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General

Perched Zone Monitoring Well Installation

by

W.D. Purtymun and A.K. Stoker

Environmental Protection Group (HSE-8)

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I. INTRODUCTION

The Hazardous Waste Permit (Hazardous and Solid Waste Amendments, 1984) issued to the United States Department of Energy (owner) and the University of California (operator) contains several Special Conditions in Module VIII, Sec. C. The first condition relates to Perched Zone Monitoring. This condition required the installation of monitoring wells or borings in the principal canyons of the Pajarito Plateau as follows: Pueblo Canyon (one exploratory boring); Los Alamos Canyon (three monitoring wells near existing wells LAO-3, LAO-4.5, and LAO-5); Sandia Canyon (two monitoring wells near water supply wells PM-1 and PM-3); Mortandad Canyon (three monitoring wells near existing wells MCO-4, MCO-6, and MCO-7); Potrillo Canyon (one monitoring well near State Road 4); Fence Canyon (one monitoring well near State Road 4); and Water Canyon (three monitoring wells: one near State Road 4, one 1 mile west of State Road 4, and one 2 miles west of State Road 4). Water samples will be collected from the wells in September 1990 and analyzed for specific constituents in accordance with the timetable specified in the permit.

These canyons were created by southeast-trending intermittent streams that have cut deeply into the surface of the plateau. The intermittent stream flow has eroded, transported, and deposited alluvium in the stream channel of these canyons. The origin of the drainage area of the canyons determines the general type of alluvium. Canyons that head on the flanks of the mountains west of the plateau contain mainly sands, gravels, cobbles, and boulders derived from dense, hard rock eroded from the flanks of the mountains. These canyons include three specified in the special condition: Pueblo, Los Alamos, and Water. Canyons that head on the plateau contain clays, silts, sands, and some gravels derived from the softer tuff that forms the plateau. These canyons include four specified in the special condition: Sandia, Mortandad, Potrillo, and Fence.

The shallow aquifers in the alluvium of the canyons is in the sands, gravels, cobbles, and boulders of canyons heading on the mountains or in the reworked and weathered clays, silts, sands, and gravels of canyons heading on the plateau.

The aquifers in the alluvium exist as a narrow ribbon of saturation along the canyon bottoms and are perched on the underlying silts and clays. The aquifers are of limited horizontal extent and are dependent on surface water for recharge. The spring snowmelt run-off causes water levels in the aquifer to rise and the aquifer to advance down the canyon. In early summer, the water levels typically decline and the aquifers retreat up the canyon. Summer run-off causes the water levels to rise and aquifers to advance down the canyon; the lack of run-off in the fall and winter causes the water level to decline and the aquifer to retreat up the canyon. These same hydrologic effects take place in canyons that also receive treated industrial and/or sanitary effluents. Thus, dependent on the amount of recharge, the thickness of the saturated part of the aquifer will vary and at times may be dry. The water levels in an aquifer may vary by 10 or more feet in the course of a year.

II. WELL DRILLING AND COMPLETION

All of the wells or borings were drilled and completed using the same basic equipment and methods. The methods generally followed the recommendations of the Resource Conservation and Recovery Act (RCRA) Ground-Water Monitoring Technical Enforcement Guidance Document (TEGD) to the extent practicable and allowing for some modifications based on more than 40 years of experience with monitoring initiated by the U.S. Geological Survey. These methods are described in this section and are applicable to all of the wells. Details of each individual well completion are provided in individual figures discussed later in this report. A pilot hole was drilled with either a standard continuous-flight auger (4.5 in. diameter) or cored with a hollow-stem auger (7.25-in. hole diameter). The depth to the base of the aquifer was determined by the cuttings and drilling pressure or by direct inspection of the continuous core retrieved from the hole.

The characteristics of the alluvium (hole collapse) require construction of the well through a hollow-stem auger. Accordingly, the pilot hole provided a guide for reaming the hole using a larger diameter hollow-stem auger (6.25 in. i.d., 9.625 in. o.d., with a 10.375-in. o.d. bit). This bit was run in the pilot hole with a knockout plate, and the auger joints were equipped with O-Ring seals. The hole was reamed below the base of the aquifer.

If water was encountered in the pilot hole, it was necessary to fill the 6.25-in. i.d. hollow-stem auger with water to a level equal to the top of the aquifer to keep sands and gravels from running into the hollow stem when the plate in the bit was knocked out. The plate was knocked out and the auger raised 0.5 to 1.0 ft to anchor the casing on the bottom of the hole. The 2-in.-diameter casing was set through the hollow stem and rested on the plate. The lowest portion of the casing consisted of one or two 10-ft lengths of screen with a plug at the bottom. (In

three wells, a 5-ft blank section was extended below the screen to provide for bailer descent to assist in collecting adequate sample volumes.)

The annulus between the hollow-stem auger and casing screen was filled with the gravel pack (sand) in increments of 2 to 3 ft, at which time the auger was pulled up a corresponding amount. Keeping the sand in the auger while raising the auger assured a continuous gravel pack between the borehole wall and the screen by preventing any formation material from caving in around the casing. Accordingly, this method is believed to be preferable to using a tremie after removal of the entire length of auger. The gravel pack was continued up to a point 2 to 3 ft above the top of the screened section. At this point, a seal of bentonite and/or cement was extended to the surface using the same method of emplacement through the auger to assure a continuous seal with no formation material collapsing in around the blank tubing.

At a depth of about 3 to 5 ft, the auger was removed from the hole. The upper part of the well was filled with cement and the wellhead security cap was set about 1.5 to 2 ft into the cement. A brass cap was set in a 2-ft-square concrete pad poured around the wellhead security cap.

III. WELL CONSTRUCTION MATERIALS

The materials used in well construction include the casing, the sand or gravel pack, the bentonite seal material, and cement. Also considered as part of the construction is the wellhead security cap that permits only authorized personnel to access the well for water-level measurements or sampling.

The casing, screen, plugs, and caps were made of polyvinyl chloride (PVC), using flush-joint, internal, upset-threaded-type connections. The casing and screen were 2 in. i.d. (2.375 in. o.d.), in 5- or 10-ft lengths. The screen openings were 0.010 in. The casing, screen, plugs, and caps were manufactured by TIMCO Manufacturing, Inc. (851 15th Street, Prairie Du Sac, Wisconsin 53578, phone 608-643-8534).

The sand used for the gravel pack was sized from 0.010 to 0.020 in. and is compatible with the screen openings in the casing of 0.010 in. Because of the nature of the aquifer material (very fine suspended particles), the smallest screen opening and appropriate size gravel pack were used. The sand used as a gravel pack came in 50- or 100-lb bags. The 100-lb bag contained about 0.97 ft^3 of pure Colorado silica sand. The sand was processed and marketed by Silica Sand, Inc. (P.O. Box 15615, Colorado Springs, Colorado 80935).

The bentonite was brand name Hole Plug, coarse-grade Wyoming bentonite, and was supplied in 50-lb bags, 0.69 ft^3 per bag (dry), and was marketed by Baroid Division (N.L. Petroleum Surveys, Inc., P.O. Box 1675, Houston, Texas).

A premix cement (1 to 5) was used to seal part of the hole and to construct the wellhead and accompanying security cap. The cement mix came in 60-lb bags, about 0.5 ft^3 per bag. The brand name of the mixture was Quikrete, marketed by the Quikrete Company, Atlanta, Georgia 30234.

Two types of well security caps were used in completion of the observation wells. The first type was a standard 8.625-in. o.d. steel casing set into the cement. The top of the casing was secured with a hinged plate and hasp welded to the casing. The other type of well security was the 8.625-in. o.d. steel casing set into the cement, covered by a removable "mushroom" cap made from a 13-in. steel casing about 0.5 ft long with a steel plate welded to one end. The 13-in. casing with cap was set on the 8.625-in. casing. Slots cut through the side of the cap and the casing were aligned to receive a steel bar that secures the cap to the top of the casing. A hole through the bar allows a lock to secure the cap and prevent removal of the bar. Both types of caps are shown in Fig. 1.

IV. WELL DEVELOPMENT

Well development was carried out using several techniques in combination. However, none of the wells that have water in them has yet been able to meet the turbidity requirement of 5 nephelometric turbidity units. This was as expected, based on previous experience with the 25- to 30-year-old U.S. Geological Survey wells, which still yield samples with considerable turbidity. The turbidity results from the fine suspended clays and silts found in the aquifer. These clays and silts are derived from weathering of the ash matrix of the tuff. As a result, the smallest size screen generally available from commercial sources (0.010 in.), with matched sand size (0.010 to 0.020 in.), was used in completing all the new wells. The presence of these suspended sediments and the fluctuation of the thickness of the aquifer have hampered or prevented well development, even without suspended sediments entering the wells during bailing.

The wells were developed using a surge block, pumping, bailing, and jetting. At least two methods were used in each well. The choice of methods depended on the depth to water and observations of the saturated thickness. Jetting was the most commonly used method and was applied to all of the Mortandad and Los Alamos canyon wells. The Pueblo Canyon well was developed mainly by pumping.

V. OBSERVATION WELLS

The observation well elevations, measuring points (MPs), and coordinates (New Mexico State Plane system) are shown in Table I. Well characteristics are presented in Table II. The log, casing schedule, and construction details for each well are found in Figs. 2 through 15. Locations of the observation wells and

holes are indicated in Fig. 16. The map in Fig. 16 also shows locations of existing monitoring wells that indicate the extent of perched ground water in the canyon alluvial systems. Some alluvial perched ground water can also be inferred to exist in portions of canyons within the facility boundaries where surface stream flow occurs throughout the year. These canyons include the portion of Pueblo Canyon (fed by effluent from the Los Alamos County sanitary sewage treatment plant), Los Alamos Canyon (fed by flow from the mountains and released from the reservoir), Sandia Canyon (fed by effluent from the TA-3 sanitary sewage treatment plant), Pajarito Canyon (fed by surface run-off from the mountains to the west), and Water Canyon (fed by springs on the flanks of the mountains to the west). These locations are generally further upstream than any of the new monitoring wells, as can be seen by the locations of old monitoring wells that contain water in Los Alamos and Pajarito Canyons (see Fig. 16).

The wells were located along the eastern third of the plateau. Seven of wells were dry when drilled, and three additional wells (two in Mortandad Canyon and one in Los Alamos Canyon) became dry during the summer because of the lack of surface run-off. Two additional wells were drilled in Mortandad Canyon because the old U.S. Geological Survey wells indicated that the water level had declined beneath the lowest part of the 10-ft screen installed in the first new wells. The replacement wells were equipped with 20-ft screen sections to allow for the considerable fluctuation in water level. The well in Los Alamos Canyon that is now dry was completed into the top of the underlying basalt, and the aquifer has receded upstream because of limited recharge from run-off. Details of individual wells are discussed below or are shown in the referenced figures.

A. Pueblo Canyon

Pueblo Canyon observation well APCO-1 was completed in alluvium underlain by siltstone and claystone. Water was perched in the alluvium (Fig. 2).

B. Los Alamos Canyon

Los Alamos Canyon observation well LAO-3A was completed in alluvium underlain by tuff. Water was perched on the weathered tuff (Fig. 3).

Three wells were completed near LAO-4.5. Two of the wells were dry but were completed as wells because there is a possibility of the alluvium or sand lens in the underlying siltstone and claystone becoming saturated with an increase of storm run-off [Fig. 4(a) and 4(b)]. The siltstone and claystone underlying the alluvium is associated with the basalt that underlies the alluvium to the east. Water occurs in a sand lens within the siltstone and claystone [Fig. 4(c)].

Los Alamos Canyon observation well LAO-6A was completed through the alluvium into the top of a basalt flow (Fig. 5). The well contained water when

completed but went dry during the summer as the aquifer retreated up the canyon.

