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

by

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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-

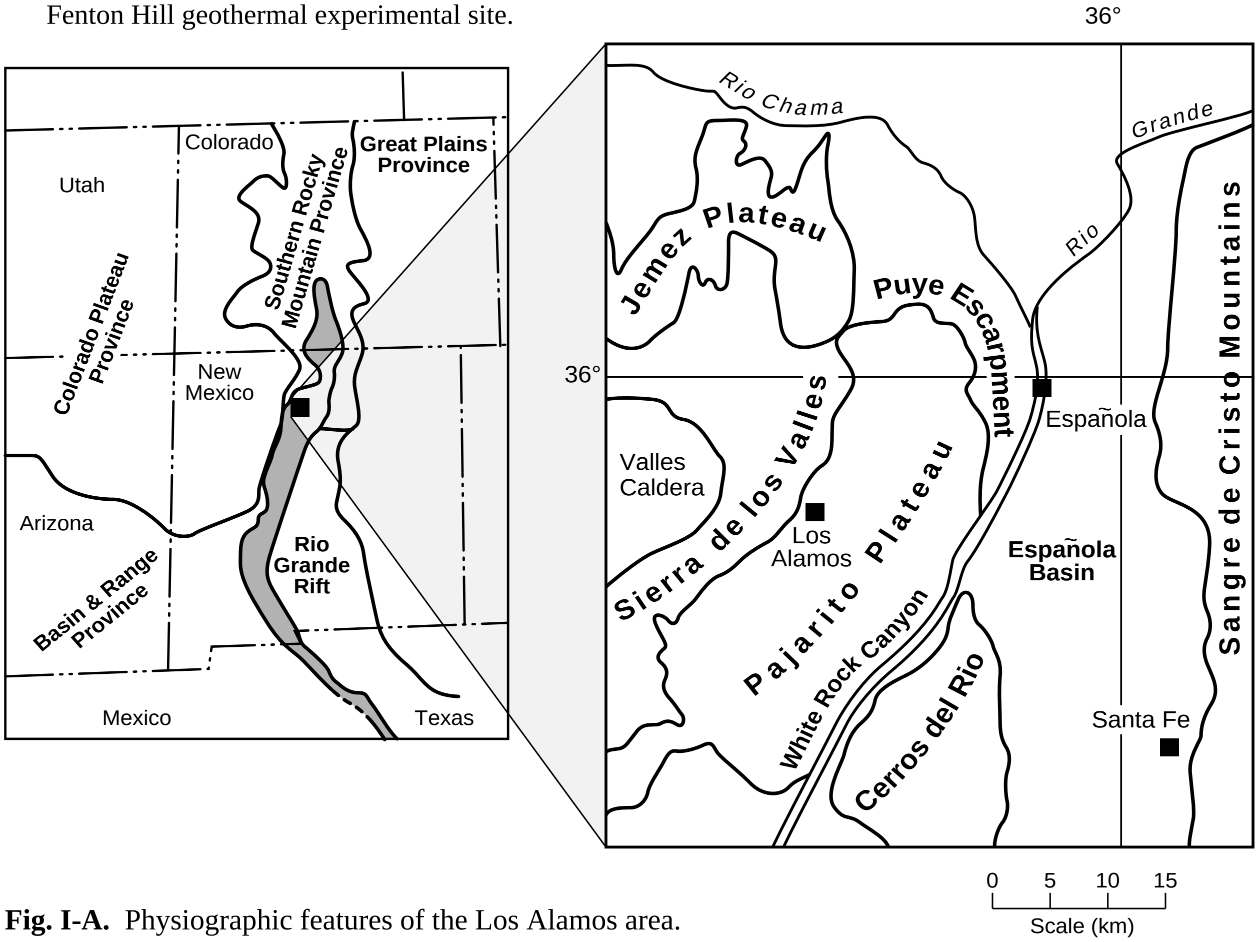
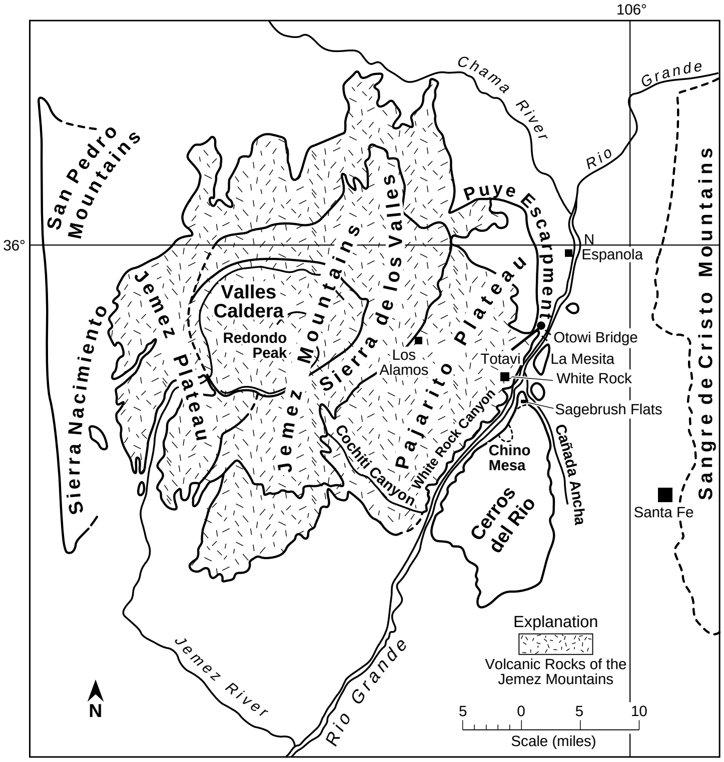


Fig. I-A. Physiographic features of the Los Alamos area.

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



Base from Geologic Map of New Mexico, 1928

Prepared by R.L. Griggs, 1954

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

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.

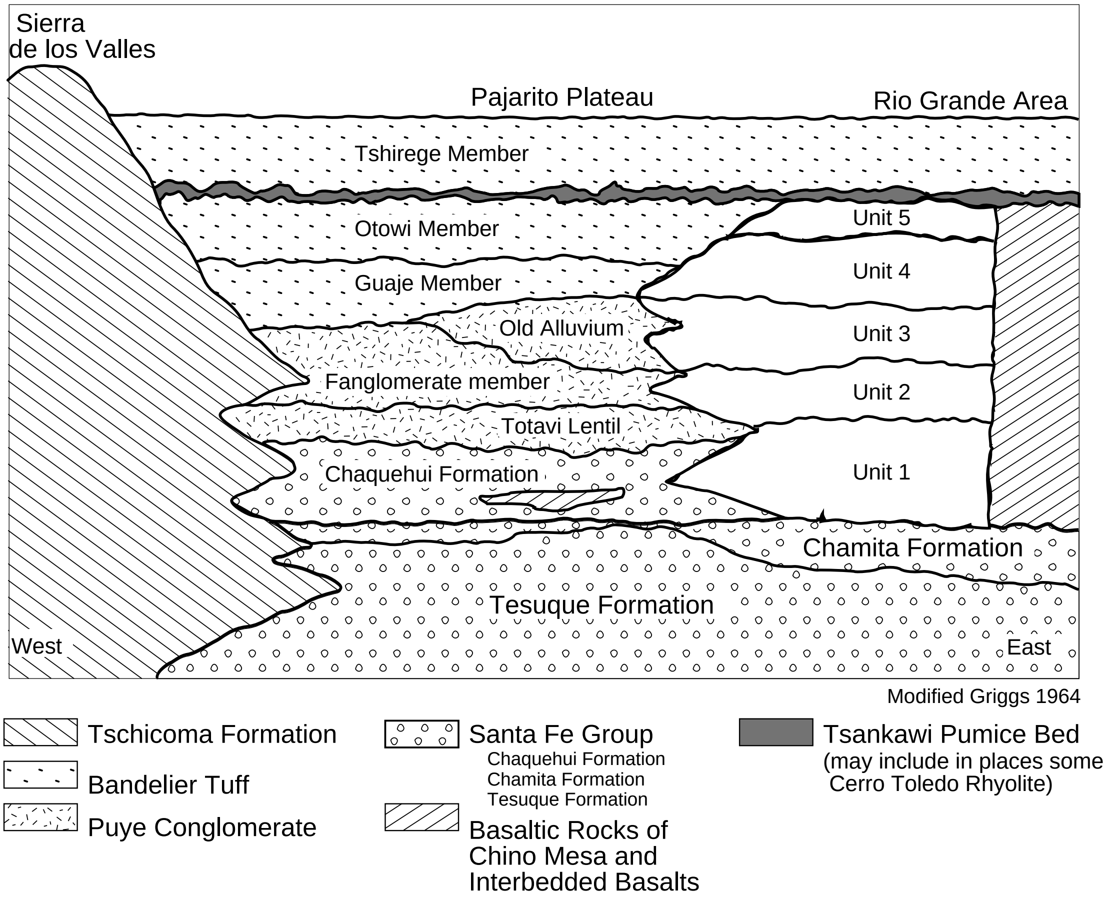
The Rio Grande lies along the eastern edge of the plateau. It drops from an elevation of about 5500 ft at Otowi (at the mouth of Los Alamos Canyon) to about 5360 ft at its junction with Frijoles Canyon. North of Otowi the Rio Grande lies in a broad valley, whereas to the south the river is confined in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

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



Modified Griggs 1964

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

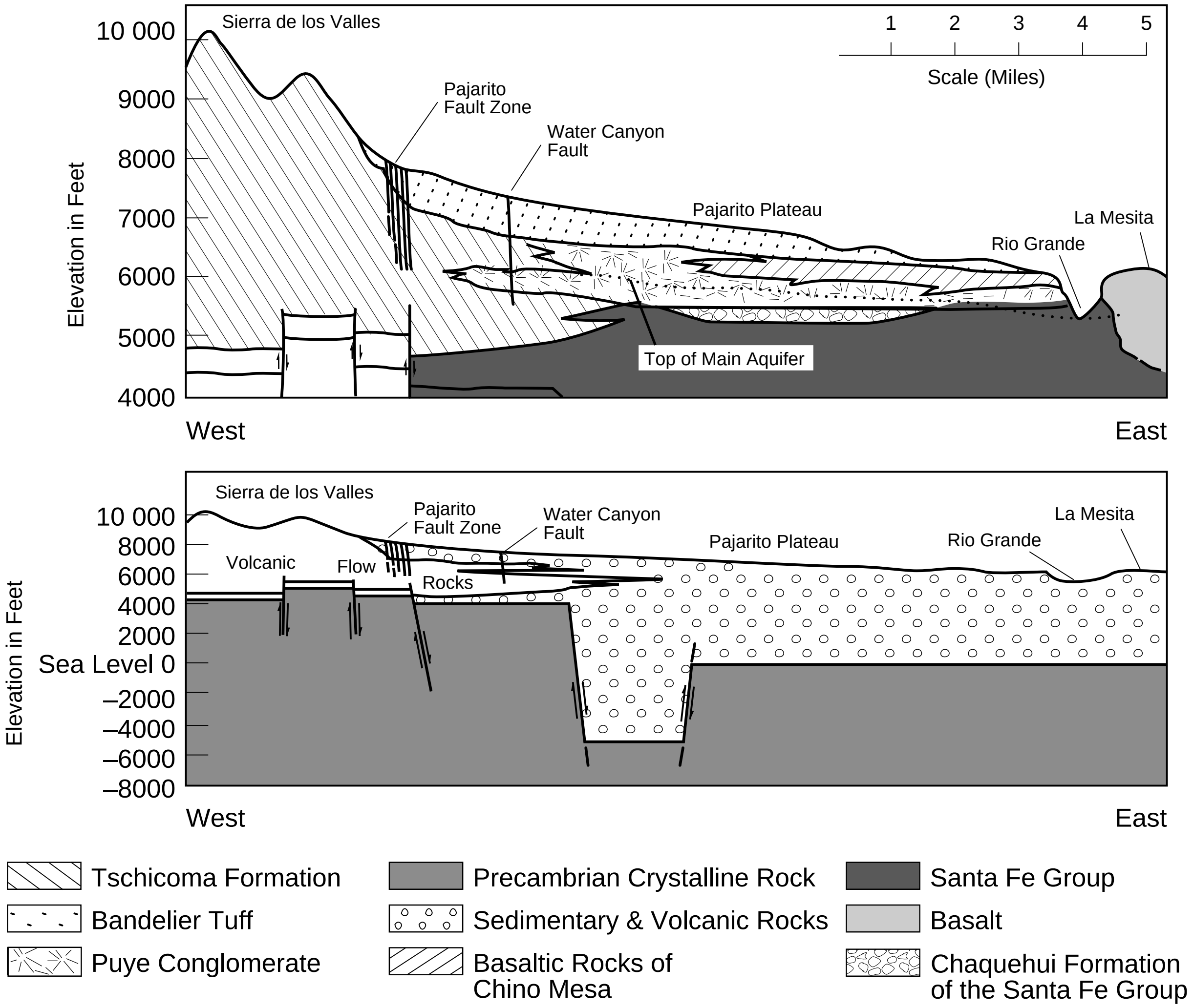


Fig. I-D. Geologic sections showing the stratigraphy and structure from the Sierra de los Valles across the Pajarito Plateau to the Rio Grande (modified Purtymun 1968).

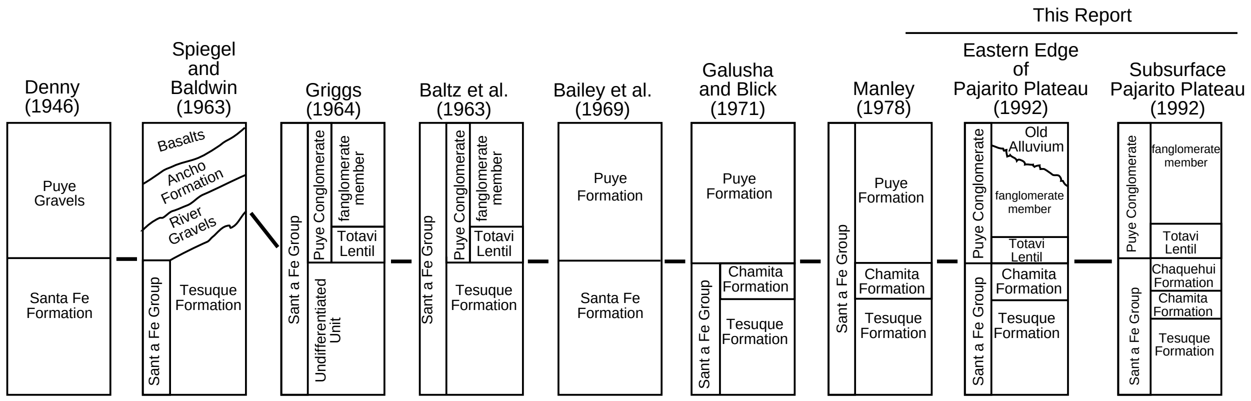


Fig. I-E. Stratigraphic nomenclature of the pre-Bandelier sediments.

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

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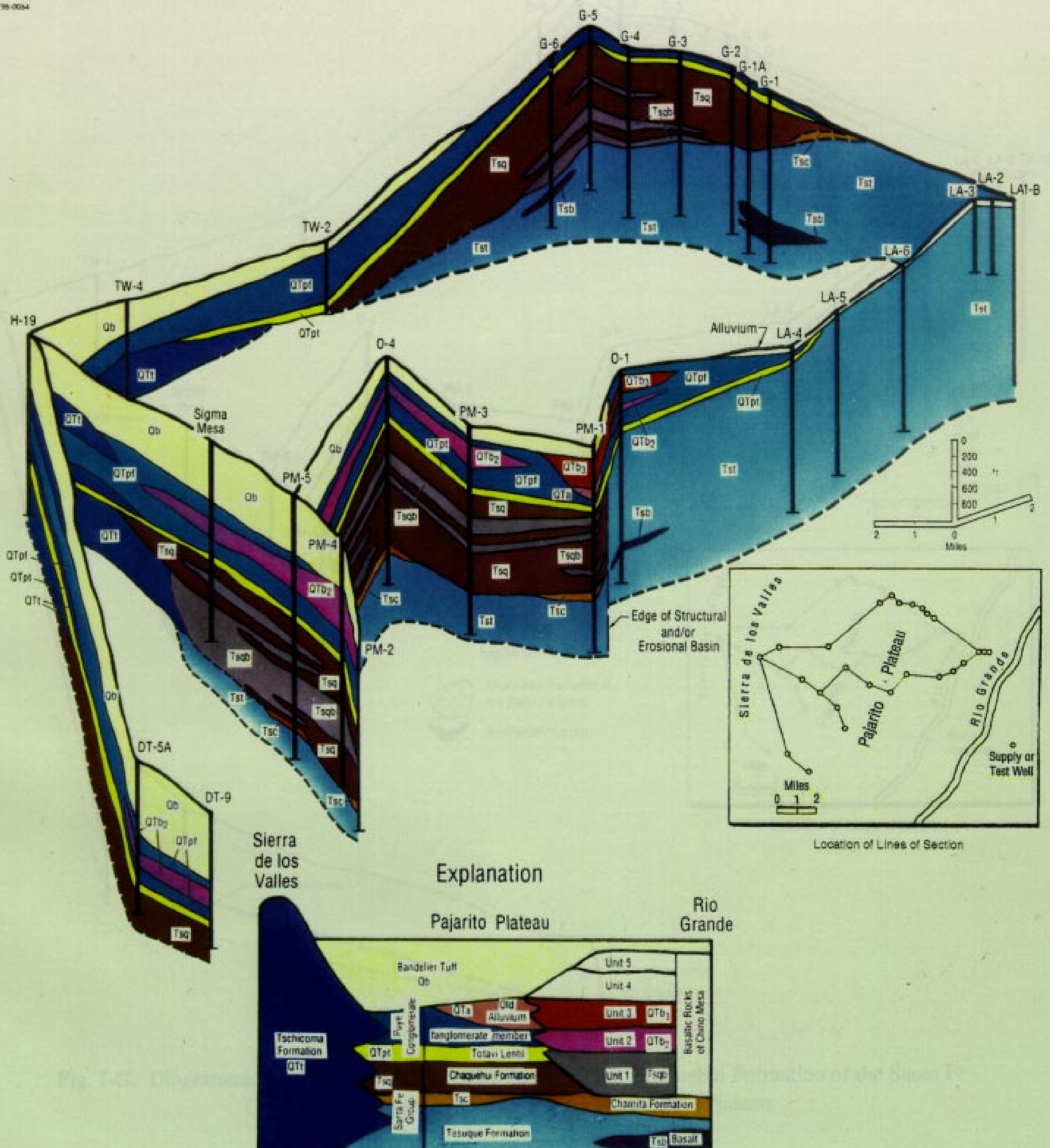

Fig. I-F. Diagrammatic section showing stratigraphy beneath the Pajarito Plateau.

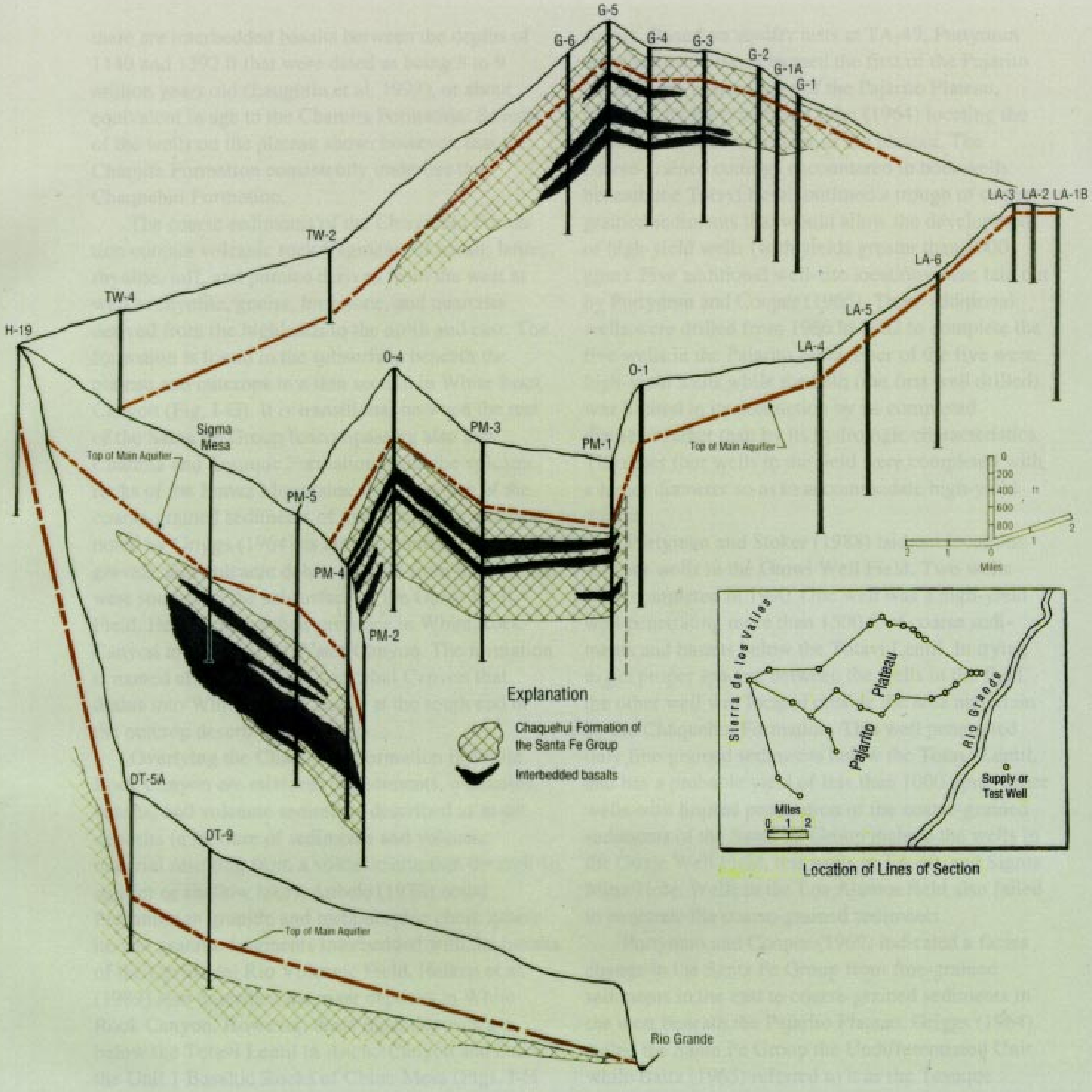

Fig. I-G. Diagrammatic section showing the distribution of the Chaquehui Formation of the Santa Fe Group and interbedded basalts beneath the Pajarito Plateau.

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

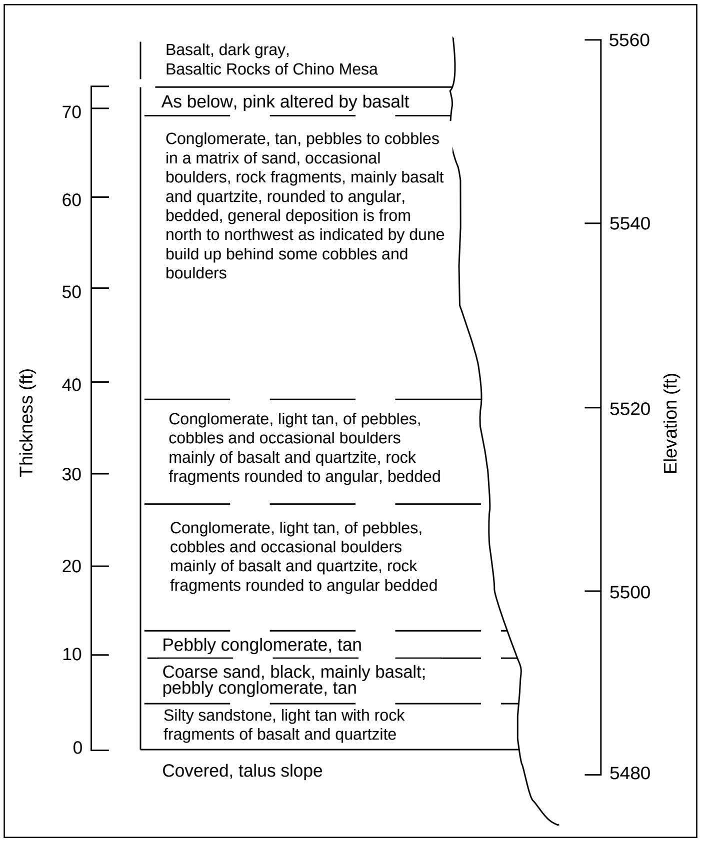

Fig. I-H. Type section of the maar sediments on the south wall of Chaquehui Canyon at the Rio Grande.

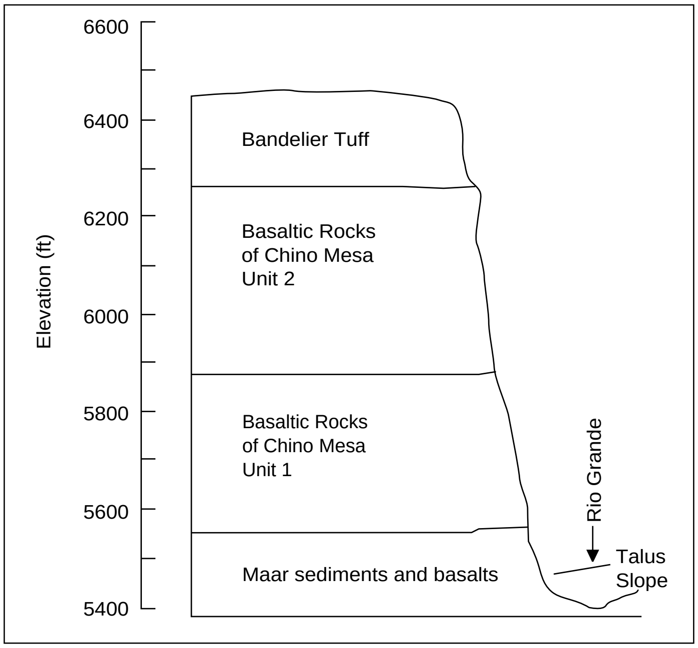

Fig. I-I. Generalized geologic section on the south wall of Chaquehui Canyon at the Rio Grande showing the maar sediments and basalts overlain by the Basaltic Rocks of Chino Mesa and Bandelier Tuff.

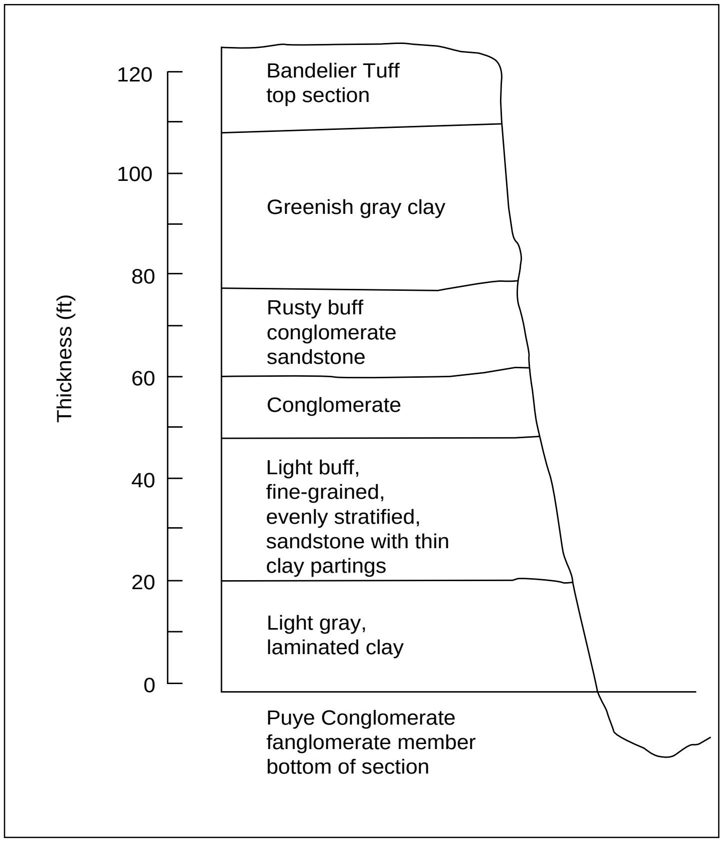

Fig. I-J. Generalized section showing the thickness of Old Alluvium in road cut near Totavi.

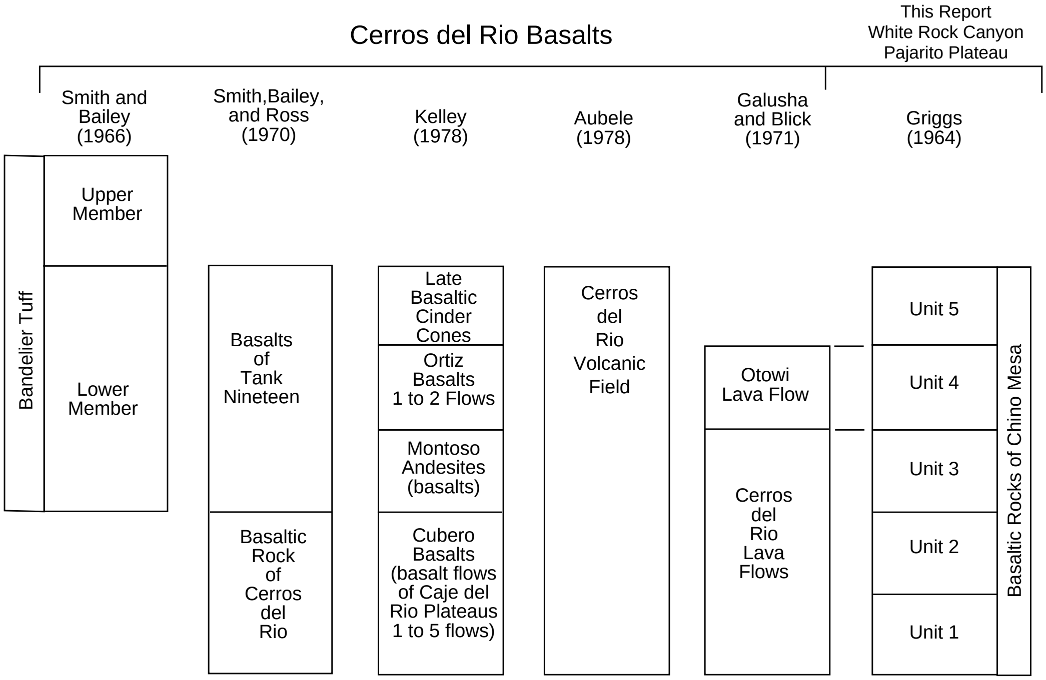

Fig. I-K. Stratigraphic nomenclature of the Cerros del Rio basalts.

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

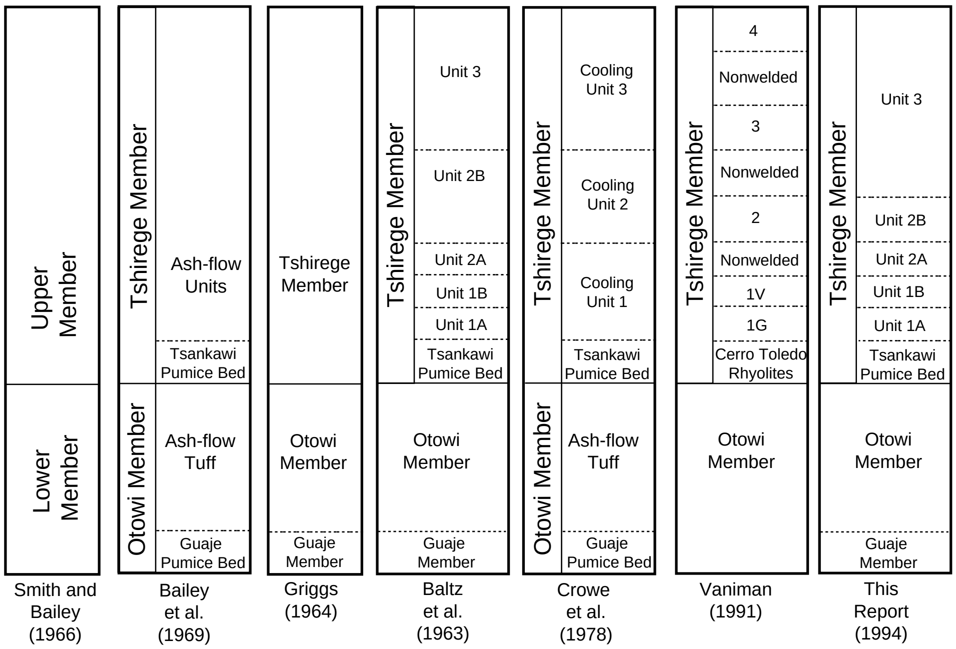

Fig. I-L. Stratigraphic nomenclature of the Bandelier Tuff.

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

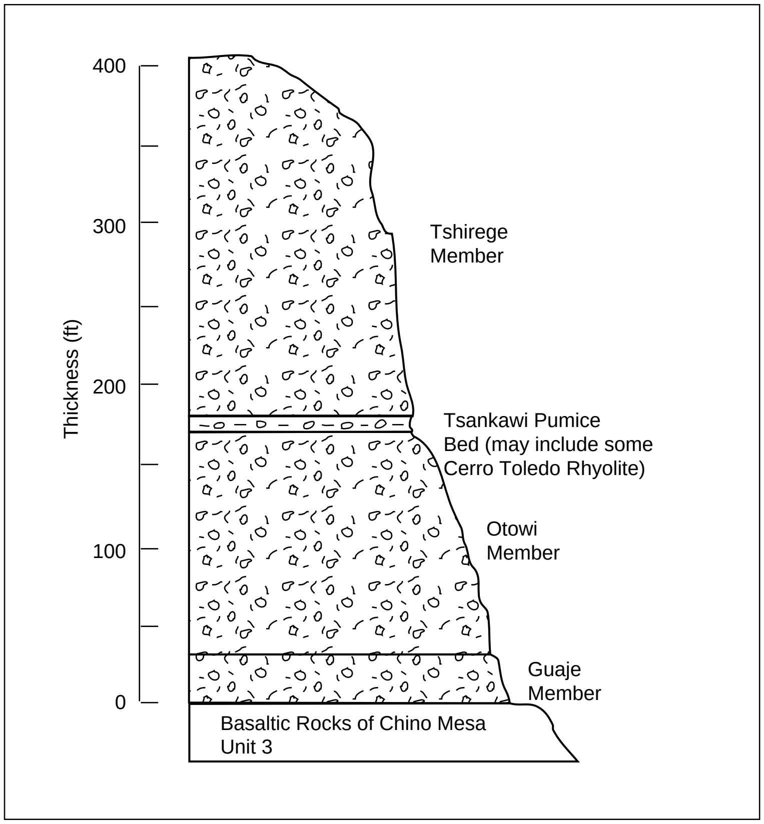

Fig. I-M. Type section showing the thickness of members of the Bandelier Tuff near the junction of State Roads 4 and 502**.**

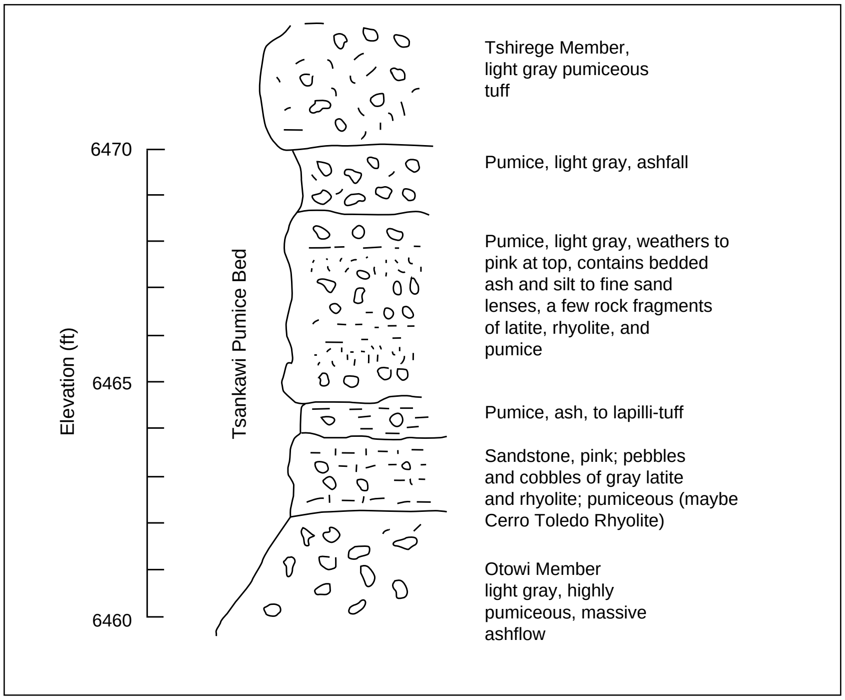

Fig. I-N. Geologic section of the Tsankawi Pumice Bed near the junction of State Roads 4 and 502.

