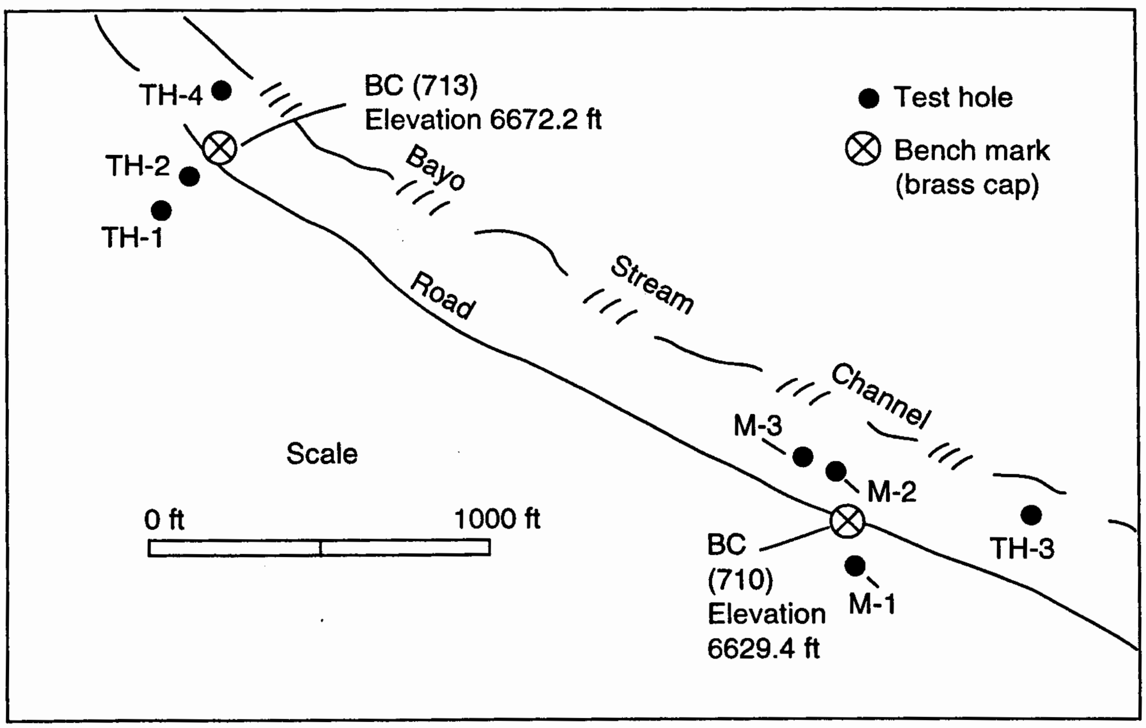

Fig. II-A. Generalized location of test holes in Bayo Canyon.

TABLE II-A. Records of Test Holes at Bayo Canyon Site, 1961 and 1973

	Elevation LSD (ft)	Depth (ft)	Alluvium (ft)	Tuff (ft)	Conglomerate (ft)
TH-1 (1961)	6660	89	—	0 to 85	85 to 89
TH-2 (1961)	6660	25	0 to 5	5 to 25	—
TH-3 (1961)	6610	70	0 to 12	12 to 65	65 to 70
TH-4 (1961)	6670	79	0 to 10	10 to 77	77 to 79
M-1 (1973)	6630	40	0 to 26 [a]	26 to 40	—
M-2 (1973)	6625	20	0 to 15 [a]	15 to 20	—
M-3 (1973)	6625	8	0 to 8 [a]	—	—

[a] Fill material or reworked tuff

Note: All holes were dry (drilled with a 4-in.-diam auger).
Test hole M-1 is near the TA-10-48 waste pit.
Test hole M-2 is near the TA-10-38 outfall stainless steel tank.
Test hole M-3 is near the TA-10-50 concrete tank.

Sources: Environmental Surveillance Group 1979; Purtymun 1994.

TABLE II-B. Locations and Elevations (NAD 1927)

TH-1	N 1,778,600	E 500,200	6660 ft
TH-2	N 1,778,700	E 500,200	6660 ft
TH-3	N 1,778,400	E 501,400	6610 ft
TH-4	N 1,779,100	E 500,100	6670 ft
M-1	N 1,778,500	E 501,000	6630 ft
M-2	N 1,778,600	E 501,000	6625 ft
M-3	N 1,778,700	E 500,800	6625 ft

III. ACID/PUEBLO CANYON

Pueblo Canyon heads on the flanks of the mountains west of the Laboratory at an elevation of 8990 ft and has a drainage area of 8.6 sq mi west of SR-4. Unlike other canyons heading on the mountains, Pueblo Canyon has no springs to create a stream flow. The alluvium in the canyons is composed of sand, gravel, cobbles, and boulders derived from the Tschicoma Formation (Fig. I-Q), the Bandelier Tuff, and in the lower part of the canyon, the fanglomerate member of the Puye Conglomerate. Stream flow in the canyon is intermittent, derived from effluent release of sanitary treatment plants and runoff from summer thunderstorms and snow melt.

Radioactive wastes were released into Acid Canyon (a tributary to Pueblo Canyon) from 1943 to 1950. From 1950 to 1964 the radioactive wastes were treated before release (Purtymun 1994). Sanitary effluents were and are now released into the canyon. The Pueblo plant that treated industrial wastes operated until 1964, when the new plant (TA-50) began operations. The Pueblo Sanitary Treatment Plant in upper Pueblo Canyon has released effluent into Pueblo Canyon from 1947 until the present (1991). The Central Sanitary Sewage Treatment Plant, located just west and north of the airport terminal, operated from the 1940s through 1964 and released effluent into the midreach of Pueblo Canyon. The Bayo Sanitary Treatment Plant that began operations in 1964 continues to release effluent into the canyon near Hamilton Bend Spring (Fig. III-A).

To monitor the chemical and radiochemical quality of the water, 6 surface water stations and 17 shallow ground water stations (wells) were established in Acid-Pueblo Canyon during the period 1950 through 1964 (Fig. III-A and Table III-A). Four of the surface water stations are still being used to monitor the quality of surface water (Acid Weir, Pueblo 1, Pueblo 2, and Pueblo 3). Some of the shallow wells consisted of 8-in.-diam corrugated metal pipe perforated in the lower 2 ft and dug 3 to 4 ft into the alluvium. They were equipped with locking caps. The other wells were 2-in.-diam galvanized pipe equipped with a 2-ft sandpoint, driven about 3 ft into the alluvium. Some of these wells were in place in 1952; some were added and replaced, but all were washed out or destroyed by 1972 (Weir et al. 1963; H-8 1981).

The stream in Pueblo Canyon has cut a small meander near Hamilton Bend Spring, where the channel cuts through the tuff onto the hard rocks of the fanglomerate member of the Puye Conglomerate (Fig. III-B). During the mid-1950s Hamilton Bend Spring flowed year-round, and there was a small seep (Otowi Seep) in the channel about 0.25 mi east of the spring. At that time sanitary effluent from the Pueblo and Central Plants, with periodic discharge from TA-45, maintained flow to about Hamilton Bend. In the fall of 1956, 14 shallow test holes were drilled in the area of Otowi Seep to determine if the flow from the spring and seep was connected with the alluvium in Bayo Canyon or with effluent flow in Pueblo Canyon (Table III-B). Of the 14 wells, only 3 wells—PO-3B (Fig. III-C), PO-4A (Fig. III-D), and PO-4B (Fig. III-E)—are presently in condition for use as observation wells. Alluvium was reported in only these test holes: PO-3B (26 ft), PO-4A (43 ft), and PO-4B (37 ft). These holes were drilled on a terrace above the stream channel. The alluvium reported may be a combination of reworked stream channel alluvium or coalluvium from the slope at the base of the cliffs. The rest of these test holes began in and were completed in the fanglomerate member of the Puye Conglomerate. Geologic logs of wells and test holes are shown in Table III-C. The study indicated that recharge to Hamilton Bend Spring and Otowi Seep was from the effluent flow and storm runoff in Pueblo Canyon (Abrahams 1966). Since the mid-1960s stream flow has extended to State Road 502 because of discharge from the Bayo Treatment Plant. Reduced flow from the Pueblo plant in the upper canyon extends eastward to near test well TW-2.

The holes were augered with a 5-in.-diam auger to various depths. Most were abandoned upon completion, but those with water were cased (Table III-B). The cased wells were not gravel packed. Those that were cased are sealed at the surface with cement and with a locked plate to prevent access. The screen sections of the plastic pipes were perforated and the steel pipe was torch slotted.

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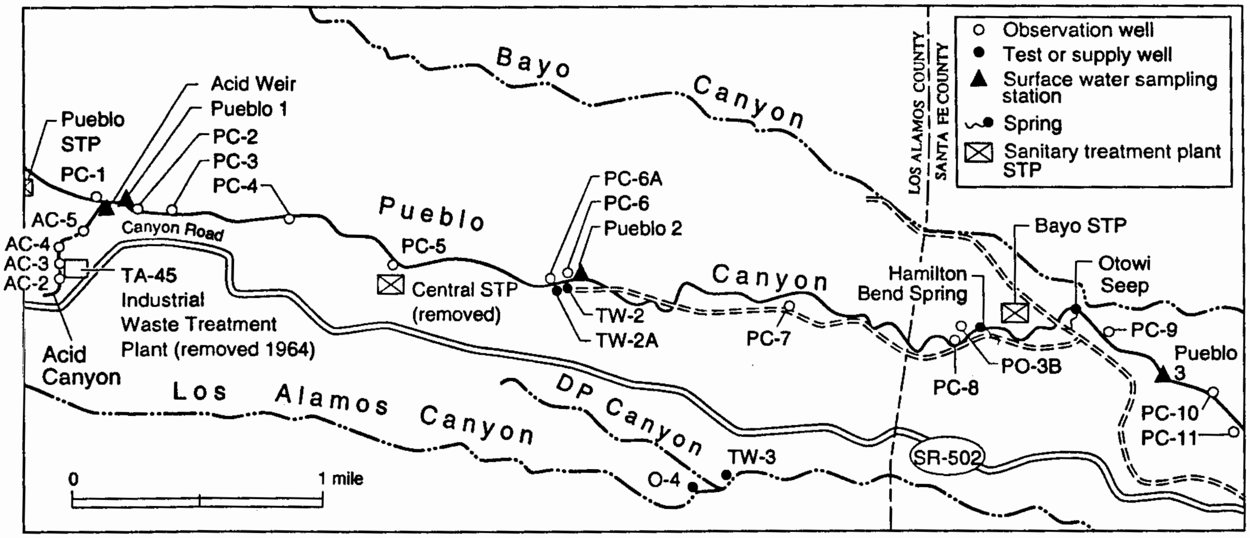

Fig. III-A. Generalized location of surface water sampling stations, shallow wells, and the spring sampling stations in Acid and Pueblo Canyons (Weir et al. 1963; Purtymun 1975).

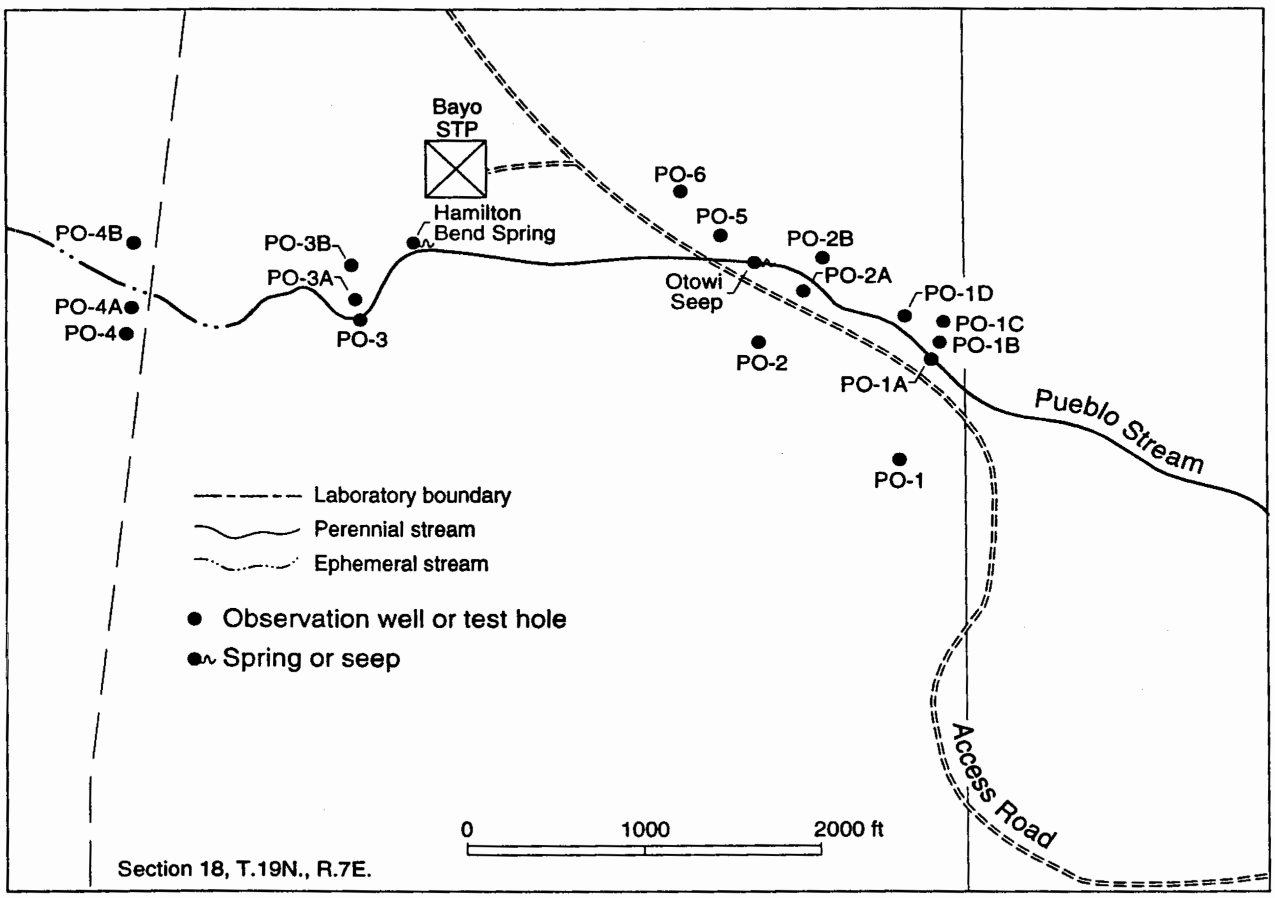

Fig. III-B. Location of observation wells and test holes in the vicinity of Hamilton Bend Spring and Otowi Seep in Pueblo Canyon (Abrahams 1966).

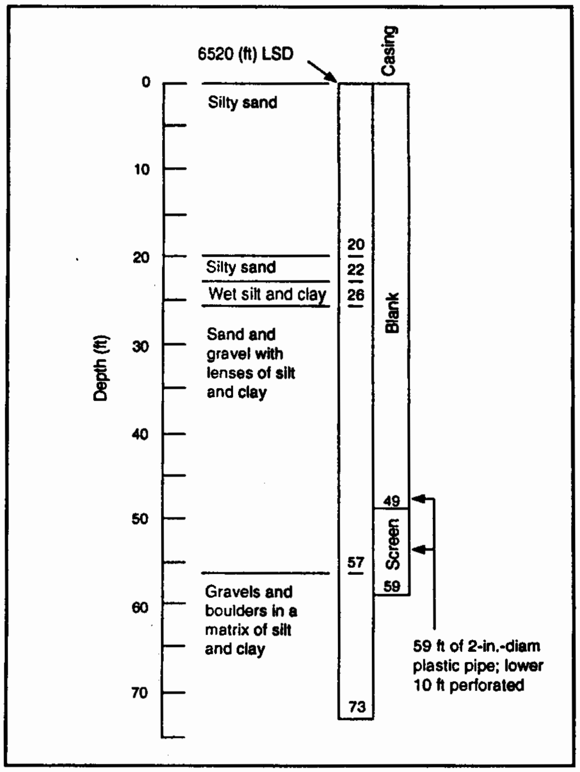

Fig. III-C. Pueblo Canyon observation well PO-3B, completed April 1956, water level 50 ft (Abrahams 1966).

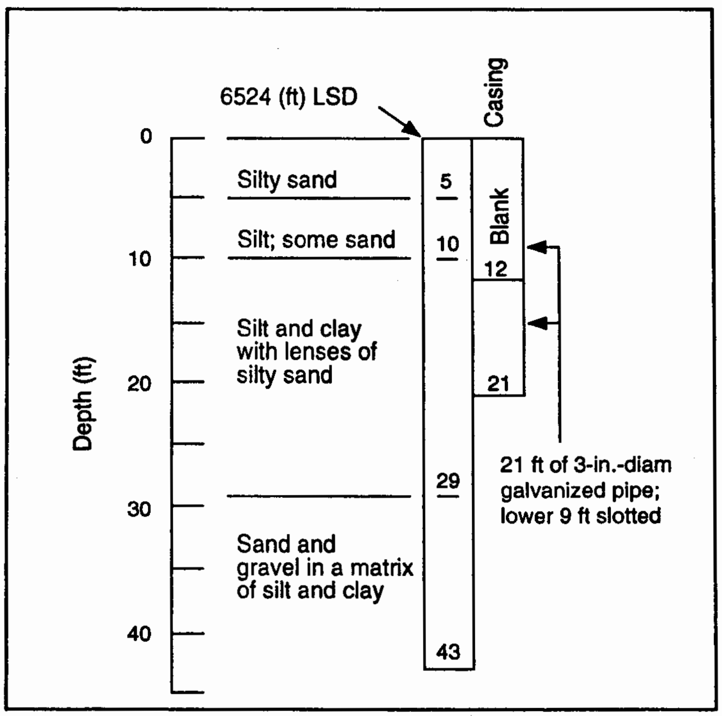

Fig. III-D. Pueblo Canyon observation well PO-4A, completed April 1956, water level 18 ft (Abrahams 1966).

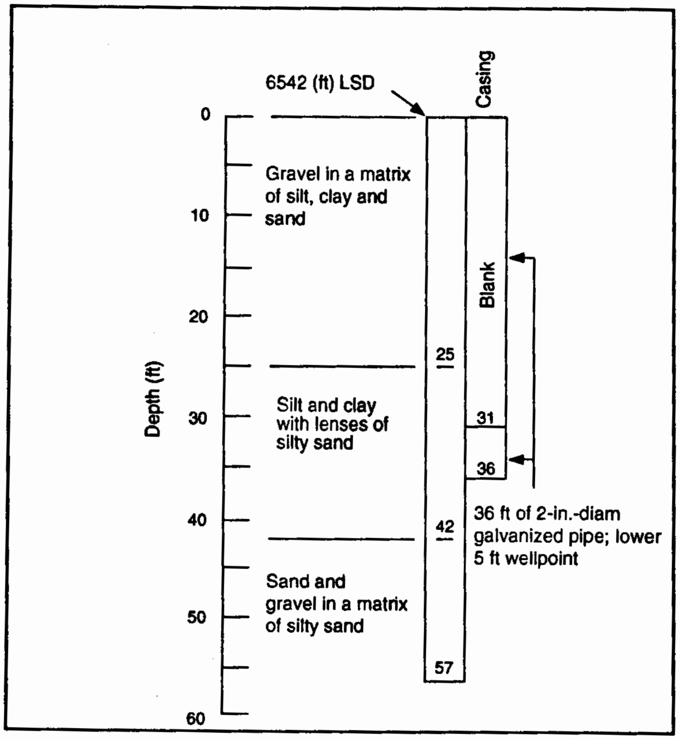

Fig. III-E. Pueblo Canyon observation well PO-4B, completed April 1956, water level 24.0 ft (Abrahams 1966).

TABLE III-A. Surface Water Stations and Shallow Wells in Acid/Pueblo Canyon

Surface Water Stations

Acid Weir:	elevation 6990 ft (current monitoring station)
Pueblo 1:	elevation 6960 ft (current monitoring station)
Pueblo 2:	elevation 6630 ft (current monitoring station)
Pueblo 3:	elevation 6423 ft (current monitoring station)
Otowi Seep:	elevation 6470 ft (dropped from the monitoring network in 1964)
Hamilton Bend Spring:	elevation 6500 ft (current monitoring station)

Notes: Pueblo 1 1953–1973: sampled below confluence with Acid Canyon; 1974 to present: sampled above confluence. Pueblo 3 collected samples 1952–1964 at the end of the flow, generally between Hamilton Bend Spring and well PC-11. Since 1964, with the completion of the Bayo Sanitary Treatment Plant (STP), samples have been collected near PC-10. Otowi Seep has been covered by sanitary effluent release from Bayo STP since 1964. Hamilton Bend Spring has been generally dry since 1964, when Central STP near the airport closed.

Shallow Well Stations

Acid Canyon	Remarks
AC-1	corrugated metal pipe (CMP)
AC-2	CMP
AC-3	CMP
AC-4	CMP
AC-5	CMP
Pueblo Canyon	
PC-1	sandpoint
PC-2	sandpoint
PC-3	sandpoint
PC-4	sandpoint
PC-5	sandpoint
PC-6	CMP
PC-6A	sandpoint
PC-7	sandpoint
PC-8	CMP
PC-9	CMP
PC-10	CMP
PC-11	CMP

Note: Sampling wells were in place by 1952; some were replaced after washouts. All were destroyed or washed out by 1972. CMP: 6-in.-diam. Sandpoint and drive pipe: 2-in.-diam galvanized.

Sources: Abrahams 1966; Purtymun 1975.

TABLE III-B. Records of Observation Wells and Test Holes in the Vicinity of Hamilton Bend Spring in Pueblo Canyon

Designation	Elevation LSD (ft)	Depth Drilled (ft)	Depth Completed (ft)	Water Level at Completion (ft)	Remarks
PO-1	6460	16	—	dry	test hole (TH)—uncased
PO-1A	6442	36	18	dry	plugged and abandoned 1969
PO-1B	6441	18	—	dry	TH—uncased
PO-1C	6446	22	—	dry	TH—uncased
PO-1D	6450	23	—	dry	TH—uncased
PO-2	6478	30	—	dry	TH—uncased
PO-2A	6452	14	8	2.0	observation (obs) well—destroyed
PO-2B	6456	11	—	dry	TH—uncased
PO-3	6499	27	12	1.0	obs well—destroyed
PO-3A	6513	33	22	10	obs well—destroyed
PO-3B	6520	73	59	50	obs well
PO-4	6524	43	27	25.8	obs well
PO-4A	6524	43	21	18	obs well
PO-4B	6542	57	36	24	obs well
PO-5	6475	22	—	dry	TH—uncased
PO-6	6520	18	—	dry	TH—uncased

Notes: Holes augered with a 4-in.-diam bit; drilled and constructed April–May 1956.

Source: Abrahams 1966.

TABLE III-C. Geologic Logs and Construction Data of Observation Wells and Test Holes in the Vicinity of Hamilton Bend Spring in Pueblo Canyon (16 Obs. Wells and Test Holes)

1. Observation Well PO-1 (TH)

Elevation (LSD) 6460 ft

Water level (WL)—Dry (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Silt, sand, gravel, and boulders	16	16

Construction
Uncased.

2. Observation Well PO-1A

Elevation (LSD) 6442 ft

WL—Dry (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Sand, gravel, and boulders	17	17
Silt and gravel	19	36

Construction
18 ft of 3-in.-diam steel pipe, lower 8 ft perforated; hole plugged and abandoned 1969.

3. Observation Well PO-1B (TH)

Elevation (LSD) 6441 ft

WL—Dry (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Clay, sand, and gravel (moist)	15	15
Silts and gravel (dry)	3	18

Construction
Uncased.

4. Observation Well PO-1C (TH)

Elevation (LSD) 6446 ft

WL—Dry (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Clay, sand, and gravel (moist)	15	15
Sand, gravel, and boulders (consolidated)	7	22

Construction
Uncased.

5. Observation Well PO-1D (TH)

Elevation (LSD) 6450 ft

WL—Dry (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Sand and gravel (dry)	23	23

Construction
Uncased.

Source: Abrahams 1966.

TABLE III-C. Geologic Logs and Construction Data of Observation Wells and Test Holes in the Vicinity of Hamilton Bend Spring in Pueblo Canyon (16 Obs. Wells and Test Holes) (Continued)

6. Observation Well PO-2 (TH)

Elevation (LSD) 6478 ft — WL—Dry (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Tuff	13	13
Silt, sand, gravel, and boulders	17	30

Construction
Uncased.

7. Observation Well PO-2A

Elevation (LSD) 6452 ft — WL—2.0 ft (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Silt and clay; boulders	14	14

Construction
8 ft of 1 $^1/_2$-in.-diam pipe with 2-ft sandpoint. Well destroyed in flood 1959.

8. Observation Well PO-2B (TH)

Elevation (LSD) 6456 ft — WL—Dry (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Silt, sand, and gravel; boulders	11	11

Construction
Uncased.

9. Observation Well PO-3

Elevation (LSD) 6499 ft — WL—1.0 ft (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Silt, sand, and gravel	18	18
Interbedded gravel, clay, and sand	9	27

Construction
12 ft of 1$^1/_2$- in.-diam pipe with 2-ft sandpoint. Hole dry several days after completion. Well destroyed in flood 1959.

10. Observation Well PO-3A

Elevation (LSD) 6513 ft — WL—10 ft (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Gravel and sand	11	11
Interbedded gravel, clay, and sand	22	33

Source: Abrahams 1966.

10. Observation Well PO-3A (Continued)

Construction
22 ft of $1^1/_2$-in.-diam. pipe with 2-ft sandpoint. Hole dry several days after completion.

11. Observation Well PO-3B

Elevation (LSD) 6520 ft

WL—50.5 ft (April 1956)
WL—50.8 ft (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Silty sand	20	20
Gravel	2	22
Wet silt and clay	4	26
Puye Conglomerate (fanglomerate member)		
Sand and gravel with lenses of silt and clay	31	57
Gravel and boulders in a matrix of silt and clay	16	73

Construction
59 ft of 2- in.-diam plastic pipe with lower 10 ft perforated. Depth 54.8 ft 1991. Measuring point (MP): top of casing (TC). Distance of MP (TC) to LSD = 0.0 ft.

12. Observation Well PO- 4

Elevation 6524 ft

WL—25.8 ft (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Sand and gravel	5	5
Tuff (weathered)	5	10
Gravel with clay and sand layers (gravel and sand wet 18–25 ft)	30	40
Cobbles and boulders	3	43

Construction
27 ft of $1^1/_2$- in.-diam pipe with 2-ft sandpoint. Water level dropped after completion until hole was dry.

13. Observation Well PO-4A

Elevation (LSD) 6524 ft

WL—18 ft (April 1956)
WL—Dry (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Silty sand	5	5
Silt, some sand	5	10
Silt and clay with lenses of silty sand	19	29
Sand and gravel in a matrix of silt and clay	14	43

Construction
21 ft of 3-in.-diam galvanized pipe with lower 6 ft slotted. Depth 18.9 ft 1991 [MP (TC) to LSD = 0.0 ft].

Source: Abrahams 1966.

TABLE III-C. Geologic Logs and Construction Data of Observation Wells and Test Holes in the Vicinity of Hamilton Bend Spring in Pueblo Canyon (16 Obs. Wells and Test Holes) (Continued)

14. Observation Well PO-4B

Elevation (LSD) 6542 ft

WL—24 ft (April 1956)
WL—Dry (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Gravel in a matrix of silt, clay, and sand	25	25
Silt and clay with lenses of silty sand	17	42
Sand and gravel in matrix of silty sand	15	57

Construction (April 1956)
31 ft of 2-in. galvanized pipe set 0 to 31 ft, 5 ft wellpoint 31 to 36 ft. Depth 34.5 ft in 1991 [MP(TC) to LSD = 0.0 ft].

15. Observation Well PO-5 (TH)

Elevation (LSD) 6475 ft

WL—Dry (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Silt, sand, and gravel	18	18
Cobbles and boulders	4	22

Construction
Uncased.

16. Observation Well PO-6

Elevation (LSD) 6520 ft

WL—Dry (1956)

Geologic Log	Thickness (ft)	Depth (ft)
Tuff and pumice	13	13
Sand and gravel	5	18

Construction
Uncased.

Source: Abrahams 1966.

TABLE III-D. Locations and Elevations (NAD 1927)

A. Surface Water Stations

Acid Weir	N 1,778,600	E 484,100	6990 ft
Pueblo 1	N 1,778,800	E 484,400	6950 ft
Pueblo 2	N 1,777,300	E 494,000	6630 ft
Pueblo 3			
Otowi Seep	N 1,776,100	E 504,600	6470 ft
Hamilton Bend Spring	N 1,776,161	E 502,420	6500 ft

B. Springs, Observation Wells and Test Holes

AC-1	N 1,777,300	E 483,200	7160 ft
AC-2	N 1,777,500	E 483,200	7140 ft
AC-3	N 1,777,900	E 483,200	7120 ft
AC-4	N 1,778,000	E 483,100	7100 ft
AC-5	N 1,778,200	E 483,500	7060 ft
PC-1	N 1,778,800	E 483,900	6960 ft
PC-2	N 1,778,700	E 484,600	6940 ft
PC-3	N 1,778,600	E 485,900	6900 ft
PC-4	N 1,778,900	E 488,200	6810 ft
PC-5	N 1,777,600	E 490,300	6720 ft
PC-6	N 1,777,300	E 493,600	6660 ft
PC-6A	N 1,777,300	E 493,600	6660 ft
PC-7	N 1,776,800	E 496,000	6610 ft
PC-8	N 1,775,800	E 502,200	6505 ft
PC-9	N 1,775,600	E 505,300	6450 ft
PC-10	N 1,774,500	E 507,400	6420 ft
PC-11	N 1,773,800	E 508,000	6390 ft
PO-1	N 1,774,800	E 505,400	6460 ft
PO-1A	N 1,775,100	E 505,600	6442 ft
PO-1B	N 1,775,400	E 505,700	6641 ft
PO-1C	N 1,775,600	E 505,800	6446 ft
PO-1D	N 1,775,800	E 505,500	6450 ft
PO-2	N 1,775,500	E 504,900	6478 ft
PO-2A	N 1,775,600	E 505,000	6452 ft
PO-2B	N 1,175,700	E 505,100	6456 ft
PO-3	N 1,775,600	E 502,200	6499 ft
PO-3A	N 1,775,800	E 502,200	6513 ft
PO-3B	N 1,776,000	E 502,200	6520 ft
PO-4	N 1,775,600	E 500,800	6524 ft
PO-4A	N 1,775,700	E 500,800	6524 ft
PO-4B	N 1,775,900	E 500,900	6542 ft
PO-5	N 1,776,200	E 504,400	6475 ft
PO-6	N 1,776,600	E 504,200	6520 ft

IV. LOS ALAMOS CANYON

The Los Alamos Canyon drainage area extends to the drainage divide that lies in the mountains west of the Laboratory at an elevation of 10 400 ft. The canyon has a drainage area of 10.6 sq mi at SR-4. The alluvium in the canyon is composed of sand, gravel, cobbles, and boulders derived from the Tschicoma Formation and the Bandelier Tuff (Fig. I-R).

Perennial surface water occurs in the upper reach of the canyon on the flanks of the mountains. A part of this surface flow is impounded at Los Alamos Reservoir. Surface flow across the plateau is intermittent.

DP Canyon is tributary to Los Alamos Canyon near the center of the plateau. Stream flow in the canyon is from the release of sanitary effluents from TA-21 and from storm runoff. Four surface water sampling stations were established in the canyon in 1967 (Fig. IV-A). Two of these surface water stations (DPS-1 and DPS-4) are still used as part of the monitoring net.

DP spring in the midreach of DP Canyon between DPS-2 and DPS-3 (N 1,774,300 E 495,500; 6930 ft) discharges 1 to 4 gpm from a contact at the base of old stream gravels under coalluvium and above Unit 1A of the Tshirege Member of the Bandelier Tuff. The spring was discovered by Braxton and Goff (ESS-1) in 1990. The flow from the spring was sampled seven times at DPS-3 between 1967 and 1970 (Purtymun 1975). Thermal and radiochemical qualities of the water indicate recharge from the stream in the canyon.

The alluvium in Los Alamos Canyon ranges from 10 to 20 ft in thickness. It contains a small body of perched water in the upper reach of the canyon. Recharge to the alluvial aquifer in the canyon is from storm runoff, past release of industrial effluents, and sanitary effluents (TA-21). The shallow ground water is perched in the alluvium on top of the tuff. The eastward extent of the saturation depends on the amount of surface water recharge. Water in the alluvium moves eastward toward the edge of the plateau.

During the period 1966 through 1970, 10 observation wells were constructed in the canyon to determine the thickness of the alluvium (Tables IV-A and IV-B) (John et al. 1967; Purtymun 1969, 1970). Geologic logs and casing schedules for 10 observation wells are shown in Figs. IV-B through IV-K. Wells LAO-C, -1, -2, -3, -4, -4.5, -5, and -6 are used as part of the monitoring network. Locations of surface water stations, gaging stations, and observation wells are shown in Table IV-C.

The holes were augered using a 4.5-in.-diam auger and all were cased with 3-in.-diam plastic pipe. The screen section of the pipe was perforated. Wells were not gravel packed. The surface of the hole was sealed with cement and a pad was constructed.

REFERENCES

E. C. John, E. Enyart, and W. D. Purtymun, "Records of Wells, Test Holes, Springs, and Surface Water Stations in the Los Alamos Area," U.S. Geological Survey Open-File Report (1967).

W. D. Purtymun, Los Alamos Scientific Laboratory, unpublished data (U.S.G.S. field notes), 1966.

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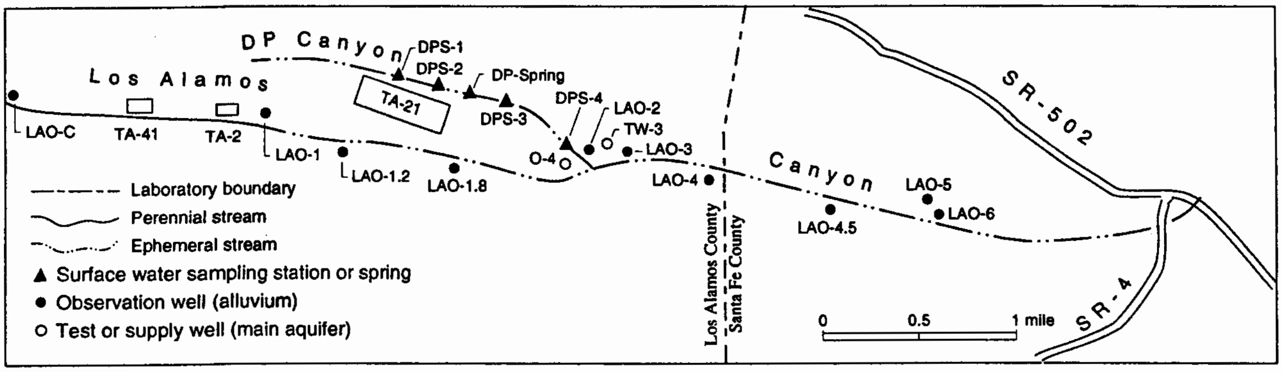

Fig. IV-A. Location of observation wells, test wells, and a supply well in Los Alamos Canyon (John et al. 1967; Purtymun 1975).

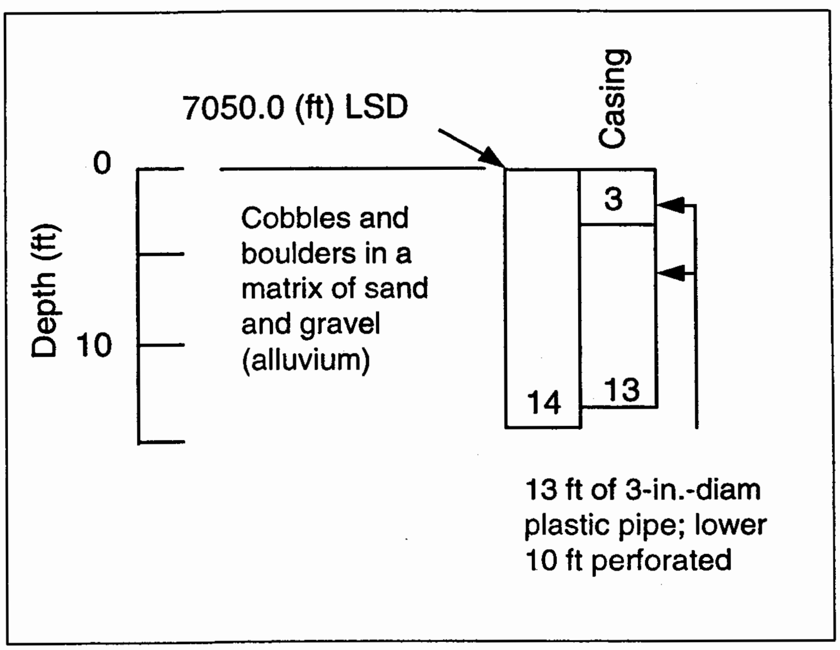

Fig. IV-B. Los Alamos Canyon observation well LAO-C, completed August 1970, water level 2.5 ft (Purtymun 1970).

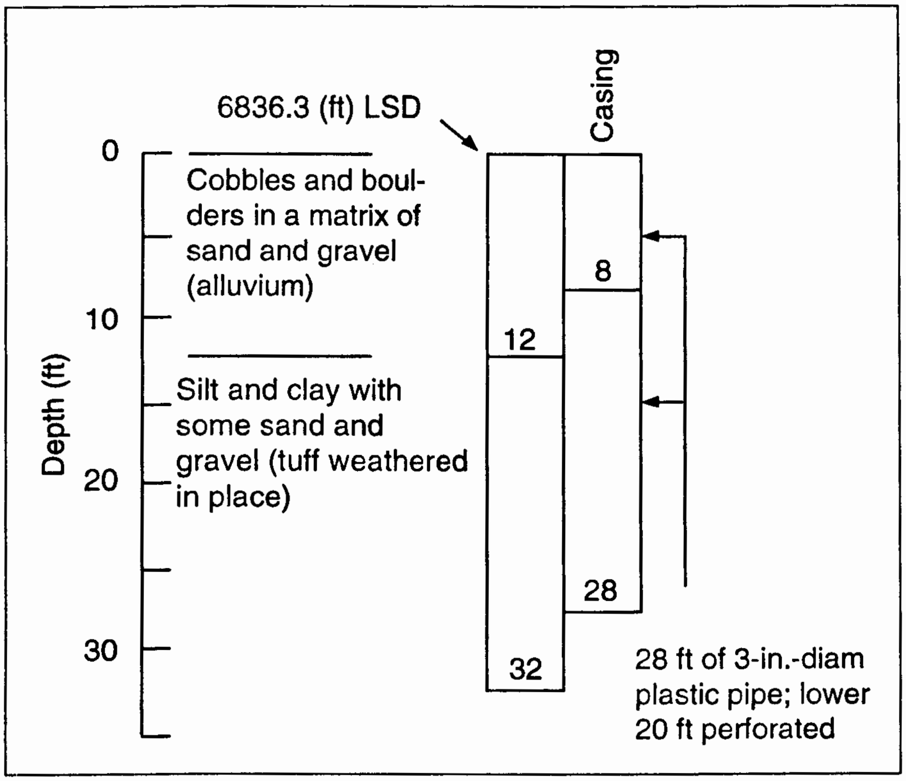

Fig. IV-C. Los Alamos Canyon observation well LAO-1, completed February 1966, water level 4.6 ft (John et al. 1967; Purtymun 1966).

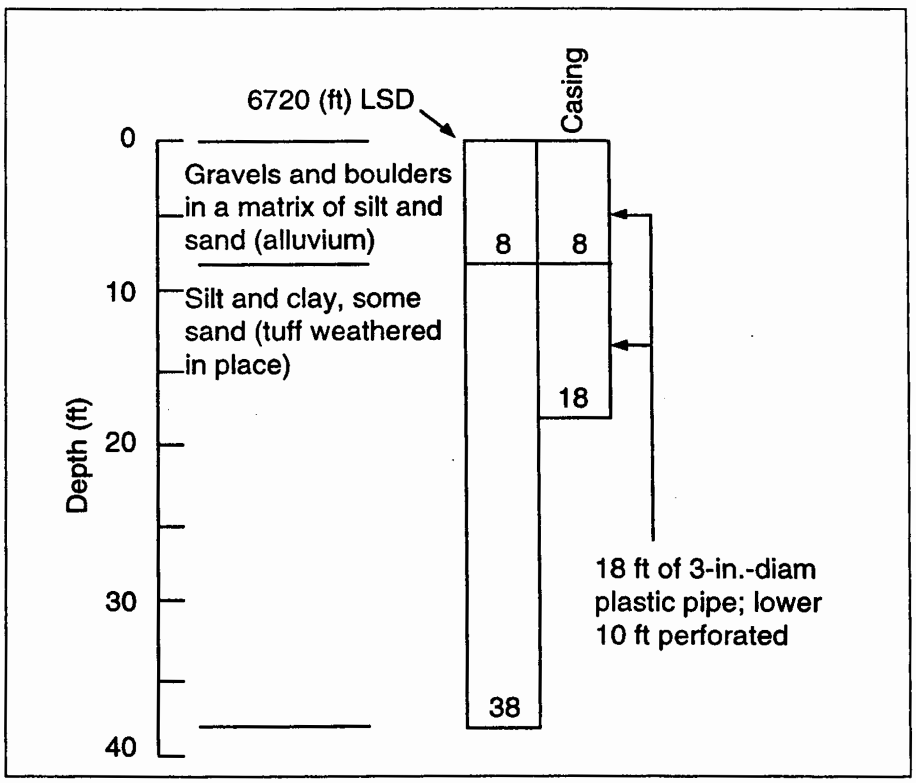

Fig. IV-D. Los Alamos Canyon observation well LAO-1.2, completed August 1969, water level 6.3 ft (Purtymun 1969).

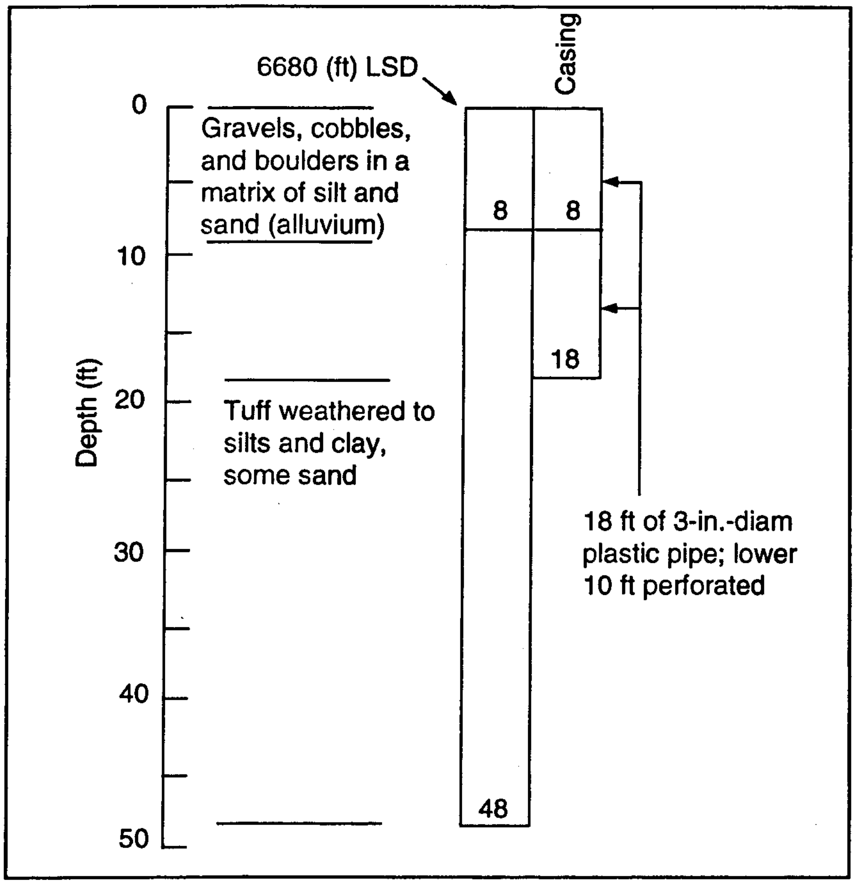

Fig. IV-E. Los Alamos Canyon observation well LAO-1.8, completed April 1969, water level 10.0 ft (Purtymun 1969).

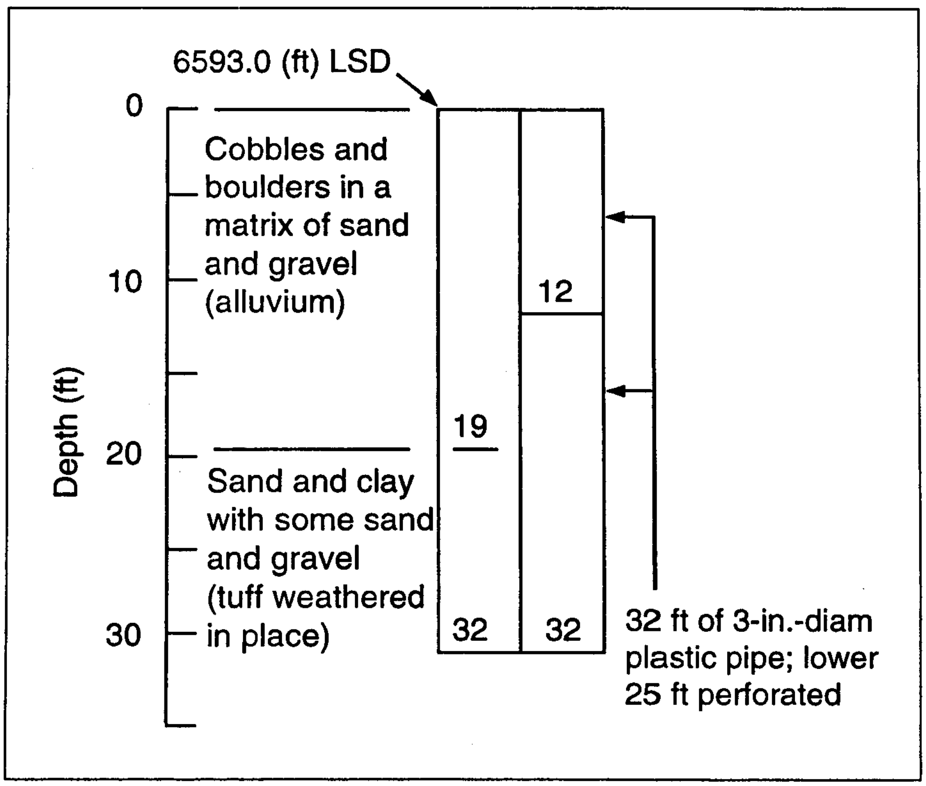

Fig. IV-F. Los Alamos Canyon observation well LAO-2, completed February 1966, water level 11.0 ft (John et al. 1967).

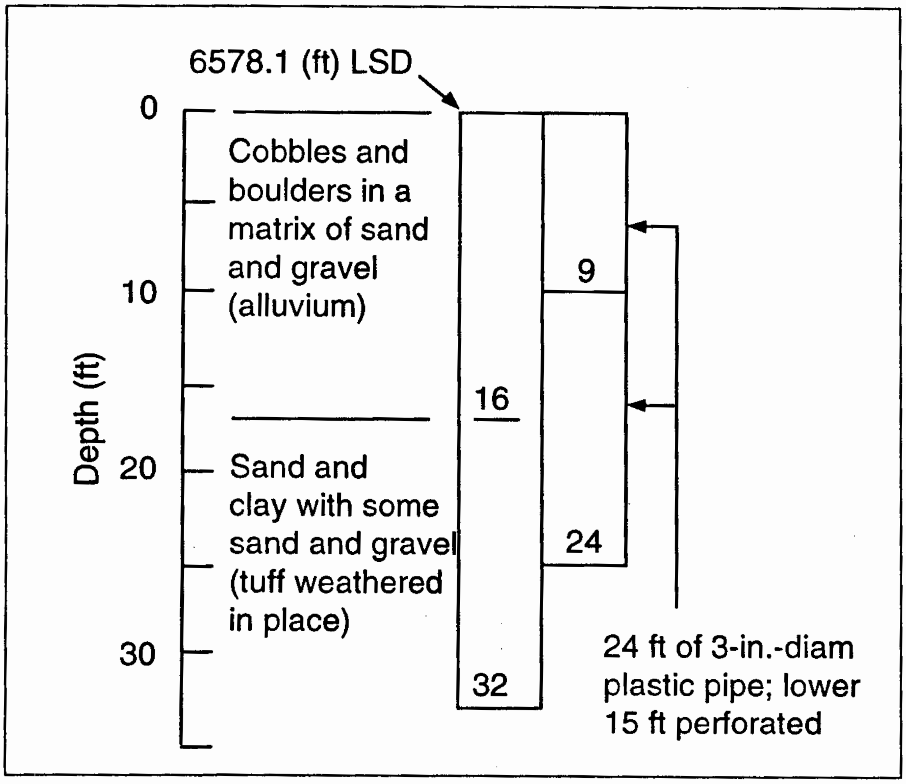

Fig. IV-G. Los Alamos Canyon observation well LAO-3, completed February 1966, water level 6.5 ft (John et al. 1967; Purtymun 1966).

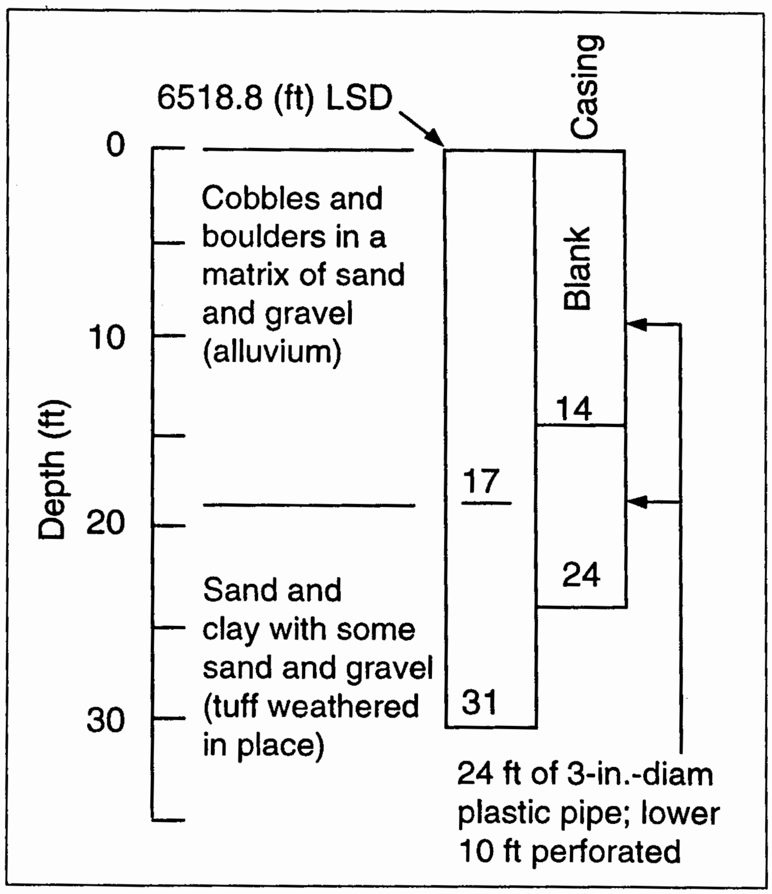

Fig. IV-H. Los Alamos Canyon observation well LAO-4, completed February 1966, water level 12.6 ft (John et al. 1967; Purtymun 1966).

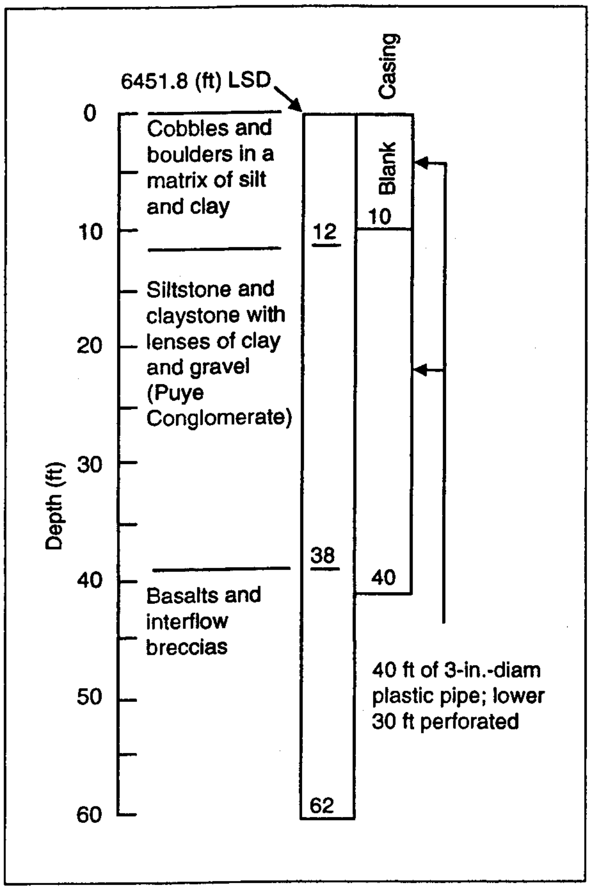

Fig. IV-I. Los Alamos Canyon observation well LAO-4.5, completed April 1969, water level 4.5 ft (Purtymun 1969).

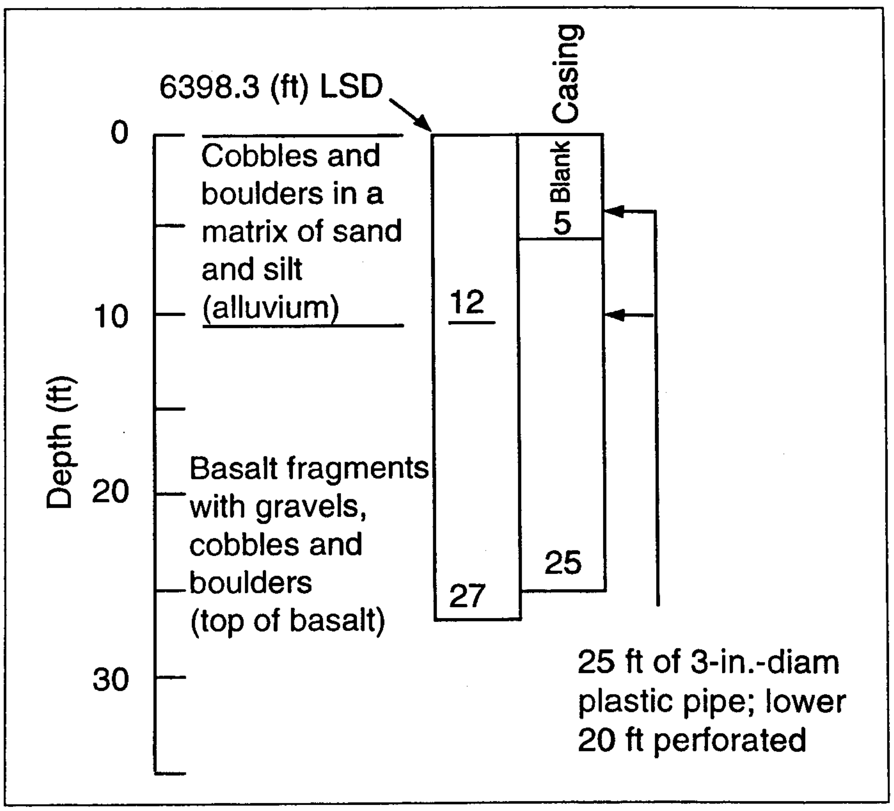

Fig. IV-J. Los Alamos Canyon observation well LAO-5, completed February 1966, dry (John et al. 1967; Purtymun 1966).

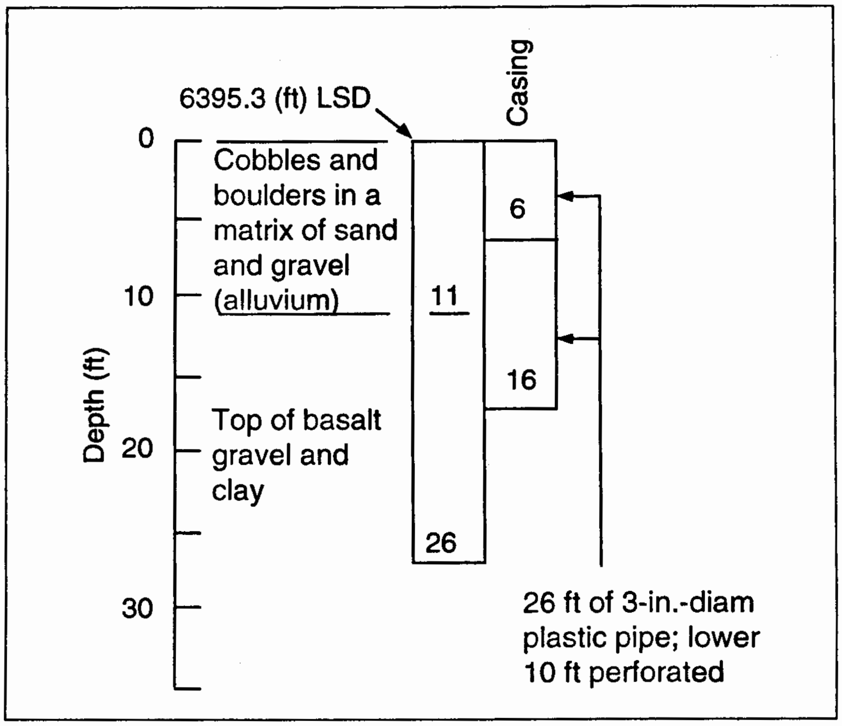

Fig. IV-K. Los Alamos Canyon observation well LAO-6, completed February 1966, dry (John et al. 1967; Purtymun 1966).

TABLE IV-A. Records of Observation Wells in Los Alamos Canyon

Observation Well	Date Drilled	Elevation LSD (ft)	Depth Drilled (ft)	Depth Completed (ft)	Water level at Completion (ft)	Remarks
LAO-C	9/70	7049.98	14	13	2.5	
LAO-1	2/66	6836.24	32	28	4.6	
LAO-1.2	4/69	6720	38	18	6.3	
LAO-1.8	4/69	6680	48	18	10.0	
LAO-2	2/66	6592.97	32	32	11.0	
LAO-3	2/66	6578.10	32	24	6.5	
LAO-4	2/66	6518.73	31	24	12.6	
LAO-4.5	4/69	6451.75	62	40	4.5	Obstruction in well (1990)
LAO-5	2/66	6398.33	27	25	dry	
LAO-6	2/66	6395.28	26	16	dry	

Sources: John et al. 1967; Purtymun 1966, 1969, and 1970.

TABLE IV-B. Geologic Logs and Construction Data of Observation Wells in Los Alamos Canyon (10 Obs. Wells)

1. Observation Well LAO-C

Elevation (LSD) 7049.98 ft

Water level (WL)—2.5 ft (September 1970)
WL—2.12 ft (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Cobbles and boulders in a matrix of sand and gravel	14	14

Construction
13 ft of 3-in.-diam plastic pipe, lower 10 ft perforated. Depth 12.2 ft (1991). Measuring point (MP) is top of casing (TC); distance to LSD is 0.03 ft.

2. Observation Well LAO-1

Elevation (LSD) 6836.24 ft

WL—4.6 ft (February 1966)
WL—7.4 ft (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Cobbles and boulders in a matrix of sand and gravel	12	12
Tuff (weathered in place)		
Silt and clay with some sand and gravel	20	32

Construction
28 ft of 3-in.-diam plastic pipe, lower 20 ft perforated. Depth 25.4 ft (1991). MP (TC) to LSD 0.25 ft.

3. Observation Well LAO-1.2

Elevation (LSD) 6720 ft

WL—6.3 ft (April 1969)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Gravel and boulders in a matrix of silt and sand	8	8
Tuff (weathered)		
Silt and clay, some sand	30	38

Construction
18 ft of 3-in.-diam plastic pipe, lower 10 ft perforated.

4. Observation Well LAO-1.8

Elevation (LSD) 6680 ft

WL—10.0 ft (April 1969)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Gravel, cobbles, and boulders in a matrix of silt and sand	18	18
Tuff (weathered)		
Silt and clay, some sand	30	48

Construction
18 ft of 3-in.-diam plastic pipe, lower 10 ft perforated.

TABLE IV-B. Geologic Logs and Construction Data of Observation Wells in Los Alamos Canyon (10 Obs. Wells) (Continued)

5. Observation Well LAO-2

Elevation (LSD) 6592.97 ft

WL—11.0 ft (February 1966)
WL—Dry (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Cobbles and boulders in a matrix of sand and gravel	19	19
Tuff (weathered in place)		
Silt and clay with some lenses of sand and gravel	13	32

Construction
32 ft of 3-in.-diam plastic pipe, lower 20 ft perforated. Depth 29 ft (1991). MP (TC) to LSD 0.07 ft.

6. Observation Well LAO-3

Elevation (LSD) 6578.10 ft

WL—6.5 ft (February 1966)
WL—13.22 ft (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Cobbles and boulders in a matrix of silt, sand, and gravel	16	16
Tuff (weathered in place)		
Silt and clay, some sand and gravel	16	32

Construction
24 ft of 3-in.-diam plastic pipe, lower 15 ft perforated. Depth 19.2 ft (1991). MP (TC) to LSD 0.50 ft.

7. Observation Well LAO-4

Elevation (LSD) 6518.73 ft

WL—12.6 ft (February 1966)
WL—13.02 ft (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Cobbles and boulders in a matrix of silt, sand, and gravel	17	17
Tuff (weathered in place)		
Silt and clay with some sand and gravel	14	31

Construction
24 ft of 3-in.-diam plastic pipe, lower 10 ft perforated. Depth 25 ft (1991). MP (TC) to LSD 0.49 ft.

8. Observation Well LAO-4.5

Elevation (LSD) 6451.75 ft

WL—4.5 ft (September 1969)
WL—Dry (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Cobbles and boulders in a matrix of sand, silt, and clay	12	12
Puye Conglomerate (fanglomerate member)		
Siltstones and claystone with some gravel and sand	26	38
Basalt (interflow breccias)		
Rock fragments of basalt with cobbles and boulders in sand and silt	24	62

Sources: John et al. 1967; Purtymun 1966, 1969, and 1970.

TABLE IV-B. Geologic Logs and Construction Data of Observation Wells in Los Alamos Canyon (10 Obs. Wells) (Continued)

8. Observation Well LAO-4.5 (Continued)

Construction
40 ft of 3-in.-diam plastic pipe, lower 30 ft perforated. Well plugged with cement fragments at a depth of 7.8 ft. MP (TC) to LSD 0.08 ft.

9. Observation Well LAO-5

Elevation (LSD) 6398.33 ft

WL—Dry (February 1966)
WL—17.38 ft (February 12, 1991)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Cobbles and boulders in a matrix of sand and silt	12	12
Basalt		
Basalt fragments with gravel, cobbles, and boulders	15	27

Construction
25 ft of 3-in.-diam plastic pipe, lower 20 ft perforated. Depth 23.7 ft (1991). MP (TC) to LSD 0.00 ft.

10. Observation Well LAO-6

Elevation (LSD) 6395.28 ft

WL—Dry (1966)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Cobbles and boulders in a matrix of silt, sand, and gravel	11	11
Basalt		
Basalt fragments with gravel, cobbles, and boulders	15	26

Construction
16 ft of 3-in.-diam plastic pipe, lower 10 ft perforated. Depth 14.6 ft (1991). MP (TC) to LSD 0.00 ft.

Sources: John et al. 1967; Purtymun 1966, 1969, and 1970.

TABLE IV-C. Locations and Elevations (NAD 1927)

A. Surface Water and Gaging Stations

DPS-1	N 1,774,796	E 493,081	7032 ft
DPS-2	N 1,774,700	E 494,200	7005 ft
DPS-3	N 1,774,400	E 494,500	6960 ft
DPS-4	N 1,773,228	E 497,258	6597 ft
DPGS-1	N 1,773,300	E 497,300	6680 ft
LAGS-1	N 1,770,827	E 507,907	6350 ft
LAGS-2	N 1,770,900	E 507,800	6390 ft

B. Observation Wells

LAO-C	N 1,775,187.6	E 481,913.6	7050.0 ft
LAO-1	N 1,773,894.3	E 489,150.7	6836.2 ft
LAO-1.2	N 1,173,300	E 492,400	6720 ft
LAO-1.8	N 1,172,600	E 495,200	6680 ft
LAO-2	N 1,773,033.8	E 497,363.4	6592.9 ft
LAO-3	N 1,773,036.3	E 497,766.3	6578.1 ft
LAO-4	N 1,772,667.4	E 500,507.7	6518.7 ft
LAO-4.5	N 1,772,025.6	E 503,414.8	6451.8 ft
LAO-5	N 1,771,362.6	E 505,958.8	6398.3 ft
LAO-6	N 1,771,267.4	E 505,977.9	6395.3 ft

Sources: John et al. 1967; Purtymun 1966, 1969, and 1970.

V. SANDIA CANYON

Sandia Canyon heads on the western edge of the Pajarito Plateau at an elevation of about 7515 ft and has a drainage area of about 2.7 sq mi west of SR-4. The alluvium in the canyon is made up of sands and gravels derived from the Bandelier Tuff (Fig. I-S).

The stream flow in the canyon is intermittent, from storm runoff, waste water from the power plant, and sanitary effluent from the treatment plant at TA-3.

Stream flow recharges a perched aquifer in the alluvium in the western part of the plateau; however, the amount of water is not sufficient to maintain saturation within the alluvium in the eastern half of the plateau.

Three surface water stations are used to monitor the quality of surface flow in the canyon (Fig. V-A). Two wells (SCO-1 and SCO-2) were drilled and cased in 1966 in the eastern part of the canyon. Both were dry. The wells were augered using a 4.5-in.-diam bit and were cased with 20 ft of 2-in.-diam plastic pipe with the lower 10 ft perforated. The wells were damaged; they have been plugged and abandoned and replaced by two new wells (SCO-1 and SCO-2) described in Section VIII. Locations of surface water stations and observation wells are shown in Table V-A.

REFERENCE

W. D. Purtymun, "Geohydrology of the Pajarito Plateau with Reference to Quality of Water, 1949–1972," Los Alamos Scientific Laboratory, Group H-8 document, 1975.

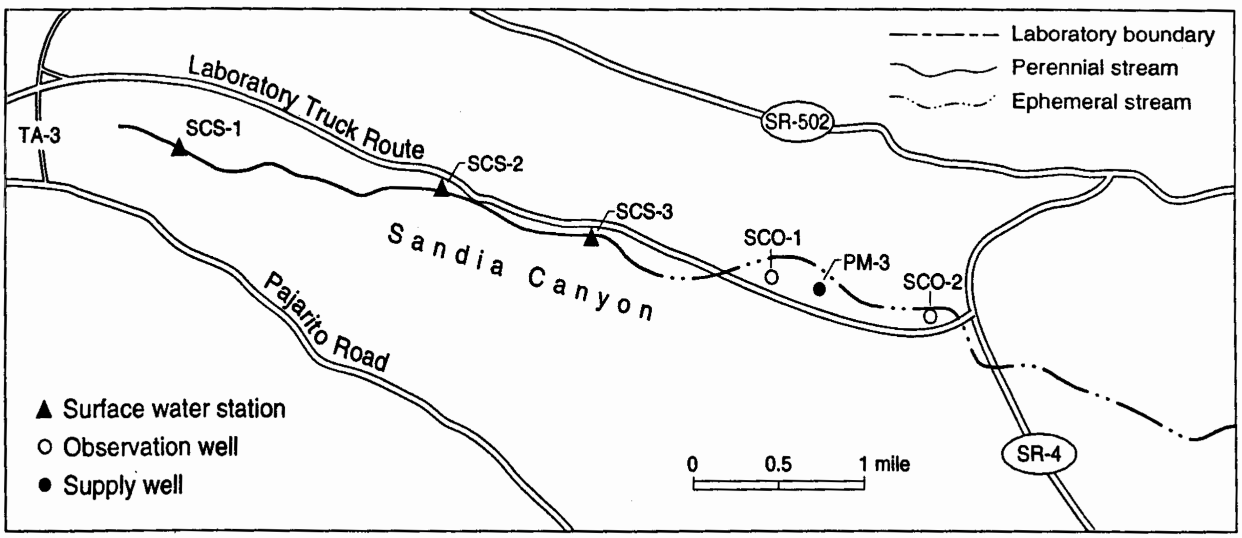

Fig. V-A. Location of sampling stations in Sandia Canyon (Purtymun 1975).

TABLE V-A. Locations and Elevations (NAD 1927)

A. Surface Water Stations			
SCS-1	N 1,773,872.1	E 490,978.1	7240.8 ft
SCS-2	N 1,771,081.3	E 492,581.2	6834.3 ft
SCS-3	N 1,770,207.0	E 495,654.8	6744.5 ft
B. Observation Wells			
SCO-1 (1966)	N 1,769,440.1	E 502,053.4	6618.7 ft
SCO-2 (1966)	N 1,767,801.8	E 507,014.9	6500.7 ft

Source: Purtymun 1975.

VI. MORTANDAD CANYON

Mortandad Canyon heads along the western edge of the plateau at an elevation of about 7500 ft and has a drainage area of 1.8 sq mi west of the boundary between the Laboratory and San Ildefonso Pueblo. The alluvium is derived from the weathering of the Bandelier Tuff, and consists of silt, sand, and gravel. Perennial surface flow occurs in the midreach of the canyon with the release of waste water from TA-46 and treated effluent from the treatment plant at TA-50. Mortandad Canyon is the major release area for treated radioactive effluents. The surface water, effluents, and storm runoff recharge an aquifer perched in the alluvium. The recharge is only sufficient to maintain an aquifer of limited extent. The surface flow and water in the alluvium is contained within the Laboratory due to the small drainage area and thick section of unsaturated alluvium (Fig. I-T).

A. Observation Wells

The geology and hydrology of the canyon was partly outlined through the construction of 21 MCO- and TSCO-series observation wells (Fig. VI-A). Some of these wells contained water, others were dry. The wells were constructed during the period 1960 through 1974 (Table VI-A). Seven of these wells are used for monitoring.

The earlier holes were augered using a 4.5-in.-diam bit. For casing, 2-in.-diam and 3-in.-diam plastic pipe was used. These wells were not gravel packed. The casing was placed in the hole, and the annulus between the casing and the hole wall was sealed with cuttings from the hole. Later wells (1974) were constructed using a 7.25-in. auger and set with 4-in. plastic pipe. These wells were gravel packed. The screen section of the plastic pipe was perforated with a 1/4-in. drill bit. At the surface the hole was sealed with cement and a security cap installed. Geologic logs and construction data are shown in Table VI-B. Geologic logs and casing schedules for 20 of these observation wells are shown in Figs. VI-B through VI-V.

B. Test Holes

To monitor the special conditions of the occurrence and movement of water in the alluvium and the underlying tuff, 14 special test holes (the MCM-, MCC-, and MT-series) were drilled to collect samples of the aquifer sediments and tuff underlying the aquifer, and to construct moisture-access holes (Fig. VI-W and Table VI-C). The investigations were to determine the movement of water into the unsaturated tuff below the aquifer (Table VI-C). The special holes were needed to determine the geology and hydrology of the canyon with reference to the distribution and movement of the wastes released into the canyon from the treatment plant at TA-50.

Special construction was necessary to complete the holes. Geologic logs and casing schedules for 13 of these test holes are shown in Figs. VI-X through VI-AJ. The holes were all augered. Deep, double-cased holes (to be used as moisture-access holes) were augered through casing set through the alluvium or through a larger hollow-stem auger set through the alluvium. The casings were sealed at the surface with cement and a pad constructed.

Two deep test holes were cored on sacred land of the San Ildefonso Pueblo in Mortandad Canyon east of the Laboratory boundary. They were cored in cooperation with San Ildefonso Pueblo and the Bureau of Indian Affairs.

Test hole SIMO, cored in September 1990 (Fig. VI-AK and Table VI-D Log 14), was completed at a depth of 104 ft. The hole was dry.

Test hole SIMO-1 was cored about 50 ft north of SIMO (see log of SIMO-1, Table VI-D Log 18). The hole was dry. Lithology was about the same as that of SIMO; both holes contain screen sections at various depths.

Test holes MCM-10-1, MCM-10-2, MCM-10-3A, and MCM-10-3B were drilled in lower Mortandad Canyon in 1991 (Fig. VI-AM and Table VI-D). The holes were drilled in areas that a seismic survey indicated should contain shallow perched water (Reynolds et al. 1990, 1991). The holes were dry.

Formation names are used to describe the material penetrated by the holes. At the base of the Tshirege Member in Mortandad Canyon is a water-laid or surge unit of coarse, crudely bedded ash and pumice lapilli, and pebbly gravels of latite and rhyolite in a matrix of sandy ash. This unit has been designated the Tsankawi Pumice Bed. It is an important unit in observation wells in Sandia and Mortandad Canyons because it underlies the alluvium in Sandia and the perched aquifer in the alluvium of the Mortandad Canyon. The following description of the alluvium, the Bandelier Tuff Unit 1A, the Tsankawi Pumice Bed, and the underlying Otowi Member was taken from a hole cored through the alluvium and into the three units mentioned above in Mortandad Canyon (MCM-5.9A, Fig. VI-AC).

1. Alluvium. The alluvium consists of silty sand, composed of crystals and crystal fragments of quartz and sanidine. Small rock fragments of pumice, tuff and rhyolite are also present in a matrix of sand and clay.

2. Tshirege Member of the Bandelier Tuff. This member consists of Unit 1A tuff, nonwelded to moderately welded, light gray, of quartz and sanidine crystals and crystal fragments, rock fragments of pumice, latite, and rhyolite in a matrix of gray ash. The weathered tuff is gray, buff, light to dark brown in color, and contains pumice and ash weathered to clay. The unit is about 60 ft thick.

3. Tsankawi Pumice Bed. This layer consists of thin lenses of silt and sand, gravels of pumice, quartz and sanidine crystal, rock fragments of latite and rhyolite ranging in color from gray to dark brown, and ash and some pumice weathered to clay. This layer represents a pumice fall, erosion, and the deposition of rock fragments of rhyolite, probably Cerro Toledo Rhyolite, on top of a massive ash flow (the Otowi Member). Thickness of the Tsankawi is about 20 ft.

4. Otowi Member. The Otowi Member consists of tuff, nonwelded to moderately welded, gray to dark brown when weathered, made up of quartz and sanidine crystals and crystal fragments, numerous pumice fragments up to 2 in. long, and rock fragments of latite and rhyolite in an ash matrix. The ash matrix and some of the pumice is weathered to silt and clay. The thickness of the member in the test hole exceeds 76 ft.

C. Moisture-Access Holes

In 1960 and 1961 we constructed 25 moisture-access holes in Mortandad Canyon, adding 2 more in 1971 and 1 in 1989 (Fig. VI-AM). The holes were completed in the alluvium or tuff (Table VI-E). Some of the holes were drilled across the canyon from an observation well, so as to transect the canyon, and some were completed as single moisture-access holes. The access holes were to be logged with the neutron moisture/density gauge to measure the distribution of moisture in the alluvium and tuff.

The moisture-access holes were drilled using a 4.5-in.-diam auger and were cased with 2-in.-diam plastic pipe with a plug in the bottom. This plug kept water out when the alluvial aquifer was penetrated. The annulus between the plastic pipe and the hole wall was packed with cuttings from the hole.

Test holes and moisture-access holes in the lower reach of the canyon were used to construct two views of the alluvium and underlying tuff. Figure VI-AN follows the axis of the canyon and shows the aquifer thinning eastward, while Fig. VI-AO shows a cross section of the canyon.

Locations of surface water stations, observation wells, test holes, and moisture-access holes are shown in Table VI-F.

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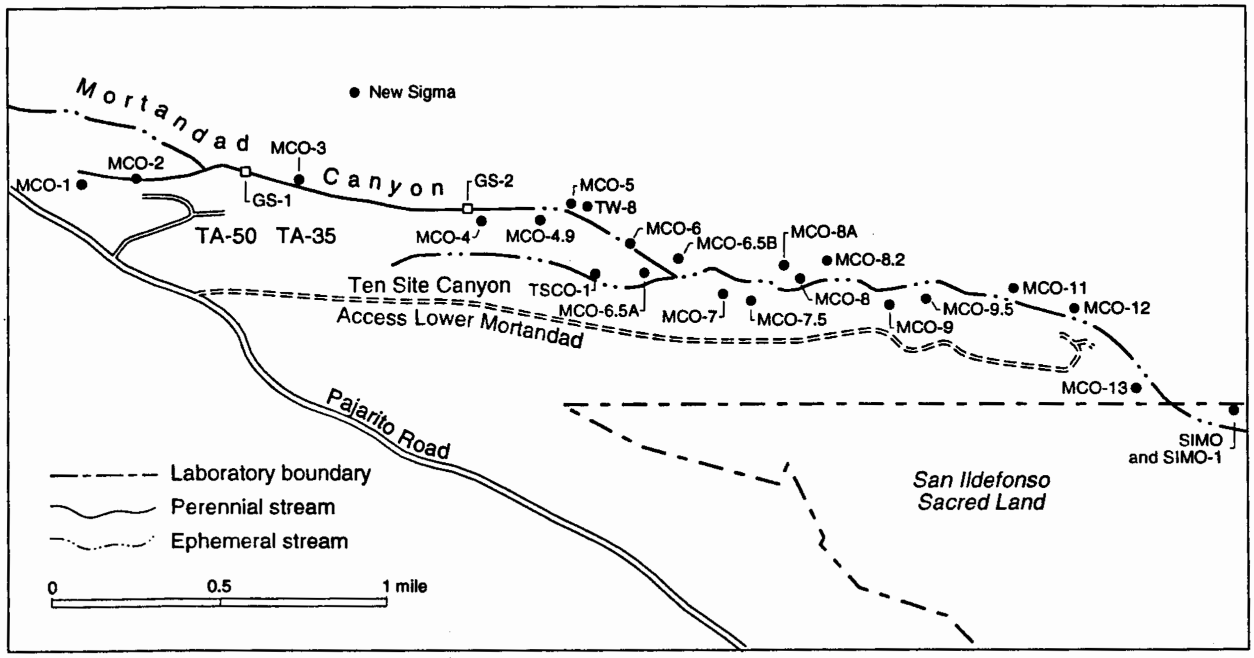

Fig. VI-A. Location of observation wells in Mortandad Canyon.

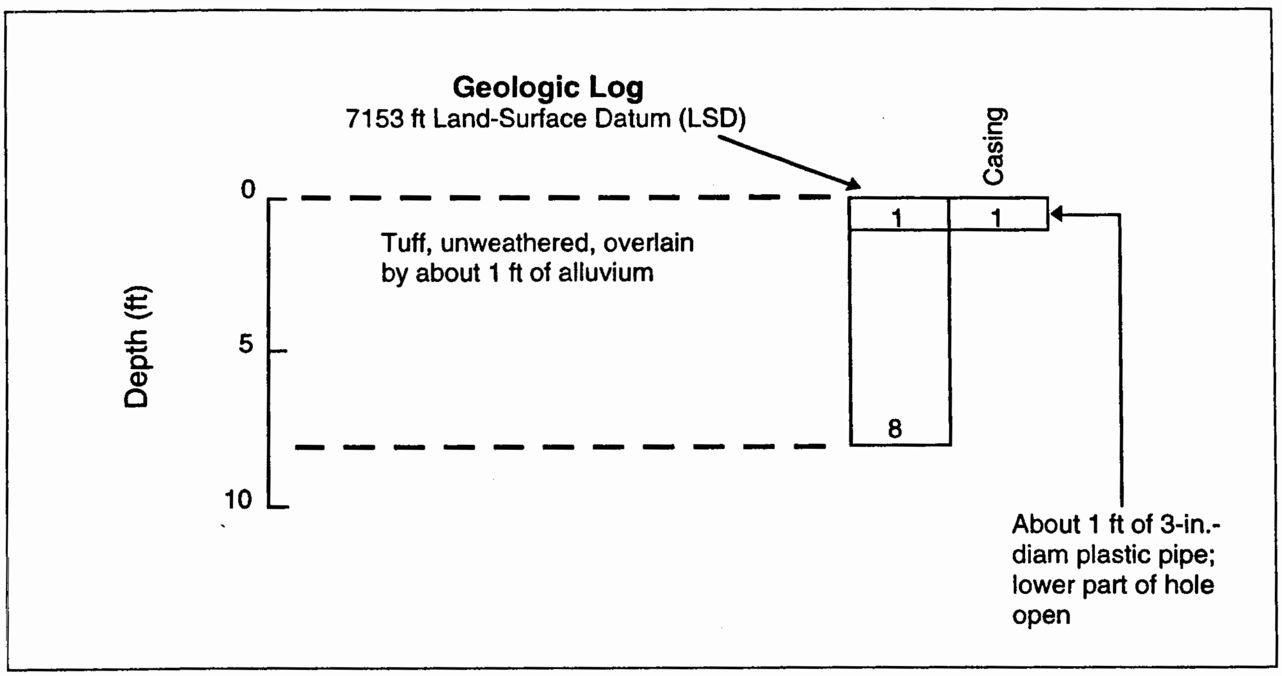

Fig. VI-B. Mortandad Canyon observation well MCO-1, completed November 1960, water level 2.8 ft; unable to locate in 1991 (Baltz et al. 1963).

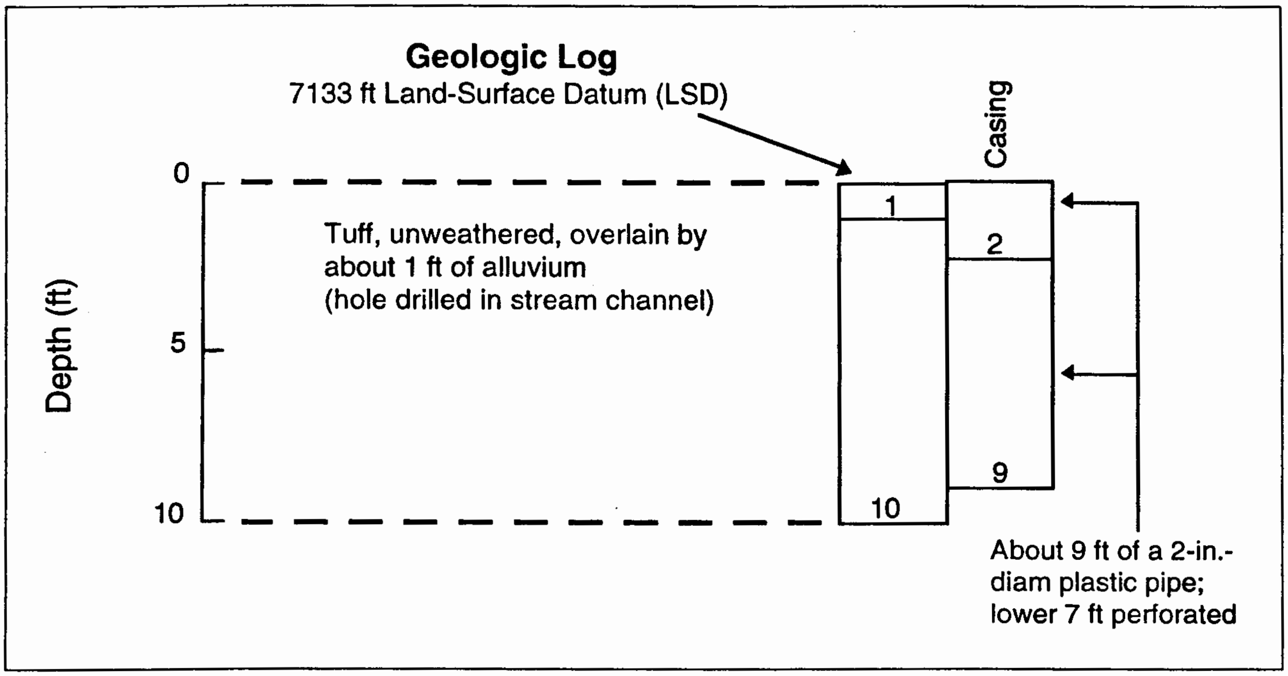

Fig. VI-C. Mortandad Canyon observation well MCO-2, completed November 1960, water level 0.3 ft (Baltz et al. 1963).

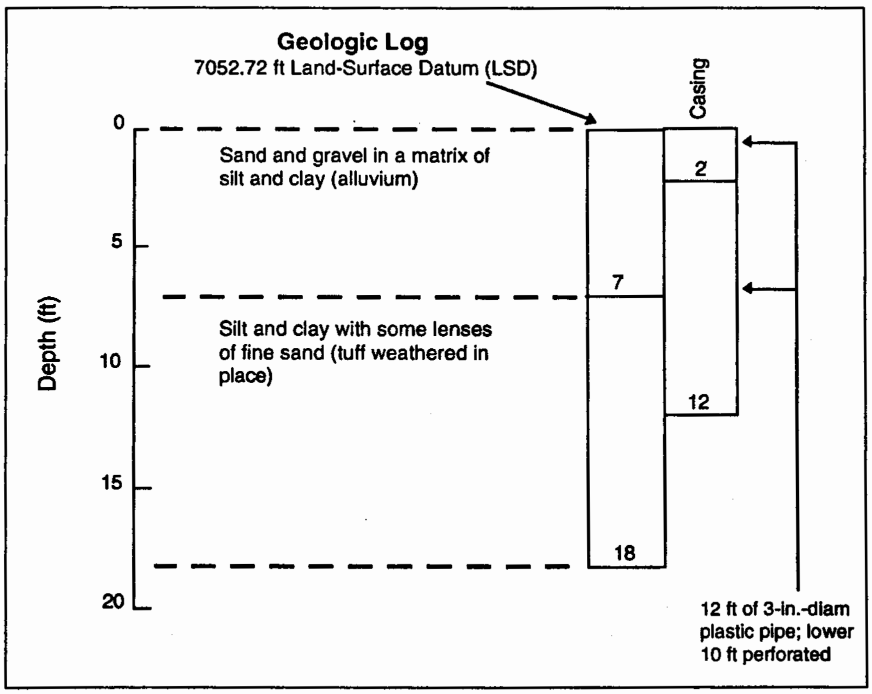

Fig. VI-D. Mortandad Canyon observation well MCO-3, redrilled March 1967 and completed with 3-in.-diam casing, water level 4.4 ft (Baltz et al. 1963; Purtymun 1964).

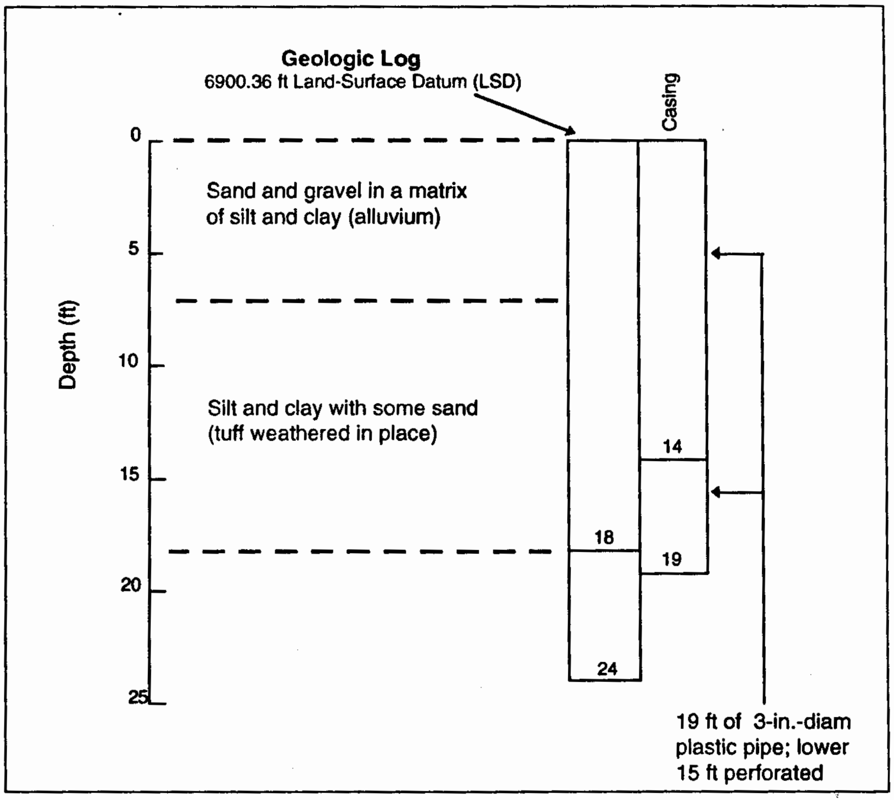

Fig. VI-E. Mortandad Canyon observation well MCO-4, redrilled October 1963, water level 3.3 ft (Baltz et al. 1963; Purtymun 1963).

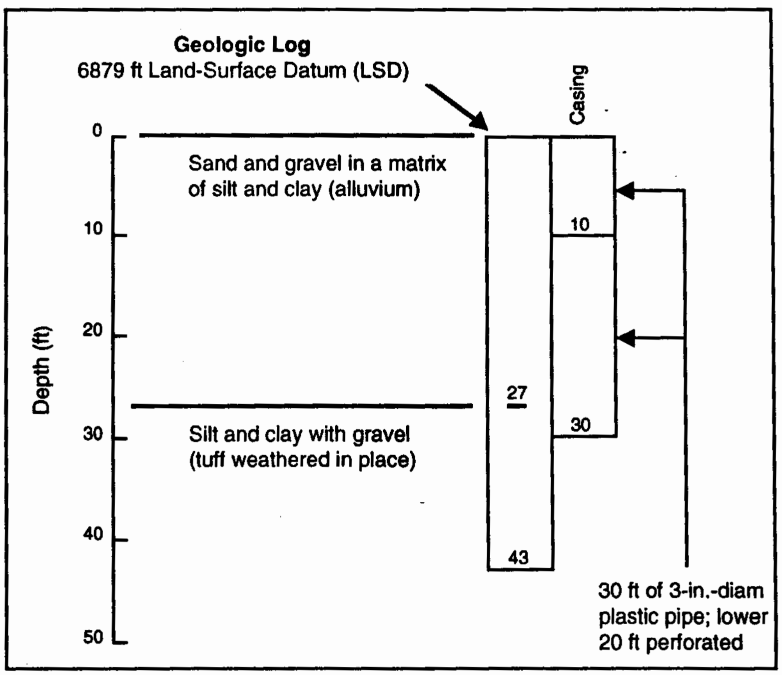

Fig. VI-F. Mortandad Canyon observation well MCO-4.9, completed July 1973, water level 23.7 ft (Purtymun 1973).

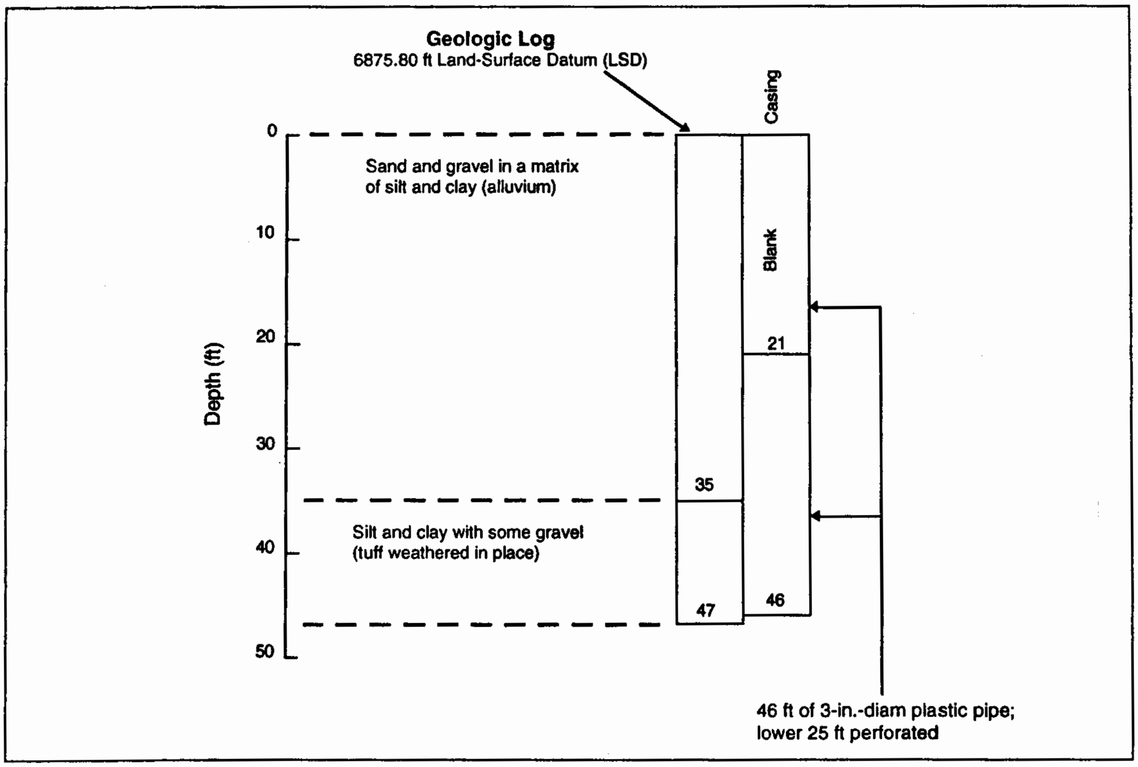

Fig. VI-G. Mortandad Canyon observation well MCO-5, completed October 1960, water level 24.6 ft (Baltz et al. 1963).

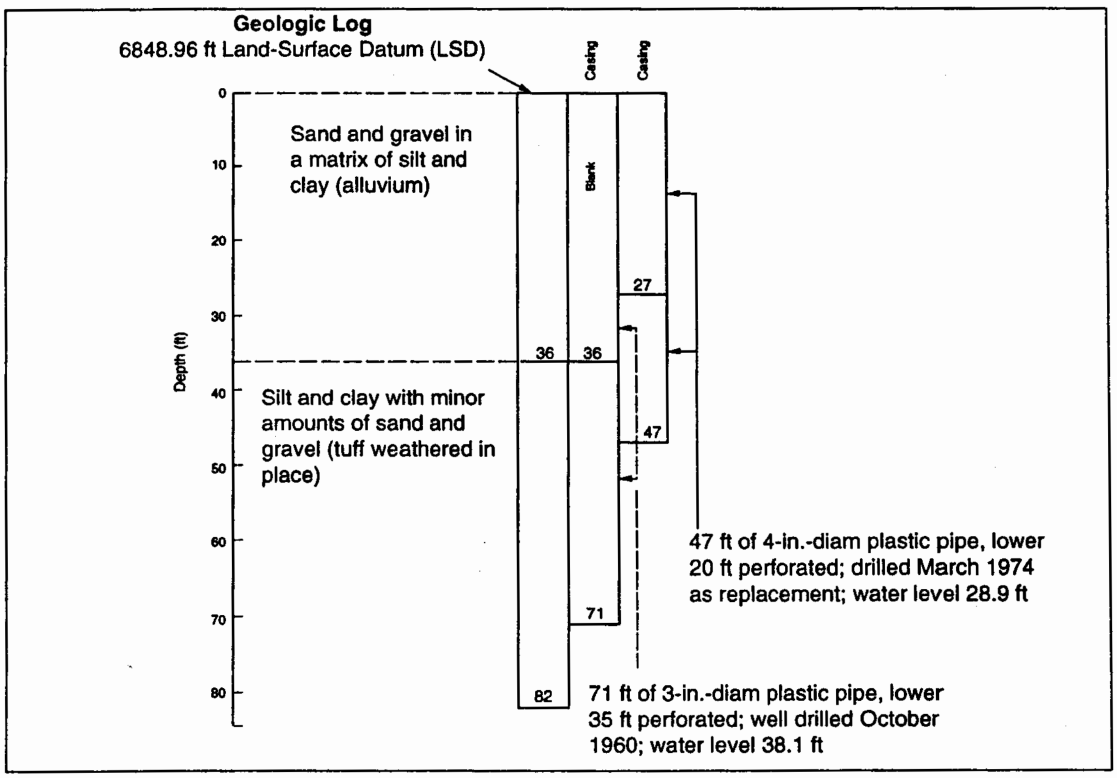

Fig. VI-H. Mortandad Canyon observation well MCO-6, completed October 1960, replaced March 1974 (Baltz et al. 1963, Purtymun 1974).

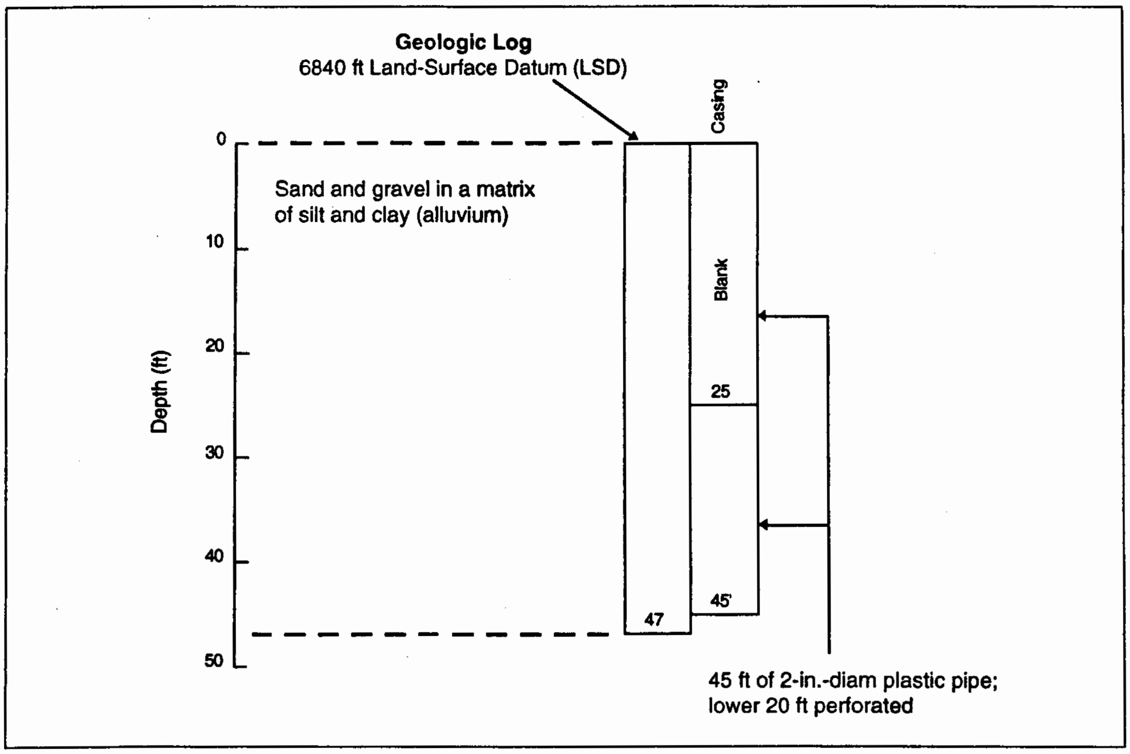

Fig. VI-I. Mortandad Canyon observation well MCO-6.5A, completed November 1961, water level 41.0 ft (Purtymun 1964).

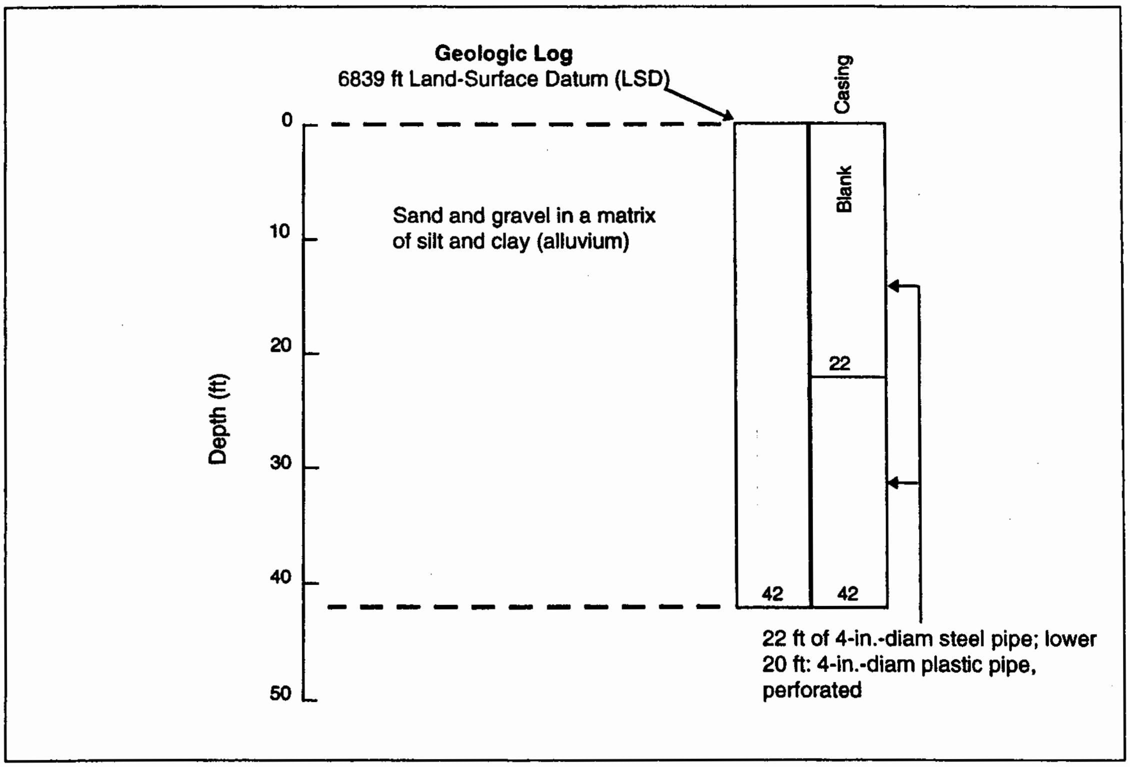

Fig. VI-J. Mortandad Canyon observation well MCO-6.5B, completed November 1961, water level 36.3 ft (Purtymun 1964).

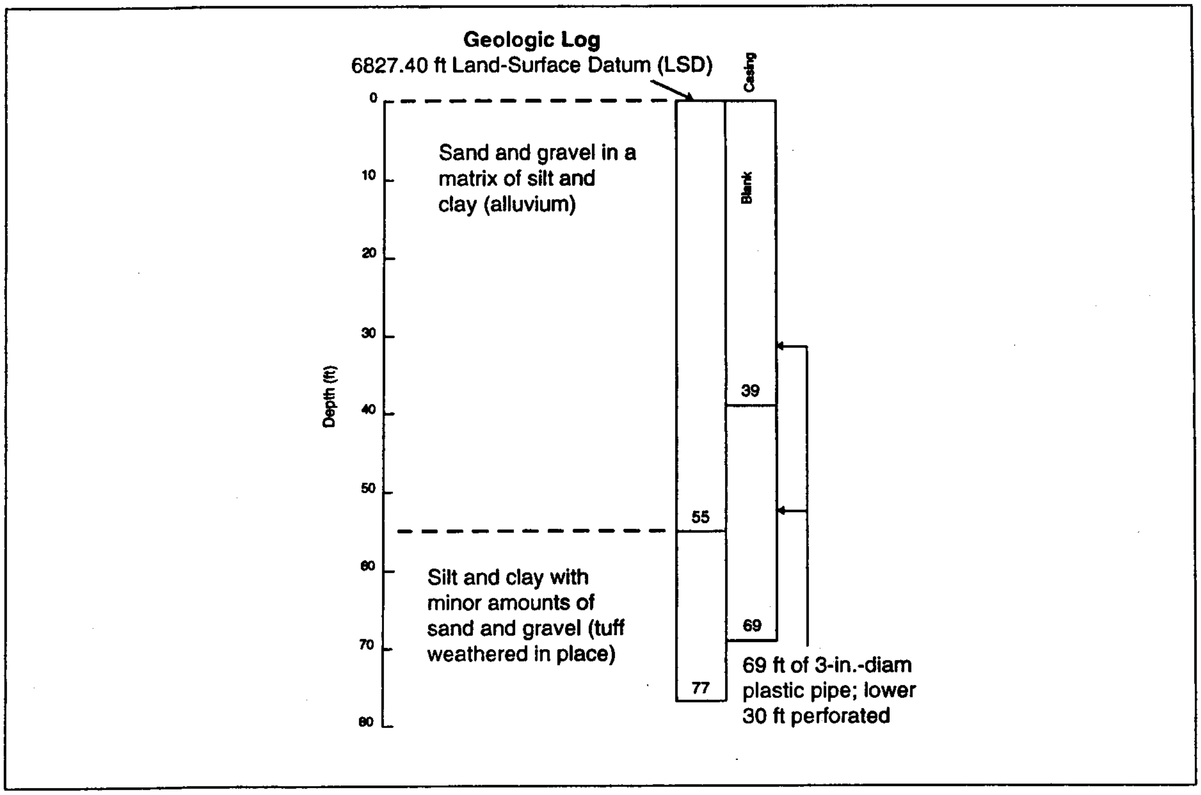

Fig. VI-K. Mortandad Canyon observation well MCO-7, completed October 1960, water level 39.7 ft (Baltz et al. 1963).

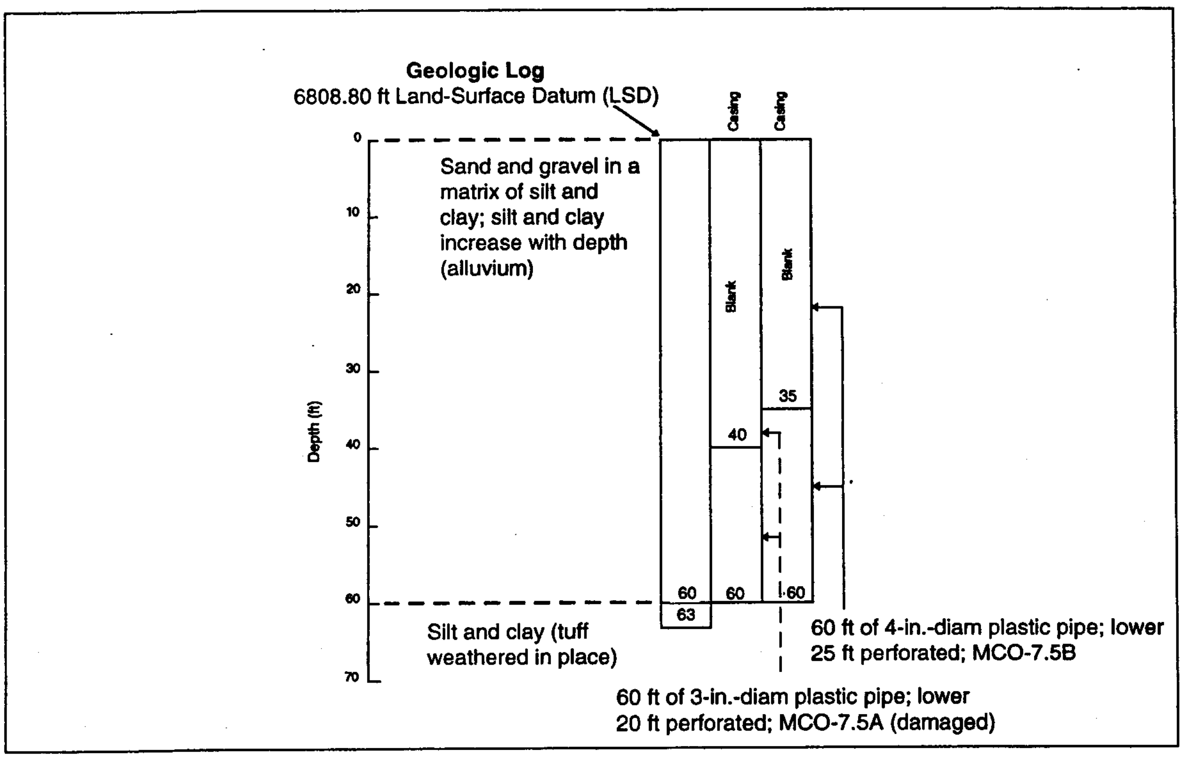

Fig. VI-L. Mortandad Canyon observation well MCO-7.5A (damaged), completed November 1961, water level 41.2 ft; and adjacent well MCO-7.5B, completed April 1974, water level 42.1 ft (Purtymun 1964, 1974).