C. Sandia Canyon

Sandia Canyon observation well SCO-1 was completed in alluvium underlain by a weathered tuff. The alluvium was dry (Fig. 6).

Sandia Canyon observation well SCO-2 was completed in alluvium underlain by a weathered tuff. The alluvium was dry (Fig. 7).

Although the alluvium was dry at both locations. the holes were finished as wells because there is a possibility an increase in run-off could saturate part of the alluvium.

D. Mortandad Canyon

Mortandad Canyon observation well MCO-4A was completed in the alluvium and contained water when completed [Fig. 8(a)]. The well went dry during the summer, and a second well (MCO-4B) was constructed through the alluvium and into the top of the weathered tuff [Fig. 8(b)]. Water was encountered in the alluvium perched above the tuff. The second well was constructed with a 20-ft screen section to allow sampling even with the wide range of water-level fluctuation in the canyon.

Mortandad Canyon observation well MCO-6A was completed in the alluvium and contained water when completed [Fig. 9(a)]. The well went dry during the summer, and a second well (MCO-6B) was drilled through the alluvium into the top of the weathered tuff [Fig. 9(b)]. Water was encountered in the alluvium above the tuff. The well was equipped with a 20-ft screen section.

Mortandad Canyon observation well MCO-7A was completed in the alluvium (Fig. 10). The well encountered water in the alluvium.

E. Potrillo Canyon

Potrillo Canyon test hole PCTH-1 was cored to a depth of 74 ft (Fig. 11). The hole penetrated a thin soil zone of reworked material and a thick section of weathered to unweathered tuff. The entire section was dry and indicated no presence of past water. The hole was abandoned and plugged with a cement-bentonite slurry.

F. Fence Canyon

Fence Canyon observation well FCO-1 penetrated a sandy soil underlain by weathered and unweathered tuff (Fig. 12). The hole was dry, but was completed as a well.

G. Water Canyon

Water Canyon observation well WCO-1 was completed through the alluvium into the top of weathered tuff (Fig 13). The well was dry.

Water Canyon observation well WCO-2 was completed through the alluvium into the top of weathered tuff (Fig. 14). The well was dry.

Water Canyon observation well WCO-3 was completed through the alluvium into the top of basalt (Fig. 15). The well was dry.

The three wells in Water Canyon were dry, but were completed as wells. Water Canyon heads high on the flanks of the mountains west of the plateau. Snowmelt run-off could recharge the alluvium to the extent the wells could contain water.

Table II. Well Characteristics and Water Levels

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

[a]Cored test hole; plugged.

Table I. Observation Well Elevations and Measuring Points

	Top of Steel Casing	PVC Casing, Measuring Point	Land Surface Datum, or Brass Cap	Measuring Point to Land Surface Datum	New Mexico State Plane Coordinates (Brass Cap)	
					Northing	Easting
Pueblo Canyon						
APCO-1	6368.95	6368.19	6367.53	–0.66	1 772 957.956	508 965.347
Los Alamos Canyon						
LAO-3A	6580.38	6579.83	6579.40	–0.43	1 773 037.645	497 736.545
LAO-4.5A	6461.58	6460.38	6459.89	–0.49	1 771 989.595	503 255.968
LAO-4.5B	6461.76	6460.59	6459.37	–1.22	1 771 992.471	503 268.080
LAO-4.5C	6459.23	6458.72	6457.63	–1.11	1 772 014.413	503 303.058
LAO-6A	6396.73	6396.26	6395.88	–0.38	1 771 281.902	505 977.349
Sandia Canyon						
SCO-1	6619.85	6619.33	6618.67	–0.66	1 769 440.143	502 053.375
SCO-2	6502.02	6501.52	6500.67	–0.85	1 767 801.850	507 014.910
Mortandad Canyon						
MCO-4A	6889.00	6888.24	6887.53	–0.71	1 769 638.132	491 784.644
MCO-4B	6889.13	6888.71	6887.56	–1.15	1 769 634.899	491 792.173
MCO-6A	6851.80	6851.45	6850.18	–1.27	1 768 899.886	493 388.651
MCO-6B	6851.84	6851.08	6850.37	–0.71	1 768 921.493	493 386.276
MCO-7A	6829.27	6828.75	6827.71	–1.04	1 768 447.198	494 259.239
Potrillo Canyon						
PCTH-1[a]	—	—	6493.40	—	1 753 105.358	503 902.595
Fence Canyon						
FCO-1	6510.41	6509.99	6509.24	–0.75	1 751 120.043	502 168.229
Water Canyon						
WCO-1	6617.75	6617.06	6616.41	–0.65	1 755 007.161	492 514.547
WCO-2	6526.07	6625.25	6524.57	–0.68	1 753 166.432	496 626.165
WCO-3	6437.73	6437.25	6436.43	–0.82	1 750 558.320	498 968.371

[a]Cored test hole; plugged.

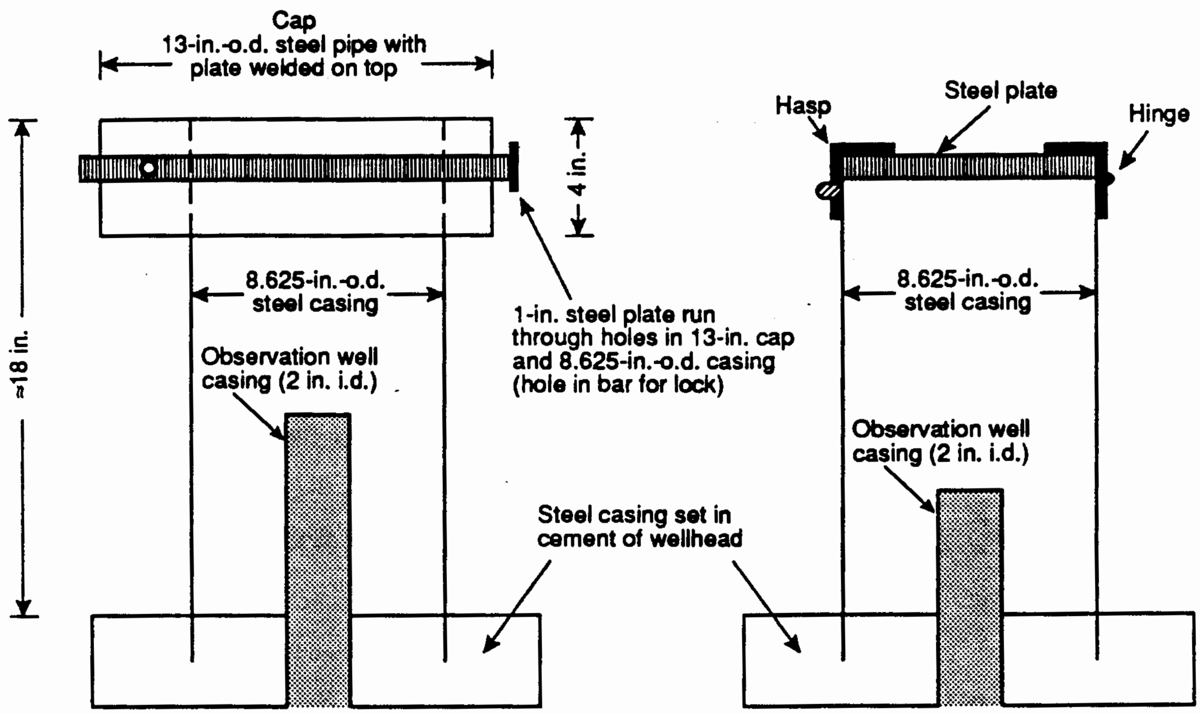


Fig. 1. Two types of wellhead security locks
used on canyon observation wells.

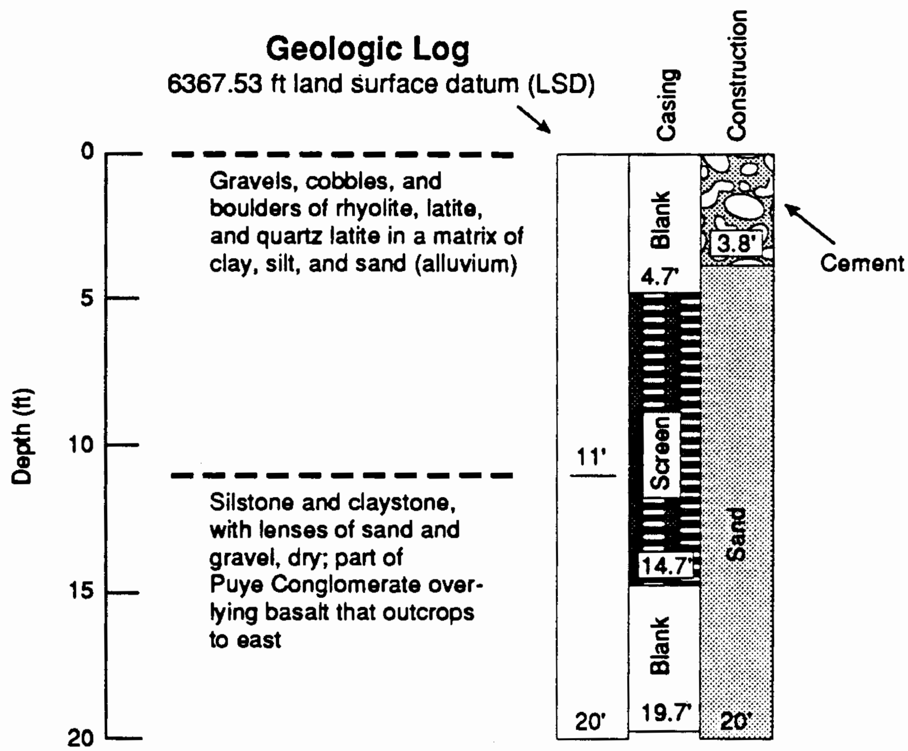


Fig. 2. Pueblo Canyon observation well APCO-1 (completed August 17, 1990, water level 6 ft).

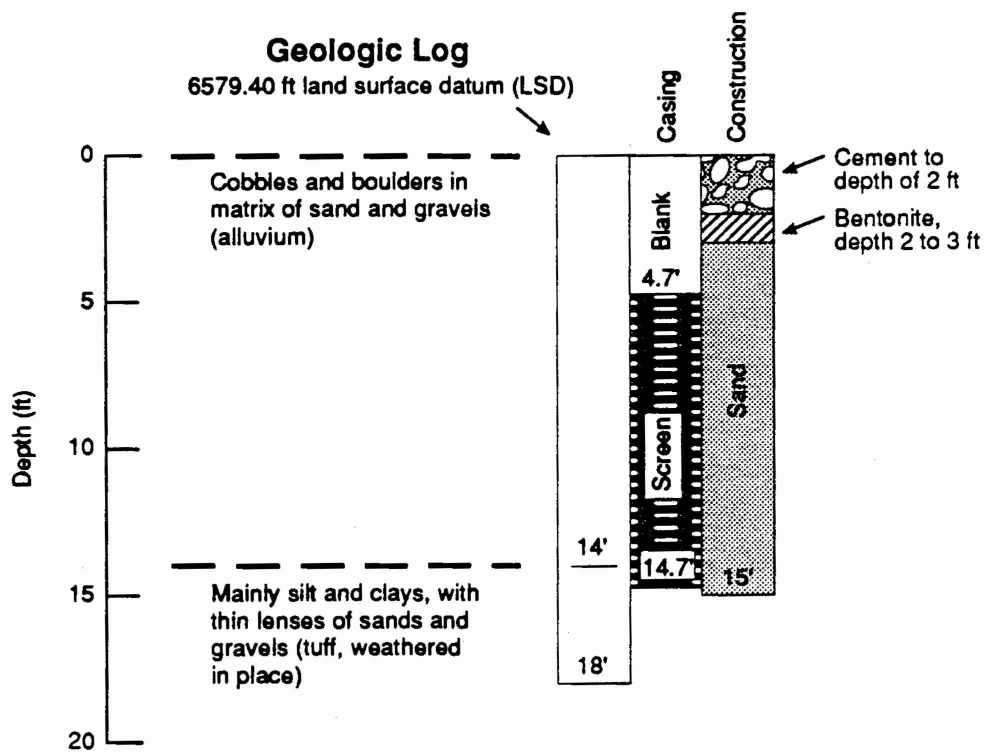


Fig. 3. Los Alamos Canyon observation well LAO-3A (completed September 14, 1989, water level 7 ft).