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

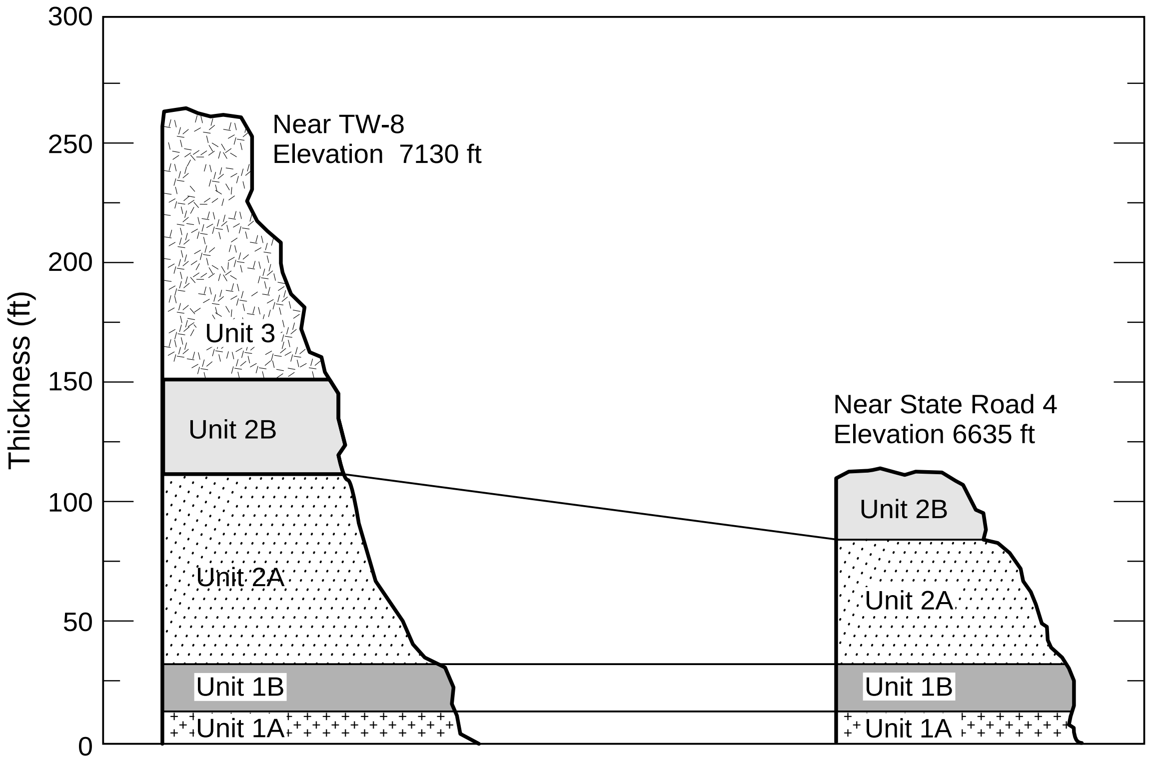

Fig. I-O. Type section of units in the Tshirege Member of the Bandelier Tuff in Mortandad Canyon.

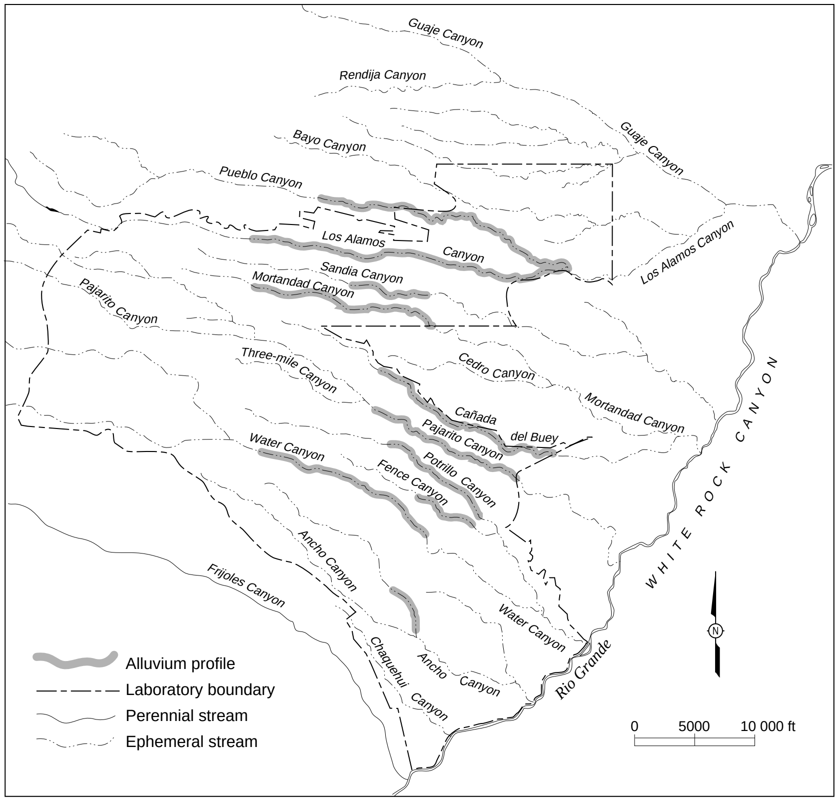

Fig. I-P. Locations of diagrammatic sections of alluvium in major canyons.

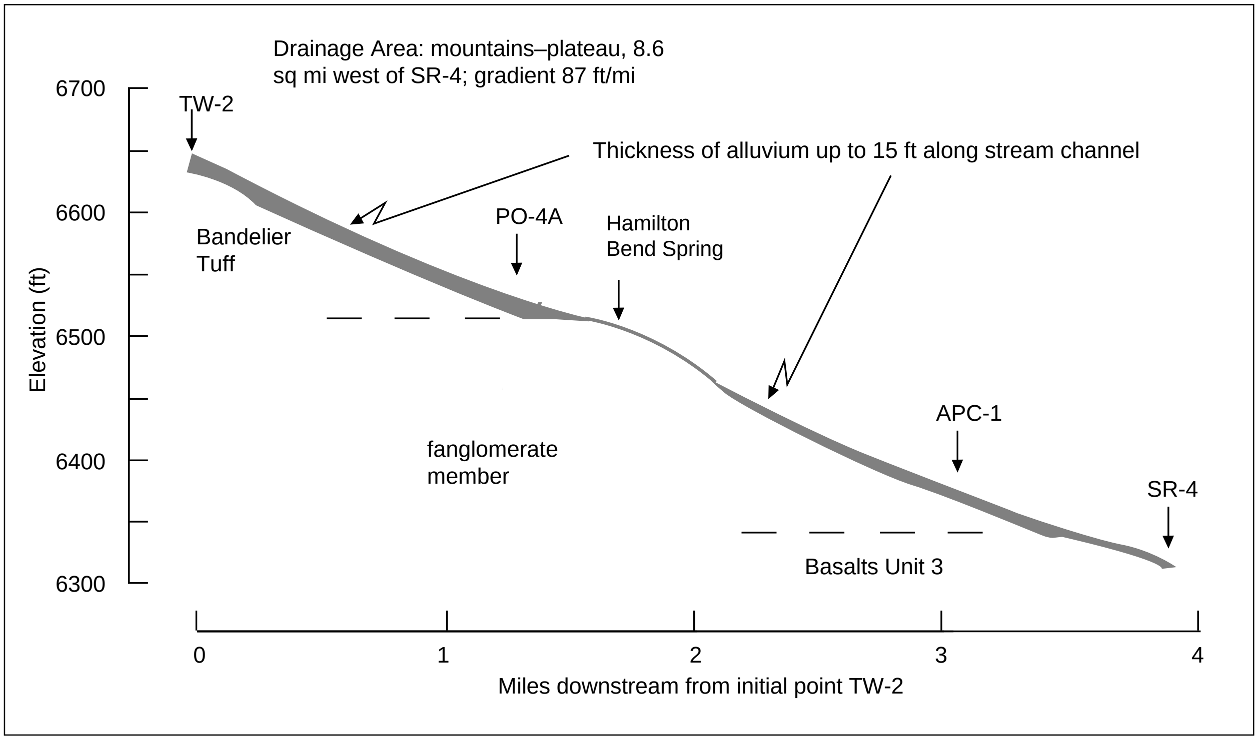

Fig. I-Q. Diagrammatic section showing rocks underlying alluvium in lower Pueblo Canyon.

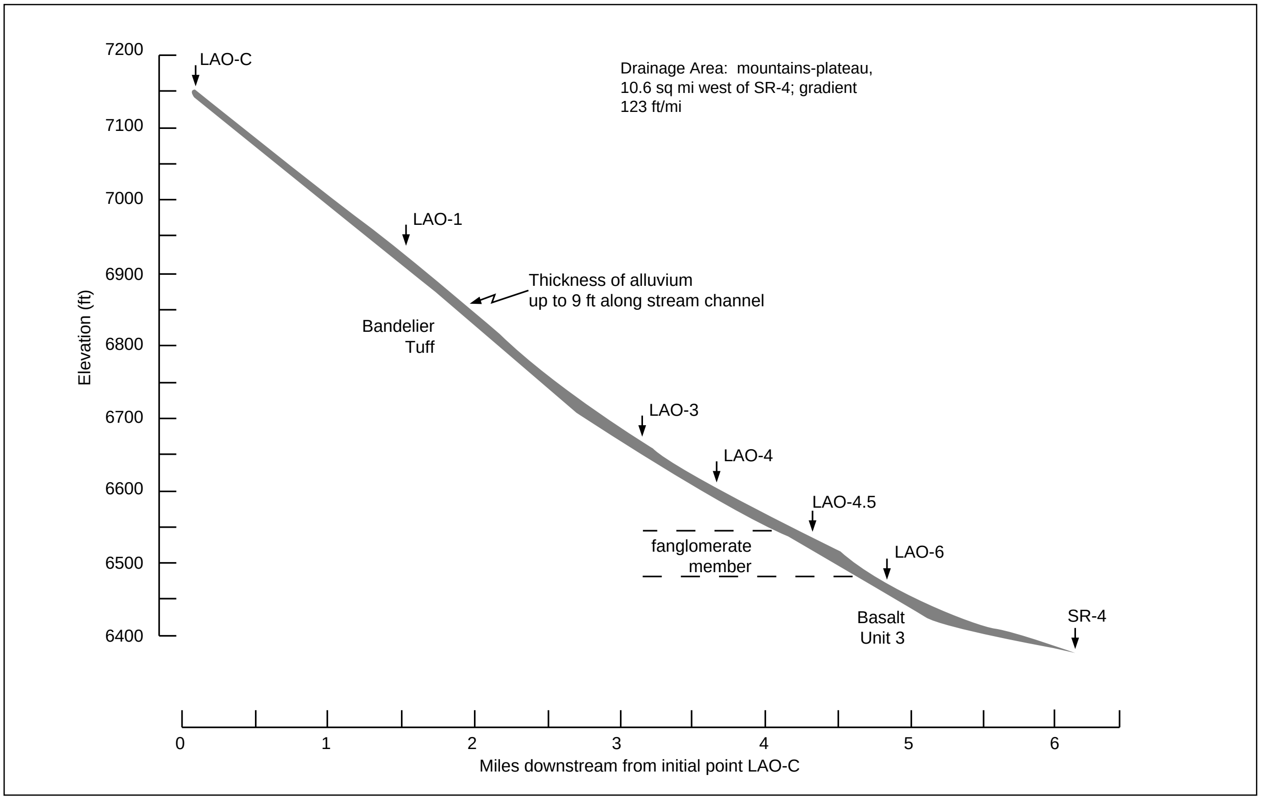

Fig. I-R. Diagrammatic section showing rocks underlying alluvium in Los Alamos Canyon.

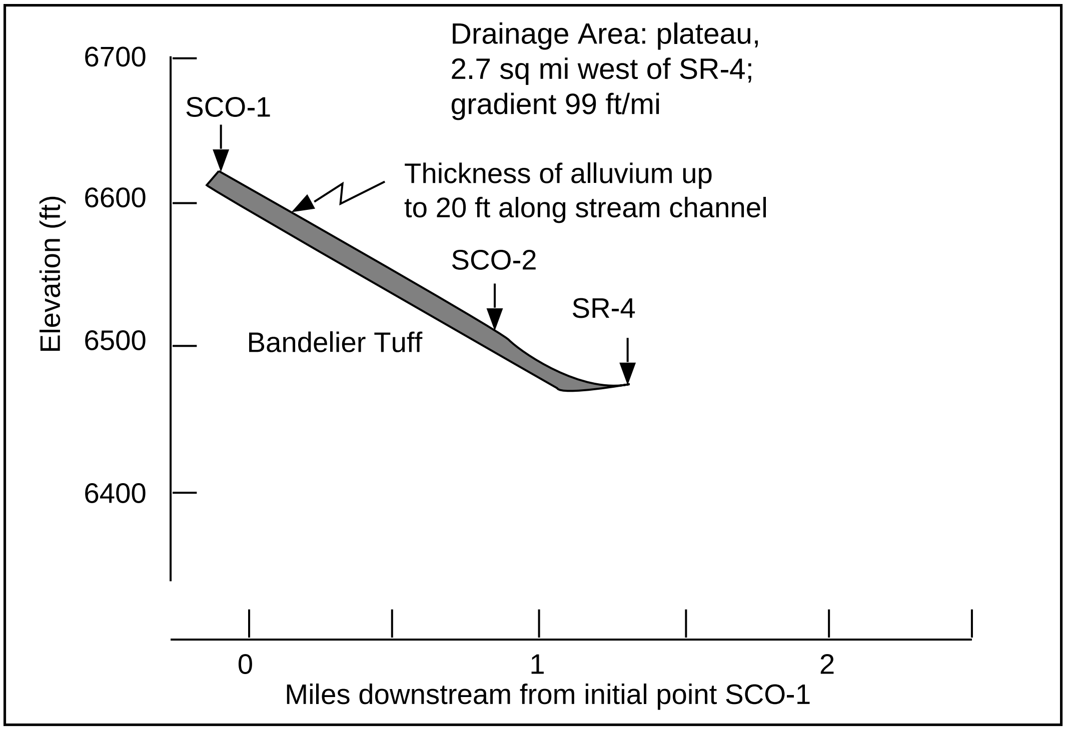

Fig. I-S. Diagrammatic section showing rocks underlying alluvium in lower Sandia Canyon.

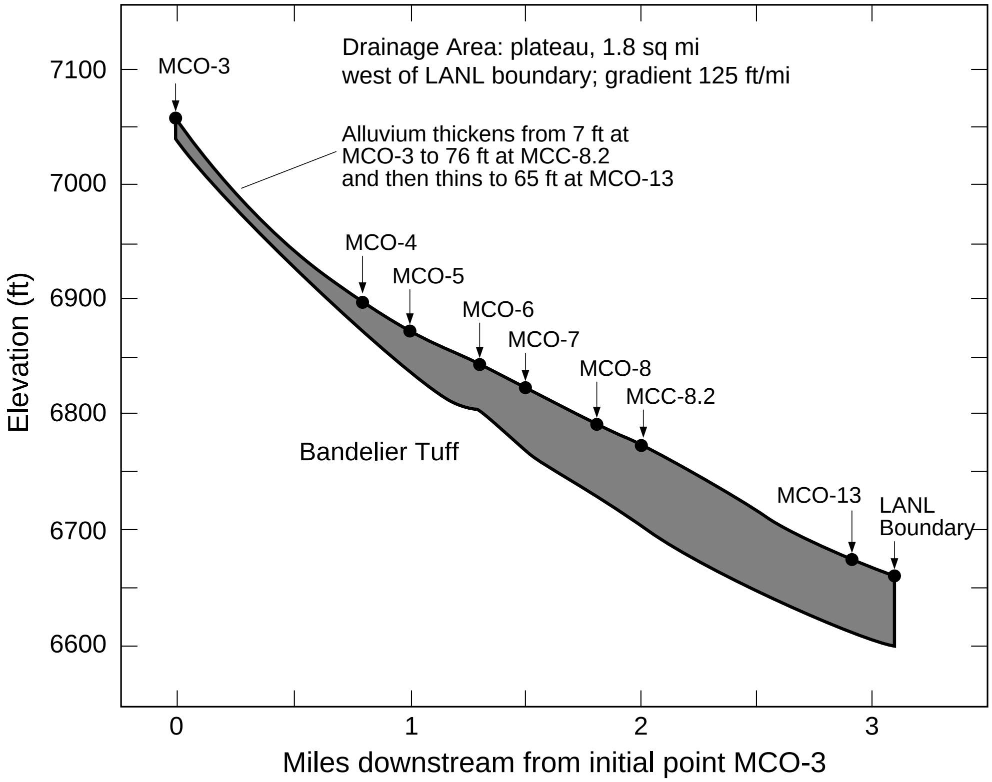

Fig. I-T. Diagrammatic section showing rocks underlying alluvium in Mortandad Canyon.

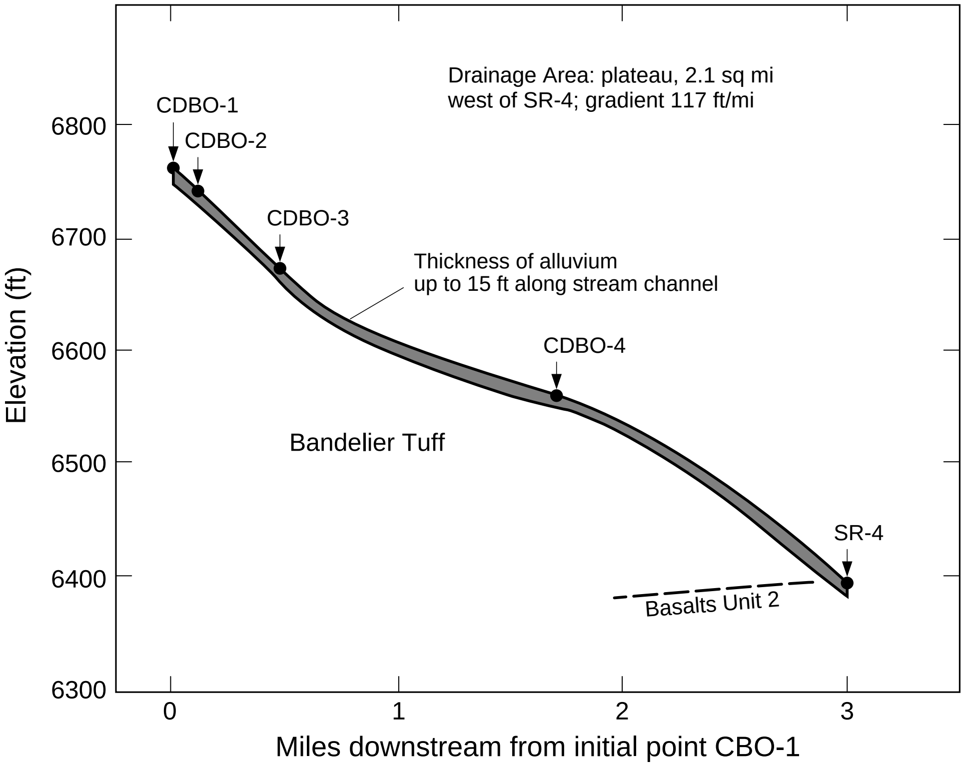

Fig. I-U. Diagrammatic section showing rocks underlying alluvium in lower Cañada del Buey.

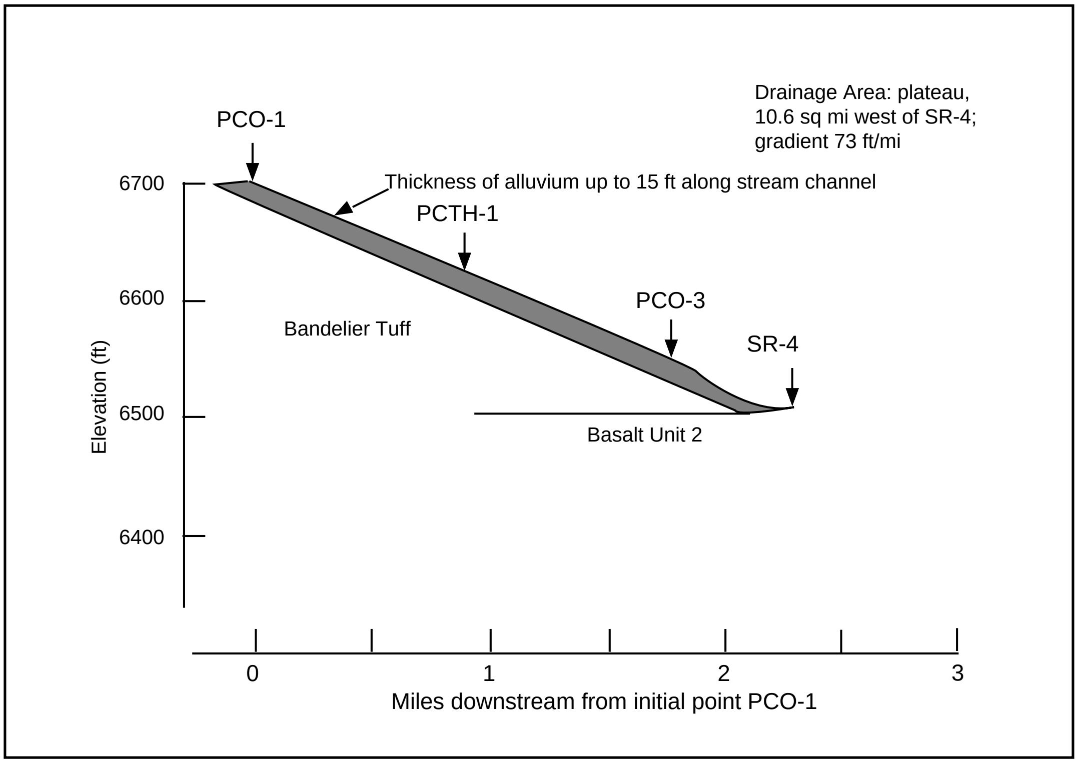

Fig. I-V. Diagrammatic section showing rocks underlying alluvium in lower Pajarito Canyon.

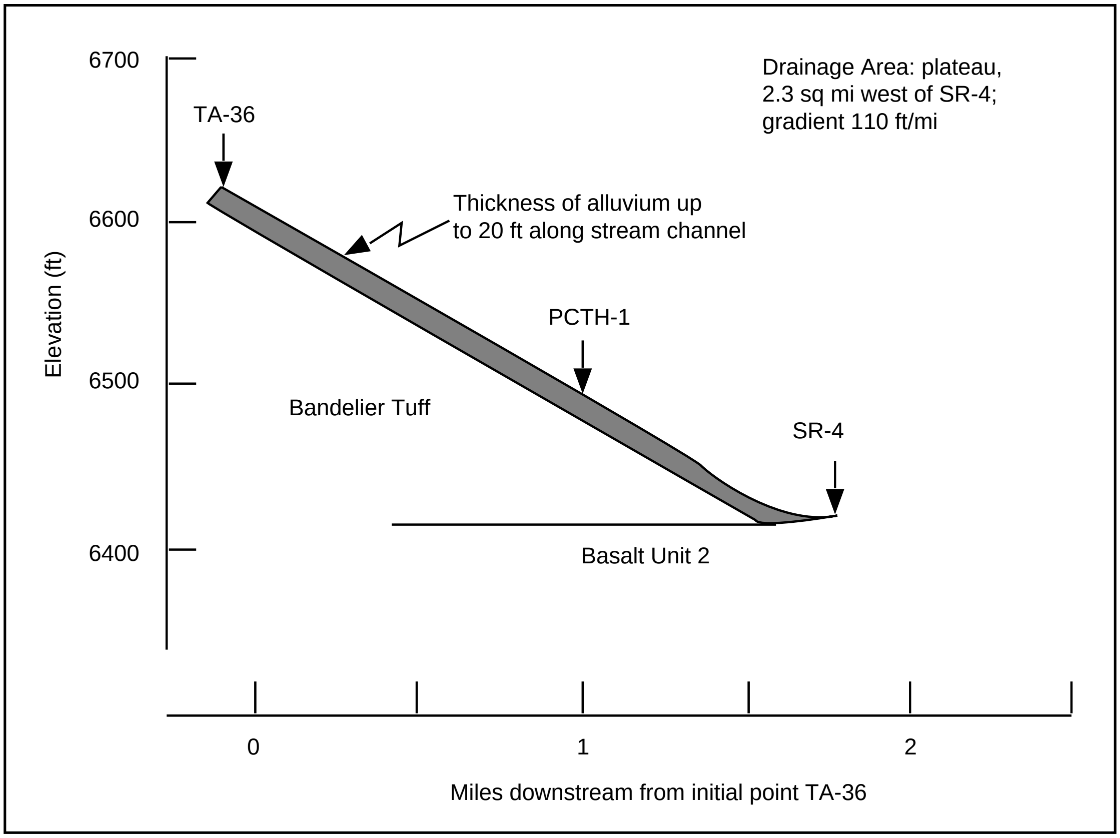

Fig. I-W. Diagrammatic section showing rocks underlying alluvium in lower Potrillo Canyon.

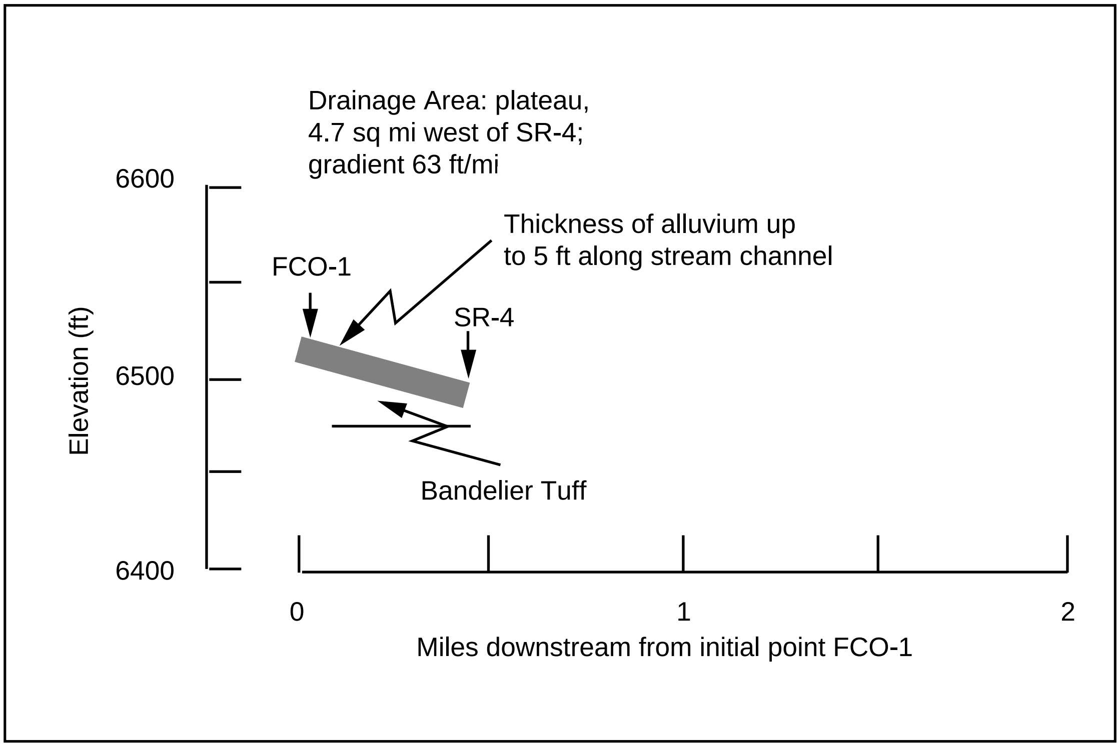

Fig. I-X. Diagrammatic section showing rocks underlying alluvium in lower Fence Canyon.

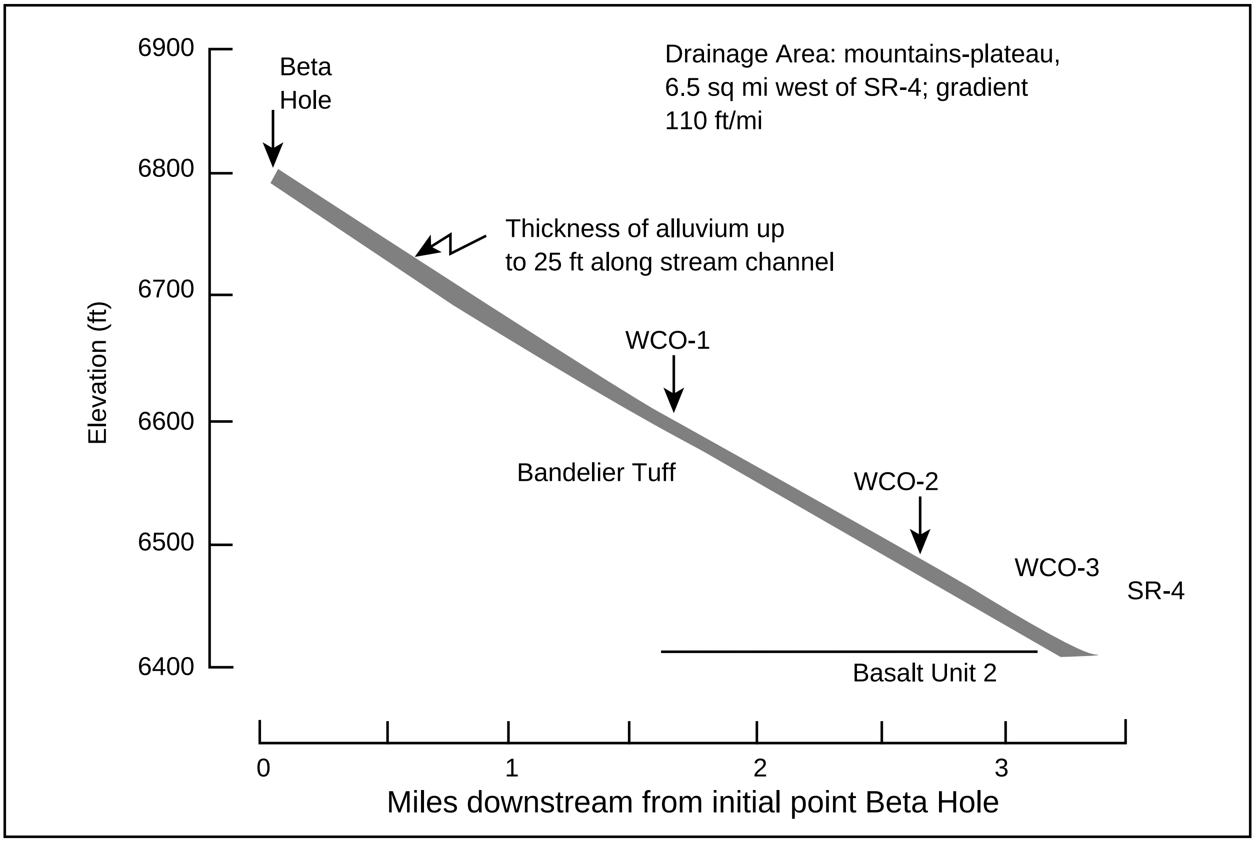

Fig. I-Y. Diagrammatic section showing rocks underlying alluvium in Water Canyon.

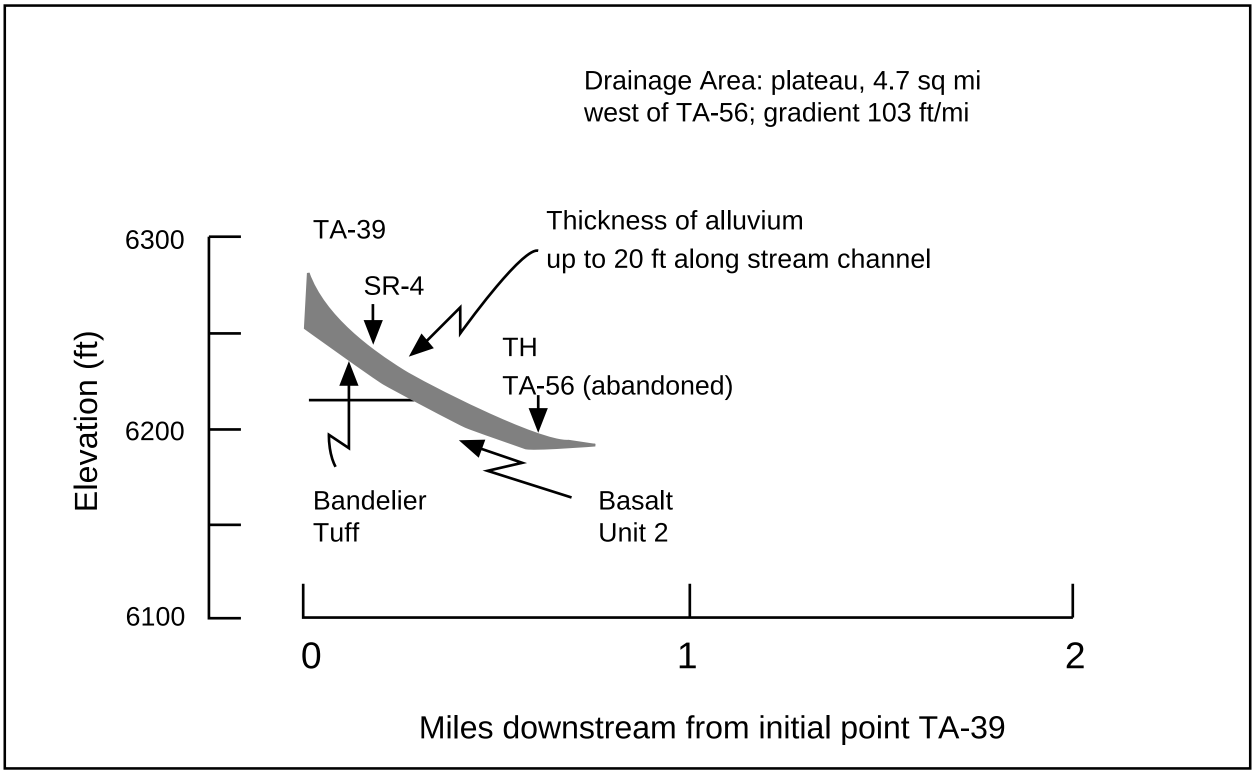

Fig. I-Z. Diagrammatic section showing rocks underlying alluvium in part of Ancho Canyon.

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).

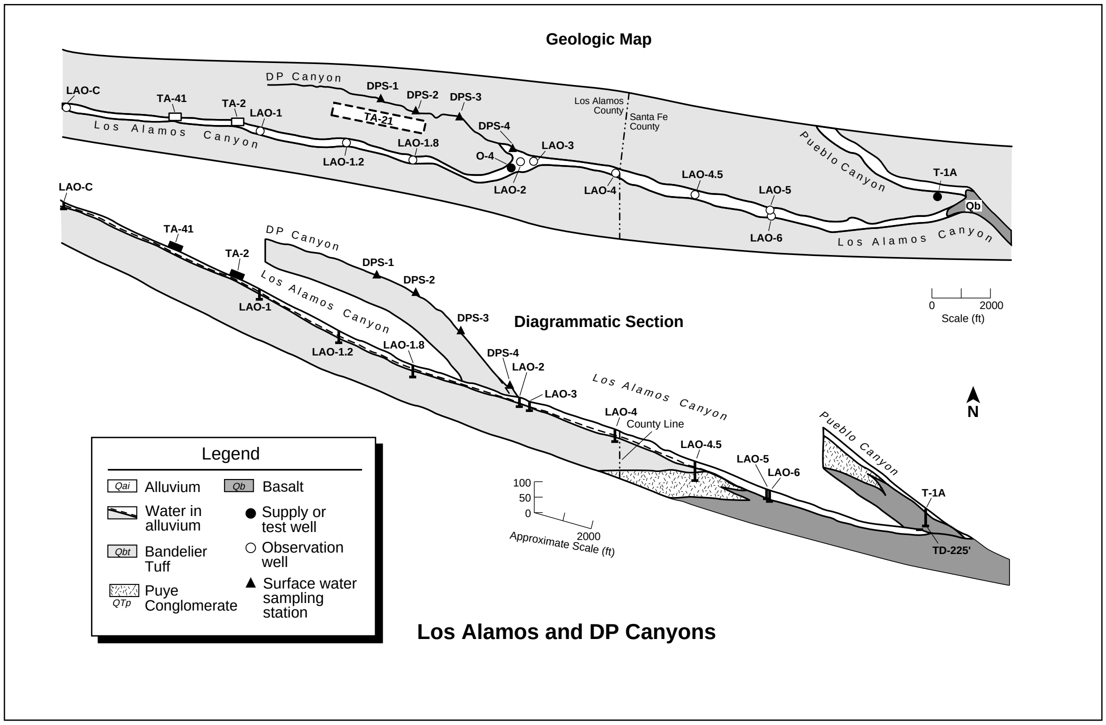

Fig. I-AA. Map showing shallow ground water in alluvium of Los Alamos and DP Canyons (Purtymun 1975).

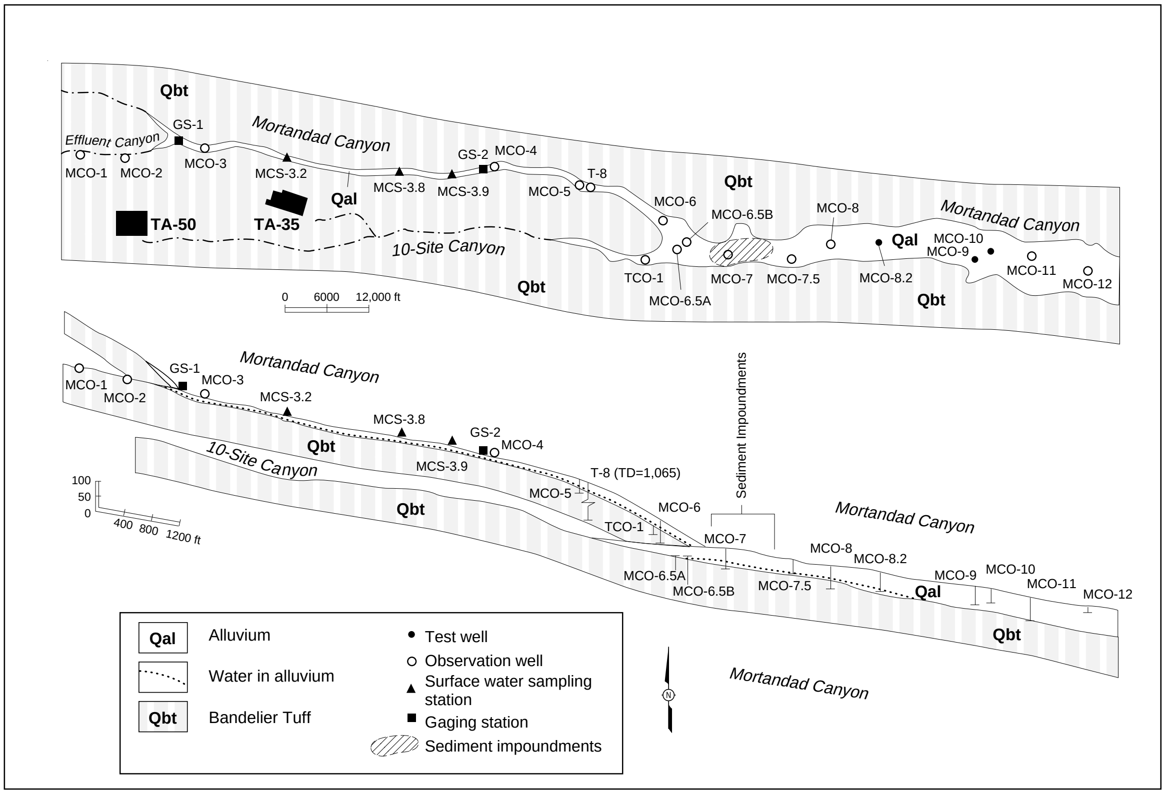

Fig. I-AB. Map showing shallow ground water in alluvium of Mortandad Canyon (Purtymun 1975).