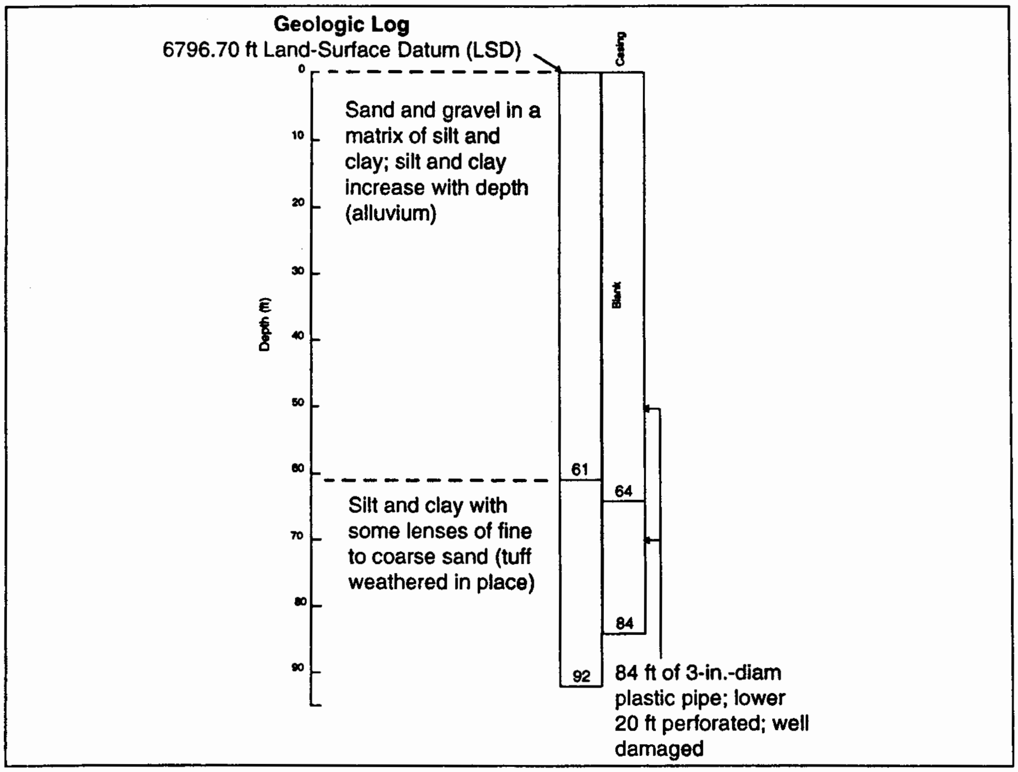

Fig. VI-M. Mortandad Canyon observation well MCO-8, completed October 1960, water level 61.6 ft; damaged beyond repair November 1976 (Baltz et al. 1963).

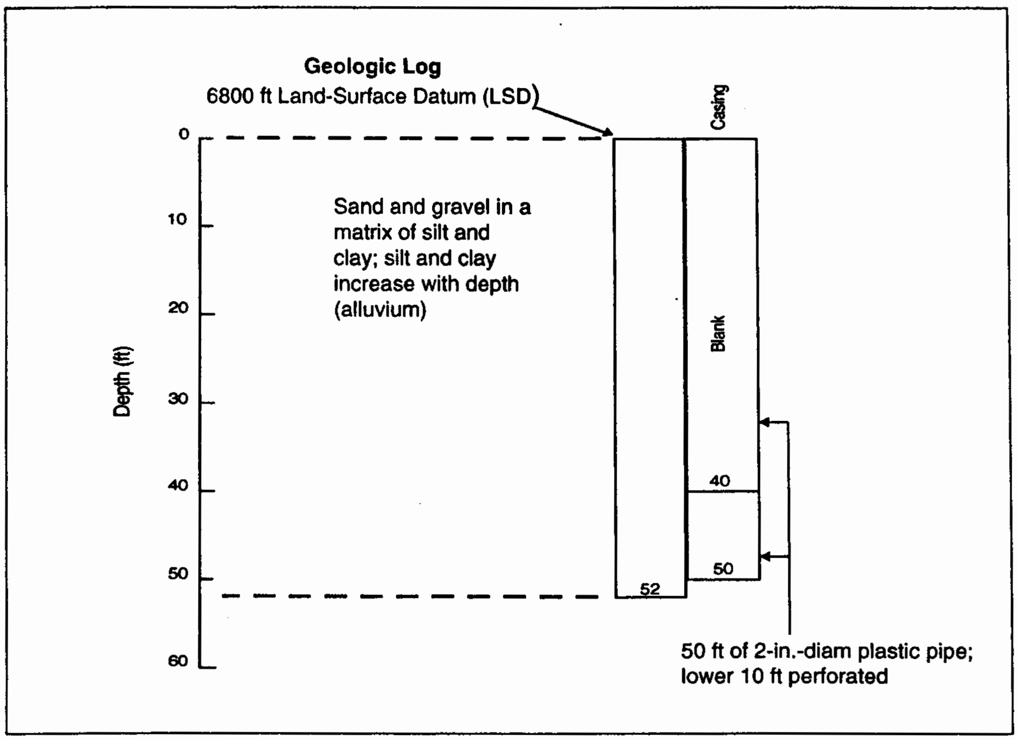

Fig. VI-N. Mortandad Canyon observation well MCO-8A, completed November 1961, dry (Purtymun 1964).

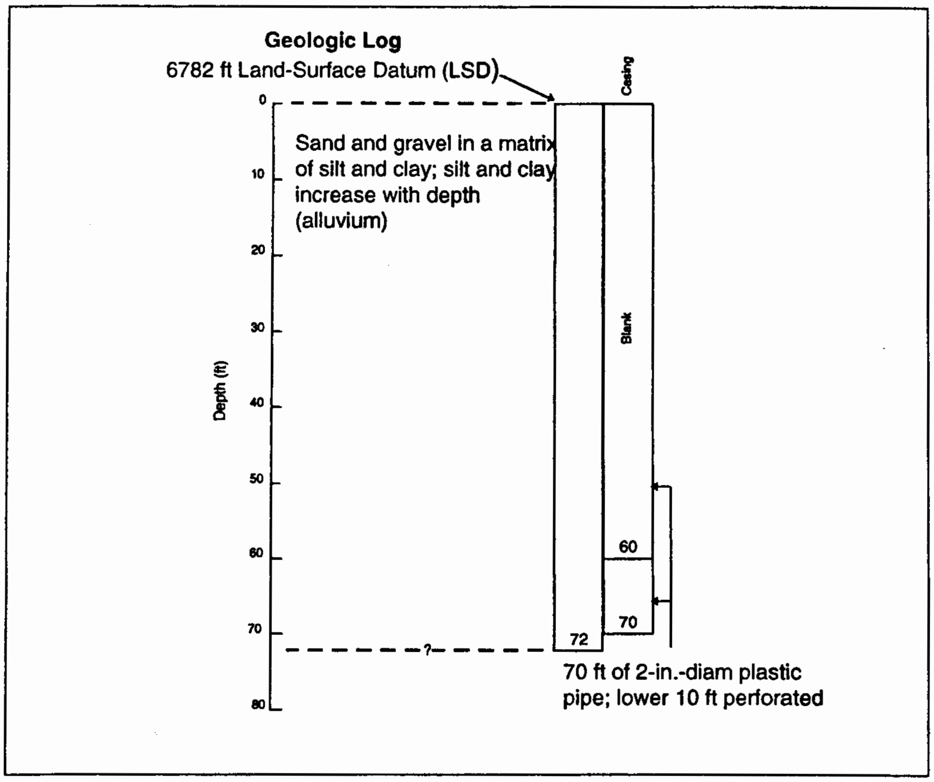

Fig. VI-O. Mortandad Canyon observation well MCO-8.2, completed November 1961, water level 59.2 ft (Purtymun 1964).

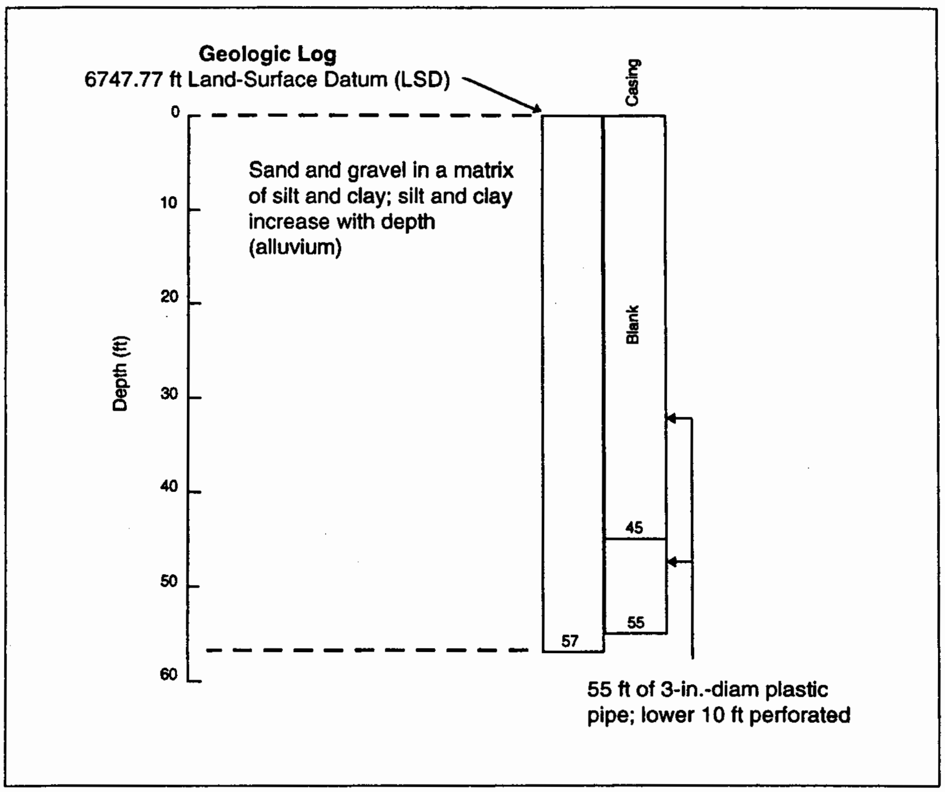

Fig. VI-P. Mortandad Canyon observation well MCO-9, completed November 1961, dry (Purtymun 1964).

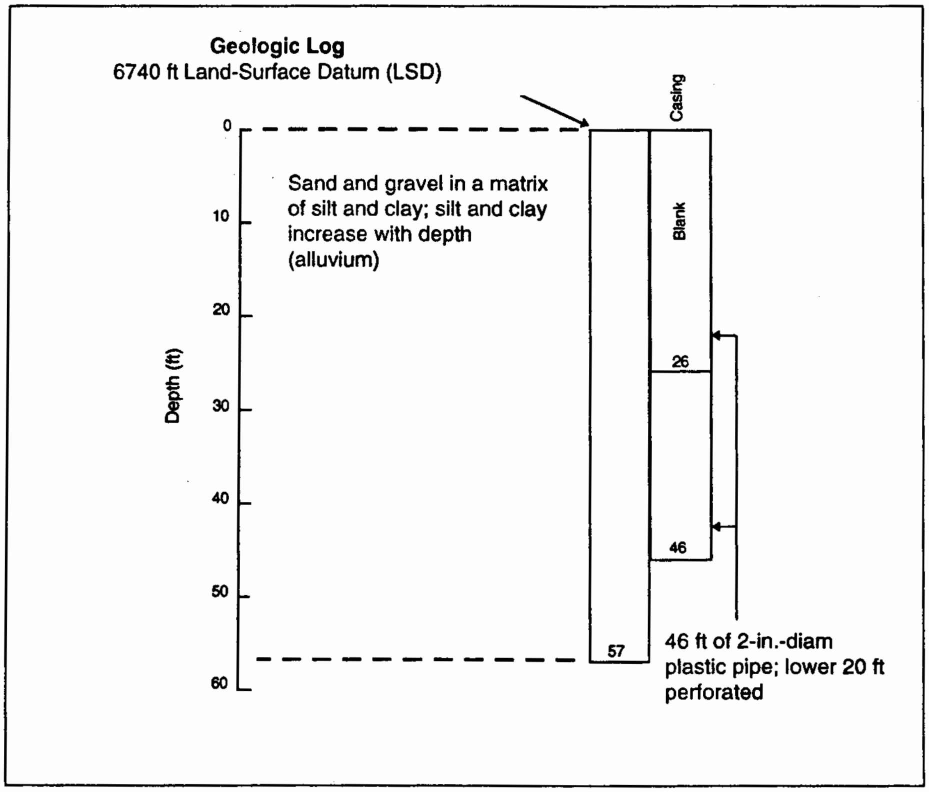

Fig. VI-Q. Mortandad Canyon observation well MCO-9.5, completed November 1961, dry (Purtymun 1964).

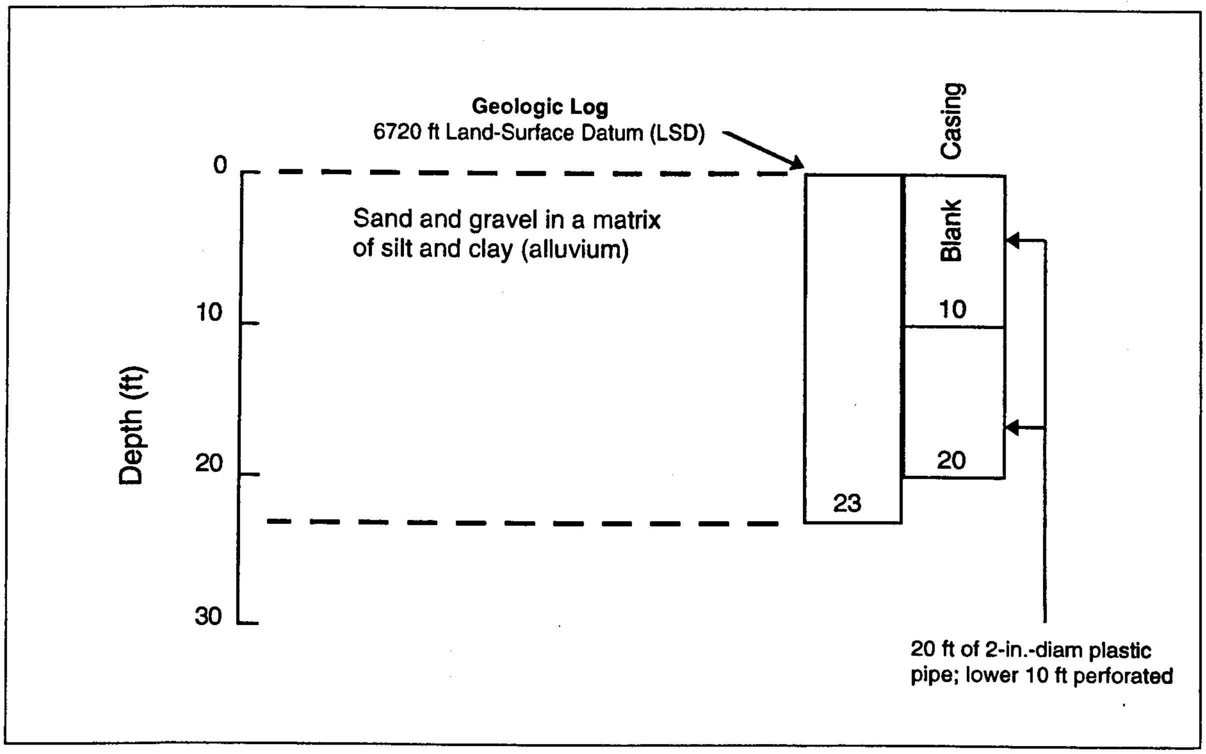

Fig. VI-R. Mortandad Canyon observation well MCO-11, completed November 1961, dry; unable to locate, February 1991 (Purtymun 1964).

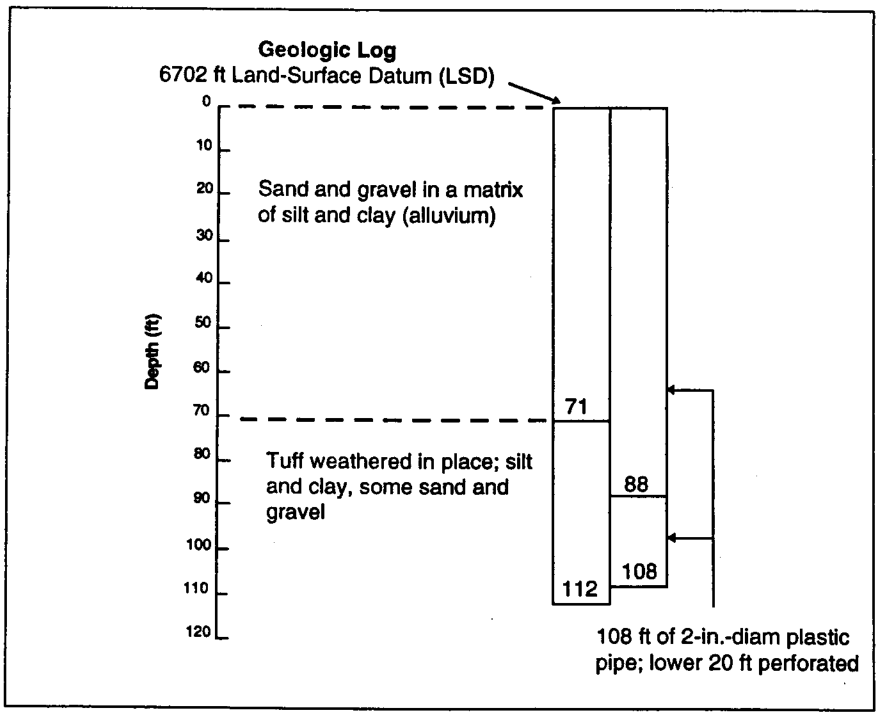

Fig. VI-S. Mortandad Canyon observation well MCO-12, completed June 1971, dry; replaced previous well MCO-12 (see Fig. VI-T.), which was plugged and abandoned about 12 ft to the south (Purtymun 1971b).

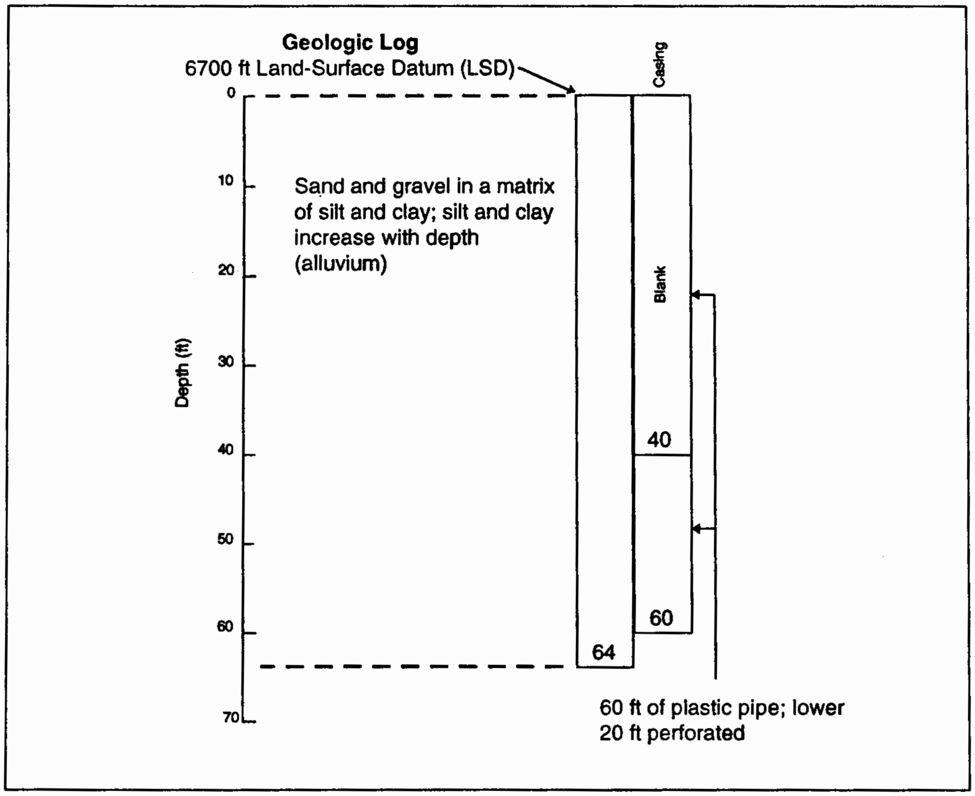

Fig. VI-T. Mortandad Canyon observation well, MCO-12, completed November 1961, dry; June 1971, well was dry, casing was pulled, well was abandoned, plugged, and relocated to the north about 12 ft (Purtymun 1964).

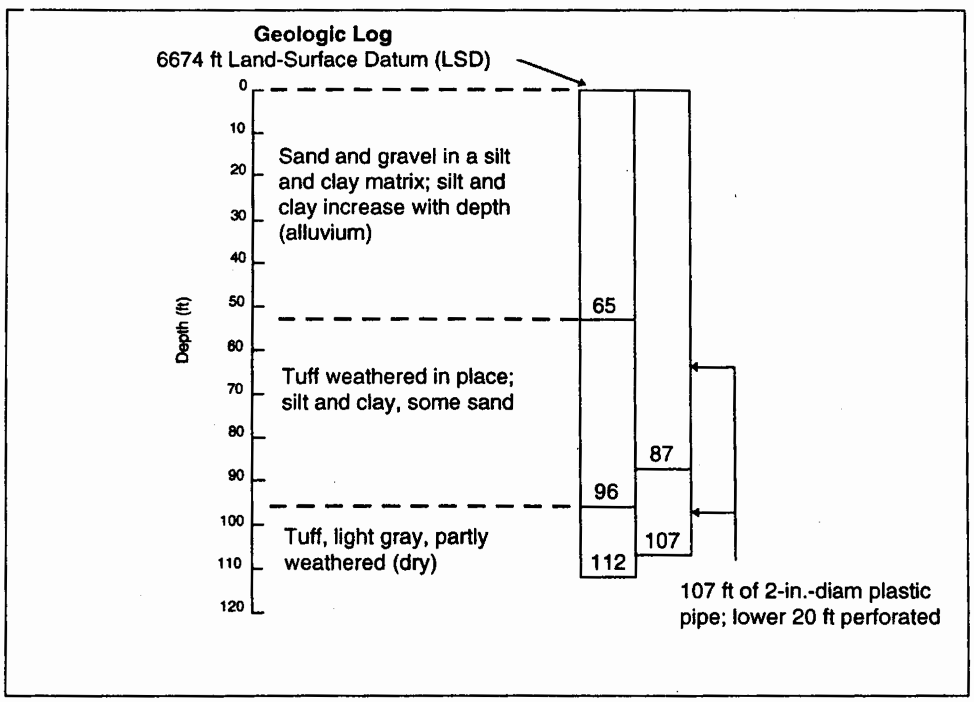

Fig. VI-U. Mortandad Canyon observation well MCO-13, completed July 1970, dry (Purtymun 1970).

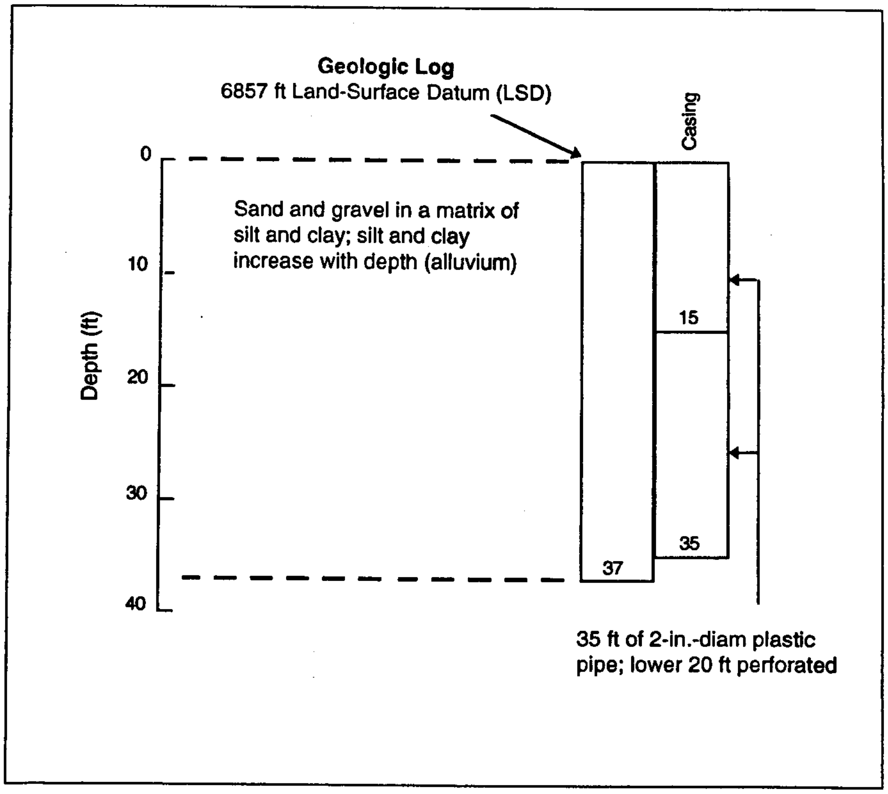

Fig. VI-V. Ten Site Canyon observation well TSCO-1, completed November 1961, dry (Purtymun 1964).

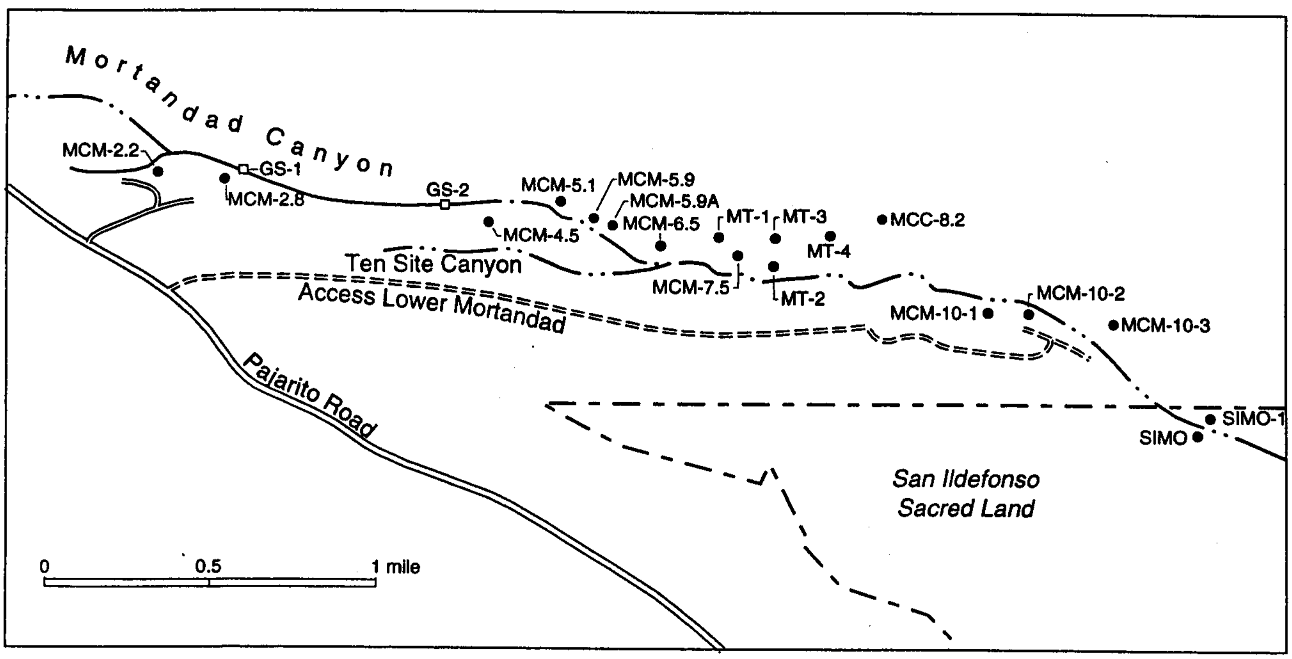

Fig. VI-W. Location of test holes and special moisture-access holes in Mortandad Canyon.

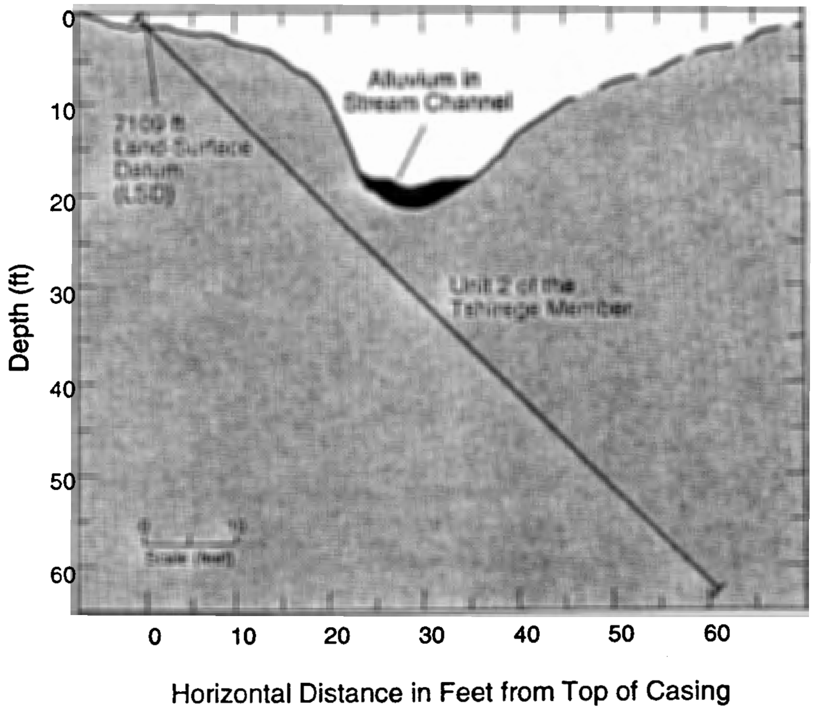

Fig. VI-X. Cross section across stream channel showing Mortandad test hole MCM-2.2 (Purtymun 1964). See Fig. VI-W and Table VI-D.

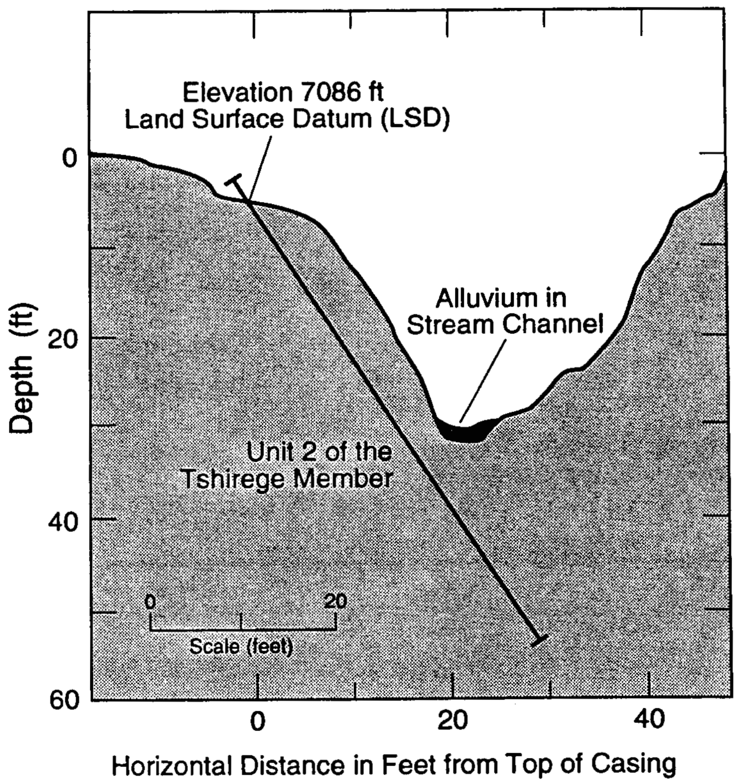

Fig. VI-Y. Cross section across stream channel showing Mortandad test hole MCM-2.8 (Purtymun 1964). See Fig. VI-W and Table VI-D.

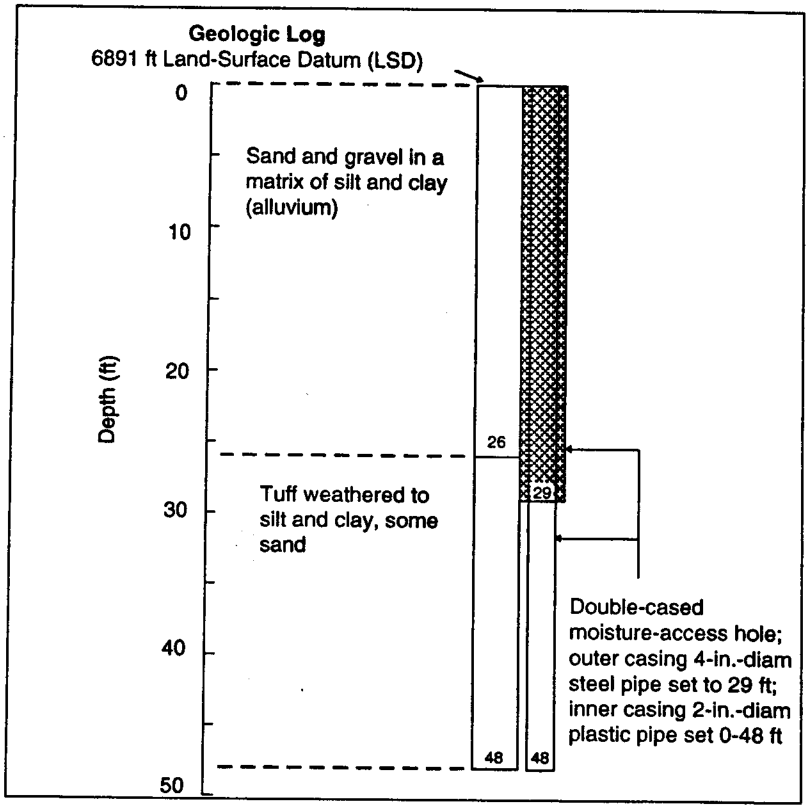

Fig. VI-Z. Mortandad test hole MCM-4.5, completed 1961, water in alluvium cased out of hole (Purtymun 1964).

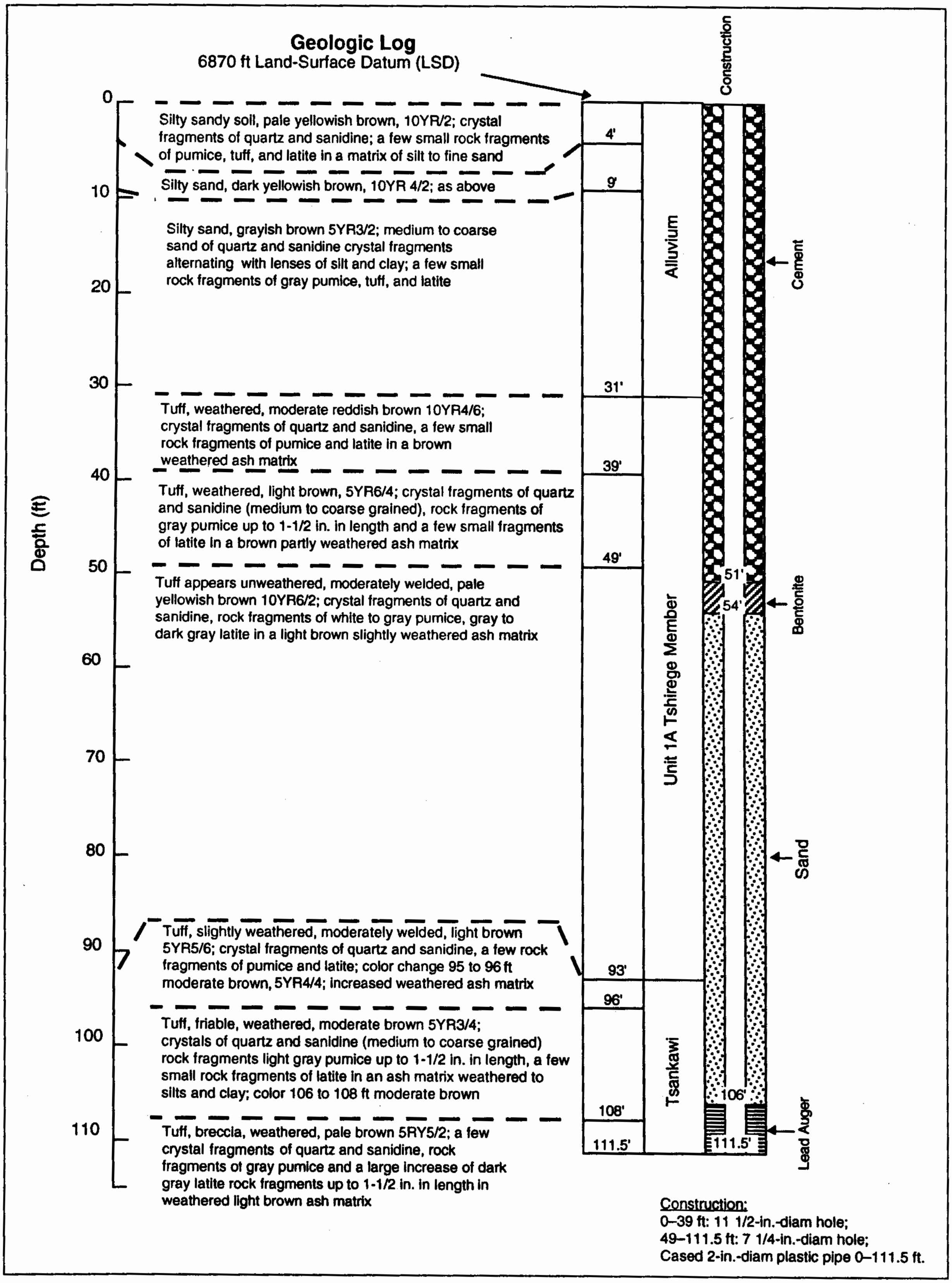

Fig. VI-AA. Mortandad test hole MCM-5.1, completed September 1990, water in alluvium cased out of hole (Stoker et al. 1991).

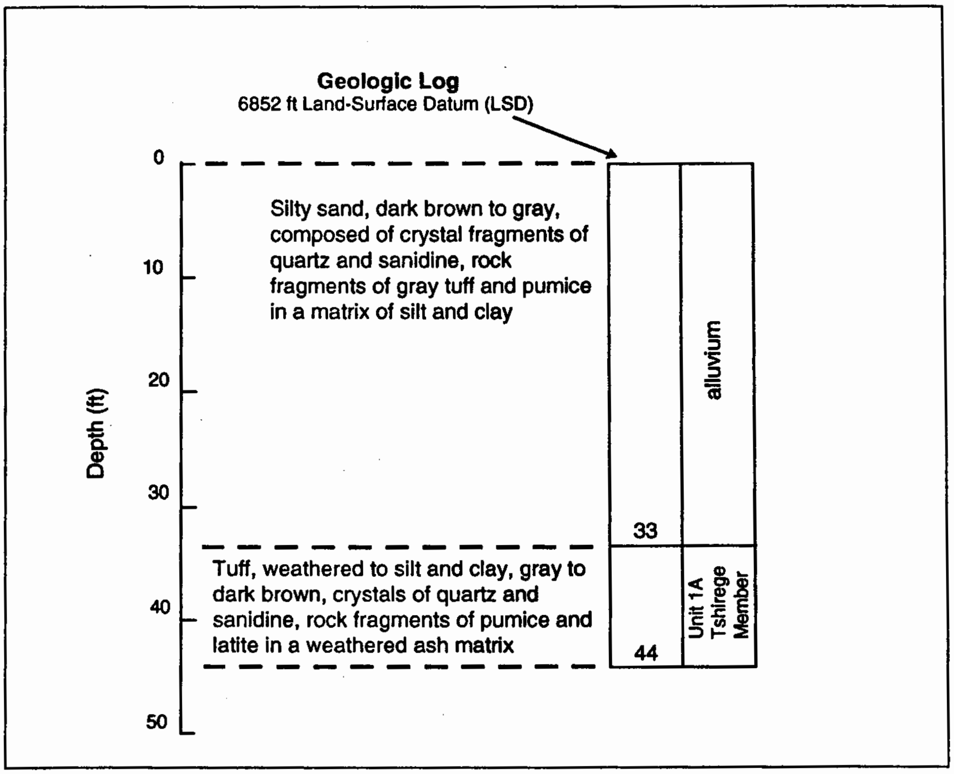

Fig. VI-AB. Mortandad test hole MCM-5.9, drilled July 1990, abandoned and plugged (Stoker et al. 1991).

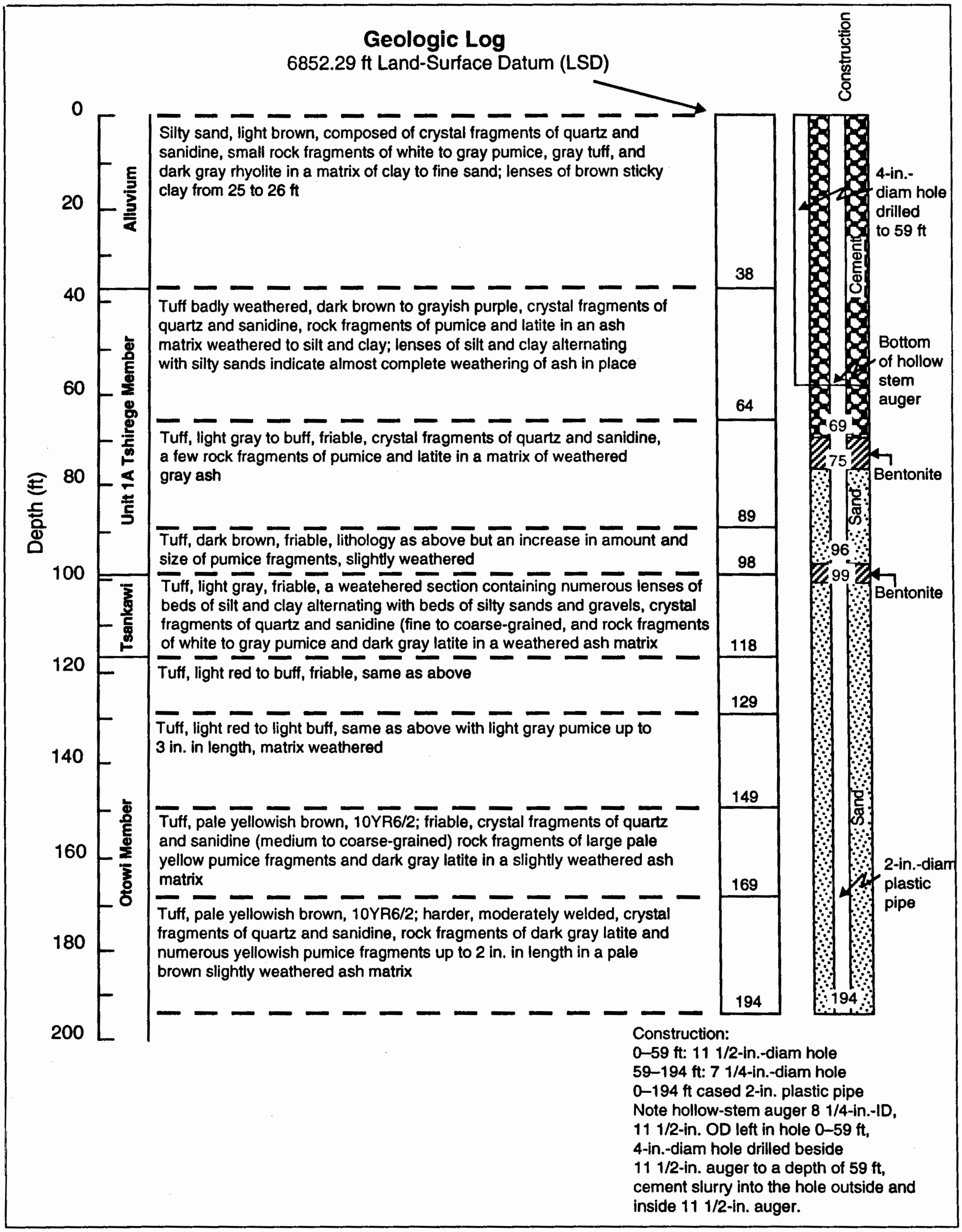

Fig. VI-AC. Mortandad test hole MCM-5.9A, completed July 1990, water in alluvium cased out of hole (Stoker et al. 1991).

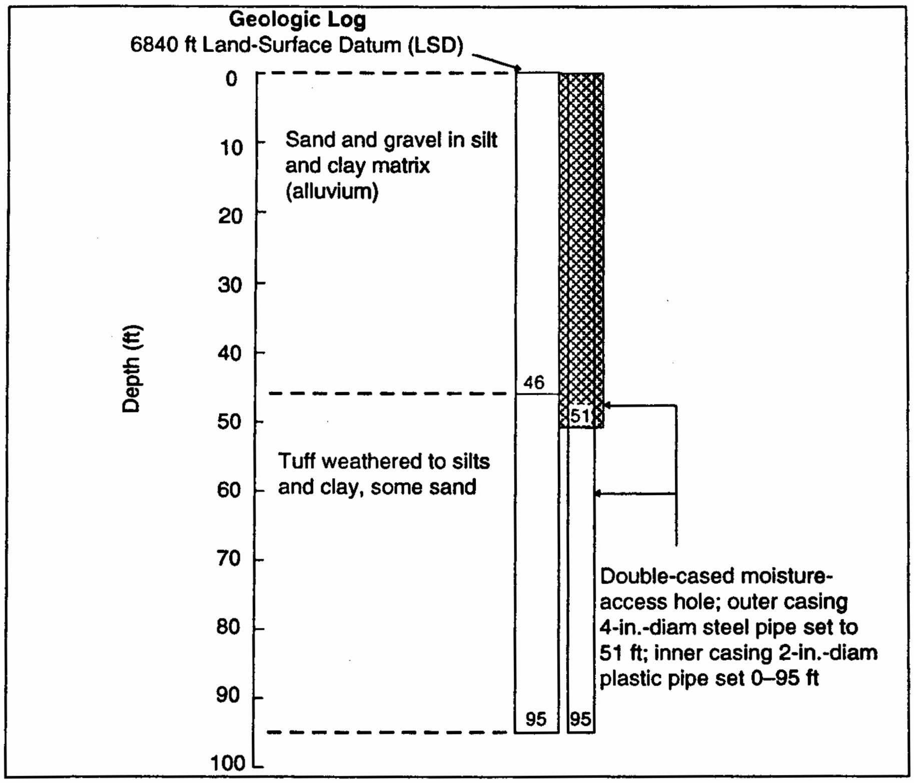

Fig. VI-AD. Mortandad test hole MCM-6.5, completed November 1961, water in alluvium cased out of hole (Purtymun 1964).

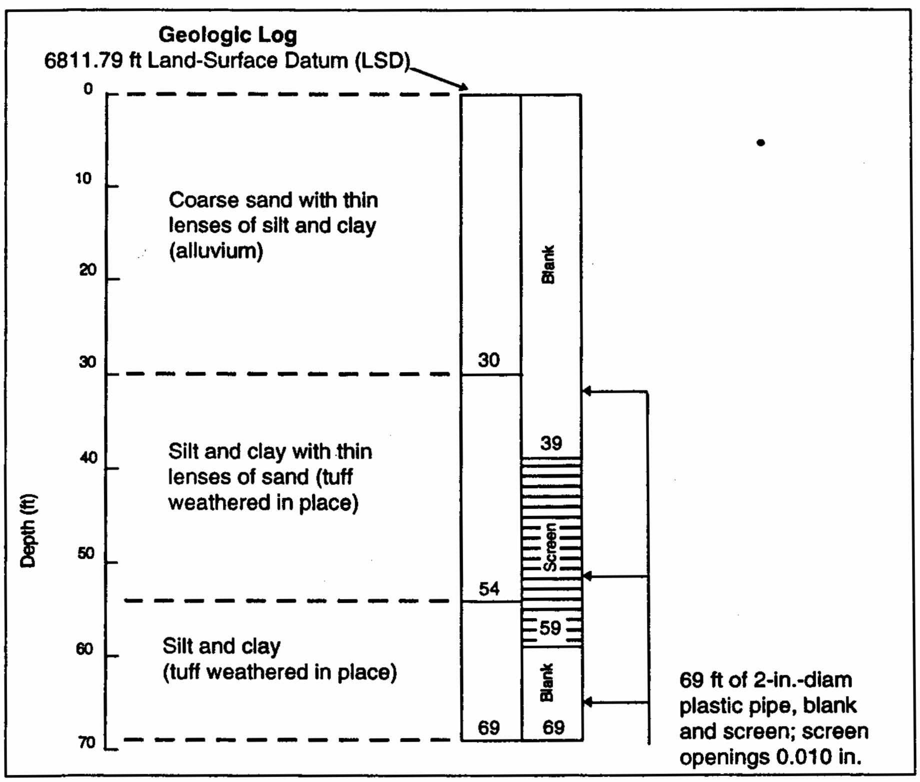

Fig. VI-AE. Mortandad test hole MT-1, completed November 1988, water level 43.0 ft (Stoker et al. 1991).

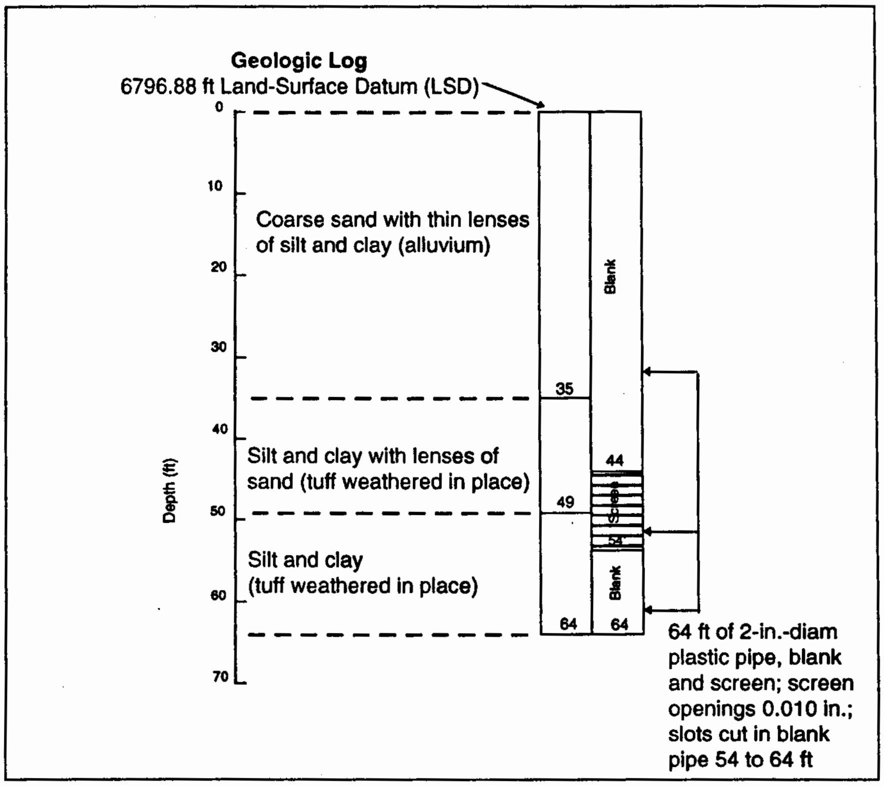

Fig. VI-AF. Mortandad test hole MT-2, completed November 1988, water level 62.0 ft (Stoker et al. 1991).

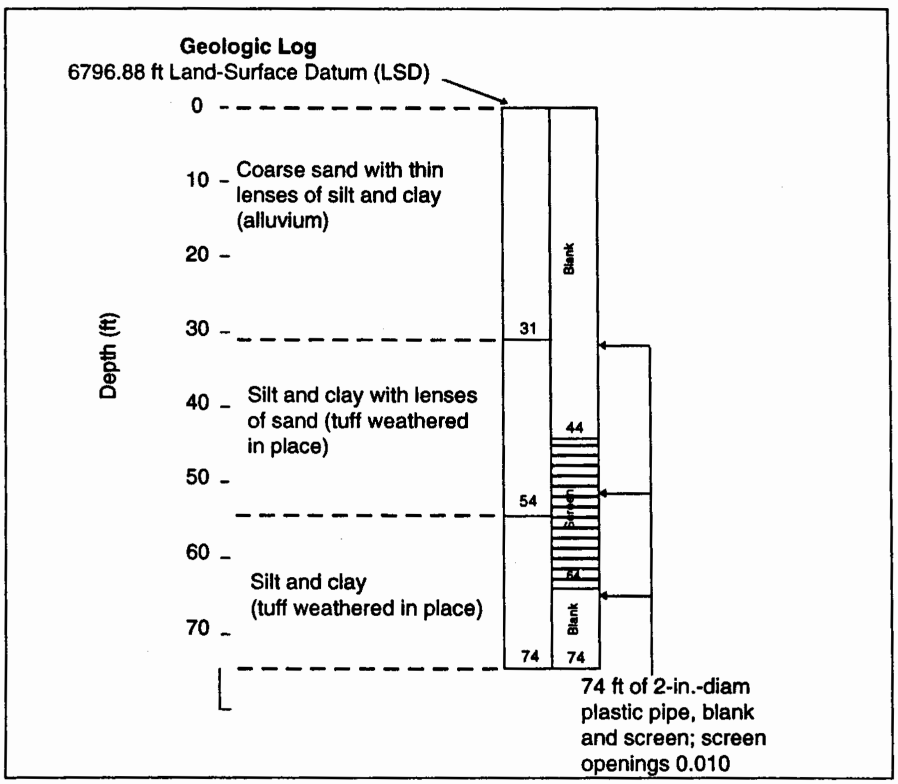

Fig. VI-AG. Mortandad test hole MT-3, completed November 1988, water level 45.0 ft (Stoker et al. 1991).

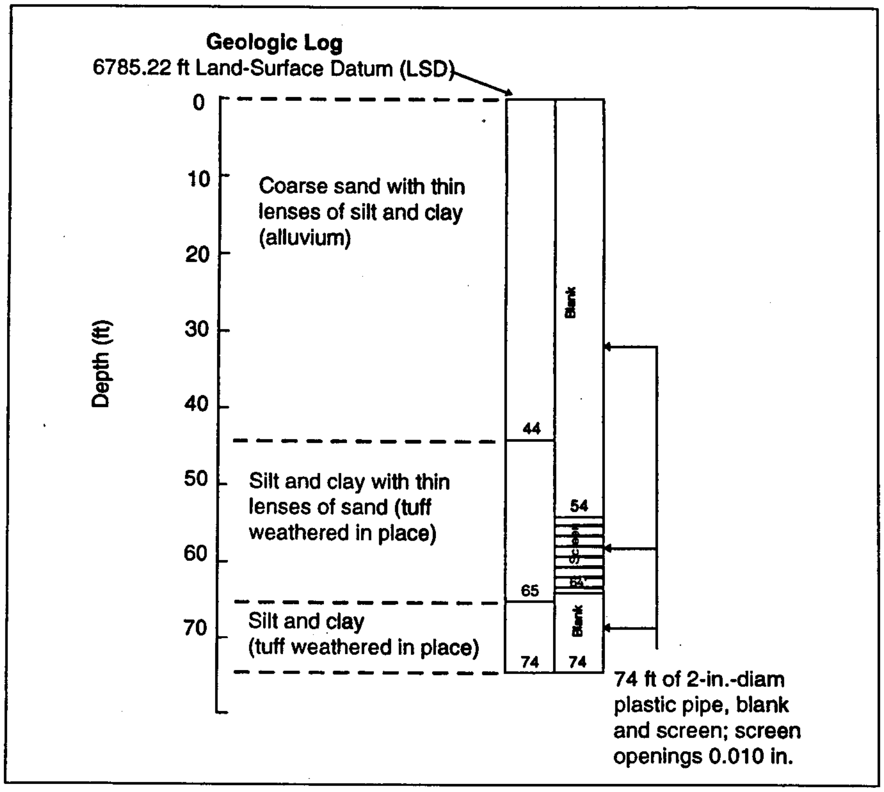

Fig. VI-AH. Mortandad test hole MT-4, completed November 1988, water level 58.0 ft (Stoker et al. 1991).

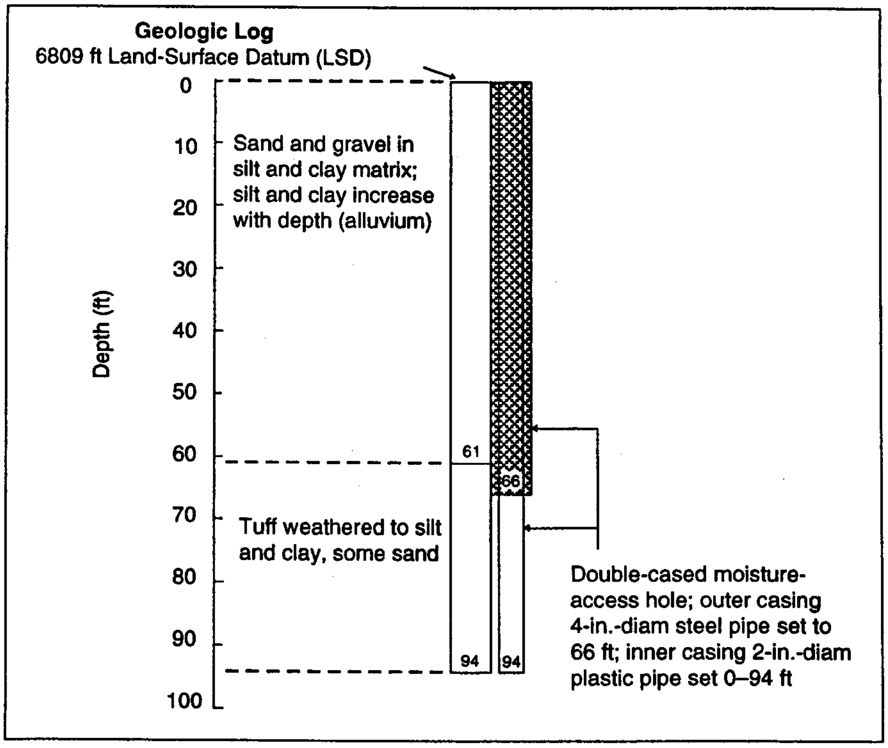

Fig. VI-AI. Mortandad test hole MCM-7.5, completed November 1961, water in alluvium cased out of hole (Purtymun 1964).

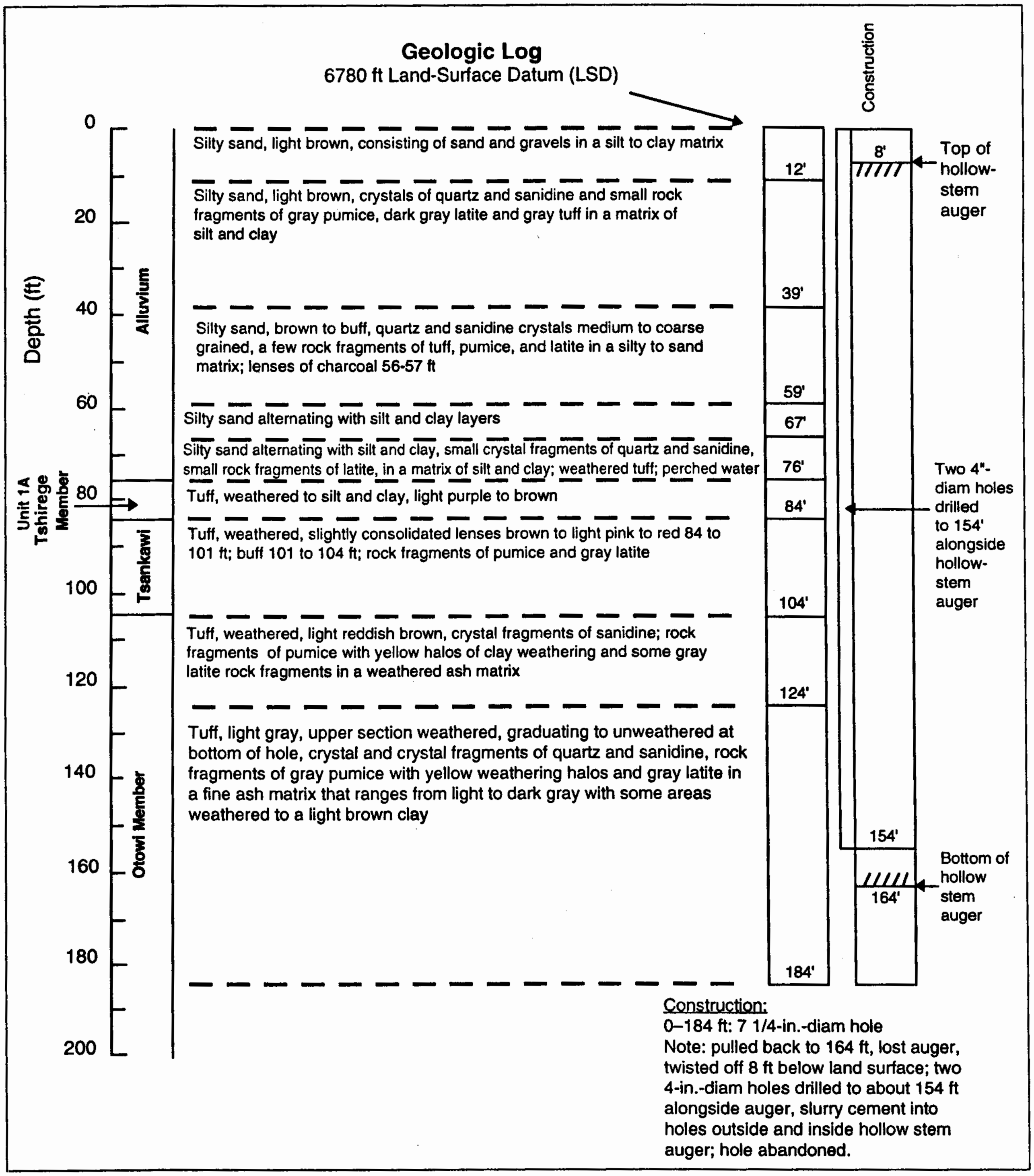

Fig. VI-AJ. Mortandad test hole MCC-8.2, core hole test April 1989, water level 73.0 ft (Stoker et al. 1991).

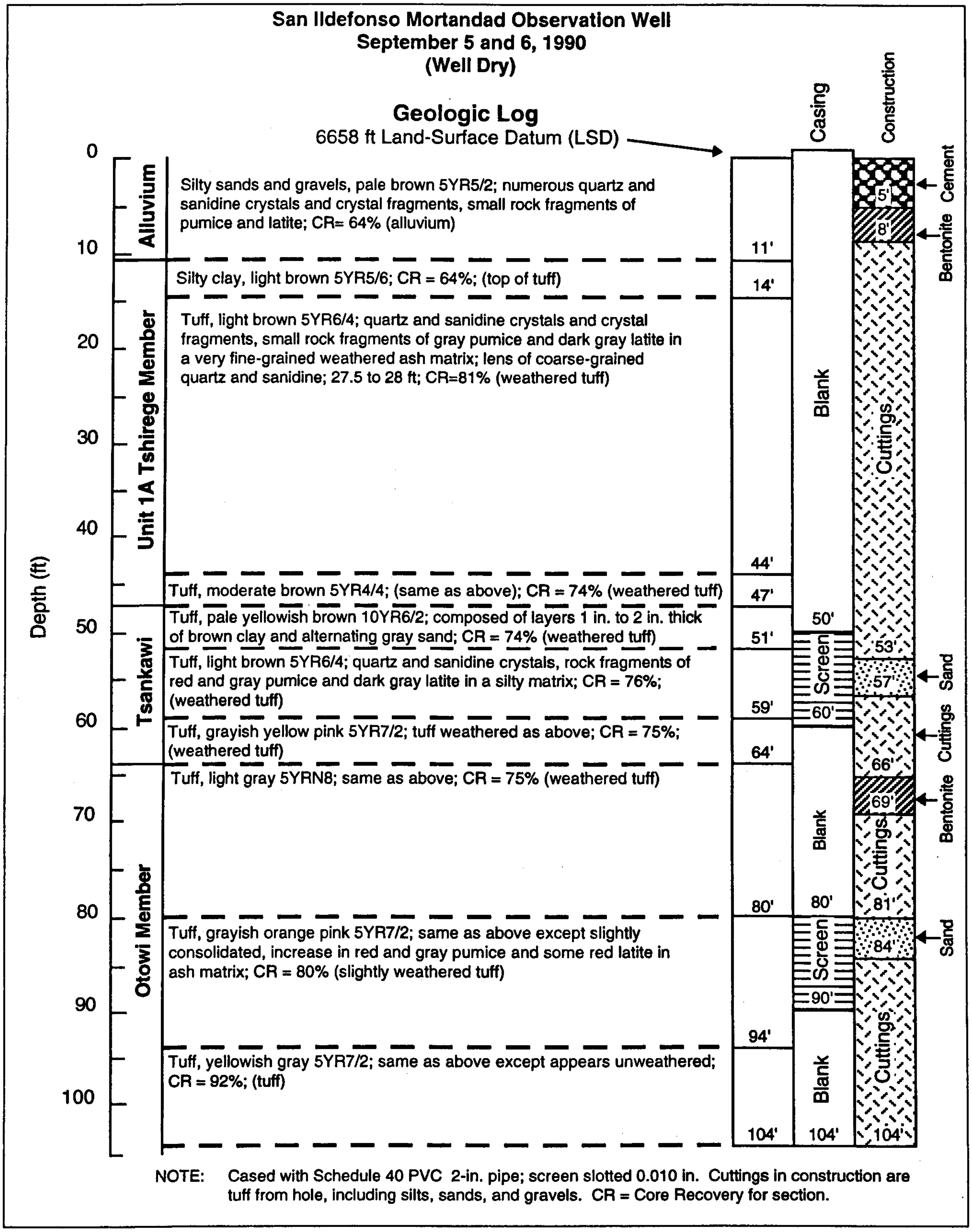

Fig. VI-AK. Mortandad test hole SIMO, drilled in cooperation with San Ildefonso Pueblo and BIA, September 1990, dry (Stoker et al. 1991).

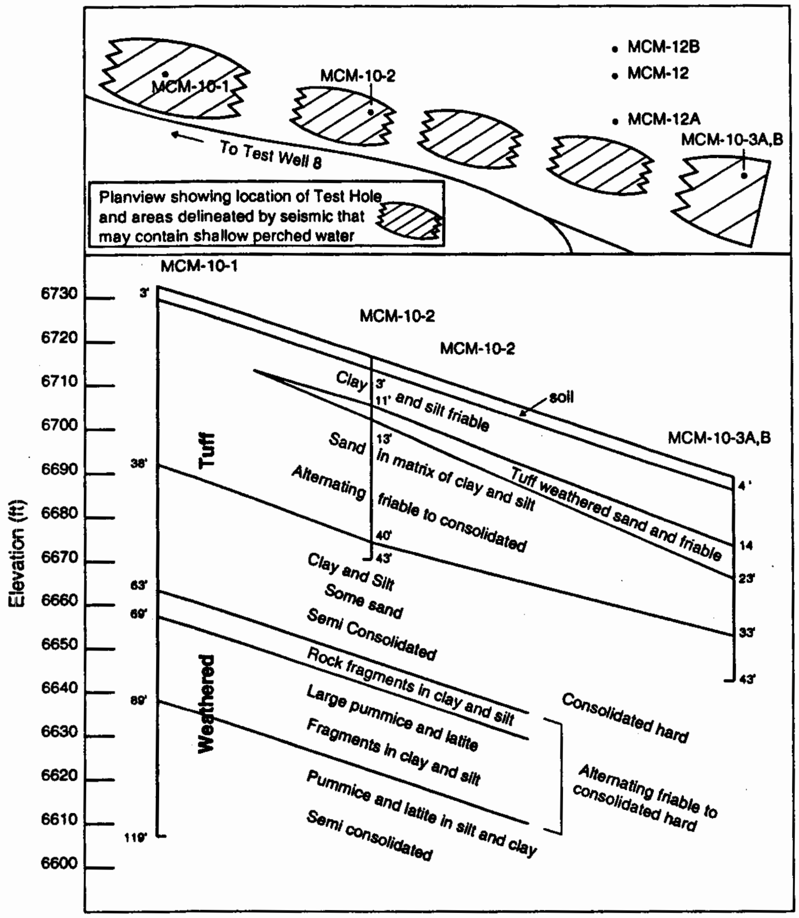

Fig. VI-AL. Mortandad test holes MCM-10-1, MCM-10-2, and MCM-10-3A-B (Purtymun 1992).

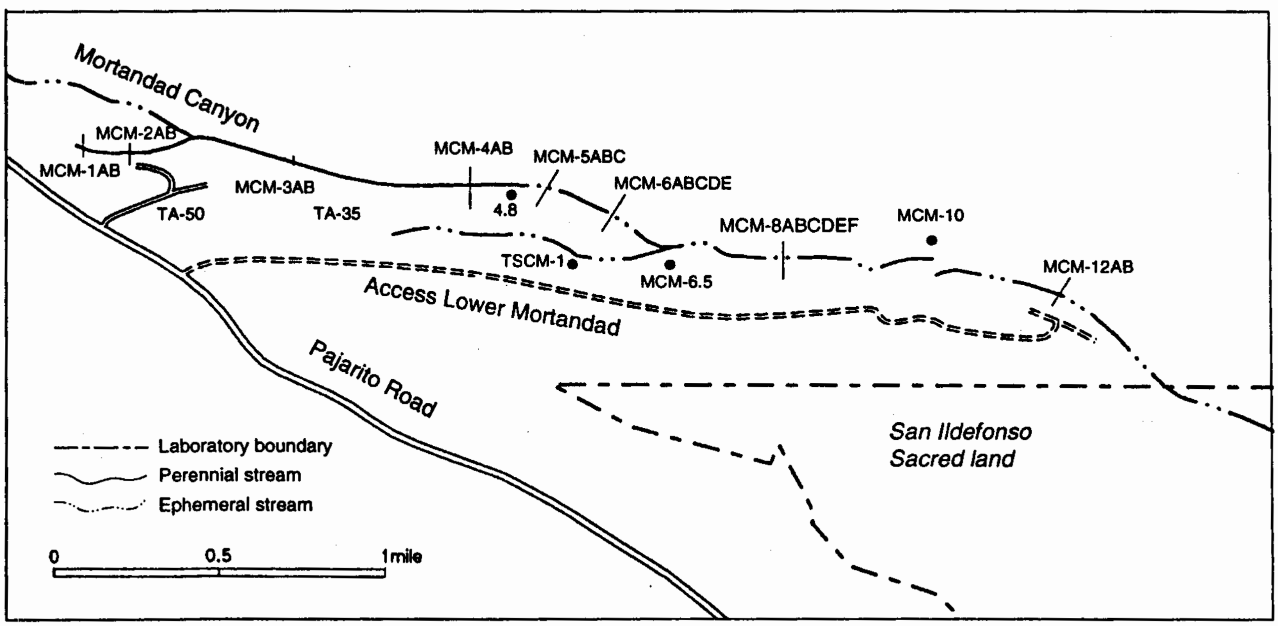

Fig. VI-AM. Locations of moisture-access holes in Mortandad Canyon (letters indicate hole designations across canyon).

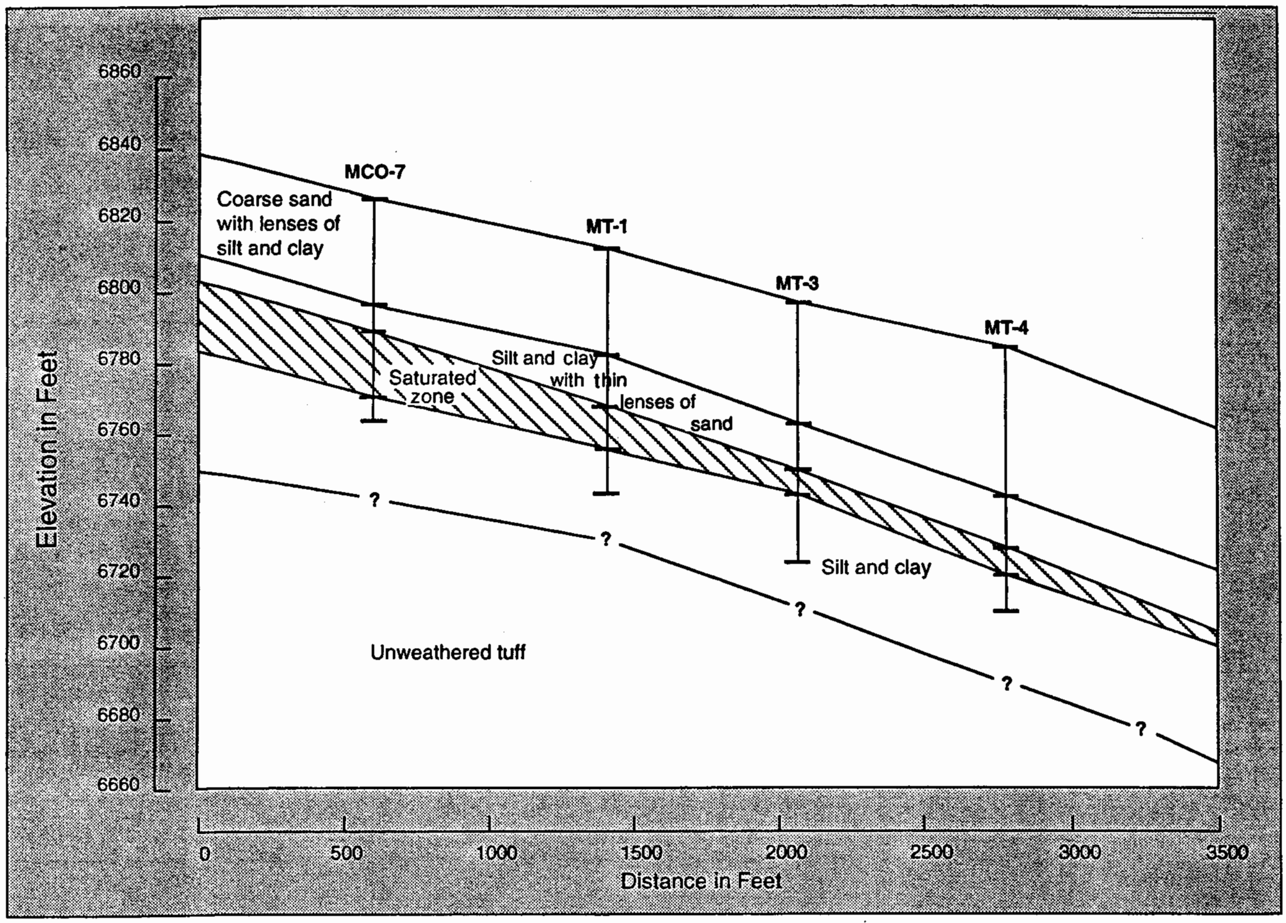

Fig. VI-AN. Geologic section showing alluvium, unweathered tuff, and the saturated zone in lower Mortandad Canyon (Stoker et al. 1991). See Figs. VI-A and VI-W for location.

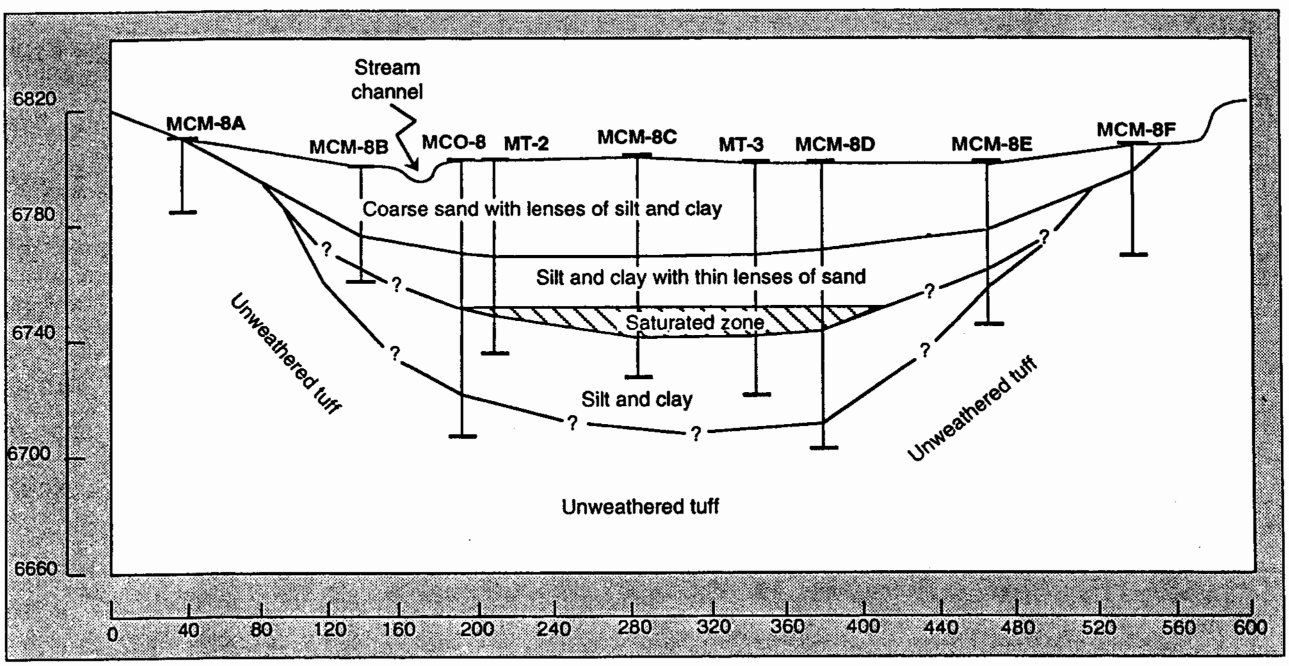

Fig. VI-AO. Geologic section showing alluvium, unweathered tuff, and the saturated zone across lower Mortandad Canyon (Stoker et al. 1991). See Fig. VI-AM for location.

TABLE VI-A. Hydrologic Data for Observation Wells in Mortandad Canyon

Observation Wells	Date Completed	Depth Drilled (ft)	Depth Completed (ft)	Depth 1991	Water Levels At Completion (ft)	Water Levels At Present Date	Water Levels (ft)	Elevation Land-Surface Datum (LSD) (ft)	Top of Casing (Measuring Point) to Land Surface Datum	Remarks
MCO-1	11/60	8	8	—	2.8	—	—	7153	—	Unable to locate in 1991
MCO-2	11/60	10	9	7.5	0.3	4/91	5.06	7133	2.00	
MCO-3	3/67	18	12	10.1	4.4	4/91	3.36	7052.72	1.54	Originally drilled 11/60; redrilled and cased 3/67
MCO-4	10/63	24	19	16.3	3.3	4/91	7.19	6900.36	1.02	
MCO-4.9	7/73	42	30	23.4	—	4/91	22.10	6879.31	1.25	
MCO-5	10/60	47	46	44.9	24.6	2/91	20.75	6875.80	1.95	
MCO-6	10/60	82	71	—	38.1	—	—	6849	—	Plugged and abandoned (relocated)
MCO-6	3/74	47	47	41.5	28.9	2/91	33.75	6848.96	2.34	
MCO-6.5A	11/61	47	45	33.3	41.0	2/91	Dry	6840	2.15	
MCO-6.5B	11/61	42	42	36.0	36.3	2/91	Dry	6839	0.70	
MCO-7	10/60	77	69	54.7	39.7	2/91	37.47	6827.40	1.24	
MCO-7.5A	11/61	63	60	—	41.2	—	—	6809	—	Well damaged (relocated)
MCO-7.5B	4/74	62	60	56.0	42.1	2/91	43.71	6808.80	1.28	
MCO-8	10/60	92	84	22.7	61.6		—	6796.70	0.25	Obstruction in well
MCO-8A	11/61	52	50	48.5	Dry	2/91	Dry	6800	0.61	
MCO-8.2	11/61	72	70	60.3	59.2	2/91	Dry	6782	2.00	
MCO-9	11/60	57	55	54.6	Dry	2/91	Dry	6747.77	1.44	
MCO-9.5	11/61	57	46	40.3	Dry	2/91	Dry	6740	2.00	
MCO-11	11/61	23	20	—	Dry	—	—	6720	—	Unable to locate in 1991
MCO-12	11/61	64	60	—	Dry	—	—	6700	—	Casing pulled; hole plugged (relocated)
MCO-12	6/71	112	108	96.2	Dry	2/91	Dry	6702	0.62	
MCO-13	7/70	112	107	106.2	Dry	2/91	Dry	6674	0.67	
TSCO-1	11/61	37	35	23.1	Dry	2/91	8.93	6857	0.97	

Sources: Baltz et al. 1963; Purtymun 1964, 1971, and 1974.

TABLE VI-B. Geologic Logs and Construction Data for Observation Wells in Mortandad Canyon (20 Obs. Wells)

1. Observation Well MCO-1

Geologic Log	Thickness (ft)	Depth (ft)
Tuff, unweathered, overlain by about 1 ft of silt and sand	8	8

Note: Well abandoned, in stream channel.

2. Observation Well MCO-2

Geologic Log	Thickness (ft)	Depth (ft)
Tuff, unweathered, overlain by about 1 ft of silt and sand	10	10

Note: Well abandoned: in stream channel.

3. Observation Well MCO-3

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay	7	7
Tuff (weathered in place)		
Silt and clay with some lenses of sand and gravel	11	18

Construction

12 ft of 3-in.-diam plastic pipe, lower 10 ft perforated.

4. Observation Well MCO-4

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay	18	18
Tuff (weathered in place)		
Silt and clay with lenses of sand	6	24

Construction

19 ft of 3-in.-diam plastic pipe, lower 15 ft perforated.

5. Observation Well MCO-4.9

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay	27	27
Tuff (weathered in place) silt and clay with gravel	16	43

Construction

30 ft of 3-in.-diam plastic pipe, lower 20 ft perforated.

TABLE VI-B. Geologic Logs and Construction Data for Observation Wells in Mortandad Canyon (20 Obs. Wells)(Continued)

6. Observation Well MCO-5

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel with lenses of silt and clay	35	35
Tuff (weathered in place)		
Silt and clay with some lenses of sand and gravel	12	47

Construction
46 ft of 3-in.-diam plastic pipe, lower 25 ft perforated.

7. Observation Well MCO-6

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand, gravel, and occasional cobbles in a matrix of silt and clay	36	36
Tuff (weathered in place)		
Silt and clay with minor amounts of sand and gravel	46	82

Construction
71 ft of 3-in.-diam plastic pipe, lower 35 ft perforated, well drilled October 1960. Well destroyed by flood, summer 1973; redrilled and constructed as a new well about 10 ft to the northeast (March 1974): 47 ft of 4-in.-diam plastic pipe, lower 20 ft perforated.

8. Observation Well MCO-6.5A

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay	47	47

Construction
45 ft of 2-in.-diam plastic pipe, lower 20 ft perforated.

9. Observation Well MCO-6.5B

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay	42	42

Construction
42 ft of casing, upper 22 ft of 4-in.-diam steel pipe; lower 20 ft of 4-in.-diam plastic pipe, perforated.

TABLE VI-B. Geologic Logs and Construction Data for Observation Wells in Mortandad Canyon (20 Obs. Wells)(Continued)

10. Observation Well MCO-7

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a silt and clay matrix	55	55
Tuff (weathered in place)		
Silt and clay with lenses of sand and gravel	22	77

Construction
69 ft of 3-in.-diam plastic pipe, lower 30 ft perforated.

11. Observation Well MCO-7.5A/7.5B

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay; silt and clay increase with depth	60	60
Tuff (weathered in place) silt and clay	3	63

Construction
November 1961, 60 ft of 3-in.-diam plastic pipe, lower 20 ft perforated; well destroyed by falling tree, replaced April 1974 about 6 ft to the west: 60 ft of 4-in.-diam plastic pipe, lower 25 ft perforated.

12. Observation Well MCO-8

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay; silt and clay increase with depth	61	61
Tuff (weathered in place)		
Silt and clay with lenses of fine to coarse sand	31	92

Construction
84 ft of 3-in.-diam plastic pipe, lower 20 ft perforated; well damaged, bailer stuck at about 23 ft.

13. Observation Well MCO-8A

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay; silt and clay increase with depth	52	52

Construction
50 ft of 2-in.-diam plastic pipe, lower 10 ft perforated.

TABLE VI-B. Geologic Logs and Construction Data for Observation Wells in Mortandad Canyon (20 Obs. Wells)(Continued)

14. Observation Well MCO-8.2

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay; silt and clay increase with depth	72	72

Construction
70 ft of 2-in.-diam plastic pipe, lower 10 ft perforated.

15. Observation Well MCO-9

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand, some gravel in a matrix of silt and clay; silt and clay increase with depth	57	57

Construction
55 ft of 3-in.-diam plastic pipe, lower 10 ft perforated.

16. Observation Well MCO-9.5

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay; silt and clay increase with depth	57	57

Construction
46 ft of 2-in.-diam plastic pipe, lower 20 ft perforated.

17. Observation Well MCO-11

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay	23	23

Construction
20 ft of 2-in.-diam plastic pipe, lower 10 ft perforated.

TABLE VI-B. Geologic Logs and Construction Data for Observation Wells in Mortandad Canyon (20 Obs. Wells)(Continued)

18. Observation Well MCO-12

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay; silt and clay increase with depth	71	71
Tuff (weathered in place)		
Silt and clay with some sand and gravel; near bottom, unweathered gray tuff	41	112

Construction

Note: This well (1971) replaces the well from 1961 that was about 64 ft deep and was located about 12 ft to the south (its casing was pulled and the hole was plugged); this new well was constructed in June 1971: 108 ft of 2-in.-diam plastic pipe, lower 20 ft perforated.

19. Observation Well MCO-13

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and some gravel in a matrix of silt and clay; silt and clay increase with depth	65	65
Tuff (weathered in place)		
Silt and clay with lenses of sand and gravel	31	96
Tuff (unweathered) light gray	16	112

Construction

107 ft of 2-in.-diam plastic pipe, lower 20 ft perforated; hole gravel packed.

20. Observation Well TSCO-1

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay	37	37

Construction

35 ft of 2-in.-diam plastic pipe, lower 20 ft perforated.

Sources: Baltz et al. 1963; Purtymun 1964, 1971, and 1974.

TABLE VI-C. Hydrologic Data for Test Wells in Mortandad Canyon

Test Wells	Date Completed	Depth Drilled (ft)	Depth Completed (ft)	Depth 1991	Water Levels At Completion (ft)	Water Levels Date	Water Levels (ft)	Elevation (LSD) (ft)	Measuring Point (MP) Top of Casing (TC) to LSD (ft)	Remarks
MCM-2.2	11/61	90	87	87	Dry	4/91	Dry	7109	2.20	Angle hole beneath channel (45°)
MCM-2.8	11/61	60	58	58	Dry	4/91	Dry	7086	5.00	Angle hole beneath channel (30°)
MCM-4.5	11/61	48	48	35	—	—		6891	1.70	Double-cased moisture-access hole
MCM-6.5	11/61	95	95	95	—	—		6840	0.20	Double-cased moisture-access hole
MCM-7.5	11/61	94	94	94	—	—		6809	1.00	Double-cased moisture-access hole
MT-1	11/88	69	69	68	43.0	2/91	42.92	6811.79	1.79	
MT-2	11/88	64	64	64	62.0	2/91	Dry	6796.88	1.60	
MT-3	11/88	74	74	73	45.0	2/91	54.72	6796.88	1.30	
MT-4	11/88	74	74	74	58.0	2/91	59.84	6785.22	1.34	
MCM-5.1	9/90	112	112	112	—	—	—	6870	0.22	
MCM-5.9	7/90	44	—	—	—	—	—	6852	—	Plugged and abandoned
MCM-5.9A	7/90	194	194	194	—	—	—	6852.29	0.94	
MCC-8.2	4/89	184	—	—	73	—	—	6780	—	Plugged and abandoned
SIMO	9/90	104	104	—	Dry	—	—	6658	—	On sacred land (San Ildefonso Pueblo)
MCM-10.1	8/91	119	119	—	Dry	—	—	6730	1.00	Moisture-access hole
MCM-10.2	8/91	43	43	—	Dry	—	—	6715	1.00	Moisture-access hole
MCM-10.3A	8/91	33	33	—	Dry	—	—	6690	1.00	Moisture-access hole
MCM-10.3B	8/91	43	43	—	Dry	—	—	6690	1.00	Moisture-access hole
SIMO-1	9/92	116	—	—	Dry	—	—	6650	—	San Ildefonso and BIA well on sacred land

Sources: Purtymun 1964, 1988–1992; Stoker et al. 1991.

TABLE VI-D. Geologic Logs and Construction Data for Test Holes in Mortandad Canyon (18 Test Wells)

1. Test Hole MCM-2.2

Elevation (LSD) 7109 ft

Geologic Log	Thickness (ft)	Depth (ft)
Tuff, light gray to dark gray, welded, crystal and crystal fragments of quartz and sanidine, rock fragments of gray latite and rhyolite, a few devitrified pumice fragments, Unit 2 Tshirege Member	60	60

Construction

Angle hole, drilled at an angle of 45° from the terrace to under the stream. Cased with 87 ft of 2-in.-diam blank plastic pipe with a plug in its end; extends 2 ft above LSD. Moisture-access hole.

2. Test Hole MCM-2.8

Elevation (LSD) 7086 ft

Geologic Log	Thickness (ft)	Depth (ft)
Tuff, light gray to dark gray, welded, quartz and sanidine crystals and crystal fragments, a few rock fragments, Unit 2 Tshirege Member	51	51

Construction

Angle hole, drilled at 30° from the vertical from the terrace to under the stream. Cased with 58 ft of 2-in.-diam blank plastic pipe with a plug in its end; extends 5 ft above LSD. Moisture-access hole.

3. Test Hole MCM-4.5

Elevation (LSD) 6891 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay	26	26
Tuff (weathered in place)		
Silt and clay, some sand	22	48

Construction

Moisture-access hole. Outer casing: 4-in.-diam steel casing set 0-29 ft into tuff to seal water out of hole; 48 ft of 2-in.-diam plastic pipe set 0 to 48 ft. Ground tuff packed in annulus around outside of plastic pipe.

4. Test Hole MCM-6.5

Elevation (LSD) 6840 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium		
Sand and gravel in a matrix of silt and clay	46	46
Tuff (weathered in place)		
Silt and clay, with lenses of sand	49	95

TABLE VI-D. Geologic Logs and Construction Data for Test Holes in Mortandad Canyon (18 Test Wells) (Continued)

4. Test Hole MCM-6.5 (Continued)

Construction

Moisture-access hole. Outer casing 4-in.-diam steel casing set 0–51 ft into tuff to seal water out of hole; 95 ft of 2-in.-diam plastic pipe set 0 to 95 ft. Ground tuff packed in annulus around plastic pipe.

5. Test Hole MCM-7.5

Elevation (LSD) 6809 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Alluvium		
Sand and gravel in a matrix of silt and clay	61	61
Tuff (weathered in place)		
Silt and clay, occasional lenses of sand	33	94

Construction

Moisture-access hole. Outer casing 4-in.-diam steel casing set 0–66 ft into tuff to seal water out of hole; 94 ft of 2-in.-diam plastic pipe set 0 to 94 ft. Ground tuff packed in annulus around plastic pipe.

6. Test Hole MT-1

Elevation (LSD) 6811.79 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Alluvium		
Coarse sand with lenses of silt and clay	30	30
Tuff (weathered in place, contains aquifer)		
Silt and clay with thin lenses of sand	24	54
Tuff (weathered in place) silt and clay	15	69

Construction

69 ft of 2-in.-diam plastic pipe set from 0–69 ft; screen 39 to 59 ft, screen openings 0.010 in. Gravel packed through screen section with 0.020-in.-diam sand.

7. Test Hole MT-2

Elevation (LSD) 6796.88 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Alluvium		
Coarse sand with thin lenses of silt and clay	35	35
Tuff (weathered in place, contains aquifer)		
Silt and clay with thin lenses of sand	14	49
Tuff (weathered in place) silt and clay	15	64

Construction

64 ft of 2-in.-diam plastic pipe set from 0–64 ft; screen 44 to 54 ft, screen openings 0.010 in.; slots cut in blank pipe 54 to 64 ft. Gravel packed through screen section with 0.020-in.-diam sand.

TABLE VI-D. Geologic Logs and Construction Data for Test Holes in Mortandad Canyon (18 Test Wells) (Continued)

8. Test Hole MT-3

Elevation (LSD) 6796.88 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Alluvium		
Coarse sand with thin lenses of silt and clay	31	31
Tuff (weathered in place, contains aquifer)		
Silt and clay with thin lenses of sand	23	54
Tuff (weathered in place) silt and clay	20	74

Construction

74 ft of 2-in.-diam plastic pipe set from 0–74 ft; screen 44 to 64 ft, screen openings 0.010 in. Gravel packed through screen section with 0.020-in.-diam sand.

9. Test Hole MT-4

Elevation (LSD) 6785.22 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Alluvium		
Coarse sand with thin lenses of silt and clay	44	44
Tuff (weathered in place, contains aquifer)		
Silt and clay with thin sand lenses	21	65
Tuff (weathered in place) silt and clay	9	74

Construction

74 ft of 2-in.-diam plastic pipe set from 0–74 ft; screen section 54 to 64 ft, screen openings 0.010 in. Gravel packed through screen section with 0.020-in.-diam sand.

10. Test Hole MCM-5.1

Elevation (LSD) 6870 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Alluvium	31	31
Tshirege Member		
Unit 1A	62	93
Tsankawi Member	19	112

Construction

Moisture-access hole. 2-in.-diam plastic pipe 0 to 112 ft. Water sealed out of hole by a cement plug from 0 to 51 ft.

11. Test Hole MCM-5.9

Elevation (LSD) 6852 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Alluvium	33	33
Tshirege Member		
Unit 1A	11	44

Construction

Hole abandoned and plugged.

TABLE VI-D. Geologic Logs and Construction Data for Test Holes in Mortandad Canyon (18 Test Wells) (Continued)

12. Test Hole MCM-5.9A

Elevation (LSD) 6852.29 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Alluvium	38	38
Tshirege Member		
Unit 1A	60	98
Tsankawi Member	20	118
Otowi Member	76	194

Construction
Moisture-access hole. 2-in.-diam plastic pipe 0 to 194 ft. Water sealed out of hole by a cement plug from 0 to 69 ft.

13. Test Hole MCC-8.2

Elevation (LSD) 6780 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Alluvium	76	76
Tshirege Member		
Unit 1A	8	84
Tsankawi Member	20	104
Otowi Member	80	184

Construction
Hole abandoned and plugged.

14. Test Hole SIMO

Elevation (LSD) 6658 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Tshirege Member		
Unit 1A	47	47
Tsankawi Member	17	64
Otowi Member	40	104

Construction
104 ft of 2-in.-diam plastic pipe with slotted sections 50 to 60 ft and 80 to 90 ft.

15. Test Hole MCM-10-1

Elevation (LSD) 6730 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Soil, clay, dark brown	4	4
Tuff, weathered, light brown, quartz and sanidine, a few small rock fragments of pumice, latite, and rhyolite in a matrix of silt and clay, friable to consolidated	34	38

15. Test Hole MCM-10-1 (Continued)

	Thickness (ft)	Depth (ft)
Tuff, weathered, light gray to grayish brown, several 2-in.-thick clay layers from 39–44 ft; quartz and sanidine crystals and fragments, a few rock fragments of pumice and latite in a silt and clay matrix, semiconsolidated	25	63
Tuff, weathered, light brown, rock fragments of pumice and latite in a silt and clay matrix, friable to consolidated	6	69
Tuff, weathered, light reddish gray, quartz and sanidine crystals and rock fragments of pumice up to 1.5 in. long in a matrix of silt and clay, friable to consolidated	20	89
Tuff, weathered, light reddish gray, rock fragments of pumice and latite up to 0.5 in.	30	119

Construction

119 ft of 2-in.-diam plastic pipe set from 0 to 119 ft, its end plugged. Moisture-access hole.

16. Test Hole MCM-10-2

Elevation (LSD) 6715 ft	Thickness (ft)	Depth (ft)
Geologic Log		
Soil, sand, and silt, dark brown	3	3
Tuff, weathered, pale red, 10 YR 6/2, friable quartz and sanidine, a few rock fragments of pumice and latite in a silt and clay matrix, friable	8	11
Tuff, weathered, pale grayish brown, 5 YR 6/2, consists mainly of friable sand of quartz and sanidine crystals; a few rock fragments of pumice and latite	2	13
Tuff, weathered, pale reddish brown, 10 YR 5/4, quartz and sanidine crystals and crystal fragments, a few small rock fragments, consolidated silt and clay 30 to 31 ft, coarse sand and gravel-sized quartz and sanidine crystals and fragments from 37 to 38 ft	27	40
Tuff, weathered, pale reddish brown, 10 YR 5/4, quartz and sanidine crystals, unweathered tuff fragments and some pumice, consolidated	3	43

Construction

43 ft of 2-in.-diam plastic pipe set 0 to 43 ft, its end plugged. Moisture-access hole.

TABLE VI-D. Geologic Logs and Construction Data for Test Holes in Mortandad Canyon (18 Test Wells) (Continued)

17. Test Hole MCM-10-3

Elevation (LSD) 6690 ft

Geologic Log	Thickness (ft)	Depth (ft)
Soil, clayey, dark brown	3	3
Tuff, weathered, greyish orange, 10 YR 7/4, quartz and sanidine crystals in a silt and clay matrix, friable, medium-grained quartz and sanidine, sand 13 to 14 ft	11	14
Tuff, weathered, light brown 5 YR 6/4, quartz and sanidine crystals and occasional pumice fragments, friable	9	23
Tuff, weathered, light brown, 5 YR 6/4, quartz and sanidine crystals in alternating clay and silt, friable to consolidated	10	33
Tuff, weathered, light brown, 5 YR 6/4, quartz and sanidine crystals in a matrix of hard clay, consolidated, hard to auger	10	43

Construction

2 holes drilled at site. First hole MCM-10-3A, total depth 33 ft, cased with 34 ft of 2-in.-diam plastic pipe 0 to 33 ft; moisture-access hole, annulus between hole and pipe filled with drill cuttings. Second hole drilled 12 ft west, MCM-10-3B, to a depth of 43 ft, cased with 43 ft of 2-in.-diam plastic pipe 0 to 43 ft; moisture-access hole, annulus between hole and pipe filled with 0.010- to 0.020-in.-diam sand. End of both casings plugged.

18. Test Hole SIMO-1

Elevation (LSD) 6650 ft

Geologic Log	Thickness (ft)	Depth (ft)
Tuff, light brown, weathered to silt and clay; clay 6% to 8% moisture by volume	13	13
Tuff, brown weathered mainly clay; dry, 10% to 15% moisture by volume	5	18
Tuff, light brown, silt and clay weathered, quartz and sanidine sand-sized crystals and crystal fragments; dry	19	37
Tuff, brown; weathered clay increases; dry, 10% to 15% moisture by volume	16	53
Tuff, light gray, unweathered quartz and sanidine crystals and crystal fragments; a few rock fragments of gray latite and pumice in a gray ash matrix (Tshirege-Otowi contact 53–58 ft); dry	18	71
Tuff, light gray, unweathered, much as above; some increase in pumice; dry	32	103
Tuff, light orange gray, some quartz and sanidine crystal fragments, large rock fragments gray latite and minor amounts of pumice; dry	15	118
Samples 118–133 ft (auger): 118–123 ft, large pumice fragments; 128–133 ft, change in color to light brown; dry	15	133

18. Test Hole SIMO-1 (Continued)

	Thickness (ft)	Depth (ft)
Tuff, gray, moderately welded to nonwelded, friable, a few small rock fragments of latite and quartz latite and pumice; dry	5	138
Sample 138–158 ft (auger): samples; dry	20	158
Tuff, medium gray, unweathered, moderately welded to nonwelded, rock fragments of dark gray latite; some quartz latite, pumice with white, small, and light yellow pumice fragments up to 1 in. long; dry	5	163

Note: Logged in plastic sleeve; in some cores the driller raised the core barrel to clean the hole, resulting in contamination of the core with cuttings.

Core runs were 5 ft; cores collected in two 2.5-ft plastic sleeves.

Run No.	Depth (ft)	Core (ft)	Recovery %
1	3–8	3.0	60
2	8–13	3.5	70
3	13–18	4.0	80
4	18–23	3.0	60
5	23–28	3.0	60
6	28–33	4.5	90
7	33–38	4.0	80
8	38–43	4.0	80
9	43–48	2.0	40
10	48–53	3.0	60
11	53–58	2.0	40
12	58–63	3.0	60
13	63–68	4.0	80
14	68–73	4.0	80
15	73–78	4.0	80
16	78–83	4.0	80
17	83–88	4.0	80
18	88–93	4.0	80
19	93–98	4.0	80
20	98–103	4.0	80
21	103–108	4.0	80
22	108–118	4.0	40
auger	118–123		bag sample
auger			bag sample
auger			bag sample
23	133–138	5.0	100
auger			bag sample
auger			bag sample
auger			bag sample
auger			bag sample
24	158–163	5.0	100

Sources: Purtymun 1964, 1988–1992; Stoker et al. 1991.

TABLE VI-E. Geologic Logs and Construction Data for Moisture-Access Holes in Mortandad Canyon (28 Moisture-Access Holes)

Moisture-Access Hole	Construction Date	Elevation LSD (ft)	Plastic Casing Diam (in.)	Length of Casing LSD (ft)	Alluvium (ft)	Bandelier Tuff (ft)	Remarks
MCM-1A	11/60	7156	2	12	0	12	
MCM-1B	11/60	7155	2	11	0	11	
MCM-2A	11/60	7139	2	11	0	11	
MCM-2B	11/60	7134	2	1	0	1	
MCM-3A	11/60	7049	2	13	10	3	
MCM-3B	11/60	7048	2	10	10	0	
MCM-4A	11/60	6901	2	9	9	0	
MCM-4B	11/60	6900	2	24	18	6	
MCM-4.8	11/61	6887	2	33	30	3	
MCM-5A	10/60	6881	2	25	22	3	
MCM-5B	10/60	6879	2	30	25	5	
MCM-5C	10/60	6878	2	37	30	7	
MCM-6A	10/60	6852	2	18	10	8	
MCM-6B	10/60	6851	2	52	37	15	
MCM-6C	10/60	6851	2	57	47	10	
MCM-6D	10/60	6850	2	35	35	0	
MCM-6E	10/60	6851	2	21	12	9	
MCM-6.5A	8/89	6839	2	23	23	—	alum. casing
MCM-8A	10/60	6807	2	20	3	17	
MCM-8B	10/60	6797	2	30	30	0	
MCM-8C	10/60	6797	2	66	57	9	
MCM-8D	10/60	6796	2	86	59	27	
MCM-8E	10/60	6797	2	53	32	21	
MCM-8F	10/60	6799	2	23	4	19	
MCM-10	10/60	6731	2	67	62	5	
MCM-12A	6/71	6718	2	98	93	5	
MCM-12B	6/71	6705	2	79	79	0	
TSCM-1	11/61	6859	2	22	22	0	

Sources: Baltz et al. 1963; Purtymun 1964 and 1971b.

TABLE VI-F. Locations and Elevations (NAD 1927)

A. Surface Water and Gaging Stations

MCS-3.9	N 1,769,648.2	E 490,479.7	6907.9 ft
MCGS-1	N 1,770,221.9	E 486,502.3	7065.9 ft
MCGS-2	N 1,769,400	E 491,800	6900 ft

B. Observation Wells

MCO-1	N 1,770,100	E 485,200	7153 ft
MCO-2	N 1,770,000	E 485,700	7133 ft
MCO-3	N 1,770,174.7	E 487,118.3	7052.7 ft
MCO-4	N 1,769,725.8	E 490,970.1	6900.4 ft
MCO-4.9	N 1,769,546.5	E 492,127.5	6880.3 ft
MCO-5	N 1,769,475.9	E 492,221.9	6875.8 ft
MCO-6	N 1,768,950	E 493,391	6850 ft
MCO-6	N 1,768,950.7	E 493,391.1	6849.0 ft
MCO-6.5A	N 1,768,600	E 493,800	6840 ft
MCO-6.5B	N 1,768,700	E 493,900	6839 ft
MCO-7	N 1,768,447.8	E 494,273.6	6827.4 ft
MCO-7A	N 1,768,447.2	E 494,259.2	6827.7 ft
MCO-7.5A	N 1,768,378	E 495,210	6809 ft
MCO-7.5B	N 1,768,378.4	E 495,210.6	6808.8 ft
MCO-8	N 1,768,467.2	E 495,776.5	6796.7 ft
MCO-8A	N 1,768,500	E 495,800	6800 ft
MCO-8.2	N 1,768,500	E 495,800	6782 ft
MCO-9	N 1,768,309.1	E 497,813.6	6747.77 ft
MCO-9.5	N 1,768,300	E 498,600	6740 ft
MCO-11	unable to locate 1991		
MCO-12	N 1,768,100	E 500,200	6700 ft
MCO-12	N 1,768,100	E 500,200	6702 ft
MCO-13	N 1,767,200	E 500,900	6674 ft
TSCO-1	N 1,768,400	E 493,100	6857 ft

C. Test Holes

MCM-2.2	N 1,769,900	E 486,200	7109 ft
MCM-2.8	N 1,769,900	E 486,600	7086 ft
MCM-4.5	N 1,769,500	E 492,000	6891 ft
MCM-6.5	N 1,768,800	E 493,900	6840 ft
MCM-7.5	N 1,768,500	E 495,300	6809 ft
MT-1	N 1,768,433.7	E 495,019.0	6811.8 ft
MT-2	N 1,768,484.9	E 495,777.5	6796.8 ft
MT-3	N 1,768,597.4	E 495,737.9	6796.9 ft
MT-4	N 1,768,572.3	E 496,314.5	6785.2 ft
MCM-5.1	N 1,769,400	E 492,500	6870 ft
MCM-5.9	N 1,768,968.6	E 493,358.7	6852.3 ft
MCC-8.2	N 1,768,700	E 496,600	6780 ft
SIMO	N 1,766,400	E 501,600	6658 ft
SIMO-1	N 1,766,500	E 501,600	6650 ft
MCM-10-1	N 1,767,900	E 498,700	6730 ft
MCM-10-2	N 1,768,000	E 498,900	6715 ft
MCM-10-3A	N 1,767,800	E 500,400	6690 ft
MCM-10-3B	N 1,767,800	E 500,400	6690 ft

TABLE VI-F. Locations and Elevations (NAD 1927)(Continued)

D. Moisture-Access Holes

MCM-1A,-1B	N 1,770,100	E 485,200	7150 ft
MCM-2A,-2B	N 1,770,000	E 485,700	7130 ft
MCM-3A,-3B	N 1,770,200	E 487,100	7050 ft
MCM-4A,-4B	N 1,769,700	E 491,000	6890 ft
MCM-4.8	N 1,769,636.3	E 491,645.2	6889.1 ft
MCM-5A,-5B,-5C	N 1,769,500	E 492,200	6880 ft
MCM-6A,-6B,-6C,-6D,-6E	N 1,768,950	E 493,400	6850 ft
MCM-6.5A	N 1,768,400	E 494,200	6839 ft
MCM-8A,-8B,-8C,-8D, -8E,-8F	N 1,768,500	E 495,800	6800 ft
MCM-10	N 1,768,400	E 499,100	6731 ft
MCM-12A	N 1,767,900	E 500,200	6718 ft
MCM-12B	N 1,768,100	E 500,200	6705 ft
TSCM-1	N 1,768,400	E 493,100	6859 ft

VII. CAÑADA DEL BUEY AND PAJARITO CANYON

Observation wells and moisture-access holes were constructed in Cañada del Buey and Pajarito Canyon (Fig.VII-A). The wells and test holes were part of a study to determine if water perched in the alluvium was present, and to determine whether any existing perched zone extended under the adjacent Mesita del Buey that lies between the two canyons (Purtymun and Kennedy 1971; Purtymun 1994).

