ER ID 099096

DRAFT

ENGINEERING, GEOLOGY, AND CONSTRUCTION DATA OF TWENTY-FIVE TEST HOLES AND TEST WELLS ON AND ADJACENT TO THE PAJARITO PLATEAU

BY
William D. Purtymun
AND
Ada Suzanne Swanton

30930

DRAFT

CONTENTS

ABSTRACT 5

I. INTRODUCTION 6

II. LOS ALAMOS PROJECT LONG-TERM MONITORING WELLS (1949 AND 1950) 9
A. TEST HOLE OS-1A AND TEST WELLS TW-1A AND TW-1 9
1. History and Hydrology 9
2. Test Hole OS-1A 12
3. Test Well TW-1A 12
4. Test Well TW-1 13
B. TEST HOLE OS-2A AND TEST WELLS TW-2B, TW-2, TW-2A 15
1. History and Hydrology 15
2. Test Well TW-2 16
3. Test Well TW-2A 18
4. Test Hole OS-2A and Test Well TW-2B 19
C. TEST WELL TW-3 and Test Hole OS-3A 20
1. History and Hydrology 21
2. Test Well TW-3 22
3. TEST HOLE OS-3A 23
D. TEST WELL TW-4 23
1. History and Hydrology 23
2. Test Well TW-4 Geologic Log 24
3. Test Well TW-4 Casing Schedule 25

III. LOS ALAMOS PROJECT WATER SUPPLY INVESTIGATION WELLS (1949) 26
A. TEST HOLE H-19 26
1. History and Hydrology 26
2. Test Hole H-19 Geologic Log 27
3. Test Hole H-19 Casing Schedule 27
B. TEST HOLE H-16 27
1. History and Hydrology 28
2. Test Hole H-16 Geologic Log 28
3. Test Hole H-16 Casing Schedule 28

IV. TEST HOLES IN PAJARITO AND ANCHO CANYONS (1950) 29
A. History and Hydrology 29
B. TEST HOLE TH-5 29
1. Test Hole TH-5 Geologic Log 29
2. Test Hole TH-5 Casing Schedule 29
C. TEST HOLE TH-6 30
1. Test Hole TH-6 Geologic Log 30
2. Test Hole TH-6 Casing Schedule 30
D. TEST HOLE TH-7 30
1. Test Hole TH-7 Geologic Log 30
2. Test Hole TH-7 Casing Schedule 31

V. TEST HOLES AND TEST WELLS AT TA-49 (1959 AND 1960) 32
A. HISTORY AND HYDROLOGY 32
B. TEST HOLE DT-5P 32
1. Test Hole DT-5P Geologic Log 33

DRAFT

2. Test Hole DT-5P Casing Schedule 33
C. TEST HOLE DT-5.....33
1. Test Hole DT-5 Geologic Log 34
2. Test Hole DT-5 Casing Schedule 34
D. TEST WELL DT-5A.....34
1. Test Well DT-5A Geologic Log 35
2. Test Well DT-5A Casing Schedule 35
E. TEST WELL DT-9.....36
1. Test Well DT-9 Geologic Log 37
2. Test Well DT-9 Casing Schedule 37
F. TEST WELL DT-10.....38
1. Test Well DT-10 Geologic Log 38
2. Test Well DT-10 Casing Schedule 39
G. LARGE DIAMETER AUGER HOLES.....39
1. Alpha Hole 40
2. Beta Hole 40

VI. TEST HOLE EGH-LA-1 (SIGMA MESA TEST HOLE) 42
A. HISTORY AND HYDROLOGY.....42
B. TEST HOLE EGH-LA-1 GEOLOGIC LOG.....42
C. TEST HOLE EGH-LA-1 CASING Schedule.....43

VII. LAYNE-WESTERN WELL 44
A. HISTORY AND HYDROLOGY.....44
B. LAYNE-WESTERN GEOLOGIC LOG.....44
C. LAYNE-WESTERN WELL CASING Schedule.....44

VIII. TEST Wells TW-8A and TW-8 46
A. HISTORY AND HYDROLOGY.....46
B. TEST WELL 8 GEOLOGIC LOG.....48
C. TEST WELL 8 CASING Schedule.....49

REFERENCES 50

APPENDIX A 52

APPENDIX B 53

APPENDIX C 54

DRAFT

FIGURES AND TABLES

FIGURES

Figure 1. Location of Test Wells and Test Holes on and Adjacent to the Pajarito Plateau
Figure 2. Access to Test Wells TW-1, TW-1A, TW-2 and TW-2A.
Figure 3. Proximity of Test Wells TW-1, TW-1A, and Test Hole OS-1A.
Figure 4. Lithologic Log of Test Hole OS-1A.
Figure 5. Lithologic Log and Casing Schedule of Test Well TW-1A.
Figure 6. Lithologic Log and Casing Schedule of Test Well TW-1.
Figure 7. Proximity of Test Wells TW-2, TW-2A, TW-2B, and Test Hole OS-2A.
Figure 8. Lithologic Log and Casing Schedule of Test Well TW-2.
Figure 9. Lithologic Log and Casing Schedule of Test Well TW-2A.
Figure 10. Lithologic Log of Offset Well OS-2A and Test Well TW-2B and Casing Schedule of Test Well TW-2B.
Figure 11. Access to Test Well TW-3.
Figure 12. Lithologic Log and Casing Schedule of Test Well TW-3.
Figure 13. Access to Test Well TW-4.
Figure 14. Lithologic Log and Casing Schedule of Test Well TW-4.
Figure 15. Access to Test Hole H-19.
Figure 16. Lithologic Log and Casing Schedule of Test Hole H-19.
Figure 17. Access to Test Hole H-16.
Figure 18. Lithologic Log of Test Hole H-16.
Figure 19. Access to Test Holes TH-5 and TH-6 along Pajarito Road.
Figure 20. Lithologic Log and Casing Schedule of Test Hole TH-5.
Figure 21. Lithologic Log and Casing Schedule of Test Hole TH-6.
Figure 22. Access to Test Hole TH-7.
Figure 23. Lithologic Log of Test Hole TH-7.
Figure 24. Access to Test Holes and Test Wells at TA-49.
Figure 25. Lithologic Log of Plugged and Abandoned Test Hole DT-5P.
Figure 26. Lithologic Log and Casing Schedule of Test Hole DT-5.
Figure 27. Lithologic Log and Casing Schedule of Test Well DT-5A.
Figure 28. Lithologic Log and Casing Schedule of Test Well DT-9.
Figure 29. Lithologic Log and Casing Schedule of Test Well DT-10.
Figure 30. Lithologic Logs and Casing Schedules of Alpha and Beta Holes.
Figure 31. Access to Sigma Mesa Test Hole EGH-LA-1.
Figure 32. Lithologic Log and Casing Schedule of Sigma Mesa Test Hole EGH-LA-1.
Figure 33. Access to Well Layne-Western.
Figure 34. Lithologic Log and Casing Schedule of Layne-Western Well.
Figure 35. Access to Test Well TW-8.
Figure 36. Lithologic Log and Casing Schedule of Test Well TW-8.
Figure 37. Casing Schedule of Test Well TW-8 Showing Air Transfer Due to Atmospheric Pressure Change.

TABLES

Table 1. Status of Test Holes and Test Well

DRAFT

ENGINEERING, GEOLOGIC, AND CONSTRUCTION DATA OF TWENTY FIVE TEST HOLES AND TEST WELLS ON AND ADJACENT TO THE PAJARITO PLATEAU

By
William D. Purtymun
AND
Ada Suzanne Swanton

ABSTRACT

Twenty-five test holes and test wells were drilled in the early days of the Los Alamos Project in the period 1949 through 1960. This report reviews the engineering design, geology, construction, and hydrology of the test wells to determine if they should be retained as part of the monitoring network or plugged and abandoned.

Of the twenty-five test holes included in the study, nine should be retained as part of the monitoring network, eleven should be plugged and abandoned, and five have already been plugged and abandoned.

The tests wells that should be retained include two wells completed in the intermediate perched aquifer, Test Wells 1A and 2A, and seven wells completed into the top of the main aquifer, TW-1, TW-2, TW-3, TW-4, DT-5A, DT-9, and DT-10. The construction of the wells is sound based on construction and water quality data. Changes in the quality of water from these wells are the result of normal recharge to the well or of contaminants introduced into the well with the recent installation of new pumps and pump columns. There is as much as 47 years of water quality data from these test wells.

Eleven test wells or test holes should be plugged and abandoned for various reasons including safety and possible contamination of the intermediate perched groundwater zone and the main aquifer. The test wells and test holes that should be plugged and abandoned are prioritized as: Alpha Hole (1), Beta Hole (2), TW-8 (3), H-19 (4), TW-2B (5), Layne-Western (6), TH-5 (7), TH-6 (8), DT-5 (9), EGH-LA-1 (10), and test hole H-16 (11).

The five test holes that have been plugged and abandoned are OS-1A, OS-2A, OS-3A, DP-5P, and TW-8A. The holes were plugged and abandoned due to drilling problems, they could not be completed as test holes or wells.

Lithologic logs, casing schedules, and vehicular access to the test hole and well locations are illustrated. Location, elevation, history, hydrology, geologic logs, and casing records are documented. A procedure for plugging each of the eleven test holes is recommended.

DRAFT

I. INTRODUCTION

Twenty-five test holes and wells were drilled in the early days of the Los Alamos project, all to determine the geology and hydrology of the area. Many that encountered ground water were completed as test wells to monitor water quality. The wells were located in canyons, on the Pajarito Plateau mesa tops, or adjacent to the mesa tops **(Figure 1)**.

The purpose of this report is to compile a history of the construction, use, geology, and hydrology of the these test holes and wells and, based on this data, recommend which wells should be retained as part of the monitoring network and which wells should be plugged and abandoned.

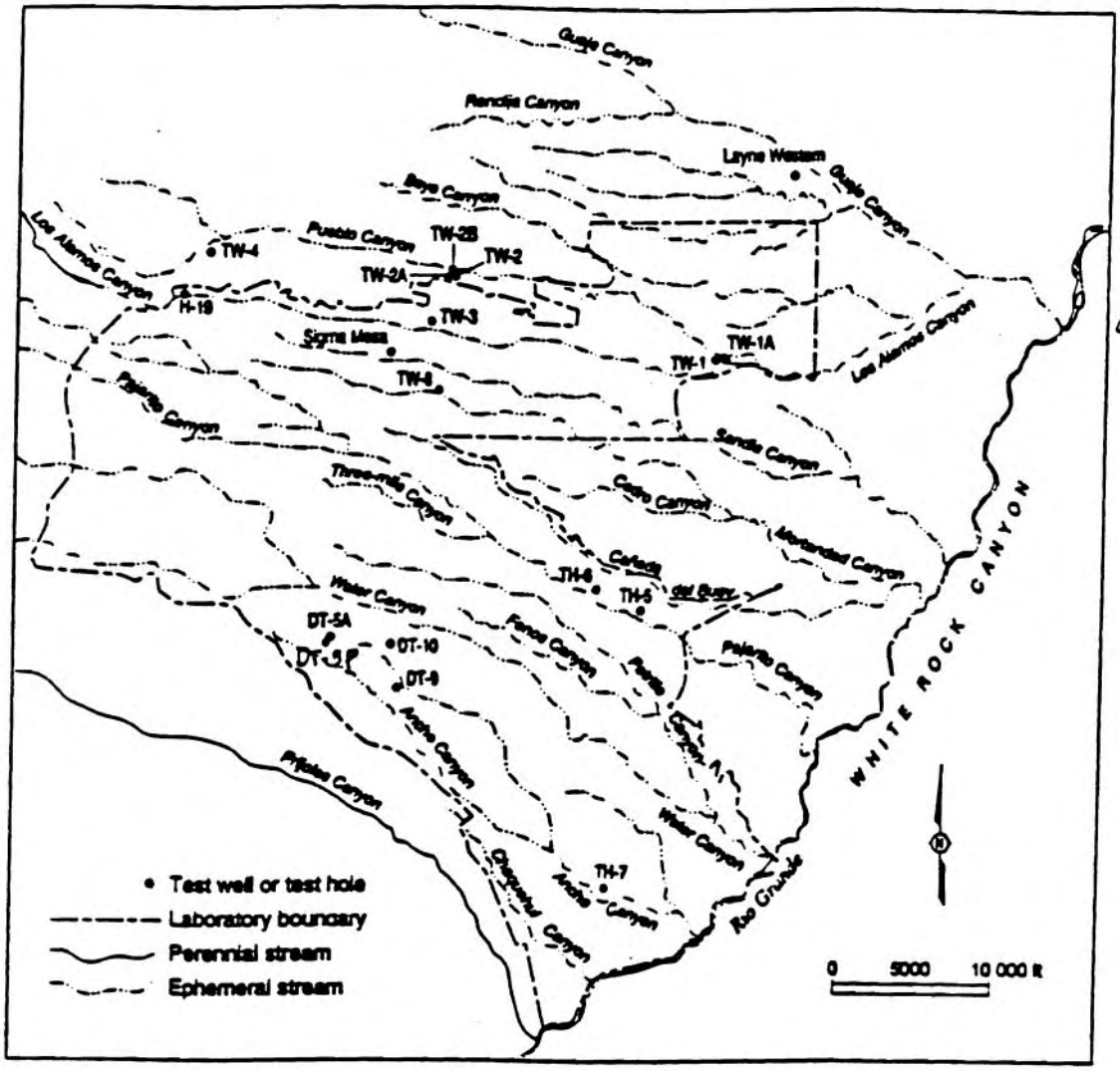
The test wells to be retained are TW-1A, and TW-2A, competed into the intermediate perched ground water zone, and TW-1, TW-2, TW-3, TW-4, DT-5A, DT-9, and DT-10, completed into the top of the main aquifer. The quality of water records from some of these wells extends back to over 47 years **(Table 1)**.

The test holes and wells which should be plugged and abandoned are prioritized as: Alpha Hole (1) and Beta Hole (2) for safety purposes, TW-8 (3) and H-19 (4) because they provide a contamination pathway into the underlying aquifers, TW-2B (5), Layne-Western (6), TH-5 (7), TH-6 (8), DT-5 (9), TH-EGH-LA-1 (10), and H-16 (11) because they provide a possible contamination pathway into the underlying aquifers.

The Alpha and Beta Holes are near TA-49 and are 2 feet in diameter and about 190 feet deep. They were dug with a bucket auger and are the only large diameter holes in the area that have not been plugged to prevent accidents. The holes are not part of the monitoring network and are not used for any other purpose. They have surface casings with locked covers. There is a possibility that the surface casing could collapse into the hole. For this reason the holes should be plugged.

The casing in Test Well TW-8 is sound and prevents the leakage of highly contaminated alluvial perched ground water into the main aquifer. However, water samples taken from the main aquifer at TW-8 show minute traces of tritium (Stoker, 1994).

The presence of tritium may be from air volume exchanges common in wells with open screen intervals above the water table (Purtymun and others 1974). These wells expel and draw air in response to changes in atmospheric pressure. Chemical (organic) and radiological (tritium) contamination has occurred in the tuff at TA-54 due to this process (Kearl and others 1986a; Kearl and others 1986b; Purtymun 1973; and Purtymun 1994). This air volume exchange has been observed at TW-8. If vapor phase tritium is present around the well head from evaporation or transpiration, it may get drawn into the well, condense on the casing, and trickle down into the main aquifer.



Added
OS well
DT-5F

Figure 1.- Location of Test wells and Test Holes on the Pajarito Plateau (Test Hole H-16 located west of the plateau on the Crest of the Sierra de los Valles).

DRAFT

TABLE 1. STATUS OF TEST HOLES AND WELLS

TEST WELL OR TEST HOLE	STATUS	PLUG[1]	RETAIN[2]	PLUGGED AND ABANDONED[3]
TW-1	Cased well completed in main aquifer		X	
TW-1A	Cased well completed in intermediate perched zone		X	
OS-1A	Abandoned test hole			X
TW-2	Cased well completed in main aquifer		X	
TW-2A	Cased well completed in intermediate perched zone		X	
TW-2B	Partially cased hole through intermediate perched zone	5		
OS-2A	Abandoned test hole			X
TW-3	Cased well completed in main aquifer		X	
OS-3A	Abandoned test hole			X
TW-4	Cased well completed in main aquifer		X	
H-19	Open hole to 2000 ft	4		
H-16	Open hole to 1269 ft	11		
TH-5	Partially cased dry hole	7		
TH-6	Partially cased dry hole	8		
TH-7	Open hole to 55 ft			X
DT-5P	Abandoned test hole			X
DT-5	Abandoned test hole	9		
DT-5A	Cased well completed in main aquifer		X	
DT-9	Cased well completed in main aquifer		X	
DT-10	Cased well completed in main aquifer		X	
ALPHA HOLE	Partially cased, large diameter hole	1		
BETA HOLE	Partially cased, large diameter hole	2		
TH-EGH-LA-1	Partially cased, partially plugged hole into main aquifer	10		
LAYNE-WESTERN	Cased well completed in an intermediate perched zone in Guaje Canyon	6		
TW-8	Cased well completed in main aquifer	X		
TW-8A	Abandoned test hole			X

1 Test holes or wells recommended for plugging for safety or possible contamination of underlying unsaturated volcanics or volcanic sediments or underlying aquifers. Numbers represent plugging priority.
2 Test well that is to be retained as part of monitoring net.
3 Test holes drilled, plugged for various reasons.

DRAFT

Test Hole H-19 lacks sufficient casing to prevent surface water or alluvial ground water from leaking down the well bore and possibly into the intermediate perched ground water zone or the main aquifer. This leakage can cause degradation in the quality of water in the existing intermediate perched ground water zone and the main aquifer.

The remaining holes recommended for plugging (TW-2B, Layne-Western, TH-5, TH-6, DT-5, TH-EGH-LA-1, and H-16) have the potential to create intermediate perched ground water zones or to cause degradation of existing intermediate perched ground water zones or the main aquifer.

Five of the test holes discussed in this report (OS-1A, OS-2A, OS-3A, DT-5P, and TW-8A) have already been plugged and abandoned. They were intended for completion as test wells but problems were encountered during drilling. Information on these holes is included for documentation purposes.

The Federal and State governments have established criteria for when test holes or wells should be plugged and abandoned. One criterion is that the well has not been used for one year. The test holes and wells proposed for plugging in this study have not been used for many years. Other criteria include damaged casings or holes that have not been completed as monitoring wells. A summary of the Federal and State criteria for well abandonment and guidance on plugging methods is given in Appendix A.

Most of the wells were drilled using cable tool technology (see Appendix B for discussion). The use of this technology often resulted in the installation of several strings of casing in the hole. Ideally, all strings of casing should be removed before the wells are plugged. However, the outermost casing may have to be left in place to prevent borehole collapse during plugging. The remaining casing is ripped to allow the cement-bentonite mixture to get between the casing and the borehole wall. This will allow proper sealing and thereby prevent the migration of water or vapor phase contaminants down the outside casing (see Appendix C for further discussion).

This report documents the location, history and hydrology, geologic logs, and casing records of the twenty-five test holes and wells. Information on how to access the wells is also given. Appendix C provides guidance on the plugging method appropriate for the eleven test holes and wells suggested for abandonment.

DRAFT

II. LOS ALAMOS PROJECT LONG-TERM MONITORING WELLS (1949 AND 1950)

Several test holes and test wells were drilled to facilitate a long-term study of the movement of contaminated liquid waste from the Los Alamos Project Areas into and through the various aquifers underlying the Project Site. Two groups of wells were located in Pueblo Canyon, one well was located on the mesa top near the Radioactive Waste Treatment Plant adjacent to upper Pueblo Canyon, and one well was located in Los Alamos Canyon. The project was planned and supervised by C. V. Theis and C. S. Conover of the U.S.G.S. (United States Geological Survey) Albuquerque District Office in 1949.

Each location was to include one test hole, drilled with a cable tool drilling rig, penetrating the main aquifer and one or more offset wells if any perched ground water zones were encountered above the main aquifer. During the drilling of the main test hole in each group of wells, samples of the drill cuttings were taken at 5-ft intervals by a U.S.G.S. representative. The geology, hydrology, and details of construction presented in the following section are taken from Black and Veatch (1950) and Griggs (1955 and 1964).

A. TEST HOLE OS-1A AND TEST WELLS TW-1A AND TW-1

Three test holes were drilled in lower Pueblo Canyon. One, OS-1A, was plugged and abandoned while the other two, TW-1 and TW-1A were completed as test wells. TW-1 was completed into the main aquifer and TW-1A was completed into an intermediate perched ground water zone. Access to this group of wells is on a gravel road off State Road 502 about 0.5 miles west of the junction with State Road 4 (**Figure 2**). The proximity of these test wells and the test hole are shown in **Figure 3**.

1. History and Hydrology

In the past, Pueblo Canyon has received effluents from both Laboratory sources and municipal sources. Treated and untreated effluent from the Laboratory's Radioactive Waste Treatment Plant at former TA-45 was released into Acid Canyon, a small tributary to Pueblo Canyon, near the western edge of the Pajarito Plateau from 1944 through 1964 (LANL 1996, LA-Pueblo workplan).

Treated sanitary effluent was also released into upper and middle Pueblo Canyon from two municipal treatment plants (the Pueblo Sewage Treatment Plant and the Central Sewage Treatment Plant) from about 1949 through 1964. The discharges from the plants sustained surface flow to several hundred yards east of Hamilton Bend before depletion by infiltration and evapotranspiration. In 1964 the Los Alamos County Sewage Treatment Plant (STP) was completed and began receiving and treating most of the municipal influent. Effluent flow in upper Pueblo Canyon was greatly diminished. Discharges from the Los Alamos County STP sustained surface flow to a point below the junction of State Road 4 and 502. The changes in locations of effluent discharge points in the canyon has resulted in different flow patterns through the years.

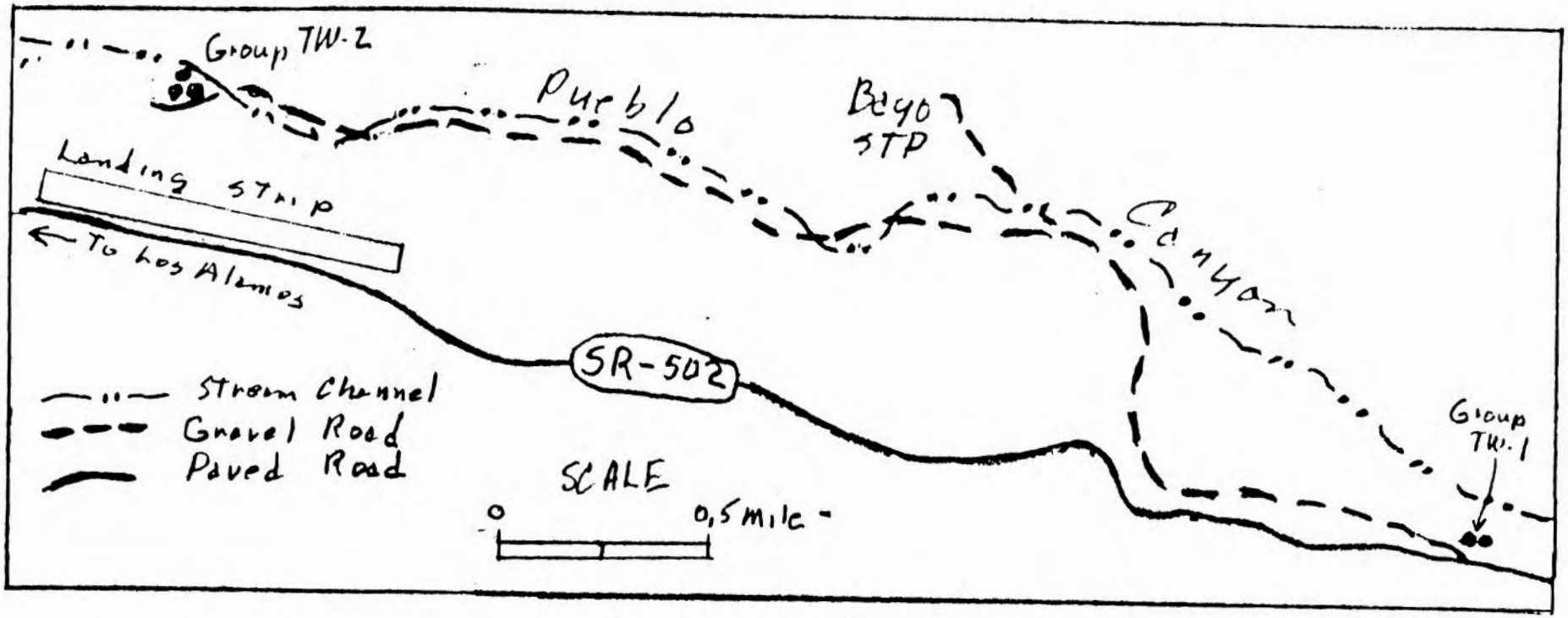


Figure 2.- Map showing Access To Groups of Wells at TW-1 and TW-2.

Land
Withdrawn

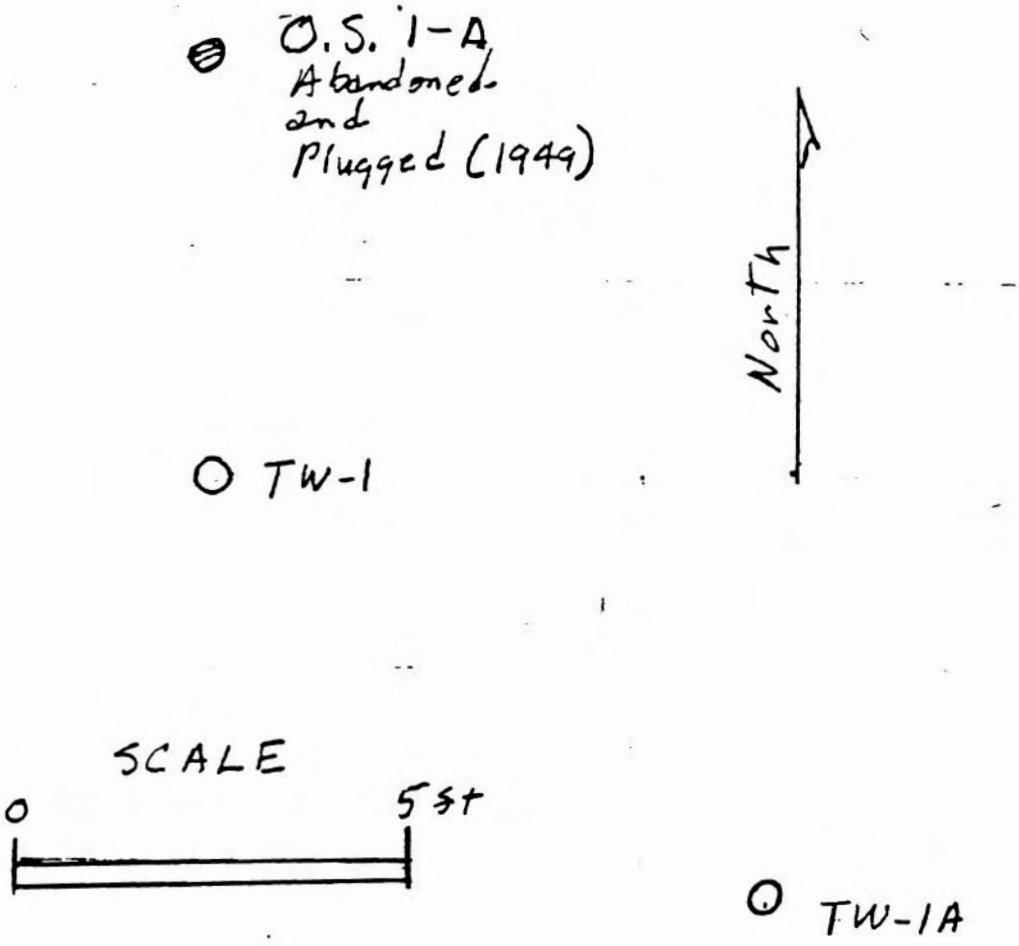


Figure 3. – Layout of series of Hole and Test Wells at TW-1.

Storm water runoff adds to the flow in Pueblo Canyon. The main area of recharge occurs east of Hamilton Bend where the canyon cuts through the Bandelier Tuff and into the fanglomerate member of the Puye Conglomerate. The alluvium overlies the gravels of the fanglomerate member and thins to the east where the stream has cut to base level on the basalts near the junction of State Road 4 and State Road 502 about a mile east of the wells. The alluvium in this part of the canyon had been saturated from about 1945 to 1995.

The intermediate perched ground water zone in TW-1A was encountered at a depth of 212 to 215 feet. It consists of a 3-foot zone within the Basaltic Rocks of Chino Mesa (Unit 3: channel fill basalt flow). The zone was reported to exhibit semi-artesian conditions. When penetrated during drilling, the potentiometric surface rose to a depth of about 183 feet indicating a pressure head of about 29 feet or 13 pounds per square inch (psi). Artesian conditions indicate that recharge is not in the immediate vicinity of the well but rather to the west where the ground water surface elevation is higher.

Pueblo Canyon stream-connected alluvial ground water is thought to be the recharge source through the fanglomerate member to the intermediate perched ground water zone at test well TW-1A for two reasons. First, the chemistry of the water from the well is similar to that of the stream and alluvial ground water. Both contain ions present in treated effluent. Second, tritium analyses in 1992 and 1993 of samples from TW-1A support recharge from Pueblo Canyon surface water and alluvial ground water as the concentrations ranged from 134 to 148 pCi/l. The presence of tritium indicates a modern surface water source.

Recharge to the well is estimated to take from two to six months. This estimate is based on water levels and chemical water quality in the stream and alluvium. The velocity of movement in the intermediate perched ground water zone was computed from an aquifer test to be about 4,500 ft/year (Weir and others 1963).

Problems arose during the drilling of TW-1 as the intermediate perched ground water zone could not be sealed out of the lower part of the hole. A 12-inch diameter casing was cemented into place at 241 feet. This sealed the perched ground water zone from the lower part of the hole.

The main aquifer was penetrated by TW-1 at a depth of 623 feet and the well was completed to a depth of 642 feet. The aquifer exhibited semi-artesian conditions as the water in the hole rose to about 583 feet indicating a head of about 40 feet or 17 psi. Recharge to the aquifer is from the west in canyons cut into the flanks of the mountains or on the Pajarito Plateau. Based on water level measurements taken during 1951 to early 1954, recharge time to the main aquifer was estimated to be about 2 years. The velocity of ground water movement in the aquifer was estimated to be about 150 feet per year (Weir and others 1963).

In 1956, a test was performed to determine if leakage was occurring through the annular space between the casing and the borehole wall at

TW-1. Water quality of the main aquifer at TW-1 differed from that at other main aquifer test wells suggesting mixing of intermediate perched ground water with the main aquifer. The test consisted of injecting about 2000 gallons of salt water into the intermediate perched zone through TW-1A to test the cement seal around the casing of TW-1. The testing indicated no leakage (Abrahams 1966).