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.

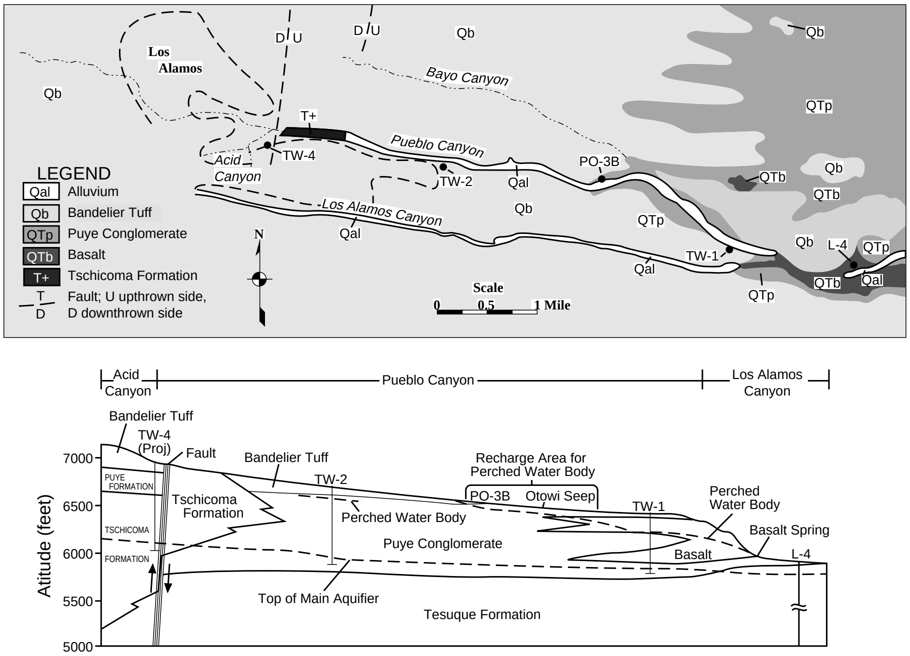

Fig. I-AC. Map with cross section along Pueblo Canyon showing perched water in volcanic sediments in the middle and lower reaches of Pueblo Canyon.

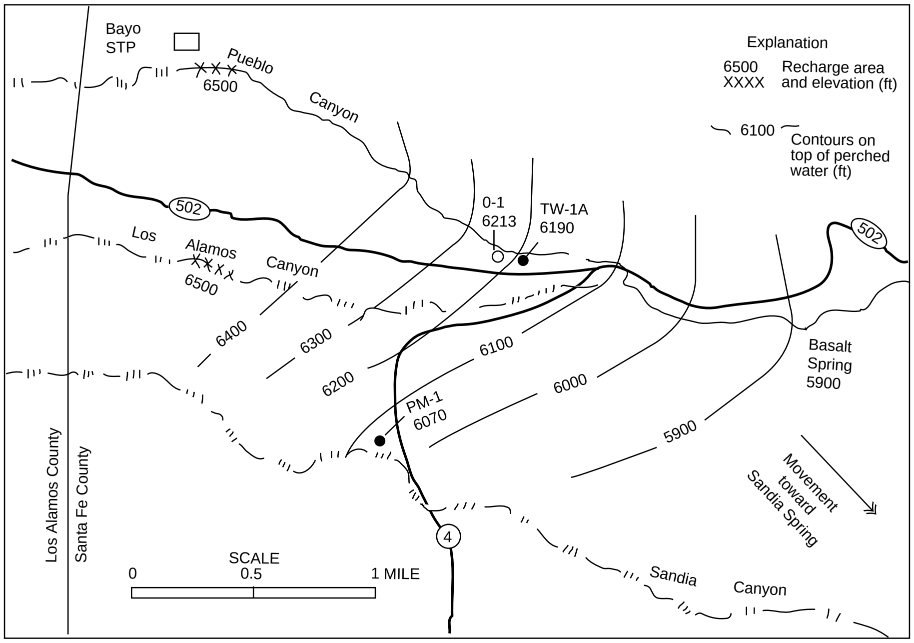

Fig. I-AD. Water level contours of the top of the perched aquifer in volcanic sediments and basalts in lower Pueblo Canyon and the midreach of Los Alamos Canyon.

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

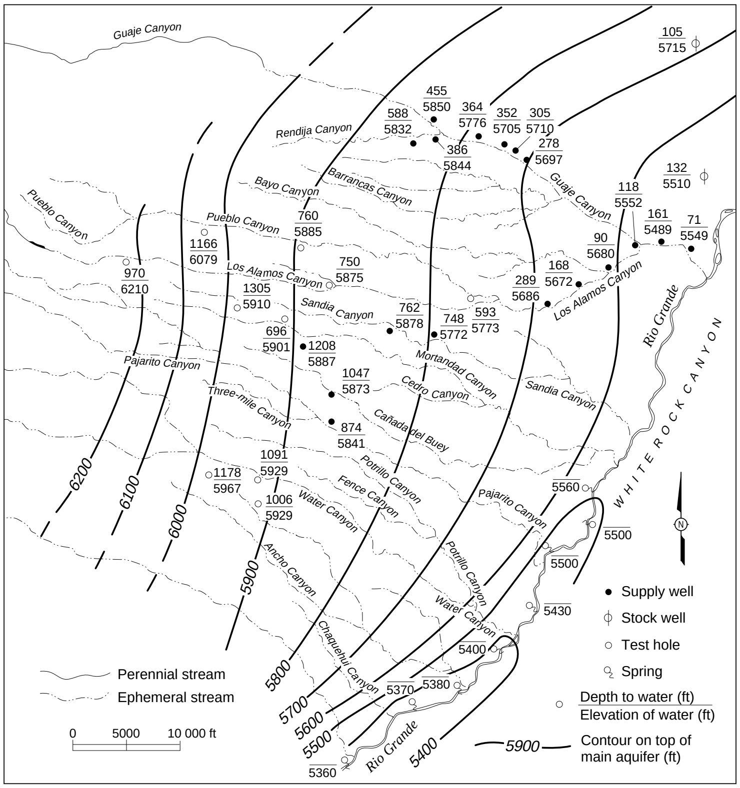

Fig. I-AE. Generalized water-level contours of the top of the main aquifer (Purtymun 1984).

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

		Saturated Thickness							
	Year	Puye Conglomerate (ft)	Chaquehui Formation (ft)	Chamita and Tesuque Formations (ft)	Pumping Rate (gpm)	Drawdown (ft)	Specific Capacity (gpm/ft of drawdown)	Transmissivity × 10^3 (gpd/ft)	Field Coefficient of Permeability (gpd/ft^2)
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.

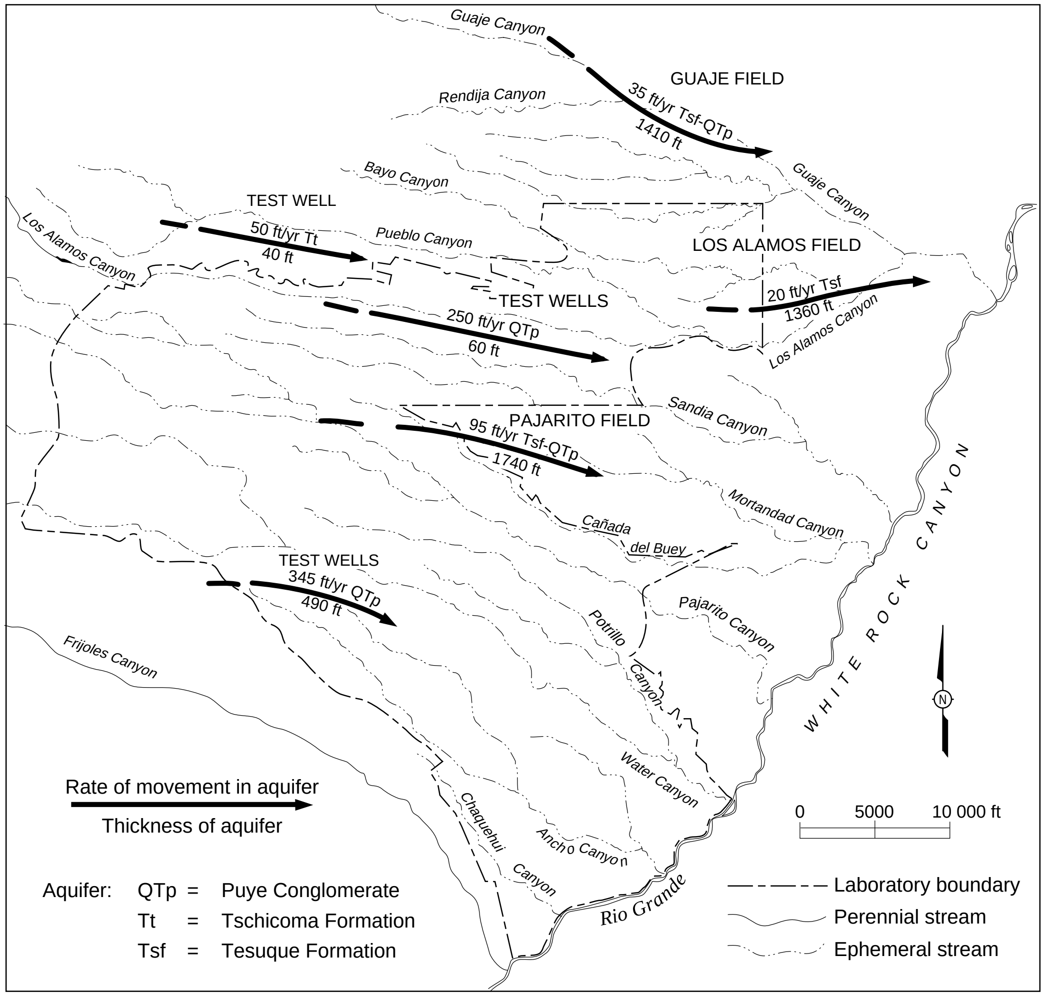

Fig. I-AF. Rate of movement of water in the main aquifer (Purtymun 1984).

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

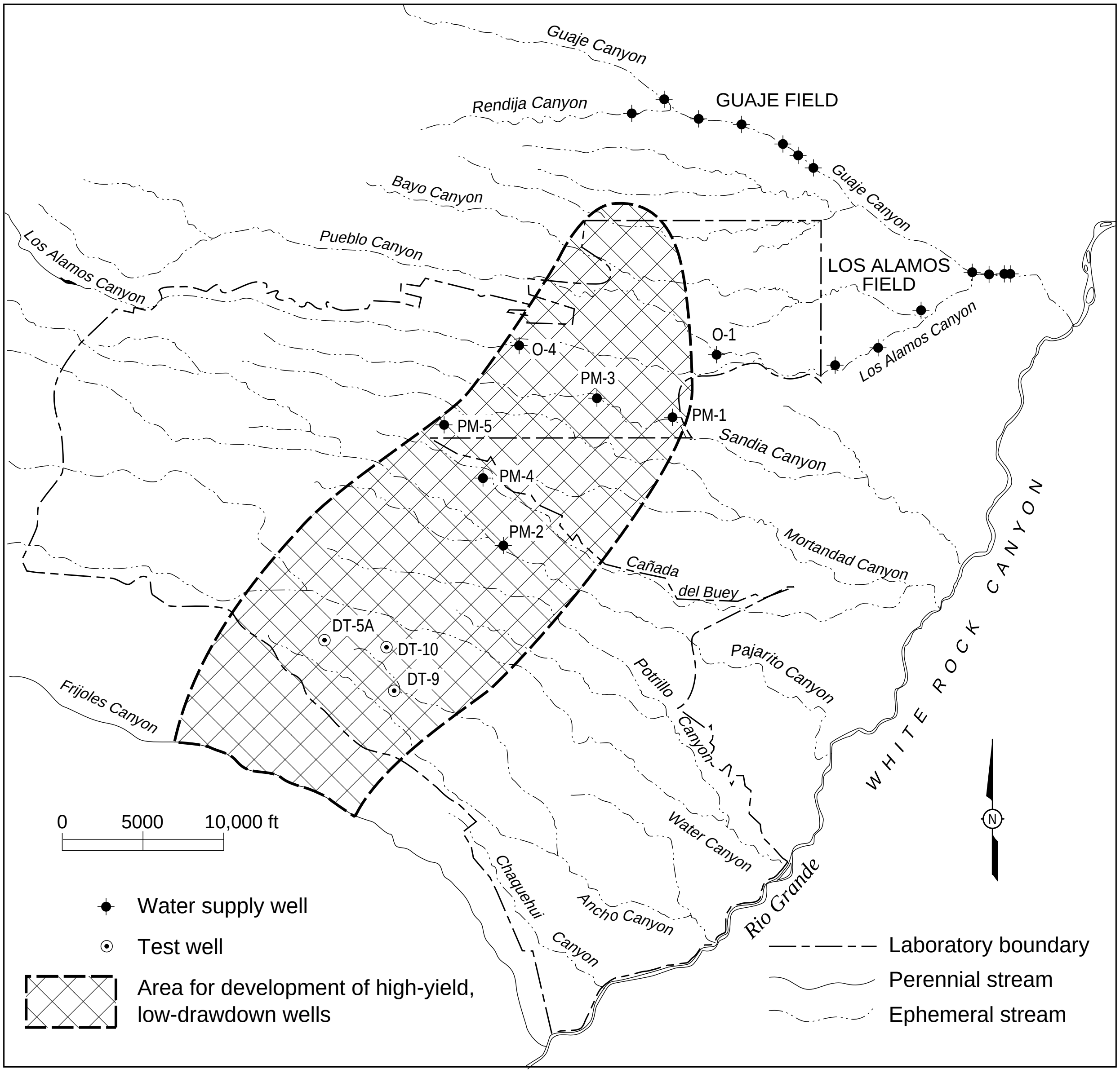

Fig. I-AG. Proposed locations for additional supply wells and area for the development of high-yield, low-drawdown wells (Purtymun 1984).

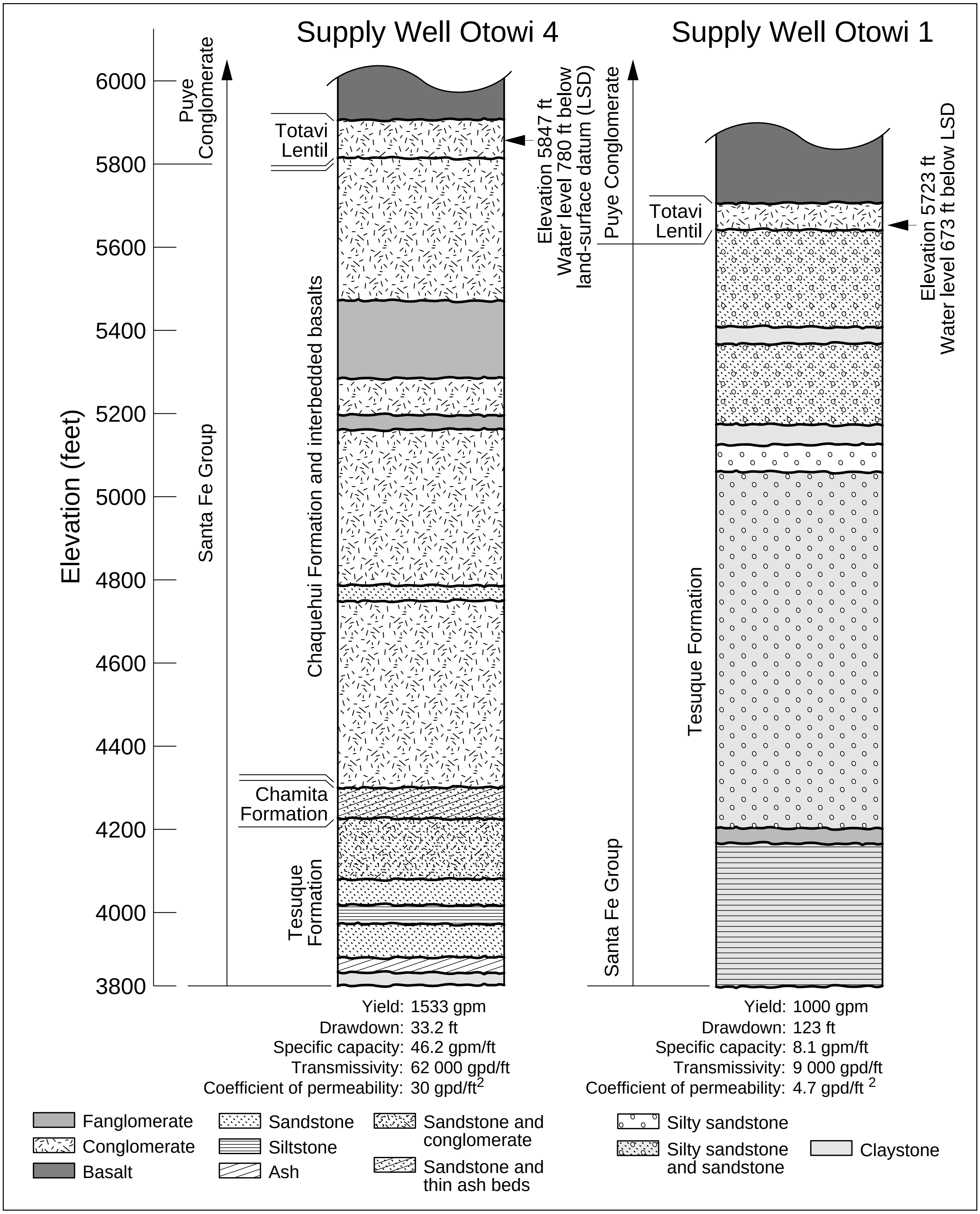

Fig. I-AH. Partial geologic logs of supply wells Otowi 1 and 4 showing equivalent saturated sections (main aquifer) in the Puye Conglomerate and Santa Fe Group and a comparison of their hydrologic characteristics (Purtymun 1993). See Figs. XXI-T and XXI-U for complete logs.

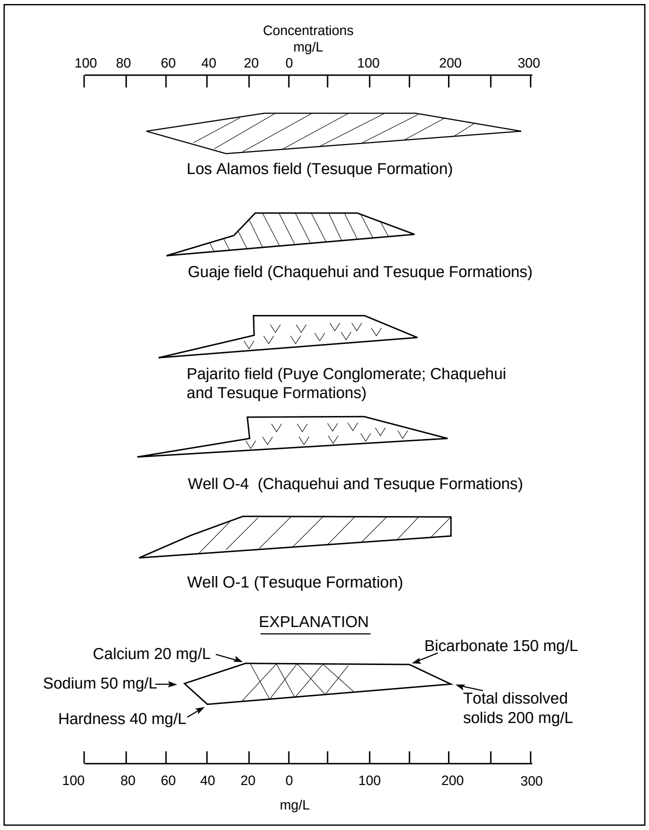

Fig. I-AI. Graphic comparsion of average chemical constituents in water in supply wells from the main aquifer (Purtymun 1993, Purtymun et al. 1994).

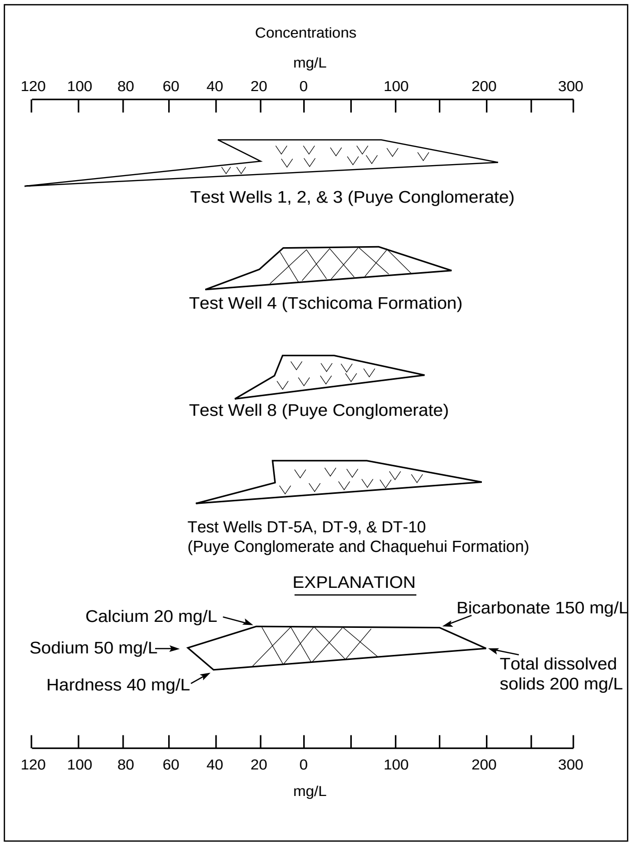

Fig. I-AJ. Graphic comparsion of average chemical constituents in water in test wells from the main aquifer (Purtymun 1993).

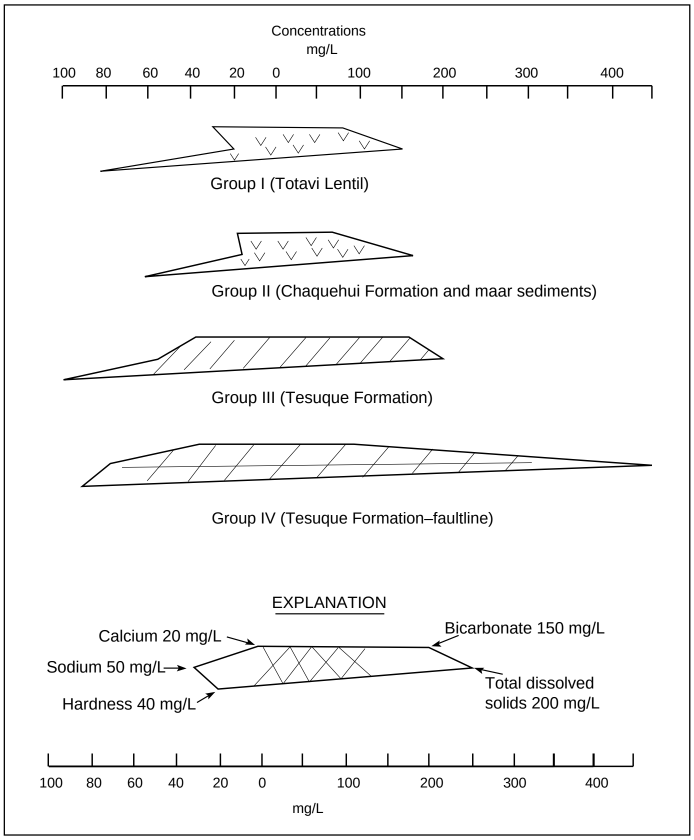

Fig. I-AK. Graphic comparison of average chemical constituents in water from the main aquifer in springs, in and adjacent to White Rock Canyon (Purtymun 1966, Purtymun et al. 1980, Purtymun 1993).

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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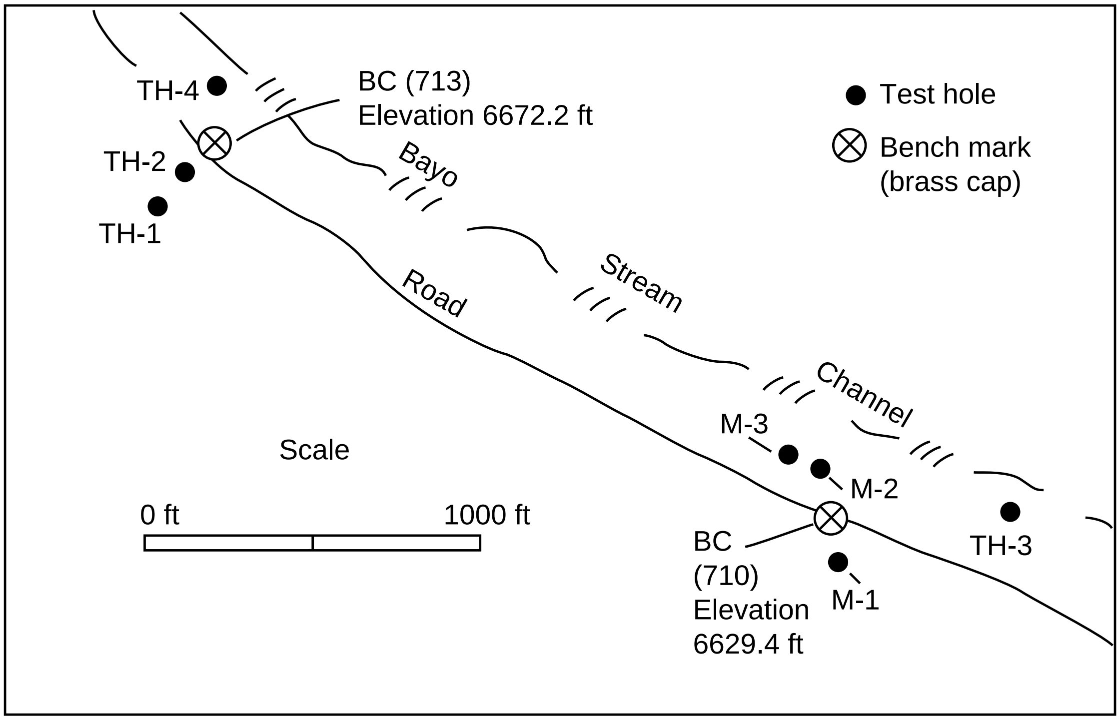

Fig. II-A. Generalized location of test holes in Bayo Canyon.

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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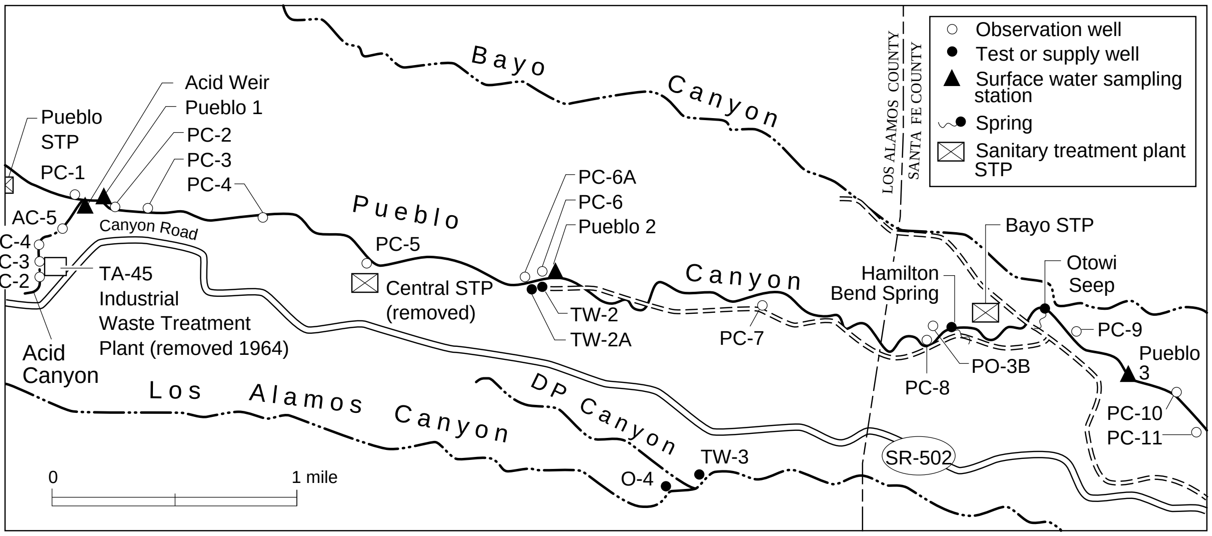

Fig. III-A. Generalized location of surface water sampling stations, shallow wells, and the spring sampling stations in Acid and Pueblo Canyons (Weir et al. 1963; Purtymun 1975).

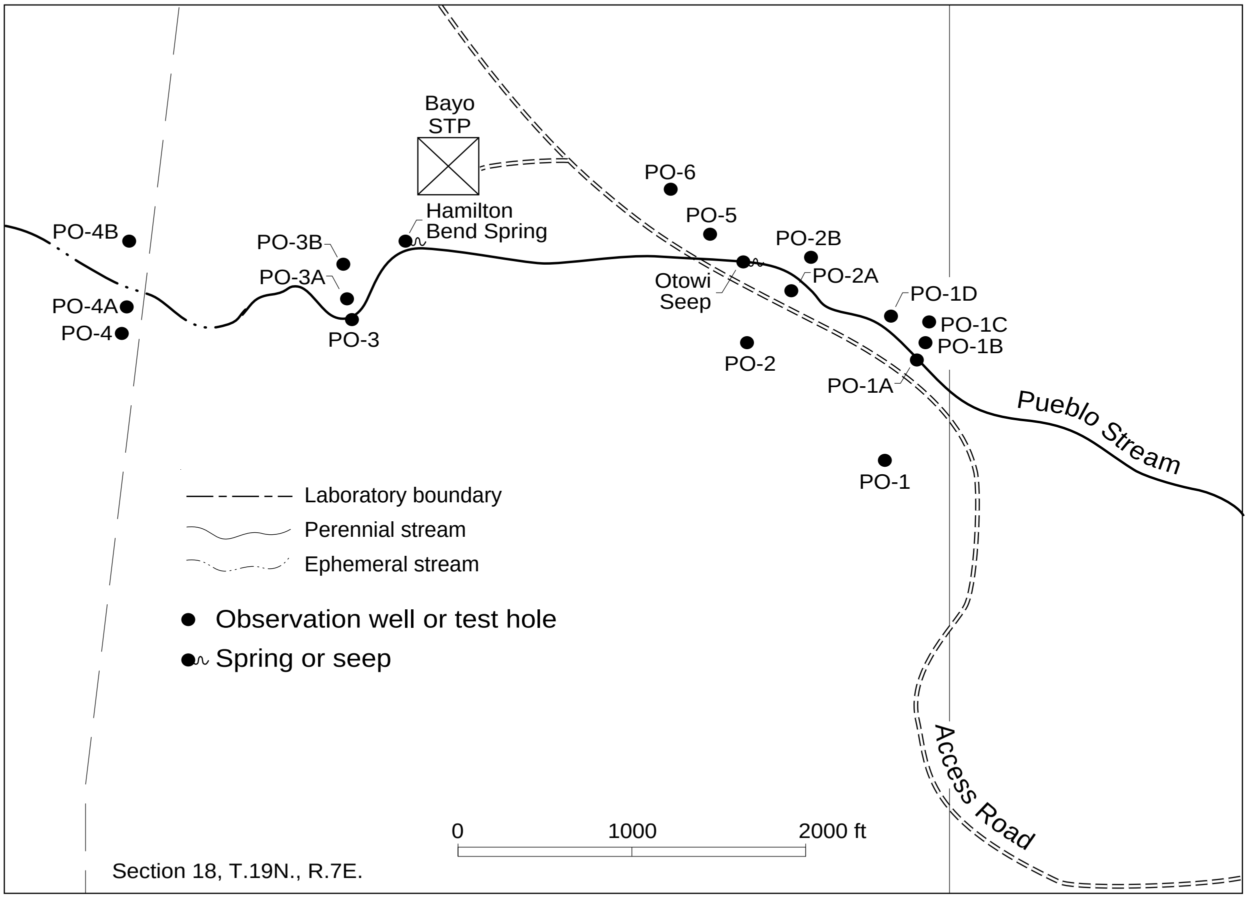

Fig. III-B. Location of observation wells and test holes in the vicinity of Hamilton Bend Spring and Otowi Seep in Pueblo Canyon (Abrahams 1966).

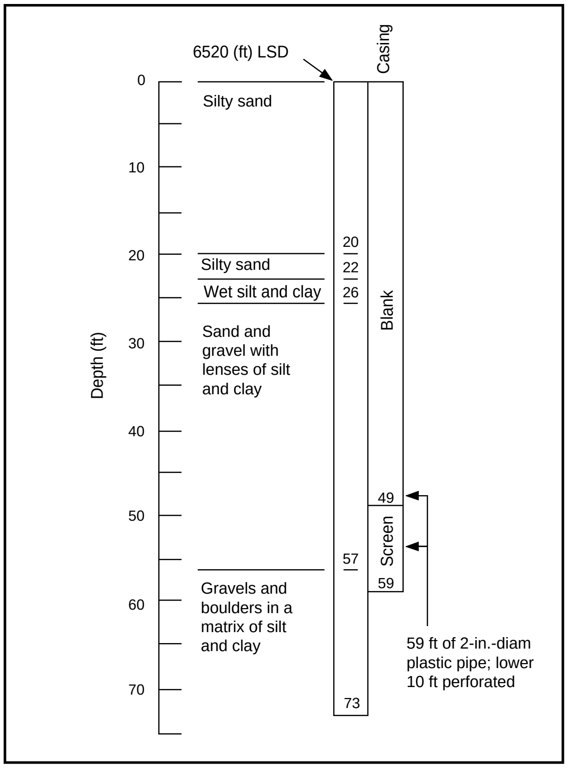

Fig. III-C. Pueblo Canyon observation well PO-3B, completed April 1956, water level 50 ft (Abrahams 1966).

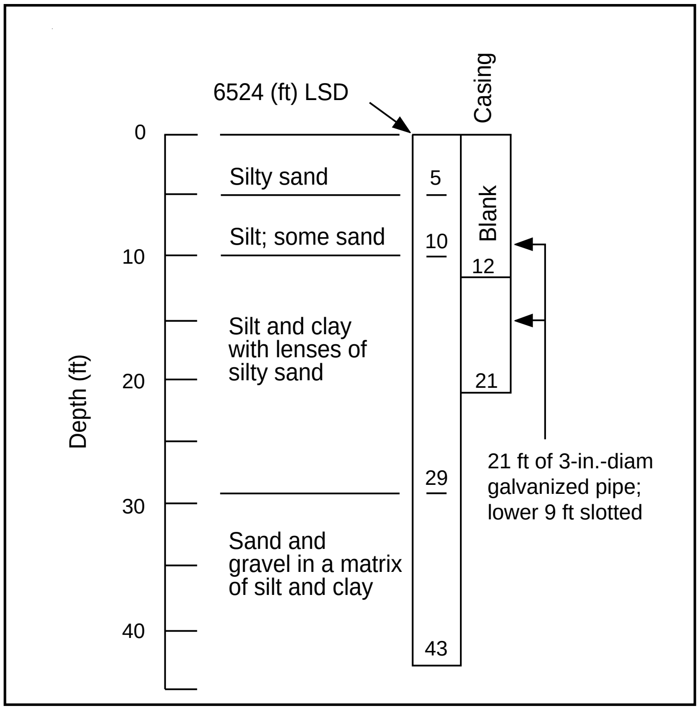

Fig. III-D. Pueblo Canyon observation well PO-4A, completed April 1956, water level 18 ft (Abrahams 1966).

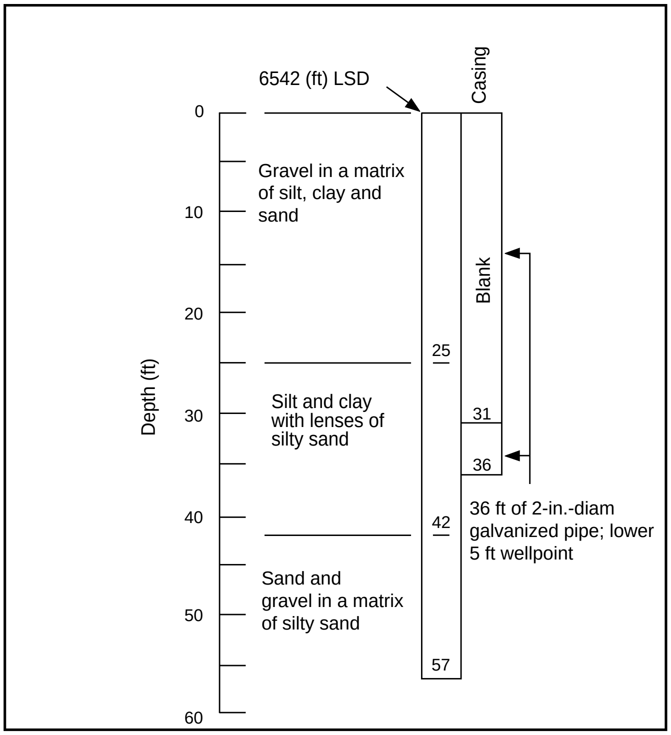

Fig. III-E. Pueblo Canyon observation well PO-4B, completed April 1956, water level 24.0 ft (Abrahams 1966).