The holes were drilled with a 7-in.-diam auger and cased with 4-in.-diam plastic pipe, with the lower sections perforated and wrapped with a stainless steel screen. The wells were gravel packed. For typical construction and well security see Fig. VII-B.

Homestead Spring in Pajarito Canyon on the western third of the plateau (N 1,768,100 E 474,300; 7390 ft) discharges 2 to 5 gpm from a surface sheet of densely welded tuff. The spring (discovered by Terry Foxx) is in the Tshirege Member of the Bandelier Tuff and is probably recharged from stream flows in Pajarito Canyon to the west.

A. Cañada del Buey (1985)

Cañada del Buey heads on the Pajarito Plateau at an elevation of about 7200 ft and has a small drainage area of about 1.3 sq mi west of SR-4. The canyon cuts into the Bandelier Tuff; thus the alluvium in the canyon is composed of silt, sand, and gravel (Fig. I-U). Stream flow in the canyon is intermittent, from storm runoff. The intermittent stream has cut a southeast-trending canyon north of the waste processing, storage, and disposal Areas G and L at TA-54.

Five test holes were drilled at the head of Cañada del Buey as part of an investigation for a proposed location for a sanitary landfill (Purtymun 1994). Three test holes were drilled in the canyon adjacent to Area L in a canyon tributary to Cañada del Buey, and one test hole further to the east in Cañada del Buey itself, to determine if the canyon contained a perched water body in the alluvium (Fig VII-A). All nine holes were dry; however, four were completed as observation wells to monitor the alluvium for possible water in the future (Table VII-A). Geologic logs and casing schedules for the four observation wells are shown in Figs. VII-D through VII-G.

B. Pajarito Canyon (1985)

Pajarito Canyon heads on the drainage divide on the flanks of the mountains at an elevation of 10 400 ft and has a drainage area of 12.8 sq mi west of SR-4. The alluvium in the canyon consists of sand, gravel, cobbles, and boulders derived from the Tschicoma Formation and the Bandelier Tuff. Stream flow in the canyon is intermittent, from the release of some waste water and from storm runoff. The intermittent stream has cut a southeast-trending canyon south of the waste processing, storage, and disposal Areas G and L at TA-54.

Three observation wells and four moisture-access holes were drilled in the canyon as part of the same project for which wells were constructed in Cañada del Buey (Fig. VII-A).

The three observation wells were drilled and cased in the canyon to outline the geology and provide a monitoring network of the water in the alluvium perched on the underlying tuff (Table VII-B). Geologic logs and casing schedules for the three observation wells are shown in Figs. VII-H through VII-J.

To outline the aquifer and to ensure that the aquifer was only in the alluvium and did not extend northward beneath the mesa, four test holes were drilled in the canyon floor north of the stream channel (Table VII-C). The test holes were dry. The 4.5-in.-diam holes were completed for use as moisture-access holes, open below the surface casing. Geologic logs and casing schedules for the four moisture-access holes are shown in Figs. VII-K through VII-N. (Devaurs 1985; Devaurs and Purtymun 1985; Purtymun 1985).

C. Cañada del Buey (1992)

A new sanitary waste-water treatment plant has been constructed on the south rim of Cañada del Buey. The plant releases treated sanitary effluent into the canyon, and became operational in September 1992. The stream flow in Cañada del Buey in early 1992 was intermittent. A series of observation wells constructed in 1985 downgradient from the plant indicated no water perched in the alluvium in that reach of the canyon (Table VII-A). To study the effect of the effluent release on the environment in the canyon, we installed additional observation wells and some moisture-access holes near the new treatment plant.

Five observation wells (CDB0-5 through CDBO-9) and two moisture-access holes (CDBM-1 and CDBM-2) were drilled and completed in 1992 (Figs. VII-O through VII-U). The holes were cored, producing 7.25-in.-diam holes and 3-in.-diam cores. The observation wells were gravel packed, while in the moisture-access holes the annulus between the hole wall and casing was packed with sand. Two holes, CDBO-6 and CDBO-7, encountered water perched in the alluvium (Table VII-D). This perched water is probably the result of a discharge to waste from well PM-4 that occurs when the well is started. The discharge is necessary so that the water pressure in the line can be increased gradually. Discharge directly into the line at start-up would result in a high pressure which would rupture the transmission line from the well to the tank.

Graphic presentation of logs and completion data for the observation wells and moisture-access holes are shown in Figs. VII-O to VII-U. Logs and completion data of the observation wells are found in Table VII-D and for the moisture holes in Table VII-E.

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M. Devaurs, "Core Analyses and Observation Well Data from Mesita del Buey Disposal Areas and in Adjacent Canyons," Los Alamos National Laboratory document LA-UR-85-4003.

M. Devaurs and W. D. Purtymun, "Hydrologic Characteristics of the Alluvial Aquifers in Mortandad, Cañada del Buey, and Pajarito Canyons," Los Alamos National Laboratory document LA-UR-85-4002.

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W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory document LA-12733-MS (1994), chapters 128, 138, and 155.

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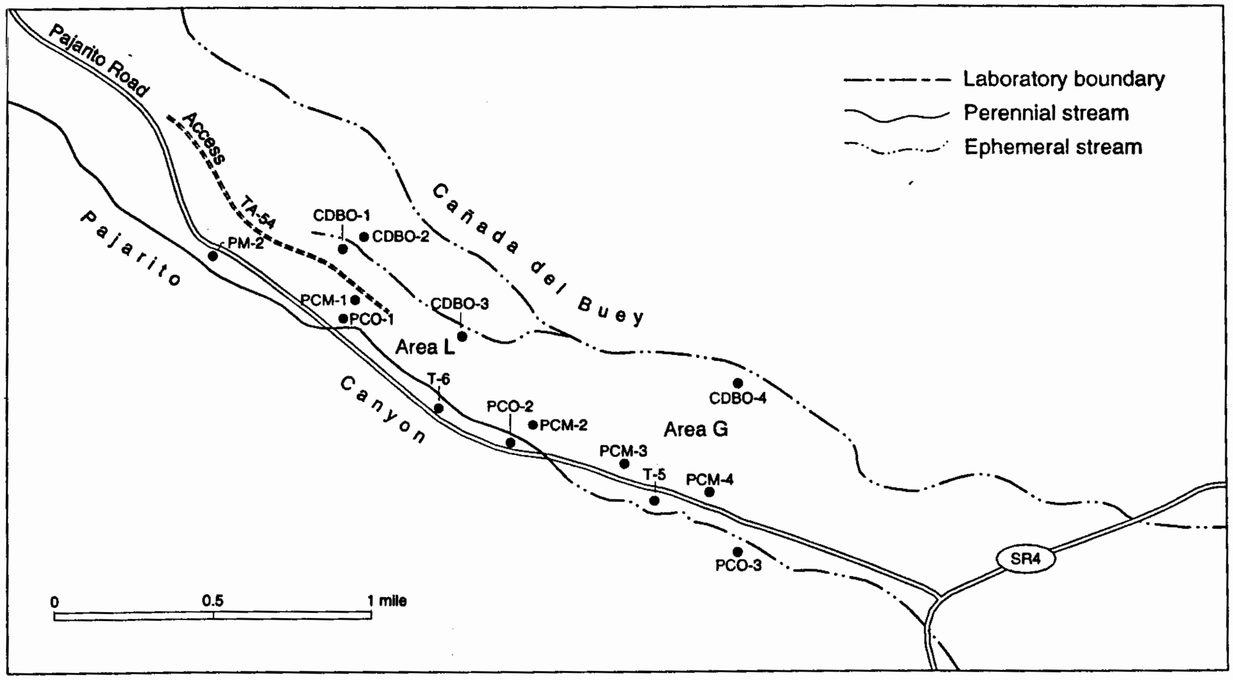

Fig. VII-A. Location of observation wells in Cañada del Buey (CDBO-series) and Pajarito Canyon (PCO-series) and moisture-access holes in Pajarito Canyon (PCM-series) (Purtymun 1985).

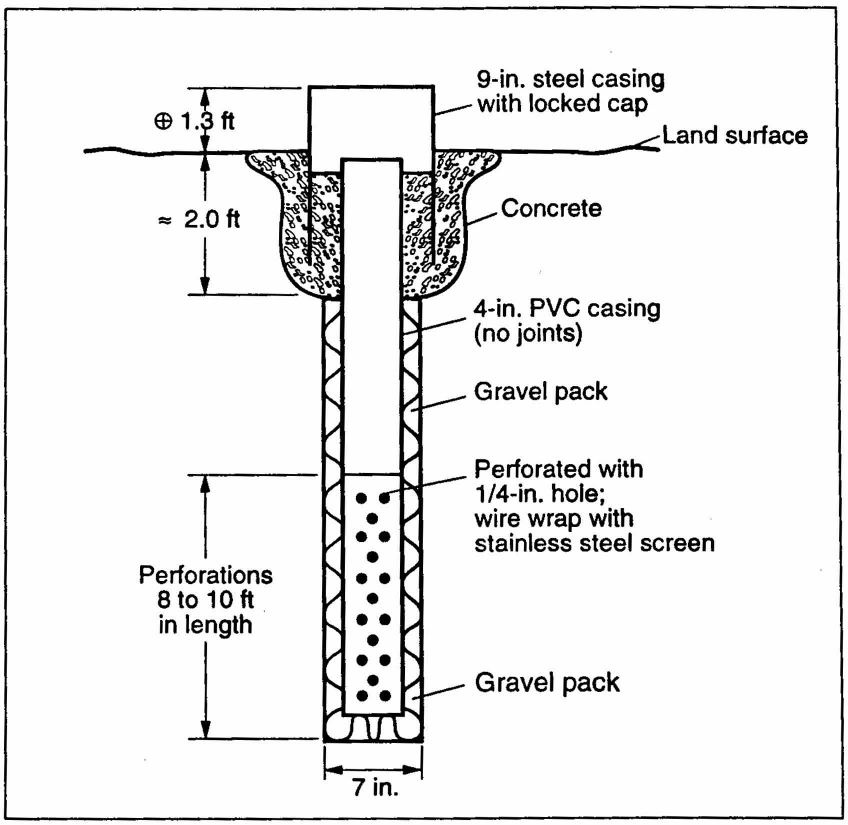

Fig. VII-B. Typical observation well construction in Cañada del Buey and Pajarito Canyon (Purtymun 1985).

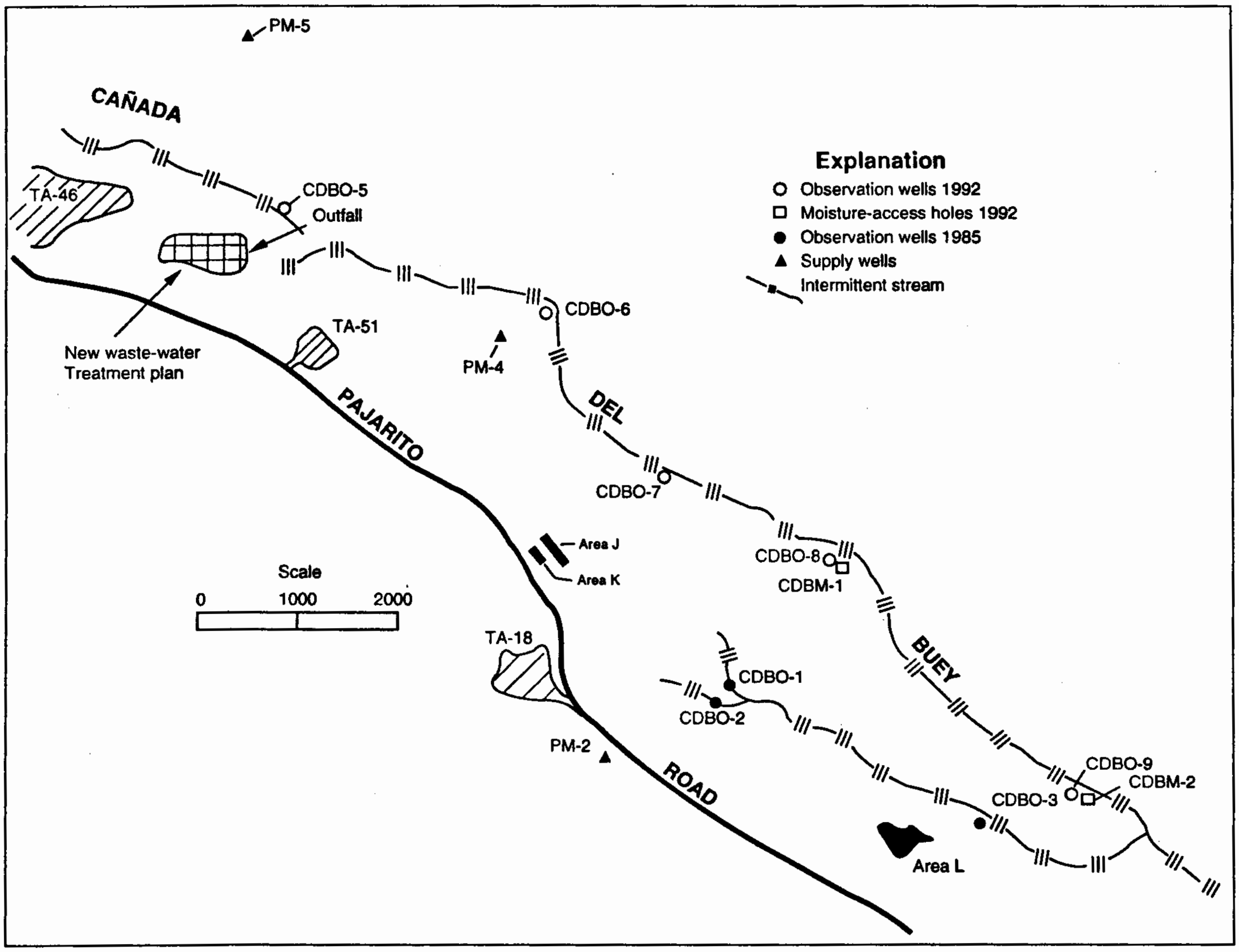

Fig. VII-C. Location of observation wells and moisture-access holes in Cañada del Buey (Purtymun 1992).

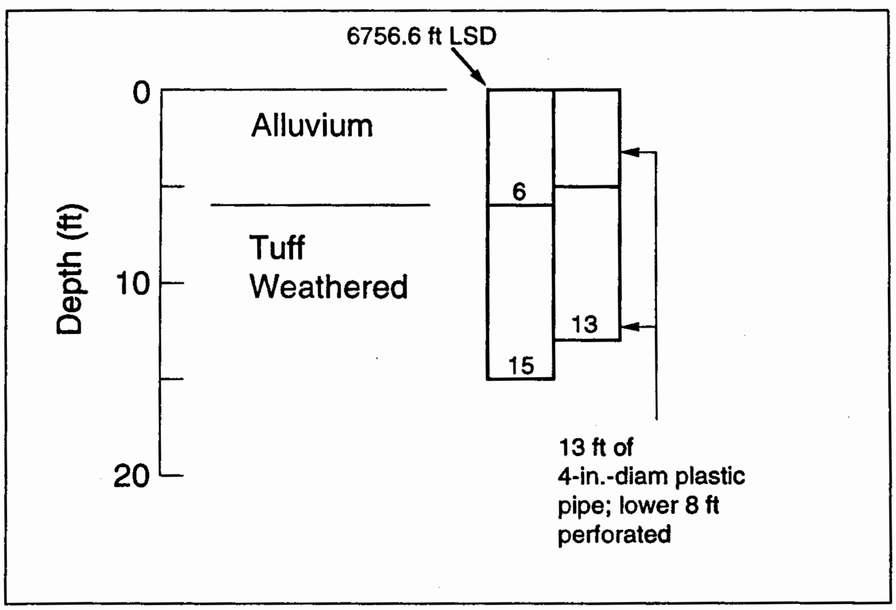

Fig. VII-D. Geologic log and casing schedule of observation well CDBO-1, dry (Purtymun 1985).

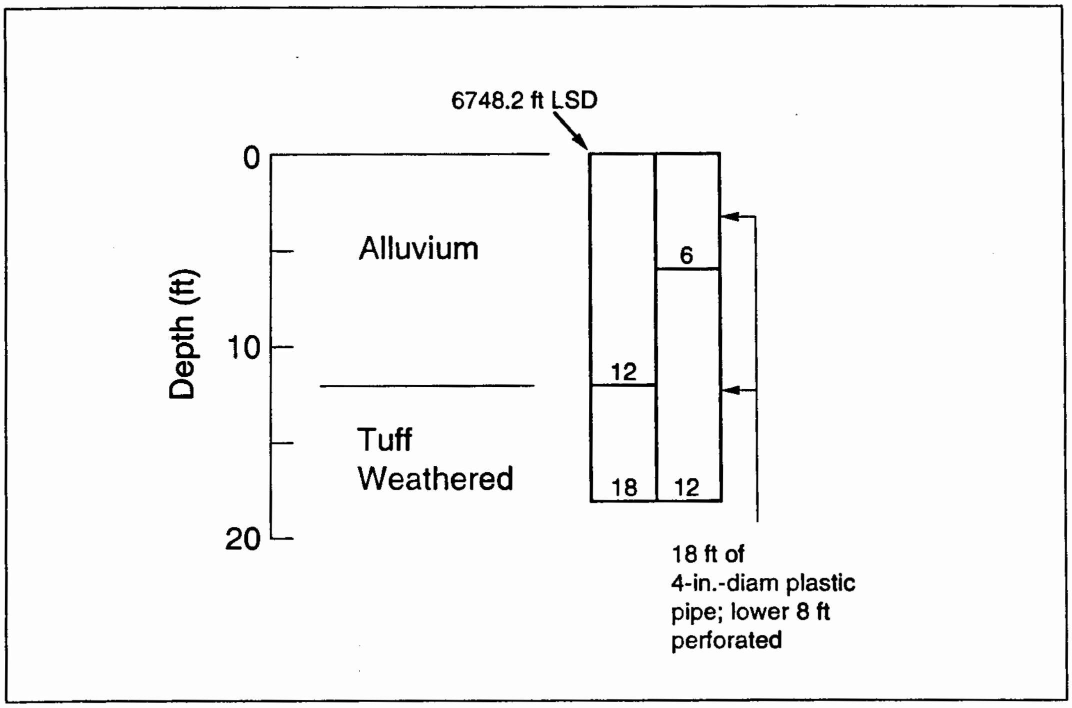

Fig. VII-E. Geologic log and casing schedule of observation well CDBO-2, dry (Purtymun 1985).

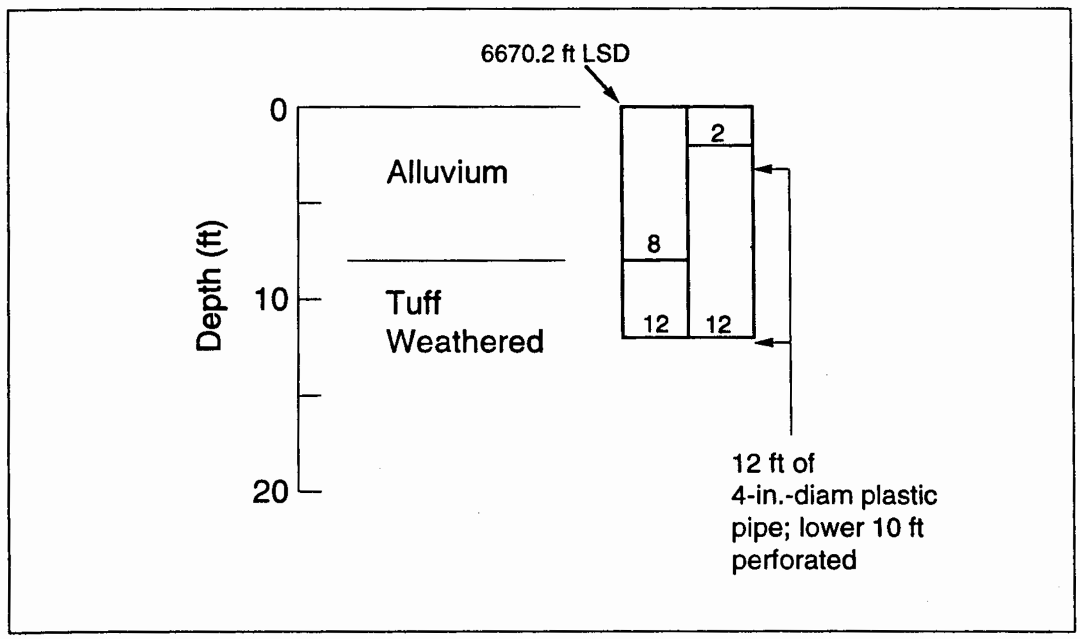

Fig. VII-F. Geologic log and casing schedule of observation well CDBO-3, dry (Purtymun 1985).

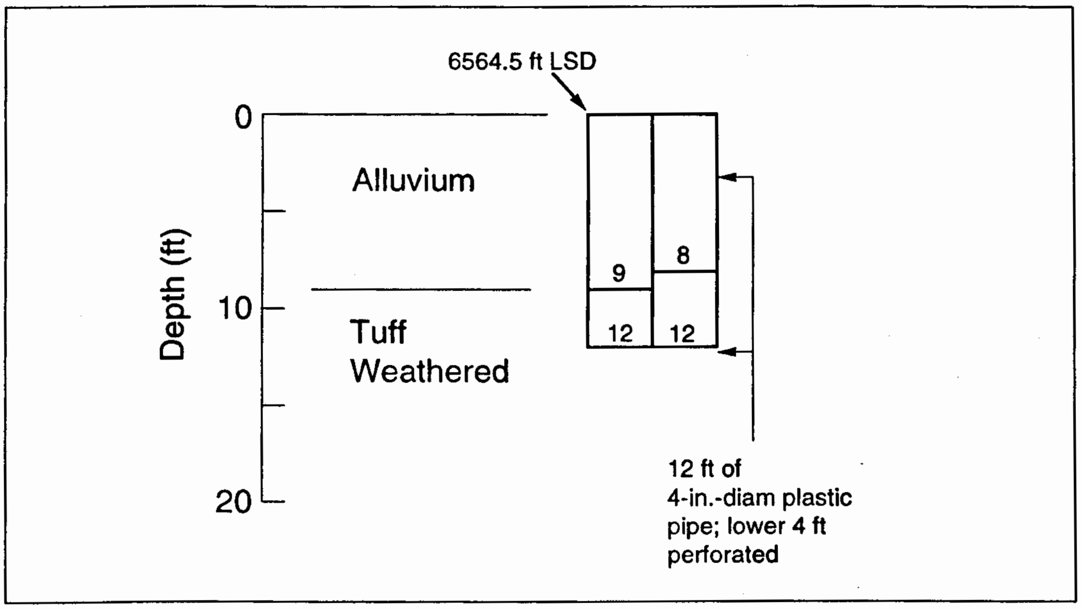

Fig. VII-G. Geologic log and casing schedule of observation well CDBO-4, dry (Purtymun 1985).

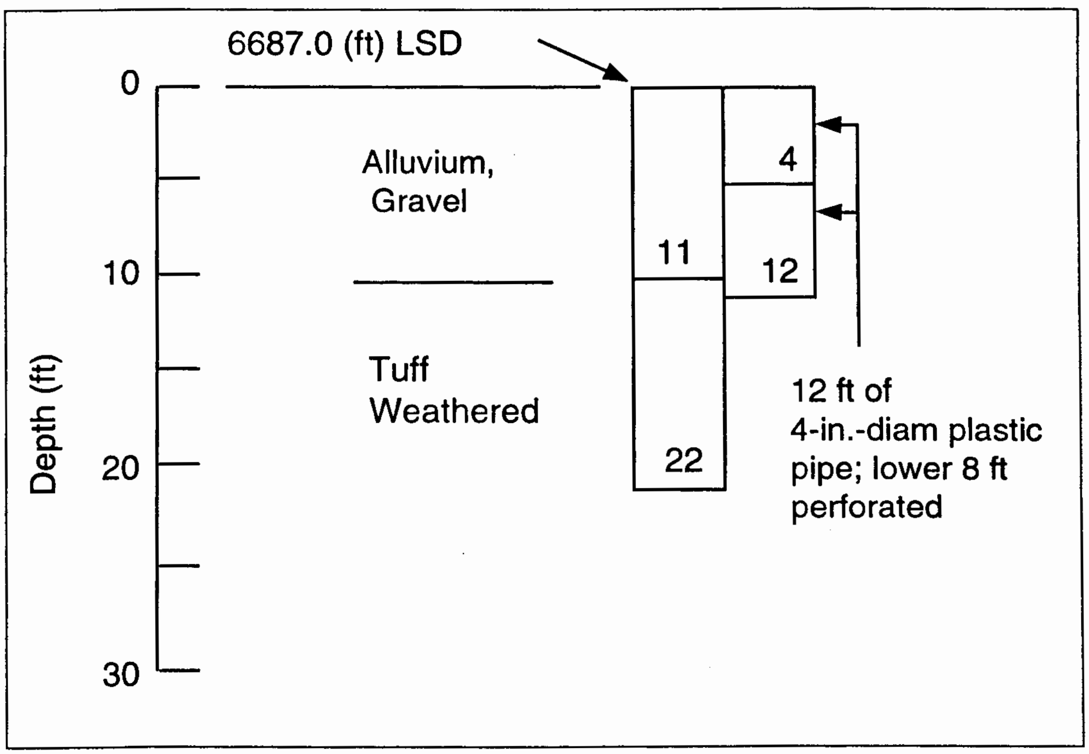

Fig. VII-H. Geologic log and casing schedule of observation well PCO-1, water level 1.3 ft (Purtymun 1985).

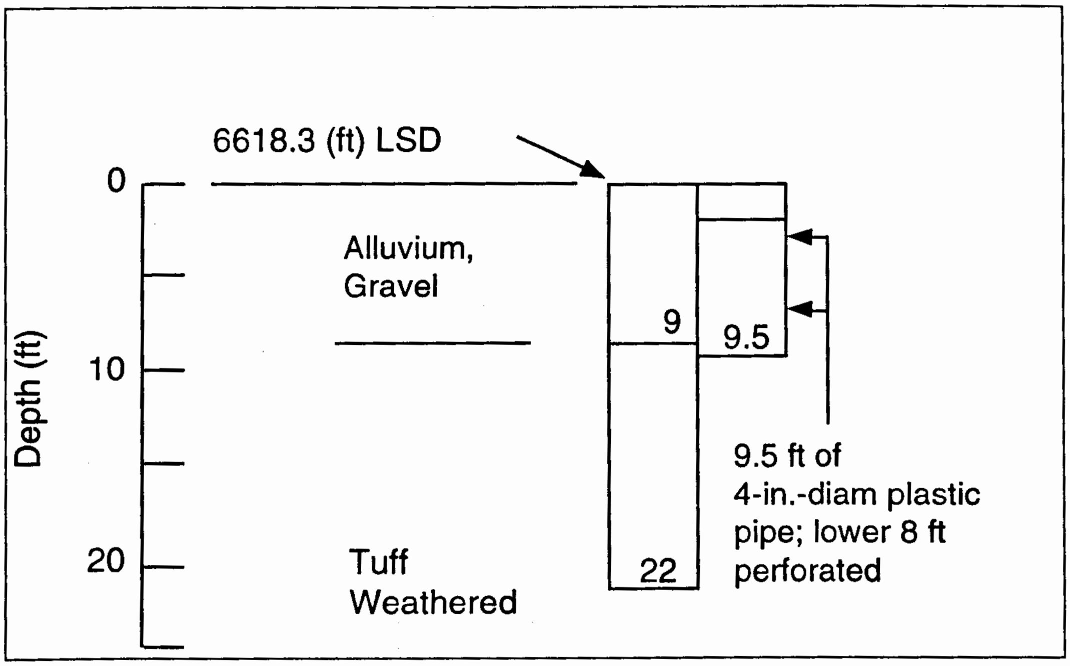

Fig. VII-I. Geologic log and casing schedule of observation well PCO-2, water level 6.3 ft (Purtymun 1985).

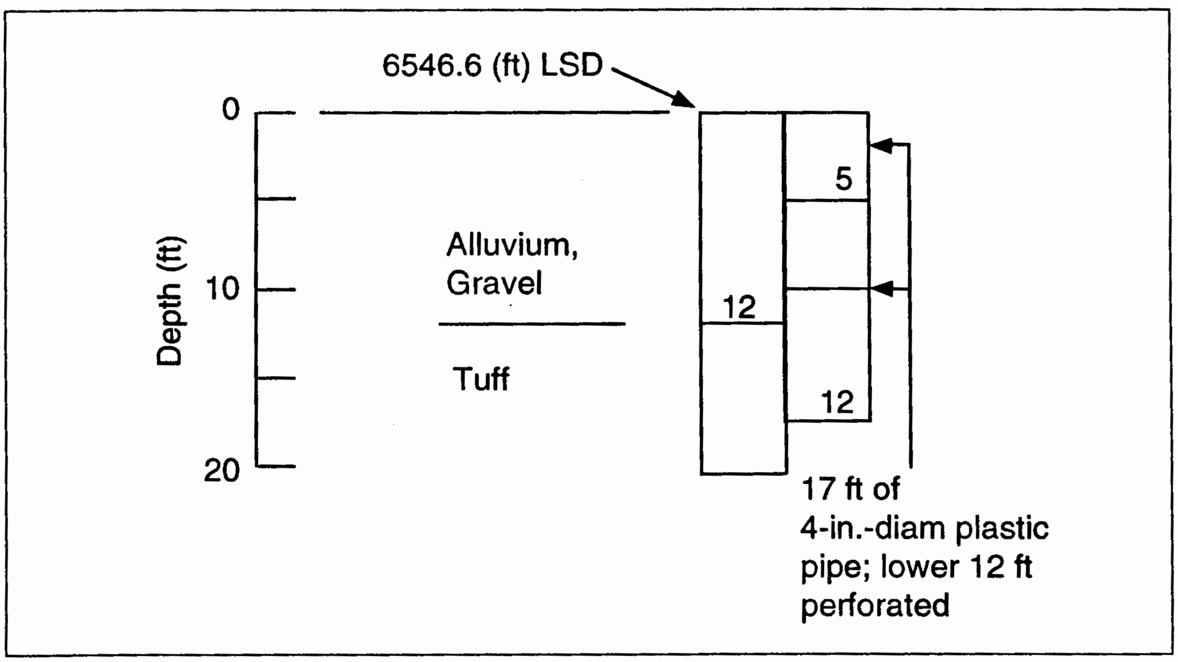

Fig. VII-J. Geologic log and casing schedule of observation well PCO-3, water level 3.1 ft (Purtymun 1985).

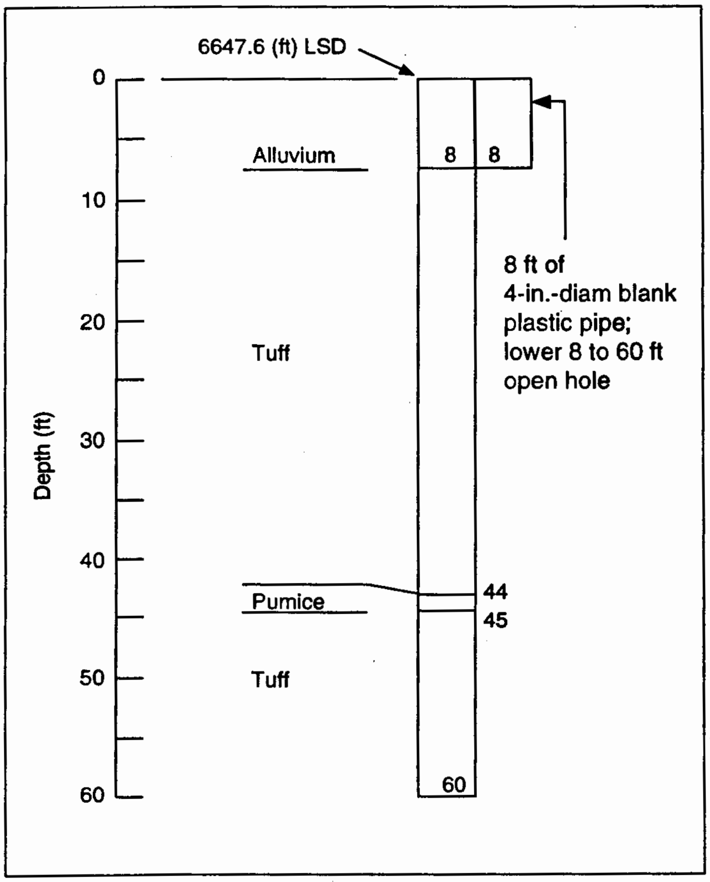

Fig. VII-K. Geologic log and casing schedule of test hole PCM-1, dry (Purtymun 1985).

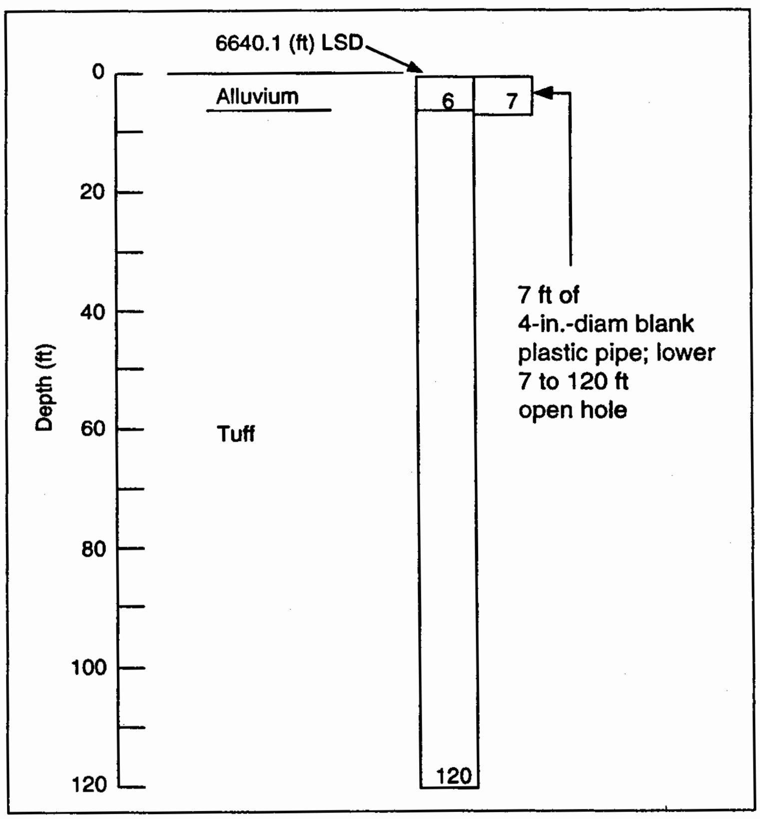

Fig. VII-L. Geologic log and casing schedule of test hole PCM-2, dry (Purtymun 1985).

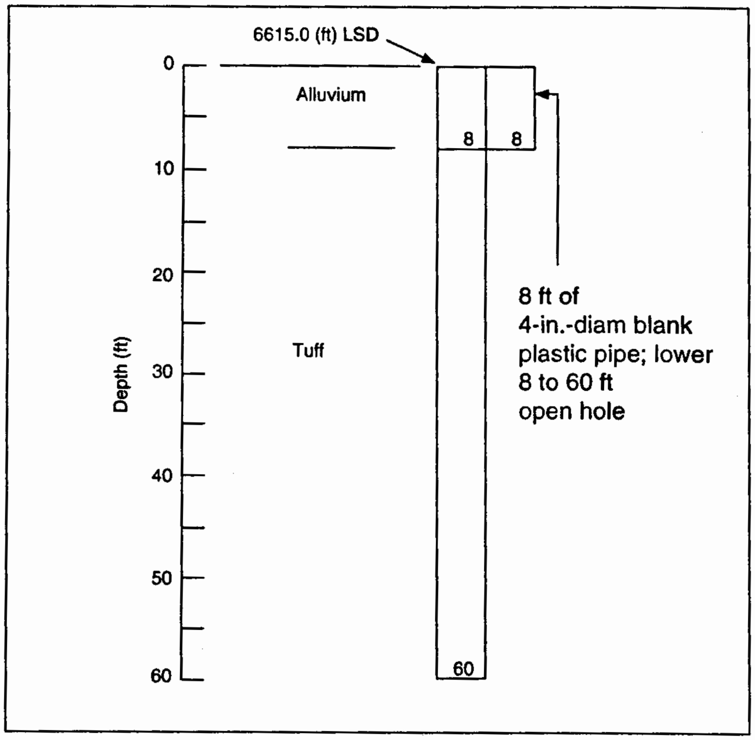

Fig. VII-M. Geologic log and casing schedule of test hole PCM-3, dry (Purtymun 1985).

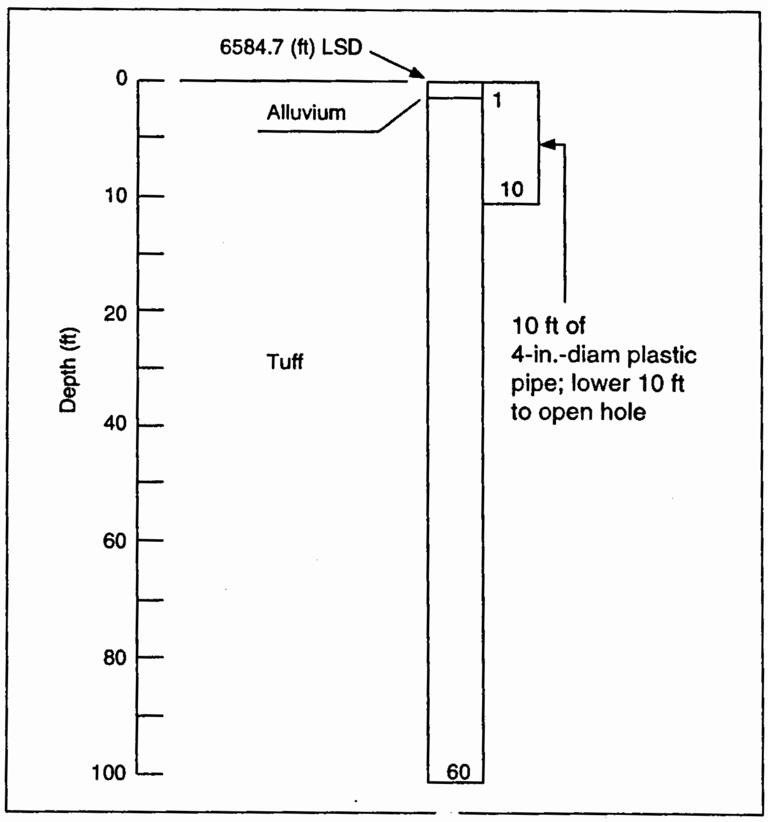

Fig. VII-N. Geologic log and casing schedule of test hole PCM-4, dry (Purtymun 1985).

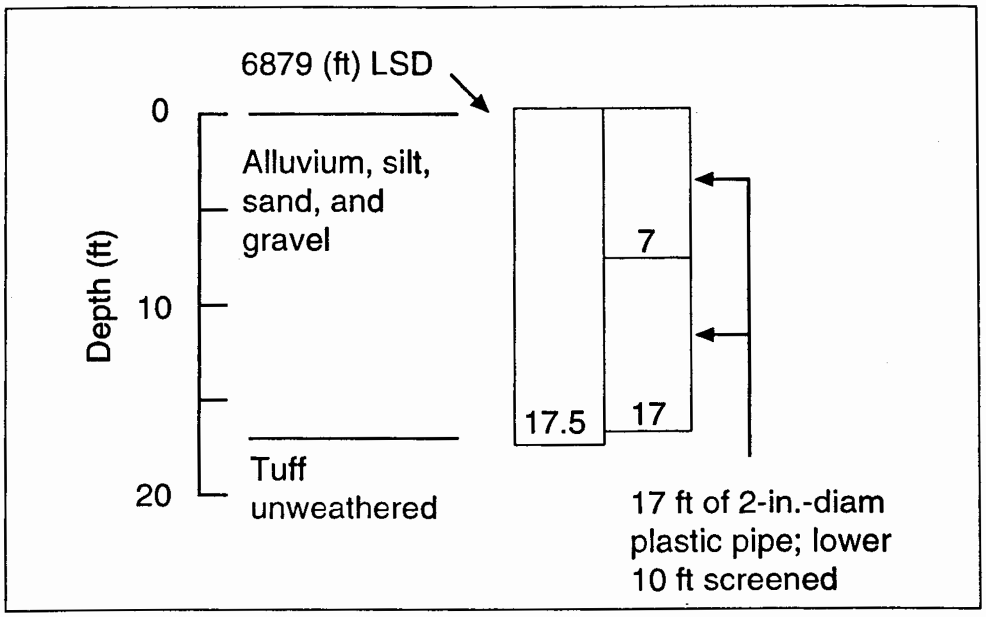

Fig. VII-O. Geologic log and casing schedule of observation well CDBO-5, dry (Purtymun 1992).

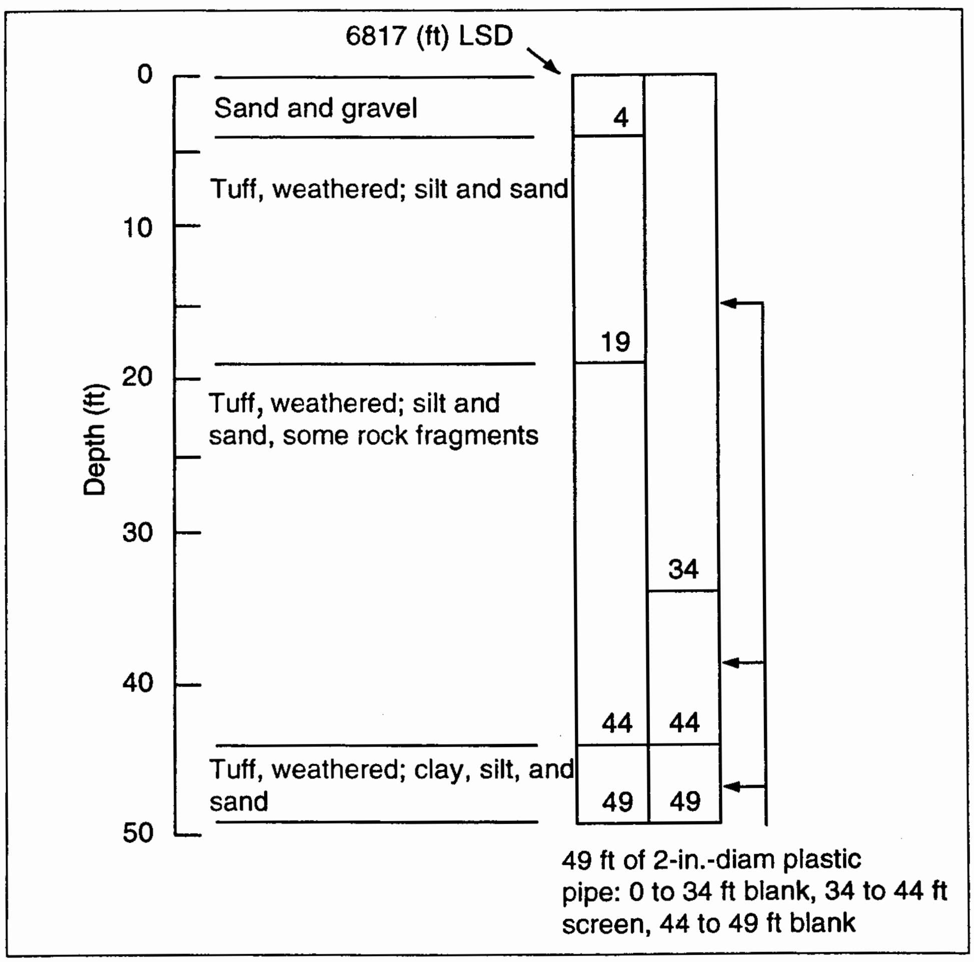

Fig. VII-P. Geologic log and casing schedule of observation well CDBO-6, perched water (Purtymun 1992).

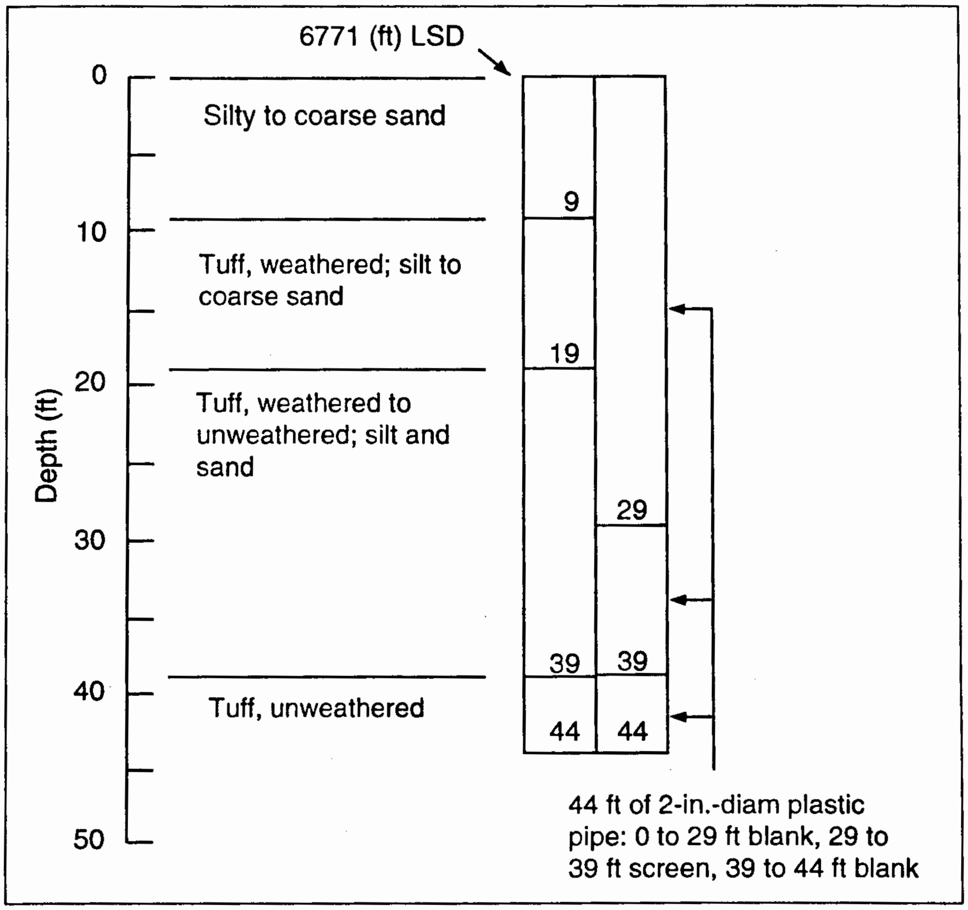

Fig. VII-Q. Geologic log and casing schedule of observation well CDBO-7, perched water (Purtymun 1992).

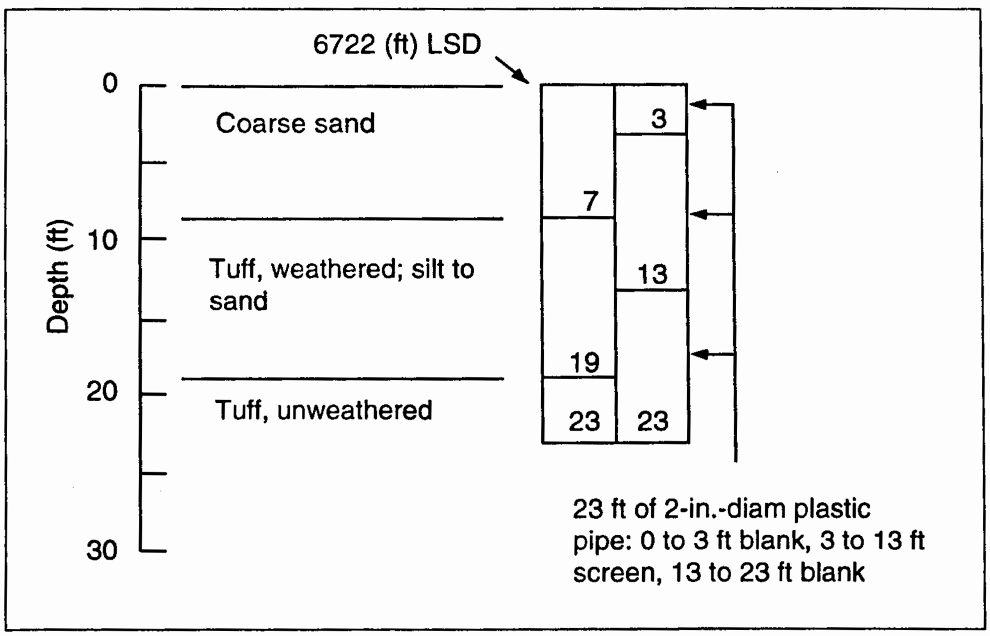

Fig. VII-R. Geologic log and casing schedule of observation well CDBO-8, dry (Purtymun 1992).

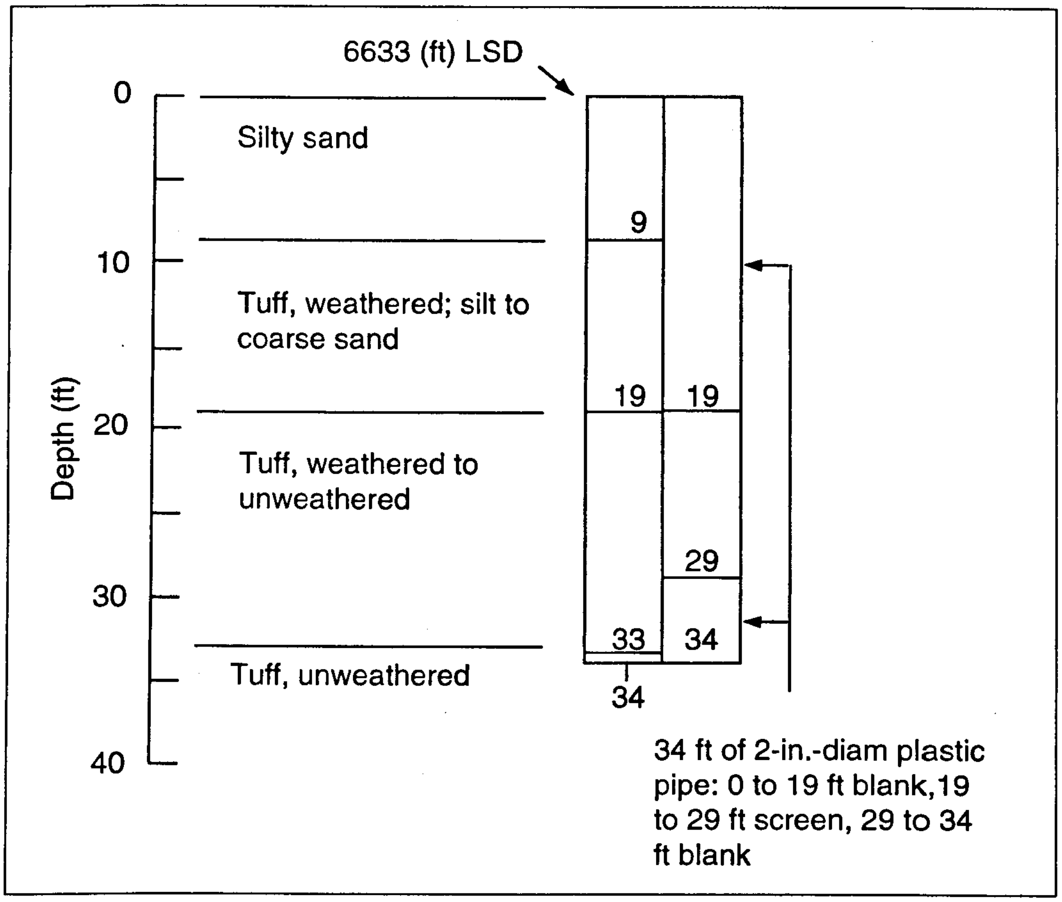

Fig. VII-S. Geologic log and casing schedule of observation well CDBO-9, dry (Purtymun 1992).

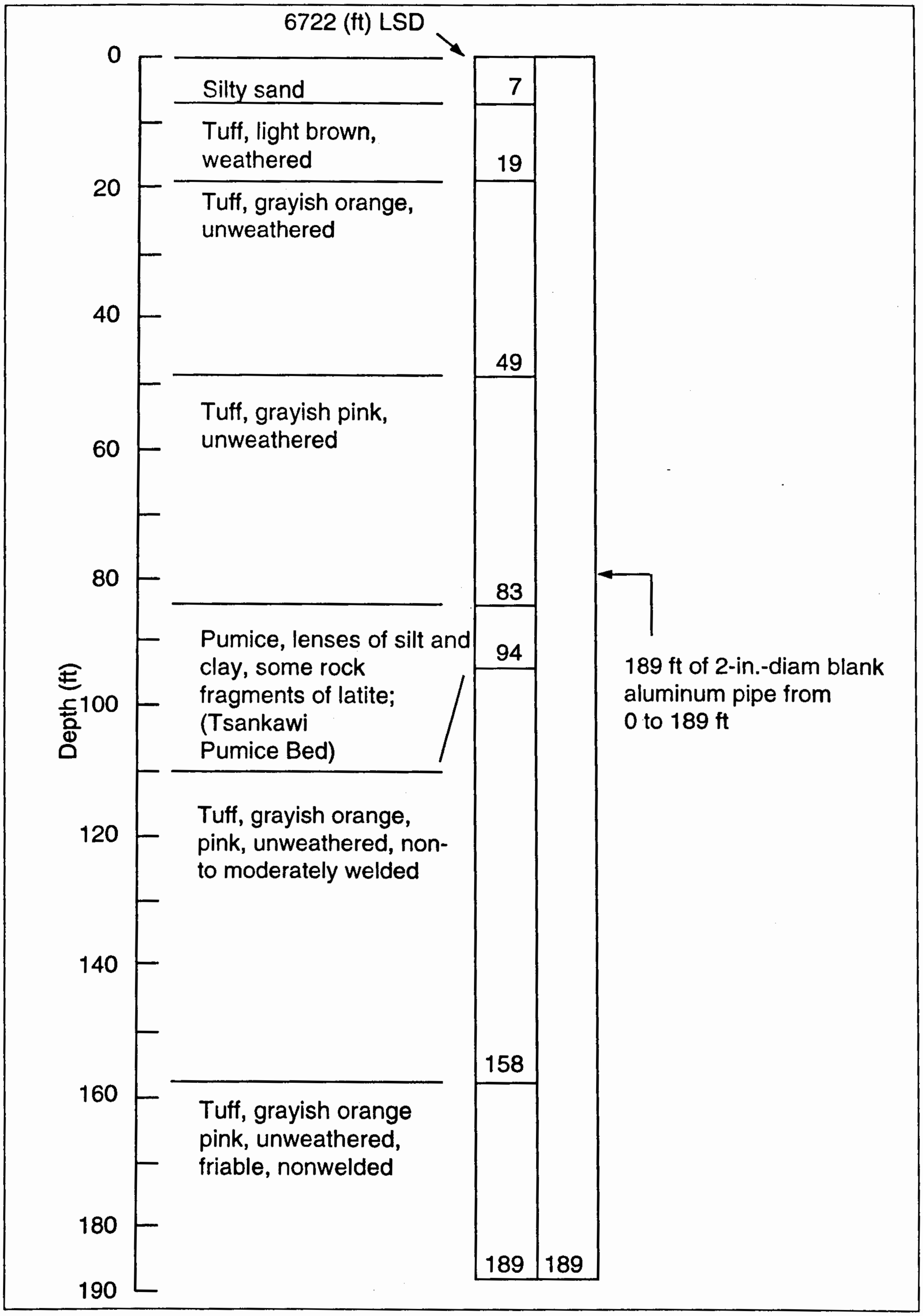

Fig. VII-T. Geologic log and casing schedule of moisture-access hole CDBM-1, dry (Purtymun 1992).

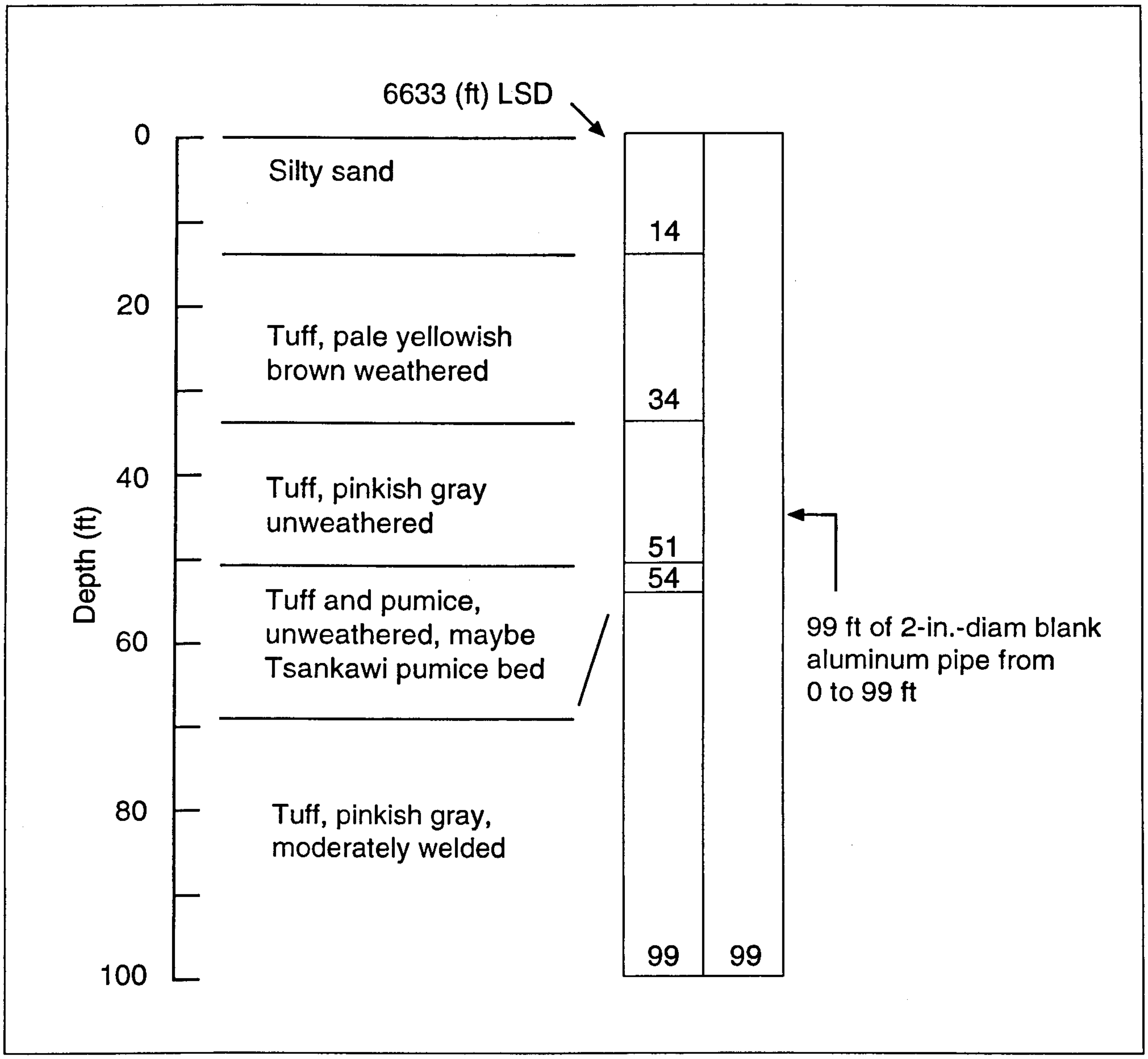

Fig. VII-U. Geologic log and casing schedule of moisture-access hole CDBM-2, dry (Purtymun 1992).

TABLE VII-A. Geologic Logs and Construction Data for Observation Wells in Cañada del Buey (4 Obs. Wells)

1. Observation Well CDBO-1

Elevation (LSD) 6757.6 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium, light brown, silty sand with some clay	6	6
Tuff, brown, weathered with quartz and sanidine crystals and crystal fragments, (weathered tuff estimated 20 to 30% silt and clay)	9	15

Construction
13.1 ft of 4-in.-diam plastic pipe set 0 to 13.1 ft, lower 8 ft perforated. Cement 0 to 2 ft; gravel packed 2 to 13 ft.

2. Observation Well CDBO-2

Elevation (LSD) 6748.2 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium, light brown silty sand, some clay	12	12
Tuff, brown, weathered with quartz and sanidine crystals and crystal fragments; some rock fragments (weathered tuff estimated 20 to 30% silt and clay)	6	18

Construction
17.9 ft of 4-in.-diam plastic pipe set 0 to 17.9 ft, lower 12 ft perforated. Cement 0 to 2 ft; gravel packed 2 to 18 ft.

3. Observation Well CDBO-3

Elevation (LSD) 6670.2 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium, light brown, silty sand, some clay	8	8
Tuff, light gray, quartz and sanidine crystals and crystal fragments, small rock fragments, slight amount of clay as a result of weathering	4	12

Construction
12.4 ft of 4-in.-diam plastic pipe set 0 to 12.4 ft lower 10 ft perforated. Cement 0 to 2 ft; gravel packed 2 to 12 ft.

TABLE VII-A. Geologic Logs and Construction Data for Observation Wells in Cañada del Buey (4 Obs. Wells) (Continued)

4. Observation Well CDBO-4

Elevation (LSD) 6564.5 ft

Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium, light brown, silty sand with some clay	9	9
Tuff, light gray, quartz and sanidine crystals and crystal fragments, some small rock fragments, slight amount of clay as a result of weathering	3	12

Construction

12.1 ft of 4-in.-diam plastic pipe set 0 to 12.1 ft, lower 4 ft perforated. Cement 0 to 2 ft; gravel packed 2 to 12 ft.

Source: Purtymun 1985.

TABLE VII-B. Geologic Logs and Construction Data for Observation Wells in Pajarito Canyon (3 Obs. Wells)

1. Observation Well PCO-1

Elevation (LSD) 6687.0 ft — Water Level: 1.3 ft (1985)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium, light brown, gravel, cobbles, and boulders in a matrix of clay, silt, and sand	11	11
Tuff, light reddish brown, weathered, quartz and sanidine crystal fragments, a few rock fragments of latite and rhyolite	11	22

Construction
12.3 ft of 4-in.-diam plastic pipe set 0 to 12.3 ft, lower 8 ft perforated. Cement 0 to 2 ft; gravel packed 2 to 12 ft.

2. Observation Well PCO-2

Elevation (LSD) 6618.3 ft — Water Level: 6.3 ft (1985)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium, light brown, gravels, cobbles, and boulders in a matrix of of clay, silt, and sand	9	9
Tuff, light reddish brown, nonwelded to moderately welded, quartz and sanidine crystal fragments, a few small rock fragments	13	22

Construction
9.5 ft of 4-in.-diam plastic pipe set 0 to 9.5 ft, lower 8 ft perforated. Cement 0 to 1 ft; gravel packed 1 to 9 ft.

3. Observation Well PCO-3

Elevation (LSD) 6546.3 ft — Water Level: 3.1 ft (1985)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium, light brown, gravel with a few cobbles in a matrix of silty sand	12	12
Tuff, light gray to light brown, weathered, some quartz and sanidine crystal fragments, a few small rock fragments in a matrix of weathered tuff, mostly silts and clay	8	20

Construction
17.7 ft of 4-in.-diam plastic pipe set 0 to 17.7 ft, lower 12 ft perforated. Cement 0 to 2 ft; gravel packed 2 to 18 ft.

Source: Purtymun 1985.

TABLE VII-C. Geologic Logs and Construction Data for Moisture-Access Holes in Pajarito Canyon (4 Moisture-Access Holes)

1. Test Hole PCM-1

Elevation (LSD) 6697.6 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	8	8
Tuff, reddish brown, pumice layer at 44 ft	52	60

Construction
8.3 ft of 4-in.-diam plastic pipe cemented in hole 0 to 8.3 ft.

2. Test Hole PCM-2

Elevation (LSD) 6640.1 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium, weathered tuff, silt and clay	6	6
Tuff, light gray to pinkish brown, pumice and rock fragments	114	120

Construction
7.2 ft of 4-in.-diam plastic pipe cemented in hole 0 to 7.2 ft.

3. Test Hole PCM-3

Elevation (LSD) 6615.0 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	8	8
Tuff, light pink, numerous rock fragments at 13 ft pumice fragments at 14 ft	52	60

Construction
8.3 ft of 4-in.-diam plastic pipe cemented in hole 0 to 8.3 ft.

4. Test Hole PCM-4

Elevation (LSD) 6584.7 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	1	1
Tuff, light grayish pink changing to brownish gray at 14 ft, reddish brown at 25 ft	59	60

Construction
9.7 ft of 4-in.-diam plastic pipe cemented in hole 0 to 9.7 ft.

Source: Purtymun 1985.

TABLE VII-D. Geologic Logs and Construction Data for Observation Wells in Cañada del Buey (1992)

1. Obs. Well CDBO-5

Elevation (LSD) 6879 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Silt and sand	10	10
Silt, sand, very moist	2	12
Very coarse sand and some gravel	5	17
Tuff (unweathered)	0.5	17.5

Construction

17 ft of 2-in.-diam plastic pipe; screen (0.010-in. slots) 7 to 17 ft; blank 0 to 7 ft. Packed (0.010–0.020-in. sand) 1 to 17 ft; cement in 0 to 1 ft with security cap.

2. Obs. Well CDBO-6

Elevation (LSD) 6817 ft — Water Level: Perched Water

Geologic Log	Thickness (ft)	Depth (ft)
Coarse sand with some clay to silt lenses (Alluvium)	4	4
Tuff, weathered grayish brown, silty sand	15	19
Tuff, weathered moderately yellowish brown (10 YR -5/4) to dark yellowish brown (10 YR - 4/2) quartz and sanidine crystals, some rock fragments of latite and pumice, moderately welded	25	44
Tuff, weathered, similar to above, containing silts and clays; water perched above this unit	5	49

Construction

49 ft of 2-in.-diam plastic pipe; 44 to 49 ft blank, 44 to 34 ft screen (0.010-in. slots), blank 0 to 34 ft; gravel packed with 0.010–0.020-in. silica sand 8 to 49 ft; bentonite 3 to 8 ft; cement 0 to 3 ft with security cap.

3. Obs. Well CDBO-7

Elevation (LSD) 6771 ft — Water Level: Perched Water

Geologic Log	Thickness (ft)	Depth (ft)
Silty sand to coarse sand (Alluvium)	9	9
Tuff, weathered, silty to coarse sand, friable	10	19
Tuff, weathered to unweathered, made up of quartz and sanidine crystals, rock fragments of latite, unweathered pumice fragments	20	39
Tuff, unweathered	5	44

Construction

44 ft of 2-in.-diam plastic pipe; 39 to 44 ft blank; 29 to 39 ft screen (0.010-in. slots), packed with 0.010–0.020-in. silica sand 4 to 44 ft; bentonite 2.5 to 4 ft; cement 0–25 ft with security cap.

TABLE VII-D. Geologic Logs and Construction Data for Observation Wells in Cañada del Buey (1992) (Continued)

4. Obs. Well CDBO-8

Elevation (LSD) 6722 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Coarse sand (alluvium)	7	7
Tuff, weathered pale yellowish brown (10 YR 6/2) containing a few rock fragments of pumice, rounded latite, and a few chunks of unweathered tuff	12	19
Tuff, unweathered, grayish orange pink, (5 YR 7/2) quartz and sanidine crystals, a few rock fragments of latite, and some pumice	4	23

Construction

23 ft of 2-in.-diam plastic pipe; blank 13 to 23 ft; screen (0.010 in. slots) 3 to 13 ft; blank 0 to 3 ft; packed with 0.010–0.020-in. silica sand 8 to 23 ft; bentonite 6 to 8 ft; cement surface to 6 ft with security cap.

5. Obs. Well CDBO-9

Elevation (LSD) 6633 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Silty sand with some brown clay	9	9
Tuff, weathered, silt to coarse sand (weathered in place)	10	19
Tuff, weathered to unweathered, silt to coarse sand (weathered in place)	14	33
Tuff, unweathered, pinkish gray (5 YR 8/1) some pumice fragments	1	34

Construction

34 ft of 2-in.-diam plastic pipe: 29 to 34 ft blank; 19 to 29 ft screen (0.010-in. slots); 0 to 19 ft blank; gravel packed with 0.010–0.020-in. silica sand 7 to 34 ft; bentonite 2 to 7 ft; cement 0 to 2 ft with a security cap.

Source: Purtymun 1992.

TABLE VII-E. Geologic Logs and Construction Data of Moisture-Access Holes in Cañada del Buey

1. Moisture-Access Hole CDBM-1

Elevation (LSD) 6722 ft — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Silty sand (alluvium)	7	7
Tuff, weathered, light brown (5 YR 6/4), to pale red (10R 6/2) quartz and sanidine crystals, rock fragments of pumice and some fragments of unweathered tuff (tuff weathered in place)	12	19
Tuff, unweathered, moderately welded, grayish orange (10 R 7/4) quartz and sanidine crystal and crystal fragments of gray pumice and latite, is a non- to moderately welded ash matrix (Unit 1A)	30	49
Tuff, unweathered, grayish pink (5 R 8/2), containing alternating beds of pumice and tuff, rock fragments of latite and quartz crystals and crystal fragments, ranges from nonwelded to moderately welded; 69 to 83 ft tuff unweathered, very light gray (N-8), nonwelded to moderately welded, rock fragments of pumice and latite, with occasional quartz and sanidine fragments	34	83
Pumice, some weathering with some latite rock fragments; some lenses of clay and silt (Tsankawi Pumice Bed)	11	94
Tuff, unweathered, grayish orange pink (5 YR 7/2) non- to moderately welded, quartz and sanidine crystals and crystal fragments, rock fragments of latite, rhyolite, and white to pink pumice (Otowi Member)	64	158
Tuff, grayish orange pink, unweathered, friable, nonwelded	31	189

Construction

189 ft of 2-in.-diam aluminum pipe, 0 to 189 ft; packed with 0.010–0.020-in. sand 19 to 189 ft; bentonite 4 to 19 ft; cement 0 to 4 ft with security cap.

TABLE VII-E. Geologic Logs and Construction Data of Moisture-Access Holes in Cañada del Buey (Continued)

2. Moisture-Access Hole CDBM-2

Elevation (LSD) 6633 ft | Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Silty to coarse sand, pale brown (5 YR 5/2) made up of quartz and sanidine crystals and crystal fragments, rock fragments of pumice	14	14
Tuff, weathered, pale yellowish brown (10 YR 6/2), quartz and sanidine crystals and crystal fragments, rock fragments of pumice	20	34
Tuff, unweathered, pinkish gray (5 YR 8/1) quartz and sanidine crystals and crystal fragments, some rock fragments of latite and pumice	17	51
Tuff and pumice, unweathered, moderate brown (5 YR 4/4) moderately welded, quartz and sanidine crystals, a few small rock fragments of rhyolite and numerous white pumice fragments in a brown ash matrix (Tsankawi Pumice Bed)	3	54
Tuff, unweathered, pinkish gray (5 R 8/1) moderately welded, quartz and sanidine crystals and crystal fragments, rock fragments of latite up to 1/2 in. long; pumice, light gray up to 1 in. long in a brown ash matrix	45	99

Construction

99 ft of 2-in.-diam aluminum pipe 0 to 99 ft; packed with 0.010–0.020-in. silica sand 24 to 99 ft; bentonite 17 to 24 ft; cement 6 to 17 ft; cuttings 2 to 6 ft; cement 0 to 2 ft with a security cap.

Source: Purtymun 1992.

TABLE VII-F. Locations and Elevations (NAD 1927)

A. Surface Water Stations			
CDB near TA-46	N 1,766,665.5	E 491,630.6	6936.4 ft
PCS near Sewage Lagoon	N 1,758,100	E 498,900	6660.0 ft
PCS at SR-4	N 1,751,098	E 505,375	8484.0 ft
B. Observation Wells			
CDBO-1	N 1,760,881.9	E 497,724.4	6757.6 ft
CDBO-2	N 1,761,041.1	E 497,874.8	6748.2 ft
CDBO-3	N 1,759,549.0	E 500,432.9	6670.2 ft
CDBO-4	N 1,758,484.9	E 505,230.8	6564.5 ft
PCO-1	N 1,759,928.6	E 497,675.1	6687.0 ft
PCO-2	N 1,757,380.0	E 501,456.2	6618.3 ft
PCO-3	N 1,755,427.3	E 505,844.4	6546.3 ft
C. Moisture-Access Holes			
PCM-1	N 1,760,100	E 497,700	6697.6 ft
PCM-2	N 1,757,700	E 501,600	6640.1 ft
PCM-3	N 1,757,100	E 502,800	6615.0 ft
PCM-4	N 1,756,500	E 504,200	6584.7 ft

TABLE VII-G. Locations and Elevations (NAD 1927)

A. Observation Wells			
CDBO - 5	N 1,765,756	E 493,339	6879 ft
CDBO - 6	N 1,764,698	E 495,965	6817 ft
CDBO - 7	N 1,763,239	E 497,156	6771 ft
CDBO - 8	N 1,762,304	E 499,050	6722 ft
CDBO - 9	N 1,759,640	E 501,874	6633 ft
B. Moisture-Access Holes			
CDBM - 1	N 1,762,293	E 499,052	6722 ft
CDBM - 2	N 1,759,635	E 501,882	6633 ft

VIII. OBSERVATION WELLS TO MEET SPECIAL PERMIT CONDITIONS

The special permit conditions (dictated by the operating permit issued to the Department of Energy and the Los Alamos National Laboratory by the U.S. Environmental Protection Agency) required construction of special observation wells to monitor the quality of water in the alluvium.

Observation wells were constructed in Pueblo Canyon (one well), Los Alamos Canyon (five wells), Sandia Canyon (two wells), Mortandad Canyon (five wells), Potrillo Canyon (one core hole), Fence Canyon (one well), and Water Canyon (three wells). Generalized location of the wells and core hole are shown on Fig. VIII-A.

The observation well elevations and measuring points are shown on Table VIII-A, while well characteristics and water levels are shown on Table VIII-B. The types of wellhead security locks used on these wells are shown in Fig. VIII-B. Graphic presentations of the geologic logs and construction data are shown in Figs. VIII-C through VIII-T.

The observation wells were constructed using a hollow-stem auger. The auger had an inside diameter of 6.25 in., and an outside diameter of 9.625 in. It was used with a 10.375-in.-diam bit. The holes were cased using 2-in.-diam plastic pipe in 5- or 10-ft lengths, with flush-joint, internal-upset, threaded-type connections. The hole packing material was 0.010–0.020-in.-diam Colorado silica sand with a compatible screen slot (of 0.010 in.) in the plastic casing.

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R. A. Bailey, R. L. Smith, and C. S. Ross, "Stratigraphic Nomenclature of the Volcanic Rocks of the Jemez Mountains, New Mexico," U.S. Geological Survey Bulletin 1274-P (1969).

Environmental Protection Group HSE-8, "Perched Zone Monitoring Wells Analytical Results," Los Alamos National Laboratory document LA-UR-90-4300.

W. D. Purtymun and A. K. Stoker, "Perched Zone Monitoring Well Installation," Los Alamos National Laboratory document LA-UR-90-3230.

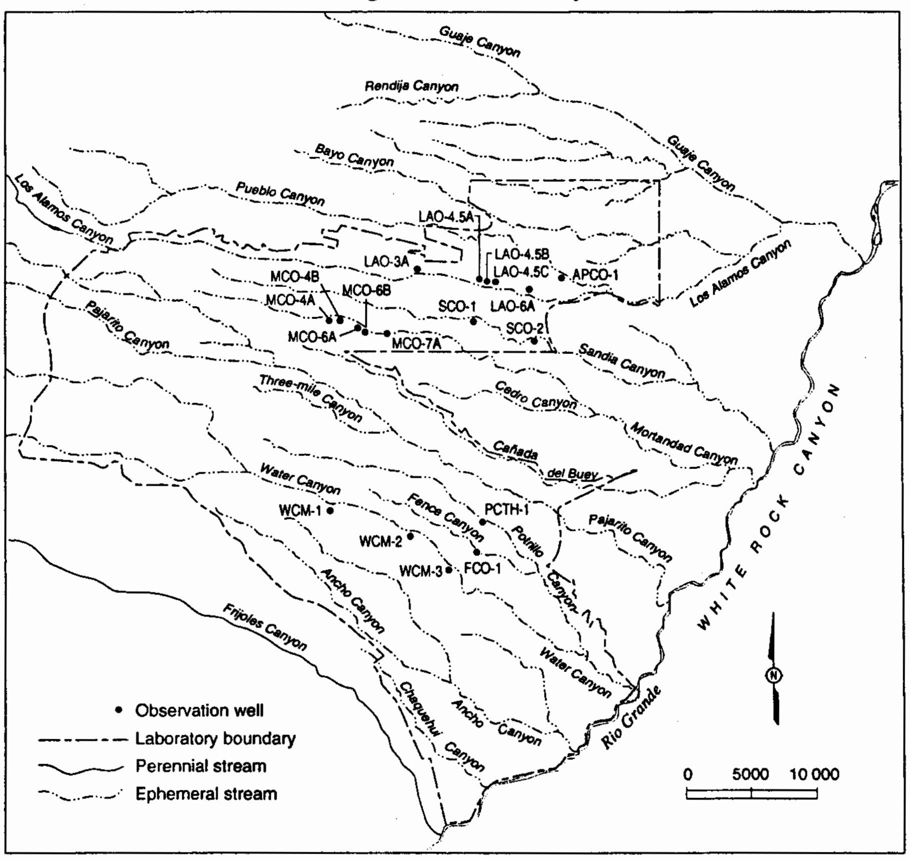

Fig. VIII-A. Locations of observation wells to meet special permit conditions.

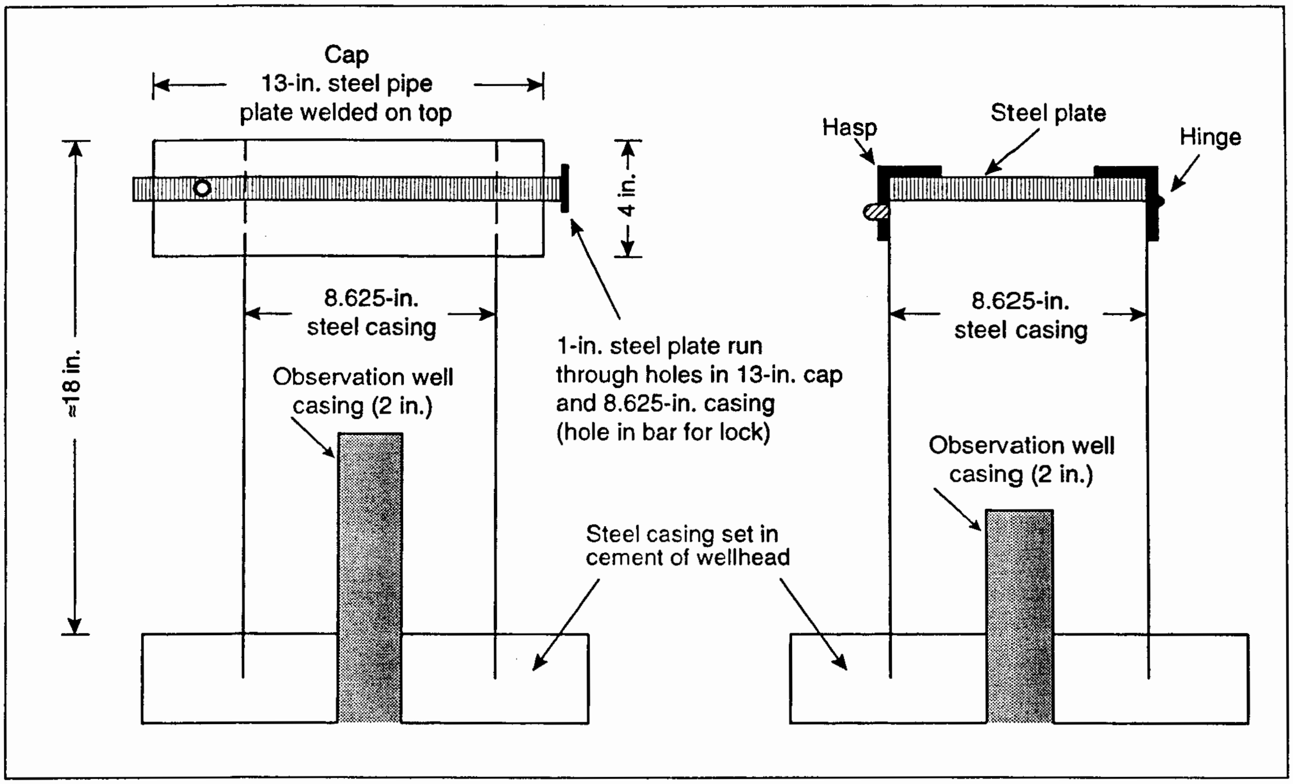

Fig. VIII-B. Type of wellhead security used on observation wells (Purtymun and Stoker 1990).

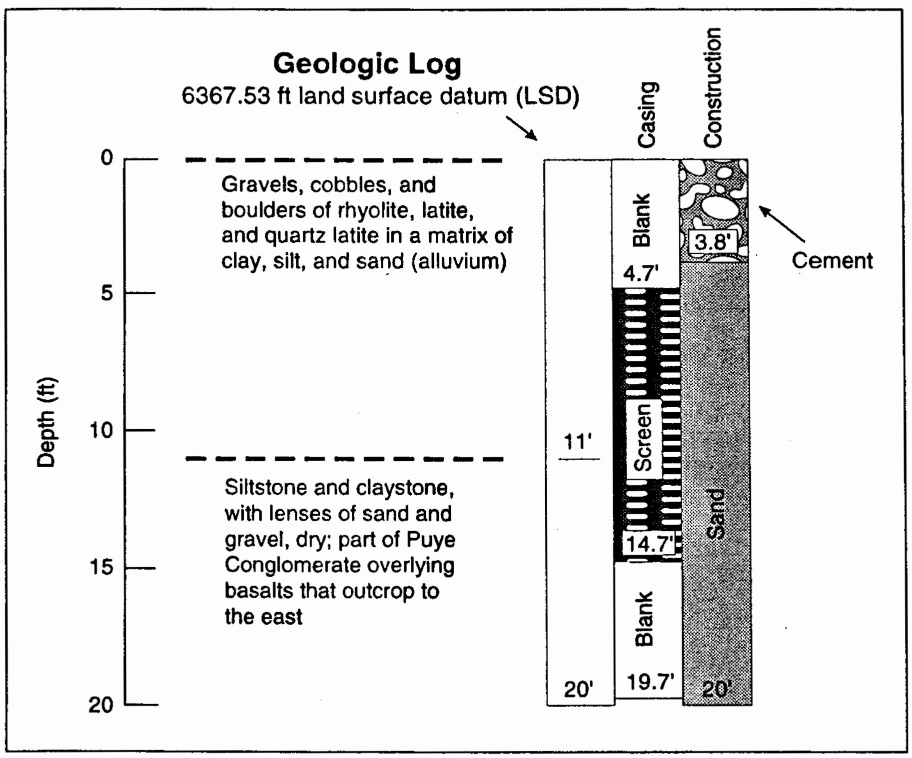

Fig. VIII-C. Pueblo Canyon observation well APCO-1, completed August 1990, water level 6.2 ft (Purtymun and Stoker 1990).

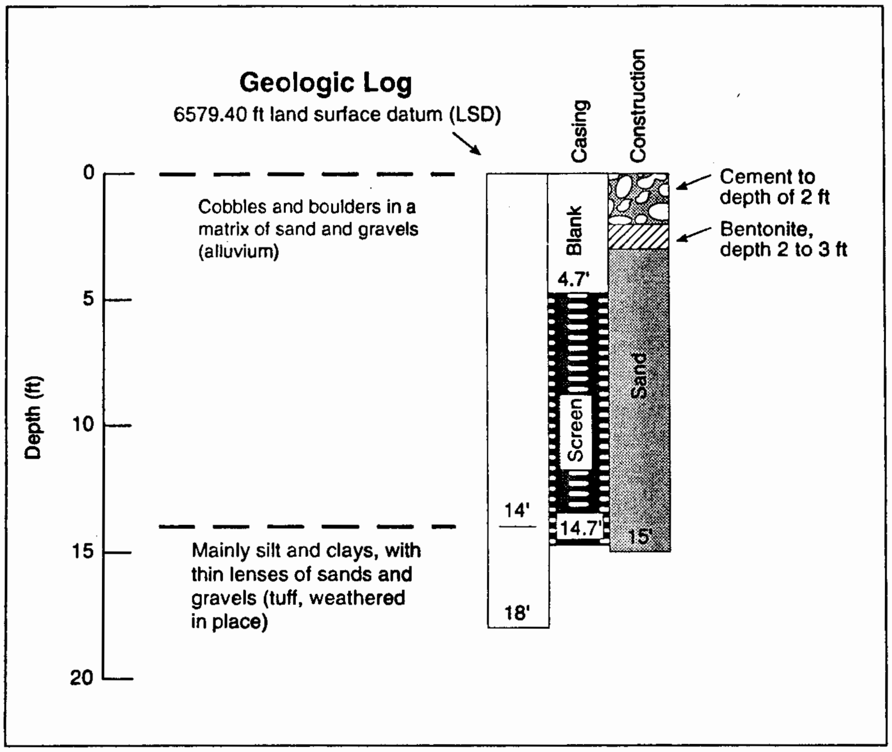

Fig. VIII-D. Los Alamos Canyon observation well LAO-3A, completed September 1989, water level 6.7 ft (Purtymun and Stoker 1990).

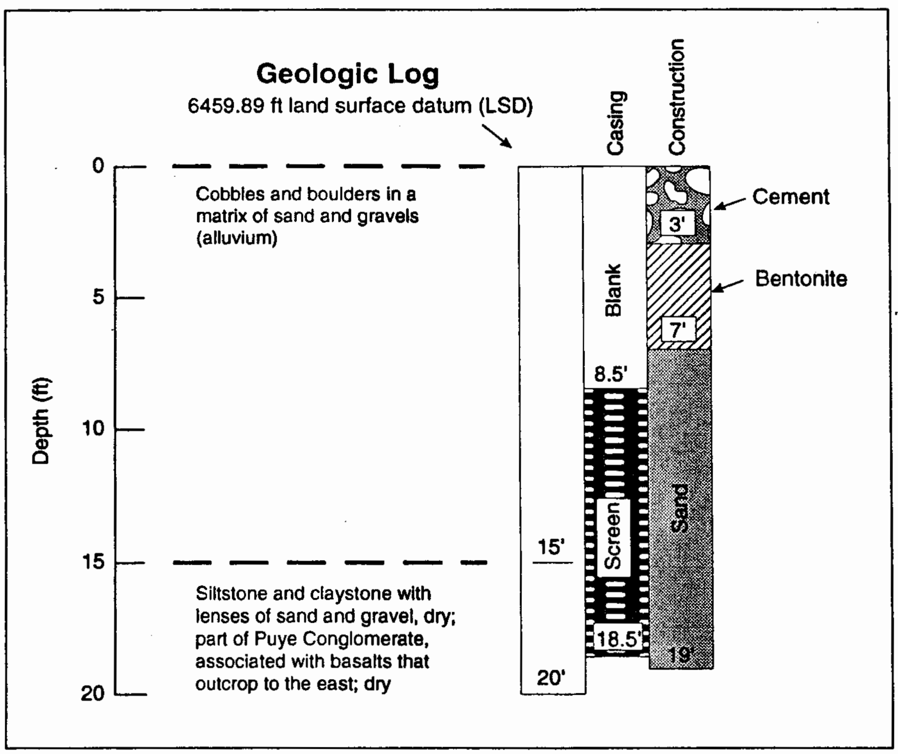

Fig. VIII-E. Los Alamos Canyon observation well LAO-4.5A, completed September 1989, dry (Purtymun and Stoker 1990).

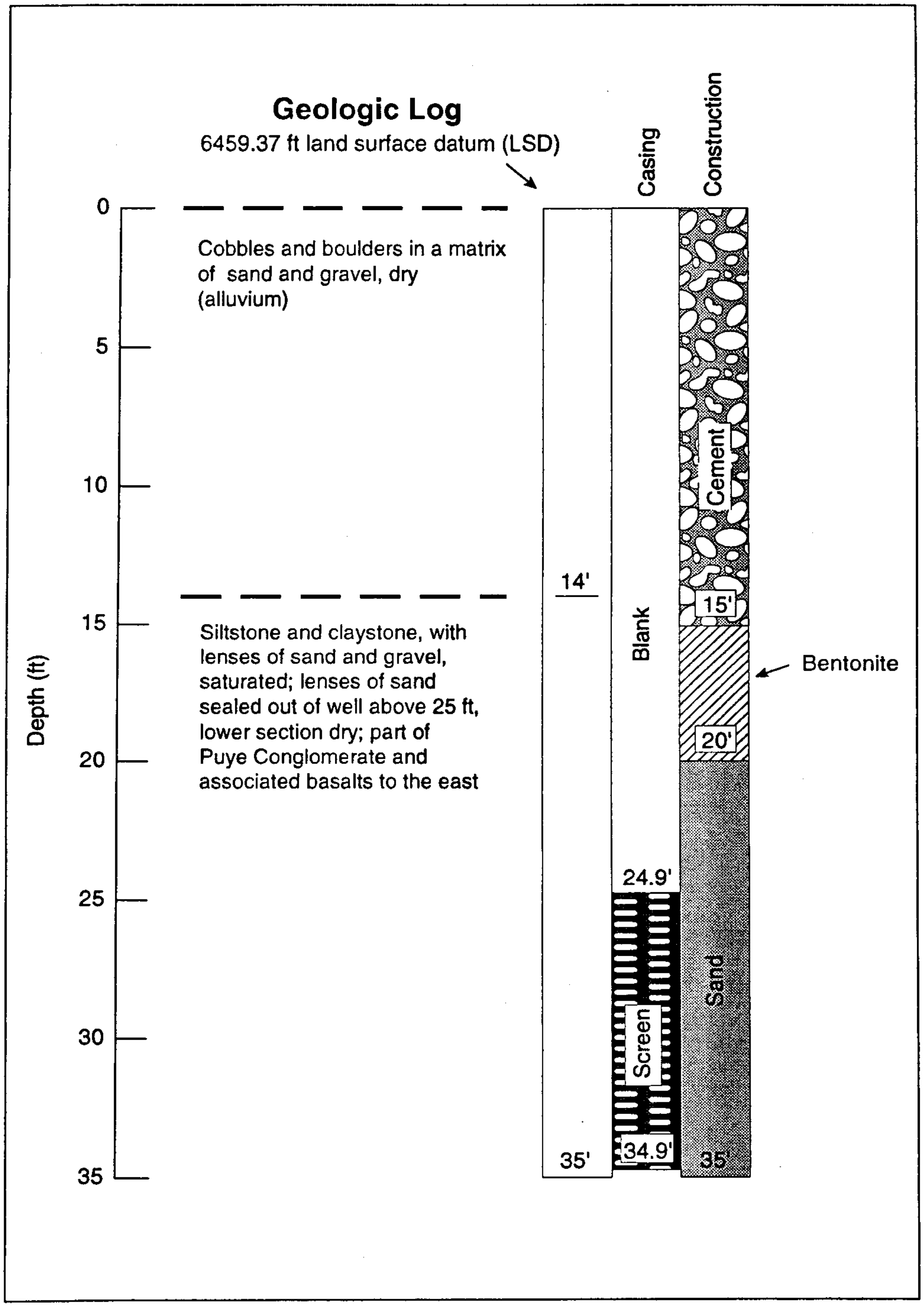

Fig. VIII-F. Los Alamos canyon observation well LAO-4.5B, completed September 1989, dry (Purtymun and Stoker 1990).

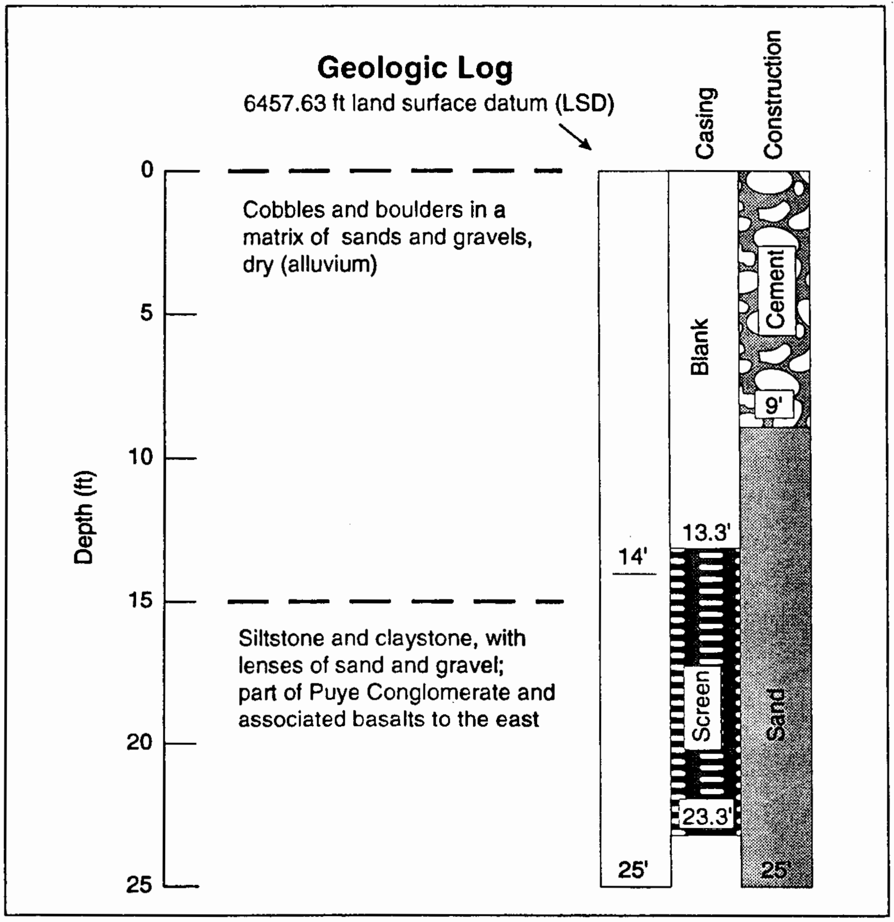

Fig. VIII-G. Los Alamos Canyon observation well LAO-4.5C, completed November 1989, water level 10.6 ft (Purtymun and Stoker 1990).

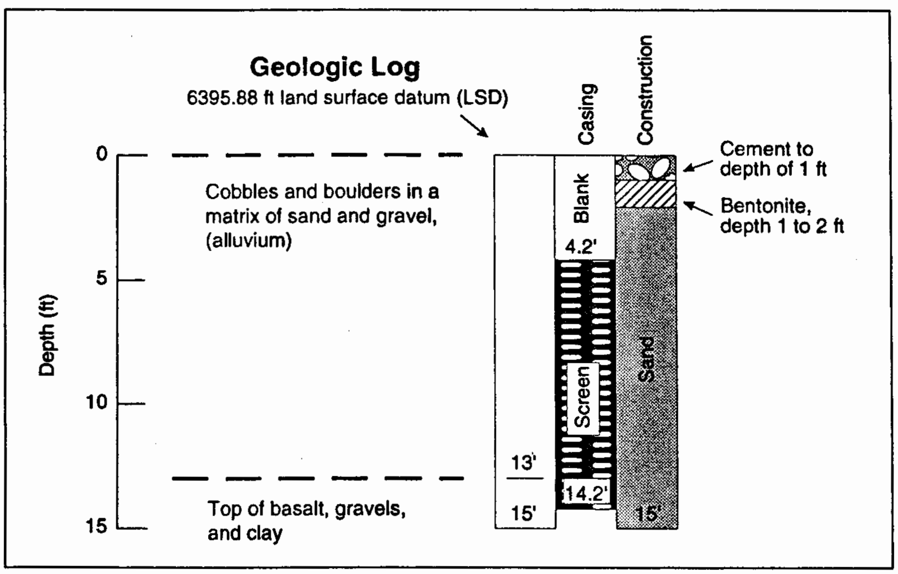

Fig. VIII-H. Los Alamos Canyon observation well LAO-6A, completed August 1989, water level 9.0 ft (Purtymun and Stoker 1990).

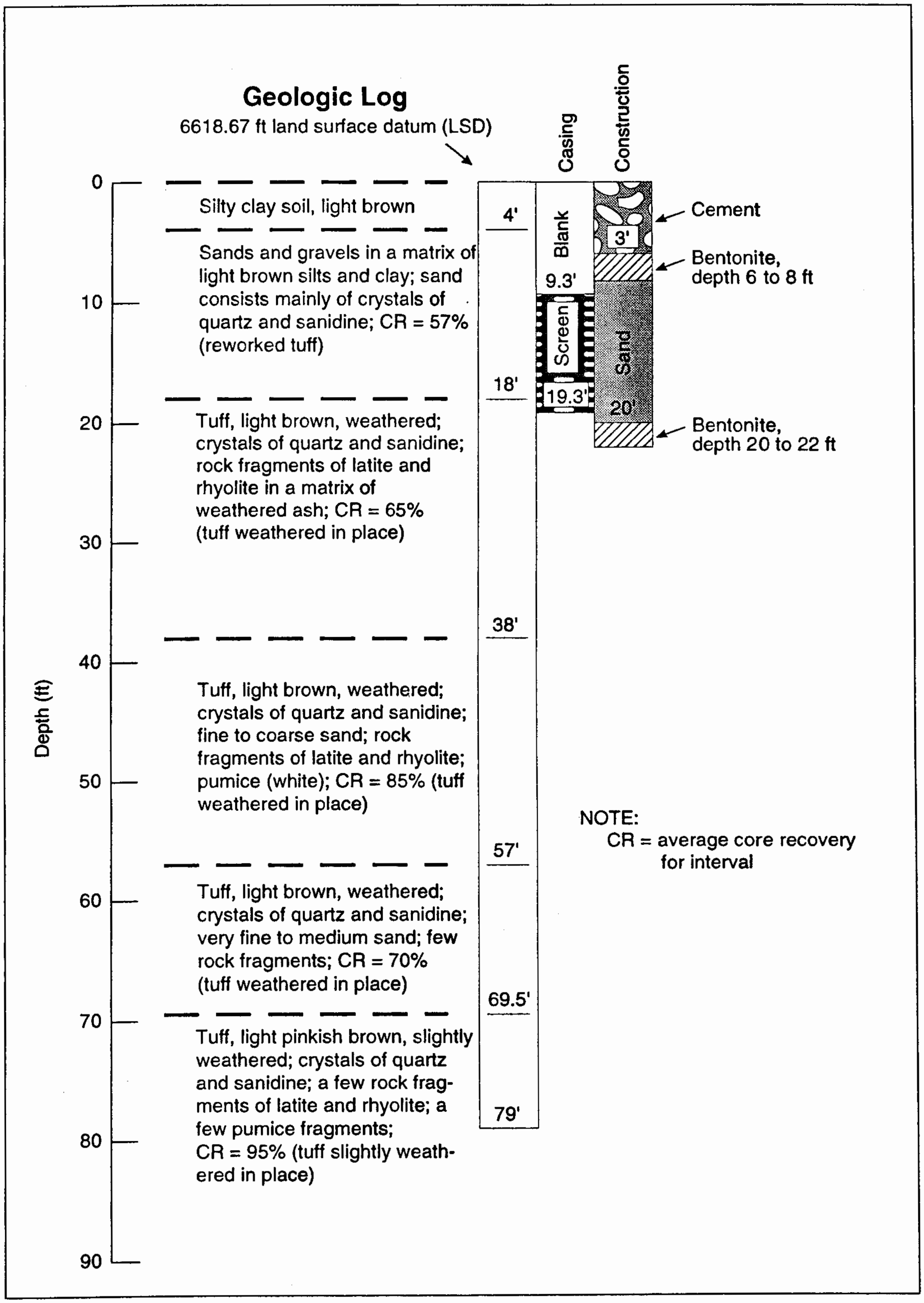

Fig. VIII-I. Sandia Canyon observation well SCO-1, completed August 1989, dry (Purtymun and Stoker 1990).

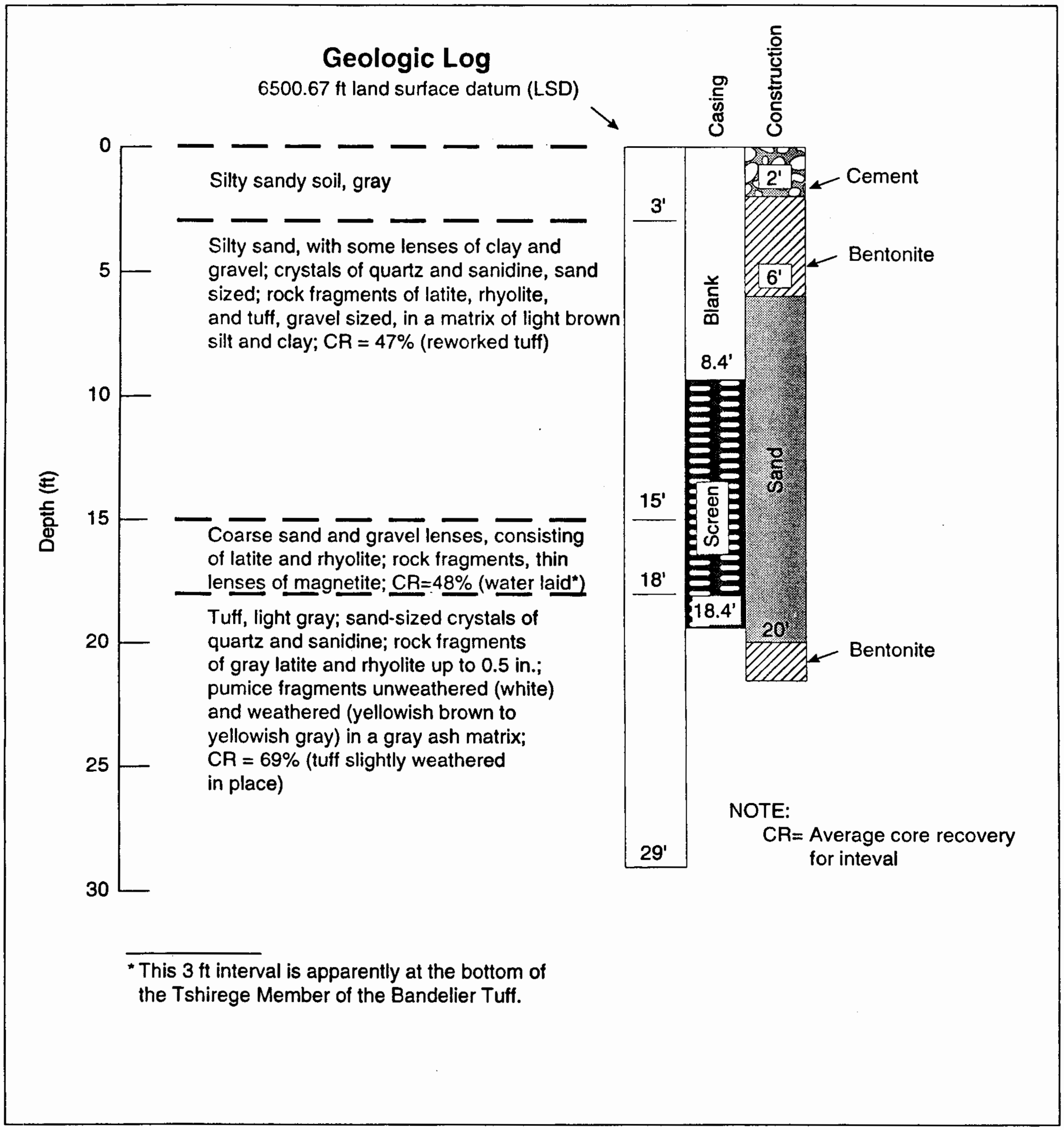

Fig. VIII-J. Sandia Canyon observation well SCO-2, completed August 1989, dry (Purtymun and Stoker 1990).