In 1991, a study was conducted to compare the quality of surface water in Pueblo Canyon, water in the alluvium, intermediated perched ground water from TW-1A, and main aquifer water from TW-1. A comparison of the data indicated that the well construction in Tests Wells TW-1A and TW-1 was sound and that no leakage was occurring at TW-1 (LANL 1993, EPG).

During this study, water levels in the two wells were also monitored over a period of time. There was no correlation of water level responses between the two wells that would indicated hydraulic connectivity between the intermediate perched ground water zone and the main aquifer at TW-1(LANL 1993, EPG).

In the spring of 1990 when supply well O-1 was completed (located about 500 feet west of TW-1), the water level in TW-1 was reported to have risen about 80 feet to a depth of 508 feet. Before O-1 was drilled, the water level in TW-1 ranged from about 584 to 594 feet. The rise in water level was attributed to loss of large amounts of drilling fluid during the drilling of O-1 which created a recharge cone in the gravels at the top of the main aquifer. This bulge was not observed in O-1. The most likely reason for this is because the surface casing for O-1 was set at 664 feet, i.e., several feet into the main aquifer and several feet below the completed depth of TW-1 (Purtymun and others 1993). The water level in TW-1 declined to about 547 feet by 1993 (Purtymun and others 1995).

An aquifer test conducted in well O-1 in the spring of 1990 created no drawdown in TW-1. The static water level in O-1 after the test was about 675 feet while that in TW-1 remained about 508 feet. Taking in the elevation difference, the first set of screens in O-1 is about 400 ft below the bottom of the screen at TW-1. Geologic logs show that the Tesuque formation is highly stratified at this location with lenses of claystone, siltstone, silty sandstone, some sandstone and pebbly conglomerate. The lack of response in TW-1 during the aquifer test indicates that the main aquifer is made up of beds of varying permeability that yield water at varying rates. This also results in water-bearing beds that exhibit slightly different chemical quality.

The tritium concentrations in 1992 and 1993 in the aquifer penetrated by TW-1 ranged from 353 to 366 pCi/L which indicated that some modern recharge is taking place (Stoker 1994). The concentrations are about three times higher than those found in the intermediate perched zone at TW-1A. The difference in tritium concentrations indicates that there is no leakage along the borehole. The difference also reflects a difference in rate and time of recharge between the two aquifers.

DRAFT

2. Test Hole OS-1A

The first test hole, OS-1A, was drilled using a Layne-Western No. 24 L cable tool rig. The rig was moved onto the site June 1, 1949 and drilling began on June 8. On July 14, the hole was abandoned at a depth of 108 ft since the lower 32 ft drilled in basalt was crooked and could not be straightened. The hole was plugged with the cuttings that were taken from the drilling operation **(Figure 4)**.

3. Test Well TW-1A

The drilling rig was shifted to a new location six feet south of abandoned hole OS-1A where drilling began on July 19 on TW-1A (location N 1,772,003, E 509,813, Elevation 6,369 ft). On August 23, the drilling of this hole was suspended at a depth 140 feet when repeated attempts, include the firing of three dynamite charges, failed to straighten the hole **(Figure 5)**.

A larger cable tool drill rig (Jenkins Drilling Company No. 36 L) was moved to a third location where test well TW-1 was completed into the main aquifer. Upon completion of TW-1 the rig was moved back to the location of TW-1A and, on January 5, 1950, advanced this hole to 225 feet. A flow of water was encountered at a depth of 212 feet and rose to a depth of 188 feet. This was considered to be the same intermediate perched ground water zone encountered during the drilling of TW-1 (see following discussion of Test Well TW. On January 10 and 11, about 214 feet of 6-inch casing with a 10-foot length of screen was set in the hole and bottomed at a depth of 225 feet (**Figure 5**).

Test well TW-1A was equipped with a submersible pump in 1950 that burned out in 1953 or 1954. The pump was pulled from the hole and a jack pump was installed in 1958. This pump operated until 1991 when it was replaced with another submersible pump.

This well has been part of the monitoring network since its completion. About 46 years of water quality records exist from test well TW-1A. During that period, the water has been mainly a sodium-bicarbonate type with total dissolved solids ranging from 250 to 450 mg/L. The water quality reflects surface water quality in the canyon to the west of the well. The slight changes in chemical quality of water that have occurred have been anticipated with the recharge. This data supports the conclusion that the construction of TW-1A is sound. There is no need to plug the well at this time.

a. Test Well TW-1A Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Soil Zone Sand, Fine to medium, and silt	0	2
Puye Conglomerate Fanglomerate member Sand and gravel with silty clay	2	50

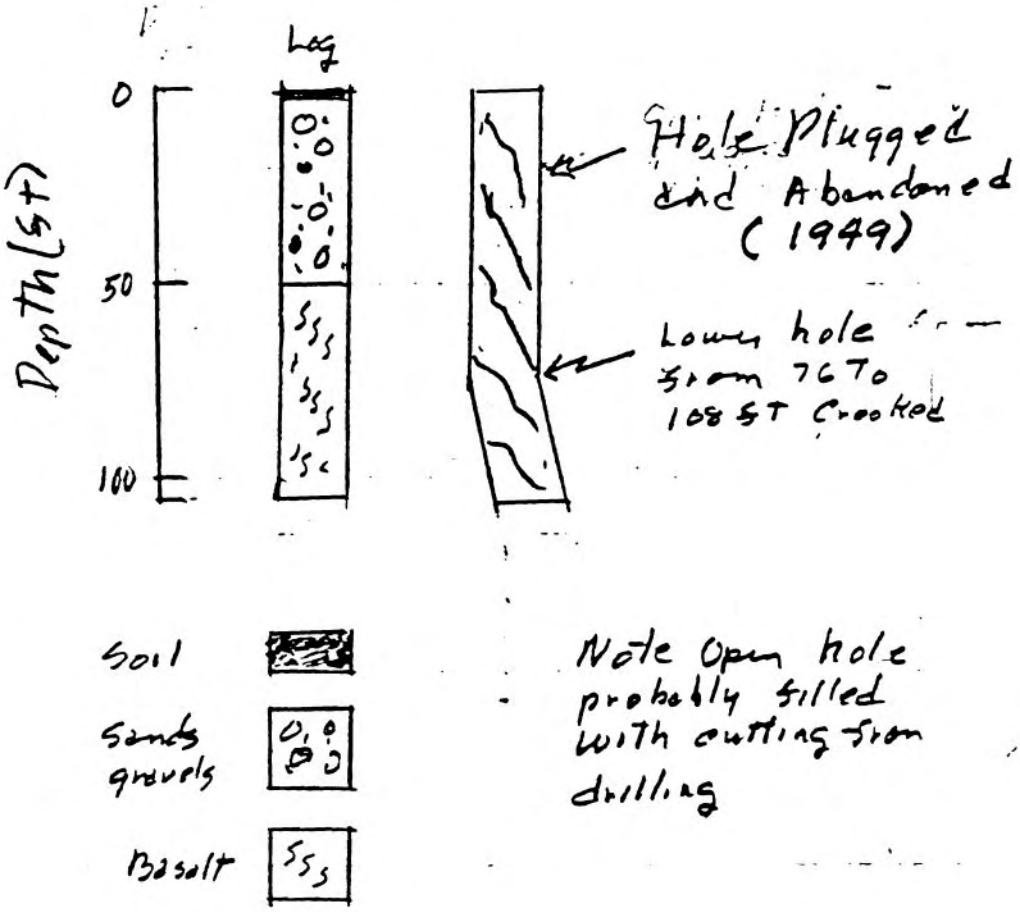


Figure 4 - Lithologic Log of Test Hole O.S.-1A.

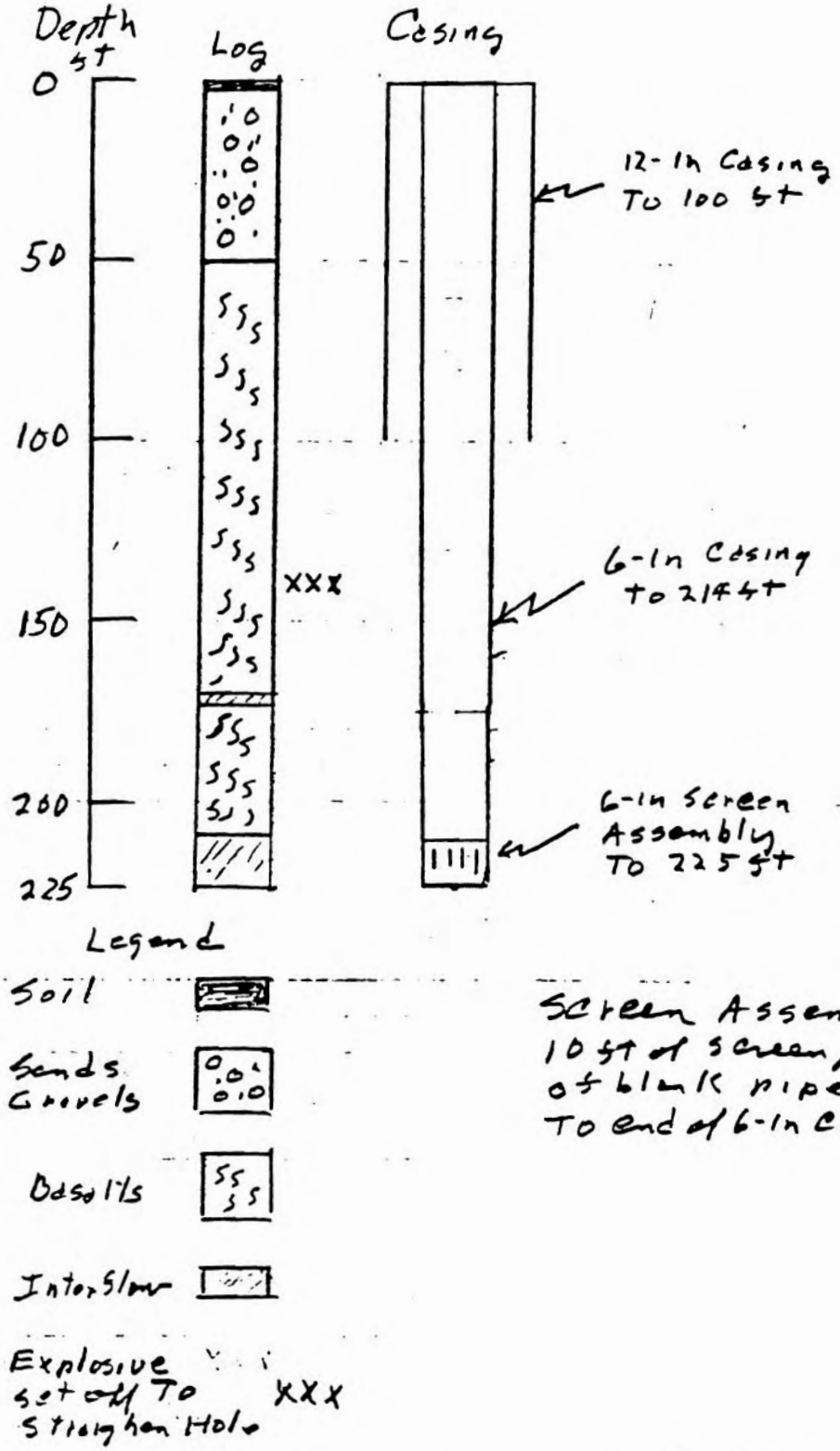


Figure 5. - Lithologic Log and Casing Schedule of Test Well TW-1A. (from Black et al. 1980)

Basaltic Rocks of Chino Mesa Unit 3 Basalts, dark gray to black basalt fine-grained, alternating from vesicular dense, jointed flows	50	173
Interflow Zone Basalt fragments, Clays to gravels	173	176
Basalt, medium gray to dark gray, Fine grained	176	210
Interflow Zone, Basalt fragments, Clays to gravels	210	225

(Black and Veatch 1950; Griggs 1955)

b. Test Well TW-1A Casing Schedule

The lithologic log and casing schedule for TW-1A are shown on **Figure 5** and taken from Black and Veatch (1950).

A 12-inch ID (internal diameter) steel casing with 13 7/8 inch OD drive shoe was set at 100 ft. The casing was probably driven.

A 6-inch ID steel casing was set at a depth of 214 ft with 10 ft 6-inch ID screen assembly at bottom set at a depth of 225 ft. No placement of gravel pack was mentioned in the driller's log.

4. Test Well TW-1

On November 27, 1949 the Jenkins rig was set at a new location about 20 ft south of temporarily abandoned hole TW-1A (Location N 1,772, 015, E 509,797, Elevation 6369). A flow of water was encountered at a depth of 212 ft, estimated at 18 gpm, which rose in the hole to a depth of 188 ft.

Drilling continued in the open hole to a depth of 350 ft and a casing was set to that depth in an unsuccessful attempt to seal off the water produced from the intermediate perched zone. The casing was pulled back to 241 feet and the remaining borehole was filled with sand. The casing was cemented in by Halliburton Oil Company on December 27 using 100 bags of Portland Cement. This effectively sealed off the flow of water from the intermediate perched zone.

With the intermediate perched zone shut out of the well, drilling continued through the 12-inch diameter casing to a depth of 642 feet. A flow of water was encountered at a depth of 623 feet and rose to about 585 feet. On January 3, 1950, this test well was completed with 627 feet of 8-inch casing. The screen assembly consists of 10 feet of 6-inch casing and 10 feet of 6-inch well screen on the bottom set at a depth of 642 ft. **(Figure 6)**.

The well was equipped with a submersible pump when completed. The pump motor burned out 1959 and the pump was replaced with a jack pump in 1973. The jack pump was removed in 1991 and replaced with another submersible pump.

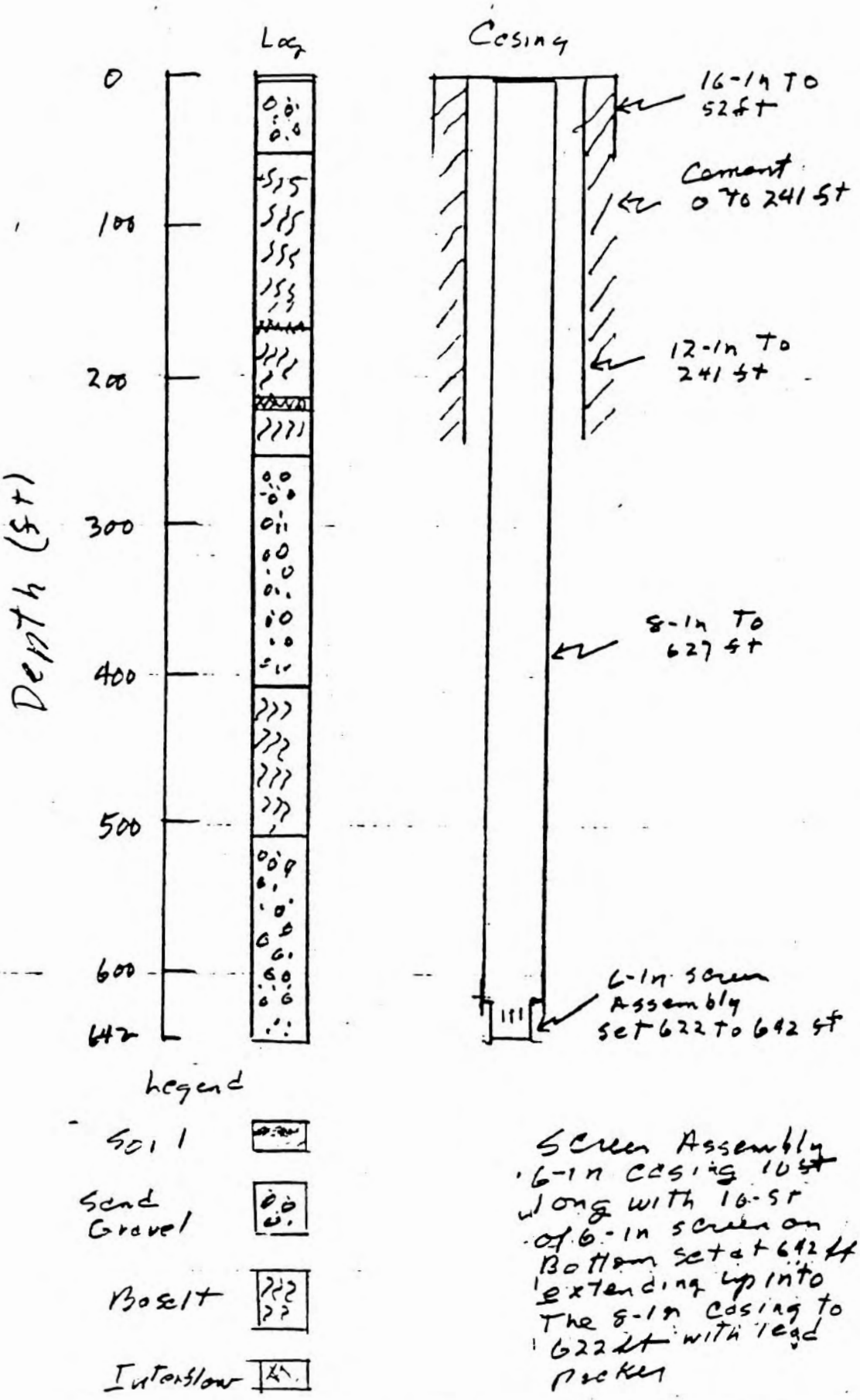


Figure 6. – Lithologic Log and Casing [illegible] Test Well TW-1 (Cont. Div. [illegible])

Quality of water records and water level data cover about 46 years. During that time the water has been mainly a calcium-bicarbonate type with total dissolved solids ranging from 150 to about 200 mg/L. Water quality has changed slightly reflecting the quality of surface water in the canyon to the west of the well. Recharge to the aquifer in the vicinity of the well has been estimated at about 2 years. Though the well is 46 years old, well construction is sound. The well should be retained as part of the monitoring network.

a. Test Well TW-1 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Soil Zone Sand, Fine to medium, and silt	0	2
Puye Conglomerate		
Fanglomerate member: Sand and gravel with silty clay	2	50
Basaltic Rocks of Chino Mesa		
Unit 3 Basalts, dark gray to black basalt fine-grained	50	173
Interflow Zone Basalt fragments, Clays, silts, and gravels	173	176
Basalt, medium gray to dark gray, Fine grained	176	210
Interflow Zone, Basalt fragments, Clays, silts, and gravels	210	225
Basalts, medium gray to dark gray, Fine-grained, vesicular at the Top and near bottom	225	255
Puye Conglomerate		
Fanglomerate member: Gravels, silts, and clays	255	410
Basaltic Rocks of Chino Mesa		
Unit 3 Basalt flows interbedded with river gravels and clays	410	510
Puye Conglomerate		
Fanglomerate member: Gravels, silts and clays	510	605
Totavi Lentil: River gravels, silts and sand	605	642

(Black and Veatch 1950; Griggs 1955)

b. Test Well TW-1 Casing Schedule

The lithologic log and casing record for TW-1 are shown on **Figure 6** and taken from Black and Veatch (1950).

A 16-inch ID casing was set at 52 feet.

A 12-inch ID casing with 13 7/8-in OD drive shoe was set at 241 feet.

An 8-inch ID casing was set to 627 feet.

Casing and screen assembly include a 6-inch ID casing 10 ft long with 10 ft of 6-inch ID Layne screen on the bottom set at 642 feet. The casing and screen assembly extends up into the 8-inch ID casing to 622 feet below land surface with the lower end of the screen at 642 feet.

B. TEST HOLE OS-2A AND TEST WELLS TW-2B, TW-2, TW-2A

Four test holes were drilled in the mid-reach of Pueblo Canyon (**Figure 7**). Access to this group of wells is on a gravel road about 0.5 miles west of the junction with State Road 4 (**Figure 2**). Two of the holes, TW-2 and TW-2A, were completed as monitoring wells, one in the main aquifer and the other in an intermediate perched ground water zone. The two other holes were drilled in search of perched ground water. Both were dry. One, TW-2B was cased and left open, and the other, OS-2A, was plugged and abandoned.

1. History and Hydrology

Surface water and alluvial ground water in Pueblo Canyon provide recharge to the intermediate perched ground water zone in the fanglomerate member at TW-2A. The depth to the intermediate perched zone is about 125 feet. The chemical quality of water samples taken from the intermediate perched zone at TW-2A is similar to that of the stream and alluvial ground water. Water levels in the intermediate perched zone generally responded to fluctuations in stream flow volume in about 8 to 10 months (Abrahams 1966). Changes in the quality of water samples taken from TW-2A over time result from changes in the water quality of the stream.

The water in the intermediate perched ground water zone was reported to be under semi-artesian conditions with a pressure head of about 19 feet (8.2 psi). Recharge is from west of the well **(Weir and others 1964)**. Pumping of the well and a subsequent aquifer test indicated a low permeability zone of limited extent. The well can be pumped dry in a short period of time at low discharge rates.

Tritium was detected in the intermediate perched zone in 1992, 1993 and 1995 and concentrations ranged from 1,897 to 2,265 pCi/L. The similar quality of water in the stream indicates recent recharge **(Rogers and others 1995)**.

Test Well TW-2 was drilled in 1950 and penetrated the main aquifer at a depth of about 765 ft The water level has since declined to 793 ft in 1993. The aquifer is under semi-artesian conditions with a pressure head of about 12 ft (3.5 psi). The quality of water is significantly different from that of the stream and the intermediate perched aquifer. The quality is similar to that in main aquifer test well TW-3. The hydrologic characteristics of the aquifer at TW-2 are quite similar to other test wells (TW-1 and TW-3) that also penetrate the sands and gravels of the main aquifer. The velocity of the water in the aquifer at this point is estimate to range from 150 to 250 ft/year **(Weir and others 1964; Purtymun 1995)**.

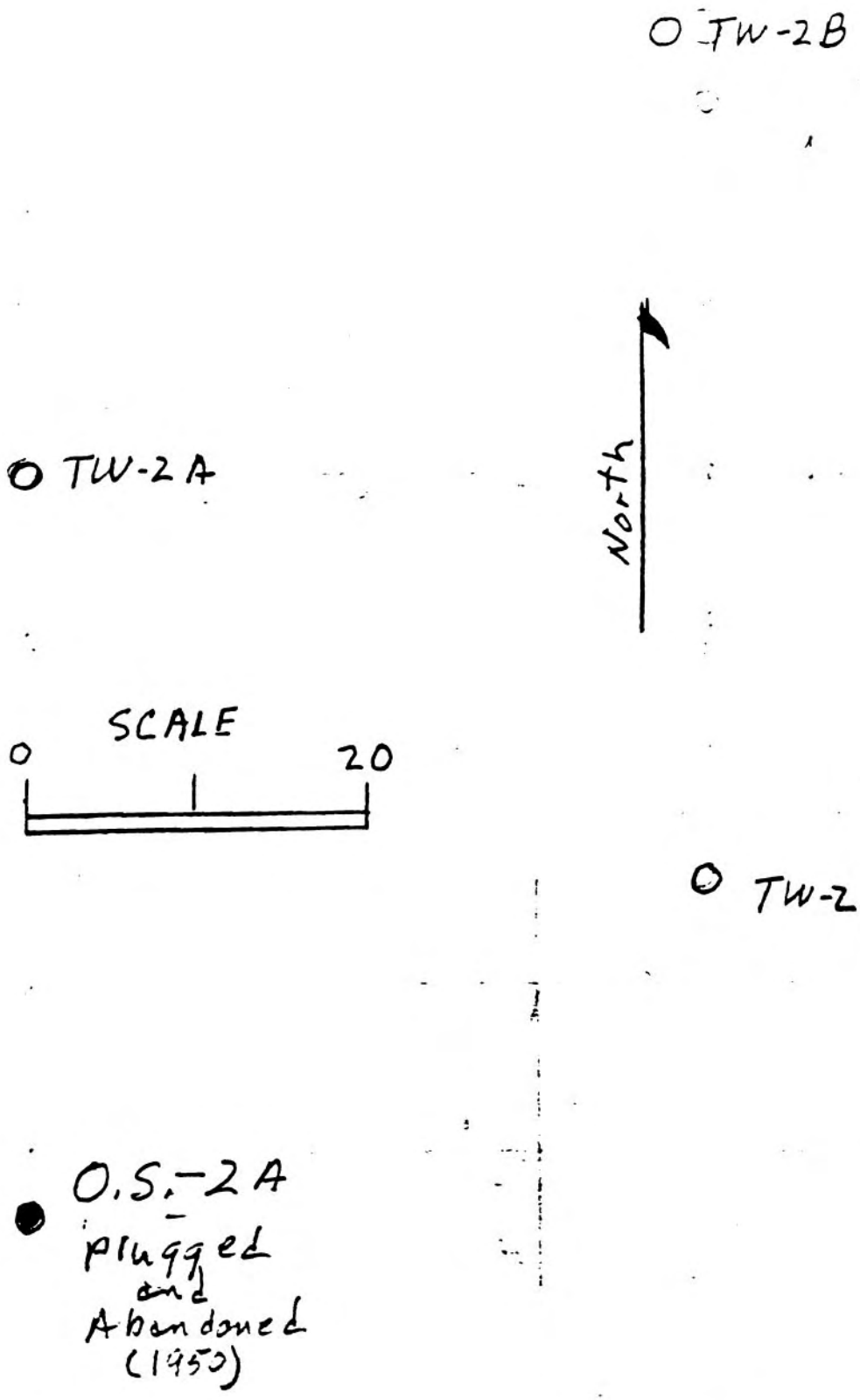


Figure 7.- Layout of Series of Test Holes and Wells at Test Well TW-2.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

Tritium was detected in the main aquifer at TW-2 in 1992, 1993, and 1995 and concentrations ranged from 0.7 to 16.8 pCi/L. The low concentrations indicate that no recent recharge is occurring. The age of the water, as determined by Carbon-14 age dating, range from 57 to 4,610 years **(Stoker and others 1963, Rogers and others 1995)**. Recharge is most likely from the west in canyons cut into the Sierra de los Valles.

2. Test Well TW-2

Drilling of Test Well TW-2 began on August 29, 1949 using a Layne-Western No. 24L cable tool rig (**Location N 1,777,206, E 493,987,** Elevation 6,648 ft). An intermediate perched ground water zone was encountered at a depth of 112 ft. The intermediate zone was sealed out of the well and drilling continued to a depth of 789 ft. The well was completed on November 3, 1949.

The main aquifer was encountered at a depth of 767 ft and exhibited semi-artesian conditions with water rising 8 ft in the hole to a depth of 759 ft. A string of 12-inch casing was driven to a depth of 197 ft to seal out the intermediate perched aquifer. Another intermediate perched zone documented in the geologist's log at 165 to 170 ft was sealed out with a 10-inch casing driven to a depth of 519 ft. (This zone was not reported in the driller's log and an attempt to locate it with test well TW-2A failed. See the following discussion on test well TW-2A.) The well was completed at a depth of 789 ft with 10 ft of screen.

By 1989, the water level of the main aquifer in test well TW-2 declined below the bottom of the well. In the spring of 1990, a cable tool rig was set up on the hole and a lead packer, 5 ft of 6-inch diameter blank casing, and a 10 ft length of 6-inch diameter screen was fished out of the well. The well was deepened from 789 to 834 ft. It was cased with 6-inch diameter casing from land surface to 834 ft with the lower section slotted from 768 to 834 ft (Figure 8).

The well was initially equipped with a submersible pump. The pump motor burned out in 1953 and pump was removed from the well. A jack pump was installed in 1958. The jack pump was removed when the well was deepened in 1990 and replaced with a submersible pump.

The water quality has fluctuated slightly ranging from a calcium-bicarbonate type to a sodium-bicarbonate type. The total dissolved solids have been very low ranging from about 100 to 150 mg/L. Water quality data, water level data, and age dating indicate that the aquifer is not readily recharged from the intermediate perched zone or the nearby stream. Over 45 years of data has been obtained from this well. The well construction is adequate. The well should be retained as part of the monitoring network.

DRAFT

a. Test Well TW-2 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Soil Zone	0	2
Alluvium: Silts, sands, gravels, and boulders	2	11
Bandelier Tuff		
Otowi Member: Light gray to gray pumaceous tuff	11	35
Guaje Member: Gray ash fall of pumice and pumice fragments, some rock fragments of dacite and rhyolite	35	63
Puye Conglomerate		
Fanglomerate member: Gravel with some sand	63	103
Silty clay with sand and gravel	103	110
Gravel with some sand	110	125
Sandy, silty clay with gravel	125	146
Gravel with a little sand and some clay zones	146	335
Sands with some gravel	335	340
Gravel with sand, some clay zones	340	380
Gravels with some sand, gravels, and boulders	380	700
Totavi Lentil: River sands, gravels, and boulders, Rounded to sub-rounded	700	834

(Black and Veatch 1950; Griggs 1955; Purtymun 1995)

b. Test Well TW-2 Casing Schedule

The lithologic log and casing record of the well are shown on **Figure 8** and taken from Black and Veatch (1950) and Purtymun (1995).

A 16-inch ID casing was set to 56 ft.

A 12-inch ID casing was first set at 141 ft but followed down the hole and finally set at 197 ft (to seal out the water from the perched zone at 112 ft)

A 10-inch ID casing was set at 519 ft.

An 8-inch ID casing was set at 778 ft.

In 1990, 15 ft of 6-inch ID blank and screen were fished from the well. The well was then drilled to 834 ft through the 8-inch casing and A 6-inch ID casing was hung in the well from 0 to 834 ft with the lower section slotted from 774 to 824 ft.

