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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
ALBUQUERQUE, NEW MEXICO

The hydrology and the chemical and radiological quality of surface and ground water at Los Alamos, New Mexico, January 1956 through June 1957

By

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Prepared in cooperation with and for administrative release only to the Atomic Energy Commission and University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

Not reviewed for conformance to
Geological Survey nomenclature or editorial standards

August 1962

9107

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The hydrology and the chemical and radiological quality of surface and ground water at Los Alamos, New Mexico, January 1956 through June 1957

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Abstract

This report is one of a series of reports describing investigations by the U.S. Geological Survey of the movement of industrial and sewage wastes in the Los Alamos area. Los Alamos, in north-central New Mexico, is on the Pajarito Plateau, which is formed by the Bandelier Tuff.

Several lines of holes 11 to 73 feet deep were drilled across the middle to lower reaches of Pueblo Canyon near where the canyon is cut into the conglomerate underlying the tuff. Water perched in the alluvium and within the conglomerate was sampled.

Most of the radioactive wastes discharged into Acid Canyon were retained in the upper foot of the alluvium and did not reach Pueblo Canyon. Concentrations of other ions in the wastes decreased sharply downgradient in Acid Canyon and were decreased further by dilution in Pueblo Canyon.

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Streamflow in Pueblo Canyon and water levels in the wells finished in the alluvium in Pueblo Canyon are controlled by precipitation and snowmelt and discharge from the waste and sewage treatment plants in Acid and Pueblo Canyons. Changes in the water level and the quality of water in the shallow test wells indicate a possible hydraulic connection between the aquifers and the surface water in Pueblo Canyon. The slightly declining water levels in the deep test wells may be due to a long-term trend.

The quality of the water from the supply wells in Los Alamos and Guaje Canyons is good and water levels are relatively stable. Slight differences in the quality of water between wells is evident.

The concentration of the ions in water from springs downgradient from the Acid-Pueblo Canyon disposal system was somewhat higher than in samples from other springs in the Los Alamos area.

Introduction

This report describes data collected in the Los Alamos area during the period January 1956 through June 1957. It is the third of a series describing waste disposal at Los Alamos (Abrahams, 1962), and is prepared in cooperation with the Atomic Energy Commission and the University of California, Los Alamos Scientific Laboratory. Much of the data and conclusions stated herein are similar to those described for the period 1949 through December 1955 (Weir and others, 1962).

The general geology and hydrology of the Los Alamos area have been described by Griggs (1955). The physiographic features of the Los Alamos area are shown on figure 1, and the stratigraphic relation

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Figure 1.--Generalized map of the physiographic features of the Jemez Mountain region, New Mexico, and sampling stations on the Rio Grande and Rio Chama.

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of rocks in the Los Alamos area is shown in figure 2.

Figure 2.--Diagrammatic cross section showing generalized stratigraphic relations of the Bandelier Tuff to older rocks in the Los Alamos area.

Samples of water from the Rio Grande and Rio Chama were collected by the Surface Water Branch of the Geological Survey, and the observation wells in Pueblo Canyon were drilled by the Denver Hydrologic Laboratory of the Geological Survey. The chemical and radiochemical analyses of water samples and the radiological analyses of samples of alluvium were made by the H-7 group of the Health Division of the Los Alamos Scientific Laboratory, under the direction of C. W. Christenson, Group leader.

The chemical quality of water is given in parts per million (ppm), whereas the radiological quality is given as either disintegrations per minute per liter (d/m/l) or counts per minute per liter (c/m/l). The geometry of the disintegrations is figured at 50 percent, with one count per two disintegrations. The chemical and radiological data are on file at the Los Alamos Scientific Laboratory at Los Alamos.

Acid-Pueblo Canyon disposal system

The floor of Acid Canyon below the waste treatment plant drops about 200 feet in less than half a mile and is cut into the Tshirege (upper) Member of the Bandelier Tuff. The alluvium beneath the channel in the canyon is 2 to 5 feet wide and generally about 1 to 3 feet thick. The alluvium in the upper one-third of the stream channel is a pebbly sand and in the lower two-thirds it is a gravelly sand.