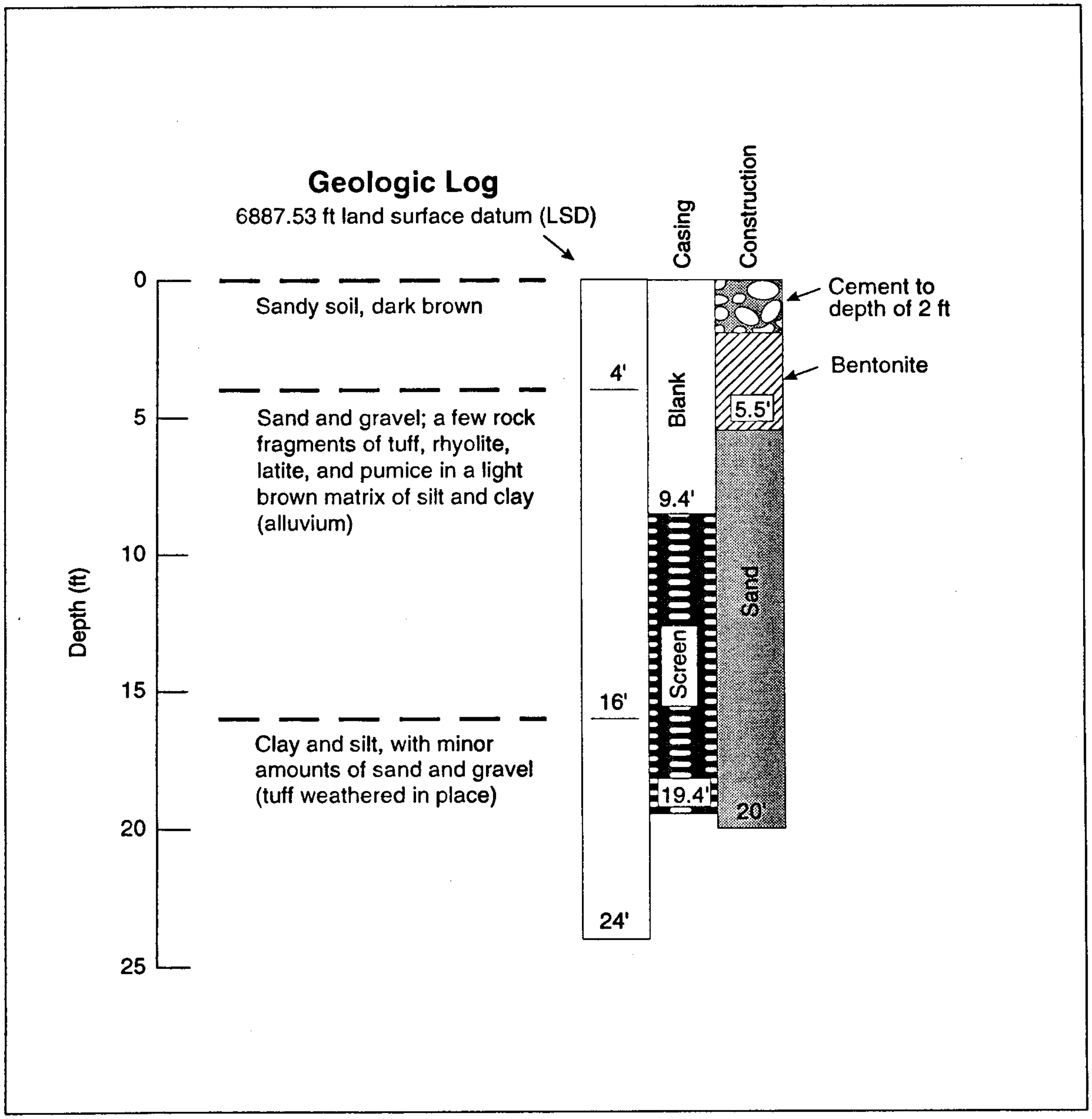

Fig. VIII-K. Mortandad Canyon observation well MCO-4A, completed November 1989, water level 5.1 ft (Purtymun and Stoker 1990).

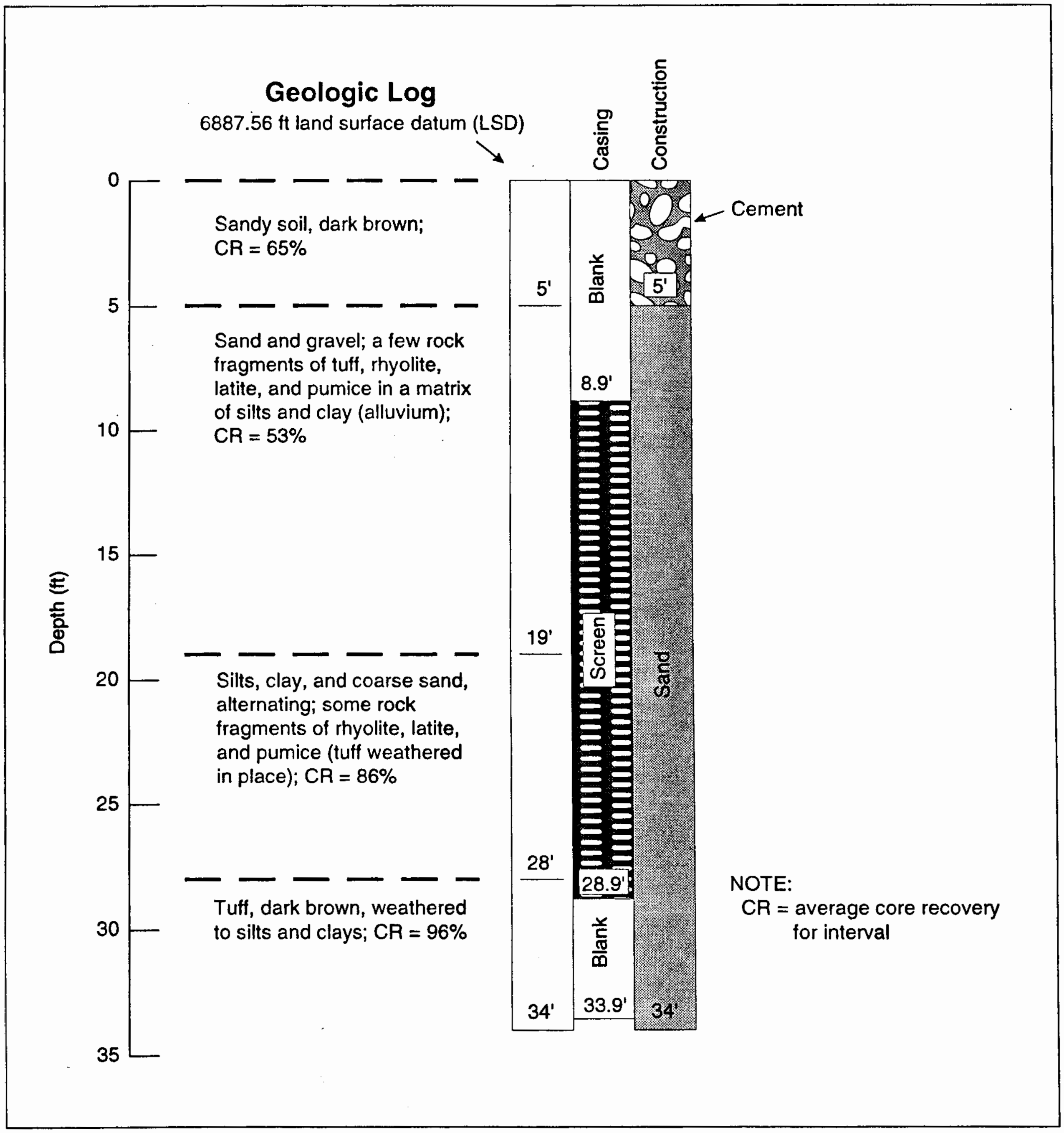

Fig. VIII-L. Mortandad Canyon observation well MCO-4B, completed August 1990, water level 21.7 ft (Purtymun and Stoker 1990).

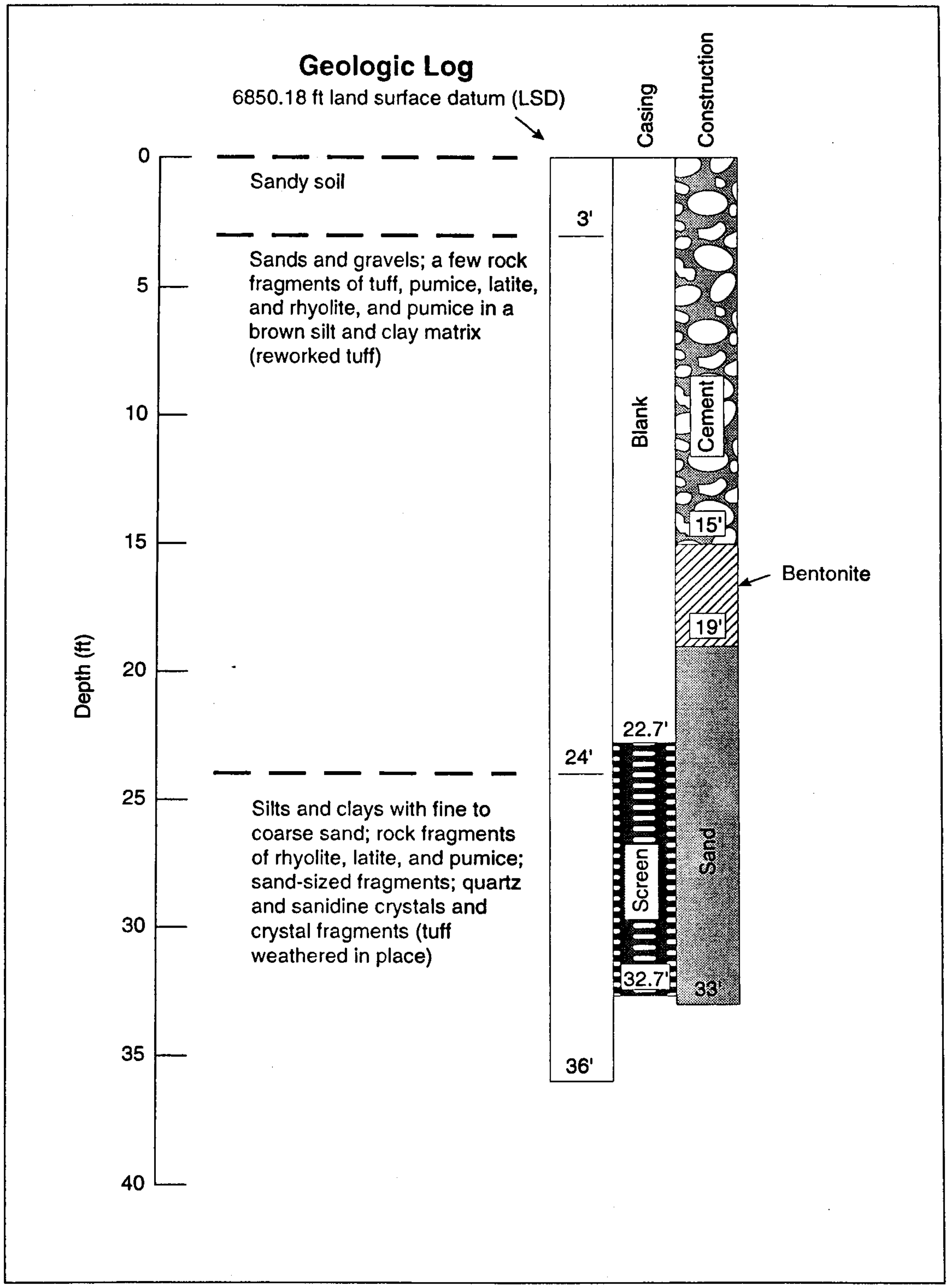

Fig. VIII-M. Mortandad Canyon observation well MCO-6A, completed November 1989, water level 30.3 ft (Purtymun and Stoker 1990).

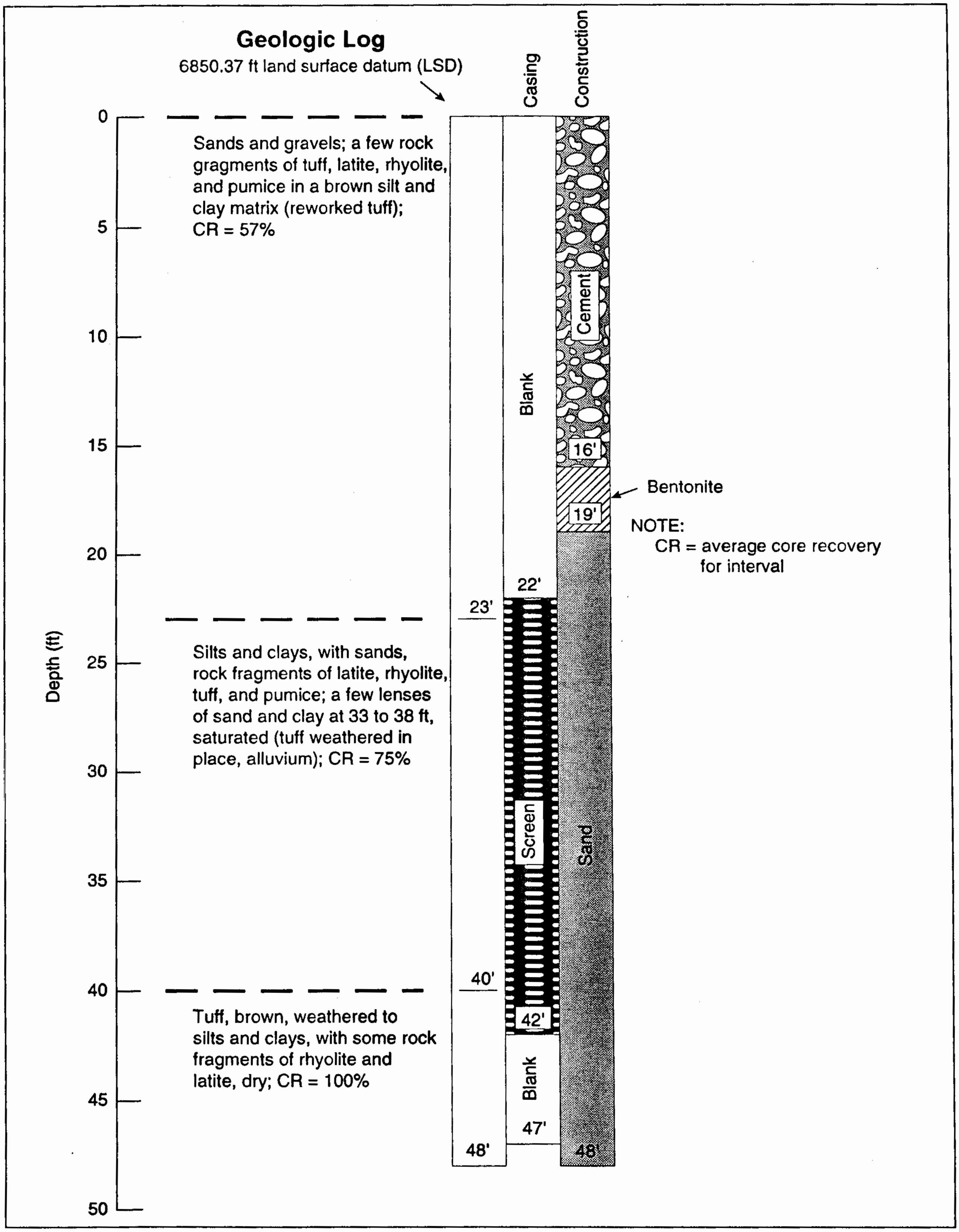

Fig. VIII-N. Mortandad Canyon observation well MCO-6B, completed August 1990, water level 32.2 ft (Purtymun and Stoker 1990).

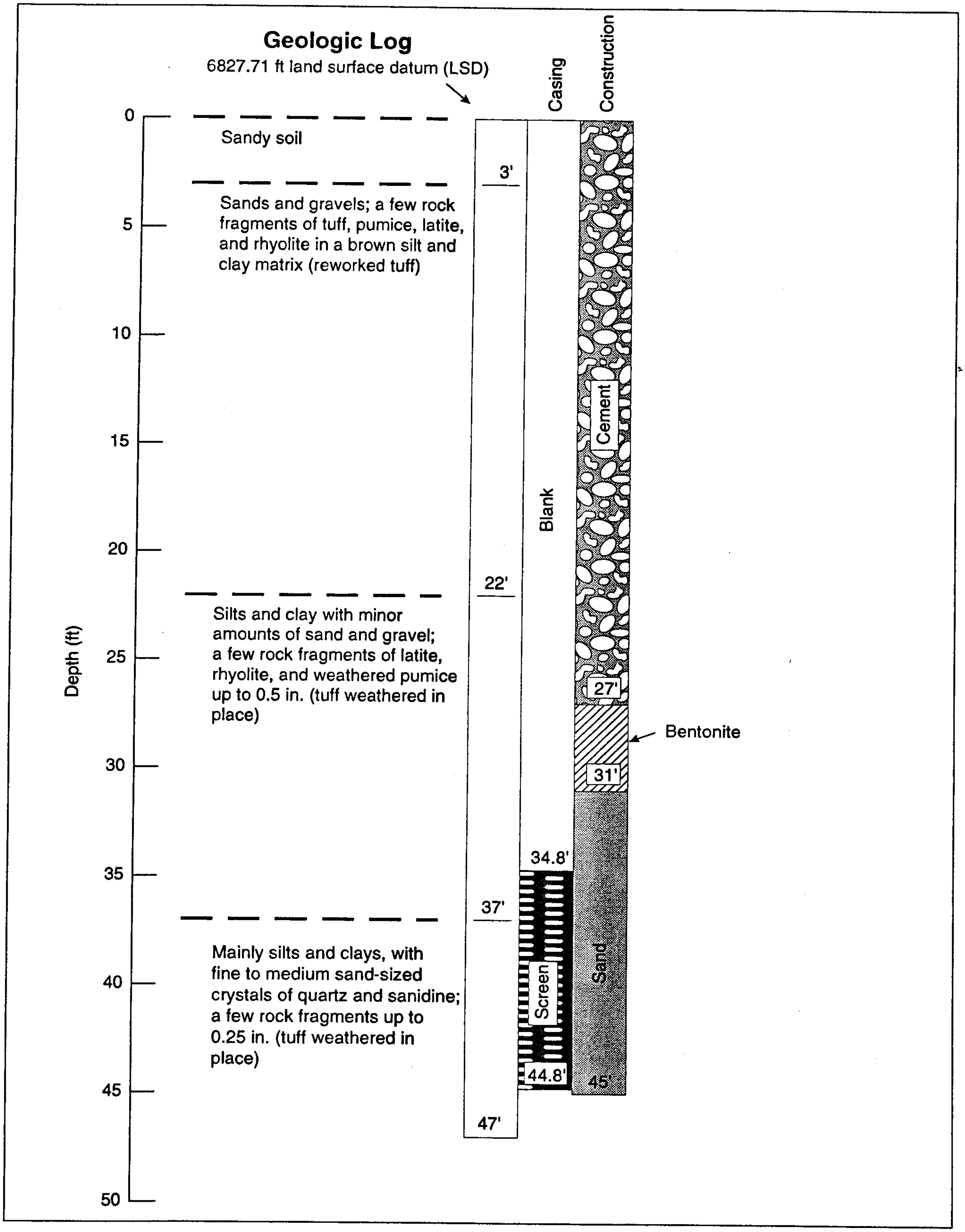

Fig. VIII-O. Mortandad Canyon observation well MCO-7A, completed November 1989, water level 35.2 ft (Purtymun and Stoker 1990).

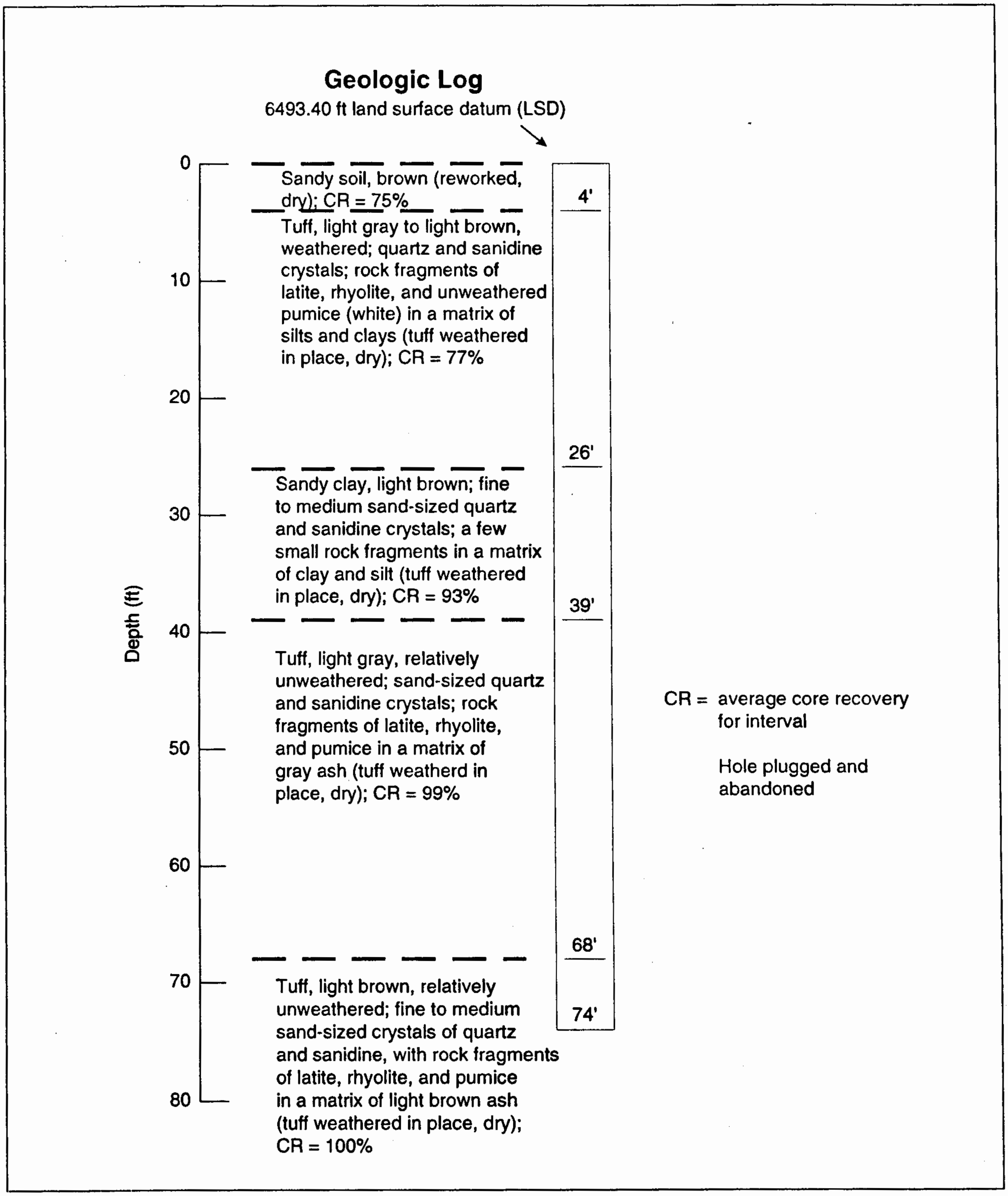

Fig. VIII-P. Potrillo Canyon test hole PCTH-1, completed October 1989, dry (Purtymun and Stoker 1990).

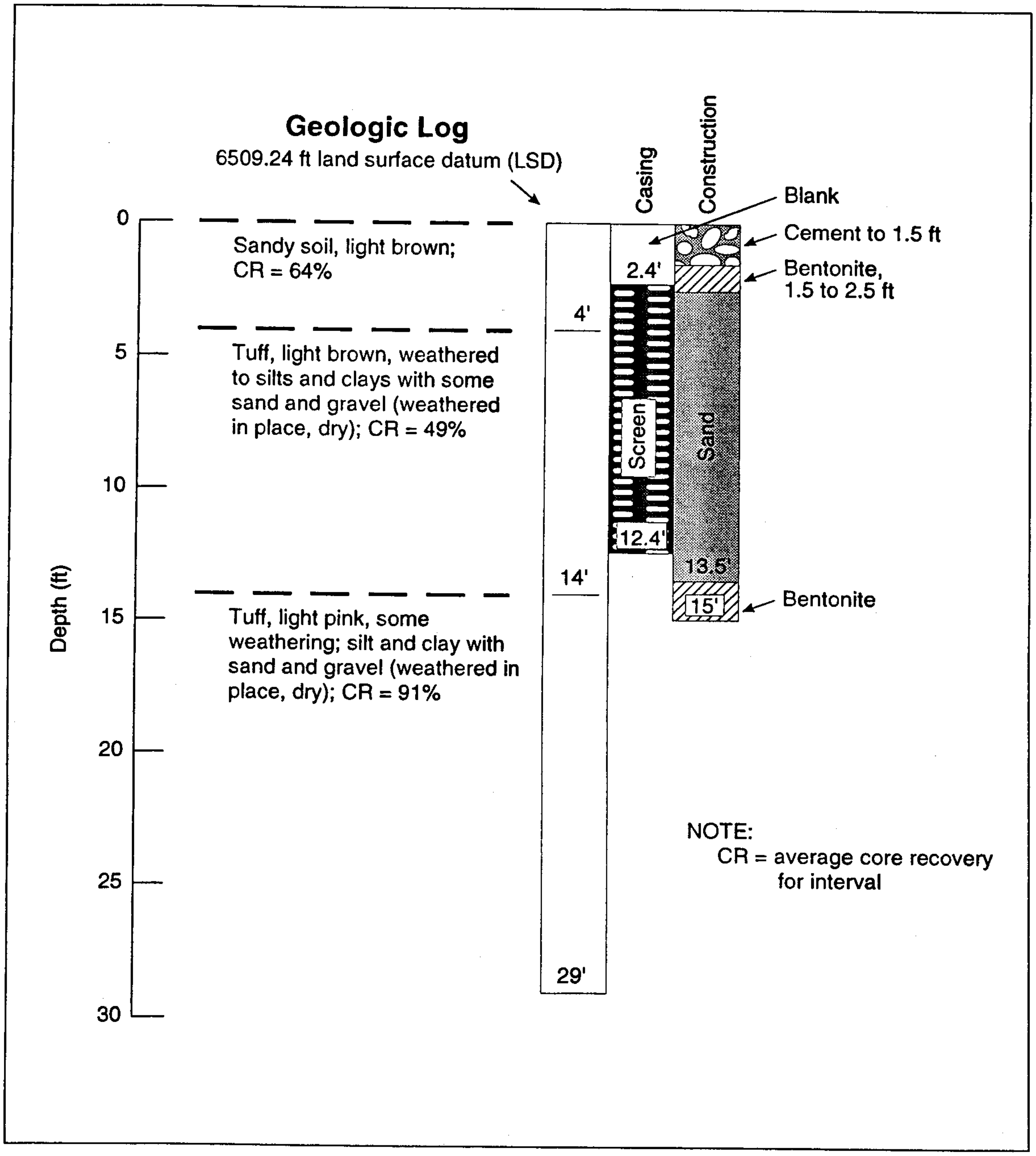

Fig. VIII-Q. Fence Canyon observation well FCO-1, completed August 1989, dry (Purtymun and Stoker 1990).

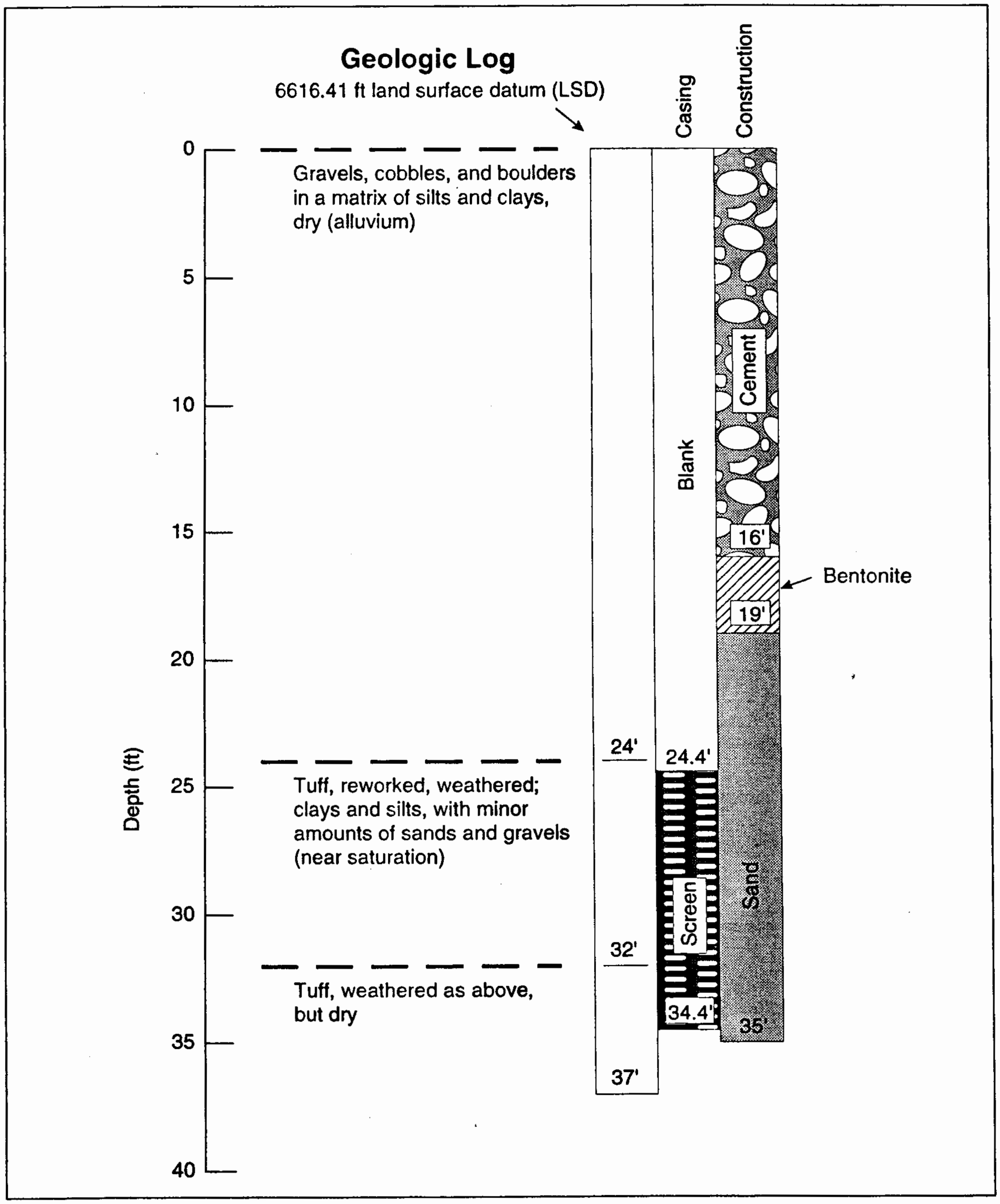

Fig. VIII-R. Water Canyon observation well WCO-1, completed October 1989, dry (Purtymun and Stoker 1990).

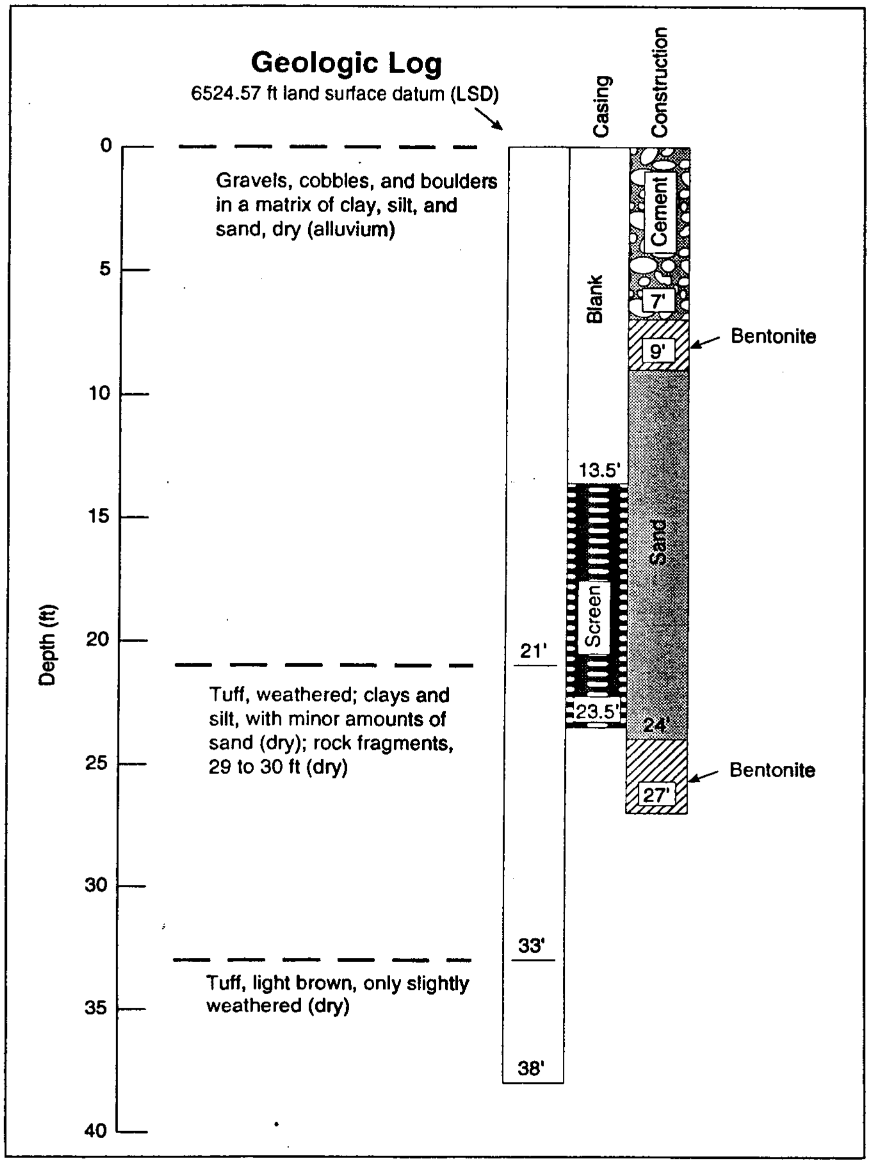

Fig. VIII-S. Water Canyon observation well WCO-2, completed October 1989, dry (Purtymun and Stoker 1990).

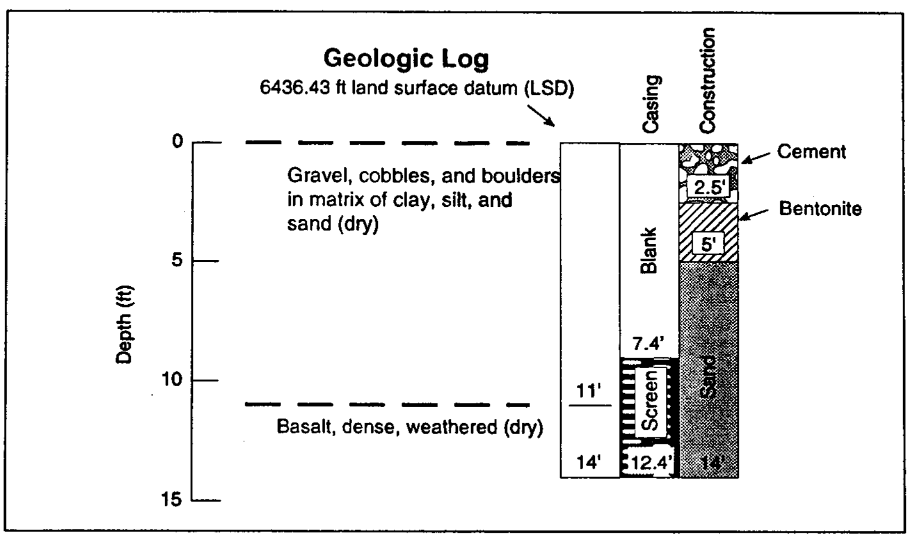

Fig. VIII-T. Water Canyon observation well WCO-3, completed October 1989, dry (Purtymun and Stoker 1990).

TABLE VIII-A. Locations, Elevations, and Measuring Points (NAD 1927)

	Top of Steel Casing	PVC Casing, Measuring Point	Land-Surface Datum of Brass Cap	Measuring Point to Land-Surface Datum	NAD 1927 Coordinates of Brass Cap	
Pueblo Canyon						
APCO-1	6368.95	6368.19	6367.53	-0.66	N 1,772,957.956	E 508 965.347
Los Alamos Canyon						
LAO-3A	6580.38	6579.83	6579.40	-0.43	N 1,773,037.645	E 497,736.545
LAO-4.5A	6461.58	6460.38	6459.89	-0.49	N 1,771,989.595	E 503,255.968
LAO-4.5B	6461.76	6460.59	6459.37	-1.22	N 1,771,992.471	E 503,268.080
LAO-4.5C	6459.23	6458.72	6457.63	-1.11	N 1,772,014.413	E 503,303.058
LAO-6A	6396.73	6396.26	6395.88	-0.38	N 1,771,281.902	E 505,977.349
Sandia Canyon						
SCO-1	6619.85	6619.33	6618.67	-0.66	N 1,769,440.143	E 502,053.375
SCO-2	6502.02	6501.52	6500.67	-0.85	N 1,767,801.850	E 507,014.910
Mortandad Canyon						
MCO-4A	6889.00	6888.24	6887.53	-0.71	N 1,769,638.132	E 491,784.644
MCO-4B	6889.13	6888.71	6887.56	-1.15	N 1,769,634.899	E 491,792.173
MCO-6A	6851.80	6851.45	6850.18	-1.27	N 1,768,899.886	E 493,388.651
MCO-6B	6851.84	6851.08	6850.37	-0.71	N 1,768,921.493	E 493,386.276
MCO-7A	6829.27	6828.75	6827.71	-1.04	N 1,768,447.198	E 494,259.239
Potrillo Canyon						
PCTH-1[a]	—	—	6493.40	—	N 1,753,105.358	E 503,902.595
Fence Canyon						
FCO-1	6510.41	6509.99	6509.24	-0.75	N 1,751,120.043	E 502,168.229
Water Canyon						
WCO-1	6617.75	6617.06	6616.41	-0.65	N 1,755,007.161	E 492,514.547
WCO-2	6526.07	6525.25	6524.57	-0.68	N 1,753,166.432	E 496,626.165
WCO-3	6437.73	6437.25	6436.43	-0.82	N 1,750,558.320	E 498,968.371

[a]Cored test hole; plugged.
Source: Purtymun and Stoker 1990.

TABLE VIII-B. Characteristics and Water Levels of Observation Wells

	Date Drilled	Date Completed	Depth Drilled (ft)	Depth Completed (ft)	Water Level (ft below Land-Surface Datum)			
					Date	Water Level	Date	Water Level
Pueblo Canyon								
APCO-1	8-15-90	8-17-90	20	19.7	—	—	8-17-90	6.2
Los Alamos Canyon								
LAO-3A	9-14-89	9-14-89	18	14.7	9-14-89	6.7	6-21-90	5.5
LAO-4.5A	9-13-89	9-14-89	20	18.5	9-14-89	Dry	6-21-90	Dry
LAO-4.5B	9-15-89	9-16-89	35	34.9	9-16-90	Dry	6-21-90	Dry
LAO-4.5C	11-21-89	11-22-89	25	23.3	11-22-89	10.6	6-21-90	10.7
LAO-6A	8-17-89	8-17-89	15	14.2	8-17-89	9.0	6-21-90	Dry
Sandia Canyon								
SCO-1	8-14-89	8-15-89	79	19.3	8-15-89	Dry	6-22-90	Dry
SCO-2	8-16-89	8-16-89	29	18.4	8-16-89	Dry	6-22-90	Dry
Mortandad Canyon								
MCO-4A	11-01-89	11-01-89	24	19.4	11-14-89	5.1	8-15-90	Dry
MCO-4B	8-20-90	8-21-90	34	33.9	—	—	8-21-90	21.7
MCO-6A	11-02-89	11-06-89	33	32.7	11-09-89	30.3	6-02-90	Dry
MCO-6B	8-09-90	8-13-90	48	47.1	—	—	8-13-90	33.2
MCO-7A	11-06-89	11-14-89	47	44.8	11-09-89	35.2	6-21-90	37.2
Potrillo Canyon								
PCTH-1[a]	10-18-89	10-20-89	74	—	10-20-89	Dry	—	—
Fence Canyon								
FCO-1	8-22-89	8-22-89	29	12.4	8-22-89	Dry	8-24-90	Dry
Water Canyon								
WCO-1	10-26-89	10-31-89	37	34.4	11-01-89	Dry	8-24-90	Dry
WCO-2	10-26-89	10-26-89	38	23.5	10-26-89	Dry	8-24-90	Dry
WCO-3	10-25-89	10-25-89	14	12.4	10-25-89	Dry	8-24-90	Dry

[a]Cored test hole; plugged.
Source: Purtymun and Stoker 1990.

IX. TECHNICAL AREA 49

Technical Area 49 (TA-49) is an experimental area for which it was necessary to define the geology and hydrology of the mesa and adjacent canyons. TA-49 is located in the southern part of the Laboratory on Frijoles Mesa just to the north of Bandelier National Monument. The mesa is capped with a thick section of the Bandelier Tuff (the Tshirege Member, Otowi Member, and Guaje Member). This is underlain by the Puye Conglomerate and the Chaquehui Formation. Basalts were found interbedded with the Puye Conglomerate.

At TA-49 the Tshirege Member of the Bandelier Tuff has been subdivided into seven units that have been penetrated by test holes and test wells (Weir and Purtymun 1962). The type section of units exposed in the north wall of Water Canyon is shown in Fig. IX-A. Our subdivision of the Tshirege Member was based on the chemical and physical properties of the tuff. This was the first attempt to divide the Tshirege Member into a number of mappable units on the Pajarito Plateau. It does not correlate perfectly with the units established at Mortandad Canyon by Baltz et al. (1963), and no attempt has been made to change the terminology or units used at TA-49 to correspond to the type section at Mortandad Canyon. The correlation of units of the Bandelier Tuff at TA-49 with the type section at Mortandad is shown on Fig. IX-B.

The units penetrated in the test wells and core hole are described below from the oldest, Unit 1A, to the youngest, Unit 6.

Unit 1A consists of a light gray to light pinkish gray pumiceous, friable, nonwelded, rhyolite tuff that contains quartz and sanidine crystals and crystal fragments, and rock fragments of latite, rhyolite, and pumice in an ash matrix. At TA-49 the unit is 156 ft thick in Area 5.

Unit 1B is a light gray to very light orange rhyolite tuff that contains quartz and sanidine crystals and crystal fragments, large to small pumice fragments, and gray subrounded rhyolite and latite rock fragments up to cobble size. The unit was 203 ft thick in test well DT-5P at TA-49.

Unit 2 is a light pinkish gray to purplish gray welded rhyolite tuff. It is hard, welded, and contains coarse-sand- to granule-sized phenocrysts of quartz and sanidine crystals and crystal fragments, light gray to gray rhyolite and latite rock fragments, and gray pumice fragments up to 1/2-in. long in a fine-grained, glassy ash matrix. Unit 2 ranges from 94 to 111 ft in the four core holes drilled at TA-49.

Unit 3 is a friable, nonwelded, pumiceous rhyolite tuff composed of medium to very coarse sand-sized crystals of quartz and sanidine, gray and white devitrified pumice fragments up 1/2 in. long, and an abundance of gray pumice and gray rhyolite and latite rock fragments in a fine-grained glassy ash matrix. The thickness of Unit 3 ranges from 52 to 76 ft in core holes and test wells at TA-49.

Unit 4 is a friable, nonwelded to moderately welded tuff with coarse-grain-sized crystals and crystal fragments of quartz and sanidine, some gray devitrified pumice fragments, and rock fragments of latite and rhyolite in an ash matrix. The average thickness of Unit 4 is about 50 ft.

Unit 5 is a thin layer of water-laid or blast-laid sand that is light gray, friable, and composed of coarse-grain-sized quartz and sanidine crystals and crystal fragments, a few small rock fragments of latite and rhyolite, and some white to gray pumice in a silty matrix of sand and ash. The unit has various bedding from foreset to parallel beds. In some places there are thin lenses of clay weathered to dark brown. The thickness of the unit varies from a knife edge between ash flows to a thickness of 6 to 8 ft (where it is in a scoured joint or fracture in a shaft in Area 10).

Unit 6 is a light gray moderately welded tuff with fine- to medium-sized quartz and sanidine crystals and crystal fragments, and some tan to gray pumice fragments, gray devitrified pumice fragments, and some light red and gray rhyolite rock fragments in a fine-grained light gray ash matrix. The average thickness of the unit is about 70 ft.

A. Deep Test Wells

The locations of deep test wells (DT-series), core holes (CH-series), and test holes (TH-series) are shown in Fig. IX-C, and construction and hydrologic data are shown in Table IX-A.

Two deep test holes, DT-5P (Fig. IX-D) and DT-5 (Fig. IX-E) were drilled for geologic and hydrologic information, but did not reach the main aquifer. Three other deep test holes, DT-5A (Fig. IX-F), DT-9 (Fig.IX-G), and DT-10 (Fig. IX-H) were drilled into the main aquifer. The geologic logs and construction data for these five holes are found in Table IX-B. In the original presentation of the geologic logs of these last three holes (Weir and Purtymun 1962), a flow was penetrated and was logged as the Tschicoma Formation. It is unlikely that the Tschicoma Formation, which is found as massive flows containing latite and dacite near the flanks of the Sierra de los Valles, would be present so far away from the mountains. It is more likely that this unit was composed of the Basaltic Rocks of Chino Mesa Unit 2. This identification was confirmed by an examination of the exposed cuttings from the wells, especially those from well DT-9. The logs of DT-5A, DT-9, and DT-10 have been revised accordingly. The basalts may not be from vents at Chino Mesa but are equivalent in age, as the basalts are interbedded with the fanglomerate member. These three wells that were completed as test wells into the main aquifer allowed us to determine the hydrologic characteristics of the aquifer.

B. Core and Test Holes

Four core holes, CH-1, CH-2, CH-3, and CH-4 (Figs. IX-I, IX-J, IX-K, and IX-L, respectively) were cored in four experimental areas to determine some of the physical and hydrologic properties of the tuff. Alpha, Beta (located on the floor of Water Canyon), and Gamma holes were drilled for geologic information (Figs. IX-M, IX-N, and IX-O, respectively).

Five shallow test holes, test holes 1, 2, 3, 4, and 5 were drilled to determine if there was infiltration of precipitation into the soil and tuff around experimental Area 2 (Figs. IX-P, IX-Q, IX-R, IX-S, and IX-T, respectively). All wells and test holes were sealed at the surface with cement. The geologic logs and construction data for these test holes are presented in Table IX-C. Test holes and wells in Water Canyon north of TA-49 are shown in Fig. IX-U. In Water Canyon near Beta Hole there is a routine surface water sampling station.

C. Moisture-Access Holes

To study and monitor the soil moisture on the surface of the mesa and in the experimental areas, 23 moisture-access holes were completed on the mesa (Fig. IX-V). We completed 2 shallow observation holes (WCM-1 and WCM-2) into the alluvium of Water Canyon to the north of the experimental areas (Fig. IX-U). Geologic logs and construction data for the 23 moisture-access holes and 2 shallow observation wells are presented on Table IX-D.

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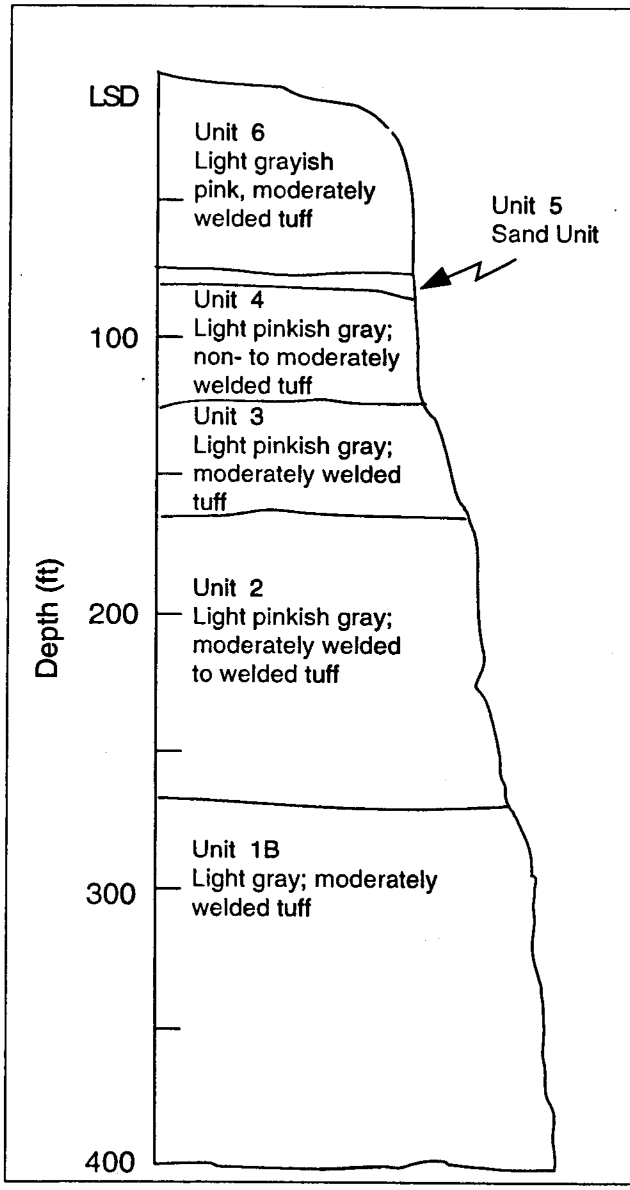


Fig. IX-A. Type section of the Tshirege Member of the Bandelier Tuff in Water Canyon north of TA-49 (Weir and Purtymun 1962).

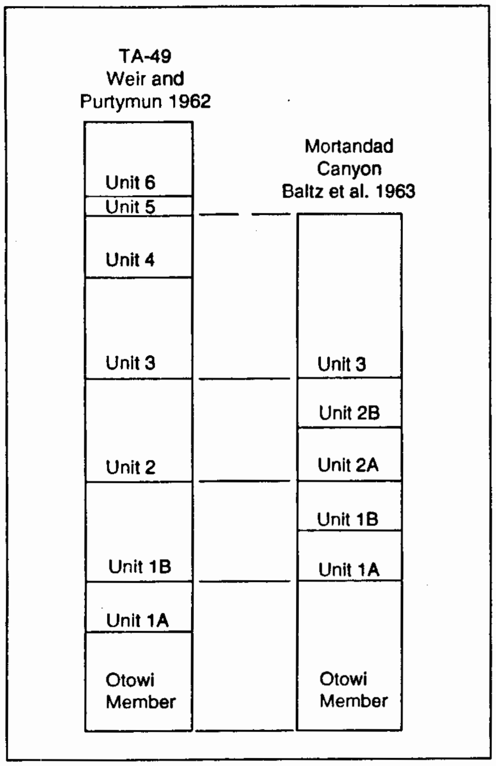


Fig. IX-B. Correlation of the units of the Tshirege Member of the Bandelier Tuff at TA-49 with the type section in Mortandad Canyon.

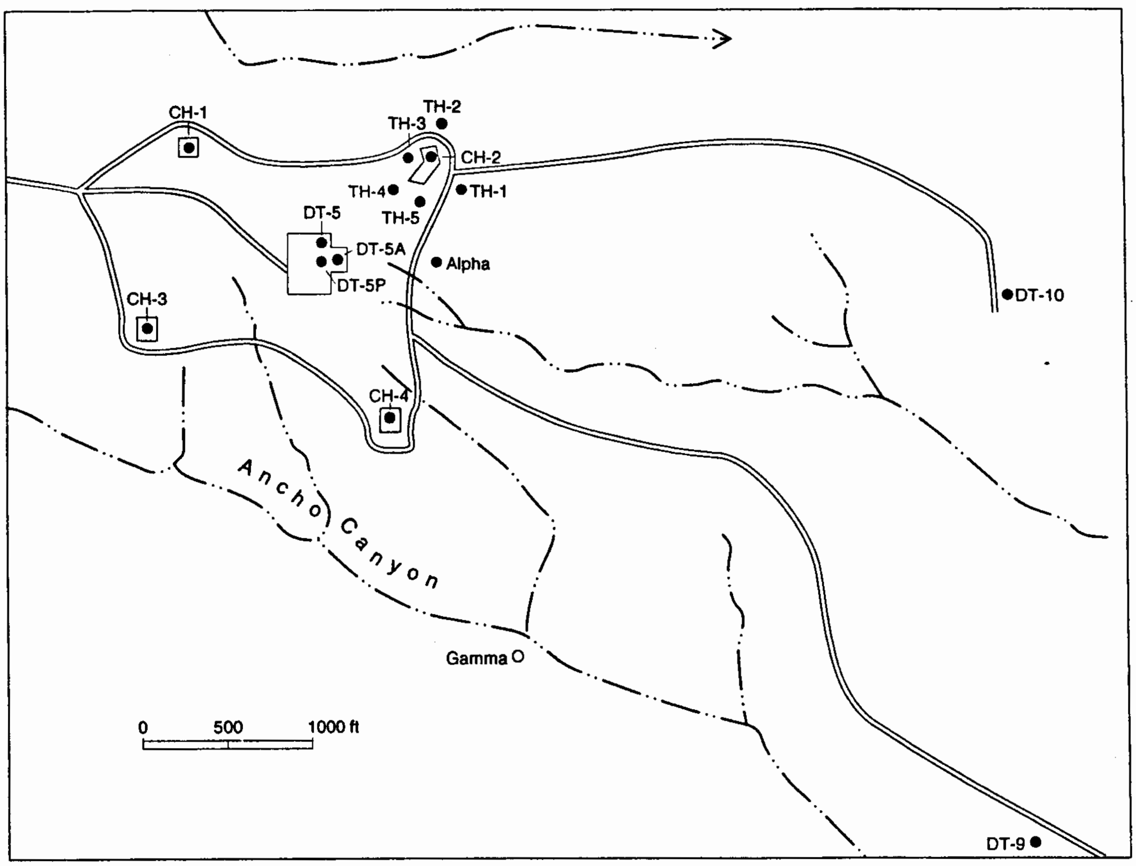


Fig. IX-C. Location of deep test wells (DT-series), core holes (CH-series), and test holes (TH-series) (Purtymun 1994).

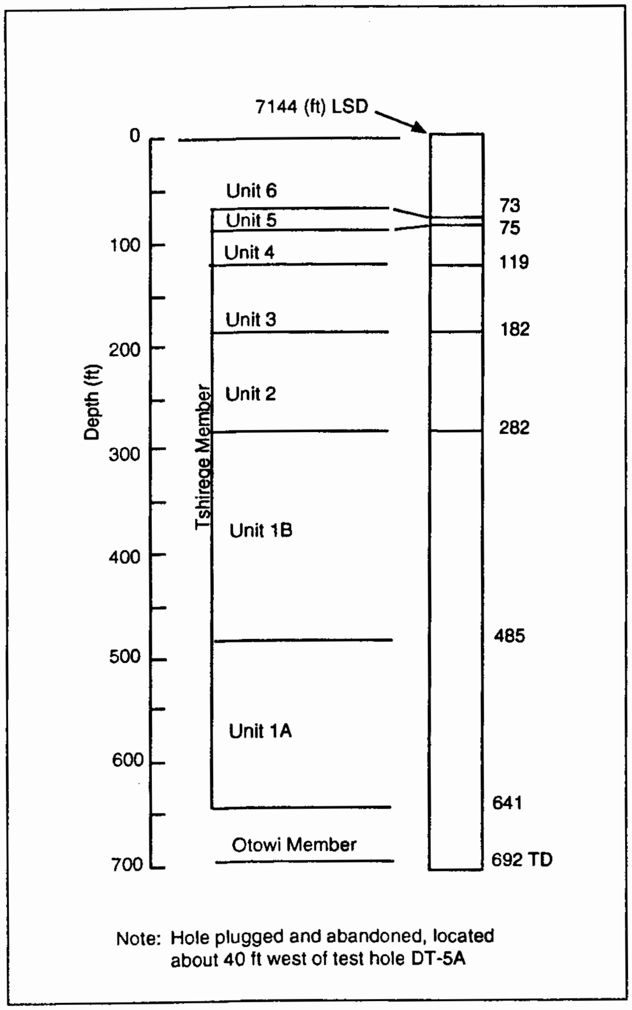


Fig. IX-D. Test hole DT-5P, completed October 1959, dry (Weir and Purtymun 1962).

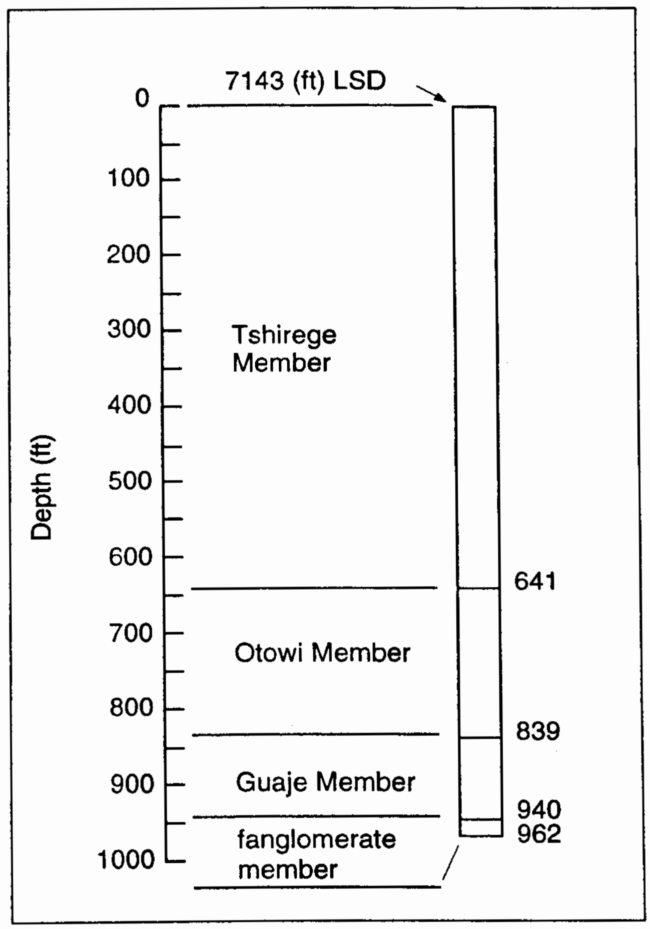


Fig. IX-E. Geologic log of test hole DT-5, completed November 1959, dry (Weir and Purtymun 1962).

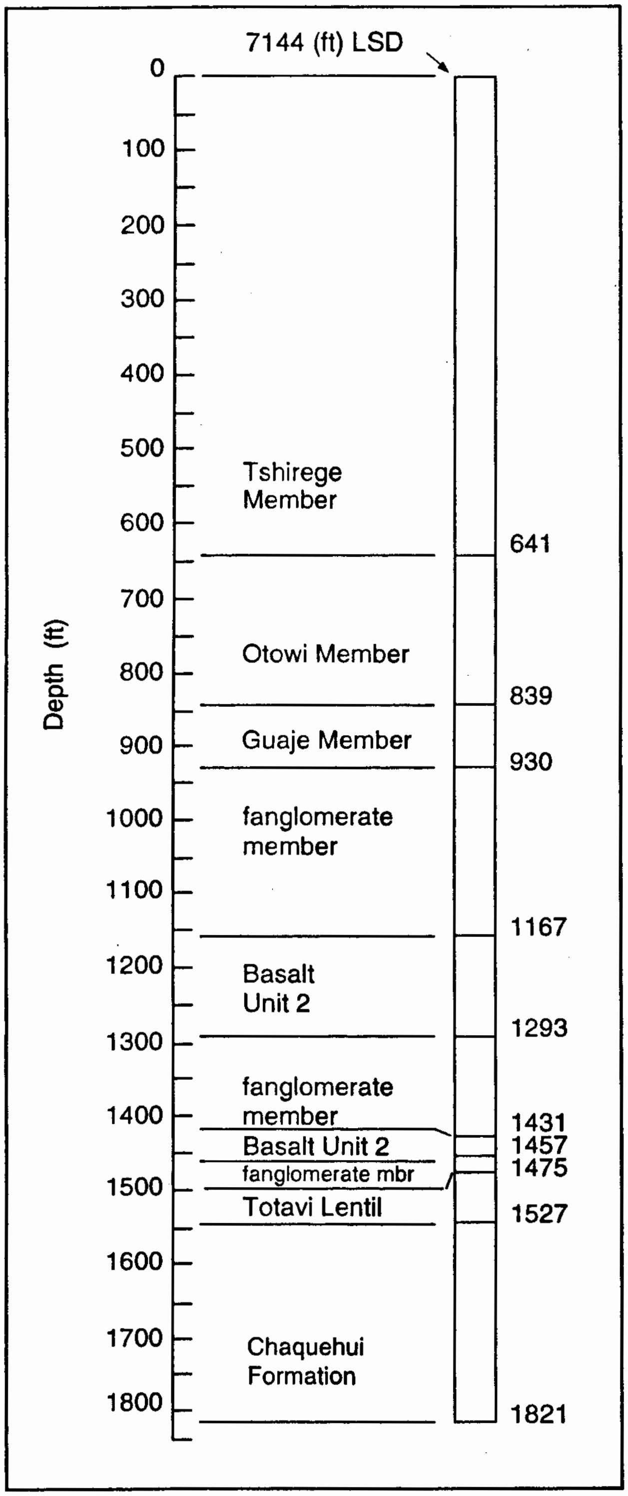


Fig. IX-F. Geologic log of test well DT-5A, completed January 1960, water level 1173 ft (Weir and Purtymun 1962, modified by Purtymun for this report).

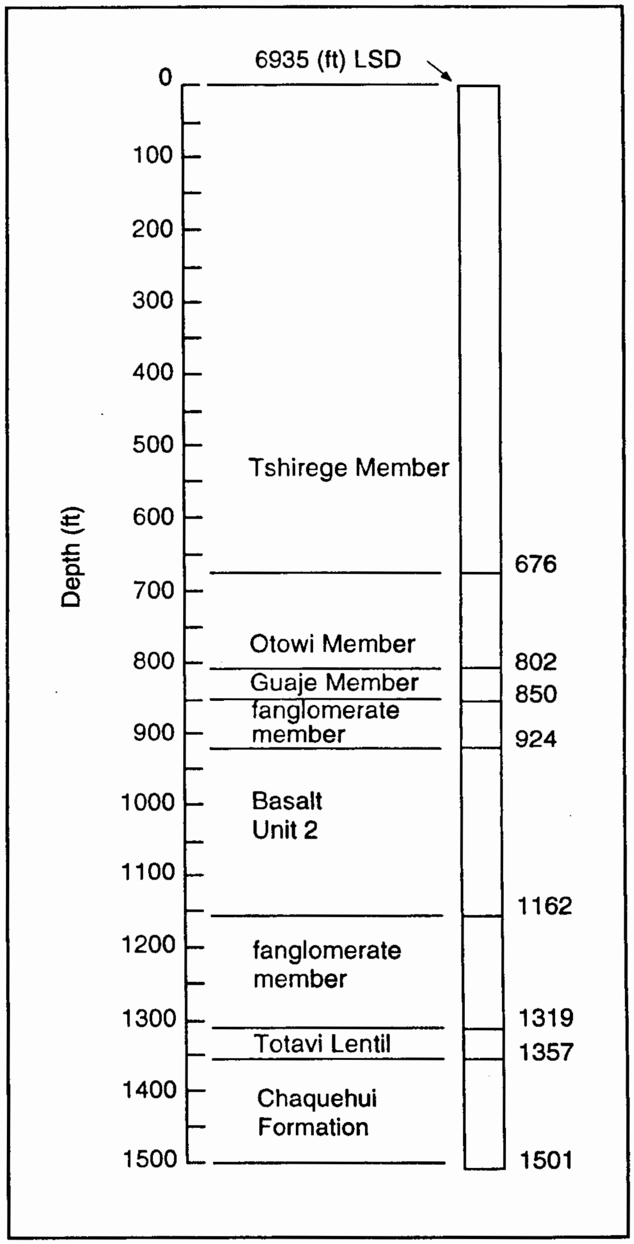


Fig. IX-G. Geologic log of test well DT-9, completed February 1960, water level 1003 ft (Weir and Purtymun 1962, modified by Purtymun for this report).

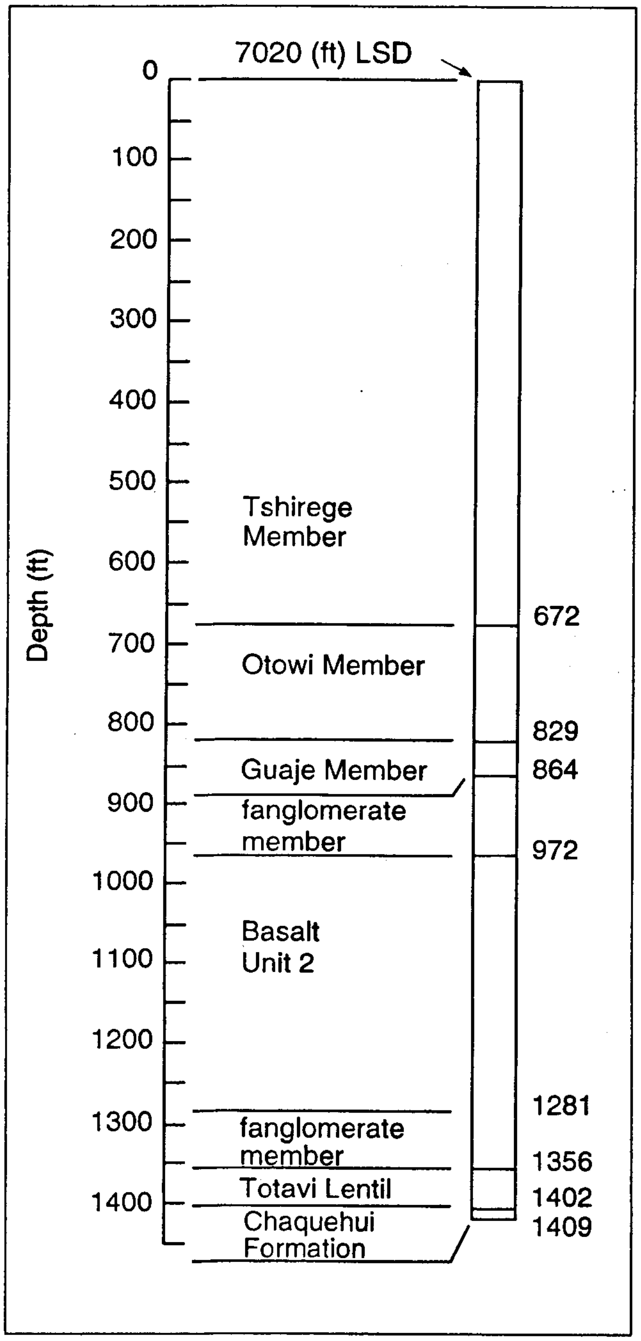


Fig. IX-H. Geologic log of test well DT-10, completed March 1960, water level 1085 ft (Weir and Purtymun 1962, modified by Purtymun for this report).

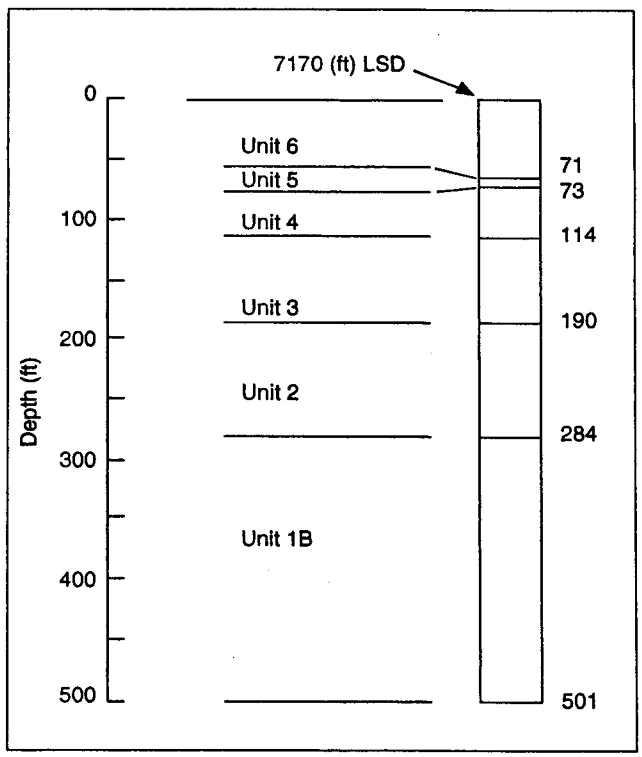


Fig. IX-I. Geologic log of core hole CH-1, completed December 1959, dry (Weir and Purtymun 1962).

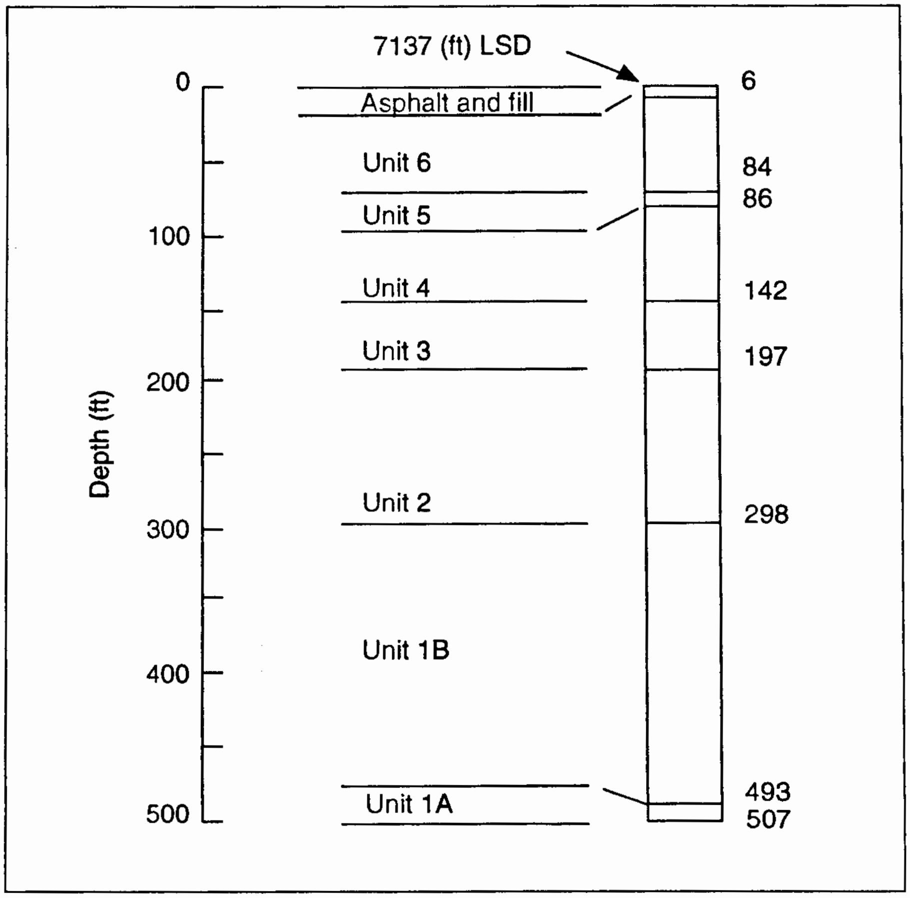


Fig. IX-J. Geologic log of core hole CH-2, completed November 1959, dry (Weir and Purtymun 1962).

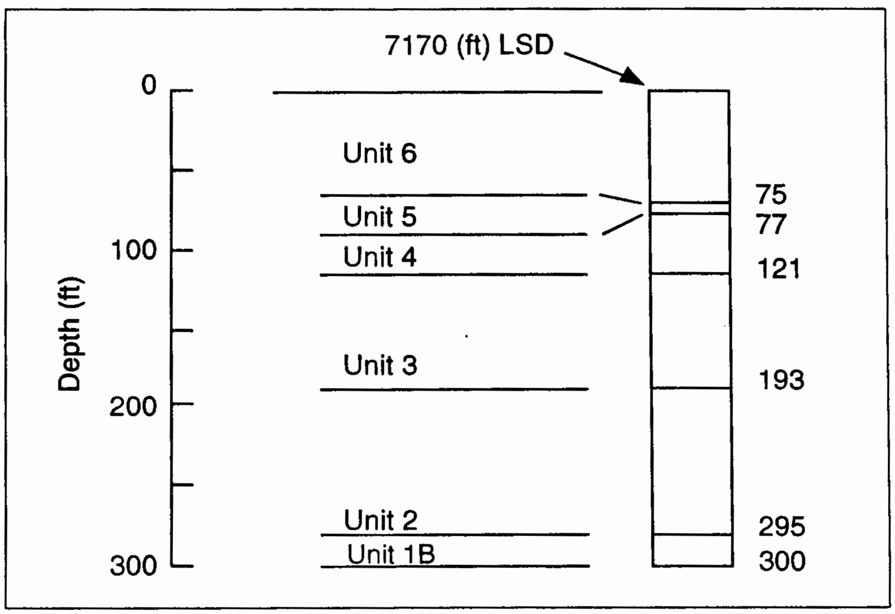


Fig. IX-K. Geologic log of core hole CH-3, completed February 1960, dry (Weir and Purtymun 1962).

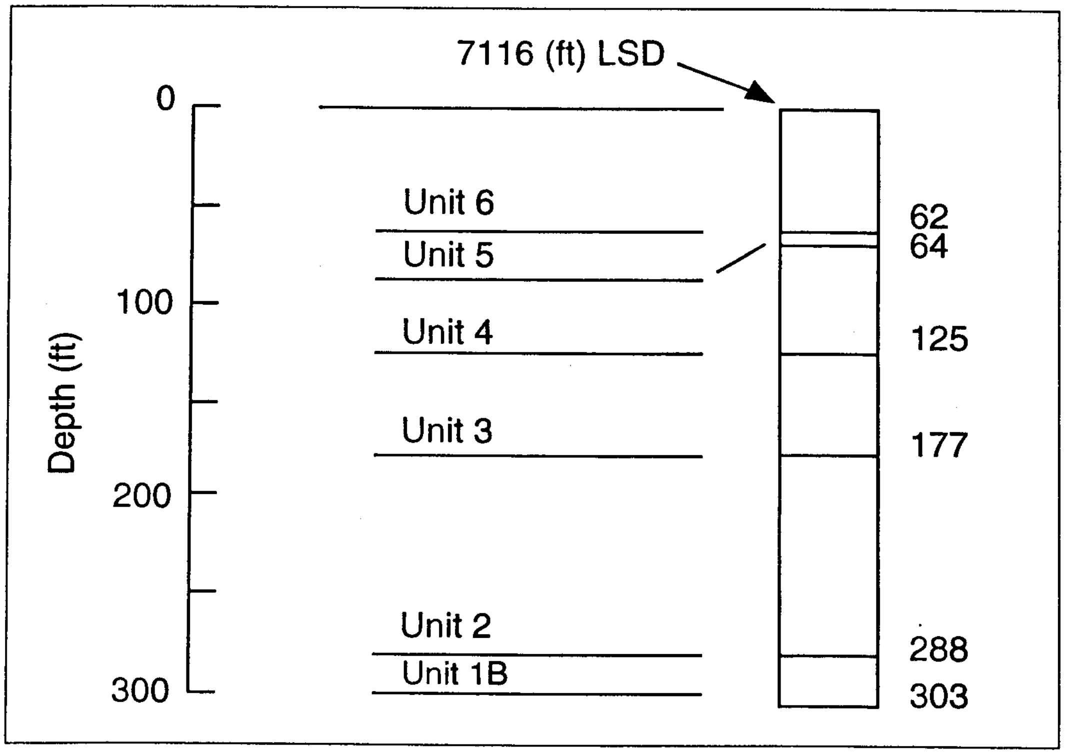


Fig. IX-L. Geologic log of core hole CH-4, completed February 1960, dry (Weir and Purtymun 1962).

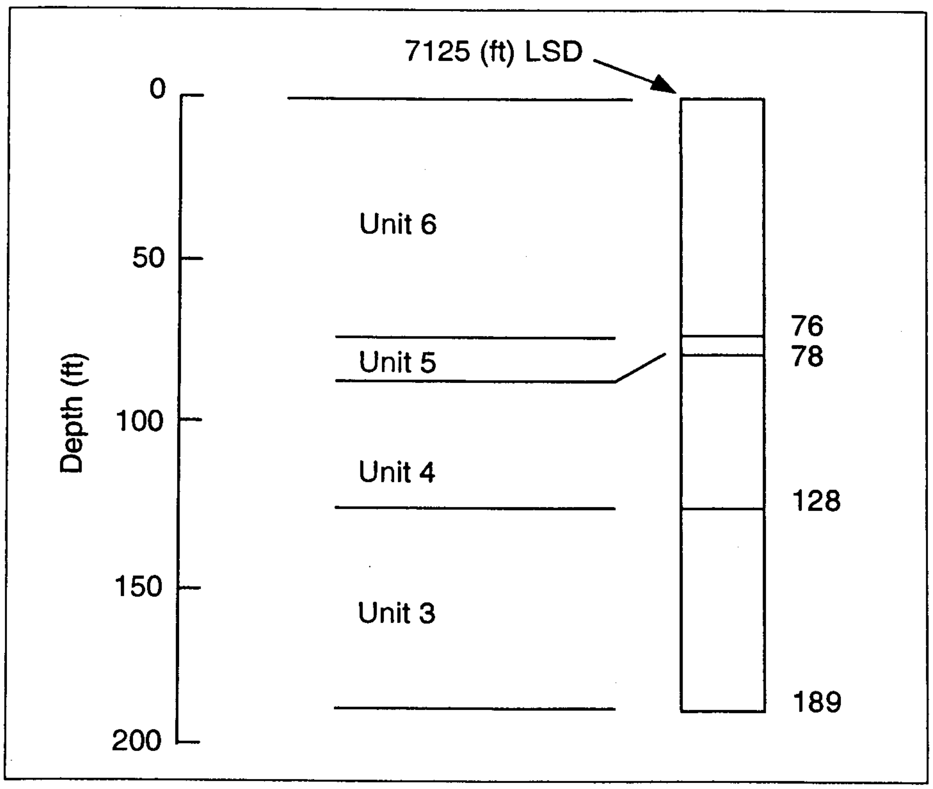


Fig. IX-M. Geologic log of Alpha Hole, completed February 1960, dry (Weir and Purtymun 1962).

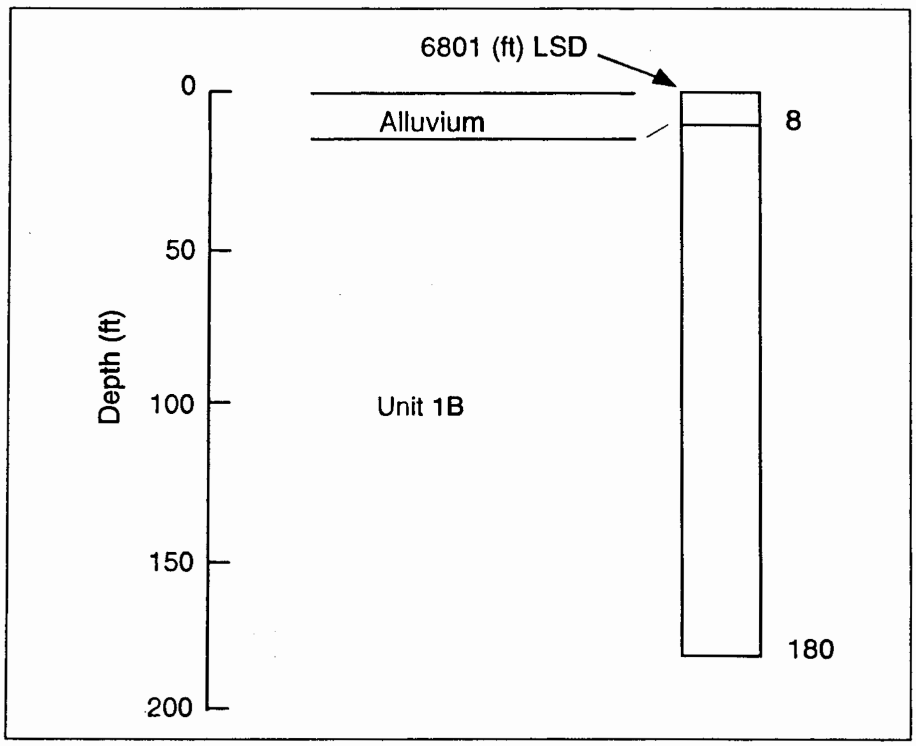


Fig. IX-N. Geologic log of Beta Hole, completed February 1960, dry (Weir and Purtymun 1962).

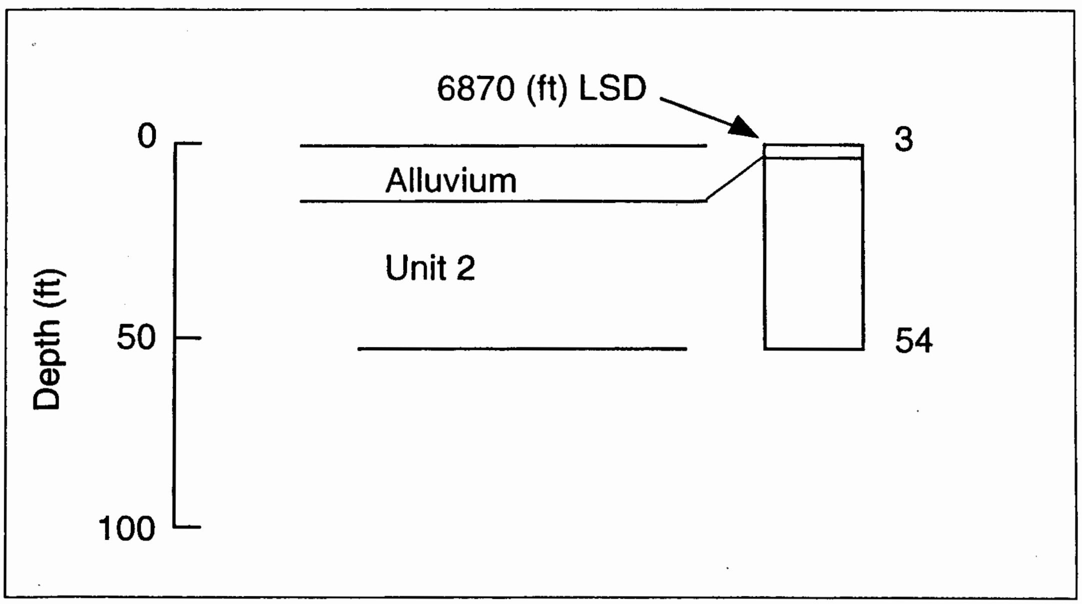


Fig. IX-O. Geologic log of Gamma Hole, completed March 1960, dry (Weir and Purtymun 1962).

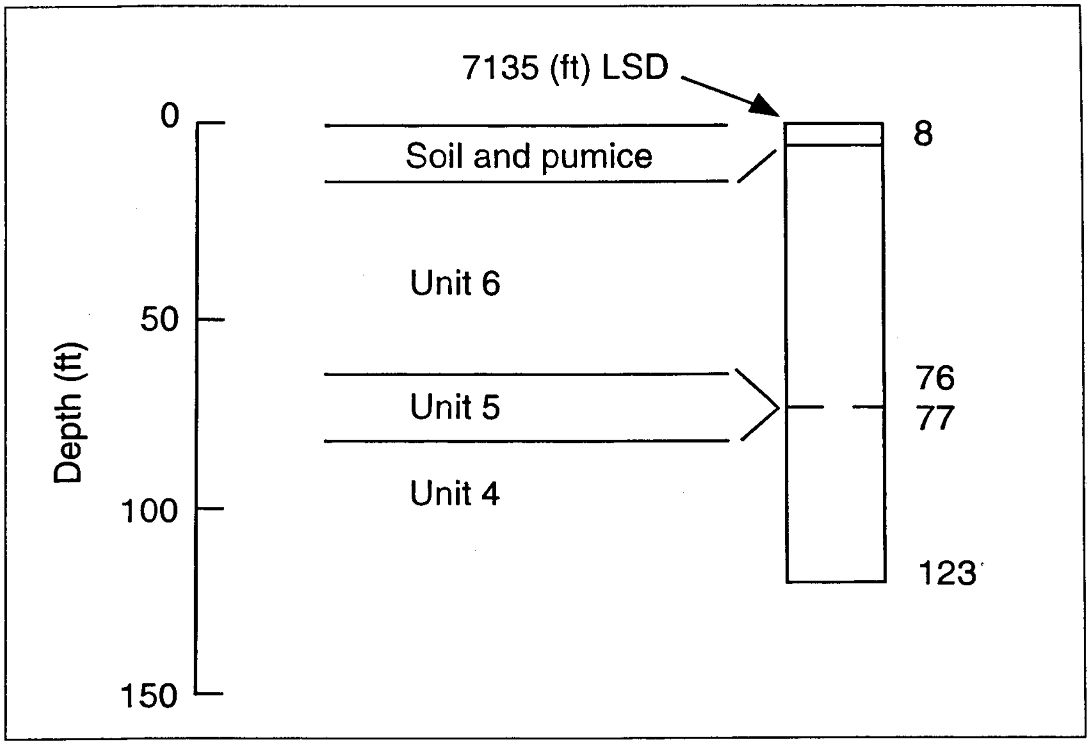


Fig. IX-P. Geologic log of Area 2 Test Hole 1, completed May 1980, dry (Purtymun 1994).

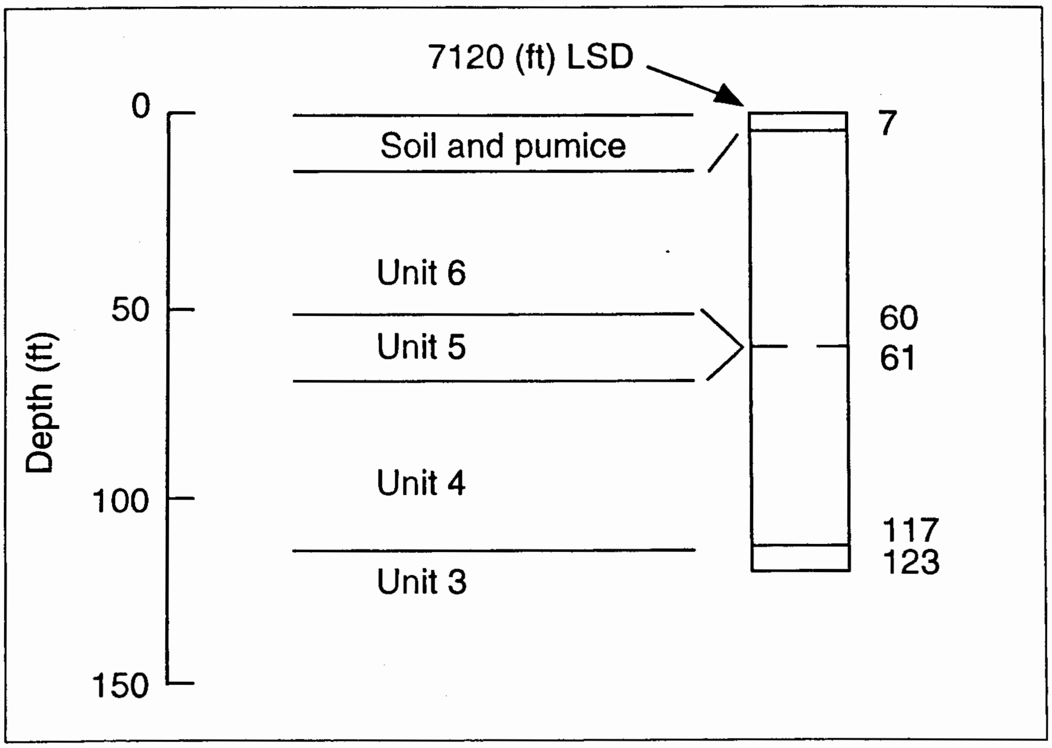


Fig. IX-Q. Geologic log of Area 2 Test Hole 2, completed May 1980, dry (Purtymun 1994).

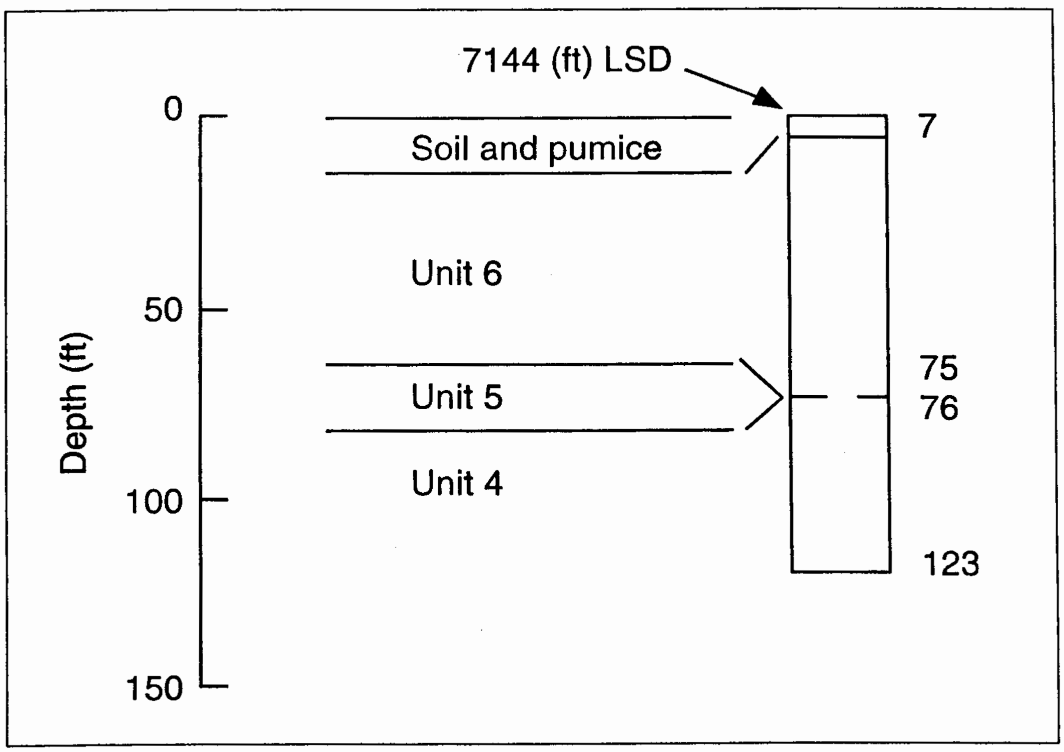


Fig. IX-R. Geologic log of Area 2 Test Hole 3, completed May 1980, dry (Purtymun 1994).

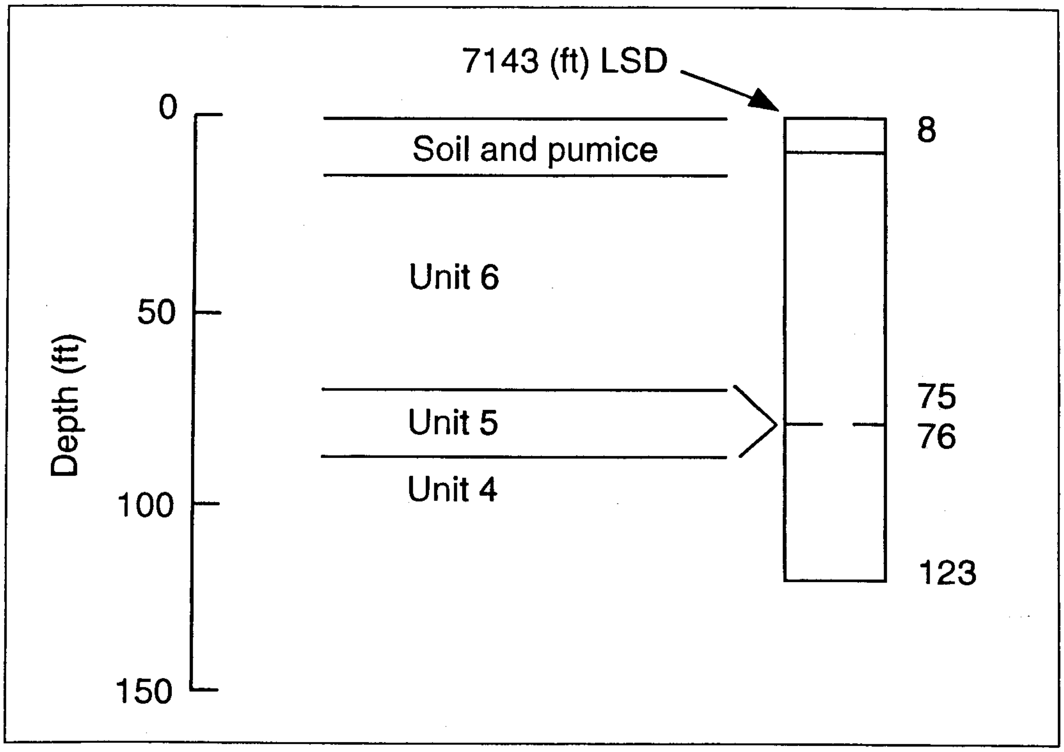


Fig. IX-S. Geologic log of Area 2 Test Hole 4, completed May 1980, dry (Purtymun 1994).

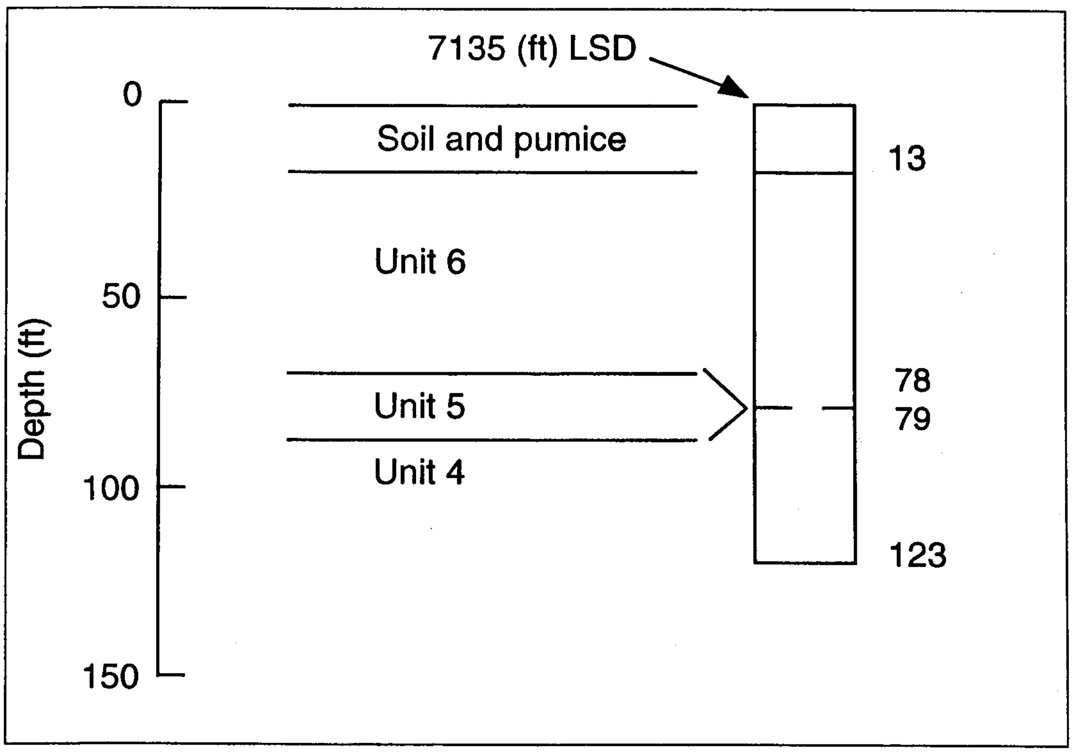


Fig. IX-T. Geologic log of Area 2 Test Hole 5, completed May 1980, dry (Purtymun 1994).

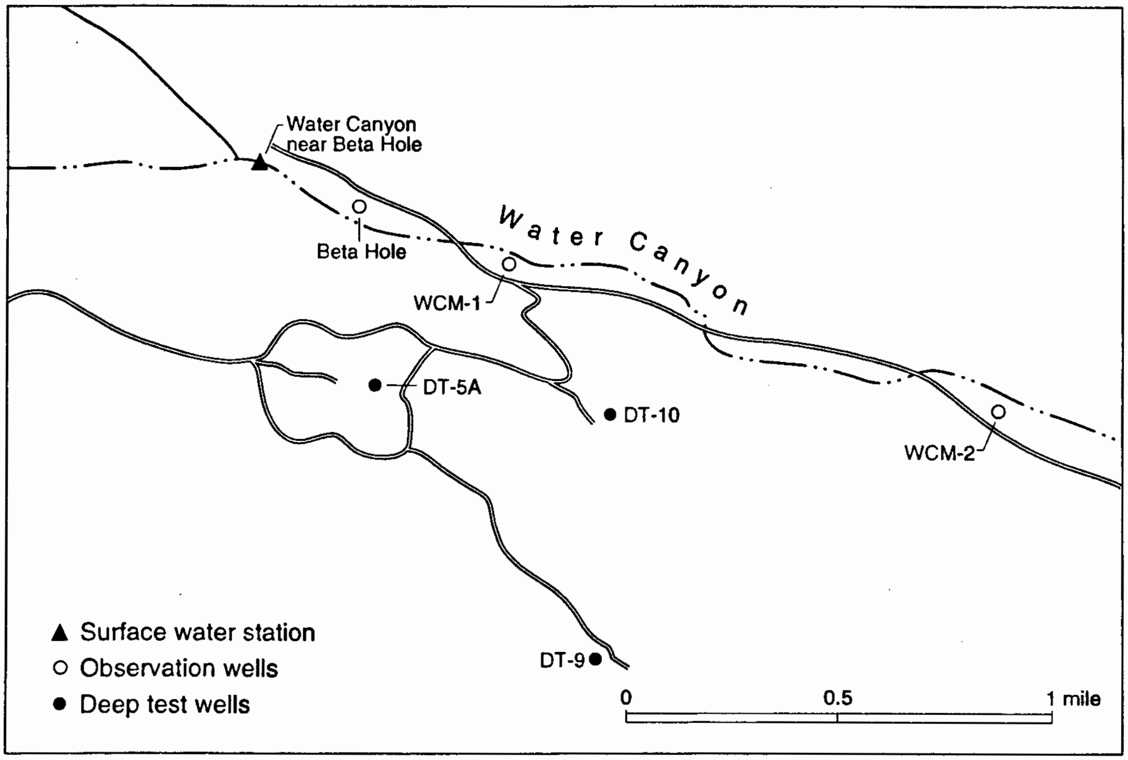


Fig. IX-U. Locations of wells, holes, and a surface water sampling station in Water Canyon north of TA-49.

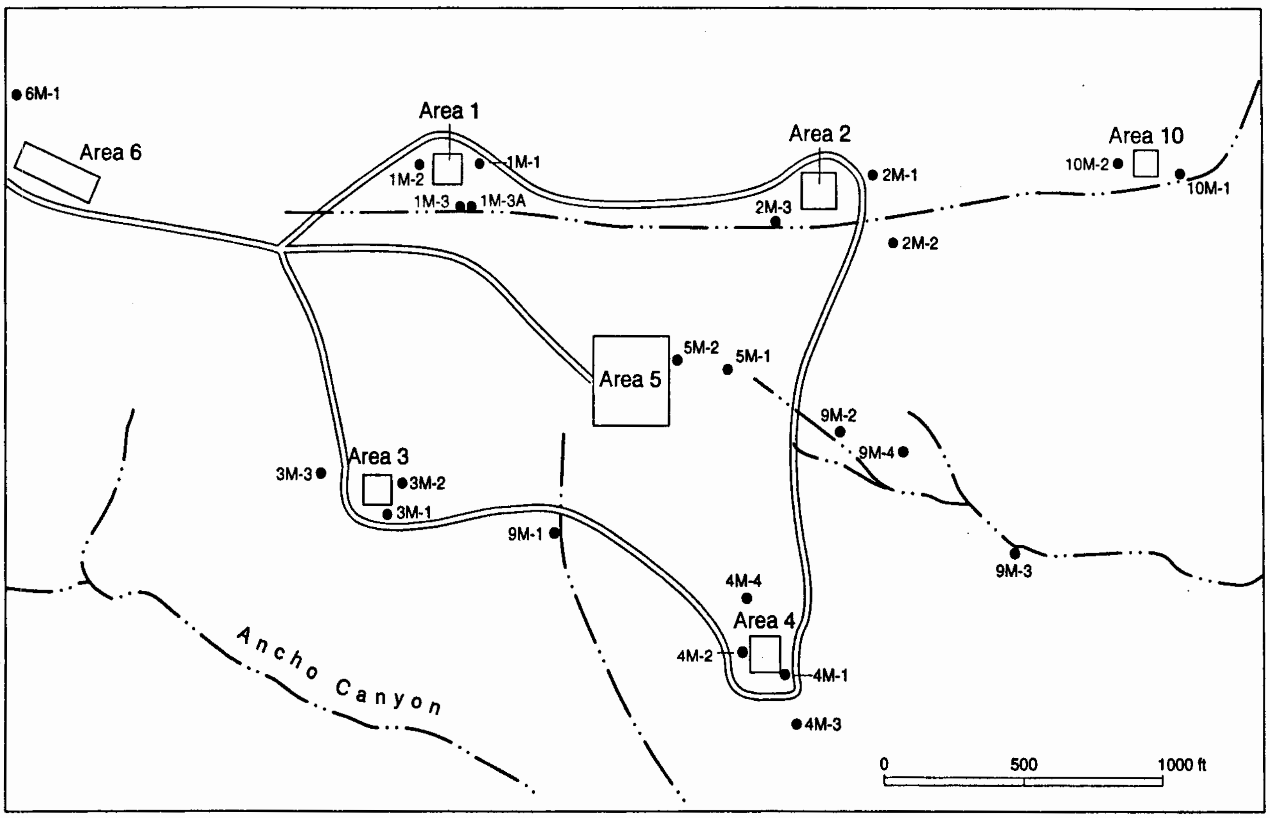


Fig. IX-V. Locations of moisture-access holes at TA-49.

TABLE IX-A. Construction and Hydrologic Data for Test Holes, Test Wells, and Core Holes at TA-49

	Year Drilled	Elevation (ft)	Depth (ft)	Water Level Completion (ft)	Remarks
Test Hole DT-5P	1959	7144	692	Dry	
Test Hole DT-5	1959	7143	962	Dry	
Test Well DT-5A	1959	7144	1821	1173	pump equipped
Test Well DT-9	1960	6935	1501	1003	pump equipped
Test Well DT-10	1960	7020	1409	1085	pump equipped
Core Hole CH-1	1959	7170	501	Dry	
Core Hole CH-2	1959	7137	507	Dry	
Core Hole CH-3	1960	7170	300	Dry	
Core Hole CH-4	1960	7116	303	Dry	
Alpha Hole	1960	7125	189	Dry	
Beta Hole	1960	6801	180	Dry	
Gamma Hole	1960	6870	54	Dry	
Area 2 Test Hole 1	1980	7135	123	Dry	
Area 2 Test Hole 2	1980	7120	123	Dry	
Area 2 Test Hole 3	1980	7144	123	Dry	
Area 2 Test Hole 4	1980	7143	123	Dry	
Area 2 Test Hole 5	1980	7135	123	Dry	

Sources: Weir and Purtymun 1962; Purtymun 1994.

TABLE IX-B. Geologic Logs and Construction Data for Test Holes and Test Wells (5 Test Holes and Wells)

1. Test Hole DT-5P

Elevation (LSD) 7144 ft

Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member		
Unit 6	73	73
Unit 5	2	75
Unit 4	44	119
Unit 3	63	182
Unit 2	100	282
Unit 1B	203	485
Unit 1A	156	641
Otowi Member	51	692

Note: Hole plugged and abandoned; located about 40 ft west of test well DT-5A.

TABLE IX-B. Geologic Logs and Construction Data for Test Holes and Test Wells (5 Test Holes and Wells) (Continued)

2. Test Hole DT-5

Elevation (LSD) 7143 ft — Water Level: Dry

Thickness

Geologic Log	Depth (ft)	(ft)
Bandelier Tuff		
Tshirege Member	641	641
Otowi Member	198	839
Guaje Member	101	940
Puye Conglomerate		
Fanglomerate member	22	962

Casing Schedule

180 ft of 8-in.-diam steel casing set 0–180 ft; open hole 180–962 ft.

Geophysical Logs

Gamma-ray/neutron, induction-electrical, and temperature logs.

3. Test Well DT-5A

Elevation (LSD) 7144 ft — Water Level: 1173 ft, April 1960

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member	641	641
Otowi Member	198	839
Guaje Member	91	930
Puye Conglomerate		
Fanglomerate member	237	1167
Basaltic Rocks of Chino Mesa		
Unit 2[a]	126	1293
Puye Conglomerate		
Fanglomerate member	138	1431
Basaltic Rocks of Chino Mesa		
Mesa Unit 2[a]	26	1457
Puye Conglomerate		
Fanglomerate member	18	1475
Totavi Lentil	52	1527
Santa Fe Group		
Chaquehui Formation	294	1821

Casing Schedule

525 ft of 12-in.-diam steel casing cemented in 0–525 ft; 1821 ft of 8-in.-diam steel casing hung 0 to 1821 ft with a total of 220 ft of torch-cut slots throughout the area below 1172 ft.

Geophysical Log

Gamma-ray/neutron, induction-electrical, temperature, microlog-caliper, laterlog, and sonic logs.

[a]Logged by Weir and Purtymun (1962) as Tschicoma Formation (see text).

TABLE IX-B. Geologic Logs and Construction Data for Test Holes and Test Wells (5 Test Holes and Wells) (Continued)

4. Test Well DT-9

Elevation (LSD) 6935 ft — Water Level: 1003 ft, February 1960

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member	676	676
Otowi Member	126	802
Guaje Member	48	850
Puye Conglomerate		
Fanglomerate member	74	924
Basaltic Rocks of Chino Mesa		
Unit 2[a]	238	1162
Puye Conglomerate		
Fanglomerate member	157	1319
Totavi Lentil	38	1357
Santa Fe Group		
Chaquehui Formation	144	1501

Casing Schedule

1335 ft of 12-in.-diam steel casing set 0–1335 ft, lower 295 ft torch slotted; 186 ft of 8-in.-diam steel casing swaged into the 12-in. casing at 1315 ft, set on bottom with 183 ft of torch-cut slots.

Geophysical Log

Gamma-ray/neutron, induction-electrical, temperature, laterlog, and sonic logs.

5. Test Well DT-10

Elevation (LSD) 7020 ft — Water Level: 1085 ft, April 1960

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member	672	672
Otowi Member	157	829
Guaje Member	35	864
Puye Conglomerate		
Fanglomerate member	108	972
Basaltic Rocks of Chino Mesa		
Unit 2[a]	319	1291
Puye Conglomerate		
Fanglomerate member	65	1356
Totavi Lentil	46	1402
Santa Fe Group		
Chaquehui Formation	7	1409

Casing Schedule

1130 ft of 12-in.-diam steel casing set 0–1130 ft, lower 50 ft torch slotted; 310 ft of 8-in.-diam casing set swaged into the 12-in.-diam casing at 1098 ft, set on bottom with a total of 141 ft of torch-cut slots throughout the section.

Geophysical Log

Gamma-ray/neutron, induction-electrical, temperature, and sonic logs.

[a]Logged by Weir and Purtymun (1962) as Tschicoma Formation (see text).
Source: Weir and Purtymun 1962, modified by Purtymun for this report.

TABLE IX-C. Geologic Logs and Construction Data for Core and Shallow Test Holes (12 Core and Test Holes)

1. Test Hole CH-1

Elevation (LSD) 7170 ft — Water Level: Dry (drilled with air)

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member		
Unit 6	71	71
Unit 5	2	73
Unit 4	41	114
Unit 3	76	190
Unit 2	94	284
Unit 1B	217	501

Casing Schedule
500 ft of 2-in.-diam galvanized pipe set 0 to 500 ft, with the lower 20 ft slotted.

Geophysical Logs
Gamma ray.

2. Core Hole CH-2

Elevation (LSD) 7137 ft — Water Level: Dry (drilled with air)[a]

Geologic Log	Thickness (ft)	Depth (ft)
Asphalt and fill	6	6
Bandelier Tuff		
Tshirege Member		
Unit 6	78	84
Unit 5	2	86
Unit 4	56	142
Unit 3	55	197
Unit 2	101	298
Unit 1B	195	493
Unit 1A	14	507

Casing Schedule
507 ft of 2-in.-diam galvanized pipe set 0 to 507 ft with the lower 20 ft slotted.

Geophysical Logs
Gamma-ray, gamma-ray/neutron, induction-electrical, and temperature logs.