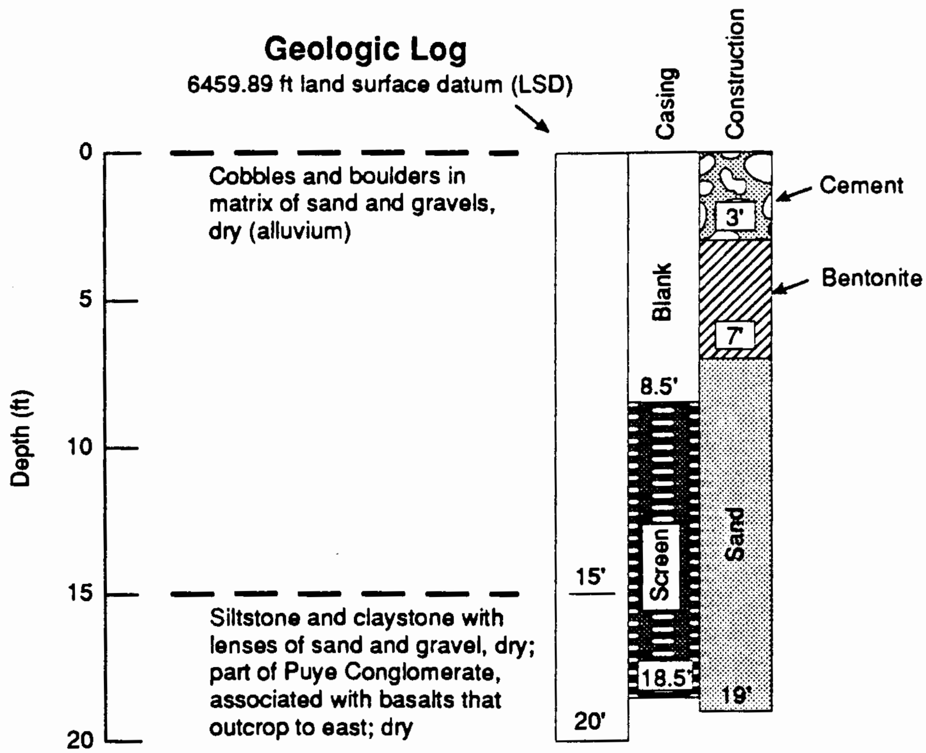


Fig. 4(a). Los Alamos Canyon observation well LAO-4.5A (completed September 14, 1989, dry).

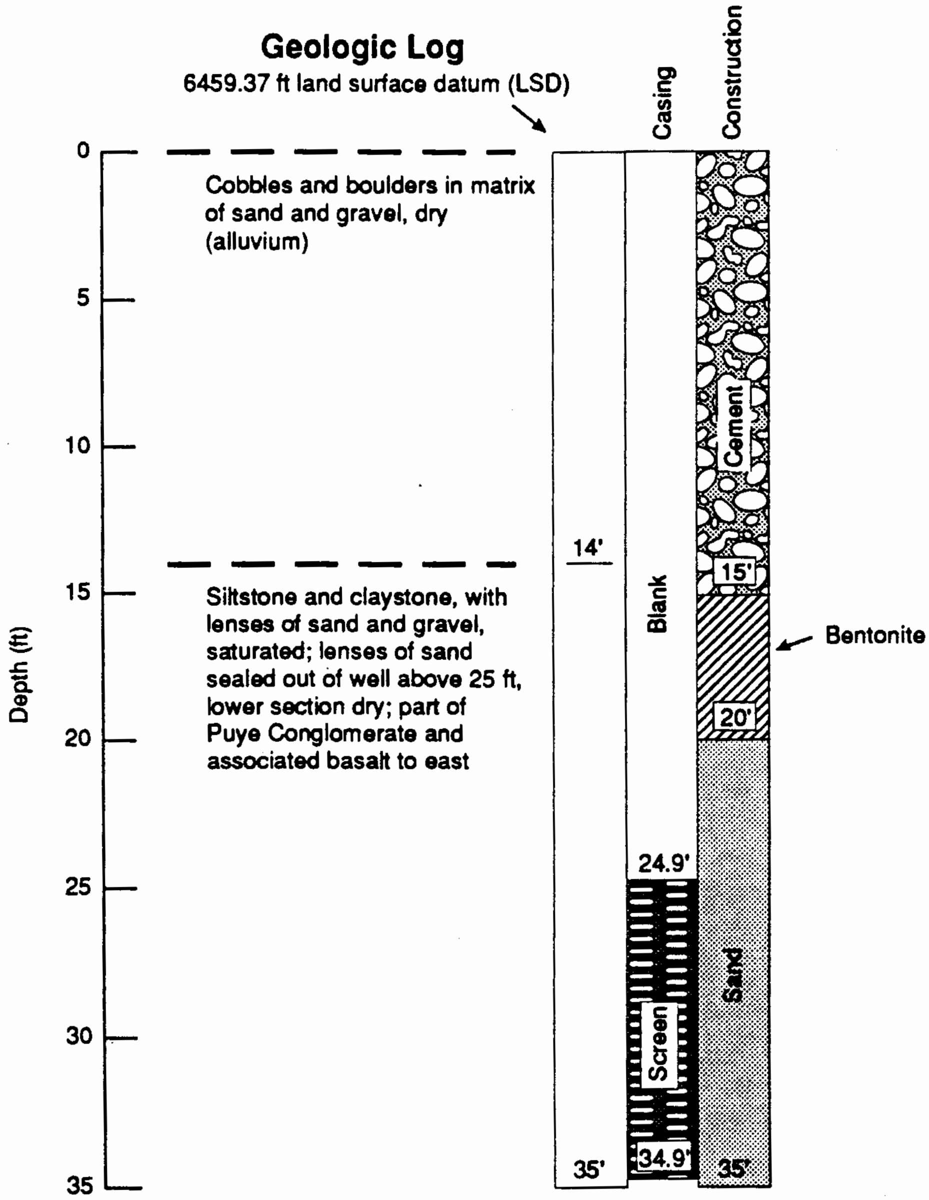


Fig. 4(b). Los Alamos Canyon observation well LAO-4.5B (completed September 16, 1989, dry)

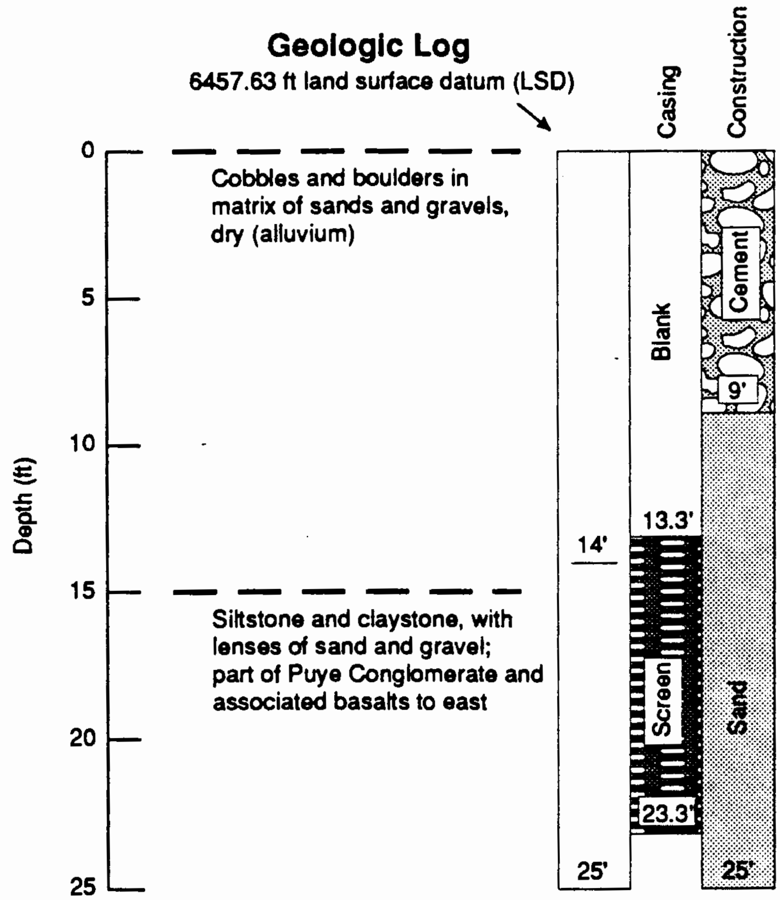


Fig. 4(c). Los Alamos Canyon observation well LAO-4.5C (completed November 22, 1989, water level 11 ft).

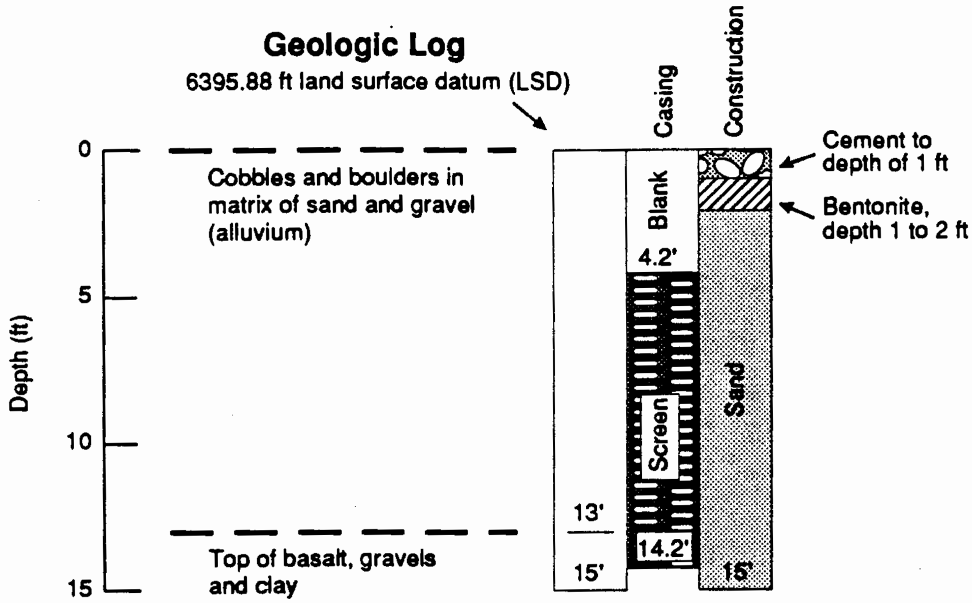


Fig. 5. Los Alamos Canyon observation well LAO-6A (completed August 17, 1989, water level 9.0 ft).