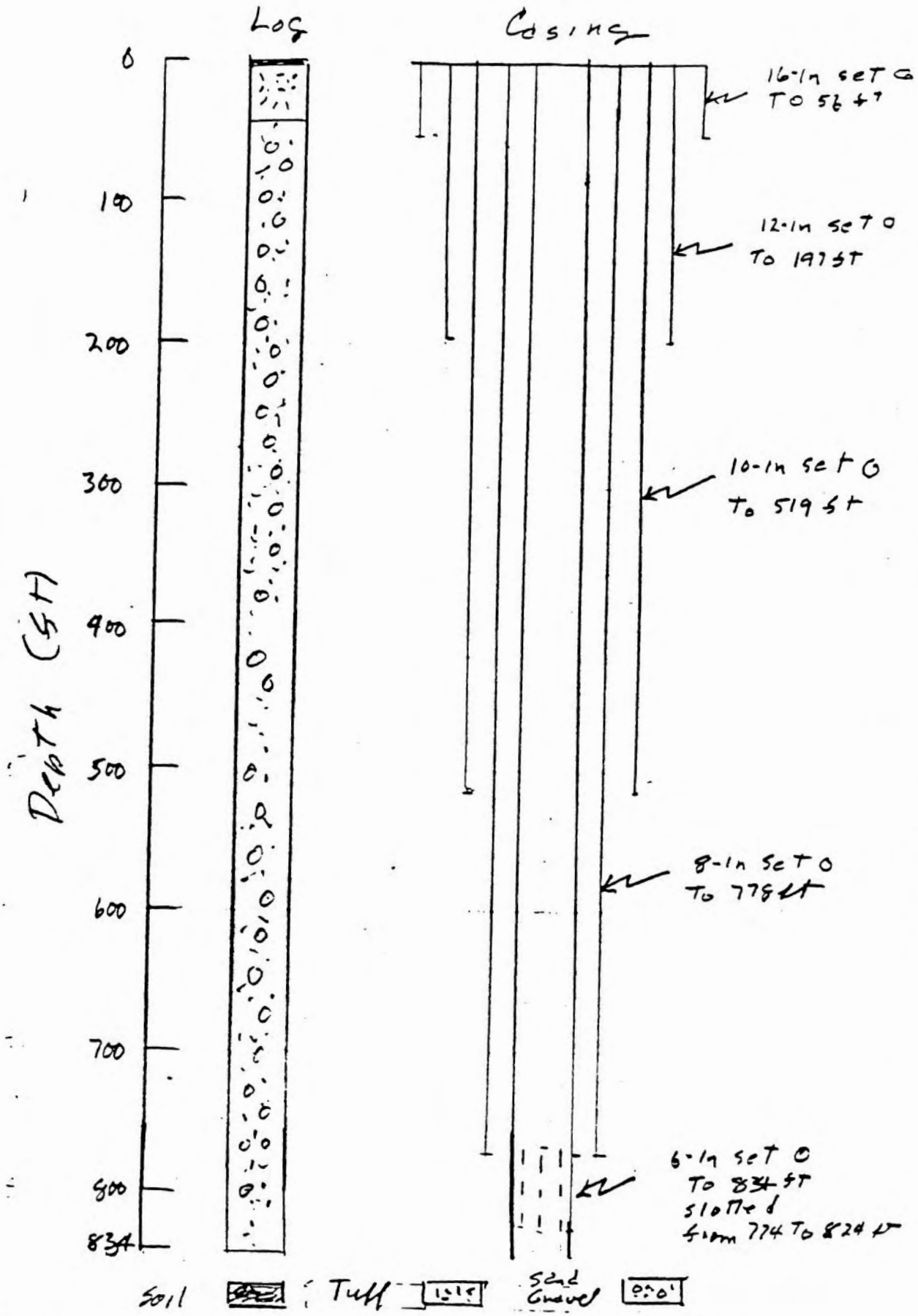


Figure 8.—Lithologic Log and Casing [illegible]

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

DRAFT

3. Test Well TW-2A

Test well TW-2A is located 50 ft west of TW-2 (Location N 1,777,226, E 493,941, Elevation 6,650 ft). The purpose of this well was to test the possible water bearing zone encountered at a depth of 165 ft in TW-2. A Jenkins No 36-L cable tool rig was moved to that location and drilling began on February 2, 1950 and continued until February 5, when a depth of 165 ft was reached. An upper water bearing zone was encountered at 112 ft and rose in the well to a depth of 93 ft. An 8-inch diameter casing was driven to a depth of 152 ft in an attempt to seal the zone. The casing was pulled up to a depth of 118 ft and the hole was filled to a depth of 133 ft. The screen assembly consists of 10 ft of 6-in casing with a 10-ft section of 6-in screen on the bottom set through the 8-in casing to a depth of 133 ft. The lead packer between the 6-in casing and 8-in casing was set at a depth of 113 ft. The well was completed on February 7 (Figure 9).

The well was initially equipped with a submersible pump. The pump motor burned out in 1954 and the pump was replaced with a jack pump in 1958. The jack pump was removed in 1991 and replaced with another submersible pump.

The water quality from test well TW-2A has varied considerably ranging from a calcium-bicarbonite type after completion to a sodium-bicarbonate type in later years. The total dissolved solids have ranged from 100 to as much a 300 mg/L. Recharge to the aquifer is from the stream channel west of the well. The stream water quality has changed over the past 46 years, representing storm and snowmelt runoff, industrial effluent, and sanitary effluent. Changes in water quality at TW-2A are to be expected as they reflect the quality of water from the stream. Well construction is sound. The well should be retained as part of the monitoring network.

a. Test Well TW-2A Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Soil Zone	0	2
Alluvium: Sands and gravels	2	11
Bandelier Tuff		
Otowi Member: Massive pumiceous ashflow tuff	11	35
Guaje Member: Pumice ash fall	35	63
Puye Conglomerate		
Fanglomerate member: Gravel with sand	63	103
Silty clay with some sand and Gravel	103	110
Gravel with some sand	110	125
Sandy, silty clay with gravel	125	146
Gravel with sand and some Clay lenses	146	152

(Black and Veatch 1950; Griggs 1955)

b. Test Well TW-2A Casing Schedule

The lithologic log and casing record are shown on **Figure 9**.

A 12-inch casing was set to 12 ft.

An 8-inch casing was set to 118 ft.

A 6-inch casing 10-ft long with a 6-inch screen on the lower end was set to a depth of 133 ft extending up in the 8-inch casing. The lead packer between the casing and screen section was set at a depth of 113 ft.

4. Test Hole OS-2A and Test Well TW-2B

The geologist's log indicated a second perched ground water zone at 165 to 170 which rose in the hole 108 ft. No mention of this water bearing zone was made in the drillers log (Black and Veatch 1950).

A second attempt to complete a sampling well (OS-2A) in this zone was located 50-ft southwest of TW-2A (**Figure 7**). Drilling on this location began on February 9 and continued to February 14 when a depth of 225 ft was reached. The upper water-bearing zone was encountered at a depth of 114 ft. A string of 8-inch ID casing was set to a depth of 124 ft which shut off the flow from the upper zone. Drilling through the 8-inch casing continued to a depth of 225 ft. No water was found below the upper zone and the hole was abandoned. The casing was pulled and the hole filled with drill cuttings (**Figure 10**).

A third attempt (TW-2B) was made to penetrate the water-bearing zone at a depth of 165 ft (**Location N 1,777,200, E 493,900**, Elevation 6,647 ft). This hole was located 36 ft northeast of Test Well TW-2A. Drilling at this location began on February 17 and continued until February 23, when a depth of 225 ft was reached. The upper water-bearing zone was encountered at a depth of 103 ft and sealed off with 112 ft of 12-inch casing. A string of 6-inch casing was run in the hole and was use to follow the drilling. The hole was completed to a depth of 225 ft, but again no water was encountered. Attempts to pull the 6-inch and the 12-inch casing from the hole failed. The two strings of casing were left in the hole. According to a caliper log that was run on March 20, 1967, the 6-inch casing was set at a depth of 130 ft. The hole was dry at 223 ft through the 6-inch casing while a water level of 88 ft was measured between the 12-inch casing and the 6-inch casing in September 1991 (Figure 10).

They were unable to pull the casing from TW-2B. A reducer was screwed on the top of the 6-inch casing and a plate welded on the top. The two strings of casing are still in the hole and the hole open below the casing.

Test well TW-2B was completed in the fanglomerate member of the Puye Conglomerate and responds to changes in atmospheric pressure. Air is expelled when low-pressure fronts move in and sucked into the hole

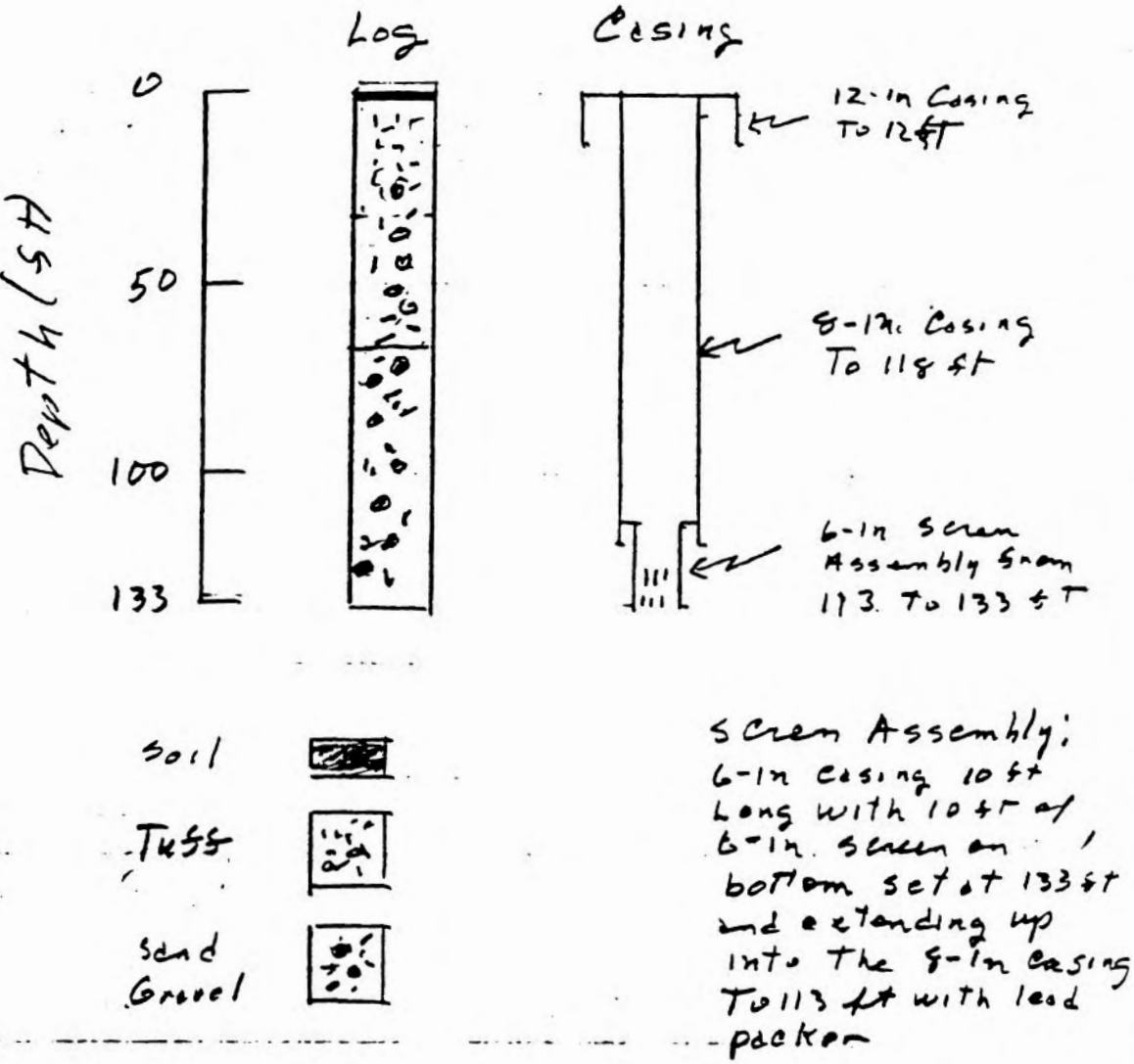


Figure 9.- Lithologic Log and Casing Schedule of Test Well TW-2A.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

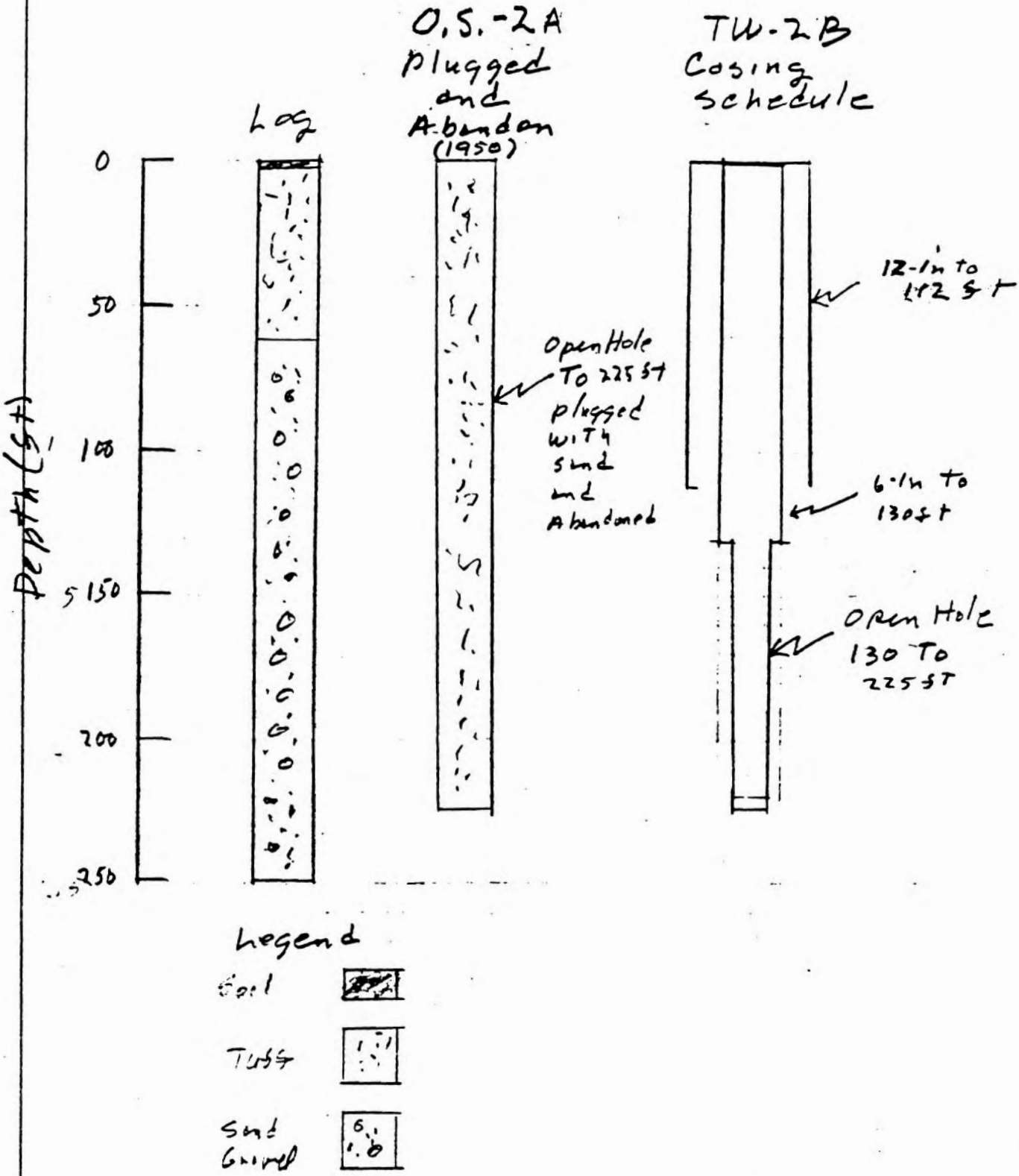


Figure 10.- Lithologic log of OSS-Test Well 2A and Test Well TW-2B and Casing Schedule of Test Well-2B.

when high pressure fronts move in. In 1967, the hole was used to develop instruments for studying air exchange caused by changes in atmospheric pressure. The hole was used because it was near an electrical power source.

Test Well TW-2B should be plugged as it serves no purpose and has not been used since 1967. If the casing should fail, it could create an artificial intermediate perched zone in the fanglomerate member. Plugging procedures are outlined in Appendix C.

a. Test Well TW-2B Geologic Log

The geologic logs of TW-2B and OS-2A are the same as for TW-2 and TW-2A.

Lithologic Description	Depth from (ft)	Depth to (ft)
Soil Zone	0	2
Alluvium: Silts, sands, gravels, and boulders	2	11
Bandelier Tuff		
Otowi Member: Light gray to gray pumiceous tuff	11	35
Guaje Member: Gray ash fall of pumice and pumice fragments, some rock fragments of dacite and rhyolite	35	63
Puye Conglomerate		
Fanglomerate member: Gravel with some sand	63	103
Silty clay with sand and gravel	103	110
Gravel with some sand	110	125
Sandy, silty clay with gravel	125	146
Gravel with a little sand and some clay zones	146	335

b. Test Well TW-2B Casing Schedule

The lithologic log and casing schedule of Test Well TW-2B are taken from Griggs, 1955 and are shown on **Figure 10**.

A 12-inch casing set to 112 ft remains in the hole.

A 6-inch casing was driven to 223 ft; the casing could not be pulled. (Griggs 1955)

C. TEST WELL TW-3 AND TEST HOLE OS-3A

Test well TW-3 is in Los Alamos Canyon. Access to the test well is from State Road 4 on a gravel road that is about 1 mile south of the junction with State Road 502 (**Figure 11**). The well is located in the canyon bottom just east of the confluence with DP-Canyon (Location N 1,773,076, E 497,483, Elevation 6,595 ft). The small Omega West

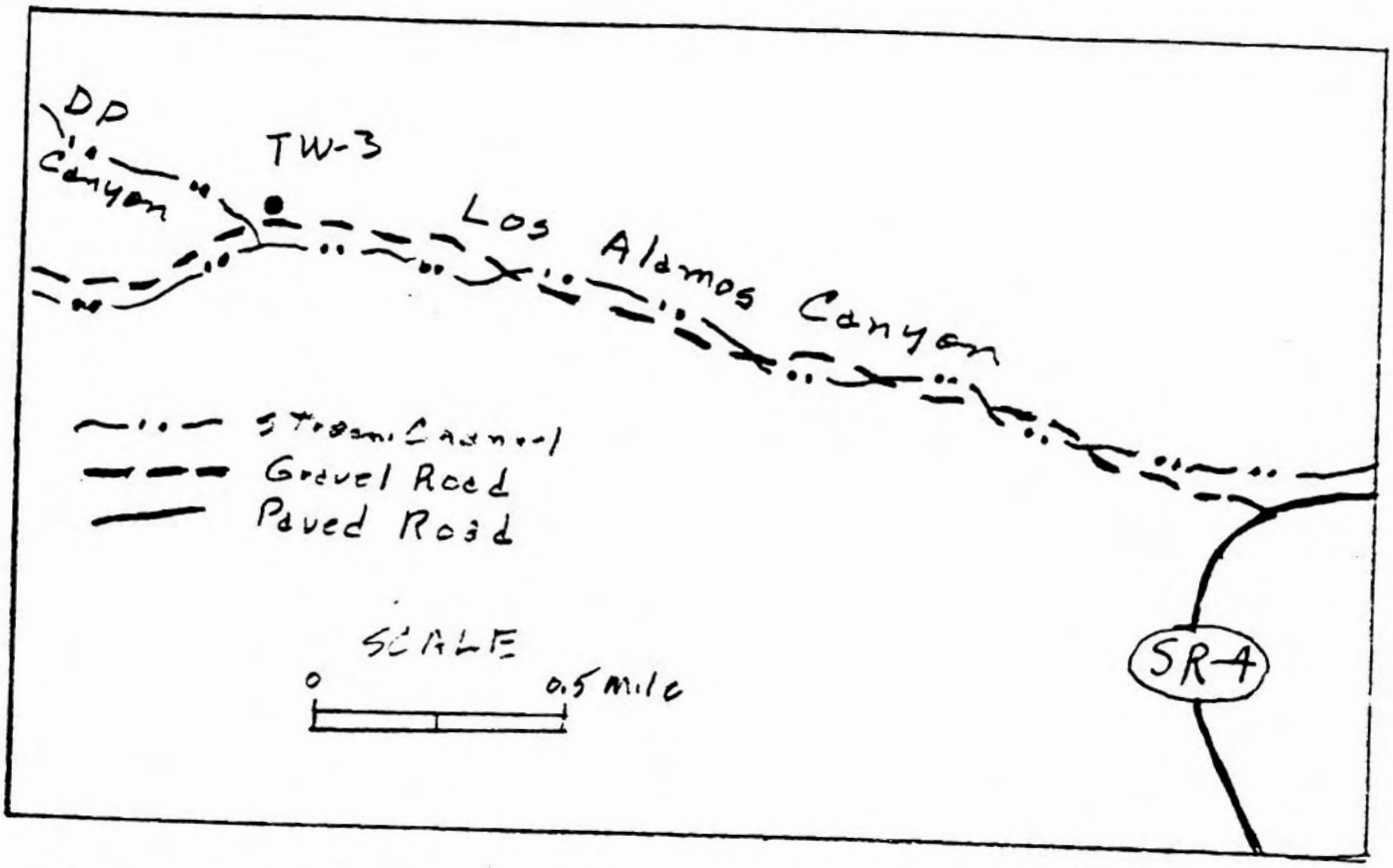


Figure 11.- Map Showing Access To Test Well TW-3

Reactor lies about 2 miles to the west in Los Alamos Canyon and was operated from the early days of the project until about 1991. DP-Canyon received treated radioactive waste effluents from about 1952 to 1982 from the treatment plant at TA-21. Some treated sanitary effluents are still released into the canyon.

1. History and Hydrology

The Jenkins No.36 cable tool rig started drilling OS-3A on October 6, 1949 and continued until October 23 when a depth of 362 feet had been reached. At this point, the drill stem broke in the wrench square and dropped the tools in the hole. The drill stem could not be fished out. Test hole OS-3A was plugged and abandoned. The rig was moved to a new location 8 ft west of the abandoned hole.

After the plugging of OS-3A, drilling of TW-3 began on November 1, 1949 and continued until November 20, when a depth of 815 ft was reached. The main aquifer was penetrated at a depth of 790 ft. The aquifer exhibited semi-artesian conditions with a pressure head of 47 ft (20.4 psi). A surface string of 16-inch casing was set at a depth of 33 ft. Drilling continued through a 10-inch casing which was finally set at a depth of 811 ft. The screen assembly consisted of 10 ft of 6-inch casing with 10 ft of screen on the bottom. The screen assembly was up into the 10-inch casing at 795 ft where a lead packer made a seal between the two casings.

No intermediate perched ground water zones were encountered above the main aquifer. The perched intermediate ground water zone reported at 264 ft during the drilling of supply well O-4 (1989) about 413 ft to the west was not penetrated in either abandoned hole OS-3A or test well TW-3 (Black and Veatch 1950). This intermediate perched zone might have been a zone in the fanglomerate member where drilling fluids were lost during the drilling of the upper section of O-4. The zone was viewed using a TV log as drilling had ceased due to the loss of the drill collar and bit down the hole and the fluid level had declined below 300 ft. As viewed on the log, the water at 264 ft was entering only about 1/3 of the hole diameter. If the hole had penetrated an intermediate perched ground water zone, water should have been entering around the total diameter of the hole. Also, the flow of water appeared to have the same consistency as drilling mud. The tools lost in the hole were fished out and drilling continued. A string of casing was set to the top of the main aquifer sealing out the "perched zone" at 264 ft.

The water in the alluvium at TW-3 is recharged from stream flow in both Los Alamos and DP Canyons. Surface flow in DP Canyon and an observation well in the alluvium contained high concentrations of chemicals and radionuclides. A comparison of the chemical and radiological quality of the surface water with that from the main aquifer indicates no leakage along the casing and no contamination of the main aquifer.

The chemical quality of water and the hydrologic characteristics of the main aquifer at test well TW-3 are quite similar to those of test

well TW-2. Recharge to the aquifer is from the west in deep canyons cut into the edge of the plateau or those canyon cuts into the flanks of the Sierra de los Valles. Movement in the top 60 ft of the aquifer is estimated at 260 ft/year to the east-south east (**Purtymun 1984**). Tritium concentrations in 1992 and 1995 ranged from <1 to 53 pCi/L and are inconclusive of age of recharge. Carbon 14 dates indicate an age ranging from 921 to 7,480 years (Stoker 1994; Rogers and others 1996).

The water level in the well has declined from 743 ft in 1950 to 776 ft in 1993. During the aquifer test of Supply Well O-4, about 55 million gallons of water were pumped from the aquifer. The test at O-4 resulted in little or no water level response in TW-3 (Purtymun and others 1995). The top of the screen in O-4 is about 400 ft below the bottom of the screen in TW-3. The lack of water level response in TW-3 during the test at O-4 is most likely due to the highly stratified sediments in the Chaquehui Formation at this point. Similar conditions were noted in TW-1 during the aquifer test of Supply Well O-1.

No exchange of air has been noted through the 8-inch casing of TW-3 as the screen area is below the water table. However, there is air exchange between the 10-inch casing and the 12-inch casing through a tube at the southeast corner of the concrete pad at the well head.

The well was equipped with a submersible pump when completed. The pump motor burned out in 1953. The pump was removed from the hole and replaced with a jack pump in 1958. The jack pump was removed in 1991 and replaced with another submersible pump.

There have been no significant changes in quality of water in the aquifer since the well was completed. The water is a calcium-bicarbonate type with total dissolved solids ranging from about 150 to 200 mg/L. Well construction is adequate; the well should be retained as part of the monitoring network as it has provided a long history of water quality records and water level data.

2. Test Well TW-3

a. Test Well TW-3 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Soil Zone	0	2
Alluvium: Sands and gravels	2	37
Bandelier Tuff		
Otowi Member: Gray nonwelded, pumiceous rhyolite tuff	37	145
Guaje Member: Pumice air fall	145	175
Puye Conglomerate		
Fanglomerate member Gravel and sand, some clay lenses	175	266
Basaltic Rocks of Chino Mesa		

Unit 3 Dark gray to black, fine grained Basalt	266	327
Interflow zone particles of basalt and gravels and clays	327	332
Gray andesite basalt	332	388
Puye Conglomerate		
Fanglomerate member: Clays, sands, and gravels	388	530
Gravels with some sands	530	620
Totavi Lentil: River sands and gravels	620	815

(Black and Veatch 1950; Griggs 1955)

b. Test Well TW-3 Casing Schedule

A lithologic log and the casing records of TW-3 are shown on **Figure 12** and taken from Black and Veatch (1950).

A 16-inch diameter surface casing was set to 33 ft.

A 10-inch diameter casing was set to 811 ft.

A 6-inch diameter casing 10 ft long with 10 ft of screen was set inside the 8-inch casing at 795 ft using a lead packer. The lower end of screen was set at 815 ft.

3. TEST HOLE OS-3A

Test Hole OS-3A, located 8 ft west of TW-3 was drilled to a depth of 362 ft. The well was plugged and abandoned in 1950 after a bit fell into the hole and could not be fished out. No further action is needed.

D. TEST WELL TW-4

Test Well TW-4 is located on the south rim of Pueblo Canyon (Location N 1,777,618, E483, 784, Elevation 7,245 ft) adjacent to where the former TA-45 Radioactive Waste Treatment Plant had been located. Access to the well is off Canyon Road behind the Jewish Center in the town area **(Figure 13)**. The plant released effluent from 1944 to 1962 into Acid Canyon. Test well TW-4 was drilled to monitor the quality of the main aquifer at a point downgradient from the effluent release area.

1. History and Hydrology

On November 5, 1949, a Layne-Western No 24L cable tool rig was moved onto the site and drilling began on November 10 and continued until March 8, 1950, when a depth of 1,205 ft was reached (**Figure 14**). No perched water was encountered above the main aquifer which was penetrated at 1,184 ft. The well was completed at a depth of 1,205 ft.

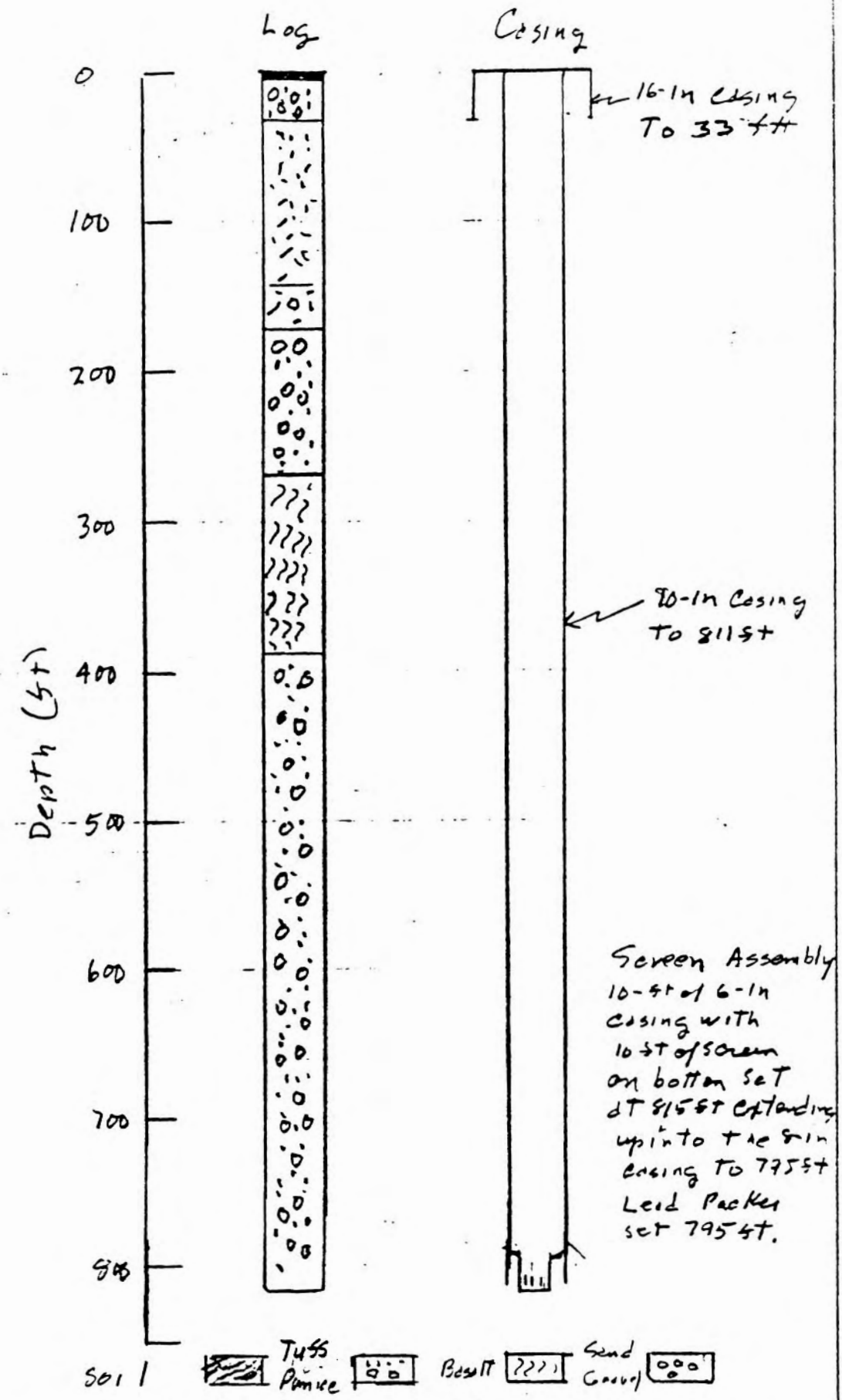


Figure 12 - Lithologic Log and Casing Schedule of Test Well TW-3 (from B&V, 1950)

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

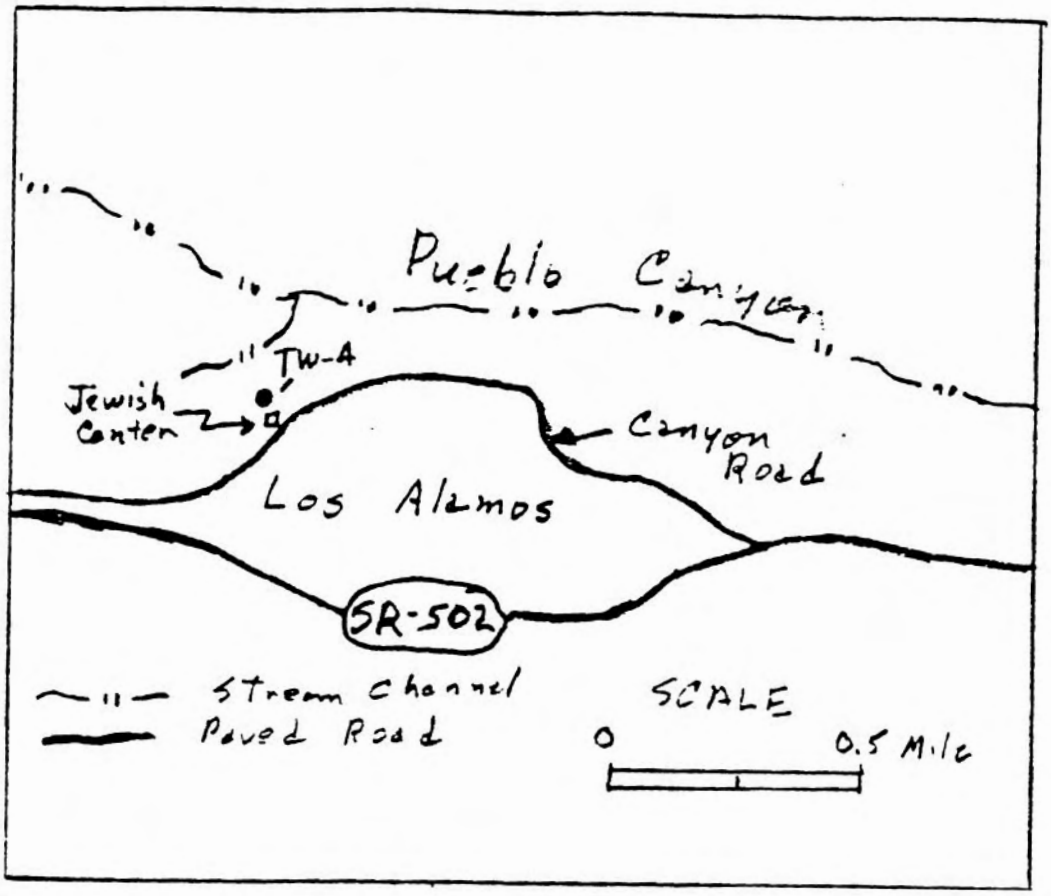


Figure 13.- Map Showing Access to Test Well TW-4.