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.

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)

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.

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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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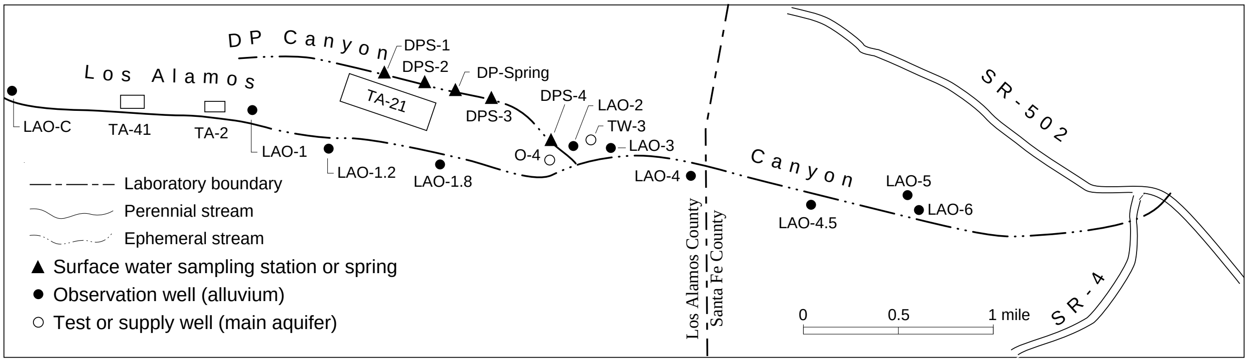

Fig. IV-A. Location of observation wells, test wells, and a supply well in Los Alamos Canyon (John et al. 1967; Purtymun 1975).

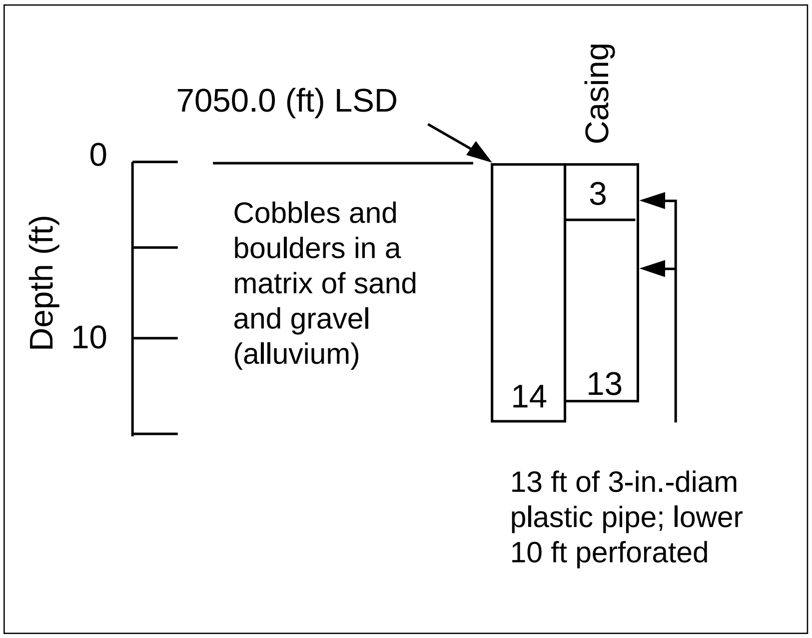

Fig. IV-B. Los Alamos Canyon observation well LAO-C, completed August 1970, water level 2.5 ft (Purtymun 1970).

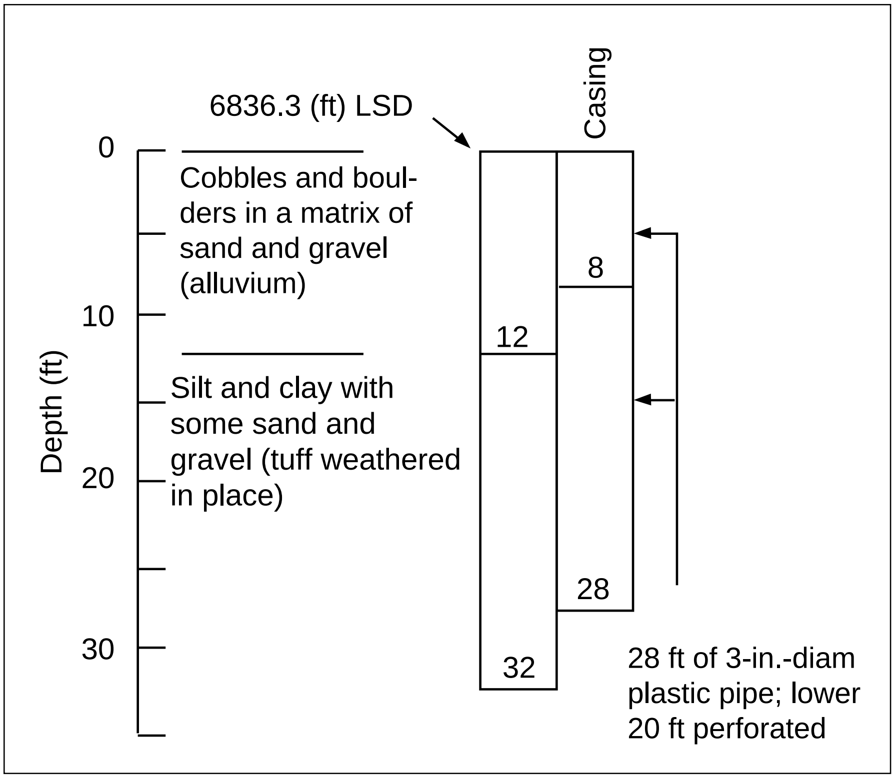

Fig. IV-C. Los Alamos Canyon observation well LAO-1, completed February 1966, water level 4.6 ft (John et al. 1967; Purtymun 1966).

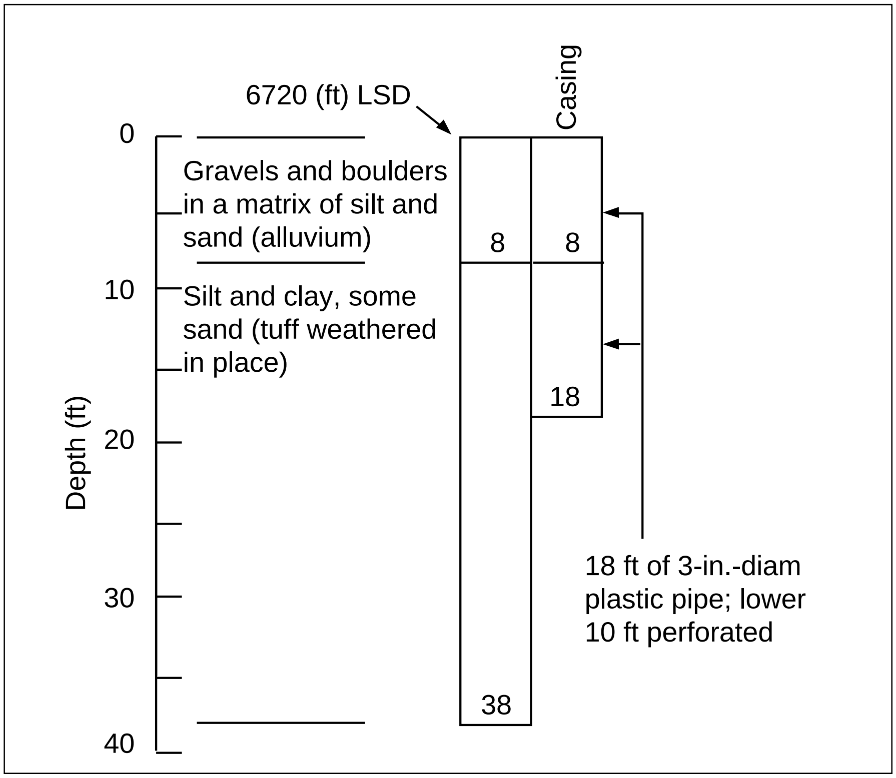

Fig. IV-D. Los Alamos Canyon observation well LAO-1.2, completed August 1969, water level 6.3 ft (Purtymun 1969).

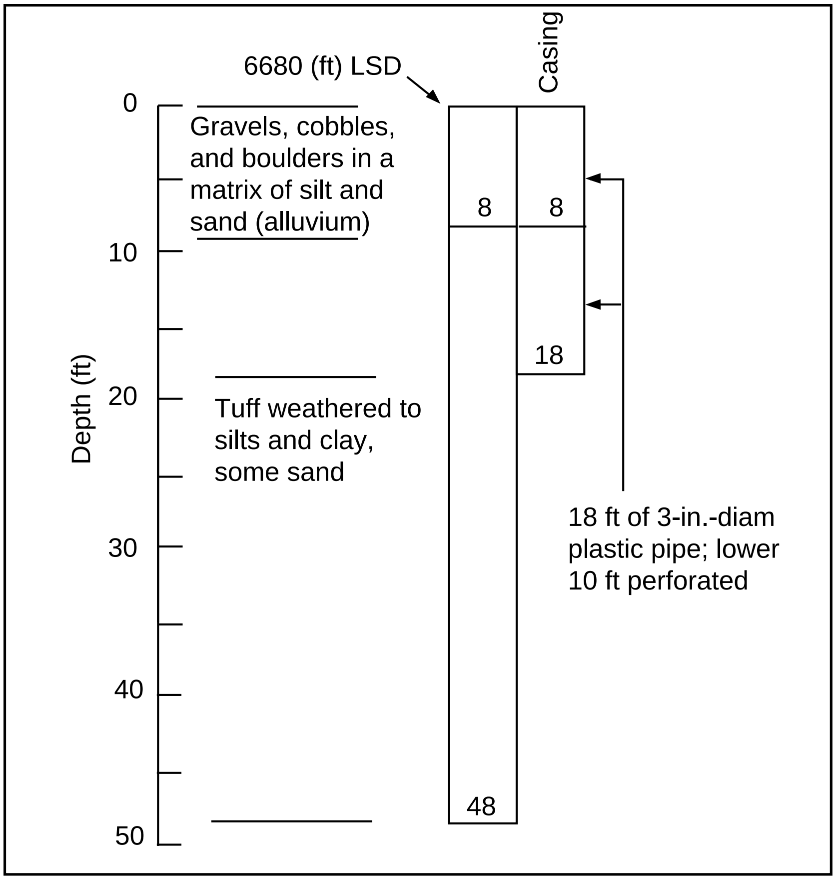

Fig. IV-E. Los Alamos Canyon observation well LAO-1.8, completed April 1969, water level 10.0 ft (Purtymun 1969).

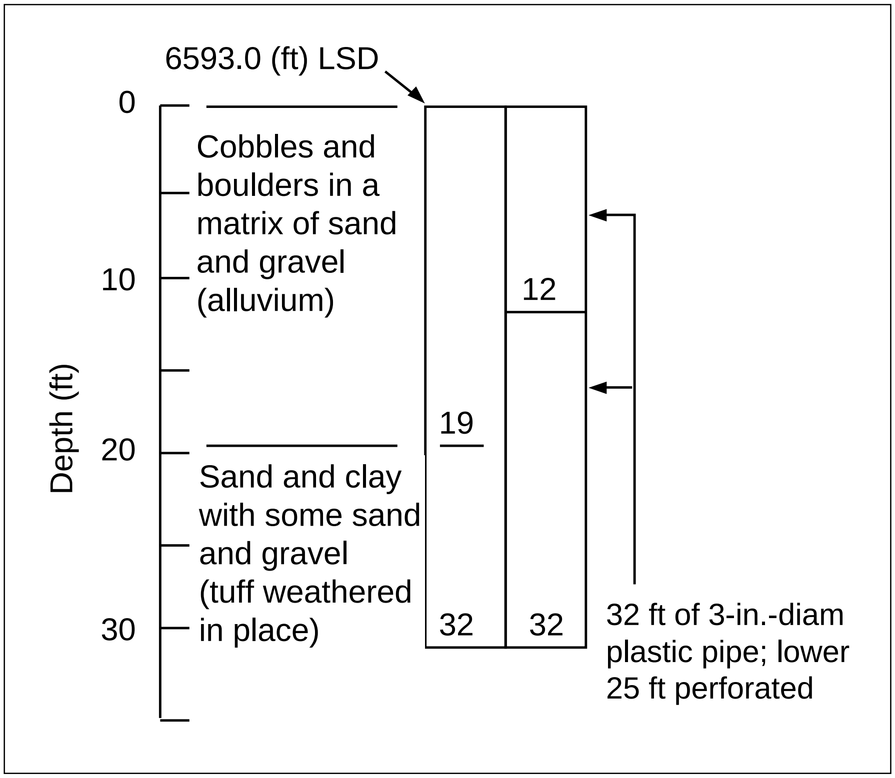

Fig. IV-F. Los Alamos Canyon observation well LAO-2, completed February 1966, water level 11.0 ft (John et al. 1967).

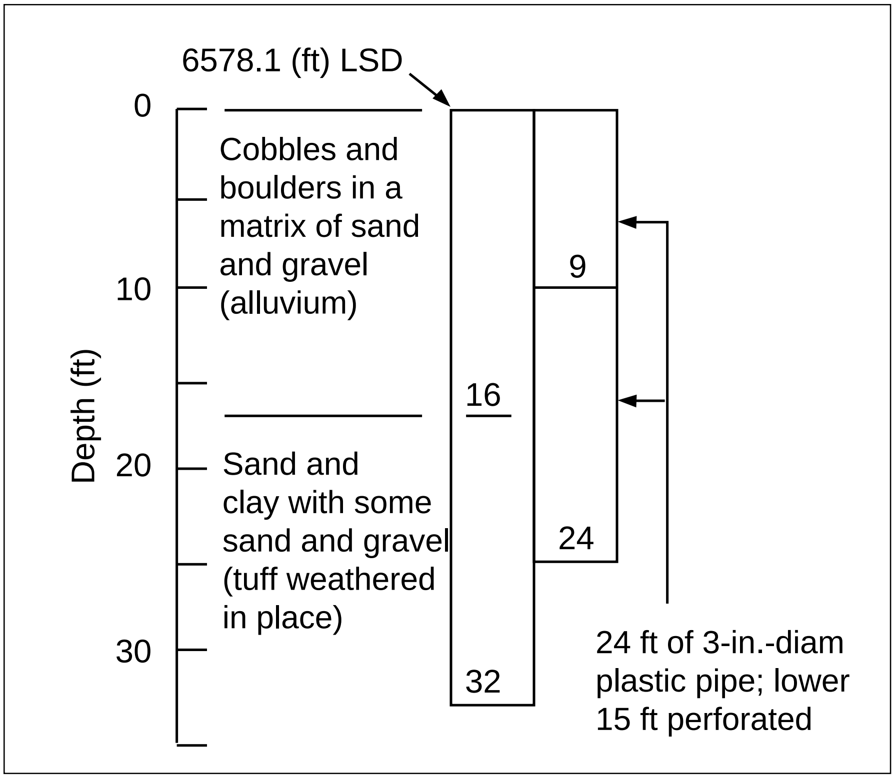

Fig. IV-G. Los Alamos Canyon observation well LAO-3, completed February 1966, water level 6.5 ft (John et al. 1967; Purtymun 1966).

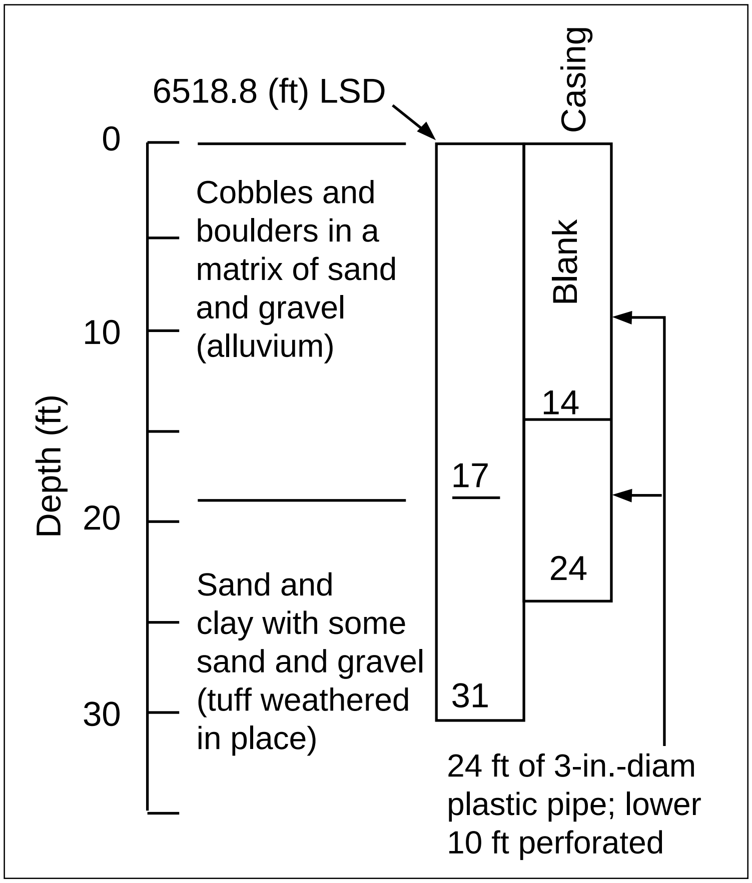

Fig. IV-H. Los Alamos Canyon observation well LAO-4, completed February 1966, water level 12.6 ft (John et al. 1967; Purtymun 1966).

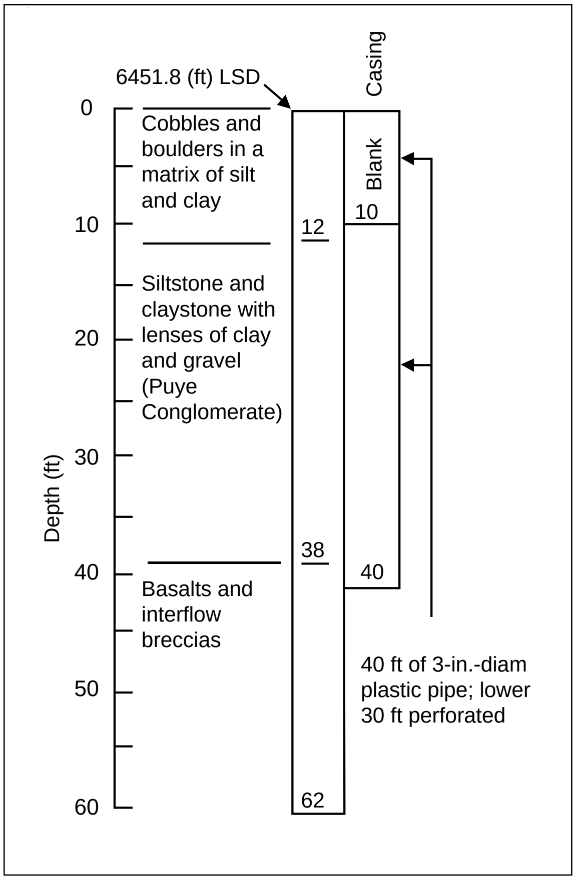

Fig. IV-I. Los Alamos Canyon observation well LAO-4.5, completed April 1969, water level 4.5 ft (Purtymun 1969).

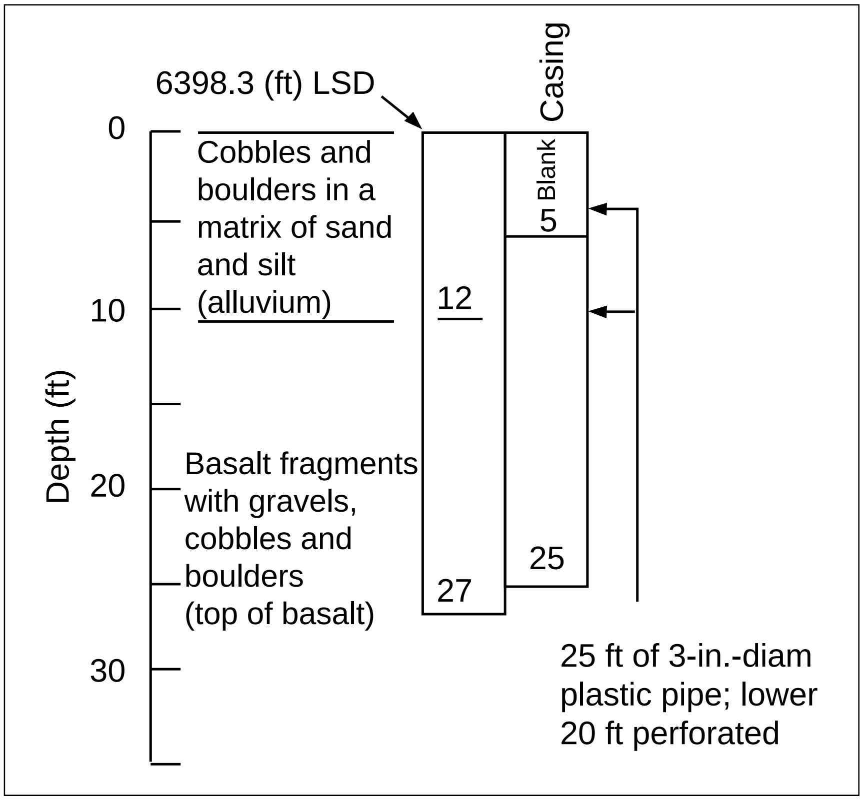

Fig. IV-J. Los Alamos Canyon observation well LAO-5, completed February 1966, dry (John et al. 1967; Purtymun 1966).

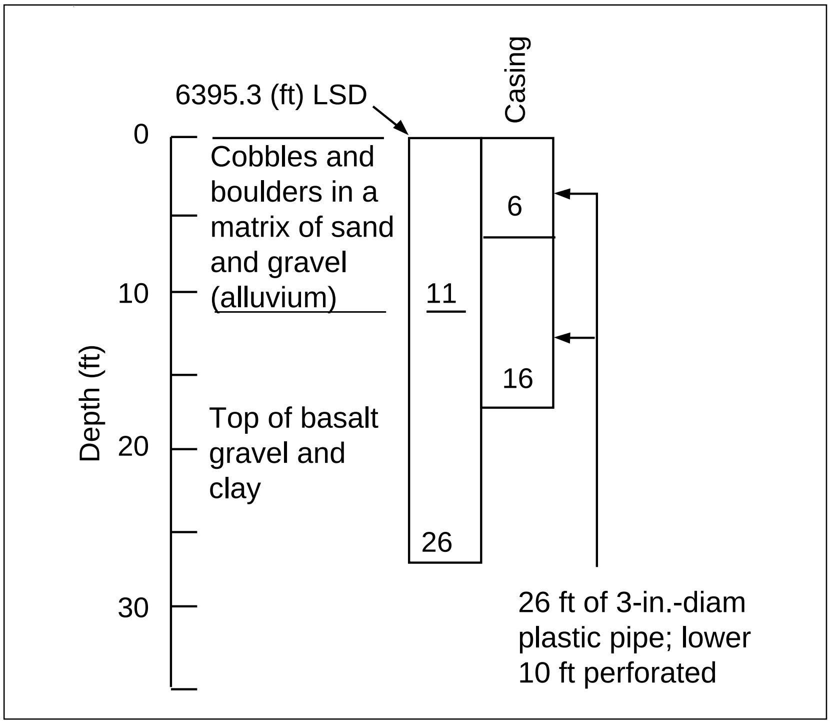

Fig. IV-K. Los Alamos Canyon observation well LAO-6, completed February 1966, dry (John et al. 1967; Purtymun 1966).

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.

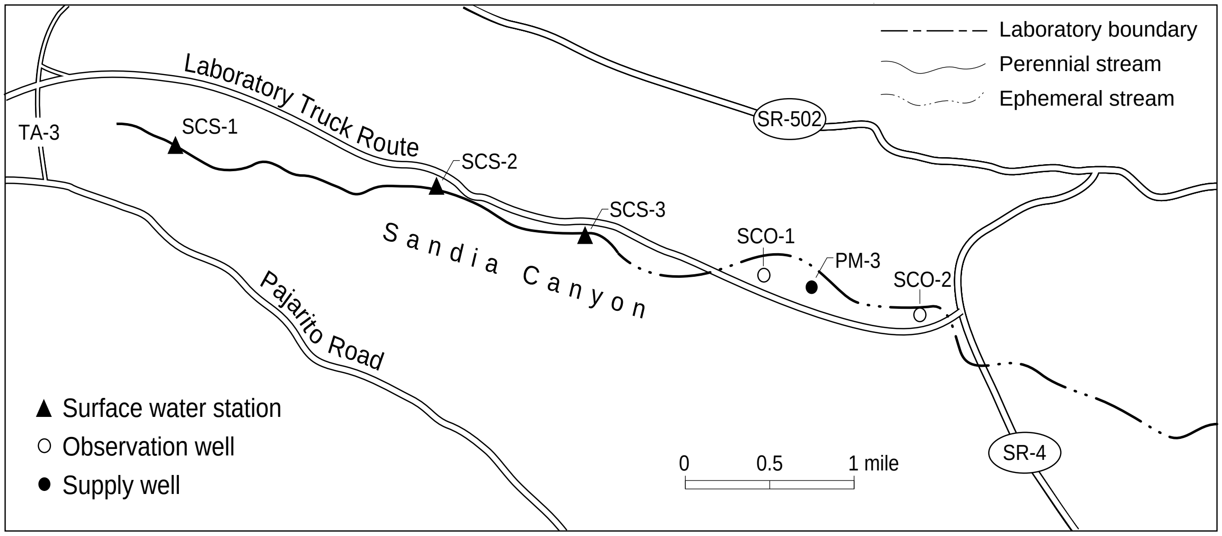

Fig. V-A. Location of sampling stations in Sandia Canyon (Purtymun 1975).

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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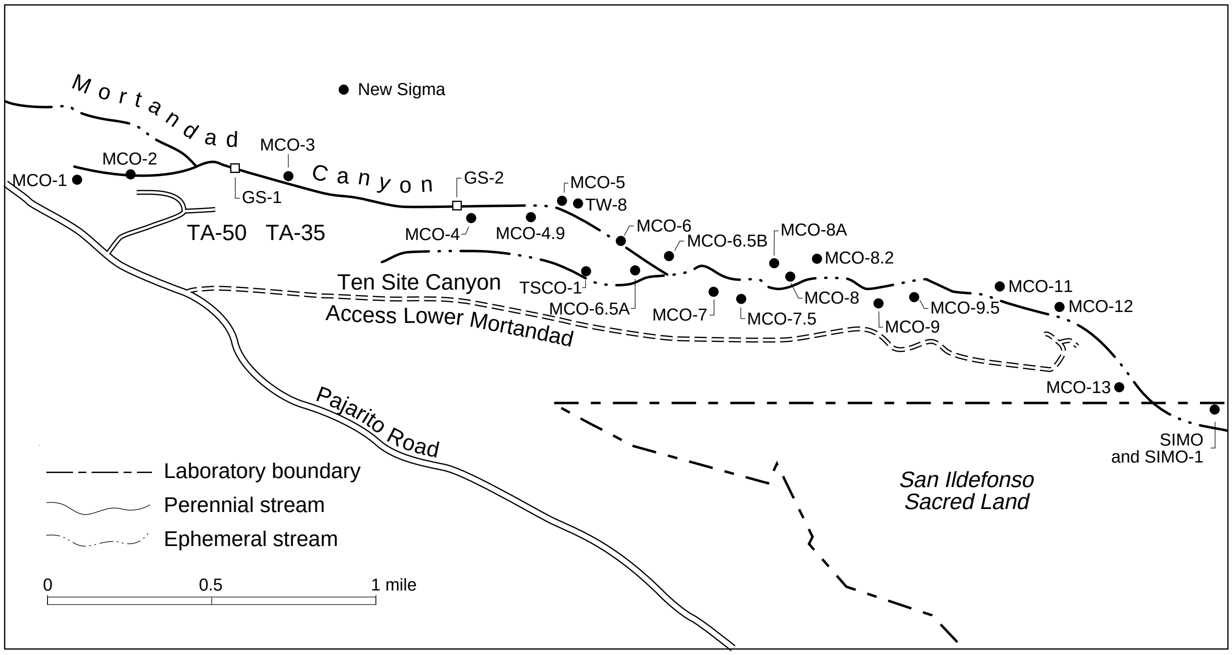


Fig. VI-A. Location of observation wells in Mortandad Canyon.

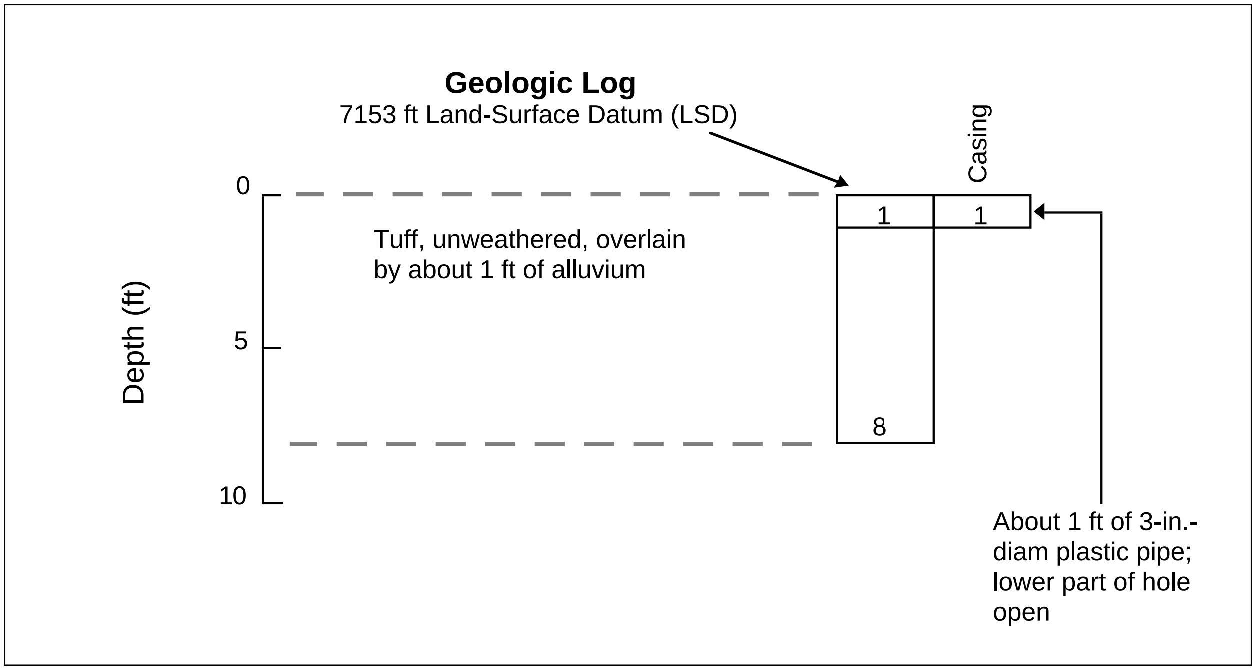


Fig. VI-B. Mortandad Canyon observation well MCO-1, completed November 1960, water level 2.8 ft; unable to locate in 1991 (Baltz et al. 1963).

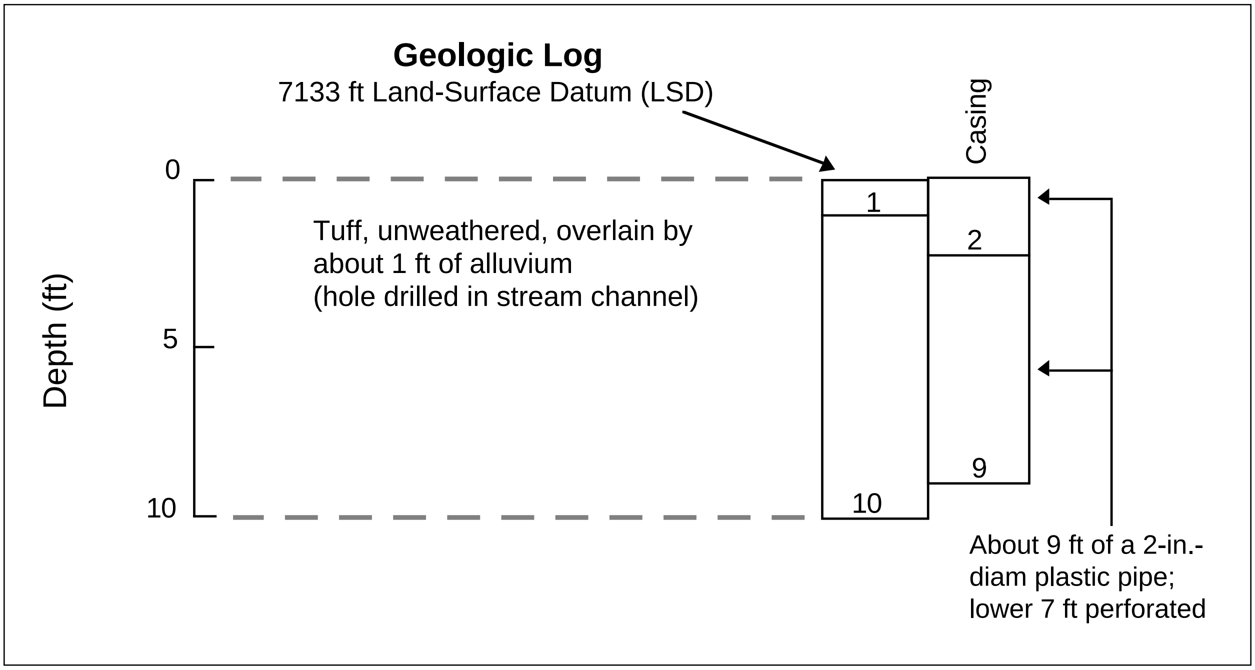


Fig. VI-C. Mortandad Canyon observation well MCO-2, completed November 1960, water level 0.3 ft (Baltz et al. 1963).

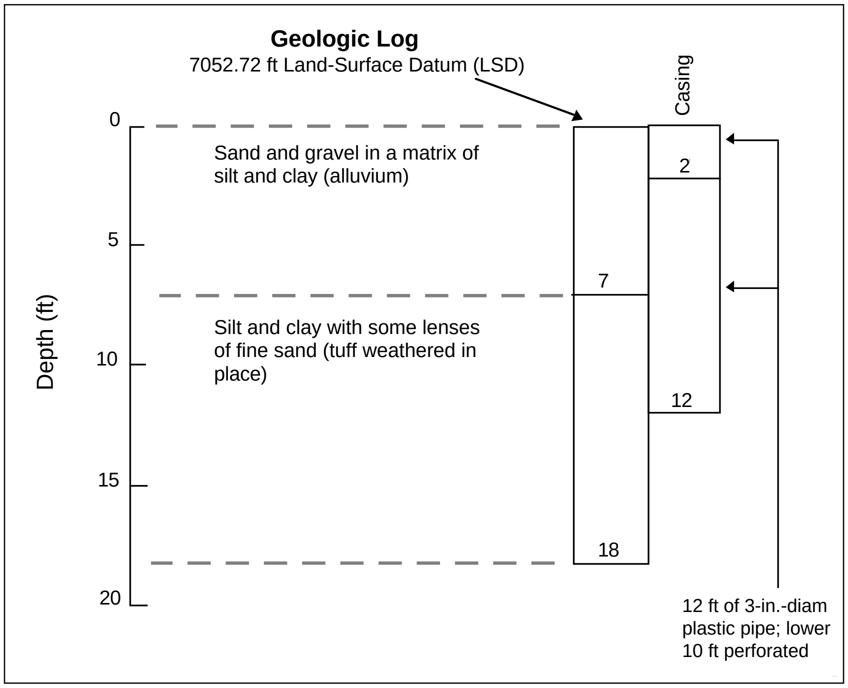


Fig. VI-D. Mortandad Canyon observation well MCO-3, redrilled March 1967 and completed with 3-in.-diam casing, water level 4.4 ft (Baltz et al. 1963; Purtymun 1964).

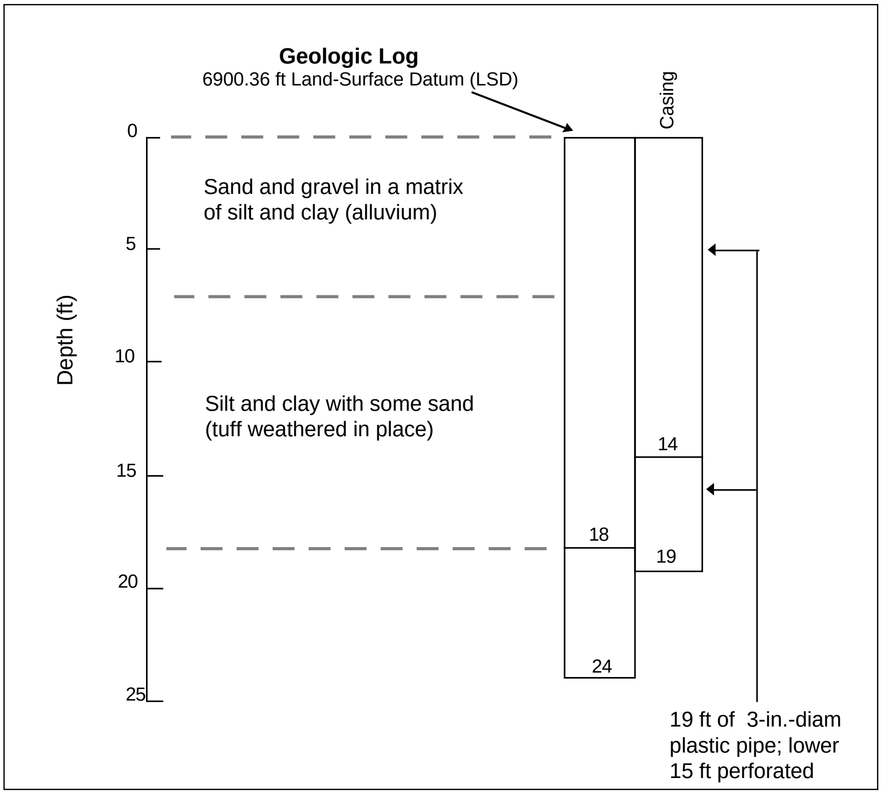


Fig. VI-E. Mortandad Canyon observation well MCO-4, redrilled October 1963, water level 3.3 ft (Baltz et al. 1963; Purtymun 1963).

