

REPORT OF DRILLING AND TESTING PROGRAM
TO LOCATE A WATER SUPPLY WELL
IN THE BANDERA CRATER AREA,
EL MALPAIS NATIONAL MONUMENT

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A water supply well was needed to supply domestic needs for the Bandera Crater Visitor Center, Trading Post area, and the National Park Service (NPS) maintenance and residence areas at El Malpais National Monument (Figures 1 and 2). A well located in this area would be used to supply water to a storage tank. Water would then be distributed to the four areas of use via underground pipelines. Existing water supply wells in the vicinity had been constructed for stock or domestic use, though none of them produce more than small, 1-2 gallons per minute (gpm), quantities of water.

The Monument and Southwest Regional Office requested assistance from the Water Resources Division in locating and developing a water supply source prior to proceeding with development plans for visitor or maintenance facilities. It was recognized that water could be a limiting resource affecting development in this area.

Location

The project area is located in the vicinity of Bandera Crater adjacent to State Highway 53, about 20 miles southwest from Grants (Figure 1). First priority was given to locating potential well sites on land already owned by NPS. Two potential well sites and three target aquifers were located within the project area.

Hydrogeology

The project area lies immediately south of the Zuni Mountains at the north end of the El Malpais lava beds. The geologic map of the area (Maxwell 1986) shows surficial outcrops of alluvium, lava, Yeso and Abo Formations in the area. Granitic basement rocks outcrop on the flanks of the Zuni Mountains and are probably found at depths of several hundred feet below land surface beneath the