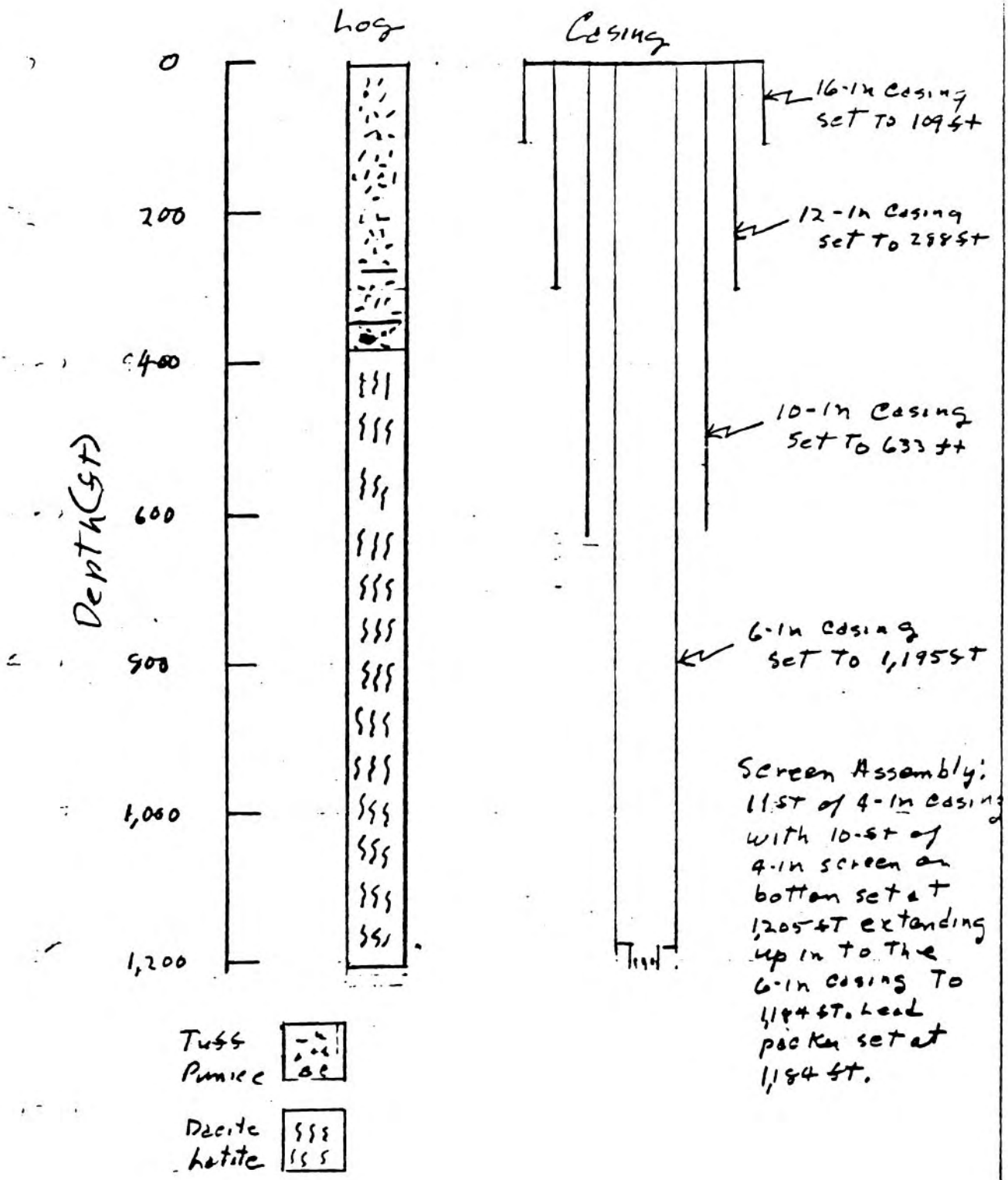


Figure 14 Lithologic Log and Casing Schedule of Test Well TW-4 (from B & V, 1950)

AMPAD 22-141 50 SHEETS 22-142 100 SHEETS 22-144 200 SHEETS

The main aquifer exhibited semi-artesian conditions with a pressure head of about 13 ft (5.6 psi). The aquifer occurs in an interflow zone within volcanic flow rocks of dacites and latites. There has been only slight water level decline from 1,174 ft in 1951 to 1,175 ft in 1993.

Age dating of the water using carbon 14 indicates an age of up to 4,600 years while tritium dates range from 35 (piston flow model) to 500 years (well mixed model) (Stoker 1994). Movement of water in the aquifer is to the east-south east at an estimated 50 ft/year (Purtymun 1995).

The well was equipped with a submersible pump when completed. The pump motor burned out in 1952 and the pump and was removed from the well in 1953.

In 1953, an experiment was carried out using polonium-84 (half-life of 138 days) to determine some of the hydrologic characteristics of the aquifer. The transmissivity and storage coefficient would be computed from the dilution and half-life of polonium-84 in the saturated section of the borehole. A drop-line was set into the aquifer and equipped with a stirrer on the bottom. The drop line was used to introduce the polonium into the well and to obtain samples at prescribed time intervals. The data collected has never been published nor have the notes of the experiment been located.

The drop-line and stirrer evidently parted in several places, ending up in the bottom of the well. The drop-line and stirrer were fished from the well prior to installation of a jack pump in 1958. The jack pump was pulled from the well in 1972 and installed in Test Well DT-5A at TA-49. There was no pump in the well until 1991 when a submersible pump was installed. Difficulties were encountered during the installation of the pump and an unknown quantity of water was introduced into the well to help start the pump.

The water in the main aquifer at TW-4 was mainly a sodium-bicarbonate type with total dissolved solids around 150 mg/L. Some contaminants have been reported in water samples from the well, but not proven. The contamination detected could have been introduced into the well through the installation of the new pump and pump column or from the water added to facilitate the pump's initial operation.

Over 45 years of water quality data and water level records exist from the well. Video logs of the cased hole show well construction is sound. The well should be retained as part of the monitoring network.

2. Test Well TW-4 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Bandelier Tuff		
Tshirege Member: Rhyolite tuff, nonwelded to welded, quartz and sanidine crystals and crystal fragments, a rock	0	280

fragments of latite, rhyolite, dacite, and pumice in a gray to buff ash matrix		
Otowi Member: Rhyolite tuff, nonwelded, quartz and sanidine with an abundance of pumice some rock fragments in a light to gray ash matrix	280	368
Guaje Member: Pumice, light gray with some rock fragments of dense rhyolite, dacite, and latite	368	395
Puye Conglomerate		
Fanglomerate member: Sand, gravels, and cobbles of latite, rhyolite, and dacite some lenses of silt, clay, and pumice	395	635
Tschicoma Formation		
Latite, rhyolite, and dacite flows with some interflows of silts, sands, and gravels	635	1205

(Black and Veatch 1950; Griggs 1955)

3. Test Well TW-4 Casing Schedule

The lithologic log and casing record of TW-4 are shown on **Figure 14** and taken from Black and Veatch (1950).

A 16-inch diameter surface casing was set from 0 to 109 ft.

A 12-inch diameter casing was set from 0 to 280 ft with a 13 7/8 inch diameter drive shoe.

A 10-inch diameter casing was set from 0 to 633 ft with a 11 1/2 inch diameter drive shoe.

A 6-inch diameter casing was set from 0 to 1,195 ft with 11 ft of 4-inch casing with 10 ft of 4-inch screen on lower end. A section of 4-inch blank pipe extends up into the 6-inch pipe with a lead packer between the 6-inch and 4-inch casing at 1,183 ft.

DRAFT

III. LOS ALAMOS PROJECT WATER SUPPLY INVESTIGATION WELLS (1949)

In the early days of the Los Alamos project, several options were undertaken to develop a water supply for the Laboratory and Community. One of the options was to develop well fields in the Valle Grande and Valle Toledo and pump the water through a tunnel dug through the rim of the caldera. Two test holes (H-19 and H-16) were drilled to investigate this option.

A. TEST HOLE H-19

Test hole H-19 was drilled with a cable tool rig to determine the geology and hydrology along the western edge of the plateau (Location N 1,775,400, E478, 200, Elevation 7,178 ft). The test hole was located in the bottom of Los Alamos Canyon. Access to the site is on West Road off Diamond Drive just south of the hospital **(Figure 15)**.

1. History and Hydrology

Test hole H-19 was completed in September 1949 at a depth of 2,000. Perched water was located in the lower part of the Bandelier Tuff at a depth of 450 to 472 ft. Yield was not sufficient to develop a water supply. The hole penetrated a large section of the Tschicoma Formation which was generally hard and massive with a low permeability. Water in the hole indicated that the top of the main aquifer was at a depth of 970 ft in the Tschicoma Formation. The Totavi Lentil at a depth of 1,480 to 1,490 ft was within the main aquifer. It was concluded from a bailing test that permeability of the saturated section in the Tschicoma Formation combined with the Totavi Lentil would not yield the required quantity of water to develop a well.

A surface string of 12-inch diameter casing was set into the alluvium to a depth of 10 ft. A smaller size casing was run down the hole as drilling advanced to keep the formation from collapsing. Upon completion of the hole and the collection of geologic and hydrologic data, the smaller casing was pulled leaving the 12-inch diameter surface casing in the hole **(Figure 16)**.

Test hole H-19 was abandoned and no effort was made to plug the formations as the casing was pulled. The hole was open to a depth of 265 ft in 1960. It was only open to a depth of 67 ft in 1992. Whether the hole has collapsed or is just bridged at those depths is unknown.

The stream flow in Los Alamos Canyon is perennial at the location of the test hole. The alluvium is a stream-connected aquifer. In 1960 and 1992, the water level stood in the surface string just a few feet below land surface. It is evident from this observation that the surface string did not penetrate the alluvium or seal the water from the hole. The abandoned test hole provides a pathway for water in the alluvium to enter the subsurface formations.

There are no laboratory facilities upgradient from H-19 in Los Alamos Canyon. Los Alamos reservoir and the ice skating rink are upgradient

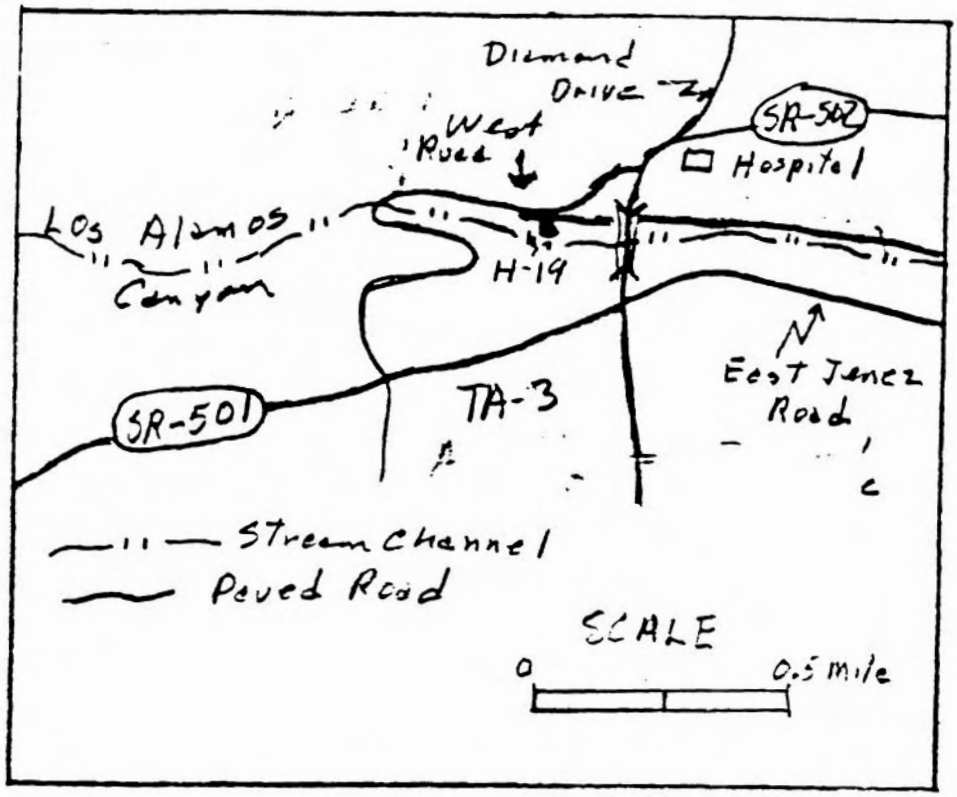


Figure 15.- Map showing access to Test Hole H-19

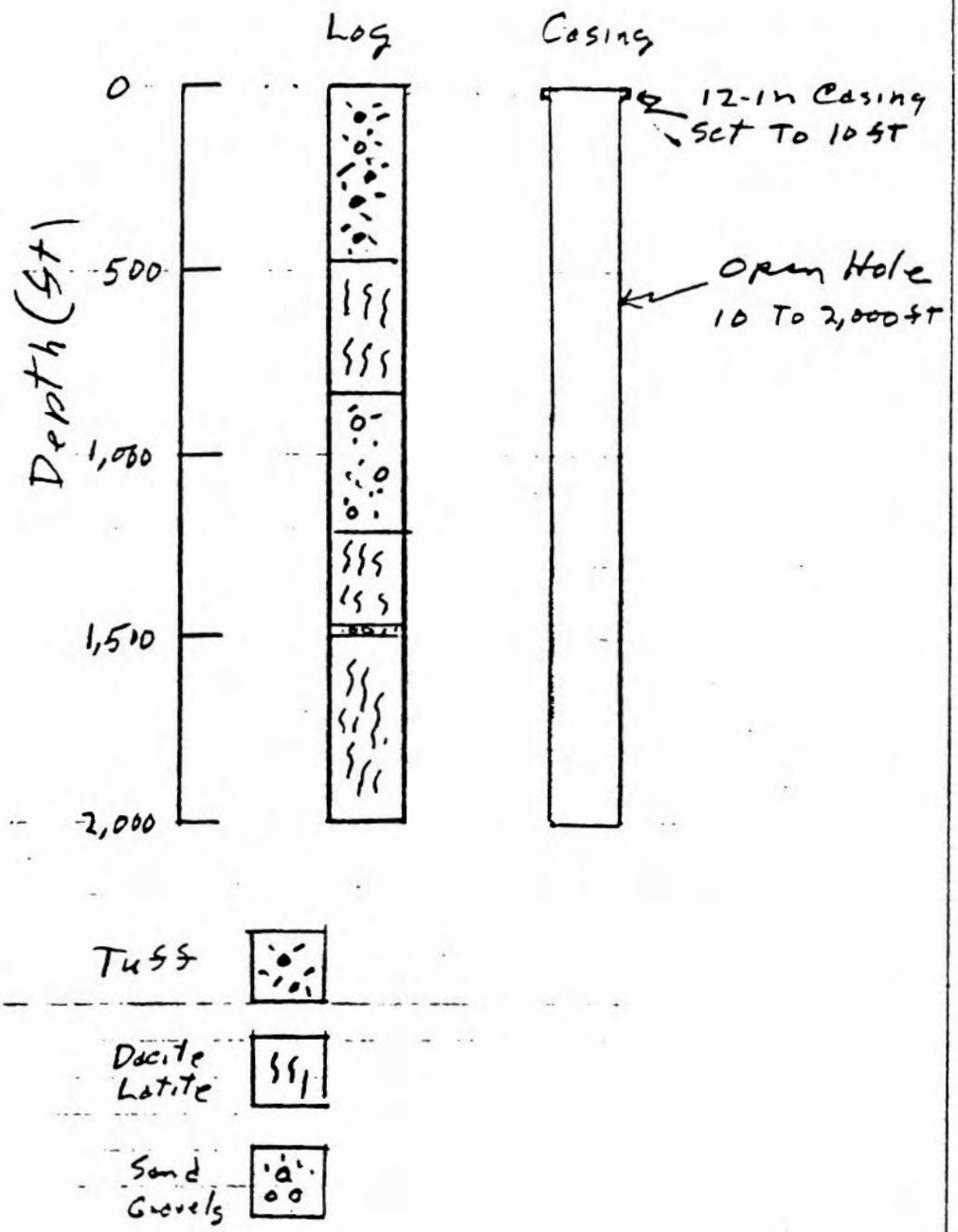


Figure 16.-Lithologic Log and Casing Schedule of Test Hole H-19

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

of H-19. The TA-3 shops, laboratories, and administrative buildings to the south drain into Sandia and Mortandad Canyons.

The open hole, though bridged in places, is a direct path from the surface water in the stream into the main aquifer. The well should be plugged or measures should be taken to prevent surface water from entering the hole. An appropriate plugging methodology is outlined in Appendix C.

2. Test Hole H-19 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Alluvium: Silts, sands, gravels, and boulders	0	27
Bandelier Tuff		
Tshirege Member: Rhyolite tuff, nonwelded to densely welded	27	200
Otowi Member: Massive ash flows of rhyolite tuff, nonwelded to moderately welded	200	415
Guaje Member: Air fall pumice	415	472
Tschicoma Formation		
Dacite flows some interflow breccias	472	819
Puye Conglomerate		
Fanglomerate member: Sand, gravels, and boulders	819	1210
Tschicoma Formation		
Dacite flows, some interflow breccias	1210	1480
Puye Conglomerate		
Totavi Lentil: Sand, gravel, boulders	1480	1490
Tschicoma Formation		
Dacite flows some interflow breccias	1490	2000

(Griggs 1955)

3. Test Hole H-19 Casing Schedule

The lithologic log and casing schedule for H-19 are given on **Figure 16.**

A 12-inch casing was set to 10 ft. No other casing was set.

B. TEST HOLE H-16

Test hole H-16 is located in the saddle on the of Sierra de los Valles (Location N 1,790,900, E 457,700, Elevation 9,505 ft). Access to the test hole is on the Quemazon Trail off the Ski Hill road to Camp May **(Figure 17**). The location was probably accessed by unimproved road from the Valles de los Posos when drilled.

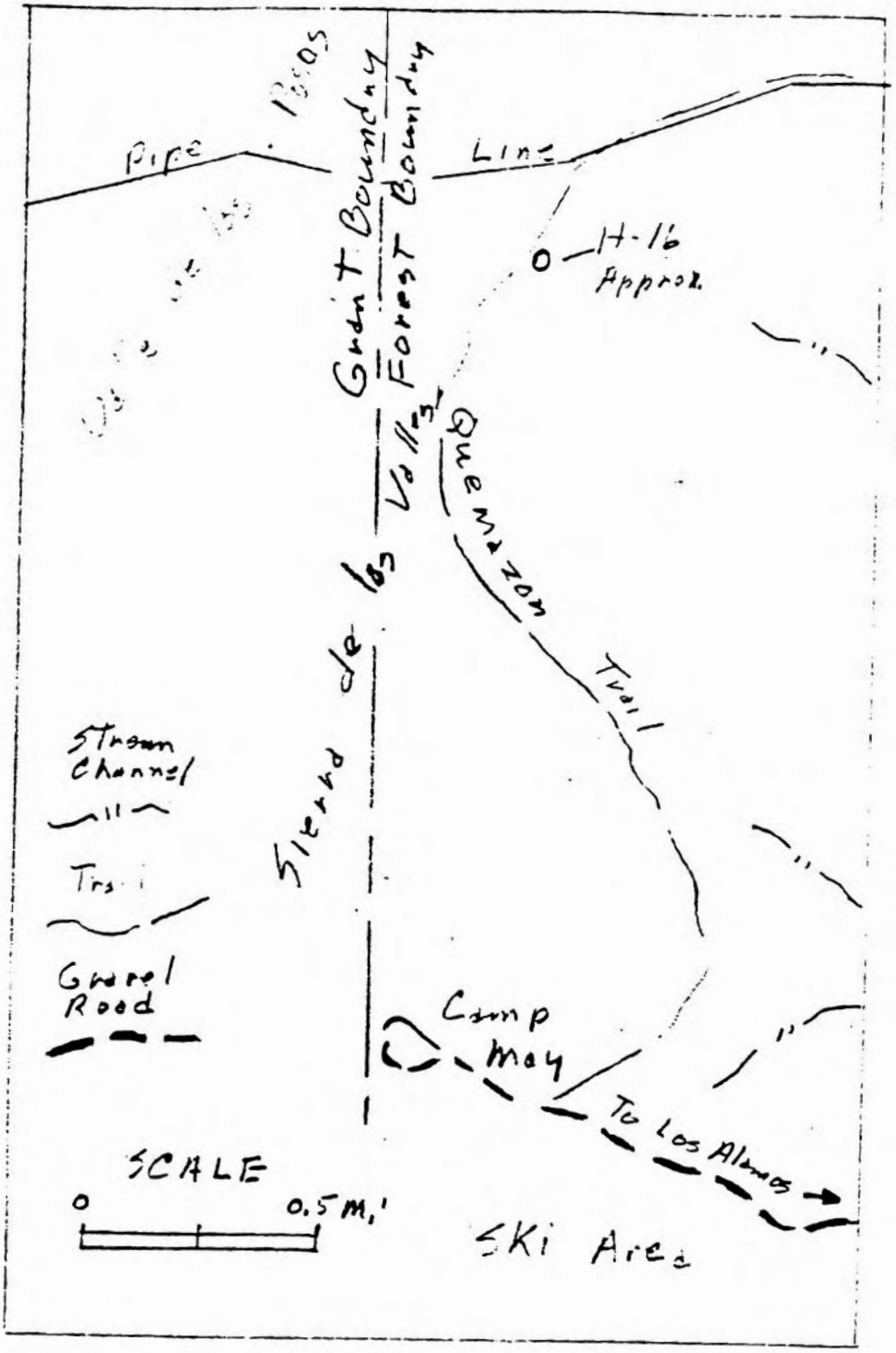


Figure 17.- Map showing access to Test Hole 16.

DRAFT

1. History and Hydrology

Test hole H-16 was drilled to investigate the geology, hydrology, and engineering aspects of the Valles water supply project (Black and Veatch, 1946, 1948, and 1950). The project was abandoned when pumping of wells in the Valle Grande and Valle Toledo decreased the stream flow and impacted the water rights of the down stream-users.

Test Hole H-16 was drilled using a cable tool to a depth of 1,269 ft (Figure 18). No casing was left in the hole. No water was encountered (Griggs, 1955).

Because the casing was removed from the hole, it is doubtful that the hole can be located. A search was conducted in the spring of 1971 by members of the Hot Dry Rock Project. They wanted to use the hole to perform heat flow measurements but were unable to locate it. Frost heaving of the soil and rocks adjacent to the hole has probably bridged the upper part of the hole.

Test Hole H-16 has not been used since it was drilled. If it could be located, some attempt should be made to plug the entire hole or at least the upper 50 ft with a cement-bentonite slurry to seal out surface water. An appropriate plugging methodology is given in Appendix C.

2. Test Hole H-16 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Bandelier Tuff		
Tshirege Member: Welded rhyolite tuff	0	295
Undifferentiated Unit (mainly the Otowi Member)	295	627
Tschicoma Formation		
Latites	627	890
Quartz latites	890	1269

(Griggs 1955)

3. Test Hole H-16 Casing Schedule

No casing was installed in the borehole. The lithologic log of H-16 is shown on **Figure 18**.

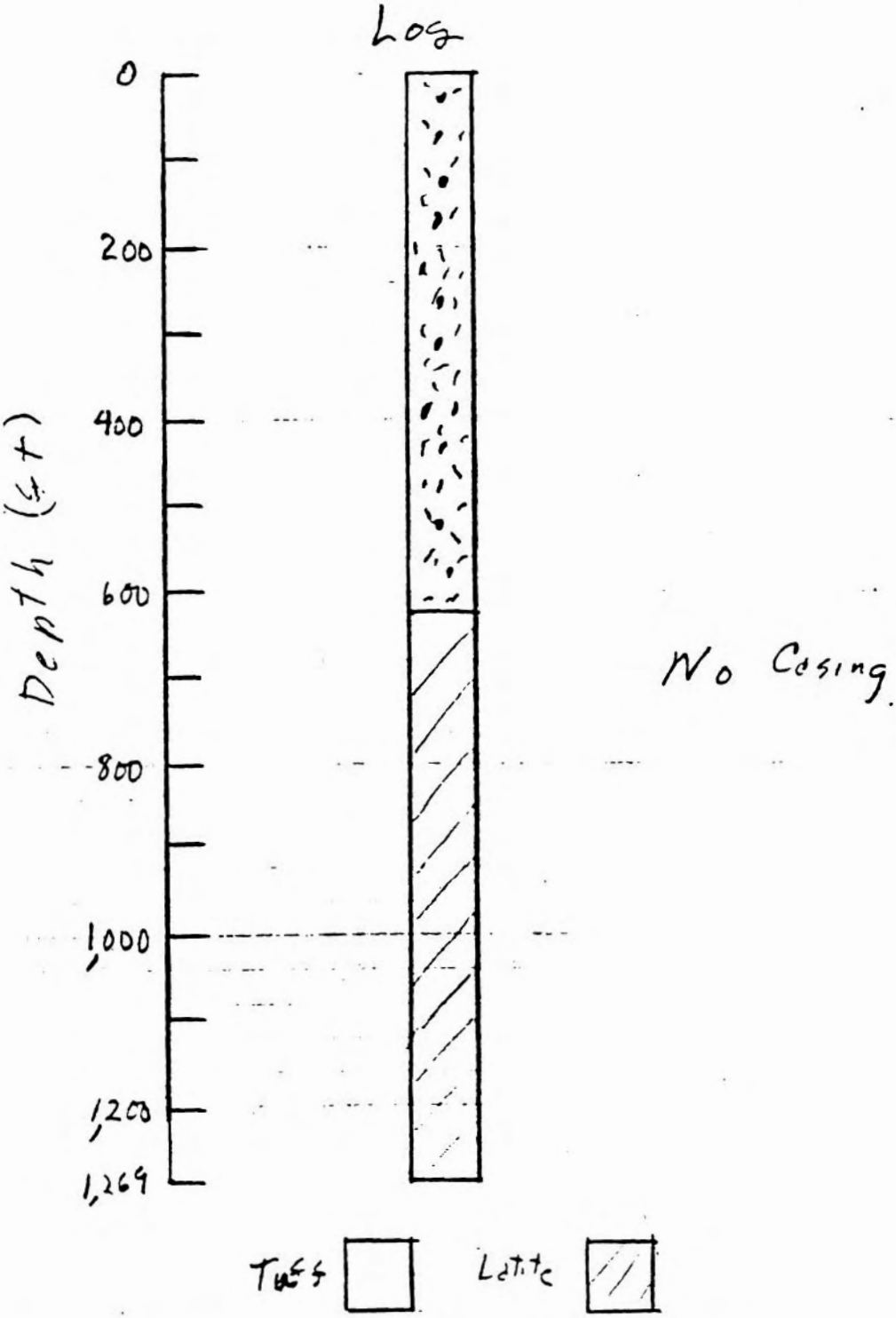


Figure 18 Geologic Log of Test Hole H-16.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

DRAFT

IV. TEST HOLES IN PAJARITO AND ANCHO CANYONS (1950)

A. HISTORY AND HYDROLOGY

Three test holes were drilled in Pajarito Canyon (TH-5 and TH-6) and in Ancho Canyon (TH-7). These three test holes were drilled for geologic and hydrologic information. The U.S. Geological Survey supervised the drilling and collected geologic and hydrologic data (Griggs 1955).

B. TEST HOLE TH-5

Test hole TH-5 was drilled in March 1950 with a cable tool rig to a depth 263 ft (Location **N 1,756,515, E 503,312,** Elevation 6,592 ft). Test hole TH-5 is located south of Pajarito Road between TA-18 and White Rock **(Figure 19)**. Water encountered in the alluvium was cased out of the hole with 24-inch diameter casing set to a depth of 24 ft. The 24-inch casing was left in hole **(Figure 20)**. Beneath the alluvium, the hole penetrated tuff and basalts that were dry (Griggs 1955).