The floor of Pueblo Canyon drops about 800 feet in 6 miles below the Pueblo Sewage Plant (fig. 3). In the upper half of this reach

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Figure 3.--Map of Los Alamos area, showing locations of sampling stations.

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the canyon is cut into the Otowi (middle) Member and the Guaje (lower) Member of the tuff and drops about 170 feet per mile. The alluvium ~~in~~ beneath the streambed generally is about 2 to 8 feet thick, although in some places it may be as much as 15 feet thick. The lower part of the canyon is cut into the Puye Conglomerate which underlies the Bandelier Tuff. The alluvium in the lower part of the channel ranges from 1 to 20 feet in thickness. ~~depending upon the consolidation of the underlying conglomerate.~~

Installation of wells

Drive points and dug wells were first installed in the Acid-Pueblo Canyon disposal system in 1954 (Weir and others, 1962, in preparation). In Acid Canyon, the dug wells AC-1 to AC-4 (fig. 3), consist of a 5 to 6 foot length of corrugated iron pipe 1 foot in diameter with about 50 holes, one-eighth inch in diameter, in the lower half for screening. Well AC-5 consists of a standard sandpoint 1½-inches in diameter driven into the alluvium. Wells PC-1 to PC-10 in Pueblo Canyon consisted of standard sandpoints 1½-inches in diameter driven into the alluvium and commonly into the underlying tuff.

Some changes in the types of wells were made during 1956 for better sample collection and because some sandpoints were destroyed in the spring of 1956 and others were destroyed in a flash flood in August 1956. Wells PC-6, PC-7, and PC-9 were replaced with dug wells in July and August 1956 because the sandpoints were driven into the unsaturated tuffaceous material underlying the alluvium and little or no water entered the wells.

Wells were drilled in Pueblo Canyon in the reach from about one-quarter of a mile upstream and about three-quarters of a mile downstream from Hamilton Bend on April 10-18, 1956, to establish an adequate observation well network and to attempt to define geologic and hydrologic conditions in the canyon (fig. 4 and table 1).

Figure 4.--Map showing location of observation wells, and the geology of the lower part of Pueblo Canyon.

The drilling equipment used, was a truck mounted power drill with a 4-inch diameter auger, and was too small for the types of materials encountered in Pueblo Canyon. The rock bit broke after several days of drilling and a reaming bit was substituted. The reaming bit proved unsatisfactory as the teeth sheared off when drilling in bouldery material and were ground off when drilling in consolidated material. Both the cuttings and sample recovery at most holes were poor.

Some wells were cased with 3-inch diameter galvanized pipe, and others with either 1½-inch diameter galvanized pipe or 2-inch diameter plastic pipe. Four rows of vertical slots 1/16 to 1/8-inch wide were cut with a torch into the lower 9 feet of the 3-inch pipe to allow water to enter. The bottom end of the 3-inch pipe was cut and welded into an "orange-peel" tip. Four rows of 1/16-inch diameter holes were drilled into the lower 10 feet of the plastic pipe and the bottom was sealed with a wooden plug. Sandpoints were used for screens on the 1½-inch pipes. After casing was installed the augered holes were backfilled around the casings to within several feet of the surface with sand from the streambed and to the surface with a silty soil above the sand.

Most of the wells located were on sections or lines across Pueblo Canyon. The sections are numbered 1 to 4 from east to west. The wells are designated by the letters "PO" followed with a number, or a number and a letter. Each well along a section is identified by the number of the section in which it is located. The south well in each section is given only the section number. Letters A, B, C, etc., are added, in order from south to north, to the section number for other wells across the section. Holes PO-5 and PO-6 are not on sections. The locations of the wells are shown on figure 4, and a brief description of them is given in table 1.

Description of findings

Examination of samples collected at the time the holes were drilled showed that some of the holes penetrated the base of the Bandelier Tuff, but that most of the holes were drilled directly into the underlying Puye Conglomerate. The stream in Pueblo Canyon apparently cuts through the Bandelier and into the Puye just west of Hamilton Bend. The gradient of the stream is about 90 feet per mile between well TW-2 and Hamilton Bend, about 70 feet per mile from just west of Hamilton Bend to Otowi Seep, and about 95 feet per mile between Otowi Seep and the basalt at the bridge in sec. 21, T. 19 N., R. 7 E.