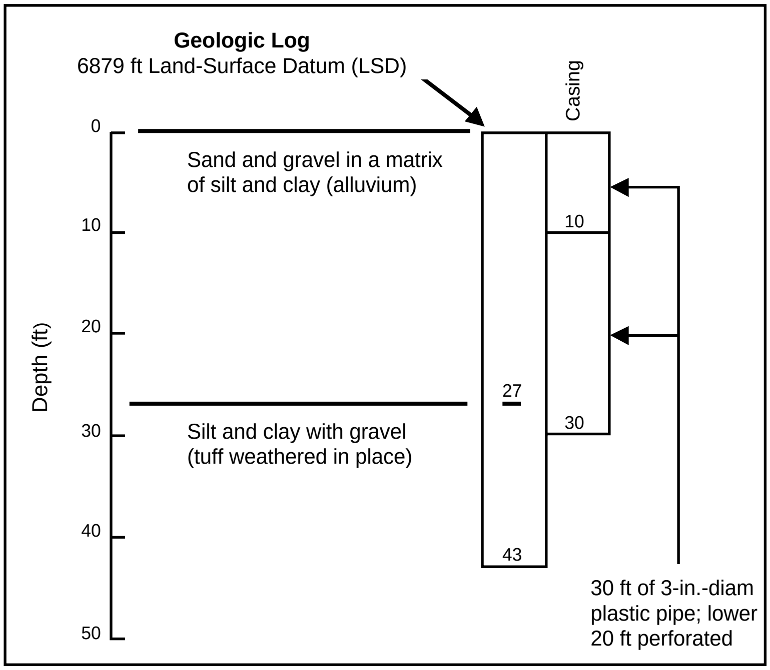


Fig. VI-F. Mortandad Canyon observation well MCO-4.9, completed July 1973, water level 23.7 ft (Purtymun 1973).

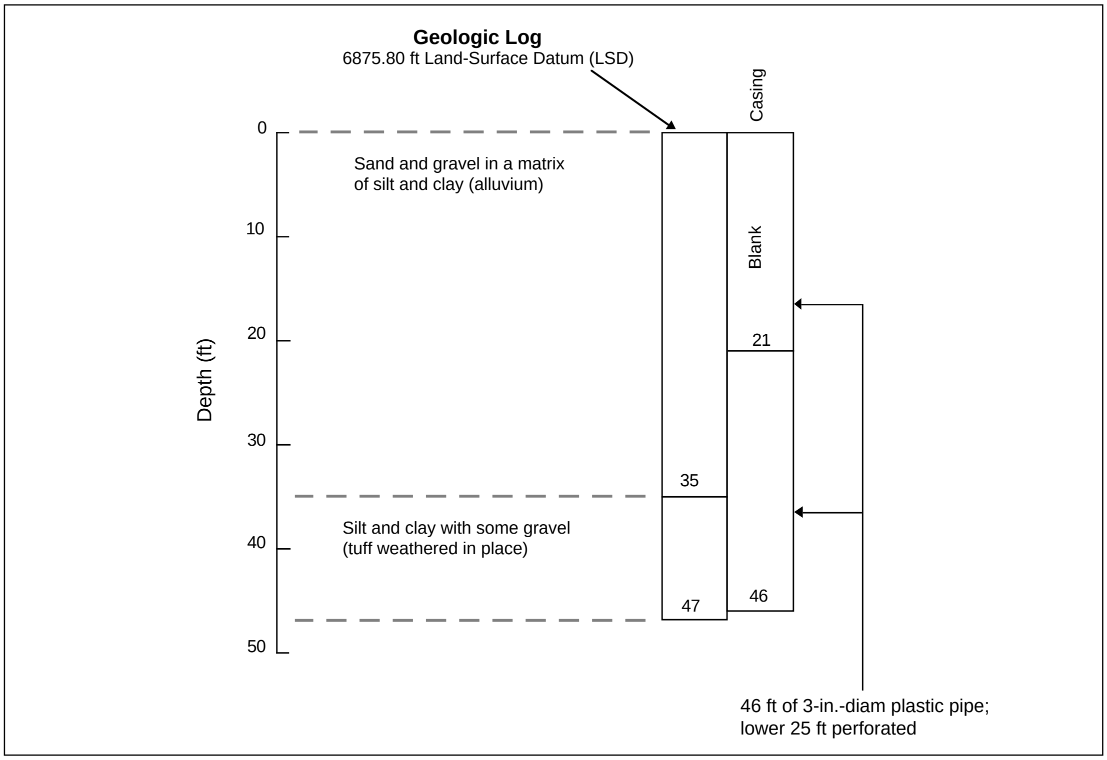


Fig. VI-G. Mortandad Canyon observation well MCO-5, completed October 1960, water level 24.6 ft (Baltz et al. 1963).

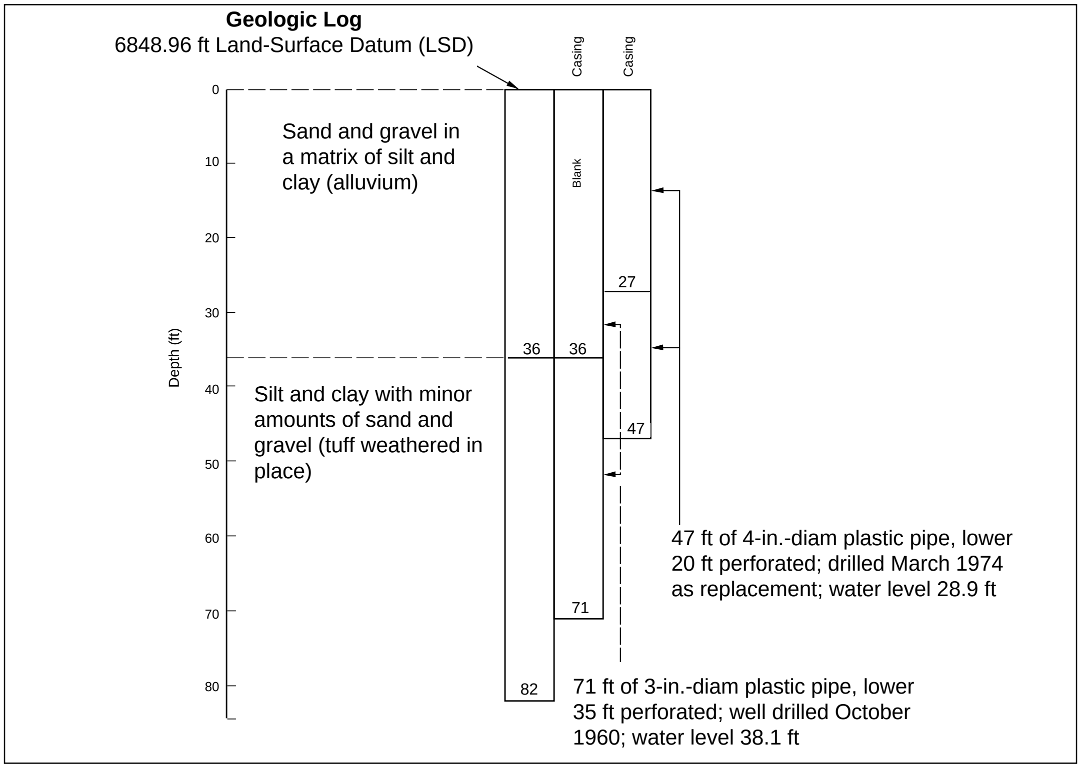


Fig. VI-H. Mortandad Canyon observation well MCO-6, completed October 1960, replaced March 1974 (Baltz et al. 1963, Purtymun 1974).

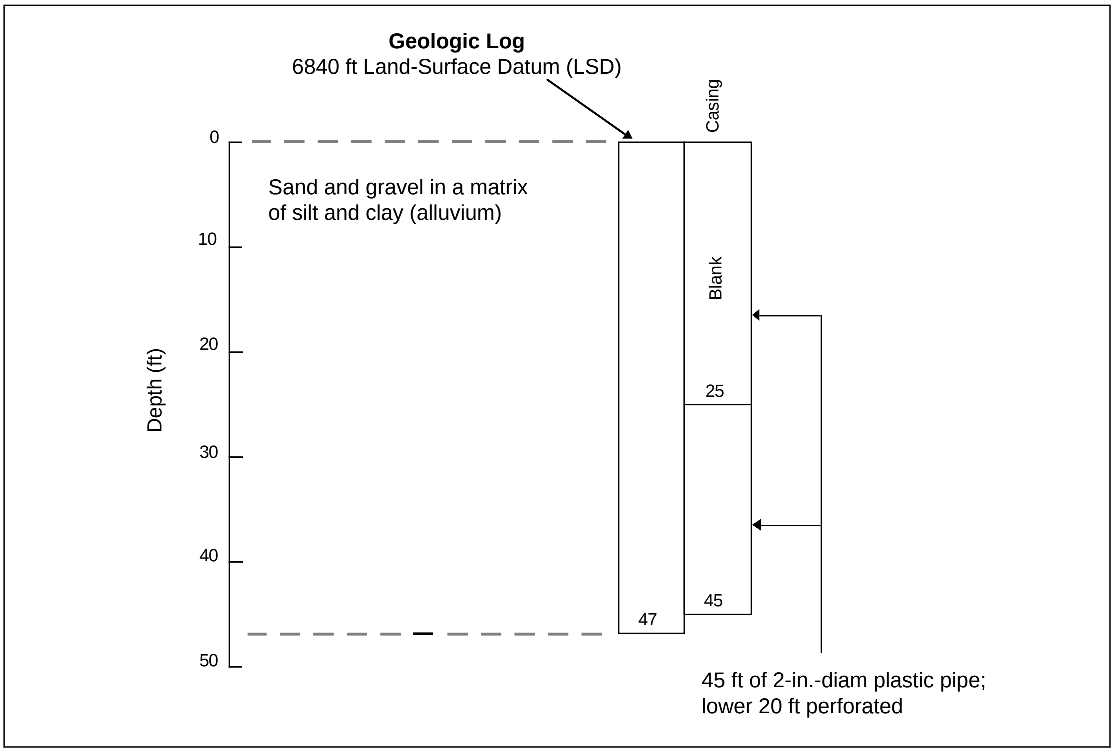


Fig. VI-I. Mortandad Canyon observation well MCO-6.5A, completed November 1961, water level 41.0 ft (Purtymun 1964).

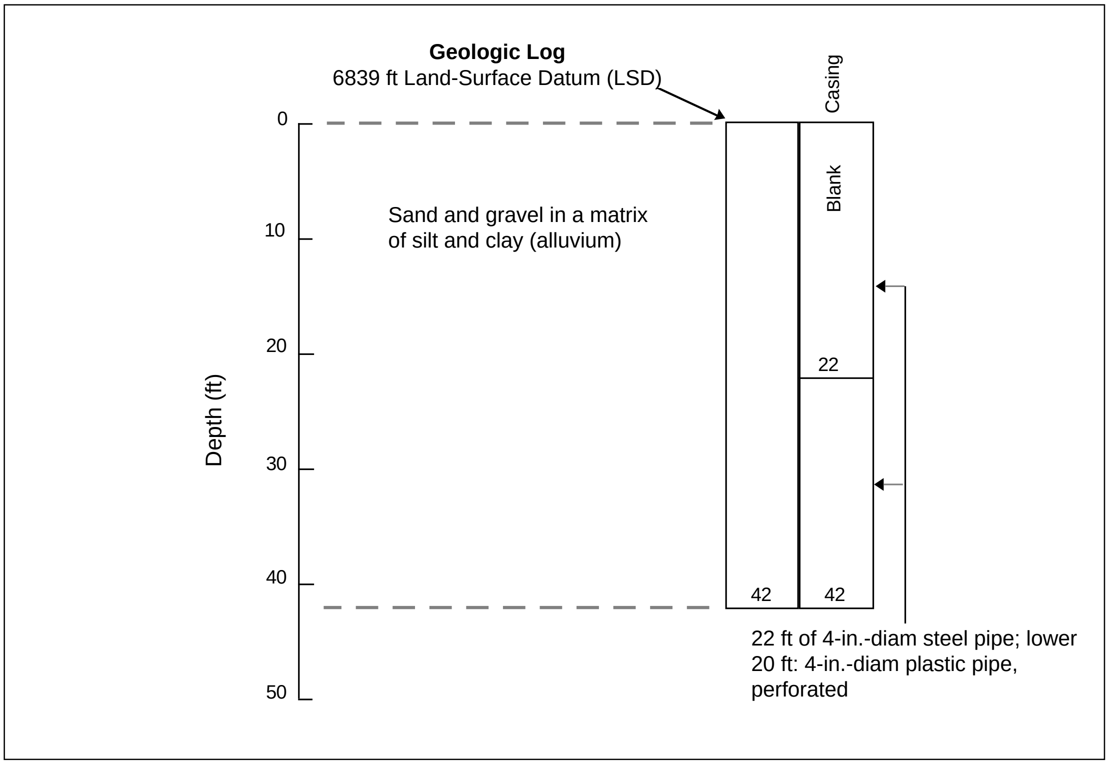


Fig. VI-J. Mortandad Canyon observation well MCO-6.5B, completed November 1961, water level 36.3 ft (Purtymun 1964).

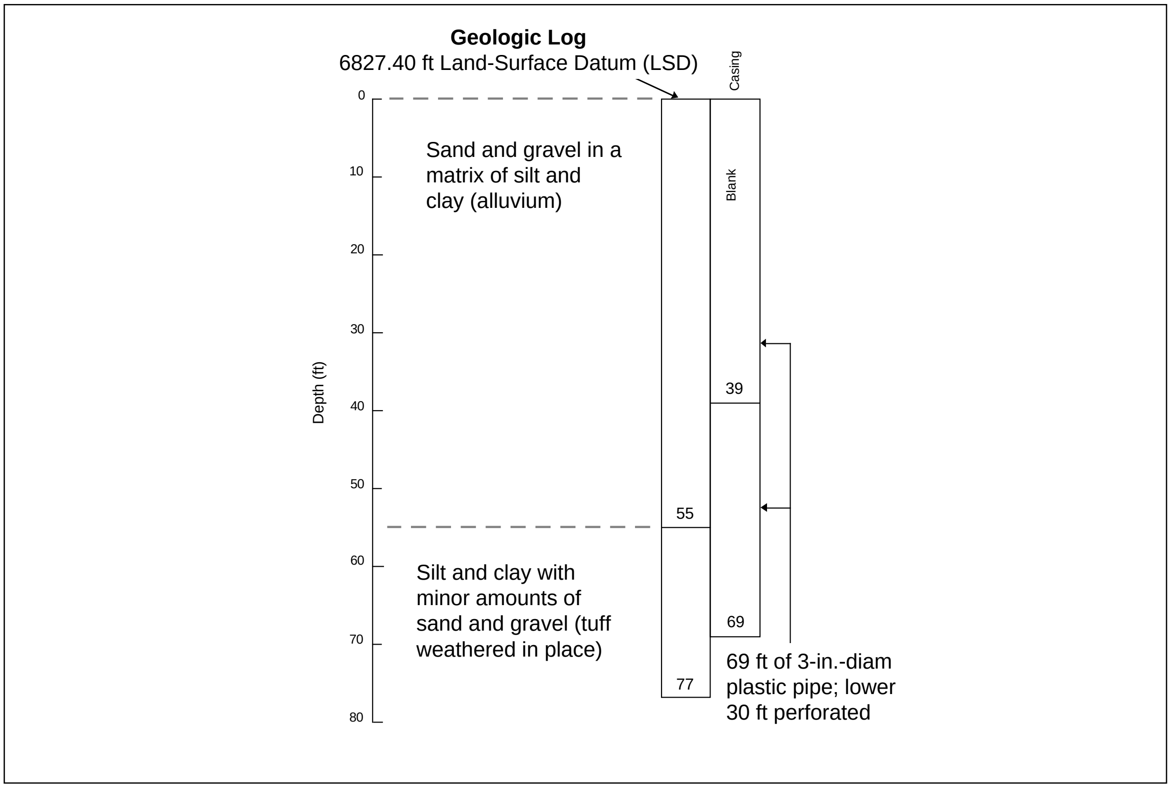


Fig. VI-K. Mortandad Canyon observation well MCO-7, completed October 1960, water level 39.7 ft (Baltz et al. 1963).

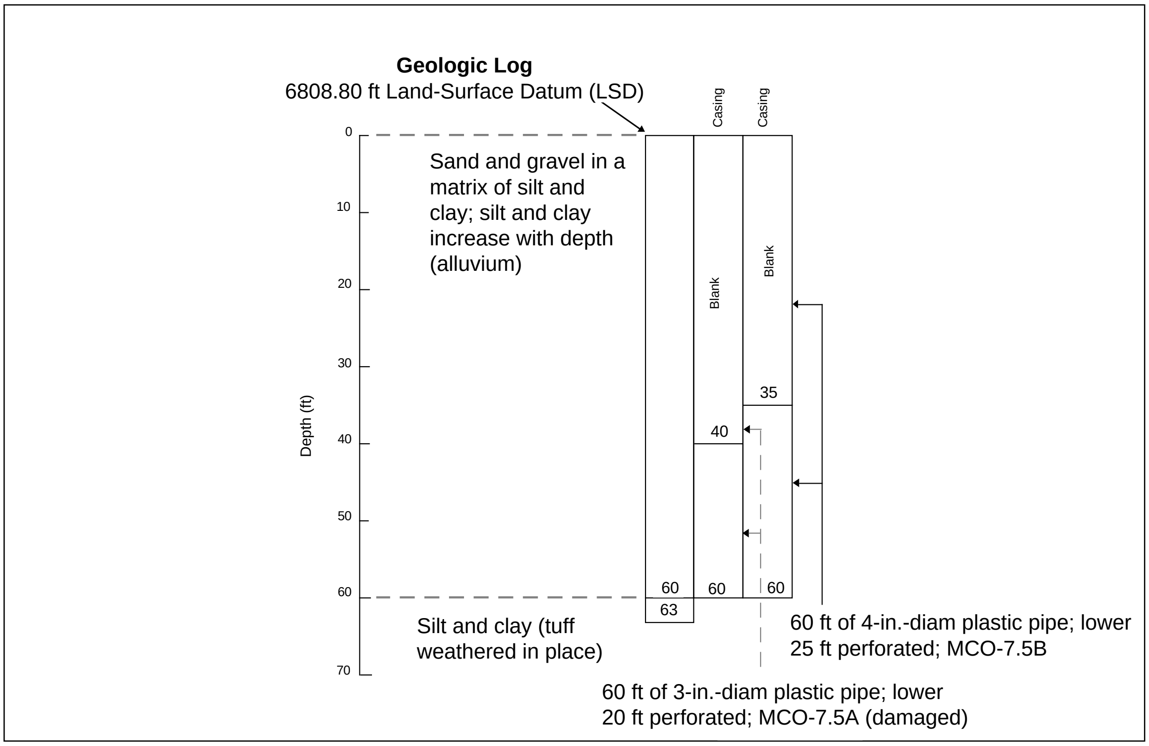


Fig. VI-L. Mortandad Canyon observation well MCO-7.5A (damaged), completed November 1961, water level 41.2 ft; and adjacent well MCO-7.5B, completed April 1974, water level 42.1 ft (Purtymun 1964, 1974).

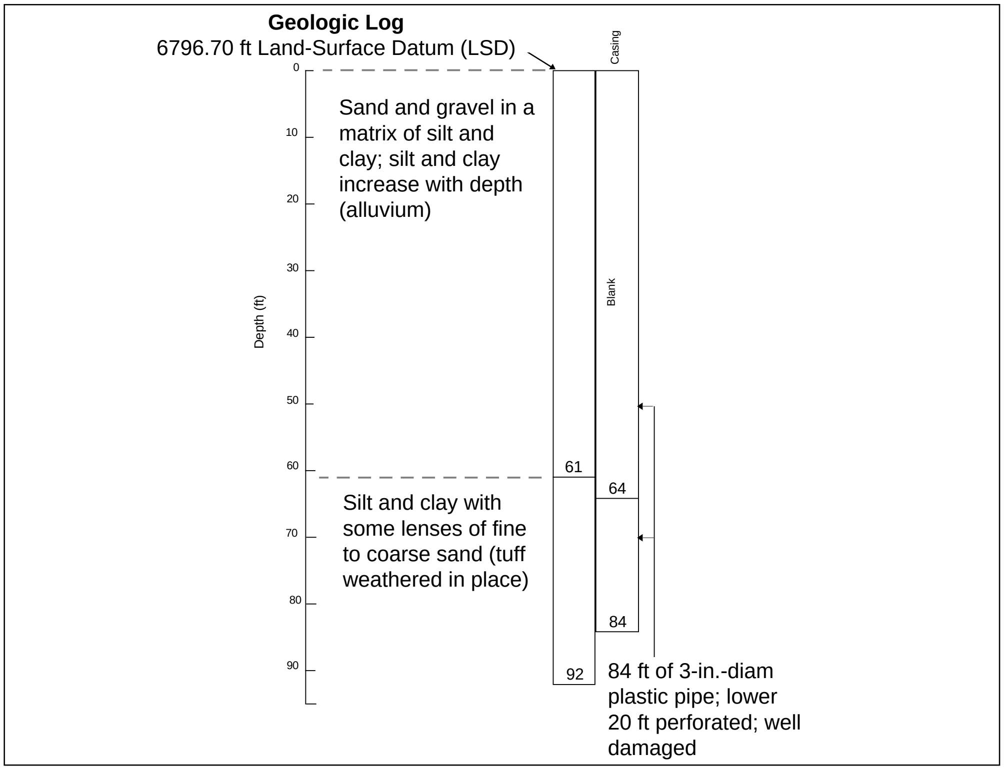


Fig. VI-M. Mortandad Canyon observation well MCO-8, completed October 1960, water level 61.6 ft; damaged beyond repair November 1976 (Baltz et al. 1963).

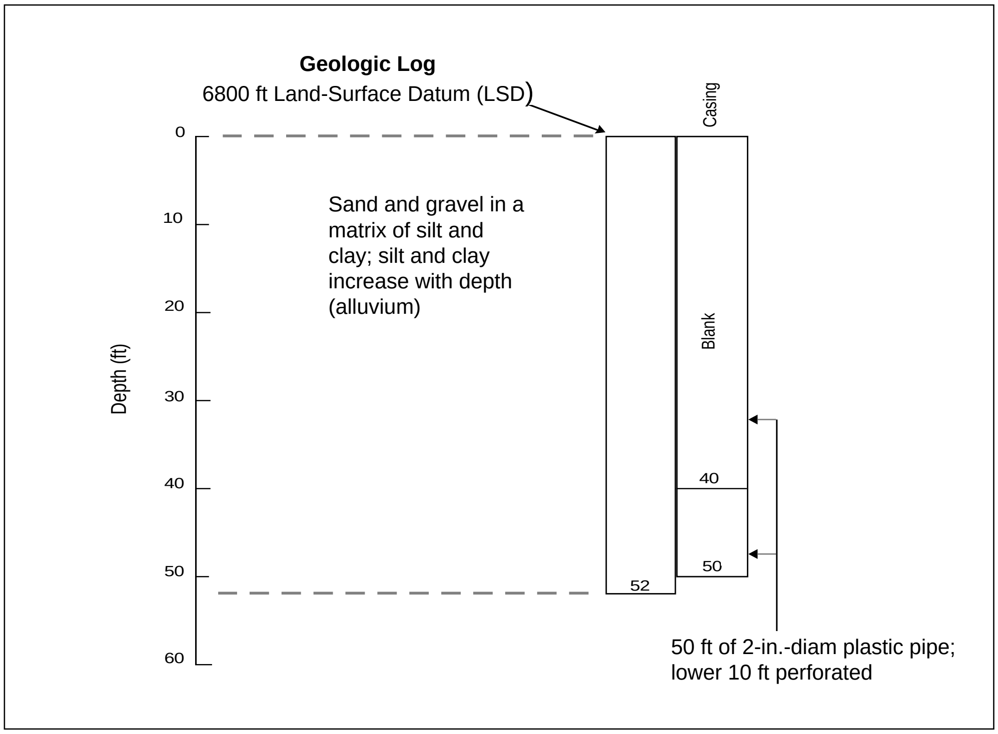


Fig. VI-N. Mortandad Canyon observation well MCO-8A, completed November 1961, dry (Purtymun 1964).

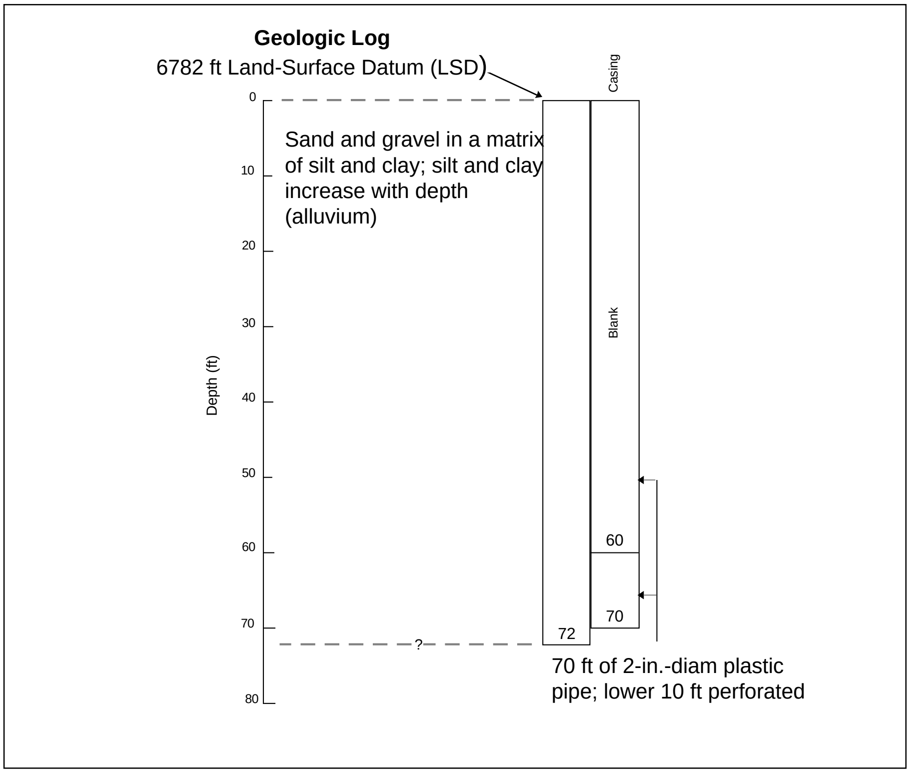


Fig. VI-O. Mortandad Canyon observation well MCO-8.2, completed November 1961, water level 59.2 ft (Purtymun 1964).

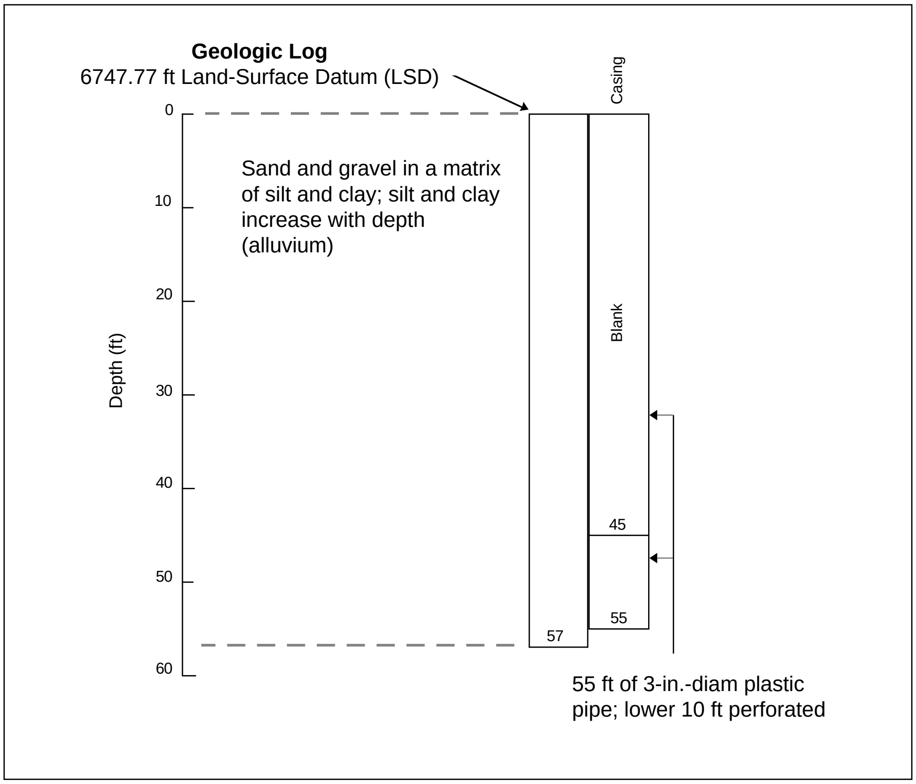


Fig. VI-P. Mortandad Canyon observation well MCO-9, completed November 1961, dry (Purtymun 1964).

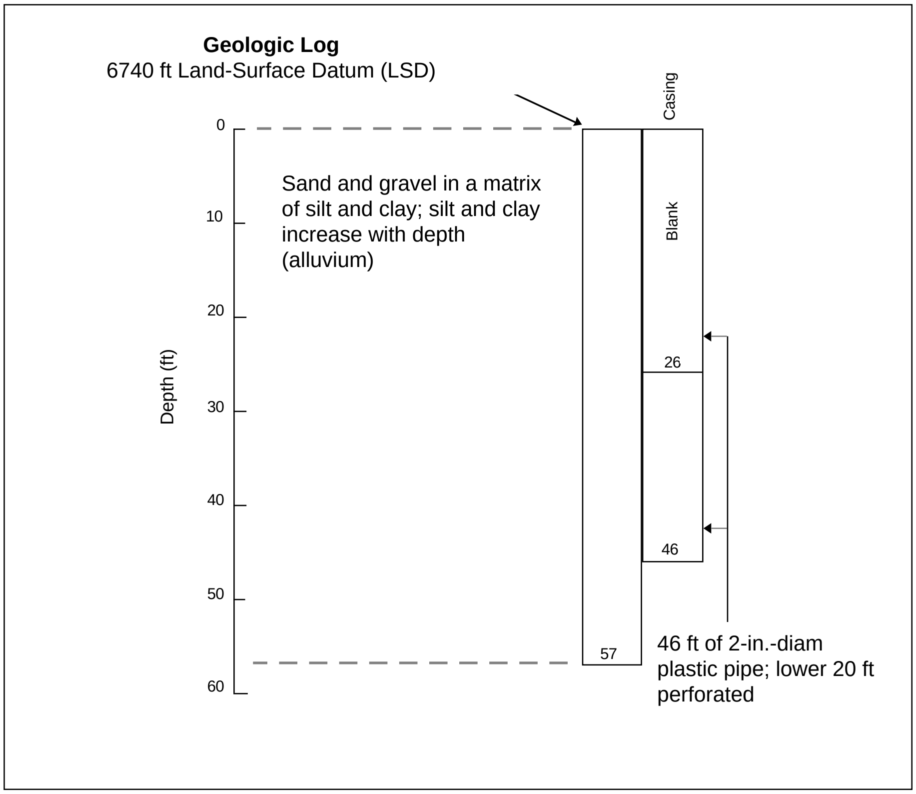


Fig. VI-Q. Mortandad Canyon observation well MCO-9.5, completed November 1961, dry (Purtymun 1964).

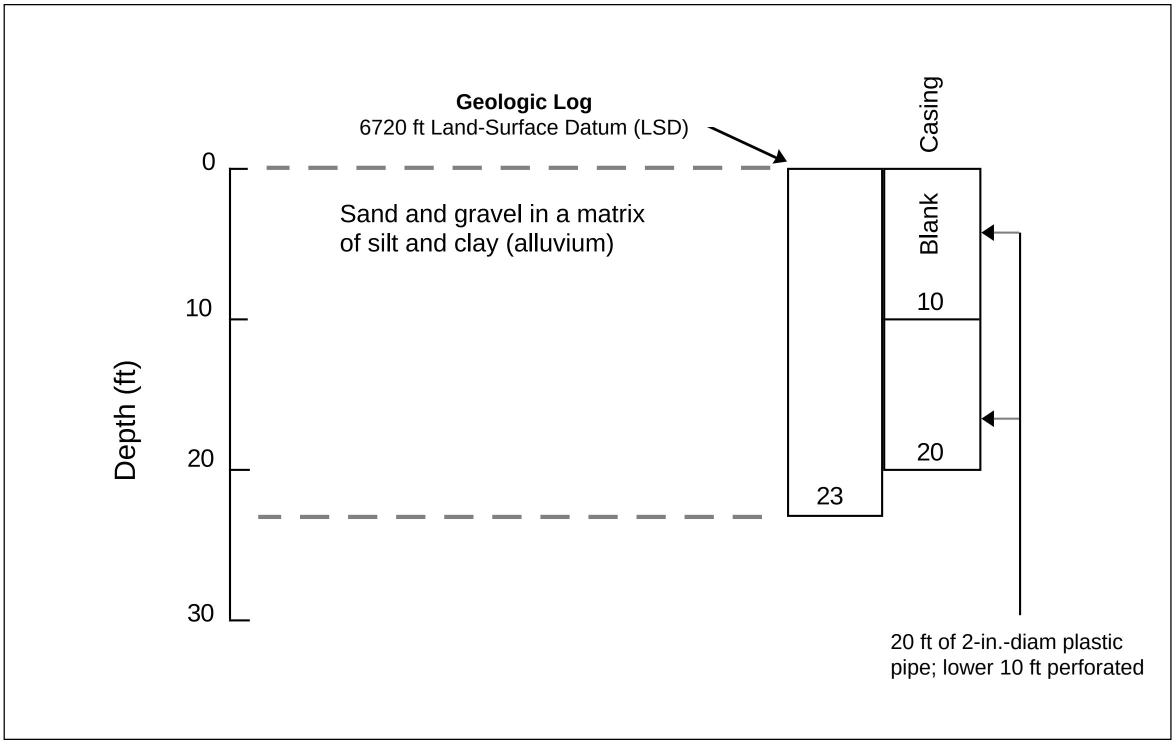


Fig. VI-R. Mortandad Canyon observation well MCO-11, completed November 1961, dry; unable to locate, February 1991 (Purtymun 1964).

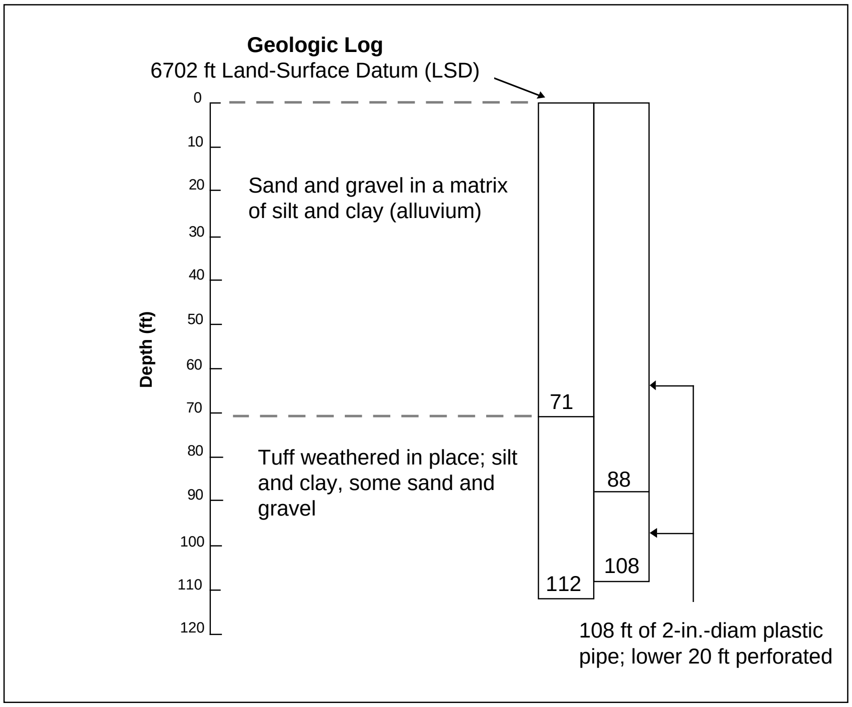


Fig. VI-S. Mortandad Canyon observation well MCO-12, completed June 1971, dry; replaced previous well MCO-12 (see Fig. VI-T.), which was plugged and abandoned about 12 ft to the south (Purtymun 1971b).