This hole has not been used in the past 46 years and should be plugged to prevent water from entering the tuff and basalt. The hole is located south of TA-54, a storage and disposal area for radioactive and chemical wastes. An appropriate plugging method for this hole is given in Appendix C.

1. Test Hole TH-5 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Alluvium: Silt, Sand, gravels, and boulders	0	23
Bandelier Tuff		
Tshirege Member: Rhyolite tuff	23	40
Otowi Member: Massive ash flow tuff	40	160
Guaje Member	160	171
Basaltic Rocks of Chino Mesa		
Unit 2	171	263

2. Test Hole TH-5 Casing Schedule

The lithologic log and casing schedule of TH-5 are from Griggs (1955) and are shown on **Figure 20.**

24-in diameter casing set to 24 ft.

Open hole from 24 ft to 263 ft.

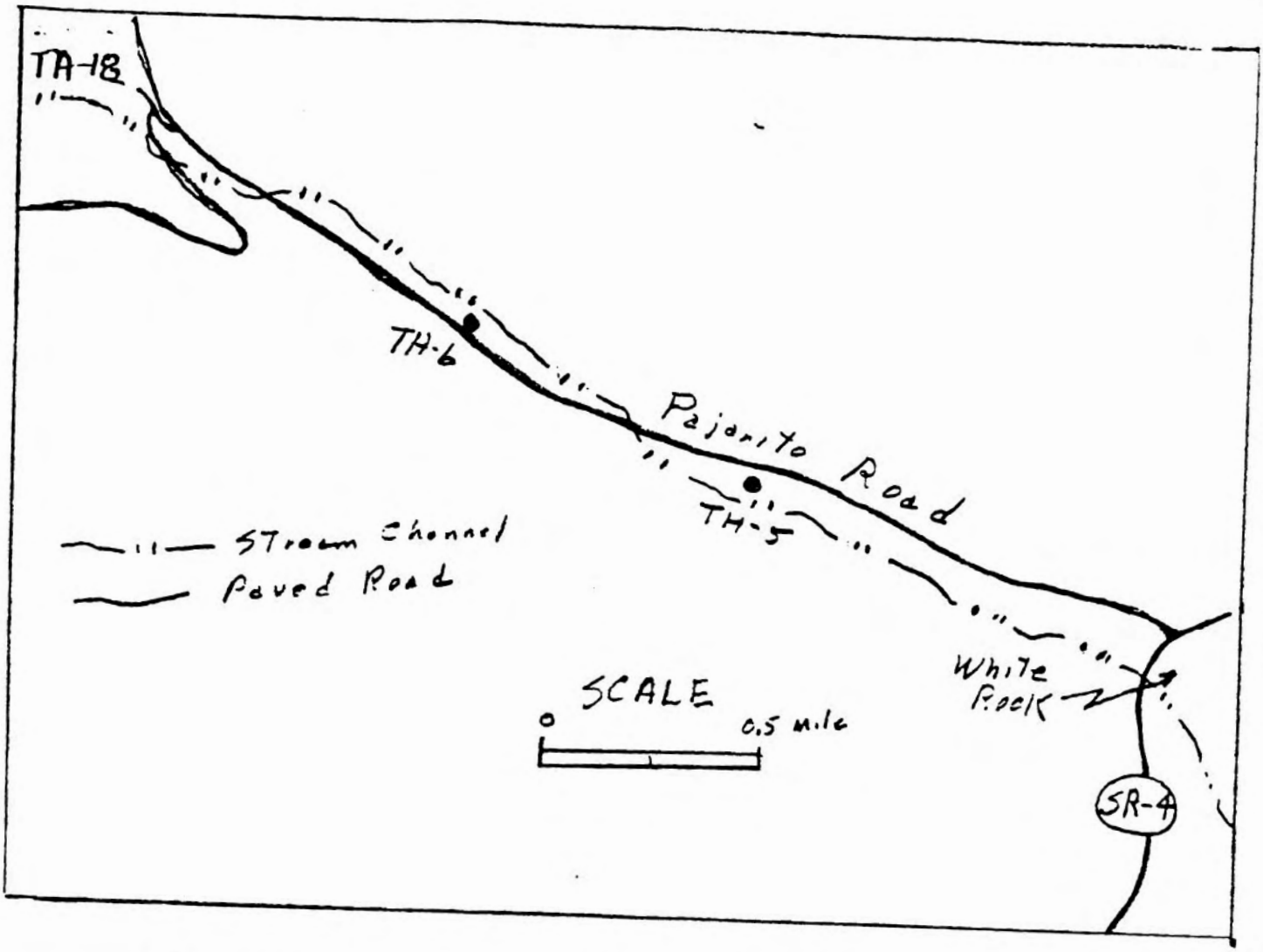


Figure 19.-Map Showing Test Hole TH-5 and TH-6 along Pajarito Road.

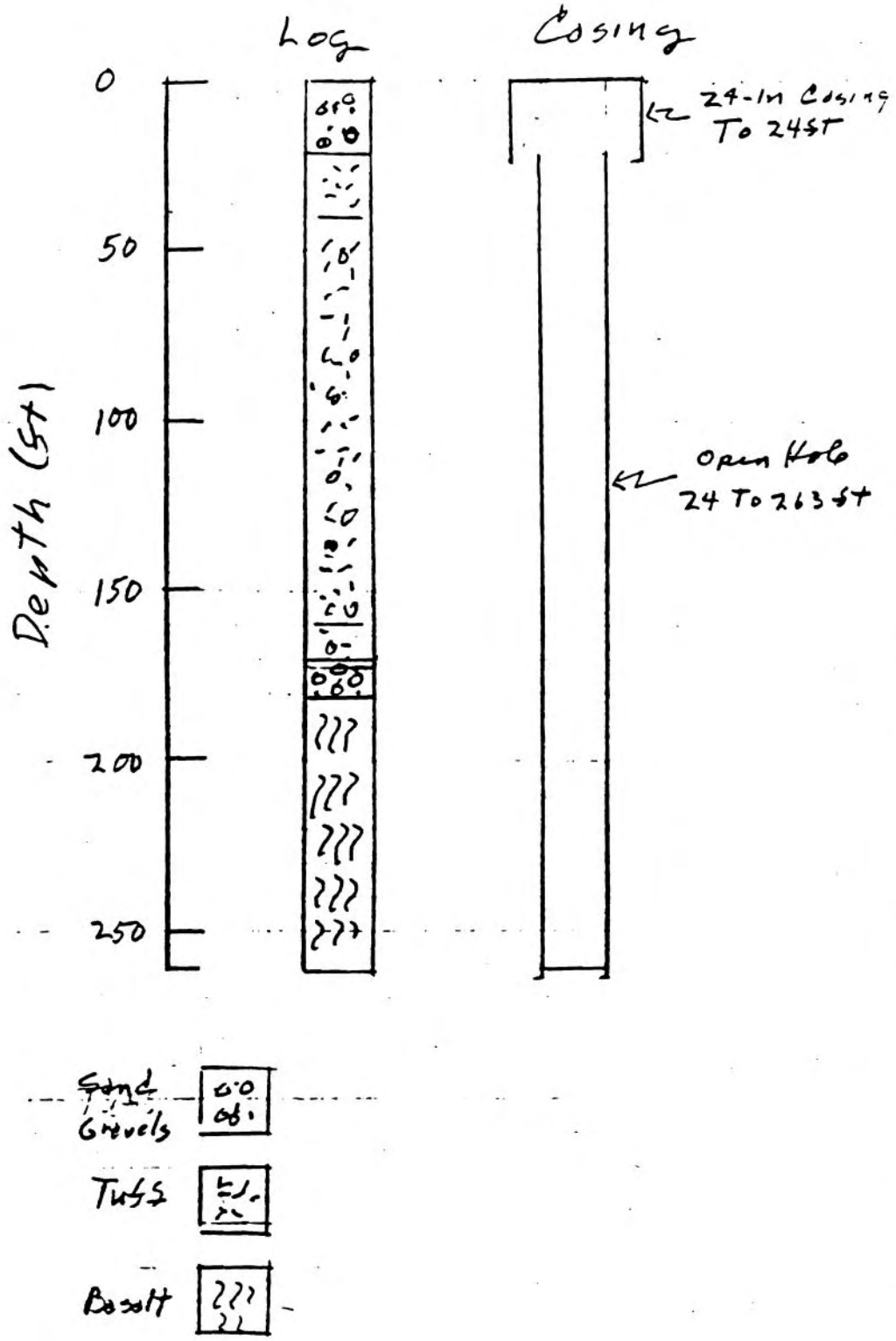


Figure 20.- Lithologic Log and Casing Schedule of Test Hole TH-5.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

C. TEST HOLE TH-6

Test Hole TH-6 was drilled in March 1950 with a cable tool to a depth of 300 ft (Location 1,757,818, E 500,272, Elevation 6,642 ft). The test hole is located north of Pajarito Road between TA-18 and White Rock (Figure 19). Water encountered in the alluvium was cased out of the hole with 6-inch diameter casing set to a depth of 120 ft (Figure 21). Beneath the alluvium, the hole penetrated tuff and sediments that were dry (Griggs 1955).

This hole has not been used in the past 46 years and should be plugged to prevent water from entering the tuff and sediments. The hole is located south of TA-54, a storage and disposal area for radioactive and chemical wastes. An appropriate plugging method for this hole is given in Appendix C.

1. Test Hole TH-6 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Alluvium	0	25
Bandelier Tuff		
Tshirege Member	25	85
Otowi Member	85	265
Guaje Member	265	285
Puye Conglomerate		
fanglomerate member	285	300

2. Test Hole TH-6 Casing Schedule

Lithologic log and casing schedule are shown on **figure 21**.

6-in casing to 120 ft.

Open hole from 120 ft to 300 ft.

D. TEST HOLE TH-7

Test Hole TH-7 was drilled in April 1950 with a cable tool to a depth of 55 ft (Location N 1,740,400, E 600,500, Elevation 6,224). The hole was located on a gravel road off State Road 4 just to the east of TA-33 (**Figure 22**). The hole was dry. No casing was used in the hole. At completion it was plugged and abandoned. No further action is needed. (Griggs 1955)

1. Test Hole TH-7 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Alluvium	0	10
Bandelier Tuff		
Otowi Member	10	45
Basaltic Rock of Chino Mesa		

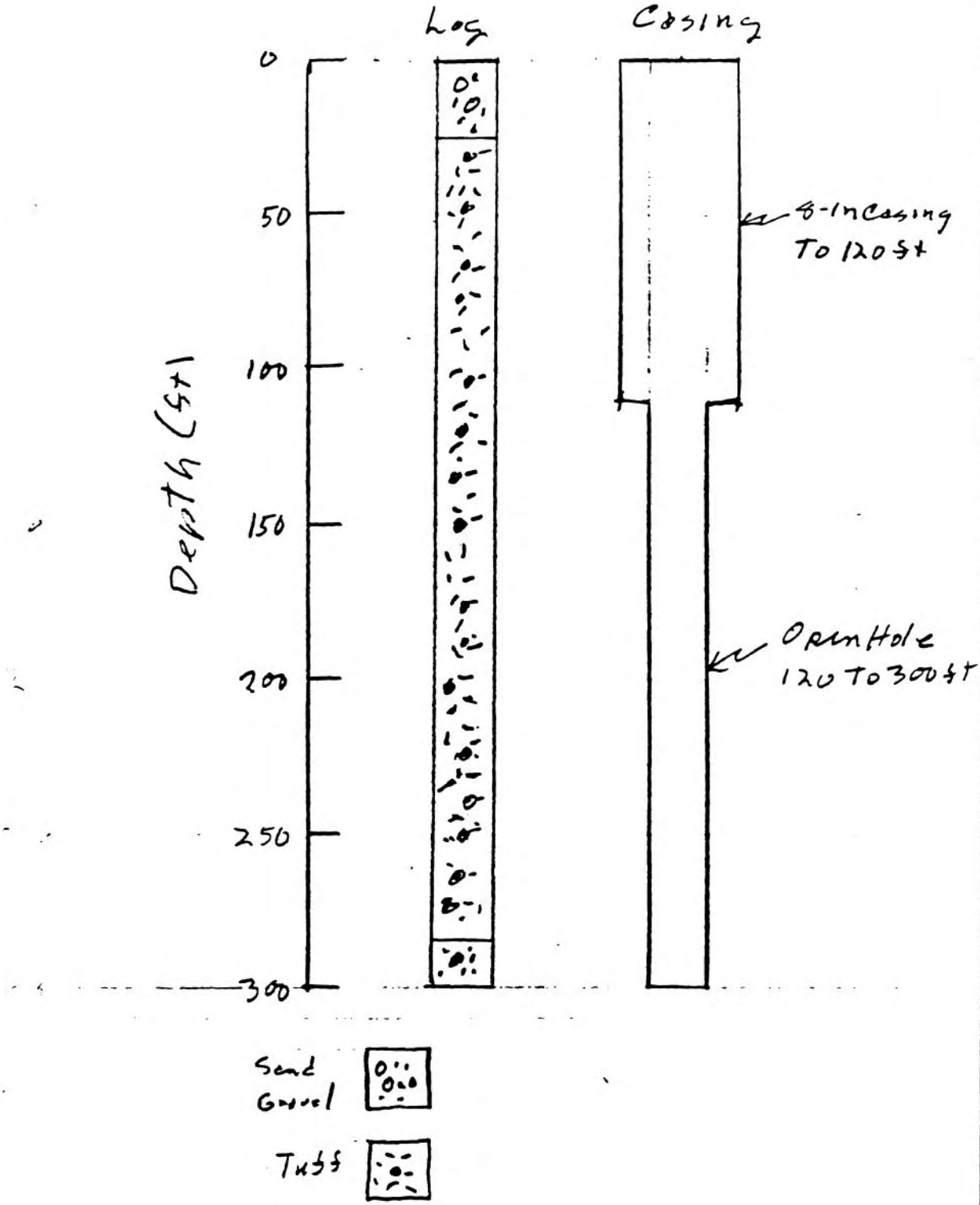


Figure 21.- Lithologic Log and Casing Schedule of Test Hole TH-6

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

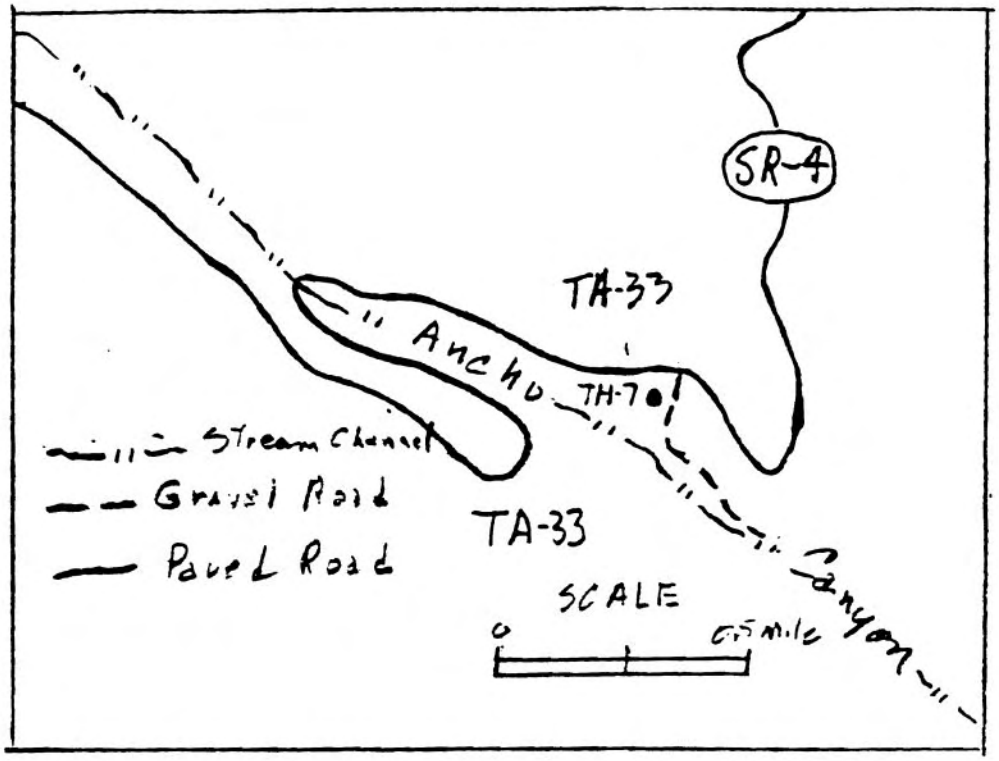


Figure 22.- Map Showing Access To Test Hole TH-7.

Unit 2	45	55

2. Test Hole TH-7 Casing Schedule

No casing was used in the hole. The lithologic log is given in **Figure 23**.

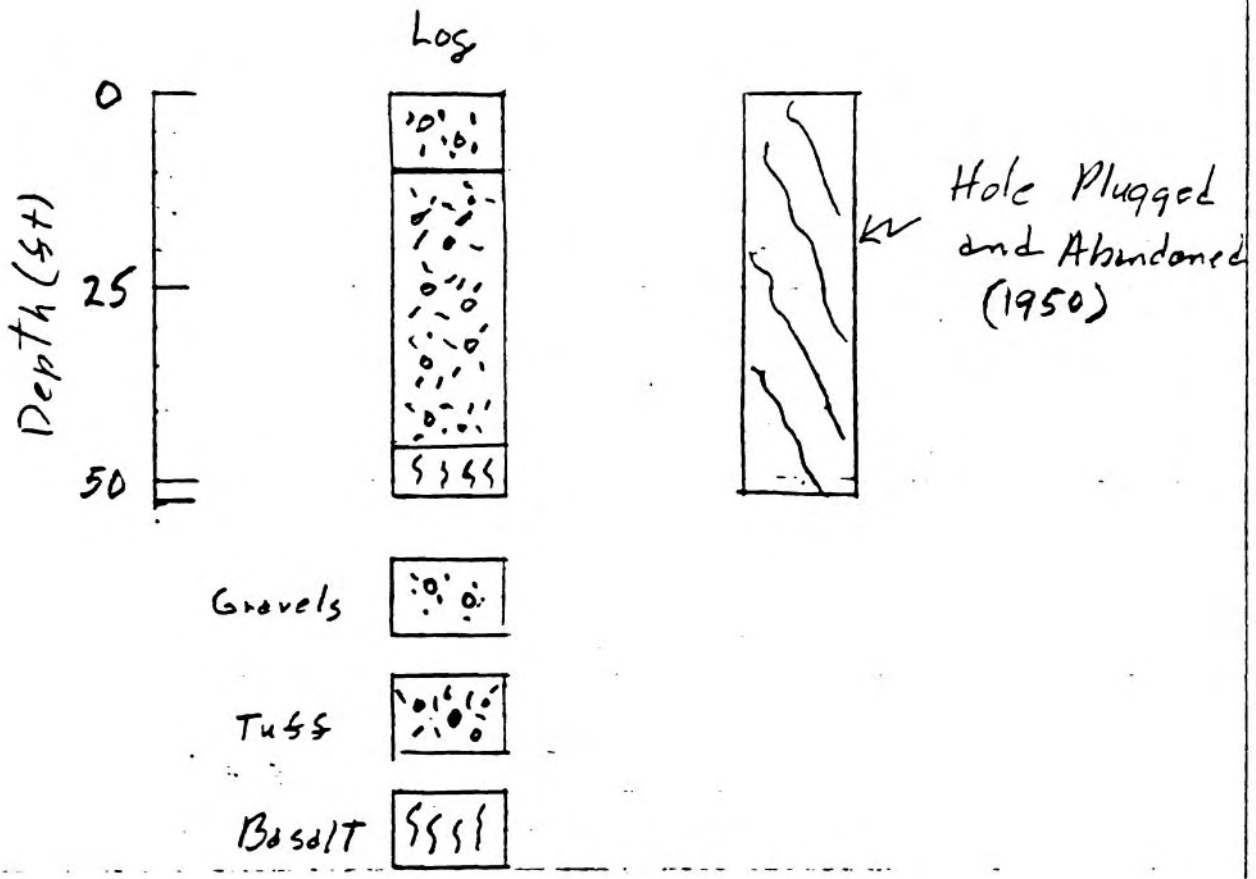


Figure 23 - Lithologic Log of Test Hole TH-7.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

DRAFT

V. TEST HOLES AND TEST WELLS AT TA-49 (1959 AND 1960)

Technical Area 49 (TA-49) was designated as a test area in 1959. The tests were to be conducted in shafts ranging from 50 to 120 ft in depth (Purtymun and Stoker 1987). Nothing was known of the geology or hydrology of the area at that time and as a result the U.S. Geological Survey was ask to perform a detail study of the geology and hydrology of the area.

A. HISTORY AND HYDROLOGY

During 1959 and 1960 five deep test holes were drilled for geologic and hydrologic information at TA-49 **(Figure 24)**. The five test holes encountered no water above the main aquifer. Two of the deep holes (DT-5P and DT-5) were abandoned above the main aquifer due to lost circulation during drilling while the other three (DT-5A, DT-9, and DT-10) were completed as wells in the main aquifer for monitoring water level and water quality beneath the test area. The three wells penetrated different thicknesses of the aquifer.

The top of the main aquifer ranged in depth from 1,173 ft near the center of the area to 1,003 ft at the eastern edge when the wells were completed in 1960 (Weir and Purtymun 1962). By 1993 the water levels had declined an average of 12 ft. The decline may be part of a natural regional decline or due to the pumping of supply wells on the plateau. The decline started prior to the pumping of the nearest supply well on the plateau, about 3 miles northeast of the test area.

The tritium age of the water from the three test wells (DT-5A, -9, and -10) gave a wide range of results from about 55 years (piston flow) to greater than 4,500 years (well mixed) while the carbon-14 age of the water ranged from 1,640 to 4,560 years (Stoker 1994).

The movement of water in the main aquifer as estimated from aquifer tests in the upper 490 ft (Basaltic Rocks of Chino Mesa, Puye Conglomerate, and Chaquehui Formation) is about 345 ft/year to the east-south east (Purtymun 1984).

The U.S. Geological Survey supervised the drilling and collected geologic and hydrologic data related to the drilling, completion, and testing of the aquifer (**Weir and Purtymun, 1964**).

B. TEST HOLE DT-5P

The first test hole, DT-5P, was drilled in the fall of 1959 using air as a cutting carrier [Location (Los Alamos Scientific Laboratory Coordinates]LASLC S 111+32, E 94+36), Elevation 7,144 ft). It was drilled to a depth of 692 ft penetrating the Tshirege Member and the top of the Otowi Member. No perched water was encountered above the depth of 692 ft **(Figure 25)**. The hole was plugged and abandoned.

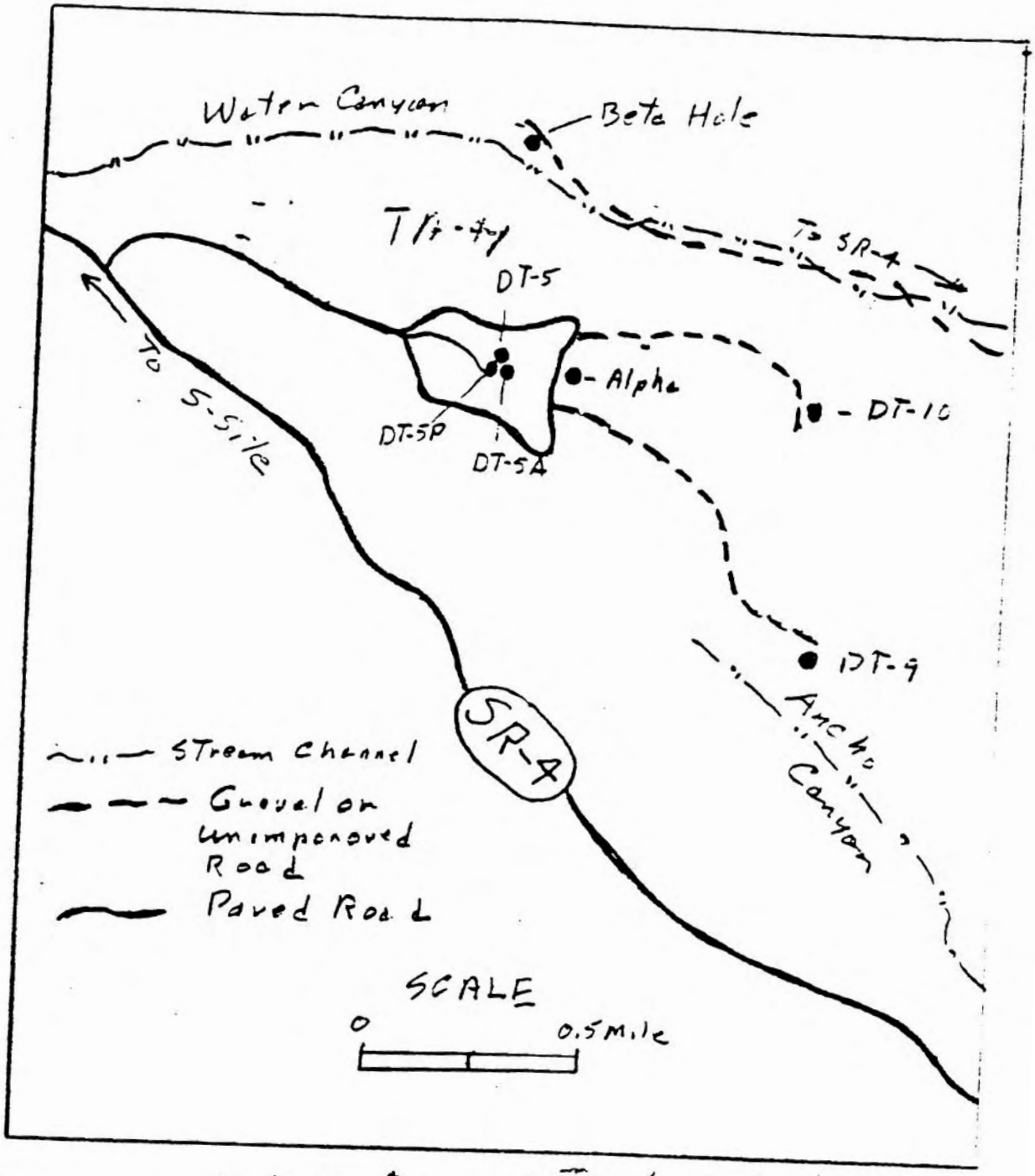


Figure 24.- Location of Test Holes and Test Well at TA-49.

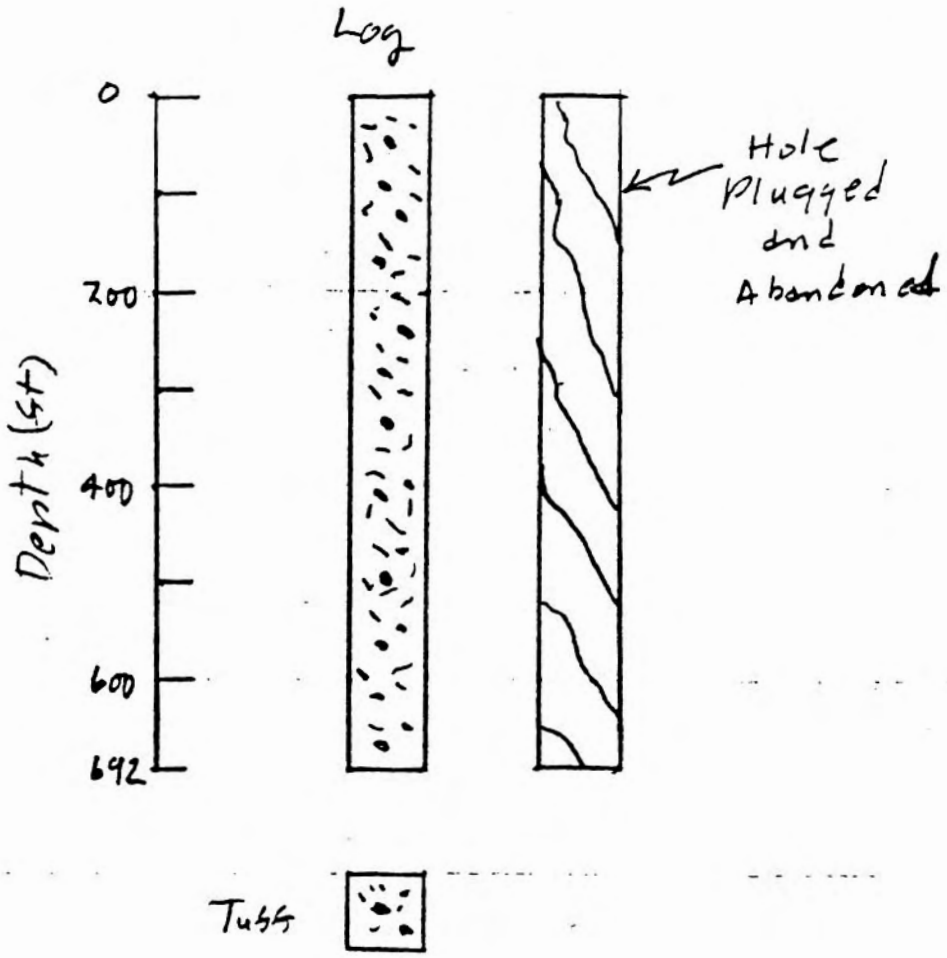


Figure 25.—Lithologic Log of Plugged and Abandon Test Hole DT-5P

DT-5P

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

DRAFT

1. Test Hole DT-5P Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Bandelier Tuff		
Tshirege Member: Unit 6	0	73
Unit 5	73	75
Unit 4	75	119
Unit 3	119	182
Unit 2	182	282
Unit 1B	282	485
Unit 1A	485	641
Ctowi Member	641	692

(Weir and Purtymun 1964)

2. Test Hole DT-5P Casing Schedule

The lithologic log for test hole DT-5P is given in **Figure 25**. No casing was installed in the borehole.

C. TEST HOLE DT-5

Test hole DT-5 was drilled in the fall of 1959 (Location LASLC S 110+99, E 93+03, Elevation 7,133 ft). The hole was drilled with a rotary rig using mud as a cutting carrier. During drilling, a loss of circulation was experienced and attempts were made to restore circulation by introducing a variety of materials into the hole such as cotton seed hulls, coal, cellulose, walnut hulls, and drilling muds. An 8-inch diameter surface string was set to a depth of 180 ft **(Figure 26)**. Circulation problems were recurrent during drilling until finally it was abandoned. An attempt to pull the string of casing failed.

The hole penetrated the entire thickness of the Bandelier Tuff and was terminated into the upper section of the Puye Conglomerate. The hole was logged in December 1959 at a depth of 962 ft and was dry. The drilling fluids had drained out of the hole. The bottom of the hole was about 200 ft above the top of the main aquifer (**Weir and Purtymun 1964**). Air exchange through the casing occurs with changes in atmospheric pressure.