3. Core Hole CH-3

Elevation (LSD) 7170 ft — Water Level: Dry (drilled with air)

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member		
Unit 6	75	75
Unit 5	2	77
Unit 4	44	121

[a]Thousands of gallons of water and drilling mud are pumped into holes for geophysical logging.

TABLE IX-C. Geologic Logs and Construction Data for Core and Shallow Test Holes (12 Core and Test Holes) (Continued)

3. Core Hole CH-3 (Continued)

Tshirege Member		
Unit 3	72	193
Unit 2	102	295
Unit 1B	5	300

Casing Schedule
300 ft of 12-in.-diam galvanized pipe set 0 to 300 ft with the lower 20 ft slotted.

Geophysical Log
Gamma ray.

4. Core Hole CH-4

Elevation (LSD) 7116 ft — Water Level: Dry (drilled with air)

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member		
Unit 6	62	62
Unit 5	2	64
Unit 4	61	125
Unit 3	52	177
Unit 2	111	288
Unit 1B	15	303

Casing Schedule
300 ft of 2-in.-diam galvanized pipe set 0 to 300 ft with the lower 20 ft slotted.

Geophysical Log
Gamma ray.

5. Alpha Hole

Elevation (LSD) 7125 ft — Water Level: Dry (drilled with a bucket auger)

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member		
Unit 6	76	76
Unit 5	2	78
Unit 4	50	128
Unit 3	61	189

Casing Schedule
7 ft of 24-in.-diam corrugated metal pipe set from 0 to 7 ft; open hole 7 to 189 ft.

Geophysical Log
Gamma-ray/neutron and induction-electrical logs.

TABLE IX-C. Geologic Logs and Construction Data for Core and Shallow Test Holes (12 Core and Test Holes) (Continued)

6. Beta Hole

Elevation (LSD) 6801 ft — Water Level: Dry (drilled with a bucket auger)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	8	8
Bandelier Tuff		
Tshirege Member		
Unit 1B	172	180

Casing Schedule

13 ft of 24-in.-diam corrugated metal pipe set from 0 to 13 ft; open hole 13 to 180 ft.

7. Gamma Hole

Elevation (LSD) 6870 ft — Water Level: Dry[a]

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	3	3
Bandelier Tuff		
Tshirege Member		
Unit 2	51	54

Casing Schedule

8 ft of 4-in.-diam steel casing set 0 to 8 ft, open hole 8 to 54 ft.

8. Area 2 Test Hole 1

Elevation (LSD) 7135 ft — Water Level: Dry (drilled with 4-in.-diam auger)

Geologic Log	Thickness (ft)	Depth (ft)
Soil and pumice	8	8
Bandelier Tuff		
Tshirege Member		
Unit 6	68	76
Unit 5	1	77
Unit 4	46	123

9. Area 2 Test Hole 2

Elevation (LSD) 7120 ft — Water Level: Dry (drilled with 4-in.-diam auger)

Geologic Log	Thickness (ft)	Depth (ft)
Soil and pumice	7	7
Bandelier Tuff		
Tshirege Member		
Unit 6	53	60
Unit 5	1	61

[a]Surface water ran in hole, spring 1960.

TABLE IX-C. Geologic Logs and Construction Data for Core and Shallow Test Holes (12 Core and Test Holes) (Continued)

9. Area 2 Test Hole 2 (Continued)

	Thickness (ft)	Depth (ft)
Tshirege Member		
Unit 4	56	117
Unit 3	6	123

Casing Schedule
4 ft of 4-in.-diam plastic pipe cemented in 0 to 3 ft; open hole 3 to 123 ft.

10. Area 2 Test Hole 3

Elevation (LSD) 7144 ft — Water Level: Dry (drilled with a 4-in.-diam auger)

Geologic Log	Thickness (ft)	Depth (ft)
Soil and pumice	7	7
Bandelier Tuff		
Tshirege Member		
Unit 6	68	75
Unit 5	1	76
Unit 4	47	123

Casing Schedule
4 ft of 4-in.-diam plastic pipe cemented in 0 to 3 ft; open hole 3 to 123 ft.

11. Area 2 Test Hole 4

Elevation (LSD) 7143 ft — Water Level: Dry (drilled with a 4-in.-diam auger)

Geologic Log	Thickness (ft)	Depth (ft)
Soil and pumice	8	8
Bandelier Tuff		
Tshirege Member		
Unit 6	67	75
Unit 5	1	76
Unit 4	47	123

Casing Schedule
4 ft of 4-in.-diam plastic pipe cemented in 0 to 3 ft; open hole 3 to 123 ft.

12. Area 2 Test Hole 5

Elevation (LSD) 7135 ft — Water Level: Dry (drilled with a 4-in.-diam auger)

Geologic Log	Thickness (ft)	Depth (ft)
Soil and pumice	13	13
Bandelier Tuff		
Tshirege Member		
Unit 6	65	78
Unit 5	1	79
Unit 4	44	123

Casing Schedule
4 ft of 4-in.-diam plastic pipe cemented in 0 to 3 ft; open hole 3 to 123 ft.

Sources: Weir and Purtymun 1962; Purtymun 1994.

TABLE IX-D. Geologic Logs of 23 Moisture-Access Holes and 2 Observation Wells at TA-49

Moisture-Access Hole	Elevation LSD (ft)	Extent of Casing below LSD (ft)	Log: Soil (ft)	Log: Bandelier Tuff (ft)
1M-1	7162	49	4.5	44.5
1M-2	7170	19	1	18
1M-3	7171	19	4	15
1M-3A	7171	49	3	46
2M-1	7129	49	1	48
2M-2	7131	10	5	5
2M-3	7141	19	5	14
3M-1	7163	50	1	49
3M-2	7169	19	2.5	16.5
3M-3	7174	20	7	13
4M-1	7112	49	2	47
4M-2	7116	20	1.5	18.5
4M-3	7107	19	3	16
4M-4	7122	19	3	16
5M-1	7136	39	2.5	36.5
5M-2	7146	19	3	16
6M-1	7210	19	9	10
9M-1	7115	19	6	13
9M-2	7104	19	6.5	12.5
9M-3	7049	19	4	15
9M-4	7097	19	12.5	6.5
10M-1	7090	29	2	27
10M-2	7093	20	4	16
WCM-1[a]	6745	10	10	—
WCM-2[a]	6650	10	10	—

Note: Moisture-access holes and observation wells completed February 1960; drilled with 2-in.-diam wagon drill with 2-in.-diam plastic pipe forced into holes. All holes dry except WCM-1 and WCM-2 (completed in the alluvium of Water Canyon).

[a] Completed as observation wells in Water Canyon, lower 5 ft perforated (see Fig. IX-U for location).

Source: Weir and Purtymun 1962.

TABLE IX-E. Locations and Elevations (NAD 1927 and LANLC)			
A. Surface Water			
Water Canyon near Beta Hole	S 82 + 63	E 91 + 36	6800 ft
B. Deep Test Holes			
DT-5P	S 111 + 32	E 94 + 36	7144 ft
DT-5	S 110 + 99	E 93 + 03	7143 ft
DT-5A	N 1,754,727	E 485,066	7144 ft
DT-9	N 1,751,431	E 488,750	6935 ft
DT-10	N 1,754,387	E 488,744	7020 ft
C. Core and Test Holes			
CH-1	S 104 + 98	E 84 + 37	7170 ft
CH-2	S 105 + 70	E 97 + 85	7137 ft
CH-3	S 114 + 94	E 82 + 06	7170 ft
CH-4	S 120 + 33	E 95 + 68	7116 ft
Alpha Hole	S 111 + 16	E 97 + 54	7125 ft
Beta Hole	S 83 + 63	E 91 + 89	6801 ft
Gamma Hole	S 133 + 20	E 104 + 00	6870 ft
TH-1	N 1,755,200	E 485,700	7135 ft
TH-2	N 1,755,500	E 485,600	7120 ft
TH-3	N 1,755,300	E 485,400	7144 ft
TH-4	N 1,755,100	E 485,400	7143 ft
TH-5	N 1,755,200	E 485,500	7135 ft
D. Moisture-Access Holes			
1M-1	S 104 + 40	E 85 + 48	7162 ft
1M-2	S 104 + 63	E 83 + 39	7170 ft
1M-3	S 105 + 92	E 84 + 95	7171 ft
1M-3A	S 105 + 92	E 85 + 02	7171 ft
2M-1	S 104 + 73	E 99 + 28	7129 ft
2M-2	S 107 + 12	E 100 + 05	7131 ft
2M-3	S 106 + 66	E 96 + 01	7141 ft
3M-1	S 115 + 97	E 82 + 03	7163 ft
3M-2	S 114 + 82	E 82 + 67	7169 ft
3M-3	S 114 + 56	E 79 + 96	7174 ft
4M-1	S 121 + 29	E 96 + 44	7112 ft
4M-2	S 120 + 57	E 94 + 70	7116 ft
4M-3	S 122 + 76	E 96 + 94	7107 ft
4M-4	S 118 + 72	E 94 + 94	7122 ft
5M-1	S 111 + 32	E 94 + 36	7136 ft
5M-2	S 111 + 05	E 92 + 38	7146 ft
6M-1	S 102 + 15	E 68 + 83	7210 ft
9M-1	S 116 + 67	E 88 + 44	7115 ft
9M-2	S 113 + 40	E 98 + 15	7104 ft
9M-3	S 117 + 02	E 104 + 57	7049 ft
9M-4	S 113 + 93	E 100 + 40	7097 ft
10M-1	S 104 + 96	E 110 + 31	7090 ft
10M-2	S 104 + 54	E 108 + 69	7093 ft
WCM-1	S 92 + 20 approx	E 111 + 20 approx	6745 ft approx
WCM-2	S 102 + 20 approx	E 145 + 00 approx	6650 ft approx

X. AIR INJECTION SITE NEAR TA-52

To study the possibility of injecting, storing, and later venting low-level short-lived radioactive gases, a site was prepared by augering four 5-in.-diam holes into the tuff (Fig. X-A). The holes were augered to 97 ft (Table X-A). Two plastic tubes were run to the bottom of each hole, with the lower 10 ft of each tube perforated. These were to be used to inject air and to measure any buildup of pressure that might occur. The injection zone at the bottom of the hole was packed with pea-sized gravel. The injection zone in each hole was isolated by a cement plug.

A 4-in.-diam hole (NE-2) was drilled with air to a depth of 297 ft, north of the cluster of four holes. The hole has two injection zones, one near the bottom from 272 to 291 ft and another at about 160 ft. These were constructed with only one tube going to each zone.

In one experiment air was pumped from the tuff, from different depths in two test holes. In NE-2 air was pumped from the zone 272 to 291 ft and from NE-1 air was pumped from the zone 78 to 83 ft. Both air samples were analyzed for carbon dioxide. The test revealed that the carbon that was present was of mixed origin, part atmospheric and part biogenic. Radiocarbon ages for the carbon dioxide could not be determined.

REFERENCE

J. L. Kunkler, "The Sources of Carbon Dioxide in the Zone of Aeration of the Bandelier Tuff, near Los Alamos, New Mexico," in U.S. Geol. Survey Prof. Paper 650-D (1969).

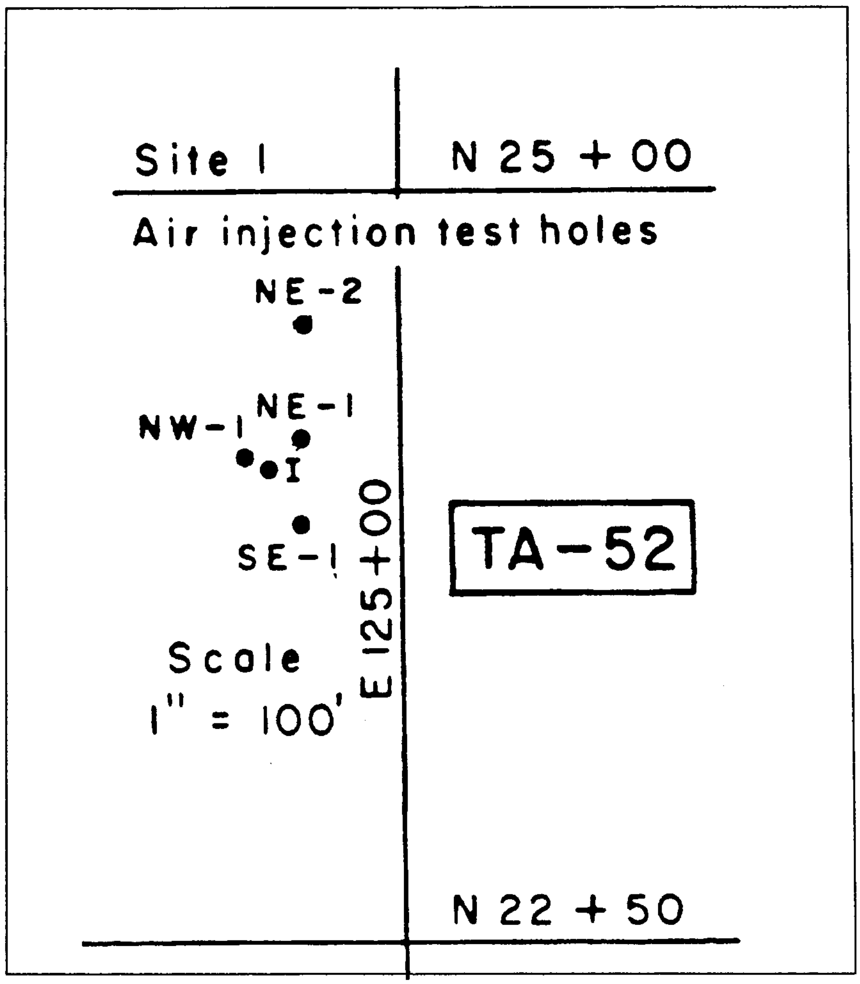


Fig. X-A. Locations of test holes at air injection site near TA-52.

TABLE X-A. Construction Data for Test Holes at Air-Tuff Transfer Site Near TA-52

Test Hole	Structure No.	Date Drilled	Elevation (LSD) (ft)	Diameter (in.)	Depth (ft)
I	TA-52-25	12/64	7168.8	5	97
NW-1	TA-52-24	12/64	7169.1	5	97
SE-1	TA-52-26	12/64	7167.4	5	97
NE-1	TA-52-23	12/64	7169.2	5	97
NE-2	TA-52-22	10/65	7171.5	4	295

Note: Holes I, NE-1, SE-1, and NW-1 have 6-in.-diam steel casing cemented into the top of the tuff. All holes have 10-ft-long gravel injection zones from 87 to 97 ft with tubes extending from the injection zones to the surface. Injection zones are isolated by cement plugs. All holes were dry.

TABLE X-B. Locations and Elevations (NAD 1927)

Hole I	N 1,768,138	E 488,802	7168.8 ft
Hole NW-1	N 1,768,140	E 488,799	7169.1 ft
Hole SE-1	N 1,768,119	E 488,811	7167.4 ft
Hole NE-1	N 1,768,144	E 488,812	7169.2 ft
Hole NE-2	N 1,768,182	E 488,816	7171.5 ft

XI. AIR AND WATER INJECTION SITES NEAR TA-50

At Site 1 near TA-50, eight holes were augered or drilled with air to study the effect of atmospheric pressure change in different zones within the tuff (Fig. XI-A). All were completed in Unit 3 of the Tshirege Member of the Bandelier Tuff. Construction details are presented in Table XI-A.

At Site 2 near TA-50 seven holes were augered with a 5-in.-diam to depths ranging from 67 to 118 ft (Fig. XI-A). Two additional 4-in.-diam holes were rotary-air drilled to a depth of 295 ft (Table XI-B). The 67 ft hole was used as the injection well, with a 10-ft injection zone from 57 to 67 ft. Two lines were run into the injection zone, one to inject water and the second to measure the pressure at the center of the injection zone. The remaining holes were left open, with 4-in.-diam plastic pipe cemented in them. These holes were used to monitor the distribution of water and its movement out of the injection zone, through the use of a neutron moisture probe and scaler.

Additional 5-in.-diam holes (the C-series) were augered to a depth of 18 ft. These three holes were used for the calibration of the neutron probe and scaler. Each was cased with 2-in.-diam plastic tubing (Table XI-B).

All holes at both sites were destroyed during the construction of a new facility in early 1980.

REFERENCES

J. L. Kunkler, "Measurement of Atmospheric Pressure and Subsurface-Gas Pressure in the Unsaturated Zone of the Bandelier Tuff, Los Alamos, New Mexico," in U.S. Geol. Survey Prof. Paper 650-D (1969).

W. D. Purtymun, E. Enyart, and S. G. McLin, "Hydrologic Characteristics of the Bandelier Tuff as Determined through an Injection Well System," Los Alamos National Laboratory report LA-11511-MS (1989).

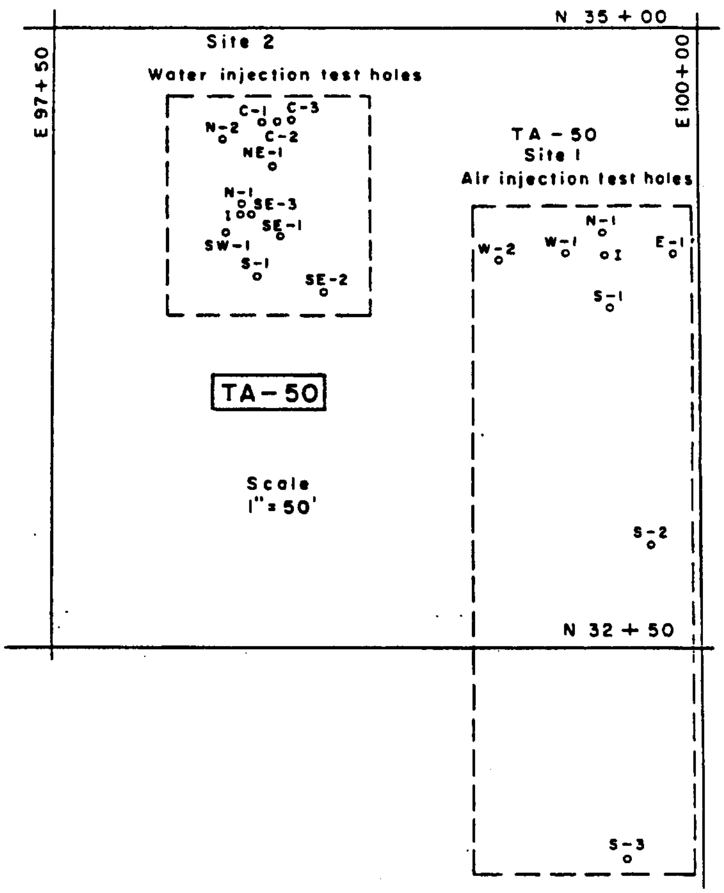


Fig. XI-A. Locations of test holes at Site 1 and Site 2 near TA-50.

TABLE XI-A. Construction Data for Test Holes at Air-Tuff Transfer Site 1 Near TA-50

Test Holes	Elevation (LSD) (ft)	Diameter (in)	Depth (ft)	Injection Zone Depth (ft) No. 1	No. 2	No. 3	No. 4	Remarks
E-1	7240.4	3	86	3–8	37–43	69–74	81–86	monitoring tubes
N-1	7241.8	5	94	3–6	25–30	54–60	86–94	injection and monitoring tubes
W-1	7241.7	3	91	3–8	39–44	69–74	86–91	monitoring tubes
W-2	7241.7	3	114	3–8	109–114	—	—	monitoring tubes
I	7241.6	5	60	3–8	25–30	55–60	—	injection and monitoring tubes
S-1	7239.7	5	90	3–8	24–29	55–60	83–90	injection and monitoring tubes
S-2	7231.6	5	56	49–56	—	—	—	water injection test
S-3	7218.3	5	43	—	—	—	—	open hole

Note: Holes E-1 and W-1 drilled air-rotary; all others augered. Injection zone consists of 3/8-in.-diam gravel. Monitoring tube is 1/2-in. plastic tubing perforated 1 foot from the bottom. Injection tube is 3/4-in. plastic tubing perforated 3 feet from the bottom. Perforations in each tube are separated from those of other tubes by lead plate. Tubes are cemented into the gravel-pack intervals. All holes were dry.

TABLE XI-B. Construction Data for Test Holes at Liquid Injection Site 2 Near TA-50

Test Hole	Date Drilled	Elevation (ft)	Diameter (in.)	Depth (ft)	Remarks
N-2	9/65	7247.7	5	112	
NE-1	9/65	7246.6	5	118	
N-1	11/64	7245.2	5	97	
I	11/64	7244.7	5	67	injection well
SE-3	10/65	7244.6	4	295	air rotary
SW-1	11/64	7244.4	5	97	
SE-1	11/64	7243.9	5	97	
S-1	10/65	7242.9	4	295	air rotary
SE-2	9/65	7241.6	5	112	
C-1	10/65	7248	5	18	
C-2	10/65	7248	5	18	
C-3	10/65	7248	5	18	

Note: All holes were completed in the tuff. Holes SE-3 and S-1 were drilled air-rotary; all others were augered. Hole I, an injection well with a gravel-pack injection zone from 55 to 65 ft, had an injection tube and observation hole extending from the injection zone to the surface. The hole was cemented from the surface to the top of the gravel pack at 55 ft. Holes C-1, C-2, and C-3 were calibration holes, cased with 2-in. plastic tubing. All other holes were open except for a short surface casing set through the soil zone. All holes were dry when drilled.

TABLE XI-C. Locations and Elevations (NAD 1927)

A. Air Study Site

Hole E-1	N 1,768,243	E 486,338	7240.4 ft
Hole N-1	N 1,769,251	E 486,354	7241.8 ft
Hole W-1	N 1,769,243	E 486,340	7241.7 ft
Hole W-2	N 1,769,242	E 486,314	7241.7 ft
Hole I	N 1,769,242	E 486,356	7241.6 ft
Hole S-1	N 1,769,321,	E 486,360	7239.7 ft
Hole S-2	N 1,769,123	E 486,368	7231.6 ft
Hole S-3	N 1,768,997	E 486,358	7218.3 ft

B. Water Study Site

Hole N-2	N 1,769,296	E 486,212	7247.7 ft
Hole NE-1	N 1,769,274	E 486,229	7246.6 ft
Hole N-1	N 1,769,270	E 486,219	7245.2 ft
Hole I	N 1,769,265	E 486,218	7244.7 ft
Hole SE-3	N 1,769,264	E 486,220	7244.6 ft
Hole SW-1	N 1,769,258	E 486,211	7244.4 ft
Hole SE-1	N 1,769,255	E 486,231	7243.9 ft
Hole S-1	N 1,769,240	E 486,221	7242.9 ft
Hole SE-2	N 1,769,231	E 486,247	7271.6 ft
Hole C-1	N 1,769,302	E 486,227	7248 ft
Hole C-2	N 1,769,302	E 486,232	7248 ft
Hole C-3	N 1,769,303	E 486,237	7248 ft

XII. TEST HOLES AT TA-21

Thirteen test holes were drilled around the perimeter of the contaminated waste disposal pit Area B west of TA-21. The holes were augered and samples collected to determine if there had been any movement of contaminants from the pit into the adjacent tuff (Fig. XII-A). The holes were also logged using the neutron probe and scaler to determine the moisture content of the tuff *in situ*.

The samples were analyzed for moisture as well as gross alpha, gross beta, plutonium, and uranium. The results of the investigation indicated no lateral migration of contaminants from the waste pit into the adjacent soil or tuff. Geologic logs of the holes are found on Table XII-A.

REFERENCE

W. D. Purtymun and W. R. Kennedy, "Distribution of Moisture and Radioactivity in the Soil and Tuff at the Contaminated Waste Pit near Technical Area 21," Los Alamos, New Mexico," U.S. Geol. Survey Open-File Report (1966).

TABLE XII-A. Geologic Logs of Test Holes Near Solid Waste Disposal Area B at TA-21

Test Hole	Elevation (ft)	Depth (ft)	Log: Soil (ft)	Log: Bandelier Tuff (ft)
DPS-1	7190	50	3	47
DPS-2	7191	25	3	22
DPS-3	7194	50	3	47
DPS-4	7202	25	3	22
DPS-5	7214	50	3	47
DPS-6	7216	50	6	44
DPS-7	7185	25	3	22
DPS-8	7181	50	6	44
DPS-9	7180	25	4	21
DPS-10	7182	35	4	31
DPS-11	7192	50	4	46
DPS-12	7192	36	3	33
DPS-13	7210	35	2	33

Note: Holes augered February 1966; holes 4-in. diam; holes plugged and abandoned after study. All holes were dry.

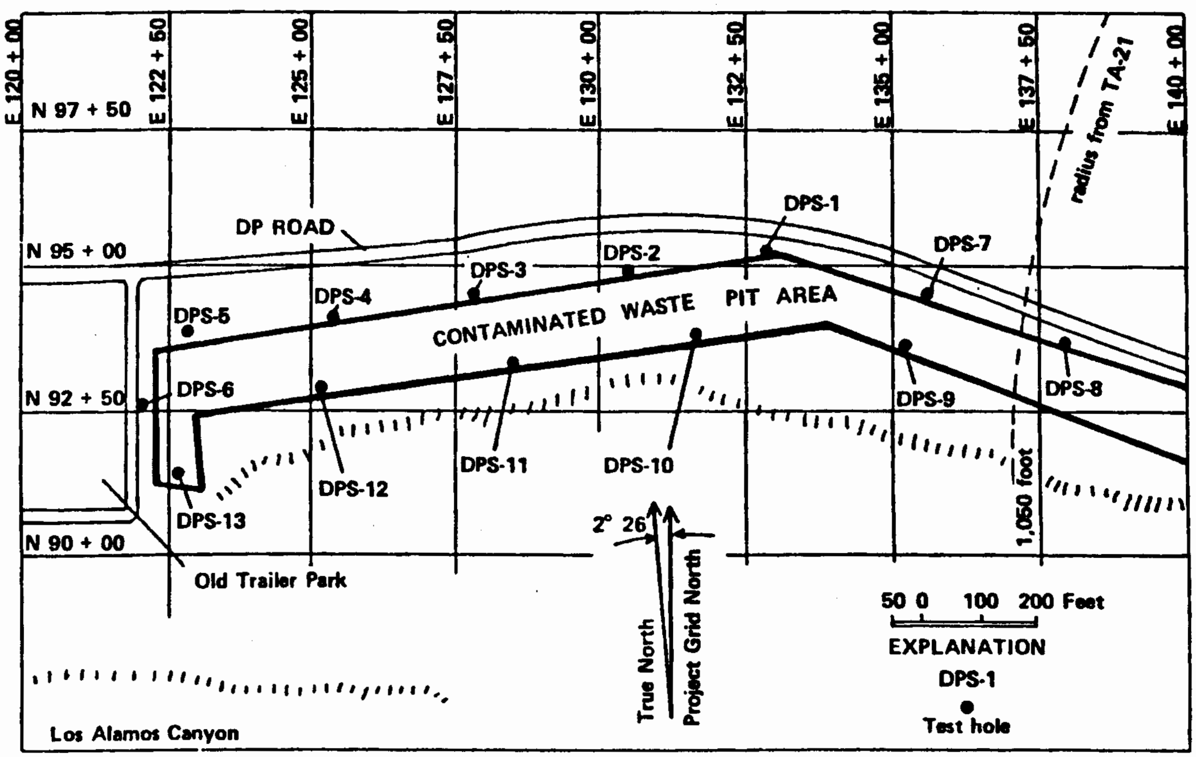


Fig. XII-A. Locations of test holes at solid waste Area B near TA-21.

TABLE XII-B. Locations and Elevations (NAD 1927)

DPS-1	N 1,775,197	E 489,945	7190 ft
DPS-2	N 1,775,172	E 489,702	7191 ft
DPS-3	N 1,775,149	E 489,432	7194 ft
DPS-4	N 1,775,130	E 489,233	7202 ft
DPS-5	N 1,775,108	E 488,928	7214 ft
DPS-6	N 1,774,989	E 488,848	7116 ft
DPS-7	N 1,775,113	E 490,213	7185 ft
DPS-8	N 1,775,028	E 490,447	7181 ft
DPS-9	N 1,775,041	E 490,160	7180 ft
DPS-10	N 1,775,056	E 489,796	7182 ft
DPS-11	N 1,775,024	E 489,490	7192 ft
DPS-12	N 1,774,997	E 489,159	7192 ft
DPS-13	N 1,774,967	E 488,909	7210 ft

XIII. TEST HOLES AT AREAS L AND G AT TA-54

A study of the waste disposal area at Areas L and G at TA-54 was made during 1985–1986. The study was requested by the State of New Mexico Environmental Department. The Laboratory contracted with Bendix Corporation of Grand Junction, Colorado for Bendix to characterize the Bandelier Tuff. As a result of that study, the Environmental Protection Group, Hazardous and Solid Waste Section, had 10 additional holes drilled in 1988–1990 in Areas L and G. These holes were completed as pore-gas monitoring holes, to determine the extent of the organic vapor plume from Area L.

A. Test Holes 1985 and 1986

In 1985 and 1986, 18 test holes were cored or augered at Areas L and G to characterize the vadose zone in and around the chemical disposal pits and shafts (Area L) and the radioactive waste disposal pits and shafts (Area G). The holes ranged in depth from 60 to 145 ft (Fig. XIII-A and Table XIII-A). Numerous samples of the sections cored were analyzed for organic and inorganic chemicals and radionuclides and to learn the hydrologic properties of the tuff.

Areas L and G are located on a narrow southeast-trending mesa that is underlain by the Bandelier Tuff. The 18 holes drilled in 1985 are located on this mesa (Fig. XIII-A). The purposes of these test holes, and their geologic logs, are found in Table XIII-A. Special construction was used in some of the core holes to allow various types of tests. The construction consisted of packing off zones in the wells to allow special testing and sampling of vapors in the tuff, as well as equipping other zones with special equipment to measure pressures, moistures, and other hydrologic parameters.

Seven additional holes were cored by Bendix in 1986. The locations of these holes are shown in Fig. XIII-B, while their geologic logs and uses are found in Table XIII-B.

The holes drilled in 1985 and 1986 were completed in the Tshirege Member of the Bandelier Tuff. The tuff has been divided into four units described from the oldest (Unit 1A) to the youngest (Unit 2B) as in the type section in Mortandad Canyon (Fig. I-O); however, the Bendix report did not recognize the same boundaries or contacts as the type section in Mortandad Canyon from Baltz et al. (1963) or Purtymun and Kennedy (1971). A correlation of the thicknesses of the units used in the Bendix reports with those of the type section in Mortandad Canyon appears in Fig. XIII-C. No attempt was made to change the thicknesses of the units described by Bendix to match those of the type section.

B. Test Holes 1988–1990

During the period 1988 through 1990 the Laboratory drilled 10 holes of 4-in. diam to monitor vapors in the tuff. A series of zones was set up with tubing to allow vapor sampling. The holes were located atop Mesita del Buey (Fig. XIII-D). All but the last 2 of the holes were drilled through the Tshirege, Otowi, and Guaje Members of the Bandelier Tuff into the top of the basalt (Purtymun 1990). The geologic logs and uses of the holes are shown in Table XIII-C. The logs in Table XIII-C reflect the description and thicknesses of the type section in Mortandad Canyon, thus the thicknesses may vary slightly from those of the logs in the Bendix report (Fig. XIII-C).

The geology used to describe the work 1988–1990 is presented in Purtymun and Kennedy (1971) and Purtymun (1990). In general, the four units thin to the southeast where the tuff was laid on top of the basalts (emplaced to the north and northwest) that came from vents east of the Rio Grande.

REFERENCES

Vadose Zone Characterization of Technical Area 54, Waste Disposal Areas G and L, Los Alamos National Laboratory, Los Alamos, New Mexico: studies undertaken by Bendix Field Engineering Corporation, Grand Junction Operations, Grand Junction, Colo., resulted in four reports:

S. M. Rush and J. J. Dexter, "Report 1: Drilling and Logging Activities," (1985a).

Bendix Field Eng. Corp., "Report 2: Down-Hole Instrumentation and Pore-Gas-Sampling/Data-Collection Procedures," (1985b).

P. M. Kearl, J. J. Decker, and M. Kautsky, "Report 3: Preliminary Assessment of the Hydrologic System," (1986a).

P. M. Kearl, J. J. Dexter, and M. Kautsky, "Report 4: Preliminary Assessment of the Hydrologic System through Fiscal Year 1986," (1986b).

E. H. Baltz, J. H. Abrahams, and W. D. Purtymun, "Preliminary Report on the Geology and Hydrology of Mortandad Canyon near Los Alamos, New Mexico with Special Reference to Disposal of Liquid Low-Level Radioactive Wastes," U.S. Geological Survey Open-File Report (1963).

W. D. Purtymun, "Geology of Mesita del Buey, Results of Drilling Pore Gas Monitoring Holes," Los Alamos National Laboratory, unpublished HSE-8 document, 1990.

W. D. Purtymun and W. R. Kennedy, "Geology and Hydrology of Mesita del Buey," Los Alamos Scientific Laboratory report LA-4600 (1971).

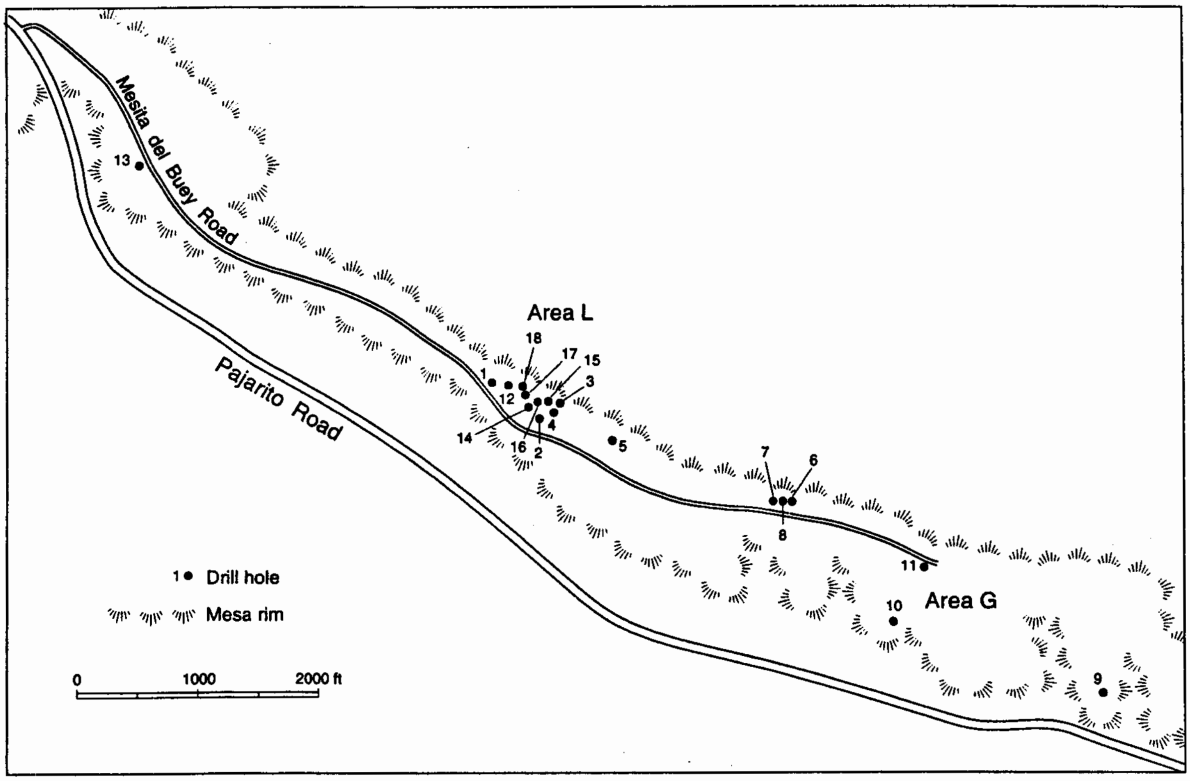


Fig. XIII-A. Locations of 18 test holes at Areas G and L on Mesita del Buey (Bendix 1985a).

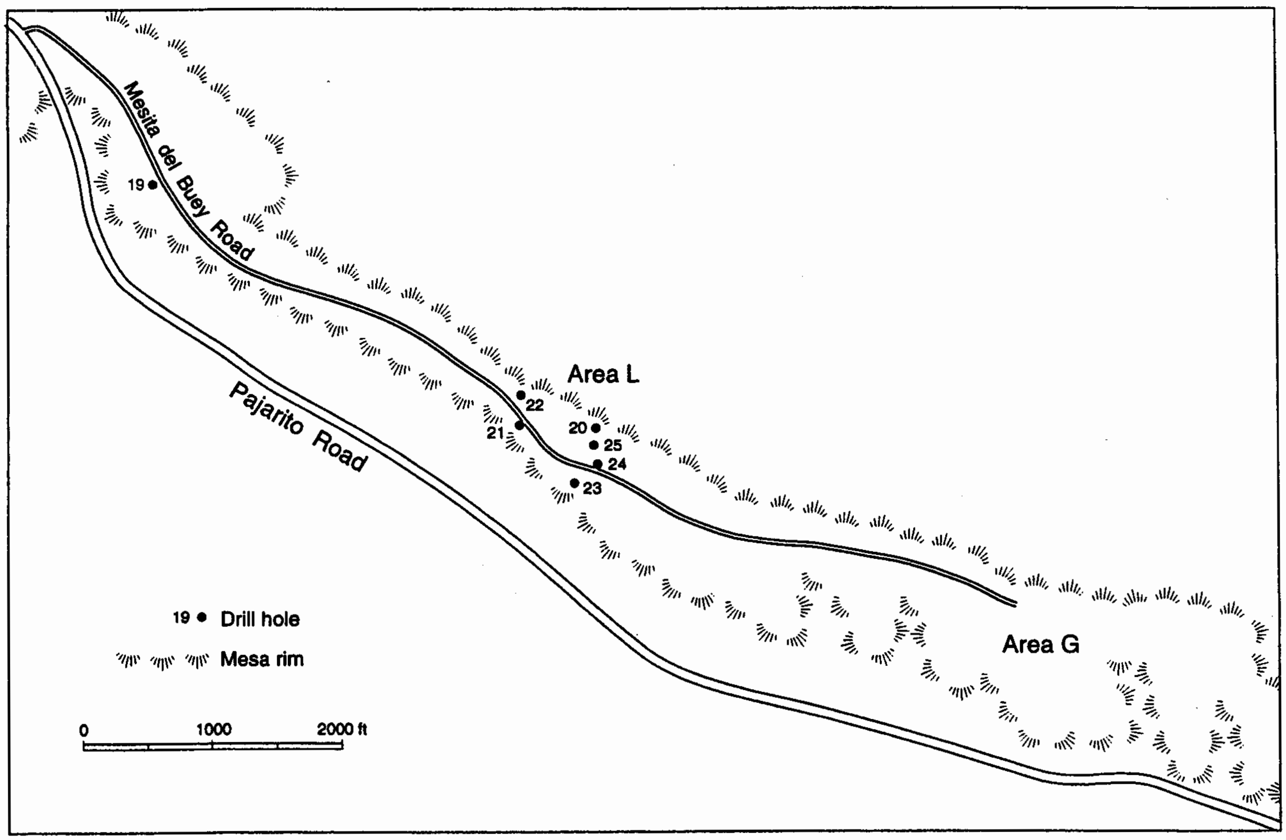


Fig. XIII-B. Locations of seven test holes on Mesita del Buey (Bendix 1986a).

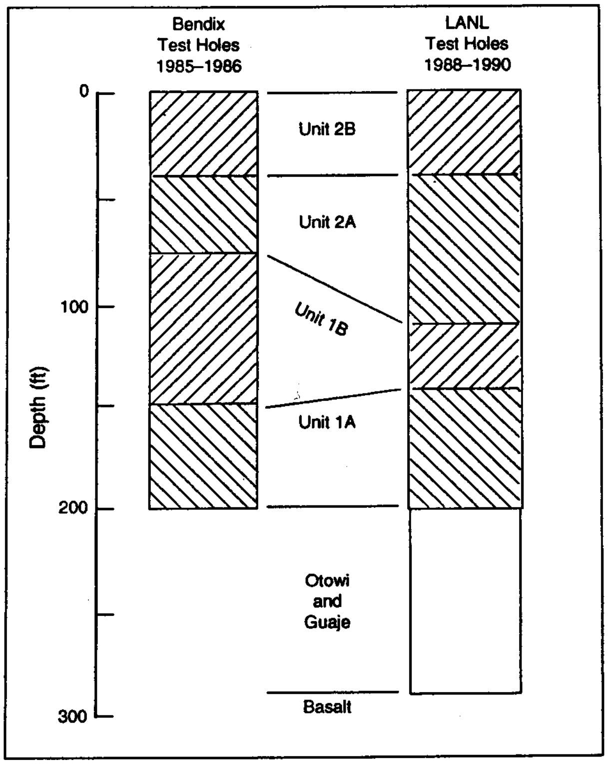


Fig. XIII-C. Correlation differences in the thicknesses of units of the Tshirege Member at Area L between Bendix test holes (1985–1986) and LANL test holes (1988–1990).

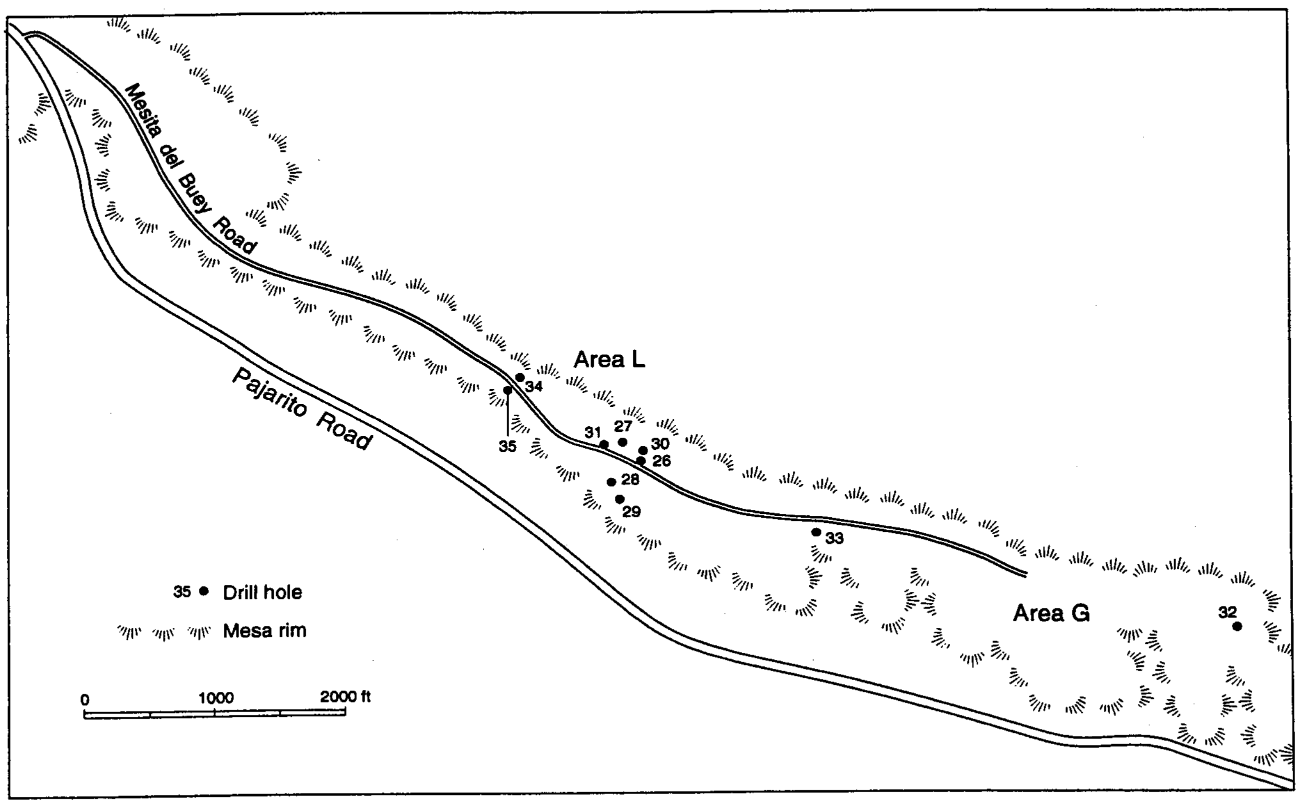


Fig. XIII-D. Locations of 10 test holes at Areas L and G on Mesita del Buey (Purtymun 1990).

TABLE XIII-A. Geologic Logs of Test Holes at Areas G and L, TA-54, Mesita del Buey (Bendix 1985a)

Hole Number	Elevation (ft)	Depth Cored (ft)	Total Depth Drilled (ft)	Geologic Log (ft)			
				Unit 2B	Unit 2A	Unit 1B	Unit 1A
LLM-85-01	6797.4	124	140	0 to 42	42 to 81	81 to 124+	—
LLM-85-02	6791.7	124	145	0 to 41	41 to 81	81 to 124+	—
LLP-85-03	6788.7	99	120	0 to 48	48 to 98	98 to 99+	—
LLN-85-04[a]	6788.0	0	120	—	—	—	—
LLM-85-05	6772.5	124	145	0 to 39	39 to 74	74 to 124+	—
LGM-85-06	6730.0	124	60	0 to 37	37 to 61	61 to 107	107 to 124+
LGP-85-07	6731.7	49	60	0 to 32	32 to 49+	—	—
LGN-85-08[a]	6731.5	0	120	—	—	—	—
LGC-85-09	6659.9	99	120	0 to 28	28 to 44	44 to 74	74 to 99+
LGC-85-10	6707.7	99	145	0 to 34	34 to 53	53 to 99+	—
LGM-85-11	6715.6	124	120	0 to 38	38 to 63	63 to 103	103 to 124+
LLC-85-12	6794.7	99	120	0 to 42	42 to 81	81 to 99+	—
LLC-85-13	6856.1	99	120	0 to 47	47 to 79	79 to 99+	—
LLC-85-14	6791.4	99	120	0 to 38	38 to 82	82 to 99+	—
LLC-85-15	6787.5	99	120	0 to 38	38 to 83	83 to 99+	—
LLC-85-16	6788.0	99	120	0 to 42	42 to 82	82 to 99+	—
LLC-85-17	6788.4	149	150	0 to 38	38 to 83	83 to141	141 to149+
LLC-85-18	6790.4	99	120	0 to 42	42 to 82	82 to 99+	—

Note: Cored 6 7/8-in.-diam hole; 3-in.-diam core; Total Depth Drilled is for the geophysical logging.

Hole Number : first letter "L," Los Alamos; second letter "L" or "G," Areas L or G at TA-54; third letter, use of hole: "M," moisture hole; "C," core and pore-gas sampling; "P," Psychrometer holes; "N," neutron moisture-access holes. All holes were dry.

[a] 4-in.-diam auger hole.

TABLE XIII-B. Geologic Logs of Test Holes at Area L, TA-54, Mesita del Buey (Bendix 1986a, 1986b)

Hole Numbers	Elevation (ft)	Depth Cored (ft)	Unit 2B	Unit 2A	Unit 1B	Unit 1A
LLC-86-19	6854.5	201	0–37	37–107	107–160	160–201+
LLC-86-20	6775.9	198	0–29	29–67	67–139	139–198+
LLC-86-21	6803.1	198	0–43	43–74	74–156	156–198+
LLC-86-22	6796.4	197	0–39	39–74	74–147	147–197+
LLC-86-23	6793.8	199	0–44	44–86	86–154	154–199+
LLC-86-24	6790.6	198	0–43	43–84	84–153	153–198+
LLC-86-25	6787.8	198	0–39	39–74	74–147	147–198+

Note: Cored 6 7/8-in.-diam hole, 3-in.-diam core. All holes were dry.
Hole Number: First letter "L," Los Alamos; second "L," Area L, TA-54; third letter "C," core and pore-gas sampling.

TABLE XIII-C. Geologic Logs of Test Holes at Areas G and L, TA-54, Mesita del Buey (Purtymun 1990)

Hole Number	Elevation (ft)	Tshirege Member				Otowi and Guaje Members	Top of Basalt
		Unit 2B	Unit 2A	Unit 1B	Unit 1A		
LLC-88-26	6788.9	0–45	45–120	120–150	150–198	—	198
LLC-88-27	6784.5	0–45	45–110	110–140	140–190	190–263	263
LLC-88-28	6796.2	0–45	45–105	105–135	135–195	195–263	263–267
LLC-88-29	6793.4	0–45	45–120	120–150	150–225	225–298	298
LLC-89-30	6782.1	0–45	45–115	115–145	145–205	205–273	273
LLC-89-31	6803.7	0–45	45–125	125–155	155–225	225–291	291
LGC-89-32	6669.2	0–35	35–85	85–105	105–150	150–171	171
LGC-89-33	6747.0	0–40	40–105	105–130	130–180	180–293	293
LLC-90-34	6800.0	0–36	36–115	115–151	151–195	195–317	—
LLC-90-35	6810.0	0–40	40–111	111–161	161–201	201–351	—

Note: Augered with 4 1/2-in.-diam solid-stem auger; geologic correlations based on cuttings returned, down pressure, and drilling breaks. All holes dry.
Hole Number: First letter "L," Los Alamos; second letter, "L" for Area L or "G" for Area G; third letter,"C," for core or pore–gas sampling.

TABLE XIII-D. Locations and Elevations (NAD 1927)

A. Test Holes 1985

LLM-85-01	N 1,759,552.34	E 499,402.86	6797.4 ft
LLM-85-02	N 1,759,260.86	E 499,853.04	6791.7 ft
LLP-85-03	N 1,759,269.11	E 499,923.76	6788.7 ft
LLN-85-04	N 1,759,265.96	E 499,924.24	6788.0 ft
LLM-85-05	N 1,758,919.02	E 500,471.44	6772.5 ft
LGM-85-06	N 1,758,437.40	E 502,239.90	6730.0 ft
LGP-85-07	N 1,758,462.39	E 502,195.69	6731.7 ft
LGN-85-08	N 1,758,457.04	E 502,205.42	6731.5 ft
LGC-85-09	N 1,756,884.15	E 504,521.44	6659.9 ft
LGC-85-10	N 1,757,487.94	E 502,748.67	6707.7 ft
LGM-85-11	N 1,757,977.36	E 502,978.01	6715.6 ft
LLC-85-12	N 1,759,536.30	E 499,477.89	6794.7 ft
LLC-85-13	N 1,761,119.07	E 496,644.14	6856.1 ft
LLC-85-14	N 1,759,355.53	E 499,782.26	6791.4 ft
LLC-85-15	N 1,759,315.73	E 499,895.35	6787.5 ft
LLC-85-16	N 1,759,350.09	E 499,850.10	6788.0 ft
LLC-85-17	N 1,759,485.35	E 499,703.83	6788.4 ft
LLC-85-18	N 1,759,440.61	E 499,698.48	6790.4 ft

B. Test Holes 1986

LLC-86-19	N 1,761,074.07	E 496,703.56	6854.5 ft
LLC-86-20	N 1,759,299.65	E 500,085.17	6775.9 ft
LLC-86-21	N 1,759,469.53	E 499,299.71	6803.1 ft
LLC-86-22	N 1,759,625.55	E 499,334.54	6796.4 ft
LLC-86-23	N 1,759,020.31	E 499,761.74	6793.8 ft
LLC-86-24	N 1,759,107.27	E 499,988.54	6790.6 ft
LLC-86-25	N 1,759,276.58	E 499,929.08	6787.8 ft

C. Test Holes 1988–1990

LLC-88-26	N 1,758,964.89	E 500,177.78	6788.9 ft
LLC-88-27	N 1,759,154.35	E 500,142.61	6784.5 ft
LLC-88-28	N 1,758,866.71	E 499,970.19	6796.2 ft
LLC-88-29	N 1,758,759.69	E 500,031.46	6793.4 ft
LLC-89-30	N 1,759,053.59	E 500,274.07	6782.1 ft
LLC-89-31	N 1,759,324.81	E 499,395.23	6803.7 ft
LGC-89-32	N 1,757,701.88	E 504,886.63	6669.7 ft
LGC-89-33	N 1,758,382.90	E 501,560.33	6747.0 ft
LLC-90-34	hole destroyed before survey		6800.0 ft
LLC-90-35	hole destroyed before survey		6810.0 ft

XIV. TEST HOLES AT AREA P AT TA-16

Area P at TA-16 has been used as an industrial landfill, and studies have been undertaken to address closure and postclosure EPA requirements. The test holes drilled in and around the landfill were part of a study to determine the type and extent of contamination.

The holes drilled at the landfill are classed into several categories: (1) exploratory holes drilled for geologic and hydrologic information (plugged and abandoned after completion); (2) a vadose monitoring system; (3) test holes completed as observation wells; and (4) test holes drilled for geologic and hydrologic information and completed as moisture-access holes (to be used to determine moisture content of the tuff).

The test holes and observation wells were drilled and completed in the Tshirege Member of the Bandelier Tuff. The tuff has been divided into five units, from oldest (Unit 2) to youngest (Unit 3D). The units are probably comparable to the type section in Mortandad Canyon (Fig. I-O). The tuff is nearer to the source, the Valles Caldera; thus, the welding is greater (the rock is denser). Unit 2 combines Unit 2A and 2B. Unit 3 was subdivided.

Unit 2 consists of a welded to densely welded rhyolite tuff, light gray to pinkish gray, with a few rock fragments of pumice and rhyolite.

Unit 3A consists of a welded rhyolite tuff, dark yellowish brown with rock fragments of pumice and porphyritic quartz latite and rhyolite.

Unit 3B consists of a welded rhyolite tuff, pale yellowish brown with rock fragments of gray and red pumice, and a few rhyolite rock fragments.

Unit 3C consists of a moderately welded rhyolite tuff, brownish gray to yellowish brown, with rock fragments of gray pumice and a few rhyolite rock fragments.

Unit 3D consists of a moderately welded rhyolite tuff, yellowish brown with a few gray pumice fragments and some pebble-sized rhyolite rock fragments. This unit forms the surface in the area and is overlain by a thin clayey soil, derived from weathering of the unit. There are a few scattered deposits of El Cajete Pumice mixed with the soil.

A. Exploratory Holes

Exploratory holes B-1, B-2, B-3, B-4, and B-5 were augered through the landfill into the underlying tuff. They were augered to determine where to site the vadose monitoring system. Test holes P-10, P-11, and P-15 were drilled to collect samples and geologic information (Fig.XIV-A). Geologic logs and data pertaining to these eight holes are shown on Table XIV-A. The holes were plugged and abandoned (Brown et al. 1988).

B. Vadose Monitoring Holes

Vadose monitoring, consisting of eight separate wells clustered together into four well nests, was set up by drilling into and below the landfill into the tuff (Fig. XIV-B). Each well nest (Table XIV-B) consisted of either a single or dual completion of a pressure-vacuum lysimeter in one bore hole and an adjacent neutron moisture-access hole (McLin 1989).

C. Observation Wells

Nine test holes were completed as ground water monitoring wells (Fig. XIV-C). The depth of these holes ranged from 10 to 35 ft, with the well completion depth from 7 to 35 ft (Table XIV-C). The wells were located above the stream channel and below the landfill. They were all completed into the tuff. All were dry and contained no free water; thus, any leachate from the landfill would be moving in the vadose zone immediately below the landfill as unsaturated flow (Brown et al. 1988).

D. Moisture-Access Holes

Five test holes were completed as neutron moisture-access holes (Fig. XIV-D). They were augered to depths ranging from 85 to 200 ft (Table XIV-D). All were dry. The holes were completed as moisture-access holes to allow logging for moisture content with the neutron moisture logger and scaler (Brown et al. 1988; McLin 1989).

REFERENCES

F. Brown, W. D. Purtymun, A. Stoker, and A. Barr, "Site Geology and Hydrology of Technical Area 16, Area P," Los Alamos National Laboratory report LA-11209-MS (1988).

S. G. Mclin, "Vadose Zone Monitoring Observations at the TA-16, Area P Landfill," Los Alamos National Laboratory report, Group HSE-8 document, 1989.

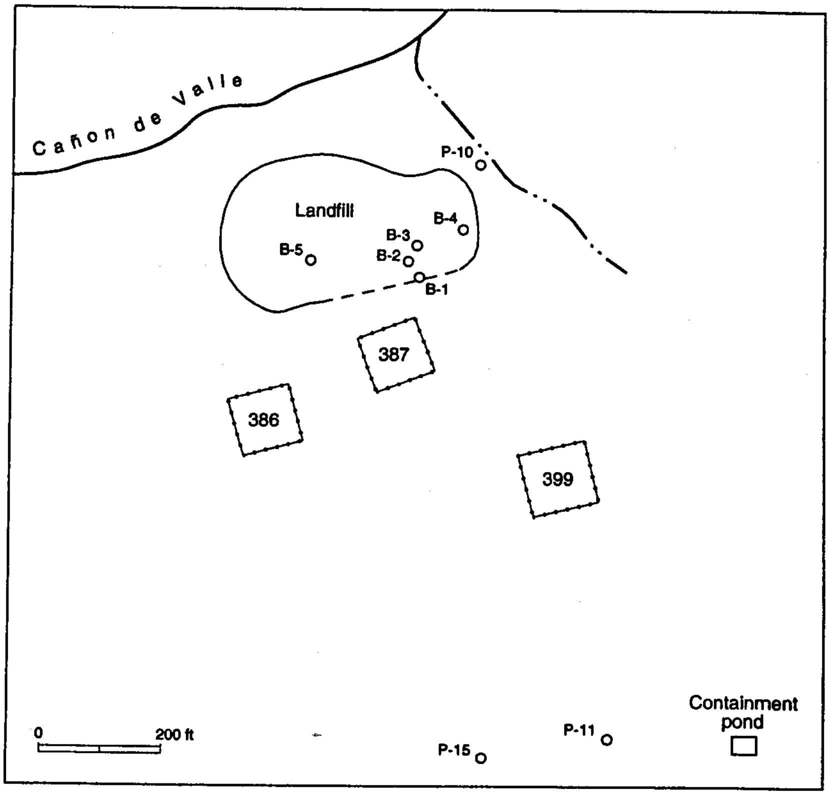


Fig. XIV-A. Locations of exploratory test holes at Area P, TA-16 (Brown et al. 1988).

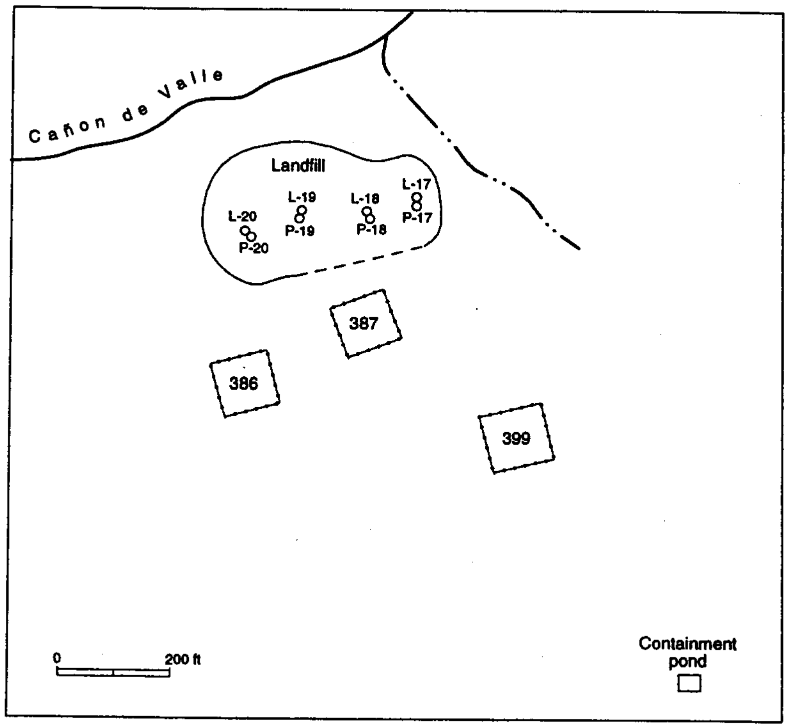


Fig. XIV-B. Locations of four sets of cluster holes (L = Lysimeter hole; P = moisture-access hole) at Area P, TA-16 (McLin 1989).

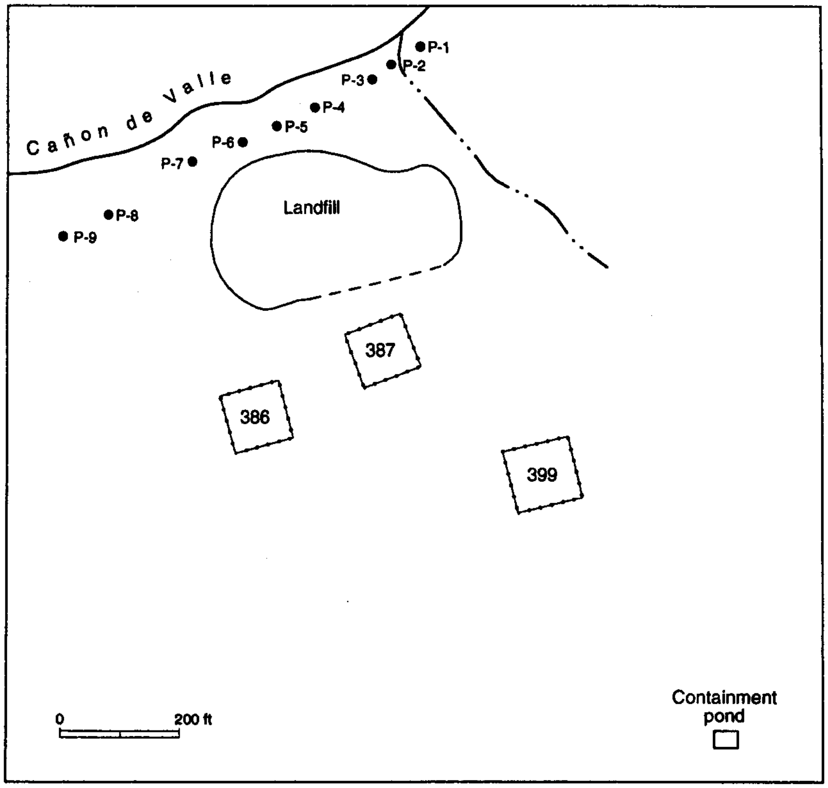


Fig. XIV-C. Locations of ground water observation wells at Area P, TA-16 (Brown et al. 1988).

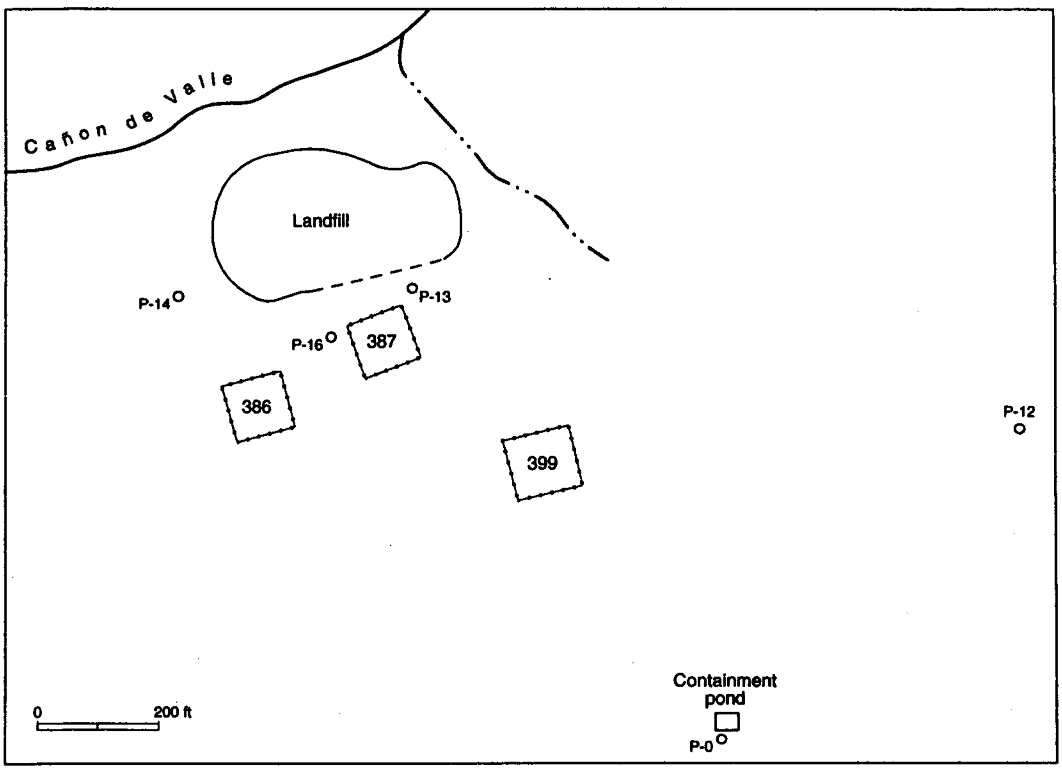


Fig. XIV-D. Locations of test holes completed as moisture-access holes at Area P, TA-16 (Brown et al. 1988; McLin 1989).

TABLE XIV-A. Geologic Logs of Exploratory Holes at TA-16 (8 Holes)

1. Test Hole B-1

Date Drilled: August 26, 1988
Elevation (LSD): 7445 ft
Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Clayey soil, dark brown, moist	2	2
Clayey soil, sandy, dark brown, may be cover-fill material	3	5

Note: Exploratory hole; filled with drill cuttings and bentonite; abandoned; no samples collected.

2. Test Hole B-2

Date Drilled: August 26, 1988
Water Level: Dry
Elevation (LSD): 7442 ft

Log	Thickness (ft)	Depth (ft)
Clayey soil, dark brown, moist	2	2
Clayey soil, sandy, dark brown, may be cover-fill material	2	4

Note: Exploratory hole; filled with drill cuttings and bentonite; abandoned; no samples collected.

3. Test Hole B-3

Date Drilled: August 26, 1988
Water Level: Dry
Elevation (LSD): 7438 ft

Log	Thickness (ft)	Depth (ft)
Cover, sandy clay, dark brown, moist	1	1
Clay, brown and sand waste, mixture; white BaO crystals	3	4
Clay, dark brown with some gray sand; waste material, mixture of fragments of tuff and charcoal; moderate moisture	4	8
Clay, dark brown to black sticky, tuff fragments with wastes	5	13
Tuff, Unit 3D	1	14

Note: Exploratory hole; filled with drill cuttings and bentonite; abandoned; no samples collected.

4. Test Hole B-4

Date Drilled: August 30, 1988
Water Level: Dry
Elevation (LSD): 7432 ft

Log	Thickness (ft)	Depth (ft)
Clay, brown with black burn debris, low moisture	3	3
Clay, brown with black burn debris, low moisture	6	9
Clay, brown with sand and burn debris	5	14
Tuff, Unit 3D	5	19

Note: Debris at 3 ft confirms explosives, Lab reports <1% TNT, HMX, and RDX; exploratory hole; filled with drill cuttings and bentonite; abandoned; no other samples taken except as noted above.

TABLE XIV-A. Geologic Logs of Exploratory Holes at TA-16 (8 Holes) (Continued)

5. Test Hole B-5

Date Drilled: September 15, 1988
Elevation (LSD): 7450 ft — Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Cover, crushed tuff, sand and clay mixture	1	1
Tuff, brown, crushed tuff cover-fill material	3	4
Tuff, brown, crushed tuff, cover-fill material (saturated lens 6 to 7 ft)	4	8
Tuff, brown, dense, dry, (tuff in place)	4	12

Note: Exploratory hole; filled with drill cuttings; abandoned.

6. Test Hole P-10

Date Drilled: July 30, 1987
Elevation (LSD): 7411 ft — Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy loam	3	3
Tuff, Unit 3C	47	50
Tuff, Unit 3B	70	120
Tuff, Unit 3A	30	150

Note: Exploratory hole; filled with cuttings and abandoned.

7. Test Hole P-11

Date Drilled: August 27, 1987
Elevation (LSD): 7409 ft — Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy loam	2	2
Tuff, Unit 3C	48	50
Tuff, Unit 3B	20	70

Note: Exploratory hole; filled with cuttings and abandoned.

8. Test Hole P-15

Date Drilled: August 27, 1987
Elevation (LSD): 7413 ft — Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy loam	4	4
Tuff, Unit 3C	51	55
Tuff, Unit 3B	15	70

Note: Exploratory hole; filled with cuttings and abandoned.

Source: Brown et al. 1988.

TABLE XIV-B. Geologic Logs and Construction Data for Vadose Monitoring Holes at TA-16 (4 Sets of Holes)

1. Lysimeter Hole L-17
   Moisture-Access Hole P-17

Date Drilled: September 6, 1988
Elevation (LSD): 7433 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Topsoil cover	1	1
Waste in landfill	10	11
Tuff, Unit 3D, low moisture, light brown tuff with rhyolite rock fragments, nonwelded to moderately welded	19	30

Construction

Hole P-17 offset 6 ft from Hole L-17.

Lysimeter Hole L-17

Cement 0 to 2 ft
Cuttings 2 to 4 ft
Sand 4 to 6 ft
Lysimeter 5 to 6 ft
Cement 6 to 8 ft
Cuttings 8 to 12 ft
Sand 12 to 18 ft
Lysimeter 16 to 17 ft
Cuttings 18 to 19 ft

Moisture-Access Hole P-17

2- in.-diam aluminum pipe set 0 to 30 ft; set in 4-in.-diam hole; annulus between pipe and hole filled with medium silica sand. Pipe cemented in 0 to 1 ft.

2. Lysimeter Hole L-18
   Moisture-Access Hole P-18

Date Drilled: September 8, 1988
Elevation (LSD): 7438 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil cover, light brown	1	1
Waste, light to dark brown clay with sand stringers	3	4
Waste, dark brown to black sticky clay with gray sand, some charcoal	9	13
Tuff, Unit 3D, light gray to light brown, nonwelded to moderately welded	17	30

Construction

Hole P-18 offset 6 ft from Hole L-18.

TABLE XIV-B. Geologic Logs and Construction Data for Vadose Monitoring Holes at TA-16 (4 Sets of Holes) (Continued)

2. Lysimeter Hole L-18 (Continued)
Moisture-Access Hole P-18

Lysimeter Hole L-18		Moisture-Access Hole P-18
Cement	0 to 2 ft	2-in.-diam aluminum pipe set 0 to 30 ft; set in 4-in.-diam hole; annulus between pipe and hole filled with medium silica sand. Pipe cemented in 0 to 1 ft.
Cuttings	2 to 5 ft	
Sand	5 to 6 ft	
Lysimeter	5 to 6 ft	
Cement	6 to 10 ft	
Cuttings	10 to 12 ft	
Sand	12 to 18 ft	
Lysimeter	17 to 18 ft	
Cuttings	18 to 19 ft	

3. Lysimeter Hole L-19
Moisture-Access Hole P-19

Date Drilled: September 14, 1988
Elevation (LSD): 7448 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil cover, dry	1	1
Crushed tuff fill, moderately dry	3	4
Crushed tuff fill, no waste apparent	10	14
Tuff, Unit 3D; light brown tuff with rhyolite rock fragements, nonwelded to moderately welded	16	30

Construction
Hole P-19 offset 6 ft from Hole L-19.

Lysimeter Hole L-19		Moisture-Access Hole P-19
Cement	0 to 2 ft	2-in.-diam aluminum pipe set 0 to 30 ft; set in 4-in.-diam hole; annulus between pipe and hole filled with medium silica sand. Pipe cemented in 0 to 1 ft.
Cuttings	2 to 10 ft	
Sand	10 to 12 ft	
Lysimeter	11 to 12 ft	
Cuttings	12 to 14 ft	

TABLE XIV-B. Geologic Logs and Construction Data for Vadose Monitoring Holes at TA-16 (4 Sets of Holes) (Continued)

4. Lysimeter Hole L-20
   Moisture-Access Hole P-20

Date Drilled: September 15, 1988

Elevation (LSD): 7446 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Crushed tuff and soil mixture, sandy to sandy clay, light brown to dark brown; does not appear to be waste	15	15
Waste, tuff, and sand with charcoal fragments	6	21
Clay, brown, weathered in place	1	22
Tuff, Unit 3D; nonwelded, low moisture	8	30

Construction

Hole P-20 offset 6 ft from Hole L-20.

Lysimeter Hole L-20

Cement	0 to 1 ft
Cuttings	1 to 2 ft
Sand	2 to 9 ft
Lysimeter	8 to 9 ft
Cuttings	9 to 22 ft
Cement	22 to 23 ft
Cuttings	23 to 27 ft
Sand	27 to 29 ft
Lysimeter	28 to 29 ft

Moisture-Access Hole P-20

2-in.-diam aluminum pipe set 0 to 30 ft; set in 4-in.-diam hole; annulus between pipe and hole filled with medium silica sand. Pipe cemented in 0 to 1 ft.

Source: McLin 1989.

TABLE XIV-C. Geologic Logs and Construction Data for Observation Wells at TA-16 (9 Obs. Wells)

1. Observation Well P-1

Date Drilled: July 29, 1987

Elevation (LSD): 7344 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Top soil	4	4
Tuff, Unit 3B	31	35

Construction

Bore hole diam 6 7/8 in.; 35 ft of 2-in.-diam teflon pipe with the lower 20 ft slotted (0.010-in.-wide slots) set in hole; cement 0–13 ft; bentonite 13 to 15 ft; medium-grained silica sand 15 to 35 ft.

2. Observation Well P-2

Date Drilled: July 23, 1987

Elevation (LSD): 7341 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil	3	3
Tuff, Unit 3B	7	10

Construction

Well plugged and abandoned.

3. Observation Well P-3

Date drilled: July 23, 1987

Elevation (LSD): 7342 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil	3	3
Tuff, Unit 3B	6	9

Construction

Bore hole diam 6 7/8 in.; 7 ft of 2-in.-diam teflon pipe with the lower 5 ft slotted (0.010-in.-wide slots) set in hole; cement and bentonite 0 to 2 ft; medium-grained silica sand 2 to 9 ft.

4. Observation Well P-4

Date drilled: July 28, 1987

Elevation (LSD): 7348 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil	4	4
Tuff, Unit 3B	6	10

Construction

Bore hole diam 6 7/8 in.; 8 ft of 2-in.-diam teflon pipe with the lower 5 ft slotted (0.010-in.-wide slots) set in hole; cement and bentonite 0 to 3 ft; medium-grained silica sand 3 to 10 ft.

5. Observation Well P-5

Date drilled: July 29, 1987

Elevation (LSD): 7353 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil	3	3
Tuff, Unit 3B	32	35

TABLE XIV-C. Geologic Logs and Construction Data for Observation Wells at TA-16 (9 Obs. Wells) (Continued)

5. Observation Well P-5 (Continued)

Construction

Bore hole diam 6 7/8 in.; 35 ft of 2-in.-diam teflon pipe with the lower 20 ft slotted (0.010-in.-wide slots) set in hole; cement 0 to 13 ft; bentonite 13 to 15 ft; medium-grained silica sand 15 to 35 ft.

6. Observation Well P-6

Date Drilled: July 28, 1987
Elevation (LSD): 7352 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil	4	4
Tuff, Unit 3B	6	10

Construction

Bore hole diam 6 7/8 in.; 7 ft of 2-in.-diam teflon pipe (with the lower 5 ft slotted) set in hole; cement and bentonite 0 to 2 ft; medium-grained silica sand 2 to 10 ft.

7. Observation Well P-7

Date Drilled: July 29, 1987
Elevation (LSD): 7356 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil	2	2
Tuff, Unit 3B	33	35

Construction

Bore hole diam 6 7/8 in.; 35 ft of 2-in.-diam teflon pipe with the lower 20 ft slotted (0.010-in.-wide slots) set in hole; cement 0 to 13 ft; bentonite 13 to 15 ft; medium-grained silica sand 15 to 35 ft.

8. Observation Well P-8

Date Drilled: July 28, 1987
Elevation (LSD): 7370 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil	3	3
Tuff, Unit 3B	7	10

Construction

Bore hole diam 6 7/8 in.; 7 ft of 2-in.-diam teflon pipe with the lower 5 ft slotted (0.010-in.-wide slots) set in hole; cement and bentonite 0 to 2 ft; medium-grained silica sand 2 to 10 ft.

9. Observation Well P-9

Date Drilled: July 29, 1987
Elevation (LSD): 7376 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Sandy soil	3	3
Tuff, Unit 3C	12	15
Tuff, Unit 3B	20	35

TABLE XIV-C. Geologic Logs and Construction Data for Observation Wells at TA-16 (9 Obs. Wells) (Continued)

9. Observation Well P-9 (Continued)

Construction

Bore hole diam 6 7/8 in.; 35 ft of 2-in.-diam teflon pipe with the lower 20 ft slotted (0.010-in.-wide slots) set in hole; cement 0 to 13 ft; bentonite 13 to 15 ft; medium-grained silica sand 15 to 35 ft.

Source: Brown et al. 1988.

TABLE XIV-D. Geologic Logs and Construction Data for Moisture-Access Holes at TA-16 (5 Moisture-Access Holes)

1. Test Hole P-0

Date Drilled: July 21, 1987
Elevation (LSD): 7399 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Top soil	3	3
Tuff, Unit 3C	37	40
Tuff, Unit 3B	70	110
Tuff, Unit 3A	25	135

Construction

Bore hole diam 6 7/8 in.; cored; 2-in.-diam aluminum pipe set in hole 0 to 120 ft; cemented 0–1 ft; tuff cuttings from 1 to 135 ft around and below pipe.

2. Test Hole P-12

Date Drilled: August 21, 1987
Elevation (LSD): 7448 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Top soil	3	3
Tuff, Unit 3D	47	50
Tuff, Unit 3C	52	102
Tuff, Unit 3B	71	173
Tuff, Unit 3A	22	195
Tuff, Unit 2	5	200

Construction

Bore hole diam 6 7/8 in.; cored; 171 ft of 2-in.-diam aluminum pipe 0 to 173 ft; cemented 0–1 ft; tuff cuttings from 1 to 200 ft around and below pipe.

TABLE XIV-D. Geologic Logs and Construction Data for Moisture-Access Holes at TA-16 (5 Moisture-Access Holes) (Continued)

3. Test Hole P-13

Date Drilled: October 3, 1987
Elevation (LSD): 7445 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Top soil	1	1
Tuff, Unit 3D	37	38
Tuff, Unit 3C	46	84
Tuff, Unit 3B	19	103

Construction
Bore hole diam 6 7/8 in.; cored; 92 ft of 2-in.-diam aluminum pipe set 0 to 92 ft; cemented 0–1 ft; tuff cuttings from 1 to 103 ft around and below pipe.

4. Test Hole P-14

Date Drilled: September 28, 1987
Elevation (LSD): 7437 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Top soil	4	4
Tuff, Unit 3D	26	30
Tuff, Unit 3C	45	75
Tuff, Unit 3B	10	85

Construction
Bore hole diam 6 7/8 in.; cored; 79 ft of 2-in.-diam aluminum pipe set 0 to 79 ft; cemented 0–1 ft; tuff cuttings from 1 to 85 ft around and below pipe.

5. Test Hole P-16

Date Drilled: September 4, 1987
Elevation (LSD): 7452 ft

Water Level: Dry

Log	Thickness (ft)	Depth (ft)
Top soil	7	7
Tuff, Unit 3D	35	42
Tuff, Unit 3C	45	87
Tuff, Unit 3B	18	105

Construction
Bore hole diam 6 7/8 in.; cored; 88 ft of 2-in.-diam aluminum pipe set 0 to 88 ft; cemented 0–1 ft; tuff cuttings from 1 to 105 ft around and below pipe.

Sources: Brown et al. 1988; McLin 1989.

TABLE XIV-E. Locations and Elevations (NAD 1927)

A. Exploratory Holes

B-1	N 1,764,300	E 475,700	7445 ft
B-2	N 1,764,325	E 475,700	7442 ft
B-3	N 1,764,350	E 475,700	7438 ft
B-4	N 1,764,375	E 475,775	7432 ft
B-5	N 1,764,325	E 475,600	7450 ft
P-10	N 1,764,473	E 475,814	7411 ft
P-11	N 1,763,584	E 475,991	7409 ft
P-15	N 1,763,520	E 475,803	7413 ft

B. Vadose Monitoring Holes

L-17; P-17	N 1,764,400	E 475,750	7433 ft
L-18; P-18	N 1,764,375	E 475,675	7438 ft
L-19; P-19	N 1,764,350	E 475,550	7448 ft
L-20; P-20	N 1,764,325	E 475,475	7446 ft

C. Observation Wells

P-1	N 1,764,645	E 475,756	7344 ft
P-2	N 1,764,617	E 475,708	7341 ft
P-3	N 1,764,596	E 475,676	7342 ft
P-4	N 1,764,562	E 475,588	7348 ft
P-5	N 1,764,532	E 475,520	7353 ft
P-6	N 1,764,514	E 475,467	7352 ft
P-7	N 1,764,491	E 475,381	7356 ft
P-8	N 1,764,405	E 475,257	7370 ft
P-9	N 1,764,381	E 475,183	7376 ft

D. Moisture-Access Holes

P-12	N 1,764,036	E 476,664	7448 ft
P-13	N 1,764,264	E 475,720	7445 ft
P-14	N 1,764,251	E 475,365	7437 ft
P-16	N 1,764,200	E 475,550	7452 ft
P-0	N 1,763,523	E 476,215	7399 ft

Sources: Brown et al. 1988; McLin 1989.

XV. U.S. GEOLOGICAL SURVEY TEST HOLE NEAR TA-52

The U.S. Geological Survey cored an experimental hole to test the use of wireline-rotary air-coring techniques in the Bandelier Tuff. A modified standard wireline core-barrel system was used. The hole was located just east of Waste Disposal Area C (Fig. XV-A). The modified equipment was used to collect uncontaminated cores of unconsolidated ash and indurated tuff to a depth of 210 ft. Core recovery was 92%. The hole was completed to study the characteristics of the vadose zone (Table XV-A).

REFERENCE

W. E. Teasdale and R. E. Pemberton, "Wireline-Rotary Air Coring of the Bandelier Tuff, Los Alamos, New Mexico," U.S. Geol. Survey Water Resources Investigation Report 84-4176 (1984).

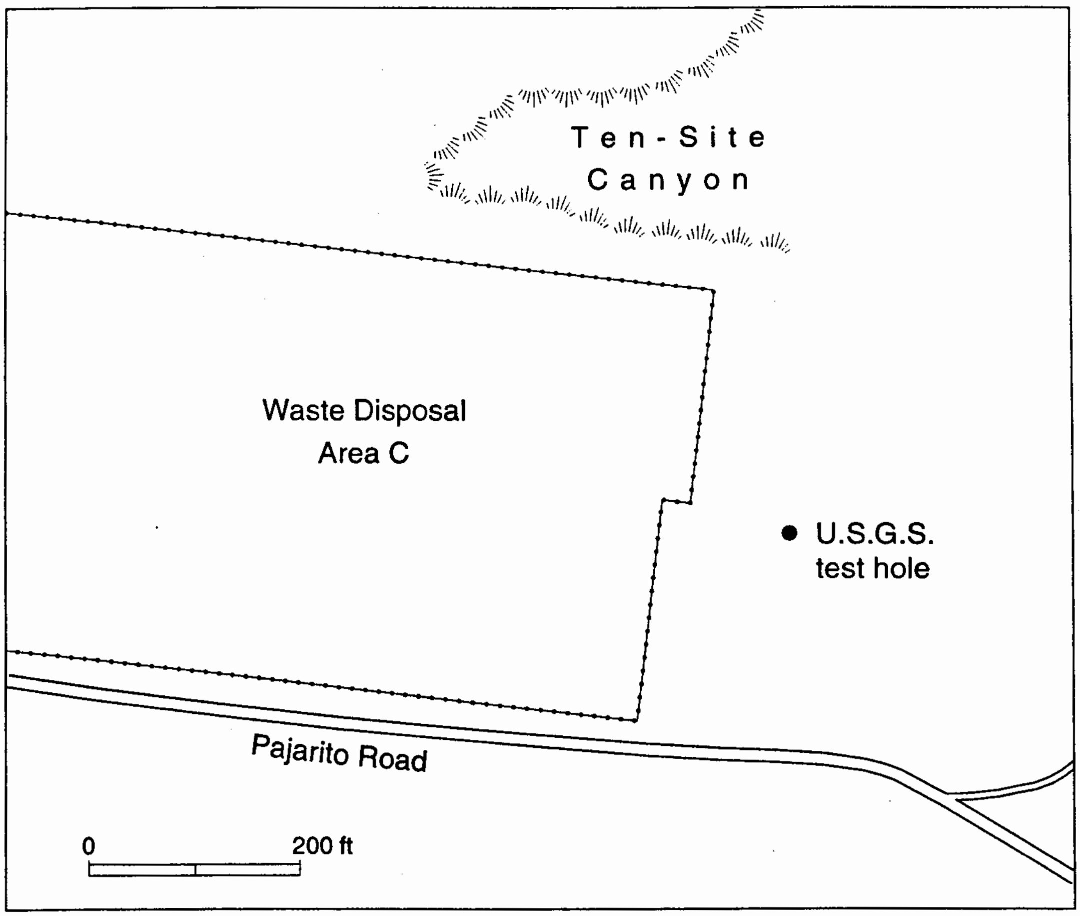


Fig. XV-A. Location of U.S. Geological Survey test hole east of Waste Disposal Area C.

TABLE XV-A. Geologic Log and Construction Data for U.S. Geological Survey Test Hole near Waste Disposal Area C

Elevation (LSD) 7220 ft

Drilled: September 1983 — Water Level: Dry

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member		
Unit 3, light gray moderately welded tuff	110	110
Unit 2, dark gray welded tuff	100	210

Construction

Completed as a vadose monitoring test hole.

Screen 1 190 to 195 ft

Screen 2 140 to 145 ft

Screen 3 105 to 110 ft

Screen 4 78 to 83 ft

Screen 5 50 to 55 ft.

Screen 6 25 to 30 ft

Instruments were set in screen sections, each section of screen sealed off with a mixture of grout (cement) and dry cuttings. Surface to 22 ft sealed with cement. Heat dissipation probe set in cuttings 118 to 122 ft. Electrical leads extend from instruments in screen section to land surface.

Geophysical Logs

Bulk density, neutron, gamma-ray, and caliper. Files available from the ESH-18 Geohydrology section.

TABLE XV-B. Locations and Elevations (NAD 1927)

U.S.G.S.TH	N 1,768,500	E 486,500	7220 ft

XVI. CARBON ISOTOPE PRODUCTION HOLES AT TA-21 AND TA-46

Carbon isotope production holes were drilled at TA-21 and TA-46 (Fig. XVI-A). The holes were used as part of a carbon 13 production plant using carbon monoxide distillation (Armstrong et al. 1970).

The preliminary testing and production of carbon 13 occurred at TA-21 building SM-3. In 1969 a hole to hold the distillation column was drilled in the northwest stairwell. The 36-in.-diam hole was augered to a depth of 125 ft. An 18-in.-diam casing was cemented in the hole. The casing extended about 15 ft above the floor level. The hole was completed in the Tshirege Member of the Bandelier Tuff. The hole was dry.

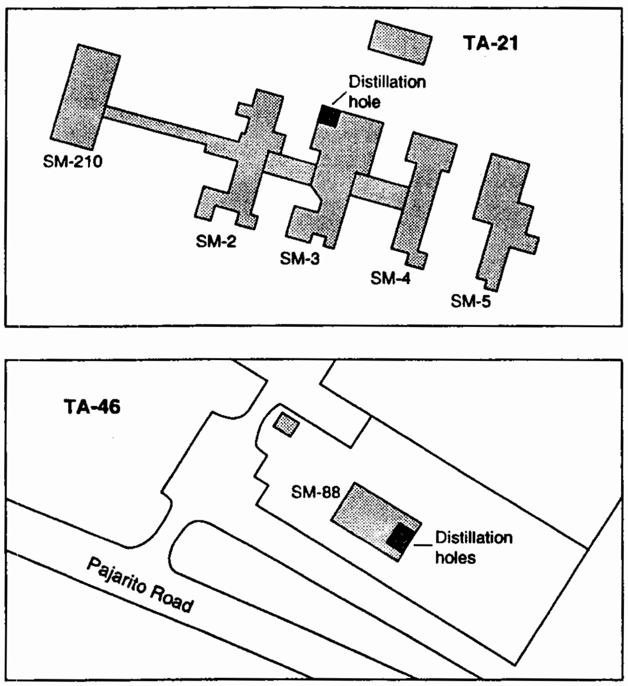


Fig. XVI-A. Distillation holes at TA-21 and TA-46.

A production plant was built at TA-46 in building SM-88 in 1971. The eastern end of the building contained a large bay about 38 ft in height. The holes were drilled in the bay with a spacing of about 20 ft. The holes were reamed out to a 16-in. diameter to a depth of about 747 ft using a mud rotary. A 13 3/8-in.-diam casing was cemented in the holes.

The holes at TA-46 penetrated the total thickness of the Bandelier Tuff and were completed into the top of the Puye Conglomerate. The holes were dry (Purtymun 1994).

Geologic Log of TA-46 Holes
Elevation 7105 ft

	Thickness (ft)	Depth
Bandelier Tuff		
Tshirege Member	360	360
Otowi Member	335	695
Guaje Member	32	727
Puye Conglomerate		
Sand, gravel, and boulders	20	747

REFERENCES

D. E. Armstrong, A. C. Briesmeister, B. B. McInteer, and R. M. Potter, "A Carbon 13 Production Plant Using Carbon Monoxide Distillation," Los Alamos Scientific Laboratory report LA-4391 (1970).

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994), chapters 21 and 76.

TABLE XVI-A. Locations and Elevations (NAD 1927)

TA-21	N 1,774,500	E 492,000	7150 ft
TA-46	N 1,765,500	E 499,500	7105 ft

XVII. TEST WELLS AND TEST HOLES ON THE PAJARITO PLATEAU

Test holes and test wells were drilled into the Pajarito Plateau to provide geologic and hydrologic information (Fig. XVII-A and Table XVII-A). The test wells provide monitoring of perched aquifers and the main aquifer. Geologic logs and casing schedules of the test wells are shown in Table XVII-B.

Test wells TW-1 (Fig. XVII-B) and TW-2 (Fig. XVII-C) were drilled and completed to monitor the water in the main aquifer in Pueblo Canyon downgradient from the waste treatment plant at TA-45 (which was removed in 1964). Perched water was encountered in the basalts at TW-1 and in the fanglomerate member at TW-2. To monitor the water in the perched aquifers, offset wells TW-1A and TW-2A were drilled and completed as monitoring wells (Figs. XVII-B and XVII-C). Test hole TH-2B in Pueblo Canyon was an attempt to isolate a zone of perched water above the main aquifer and the water in the alluvium in the canyon. The perched aquifer was not there or was of such limited extent that it could not be located (Black and Veatch 1950; Griggs 1955).

Test well TW-3 monitors the water in the main aquifer beneath the alluvial aquifer in Los Alamos Canyon (Fig. XVII-D). Test well TW-4 (Fig. XVII-E) is located to monitor the water in the main aquifer in the vicinity of the old waste treatment plant at TA-21 (which has been removed) (Black and Veatch 1950; Griggs 1955).

Test holes TH-5, TH-6, and TH-7 were exploratory holes to determine the geology and determine if water occurred in the rocks underlying the alluvium (Figs. XVII-F through XVII-H) in Pajarito and Ancho Canyons (Griggs 1955).

Test well TW-8 was drilled and completed to test the quality of water of the main aquifer beneath Mortandad Canyon (Fig. XVII-I). Mortandad Canyon receives treated industrial effluents from the waste treatment plant at TA-50 (Baltz et al. 1963).

Test hole H-19 was drilled for geologic and hydrologic information (Fig. XVII-J). The test hole was drilled as part of the water investigation of the Valles Caldera in 1949. The test hole encountered massive, thick sections of latite and dacite flows of the Tschicoma Formation. The hydrologic properties of the Tschicoma show that it is not capable of being developed as a water supply (Griggs 1955).

Test hole Sigma Mesa was intended as a test of the geothermal potential of the plateau area. The hole was targeted for a depth of 6000 ft. The hole was started on July 2, 1979. The hole experienced serious drilling problems with lost drilling fluids, essentially right out of the conductor pipe. The magnitude of the lost circulation problem is summarized in Table XVII-C. During July, 19 zones in the 1264 ft of hole drilled were cemented to shut off the zones that lost circulation. A total of 7280 sacks of cement were used. The last plug set (No. 19) indicates the lack of success of the operations; the cement plug disappeared completely into the formation. The drilling continued until December, when the project ran out of money and luck. The test hole was drilled to a total depth of 2292 ft. Most of the hole was drilled with little or no circulation or drill cutting returns. At a depth of about 2292 ft the drill string separated, leaving an unknown number of drill stems, drill collars, and the bit in the hole. The cuttings from the hole were few, while those captured contained much of the lost circulation material and redrilled sections. As a result, the geologic log prepared in 1979 was reviewed and revised using geophysical logs, a comparison of logs of nearby test wells and supply wells, and the R. F. Smith Corp. Geothermal Data Log of the hole (Table XVII-B and Fig. XVII-K).

Layne Western, located in Guaje Canyon, was drilled in 1950 (Tables XVII-A and XVII-B) to supply drilling water for the drilling and construction of the supply wells of the Guaje Field (Griggs 1955).

Four test holes were drilled in 1985 at the ski area on Pajarito Mountain west of the Laboratory. The westernmost hole encountered water and was completed as a well. The other three holes drilled to the east did not encounter water. They were drilled to depths of 400 ft through the volcanic rocks of the Bandelier Tuff and Tschicoma Formation (Tables XVII-A and XVII-B).

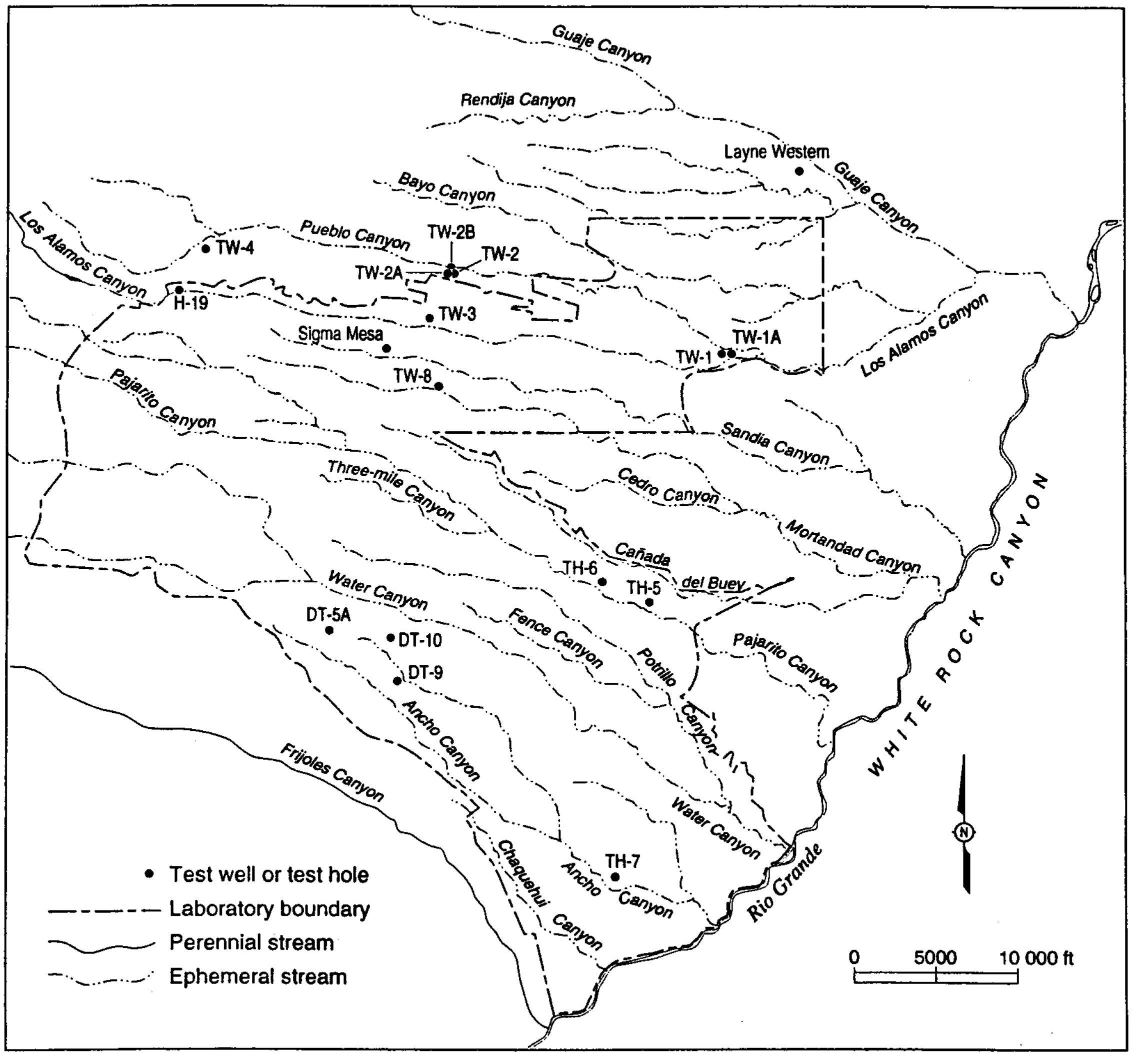


Fig. XVII-A. Test wells and test holes on the Pajarito Plateau.

REFERENCES

E. H. Baltz, J. H. Abrahams, and W. D. Purtymun, "Preliminary Report on the Geology and Hydrology of Mortandad Canyon, Los Alamos, New Mexico, with Special Reference to Disposal of Liquid Low-Level Radioactive Wastes," U.S. Geological Survey Open-File Report (1963).

Black and Veatch (Consulting Engineers), "Ground-Water Observation Wells, Los Alamos, New Mexico," Administrative Report prepared for the U.S. Atomic Energy Commission (1950).

R. L. Griggs, "Geology and Ground-Water Resources of the Los Alamos Area, New Mexico," U.S. Geol. Survey Admin. Report to the U.S. Atomic Energy Commission (1955).

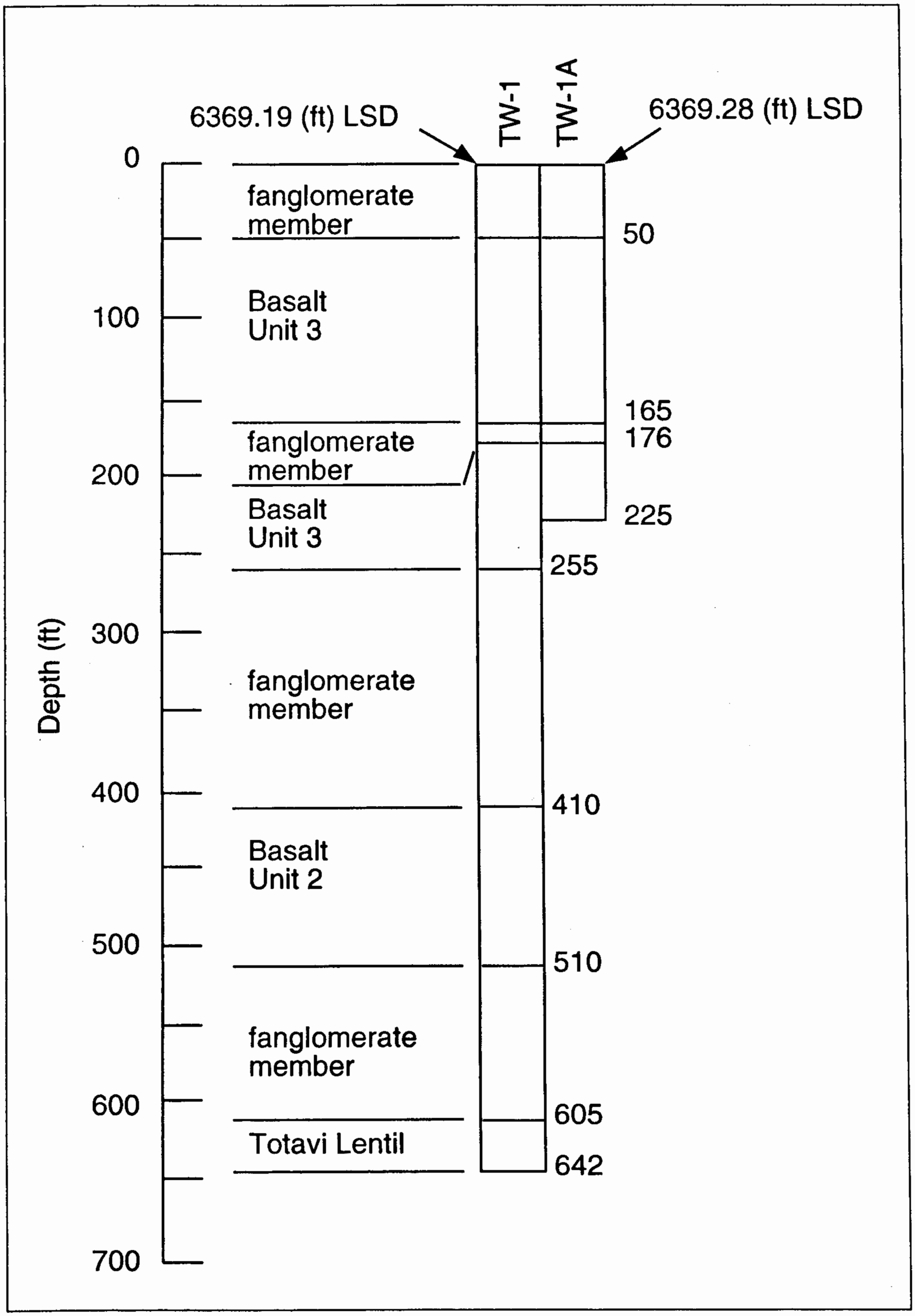


Fig. XVII-B. Geologic logs of test well TW-1, completed January 1950, water level 585 ft, and offset test well TW-1A, completed January 1950, water level 188 ft (Griggs 1955).

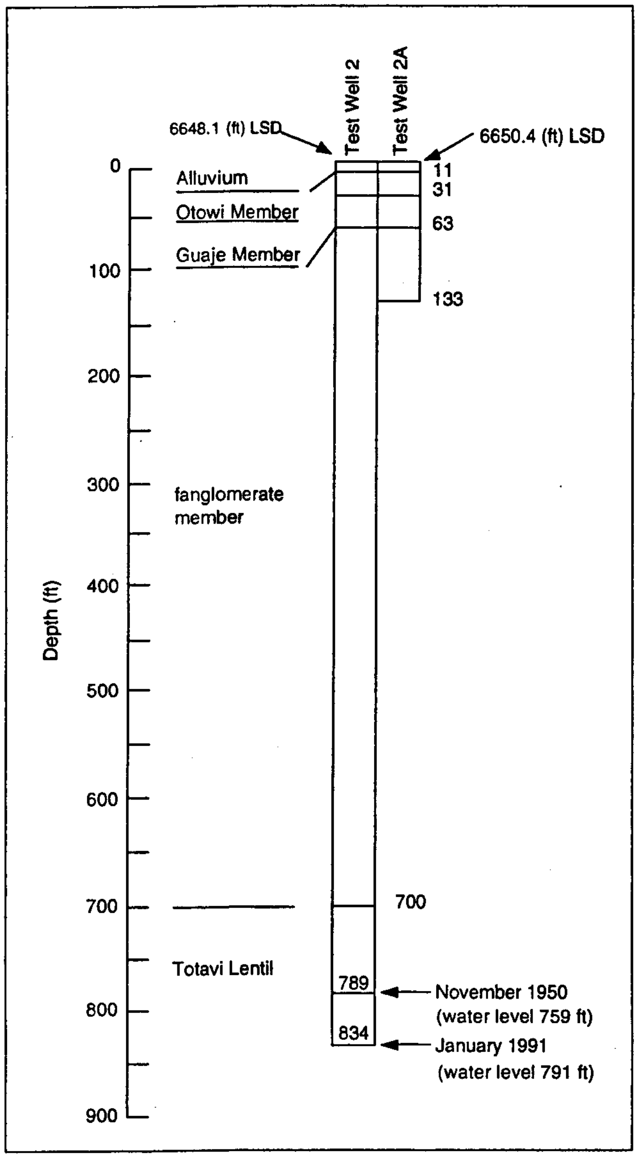


Fig. XVII-C. Geologic logs of test well TW-2, completed November 1949, water level 759 ft, and offset test well TW-2A, water level 121 ft (Griggs 1955).

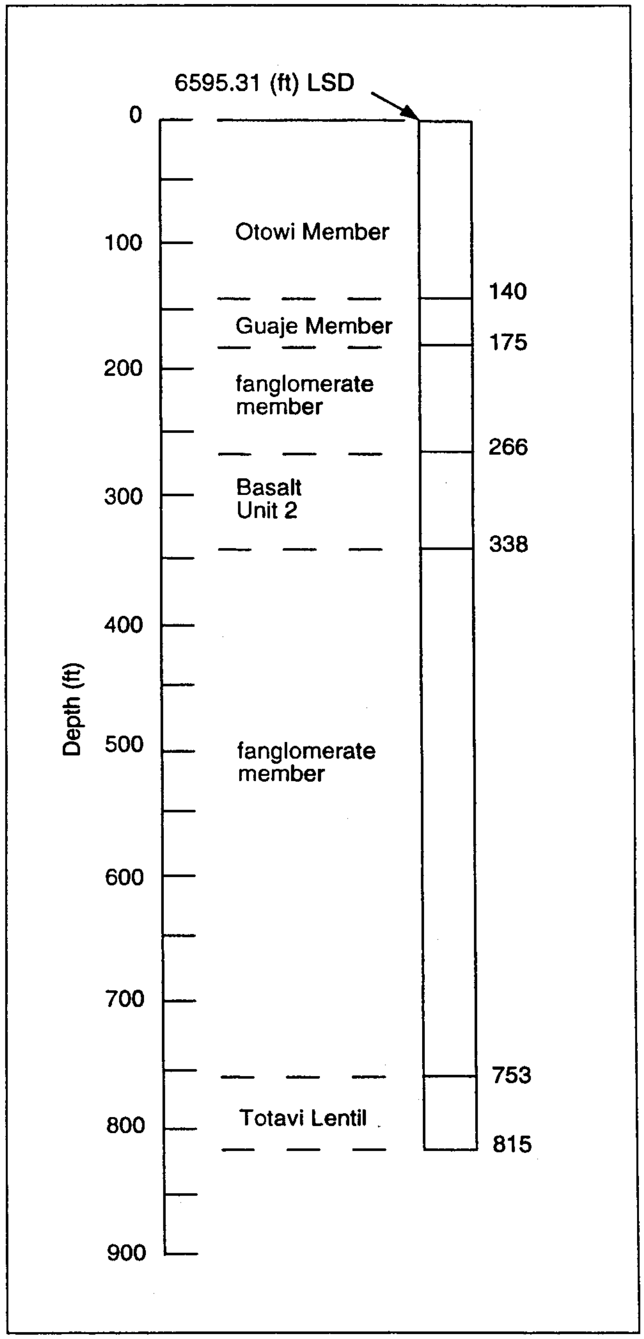


Fig. XVII-D. Geologic log of test well TW-3, completed November 1949, water level 743 ft (Griggs 1955).