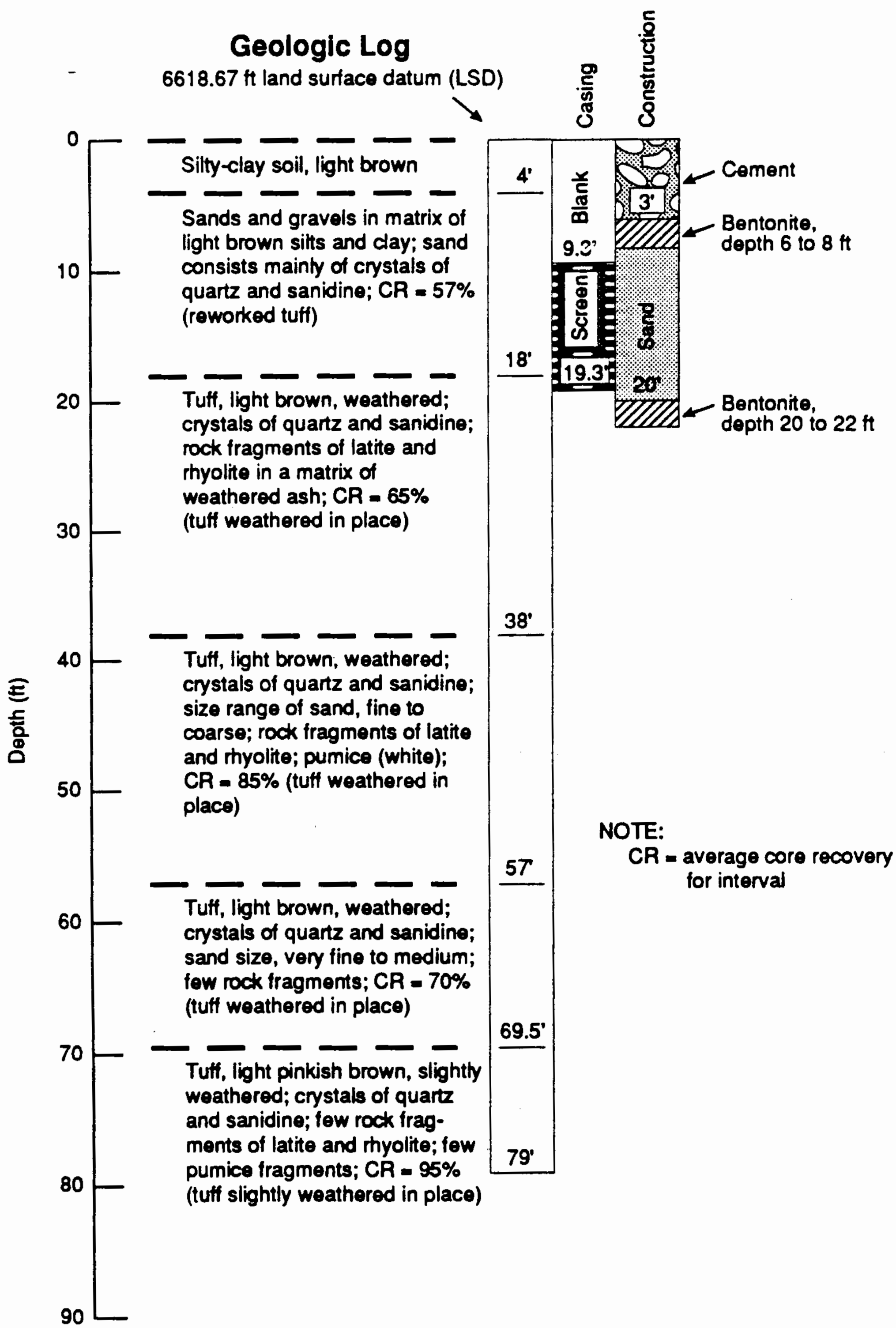
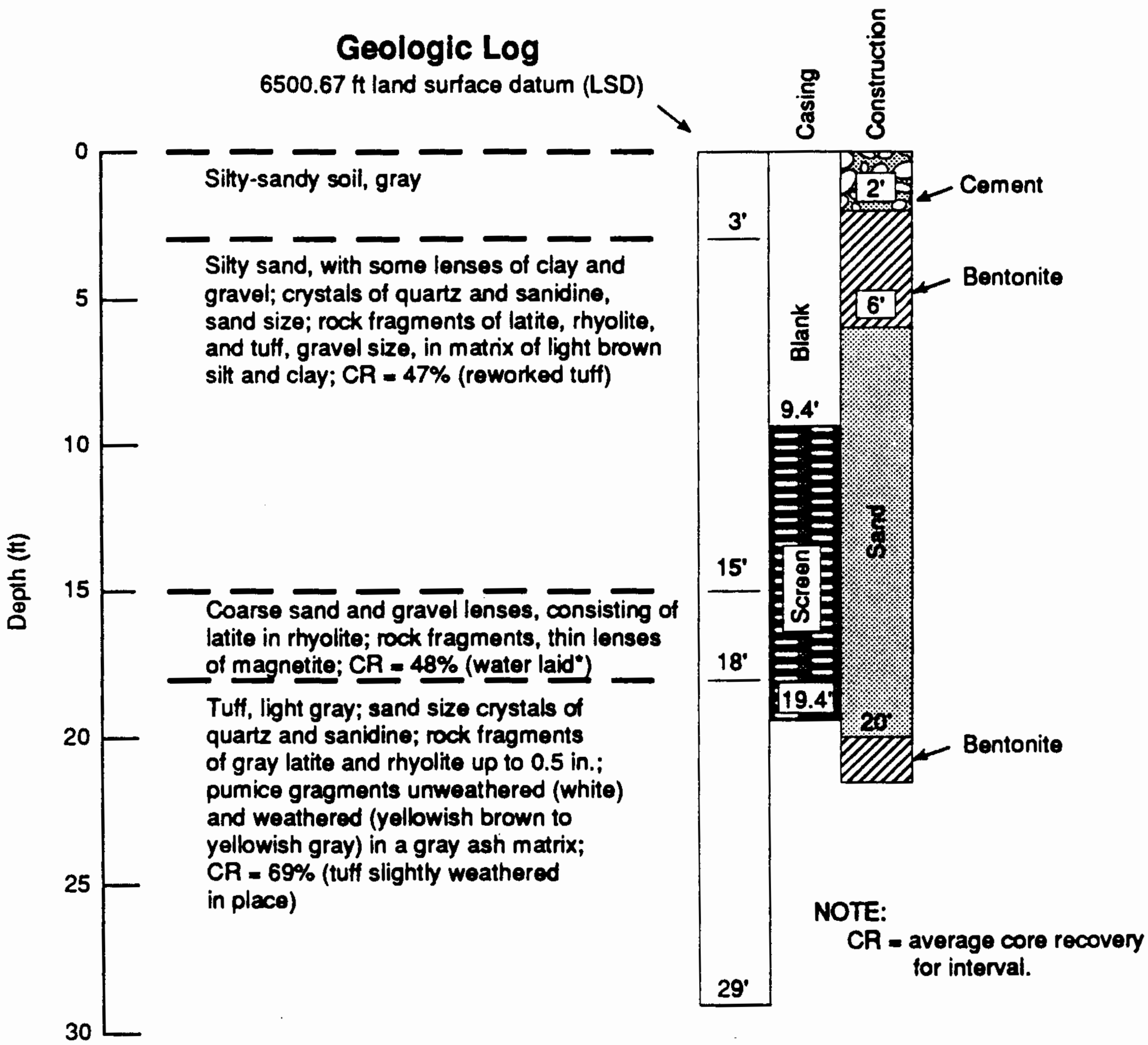


Fig. 6. Sandia Canyon observation well SCO-1 (completed August 15, 1989, dry).



*This 3-ft interval is apparently at the bottom of the Tshirege Member of the Bandelier Tuff (Tsankawi Member, Bailey 1967).

Fig. 7. Sandia Canyon observation well SCO-2 (completed August 16, 1989, dry).

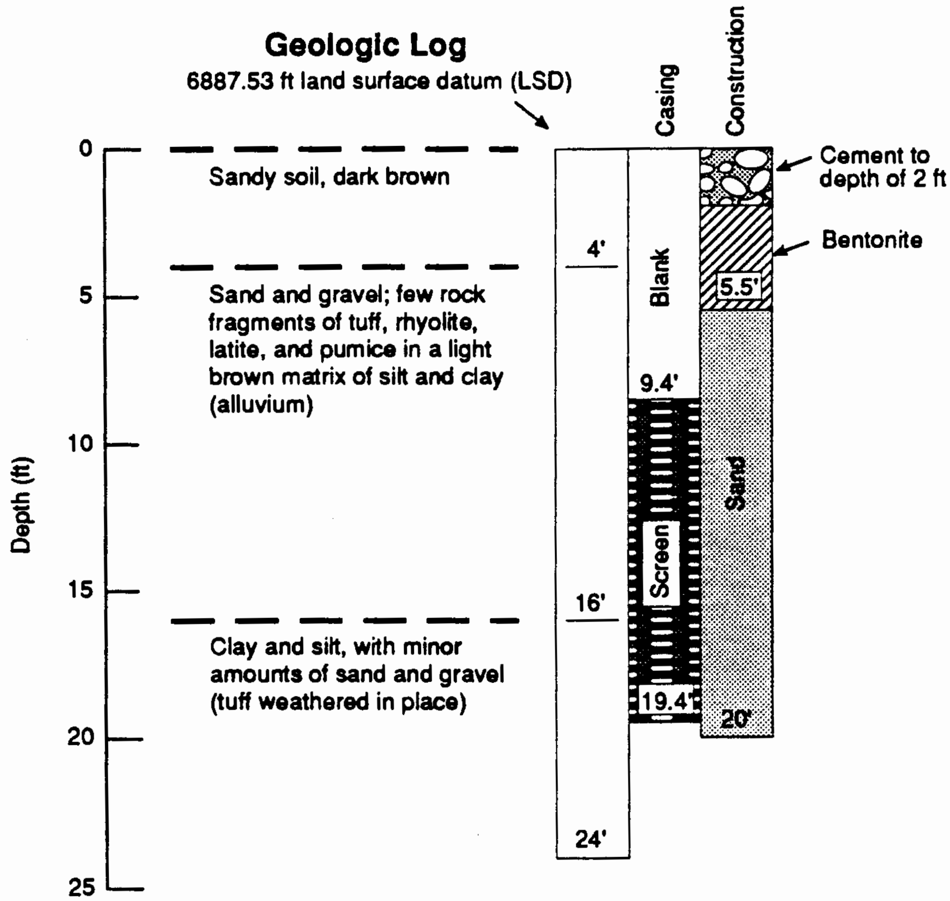


Fig. 8(a). Mortandad Canyon observation well MCO-4A (completed November 1, 1989, water level 5 ft).