The hole has not been used in 35 years and should be plugged and abandoned to prevent migration of fluids down the hole and possible creation of an artificial intermediate perched ground water zone or contamination of the main aquifer. An appropriate plugging method is given in Appendix C.

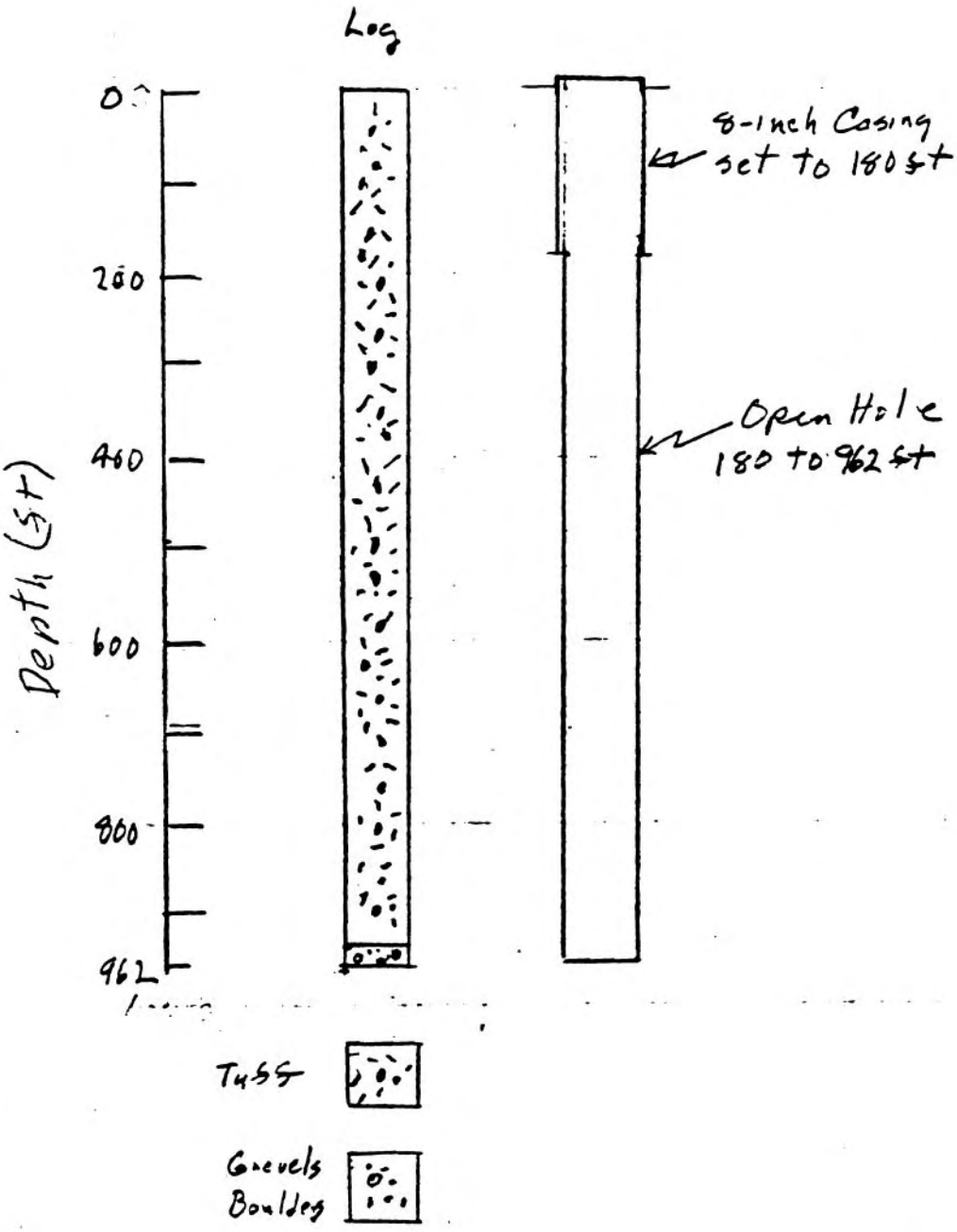


Figure 26 Lithologic log and Casing Schedule of Test Hole DT-5

DRAFT

1. Test Hole DT-5 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Bandelier Tuff		
Tshirege Member: Ash flows of rhyolite tuff, nonwelded to welded	0	641
Otowi Member: Massive ash flow of rhyolite tuff, nonwelded to moderately welded	641	839
Guaje Member: Ash fall of rhyolite pumice	839	940
Puye Conglomerate		
Fanglomerate member: Sands, gravels, cobbles, and boulders	940	962

(**Weir and Purtymun 1964**)

2. Test Hole DT-5 Casing Schedule

The lithologic log and casing schedule are shown on **figure 26**.

An 8-inch diameter surface string was set to a depth of 180 ft.

The hole is open from 180 ft to 962 ft.

D. TEST WELL DT-5A

The drilling of test well DT-5A began in December 1959 and was completed in March 1960 (Location N **1,754,727, E 485,066**, Elevation 7,144 ft). The hole was drilled with a mud rotary rig. Lost circulation was a problem in drilling the hole due to the large thickness of unsaturated tuff and volcanic sediments (about 1,150 ft). A surface string of 12-inch diameter casing was set to a depth of 525 ft (Figure 27). The surface casing was cemented in by pressure grouting through the drill stem set in a packer at the bottom of the casing. The cement was forced upward between the casing and bore hole wall. Though there was continued lost circulation, the surface string solved part of the problem as drilling continued through the surface string. The well was completed at a depth of 1,821 ft in the Chaquehui Formation. The main aquifer was penetrated at a depth of about 1,172 ft.

By 1993 the water level had declined to 1,183 ft. Air exchange through the casing occurs with changes in atmospheric pressure. The casing is slotted above the water table and is exposed to the bore hole wall.

The jack pump from TW-4 was installed in the well in 1972. It was replaced in 1992 with a submersible pump.

Water chemistry at DT-5A is a calcium-sodium-bicarbonate type with a total dissolved solids concentration of about 100 mg/L. There has been no significant change in the quality of water from the well. The well

construction is sound and the well should be retained as part of the monitoring network.

1. Test Well DT-5A Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Bandelier Tuff		
Tshirege Member: Ash flows of rhyolite tuff, nonwelded to welded	0	641
Otowi Member: Massive ash flow of rhyolite tuff, nonwelded to moderately welded	641	839
Guaje Member: Air fall of lump pumice	839	930
Puye Conglomerate		
Fanglomerate member: Silts, sands, gravels, cobbles and boulders	930	1167
Basaltic Rocks of Chino Mesa		
Unit 2 Basalt flows and interflow breccias	1167	1293
Puye Conglomerate		
Fanglomerate member Sands, gravels, cobbles, and boulders	1293	1431
Basaltic Rocks of Chino Mesa		
Unit 2 Basalt flow	1431	1457
Puye Conglomerate		
Fanglomerate member Sands, gavels, cobbles and boulders	1457	1525
Totavi Lentil Sand, gravels, and boulders	**1524**	1527
Santa Fe Group		
Chaquehui Formation Sands, gravels and boulders	**1526**	1821

(**Weir and Purtymun 1964;** Purtymun 1995)

2. Test Well DT-5A Casing Schedule

The lithologic log and casing schedule of DT-5A are shown on **figure 27.**

A 12-inch diameter casing was set to a depth of 520 ft and pressure grouted to seal the annulus.

An 8-inch diameter casing was set from the land surface through the 12-inch casing to a depth of 1,820 ft with 220 ft of torch cut slots below a depth of 1,172 ft as given below.

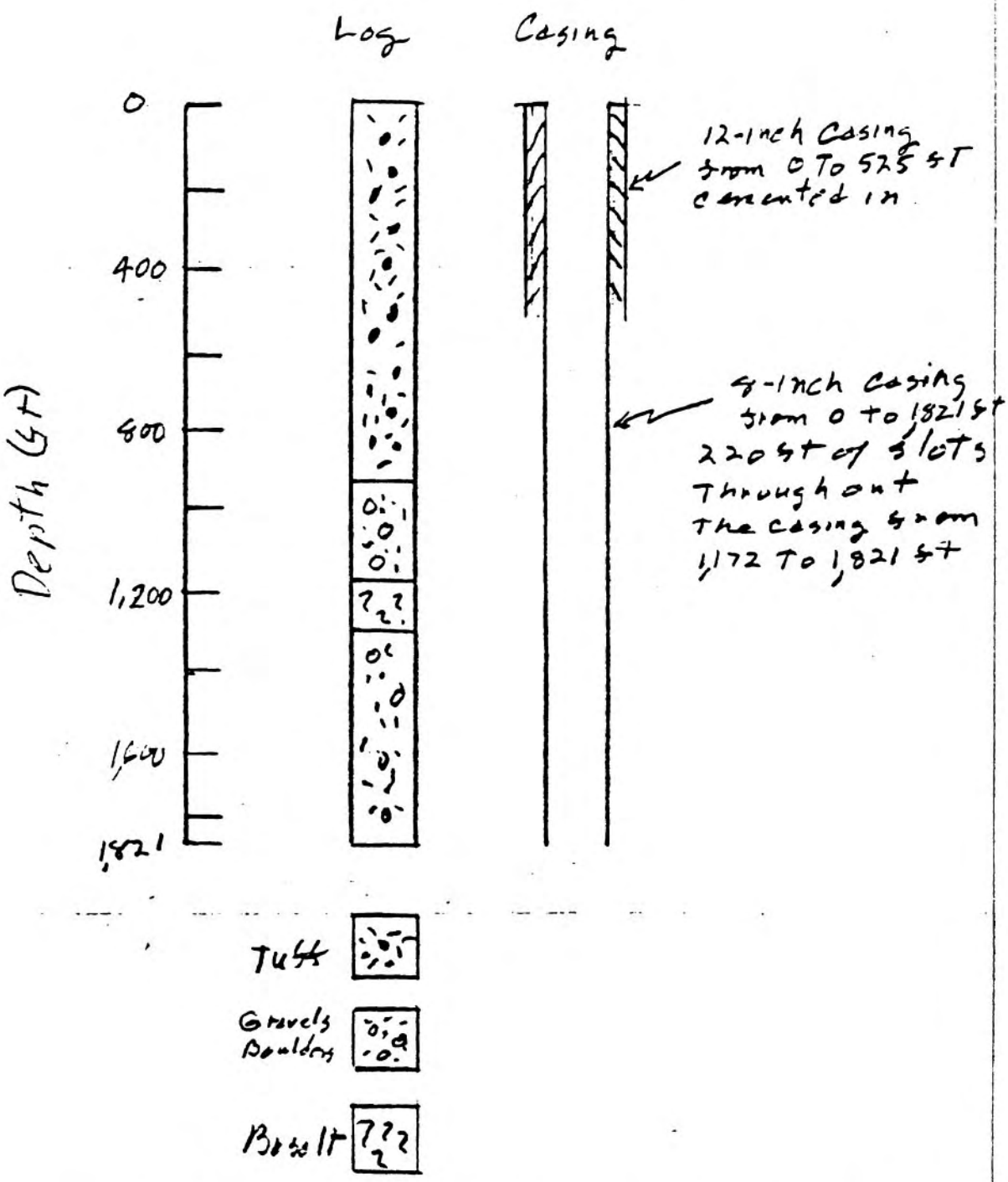


Figure 27.-Lithologic Log and Casing Schedule of Test Well DT-5A

8-inch diameter casing	Depth from (ft)	Depth to (ft
Blank	0	1172
Slotted	1172	1192
Blank	1192	1280
Slotted	1280	1290
Blank	1290	1336
Slotted	1336	1381
Blank	1381	1415
Slotted	1415	1445
Blank	1445	1535
Slotted	1535	1555
Blank	1555	1591
Slotted	1591	1615
Blank	1615	1635
Slotted	1635	1655
Blank	1655	1708
Slotted	1708	1728
Blank	1728	1740
Slotted	1740	1750
Blank	1750	1768
Slotted	1768	1788
Blank	1788	1821

(**Weir and Purtymun 1964**)

E. TEST WELL DT-9

Test Well DT-9 was drilled with a cable tool rig (Location **N 1,751,431, E 488,750,** Elevation 6,935 ft). Drilling began in January 1960 and was completed in February. The well was completed at a depth of 1,509 ft and penetrated rocks of the Bandelier Tuff, Puye Conglomerate, Basaltic Rocks of Chino Mesa and sediments of the Santa Fe Group. The first 1,335 ft of the borehole was logged using geophysical methods. Data from the well was used to determine the geology and hydrology of the area. A string of casing was set at 1,335 ft to prevent borehole collapse. Drilling continued through the casing to the total depth of 1,501 ft. An 8-inch liner was set to the bottom through the initial string of casing **(Figure 28)**.

The top of the main aquifer was encountered at a depth of 1,003 ft. By 1993, the water level had declined to 1,016 ft. Air exchange occurs through the casing with changes in atmospheric pressures due to a portion of the slotted casing being set in the unsaturated zone. The well was used in the 1964 energy and air exchange study conducted at TA-49 (Purtymun and others 1974).

Pump Info,
Water chemistry

Test Well DT-9 has been used to monitor the main aquifer since it was completed in 1960. It should be retained as part of the monitoring well network.

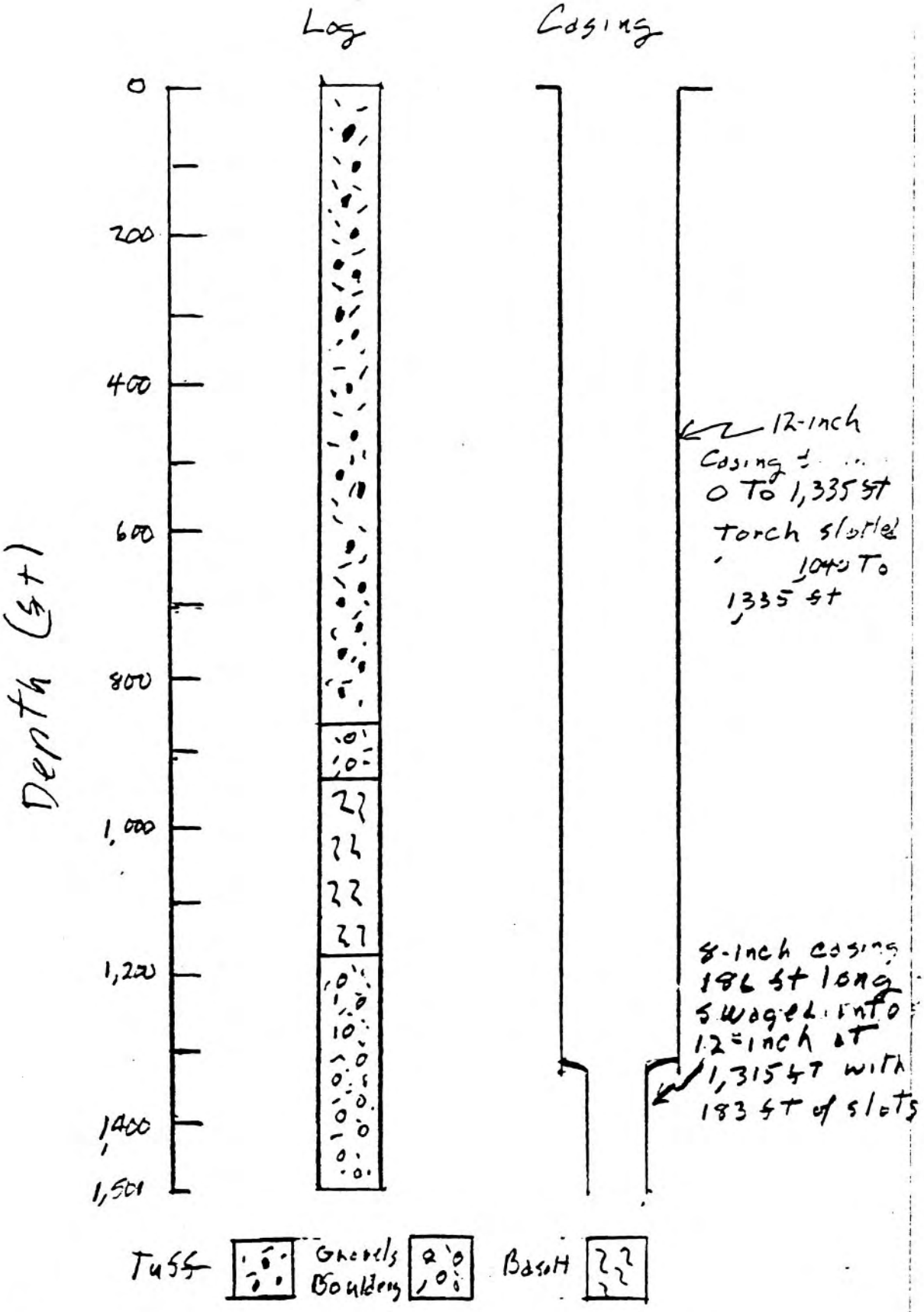


Figure 28.- Lithologic log and casing schedule of Test Well DT-9

DT-9

DRAFT

1. Test Well DT-9 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Bandelier Tuff		
Tshirege Member: Rhyolite ash flows of nonwelded to welded tuff	0	676
Otowi Member: Massive ash flow of nonwelded to moderately welded tuff	676	802
Guaje Member: Lump pumice	802	850
Puye Conglomerate		
fanglomerate member: Sands, gravels, cobbles, and boulders	850	924
Basaltic Rocks of Chino Mesa		
Unit 2: Basalt flows and interflow breccias	924	1162
Puye Conglomerate		
fanglomerate member: Sand, gravels, cobbles, and boulders	1162	1319
Totavi Lentil: River sands, gravels, and boulders	1319	1357
Santa Fe Group		
Chaquehui Member	1357	1501

(**Weir and Purtymun 1964**; Purtymun 1995)

2. Test Well DT-9 Casing Schedule

The lithologic log and casing schedule are shown on **figure 28**.

A 12-inch diameter steel casing to a depth of 1,335 ft. The casing was slotted (torch-cut) below a depth of 819 ft as given below.

12-inch I.D. Steel Casing	Depth from (ft)	Depth to (ft)
Blank	0	819
Slotted	819	878
Blank	878	903
Slotted	903	934
Blank	934	958
Slotted	958	983
Blank	983	1002
Slotted	1002	1036
Blank	1036	1057
Slotted	1057	1093
Blank	1093	1142
Slotted	1142	1208
Blank	1208	1266

Slotted	1266	1310
Blank	1310	1333

An 8-inch diameter steel casing was set from 1,335 ft to 1,501 ft. The top of the 8-inch diameter casing was swaged to the 12-inch casing and run as a liner to a total depth of 1,500 ft. The top of the bell is at a depth of about 1,313 ft in the 12-inch diameter casing (telescopes about 19.9 ft into the 12-inch diameter). The upper 4 ft of the bell and liner is blank while the lower 183 ft of the liner is slotted (**Weir and Purtymun 1964**).

F. TEST WELL DT-10

Test well DT-10 was drilled using a cable tool (Location **N 1,754, 387, E 488,744,** Elevation 7,020 ft). Drilling began in February 1960 and the test hole was completed in March. The well was completed to a depth of 1,408 ft and penetrated the same sequence of rocks as DT-9 (**Figure 29**). The well was completed in sands, gravels, and boulders of the Chaquehui Formation.

The top of the main aquifer was encountered at a depth of 1,091 in 1960 and had decline to 1,097 ft by 1993. Air exchange occurs through the casing in response to changing atmospheric pressure changes. The casing is slotted above the water table and the bore hole wall is exposed through the casing.

The well was equipped with a jack pump in 1976. It was replaced with a submersible pump in 1992.

The water from the well is a calcium-sodium-bicarbonate type with a total dissolved solids concentration of about 100 mg/L. There has been no significant change in the quality of water since the well was completed. The well construction is sound and the well should be retained as part of the monitoring network.

1. Test Well DT-10 Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Bandelier Tuff		
Tshirege Member: Rhyolite ash flows of nonwelded welded tuff	0	672
Otowi Member: Rhyolite tuff, nonwelded to moderately welded, massive ash flow	672	829
Guaje Member: Rhyolite pumice, air fall	829	846
Puye Conglomerate		
fanglomerate member: Silt, sand, gravels, cobbles, and boulders	846	972
Basaltic Rocks of Chino Mesa		
Unit 2: basalt flows and interflow breccias	972	1291

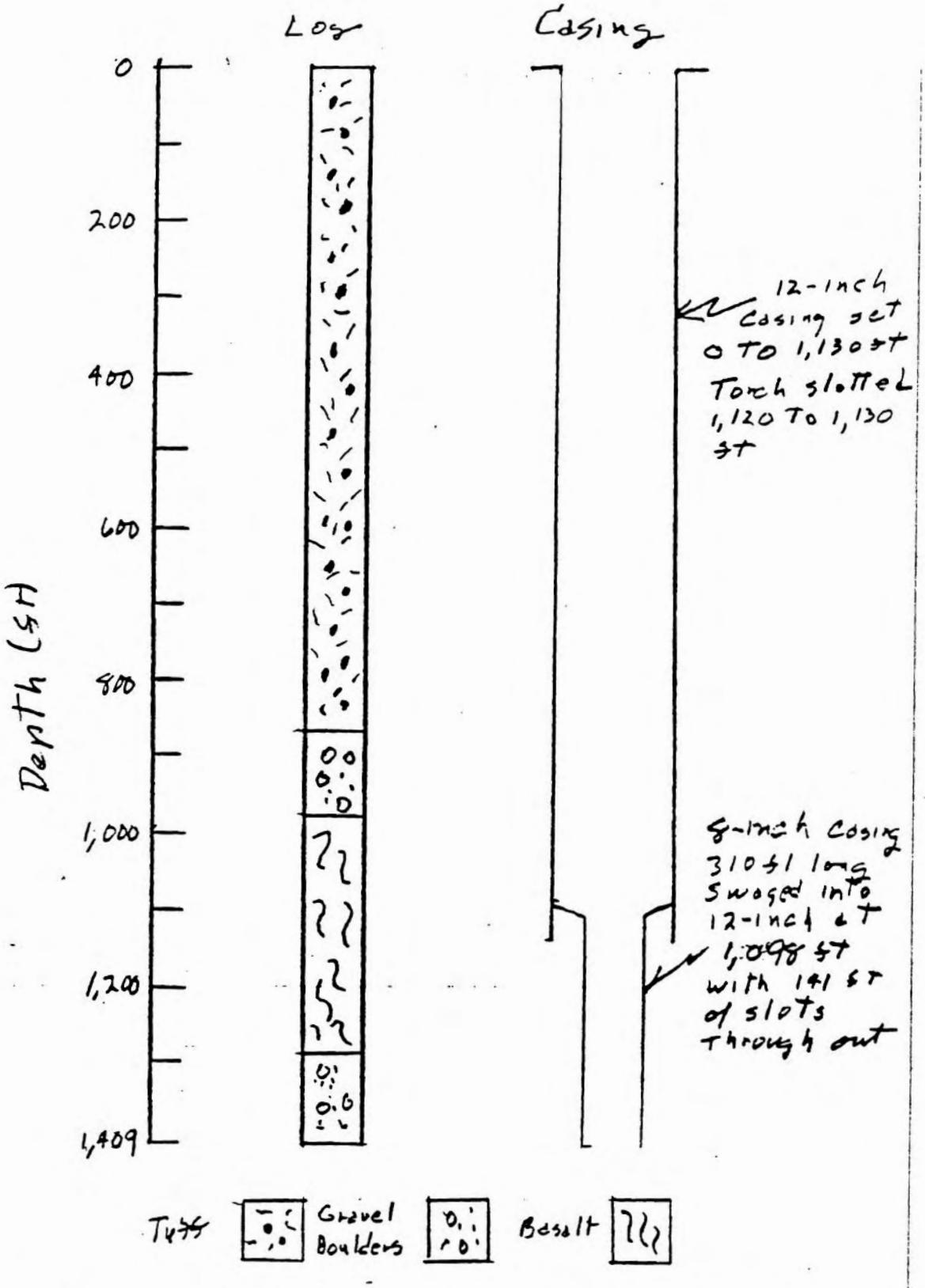


Figure 29.- Lithologic Log and Casing schedule of Test Well DT-10

Puye Conglomerate		
fanglomerate member: Silts, sand, gravels, cobbles, and boulders	1291	1356
Totavi Lentil River sands, gravels, and boulders	1356	1402
Santa Fe Group		
Chaquehui Formation: Sands, gravels, and boulders	1402	1409

(Weir and Purtymun 1964; Purtymun 1995)

2. Test Well DT-10 Casing Schedule

The lithologic log and casing schedule of test well DT-10 are shown on **figure 29**.

A 12-inch diameter casing was set to a depth of 1,125 ft with the bottom 48 ft slotted as given below.

12-inch I.D. Steel Casing	Depth from (ft)	Depth to (ft)
Blank	0	1078
Slotted	1078	1126

An 8-inch diameter steel casing was run to the bottom of the hole. The top of the 8-inch diameter casing was swaged out to 11-inch O.D. and run as a liner in the 12-inch diameter casing. The top of the swaged casing sits at a depth of 1,096 ft in the 12-inch casing. The 311 ft 8-inch liner was torch-slotted at various intervals as follows.

8-inch diameter liner	Depth from (ft)	Depth to (ft)
Blank and swage	1096	1097
Slotted	1097	1118
Blank	1118	1196
Slotted	1196	1206
Blank	1206	1228
Slotted	1228	1258
Blank	1258	1268
Slotted	1268	1278
Blank	1278	1302
Slotted	1302	1322
Blank	1322	1332
Slotted	1332	1342
Blank	1342	1362
Slotted	1362	1408

(Weir and Purtymun 1964)

G. LARGE DIAMETER AUGER HOLES

Two auger holes 24-inch in diameter and up to 189 ft deep were drilled on Frijoles Mesa at TA-49 (Alpha Hole) and in Water Canyon to the north (Beta Hole). The holes were drilled for geologic and hydrologic information (Figure 24). Both holes were dry; however, they respond to

changing atmospheric pressure by exhausting air during atmospheric lows and taking in air during atmospheric highs.

Both holes were cased to a depth of about 7 ft with corrugated metal pipe which extends above land surface. Frost heave has broken up the cement pad holding the casing in Beta Hole.

1. Alpha Hole

Alpha hole was drilled on Frijoles Mesa using a 2-ft diameter bucket auger to a depth of 189 in the spring of 1960 (Location LASLC S 111+16, E 97+54, Elevation 7,125 ft). Geologic and hydrologic data was collected and later the hole was used in a study of air exchange in relation to atmospheric pressure changes (Purtymun and others 1974). The hole penetrated four ash flow units of the tuff **(Figure 30)** but never encountered any subsurface water.

The hole has not been used for a number of years. If the tuff around the pad should give way, all would collapse into the hole. Thus, the hole presents a safety hazard. The hole should be plugged just as all other large diameter holes in the area have been plugged. An appropriate plugging method is given in Appendix C.

a. Alpha Hole Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Bandelier Tuff		
Tshirege Member: Unit 6 Moderately welded tuff	0	76
Unit 5 Sand and gravel	76	78
Unit 4 Moderately welded tuff	78	128
Unit 3 Nonwelded to Moderately welded tuff	128	189

Note: hole was dry
(Weir and Purtymun 1964)

b. Alpha Hole Casing Schedule

Lithologic log and casing schedule are shown on **Figure 30**.

A 7-ft section of corregated metal pipe was set as a surface casing. The hole is open from about 7 ft to 189 ft.

2. Beta Hole

Beta Hole was drilled in the bottom of Water Canyon using 2 ft diameter bucket auger to a depth of 180 ft in February 1960 (Location LASLC S 83+63, E 91+89, Elevation 6,801 ft). The hole was located to the north of TA-49. Access to the hole is a gravel road that connects with State Road 4 about 3 miles to the west in Water Canyon. The hole was drilled for geologic and hydrologic information (**Figure 30**). The hole was dry.

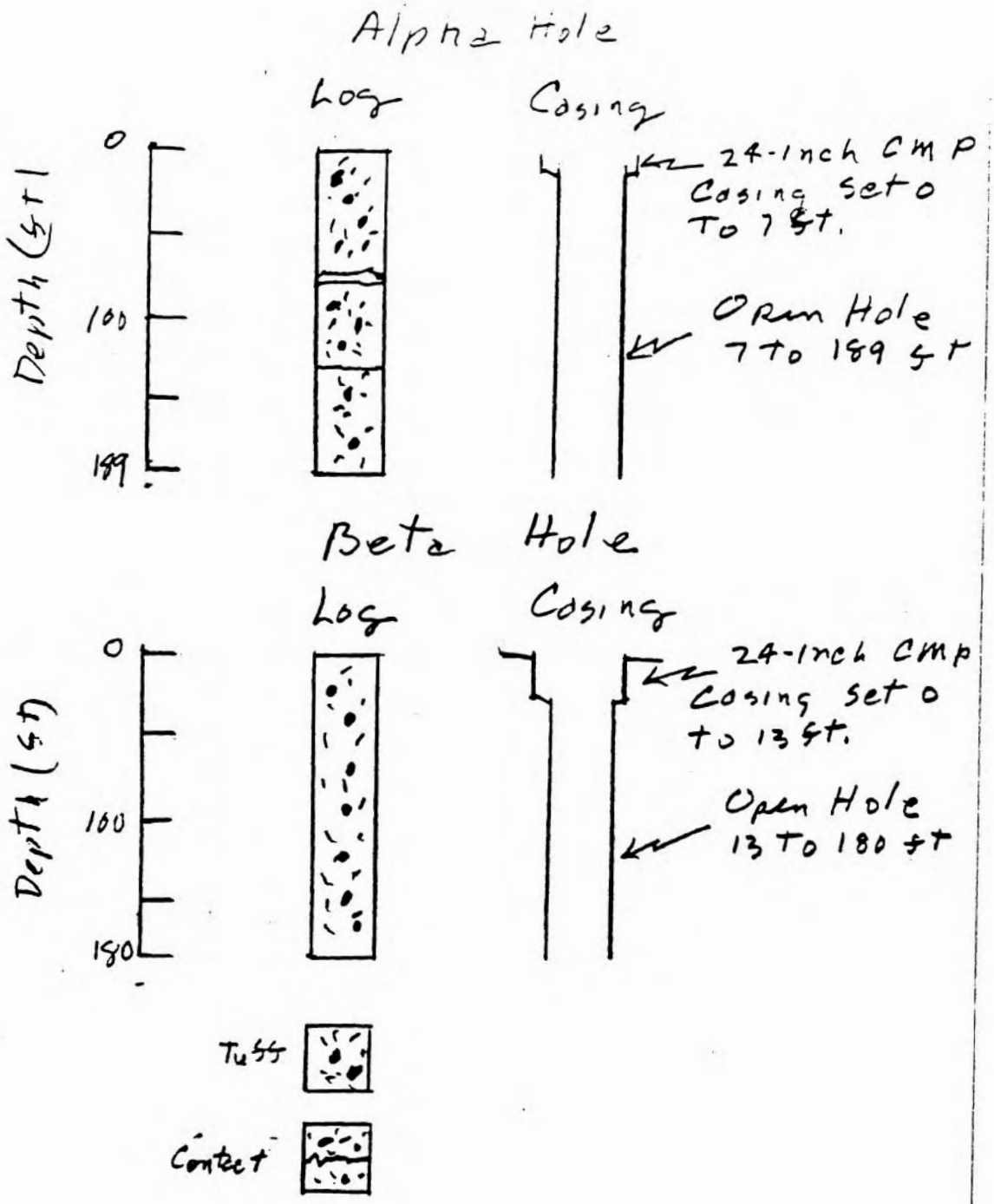


Figure 30: Lithologic Logs and Casing Schedules of Alpha and Beta Holes.