Three general types of deposits within the upper part of the Puye Conglomerate are traversed by the stream between the tuff above Hamilton Bend and the basalt at the bridge in sec. 21, T. 19 N., R. 7 E. The southern extent of an alluvial fan is exposed in the southwestern part of section 17 and the northeastern part of section 18 (fig. 4). It is composed of fanglomerate which has chaotic sorting of angular blocks, boulders, and gravel in a matrix of sand. Some blocks are as much as 5 feet across. A second type of deposit laps onto this fan from the west side and is a water-laid material containing lenses of boulders, gravel, and sand in a matrix of silt-size reworked tuff. A third type of deposit crops out at the head of Capture Canyon and between the fan and the confluence of Pueblo and Los Alamos Canyons. This deposit is a water-laid silt or reworked tuff in which the rock and tuff particles are a maximum of about one-half inch in diameter. The finer material on the west, south, and east sides of the fan were apparently derived by erosion of the fan itself.

The deposit of silt or reworked tuff is covered by thin alluvium from a point upstream from Hamilton Bend to about 200 feet upstream from well PO-1A, where it appears to dip eastward beneath the alluvium. It is at a depth of about 17½ feet at well PO-1A and at about 22 feet at well PO-1C. The top of this deposit at well PO-2 is about 3 feet beneath the level of the alluvium in the streambed, which may indicate that it has a southward dip at this site.

Water was found in all holes in sections 3 and 4, but drained from wells PO-3 and PO-3A within several days and from well PO-4 within several months. Water in wells PO-3 and PO-4 was perched on the layer of silt and apparently poured into the hole during drilling. It drained slowly out of the wells after the screens were sealed off from the overlying lens of water by the backfill around the casing. The water in well PO-4 probably was perched within the Puye and received recharge from the stream. Water was not found at sections 1 and 2, except for a thin lens perched on the layer of silt in the alluvium at well PO-2A.

Wells PO-3B, PO-4A, and PO-4B also were finished within the Puye. The aquifer or lenses of water supplying wells PO-4A and PO-4B probably are recharged by Pueblo stream. The source of water in well PO-3B is not certain. The water level in well PO-3B is about 20 feet beneath the streambed and about 25 feet beneath the level of Hamilton Bend Spring which is about 300 feet to the east. The silt layer which perches the water at Hamilton Bend Spring may also perch the water at well PO-4B.

About 40 gallons of water were poured through a hose into well PO-3B within about 14 minutes on May 8, 1957 to study the characteristics of the zone of perched water supplying the well. The water level was 4.65 feet above the pre-pouring level three minutes after pouring stopped, and the pre-pouring level of the water was not reached until about 9 hours later. This indicates that the transmissibility of the zone is low and the discharge from the well would be small if pumped.

The layers of sediments between the holes in section 3 that can be correlated indicate a southward dip of the bedding within the Puye. No correlation at section 4 was attempted. The tuff at PO-4B appears to be eroded away, which indicates that the main Pueblo stream at one time may have been several hundred feet north of its present position. Several feet of the base of the Guaje Member of the tuff may underlie the alluvium in the south part of the canyon. A stream draining a box canyon on the south side of Pueblo Canyon cuts through the base of the tuff into the underlying Puye several hundred feet east of well PO-4.

Water-level measurements

Factors affecting ground water levels and streamflow in Acid-Pueblo Canyon are precipitation, discharge from the two sewage-treatment plants in Pueblo Canyon, and discharge from the waste-treatment plant in Acid Canyon. The precipitation (fig. 5) during 1956 was 11.53 inches, which was 6.80 inches below normal and near the record low. Discharge from the sewage-treatment plants (table 2) decreased substantially during the spring and summer months. The discharge from the waste-treatment plant in Acid Canyon was about 3 to 4 million gallons per month during the period of this study.