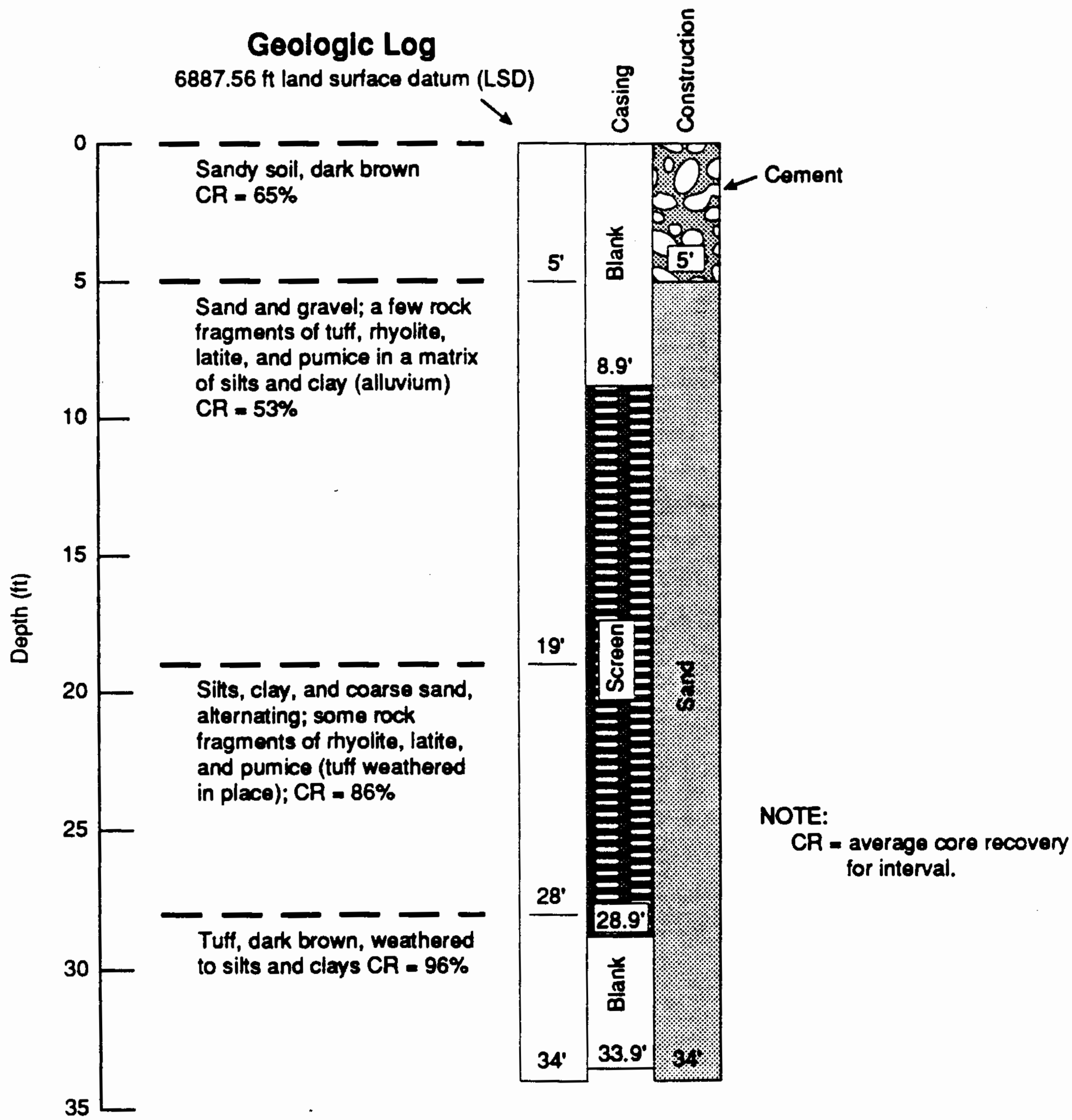


Fig. 8(b). Mortandad Canyon observation well MCO-4B (completed August 21, 1990, water level 22 ft).

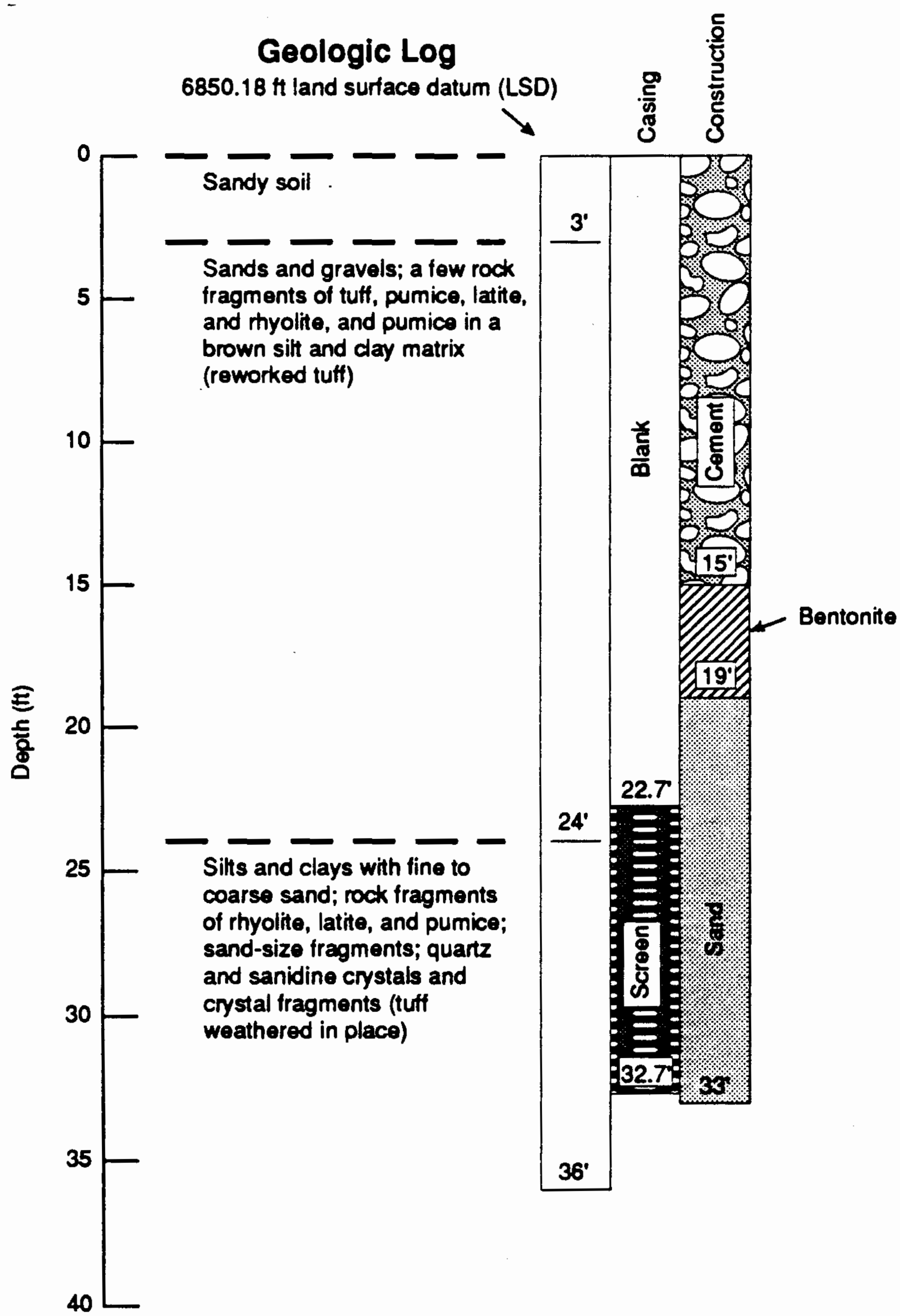


Fig. 9(a). Mortandad Canyon observation well MCO-6A (completed November 6, 1989, water level 30 ft).

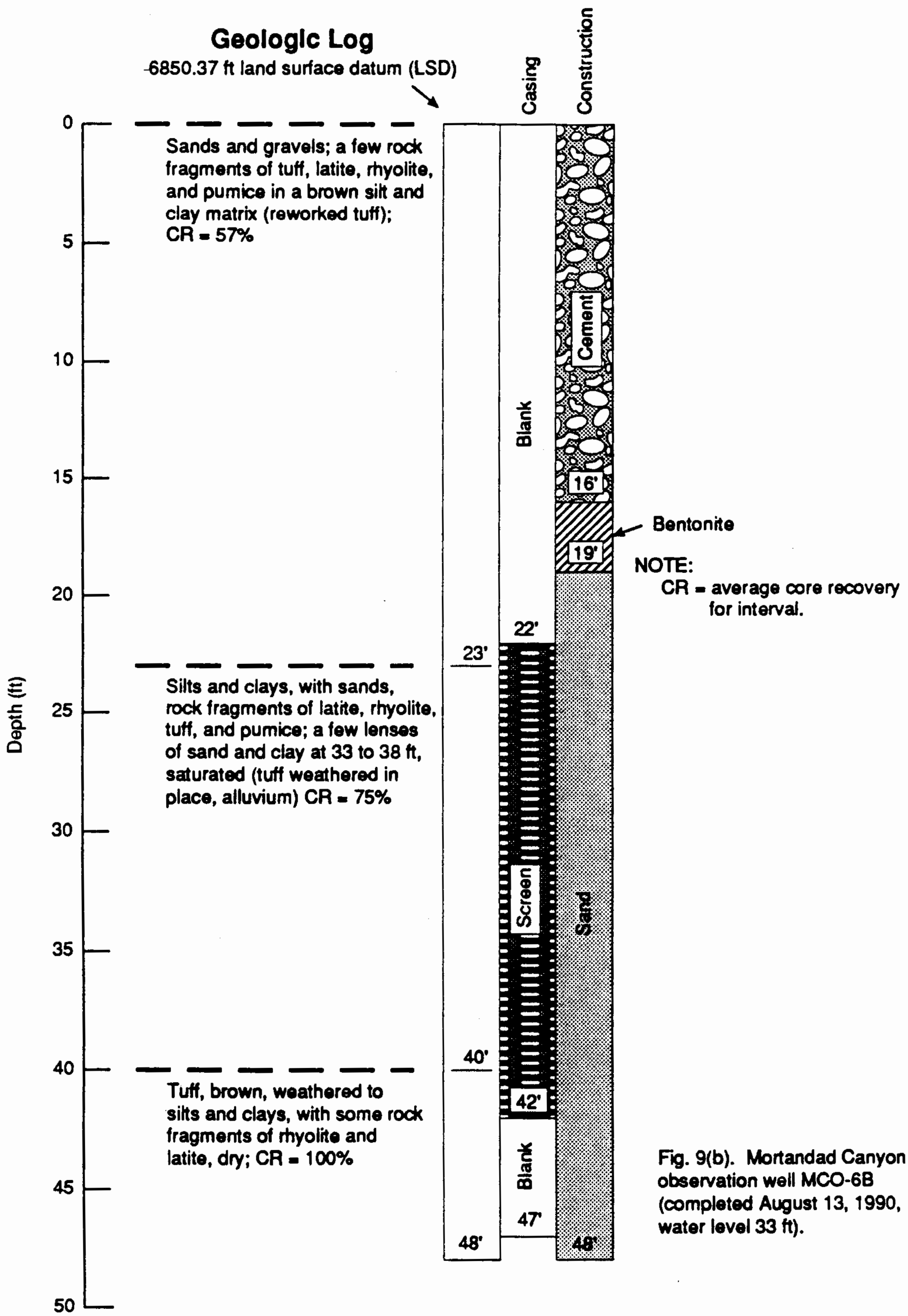


Fig. 9(b). Mortandad Canyon observation well MCO-6B (completed August 13, 1990, water level 33 ft).