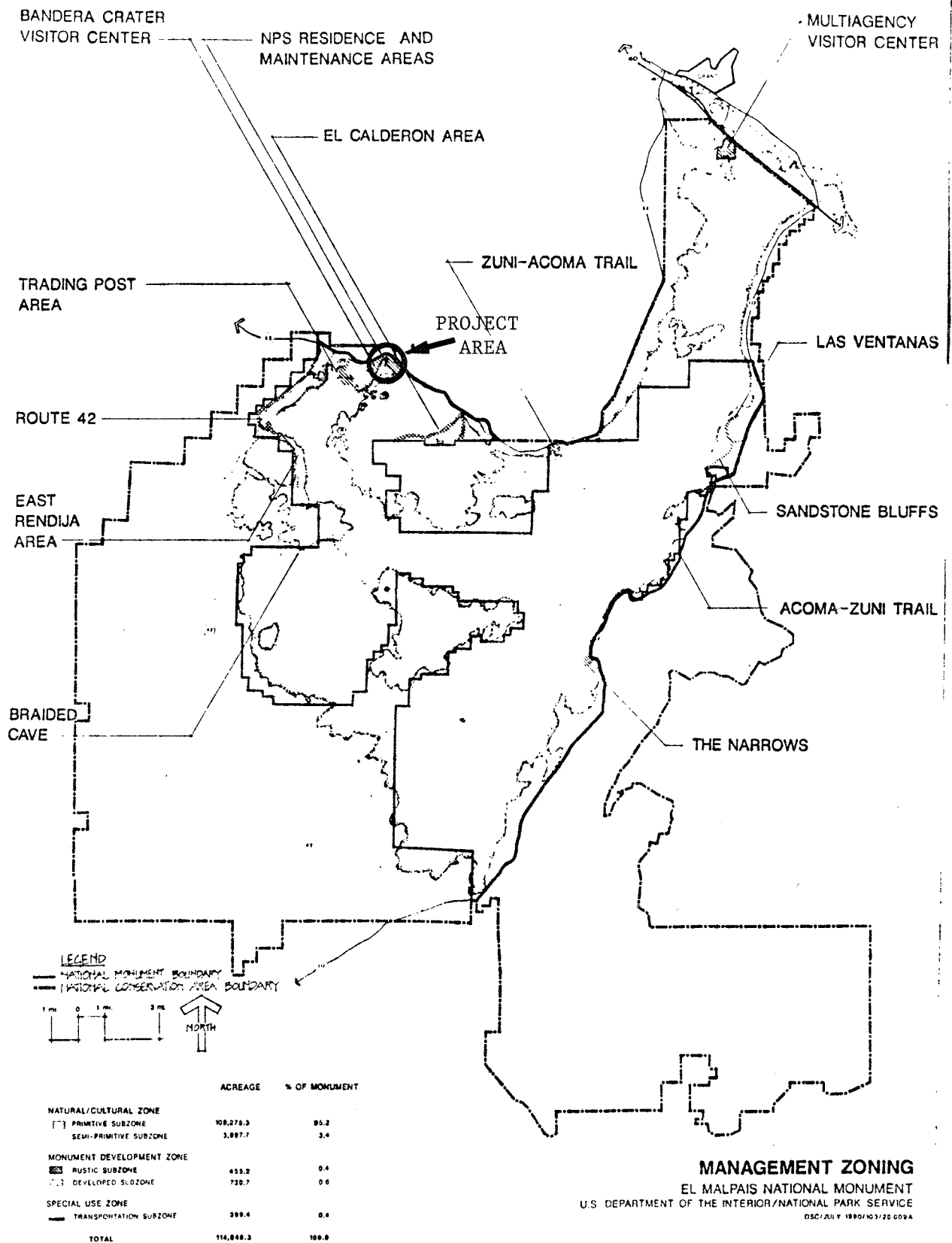


Figure 1. Location of project area in El Malpais N. M.