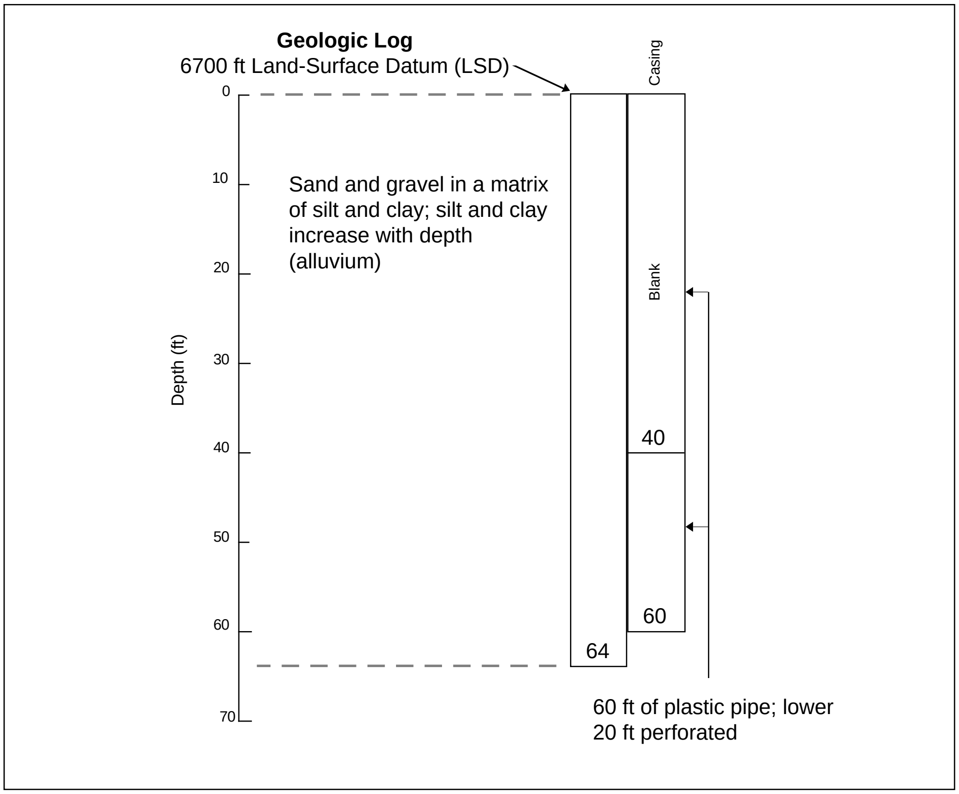


Fig. VI-T. Mortandad Canyon observation well, MCO-12, completed November 1961, dry; June 1971, well was dry, casing was pulled, well was abandoned, plugged, and relocated to the north about 12 ft (Purtymun 1964).

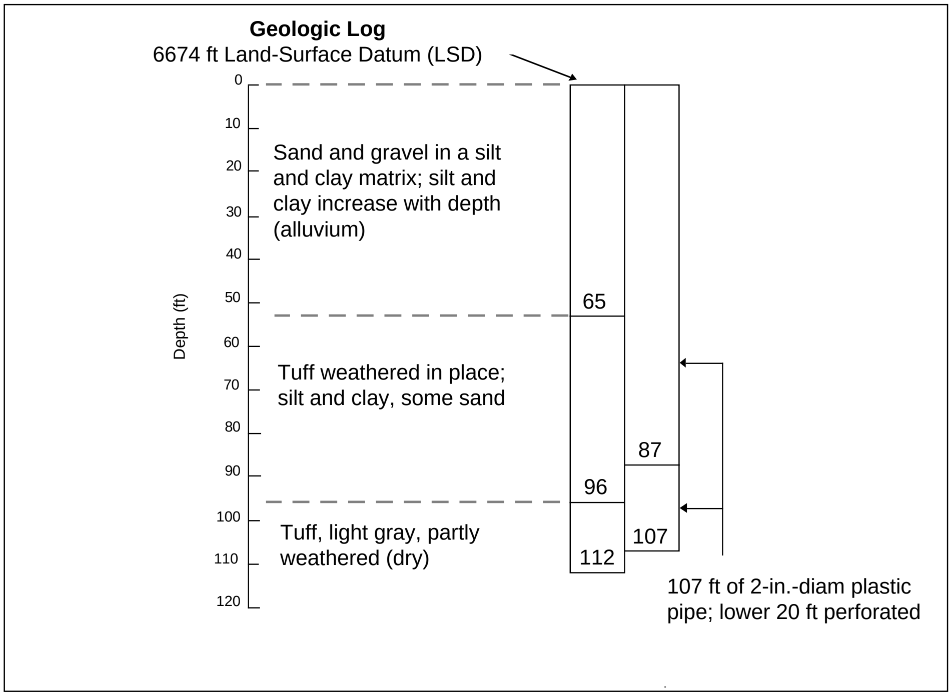


Fig. VI-U. Mortandad Canyon observation well MCO-13, completed July 1970, dry (Purtymun 1970).

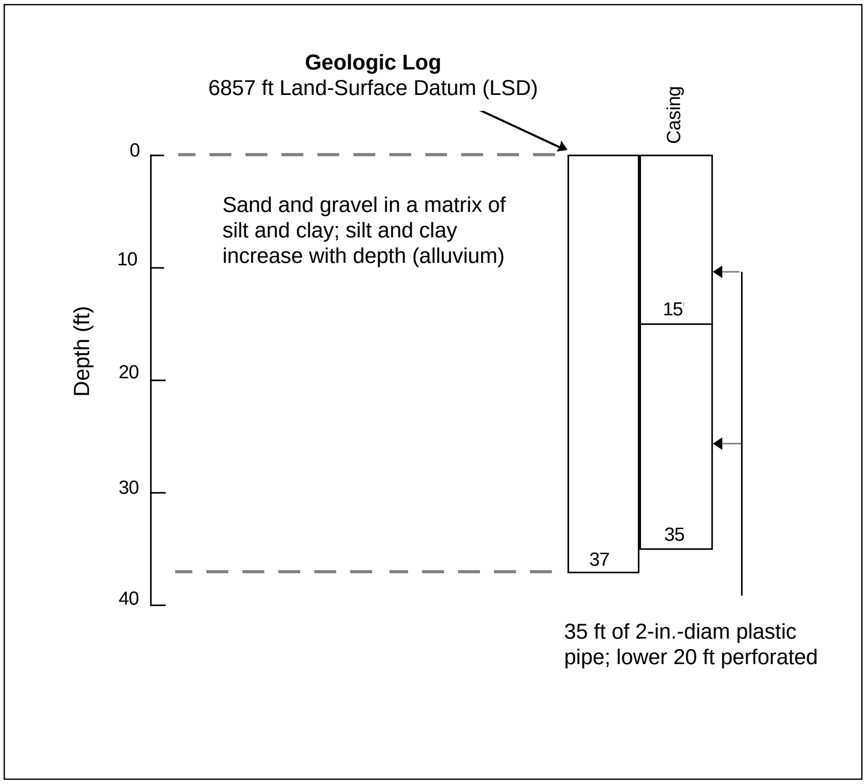


Fig. VI-V. Ten Site Canyon observation well TSCO-1, completed November 1961, dry (Purtymun 1964).

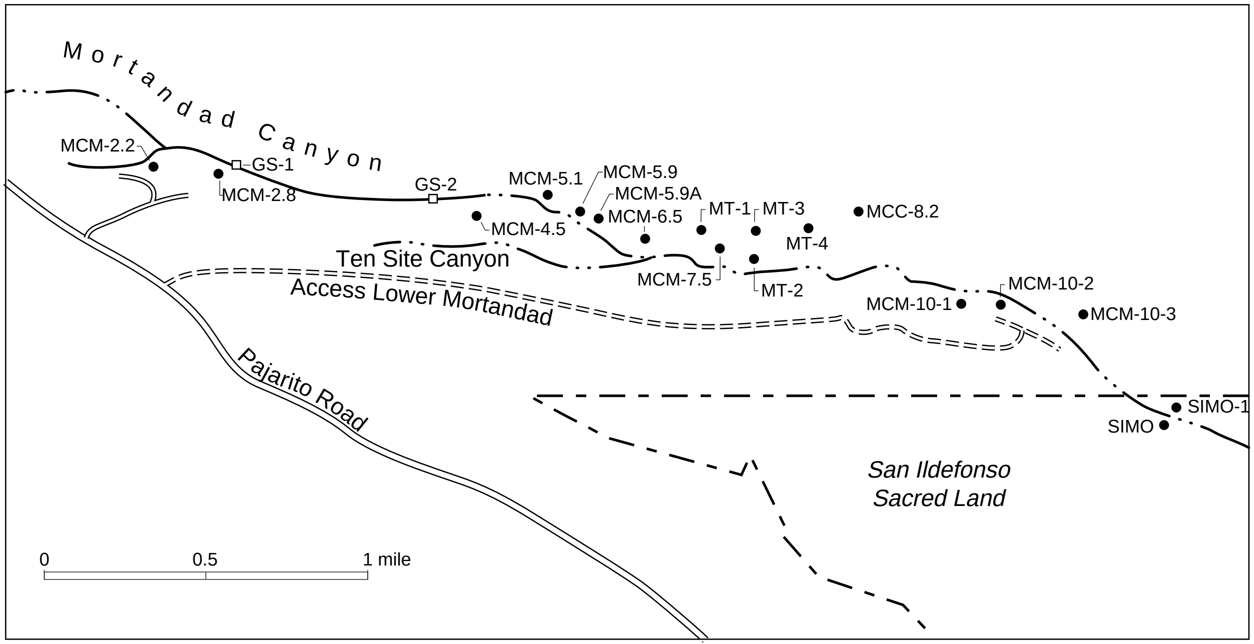


Fig. VI-W. Location of test holes and special moisture-access holes in Mortandad Canyon.

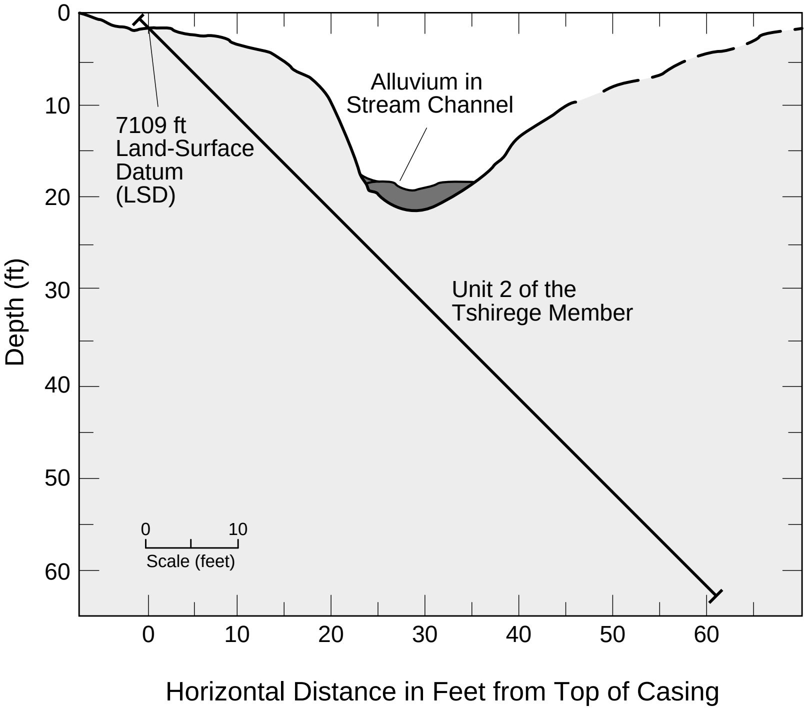


Fig. VI-X. Cross section across stream channel showing Mortandad test hole MCM-2.2 (Purtymun 1964). See Fig. VI-W and Table VI-D.

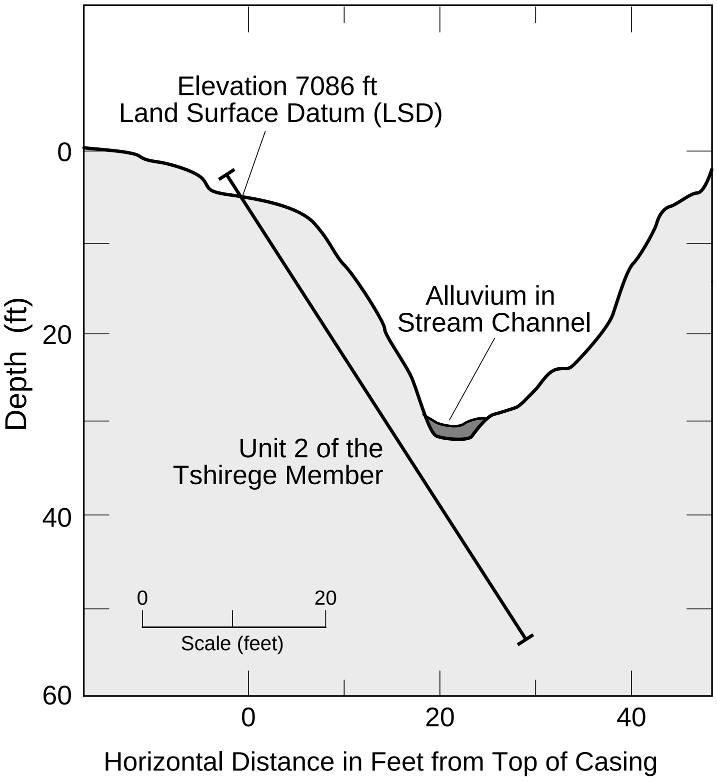


Fig. VI-Y. Cross section across stream channel showing Mortandad test hole MCM-2.8 (Purtymun 1964). See Fig. VI-W and Table VI-D.

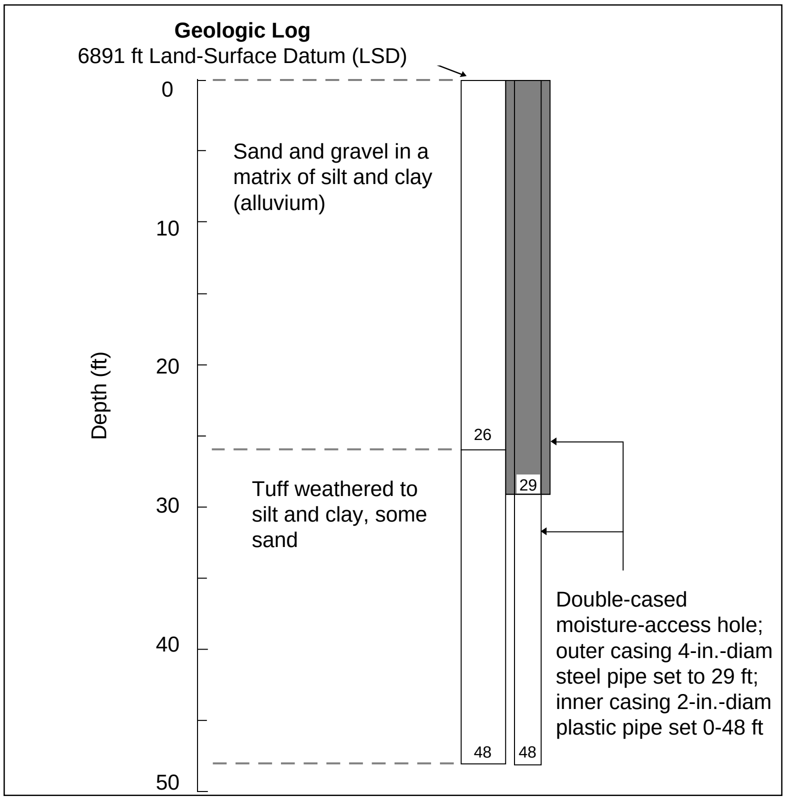


Fig. VI-Z. Mortandad test hole MCM-4.5, completed 1961, water in alluvium cased out of hole (Purtymun 1964).

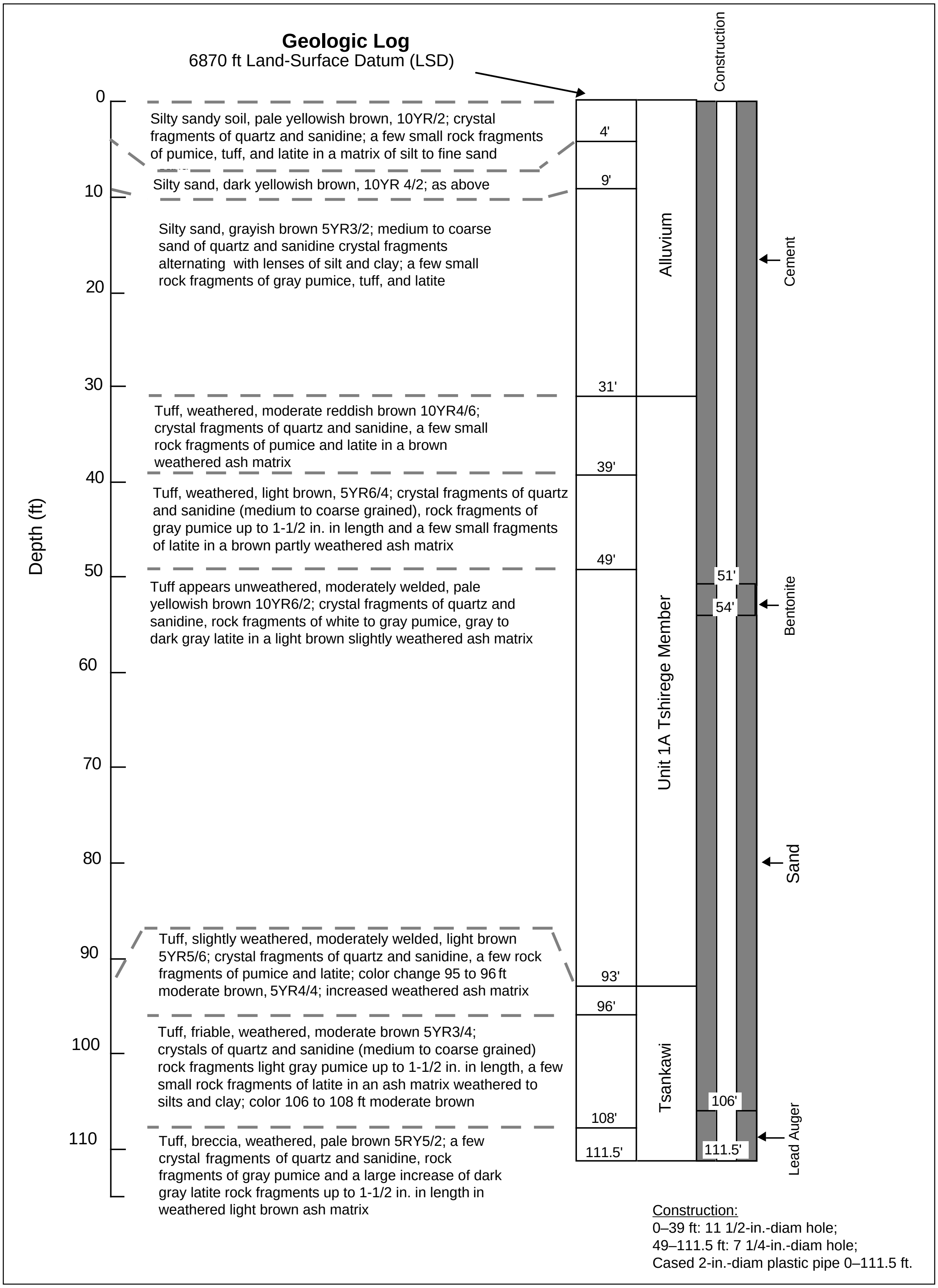


Fig. VI-AA. Mortandad test hole MCM-5.1, completed September 1990, water in alluvium cased out of hole (Stoker et al. 1991).

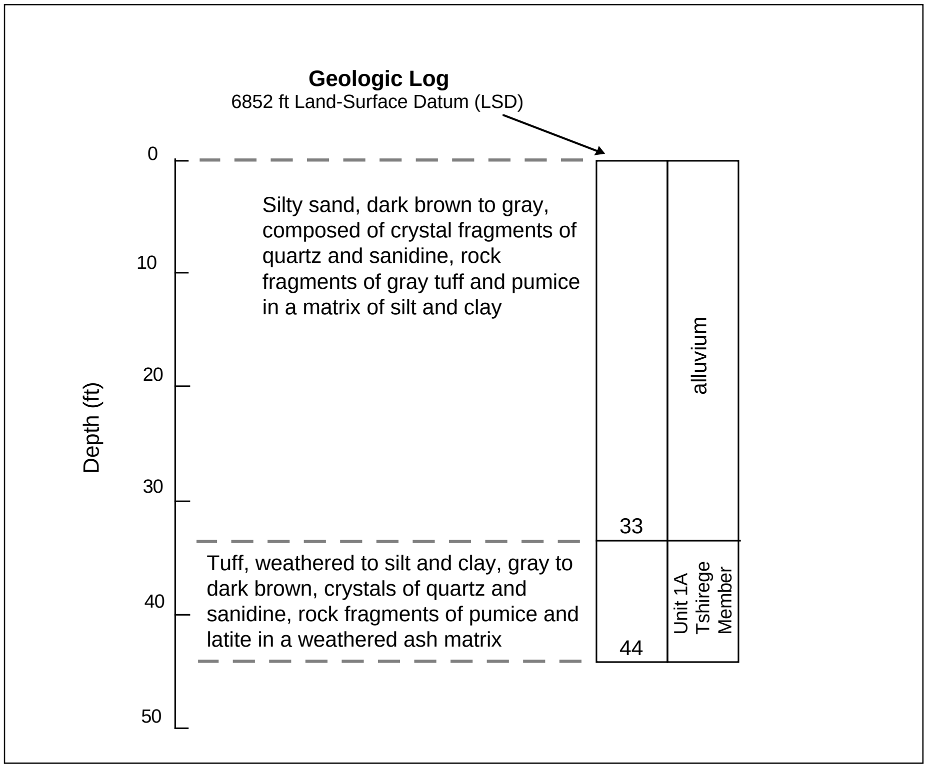
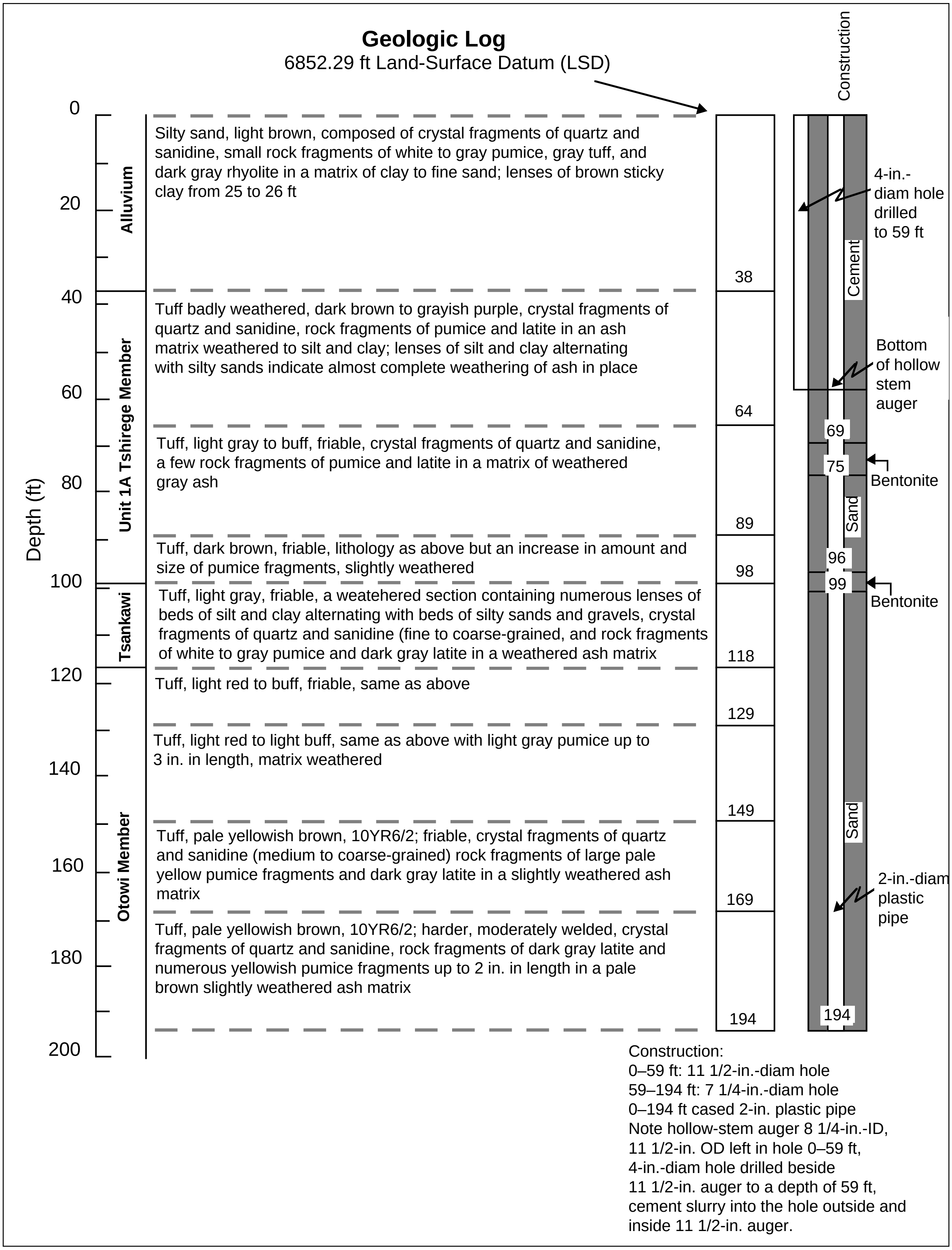


Fig. VI-AB. Mortandad test hole MCM-5.9, drilled July 1990, abandoned and plugged (Stoker et al. 1991).



Silty sand, light brown, composed of crystal fragments of quartz and sanidine, small rock fragments of white to gray pumice, gray tuff, and dark gray rhyolite in a matrix of clay to fine sand; lenses of brown sticky clay from 25 to 26 ft

Tuff badly weathered, dark brown to grayish purple, crystal fragments of quartz and sanidine, rock fragments of pumice and latite in an ash matrix weathered to silt and clay; lenses of silt and clay alternating with silty sands indicate almost complete weathering of ash in place

Tuff, light gray to buff, friable, crystal fragments of quartz and sanidine, a few rock fragments of pumice and latite in a matrix of weathered gray ash

Tuff, dark brown, friable, lithology as above but an increase in amount and size of pumice fragments, slightly weathered

Tuff, light gray, friable, a weatehered section containing numerous lenses of beds of silt and clay alternating with beds of silty sands and gravels, crystal fragments of quartz and sanidine (fine to coarse-grained, and rock fragments of white to gray pumice and dark gray latite in a weathered ash matrix

Tuff, light red to buff, friable, same as above

Tuff, light red to light buff, same as above with light gray pumice up to 3 in. in length, matrix weathered

Tuff, pale yellowish brown, 10YR6/2; friable, crystal fragments of quartz and sanidine (medium to coarse-grained) rock fragments of large pale yellow pumice fragments and dark gray latite in a slightly weathered ash matrix

Tuff, pale yellowish brown, 10YR6/2; harder, moderately welded, crystal fragments of quartz and sanidine, rock fragments of dark gray latite and numerous yellowish pumice fragments up to 2 in. in length in a pale brown slightly weathered ash matrix

Construction:
0–59 ft: 11 1/2-in.-diam hole
59–194 ft: 7 1/4-in.-diam hole
0–194 ft cased 2-in. plastic pipe
Note hollow-stem auger 8 1/4-in.-ID, 11 1/2-in. OD left in hole 0–59 ft, 4-in.-diam hole drilled beside 11 1/2-in. auger to a depth of 59 ft, cement slurry into the hole outside and inside 11 1/2-in. auger.

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

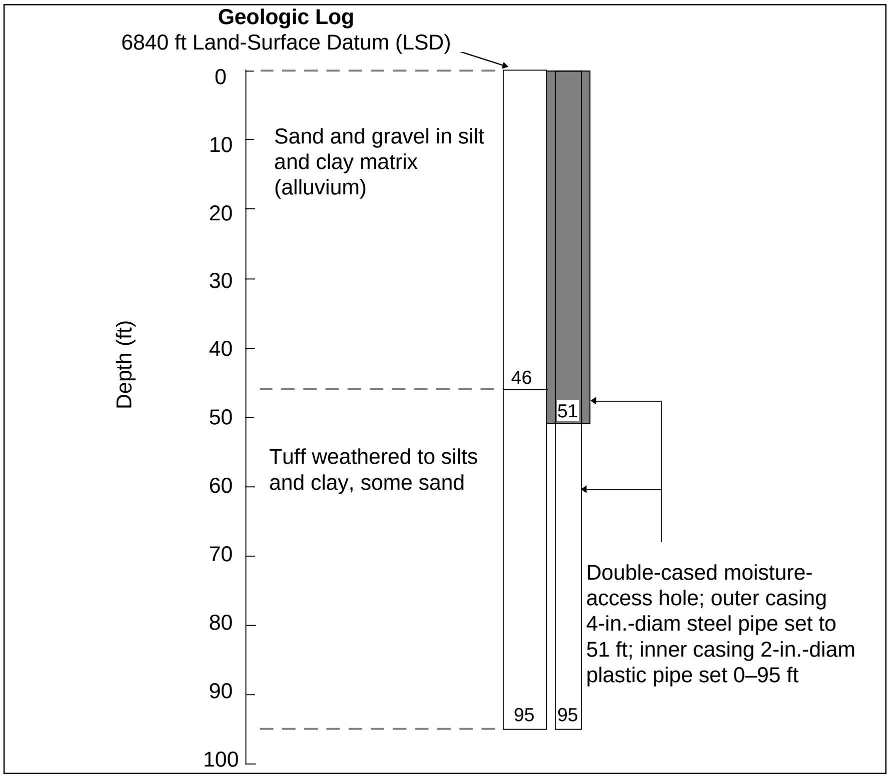


Fig. VI-AD. Mortandad test hole MT-6.5, completed November 1961, water in alluvium cased out of hole (Purtymun 1964).

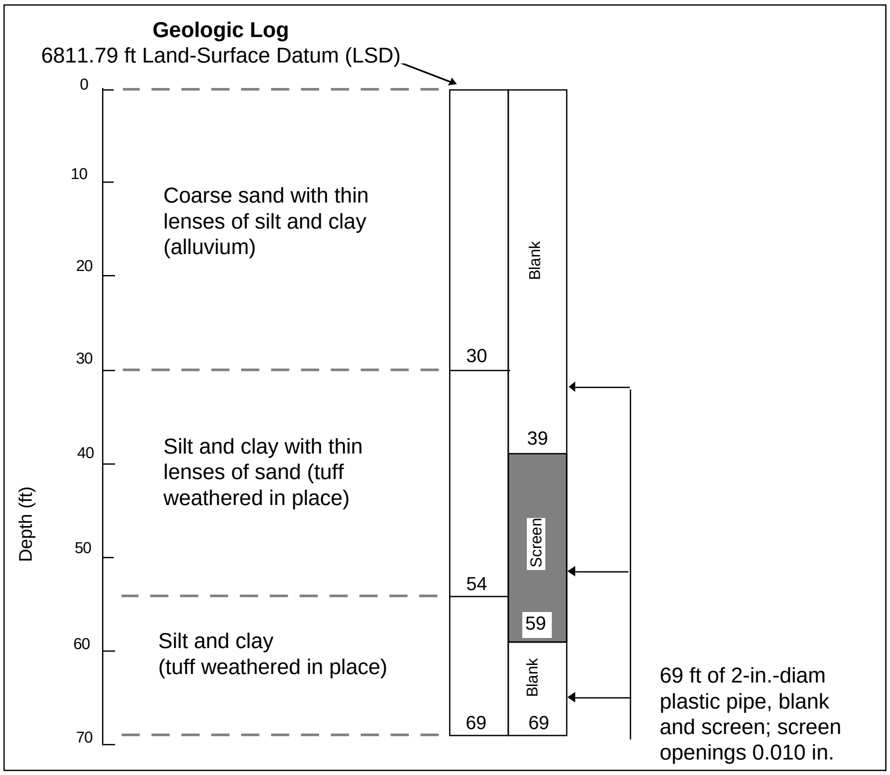


Fig. VI-AE. Mortandad test hole MT-1, completed November 1988, water level 43.0 ft (Stoker et al. 1991).

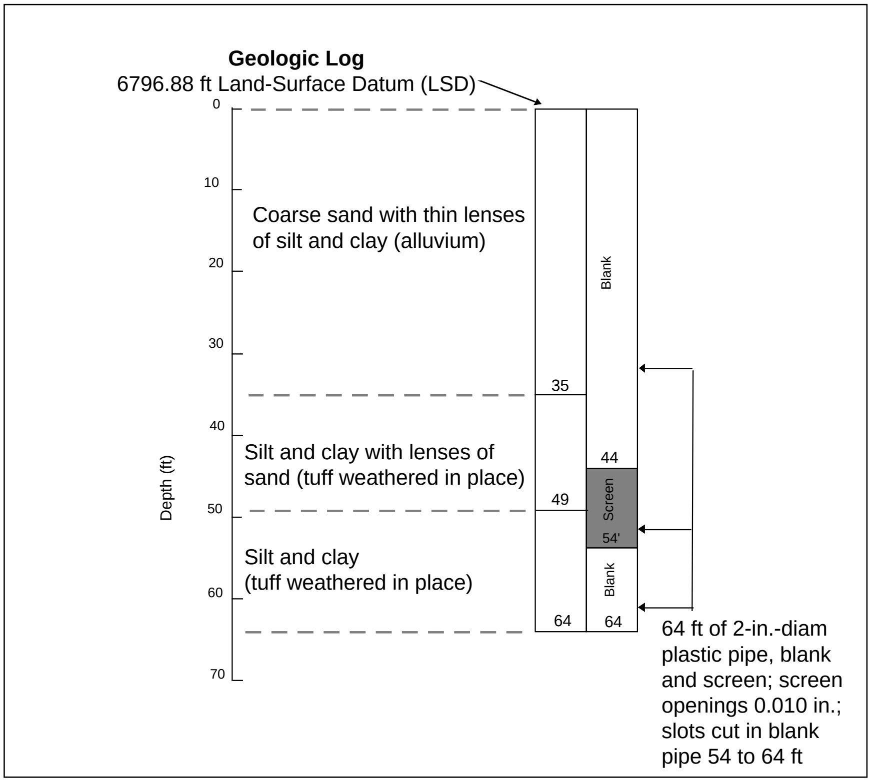


Fig. VI-AF. Mortandad test hole MT-2, completed November 1988, water level 62.0 ft (Stoker et al. 1991).

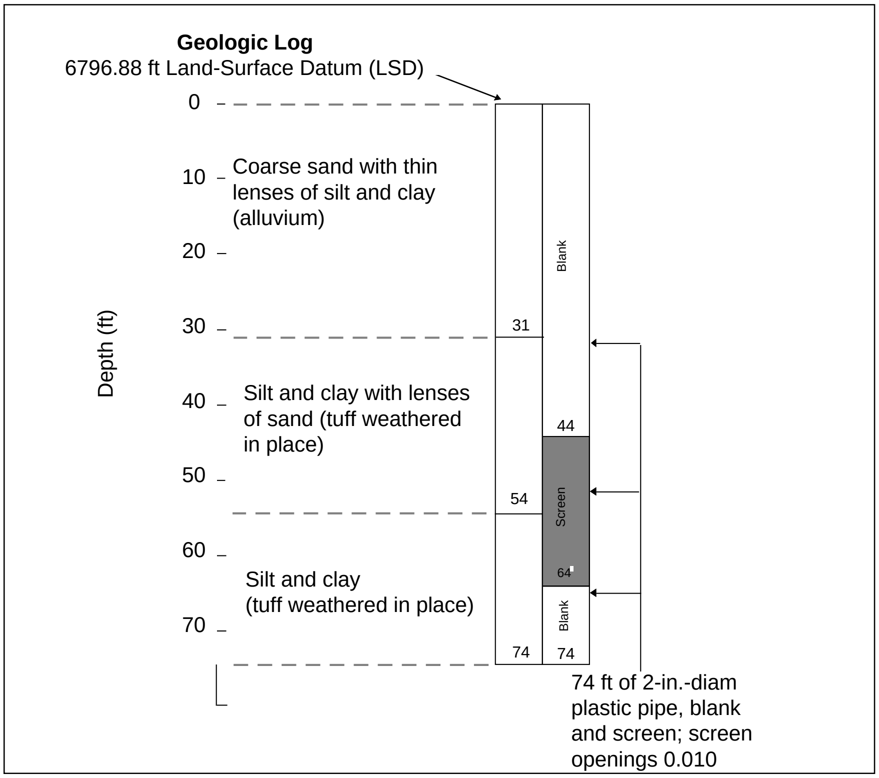


Fig. VI-AG. Mortandad test hole MT-3, completed November 1988, water level 45.0 ft (Stoker et al. 1991).

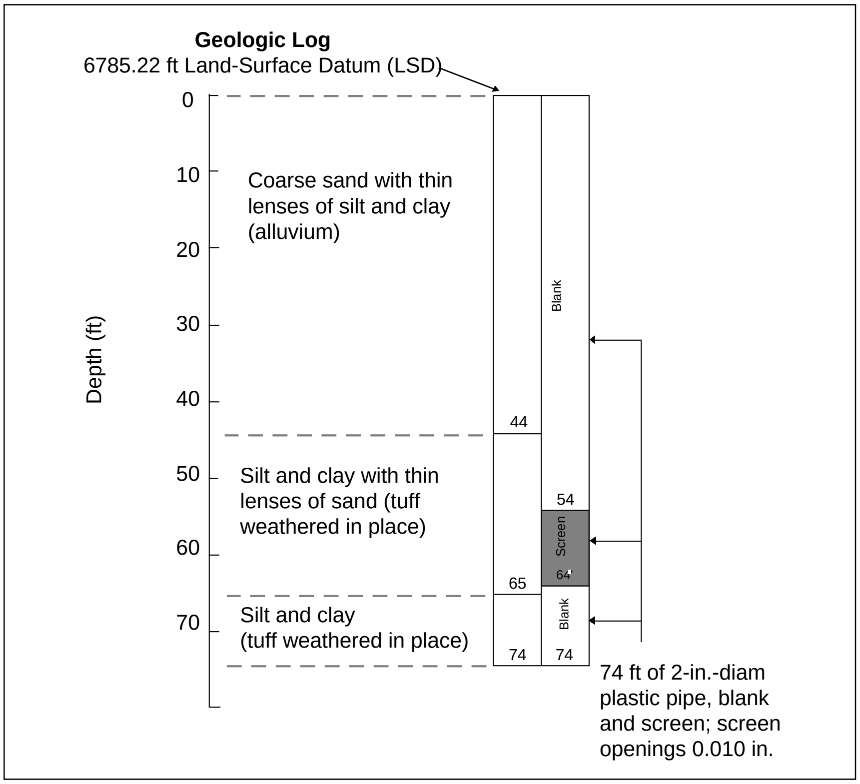


Fig. VI-AH. Mortandad test hole MT-4, completed November 1988, water level 58.0 ft (Stoker et al. 1991).