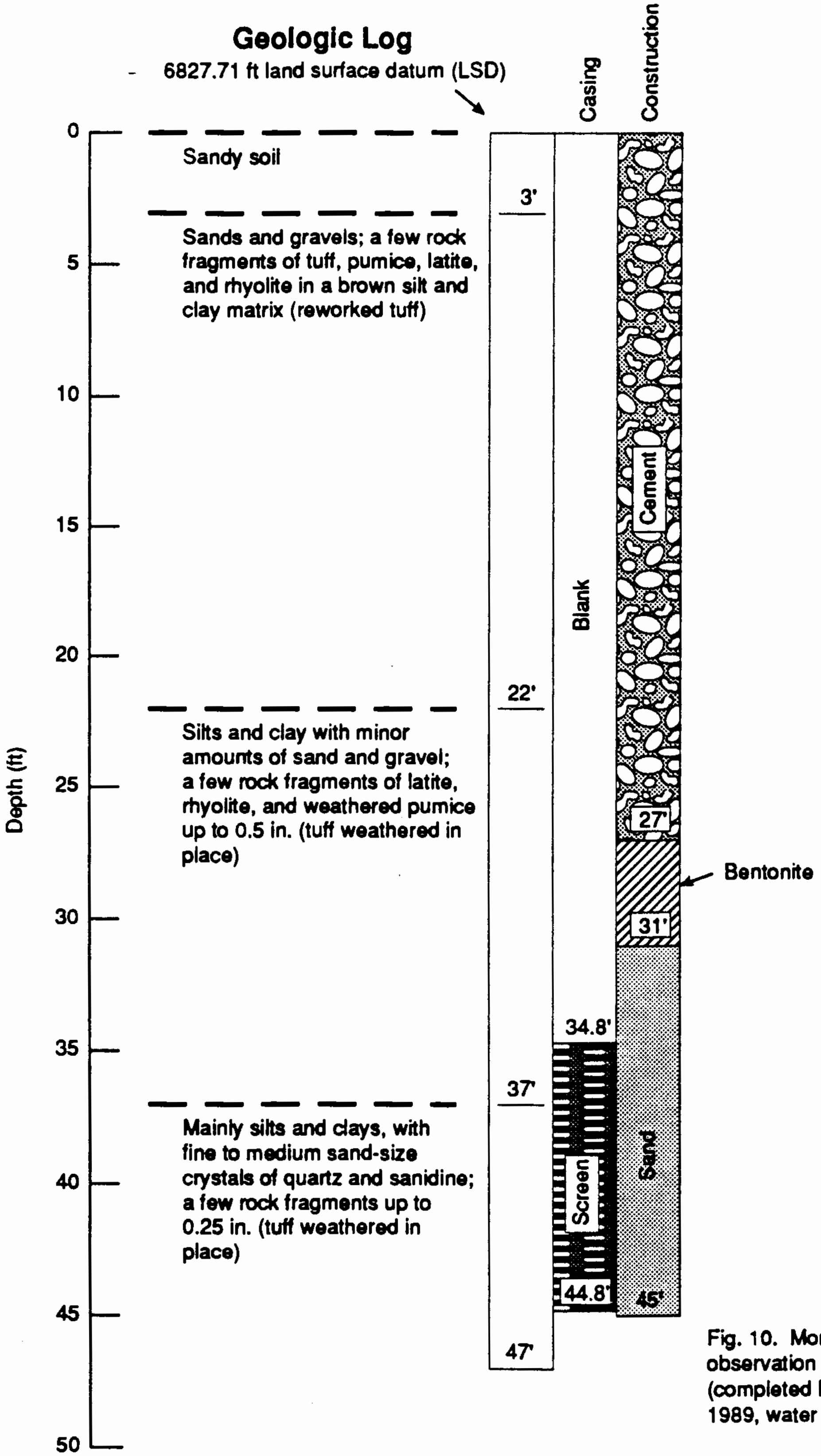


Fig. 10. Mortandad Canyon observation well MCO-7A (completed November 14, 1989, water level 35 ft).

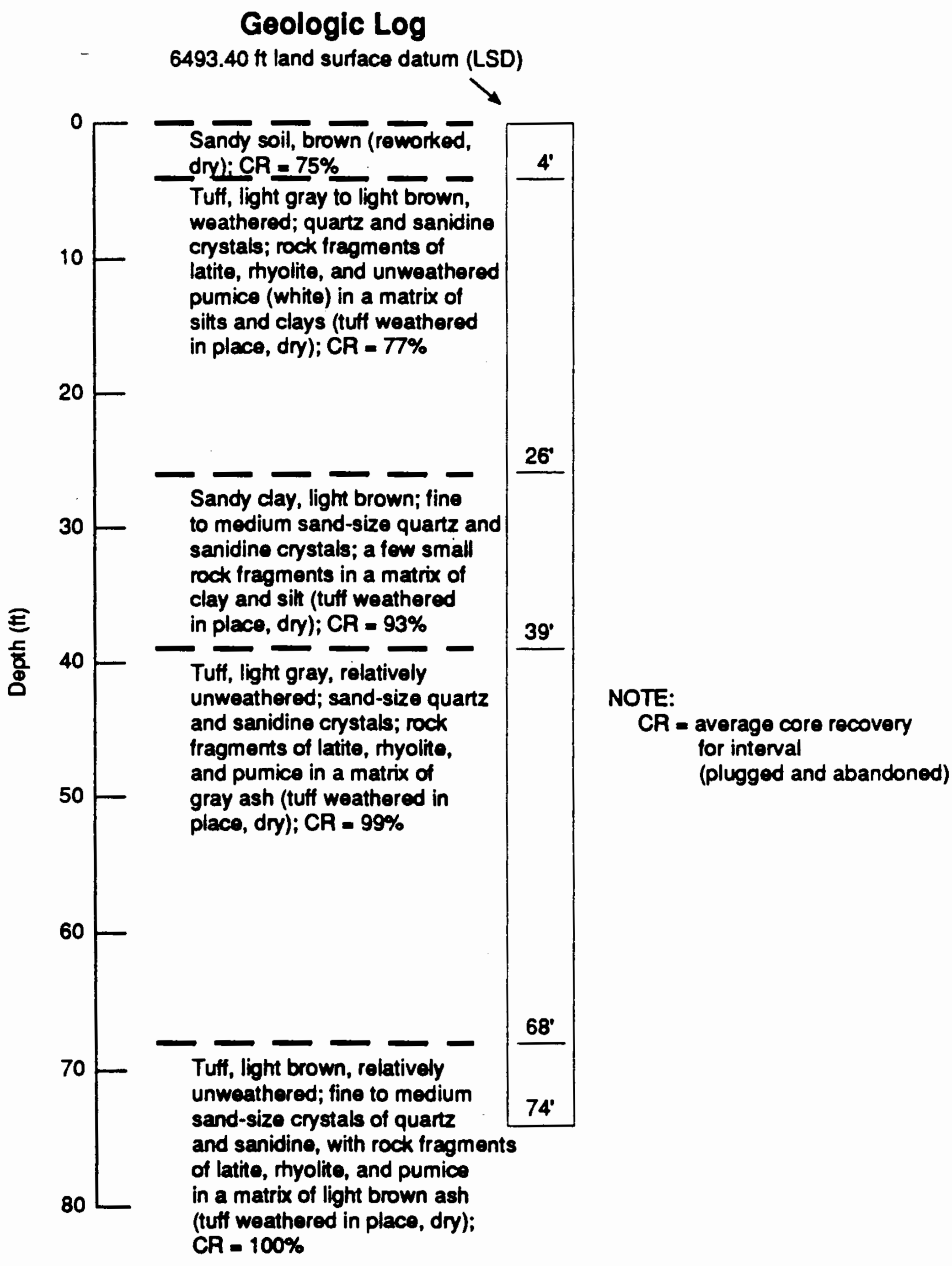


Fig. 11. Potrillo Canyon test hole PCTH-1 (completed October 20, 1989, dry).

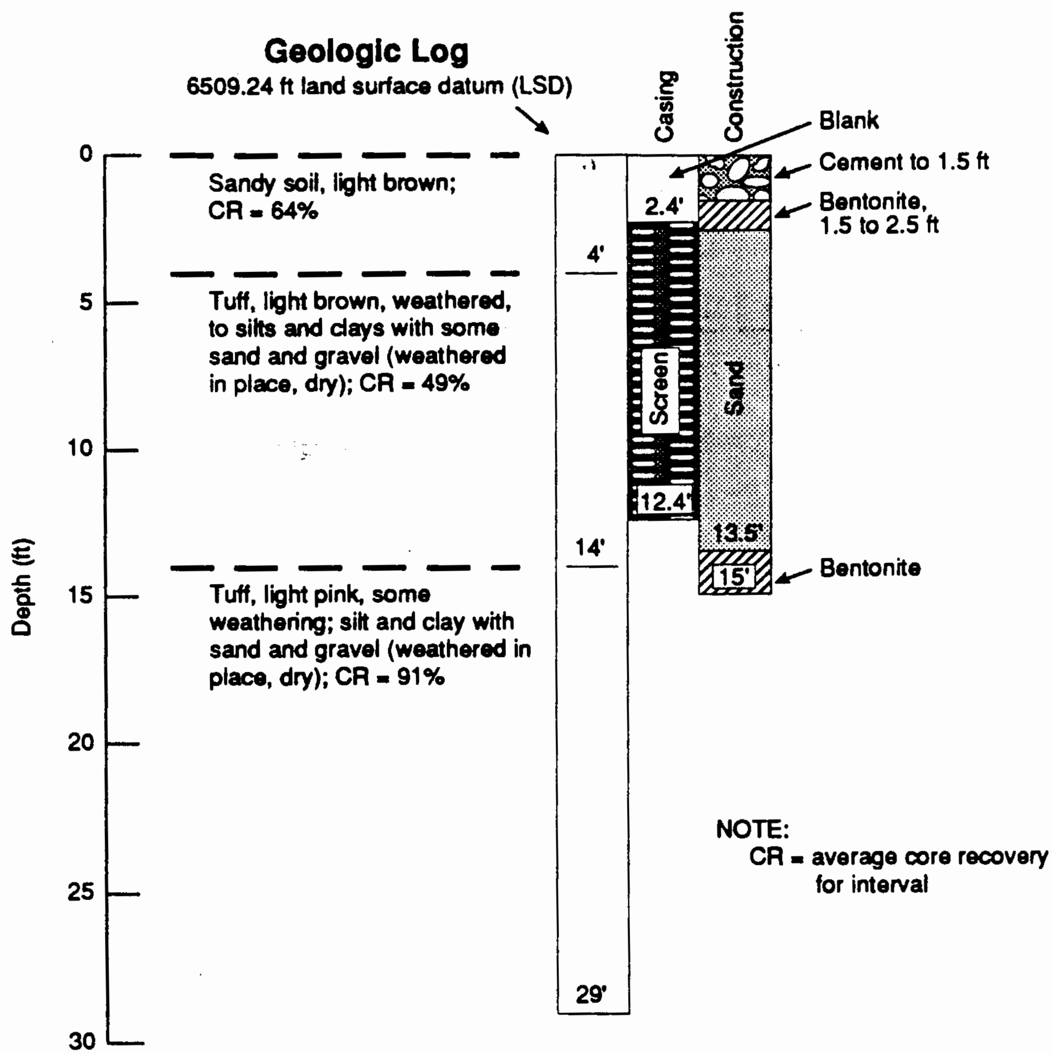


Fig. 12. Fence Canyon observation well FCO-1 (completed August 22, 1989, dry).