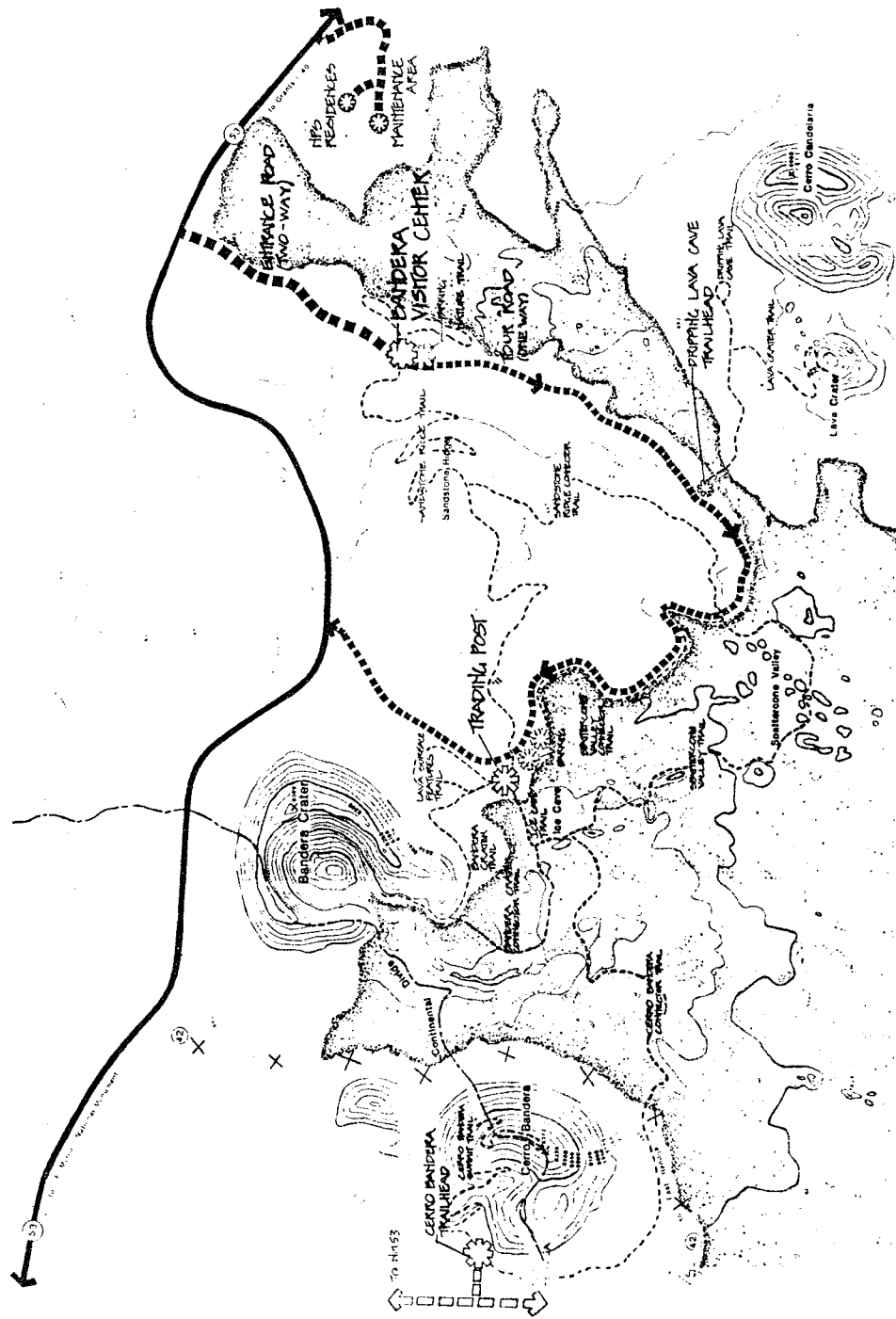


Figure 2. Proposed development in the Bandera Crater area.

alluvium and lava. A simplified geologic map based on Maxwell's map is shown in Figure 3.

Thickness of the alluvium in the Agua Fria Creek valley is not known. A windmill north of the highway, in Section 18 is reported to be 180 feet (ft) deep and completed in alluvium. This well yields only a few gallons per minute during the wet season, with yield decreasing in the dry periods of the year. The method of well construction and efficiency are not known. The drainage basin of Aqua Fria Creek is large enough to maintain groundwater flow in the alluvium.

The extent and thickness of lava in the project area is unknown. The large porosity of lava is conducive to recharge of most of the precipitation falling on it, and thus has the potential for holding large volumes of water. Lava is not known to be a reliable source of groundwater in this area. It may be that the high porosity and hydraulic conductivity allow rapid movement of water through the lava toward discharge areas.

The Yeso Formation (Fm.) is a medium-to-fine grained cross-bedded sandstone and siltstone. The formation is 1300 ft thick toward the center of the basin. Outcrops of the Yeso Fm. generally occur to the southwest of the area considered for well locations.

The Abo Fm. is a reddish sandstone and siltstone with layers of conglomerate in the lower 200 ft. Layers of mudstone and claystone are interbedded with the coarser grained layers. The Abo Fm. is a flood-plain deposit that accumulated under both fluvial and quiet-water conditions. It is from 600 to 650 ft thick. The well on the Bill Vance property a few miles to the northwest is reported to be completed in either the Abo or overlying Yeso Formations. This well produces a few gallons per minute of good quality water.

The granitic rocks of the Zuni Mountains yield small quantities of water to springs or wells from faults or fractured zones. It was thought that there was a possibility that Aqua Fria Creek may be aligned with local faulting or fractures following a northwest-southeast trend. There is a general trend throughout northern New Mexico of lineaments following a N55E orientation (Tom Crouch, USGS, pers. comm.). Satellite photos and topographic maps were examined to identify locales where a N55E trending feature intersected the valley of Aqua Fria Creek to identify areas of higher than average potential for intersecting fractures in the granitic rocks.