Streamflow from snowmelt in Pueblo Canyon was maximum during late May 1956 and reached to the Otowi Seep area. The eastern extent of the surface flow receded from east of well PO-1A by May 23, 1956 to near Hamilton Bend by May 24, and to between wells PC-4 and PC-5 by June 7.

The streamflow in 1957 was greater and more sustained than in 1956 due to increased precipitation, and, apparently, bodies of perched water collected in the alluvium along section 4 and in the middle part of Pueblo Canyon. Only a limited amount of water reached the lower part of Pueblo Canyon. Flow measurements in March, April, and May 1957 (table 3) show that some water was lost to the alluvium above the outfall from the sewage-treatment plant and near well PO-4A. The increase in streamflow between well PC-2 and well PC-3 may reflect a slug of water discharged from the plant in Acid Canyon, and the increase at well PC-5 reflects the discharge from the sewage-treatment plant. The crest at well PO-4A was reached in early April and at well PC-10 in June.

The depth to water in the observation wells, well PC-10, and the shallow test wells, are shown in figure 5. The water levels in well PO-4A

Figure 5.--Depth to water in observation wells, well PC-10, and the shallow test wells in Pueblo Canyon, and precipitation data January 1956 through June 1957.

during 1956 and in well PO-1A during 1957 may represent water standing in the casings rather than the true water levels. The sharp decline of the water level in well PO-4 may represent the decrease in discharge from the sewage-treatment plants in the spring months and the end of snowmelt in the high country to the west. The casing on well PO-4 was broken off about 15 feet below land surface during an attempt to deepen the well, and the recovery of the water level in 1957 could not be determined. However, water levels in well PO-4A and PC-10 responded to increased streamflow in 1957 due to snowmelt, increased precipitation, and continued high discharge from the Central Sewage Plant.

It is not known where the water from these perched bodies moves. The water along section 4 apparently does not recharge the water-bearing bed supplying well PO-3B, as evidenced by the relatively stable water level in the well, although the source of recharge to the water-bearing bed at well PO-3B may be further west in the canyon. Some water probably moves eastward on a perching layer and is the source for Hamilton Bend Spring, a small seep near well PC-8 and Otowi Seep. Surface outlets for the body of water perched in the alluvium near PC-10 have not been found. There are no springs or seeps in Bayo or Capture Canyons to the northeast, and water flow in the lower part of Pueblo Canyon only during spring runoff or during summer storms. However, the water may move through joints in the underlying basalt and recharge the perched zone supplying test well 1A.

Changes of water levels in test wells TW-1A and TW-2A (fig. 5) indicate that the wells to some degree are hydraulically connected to the Pueblo stream. Water-level fluctuations caused by periodic pumping of these wells to collect water samples makes interpretation of the data difficult. The water level in well TW-2A continued to rise slowly from early 1953 through June 1957, even though the precipitation during the previous 10 years was substantially less than normal. This rise was probably due to the general increase of waste discharge into upper Pueblo Canyon during this same period. This constant flow infiltrated the upper reaches of Pueblo Canyon instead of moving downstream as did high flows during spring runoff and floodflow, and thus did not reach the probable recharge area of well TW-1A. The water level in well TW-1A declined slowly since 1950, except for a period in 1952 after heavier than normal precipitation. The time of response of water levels to recharge appears to be about 4 to 6 months at well TW-2A and about 1½ to 2 months at well TW-1A, although the data are inconclusive.

Chemical and radiochemical quality of water and radiochemical quality of streambed materials

Water samples from Acid Canyon generally were collected during the early morning hours before the start of discharge from the waste-treatment plant.

The sampling point near well AC-4 was in a small pocket of silty clay; the other sampling points were in sandy alluvium. Samples collected at Acid Weir generally consisted of water from a small seep in the streambed. Samples were collected from wells AC-3, AC-4, and near Acid Weir on eleven dates during the period of this report at approximate bi-monthly intervals. Well AC-5 was sampled several times. Samples in Pueblo Canyon were collected on ten dates, although not from each well on each sampling date.

The wells generally were prepumped for 5 to 10 minutes before each sample was collected so that the sample would be representative of water in the alluvium. Sample collection usually was started in Acid Canyon and continued in sequence to lower Pueblo Canyon.