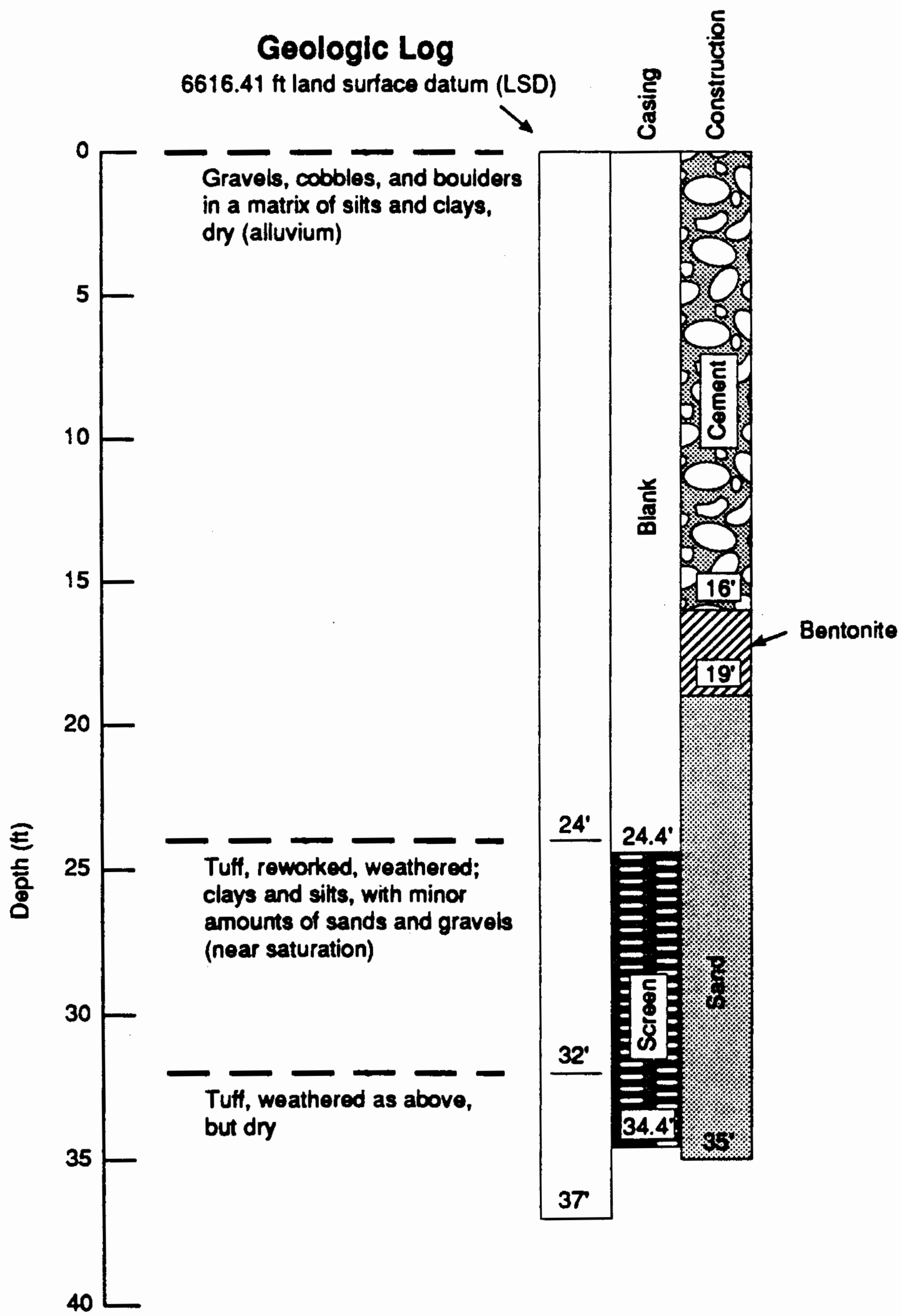


Fig. 13. Water Canyon observation well WCO-1 (completed October 31, 1989, dry).

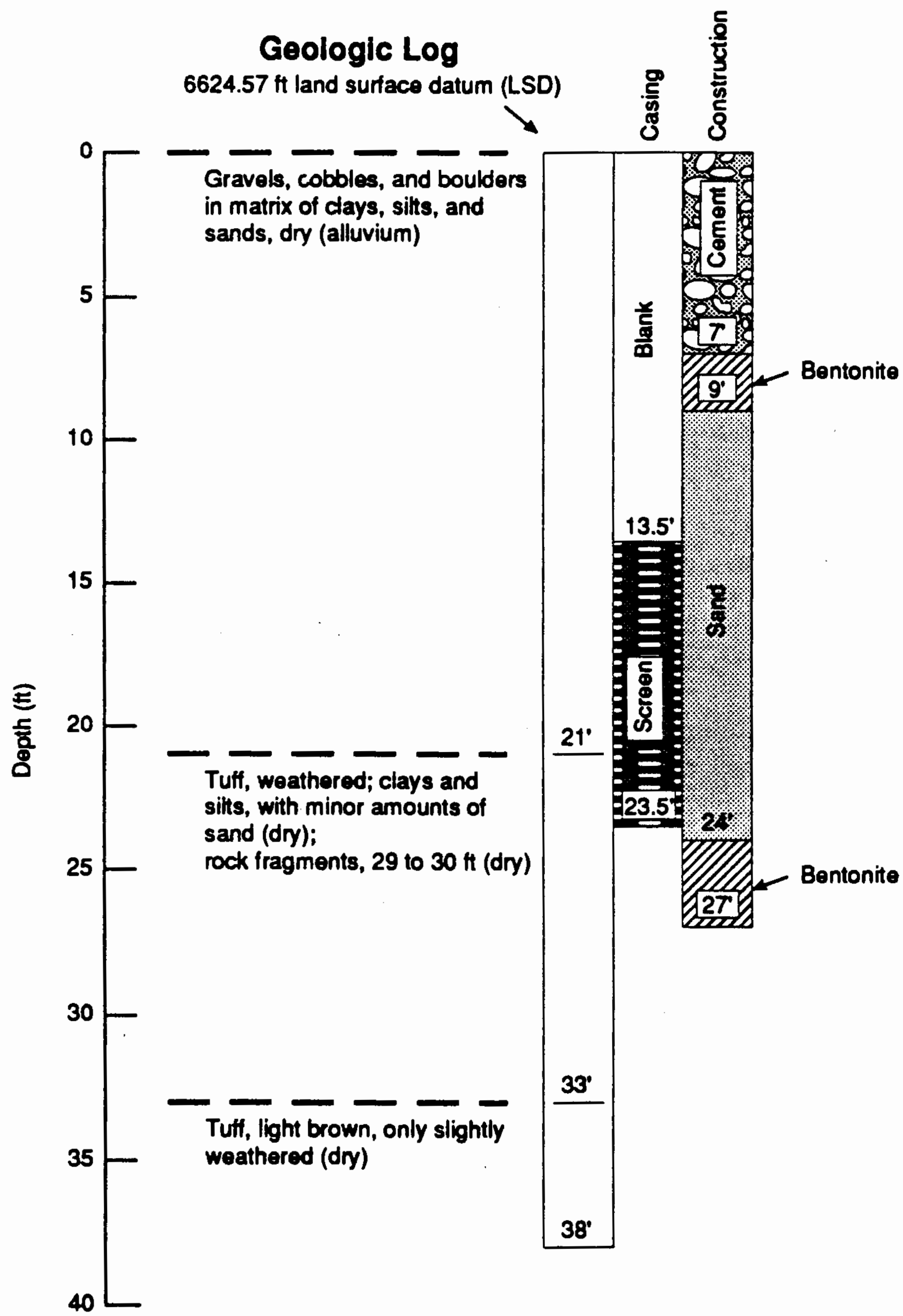


Fig. 14. Water Canyon observation well WCO-2 (completed October 26, 1989, dry).

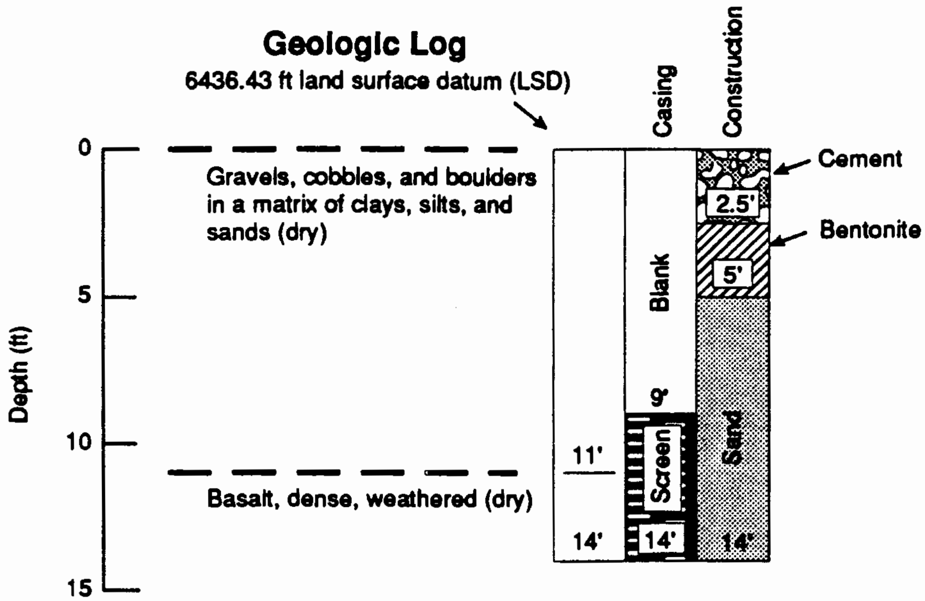


Fig. 15. Water Canyon observation well WCO-3 (completed October 25, 1989, dry).

LA-UR:90-4300

PERCHED ZONE MONITORING WELLS
ANALYTICAL RESULTS

ENVIRONMENTAL RESTORATION PROGRAM

December 19, 1990

PERCHED ZONE MONITORING WELLS
ANALYTICAL RESULTS

Module VIII of the Hazardous and Solid Waste Permit includes the requirement of Perched Zone Monitoring under Section C.1. In conformance with those requirements, new monitoring wells were installed in several of the canyons. The installation and construction of those wells was previously documented (Perched Zone Monitoring Well Installation, Los Alamos National Laboratory document LA-UR-90-3230, September 1990).

The special condition further requires: "Within 90 days of the installation of wells, the Permittee shall sample each well for Appendix IX constituents. Analytical results from those samples shall be sent to the administrative authority within 120 days of well installation."

In accord with these requirements, the new wells that contained water were sampled on September 11 and 12, 1990. The new wells sampled include MCO-4B, MCO-6B, and MCO-7A in Mortandad Canyon, LAO-3A and LAO-4.5C in Los Alamos Canyon, and APCO-1 in Pueblo Canyon. The samples were submitted to the Los Alamos National Laboratory Environmental and Health Chemistry Group, HSE-9, for analysis of radionuclides, most Appendix IX constituents, and some additional general chemical parameters. These samples were collected and analyzed in accordance with sampling procedures and QA/QC program elements documented in previous submissions to EPA under Special Permit Conditions C.2 and C.7.

At the same time, samples were collected from adjacent older wells in Mortandad and Los Alamos canyons to permit comparison of the results from those wells with results from the new wells constructed in accord with the permit conditions. (The older wells include MCO-4, MCO-6, and MCO-7 in Mortandad Canyon, and LAO-3 and LAO-4 in Los Alamos Canyon.) These older wells have long been monitored under the routine Environmental Surveillance program and data from them have been published annually in the Environmental Surveillance Reports which have been previously submitted to EPA and are now required by Special Permit Condition C.2.

The new wells were also sampled by the International Technology Corporation (IT) on November 1 and 2, 1990, for analysis of the entire Appendix IX list of constituents, including some analyses not presently performed by the Los Alamos Group HSE-9. The IT procedures and QA/QC program are documented in the attached report.

The results of the laboratory analyses are summarized in four attached tables:

Table I summarizes Radiochemical Analyses for Gross Gamma, Gross Alpha, ^{241}Am, Total U, ^{3}H, ^{137}Cs, ^{238}Pu, and ^{239,240}Pu. All of the constituents were present in locations and amounts expected from the results of the long term monitoring program.

Table II summarizes the Appendix IX Inorganic Constituents. Most of the metals were found in concentrations above detection limits in some or all of the samples, and in general, fit expectations of occurrence based on results of the long term monitoring program. Barium and lead levels were higher than previously observed. Sulfides were found in all the new wells at levels from 1 to 2.8 milligrams/L. Results from the two laboratories were comparable considering possible variation because of approximately seven weeks difference in sampling dates.

Table III summarizes the Appendix IX Organic Compounds Detected. The only Appendix IX organics detected that could not be attributed to minor analytical laboratory contamination included diethylphthalate (1800 micrograms/L) in the sample from one of the old wells (MCO-4.5) and the possible presence of N-nitrosomorpholine (3 micrograms/Liter) in two of the new wells (MCO-4B and MCO-6B) but at levels less than one-third of the reporting limit (10 micrograms/L) for the analytical method.

Table IV summarizes the general chemical parameters analyzed. These results indicate generally good comparability between the paired old and new wells.