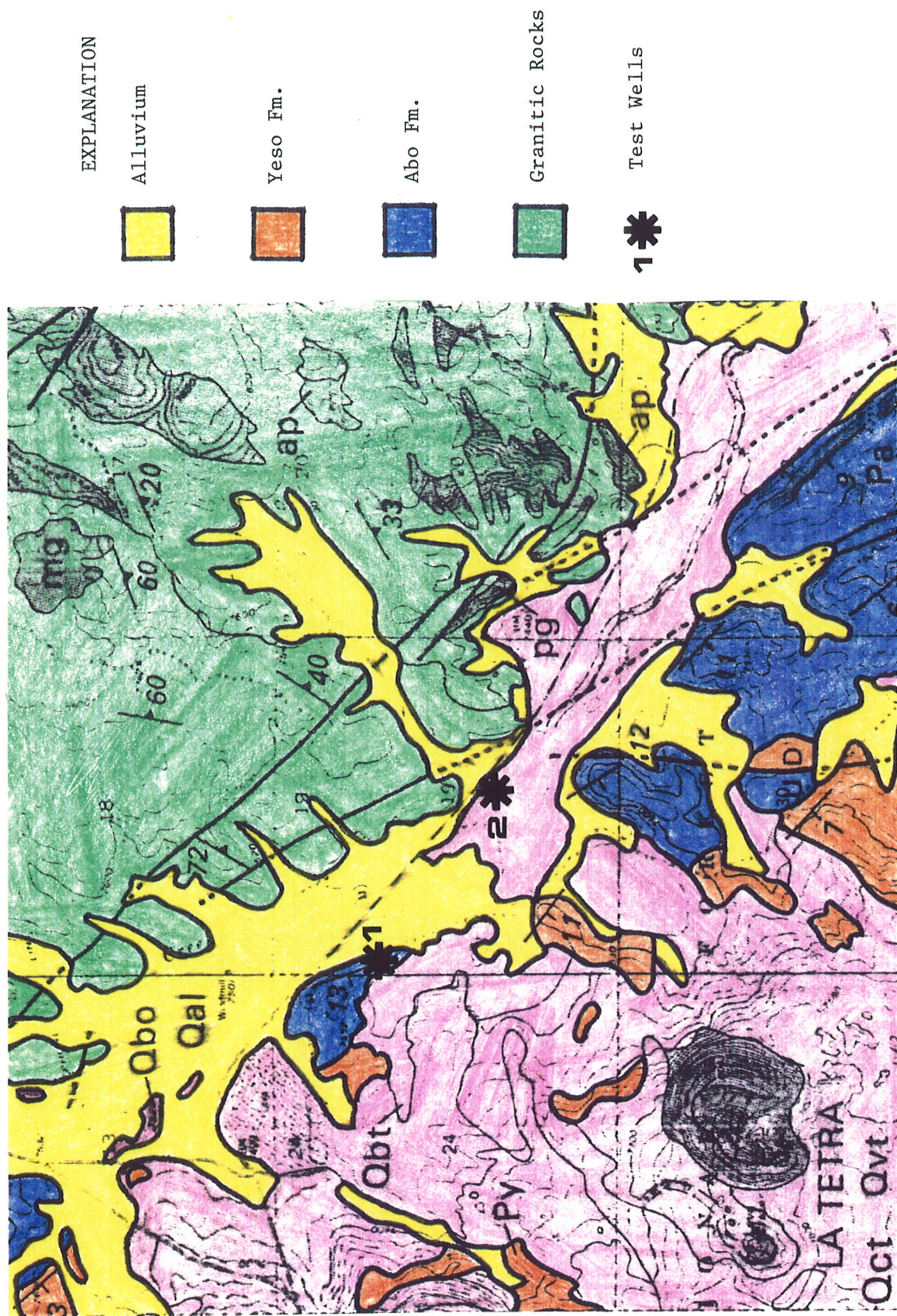


Figure 3. Generalized Geologic Map of the project area (after Maxwell, 1986).

Test Well Sites

The Abo Fm. was selected as a potential target aquifer in the project area because of the presence of the basal conglomerates. It should have suitable water quality because of proximity to recharge areas on the flanks of the Zuni Mountains. Further out in the basin the water in the Abo Fm. is saline due to long residence time in the formation. The alluvium is a potential source for the water supply, but a windmill immediately north of the area produces only 1-2 gpm. It is not known if better well construction methods could result in higher yield. Granitic rock underlying the alluvium could be a potential water source if fractures are encountered.

Locations for test wells were identified in the field with assistance from Kent Carlton and John Zubia (NPS) on June 5, 1991. The primary site is located on a small ridge outcropping of Abo Fm. in the SW1/4, of the NW1/4, of the NW1/4 of Section 19 (Figure 3). The Abo Fm. in this area is probably about 600-650 ft thick or less, depending on the amount that may have been removed through erosion processes. This particular site was selected because of its accessibility, proximity to points of use, favorable geology, and because the land is already owned by the NPS. The Abo Fm. yields good quality water to domestic wells at several locations within a few miles northwest of this site. It is reported to have a basal conglomerate layer that may yield larger quantities of water.