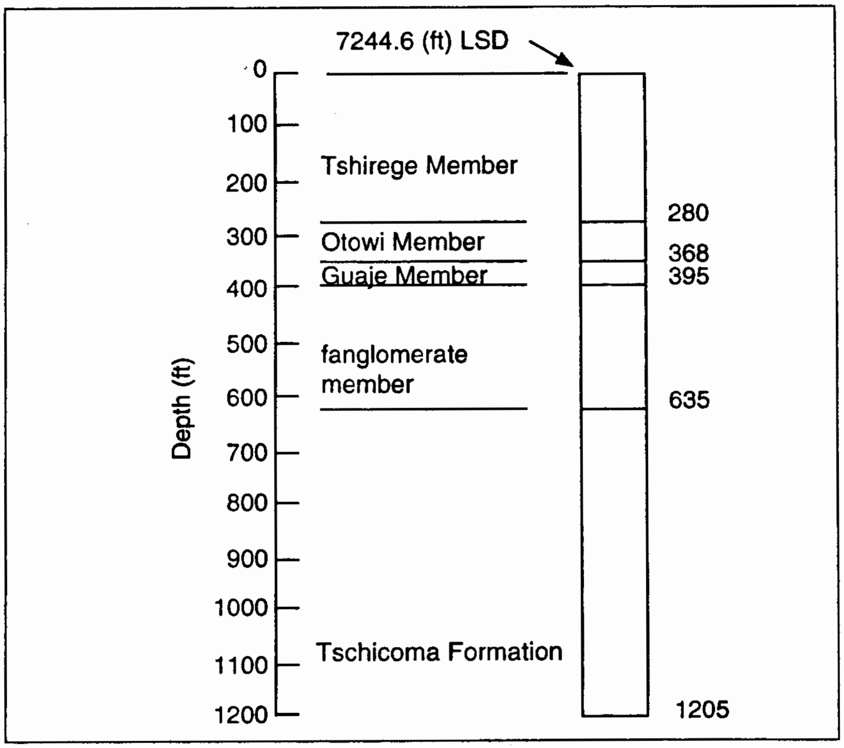


Fig. XVII-E. Geologic log of test well TW-4, completed March 1950, water level 1171 ft (Griggs 1955).

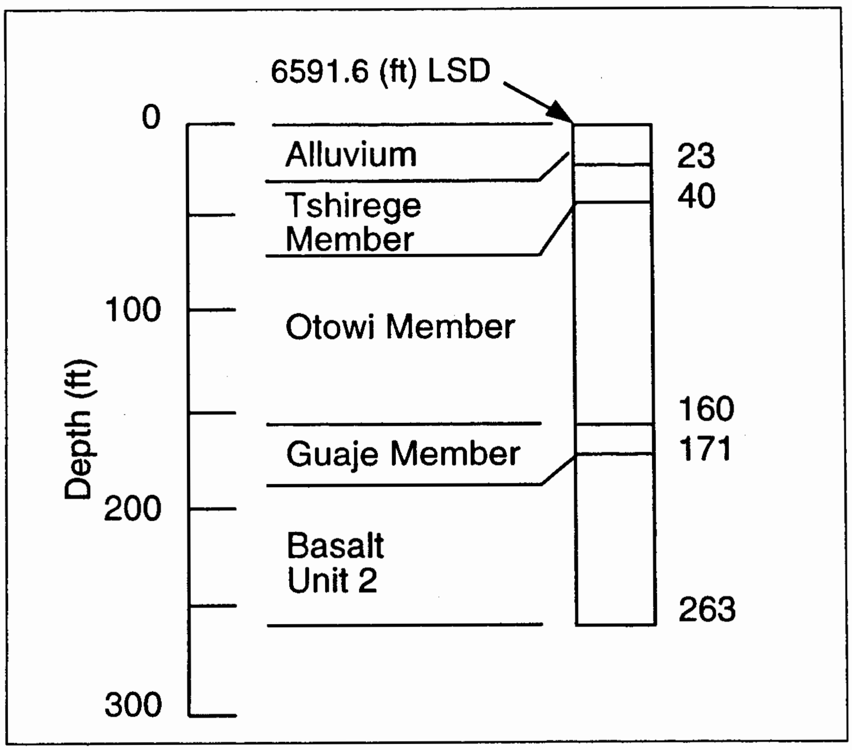


Fig. XVII-F. Geologic log of test hole TH-5, completed March 1950, dry (Griggs 1955).

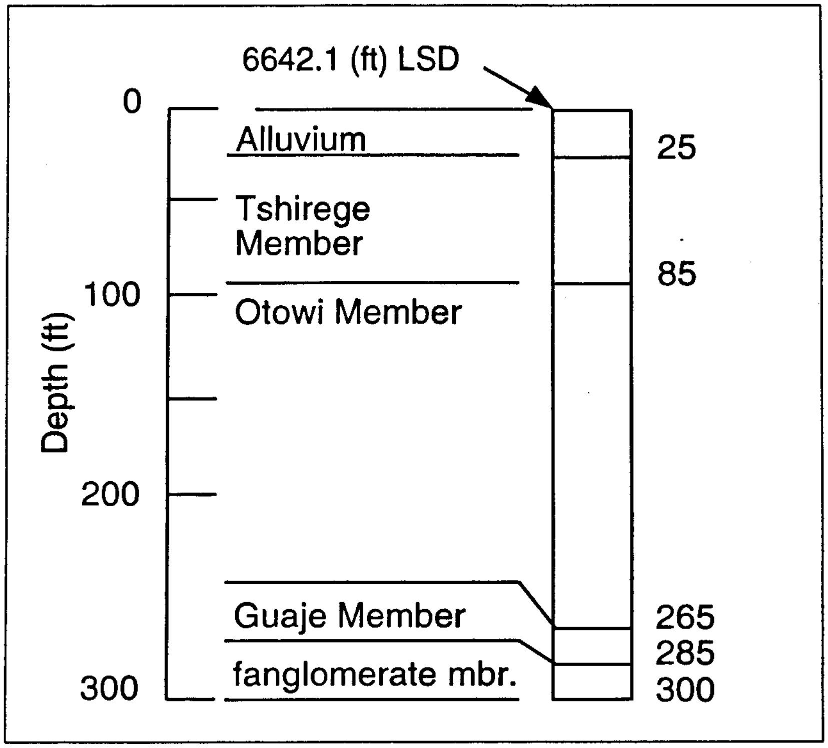


Fig. XVII-G. Geologic log of test hole TH-6, completed March 1950, dry (Griggs 1955).

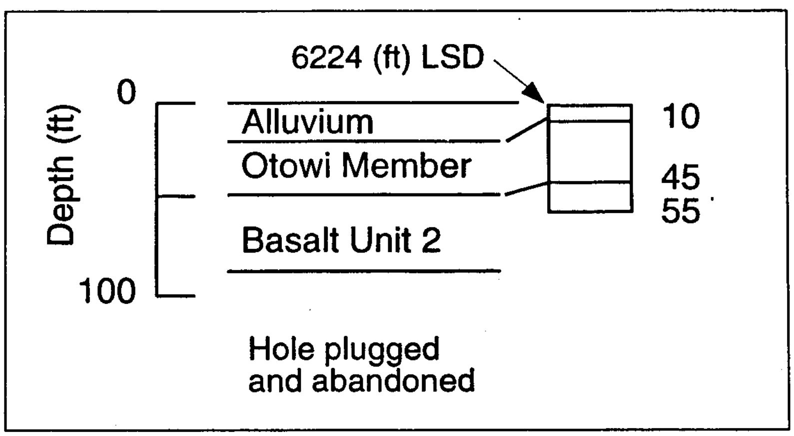


Fig. XVII-H. Geologic log of test hole TH-7, completed April 1950, dry (Griggs 1955).

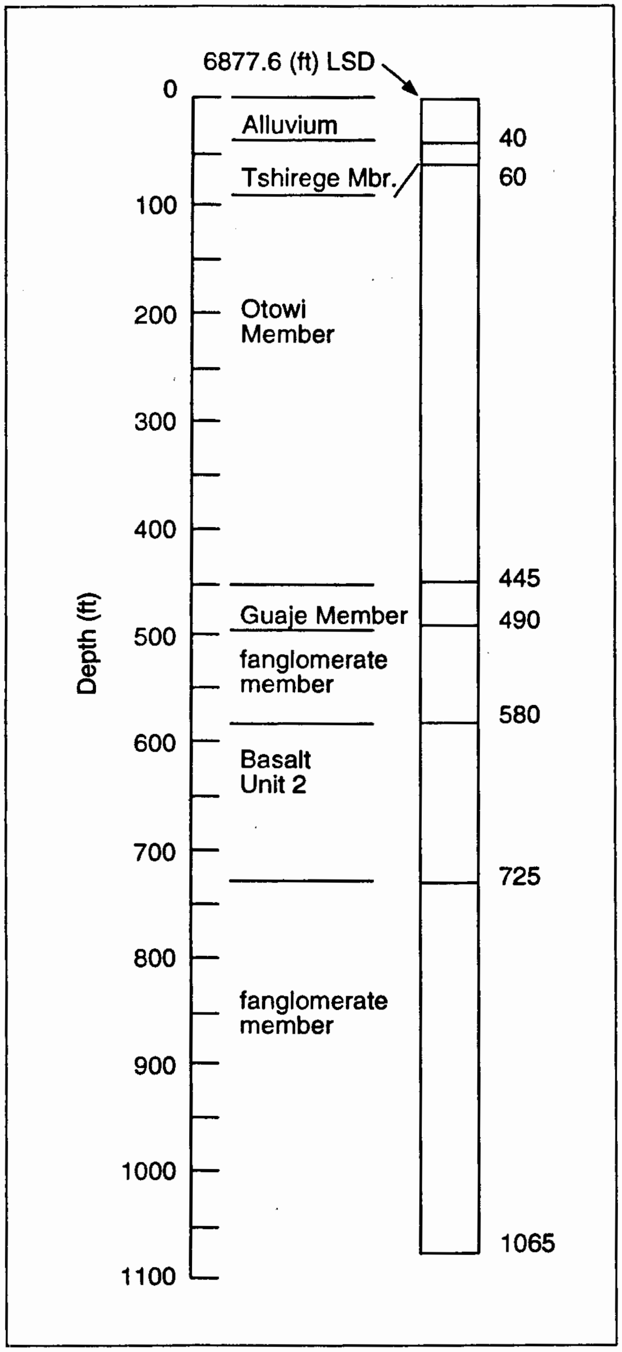


Fig. XVII-I. Geologic log of test well TW-8, completed December 1960, water level 968 ft (Baltz et al. 1963).

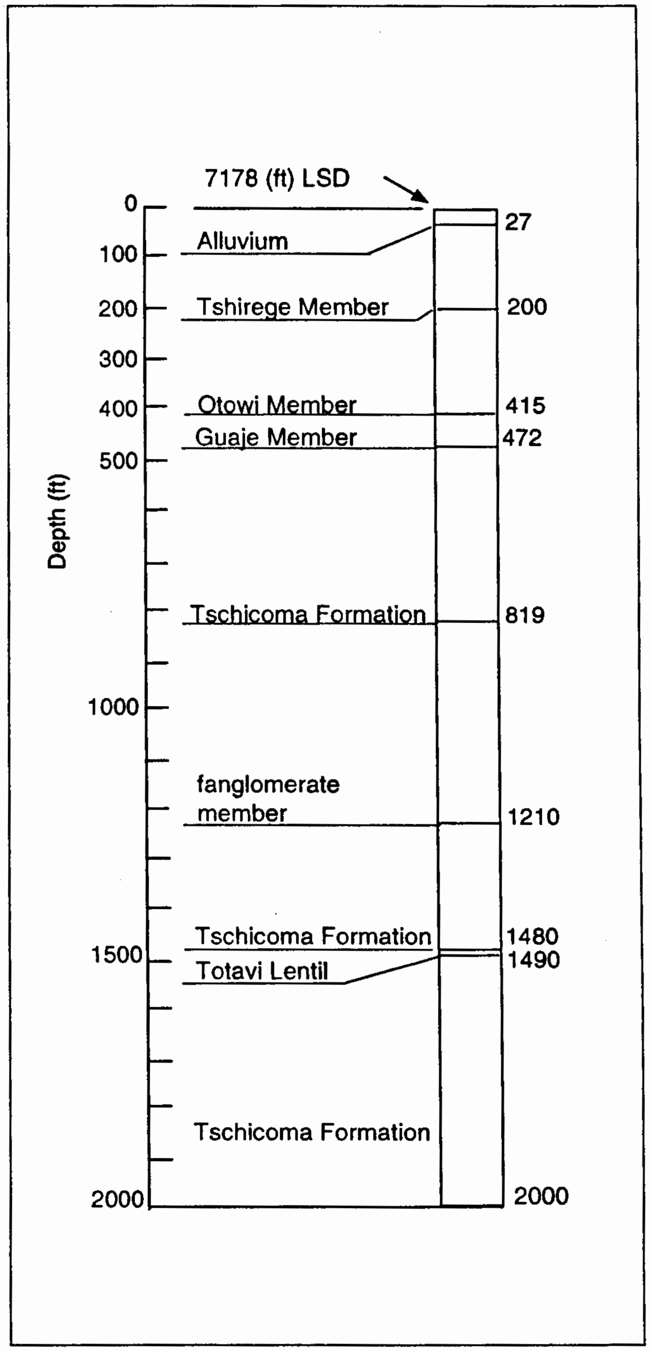


Fig. XVII-J. Geologic log of test hole H-19, completed September 1949, water level 950 ft (Griggs 1955).

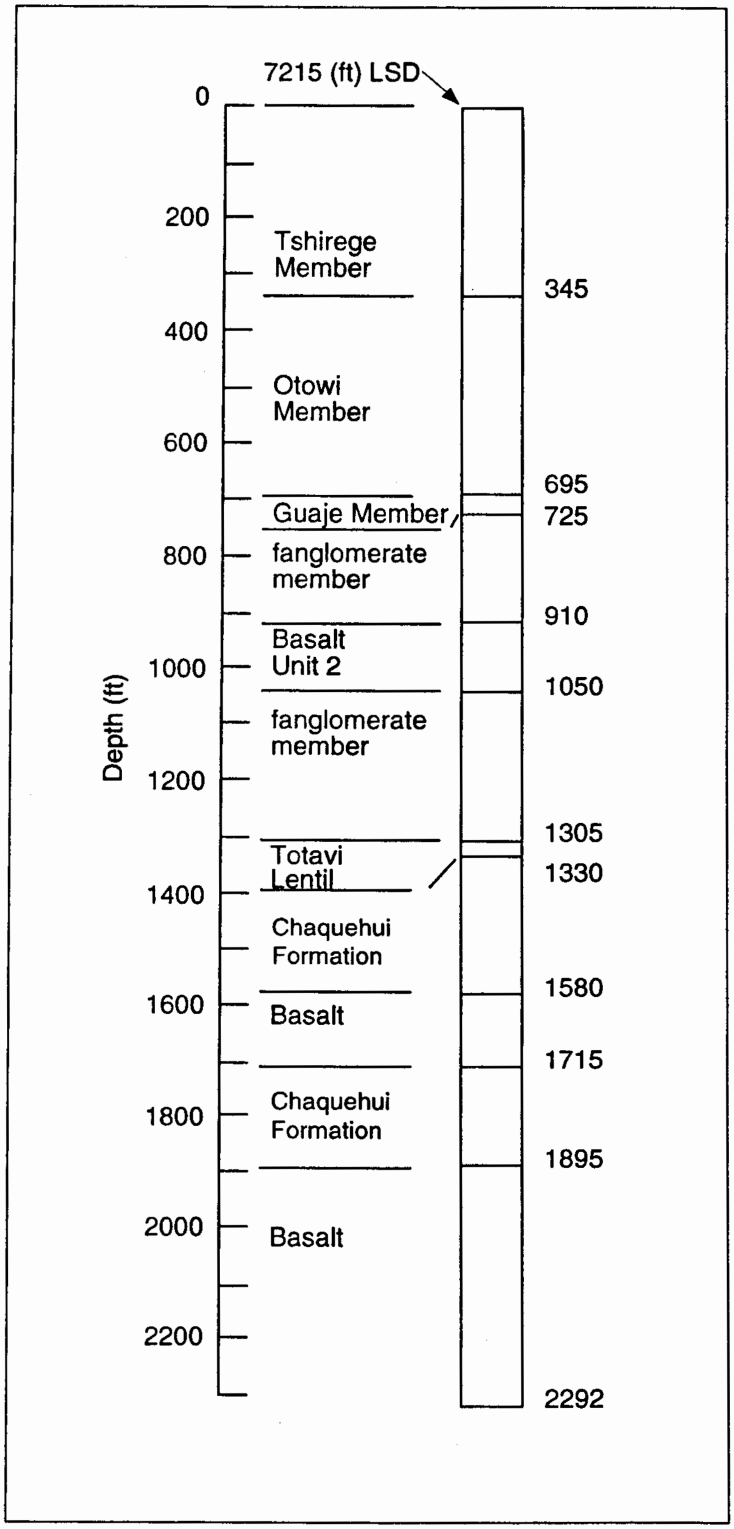


Fig. XVII-K. Geologic log of test hole Sigma Mesa, drilled July–November 1979, water level about 1330 ft (data from unpublished log by Carolyn Potzich modified by Purtymun; see text and Table XVII-B).

TABLE XVII-A. Construction and Hydrologic Data for Test Wells and Test Holes on the Pajarito Plateau						
Test Wells or Test Holes	Month Completed	Depth Drilled (ft)	Depth Completed (ft)	Elevation (LSD) (ft)	Water Level at Completion (ft)	Remarks
Test Well TW-1	1/50	642	642	6369.19	585	
Test Well TW-1A	1/50	225	225	6369.28	188	
Test Well TW-2	11/49	789	789	6648.1	759	
Test Well TW-2[a]	1/91	834	834	6648.06	791	
Test Well TW-2A	11/49	133	133	6650.40	121	
Test Hole TH-2B	11/49	233	—	6647	Dry	
Test Well TW-3	11/49	815	815	6595.31	743	
Test Well TW-4	3/50	1205	1205	7244.6	1171	
Test Hole TH-5	3/50	263	—	6591.6	Dry	
Test Hole TH-6	3/50	300	—	6642.1	Dry	
Test Hole TH-7	4/50	55	—	6224	Dry	plugged and abandoned
Test Well TW-8	12/60	1065	1065	6877.62	968	
Test Hole H-19	9/49	2000	—	7178	950	plugged and abandoned
Test Hole Sigma Mesa	12/79	2292	1425	7215	1330	
Layne Western	3/50	157	147	5971	100	yielded water to drill Guaje wells
Ski Basin Well	6/85	400	392	9310	245	

[a] Well completed to 789 ft in 1949, drilled and cased to 834 ft in 1991.

TABLE XVII-B. Geologic Logs and Construction Data for Test Wells and Test Holes on the Pajarito Plateau (15 Test Wells and Test Holes)

1. Test Well TW-1

Elevation (LSD): 6369.19 ft — Water Level: 585 ft (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Puye Conglomerate		
Fanglomerate member	50	50
Basaltic Rocks of Chino Mesa		
Unit 3	115	165
Puye Conglomerate		
Fanglomerate member	11	176
Basaltic Rocks of Chino Mesa		
Unit 3	79	255
Puye Conglomerate		
Fanglomerate member	155	410
Basaltic Rocks of Chino Mesa		
Unit 2	100	510
Puye Conglomerate		
Fanglomerate member	95	605
Totavi Lentil	37	642

Casing Schedule

Inner Diam (in.)	Depth (ft)	
16	0–52	
12	0–241	
8	0–627	
6	622–632	(swaged into bottom of 8-in. casing)

10 ft of 6-in.-diam screen from 632 to 642 ft swaged into the bottom of the 6-in. casing.

2. Test Well TW-1A

Elevation (LSD): 6369.28 ft — Water Level: 188 ft (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Puye Conglomerate		
Fanglomerate member	50	50
Basaltic Rocks of Chino Mesa		
Unit 3	115	165
Puye Conglomerate		
Fanglomerate member	11	176
Basaltic Rocks of Chino Mesa		
Unit 3	49	225

Casing Schedule

Inner Diam (in.)	Depth (ft)
16	0–39
12	0–100
6	0–215

10 ft of 6-in.-diam screen from 215 to 225 ft swaged into the bottom of the 6-in. casing.

3. Test Well TW-2

Elevation (LSD): 6648.1 ft — Water Level: 759 ft (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	11	11
Bandelier Tuff		
Otowi Member	20	31
Guaje Member	32	63
Puye Conglomerate		
Fanglomerate member	637	700
Totavi Lentil	134	834

Casing Schedule

Inner Diam (in.)	Depth (ft)	
16	0–57	
12	0–197	
10	0–519	
8	0–779	
6	0–834	(with slotted section 768 to 824 ft)

Note: Well completed to 789 ft in 1949; screen removed 779 to 789 ft and drilled and cased 0 to 834 ft December 1990.

4. Test Well TW-2A

Elevation (LSD): 6650.4 ft — Water Level: 121 ft (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	11	11
Bandelier Tuff		
Otowi Member	20	31
Guaje Member	32	63
Puye Conglomerate		
Fanglomerate member	70	133

Casing Schedule

Inner Diam (in.)	Depth (ft)
12	0–12
8	0–118
6	0–128

5 ft of 6-in.-diam screen run from the bottom of the 6-in. casing 128–133 ft.

5. Test Well TW-2B

Elevation (LSD): 6647 ft — Water Level: See Note

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	11	11
Bandelier Tuff		
Otowi Member	20	31
Guaje Member	32	63

TABLE XVII-B. Geologic Logs and Construction Data for Test Wells and Test Holes on the Pajarito Plateau (15 Test Wells and Test Holes) (Continued)

5. Test Well TW-2B (Continued)

	Thickness (ft)	Depth (ft)
Puye Conglomerate		
Fanglomerate member	160	223

Casing Schedule

Inner Diam (in.)	Depth (ft)
12	0–112
6	0–223

Geophysical Log

Caliper (3-20-69), files available from the ESH-18 Geohydrology section.

Note: Between 12-in. and 6-in. casing: water level 88.1 ft; in 6-in. casing, dry at 223 ft.

6. Test Well TW-3

Elevation (LSD): 6595.31 ft — Water Level: 743 ft (1949)

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Otowi Member	140	140
Guaje Member	35	175
Puye Conglomerate		
Fanglomerate member	91	266
Basaltic Rocks of Chino Mesa		
Unit 2	72	338
Puye Conglomerate		
Fanglomerate member	415	753
Totavi Lentil	62	815

Casing Schedule

Inner Diam (in.)	Depth (ft)
16	0–33
10	0–805

10 ft of 6-in.-diam screen swaged into the bottom of the 10-in. casing from 805 to 815 ft.

7. Test Well TW-4

Elevation (LSD): 7244.6 ft — Water Level: 1171 ft (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member	280	280
Otowi Member	88	368
Guaje Member	27	395
Puye Conglomerate		
Fanglomerate member	240	635
Tschicoma Formation		
Latite flows and interflow breccias	570	1205

7. Test Well TW-4 (Continued)

Casing Schedule

Inner Diam (in.)	Depth (ft)
16	0–109
12	0–288
10	0–633
6	0–1195

10 ft of 6-in.-diam screen run from the bottom of the 6-in. casing, from 1195 to 1205 ft.

Geophysical Log
Gamma-ray (5-7-60), Files ESH-18.
Note: Water level 1168.9 ft (5-7-60); water level 1172 ft (7-20-92).

8. Test Hole TH-5

Elevation (LSD): 6591.6 ft

Water Level: Dry (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	23	23
Bandelier Tuff		
Tshirege Member	17	40
Otowi Member	120	160
Guaje Member	11	171
Basaltic Rocks of Chino Mesa		
Unit 2	92	263

Casing Schedule

Outer Diam (in.)	Depth (ft)
24	0–24
Open Hole	24–163

Note: Water in alluvium cased out of hole.

9. Test Hole TH-6

Elevation (LSD): 6642.1 ft

Water Level: Dry (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	25	25
Bandelier Tuff		
Tshirege Member	60	85
Otowi Member	180	265
Guaje Member	20	285
Puye Conglomerate		
Fanglomerate member	15	300

Casing Schedule

Outer Diam (in.)	Depth (ft)
8	0–120
Open Hole	120–300

Note: Water in alluvium cased out of hole.

TABLE XVII-B. Geologic Logs and Construction Data for Test Wells and Test Holes on the Pajarito Plateau (15 Test Wells and Test Holes) (Continued)

10. Test Hole TH-7

Elevation (LSD): 6224 ft — Water Level: Dry (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	10	10
Bandelier Tuff		
Otowi Member	35	45
Basaltic Rocks of Chino Mesa		
Unit 2	10	55

Hole plugged and abandoned.

11. Test Well TW-8

Elevation (LSD): 6877.62 ft — Water Level: 968 ft (1960)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	40	40
Bandelier Tuff		
Tshirege Member	20	60
Otowi Member	385	445
Guaje Member	45	490
Puye Conglomerate		
Fanglomerate member	90	580
Basalt Unit 2	145	725
Fanglomerate member	340	1065

Casing Schedule

44 ft of 20-in. corrugated metal pipe from 0 to 44 ft; 64 ft of 14-in.-outside-diam steel casing 0 to 64 ft cemented in; 1065 ft of 8-in.-inside-diam steel casing from 0 to 1065 ft with the lower 112 ft slotted.

Geophysical Log

Gamma-ray (11-29-61), files available from the ESH-18 Geohydrology section.

12. Test Hole H-19

Elevation (LSD): 7178 ft — Water Level: 950 ft (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	27	27
Bandelier Tuff		
Tshirege Member	173	200
Otowi Member	215	415
Guaje Member	57	472
Tschicoma Formation	347	819
Puye Conglomerate		
Fanglomerate member	391	1210
Tschicoma Formation	270	1480
Puye Conglomerate		
Totavi Lentil	10	1490
Tschicoma Formation	510	2000

TABLE XVII-B. Geologic Logs and Construction Data for Test Wells and Test Holes on the Pajarito Plateau (15 Test Wells and Test Holes) (Continued)

12. Test Hole H-19 (Continued)

Casing Schedule

10 ft of 12-in.-diam surface casing set 0 to 10 ft. Exploratory hole drilled by cable tool, casing pulled at end of tests in 1949. Hole open to 265 ft (5-7-60); to 69 ft (7-20-92).

Geophysical Log

Gamma-ray (5-7-60), files available from the ESH-18 Geohydrology section.

13A. Test Hole Sigma Mesa EGH-LA-1 (1979)

Elevation (LSD): 7215 ft LSD

Geologic Log[a]	Thickness (ft)	Depth (ft)
Tshirege Member Bandelier Tuff	270	270
Ash flow of Otowi Member Bandelier Tuff	430	700
Guaje Pumice Bed	35	735
Puye Conglomerate with interbedded basalt	110	845
Aphyric Tschicoma Flow	80	925
Hornblende-bearing Tschicoma Flow	45	970
Fanglomerate member of Puye Conglomerate	365	1335
Totavi Lentil of the Puye Formation	65	1400
Chamita Formation of the Santa Fe Group	500	1900
Tschicoma Flow	35	1935
Chamita Formation of the Santa Fe Group	60	1995
Tschicoma Flow	297	2292

13B. Test Hole Sigma Mesa EGH-LA-1 (1992)

Elevation (LSD): 7215 ft LSD

Water Level: 1330 ft (1979, geophysical log)

Geologic Log[b]	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member	345	345
Otowi Member	350	695
Guaje Member	30	725
Puye Conglomerate		
Fanglomerate member	185	910
Basalt Unit 2	140	1050
Fanglomerate member	255	1305
Totavi Lentil	25	1330
Santa Fe Group		
Chaquehui Formation	250	1580
Basalt and basalt breccias	135	1715
Chaquehui Formation	180	1895
Basalt and basalt breccias	397	2292

[a] Logged by Carolyn Potzich.

[b] Revised log by W. D. Purtymun from geophysical logs, comparision with logs of nearby supply and test wells, and R. F. Smith Corp. Geothermal Data Log.

13B. Test Hole Sigma Mesa EGH-LA-1 (1992) (Continued)

Casing Schedule
Hole size: 36-in. diam to 85 ft, 26-in. diam to 2292 ft; casing size 30-in. diam to 85 ft, 20-in. diam to 1627 ft. Hole plugged with cement at about 1425 ft; unknown length of drill stem, drill collars, and bit lost in the bottom of the hole. The hole had a bad history of lost circulation throughout the entire depth drilled; large volumes of water, drilling mud, lost circulation materials, and cement were pumped into the hole. The hole was abandoned in December 1979.

Geophysical Logs
Temperature, compensated neutron-formation density; dual induction–SFL with linear correlation log; and R.F. Smith Corp. Geothermal Data Log (files available from the ESH-18 Geohydrology section).

14. Layne Western

Elevation (LSD): 5971 ft — Water Level: 100 ft (1950)

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	12	12
Puye Conglomerate		
Fanglomerate member	13	25
Totavi Lentil	50	75
Tesuque Formation		
Siltstone and sandstone	82	157

Casing Schedule
147 ft of 8-in.-diam casing set from 0 to 147 ft, screen from 127 to 147 ft.

15. Ski Basin Well

Elevation (LSD): 9310 ft — Water Level: 245 ft (June 1985)

Geologic Log	Thickness (ft)	Depth (ft)
Tough sandstone (probably Tshirege Member Bandelier Tuff, welded unit)	35	35
Lost circulation: same formation throughout, probably Tschicoma Formation latite and rhyolite flow, water perched on interflow breccia of pebbly cobbles in a matrix of silt and clay	365	400

Casing Schedule
392 ft of 4 1/2-in. plastic casing with perforations from 332 to 352 ft and 372 to 392 ft. Data from drillers' log.

TABLE XVII-C. Drilling Progress Report for Sigma Mesa EGH-LA-1

Lost Circulation Depth (ft)	Cement Plug (No.)	Number of Sacks of Cement	Top Depth after Setting Plug (ft)
787	1–8	3005	75
240	9	900	62
461	10	325	437
749	11	350	681
733	12	450	539
760	13	450	683
773[a]	14	450	618
987	15	450	816
1133	16	225	1057
1412[b]	17–19	675	1264
		Total 7280	

[a] Drilled without returns from 773 ft to 818 ft when plug 14 was set.

[b] Plug 17 was set at 1412 ft and tagged at 1348 ft. Lost 500 barrels of mud trying to establish returns. Set plug 18 at 1348 ft and tagged at 1264 ft. Still could not establish circulation, attempted to set plug 19. Plug 19 disappeared completely into the formation.

From the technical status report for July 1979.

TABLE XVII-D. Locations and Elevations (NAD 1927)

Test Well TW-1	N 1,772,014.8	E 509,797.3	6369.2 ft
Test Well TW-1A	N 1,772,003.7	E 509,812.7	6369.3 ft
Test Well TW-2	N 1,777,205.8	E 493,986.9	6648.1 ft
Test Well TW-2A	N 1,777,226.0	E 493,940.6	6650.4 ft
Test Well TW-2B	N 1,777,200	E 493,900	6647 ft
Test Well TW-3	N 1,773,075.9	E 497,483.2	6595.3 ft
Test Well TW-4	N 1,777,618.0	E 483,783.9	7244.6 ft
Test Hole TH-5	N 1,756,514.6	E 503,312.1	6591.6 ft
Test Hole TH-6	N 1,757,817.7	E 500,272.2	6642.1 ft
Test Hole TH-7	N 1,740,400	E 500,500	6224 ft
Test Well TW-8	N 1,769,444.6	E 492,329.6	6877.6 ft
Test Hole H-19	N 1,775,400	E 478,200	7178 ft
Sigma Mesa	N 1,771,800	E 484,100	7215 ft
Layne Western	N 1,783,200	E 516,000	5971 ft
Ski Basin Well	N 1,780,700	E 457,700	9310 ft

XVIII. TEST HOLES IN THE VALLE TOLEDO AND VALLE GRANDE (1948)

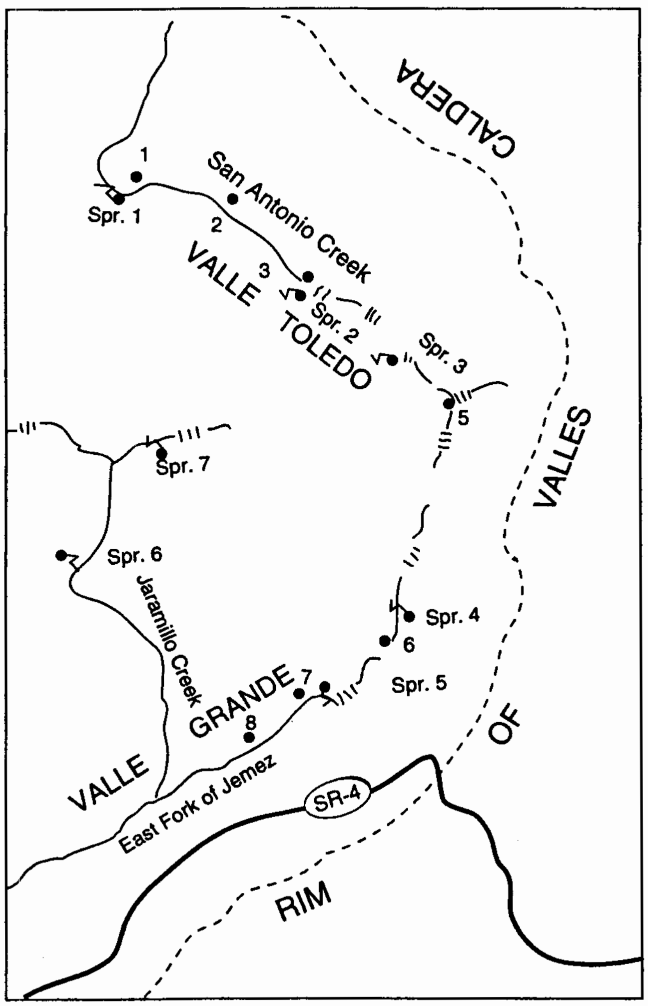
Seven test holes ranging in depth from 31 to 361 ft were drilled in the Valle Toledo and Valle Grande during the spring and summer of 1948 (Fig. XVIII-A, Table XVIII-A). The holes were drilled to determine if a water supply for Los Alamos could be obtained from the Valle Toledo or Valle Grande in Valles Caldera west of Los Alamos (Stearns 1948).

The seven test holes drilled in the caldera encountered water in the alluvium along the stream channels of San Antonio Creek, the East Fork of the Jemez and the older lake clay and sediments (Table XVIII-B). Bailing tests indicated that water was available; however, the amount could not be determined without additional investigation.

An inventory was made of the springs in the two areas (Fig. XVIII-A and Table XVIII-C). The discharge from the three springs in the Valle Toledo and the four springs in the Valle Grande ranged from 15 to 875 gpm.

REFERENCE

H. T. Stearns, "Ground-Water Supplies for Los Alamos," Consulting Report to the U.S. Atomic Energy Commission (1948).



● Test Hole SCALE Spring

0 1 2 Miles

Fig. XVIII-A. Test wells and springs in the Valle Toledo and Valle Grande (Stearns 1948).

TABLE XVIII-A. Records of the Test Holes in the Valle Toledo and Valle Grande

	Date Drilled (1948)	Elevation LSD (ft)	Depth (ft)	Depth to Water (ft)	Water Level Above Nearby Stream (ft)	Remarks
Valle Toledo						
TH-1	6/19	8599	100	10	5	
TH-2	6/21	8650	100	+2	17	artesian
TH-3	6/23	8740	31	4.5	5	
TH-4	—	—	—	—	—	test hole not drilled
TH-5	6/25	8930	361	128.8	—	
Valle Grande						
TH-6	6/28	8590	140	7.7	-21	
TH-7	6/29	8532	40	6.0	2	
TH-8	6/30	8507	299	2.6	—	

Source: Stearns 1948.

TABLE XVIII-B. Geologic Logs of Test Holes in the Valle Toledo and Valle Grande (7 Test Holes)

1. Test Hole 1

Location: Valle Toledo
Depth: 100 ft
Depth to water: 10 ft after 15 min bailing and 10 min recovery; hole filled up to 73 ft with sand while bailing; abundant water.

Log	Thickness (ft)	Depth (ft)
Silt, sand, and gravel	11	11
Sand and gravel alternating with sticky brown clay	89	100

2. Test Hole 2

Location: Valle Toledo
Depth: 100 ft
Depth to water: artesian flow at 73 gpm.

Log	Thickness (ft)	Depth (ft)
Silt, sand, and gravel, cobbles	11	11
Sand and gravel alternating with sticky clay	89	100

3. Test Hole 3

Location: Valle Toledo
Depth: 31 ft
Depth to water: 4.5 ft; hole abandoned due to running sand.

Log	Thickness (ft)	Depth (ft)
Loose rock, sand, gravel, and clay	31	31

4. Test Hole 4

No hole drilled.

5. Test Hole 5

Location: Valle Toledo
Depth: 361 ft
Depth to water: 128.8 ft; there was some flow of water into the hole from the 15 ft level.

Log	Thickness (ft)	Depth (ft)
Sand and gravel, some angular, volcanic rock	11	11
Sand, gravel, with some clay lenses, all volcanic rock, containing much pumice	350	361

Note: The whole section or deposit compacted to stand as an open hole, but was not firm enough to core; from 26 to 361 ft lapilli of rhyolitic tuff, weakly consolidated.

TABLE XVIII-B. Geologic Logs of Test Holes in the Valle Toledo and Valle Grande (7 Test Holes) (Continued)

6. Test Hole 6

Location: Valle Grande
Depth: 140 ft
Depth to water: 10 ft; bailed at 30 gpm without lowering water level; hole filled up with sand to 70 ft after bailing.

Log	Thickness (ft)	Depth (ft)
Gravel with some clay	10	10
Gravel, clay, volcanic debris and pumice	130	140

7. Test Hole 7

Location: Valle Grande
Depth: 40 ft
Depth to water: 5.5 ft (6-29-48); 6.0 (7-1-48)

Log	Thickness (ft)	Depth (ft)
Rhyolite and obsidian gravel	40	40

Note: Hole abandoned due to broken core barrel.

8. Test Hole 8

Location: Valle Grande
Depth: 299 ft
Depth to water: 3.5 ft (6-30-48); 2.6 (7-1-48)

Log	Thickness (ft)	Depth (ft)
Sticky brown lake-bed clay	288	288
White pumice sand with quartz grains	11	299

Source: Stearns 1948.

TABLE XVIII-C. Records of Springs in the Valle Toledo and Valle Grande

	Elevation LSD (ft)	Topographic Situation and Geologic Conditions	Estimated Discharge (gpm)
Valle Toledo			
Spring 1	8570	Contact alluvium and rhyolite	875
Spring 2	8732	Contact alluvium and rhyolite	350
Spring 3	8768	Alluvium	15
Valle Grande			
Spring 4	8600	Alluvium	15
Spring 5	8524	Fractured rhyolite	1000
Spring 6	8640	Rhyolite	15
Spring 7	8700	Contact alluvium and rhyolite	30

Note: Elevations estimated with aneroid barometer; data collected June 1948.

Source: Stearns 1948.

TABLE XVIII-D. Locations and Elevations (NAD 1927)

A. Valle Toledo			
TH-1	N 1,804,000	E 431,000	8599 ft
TH-2	N 1,802,000	E 437,000	8650 ft
TH-3	N 1,799,000	E 441,000	8740 ft
TH-4	(hole not drilled)		
TH-5	N 1,791,000	E 451,000	8930 ft
B. Valle Grande			
TH-6	N 1,776,000	E 447,000	8590 ft
TH-7	N 1,773,000	E 441,000	8532 ft
TH-8	N 1,770,000	E 439,000	8507 ft
C. Valle Toledo			
Spring 1	N 1,804,000	E 430,000	8570 ft
Spring 2	N 1,799,000	E 441,000	8732 ft
Spring 3	N 1,794,000	E 444,000	8768 ft
D. Valle Grande			
Spring 4	N 1,778,000	E 447,000	8600 ft
Spring 5	N 1,773,000	E 444,000	8524 ft
Spring 6	N 1,780,800	E 427,500	8640 ft
Spring 7	N 1,788,000	E 431,000	8700 ft

Note: Location to the nearest 1000 ft; no topographic map existed when work was done (see Fig. XVIII-A).

Source: Stearns 1948.

XIX. TEST HOLES IN THE VALLE TOLEDO, VALLE GRANDE, AND VALLE DE LOS POSOS (1949)

As a result of the 1948 investigation (see Section XVIII), 17 test holes were drilled in the Valle Toledo, Valle Grande, Valle de los Posos, and adjacent areas (Figs. XIX-A, XIX-B, and XIX-C). Six holes in the Valle Toledo (H-1 through H-6) and six holes in the Valle Grande (H-7 through H-12) were laid out for aquifer tests (Fig. XIX-D and Fig. XIX-E). The remaining holes were drilled for additional geologic and hydrologic information in the Valle de los Posos (H-13, H-17), one (H-14) on the divide between Valle Toledo and Valle Grande, one (H-15) at the upper end of the Valle Grande, and one (H-16) on the east rim of the caldera (Table XIX-A).

The test holes penetrated alluvium, Quaternary fill (gravels washed out from the flanks of the caldera), and caldera fill (lake sediments and gravels). A lake occupied the depression after the formation of the Valles Caldera. Sediments that accumulated in the lake consisted of clayey silt, sand, and gravel derived from the volcanic debris that formed the inner walls and rim of the caldera. Gravel lenses are numerous, interbedded with sand and silt lenses. The lake sediments and caldera fill are porous and permeable.

The wells used in the aquifer tests were completed into the lake sediments or caldera fill as shown by the geologic logs and construction details (Table XIX-B). The results of the aquifer tests indicated that there was water available for a water supply for Los Alamos; however, the testing indicated that the amount of water that would need to be pumped would deplete the stream flow. As water in the stream was already owned by downstream users, additional testing was discontinued. The planned development of a water supply from the Valle Toledo and Valle Grande was terminated (Griggs 1955, Conover et al. 1963).

REFERENCES

R. L. Griggs, "Geology and Water Resources of the Los Alamos Area, New Mexico," U.S. Geol. Survey Admin. Report to the U.S. Atomic Energy Commission (1955).

C. S. Conover, C. V. Theis, and R. L. Griggs, "Geology and Hydrology of the Valle Grande and Valle Toledo, Sandoval County, New Mexico," U.S. Geol. Survey Water-Supply Paper 1619-Y (1963).

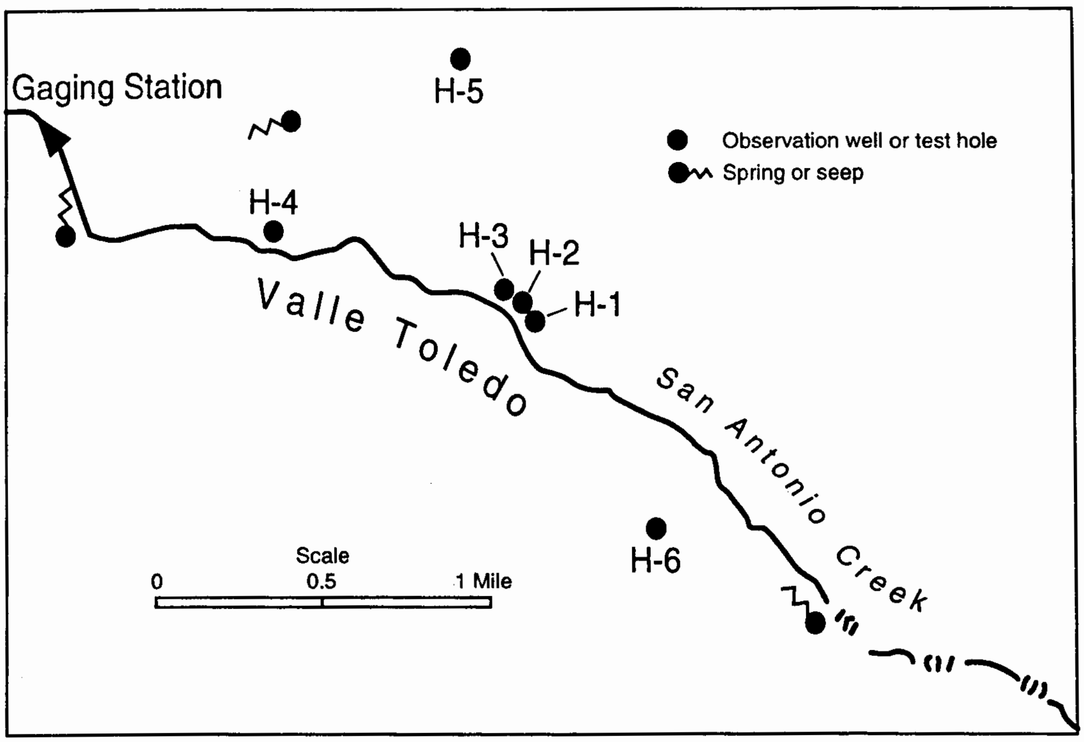


Fig. XIX-A. Locations of test holes in the Valle Toledo (1949).

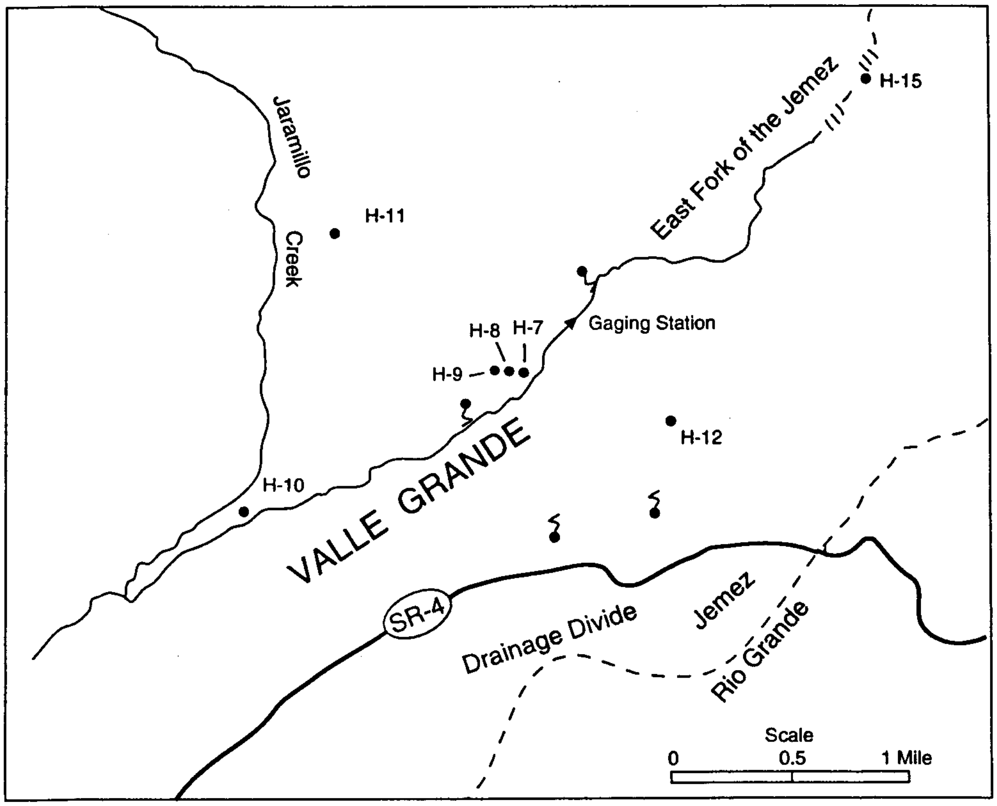


Fig. XIX-B. Generalized location of test holes in the Valle Grande (1949).

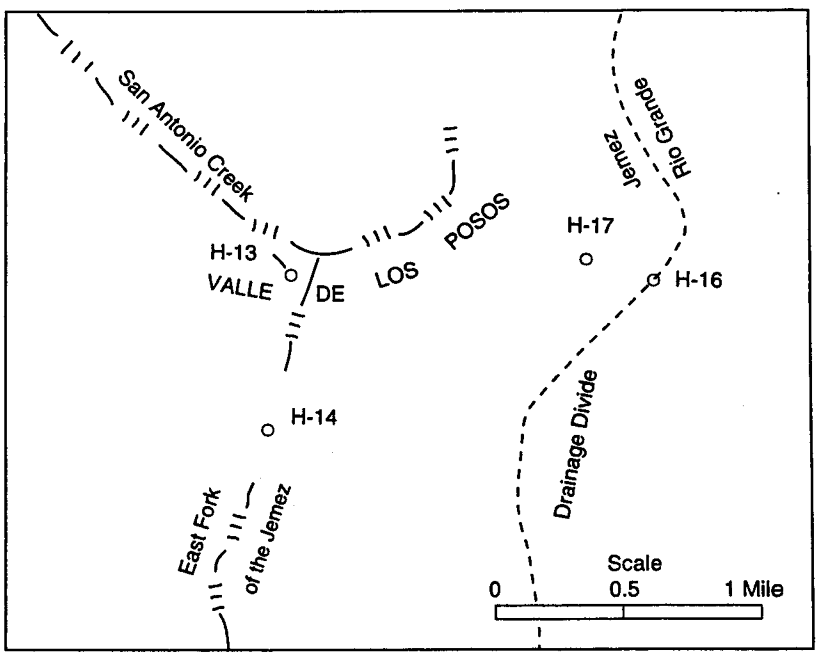


Fig. XIX-C. Locations of test holes in the Valle de los Posos and on the drainage divide.

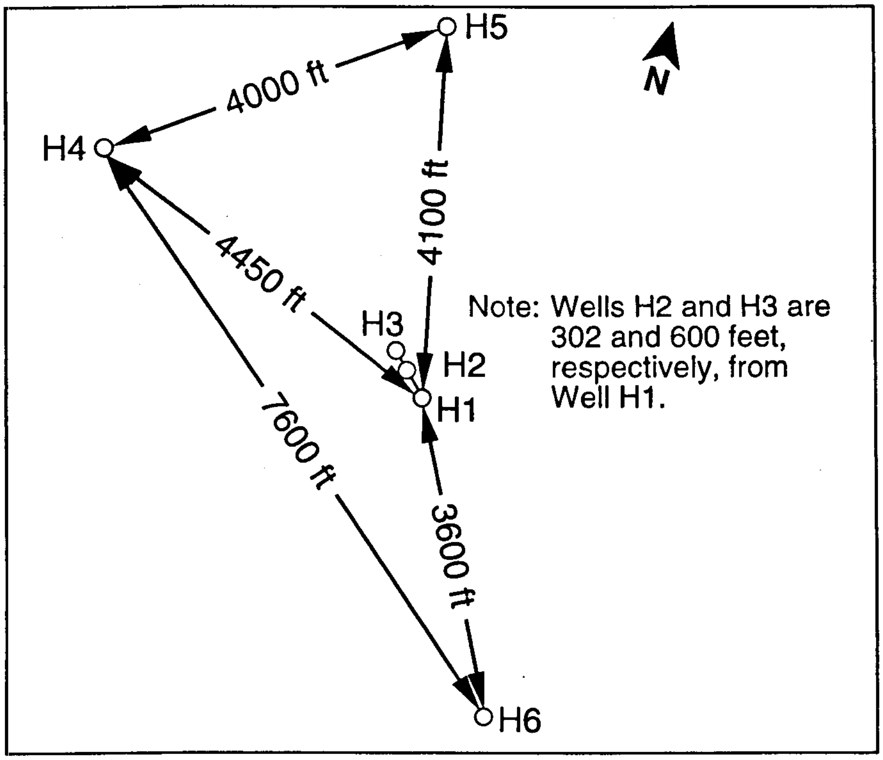


Fig. XIX-D. Locations of test holes used in the aquifer test in the Valle Toledo (Griggs 1955). See also Fig. XIX-A.

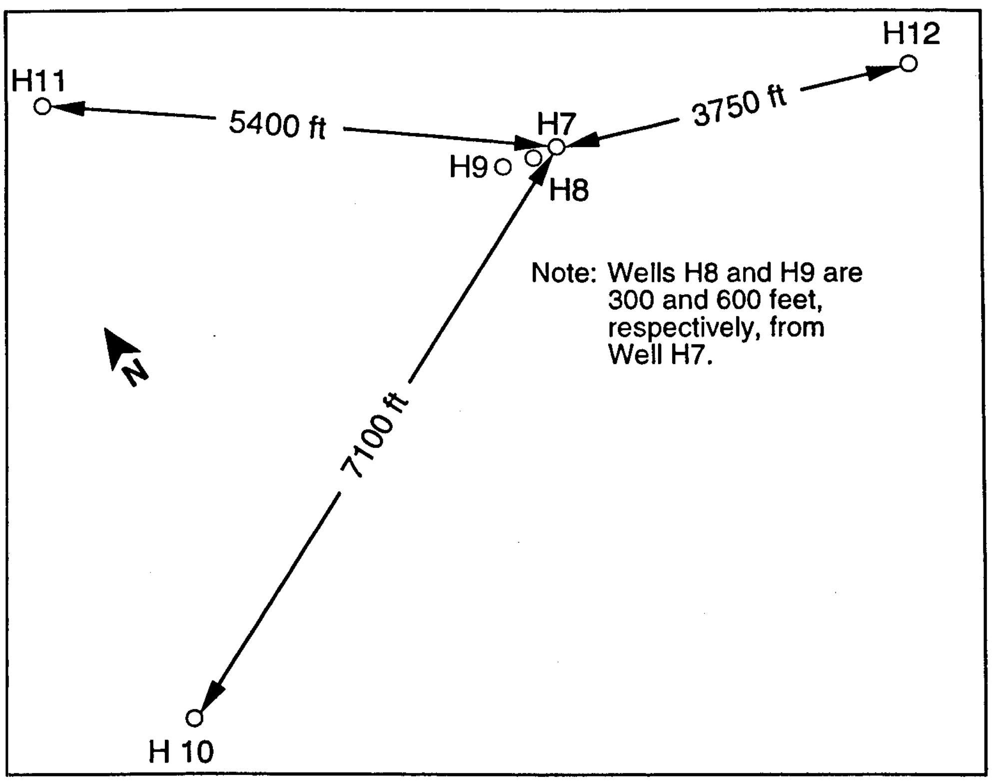


Fig. XIX-E. Locations of test holes used in the aquifer test in the Valle Grande (Griggs 1955). See also Fig. XIX-B.

TABLE XIX-A. Records of Test Holes in the Valle Toledo, Valle Grande, and Adjacent Areas					
	Month Completed	Elevation LSD (ft)	Depth (ft)	Head of Pressure When Completed (+ft) Water Level below LSD (ft)	Remarks
Valle Toledo					
H-1	10/49	8650	652	+36	Specific capacity: 50 gpm/ft of drawdown
H-2	10/49	8648	410	+35	
H-3	10/49	8647	405	+38	
H-4	10/49	8603	285	-7.5	
H-5	10/49	8769	530	-71	
H-6	10/49	8684	444	+19	
Valle Grande					
H-7	11/49	8507	1185	+9.6	Specific capacity: 10 gpm/ft of drawdown
H-8	11/49	8506	595	+11	
H-9	11/49	8506	595	+11	
H-10	11/49	8491	589	+23	
H-11	11/49	8534	630	-16	
H-12	11/49	8545	634	-15	
Valle de los Posos					
H-13[a]	10/49	8930	800		Log—no mention of water
Divide					
H-14[a]	10/49	8990	420		Log—no mention of water
Valle Grande					
H-15[a]	10/49	9505	1269		Log—several water-bearing zones
East Rim of Caldera					
H-16[a]	1949	9505	1269		Log—no mention of water
Valle de los Posos					
H-17[a]	1949	9237	493		Log—no mention of water

Note: Test holes completed in caldera fill, except for H-16 and H-17 (completed in the Bandelier Tuff and Tschicoma Formation).

[a]No casing.
Source: Griggs 1955.

TABLE XIX-B. Geologic Logs and Casing Schedules of Test Holes in the Valle Toledo, Valle Grande, and Adjacent Areas (17 Test Holes)

1. Hole H-1

Location: Valle Toledo
Depth: 652 ft

Log	Thickness (ft)	Depth (ft)
Alluvium	12	12
Caldera fill	640	652
Water: 95 to 140 ft		
Water: 175 to 345 ft		
Water: 370 to 410 ft		

Casing Record
70 ft of 16-in.-diam surface casing cemented in 0 to 70 ft; 450 ft of 12-in.-diam casing with 40 ft of screen from 383 to 427 ft; 12-in.-diam casing perforated from: 80 to 120 ft; 125 to 150 ft; 170 to 240 ft; 265 to 300 ft; and 329 to 340 ft.

2. Hole H-2

Location: Valle Toledo
Depth: 410 ft

Log
Same as Hole H-1, 300 ft east

Casing Record
79 ft of 6-in.-diam surface casing cemented in 0 to 79 ft; 407 ft of 2-in.-diam tubing with 30-in. sandpoint at lower end, set 0 to 407 ft.

3. Hole H-3

Location: Valle Toledo
Depth: 405 ft

Log
Same as Hole H-1, 600 ft east

Casing Record
64 ft of 6-in.-diam casing cemented in 0 to 64 ft; 405 ft of 2-in.-diam tubing with 30-in. sandpoint at lower end, set 0 to 405 ft.

4. Hole H-4
Location: Valle Toledo
Depth: 285 ft

Log	Thickness (ft)	Depth (ft)
Alluvium	10	10
Caldera fill	275	285
Water: 115 to 210 ft		

Casing Record
49 ft of 6-in.-diam casing cemented in 0 to 49 ft; 240 ft of 4-in.-diam tubing with 30-in. sandpoint at lower end, set 0 to 240 ft.

TABLE XIX-B. Geologic Logs and Casing Schedules of Test Holes in the Valle Toledo, Valle Grande, and Adjacent Areas (17 Test Holes) (Continued)

5. Hole H-5

Location: Valle Toledo
Depth: 530 ft

Log	Thickness (ft)	Depth (ft)
Terrace material		
Gravel, sandy to silty, light gray	32	32
Caldera fill	498	530
Water: 320 to 530 ft		

Casing Record
99 ft of 6-in.-diam casing cemented in 0 to 99 ft; 527 ft of 2-in.-diam tubing with a 30-in. sandpoint on lower end set 0 to 530 ft.

6. Hole H-6

Location: Valle Toledo
Depth: 444 ft

Log	Thickness (ft)	Depth (ft)
Alluvium	5	5
Caldera fill	439	444
Water: 110 to 400 ft		

Casing Record
99 ft of 6-in.-diam casing cemented in 0 to 99 ft; 441 ft of 2-in.-diam tubing with 30-in. sandpoint on lower end, set 0 to 444 ft.

7. Hole H-7

Location: Valle Grande
Depth: 1185 ft

Log	Thickness (ft)	Depth (ft)
Alluvium	10	10
Caldera fill	1175	1185
Water: 300 to 860 ft		

Casing Record
66 ft of 16-in.-diam surface casing cemented in 0 to 66 ft; 595 ft 12-in.-diam casing with five 10-ft screen sections set up at intervals, 300 to 595 ft; the 12-in.-diam casing between the screen sections torch slotted.

8. Hole H-8

Location: Valle Grande
Depth: 595 ft

Log
Same as Hole H-7, 300 ft east

Casing Record
60 ft of 6-in.-diam casing cemented in 0 to 60 ft, 592 ft of 2-in.-diam tubing with 30-in. sandpoint at lower end, set 0 to 595 ft.

TABLE XIX-B. Geologic Logs and Casing Schedules of Test Holes in the Valle Toledo, Valle Grande, and Adjacent Areas (17 Test Holes) (Continued)

9. Hole H-9

Location: Valle Grande
Depth: 595 ft

Log
Same as Hole H-7, 700 ft east

Casing Record
67 ft of 6-in.-diam casing cemented in 0 to 67 ft; 592 ft of 2-in.-diam tubing with 30-in. sandpoint on lower end, set 0 to 595 ft.

10. Hole H-10

Location: Valle Grande
Depth: 589 ft

Log	Thickness (ft)	Depth (ft)
Alluvium	15	15
Caldera fill	574	589
Water: 205 to 589 ft		

Casing Record
65 ft of 6-in.-diam casing cemented in 0 to 65 ft; 581 ft of 2-in.-diam tubing with 30-in. sandpoint at lower end, set 0 to 584 ft.

11. Hole H-11

Location: Valle Grande
Depth: 630 ft

Log	Thickness (ft)	Depth (ft)
Terrace material, Sand and gravel, light gray to light buff	72	72
Caldera fill	558	630
Water: 275 to 305 ft		
Water: 310 to 630 ft		

Casing Record
88 ft of 6-in.-diam casing cemented in 0 to 88 ft; 622 ft of 2-in.-diam tubing with 30-in. sandpoint at lower end, set 0 to 625 ft.

12. Hole H-12

Location: Valle Grande
Depth: 634 ft

Log	Thickness (ft)	Depth (ft)
Terrace material Gravel, sandy, light buff	35	35
Caldera fill	599	634
Water: 212 to 634 ft		

TABLE XIX-B. Geologic Logs and Casing Schedules of Test Holes in the Valle Toledo, Valle Grande, and Adjacent Areas (17 Test Holes) (Continued)

12. Hole H-12 (Continued)

Casing Record
71 ft of 6-in.-diam casing cemented in 0 to 77 ft; 634 ft of 2-in.-diam tubing with 30-in. sandpoint at lower end, set 0 to 634 ft.

13. Hole H-13

Location: Valle de los Posos
Depth: 800 ft

Log	Thickness (ft)	Depth (ft)
Quaternary fan		
Gravel outwash, gray	30	30
Caldera fill	770	800
(no water)		

Casing Schedule
No casing.

14. Hole H-14

Location: Divide between the Valle Grande and the Valle de los Posos

Depth: 420 ft

Log	Thickness (ft)	Depth (ft)
Quaternary fan		
Gravel outwash, gray	97	97
Caldera Fill	311	408
Valle Rhyolite: rhyolite dome of pumiceous glass, sanidine, quartz, biotite, and hornblende	12	420
(no water)		

Casing Schedule
No casing.

15. Hole H-15

Location: Valle Grande
Depth: 600 ft

Log	Thickness (ft)	Depth (ft)
Quaternary fan		
Gravel outwash	7	7
Caldera fill	593	600
Water: 125 to 400 ft		

Casing Schedule
No casing.

TABLE XIX-B. Geologic Logs and Casing Schedules of Test Holes in the Valle Toledo, Valle Grande, and Adjacent Areas (17 Test Holes) (Continued)

16. Hole H-16

Location: East Rim of Caldera
Depth: 1269 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member	295	295
Bandelier Tuff		
Undifferentiated	332	627
Tschicoma Formation		
latite and quartz, latite flows (no water)	642	1269

Casing Schedule
No casing.

17. Hole H-17

Location: Valle de los Posos
Depth: 493 ft

Log	Thickness (ft)	Depth (ft)
Quaternary fan: gravel	10	10
Bandelier Tuff	413	423
Tschicoma Formation		
Latite flow (no water)	70	493

Casing Schedule
No casing.

Source: Griggs 1955.

TABLE XIX-C. Locations and Elevations (NAD 1927)			
A. Valle Toledo			
H-1	N 1,802,400	E 437,200	8650 ft
H-2	N 1,802,700	E 436,900	8648 ft
H-3	N 1,802,900	E 436,700	8647 ft
H-4	N 1,803,900	E 432,900	8603 ft
H-5	N 1,806,600	E 436,000	8769 ft
H-6	N 1,799,600	E 438,900	8684 ft
B. Valle Grande			
H-7	N 1,769,900	E 439,200	8507 ft
H-8	N 1,769,900	E 438,900	8506 ft
H-9	N 1,770,000	E 438,600	8506 ft
H-10	N 1,766,600	E 432,700	8491 ft
H-11	N 1,773,100	E 434,800	8534 ft
H-12	N 1,768,700	E 442,700	8545 ft
C. Valle de los Posos			
H-13	N 1,790,900	E 450,500	8930 ft
D. Divide			
H-14	N 1,787,800	E 449,800	8990 ft
E. Valle Grande			
H-15	N 1,777,800	E 447,300	8595 ft
F. East Rim of Caldera			
H-16	N 1,790,900	E 457,700	9505 ft
G. Valle de los Posos			
H-17	N 1,792,100	E 457,100	9237 ft

Source: Griggs 1955.

XX. TEST HOLES ALONG THE RIO GRANDE AND LOWER LOS ALAMOS CANYON

Four test holes (the Rio Grande Tests) were drilled north of Otowi on the west side of the Rio Grande (Fig. XX-A). These holes, drilled in 1946, were completed to determine whether a ground water supply could be obtained from the alluvium along the river or from the sediments underlying the alluvium (Table XX-A). The holes ranged in depth from 53 to 497 ft. Limited saturation of the alluvium and the low permeability of the claystone, siltstone, and silty sandstone of the Tesuque Formation precluded their use as a water supply.

Five test holes (the Guaje Tests) were drilled west of Otowi in lower Los Alamos Canyon (Fig. XX-A). These holes were drilled in 1946 to determine whether a water supply could be developed from the alluvium or sediments underlying the alluvium (Table XX-A). The depth of these test holes ranged from 50 to 475 ft (Black and Veatch 1946, 1948). The alluvium in the canyon is too thin to provide an entire municipal supply on its own. Water flowed from the deeper test holes when completed. The sediments below the alluvium were considerably more permeable than those at the Rio Grande test holes, and the Los Alamos well field was developed in 1947 with the drilling and completion of wells LA-1, LA-2, and LA-3.

REFERENCES

Black and Veatch (Consulting Engineers, Kansas City, Mo.), "Report on Additional Water Supply Sources, Los Alamos, New Mexico," report to the U.S. Atomic Energy Commission (two reports: 1946 and 1948).

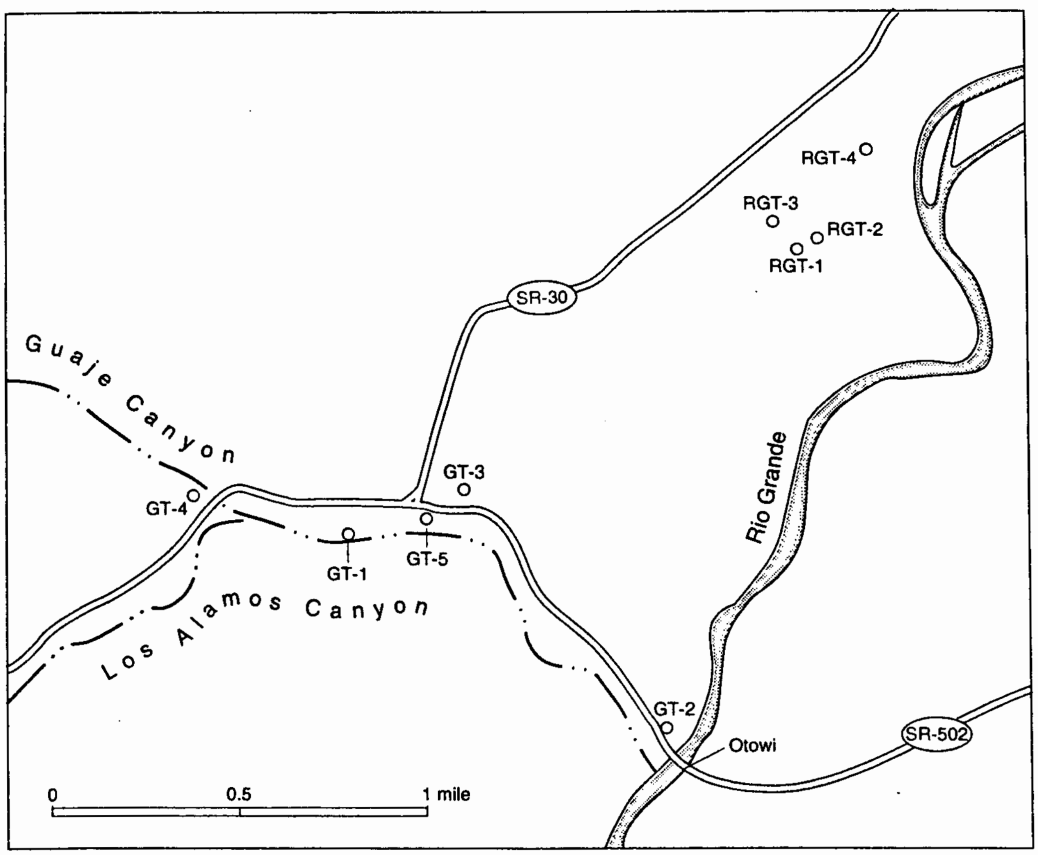


Fig. XX-A. Locations of Rio Grande and Guaje test holes.

TABLE XX-A. Geologic Logs and Construction Data of Rio Grande and Guaje Test Holes

	Month Drilled	Elevation (ft)	Depth (ft)	Casing	Geologic Log: Alluvium (ft)	Geologic Log: Tesuque Formation (ft)	Remarks
Rio Grande Tests							
RGT-1	2/46	5530	53	a	48	5	
RGT-2	2/46	5525	497	a	41	456	Water in alluvium
RGT-3	2/46	5545	495	a	68	427	Water in alluvium
RGT-4	2/46	5537	495	a	47	448	Water in alluvium
Guaje Tests							
GT-1	3/46	5624	400	b	78	322	Artesian (also known as well LA-1A)
GT-2	3/46	5560	50	a	40	10	
GT-3	3/46	5620	475	a	31	444	Artesian
GT-4	3/46	5675	315	c	54	261	Artesian (also known as well LA-3A)
GT-5	3/46	5609	475	d	38	475	Artesian (also known as Stop Sign well)

[a] Open hole.
[b] 6-in.-diam steel 0 to 76 ft; 4-in.-diam steel 0 to 400 ft.
[c] 2-in.-diam galvanized steel 0 to 315 ft; perforated 60 to 315 ft.
[d] 2-in.-diam galvanized steel 0 to undetermined depth (sounded 10/65 to 275 ft).

Source: Black and Veatch 1946, 1948.

TABLE XX-B. Locations and Elevations (NAD 1927)

A. Rio Grande Tests			
RGT-1	N 1,780,700	E 533,800	5530 ft
RGT-2	N 1,780,900	E 534,100	5525 ft
RGT-3	N 1,781,100	E 533,600	5545 ft
RGT-4	N 1,782,100	E 534,700	5537 ft
B. Guaje Tests (Lower Los Alamos Canyon)			
GT-1	N 1,776,800	E 527,700	5624 ft
GT-2	N 1,773,900	E 532,100	5560 ft
GT-3	N 1,777,300	E 529,200	5620 ft
GT-4	N 1,777,200	E 525,700	5675 ft
GT-5	N 1,776,900	E 528,800	5609 ft

Source: Black and Veatch 1946, 1948.

XXI. SUPPLY WELLS

Municipal and industrial water supply for the Laboratory and the communities of Los Alamos and White Rock is from four well fields: Los Alamos, Guaje, Pajarito, and Otowi (Fig. XXI-A). The wells in the fields range in depth from 870 ft in lower Los Alamos Canyon to 3093 ft on the Pajarito Plateau (Table XXI-A). Water levels at completion ranged from free-flowing in lower Los Alamos Canyon to over 1200 ft near the center of the plateau. The wells were completed in the main aquifer, the only aquifer in the area capable of municipal and industrial water supply.

A. Los Alamos Field

The Los Alamos Field was composed of seven wells, six completed in 1946–1948, the seventh added in 1960 (Fig. XXI-A). During the spring of 1992, production from the field was terminated. The relocation of State Road 502 crossed the transmission line. Due to the age of the wells, the production from the field had decreased to the point where it was not economically feasible to relocate the line. Pumps were removed from all wells except LA-2, which was used by the road contractor. Some of the wells were plugged and abandoned while others will be used for hydrologic data collection. Well LA-6 was taken off-line in 1977 due to excess amounts of naturally occurring arsenic.

Geologic logs for the seven supply wells are shown in Figs. XXI-B through XXI-H. Logs and construction data are presented in Table XXI-B. No record can be found of the surface casing for the six wells drilled 1946–1948. It could be assumed that surface casing was set through the alluvium into the Tesuque Formation to prevent fluid loss during drilling of the well and to allow gravel pack of the well upon completion of the drilling operation (Black and Veatch 1946, 1948, and 1951; Cushman 1965).

B. Guaje Field

The Guaje Field is composed of seven wells, six completed in the period 1950 to 1952, the seventh well added in 1964 (Fig. XXI-A and Table XXI-C). Only six wells are operational; however, the yield has declined in several of the wells so that they are not pumped except when there is heavy water demand. The well casing failed in well G-3, and when water is pumped from it, gravel pack and sand enter the well, reducing its usability.

Geologic logs for the six wells are presented in Figs. XXI-I through XXI-O. No record can be found of the surface casing of the wells drilled 1950 to 1952. Surface casing, as stated in the previous section, is probably set through the alluvium and friable fanglomerate member into the consolidated Tesuque Formation (Black and Veatch 1951; Cushman 1965; Cooper et al. 1965).

C. Pajarito Field

The Pajarito Field is composed of five wells, three completed 1964 to 1967, one added in 1981, and another in 1982 (Fig. XXI-A and Table XXI-A). All wells are operational (Cooper et al. 1965; Purtymun 1967; Purtymun et al. 1983 and 1984).

Geologic logs and construction data are presented in Table XXI-D. Geologic logs are also shown in Figs. XXI-P through XXI-T. All wells have surface casing that extends to or near the top of the main aquifer. This casing is cemented in from the bottom, to prevent surface contamination from reaching the main aquifer.

D. Otowi Field

The Otowi Field is composed of two supply wells that were completed in 1990 (Fig. XXI-A and Table XXI-A). These wells are not equipped with pumps, nor are the storage reservoirs and transmission lines complete. Geologic logs and construction data are presented in Table XXI-E. Geologic logs of the two wells are shown in Figs. XXI-U and XXI-V (Stoker et al. 1992). The wells have casing that extends from the land surface to near the top of the main aquifer. The casing is cemented in from the bottom to prevent surface contamination from reaching the main aquifer.

E. Water Supply Reports

A summary report (1947–1971) and annual reports related to well and well-field characteristics have been published to ensure a continuing historical record and to provide guidance for the management of water resources in long-range planning for the water supply system.

1947–1971 data: LA-5040-MS, November 1972
1971 data: LA-5039-MS, October 1972
1972 data: LA-5296-MS, December 1973
1973 data: LA-5636-MS, June 1974
1974 data: LA-5998-MS, June 1975
1975 data: LA-6461-PR, September 1976
1976 data: LA-6814-PR, May 1977
1977 data: LA-7436-MS, August 1978
1978 data: LA-8074-PR, October 1979
1979 data: LA-8504-PR, August 1980
1980 data: LA-9007-PR, September 1981
1981 data: LA-9734-PR, May 1983
1982 data: LA-9896-PR, January 1984
1983 data: LA-10327-PR, February 1985
1984 data: LA-10584-PR, January 1986
1985 data: LA-10835-PR, October 1986
1986 data: LA-11046-PR, August 1987
1987 data: LA-11478-PR, January 1989
1988 data: LA-11679-PR, October 1989
1989 data: LA-12276-PR, May 1992
1990 data: LA-12471-PR, February 1993
1991 data: LA-12770-PR, June 1994

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Black and Veatch, "Report on Additional Water Supply Sources, Los Alamos, New Mexico," Consulting Engineers, Kansas City, Mo., report to the U.S. Atomic Energy Commission (three reports: 1946, 1948, and 1951).

R. L. Cushman, "An Evaluation of Aquifer and Well Characteristics of Municipal Well Fields in the Los Alamos and Guaje Canyons Near Los Alamos, New Mexico," U.S. Geol. Survey Water-Supply Paper 1809-D (1965).

J. B. Cooper, W. D. Purtymun, and E. C. John, "Records of Water-Supply Wells Guaje Canyon 6, Pajarito Mesa 1, and Pajarito Mesa 2, Los Alamos, New Mexico, Basic Data Report," U.S. Geol. Survey Open-File Report (1965).

R. L. Griggs, "Geology and Water Resources of the Los Alamos Area, New Mexico," U. S. Geological Survey Admin. Report to the U. S. Atomic Energy Commission (1955).

W. D. Purtymun, "Record of Water-Supply Well PM-3, Los Alamos New Mexico," U.S. Geol. Survey Open-File Report (1967).

W. D. Purtymun, N. M. Becker, and M. Maes, "Water Supply at Los Alamos During 1981," Los Alamos National Laboratory report LA-9734-PR (1983).

W. D. Purtymun, N. M. Becker, and M. Maes, "Water Supply at Los Alamos During 1982," Los Alamos National Laboratory report LA-9896-PR (1984).

W. D. Purtymun, A. Stoker, S. McLin, M. Maes, and G. Hammock, "Water Supply at Los Alamos During 1990," Los Alamos National Laboratory report LA-12471-PR (1993).

A. Stoker, S. McLin, W. D. Purtymun, M. Maes, and G. Hammock, "Water Supply at Los Alamos During 1989," Los Alamos National Laboratory report LA-12276-PR (1992).

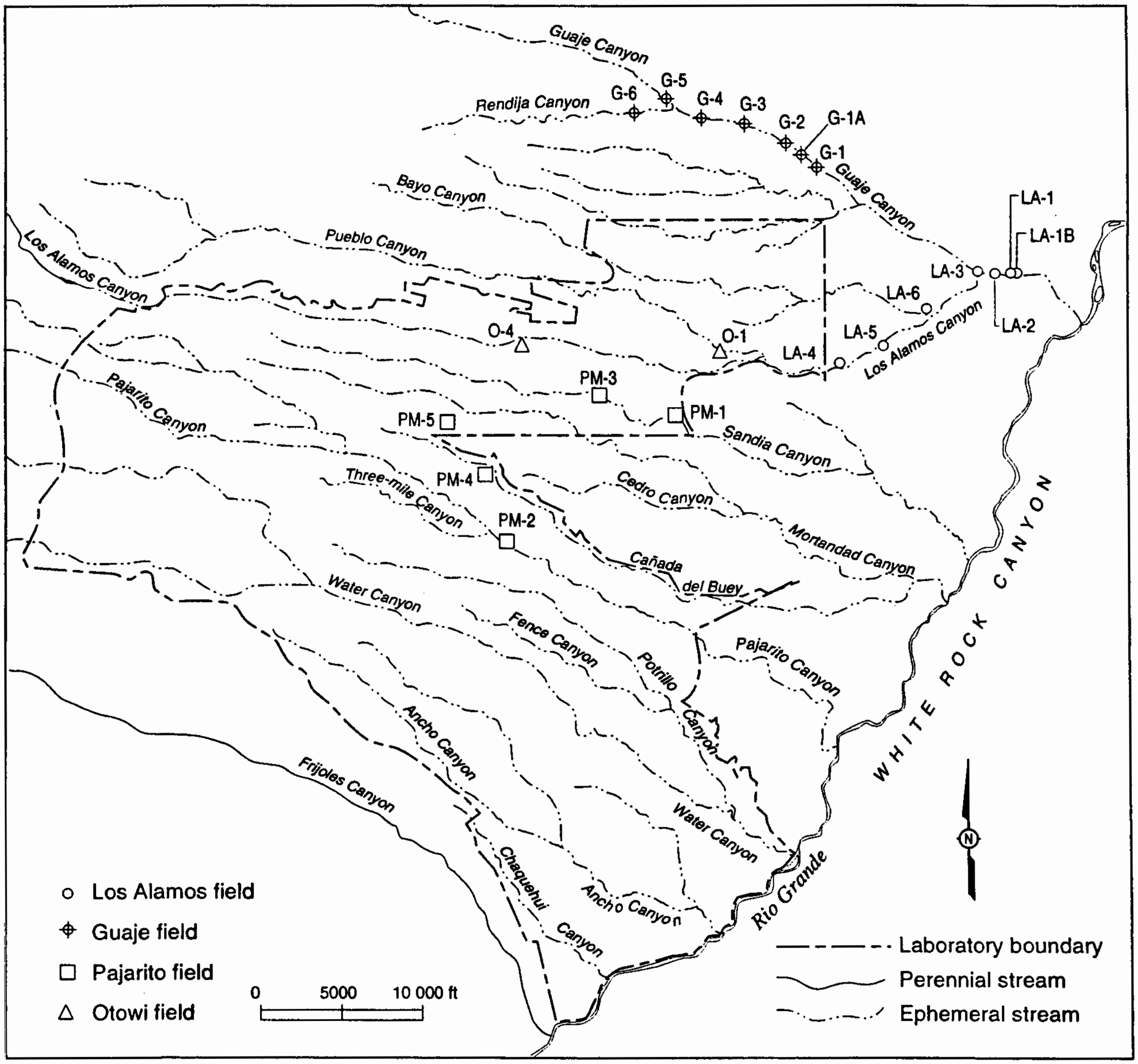


Fig. XXI-A. Locations of supply wells in the Los Alamos, Guaje, Pajarito, and Otowi well fields.

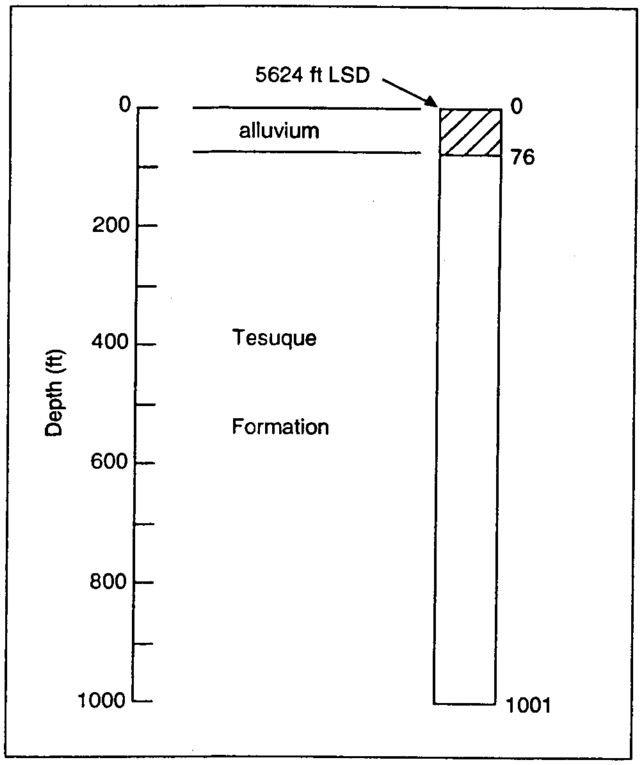


Fig. XXI-B. Geologic log of supply well LA-1, completed November 1946, flowing (Black and Veatch 1948; Cushman 1965).

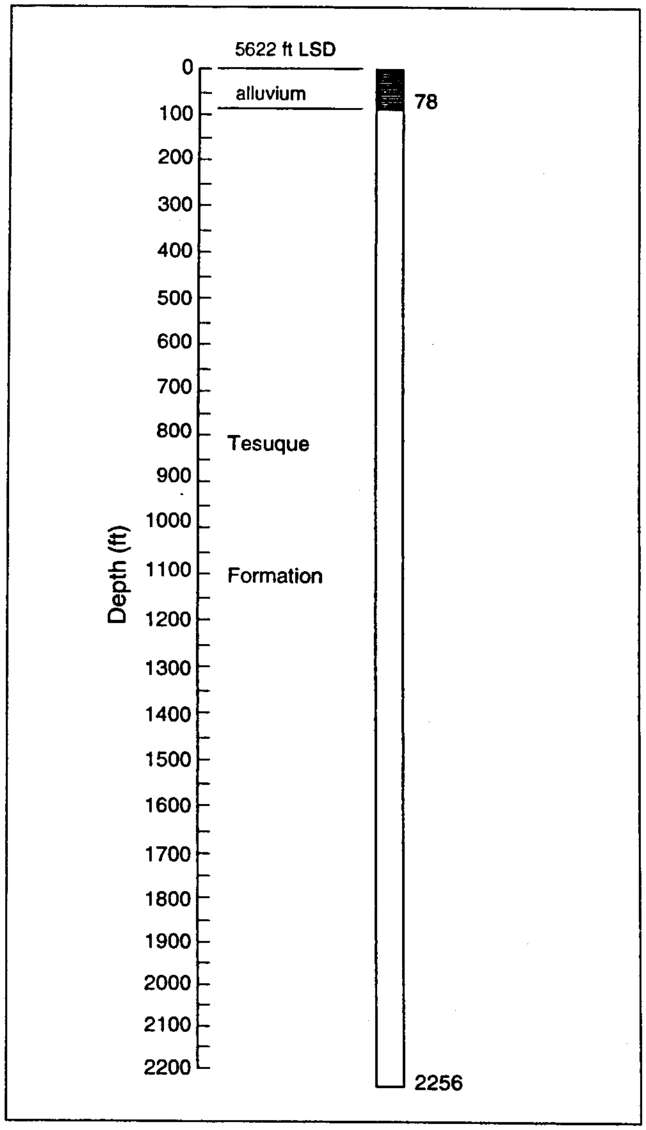


Fig. XXI-C. Geologic log of supply well LA-1B, completed May 1960, flowing (Cushman 1965).

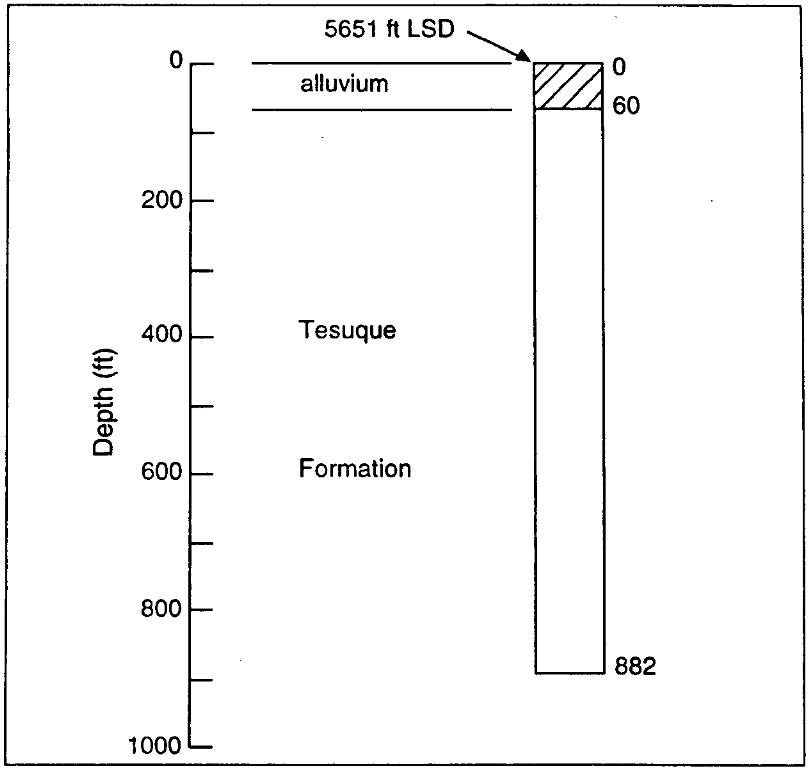
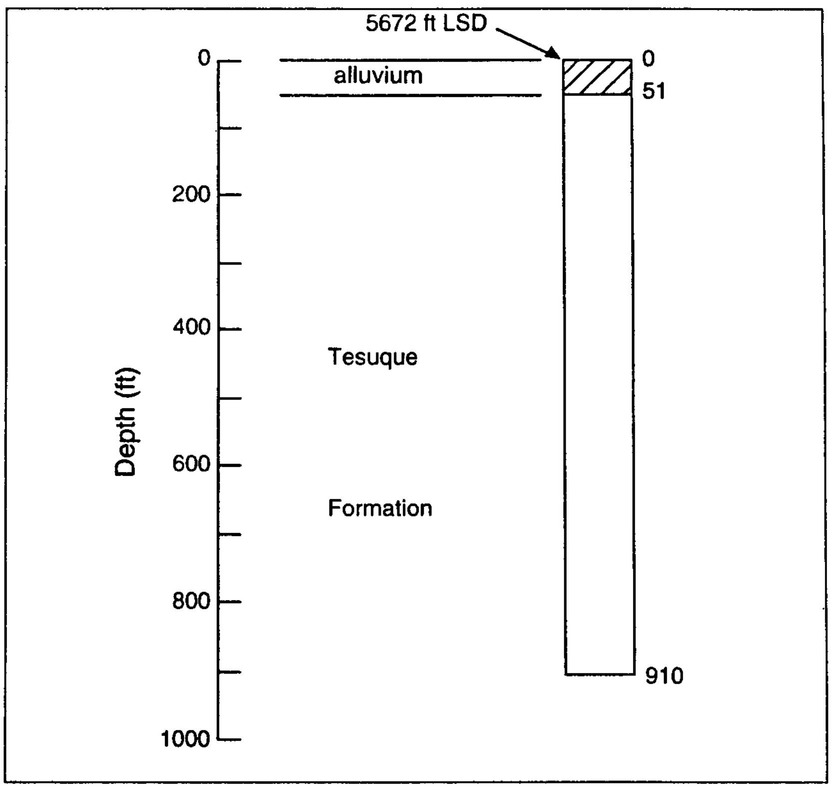


Fig. XXI-D. Geologic log of supply well LA-2, completed December 1946, flowing (Black and Veatch 1948; Cushman 1965).



F'g. XXI-E. Geologic log of supply well LA-3, completed May 1947, flowing (Black and Veatch 1948; Cushman 1965).

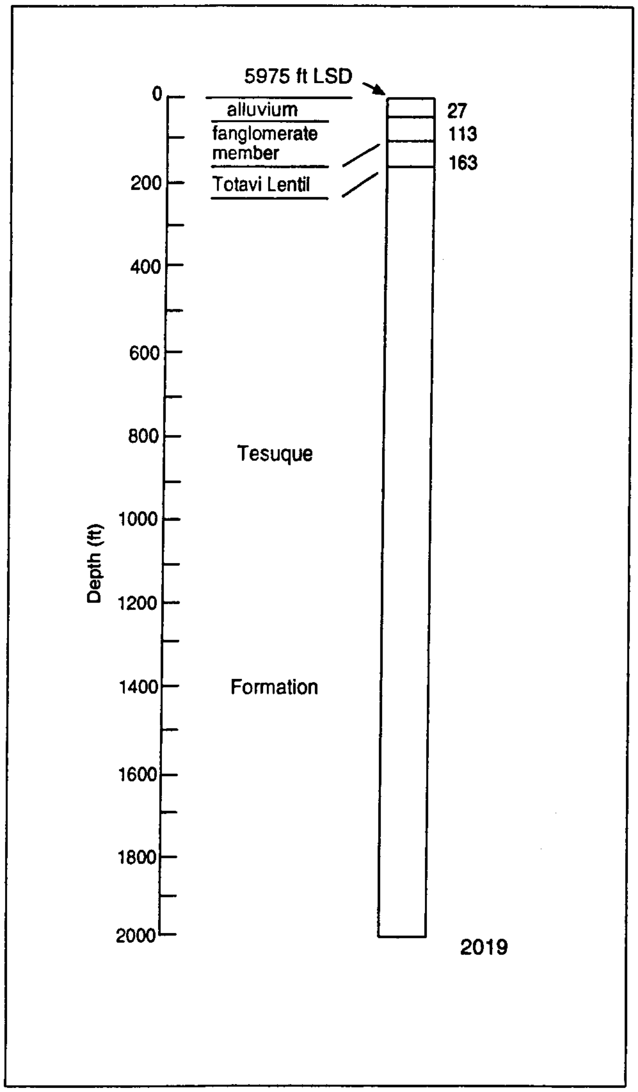


Fig. XXI-F. Geologic log of supply well LA-4, completed July 1948, water level 189 ft (Black and Veatch 1951; Cushman 1965).

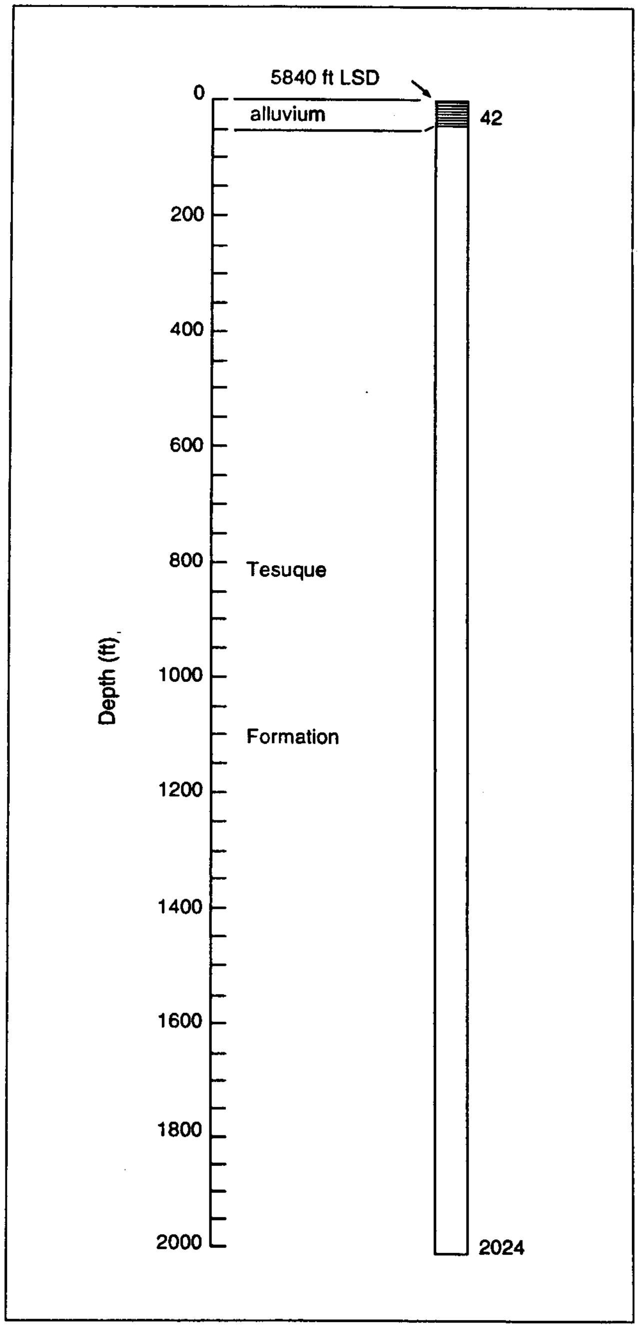


Fig. XXI-G. Geologic log of supply well LA-5, completed September 1948, water level 71 ft (Black and Veatch 1951; Cushman 1965).

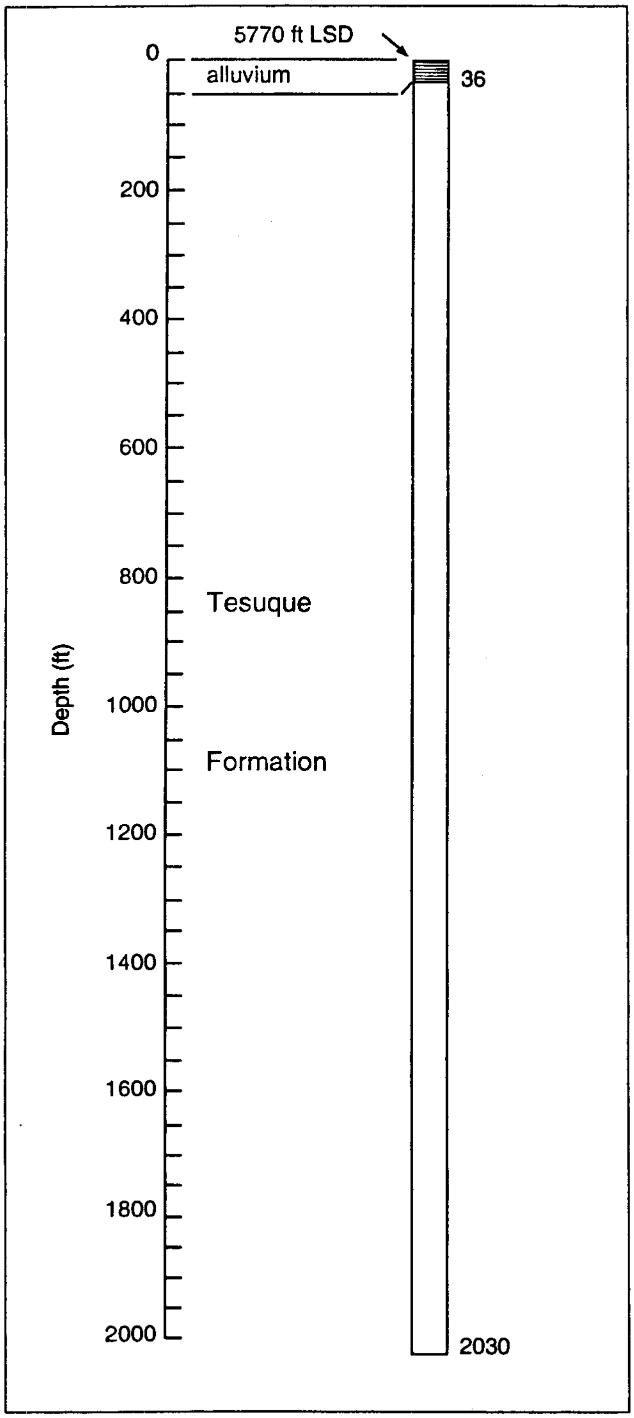


Fig. XXI-H. Geologic log of supply well LA-6, completed December 1948, water level 2 ft (Black and Veatch 1951; Cushman 1965).

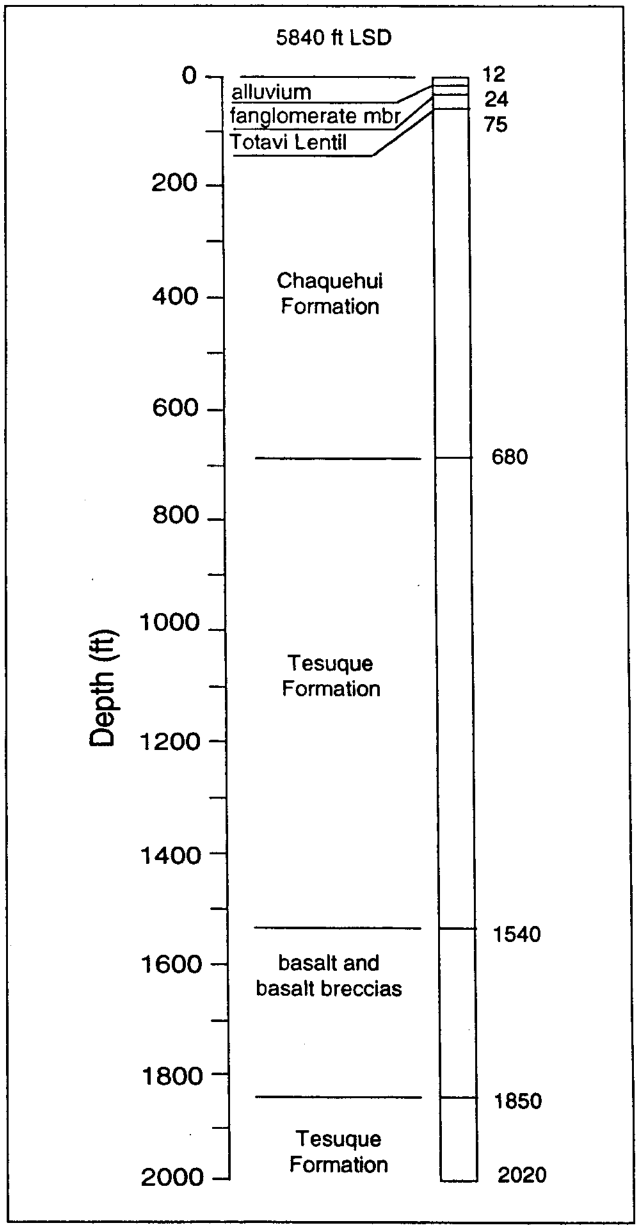


Fig. XXI-I. Geologic log of supply well G-1, completed July 1950, water level 192 ft (Black and Veatch 1951; Griggs 1955; and Cushman 1965: modified by Purtymun for this report).

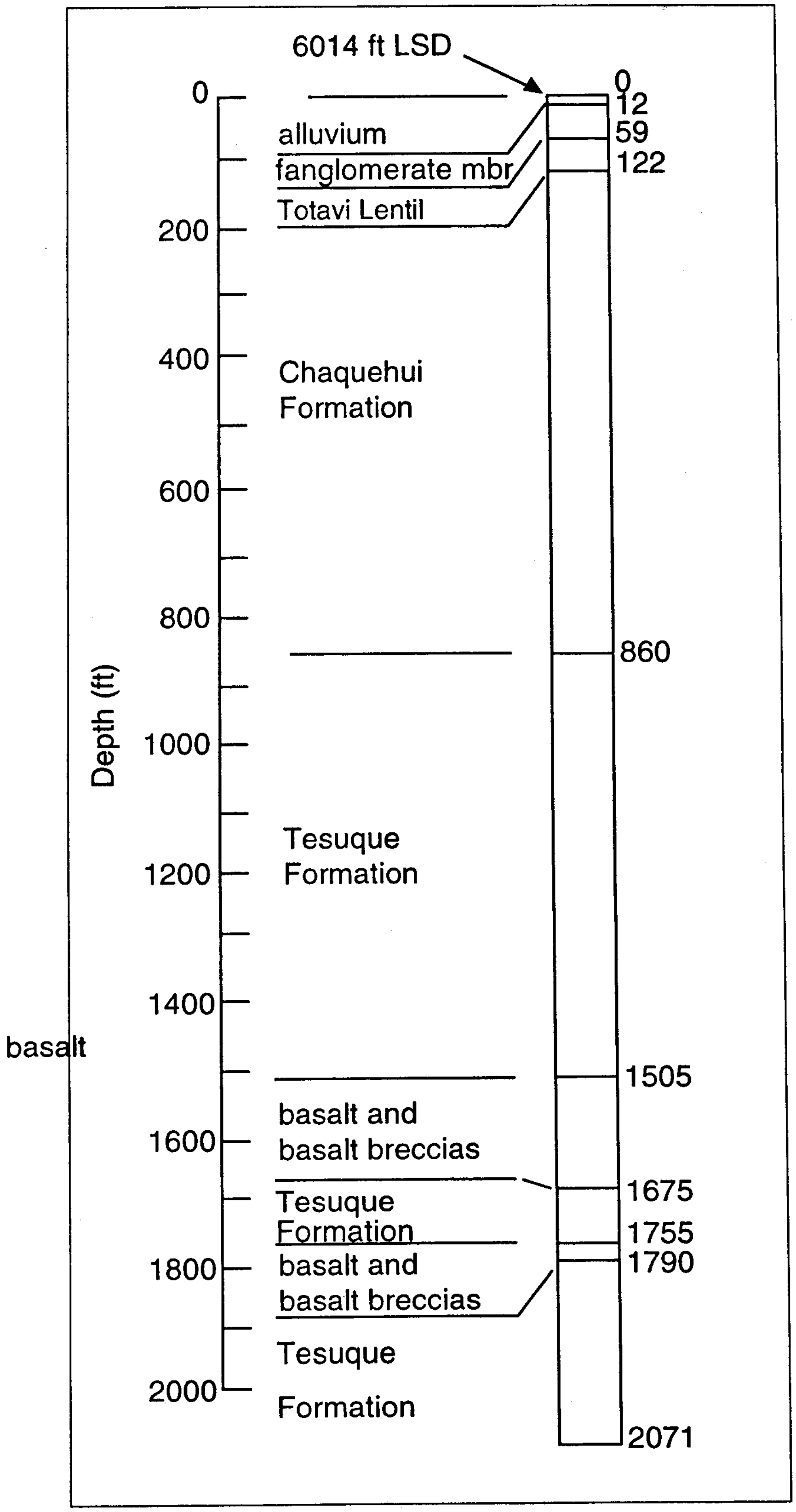


Fig. XXI-J. Geologic log of supply well G-1A, completed October 1954, water level 250 ft (Cushman 1965, modified by Purtymun for this report).

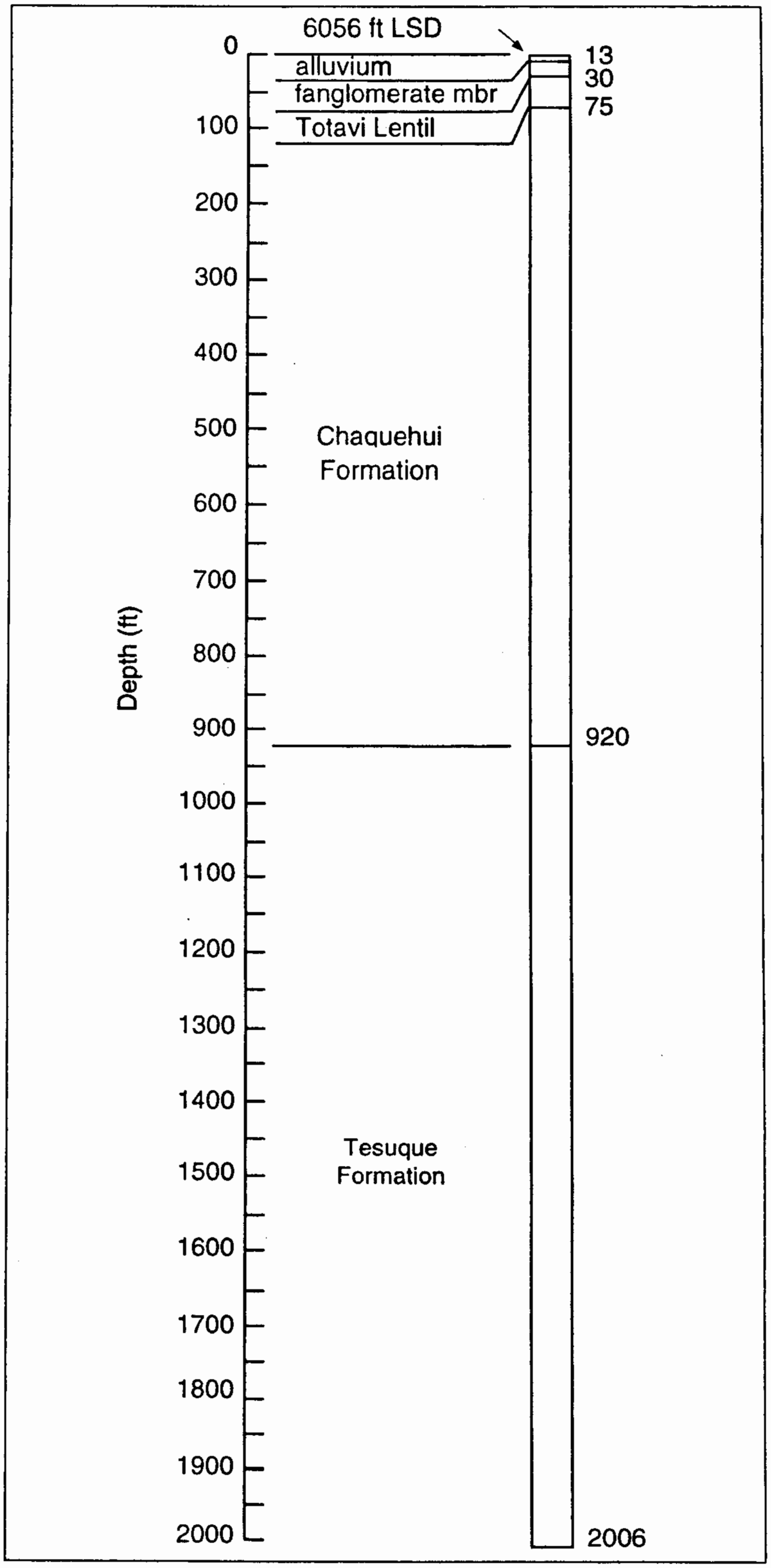


Fig. XXI-K. Geologic log of supply well G-2, completed August 1951, water level 259 ft (Black and Veatch 1951; Griggs 1955; Cushman 1965; modified by Purtymun for this report).