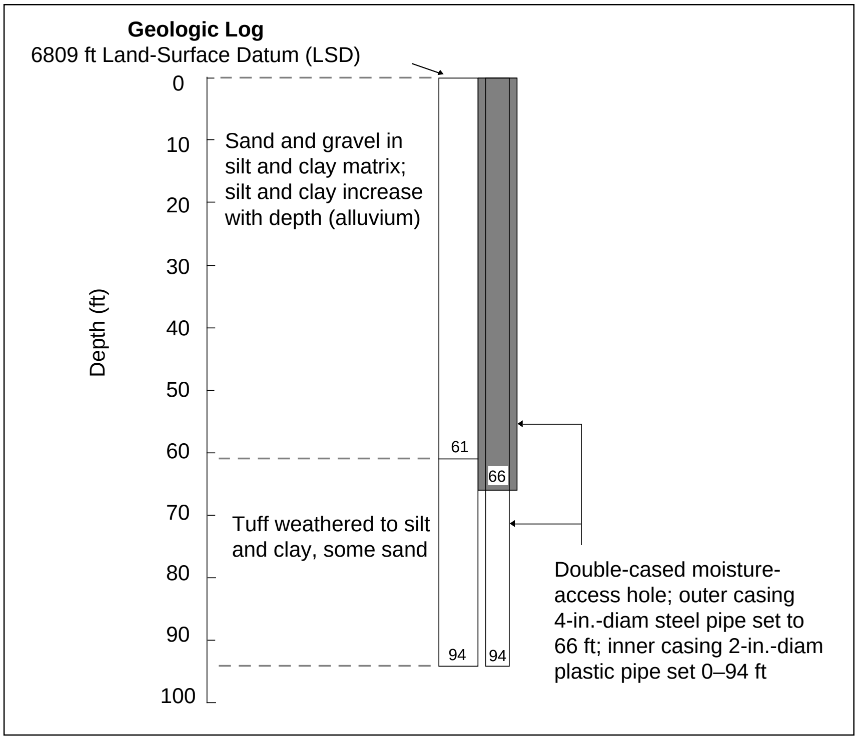


Fig. VI-AI. Mortandad test hole MCM-7.5, completed November 1961, water in alluvium cased out of hole (Purtymun 1964).

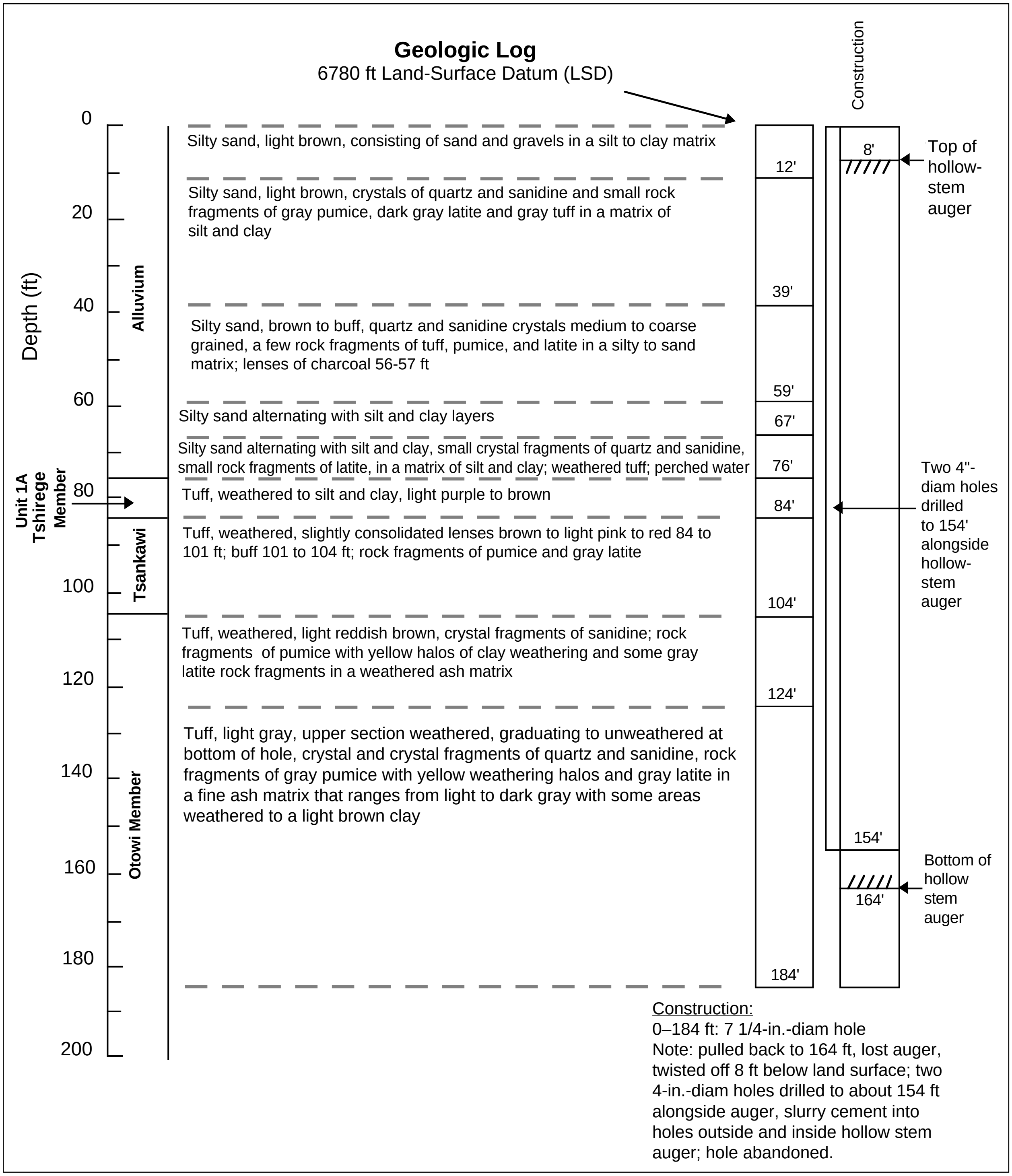


Fig. VI-AJ. Mortandad test hole MCC-8.2, core hole test April 1989, water level 73.0 ft (Stoker et al. 1991).

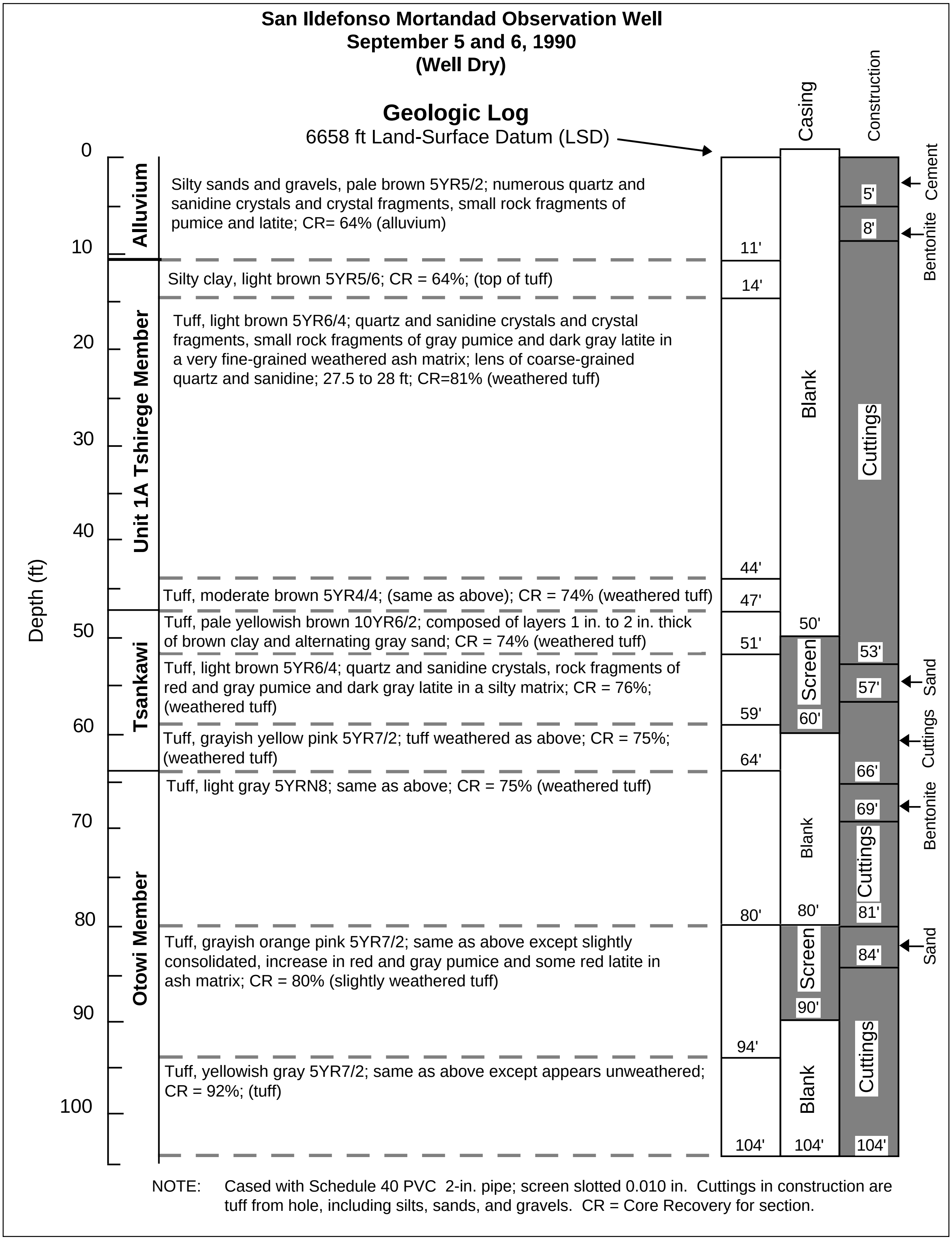


Fig. VI-AK. Mortandad test hole SIMO, drilled in cooperation with San Ildefonso Pueblo and BIA, September 1990, dry (Stoker et al. 1991).

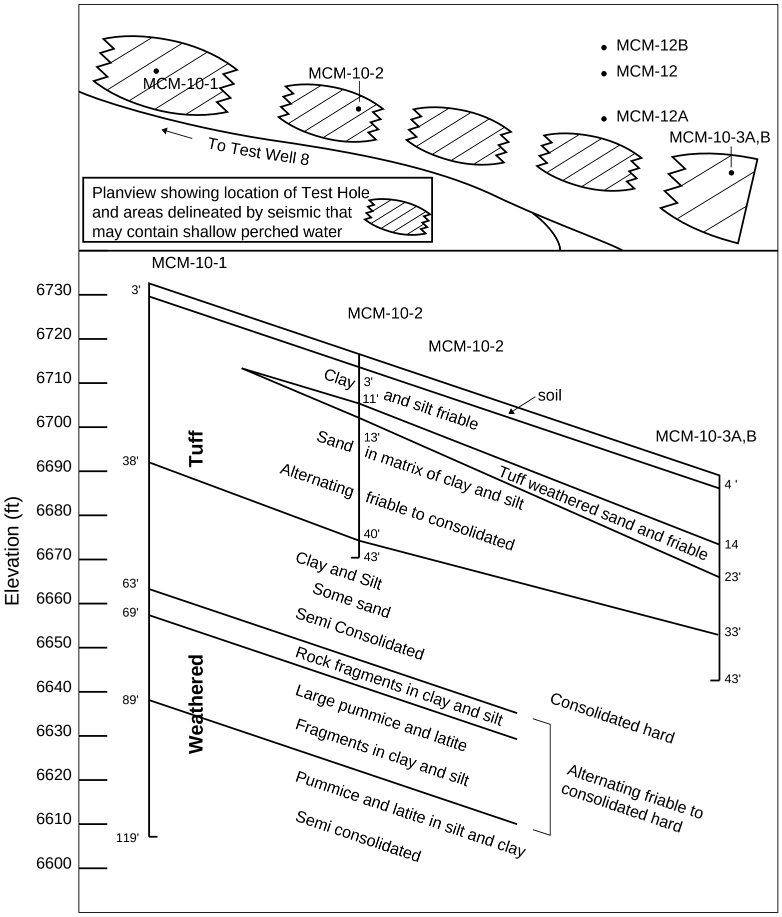


Fig. VI-AL. Mortandad test holes MCM-10-1, MCM-10-2, and MCM-10-3A-B (Purtymun 1992).

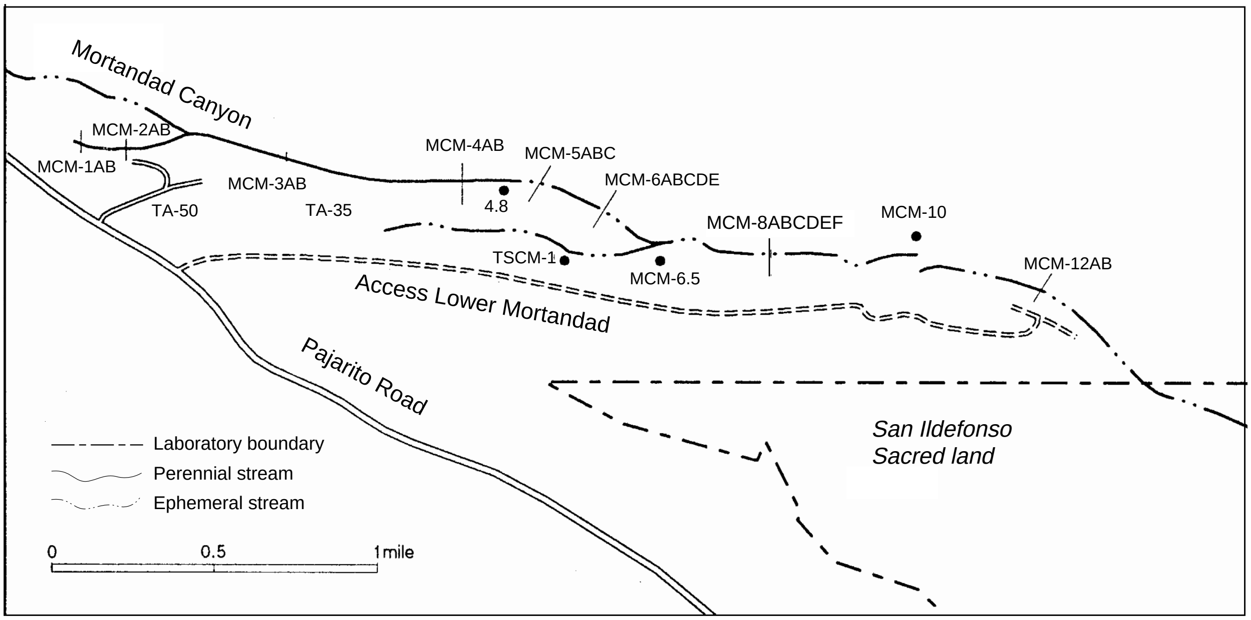


Fig. VI-AM. Locations of moisture-access holes in Mortandad Canyon (letters indicate hole designations across canyon).

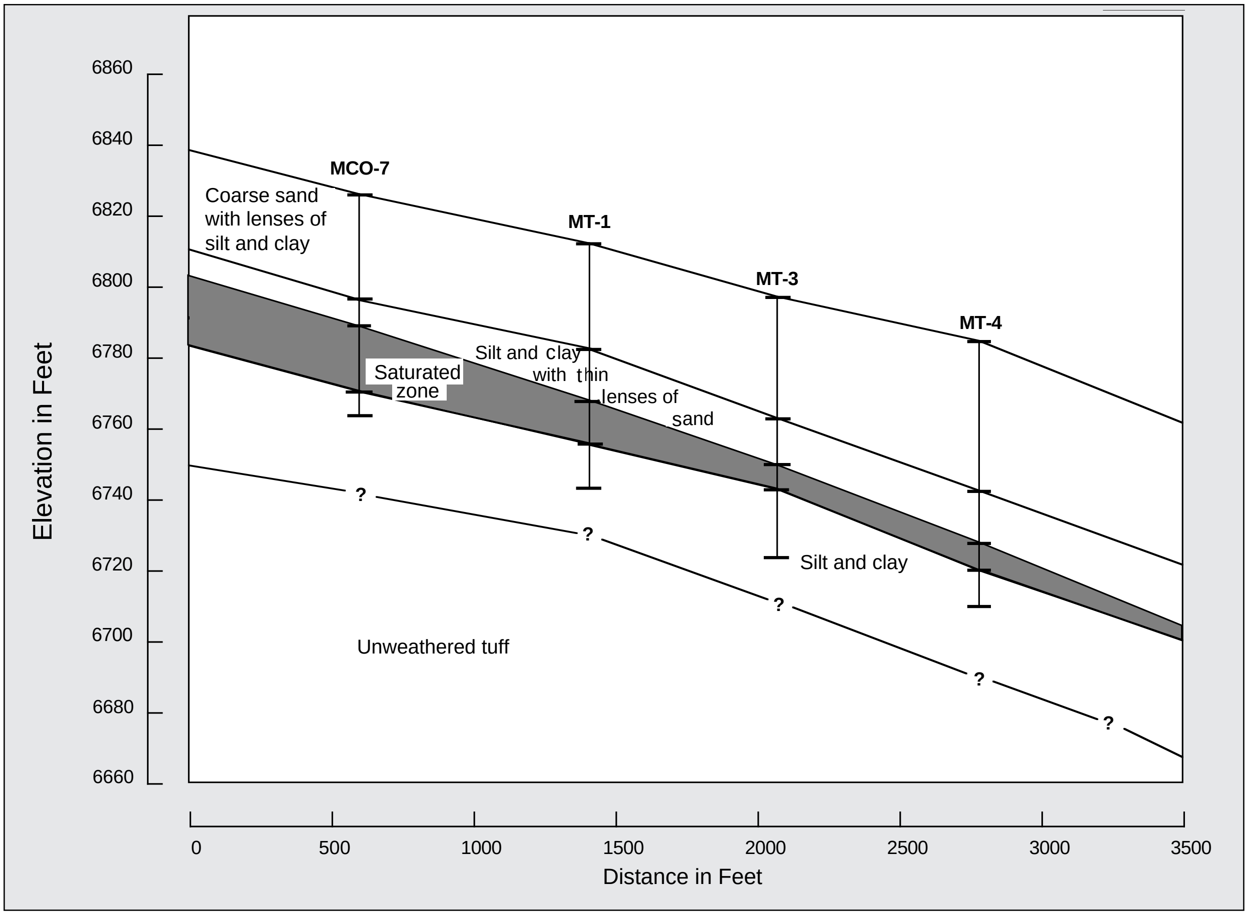


Fig. VI-AN. Geologic section showing alluvium, unweathered tuff, and the saturated zone in lower Mortandad Canyon (Stoker et al. 1991). See Figs. VI-A and VI-W for location.

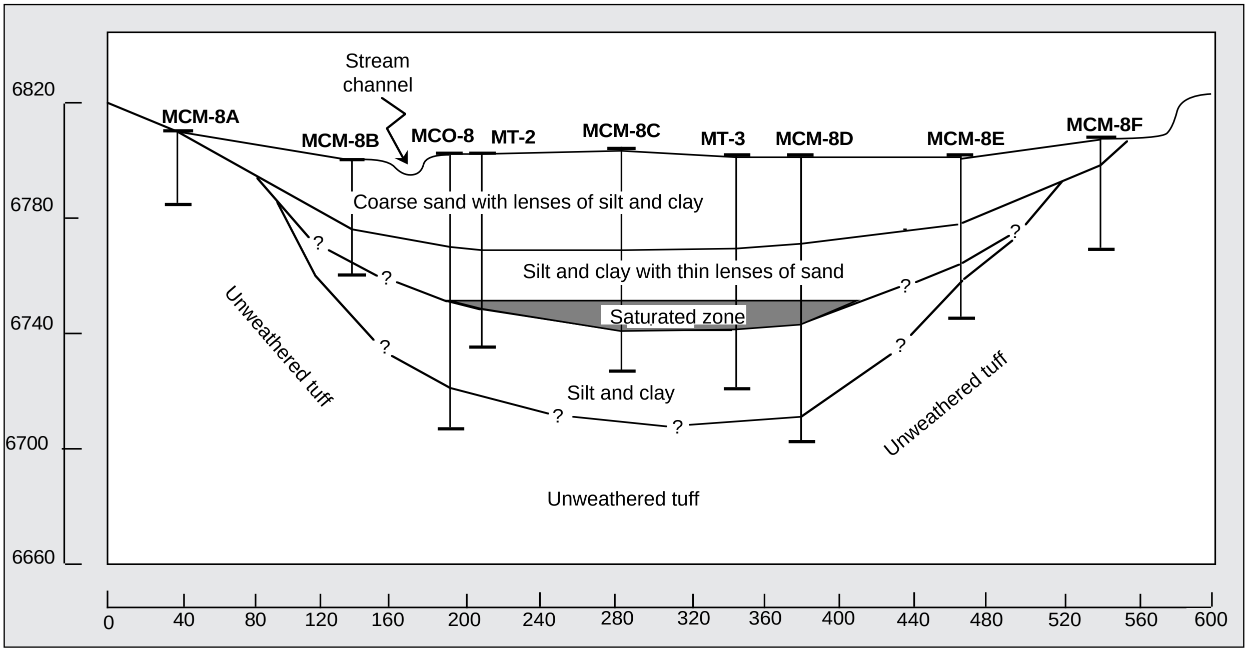


Fig. VI-AO. Geologic section showing alluvium, unweathered tuff, and the aquifer across lower Mortandad Canyon (Stoker et al. 1991). See Fig. VI-AM for location.

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

					Water Levels					
Observation Wells	Date Completed	Depth Drilled (ft)	Depth Completed (ft)	Depth 1991	At Completion (ft)	At Present Date	(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	Thickness (ft)	Depth (ft)
Geologic Log		
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	Thickness (ft)	Depth (ft)
Geologic Log		
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	Thickness (ft)	Depth (ft)
Geologic Log		
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	Thickness (ft)	Depth (ft)
Geologic Log		
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.

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.

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

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

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.

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.

B. Gallaher, Los Alamos National Laboratory, personal communication, 1992.

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.

W. D. Purtymun, Los Alamos National Laboratory, unpublished data (field notes), 1985 and 1992.

W. D. Purtymun and W. R. Kennedy, “Geology and Hydrology of Mesita del Buey,” Los Alamos Scientific Laboratory report LA-4660 (1971).

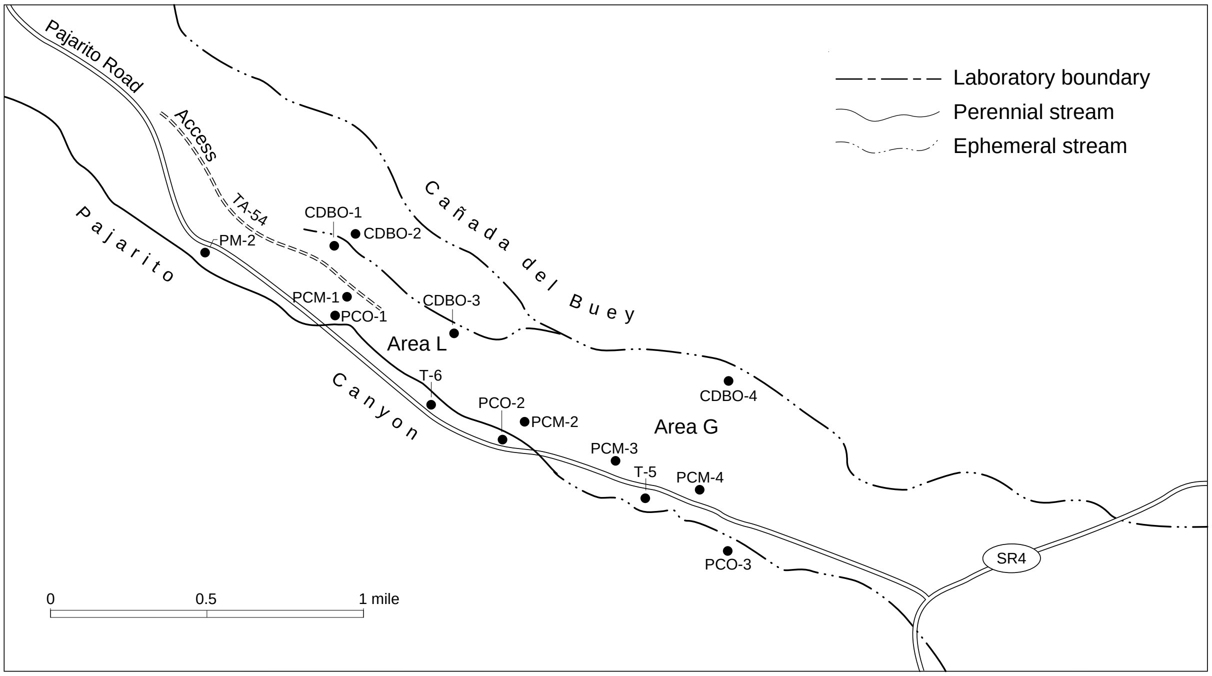

Fig. VII-A. Location of observation wells in Cañada del Buey (CDBO-series) and Pajarito Canyon (PCO-series) and moisture-access holes in Pajarito Canyon (PCM-series) (Purtymun 1985).

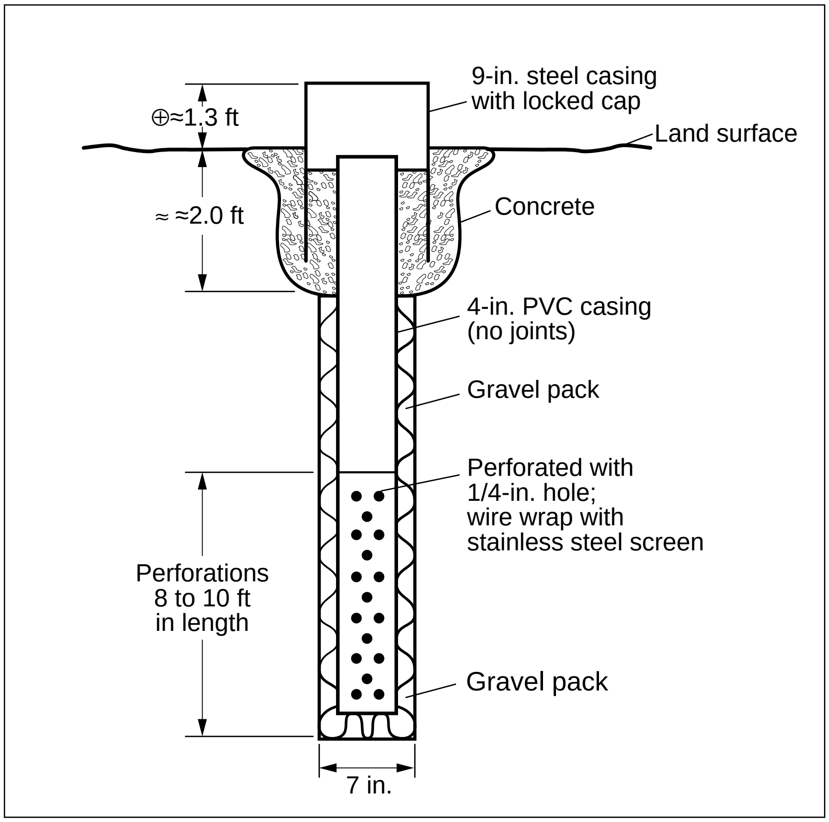

Fig. VII-B. Typical observation well construction in Cañada del Buey and Pajarito Canyon (Purtymun 1985).

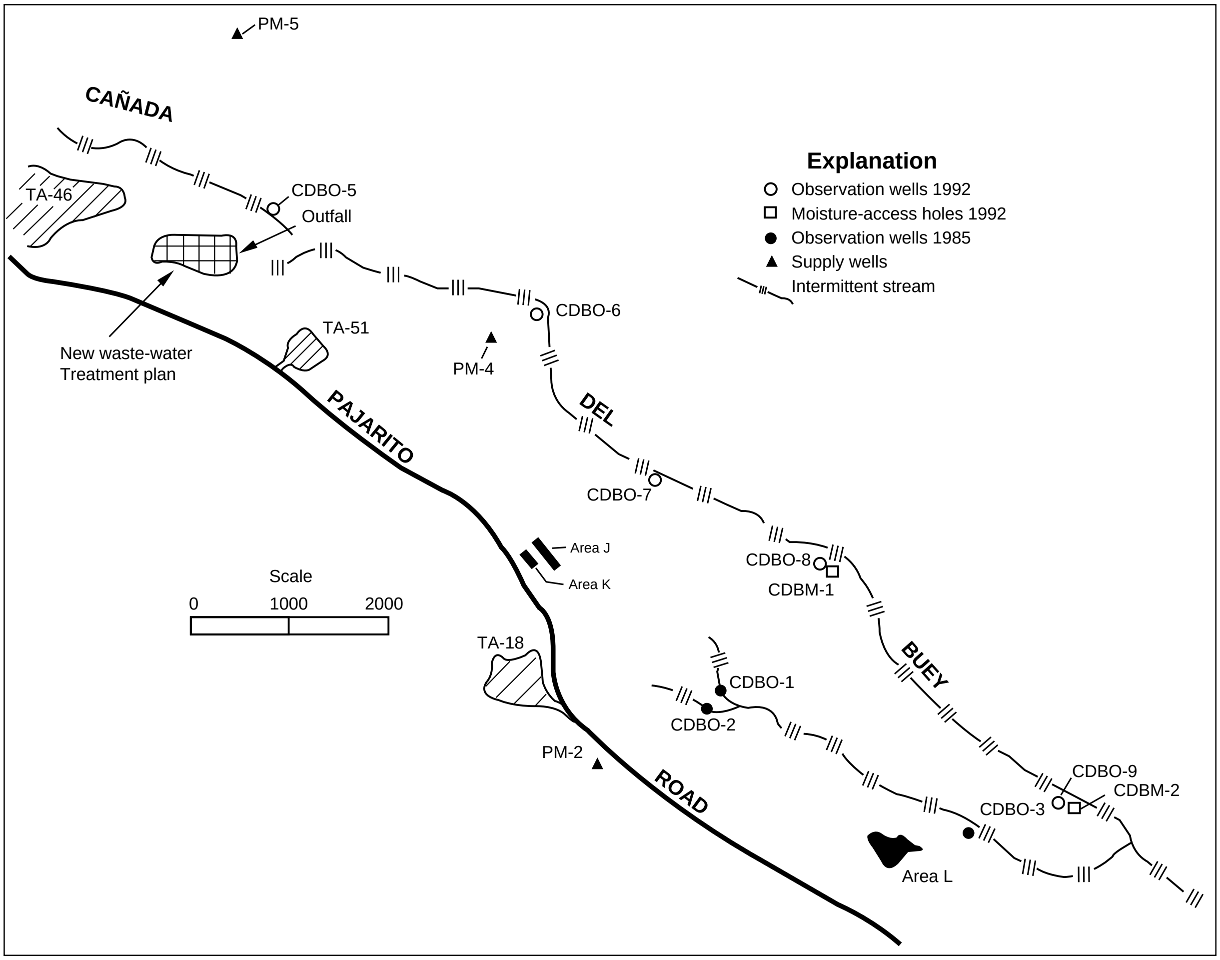

Fig. VII-C. Location of observation wells and moisture-access holes in Cañada del Buey (Purtymun 1992).

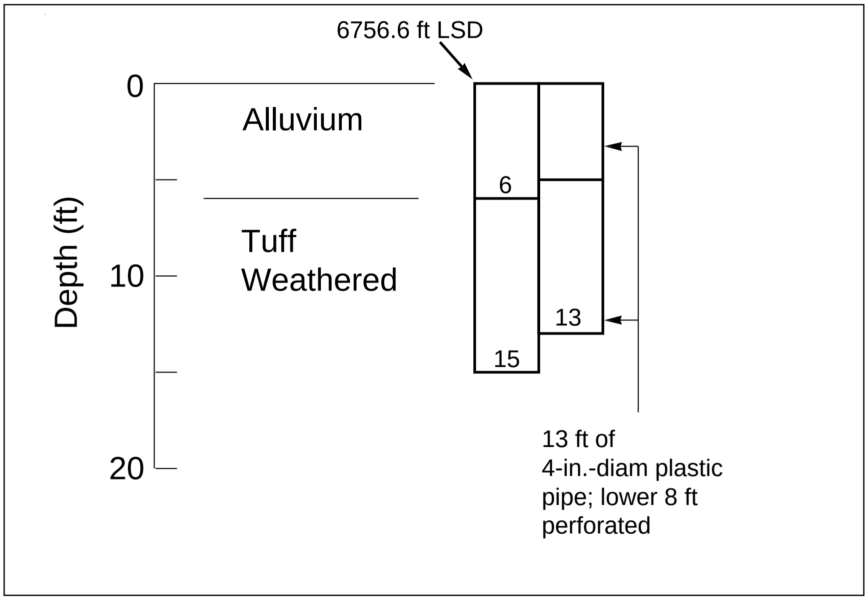

Fig. VII-D. Geologic log and casing schedule of observation well CDBO-1, dry (Purtymun 1985).

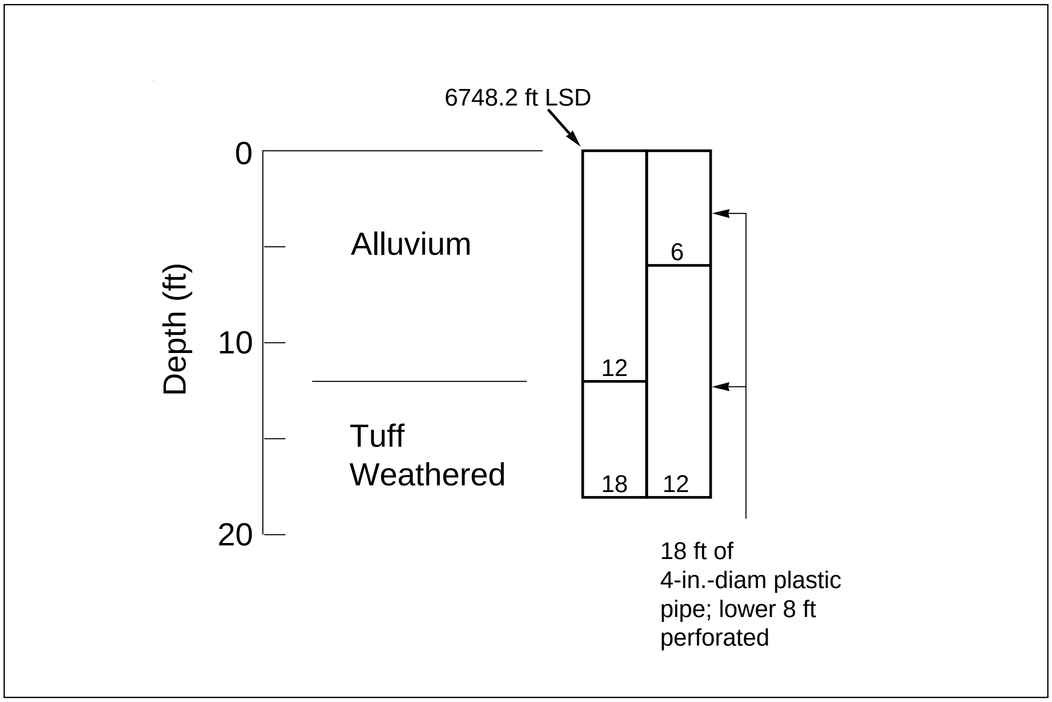

Fig. VII-E. Geologic log and casing schedule of observation well CDBO-2, dry (Purtymun 1985).

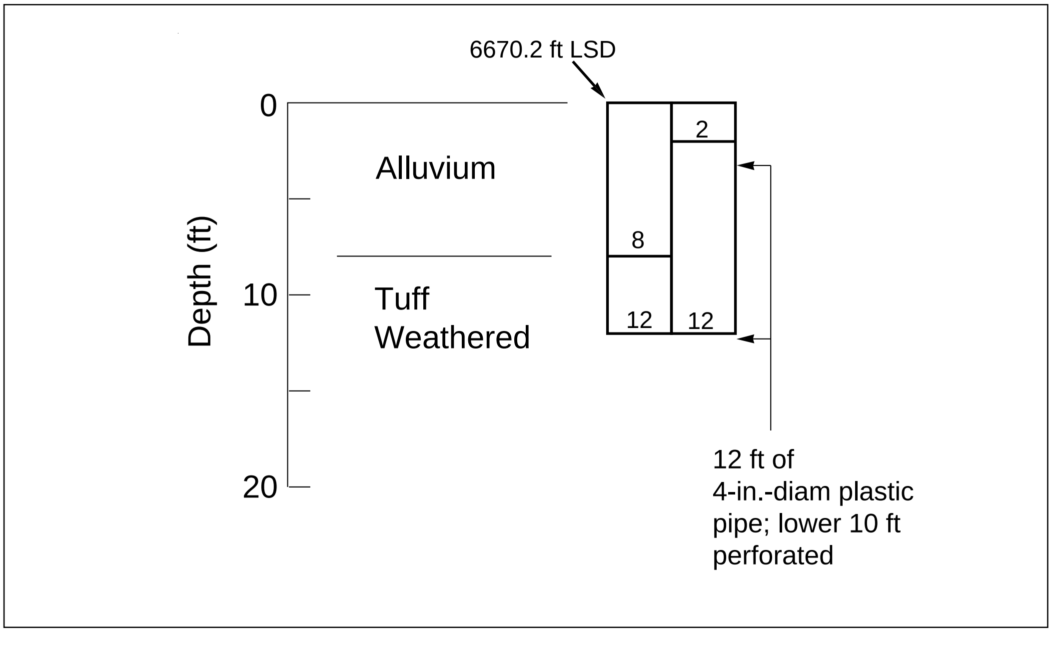

Fig. VII-F. Geologic log and casing schedule of observation well CDBO-3, dry (Purtymun 1985).