The hole has not been used for a number of years. The cement pad has been broken up by frost heave. If the alluvium around the top of the hole should collapse, the broken pad and casing would fall into the hole. The hole presents a safety hazard and should be plugged. An appropriate plugging method is given in Appendix C.

a. Beta Hole Geologic Log

Lithologic Description	Depth from (ft)	Depth to (ft)
Alluvium: Gravels, cobbles, and boulders	0	8
Bandelier Tuff		
Tshirege Member: Unit 1B nonwelded to moderately welded tuff	8	180

Note: Unit 1B contains numerous large pumice fragments up to 6 inches in length. Most of these fragments were weathered to clay indicating movement of water from the canyon stream into the tuff (**Weir and Purtymun 1964**). Movement of water in the tuff adjacent to the hole is as unsaturated flow as no free water has occurred in the hole in the past 36 years. (**Weir and Purtymun 1964**)

b. Beta Hole Casing Schedule

Lithologic log and casing schedule are shown on **Figure 30**.

A 7-ft section of corregated metal pipe was set as a surface casing. The hole is open from about 7 ft to 180 ft.

DRAFT

VI. TEST HOLE EGH-LA-1 (SIGMA MESA TEST HOLE)

Test Hole EGH-LA-1 is located on Sigma Mesa near the center of the Pajarito Plateau. The purpose of this well was to investigate the geothermal potential of the plateau (Location N 1,771,800, E 484,100, Elevation 7,215 ft). Access to the hole is off Diamond Drive to Eniwetok Drive through TA-60 on a paved road that turns to gravel (**Figure 31**).

A. HISTORY AND HYDROLOGY

Drilling started on July 2, 1979 with intentions to drill to a depth of 6,000 ft. Drilling ended in December at a depth of 2,292 ft when the hole was partially plugged and abandoned due to lost circulation problems and the loss of tools down the hole (**Figure 32**).

Cement and other materials designed to restore circulation were placed in the hole. At 2,292 ft, the drill stem parted leaving an unknown number of drill stems and the bit in the hole. Fishing operations and an attempt to side-track the lost tools failed.

These operations continued into December 1979 when the project ran out of luck and money. The hole was partially cased to a depth of 1,627 ft, filled with cement up to 1,425 ft, and abandoned. The top of the main aquifer was encountered at a depth of 1,330 ft (Purtymun 1995).

Suggestions to open Test Hole EGH-LA-1 and complete it as a supply well should be discounted. There have been large amounts of circulation material pumped down the hole and the lost drilling equipment is still in the hole. It would be impossible to develop any appreciable yield from the hole.

Test Hole EGH-LA-1 has no apparent use. It has not been used since it was abandoned in 1979. The hole should be plugged and abandoned. It presents no safety or environmental problem so it is not high on the priority list for plugging. An appropriate plugging method is given in Appendix C.

B. TEST HOLE EGH-LA-1 GEOLOGIC LOG

Lithologic Description	Depth from (ft)	Depth to (ft)
Bandelier Tuff		
Tshirege Member: A series of ash flows of rhyolite tuff ranging from moderately to densely welded	0	345
Otowi Member: A massive ash flow of rhyolite tuff ranging from nonwelded to moderately welded	345	695
Guaje Member: A thin ash fall of rhyolite pumice	695	725
Puye Conglomerate		
fanglomerate member	725	910

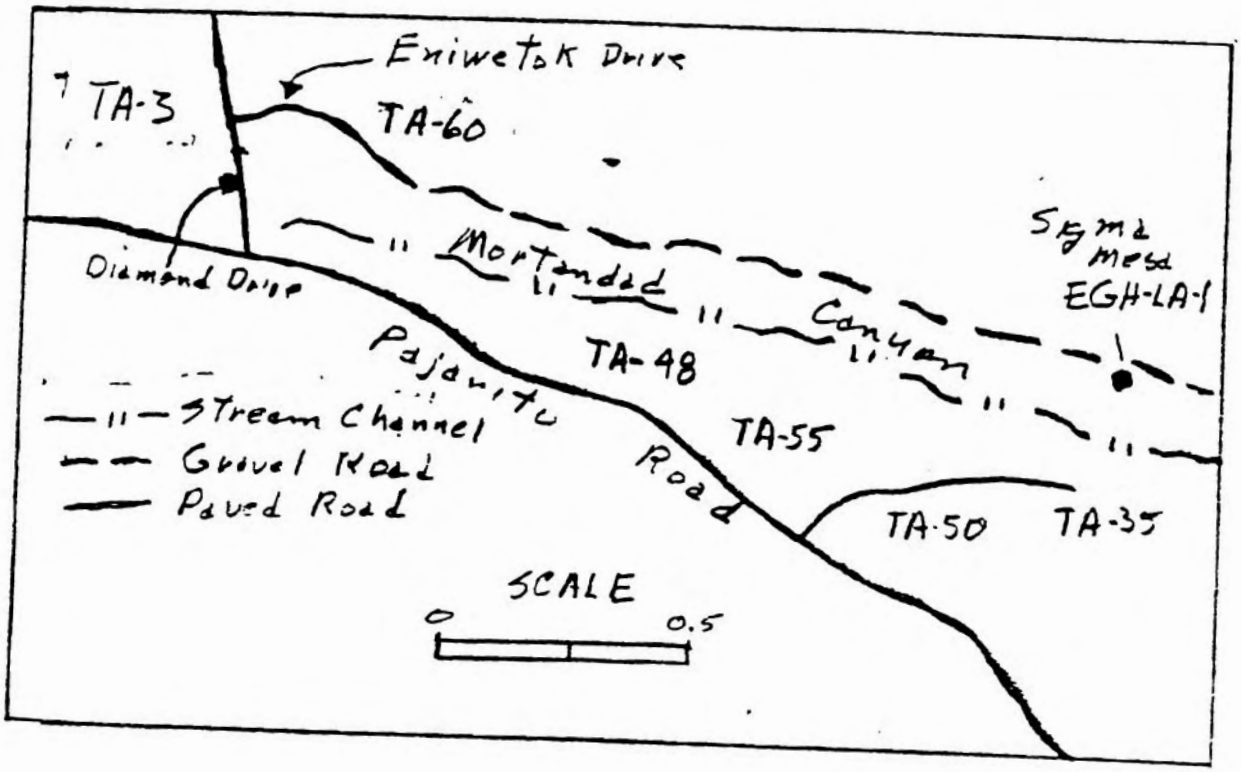


Figure 1. - Map Showing Areas To Sigma Mesa EGH-LA-1.

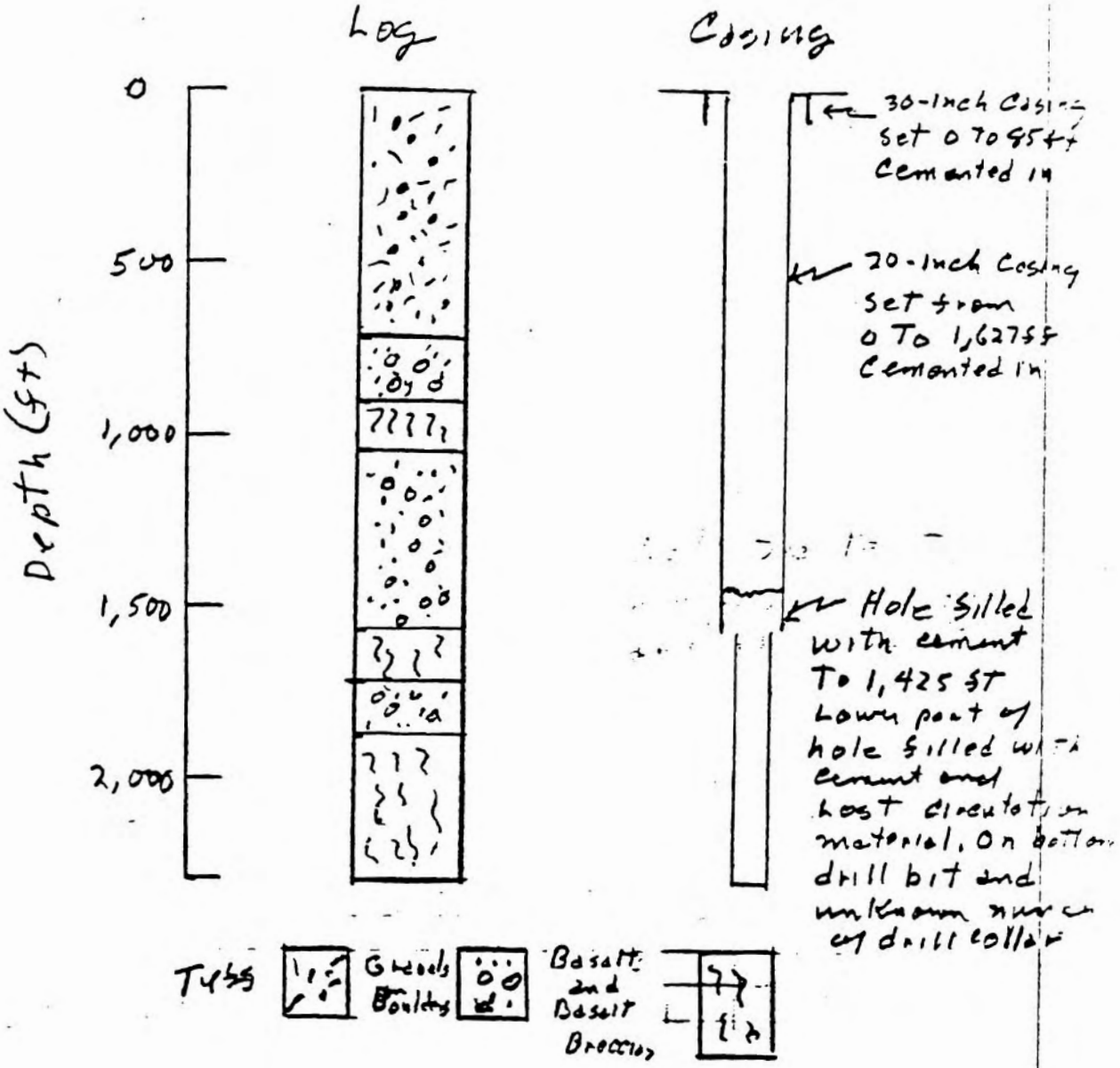


Figure 32.- Lithologic Log and Casing Schedule of Sigma Mesa Test Hole EGH-LA-1

Sands, gravels, cobbles and boulders of rhyolite, dacite, and latite with a few beds of clay and ash		
Basaltic Rocks of Chino Mesa		
Unit 2 flows of gray to dark gray basalt with a few inter flow breccias	910	1050
Puye Conglomerate		
fanglomerate member	1050	1305
Totavi Lentil: Channel deposit of quartzite and granitic material in a arkosic matrix of sand	1305	1330
Santa Fe Group		
Chaquehui Formation Sands, gravels, cobbles, and boulder that are a mixture of rhyolites, latites, dacites, quartzites, granitic debris that contains interbedded basalts and basalt breccias from 1,580 to 1,715 ft and from 1,895 to 2,292 ft	1330	2292

(Purtymun (1995)

C. TEST HOLE EGH-LA-1 CASING SCHEDULE

The lithologic log and casing schedule are shown on **Figure 32**.

A 30-inch diameter casing was set to 85 ft

A 20-inch diameter casing was set to 1,627 ft.

The hole was filled with cement from 2,292 ft up to 1,425 ft.

DRAFT

VII. LAYNE-WESTERN WELL

The Layne-Western well was drilled with a cable tool rig in 1950 to supply water for the drilling of the Guaje Well Field (Location N 1,783,200, E 516,000, Elevation 5,971 ft). The Layne-Western well is located at the lower end of the Guaje Well Field. Access to the well is up Guaje Canyon on a gravel road off State Road 4 (**Figure 33**).

A. HISTORY AND HYDROLOGY

The U.S. Geological Survey monitored the water level in the hole during the 1950s. The water level remained around 100 ft. It apparently yielded water from a perched aquifer in the upper part of Chaquehui Formation above the top of the main aquifer. The well is about 100 ft from supply well G-1 however, pumping of well G-1 does not effect the water level in the Layne-Western well (**Figure 34**). The water level in well G-1 in 1960 was 242.54 ft below the top of the casing (**Field Notes Purtymun 1960**), much lower than the 104.88 foot water level recorded in the Layne-Western well.

The well was equipped with a pump that was removed in 1950 when the last supply well was completed.

The Layne-Western well has not been used since 1950. It should be plugged and abandoned. It presents no safety or environmental problem so it is not high on the priority list for plugging. An appropriate plugging method is given in Appendix C.

B. LAYNE-WESTERN GEOLOGIC LOG

Lithologic Description	Depth from (ft)	Depth to (ft)
Alluvium: Sands, gravels, cobbles, and boulders of rhyolite, latite, and dacite	0	12
Puye Conglomerate		
fanglomerate member: Sand, gravels, cobbles, and boulders	12	25
Totavi Lentil: Gravels, cobbles and boulder of quartzite, rhyolite, and granitic debris in a matrix of arkosic sand	25	75
Santa Fe Group		
Chaquehui Formation: Sands, gravels, cobbles and boulders	75	157

(Purtymun 1995)

C. LAYNE-WESTERN WELL CASING SCHEDULE

The lithologic log and casing records is shown on **figure 34**.

A surface casing 12- or 14-inch in diameter was driven to a depth of 10 to 12 ft.

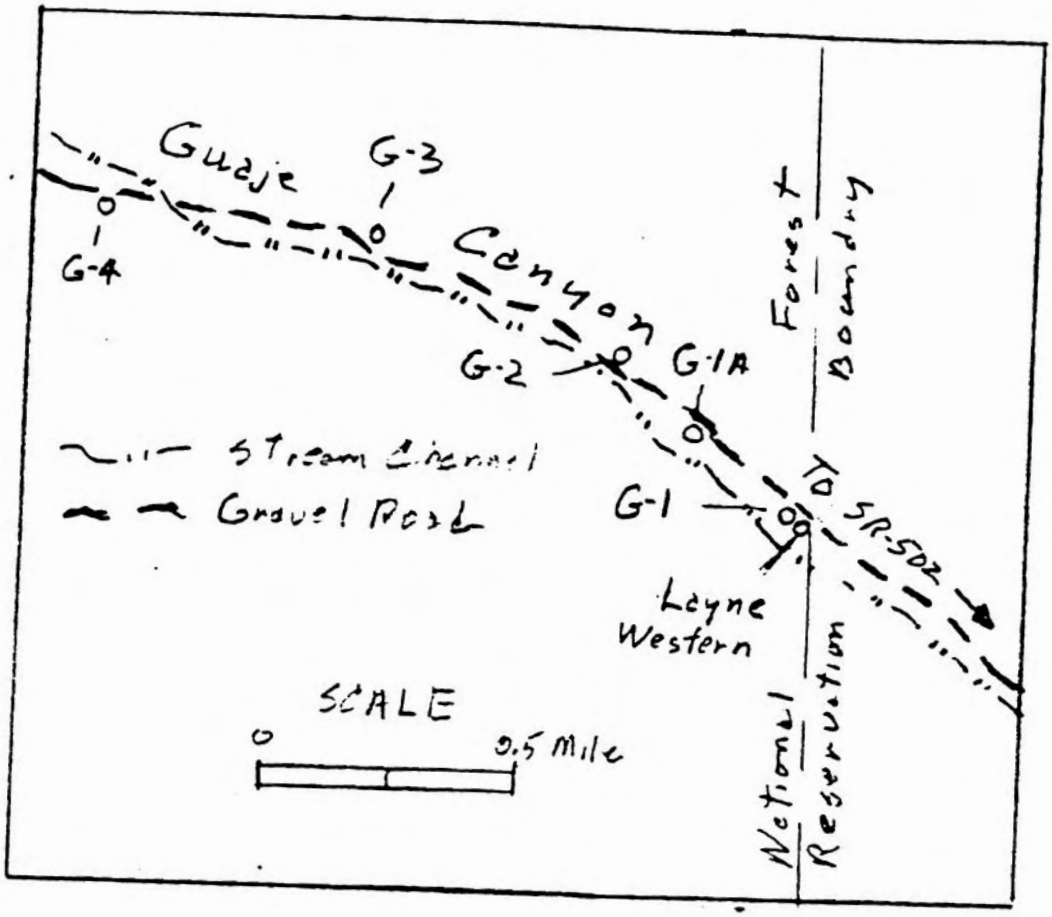


Figure 33 Map Showing Access To Well Layne Western.

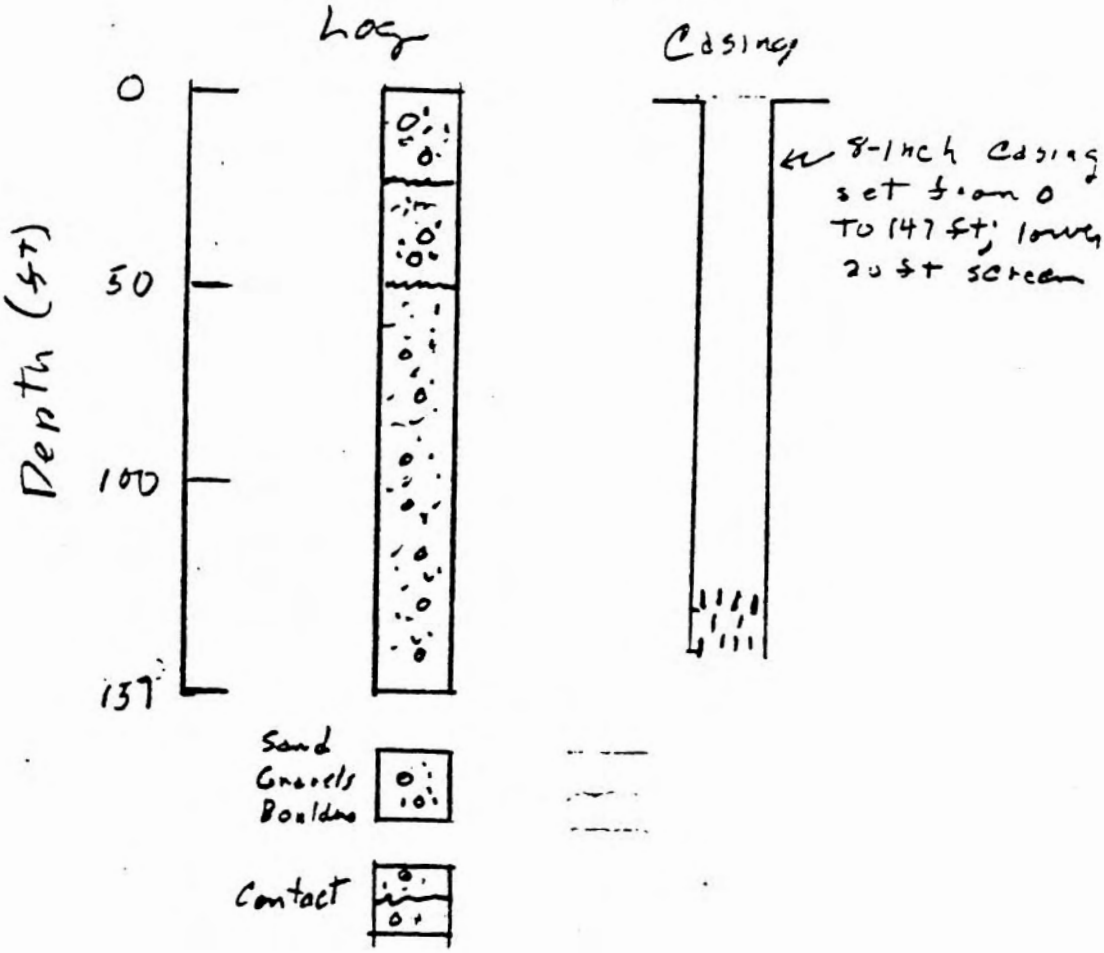


Figure 34.-Lithologic Log and Casing Schedule of Well Layne Western

DRAFT

An 8-inch diameter casing was set from to 147 ft with an 8-inch diameter screen from 147 to 157 ft welded on the end.

DRAFT

VIII. TEST WELLS TW-8A AND TW-8

Test wells TH-8A and TW-8 are located on the floor of Mortandad Canyon. Test well TW-8 is located at N 1,769,445, E 492,330 (elevation 6,878 ft) and TW-8A is about 50 ft to the east. Access is off Pajarito Road to Puye Drive and through TA-52. A gravel road follows the top of the mesa eastward to the end where it descends into the canyon and then turns west up the canyon bottom to the well (**Figure 35**).

A. HISTORY AND HYDROLOGY

Mortandad Canyon has a small drainage area on the plateau. The lower reach of the canyon east of the laboratory boundary contains a large thickness of unsaturated alluvium. Perennial flow in the canyon occurs in the midreach from the release of effluent from the TA-50 Radioactive Liquid Waste Treatment Plant that was built in 1963. Effluent and storm water runoff recharge a shallow ground water zone in the alluvium that is perched on the underlying tuff. The recharge is only sufficient to maintain the perched zone to a limited extent within the laboratory boundary.

The USGS laid out a system to monitor the movement of water and the chemical and radiochemical quality in the shallow perched ground water zone. The system consisted of one observation well (TW-8) and several moisture access tubes. Test well TW-8 was drilled to monitor the water in the main aquifer.

1. Test Well TW-8A

Test well TW-8A was started with a cable tool rig in early November 1960. The hole was drilled to about 32 ft and cased with 31 or 32 ft of 20-inch diameter corrugated metal pipe that was being driven along with the drilling. The drill bit that was being sharpened was set in a wrench on top of the metal pipe. The chain holding the wrench to the bit parted and the bit and wrench fell into the hole. The equipment was unable to be recovered because of water in the borehole. The hole was covered, the rig was skidded about 50 ft to the west and TW-8 was drilled. Test well TW-8A was used as an alluvial perched ground water observation and monitoring well until about 1987 when it was filled with soil and gravel. No further action is needed.

2. Test Well TW-8

Test well TW-8 was drilled by cable tool in November and December of 1960. (**Figure 36**). The hole was drilled 20-inches in diameter to a depth of 85 ft. From 85 ft to the total depth of 1,065 ft the hole was drilled 13 5/8-inches in diameter (Baltz and others 1963).

At the time the well was drilled it was thought that sufficient surface casing was not available to prevent surface water and water in the alluvium from seeping down the borehole walls. A packer was set at 465 ft, isolating the annulus between the 8-inch casing and the bore hole wall. Access to the annulus was constructed through the well head with a 3-inch diameter pipe welded through and into the 14-inch

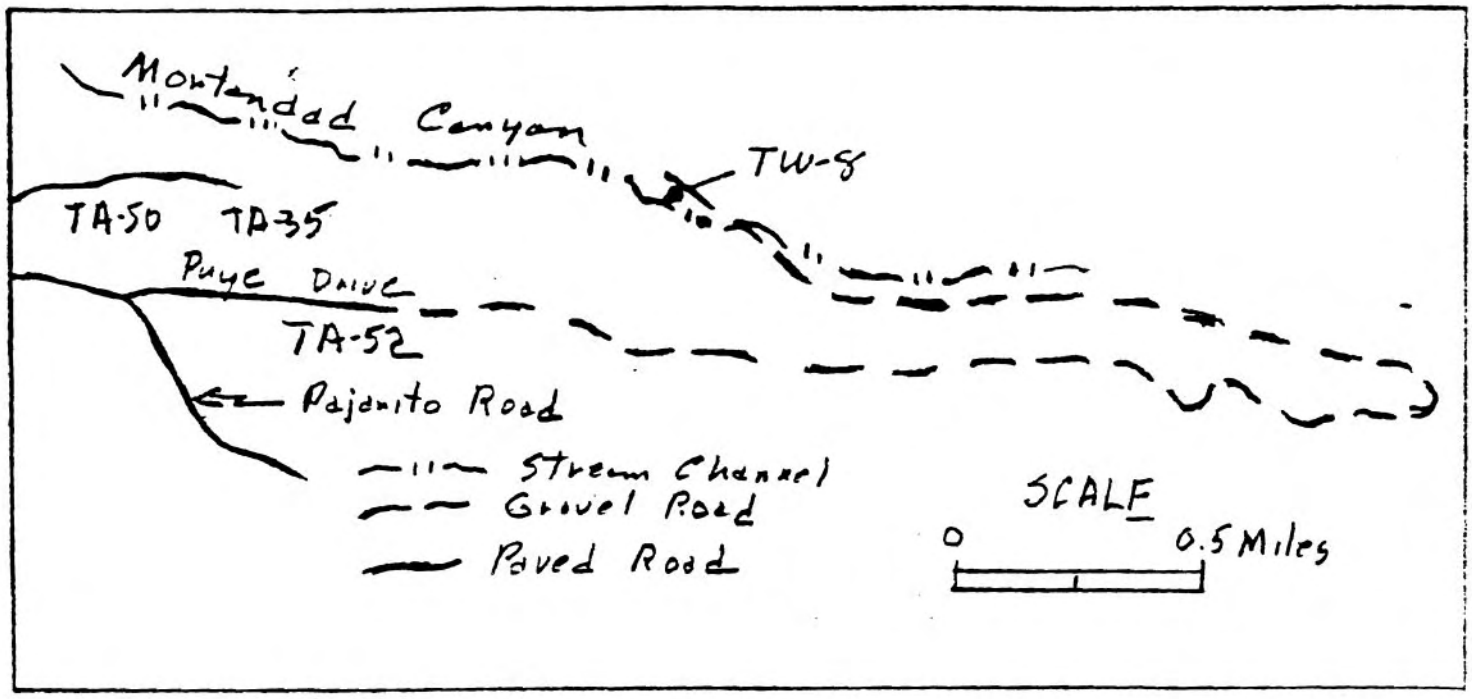


Figure 35.- Map Showing Access To Test Well TW-8.

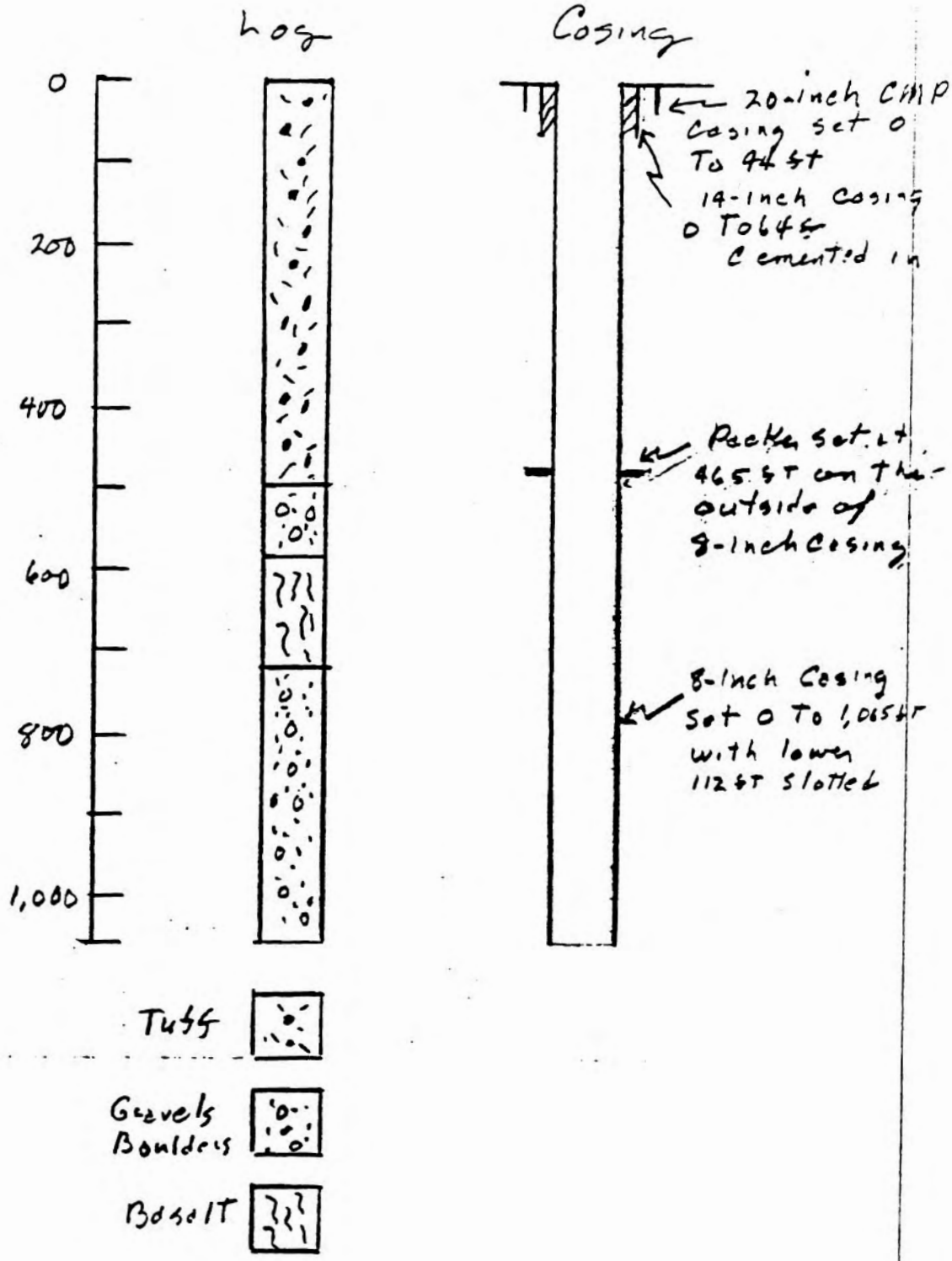


Figure 36.- Lithologic Log and Casing Schedule of Test Well TW-8.

diameter casing set to a depth of 64 ft. Cement slurry could be pumped through the 3-inch diameter pipe and effectively seal the well to a depth of 465 ft out side the 8-inch casing. Prior to welding a cap on the 3-inch pipe, a large volume of air was noted through the pipe from above the depth of 465 ft. A plate was welded on the 3-inch pipe in February 1961 (Figure 37).