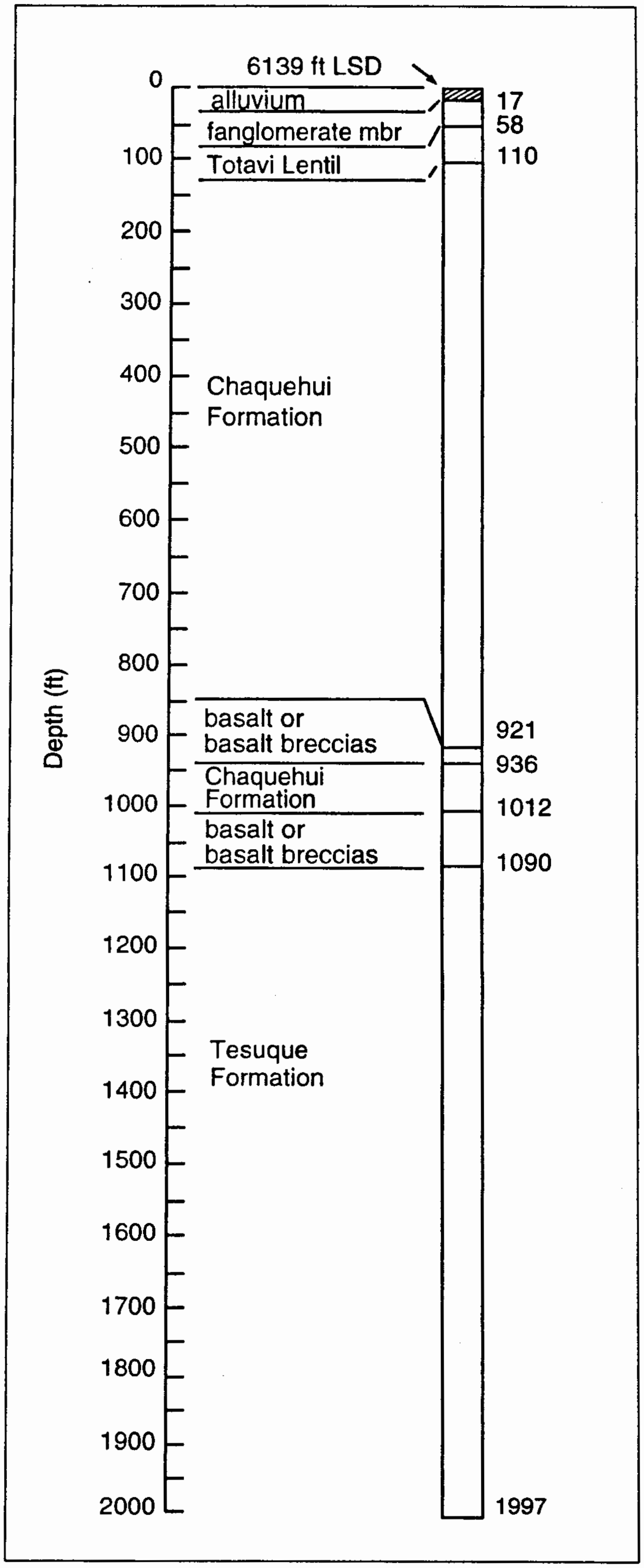


Fig. XXI-L. Geologic log of supply well G-3, completed July 1951, water level 280 ft (Black and Veatch 1951; Griggs 1955; Cushman 1965: modified by Purtymun for this report).

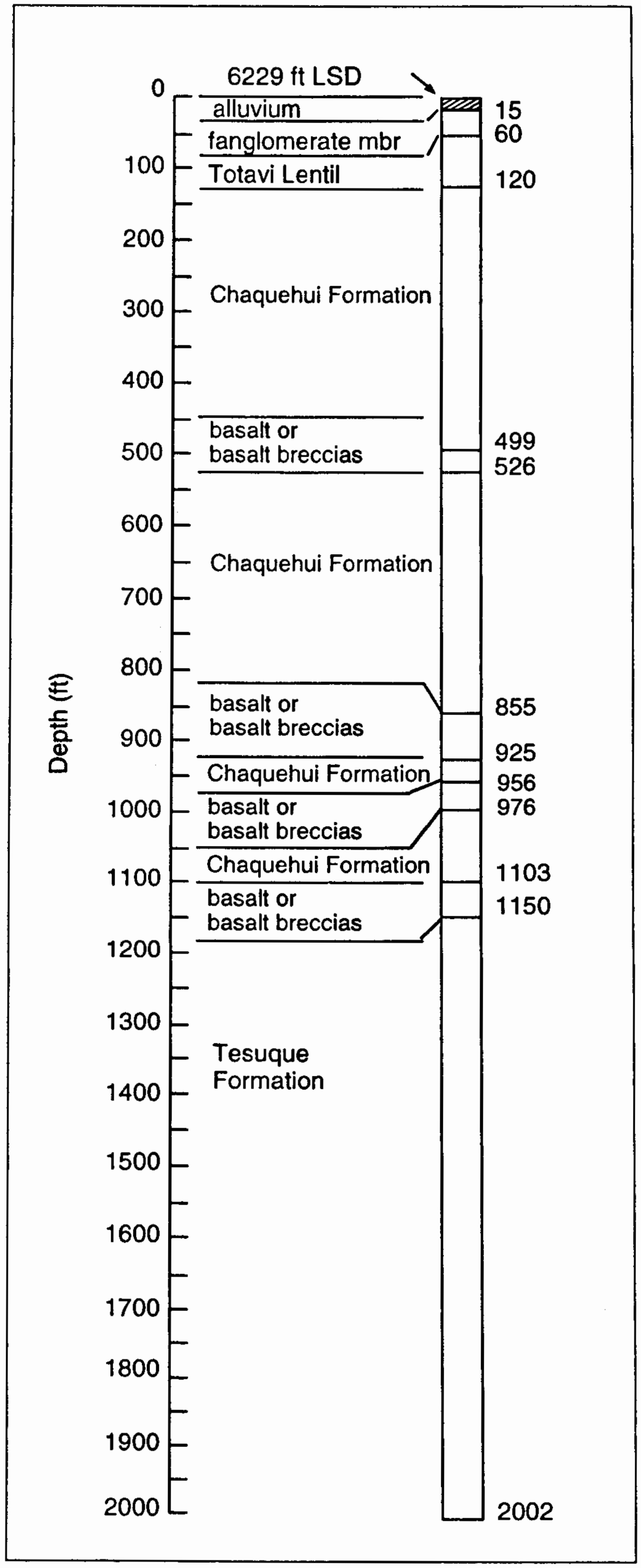


Fig. XXI-M. Geologic log of supply well G-4, completed May 1951, water level 347 ft (Black and Veatch 1951; Griggs 1955; Cushman 1965: modified by Purtymun for this report).

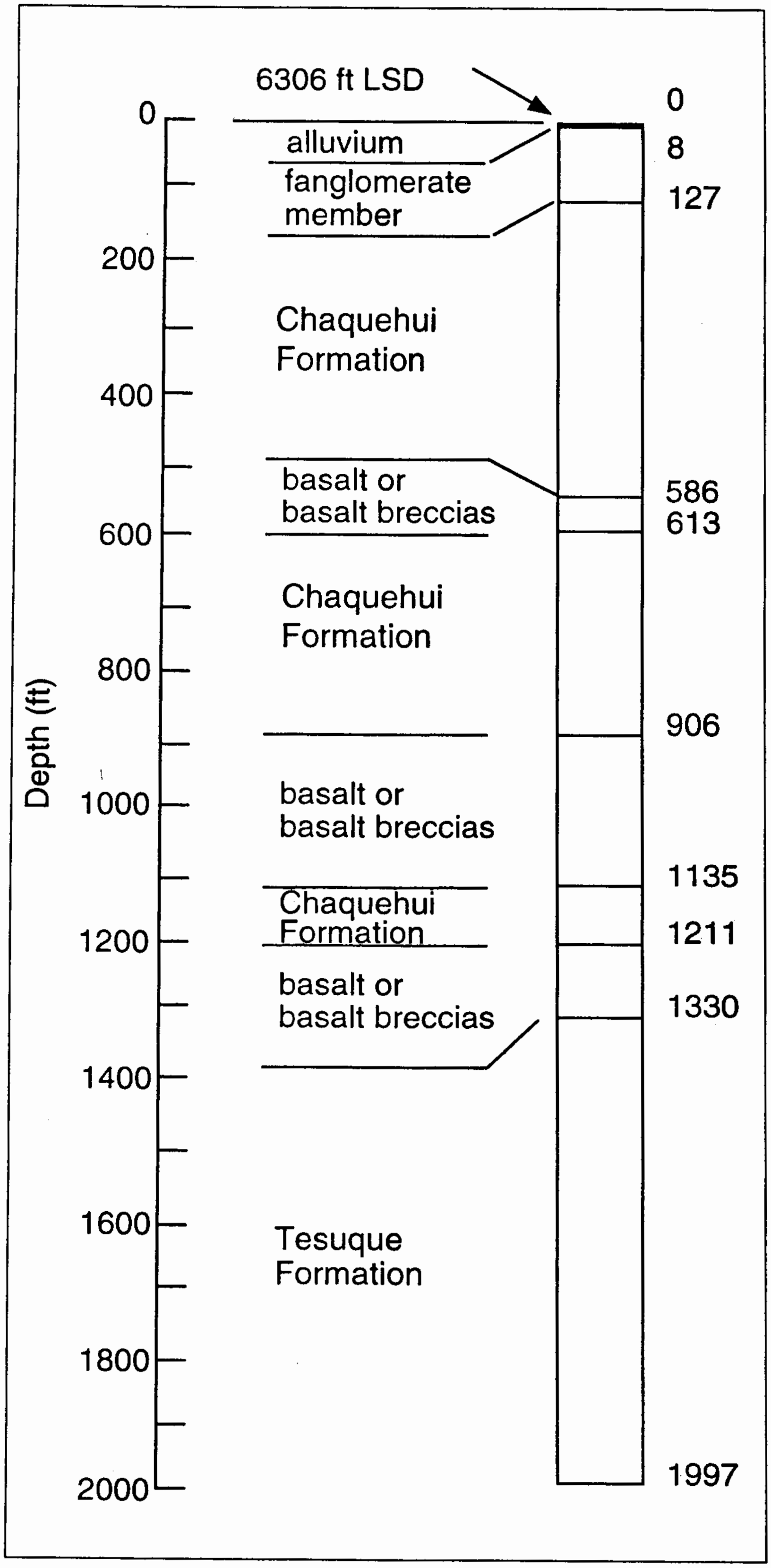


Fig. XXI-N. Geologic log of supply well G-5, completed May 1951, water level 411 ft (Black and Veatch 1951; Griggs 1955; Cushman 1965: modified by Purtymun for this report).

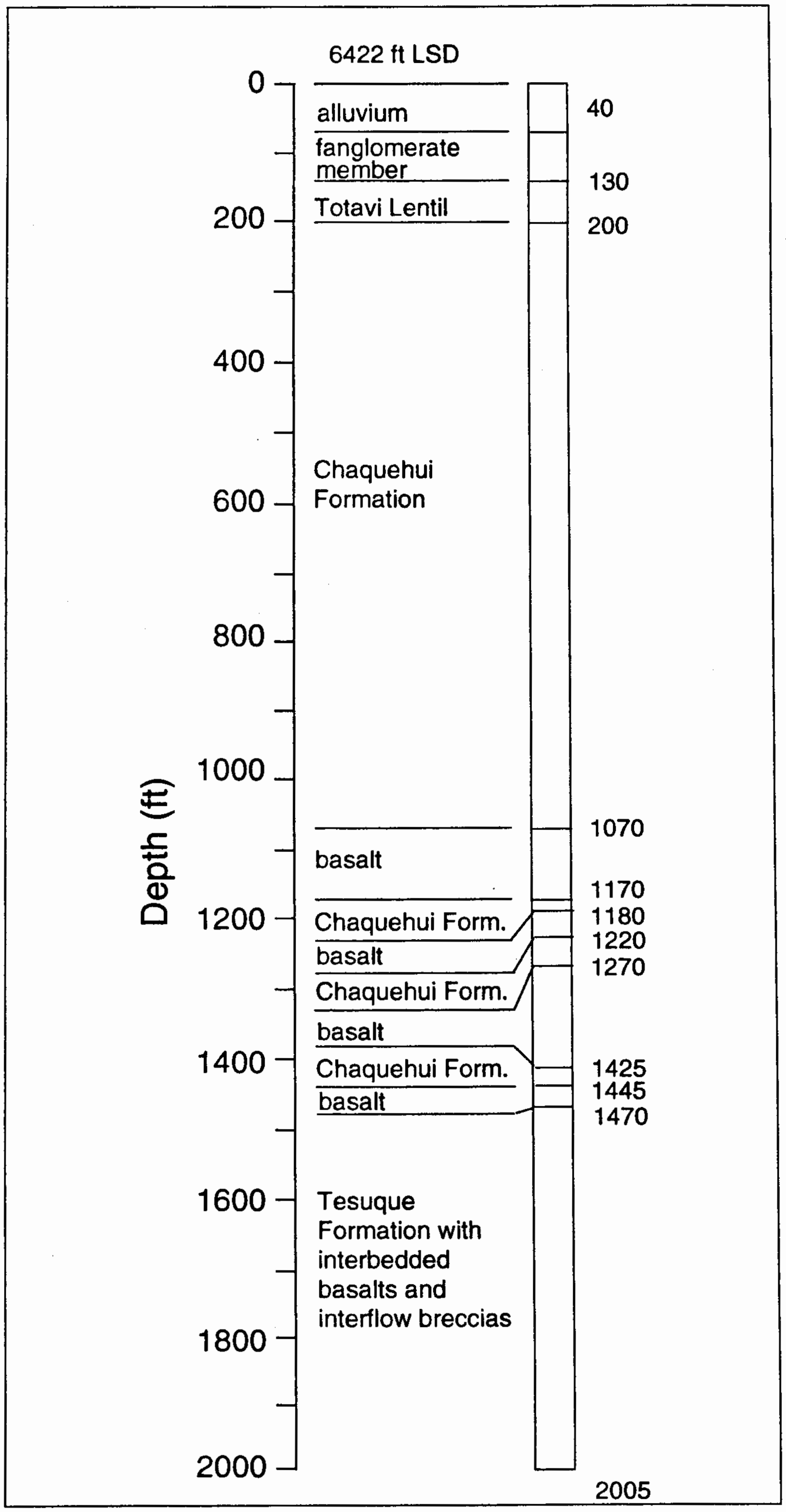


Fig. XXI-O. Geologic log of supply well G-6, completed March 1964, water level 572 ft (Cooper et al. 1965, modified by Purtymun for this report).

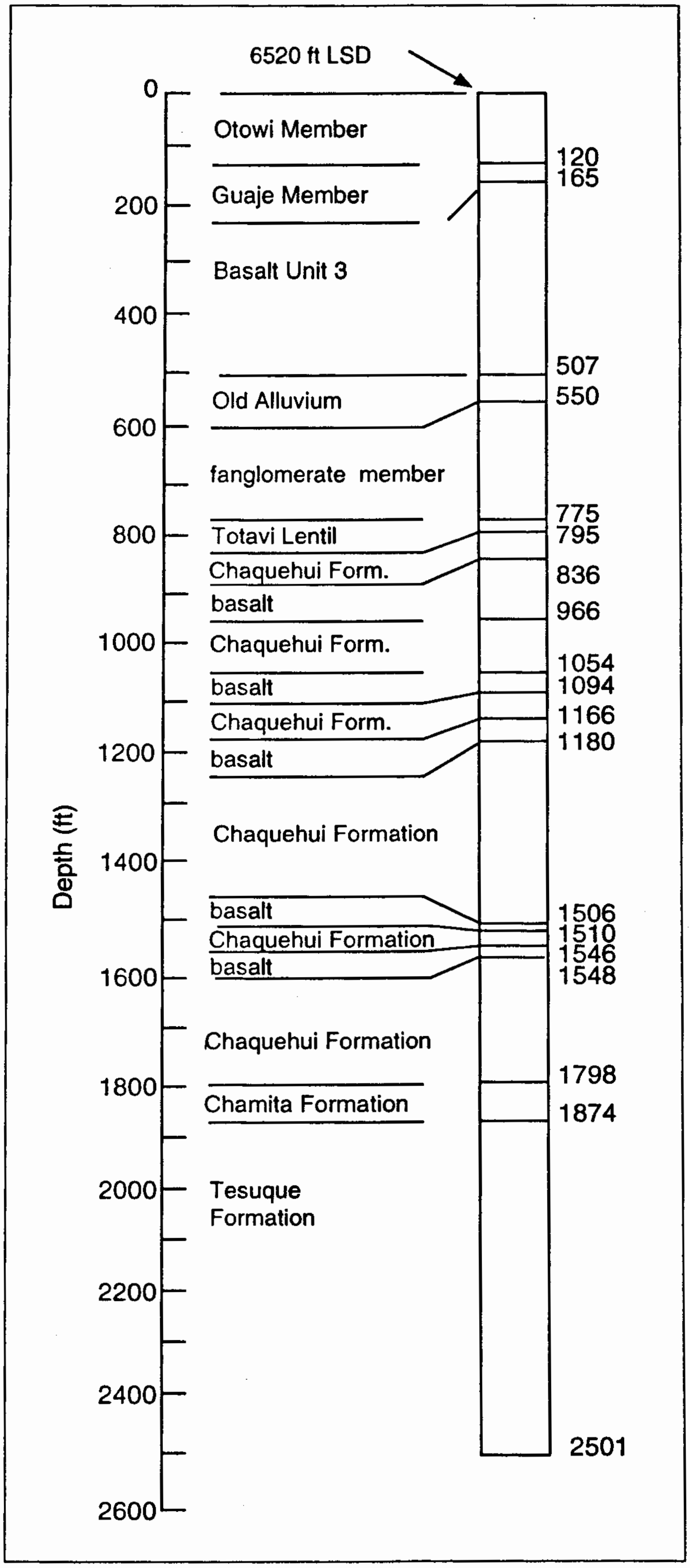


Fig. XXI-P. Geologic log of supply well PM-1, completed February 1965, water level 722 ft (Cooper et al. 1965, modified by Purtymun for this report).

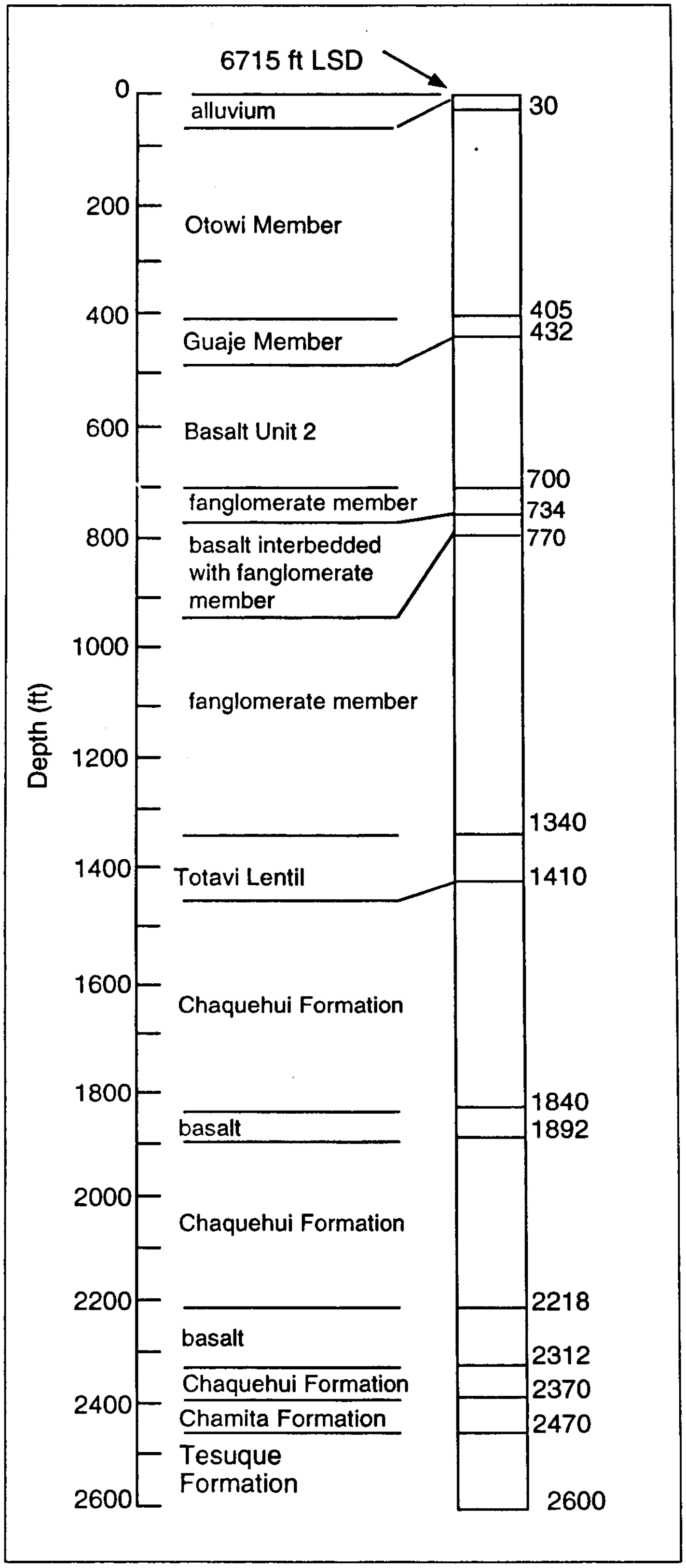


Fig. XXI-Q. Geologic log of supply well PM-2, completed July 1965, water level 823 ft (Cooper et al. 1965, modified by Purtymun for this report).

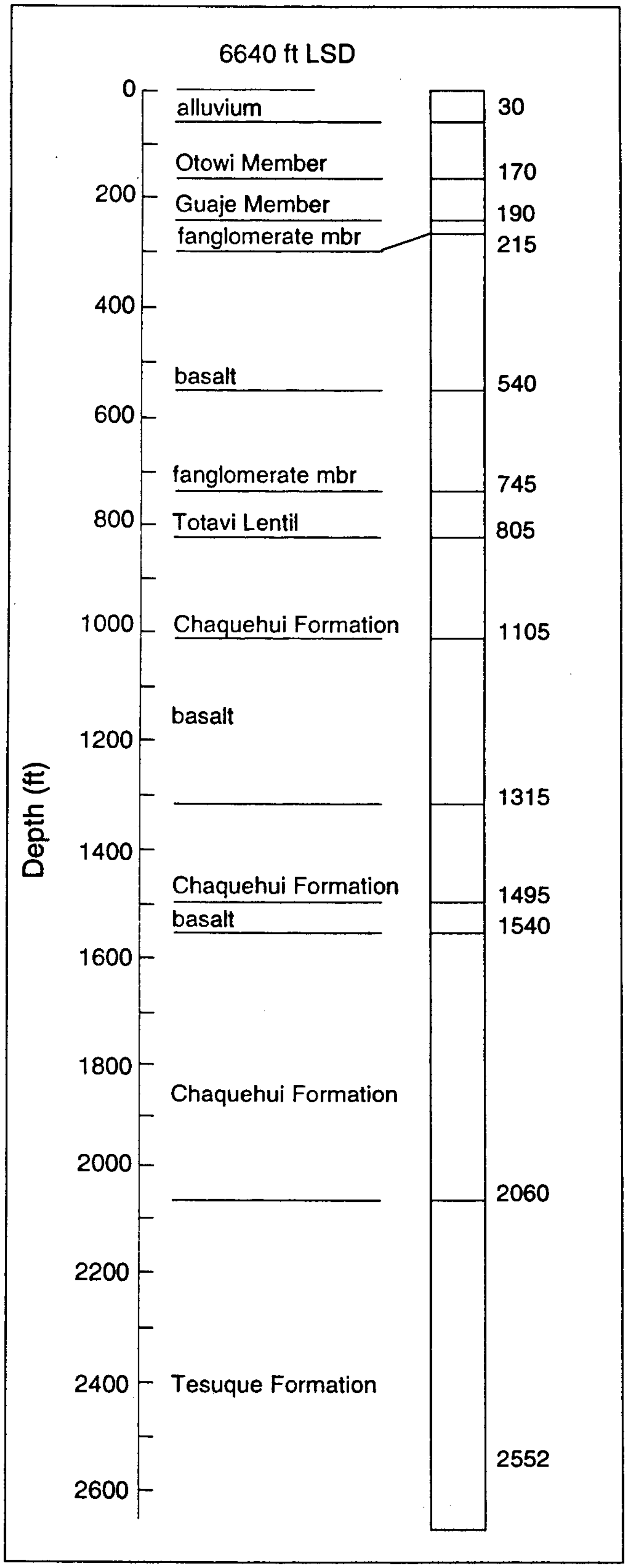


Fig. XXI-R. Geologic log of supply well PM-3, completed November 1966, water level 740 ft (Purtymun 1967, modified by Purtymun for this report).

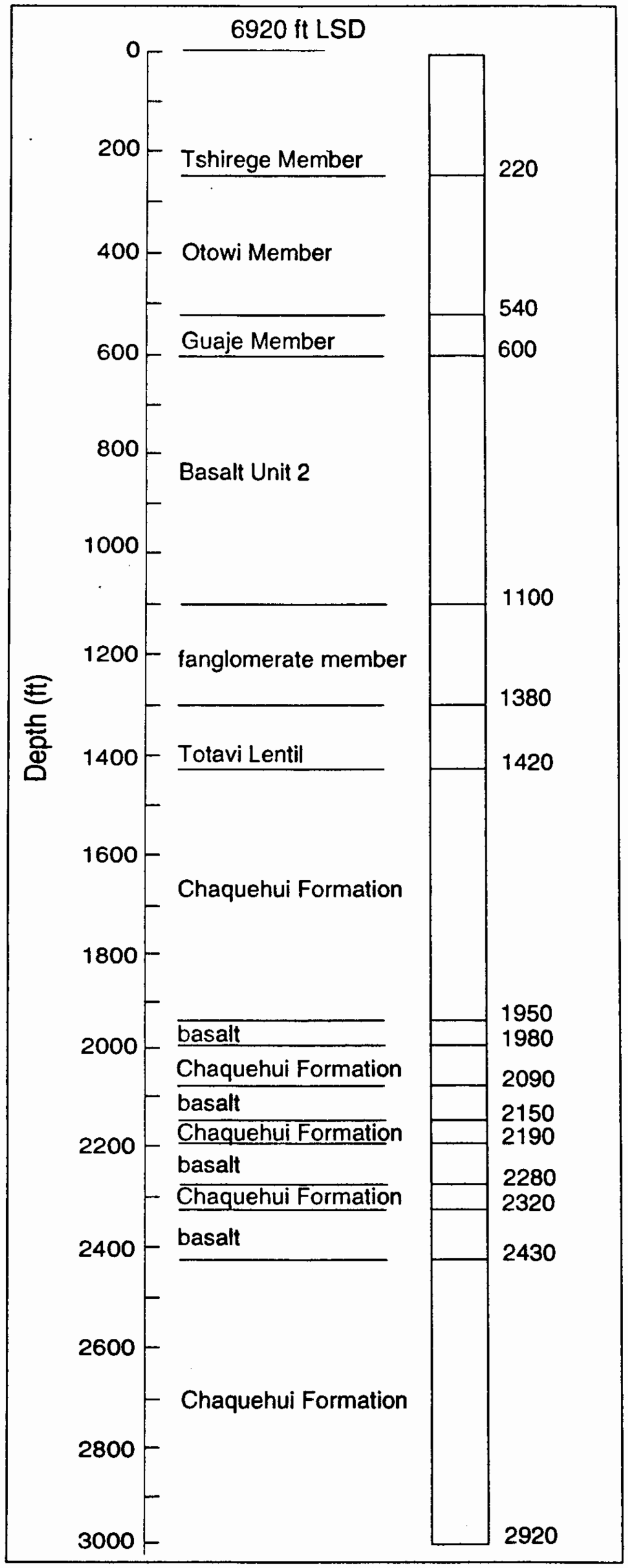


Fig. XXI-S. Geologic log of supply well PM-4, completed August 1981, water level 1060 ft (Purtymun et al. 1983, modified by Purtymun for this report).

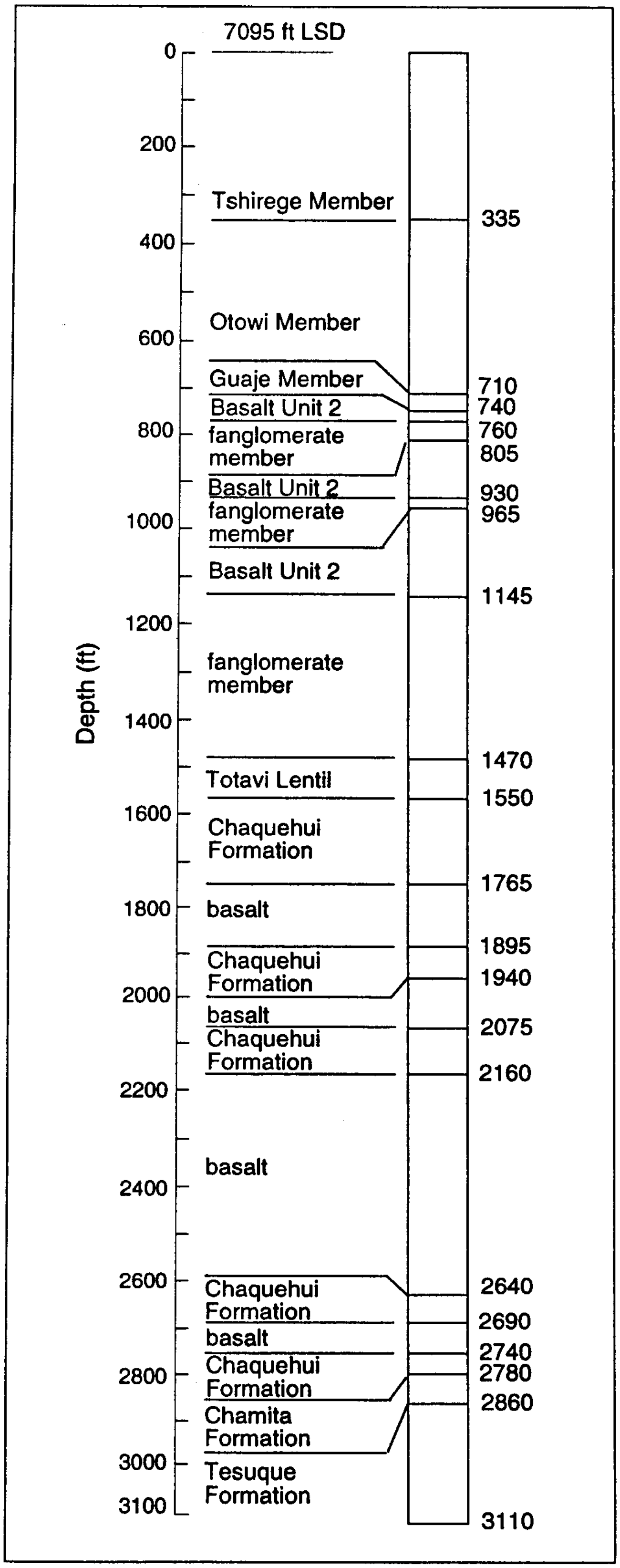


Fig. XXI-T. Geologic log of supply well PM-5, completed September 1982, water level 1208 ft (Purtymun et al. 1984, modified by Purtymun for this report).

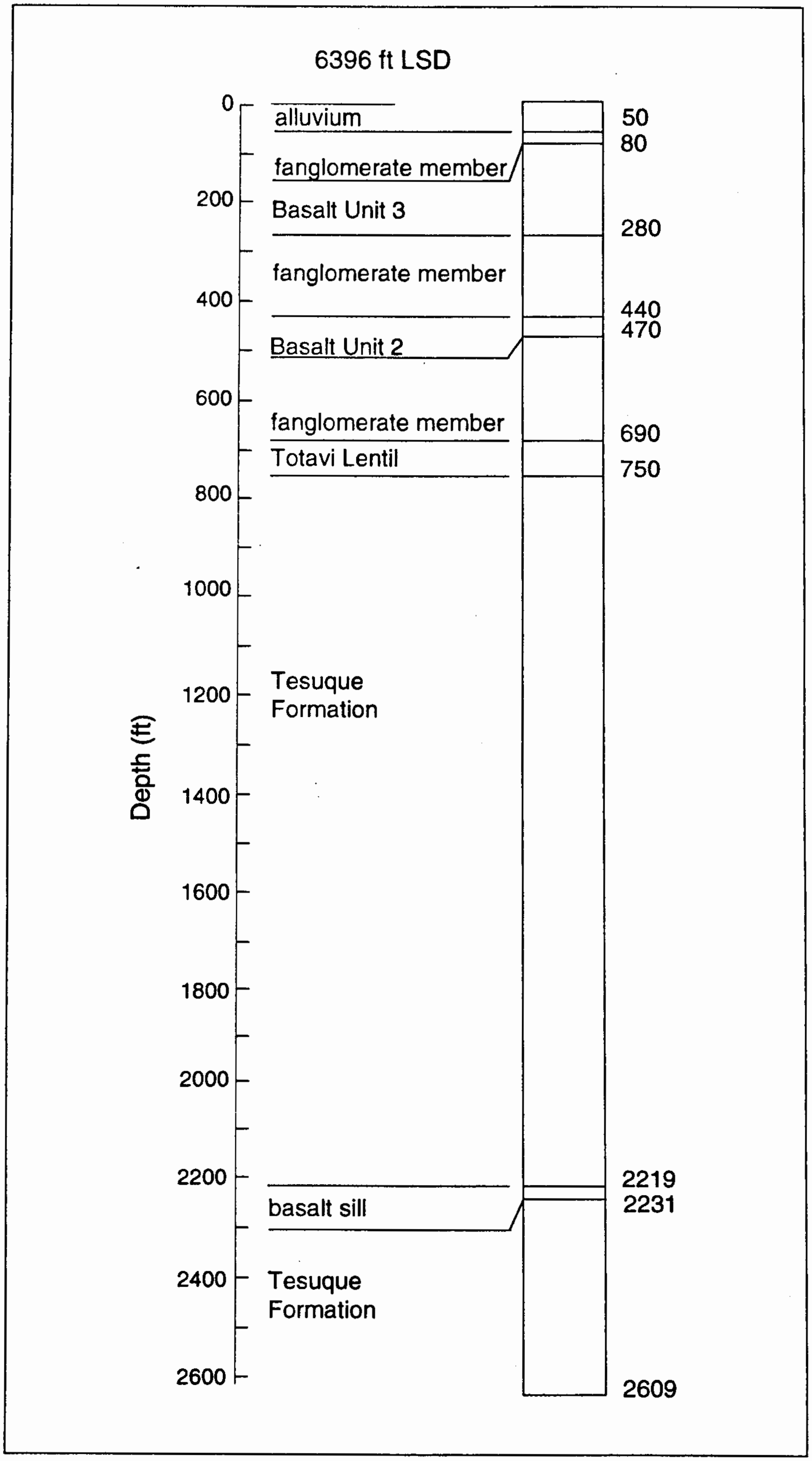


Fig. XXI-U. Geologic log of supply well O-1, completed July 1990, water level 673 ft (Purtymun et al. 1993).

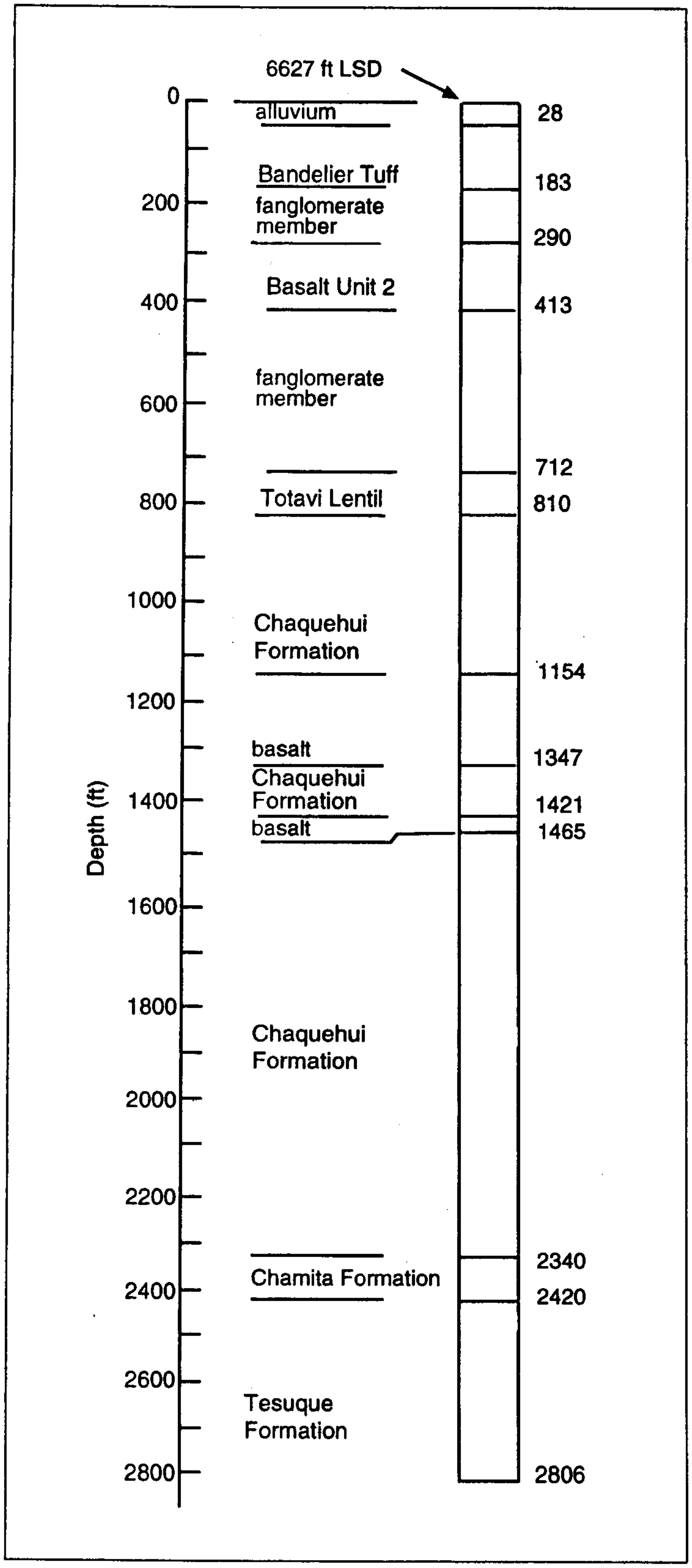


Fig. XXI-V. Geologic log of supply well O-4, completed April 1990, water level 780 ft (Stoker et al. 1992, modified by Purtymun for this report).

TABLE XXI-A. Construction Data and Hydrologic Characteristics of Supply Wells in the Los Alamos, Guaje, Pajarito, and Otowi Well Fields

	Construction					Hydrologic Characteristics				
	Year Completed	Depth Drilled (ft)	Depth Cased (ft)	Depth Open[a]	Year	Head of Pressure When Cased (+ft) or Water Level (ft) below LSD	Current Water Level (ft)	Yield (gpm)	Specific Capacity gpm/ft	Remarks
Los Alamos Well Field										
Well LA-1	1946	1001	870	598	1960	F (1946)	84 (1990)	366	0.8	unequipped (1990)
Well LA-1B	1960	2256	1750	1655	1983	+34 (1960)	70 (1990)	561	4.4	unequipped (1992)
Well LA-2	1946	882	870	878	1962	F (1946)	134 (1990)	280	1.4	
Well LA-3	1947	910	870	816	1983	F (1947)	122 (1990)	302	1.7	unequipped (1992)
Well LA-4	1948	2019	1964	1907	1988	189 (1948)	284 (1986)	552	5.9	unequipped (1990)
Well LA-5	1948	2024	1750	1954	1962	71 (1948)	168 (1986)	419	2.9	unequipped (1994)
Well LA-6	1948	2030	1710	1200	1976	2 (1948)	92 (1985)	580	10.2	unequipped (1990)
Guaje Well Field										
Well G-1	1950	2020	2000	1750	1962	192 (1951)	284 (1990)	241	1.4	
Well G-1A	1954	2071	1519	1500	1973	250 (1954)	322 (1990)	499	12.4	
Well G-2	1951	2006	1970	1707	1981	259 (1951)	321 (1990)	443	11.6	
Well G-3	1951	1997	1792	1238	1988	280 (1951)	375 (1986)	196	1.9	not on-line
Well G-4	1951	2002	1930	1177	1981	347 (1951)	381 (1990)	177	0.9	
Well G-5	1951	1997	1840	703	1986	411 (1951)	491 (1990)	390	10.0	
Well G-6	1964	2005	1530	1480	1979	572 (1964)	589 (1990)	272	3.3	
Pajarito Well Field										
Well PM-1	1965	2501	2499	2479	1973	722 (1965)	752 (1990)	561	31.6	
Well PM-2	1965	2600	2300	2286	1987	823 (1965)	860 (1990)	1319	17.6	
Well PM-3	1966	2552	2552	2552	1966	740 (1966)	767 (1990)	1382	64.7	
Well PM-4	1981	2920	2875	2875	1981	1060 (1981)	1083 (1990)	1293	34.3	
Well PM-5	1982	3120	3092	3092	1982	1208 (1982)	1234 (1990)	1250	11.7	
Otowi Well Field										
Well O-1	1990	2609	2497	2497	1990	673 (1990)	—	1000	8.1	data from aquifer test
Well O-4	1990	2806	2595	2595	1990	780 (1990)	—	1533	46.2	data from aquifer test

[a]Depth of well to where infiltrating sand has filled it in.

TABLE XXI-B. Geologic Logs and Casing Schedules for Supply Wells in the Los Alamos Well Field (7 Wells)

1. Well LA-1

Elevation (LSD): 5624 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	76	76
Santa Fe Group		
Chamita Formation	0	
Tesuque Formation	925	1001

Casing Schedule
870 ft of 12-in.-diam casing set from 0 to 870 ft; 805 ft of slots between 60 and 865 ft; gravel packed.

Geophysical Log
None.

2. Well LA-1B

Elevation (LSD): 5622 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	78	78
Santa Fe Group		
Chamita Formation	0	
Tesuque Formation	2178	2256

Casing Schedule
64 ft of 36-in.-diam corrugated metal pipe set from 0 to 64 ft; 104 ft of 26-in.-diam steel casing set from 0 to 104 ft; 650 ft of 12-in.-diam wrought iron casing set from 0 to 650 ft; 1100 ft of 10-in.-diam wrought iron casing welded to 12-in.-diam casing set from 650 ft to 1750 ft; 591 ft of perforations between 326 ft and 1694 ft; gravel packed.

Geophysical Log
Electrical log (Cushman 1965).

3. Well LA-2

Elevation (LSD): 5651 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	60	60
Santa Fe Group		
Chamita Formation	0	
Tesuque Formation	822	882

Casing Schedule
870 ft of 12-in.-diam casing set from 0 to 870 ft; 760 ft of slotted casing and screen between 105 and 865 ft; gravel packed.

Geophysical Logs
None.

4. Well LA-3
Elevation (LSD): 5672 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	51	51

4. Well LA-3 (Continued)

Santa Fe Group		
Chamita Formation	0	
Tesuque Formation	859	910

Casing Schedule

870 ft of 12-in.-diam casing set from 0 to 870 ft; 760 ft of slotted casing and screen between 105 and 865 ft; gravel packed.

Geophysical Logs

None.

5. Well LA-4

Elevation (LSD): 5975 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	27	27
Puye Conglomerate		
Fanglomerate member	86	113
Totavi Lentil	50	163
Santa Fe Group		
Chamita Formation	0	
Tesuque Formation	1856	2019

Casing Schedule

754 ft of 12-in.-diam casing set 0 to 754 ft; with 1211 ft of 10-in.-diam casing from 754 to 1965 ft; 350 ft of slotted casing between 754 ft and 1964 ft; gravel packed.

Geophysical Log

Electrical (Cushman 1965).

6. Well LA-5

Elevation (LSD): 5840 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	42	42
Santa Fe Group		
Chamita Formation	0	
Tesuque Formation	1982	2024

Casing Schedule

630 ft of 12-in.-diam casing set from 0 to 630 ft; 1120 ft of 10-in.-diam casing from 630 to 1750 ft; 350 ft of slotted casing between 440 ft and 1740 ft; gravel packed.

Geophysical Log

Electrical (Cushman 1965).

TABLE XXI-B. Geologic Logs and Casing Schedules for Supply Wells in the Los Alamos Well Field (7 Wells) (Continued)

7. Well LA-6

Elevation (LSD): 5770 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	36	36
Santa Fe Group		
Chamita Formation	0	
Tesuque Formation	1994	2030

Casing Schedule

597 ft of 12-in.-diam casing set from 0 to 597 ft; 1193 ft of 10-in.-diam casing from 597 to 1790 ft; 400 ft of slotted casing between 420 ft and 1778 ft; gravel packed.

Geophysical Log

Electrical (Cushman 1965); conductivity, temperature, gamma-ray/neutron (Purtymun 1977).

TABLE XXI-C. Geologic Logs and Casing Schedules for Supply Wells in the Guaje Well Field (7 Wells)

1. Well G-1

Elevation (LSD): 5973 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	12	12
Puye Conglomerate		
Fanglomerate member	13	25
Totavi Lentil	50	75
Santa Fe Group		
Chaquehui Formation	605	680
Chamita Formation	0	
Tesuque Formation		
Basalts or basalt breccias logged from 1540 to 1838 ft	1340	2020

Casing Schedule
490 ft of 12-in.-diam casing set 0 to 490 ft; 1510 ft of 10-in.-diam casing from 490 to 2000 ft; 490 ft of slotted casing between 282 and 1980 ft; gravel packed.

Geophysical Log
Electrical (Cushman 1965).

2. Well G-1A

Elevation (LSD): 6014 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	12	12
Puye Conglomerate		
Fanglomerate member	47	59
Totavi Lentil	63	122
Santa Fe Group		
Chaquehui Formation	738	860
Chamita Formation	0	
Tesuque Formation		
Basalt or basalt breccias logged from 1505 to 1675 ft; 1755 to 1790 ft	1211	2071

Casing Schedule
663 ft of 12-in.-diam casing set from 0 to 663 ft; 856 ft of 10-in.-diam casing from 663 to 1519 ft; 563 ft of slotted casing between 272 and 1513 ft; gravel packed.

Geophysical Log
Electrical (Cushman 1965).

3. Well G-2

Elevation (LSD): 6056 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	13	13
Puye Conglomerate		
Fanglomerate member	17	30
Totavi Lentil	45	75

TABLE XXI-C. Geologic Logs and Casing Schedules for Supply Wells in the Guaje Well Field (7 Wells) (Continued)

3. Well G-2 (Continued)

Santa Fe Group		
Chaquehui Formation	845	920
Chamita Formation	0	
Tesuque Formation	1086	2006
(no basalts logged)		

Casing Schedule
600 ft of 12-in.-diam casing set from 0 to 600 ft; 1370 ft of 10-in.-diam casing from 600 to 1970 ft; 425 ft of slotted casing from 281 to 1960 ft; gravel packed.

Geophysical Log
Electrical (Cushman 1965).

4. Well G-3

Elevation (LSD): 6139 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	17	17
Puye Conglomerate		
Fanglomerate member	41	58
Totavi Lentil	52	110
Santa Fe Group		
Chaquehui Formation		
Basalt or basalt breccias logged from 921 to 936 ft; 1012 to 1090 ft	980	1090
Chamita Formation	0	
Tesuque Formation	906	1997

Casing Schedule
12-in.-diam casing set from 0 to 695 ft; 1097 ft of 10 in.-diam casing from 695 to 1792 ft; 400 ft of slotted casing between 441 and 1785 ft; gravel packed.

Geophysical Log
Electrical (Cushman 1965).

5. Well G-4

Elevation (LSD): 6229 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	15	15
Puye Conglomerate		
Fanglomerate member	45	60
Totavi Lentil	60	120
Santa Fe Group		
Chaquehui Formation		
Basalt or basalt breccias from 499 to 526 ft; 855 to 925 ft; 956 to 976 ft; 1103 to 1150 ft	1030	1150
Chamita Formation	0	
Tesuque Formation	852	2002

TABLE XXI-C. Geologic Logs and Casing Schedules for Supply Wells in the Guaje Well Field (7 Wells) (Continued)

5. Well G-4 (Continued)

Casing Schedule
720 ft of 12-in.-diam casing set 0 to 720 ft; 1210 ft of 10-in.-diam casing from 720 to 1930 ft; 360 ft of slotted casing between 426 and 1925 ft; well damage repaired 1977, slotted liner set in well from 1214 to 1750 ft; gravel packed.

Geophysical Log
Electrical (Cushman 1965).

6. Well G-5

Elevation (LSD): 6306 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	8	8
Puye Conglomerate		
Fanglomerate member	119	127
Totavi Lentil		
Santa Fe Group		
Chaquehui Formation		
Basalt or basalt breccias from 586 to 613 ft; 906 to 1135 ft; 1211 ft to 1330 ft	1203	1330
Chamita Formation	0	
Tesuque Formation	667	1997

Casing Schedule
739 ft of 12-in.-diam casing set from 0 to 739 ft; 1101 ft of 10-in.-diam casing from 739 to 1840 ft; 400 ft of slotted casing between 462 and 1830 ft.

Geophysical Log
Electrical (Cushman 1965).

7. Well G-6

Elevation (LSD): 6422 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	40	40
Puye Conglomerate		
Fanglomerate member	90	130
Totavi Lentil	70	200
Santa Fe Group		
Chaquehui Formation		
Basalt from 1070 to 1170 ft; 1180 to 1220 ft; 1270 to 1425 ft; 1445 ft to 1470 ft	1270	1470
Chamita Formation	0	
Tesuque Formation		
Basalt 1605 to 1665 ft; basalt or basalt breccias 1720 to 1730 ft; 1815 to 1825 ft; 1905 to 1915 ft; 1955 to 1970 ft	535	2005

TABLE XXI-C. Geologic Logs and Casing Schedules for Supply Wells in the Guaje Well Field (7 Wells) (Continued)

7. Well G-6 (Continued)

Casing Schedule

206 ft of 24-in.-diam casing cemented in 0 to 206 ft; 1530 ft of 12-in.-diam casing: blank from 0 to 700 ft with louvers from 700 to 1510 ft, blank from 1510 to 1530 ft.

Geophysical Log

Temperature, gamma-ray/neutron, induction-electric, and microlog with caliper (Cooper et al. 1965).

TABLE XXI-D. Geologic Logs and Casing Schedules for Supply Wells in the Pajarito Well Field (5 Wells)

1. Well PM-1

Elevation (LSD): 6520 ft

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Otowi Member	120	120
Guaje Member	45	165
Basaltic Rocks of Chino Mesa		
Unit 3	342	507
Old Alluvium	43	550
Puye Conglomerate		
Fanglomerate member	225	775
Totavi Lentil	20	795
Santa Fe Group		
Chaquehui Formation		
Basalt from 836 to 966 ft; 1054 to 1094 ft; 1166 to 1180 ft; 1506 to 1510 ft; 1546 to 1548 ft	1003	1798
Chamita Formation	76	1874
Tesuque Formation	627	2501

Casing Schedule

474 ft of 24-in.-diam casing cemented in hole from 0 to 474 ft; 2499 ft of 12-in.-diam casing: blank from 0 to 945 ft; with louvers from 945 to 2479 ft; blank from 2479 to 2499 ft; gravel packed.

Geophysical Logs

Temperature, gamma-ray/neutron, induction-electric, microlog with caliper (Cooper et al. 1965.)

2. Well PM-2

Elevation (LSD): 6715 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	30	30
Bandelier Tuff		
Otowi Member	375	405
Guaje Member	27	432
Basaltic Rocks of Chino Mesa		
Unit 2	268	700
Puye Conglomerate		
Fanglomerate member		
Basalt Unit 2 from 734 to 738 ft; 758 to 770 ft	640	1340
Totavi Lentil	70	1410
Santa Fe Group		
Chaquehui Formation		
Basalt from 1840 to 1892 ft; 2218 to 2312 ft	960	2370
Chamita Formation	40	2410
Tesuque Formation	190	2600

TABLE XXI-D. Geologic Logs and Casing Schedules for Supply Wells in the Pajarito Well Field (5 Wells) (Continued)

2. Well PM-2 (Continued)

Casing Schedule
504 ft of 26-in.-diam casing cemented in 0 to 504 ft; 2300 ft of 14-in.-diam casing: blank from 0 to 1004 ft, louvers from 1004 to 2280 ft, blank from 2280 to 2300 ft.

Geophysical Logs
Temperature, gamma-ray/neutron, induction-electrical, and microlog with caliper (Cooper et al.1965.)

3. Well PM-3

Elevation (LSD): 6640 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	30	30
Bandelier Tuff		
Otowi Member	140	170
Guaje Member	20	190
Puye Conglomerate		
Fanglomerate member	25	215
Basaltic Rocks of Chino Mesa		
Unit 2	325	540
Puye Conglomerate		
Fanglomerate member	205	745
Totavi Lentil	60	805
Santa Fe Group		
Chaquehui Formation		
Basalt from 1105 to 1315 ft; 1495 to 1540 ft	1255	2060
Chamita Formation	0	
Tesuque Formation	492	2552

Casing Schedule
552 ft of 26-in.-diam casing cemented in 0 to 552 ft; 2552 ft of 14-in.-diam casing: blank from 0 to 956 ft, louvers from 956 ft to 2532 ft, blank from 2532 to 2552 ft; gravel packed.

Geophysical Logs
Temperature, gamma-ray/neutron, induction-electrical, and microlog with caliper (Purtymun 1967).

4. Well PM-4

Elevation (LSD): 6920 ft

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member	220	220
Otowi Member	320	540
Guaje Member	60	600
Basaltic Rocks of Chino Mesa		
Unit 2	500	1100

TABLE XXI-D. Geologic Logs and Casing Schedules for Supply Wells in the Pajarito Well Field (5 Wells) (Continued)

4. Well PM-4 (Continued)

Puye Conglomerate		
Fanglomerate member	280	1380
Totavi Lentil	40	1420
Santa Fe Group		
Chaquehui Formation		
Basalt 1950 to 1980 ft; 2090 to 2150 ft; 2190 to 2280; 2320 to 2430 ft	1500	2920

Casing Schedule

41 ft of 42-in.-diam casing cemented in from 0 to 41 ft; 923 ft of 28-in.-diam casing cemented in 0 to 923 ft; 2874 ft of 16-in.-diam casing: blank from 0 to 1260 ft; louvers from 1260 to 2854 ft; blank 2854 to 2874 ft; gravel packed.

Geophysical Logs

Dual-induction, microlaterolog-microlog, compensated neutron-formation density, and temperature (files available from ESH-18 Geohydrology section).

5. Well PM-5

Elevation (LSD): 7095 ft

Geologic Log	Thickness (ft)	Depth (ft)
Bandelier Tuff		
Tshirege Member	335	335
Otowi Member	375	710
Guaje Member	30	740
Basaltic Rocks of Chino Mesa		
Unit 2	20	760
Puye Conglomerate		
Fanglomerate member	45	805
Basaltic Rocks of Chino Mesa		
Unit 2	125	930
Puye Conglomerate		
Fanglomerate member	35	965
Basaltic Rocks of Chino Mesa		
Unit 2	180	1145
Puye Conglomerate		
Fanglomerate member	325	1470
Totavi Lentil	80	1550
Santa Fe Group		
Chaquehui Formation		
Basalt from 1765 to 1895 ft; 1940 to 2075 ft; 2160 to 2640 ft; 2690 to 2740 ft	1230	2780
Chamita Formation	80	2860
Tesuque Formation	250	3110

Casing Schedule

40 ft of 42-in.-diam casing cemented in 0 to 40 ft; 1178 ft of 28-in.-diam blank casing cemented in 0 to 1178 ft; 3092 ft of 16-in.-diam casing: blank 0 to 1440 ft, louvers from 1440 to 3072 ft, blank 3072 to 3092 ft.

Geophysical Log

Dual-induction, microlaterolog-microlog, compensated neutron-formation density, and temperature (files available from ESH-18 Geohydrology section).

TABLE XXI-E. Geologic Logs and Casing Schedules for Supply Wells in the Otowi Well Field (2 Wells)

1. Well O-1

Elevation (LSD): 6396 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	50	50
Puye Conglomerate		
Fanglomerate member	30	80
Basaltic Rocks of Chino Mesa		
Unit 3	200	280
Puye Conglomerate		
Fanglomerate member	160	440
Basaltic Rocks of Chino Mesa		
Unit 2	30	470
Puye Conglomerate		
Fanglomerate member	220	690
Totavi Lentil	60	750
Santa Fe Group		
Chaquehui Formation	0	
Chamita Formation	0	
Tesuque Formation		
Basalt sill from 2219 to 2231 ft	1859	2609

Casing Schedule
60 ft of 38-in.-diam blank casing cemented in 0 to 60 ft; 662 ft of 28-in.-diam blank casing cemented in 0 to 662 ft; 2498 ft of 16-in.-diam casing: blank 0 to 1017 ft; louvers 1017 to 2477 ft; 20 ft blank casing 2477 to 2497 ft.

Geophysical Logs
Temperature, microlog, compensated neutron-formation density, and dual induction–SFL (files available from ESH-18 Geohydrology section).

2. Well O-4

Elevation (LSD): 6627 ft

Geologic Log	Thickness (ft)	Depth (ft)
Alluvium	28	28
Bandelier Tuff	155	183
Puye Conglomerate		
Fanglomerate member	107	290
Basaltic Rocks of Chino Mesa		
Unit 2	123	413
Puye Conglomerate		
Fanglomerate member	299	712
Totavi Lentil	98	810
Santa Fe Group		
Chaquehui Formation		
Basalt from 1154 to 1347 ft ; 1421 to 1465 ft	1530	2340
Chamita Formation	80	2420
Tesuque Formation	386	2806

Casing Schedule
60 ft of 38-in.-diam blank casing cemented in 0 to 60 ft; 723 ft of 28-in.-diam blank casing cemented in 0 to 723 ft; 2617 ft of 16-in.-diam casing: blank 0 to 1115 ft, louvers 1115 to 2596 ft blank 2596 to 2617 ft.

Geophysical Logs
Temperature, microlog, compensated neutron-formation density, and dual induction–SFL (files available from ESH-18 Geohydrology section).

TABLE XXI-F. Locations and Elevations (NAD 1927)

A. Los Alamos Well Field

Well LA-1	N 1,776,865	E 527,838	5624 ft
Well LA-1B	N 1,776,890	E 528,004	5622 ft
Well LA-2	N 1,777,157	E 526,681	5651 ft
Well LA-3	N 1,777,123	E 525,747	5672 ft
Well LA-4	N 1,771,171	E 517,203	5975 ft
Well LA-5	N 1,772,471	E 519,582	5840 ft
Well LA-6	N 1,774,531	E 522,637	5770 ft

B. Guaje Well Field

Well G-1	N 1,783,547	E 515,946	5973 ft
Well G-1A	N 1,784,291	E 514,997	6014 ft
Well G-2	N 1,785,061	E 513,966	6056 ft
Well G-3	N 1,786,156	E 511,432	6139 ft
Well G-4	N 1,786,390	E 508,705	6229 ft
Well G-5	N 1,787,845	E 506,705	6306 ft
Well G-6	N 1,786,789	E 504,580	6422 ft

C. Pajarito Well Field

Well PM-1	N 1,768,050	E 507,490	6520 ft
Well PM-2	N 1,760,264	E 496,542	6715 ft
Well PM-3	N 1,769,364	E 505,387	6640 ft
Well PM-4	N 1,764,612	E 495,472	6920 ft
Well PM-5	N 1,767,747	E 492,839	7095 ft

D. Otowi Well Field

Well O-1	N 1,772,169	E 509,152	6396 ft
Well O-4	N 1,772,933	E 497,093	6627 ft

XXII. SPRINGS IN THE LOS ALAMOS AREA

Springs in the Los Alamos area divide into three groups: (1) springs on the flanks of the Sierra de los Valles; (2) springs in lower Los Alamos Canyon; and (3) springs in White Rock Canyon. Springs in DP and Pajarito canyons were discussed in sections IV and VII respectively.

A. Springs on the Flanks of the Mountains

There are 13 springs located on the flanks of the mountains west of the Pajarito Plateau (Fig. XXII-A). Some discharge from alluvium in the canyon bottoms from seepage from coalluvium on the canyon walls or from perched areas in the Bandelier Tuff (Table XXII-A). A number of these springs furnished the early water supply to the ranch school (prior to 1943) and the Laboratory (thereafter).

The 1948 investigation of the caldera included a study of springs on the flanks of the mountains, with the aim of determining whether they could furnish a water supply to Los Alamos. The study indicated that only a small number of springs were suitable for water supply development, and that the amount of water available fell short of the projected demand (Stearns 1948).

B. Springs in Lower Los Alamos Canyon

Basalt Spring, in Los Alamos Canyon, discharges from Unit 3 of the Basaltic Rocks of Chino Mesa from a perched aquifer located in Pueblo, Los Alamos and Sandia Canyons to the west (Fig. XXII-B). This same perched aquifer probably recharges Sandia Spring, which discharges from the Totavi Lentil. Los Alamos Spring discharges from Unit 4 of the Basaltic Rocks of Chino Mesa (Table XXII-A). The spring is a seep recharged locally.

Indian and Sacred Springs discharge from a fault zone in the siltstones and silty sandstones of the Tesuque Formation that extends north/south from Los Alamos Canyon to the unnamed canyon to the north.

C. Springs in White Rock Canyon

Twenty-seven springs discharge from the main aquifer in and along the Rio Grande in White Rock Canyon (Fig. XXII-B). Twenty-two of the springs are separated into three groups of similar aquifer-related chemical quality (Table XXII-A). The five remaining springs make up a fourth group that varies in quality according to localized conditions in the aquifer.

Group I springs discharge from the Totavi Lentil that is composed of sand, gravel, cobbles, and boulders of quartzite, massive white-to-pink quartz, granite, and other felsic rock debris. The lentil is generally less than 50 ft thick. The water is mainly a calcium-bicarbonate type with average total dissolved solids of 165 mg/L.

Group II springs discharge from the coarse-grained sediments composed of arkosic siltstones and sandstone with a mixture of volcanic sediments. These sediments represent the Chaquehui Formation and associated maar sediments. They are interbedded in some places with some of the older basalt flows. The water is a sodium-bicarbonate type with average total dissolved solids of 185 mg/L.

Group III springs discharge from fine-grained sediments of the Tesuque Formation that consist of arkosic siltstones and silty sandstones, with an occasional lens of siltstone or pebbly conglomerate. The water is mainly a calcium-bicarbonite type, with average total dissolved solids of 215 mg/L.

Group IV springs are five springs located on the east side of the river which discharge from the fine-grained sediments of the Tesuque Formation in areas that are associated with faulting or basalt plugs. Chemical constituents are higher in general, with average total dissolved solids of 510 mg/L.

Spring 4A and Ancho Spring discharge from the Totavi Lentil above the river in the lower parts of Pajarito and Ancho Canyons (Fig. XXII-B and Table XXII-A). Stream flow from these springs is of sufficient volume to reach the Rio Grande (Table XXII-B). There are 11 major canyons that enter the Rio Grande in the 12-mile reach of the river from Otowi to the mouth of Frijoles Canyon.

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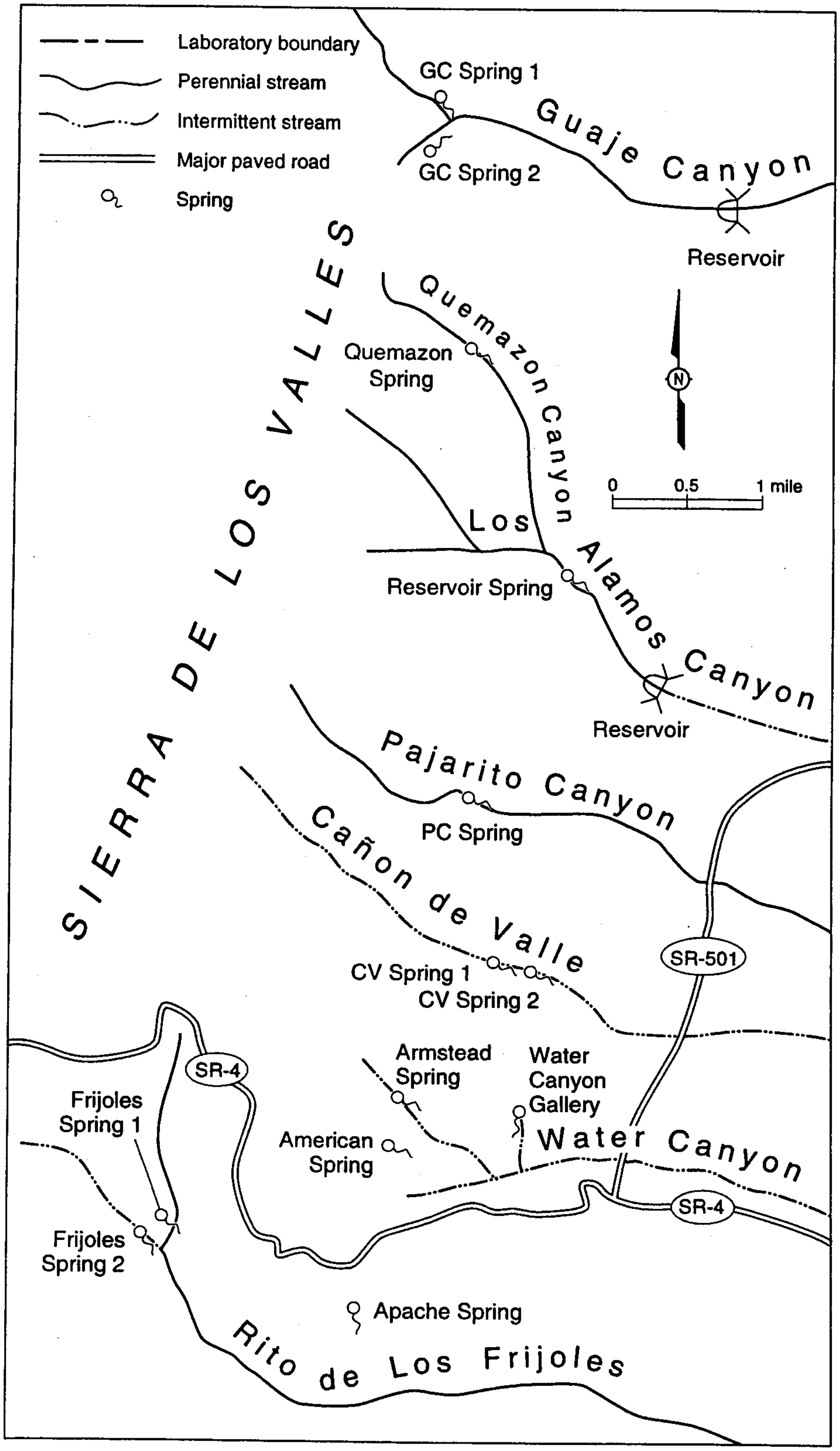

Fig. XXII-A. Locations of springs on the east flank of the Sierra de los Valles.

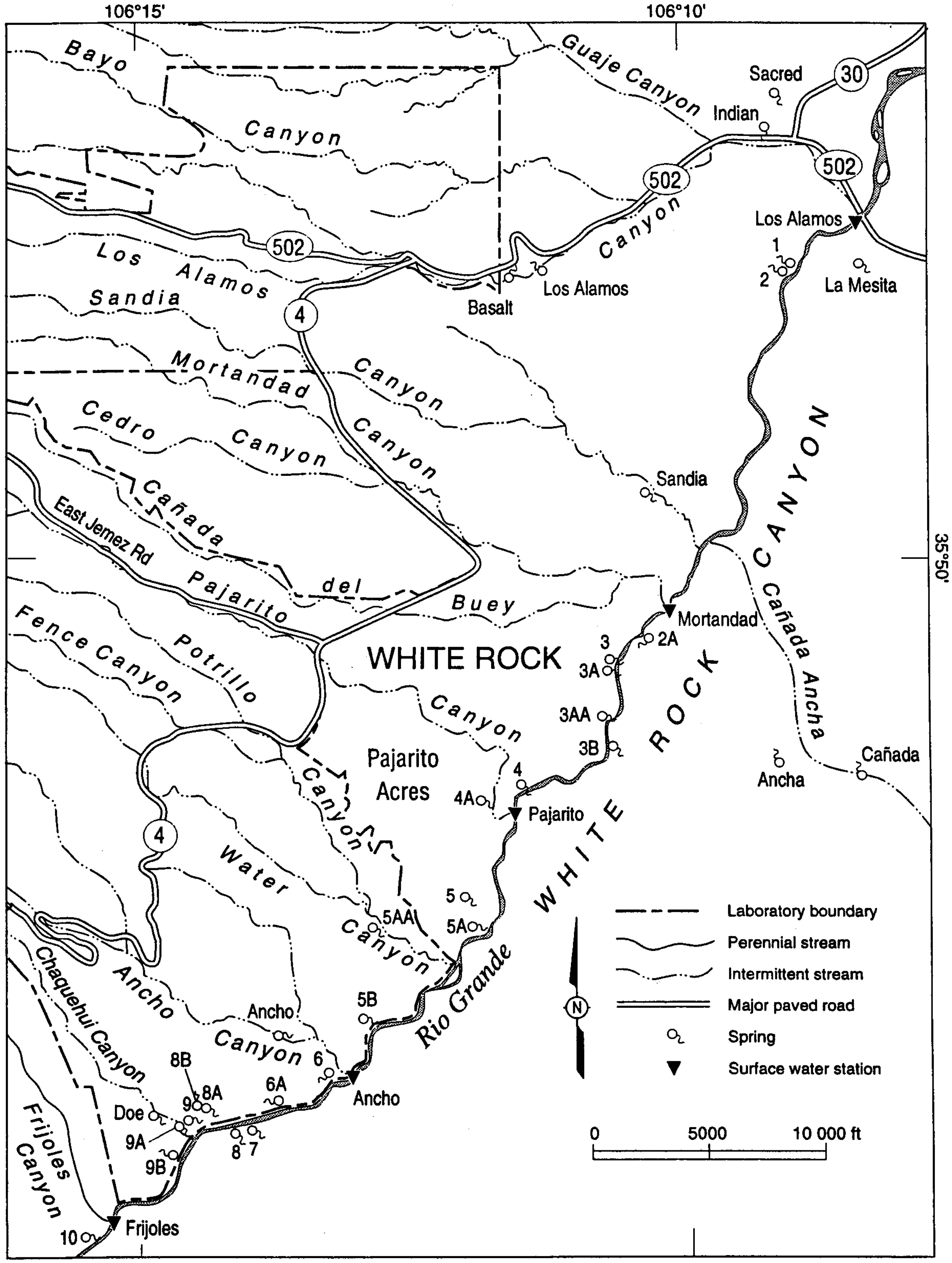

Fig. XXII-B. Locations of springs in lower Los Alamos Canyon and in White Rock Canyon along the Rio Grande.

TABLE XXII-A. Records of Springs in the Los Alamos Area (46 Springs)

	Elevation LSD (ft)	Topographic Situation and Geologic Formation	Temp. (°F)	Estimated Discharge into Rio Grande (gpm)	Remarks
Springs on the Eastern Flank of the Sierra de los Valles					
GC Spring 1	8850	Canyon floor Qb_t		25	base flow Guaje Stream
GC Spring 2	8840	Canyon floor Qb_t		40	base flow Guaje Stream
Quemazon Spring	8660	Canyon floor Qal–Qb_t		15	
Reservoir Spring	8000	Canyon floor Qal–Qb_t		20	
PC Springs	8660	Canyon floor Qal–Qb_t		25	
CV Spring 1	8260	Canyon floor Qal–Qb_t		4	
CV Spring 2	8240	Canyon floor Qal–Qb_t		4	
Water Canyon Gallery	8000	Cliff end of canyon Qb_t		≈150	industrial water supply S-Site
Armstead Spring	8216	Canyon floor Qal–Qb_t		2	probably seepage from talus
American Spring	8280	Ridge above canyon Qb_t		5	
Apache Spring	8320	Steep slope Qb_t		<1	CCC - stock tank
Frijoles Spring 1	8430	West wall– North Fork Frijoles Canyon Qb_t		100	base flow Frijoles Stream
Frijoles Spring 2	8430	North wall– West Fork Frijoles Canyon Qb_t		110	base flow Frijoles Stream
Springs in the Vicinity of Lower Los Alamos Canyon					
Basalt Spring	6000	Talus slope - QTb_3	≈51	3	
Los Alamos Spring	6000	Seepage from basalt - QTb_4	≈51	<1	
Indian Spring	5640	Canyon slope - road cut - T_t	≈62	<1	discharge from fault zone
Sacred Spring	5640	Seep area above stream - T_t	≈58	<1	discharge from fault zone
Springs in White Rock Canyon					
Group I					
Totavi Lentil					
Sandia Spring	5700	Seep area in and adjacent to channel	72	0	Sandia Canyon
Spring 3	5560	Gravel terrace above river	72	20	
Spring 3A	5560	Gravel terrace above river	72	50	
Spring 3AA	5460	Gravel terrace above river	66	<1	
Spring 4	5570	Gravel slope above river	66	80	
Spring 4A	5570	Gravel terrace above channel	70	120	Pajarito Canyon
Spring 5	5770	Gravel on steep slope above river	70	10	
Spring 5AA	5760	Seep in channel forms pools	64	0	Water Canyon
Ancho Spring	5700	Gravels underlying basalt in channel	72	65	Ancho Canyon

TABLE XXII-A. Records of Springs in the Los Alamos Area (46 Springs) (Continued)

	Elevation LSD (ft)	Topographic Situation and Geologic Formation	Temp. (°F)	Estimated Discharge into Rio Grande (gpm)	Remarks
Springs in White Rock Canyon					
Group II					
Chaquehui Formation and Associated Basalts and Maar Sediments					
Spring 5A	5395	Fractures in basalt at edge of river	70	25	
Spring 5B	5390	Steep slope at edge of river	61	10	
Spring 6	5380	Fractures in basalt at edge of river	73	60	
Spring 6A	5375	Fractures in basalt at river level	72	150	
Spring 7	5370	Slope at edge of river	70	175	
Spring 8	5370	Slope at edge of river	72	70	
Spring 8A	5370	Slope at edge of river	72	25	
Spring 8B	5380	Seep in channel above river	68	10	
Spring 9	5385	Large seep above river	68	10	
Spring 9A	5525	Seep area on canyon wall	66	0	Chaquehui Canyon
Spring 9B	5525	Seep in cave/canyon wall	65	0	west side Rio Grande
Spring 10	5390	Edge of alluvium above river	66	<1	Frijoles Canyon
Doe Spring	5600	Seep area in channel and canyon wall	70	<1	Chaquehui Canyon
Group III					
Tesuque Formation					
Spring 1	5615	Seep area on slope above river	65	<1	
Spring 2	5600	Seep area on slope above river	65	<1	
Group IV					
Tesuque Formation (fine-grained basalt intrusion or faults)					
La Mesita Spring	5580	Seep area above channel	65	<1	remains of gallery above channel
Ancha Spring	5775	Seep area in channel, basalt sediments	70	0	
Spring 2A	5490	Gravels along edge of river	72	<1	
Spring 3B	5450	Terrace on slope above river	68	30	
Cañada Spring	5780	Seep area in channel	66	0	

Note:
Qal–recent alluvium
QTb_4–Basaltic Rocks of Chino Mesa Unit 4
QTb_3–Basaltic Rocks of Chino Mesa Unit 3
Qbt–Bandelier Tuff
T_t–Tesuque Formation

TABLE XXII-B. Major Canyons and Streams Entering the Rio Grande in White Rock Canyon

Canyon	Drainage Area (mi^2)	Elevation at River (ft)	Type of Flow[a]	Discharge at River (gpm)	Source
Los Alamos	58.7	5495	I	—	—
La Mesita	—	5490	P	≈2	La Mesita Spring
Sandia	5.6	5465	I	—	—
Cañada Ancha	—	5445	I	—	—
Mortandad	10.4	5435	P	10 to 100	sanitary effluent
Spring 3B	—	5420	P	≈10	Spring 3B
Pajarito	13.6	5410	P	≈450	Spring 4A
Water	19.5	5395	I	—	—
Ancho	7.0	5390	P	≈30	Ancho Spring
Chaquehui	1.5	5370	I	—	—
Frijoles	18.0	5365	P	≈20	Frijoles Springs 1 and 2

Note: La Mesita, Cañada Ancha, and Spring 3B enter the Rio Grande from the east; the others enter the Rio Grande from the west or from the Pajarito Plateau.\

[a]I = intermittent; P = perennial

TABLE XXII-C. Locations and Elevations (NAD 1927)

A. Springs on the Flank of the Mountains

Guaje Spring 1	N 1,797,700	E 460,200	8850 ft
Guaje Spring 2	N 1,796,000	E 460,200	8840 ft
Quemazon Spring	N 1,788,400	E 462,800	8660 ft
Reservoir Spring	N 1,778,800	E 465,700	8000 ft
PC Spring	N 1,773,200	E 461,600	8660 ft
Valle Spring 1	N 1,766,400	E 463,900	8260 ft
Valle Spring 2	N 1,766,500	E 464,100	8240 ft
Water Canyon Gallery	N 1,762,500	E 463,900	8000 ft
Armstead Spring	N 1,762,700	E 459,500	8216 ft
American Spring	N 1,760,000	E 460,800	8280 ft
Apache Spring	N 1,753,600	E 458,900	8320 ft
Frijoles Spring 1	N 1,759,500	E 452,100	8430 ft
Frijoles Spring 2	N 1,759,300	E 449,100	8430 ft

B. Springs in Lower Los Alamos Canyon

Basalt Spring	N 1,770,700	E 516,300	6000 ft
Los Alamos Spring	N 1,770,900	E 517,200	6000 ft
Indian Spring	N 1,777,200	E 525,700	5640 ft
Sacred Spring	N 1,780,300	E 529,800	5640 ft

C. Springs in White Rock Canyon

Group I (Totavi Lentil)

Sandia Spring	N 1,761,500	E 523,000	5700 ft
Spring 3	N 1,753,611	E 521,071	5560 ft
Spring 3A	N 1,753,345	E 521,100	5560 ft
Spring 3AA	N 1,751,492	E 520,883	5460 ft
Spring 4	N 1,748,348	E 517,189	5570 ft
Spring 4A	N 1,747,815	E 515,904	5570 ft
Spring 5	N 1,742,987	E 515,240	5770 ft
Spring 5AA	N 1,742,500	E 510,900	5760 ft
Ancho Spring	N 1,737,900	E 505,400	5700 ft

Group II (Chaquehui Formation and Associated Basalts and Maar Sediments)

Spring 5A	N 1,741,921	E 515,500	5395 ft
Spring 5B	N 1,738,109	E 510,836	5390 ft
Spring 6	N 1,735,617	E 508,947	5380 ft
Spring 6A	N 1,734,503	E 507,146	5375 ft
Spring 7	N 1,733,541	E 504,763	5370 ft
Spring 8	N 1,733,417	E 504,168	5370 ft
Spring 8A	N 1,733,958	E 503,173	5370 ft
Spring 8B	N 1,733,491	E 503,040	5380 ft
Spring 9	N 1,733,676	E 502,687	5385 ft
Spring 9A	N 1,733,407	E 502,408	5525 ft
Spring 9B	N 1,732,876	E 502,193	5525 ft
Spring 10	N 1,728,932	E 498,467	5390 ft
Doe Spring	N 1,733,800	E 501,800	5600 ft

Group III (Tesuque Formation)

Spring 1	N 1,771,547	E 529,268	5615 ft
Spring 2	N 1,771,084	E 529,052	5600 ft

Group IV (Tesuque Formation - Basalt Intrusion or Fault)

La Mesita Spring	N 1,771,600	E 532,100	5580 ft
Ancha Spring	N 1,749,600	E 528,900	5775 ft
Spring 2A	N 1,754,818	E 522,427	5490 ft
Spring 3B	N 1,749,934	E 521,345	5450 ft
Cañada Spring	N 1,748,600	E 532,500	5780 ft

D. Streams Entering the Rio Grande in White Rock Canyon

Los Alamos	N 1,773,000	E 532,300	5495 ft
La Mesita	N 1,772,700	E 531,600	5490 ft
Sandia	N 1,759,300	E 525,400	5465 ft
Cañada Ancha	N 1,754,100	E 535,500	5445 ft
Mortandad	N 1,756,400	E 523,500	5435 ft
Spring 3B	N 1,749,600	E 520,900	5420 ft
Pajarito	N 1,747,400	E 516,800	5410 ft
Water	N 1,741,000	E 513,300	5395 ft
Ancho	N 1,735,700	E 509,400	5390 ft
Chaquehui	N 1,733,100	E 502,600	5370 ft
Frijoles	N 1,729,500	E 499,300	5365 ft

XXIII. DOCUMENTED STUDIES RELATED TO GEOLOGY, HYDROLOGY, OR SURVEILLANCE

Specific studies related to geology, hydrology, or surveillance have been reported in formal and semi-formal reports. The purpose of this section is to identify reports that were the results of these studies. The reports resulting from the studies are referenced, and the locations of their subjects are shown on a generalized map of the area (Fig. XXIII-A).

A. Decontamination of TA-1

Over 140 test holes ranging in depth from 3 ft to over 30 ft were drilled to collect samples for radiochemical analyses in the decontamination of former TA-1. Map location TA-1-A (Fig. XXIII-A).

REFERENCES

A. J. Ahiquist, A. K. Stoker, and L. K. Trocki, "Radiological Survey and Decontamination of the Former Main Technical Area (TA-1) at Los Alamos, New Mexico," Los Alamos Scientific Laboratory report LA-6887 (1977).

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994), chapters 49, 50, 51, 52, 53, and 57.

B. Test Holes in Seepage Beds at TA-21 (1953)

To determine the retention of plutonium in the soil and tuff under and adjacent to seepage pits used to dispose of radioactive effluents, five test holes were drilled to collect samples from the berm adjacent to the pits (two holes), through the seepage bed (two holes), and under the seepage bed (one angle hole). Holes ranged in depth from 10 ft to 20 ft. Map location TA-21-A (Fig. XXIII-A).

REFERENCE

W. D. Purtymun, "Geohydrology of the Pajarito Plateau with Reference to Quality of Water 1949–1972," Los Alamos Scientific Laboratory, Group H-8 internal document, 1975, pp. 69–71.

C. Test Holes in Seepage Beds at TA-21 (1985)

Four holes were cored through the seepage pits that received radioactive effluents from 1943 to 1952 to determine the depth to which contamination was carried beneath the pits. The holes were cored to a depth of 100 ft. Map location TA-21-B (Fig. XXIII-A).

REFERENCE

J. Nyhan, B. Drennon, W. Abeele, M. Wheeler, W. D. Purtymun, G. Trujillo, W. Herrera, and J. Booth, "Distribution of Plutonium and Americium beneath a 33-Year-Old Liquid Waste Disposal Site," *Journal of Environmental Quality* **14**, no. 4 (Oct–Dec 1985).

D. Movement of Plutonium through Tuff at TA-21

A shaft about 6 ft wide, 12 ft long, and 30 ft deep was dug in the berm between two of the seepage pits that received radioactive wastes from 1944 through 1952. Horizontal holes were drilled from the shaft under the pit. The holes were paired at various depths, one hole was used as a moisture-access hole, the other equipped with a vacuum cup system. Water or effluent was added to the seepage pit, moisture measured, and samples of fluids collected by the vacuum system, if possible. Six vertical holes were drilled in the berm around the shaft to depths of about 100 ft. These holes were used as moisture-access holes to determine the moisture content of the tuff at depths below the shaft and seepage pit. Map location TA-21-C (Fig. XXIII-A).

REFERENCE

C. W. Christenson and R. G. Thomas, "Movement of Plutonium through Los Alamos Tuff," in Second Ground Disposal of Radioactive Waste Conference, U.S. Department of Commerce TID-7628 (1962).

E. Movement of Fluids and Plutonium from Shafts at TA-21

A study was done in two parts: (1) to determine the movement of fluids (water containing treated chemicals) and radioactive contaminates from a shaft filled with waste-cement paste under normal operation conditions, and (2) to determine the movement of fluids and plutonium under test conditions without the radioactive sludge fixed with cement.

In the first part of the study, a 59-ft-deep, 6-ft-diam shaft was drilled about 2 ft from a previously constructed 100-ft moisture-access hole. The shaft was filled with contaminated-sludge-cement paste. Moisture moving from the paste into the tuff was measured. A second test hole was drilled and samples collected for analysis.

In the second part of the study, a 20-ft-deep, 2-ft-diam shaft was constructed, with four moisture-access holes (40 ft deep) at various distances from the shaft. The shaft was partly filled with contaminated sludge. Moisture moving from the sludge into the tuff was monitored. When moisture in the tuff did not change, three holes were cored to a depth of about 35 ft. Samples were collected for analysis in holes at various distances from the shaft and at different depths. Map location TA-21-D (Fig. XXIII-A).

REFERENCE

W. D. Purtymun, R. Garde, and R. Peters, "Movement of Fluids and Plutonium from Shafts at Los Alamos, New Mexico," Los Alamos Scientific Laboratory report LA-7379-MS (1978).

F. Exploratory and Foundation Test Holes at TA-3 (1948)

The report cited describes the core drilling of exploratory and foundation test holes for the new main technical area (TA-3) on South Mesa (south of Los Alamos Canyon), for the bridge crossing Los Alamos Canyon south and west of the present hospital, and for foundation tests at the hospital itself.

There were 63 holes cored during the study. Forty-nine of the holes were drilled in the South Mesa area (TA-3), 12 at the bridge crossing, and 2 at the new hospital site. Seven of the holes were 350 ft deep and the remaining holes ranged in depth from 50 ft to 100 ft. Load-bearing tests were conducted at the proposed locations for the three heaviest structures: the power plant, the Van de Graaff Building, and the main warehouse. Map location TA-3-A (Fig. XXIII-A).

REFERENCE

W. C. Kruger & Associates, "Subsurface Investigation of South Mesa and Vicinity," Kruger and Associates, Architect-Engineers report to the U.S. Atomic Energy Commission and Engineering Division of Los Alamos Scientific Laboratory (1948).

G. Exploratory and Foundation Test Holes at TA-53 (1966)

During the preliminary site investigation for the Meson Physics Facility, 28 test holes were cored on the Mesita de los Alamos. In addition to performing detailed geologic mapping, bearing capacities of the tuff and ground vibration characteristics of the mesa were determined. Map location TA-53-A (Fig. XXIII-A).

REFERENCES

W. D. Purtymun, "Geology and Physical Properties of the Near-Surface Rocks of Mesita de los Alamos, Los Alamos County, New Mexico," U.S. Geol. Survey Open-File Report (1966).

M. D. Keller, "Geologic Studies and Material Property Investigations of Mesita de los Alamos," Los Alamos Scientific Laboratory report LA-3728 (1968).

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994), chapters 4, 5, 6, 9, 17, 18, 72, 95, 96, 101, 180, and 193.

H. Preliminary Site Investigation of the Plutonium Processing Facility at TA-55

A detailed investigation was made of the geology, hydrology, and seismic characteristics of the site. A number of test holes were drilled to determine the physical characteristics of the tuff. The study also included trenching to determine if there was any possibility of extension of the Los Alamos fault into the area from the north. Map location TA-55-A (Fig. XXIII-A).

REFERENCE

Dames and Moore, "Report of Geologic, Foundation, Hydrologic, and Seismic Investigations for the Plutonium Processing Facility at the Los Alamos Scientific Laboratory," Consulting Engineers report to the U.S. Atomic Energy Commission and the Los Alamos Scientific Laboratory (1972).

I. Movement of Tritium through Tuff at TA-54 Area G

The movement of tritium from wastes disposed of in shafts at TA-54 Area G was investigated by drilling 14 test holes to a depth of 50 ft adjacent to a shaft disposal area that contained tritium wastes. The tuff was not saturated, having a moisture content of less than 8% by volume. Tritium migrated in the vapor phase a distance of 105 ft in 4 years. Map location TA-54-A (Fig. XXIII-A).

REFERENCES

W. D. Purtymun, "Underground Movement of Tritium from Solid-Waste Storage Shafts," Los Alamos Scientific Laboratory report LA-5286-MS (1973).

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994), chapter 20.

J. Containment of Tritium in Buried Wastes at TA-54, Area G

Asphalt had been used since 1970 to contain the migration of tritium from disposal shafts. Methods used have not been effective and new techniques are being implemented. During this investigation 18 test holes were drilled, and samples were collected and analyzed for moisture and tritium. The test holes were drilled to a depth of 40 ft. Map location TA-54-B (Fig. XXIII-A).

REFERENCE

M. L. Wheeler and J. L. Warren, "Tritium Containment after Burial of Contaminated Solid Waste," *Proceedings of 23rd Conference on Remote Systems Technology*, San Francisco, Calif. (1975).

K. Horizontal Core Holes at TA-54 Area G and Other Studies at TA-54 Areas G and L

Five horizontal holes were cored from a canyon under a waste disposal pit at Area G. The length of the holes ranged from 240 ft to 287 ft. They were drilled using air as a cuttings carrier. The holes penetrated both Units 2A and 2B of the Tshirege Member of the Bandelier Tuff. Total core recovery ranged from 51% to 75%. A vertical hole was cored from the same drill pad to a depth of 157 ft. The hole penetrated the lower units of the Tshirege Member, the Otowi Member, and the Guaje Member, and was completed into the top of Unit 2 of the Basaltic Rocks of Chino Mesa. No core was recovered. The purpose of the holes was to determine if contamination had leached from the pits into the underlying tuff. No apparent contamination was encountered. Map Location TA-54-C (Fig. XXIII-A). Other studies related to storage and disposal of wastes and to the geology of Areas G and L may be found in Purtymun (1994).

REFERENCES

Reynolds Electric and Engineering Co., "Horizontal Monitoring Holes, Los Alamos, New Mexico," Completion Report to U.S. Energy Research and Development Agency, Contract E(26-1)-410 (1976).

W. D. Purtymun, M. L. Wheeler, and M. A. Rogers, "Geologic Description of Cores from Holes P-2 MH-1 through P-2 MH-5, Area G, Technical Area 54," Los Alamos Scientific Laboratory report LA-7308-MS (1978).

W. D. Purtymun, M. L. Wheeler, and M. A. Rogers, "Radiochemical Analyses of Samples from Beneath a Solid Radioactive Waste Disposal Pit at Los Alamos, New Mexico," Los Alamos Scientific Laboratory report LA-8422-MS (1980).

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994), chapters 7, 8, 20, 25, 32–34, 58, 98, 104, 109, 110, 116, 118, 119, 121–123, 125, 136, 137, 139, 140, 143, 147, 150, 155, 156, 163, 168, 171, 174, 185, 186, 196, and 202.

L. Test Holes at TA-33

During an investigation to determine the extent of any possible contamination resulting from underground experiments, six holes were cored with depths ranging from 29 ft to 59 ft at Area D; six holes were cored with depths ranging from 29 ft to 59 ft at Area E; and two holes with depths of 149 ft and 174 ft were cored at the tritium facility at Area T. Map location T-33-A (Fig. XXIII-A).

REFERENCES

Weston, Consulting Engineers, "Weston Data Material from Areas T and E," Volumes 1 and 2, and "Weston Data Material from Area D, TA-33," Basic Data Report in the files of Group CL-1 (1989).

M. Near-Surface Land Disposal Facilities for Radioactive Wastes (Areas A, B, C, D, E, F, G, and T)

A source document concerning the history and environmental setting of eight LASL near-surface land disposal facilities was prepared in two volumes. The report contains a number of references to test holes drilled in the solid disposal area. Map location TA-0-A (Fig. XXIII-A).

A second similar type of report was prepared by the U.S. Geological Survey covering the same sites.

REFERENCES

M. A. Rodgers, "History and Environmental Setting of LASL Near-Surface Land Disposal Facilities for Radioactive Wastes (A, B, C. D, E, F, G, and T), A Source Document," Los Alamos Scientific Laboratory report LA-6848-MS, Vol. I and II (1977).

T. E. Kelley, "Evaluation of Monitoring of Radioactive Solid-Waste Burial Sites at Los Alamos, New Mexico," U.S. Geol. Survey Open-File Report 75-406 (1975).

N. Pumice Investigation

One of the first geologic reports prepared for the U.S. Atomic Energy Commission related to the development and mining of pumice from the lower beds of the Bandelier Tuff or Guaje Member. Data related to the thickness and distribution of the pumice. Map location TA-0-B (Fig. XXIII-A).

REFERENCE

V. C. Kelley, "Geology and Pumice Deposits of the Pajarito Plateau, Sandoval, Santa Fe, and Rio Arriba Counties, New Mexico," Los Alamos Project—Pumice Investigations for the Operations Division, Los Alamos Scientific Laboratory, Contract No. AT-(29-1)-553 (1948).

O. Subsurface Geology of the Pajarito Plateau

Geologic report integrating data from wells, geophysical surveys, and surface exposures to develop structure contour and paleogeologic maps of the pre-Bandelier Tuff surface beneath the Pajarito Plateau. Map location TA-0-C (Fig. XXIII-A).

REFERENCE

B. J. Dransfield and J. N. Gardner, "Subsurface Geology of the Pajarito Plateau, Española Basin, New Mexico," Los Alamos National Laboratory report LA-10455-MS (1985).

P. Proposed Borrow Pit in Mortandad Canyon

Test holes drilled in the eastern part of Mortandad Canyon indicated that in the study area about 170 000 cubic yards of uncontaminated fill material is available in the upper 9 yards of the canyon bottom. Map location TA-O-D (Fig. XXIII-A).

REFERENCE

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994), chapter 132.

Q. Construction of Sediment Retention Ponds in Mortandad Canyon

Prior to the construction of retention ponds, five injection shafts were constructed in the stream bed to retain and store runoff and suspended sediments in lower Mortandad Canyon. Map location TA-O-E (Fig. XXIII-A).

REFERENCE

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994), chapters 40, 41, and 181.

R. Long-Range Plan for Water Supply (1986)

A long-range plan concerning the water supply at Los Alamos was prepared for the Department of Energy. This included a short-term management plan for the San Juan–Chama water.

REFERENCE

U.S. Corps of Engineers, "Los Alamos Water Supply, Los Alamos, New Mexico," Contract No. D.E.-A132-83A122421, U.S. Corps of Engineers, Albuquerque, New Mexico (1986).

S. Buckman Well Field

The Buckman Well Field, which furnishes a part of the water supply to Santa Fe, lies east of the Rio Grande about a mile south of Otowi. A preliminary report was prepared to define the geologic and hydrologic properties of the aquifer underlying the Buckman Well Field and the effects of pumpage on the aquifer.

REFERENCE

Black and Veatch (Consulting Engineers), "Preliminary Report to the Public Service Company of New Mexico, Buckman Well Field," Black and Veatch, Project 6607, Denver, Colo. (1976).

T. Ground Water Model of the Buckman Well Field

A ground water flow model was prepared to evaluate the ground water withdrawal from the Buckman Well Field. A simulated effect of the historic withdrawal 1972 to 1986 was prepared as was the future effect on the aquifer for the period 1987 to 2045.

REFERENCE

D. P. McAda, "Simulation Effect of Ground-Water Withdrawal from a Well Field Adjacent to the Rio Grande, Santa Fe County, New Mexico," U.S. Geol. Survey Water Resources Investigation Report 89-4184 (1990).

U. Test Holes Drilled on the Cerros del Rio

Across the Rio Grande from the Pajarito Plateau 106 test holes were drilled into the Cerros del Rio. The holes were drilled and logged as part of a uranium investigation. Geologic logs and some hydrologic data related to the test holes are available from the State Engineer.

REFERENCE

R. L. Borton, "A Listing of Geohydrologic Data for 106 Exploratory Holes Drilled by Nuclear Dynamics, Inc., in Rio Arriba, Sandoval, and Santa Fe Counties, New Mexico 1970-1972," State Engineer Open-File Report (1974).

V. Environmental Study of the Pueblo of San Ildefonso

A cooperative agreement was made between the Pueblo of San Ildefonso, the Bureau of Indian Affairs, and the Department of Energy in order to evaluate the environmental impact of the Laboratory operation on off-site areas. The agreement in 1987 was the beginning of annual investigations made to evaluate the quality of surface and ground water, soil, and sediments in the pueblo.

REFERENCES

W. D. Purtymun and M. N. Maes, "Environmental Study of the Pueblo of San Ildefonso: Reference to Water, Soil, and Sediments," Los Alamos National Laboratory document LA-UR-88-3646 (1988). Reporting data annually in LA-11628-ENV (1988), LA-12000-ENV (1989), and LA-12271-MS (1990).

W. Seismic Hazards Program Core Holes

Four holes were cored as part of the Laboratory's Seismic Hazards Program for the purpose of determining near-surface seismic velocity at key Laboratory facilities (Fig. XXIII-B). The report does not cover the velocity structure surveys but reports on characteristics of the drilling, geology, and some of the hydrologic aspects of the holes.

REFERENCE

J. N. Gardner, T. Kolbe, and S. Chang, "Geology, Drilling, and Some Hydrologic Aspects of Seismic Hazards Program•Core Holes, Los Alamos National Laboratory, New Mexico," Los Alamos National Laboratory report LA-12460-MS (1993).

X. Earthquake and Rockfall Potential at Omega Site

In August 1970 the U.S. Geological Survey conducted a brief geologic reconnaissance in the vicinity of the Omega West Reactor in order to determine the possibility of damage to the reactor by rockfalls triggered by earthquakes or other factors. Other rockfall investigations were conducted and are reported in Purtymun (1994).

REFERENCES

T. E. Kelley, "Earthquake and Rockfall Potential near Omega Site, Los Alamos, New Mexico," U.S. Geological Survey informal report, Albuquerque, New Mexico, September 1970.

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994), chapters 68, 85, 100, 117, 131, 145, 176, 191, 199, 200, 204, and 205.

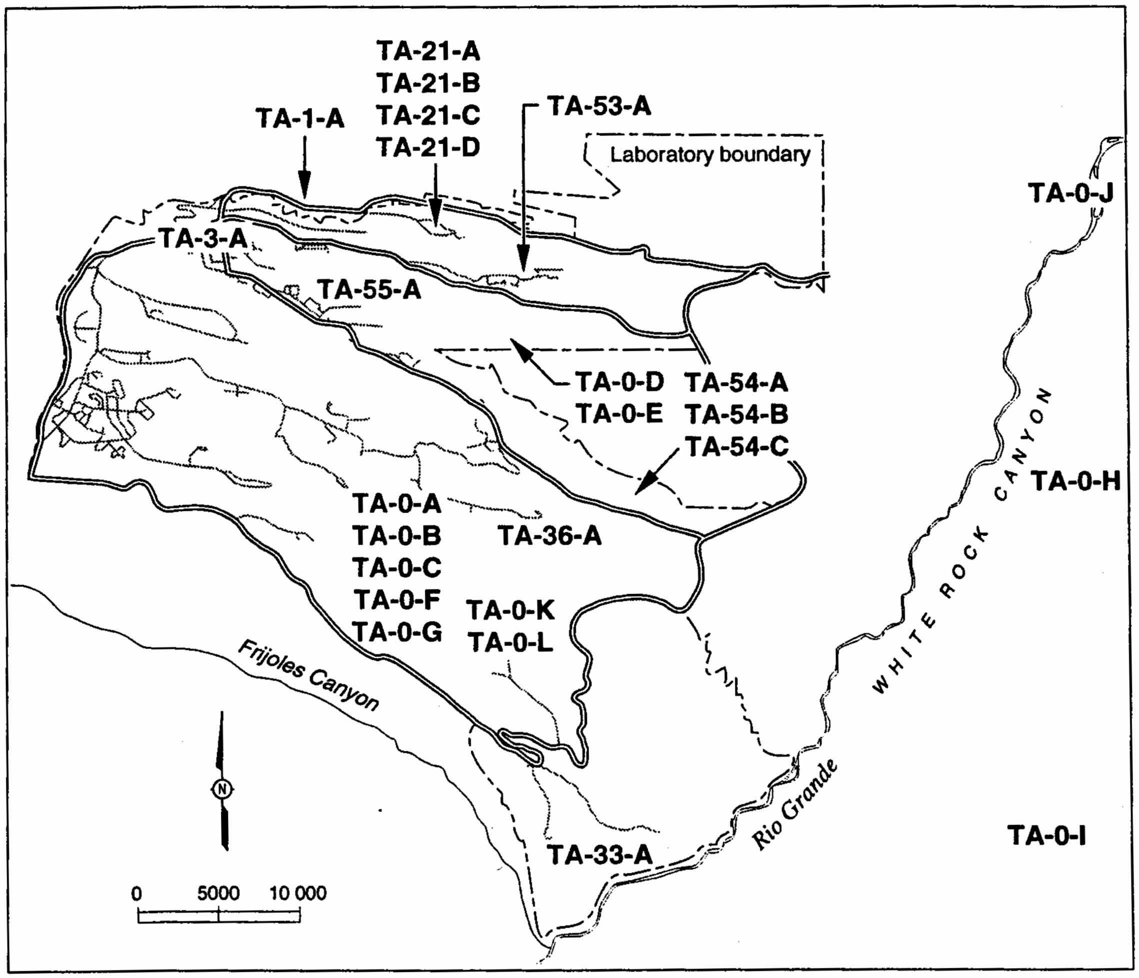

Fig. XXIII-A. Locations of geologic, hydrologic, engineering, and environmental investigations.

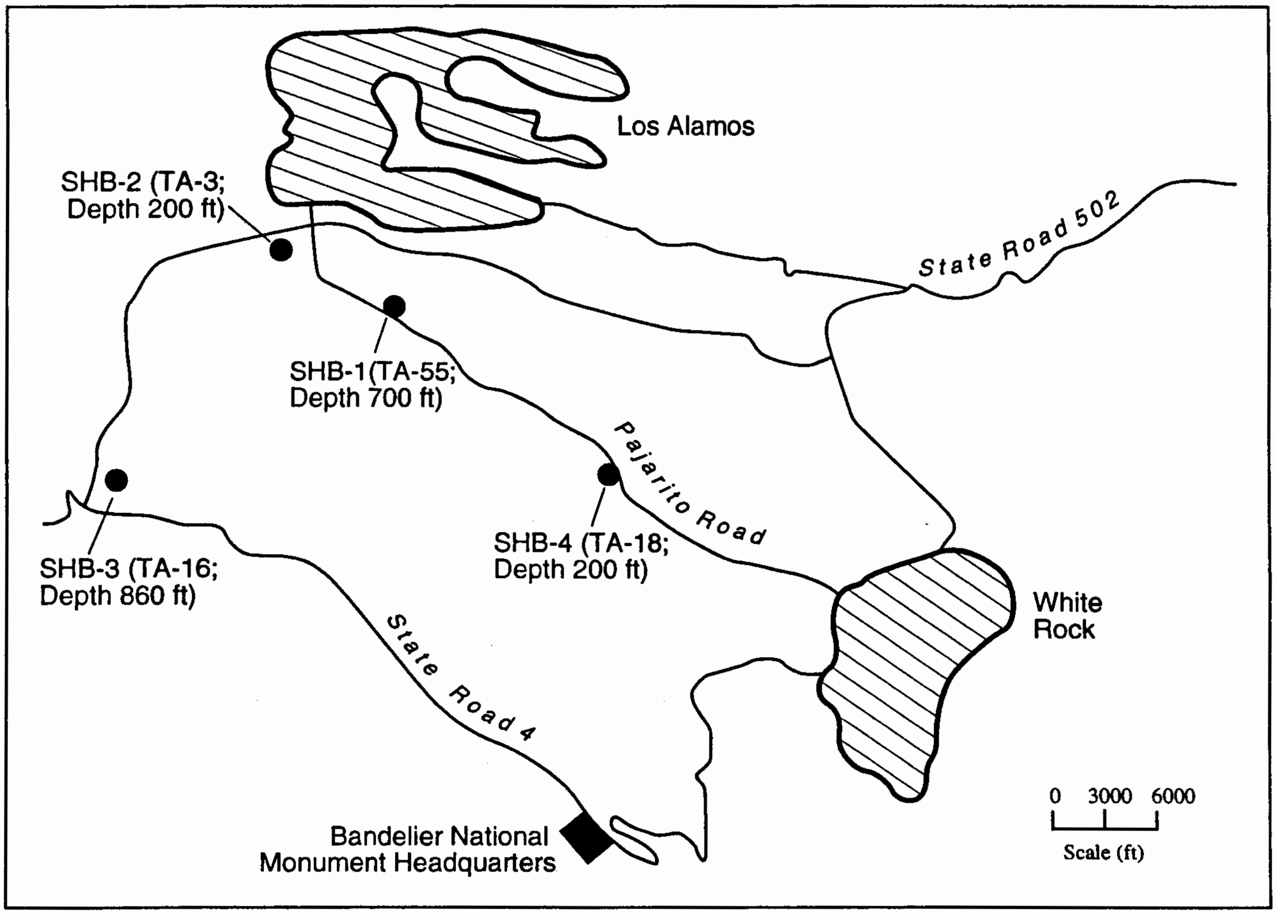

Fig. XXIII-B. Locations of test holes for seismic investigation.

XXIV. RACK ASSEMBLY ALIGNMENT FACILITIES

In order to check the tolerance and alignment of instruments and instrument packages to be run down holes at the Nevada Test Site, towers or bays were constructed over holes. The older RAAC (Rack Assembly Alignment Complex) facilities are at TA-3 near SM-38 (Fig. XXIV-A). These facilities are no longer in use, and the testing is now done at TA-60.

The older RAAC facilities at TA-3 consisted of three test holes. The oldest test hole at SM-245 was about 3 ft in diameter and about 100 ft deep. This hole was plugged and abandoned. The next oldest test hole at TA-3, at SM-447, has a hole drilled to a depth of 96 ft. The upper part of the hole is cased to a depth of 20 ft with a 5-ft-4-in.-diam CMP (corrugated metal pipe). The holes were completed in the Tshirege Member of the Bandelier Tuff.

The last RAAC structure is at SM-1483. The hole was drilled to a depth of 120 ft. The upper part of the hole is cased with 20 ft of 7.5-ft-diam CMP.

The new rack facilities are located at TA-60 at SM-19 (Fig. XXIV-A). There are two holes augered to a depth of 100 ft. The diameter of the holes is 11 ft. The upper part of both holes is cased to a depth of 20 ft with 10-ft-2-in.-diam CMP.

REFERENCE

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994), chapter 134.