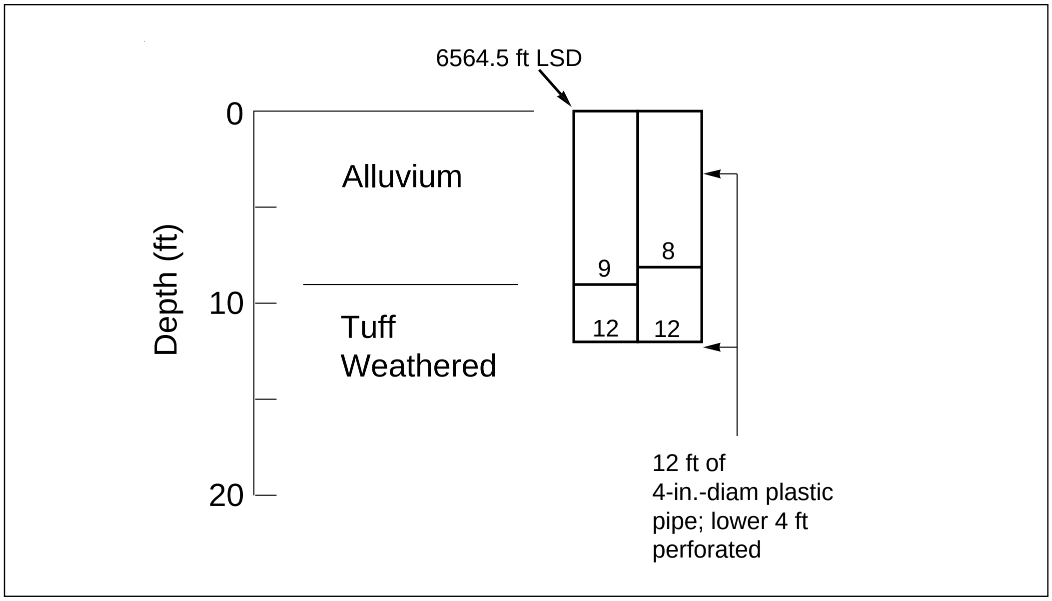

Fig. VII-G. Geologic log and casing schedule of observation well CDBO-4, dry (Purtymun 1985).

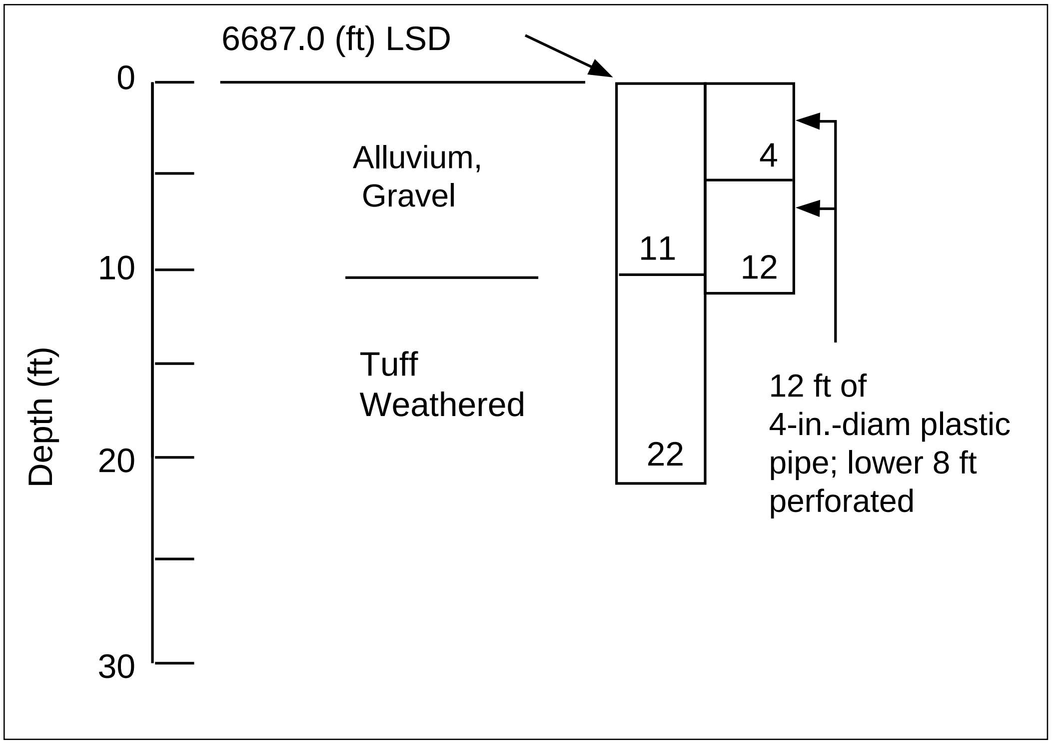

Fig. VII-H. Geologic log and casing schedule of observation well PCO-1, water level 1.3 ft (Purtymun 1985).

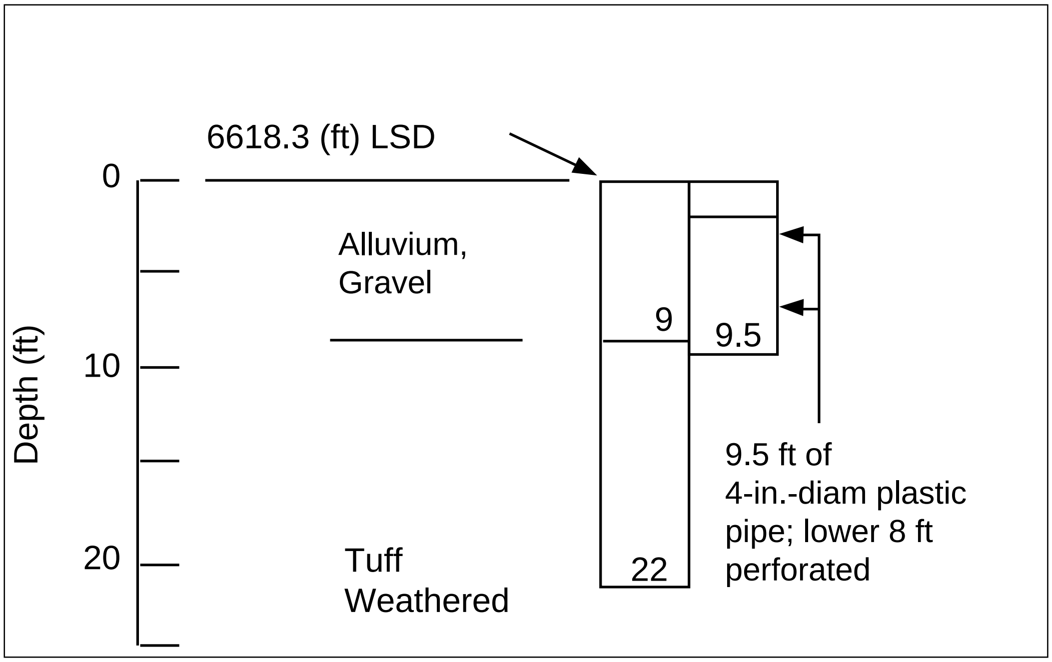

Fig. VII-I. Geologic log and casing schedule of observation well PCO-2, water level 6.3 ft (Purtymun 1985).

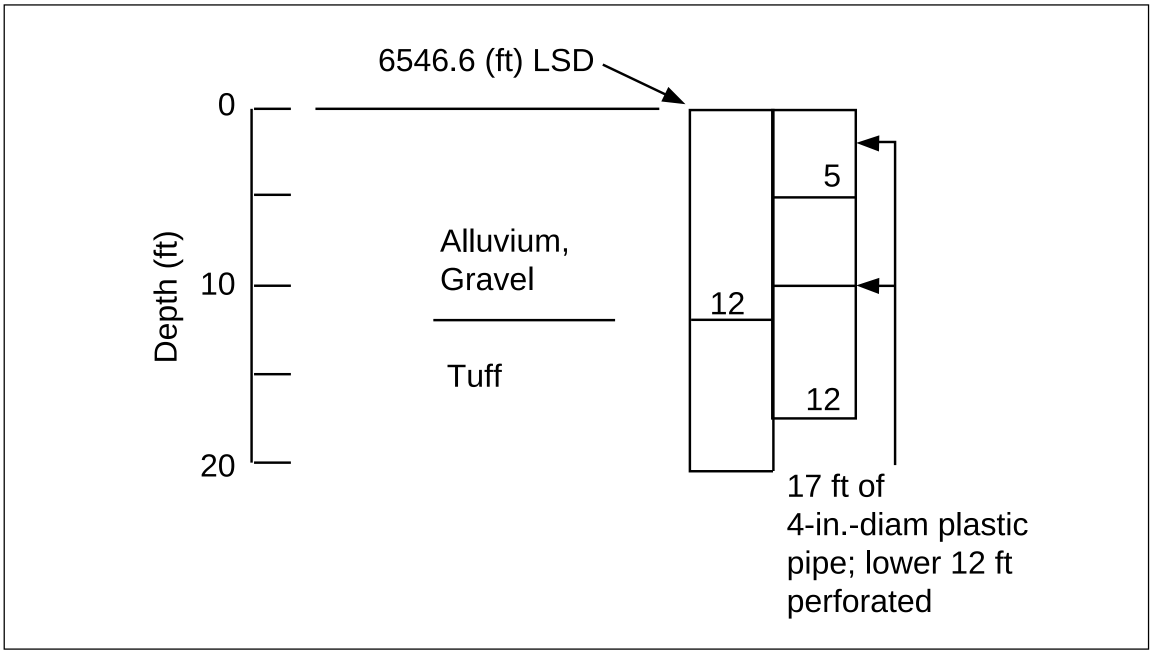

Fig. VII-J. Geologic log and casing schedule of observation well PCO-3, water level 3.1 ft (Purtymun 1985).

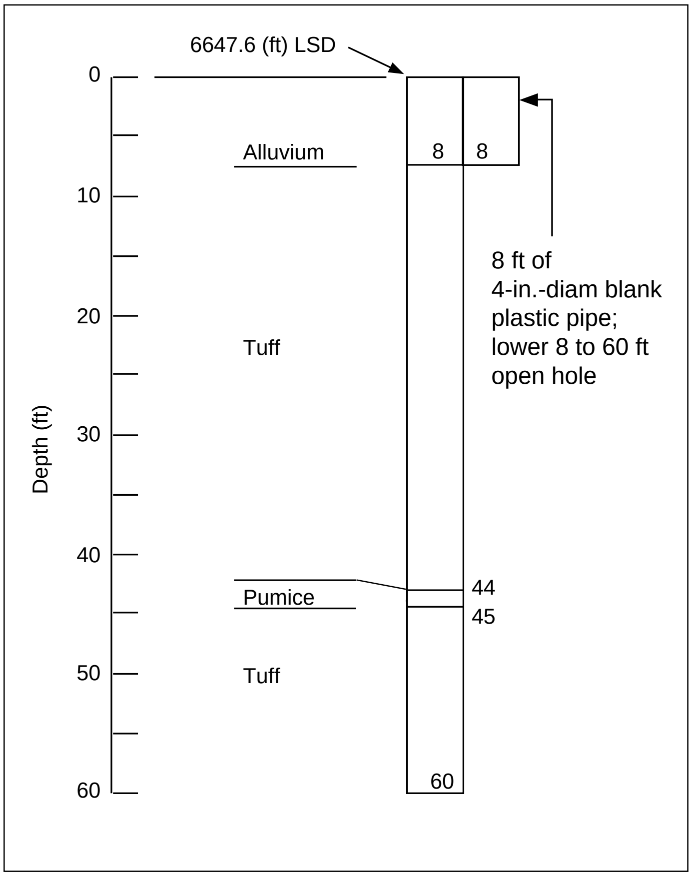

Fig. VII-K. Geologic log and casing schedule of test hole PCM-1, dry (Purtymun 1985).

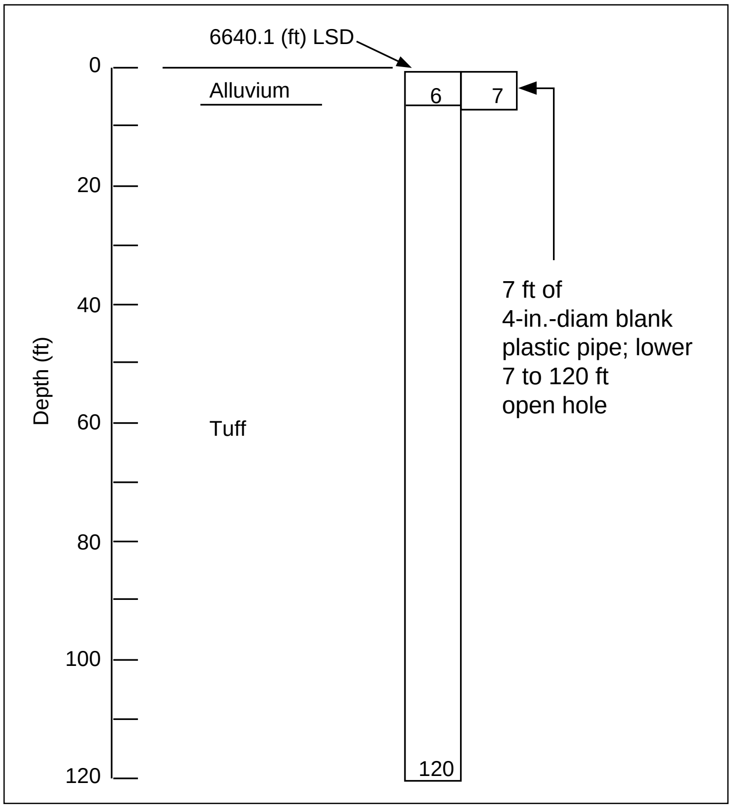

Fig. VII-L. Geologic log and casing schedule of test hole PCM-2, dry (Purtymun 1985).

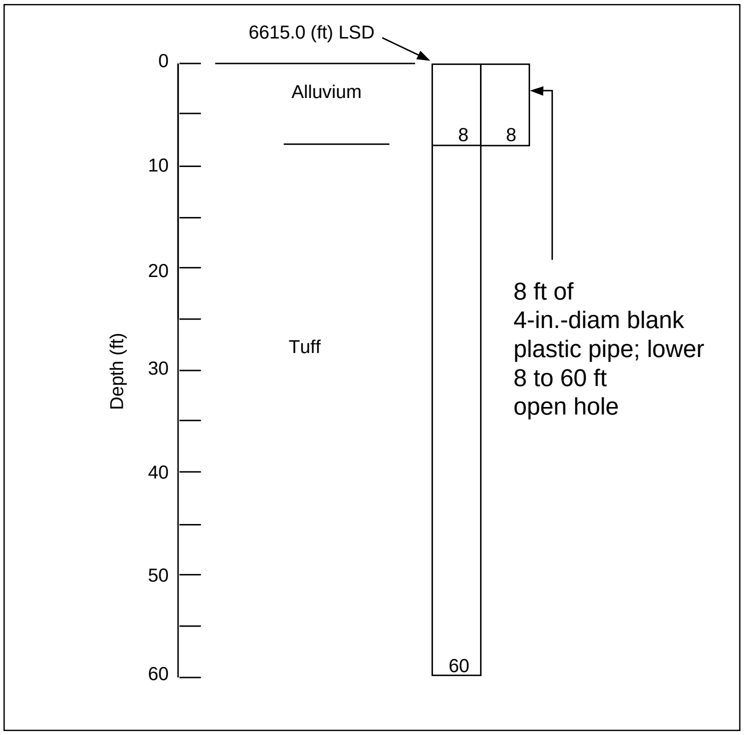

Fig. VII-M. Geologic log and casing schedule of test hole PCM-3, dry (Purtymun 1985).

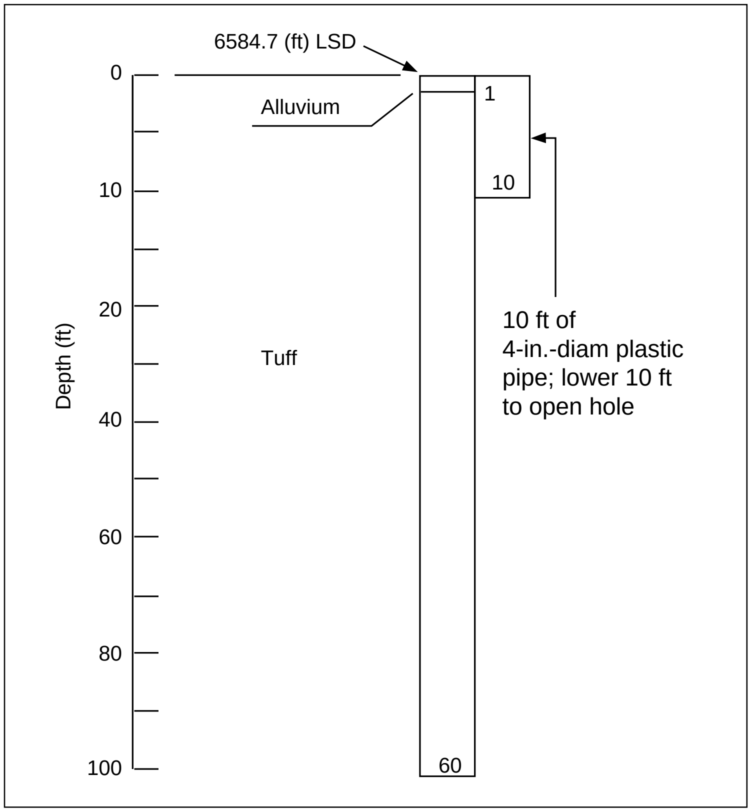

Fig. VII-N. Geologic log and casing schedule of test hole PCM-4, dry (Purtymun 1985).

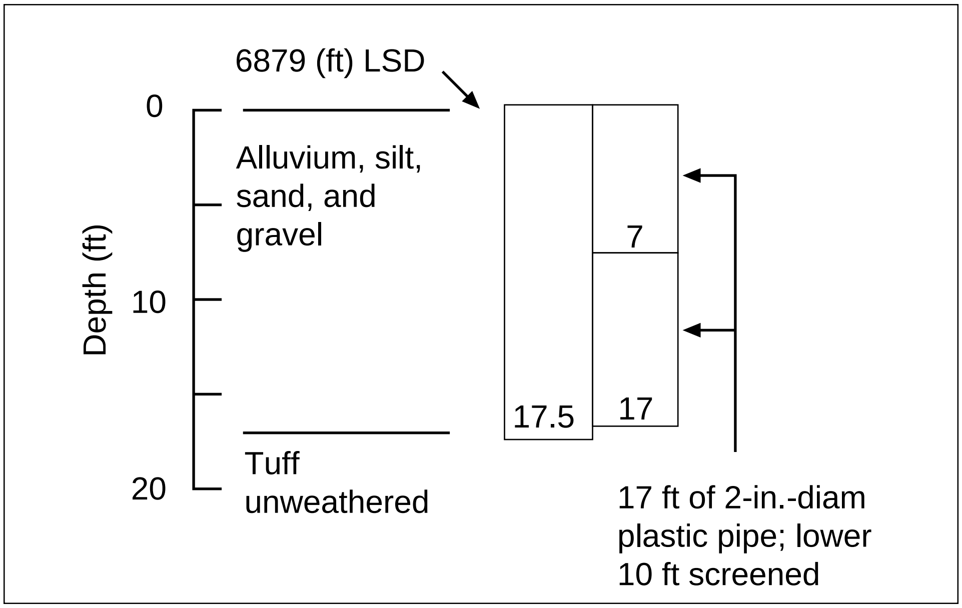

Fig. VII-O. Geologic log and casing schedule of observation well CDBO-5, dry (Purtymun 1992).

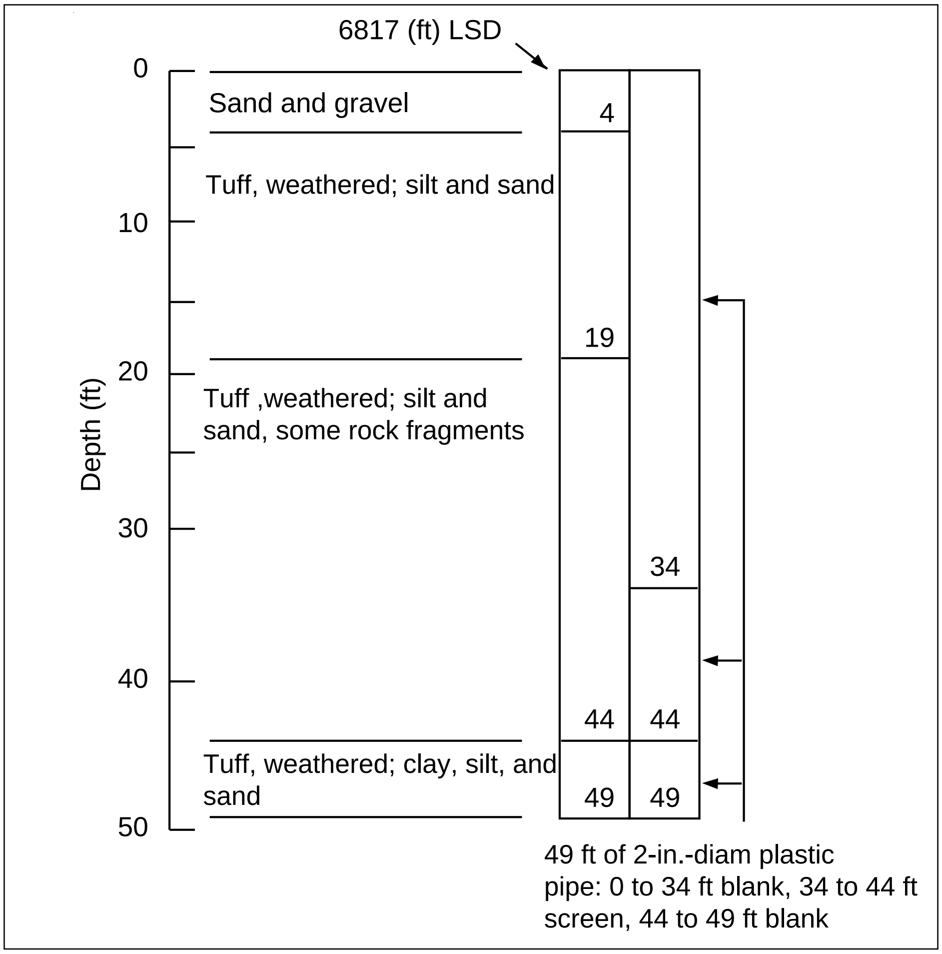

Fig. VII-P. Geologic log and casing schedule of observation well CDBO-6, perched water (Purtymun 1992).

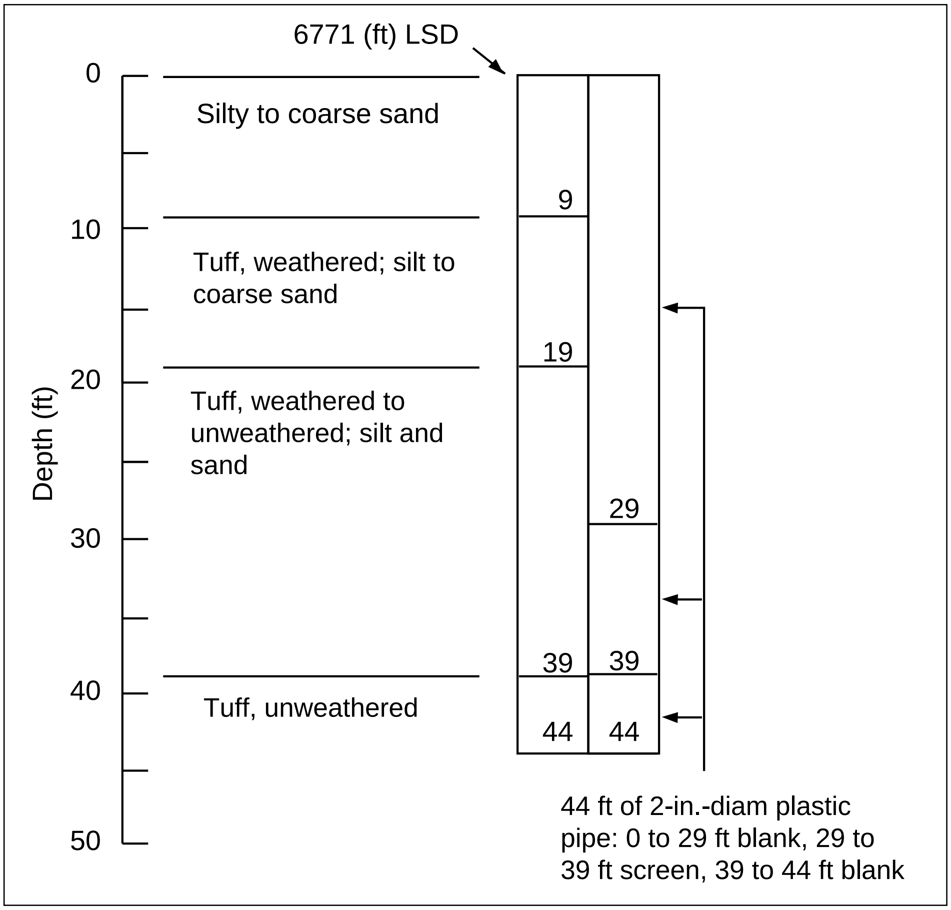

Fig. VII-Q. Geologic log and casing schedule of observation well CDBO-7, perched water (Purtymun 1992).

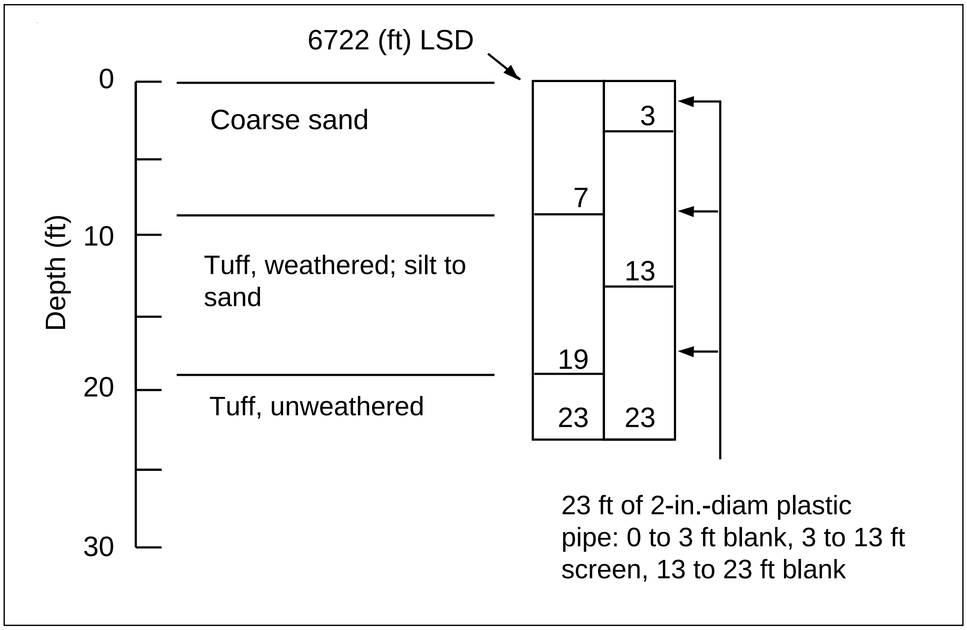

Fig. VII-R. Geologic log and casing schedule of observation well CDBO-8, dry (Purtymun 1992).

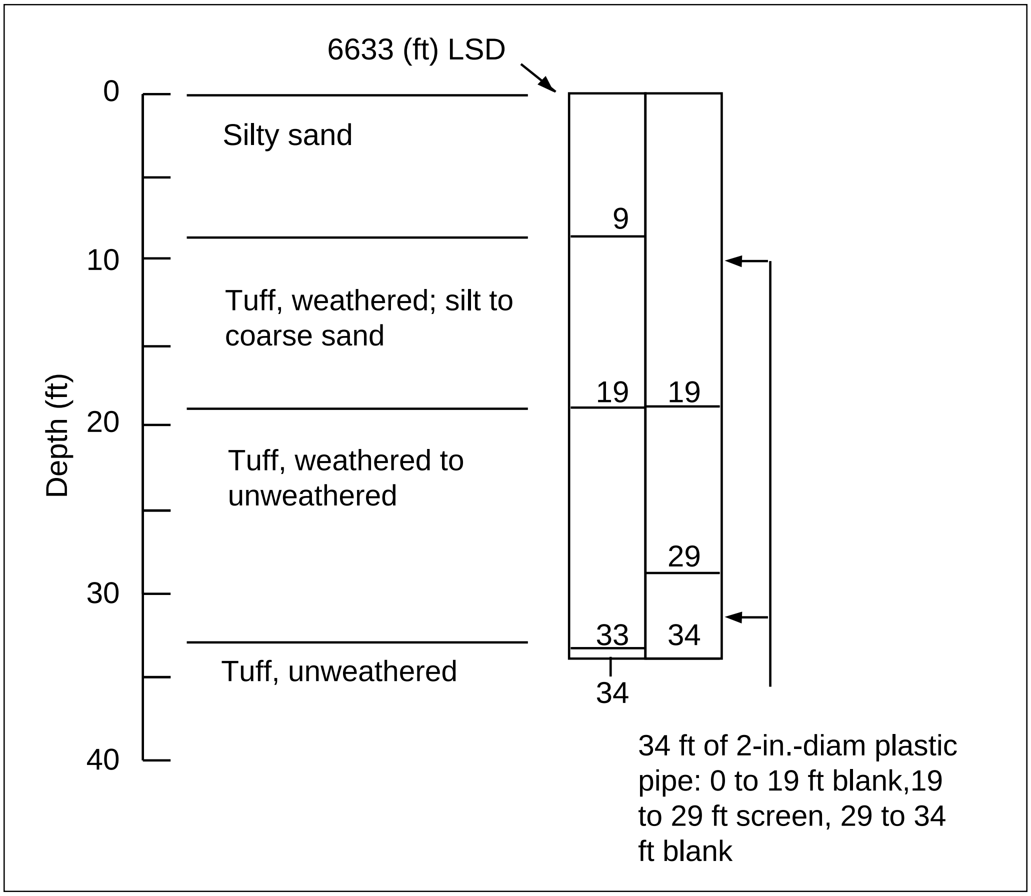

Fig. VII-S. Geologic log and casing schedule of observation well CDBO-9, dry (Purtymun 1992).

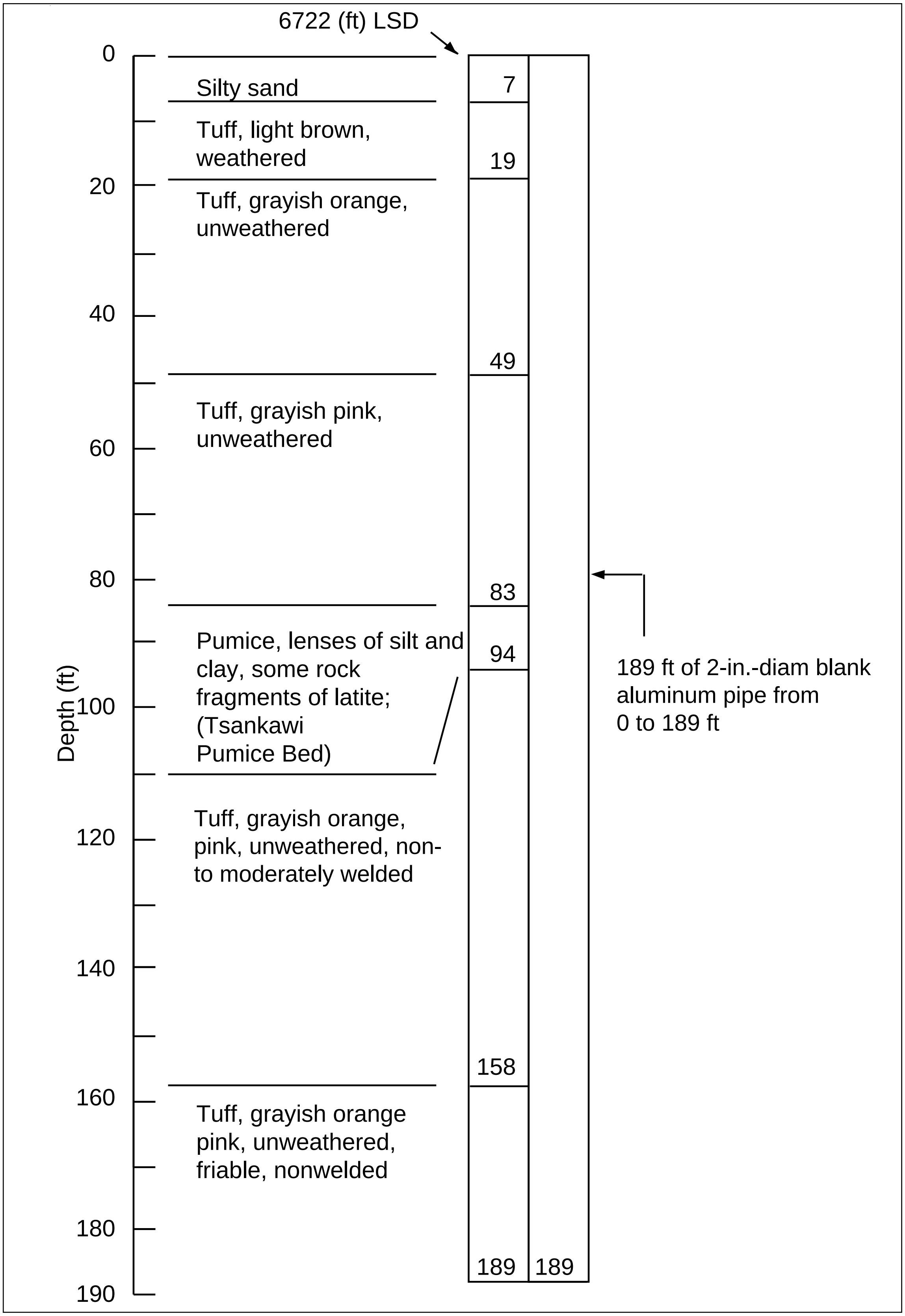

Fig. VII-T. Geologic log and casing schedule of moisture-access hole CDBM-1, dry (Purtymun 1992).

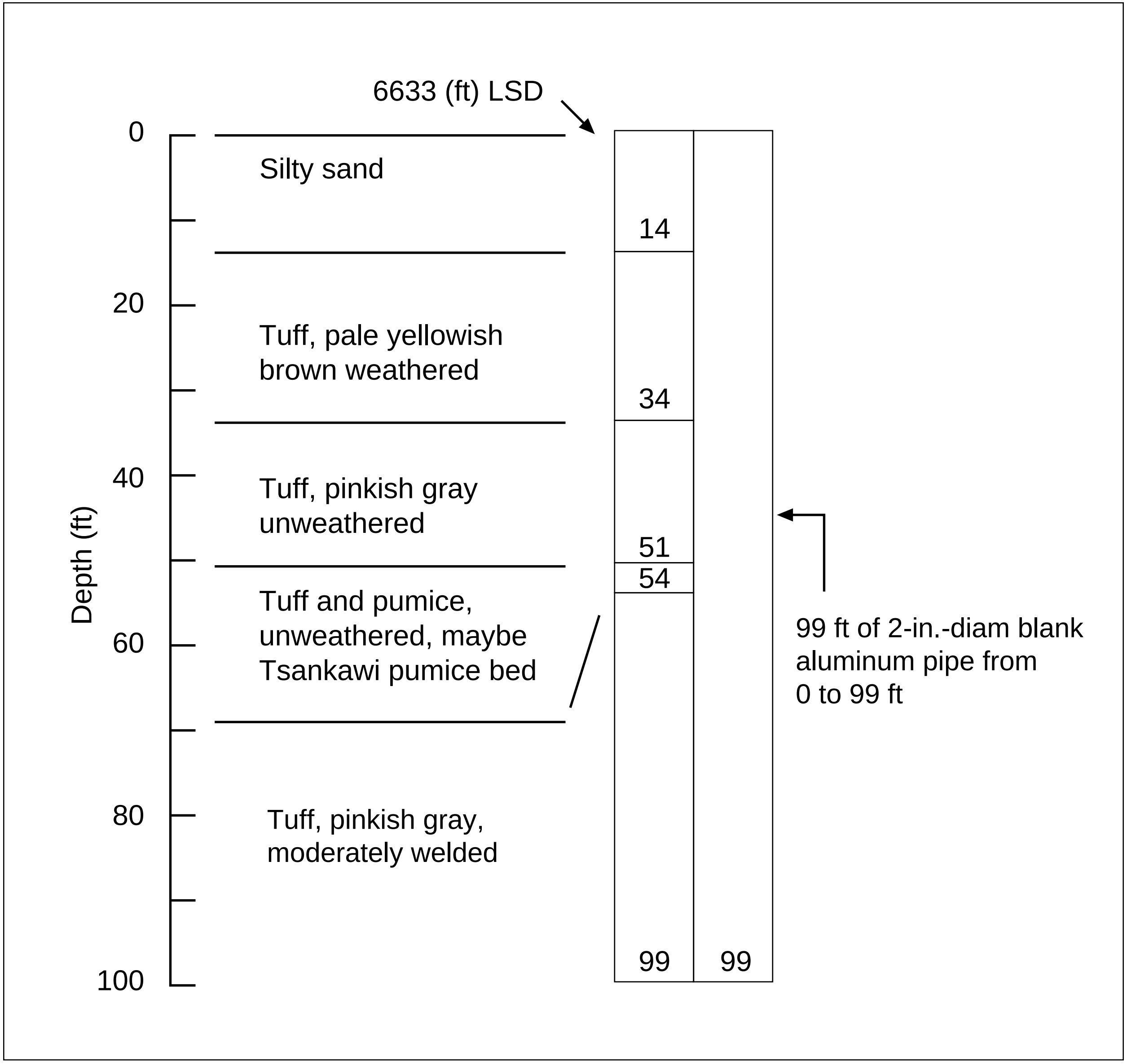

Fig. VII-U. Geologic log and casing schedule of moisture-access hole CDBM-2, dry (Purtymun 1992).

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