The water level when the well was completed was about 963 ft. The 8-inch casing was slotted from 953 ft to 1065 ft. In 1961 about 10 ft of the slots were above the water table and by 1993 the water level had declined so that 40 ft of the slots were above the water table. This decline is part of a regional decline on the plateau that has taken place in the last 30 years. Air exchange through the 8-inch casing with changing atmospheric changes has been noted since the well was completed in 1960. The area behind the casing below the packer subject to air exchange has ranged from 489 ft in 1960 to 528 ft in 1993. The air reservoir has included pumice, basalt flows and interflow breccias, sands, gravels, cobbles, and boulders (Figure 36).

In 1991, TW-8 was sampled subsequent to having the pump replaced. Tritium concentrations were below the limit of detection (700 pCi/L) of the analytical method used. In 1993, samples from TW-8 were sent to an outside laboratory for low-level tritium analyses. Results indicated values of about 80 pCi/L, which are indicative of recent recharge or contamination of the aquifer. The well was pumped again in 1995 and two samples were collected, one after one borehole volume of water was removed, and the other after five boreholes of water were removed. Low-level tritium analyses values were about 16 pCi/L and the second sample concentration was about 5 pCi/L (Rogers and others 1996). The decrease in tritium concentrations with pumping does not indicate a source of tritium consistent with leakage around the casing, through faults and fractures, or movement through the unsaturated rocks above the main aquifer. If that were the case, the tritium concentration in the main aquifer would have remained about the same or increased slightly.

TW-8 responds to atmospheric pressure changes similar to some of the other wells on the plateau previously discussed. The exchange occurs through the portion of the perforated casing that is above the water table (**Figure 37**). Because water chemistry of the main aquifer suggests that no mixing with alluvial perched water is occurring, tritium may be entering the well by another mechanism.

As observed at TA-54 (ref), tritium vapor generated by shrubs and ground cover near the wellhead might be sucked into the well during periods of atmospheric high pressure and precipitated onto the casing. The precipitate would then trickle down the casing into the main aquifer. It should be noted that transpiration from vegetation and trees in the canyon at TW-8 contained tritium in about the same concentration as found in the alluvial perched zone. The tritium in the perched zone ranged from 100,000 pCi/L to over 1,000,000 pCi/L (Stoker 1994).

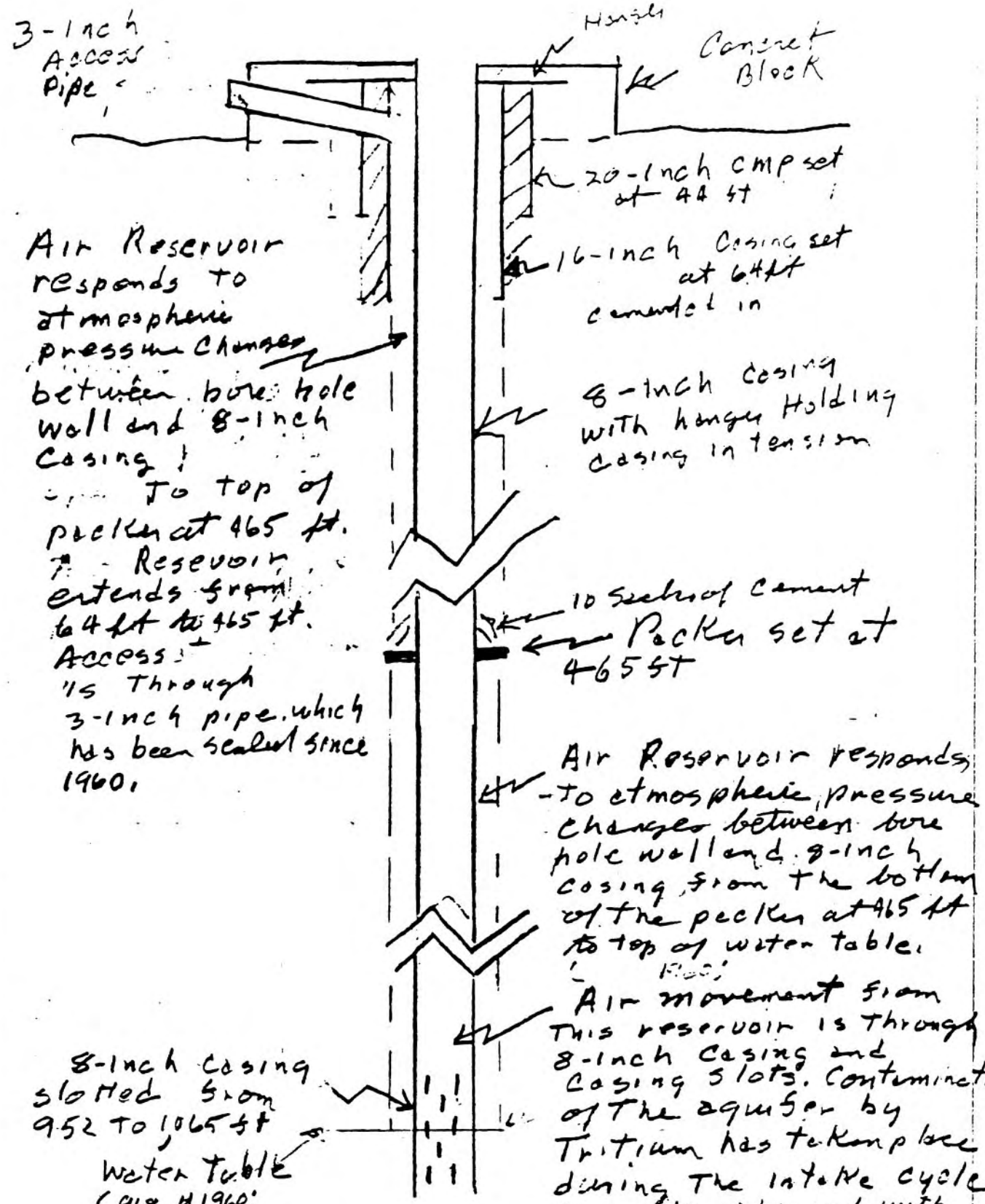


Figure 37. Casing Schedule showing Air Transfer of Tritium [illegible] Pressure Changes

DRAFT

There has been no significant change in the chemical quality of water in the main aquifer at Test Well TW-8 for over the past 35 years that can be attributed to leakage of water down the casing or recharge from the water in the alluvium at the wellhead. The water in the alluvium in 1993 contained high concentrations of calcium (37 mg/L), sodium (100 mg/L), chloride (17 mg/L), nitrate (47 mg/L), and total dissolved solids (575 mg/L) while water in the main aquifer at TW-8 contained much lower concentrations of calcium (12 mg/L), sodium (10 mg/L), chloride (3 mg/L), nitrate (0.17 mg/L), and total dissolved solids (about 100 mg/L).

The concentration of tritium detected in the main aquifer at TW-8 is minor. However, the transfer of contamination in the vapor phase with atmospheric pressure changes suggests that it will be necessary to seal the well behind the casing. The well should be plugged and abandoned. However, additional testing should be undertaken prior to plugging and abandoning the well.

Three areas require investigation: 1) tritium in the main aquifer, 2) tritium exchange through the inside of the 8-inch diameter casing, and 3) tritium concentrations and possible exchange through the 3-inch diameter access pipe that exposes the borehole wall outside the 8-inch diameter casing to a depth of about 465 ft above the packer. As the access to the 465-ft zone has been sealed for over 35 years care should be taken to obtain samples before allowing it to respond to atmospheric pressure changes.

A testing plan should be completely worked out before any tests are performed. As testing proceeds, the plan should be modified accordingly as results are obtained.

B. TEST WELL 8 GEOLOGIC LOG

Lithologic Description	Depth from (ft)	Depth to (ft)
Alluvium: Silts, sands, and gravels	0	40
Bandelier Tuff		
Tshirege Member: Rhyolite tuff, nonwelded	40	60
Otowi Member: Rhyolite tuff, nonwelded	60	445
Guaje Member: Rhyolite pumice	445	490
Puye Conglomerate		
fanglomerate member Sands, gravels, cobbles, and boulders	490	580
Basaltic rocks of Chino Mesa		
Unit 2, basalt flows and interflow breccias	580	725
Puye Conglomerate		
fanglomerate member: Sands, gravels, cobbles, and boulders	725	1065

(Baltz and others 1963)

C. TEST WELL 8 CASING SCHEDULE

The lithologic log and casing record is shown on figure 36.

A 20-inch diameter corrugated metal pipe was driven into the top of the tuff, sealing out the alluvial perched water to a depth of 44 ft.

A 14-inch diameter steel casing was set to 64 ft.

An 8-inch diameter steel casing was hung in the hole to 1,065 ft with the lower 112 ft torch slotted.

A machine belt packer was set at about 465 ft near the base of the Bandelier Tuff. About 10 bags of cement slurry were poured on top of the packer.

DRAFT

REFERENCES

J.H. Abrahams, "The Hydrology and Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, January 1956 through June 1957," U.S. Geological Survey Admin. Rept. (1966)

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

Black and Veatch, "Report on Additional Water Supply Sources, Los Alamos, New Mexico," Consulting Engineers, Kansas City, Missouri., Report to the U.S. Atomic Energy Commission (three reports 1946,1948, and 1951).

Black and Veatch, "Ground-Water Observation Wells, Los Alamos, New Mexico", Consulting Engineers, Kansas City, Missouri., Report to the U.S. Atomic Energy Commission (1950).

Environmental Protection Group (ESG), "Environmental Surveillance at Los Alamos during 1991, Los Alamos National Laboratory Rept. LA-12572-ENV (1993).

R.L. Griggs, "Geology and Ground-Water Resources of the Los Alamos Area, New Mexico," U.S. Geological Survey Admin. Rept. to the U.S. Atomic Energy Commission (1955).

R.L. Griggs, Geology and Ground-Water Resources of the Los Alamos Area, New Mexico," U.S. Geological Water-Supply Paper 1753 (1964).

P.M. Kearl, J.J. Decker, and M. Kautsky, Report 3: Preliminary Assessment of the Hydrologic System," Bendix Field Engineering Corporation, Grand Junction, Colorado (1986A).

P.M. Kearl, J.J. Decker, and M. Kautsky, "Report 4: Preliminary Assessment of the Hydrologic System through Fiscal Year 1986," Bendix Field Engineering Corporation, Grand Junction, Colorado (1986B).

W.D. Purtymun, "Underground Movement of Tritium from Solid-Waste Storage Shafts," Los Alamos Scientific Laboratory Rept. LA-5286-MS (1973).

W.D. Purtymun, F.C. Koopman, S. Barr, and W.E. Clements, "Air Volume and Energy Transfer Through Test Holes and Atmospheric Pressure Effects on the Main Aquifer," Los Alamos Scientific Laboratory Rept. LA-5725-MS (1974).

W.D. Purtymun, "Dispersion and Movement of Tritium in a Shallow Aquifer in Mortandad Canyon a the Los Alamos Scientific Laboratory," Los Alamos Scientific Laboratory Rept. LA-5716-MS (1974).

DRAFT

W.D. Purtymun and A.K. Stoker, "Environmental Status of Technical Area 49, Los Alamos, New Mexico," Los Alamos National Laboratory Rept. LA-11135-MS (1987).

W.D. Purtymun, S.G. McLin, A.K. Stoker, M.N. Maes, B.G. Hammock, Water Supply at Los Alamos during 1990," Los Alamos National Laboratory Rept. LA-12471-PR (1993).

W.D. Purtymun, "Source Document Compilation: Los Alamos Investigations Related to Environment, Engineering, Geology, and Hydrology 1961 1990, Los Alamos National Laboratory Rept. LA-12733-MS, Vol. 1 and 2, (1994).

W.D. Purtymun, A.K. Stoker, S.G. McLin, M.N. Maes, and T.A. Glasco,"Water Supply at Los Alamos during 1993," Los Alamos National Laboratory Rept. LA-12951-MN (1995).

W.D. Purtymun, "Geologic and Hydrologic Records of Observation Wells, Test Holes, Test Wells, Supply Wells, Springs, and Surface Water Stations in the Los Alamos Area," Los Alamos National Laboratory Rept. LA-12883-MS (1995).

D.B. Rogers, S.G. McLin, B. M. Gallaher, and A.K. Stoker, "Recharge to the Pajarito Plateau Regional Aquifer System," Draft Report for Publications HSE-18 (1996).

A.K. Stoke, W.D. Purtymun, S.G. McLin, and M.N. Maes, Extent of Saturation in Mortandad Canyon," Los Alamos National Laboratory Rept. LA-UR-91-1660 (1961).

A.K. Stoker, "Measurements of Low Level Tritium and Other Isotopes in Groundwater in the Los Alamos Environs," Fact Sheet HSE-8 September 21 (1994).

J.E. Weir and W.D. Purtymun, "Geology and Hydrology of Technical Area 49, Frijoles Mesa, Los Alamos County, New Mexico," U.S. Geological Survey Admin. Rept. (1962).

J.E. Weir, J.H. Abrahams, J.F. Waldron, and W.D. Purtymun, "The Hydrology and the Chemical and Radiochemical Quality of Surface and Ground Water at Los Alamos, New Mexico, 1949-1955," U.S. Geological Survey Admin. Rept. (1963).

DRAFT

APPENDIX A

FEDERAL AND STATE CRITERA FOR PLUGGING AND ABANDONING WELLS OR TEST HOLES

Major criteria as to when and why wells or test holes should be plugged is presented as follows:

U.S. Environmental Protection Agency:

Wells should be plugged when they do not meet performance standards (dry hole, not properly constructed). The well should be plugged according to Aller et al (1989) Handbook of Suggested Practices for Design and Installation of Ground_Water Monitoring Wells (EPA/600/4-89034) and Lamb and Kenney (1989) Decommissioning Wells -Techniques and Pitfalls NWWA (May 22-25, 1989).

N.M. Evironmental Improvement Division:

Monitoring wells no longer used shall be plugged. Well casing shall be removed and expanding cement shall be pumped into the borehole from bottom to top through a tremie pipe. Where casing cannot be removed, the casing shall be cut off at the level of the concrete pad and the bore hole filled with bentonite pellets from the bottom to top (NMEID Monitoring Well Construction and Abandonment Policy ,1989, from EIP/USTR 1-14 Appendix D, pp 12-31).

N.M. State Engineer:

Wells must be plugged when water rights have been removed or if the well has not been used for a year. Rights can be maintained if proposed use in the future is filed with the State Engineer. Shallow wells shall have the casing removed and be filled to land surface with cement or bentonite. If the casing can not be removed, the well shall be sealed by welding a steel plate to top of the casing. Artesian wells to be plugged will require a plan filed and approved by the State Engineer and also supervised by the State Engineer's office.

DRAFT

APPENDIX B

METHODS OF WELL DRILLING AND CONSTRUCTION

Most of the test wells and test holes were drilled with a cable tool rig. The cable tool rig is a percussion method where the steel bit suspended on a cable is carefully controlled, alternately lifted and dropped, pounding and chipping a hole in the rock. Very little water is used, just enough to mud the cutting so they can be removed with a bailer. The as the hole is drilled, casing is advanced with the drilling to prevent the bore walls from collapsing. The casing being advanced can be stuck in the hole or may be driven and left in the hole to seal out a water-bearing zone. Thus, the casing is left and a smaller size casing is run in the hole and drilling continued with a smaller bit. In this way upon completion of the hole there maybe several strings of casing in the well or test hole.

When water is encountered final or permanent string of casing is set in the well. This string of casing maybe slotted on the lower end and run in the well. Or the casing used to advance with the drilling maybe used as the part of the final casing. The hole is drilled beyond end of the casing and a screen assembly (blank pipe and screen on the end) run through the casing into the open hole. The screen assembly extends into the blank casing above and is usually secured with a lead packer or a belled out assembly that is just slightly smaller than the blank casing.

A second method of drilling is the use of a rotary. The drill bit, a roller cone, is rotated on a drill stem. The drill stem is hollow and mud or air is pumped down the hollow stem which returns to the surface with the cuttings between the drill stem and bore hole wall. The stem and bit are advanced down the hole as drilling progresses. With the use of drilling mud the hole stands open and the casing is generally run when the well is completed; however, in some cases due to lost circulation a string of casing may be run and cemented in to seal out the lost circulation zone. Drilling then continues with a smaller bit through the set casing. Only three wells in this report were drill using the rotary method, DT-5P, DT-5, and DT-5A.

A third method of drilling the test holes is use of a bucket auger. The auger is used to drill large diameter holes and consists of a three foot high steel bucket with wedge like teeth attached to the a bottom that is partly open to receive the cuttings and is hinged to allow the cuttings to be dumped at the surface. The bucket auger is rotated on a string of drill stem.

DRAFT

APPENDIX C

METHOD OF WELL PLUGGING AND ABANDONMENT

1. GENERAL PLUGGING PROCEDURES

The method use to plug a test hole will depend on the number of casings in the hole. To successfully plug the test well or hole, it is necessary to isolate and seal the aquifer penetrated as well as the borehole wall behind the casing. Where drilling difficulties were encountered or perched aquifers are present, there may be several strings of casing in the hole.

To effectively seal the well, the casing must be either ripped or removed to allow the cement-bentonite slurry to contact the borehole wall. Casing that has been in contact with the borehole wall for a long period of time may not be able to be pulled without parting. The parting or pulling of the casing may result in collapse of the borehole in which case it will be impossible to effectively plug the hole.

In general, each well head is completed with a concrete block which secures the top of the casing and forms the foundation for a pump. It will be necessary to break up and remove the block to expose the casing. A down hole video camera should be used to document the condition of the casing prior to ripping as well as afterward to verify adequate exposure of the borehole for plugging.

All inner strings of casing should be cut off and removed, leaving only the outermost casing closest to the borehole wall. This casing can be ripped with a tool specifically for that purpose. A cement-bentonite slurry is pumped into that section of the hole. The slurry flows through the holes in the casing and forms a seal between the outer part of the casing and borehole wall.

The cement-bentonite slurry mix should consist of about 10 sacks of cement to 1 sack of bentonite. Bentonite added to the slurry reduces the shrinkage of the cement as it sets up preventing fractures or cracks. The cement and bentonite is mixed in a hopper with water and then is pumped down the hole through a drop line or tremie pipes.

The wells or holes are plugged from bottom to top. A tremie pipe is set near the bottom of the hole and the cement-bentonite slurry is pumped into the hole through the tremie pipe. As the annulus behind the casing and borehole wall is filled with the slurry, a section of the tremie pipe is removed and pumping continues. The operation continues until both the annulus behind the casing and the hole are filled.

The job should be planned so that at the end of the shift, the cement mixture should cover the ripped or perforated section of the casing.

The depth to the cement plug should determined at shift changes and in the morning before work begins. A daily log should be kept recording the depth to the plug at the beginning and end of the shift, the amount and volume of cement-bentonite slurry pumped down the hole, and any other data that will be useful in evaluating the effectiveness of the plugging operation.

2. SPECIFIC PLUGGING METHODS FOR NINE WELLS

The following sections outline specific plugging methods for each of the nine test wells in need of plugging as suggested by this report. The methods given are suggestions based on consideration of each well's construction, completion, and most currently known condition.

A. TEST WELL TW-2B PLUGGING METHOD

Test Well TW-2B was drilled to 225 ft in 1967 and has not been used since. Intermediate perched water was encountered at 103 ft and sealed out of the hole. The well is dry and contains two strings of casing that could not be pulled. The bottom two feet of the hole are not cased and the hole responds to changes in atmospheric pressure.

The following steps outline the plugging of TW-2B.

1. Using tremie lines, fill the open hole from total depth (225 ft) to 130 ft with cement-bentonite slurry and let set over night as the next step (ripping the casing) will dump water from the perched ground water zone in the hole.

2. Rip the 6-inch casing from 130 to 115 ft and fill with a cement-bentonite slurry.

3. Cut off the 6-inch casing at 115 ft and remove from the hole.

4. Rip the 12-inch casing to near land surface and fill with cement-bentonite slurry.

5. Cut the 12-inch casing off a few feet below land surface, fill the hole with soil, and restore to native surface conditions.

B. TEST HOLE H-19 PLUG AND ABANDON METHOD

Test hole H-19 was drilled to 2,000 ft in 1949 with a water level at 950 ft. It was abandoned with a surface string of casing set to 10 ft that does not penetrate the alluvium which is 27 ft thick.

The first step in plugging the test hole will be to shut out the water in the alluvium with a surface string. The existing string may be added to and driven to a depth of about 50 ft into the tuff. If this does not shut out the water in the alluvium it may be necessary to remove the existing casing, drill the hole to about 50 ft and cement in a surface string to tha th.

The tuff generally drills easily and to gauge (usual diameter of the bit). Using fluids, drilling mud or air for a cutting carrier often results in lost circulation problems. To start out, it may be best to try cleaning out the hole using a cable tool rig. Water can be bailed from the hole after the surface casing has been reset to seal out the alluvial water.

The following steps outline the plugging of test hole H-19.

1. Set a surface casing through the alluvium and into the Bandelier Tuff.

2. Clean the hole out to a depth of about 1,510 ft which is below the water bearing Totavi Lentil.

3. Place tremie pipes to a depth of 1,450 ft and pump the hole full of the cement-bentonite slurry, removing about 100 ft of tremie pipe at a time.

4. Cut off casing below land surface and remove the concrete at the well head. Fill the rest of the hole with soil and restore the well head to native surface conditions.

If difficulty is encountered opening the hole to 1,510 ft, it may be possible to open it to 850 ft. This depth is below the Bandelier Tuff section and plugging the hole at this point would seal out the perched water in the tuff from the hole.

If this alternative is used:

1. Set a surface casing through the alluvium and into the Bandelier Tuff.

2. Clean the hole out to a depth of 850 ft.

3. Place the tremie pipes to a depth of 700 ft and pump the hole full of cement-bentonite slurry, removing about 100 ft of tremie pipe at a time.

4. Remove the concrete at the well head and cut off casing below land surface. Fill the hole with soil and restore to native land surface conditions.

C. TEST HOLE H-16 PLUG AND ABANDON METHOD

Test hole H-16 was drilled in 1949 to a depth of 1269 ft. The hole was dry and contains no casing. Attempts to locate the hole in 1971 failed. If the hole can be located it should be plugged, at least to a depth of 50 ft to seal out surface water.

The following steps outline the plugging of test hole H-16.

1. Clean out the hole to 50 ft if needed.

2. Fill the hole with cement-bentonite slurry.

D. TEST HOLE TH-5 PLUG AND ABANDON METHOD

Test hole TH-5 was drilled in 1950 to a depth of 263 ft. The hole is dry and contains a 24-inch surface casing set to 24 ft to seal out alluvial water. The hole has not been used since it was drilled.

The following steps outline the plugging of test hole TH-5.

1. Pump the hole and casing full of cement-bentonite slurry using a tremie pipe.

2. Remove any concrete remaining at the well head and cut off casing below land surface. Fill hole with soil and restore to the native land surface conditions.

E TEST HOLE TH-6 PLUG AND ABANDON METHOD

Test hole TH-6 was drilled in 1950 to a depth of 300 ft. The hole was dry and contains a 6-inch casing set to 120 ft after which it is not cased. The hole has not been used since it was drilled.

The following steps outline the plugging of test hole TH-6.

1. Pump the hole and casing full of cement-bentonite slurry through a tremie pipe. The casing does not need to be ripped because water in the alluvium is effectively sealed out of the hole.

2. Remove any concrete remaining at the well head and cut off casing below land surface. Fill hole with soil and restore to the native land surface conditions.

F. TEST HOLE DT-5 PLUG AND ABANDON METHOD

Test hole DT-5 was drilled in 1952 to a depth of 962 ft. The hole was dry and contains an 8-inch surface casing set to 180 ft. Attempts to pull the casing failed. The hole is open below the surface casing and responds to changes in atmospheric pressure and could be a conduit into the fanglomerate member.

The hole below the bottom of the casing is probably bridged in places or collapsed. It will be necessary to open it up prior to plugging. The hole should be opened using either air rotary methods or cable tool methods with as little water as possible. Circulation can not be maintained using water which is why the hole was abandoned in the first place.

The following steps outline the plugging of test hole DT-5.

1. Open the hole to the total depth of 962 ft if possible. If not, open to at least below the base of the Bandelier Tuff at 940 ft.

2. Starting at about 875 ft, fill the hole in 100-ft intervals with cement-bentonite slurry using tremie pipes. The depth to the plug should be carefully measured at the beginning and end of each shift to see if plug has dropped during the night. This may occur if the hole is not opened to total depth or if there are any voids in the formation adjacent to the hole caused by the initial drilling.

3. Once the hole has been filled to a depth of 180 ft, an attempt should be made to pull the surface casing. If it cannot be pulled then it should be ripped.

4. Fill the hole with cement-bentonite slurry from 180 ft to near land surface. If the casing remains in hole, cut it off below land surface and remove any concrete at well head. In either case, fill the remainder of the hole with soil and restore to native land surface conditions.

G. ALPHA HOLE PLUG AND ABANDON METHOD

Alpha Hole was drilled using a 2-ft bucket auger to a depth of 189 ft in 1960. The hole is dry and contains about 7 ft of corrugated metal pipe that has been cemented in at land surface. Frost heave has broken the cement pad around the hole and has created a safety hazard. The hole responds to changes in atmospheric pressure. It has not been used for several years and should be plugged.

The following steps outline the plugging of Alpha Hole.

1. Pour a cement-bentonite plug from 189 ft up to 186 ft.

2. Fill with tuff (crushed in part but containing gravel to boulder size fragments) from 186 ft up to 130 ft.

3. Pour a cement-bentonite plug from 130 ft up to 126 ft.

4. Fill with tuff from up to 80 ft.

5. Pour a cement-bentonite plug from 80 ft up to 74 ft.

6. Fill with tuff from 74 ft up to 8 ft.

7. Remove cement base and casing and pour a cement-bentonite plug from 8 ft up to 5 ft.

8. Fill remaining hole with soil and restore to native land surface conditions.

DRAFT

H. BETA HOLE PLUG AND ABANDON METHOD

Beta Hole was drilled using a 2-ft bucket auger to a depth of 180 ft in 1960. The hole is dry and contains about 7 ft of corrugated metal pipe that has been cemented in at land surface. Frost heave has broken the cement pad around the hole and has created a safety hazard. The hole responds to changes in atmospheric pressure. It has not been used for several years and should be plugged.

The following steps outline the plugging of Beta Hole.

1. Pour cement-bentonite slurry from 180 ft up to 175 ft.

2. Fill with tuff from 175 ft up to 90 ft.

3. Pour a cement-bentonite plug from 90 ft to 85 ft.

4. Fill with tuff from 85 ft to 15 ft.

5. Remove concrete base and casing and pour cement-bentonite slurry from 15 ft up to 8 ft.

6. Fill the remaining hole with gravel and soil and restore to natural land surface conditions.

I. TEST HOLE EGH-LA-1 PLUG AND ABANDON METHOD

Test hole EGH-LA-1 was drilled in 1979 to a depth of 2,292 ft. The hole was plugged up to 1,425 ft. It contains 30-inch and 20-inch casings down to the cement-bentonite plug with no uncased sections. The main aquifer was encountered at 1,330 ft.

The following steps outline the plugging of EGH-LA-1.

1. Starting at about 1,300 ft, fill the 20-inch casing with cement-bentonite slurry to just below land surface. There is probably no need to rip the casing as it has been cemented in.

2. Cut the casing off below land surface and remove any concrete at the well head.

3. Fill the remaining hole with soil and restore to natural land surface conditions.

J. LAYNE-WESTERN PLUG AND ABANDON METHOD

The Layne-Western well was drilled in 1950 to a depth of 157 ft. The well contains 10 ft of 12 or 14-inch surface casing and an 8-inch casing down to 147 ft. The well has not been used since 1950.

The following steps outline the plugging of the Layne-Western well.

1. Starting at the bottom of the well, rip the screen and casing in stages filling the ripped section with cement-bentonite slurry through tremie pipes. Stop just below land surface.

2. Cut the casing off several feet below land surface, remove any concrete around the well head.

3. Fill the remaining hole with soil and restore surface to native conditions.

K. TEST WELL 8 PLUG AND ABANDON METHOD

Test well TW-8 was drilled in 1960 to a depth of 1065 ft. It contains several strings of casing. Part of the screened interval is above the water table which causes the well to respond to changes in atmospheric pressure.

The following steps outline the plugging of TW-8.

The most important phase of the plugging of this well is getting the slurry behind the casing so that the formations will be sealed to airflow.

1. Rip the casing from the bottom of the hole to the top of the slots (953 ft) and pump full of slurry.

2. Continue to rip the casing and pump full of slurry to a depth of 465 ft. The length of casing ripped and plugged should be done in sections that can be completed in a shift.

3. The 8-inch diameter casing should be ripped from 400 to 465 ft. The slurry should be pumped through the 3-inch access tube to fill the annular space behind the 8-inch diameter casing and borehole wall. Care should be taken not to collapse the 8-inch diameter casing with the pressure grout. A down-hole TV camera should be used to inspect the adequacy of the results.

4. Proceed in ripping and filling the 8-inch diameter casing through the 3-inch access pipe. The length of casing ripped and plugged should be done in sections that can be completed in a shift.

5. Cut off casing below land surface and remove any concrete around the well head.

6. Fill the remaining hole with soil and restore surface to natural conditions.

Los Alamos Technical Associates, Inc.

P.O. Box 410 / 1200 Trinity Drive / Los Alamos, NM 87544 / Telephone (505) 662-9080 / FAX (505) 662-1757

February 9, 1998

Mr. Steve Rae
Los Alamos National Laboratory
Mail Stop K497
PO Box 1663
Los Alamos, NM 87545

SUBJECT: Draft Report *Engineering, Geology, and Construction Data of Twenty-Five Test Holes and Test Wells on and Adjacent to the Pajarito Plateau.*

Dear Mr. Rae,

In partial fulfillment of the terms of Subcontract No. 9-X52-N6321-1, Task 015, we are submitting draft copies of the document "Engineering, Geology, and Construction Data of Twenty-Five Test Holes and Test Wells on and Adjacent to the Pajarito Plateau." Document information was prepared for Bruce Gallaher and compiled by Bill Purtymun with review for content and consistency by Sue Swanton.

The document still needs some final editing including drafted figures, reference citations, conversion of 1927 North American Datum (NAD) and LASL coordinates to 1983 NAD coordinates, and final formatting. Please let us know if, subsequent to your review, you would like us to finalize this document for publication.

Please call me at 662-1829 or Sue Swanton at 662-1830 if you have any questions or comments.

Sincerely,

Robert W. Hull,
Program Manager
Environment, Safety & Health

RWH/as

Attachment: Document as stated

Cy:
Bruce Gallaher, K497
Steve McLin, K497
Celina M. Vigil, P274 w/o att.