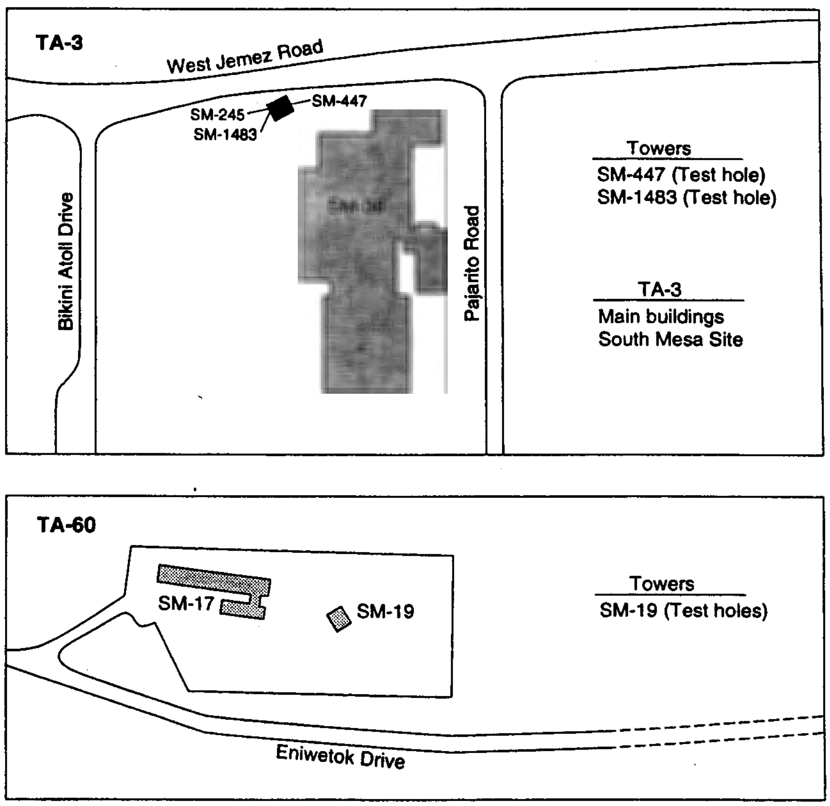

Fig. XXIV-A. Locations of rack alignment holes at TA-3 and TA-60.

TABLE XXIV-A. Locations and Elevations (NAD 1927)

A. TA-3	N 1,774,200	E 477,200	7440 ft
B. TA-60	N 7,771,800	E 483,000	7330 ft

XXV. TEST HOLES IN UPPER GUAJE CANYON

Two shallow test holes were drilled in upper Guaje Canyon between the Los Alamos and Guaje Faults in the fall of 1966 (Fig. XXV-A). The holes were drilled to determine the rock type and the depth of saturation between the two faults, and to explore the possibility of developing short-term high-yield wells.

Test hole 1 (elevation 7180 ft) was drilled to a depth of about 23 ft and was completed in the alluvium. The alluvium was saturated to near the stream level. Test hole 2 (elevation 7060 ft) was drilled to a depth of 103 ft, penetrating 17 ft of alluvium and 86 ft of the gravel of the Puye Conglomerate. The alluvium and gravel were saturated to near the stream level.

Both holes were cased with 2-in.-diam perforated plastic pipe; the depth and the length of the perforations are unknown. The test holes indicated a saturated thickness of the gravels penetrated; however, the saturated thickness is not sufficient to develop a high-yield well. Additional testing would be necessary to determine the total thickness of saturated gravels between the two faults.

REFERENCE

W. D. Purtymun, "Geohydrology of the Pajarito Plateau with Reference to Quality of Water 1949–1972," Los Alamos Scientific Laboratory internal document, 1975.

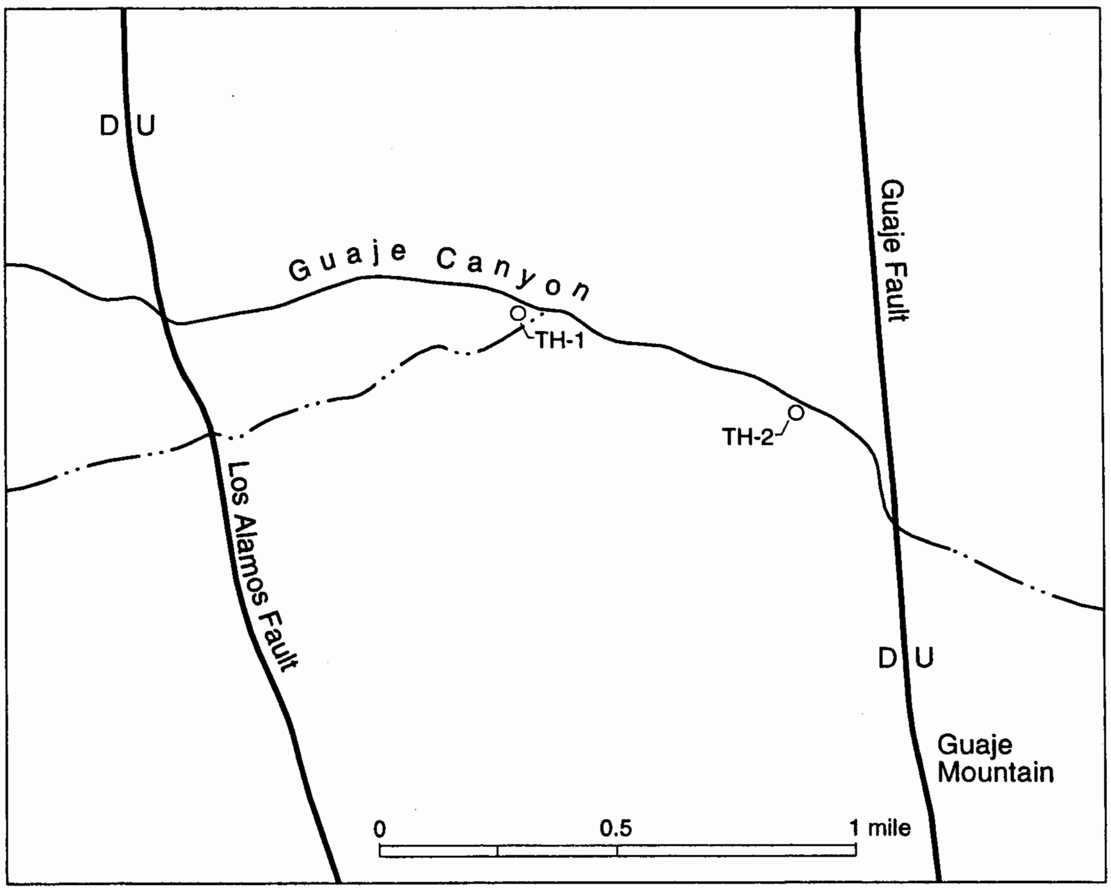

Fig. XXV-A. Location of test holes in upper Guaje Canyon.

TABLE XXV-A. Locations and Elevations (NAD 1927)

A. Test Hole 1	N 1,795,700	E 484,600	7180 ft
B. Test Hole 2	N 1,794,600	E 486,600	7060 ft

XXVI. FENTON HILL

Fenton Hill is located about 35 miles west of Los Alamos on the western flanks of the Valles Caldera. The studies at this site have been based on extracting heat from dry geothermal reservoirs by developing artificial hydrothermal systems. Two systems were developed at the site. The first system was composed of two deep holes drilled into the dry Precambrian rock to a depth of about 10 000 ft. The holes are connected by a fracture induced by hydrologic pressure. Water is circulated under pressure through this system to recover heat from the fractured area.

The second similar system has been developed at the site to a depth of about 14 000 ft. Both systems have been tested.

Site selection for the test area began in the winter of 1971–1972. In December 1971, seven shallow heat-flow holes (Sites 1, 2, 3, 4, 5, 6, and 7) were drilled to about 100 ft around the Valles Caldera (Fig. XXVI-A). Three additional holes (Sites 8, 9, and 10) were drilled on the west side of the caldera in February 1972 (Fig. XXVI-A). These holes were less than 80 ft deep and were cased with 2-in.-diam plastic pipe. The heat-flow measurements in the holes indicated that the heat flow was greatest west of the caldera, and other data from the U.S. Geological Survey indicated that the geologic structure there was the least complex and that the depth to the Precambrian rocks was moderate. This was the type of geologic environment necessary for the development of dry geothermal energy.

In the spring of 1972, test holes TH-A, TH-B, TH-C, and TH-D were drilled around the west rim of the Valles Caldera (Fig. XXVI-B). Cores were taken in 10-ft samples for every 100 ft of depth. The holes ranged from 500 to 750 ft in depth (geologic logs and construction data appear in Table XXVI-A). Surface casing was cemented in the top of the holes and blank casing was set into the lower part to facilitate heat-flow logging. The heat-flow measurements indicated that the heat flow was greatest near the rim of the caldera and decreased westward. Upon completion of the core holes and heat-flow logging, a deep test hole GT-1 (depth 2575 ft) was drilled 470 ft into the top of the Precambrian granite (Fig. XXVI-B, Table XXVI-A). Based on heat-flow measurements and geology, the test site, Fenton Hill TA-57, was located north of La Cueva at the top of Fenton Hill, just off State Road 126 (Fig. XXVI-B).

Two test holes were drilled near Fenton Hill for the placement of geophones for the site seismic operations and to obtain geologic and hydrologic information (Fig. XXVI-B). The holes, PC-1 and PC-2, were drilled through the volcanics and into the sediments. The holes were completed in the sediments just above the Precambrian level (Table XXVI-B).

Within the site, two sets of energy extraction holes were drilled, GT-2 and EE-1 (about 10 000 ft deep) and EE-2 and EE-4 (about 14 000 ft deep), both completed in the Precambrian rocks (Fig. XXVI-C). A well was drilled and completed in a shallow aquifer to provide a water supply (water level about 360 ft, base of aquifer at about 460 ft). Two additional wells were added (Fig. XXVI-C, Table XXVI-C). Five observation wells, 6 in. in diameter, were drilled to depths of 500 ft. They were used to test the aquifer and as a support for applications for water rights. The observation wells were completed through the aquifer, the Abiquiu Tuff, and into the perching formation of silts and clays of the Abo Formation. They were cased with 2-in.-diam galvanized pipe with the lower 50 ft slotted.

A preliminary study of the quality of surface and ground water in the drainage area of the Jemez River and the Rio Guadalupe was made to establish background data, prior to any experiments by the Laboratory. The data include chemical analyses from 17 surface water stations, 15 mineral and thermal springs (Fig. XXVI-D), and 53 ground water stations (Fig. XXVI-E).

Based on the preliminary study of the quality of water in the vicinity of Fenton Hill, a number of surface and ground water stations were established to monitor any effect of the operations of the Fenton Hill site on the environment. The collection of quality-of-water data began in 1974 and has continued to the present (Fig. XXVI-F). The number of stations has remained about the same, with little change: 13 surface water stations (Table XXVI-D) and 20 ground water stations (Table XXVI-E). The chemical quality of the surface and ground water is grouped around common chemical properties and total dissolved solids. The water-quality data and related hydrologic data collected at Fenton Hill have been published in a series of Los Alamos reports:

1974 data: LA-6093-MS, December 1975
1975 data: LA-6511-MS, September 1976
1976 data: LA-7307-MS, May 1978
1977 data: LA-7468-PR, September 1978
1978 data: LA-8217-PR, January 1980
1979 data: LA-8424-PR, June 1980
1980 data: LA-9007-PR, September 1981
1981–1982 data: LA-9854-PR, September 1983
1983–1984 data: LA-10892-PR, January 1987
1985–1986 data: LA-11210-PR, March 1988
1987–1988 data: LA-12030-PR, March 1991
1989 data: LA-12000-ENV, December 1990
1990 data: LA-12271-MS, March 1992

REFERENCES

American Ground Water Consultants, Inc., "Hydrology of the Hot Dry Rock Site at Fenton Hill, Sandoval County, New Mexico," report submitted to the Los Alamos Scientific Laboratory (June 1980).

American Ground Water Consultants, Inc., "Results of Ground Water Model Studies at Fenton Hill, Sandoval County, New Mexico," report submitted to the Los Alamos Scientific Laboratory (July 1980).

N.M. Becker, W. D. Purtymun, and W. C. Ballance, "Aquifer Evaluation at Fenton Hill, October and November 1980," Los Alamos National Laboratory report LA-8964-MS (1981).

W. D. Purtymun, "Geology of the Jemez Plateau West of the Valles Caldera," Los Alamos Scientific Laboratory report LA-5124-MS (1973).

W. D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to the Environment, Engineering, Geology, and Hydrology, 1961–1990," Los Alamos National Laboratory report LA-12733-MS (1994) chapters 26, 28, 36, 44, 54, 59, 60, 73, 79, 80, 86, 87, 89, 116, 154, 166, and 198.

W. D. Purtymun, R. W. Ferenbaugh, A. K. Stoker, W. H. Adams, "Quality of Water in the Vicinity of Fenton Hill, 1979," Los Alamos Scientific Laboratory report LA-8424-PR (1980).

W. D. Purtymun, R. W. Ferenbaugh, N. M. Becker, M. C. Williams, and M. N. Maes, "Water Quality in the Vicinity of Fenton Hill, 1983 and 1984," Los Alamos National Laboratory report LA-10892-PR (1987)

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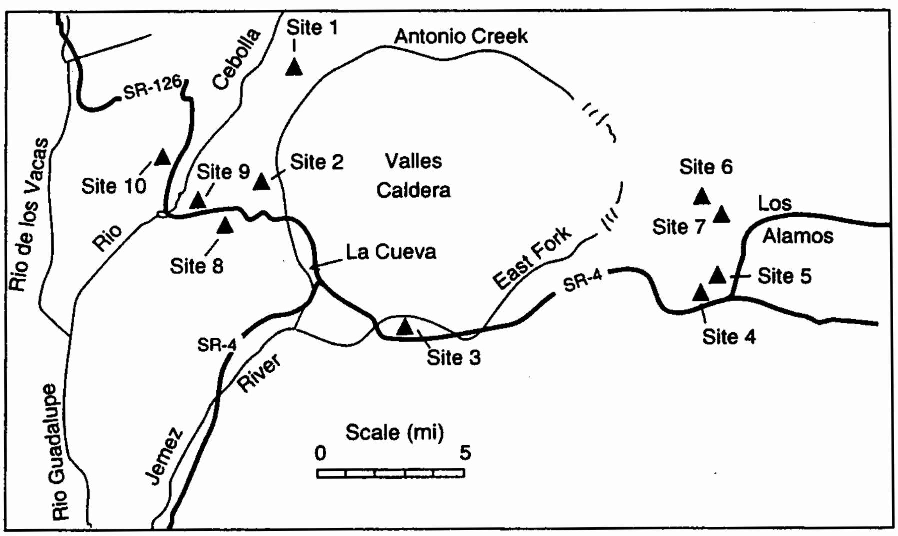


Fig. XXVI-A. Heat-flow sites, December 1971 and February 1972 (Purtymun 1994).

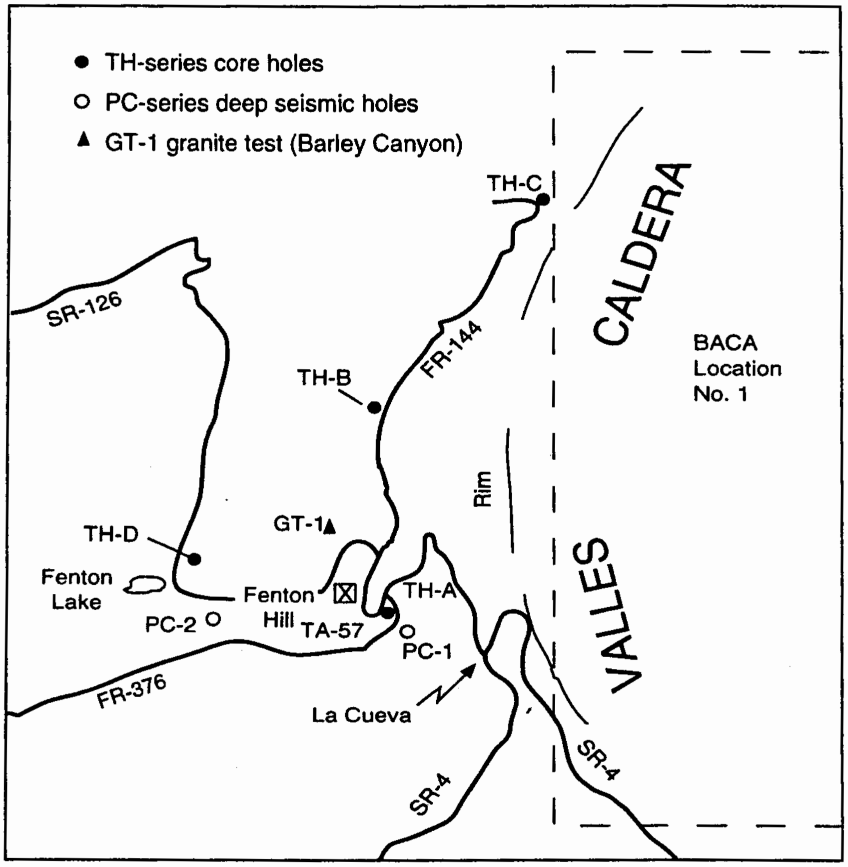


Fig. XXVI-B. Location of test holes (TH-series, PC-series, and GT-1) west of the Valles Caldera (Purtymun et al. 1987).

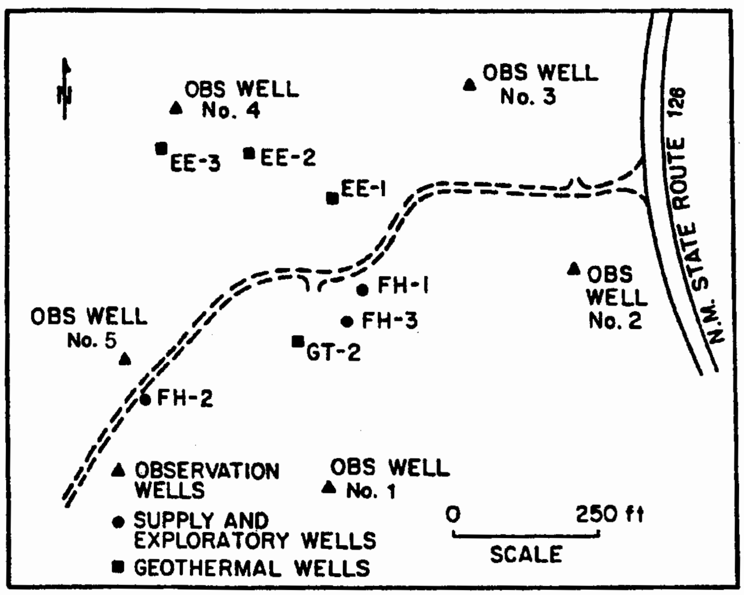


Fig. XXVI-C. Site map of Fenton Hill showing locations of observation, supply, exploratory, and geothermal wells (Becker et al, 1981).

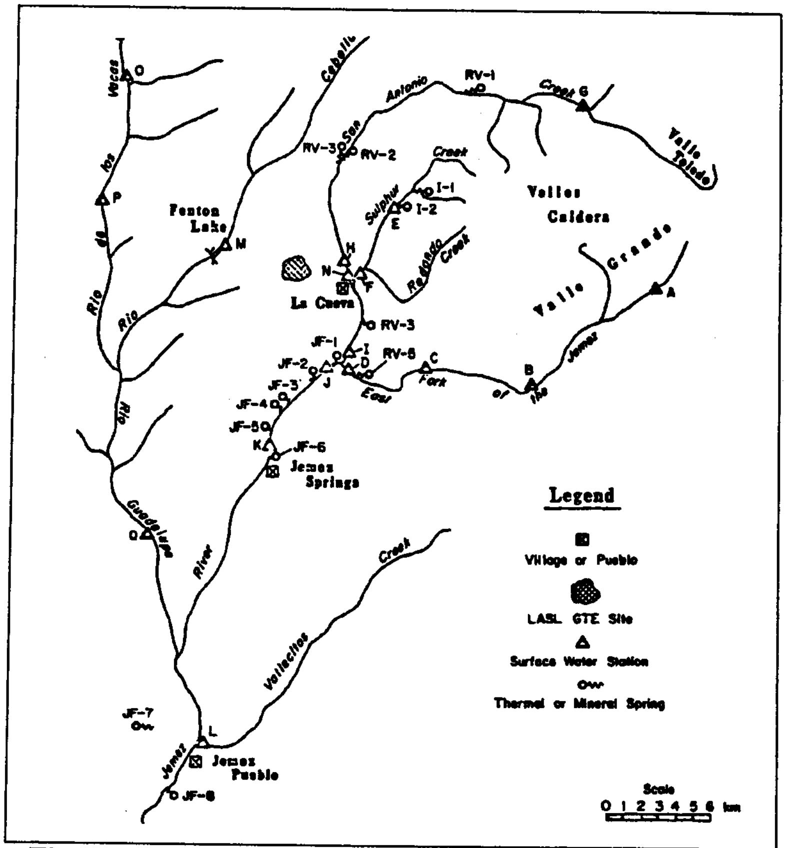


Fig. XXVI-D. Surface water stations, thermal and mineral springs (Purtymun et al. 1974).

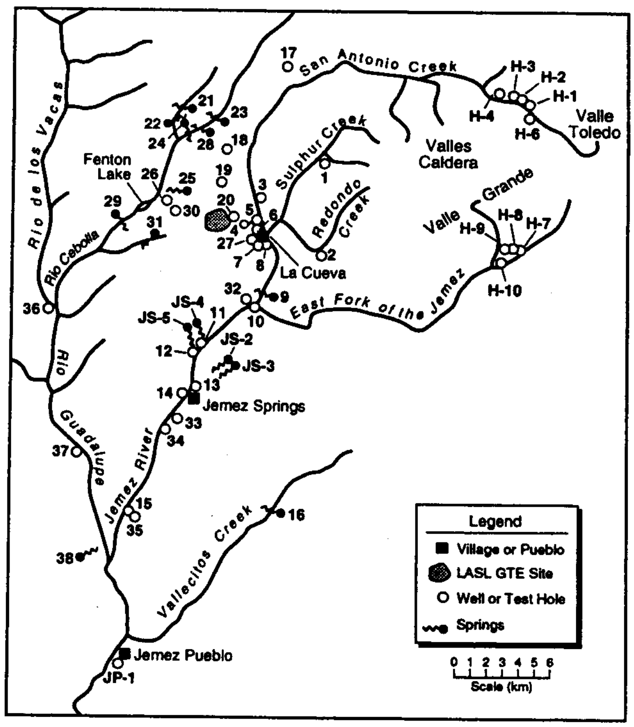
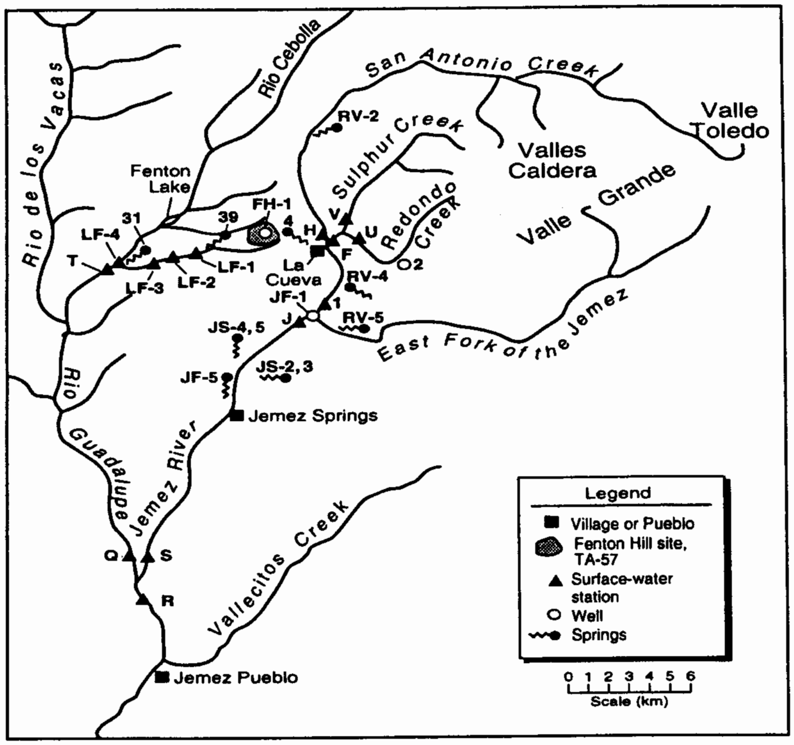
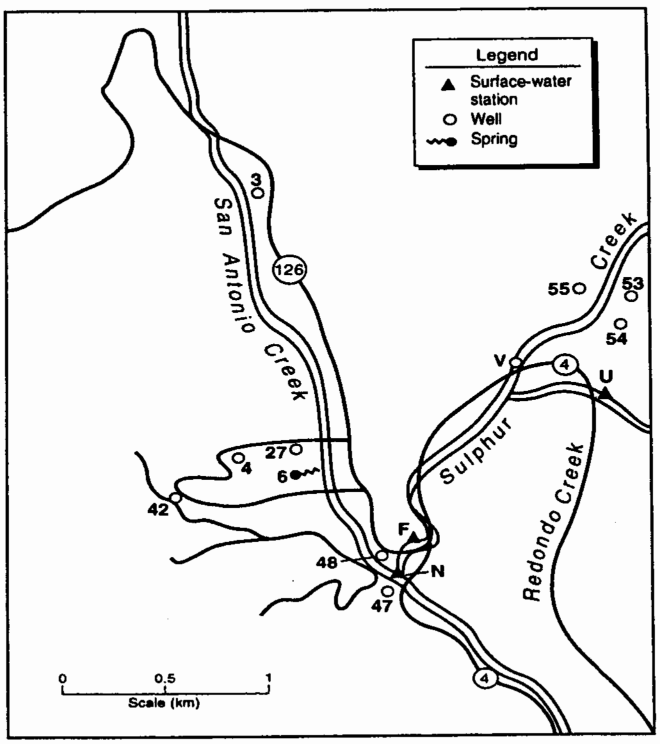


Fig. XXVI-E. Wells, test holes, and springs (Purtymun et al. 1974).



Locations of sampling stations



Locations of sampling stations at La Cueva

Fig. XXVI-F. Locations of surface-water stations and wells used in monitoring quality of water after 1974 (Purtymun et al. 1980).

TABLE XXVI-A. Geologic Logs and Construction Data for Granite Test Hole (GT-1) and Test Holes TH-A, TH-B, TH-C, and TH-D

GT-1 — June 1972 — Elevation 8475 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff	60	60
Abiquiu Tuff	100	160
Abo Formation	910	1070
Magdalena Group		
Upper limestone member	590	1660
Lower limestone member	155	1815
Sandia Formation		
Upper clastic member	235	2050
Lower limestone	55	2105
Precambrian rock	470	2575

TH-A — April 1972 — Elevation 8450 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff	30	30
Abiquiu Tuff	120	155
Abo Formation	435	590

TH-B — April 1972 — Elevation 8625 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff	380	380
Abiquiu Tuff	60	440
Abo Formation	210	650

TH-C — April 1972 — Elevation 8700 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff	240	240
Abiquiu Tuff	340	580
Abo Formation	170	750

TH-D — April 1972 — Elevation 7900 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff	120	120
Abo Formation	380	500

TABLE XXVI-A. Geologic Logs and Construction Data for Granite Test Hole (GT-1) and Test Holes TH-A, TH-B, TH-C, and TH-D (Continued)

Construction

GT-1	Depth 2575 ft	
Hole diam		3 3/4 in. to 280 ft
		9 7/8 in. to 1600 ft
		6 3/4 in. to 2410 ft
		4 1/4 in. to 2575 ft
Casing schedule (outside diam)		10 3/4 in. to 258 ft
		7 5/8 in. to 1357 ft
		5 in. to 2400 ft
		open hole 2400 to 2575 ft

Drilled air-mist-rotary to 2410 ft, core-water-rotary to 2410 to 2575 ft, all strings cemented in.

TH-A	Depth 590 ft	
Hole diam		9 5/8 in. to 100 ft
		6 1/4 in. to 590 ft
Casing schedule (outside diam)		7 in. to 97 ft
		4 1/2 in. to 578 ft
TH-B	Depth 650 ft	
Hole diam		9 5/8 in. to 100 ft
		6 1/4 in. to 650 ft
Casing schedule (outside diam)		7 in. to 97 ft
		4 1/4 in. to 566 ft
TH-C	Depth 750 ft	
Hole diam		9 5/8 in. to 100 ft
		6 1/4 in. to 500 ft
Casing schedule (outside diam)		7 in. to 97 ft
		4 1/4 in. to 750 ft
TH-D	Depth 500 ft	
Hole diam		9 5/8 in. to 100 ft
		6 1/4 in. to 750 ft
Casing schedule (outside diam)		7 in. to 97 ft
		4 1/4 in. to 500 ft

Note: TH-A,-B,-C,-D were mud-rotary drilled and cored at intervals; 4-1/4 in.-outside-diam (o.d.) final string for heat-flow measurements: no slots, open end. Only the surface string had a 7-in.-o.d. pipe cemented in.

Source: Purtymun 1973.

TABLE XXVI-B. Precambrian Test Holes PC-1 and PC-2

PC-1 December 1983 Elevation 8400 ft

Log	Thickness (ft)	Depth (ft)
Overburden	12	12
Bandelier Tuff	181	193
Abo Formation	814	1007
Madera Limestone	1171	2178

Note: Completed in granite wash above the Precambrian. Hole cased to depth of 2175 ft. Drilled by cable tool. No geophysical logs. Geology by Dan Miles in Purtymun et al. 1987.

PC-2 December 1983 Elevation 8623 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff	394	394
Abo Formation	737	1131
Madera Limestone	694	1825

Note: Hole blew out at a depth of 1825 ft when a pocket of gas was encountered; hole cased to a depth of 1819 ft. Drilled by cable tool. No geophysical logs. Geology by Dan Miles in Purtymun et al. 1987.

Source: Purtymun et al. 1987.

TABLE XXVI-C. Geologic Logs and Construction Data for Supply Wells at Fenton Hill

Supply Wells

FH-1 August 1976 Elevation 8690 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff	50	50
Paliza Canyon Formation	310	360
Abiquiu Tuff	90	450

FH-2 December 1980 Elevation 8691 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff	50	50
Paliza Canyon Formation	310	360
Abiquiu Tuff	73	433
Abo Formation	17	450

FH-3 March 1980 Elevation 8692 ft

Log	Thickness (ft)	Depth (ft)
Bandelier Tuff	50	50
Paliza Canyon Formation	310	360
Abiquiu Tuff	95	455
Abo Formation	5	460

Well Construction FH-1, FH-2, and FH-3

	FH-1	FH-2	FH-3
Diameter of Casing (in.)	7[a]	16	16
Depth Cased (ft)	450	450	460
Depth to Water (ft)	372	371	373
Elevation to Water Surface (ft)	8318	8320	8319
Thickness to Aquifer (ft)	78+	63	85
Length of Screen or Slots (ft)	60[b]	59[c]	69[c]
Specific Capacity (gpm/ft)	100+	≈1	<1

[a]Set with screen on liner 5-1/2 in.
[b]Slotted screen 0.025-in. slots
[c]Torch-slotted casing.

Note: Water levels from 1980 measurements.

Source: Becker et al. 1981.

TABLE XXVI-D. Surface Water Quality at Water Stations in the Jemez Mountains	
Sodium Chloride	Remarks
Redondo Creek (U)	above confluence with Sulphur Creek
Jemez River (R)	below confluence with Rio Guadalupe
Calcium Bicarbonate	
San Antonio Creek (N)	above confluence with Sulphur Creek
Rio Cebolla (T)	below confluence with Lake Fork Canyon
Rio Guadalupe	above confluence with Jemez River
Lake Fork 1 (LF-1)	at crossing to stock corral
Lake Fork 2 (LF-2)	change in channel gradient
Lake Fork 3 (LF-3)	bend in road, old beaver dam in channel
Lake Fork 4 (LF-4)	below corral on north side of valley
Calcium Sulfate	
Sulphur Creek (V)	at SR-4 above confluence with Redondo Creek
Sulphur Creek (F)	above confluence with San Antonio Creek
Sodium Bicarbonate	
Jemez River (J)	at U.S. Geol. Survey gaging station

Note: Letters or combinations of letters and numbers refer to the sampling locations shown in Fig. XXVI-F.

Sources: Purtymun et al. 1974 and 1991.

TABLE XXVI-E. Ground Water Quality at Water Stations in the Jemez Mountains

Sodium Chloride	Remarks
Location JF-1	Limestone Spring (mineral) CMP under SR-4
Location JF-5	Soda Dam (Hot Spring) west side SR-4
Calcium Bicarbonate	
FH-1	supply well Fenton Hill site
FH-2	observation well Fenton Hill site
Location 6	spring overflow (pump house) in valley
Location 27	artesian well overflow from tank
Location 39	USFS cattle tank—Lake Fork Canyon
Location 42	well (Goldstone)
Location 48	well (La Cueva Lumber Yard)
Location 53	well (Crane, Sulphur Creek)
Location 54	well (Hansen, Sulphur Creek)
Location 55	well (Olsen, Sulphur Creek)
Sodium Bicarbonate	
JS-2,3	USFS Compound—Water Supply Jemez
JS-4,5	USFS Office—Water Supply Jemez
Location 4	Hofheins, Community Water Source
Location 31	Cold Spring—discharge Bandelier Tuff
RV-2	San Antonio Hot Spring
RV-4	Spence Hot Spring
RV-5	McCannley Hot Spring
Location 47	well (Lewis)

Note: Numbers or combinations of numbers and letters refer to the sampling locations shown in Fig. XXVI-F.

Sources: Purtymun et al. 1974 and 1991.

TABLE XXVI-F. Locations and Elevations (NAD 1927)

A. Heat-Flow Sites

No locations (generalized in Fig. XXVI-A)

B. Test Holes

GT-1	N 1,784,600	E 375,600	8475 ft
TH-A	N 1,775,700	E 376,700	8450 ft
TH-B	N 1,799,600	E 380,600	8625 ft
TH-C	N 1,808,600	E 389,300	8700 ft
TH-D	N 1,779,600	E 363,400	7900 ft
PC-1	N 1,774,600	E 378,000	8400 ft
PC-2	N 1,774,400	E 371,500	8623 ft

C. Supply Well and Observation Holes

No coordinates or elevations (within TA-57, see Fig. XXVI-C)

TA-57	N 1,775,800	E 375,000	8700 ft

D. Surface Water Stations

Redondo Creek (U)	N 1,774,500	E 388,100	7750 ft
Jemez River (R)	N 1,699,300	E 356,200	5645 ft
Jemez River (S)	N 1,699,900	E 356,100	5650 ft
San Antonio Creek (N)	N 1,770,800	E 384,700	7620 ft
Rio Cebolla (T)	N 1,766,200	E 348,000	7460 ft
Rio Guadalupe (Q)	N 1,699,900	E 355,900	5650 ft
Lake Fork 1 (LF-1)	N 1,769,800	E 360,500	7845 ft
Lake Fork 2 (LF-2)	N 1,768,300	E 357,000	7800 ft
Lake Fork 3 (LF-3)	N 1,766,800	E 352,500	7610 ft
Lake Fork 4 (LF-4)	N 1,766,900	E 350,800	7510 ft
Sulphur Creek (V)	N 1,774,700	E 386,800	7720 ft
Sulphur Creek (F)	N 1,770,900	E 385,000	7620 ft
Jemez River (J)	N 1,756,500	E 381,300	6750 ft

E. Ground Water Stations

Location JF-1 (Hot Spring)	N 1,757,500	E 382,300	6780 ft
Location JF-5 (Hot Spring)	N 1,743,600	E 370,600	6400 ft
FH-1 Supply Well	N 1,775,800	E 375,000	8675 ft
FH-2 Observation Well	N 1,775,800	E 375,000	8692 ft
Location 6 (Spring)	N 1,772,800	E 383,600	7670 ft
Location 27 (Well)	N 1.773,600	E 383,900	7650 ft
Location 39 (Spring)	N 1,770,300	E 361,900	7880 ft
Location 42 (Well)	N 1,772,300	E 381,400	7840 ft
Location 48 (Well)	N 1,771,200	E 384,600	7630 ft
Location 53 (Well)	N 1,776,700	E 388,800	7835 ft
Location 54 (Well)	N 1,776,200	E 388,200	7795 ft
Location 55 (Well)	N 1,776,600	E 388,500	7805 ft
JS-2, 3 (Spring)	N 1,735,700	E 369,300	6220 ft
JS-4, 5 (Spring)	N 1,741,100	E 370,800	6265 ft
Location 4 (Well)	N 1,773,000	E 382,200	7760 ft
Location 31 (Spring)	N 1,767,200	E 350,900	7600 ft
RV-2 (Hot Spring)	N 1,796,800	E 383,000	8360 ft
RV-4 (Hot Spring)	N 1,764,700	E 387,800	7360 ft
RV-5 (Hot Spring)	N 1,753,900	E 388,300	7340 ft
Location 47 (Well)	N 1,770,700	E 384,600	7640 ft

XXVII. GUAJE AND LOS ALAMOS RESERVOIRS

Water from Guaje and Los Alamos Reservoirs was used for municipal and industrial use at Los Alamos during the early days of the Manhattan Project (Fig. XXVII-A). Use of the water from the reservoirs was discontinued in 1959 because of intermittent periods of turbidity caused by storm runoff and because of difficulties in maintaining bacteriological levels below the limits allowed for municipal supply.

Both of the reservoirs and adjacent areas are open for recreational use. Water from the reservoirs is available for irrigation of lawns and shrubs in the community and Laboratory. Parts of the water lines are above ground and are subject to freezing; thus, water use from the reservoirs is limited to the period from late spring to early fall.

Guaje Reservoir in upper Guaje Canyon has a capacity of 250 000 gallons and has a drainage area of 5.6 sq mi. The reservoir is for diversion rather than storage, as perennial flow is maintained by a spring in the canyon above the reservoir. Water flows by gravity through 6.8 miles of distribution lines to Los Alamos.

Los Alamos Reservoir in upper Los Alamos Canyon has a capacity of about 13 000 000 gallons and has a drainage area of 6.4 sq mi. Water flows by gravity through 2.6 miles of distribution lines to the townsite.

Since 1958, the water lines from both reservoirs have not been part of, or been connected to, the distribution system for the municipal water supply.

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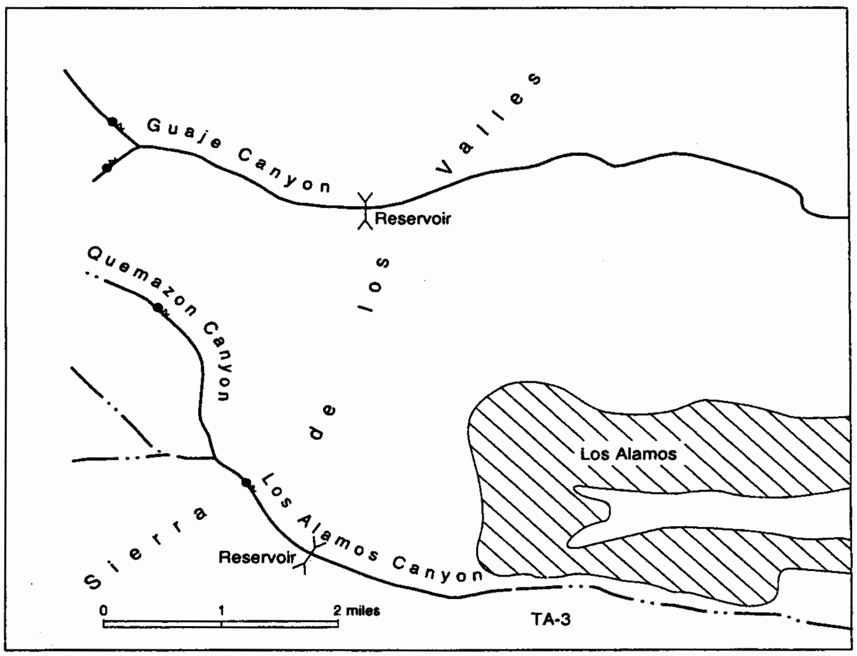

Fig. XXVII-A. Locations of Guaje and Los Alamos reservoirs.

TABLE XXVII-A. Locations and Elevations (NAD 1927)

Guaje Reservoir	N 1,794,000	E 471,600	8017 ft
Los Alamos Reservoir	N 1,777,200	E 468,600	7659 ft

XXVIII. LOW-FLOW INVESTIGATIONS IN SANTA CLARA, GUAJE, LOS ALAMOS, AND FRIJOLES CANYONS

Low-flow investigations were made in Santa Clara, Guaje, Los Alamos, and Frijoles Canyons in 1958, 1959, and 1960 (Fig. XXVIII-A). An additional set of measurements were made in Santa Clara Canyon in 1967. The low-flow investigations were made to relate geology or geologic structure to loss or gain in stream flow in evaluating recharge or discharge to stream-connected aquifers or the main aquifer.

Geologic sections were prepared along the stream channels of Santa Clara (Fig. XXVIII-B), Guaje (Fig. XXVIII-C), and Los Alamos Canyons (Fig. XXVIII-D), and the Rito de los Frijoles (Fig. XXVIII-E) using existing geologic maps modified by field investigations. The subsurface correlations were interpreted from outcrops and logs of existing test holes or wells.

The results of the low-flow measurements (cu ft/s) for Santa Clara, Guaje, Los Alamos, and Frijoles Canyons are shown in Tables XXVIII-A through XXVIII-D respectively. The annual runoff (volume of runoff as determined from gaging station records as compared to drainage area) for Santa Clara and Frijoles Canyons is also shown on the tables for those canyons.

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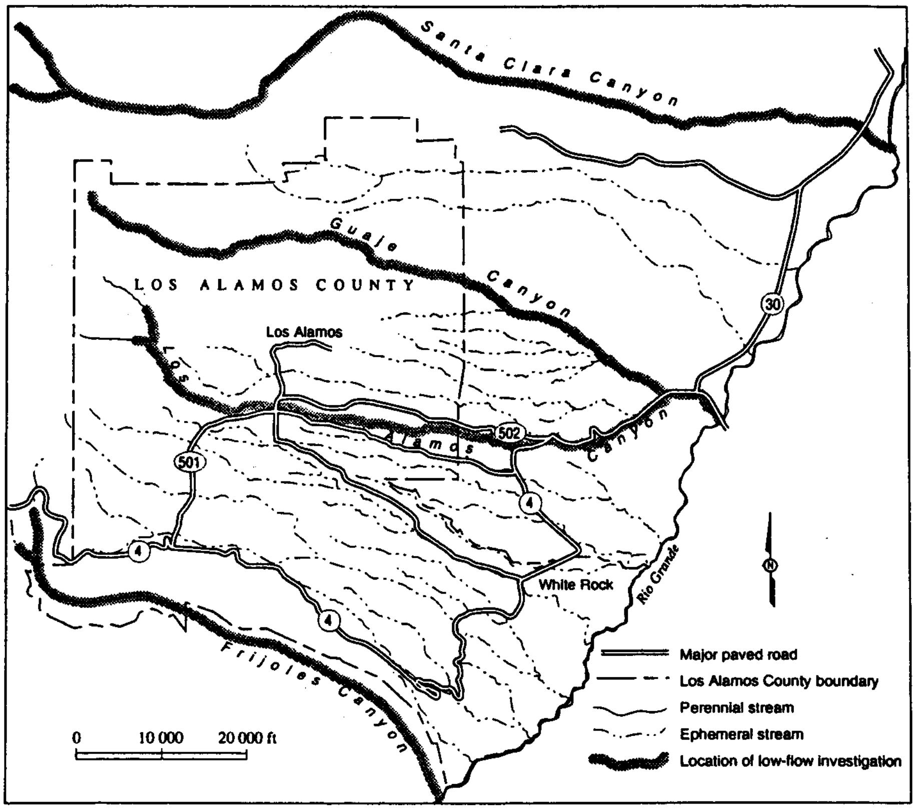

Fig. XXVIII-A. Locations of low-flow investigations in Santa Clara, Guaje, Los Alamos, and Frijoles Canyons.

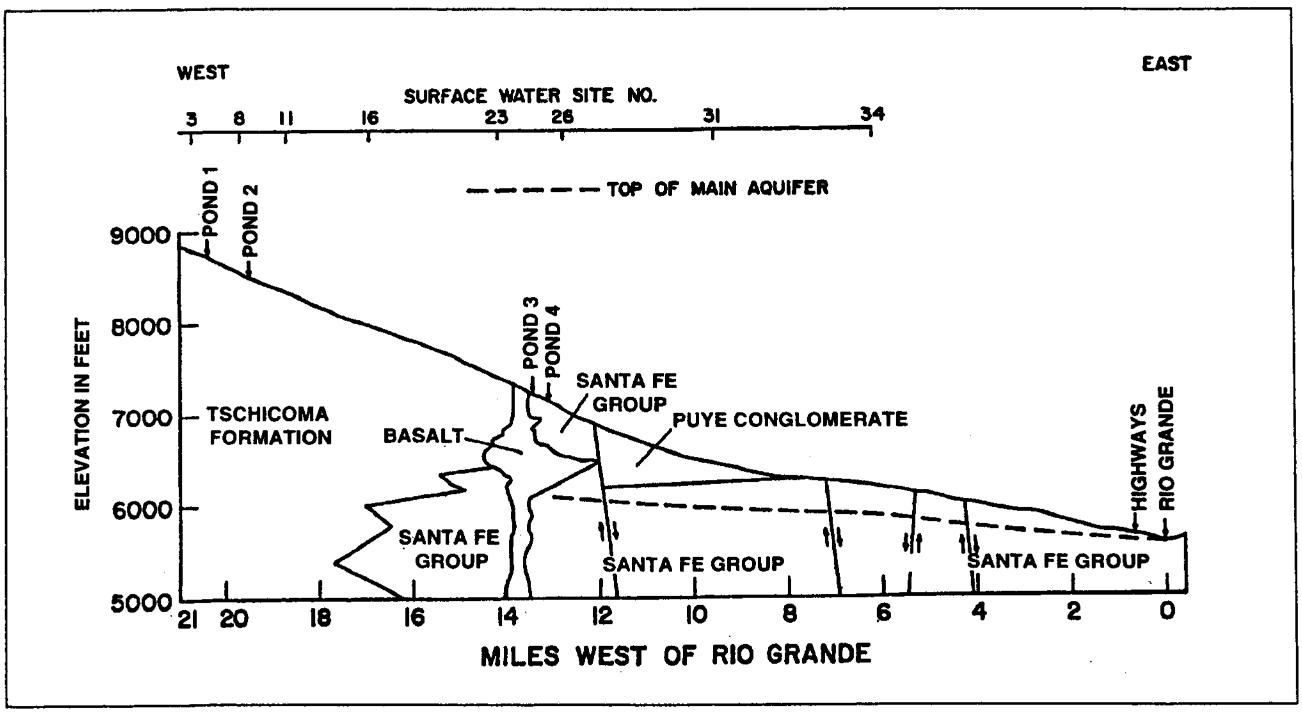

Fig. XXVIII-B. Geologic section of Santa Clara Canyon showing locations of low-flow measurements.

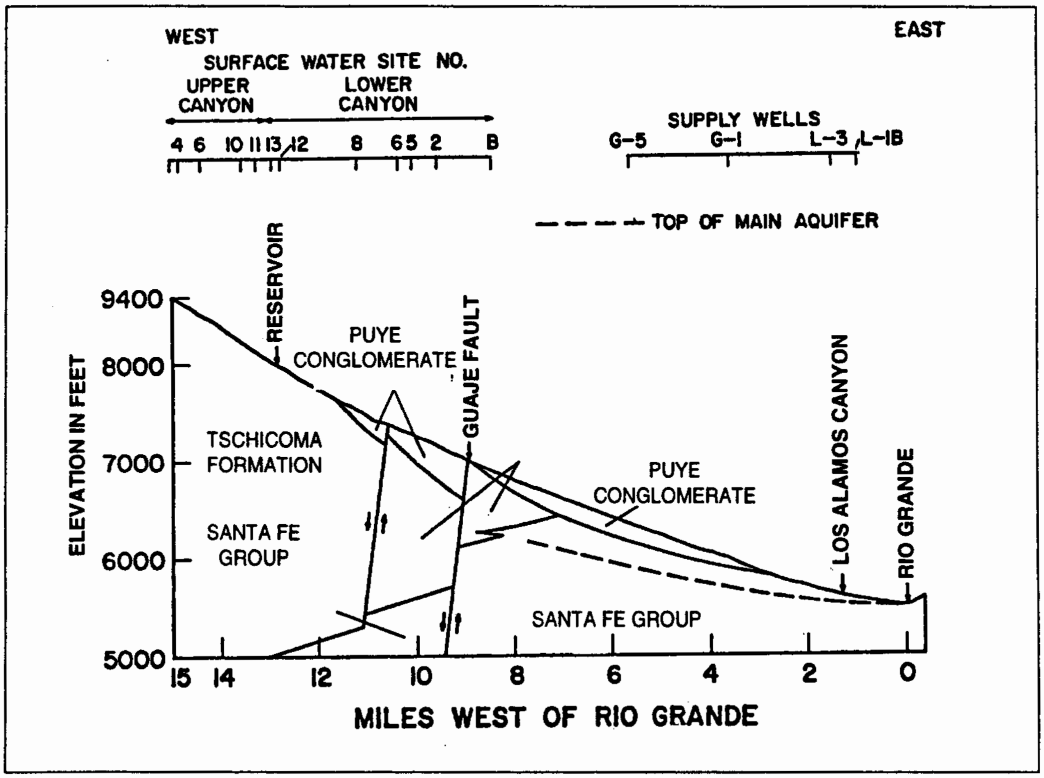

Fig. XXVIII-C. Geologic section of Guaje Canyon showing locations of low-flow measurements.

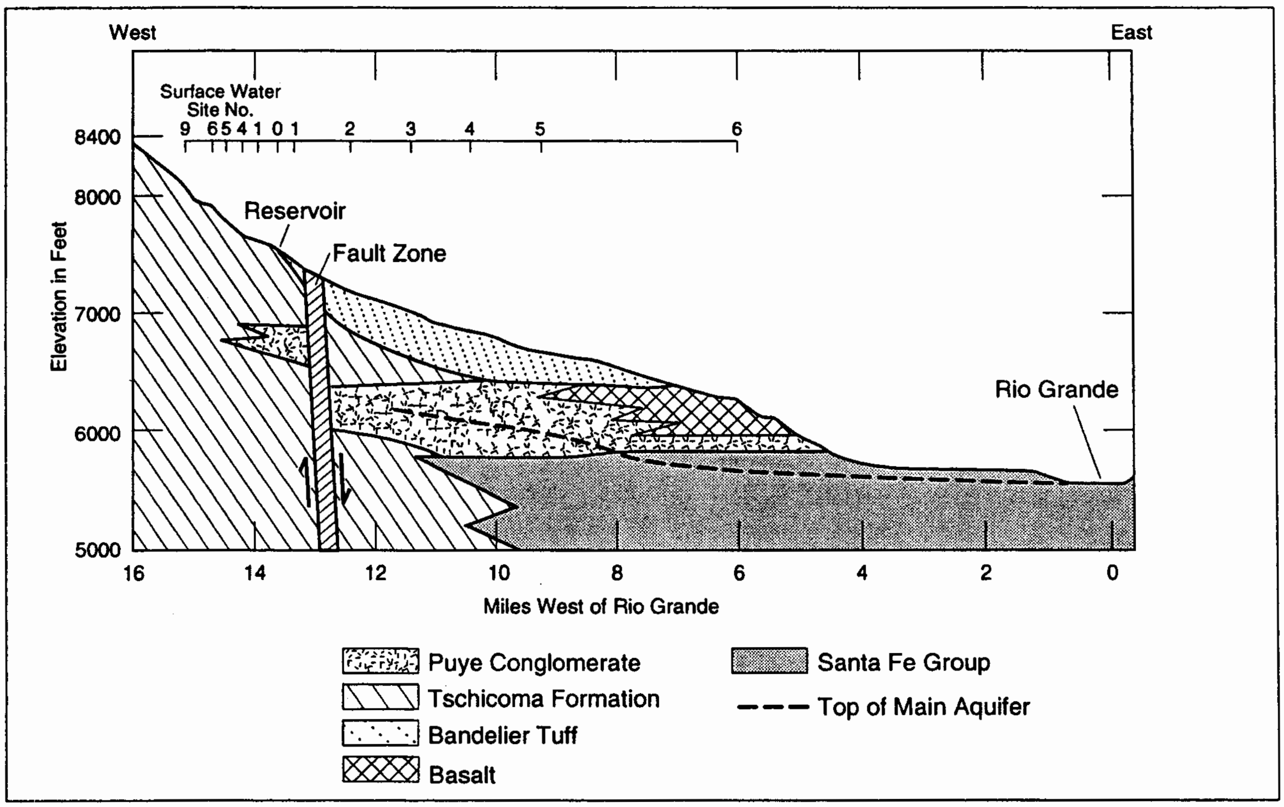

Fig. XXVIII-D. Geologic section of Los Alamos Canyon showing locations of low-flow measurements.

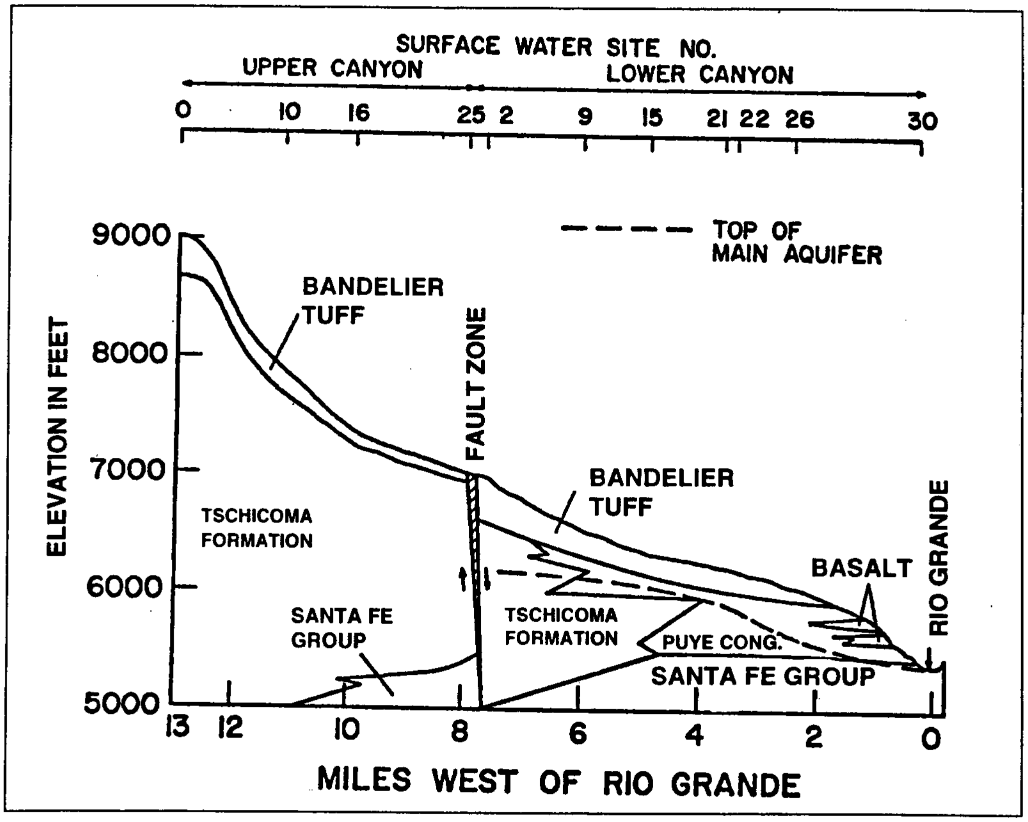

Fig. XXVIII-E. Geologic section of Frijoles Canyon showing locations of low-flow measurements.

TABLE XXVIII-A. Low-Flow Measurements and Annual Runoff in Santa Clara Canyon

Santa Clara Low-Flow Measurements (cubic feet per second)

	1958	1959				1960		1967
Site No.	Oct. 14–15	Apr. 14	June 2	Aug. 31	Oct. 12–14	May 16–17	June 20–22	June 30
3	2.0	2.2	2.7	2.6	2.2	5.4	1.9	—
8	4.0	4.0	4.9	4.1	3.4	7.1	2.0	3.6
11	4.0	4.1	5.2	4.8	3.8	8.6	2.8	3.5
16	4.6	5.4	4.9	5.6	4.5	8.6	2.8	3.4
23	4.5	5.4	5.2	6.1	4.3	7.9	3.7	3.4
26	3.9	6.0	5.3	4.9	4.2	8.8	4.3	3.2
31	5.5	5.0	4.6	5.3	3.4	8.3	3.6	2.7
34	3.1	3.6	3.9	4.3	3.2	7.4	2.1	—

Annual Runoff at Gaging Station in Santa Clara Canyon

Water Year	Annual Runoff	
	Acre Feet	Inches
1937	3368	1.8
1938	3039	1.7
1939	2630	1.4
1940	2825	1.5
1941	5602	3.0
1950	2460	1.3

Drainage area 34.5 sq mi.

TABLE XXVIII-B. Low-Flow Measurements in Guaje Canyon

Guaje Canyon Low-Flow Measurements (cubic feet per second)

1958		1959				1960		1967	
Site No.	Oct. 17	Apr. 15	June 3	Sept. 1 & 4	Oct. 12–14	May 16–17	June 20–22	May 3[a]	June 9[a]
4	0.2	0.2	0.3	0.5	0.2	0.4	0.3		
6	0.4	0.4	0.4	1.0	0.4	1.0	0.5		
10	0.4	0.4	0.5	2.0	0.4	1.1	0.5		
11	0.5	0.5	0.5	2.0	0.4	1.0	0.6		
13	0.4	0.6	0.4	2.7	0.5	1.5	0.5	0.34	0.31
Dam[b]									
12	0.3	0.7	0		0	0.9	0	0.36	0.34
8	0.3	0.8	0.04		0.01	0.8	0.04	0.29	0.26
6	0.2	0.5	0.02		0	1.0	0.05	0.24	0.21
5	0.03	0.3	0		0	1.0	0	0.17	0.15
2	0.05	0.4	0.04		0.08	1.2	0.1	0.21	0.18
B	0	—	0		0	0.9	0	0	0

[a] Measurements with Parshall flume.

[b] Water diverted to Los Alamos on all runs except April 15, 1959.

TABLE XXVIII-C. Low-Flow Measurements in Los Alamos Canyon

Los Alamos Canyon Low-Flow Measurements (cubic feet per second)

	1958		1959		1961
Site No.	May 23	Oct. 30	Apr. 15	May 15	Apr 27
9	—	0.0	0.0	0.0	—
6	—	0.4	0.3	0.4	—
5	—	0.1	0.4	0.4	—
4	—	0.1	0.4	0.4	—
1	—	0.1	0.5	0.5	—
Dam					
1	—	—	—	—	3.2[a]
2	—	—	—	—	3.2
3	9.0[a]	—	—	—	2.9
4	—	—	—	—	3.1
5	6.3	—	—	—	1.2
6	5.5	—	—	—	0.3

[a] Runoff over dam.

TABLE XXVIII-D. Low-Flow Measurements and Annual Runoff in Frijoles Canyon

Frijoles Canyon Low-Flow Measurements (cubic feet per second)

Site No.	1958 Oct. 20	1959 Apr. 16	Apr. 29	June 2–3	Sept. 2–3	Oct. 12–14	1960 May 16–17	June 20–22
10	—	—	0.9	0.5	0.3	0.1	0.9	0.5
16	—	—	1.4	0.9	0.6	0.6	1.4	0.9
25	—	—	2.1	1.5	1.2	1.2	1.6	1.2
2	1.9	2.7	—	1.6	—	1.4	2.1	1.2
9	1.2	2.6	—	1.5	1.2	1.0	1.5	0.8
15	1.5	2.4	—	1.1	1.2	1.1	—	0.9
21	1.2	2.2	—	1.3	1.2	1.0	1.7	1.0
22	1.3	2.6	—	1.1	1.1	1.0	1.5	0.8
26	1.2	1.6	—	1.1	1.2	0.8	1.4	0.8
30	—	—	—	—	0.7	0.5	1.2	0.3

Annual Runoff at Gaging Station in Frijoles Canyon

Water Year	Annual Runoff	
	Acre Feet	Inches
1960	1332	2.8
1961	1180	2.5
1962	1240	2.6
1963	—	—
1964	580	0.6
1965	830	0.8
1966	735	0.8
1967	673	0.7
1968	1260	1.3
1969	1040	1.1

Gaging station moved in 1963; drainage area 1960–1962, 8.9 sq mi; 1964–1967, 17.5 sq mi.

TABLE XXVIII-E. Locations and Elevations

Locations of low-flow stations in each of the four canyons are shown in Figs. XXVII-B through E.

XXIX. SURFACE WATER GAGING STATIONS ON THE RIO CHAMA, RIO GRANDE, JEMEZ RIVER, RIO GUADALUPE, SANTA CLARA CREEK, AND RITO DE LOS FRIJOLES

Surface water stations that have gaging records on the Rio Chama, Rio Grande, Jemez River, Rio Guadalupe, Santa Clara Creek, and Rito de los Frijoles have been used in monitoring the quality of surface and ground water at or adjacent to Los Alamos or in low-flow investigations in the area (Fig. XXIX-A). The stations have been operated by the U.S. Geological Survey Water Resources Division in Albuquerque, New Mexico. The Laboratory has used these stations upgradient from Los Alamos for the collection of surface water for chemical and radiochemical background, and to evaluate the effect (if any) of the Laboratory's operation on the downgradient stations.

A. Rio Chama

The Rio Chama at Chamita has a drainage area of about 3144 sq mi in north-central New Mexico and a small part of southern Colorado. The Rio Chama is tributary to the Rio Grande about 2.5 mi west of the gaging station. The river also receives some transmountain diversion water from the San Juan River. The period of record is from October 1912 to 1990. The range in discharge during the period of record has been from no flow at times to as much as 15 000 cfs (cubic ft/sec) on May 22, 1920.

B. Rio Grande

The three stations on the Rio Grande used for monitoring that have gaging stations are at Embudo, Otowi, and Cochiti. A fourth station that has no gaging station at present but is used for monitoring is on the Rio Grande at Bernalillo (Fig. XXIX-A).

The Rio Grande at Embudo has a drainage area of about 10 400 sq mi in north-central New Mexico and southern Colorado. The period of record is from January 1889 to 1990. The discharge during the period of record has ranged from 130 cfs on June 30, 1902, to 16 200 cfs on June 19, 1903.

The Rio Grande at Otowi has a drainage area of about 14 300 sq mi in north-central New Mexico and southern Colorado. The period of record is from February 1895 to 1905 and from June 1909 to 1990. The discharge during the period of record has ranged from 60 cfs July 4–5, 1902, to 24 400 cfs May 23, 1920.

The Rio Grande below Cochiti Dam has a drainage area of about 14 900 sq mi in north-central New Mexico and southern Colorado. The period of record is from October 1970 to 1990. The discharge is controlled by Cochiti Reservoir and has ranged from 0.5 cfs August 3–5, 1977, to 10 300 cfs on July 26, 1971.

The Rio Grande at Bernalillo (at SR-44) has been used as a monitoring station from the early 1970s. The drainage area above the station is 25 400 sq mi in north-central New Mexico and southern Colorado. A gaging station was operated at the site from May 1941 to September 1969, when it was discontinued. The discharge during the period of record ranged from no flow at times to 25 400 cfs.

C. Jemez River

There are two gaging stations on the Jemez River and one on the Rio Guadalupe, a tributary of the Jemez, that are near or at monitoring stations.

The upper gaging station is on the Jemez River below the East Fork, Jemez Springs, NM. The drainage area above the station is 173 sq mi, mainly from the Valles Caldera. The periods of record are from July 1949 to October 1950, May 1951 to September 1957, March 1958 to September 1976, and July 1981 to September 1990, when the station was discontinued.

The discharge during these periods ranged from 0.9 cfs on January 24, 1969, to 2500 cfs on April 21, 1958.

The second station lies on the Jemez River below the confluence with the Rio Guadalupe, near Jemez, NM. Its drainage area is about 470 sq mi, from the Valles Caldera and the western side of the caldera. The periods of record are from June 1936 to May 1941, August 1949 to October 1950, May 1951 to September 1952, and March 1953 to 1990. The discharge during these periods ranged from 1.2 cfs on July 25, 1981, to 5900 cfs April 21, 1958.

D. Rio Guadalupe

The drainage area above the gaging station on the Rio Guadalupe at Box Canyon, NM is about 235 sq mi, along the western side of the Valles Caldera. The periods of record are from November 1938 to September 1942, August 1949 to September 1950, May 1951 to September 1957, May 1958 to September 1976, and July 1981 to 1990. The discharge during these periods ranged from 2.8 cfs on December 9, 1967, to 3190 cfs on May 13 and 14, 1941.

E. Santa Clara Creek

Low-flow investigations utilized some of the data from the gaging station on Santa Clara Creek. Santa Clara Creek is on the Santa Clara Pueblo Indian Reservation. The drainage area above the gaging station is 34.5 sq mi, along the eastern flank of the Sierra de los Valles and part of the Pajarito Plateau. The creek discharges into the Rio Grande. The periods of record for the station are from February 1936 to September 1941, August 1949 to September 1961, and April 1984 to 1990. There is some diversion for irrigation above the gage. The discharge during the periods of record ranged from no flow August 8–13, 1984 and March 9, 1990 (during periods of extreme diversion), to 970 cfs on September 22, 1941.

F. Rito de los Frijoles

The Rito de los Frijoles heads on the flanks of the Sierra de los Valles and has cut a deep canyon across the Pajarito Plateau to discharge into the Rio Grande. The stream and canyon are in Bandelier National Monument. Gaging stations have been operated on the Rito de los Frijoles at two different locations. In 1959 a station was located about 5.8 mi west of the park headquarters at the upper crossing. The station was operated at the western edge of the Pajarito Plateau (at the Pajarito Fault Zone) to aid in the low-flow investigations. In 1963 the station was moved to the park headquarters, to monitor flow across the plateau.

The drainage area above the gaging station at the upper crossing (on the flanks of the mountains) is 8.9 sq mi. The period of record for the station was from August 1959 to October 1963. The discharge during that period ranged from 0.7 cfs on April 7, 1960, to 13 cfs on June 29, 1960.

When the station was moved to near the park headquarters, the drainage area above the station increased to 18.1 sq mi. The periods of record for the new station were July 1963 to September 1969 and July 1977 to September 1982. The discharge ranged from no flow (due to a freeze-up) on February 6, 1968, to 3030 cfs on July 21, 1978. Prior to the 1977 forest fire that destroyed 44% of the vegetation and trees in the drainage area, the largest discharge was 19 cfs on June 18, 1965. The forest fire changed the runoff characteristics of the canyon.

REFERENCES

W. D. Purtymun, "Geohydrology of Bandelier National Monument, New Mexico," Los Alamos Scientific Laboratory report LA-5716-MS (1980).

Surface Water Records for the above U.S. Geol. Survey Gaging Stations from 1936 to 1961 are found in the annual reports "Surface Water Supply of the United States, Part 8, Western Gulf of Mexico Basins," U.S. Geol. Survey Water-Supply Papers.

Surface Water Records for the above U.S. Geol. Survey Gaging Stations from 1961 through 1990 are found in the annual reports "Water Resources Data For New Mexico," U.S. Geol. Survey, Water Resources Division, Albuquerque, New Mexico.

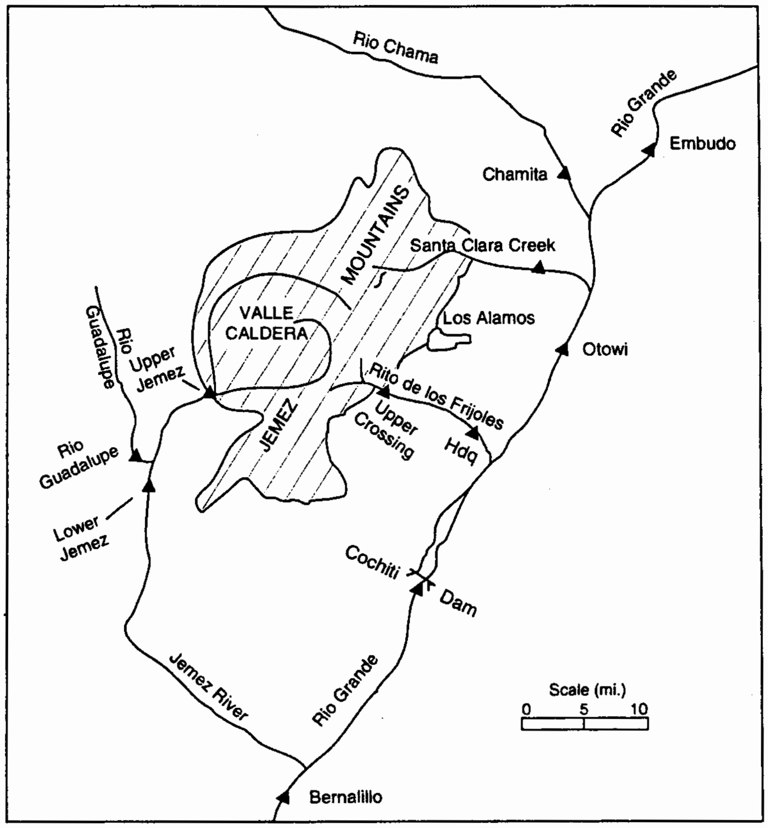

Fig. XXIX-A. Locations of gaging stations on the Rio Chama, Rio Grande, Jemez River, Rio Guadalupe, Santa Clara Creek, and Rito de los Frijoles.

TABLE XXIX-A. Locations and Elevations of Gaging Stations (NAD 1927)

A. Rio Chama			
Chamita	N 1,846,000	E 541,200	5660 ft
B. Rio Grande			
Embudo	N 1,874,100	E 584,400	5812 ft
Otowi	N 1,773,600	E 533,000	5495 ft
Cochiti (below dam)	N 1,685,400	E 479,500	5240 ft
Bernalillo	N 1,552,700	E 379,900	5054 ft
C. Jemez River			
Near Jemez Springs	N 1,756,200	E 381,400	6700 ft
Near Jemez Pueblo	N 1,699,600	E 353,500	5650 ft
D. Rio Guadalupe			
Box Canyon	N 1,722,000	E 347,900	6040 ft
E. Santa Clara Creek			
Gaging Station	N 1,810,300	E 525,300	6080 ft
F. Rito de los Frijoles			
Upper Crossing	N 1,751,900	E 467,100	7015 ft
Park Headquarters	N 1,738,100	E 494,500	6040 ft

XXX. STUDY OF SURFACE IMPOUNDMENT AT TA-53

The study of the surface impoundment at TA-53 was made to meet certain requirements of the Resource Conservation and Recovery Act and to support the Part B permit application for surface impoundment. The basic information collected describes the potential for human exposure to contaminants via several pathways. The main pathways referred to in this report are ground water, surface water, and release from the soil. In the course of this investigation, eight test holes were drilled; five were completed as moisture-access holes for future monitoring of the dispersion and movement of moisture from the surface impoundments; one was completed as a pore gas monitoring hole with five sampling ports at various depths; and two open holes were drilled for geologic and hydrologic information.

The moisture-access and pore gas sampling holes and one of the open holes were completed on the surface of the mesa (Fig. XXX-A). The eighth hole was completed in Sandia Canyon just south of the surface impoundment that is on the mesa top. Geologic logs and completion data for the test holes are shown on Table XXX-A. Geologic descriptions used are after Baltz (1963), Keller (1968), and Purtymun (1966); see also sections I-D4 and XXIII-G of this report. The locations and elevations of these holes were not surveyed.

REFERENCE

S. G. McLin, "Identification of Potential Pathways of Human Exposure to Hazardous Wastes Constituent Releases from the TA-53 Surface Impoundments," Los Alamos National Laboratory, Group EM-8 internal document, Sept. 6, 1991.

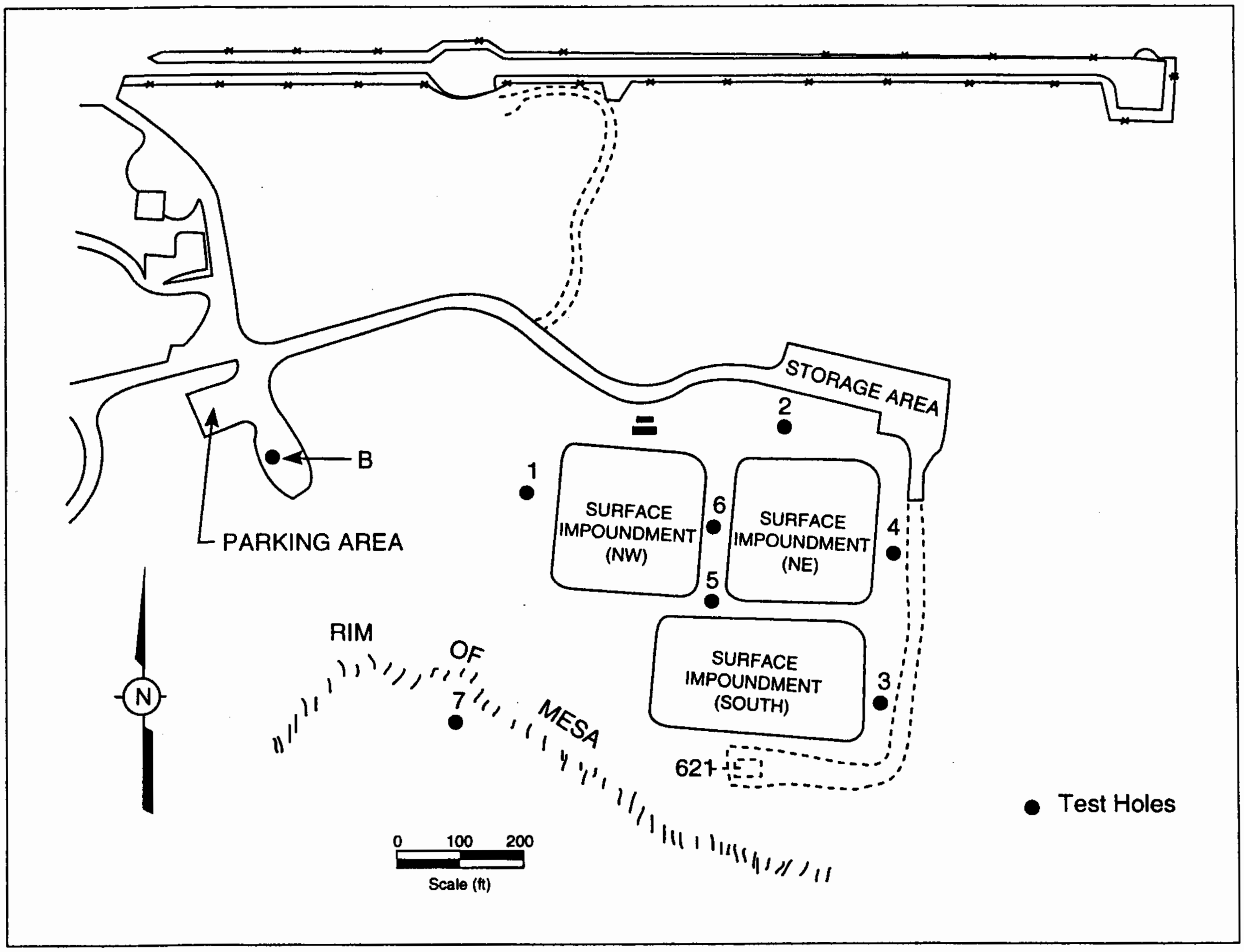

Fig. XXX-A. Locations of test holes near the TA-53 surface impoundment.

TABLE XXX-A. Geologic Logs and Construction Data for Test Holes at TA-53

1. Test Hole B-53
Moisture-Access Hole

Hole: Dry

Log	Thickness (ft)	Depth (ft)
Surface fill material	1	1
Tuff, Tshirege Member, Unit 2B low moisture content	48	49

Construction: Hole augered to 4-in. diam; 45 ft of 2-in.-diam aluminum pipe set 0 to 45 ft; steel locking cap.

2. Test Hole 1-53
Moisture-Access Hole

Hole: Dry

Log	Thickness (ft)	Depth (ft)
Surface fill material	1	1
Tuff, Tshirege Member, Unit 2B low moisture content	48	49

Construction: Hole augered to 4-in. diam; 46 ft of 2-in.-diam aluminum pipe set 0 to 46 ft; steel locking cap.

3. Test Hole 2-53
Moisture-Access Hole

Hole: Dry

Log	Thickness (ft)	Depth (ft)
Surface fill material	1	1
Tuff, Tshirege Member, Unit 2B low moisture content	48	49

Construction: Hole augered to 4-in. diam; 46 ft of 2-in.-diam aluminum pipe set 0 to 46 ft; steel locking cap.

4. Test Hole 3-53
Moisture-Access Hole

Hole: Dry

Log	Thickness (ft)	Depth (ft)
Surface fill material	1	1
Tuff, Tshirege Member, Unit 2B low moisture content	48	49

Construction: Hole augered to 4-in.-diam; 48 ft of 2-in.-diam aluminum pipe set 0 to 48 ft; steel locking cap.

5. Test Hole 4-53
Moisture-Access Hole

Hole: Dry

Log	Thickness (ft)	Depth (ft)
Surface fill material	1	1
Tuff, Tshirege Member, Unit 2B low moisture content	48	49

Construction: Hole augered to 4-in. diam; 47 ft of 2-in.-diam aluminum pipe set 0 to 47 ft; steel locking cap.

TABLE XXX-A. Geologic Logs and Construction Data for Test Holes at TA-53 (Continued)

6. Test Hole 5-53 — Hole: Dry

Pore Gas Well

Log	Thickness (ft)	Depth (ft)
Surface fill material	3	3
Tuff, Tshirege Member, Unit 2B low moisture content	65	68
Tuff, Tshirege Member, Unit 2A low moisture content	32	100

Construction: Hole augered to 4-in. diam; 4 ft of aluminum casing 0 to 4 ft; cement 0 to 1 ft; bentonite 1 to 4 ft; sampling ports at 20 ft, 40 ft, 60 ft, 80 ft, and 93.5 ft; hole adjacent to sampling tube filled with sand; steel locking cap.

7. Test Hole 6-53 — Hole: Dry

Open Hole

Log	Thickness (ft)	Depth (ft)
Surface fill material	3	3
Tuff, Tshirege Member, Unit 2B low moisture content	65	68
Tuff, Tshirege Member, Unit 2A low moisture content	45	113
Tuff, Tshirege Member, Unit 1B	20	133
Tuff, Tshirege Member, Unit 1A	17	150

Construction: Open hole.

8. Test Hole 7-53 — Hole: Dry

Open Hole

Log	Thickness (ft)	Depth (ft)
Alluvium	1	1
Tuff, Tshirege Member, Unit 2B low moisture content	23	24
Tsankawi Member, low moisture content	19	43
Otowi Member, low moisture content	37	80

Construction: 77 ft of 2-in.-diam aluminum pipe set in hole 0 to 77 ft; bentonite pellets 0 to 0.5 ft; silica sand 0.5 to 35 ft; bentonite 35 to 37 ft; lysimeter port at 37 ft with fine silica from 37 to 39 ft; 39 ft to 40 ft silica sand; 40 to 77 ft fine sand; steel locking cap; hole cored to 6.875-in. diam; hole diam 7.25 in.

XXXI. TRANSPORT STUDIES OF URANIUM IN POTRILLO CANYON TA-36

Three shallow moisture-access holes were drilled in Potrillo Canyon in 1989 to investigate the infiltration of surface water into the alluvium. Two deeper holes were cored in 1991. These test holes were completed as wells. One had three zones at various depths separated from each other by bentonite and cement; the second well was constructed with two zones. The zones were packed with sand. The moisture-access holes and wells were completed as part of a study to determine whether there was recharge to the alluvium and underlying tuff and transport of depleted uranium from the intermittent stream in Potrillo Canyon in TA-36. The wells were installed to study the chemistry and radiochemistry of infiltrating water at different depths.

The locations of the three moisture-access holes and two wells are shown in Fig. XXXI-A. The construction and geologic logs for the moisture-access holes appear in Table XXXI-A, while the logs for the test wells appear in Figs. XXXI-B and XXXI-C.

REFERENCE

N. M. Becker, "Influence of Hydraulic and Geomorphologic Components of a Semi-Arid Watershed on Depleted Uranium Transport," Los Alamos National Laboratory document LA-UR-93-2165.

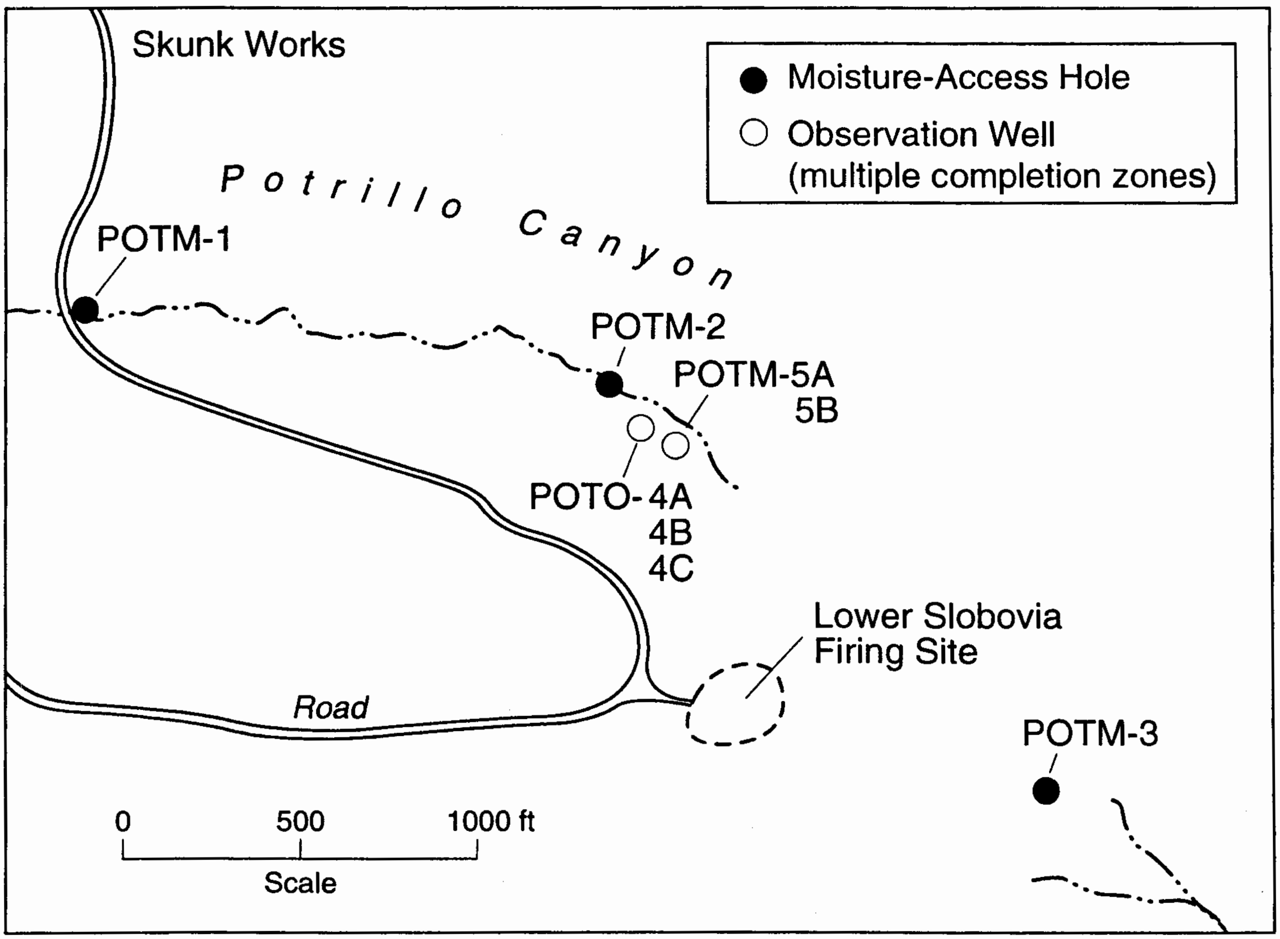

Fig. XXXI-A. Locations of moisture-access holes and observation wells in Potrillo Canyon.

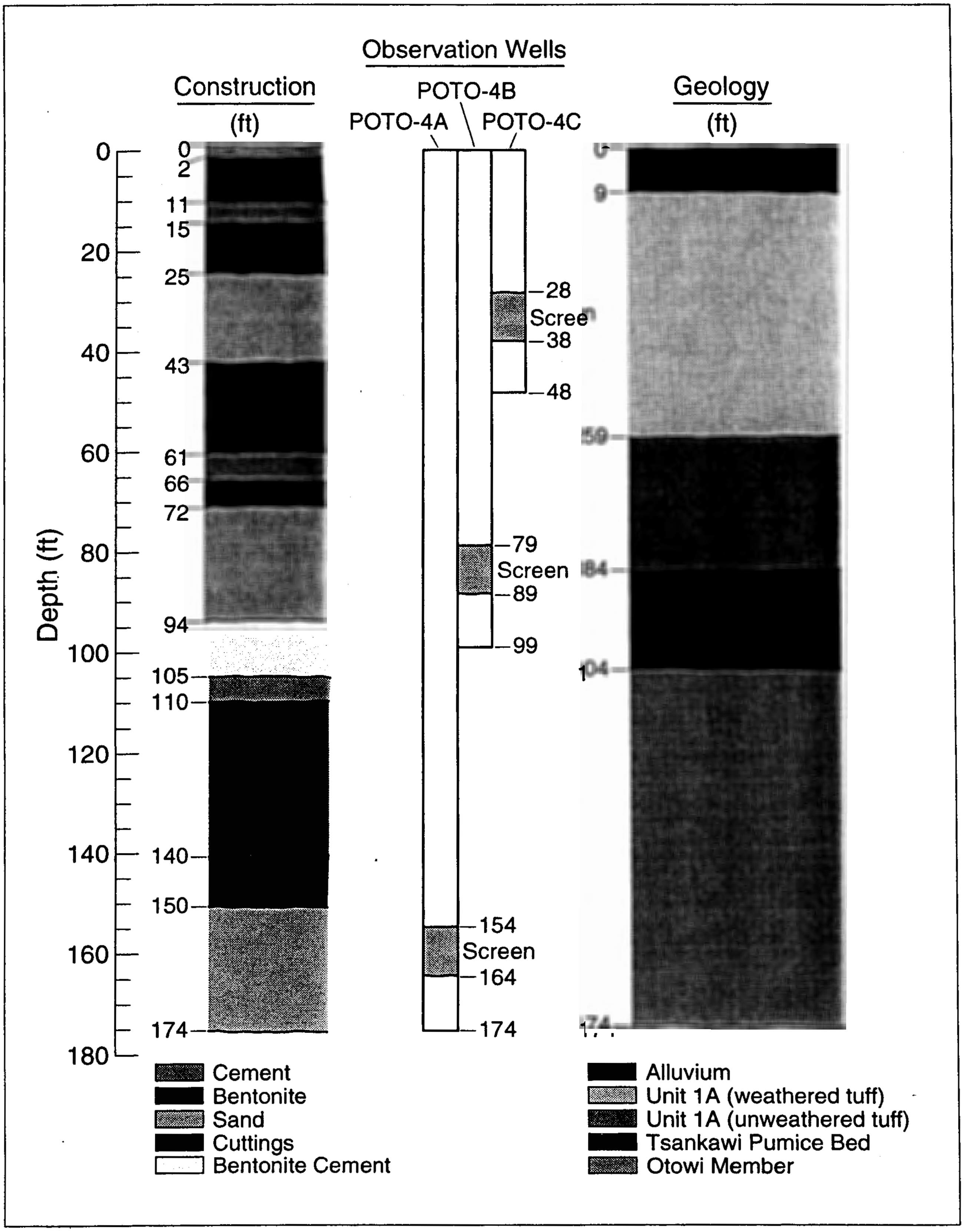

Fig. XXXI-B. Construction and geologic logs of observation wells POTO-4A, POTO-4B, and POTO-4C.

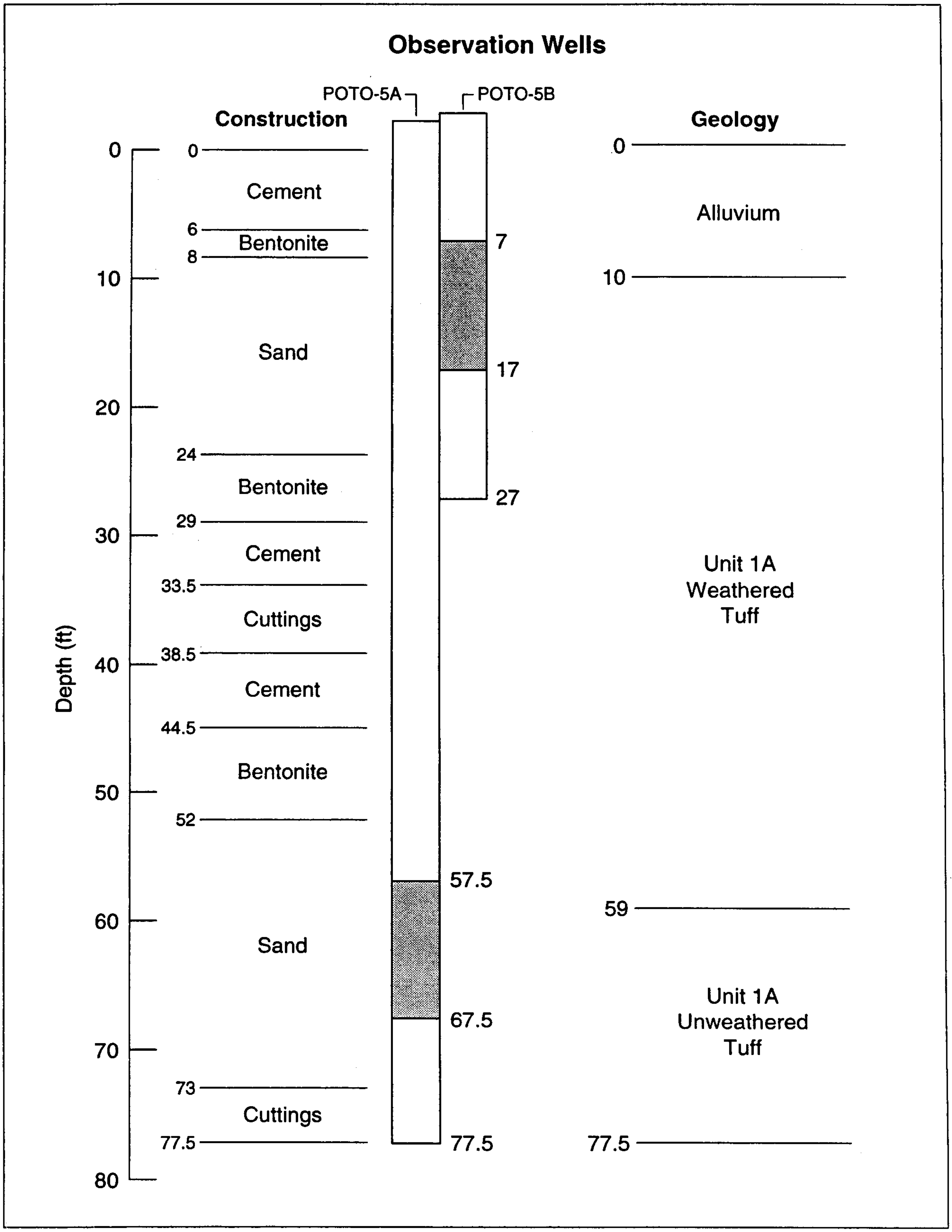

Fig. XXXI-C. Construction and geologic logs of observation wells POTO-5A and POTO-5B.

TABLE XXXI-A. Geologic Logs and Construction Data for Moisture-Access Holes in Potrillo Canyon

	POTM-1	POTM-2	POTM-3
Alluvium	0–28	0–11	0–15
Weathered Tuff (ft)	28–50	11–56	15–52
Casing Tuff (ft)	47	54	48

Construction: 2-in.-diam aluminum casing with cap welded on bottom, casing cemented in 5 to 9 ft; holes offset with shallow moisture-access holes 5 to 9 ft to study moisture content of alluvium adjacent to the cemented sections of deeper moisture-access holes.

TABLE XXXI-B. Locations and Elevations (NAD 1927)

POTM-1	N 1,757,200	E 497,600	6655 ft
POTM-2	N 1,757,100	E 498,300	6620 ft
POTM-3	N 1,755,600	E 500,000	6575 ft
POTM-4 ABC	N 1,757,000	E 498,400	6620 ft
POTM-5 AB	N 1,757,000	E 498,400	6620 ft

XXXII. SPECIAL TEST HOLES AT TA-49 TO MEASURE BAROMETRIC EFFECTS AND DEFORMATION OF THE TUFF

Two test holes were cored (7 1/4-in. diam) near the eastern edge of TA-49 near well DT-10 (Fig. XXXII-A). The holes were completed in the upper units of the Tshirege Member of the Bandelier Tuff (Fig. XXXII-B). Geologic units are those described by Weir and Purtymun (1962).

Test hole TBM-1 was constructed to measure the barometric effect in the tuff caused by atmospheric pressure changes (Fig. XXXII-C). Test hole TBM-2 was equipped with a Geodetic Biaxial Tiltmeter to determine the deformation of the tuff caused by seismic events. The wellheads for both holes have an 8-ft-sq concrete slab about 6 in. thick. Location is N 1,754,534 E 488,302 (NAD 1927) at an elevation of 7038 ft.

REFERENCES

W. D. Purtymun, Los Alamos National Laboratory, unpublished data (EM-8 field notes), 1993.

J. E. Weir and W. D. Purtymun, "Geology and Hydrology of Technical Area 49, Frijoles Mesa, Los Alamos County, New Mexico," U.S. Geol. Survey Admin. Report (1962).

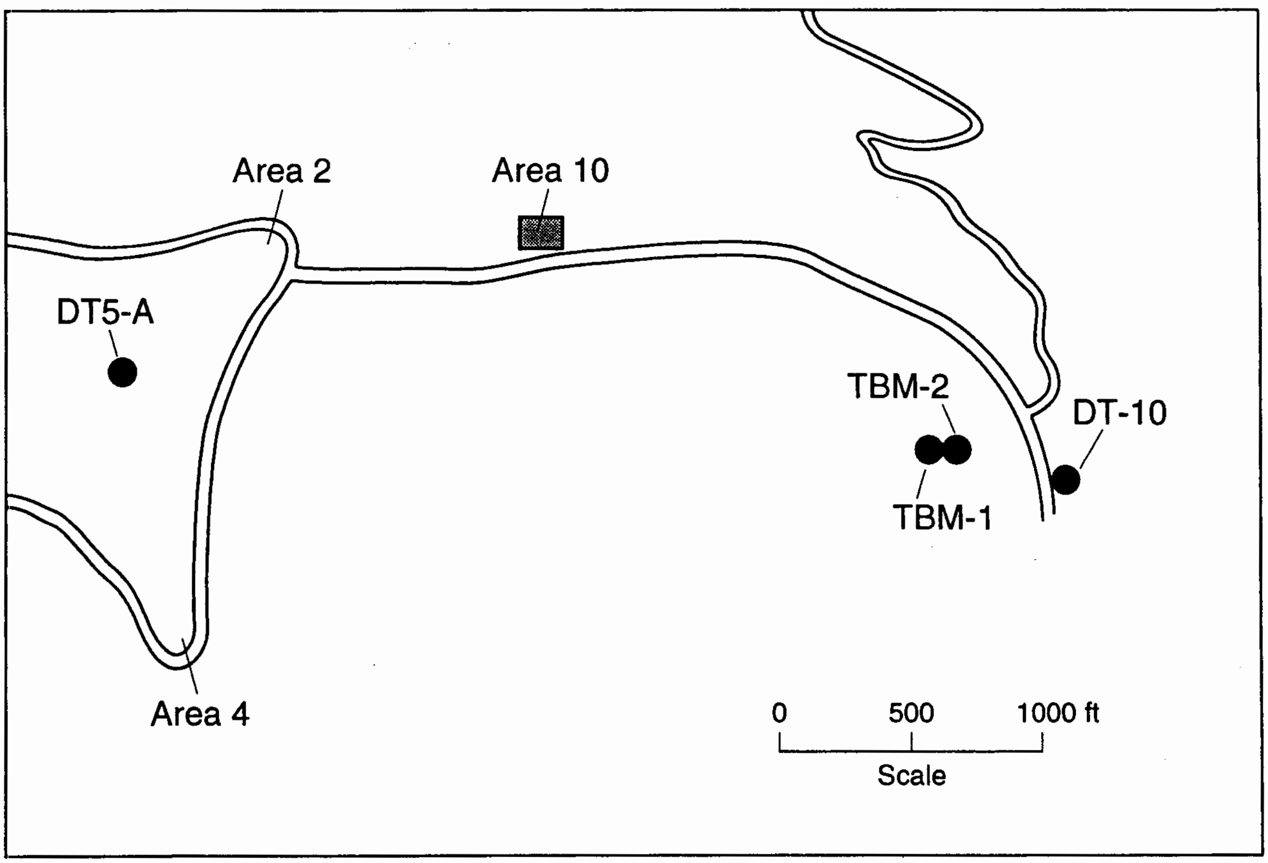

Fig. XXXII-A. Locations of test holes TBM-1 and TBM-2 at TA-49 (Purtymun 1993).

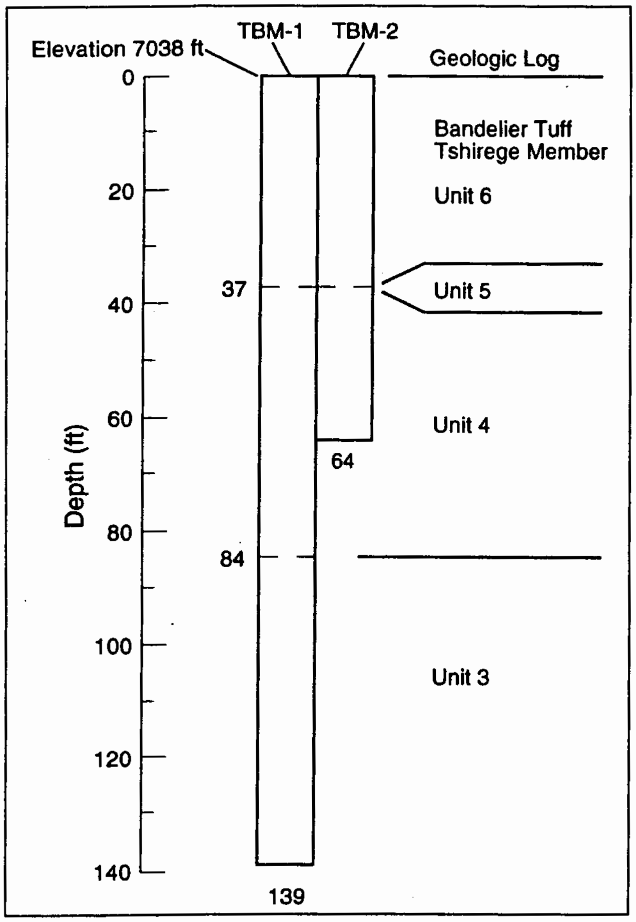

Fig. XXXII-B. Geologic logs of test holes TBM-1 and TBM-2 at TA-49 (Purtymun 1993).

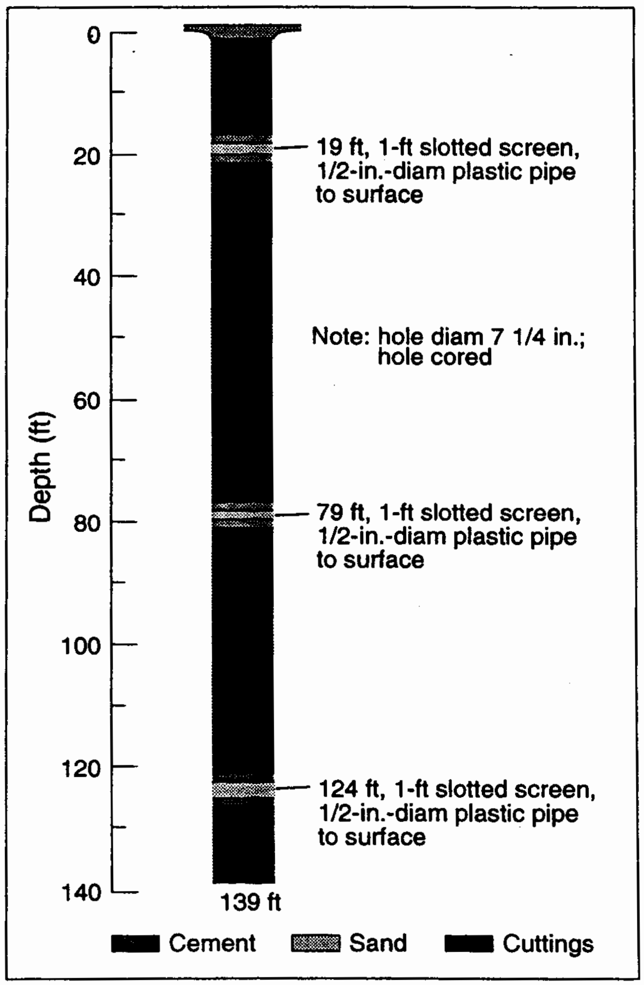

Fig. XXXII-C. Test hole TBM-1 constructed with three zones to measure barometric pressures in the tuff at depths of 19, 79, and 124 ft.

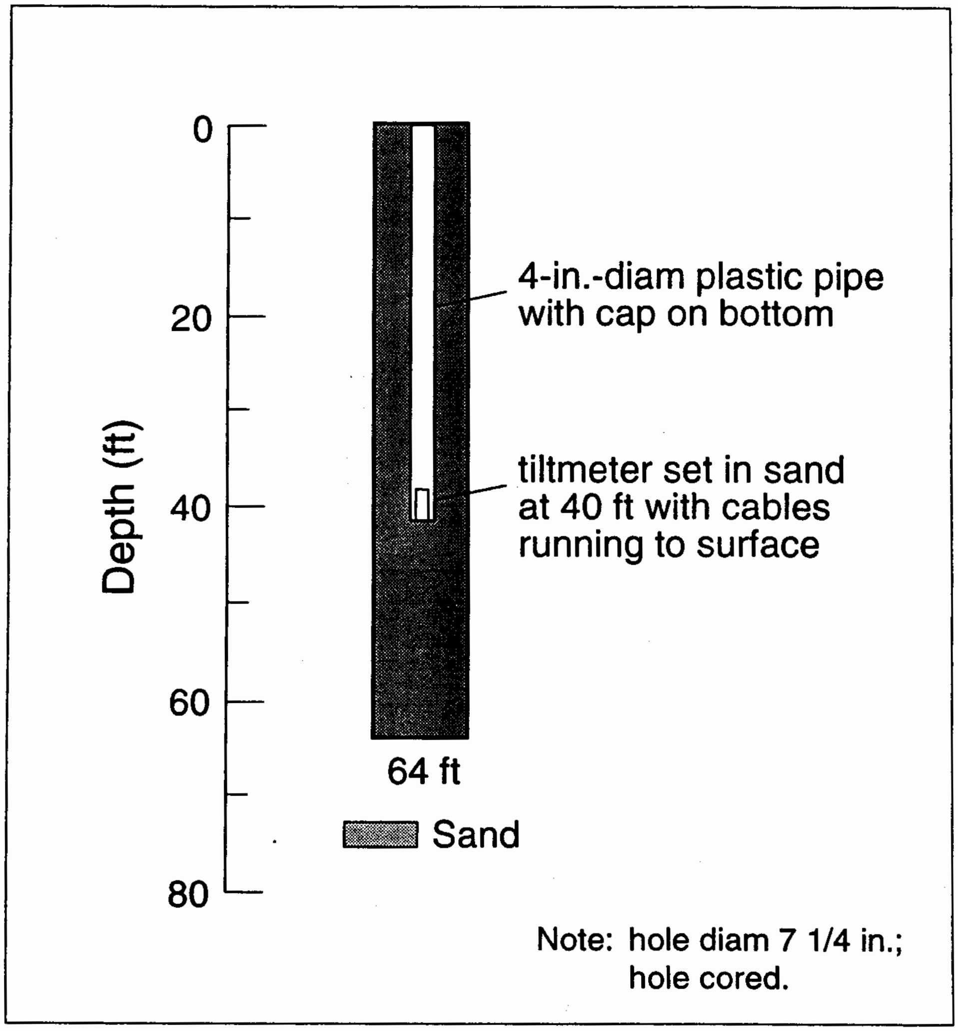

Fig. XXXII-D. Test hole TBM-2 equipped with a biaxial tiltmeter to measure deformation of the tuff at 40 ft.

Traditional drilling equipment on the CM-55 drill rig.

ACKNOWLEDGMENTS

The data contained in this report cover an almost 50-year span and were collected by many individuals. From the U.S. Geological Survey Water Resources Division, Roy Griggs, Bert Weir, Elmer Baltz, Bob Cushman, Jim Cooper, J. L. Kunkler, and John Abrahams must be acknowledged. Frank Koopman was the greatest; he taught me that the studies that were in progress were not work, but an adventure. Also acknowledged is the work of Roy Bailey and Bob Smith of the Geologic Division of the U.S. Geological Survey.

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Close ties existed with the AEC and DOE in the development of the water supply for Los Alamos. Those that provided support were Edwin Wingfield, Tom Roehl, Cecil Bingham, and Eloy Nuñez. Glenn Hammock, consulting engineer, provided technical support on drilling and well construction over a period of 26 years with the construction of 8 supply wells.

Environmental issues became a front runner in popularity in the early 1980s, but the AEC and the Laboratory began monitoring water, soil, and sediments in the mid-1940s. The Environmental Studies Group, H-8 (formed in 1971), and the Water Quality and Hydrology Group (ESH-18) have been major players in monitoring the environment. Those in the group that contributed support and collection of data used in this report are Eric Koenig, Steve McLin, Don Van Etten, and Naomi Becker. Naomi's support through countless field studies is especially appreciated. Dick Peters provided radiochemistry support and took part in many of the studies. Max Maes has been my good arm during the period from 1972 to the present. Max has collected tons of water, as well as soil and sediment samples, for analysis as part of the monitoring program. He has been a big help in reducing the hydrologic data from the supply wells into a usable form. The two of us have drilled hundreds of wells and test holes together.

The list of acknowledgments would not be complete without Alan Stoker, my mentor. He provided support, contributed to the data collection, and made suggestions for studies. I also wish to acknowledge Steven Reneau (EES-1), Jake Turin (EES-1), John Schrandt (ESH-18), Bruce Gallaher of ESH-18 (who performed the technical review of this report), and Jered Sneesby and Greg Cole of EES-1, who checked and corrected many of the NAD 1927 locations.

Special thanks are due to the staff of CIC-1 Central. Vai Stewart edited this report, harmonizing and correcting the text, figures, and tables, and coordinating the project. Many compositors (in our group as well as in CIC-1) put together the many papers and reports that make up this report. Deidre´ Plumlee composed this report's final version, revising and redrawing many of the figures. Kim Valencia and Joyce Martinez created many of the figures in the report. Patrick McFarlin contributed to the composition and the drawing of figures, as did Chad Kieffer, Karina Berta, and Zena Kolshorn. Eileen Patterson proofread the report when it was near its final form.

Although the data presented here will undoubtedly be expanded and clarified in the future, this represents the amalgamation and distillation of the efforts of three generations of investigators, who have sought to understand our local environment and who have worked hard to protect it. My hope is that this report will contribute to the continuation of that work.

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Back cover photo: the venerable CM-55 coring drill rig.