The pH of the wastes discharged generally was high, and in water samples collected in Acid Canyon was commonly above 10. The range of the pH in the samples was 6.7 to 11.8, although about 90 percent were higher than 9. Water of pH 10 or above, where the hydroxyl ion may be dominant, is unstable and the quality tends to change. The pH decreased downstream on 8 of the 11 sampling dates (table 4), so that the pH of water entering Pueblo Canyon from Acid Canyon generally was about 8.0 to 8.5.

An overall trend of the concentrations of the cations in samples collected in Acid and Pueblo Canyons were not evident. The concentration of calcium ions was slightly less in samples from well AC-4 than in samples from well AC-3, possibly indicating some uptake of the calcium ions in the clays around well AC-4. A slight decreasing trend in the concentration of the sodium ion in Pueblo Canyon was evident. The differences in the ranges of the concentrations in Acid and Pueblo Canyons are listed below:

Ion	Acid Canyon		Pueblo Canyon	
	Range, in parts per million	Percent of samples within indicated range	Range, in parts per million	Percent of samples within indicated range
Calcium	20 - 60	95	6 - 40	100
Magnesium	0 - 5	50	5 - 15	70
Sodium	40 - 200	90	40 - 100	85

The concentrations of the calcium and sodium ions were less in Pueblo Canyon, probably due to dilution.

The pH and the average concentration of anions and total solids generally were less in Pueblo Canyon (table 4) than in Acid Canyon, primarily due to dilution. The concentrations of chemical constituents in water collected from well PC-2 generally averaged slightly higher than in water from well PC-1, indicating that the higher concentrations were added from Acid Canyon. The average concentrations generally decreased downstream from well PC-2. The concentration of fluoride ions ranged between 4 and 9 ppm in about 60 percent of the samples collected in Acid Canyon, but decreased to approximately the municipal tolerance of 1.5 ppm (based on daily air tempertures of 53.8-58.3) in the lower part of Pueblo Canyon. The concentration of the chloride ion ranged between 20 and 50 ppm in about 85 percent of the samples collected in Acid Canyon, and only slightly less in Pueblo Canyon. The concentration of the nitrate ion was less than 60 ppm in about 90 percent of the samples collected in Acid Canyon and significantly lower in Pueblo Canyon. The relatively high average of nitrates in samples from well PC-4 persisted on most sample dates. The dissolved solids did not decrease significantly in Pueblo Canyon and were slightly above municipal tolerances of 500 ppm at wells PC-9 and PC-10 in the lower part of Pueblo Canyon. The dissolved solids in two samples collected in 1956 from Otowi Seep, in the streambed near well PC-9, averaged 2,731 ppm. The quality of water in samples from Hamilton Bend Spring in Pueblo Canyon was similar to that from the Pueblo Canyon wells.

There were no significant trends of changes of the plutonium or uranium ions or the gross alpha in Acid Canyon (table 4 A and 4B) except that the concentrations were significantly higher through October 1956 than after that date. These high concentrations may have been due to uptake on fine particles of clay which were not filtered out before analysis. When samples were centrifuged and filtered, after October 1956, the average values decreased considerably. The high average concentration of plutonium in samples collected before October 1956 was due in part to concentrations on several sampling dates as high as 468 d/m/l.

The highest concentration of uranium and gross alpha and gross beta, 614 d/m/l, 664 d/m/l, and 3,400 c/m/l, respectively, were obtained in samples collected on June 26, 1956 during discharge from the treatment plant. The sample containing the 3,400 c/m/l of gross beta was surface flow at Pueblo 1 near PC-2; samples from several wells, Acid Canyon and PC-2 also contained relatively high counts of gross beta on that date (table 4A).

The concentrations of the radioactive constituents in water samples collected at most stations in Acid and Pueblo Canyons also were significantly higher through October 1956 than those collected after this date (tables 4A and 4B). The high average gross beta was due primarily to samples collected on June 26, 1956. The concentration of the radioactive ions tended to decrease downstream, but the trend was too irregular to form a pattern. Concentrations in the surface flow seemed to reflect those in Acid Canyon to some extent.