All of the detailed analytical laboratory documentation is included as appendixes. The first appendix contains Los Alamos National Laboratory Environmental and Health Chemistry Group (HSE-9) documentation. The documentation is grouped with all radiochemical results first, all organic results second, and all inorganic results third. The second appendix contains the report of results obtained for Los Alamos by International Technology Corporation.

TABLE I

SUMMARY OF RADIOCHEMICAL ANALYSES OF SAMPLES FROM PERCHED ZONE MONITORING WELLS

		PARAMETER (pCi/L except where noted, +/- value is analytical standard deviation)								
WELL	LAB[1]	^{3}H	^{238}Pu	$^{239,240}Pu$	^{137}Cs	^{241}Am	Gross Alpha	Gross Beta (cm/L)	Gross Gamma	Total U (mg/L)
MCO-4B	HSE-9	67000±7000	0.0529±0.0213	0.112±0.027	28±69	1.47±0.10	9±3	120±10	110±80	6.4±0.1
MCO-4	HSE-9	43000±4000	0.371±0.042	1.42±0.92	101±70	4.14±0.19	8±3	160±20	80±80	1.5±0.1
MCO-6B	HSE-9	130000±10000	0.0187±0.0148	0.0327±0.0169	163±73	2.27±0.13	34±8	59±6	10±80	18.1±0.4
MCO-6	HSE-9	100000±10000	1.12±0.01	3.18±0.20	90±71	2.52±0.13	10±3	100±10	180±80	5.9±0.1
MCO-7A	HSE-9	21000±2000	0.0172±0.0106	0.0344±0.0137	20±70	0.375±0.042	7±2	18±2	20±80	6.5±0.2
MCO-7	HSE-9	13000±1000	0.0178±0.0154	0.444±0.0155	87±70	0.216±0.034	3±1	12±1	210±80	1.4±0.1
APCO-1	HSE-9	0±300	0.0038±0.0085	0.152±0.026	46±71	0.0584±0.0178	23±6	18±2	80±80	1.7±0.2
LAO-3A	HSE-9	1100±300	0.0047±0.0081	0.0094±0.0094	0±83	0.0389±0.0168	5±2	130±10	10±80	0.1±0.1
LAO-3	HSE-9	1300±300	0.0089±0.0089	0.0045±0.0077	11±63	0.0635±0.0203	5±2	130±10	20±80	6.6±0.7
LAO-4.5C	HSE-9	700±300	0.039±0.0184	0.0742±0.0197	83±70	0.098±0.216	4±1	9±1	120±80	0.3±0.1
LAO-4.5	HSE-9	700±300	0.0084±0.0103	0.0126±0.0094	2±64	0.171±0.0306	2.4±0.9	7.5±0.9	280±80	0.1±0.1

Notes:
[1] Entry indicates particular sampling date and analytical laboratory performing analyses.

HSE-9 samples collected on September 11 (MCO-4B, MCO-4, MCO-6B, MCO-7A, and MCO-7) or September 12, 1990 (MCO-6, APCO-1, LAO-3A, LAO-3, LAO-4.5C, and LAO-4.5) and analyzed by Los Alamos National Laboratory, Environmental and Health Chemistry Group, HSE-9.

TABLE II

SUMMARY OF APPENDIX IX INORGANIC ANALYSES ON SAMPLES FROM PERCHED ZONE MONITORING WELLS

		PARAMETER (micrograms/L)																		
WELL	LAB[1]	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Ni	Se	Ag	Tl	Sn	V	Zn	CN (mg/L)	Sulfides (mg/L)
MCO-4B	IT	<30	<40	190	<1	<5	<10	<20	10	<30	<1	<20	<60	<5	<40	<20	<10	81	0.01	2.0
	HSE-9	0.5	15.1	337	2.1	0.9	17.3		16.5	42.3	<0.2	10.9	2.5	0.3	0.4		171	72	0.041	
MCO-4	HSE-9	0.7	19.1	128	<0.1	0.9	15.9		17	2.8	<0.2	14.8	2.4	0.2	0.2		215	20	0.036	
MCO-6B	IT	<30	<40	690	4	<5	30	<20	30	70	<1	<20	<60	<5	<40	<20	30	150	<0.01	1.0
	HSE-9	<0.5	12.7	1670	8.3	0.7	22.5		17	163	<0.2	17.3	2.2	1.3	2.1		155	149	0.046	
MCO-6	HSE-9	<0.5	17.7	231	0.4	0.6	19.8		12.3	16.2	<0.2	16.3	2.6	<0.2	0.2		185	43	0.046	
MCO-7A	IT	<30	<40	420	3	<5	20	<20	30	50	<1	30	<60	<5	<40	<20	40	100	<0.01	1.6
	HSE-9	<0.5	15.8	820	4.7	0.7	28		21.2	94	<0.2	20.3	1	0.4	0.8		147	107	0.026	
MCO-7	HSE-9	<0.5	15.6	254	0.9	<0.5	15.8		49.7	16.8	<0.2	10.3	1	0.6	0.2		126	74	0.026	
APCO-1	IT	<30	<40	970	4	<5	30	40	120	80	<1	50	<60	<5	<40	<20	70	200	<0.01	1.6
	HSE-9	0.5	3.5	301	2.1	1.1	29.5		33	10.6	<0.2	37	1.	1.0	0.5		91	123	0.26	

TABLE II (continued)

WELL	LAB[1]	Sb	As	Ba	Be	Cd	Cr	Co	Cu	Pb	Hg	Ni	Se	Ag	Tl	Sn	V	Zn	CN (mg/L)	Sulfides (mg/L)
		PARAMETER (micrograms/L)																		
LAO-3A	IT	<30	<40	180	2	<5	20	<20	30	40	<1	<20	<60	<5	<40	<20	10	54	<0.01	2.8
	HSE-9	<0.5	<1	96.1	<0.1	0.6	1.9		<1	<0.5	<0.2	3.4	1.7	<0.2	<0.2		<1	<5	0.015	
LAO-4.5C	IT	<30	<40	95	<1	<5	10	<20	30	<30	<1	<20	<60	<5	<40	<20	<10	52	<0.01	2.2
	HSE-9	<0.5	<1	46.5	0.2	0.6	3.2		3	2	<0.2	4.1	<1.	<0.2	<0.2		4.1	20	0.01	
LAO-4.5	HSE-9	<0.5	<1	41.7	0.4	<0.5	14.4		38	<0.5	<0.2	7.3	1.	<0.2	<0.2		100	34	0.01	

Notes:

[1] Entry indicates particular sampling date and analytical laboratory performing analyses.

IT samples collected on November 1,1990, and analyzed by IT Corporation.

HSE-9 samples collected on September 11 (MCO-4B, MCO-4, MCO-6B, MCO-7A, and MCO-7) or September 12, 1990 (MCO-6, APCO-1, LAO-3A, LAO-3, LAO-4.5C, and LAO-4.5) and analyzed by Los Alamos National Laboratory, Environmental and Health Chemistry Group, HSE-9.

TABLE III

SUMMARY OF APPENDIX IX ORGANIC ANALYSES (COMPOUNDS DETECTED) ON SAMPLES FROM PERCHED ZONE MONITORING WELLS[1]

WELL	LAB[2]	RESULTS
MCO-4B	IT	N-Nitrosomorpholine, estimated at 3 ug/l, noted by laboratory as below reporting limit of10 ug/L for method.
	HSE-9	
MCO-4	HSE-9	Diethyl phthalate, 18 ug/L; also found in blank at 13.7 ug/L, analyst judges to be from laboratory contamination.
MCO-6B	IT	N-Nitrosomorpholine, estimated at 2 ug/L, noted by laboratory as below reporting limit of 10 ug/L for method
	HSE-9	Methylene chloride 6 ug/L, analyst judges to be from sample preparation or storage.
MCO-6	HSE-9	
MCO-7A	IT	Organophosphorus pesticide sample fraction exceeded holding time one day, nothing detected; resampled on Nov. 30 for reanalysis
	HSE-9	
MCO-7	HSE-9	1,1,2-Trichloro-1,2,2-trifluoroethane 6 ug/L, analyst judges to be from sample preparation or storage.
APCO-1	IT	
	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 ug/L; analyst judges to be laboratory contamination)
LAO-3A	IT	
	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 ug/L; analyst judges to be laboratory contamination)

TABLE III (continued)

WELL	LAB[2]	RESULTS
LAO-3	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 ug/L; analyst judges to be laboratory contamination)
LAO-4.5C	IT	
	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 ug/L; analyst judges to be laboratory contamination)
LAO-4.5	HSE-9	Carbon disulfide (same level as laboratory blank, about 35 ug/L; analyst judges to be laboratory contamination). Diethylphthalate, 1800 ug/L; 13.7 ug/l in lab blank.

Notes:

1 This table notes compounds detected and summarizes related interpretations.
See the detailed appendixes of analytical laboratory reports for details on all compounds all compounds analyzed, limits of quantification, and quality assurance information.

2 Entry indicates particular sampling date and analytical laboratory performing analyses.
IT samples collected on November 1,1990, and analyzed by IT Corporation.

HSE-9 samples collected on September 11 (MCO-4B, MCO-4, MCO-6B, MCO-7A, and MCO-7) or September 12, 1990 (MCO-6, APCO-1, LAO-3A, LAO-3, LAO-4.5C, and LAO-4.5) and analyzed by Los Alamos National Laboratory, Environmental and Health Chemistry Group, HSE-9.

TABLE IV

SUMMARY OF GENERAL CHEMICAL PARAMETER ANALYSES OF SAMPLES FROM PERCHED ZONE MONITORING WELLS

		PARAMETER (mg/L except where noted)													
WELL	LAB[1]	Ca	Mg	K	Na	P	SO4	Cl	NO3-N	Al	Fe	Mn	TDS	pH (pH)	Cond. (μmho/cm)
MCO-4B	HSE-9	55.4	5.66	45.1	209	0.361	46.5	<0.5	50.2	15	–	0.518	712	7.54	717
MCO-4	HSE-9	55.4	3.64	46.5	142	0.276	40.9	19.2	40.5	1.5	–	0.030	568	7.47	635
MCO-6B	HSE-9	53	10.2	32.8	278	0.876	54.9	34.4	15	113	–	2.56	834	7.31	905
MCO-6	HSE-9	57.6	6.61	54.9	268	0.333	49.4	29.3	70.1	8.3	–	0.265	884	7.37	894
MCO-7A	HSE-9	25	5.78	11.3	112.6	0.924	22.9	28.1	18.8	57.4	–	1.62	220	6.96	220
MCO-7	HSE-9	26.9	5.42	8.90	89.6	0.566	21.6	<0.5	13.7	280	–	0.206	280	7.06	300
APCO-1	HSE-9	22.4	3.43	14.8	103	6.12	40	17.3	4.52	448	2.9	1.05	448	7.04	304
LAO-3A	HSE-9	29.1	5.55	12.1	47.9	0.317	20	17.5	1.16	58	<0.02	0.015	274	7.0	257
LAO-3	HSE-9	29.4	5.67	11.7	47.2	0.328	20.3	17.3	1.05	116	15	0.412	234	7.08	294
LAO-4.5C	HSE-9	18.4	5.16	5.93	46	0.146	20.5	13.3	0.094	2.6	0.037	0.011	188	7.01	185
LAO-4.5	HSE-9	4.12	5.05	5.51	46.8	0.161	17.4	13.5	0.073	2.5	<0.02	0.002	154	7.12	201

Notes:

1 Entry indicates particular sampling date and analytical laboratory performing analyses.

HSE-9 samples collected on September 11 (MCO-4B, MCO-4, MCO-6B, MCO-7A, and MCO-7) or September 12, 1990 (MCO-6, APCO-1, LAO-3A, LAO-3, LAO-4.5C, and LAO-4.5) and analyzed by Los Alamos National Laboratory, Environmental and Health Chemistry Group, HSE-9.