An alternative drilling location and target aquifers were also identified. The alternative site is in the valley of Aqua Fria Creek in the NW1/4, of the NW1/4, of the SE1/4 of Section 19, on the southwest side of the highway, across from an unnamed tributary canyon (Figure 3). The first target aquifer at this site would be the alluvium. The alluvium in this area is probably at least 150 ft thick, based on information available for the windmill in Section 18. If the alluvium proves to be an unacceptable aquifer, the well could be deepened to attempt to intersect fractures in the underlying granitic rock. Fracture systems in northwestern New Mexico generally trend N55°E. This location was selected because the tributary canyon is oriented at approximately N55°E. If the canyon location is in any way correlated to bedrock fractures, the chances of obtaining suitable quantities of water are enhanced.

Test Drilling Results

The first test well was drilled in the Abo Fm. in the SW1/4, of the NW1/4, of the NW1/4 of Section 19. The Abo Fm. forms a low ridge rising about 50 ft above the Aqua Fria Creek valley in this area.

Drilling at the site was conducted from November 4-7, 1991. Drilling was through Abo Fm. to a depth of 405 ft. Drilling was continued for another 15 ft into the granitic rocks. No water was encountered in this hole. It remained dry even after being allowed to set overnight. The hole was backfilled with cuttings and a cement surface seal.

The second test hole was drilled in the NW1/4, of the NW1/4, of the SE1/4 of Section 19, on the southwest side of the highway, across from an unnamed tributary canyon. Drilling and preliminary testing was conducted from November 9-20, 1991. Water was encountered in this hole from a fracture(s) in the granite at about 270-275 ft below land surface. The log for this hole is listed below.

Log of Test Hole No. 2

<u>DEPTH (in feet)</u>	<u>Description</u>
0-30	Lava, vesicular, dark-grey to black.
30-35	Cinders, weathered, very soft, reddish.
35-57	Lava, hard, dense, light grey.
57-80	Lava, soft. red.
80-138	Lava, hard, fine-grained, black.
138-145	Alluvium?, possibly weathered granite surface?, easy drilling, caving zone.
145-245	Granitic rock, medium hard, pinkish, cuttings are approximately 1/4" chips.
245-295	Granite, hard, pinkish, cuttings are ground to sand-size.
295-320	Granite, medium hard, pinkish, cuttings are approximately 1/4" chips.

The hole was dry until drilling passed a depth of about 270 ft below land surface. Water level in the well then rose to about 120 ft below land surface, indicating that an artesian aquifer had been encountered. Problems were encountered with trying to keep the uncased hole open at about 140 ft below land surface. Loose material from the 138-145 ft interval was apparently sloughing into the hole. The contractor was concerned about getting equipment

stuck in the hole and further destruction of the hole while trying to develop it. After several unsuccessful attempts to stabilize the hole, it was decided that it would be necessary to install casing prior to conducting an aquifer test.

It was decided that the 6-inch test hole would be reamed to a 9-inch diameter and that 6-inch casing and screen would be installed prior to testing. Since it was necessary to use drilling mud to stabilize the hole during this procedure, it was decided to temporarily suspend the project and wait for warmer weather in the spring.

Work on the project was resumed on April 28, 1992. The test hole was reamed to 9-inch diameter. Bentonite drilling mud was used to maintain a stable open hole, particularly through the caving zone at about 140 ft. Cellophane flakes were added to the drilling mud to get circulation back through the porous lava flows. Reaming to a depth of 298 ft was completed on May 5th.

The well was completed by installing 6-inch well screen and casing. Ten feet of slotted (0.030-inch) Johnson-type stainless steel well screen was placed at 273-283 ft below land surface. Fifteen feet of blank casing was attached to the bottom of the screen at 283-298 ft below land surface. Six-inch casing extends from the top of the well screen to two feet above land surface. Formation packers (shale traps) were installed at depths of 40, 158, and 178 ft below land surface.

The well was developed by a combination of injecting water through a jetting tool, airlifting, and surging. Development was continued until the water remained clear and the conductivity remained fairly stable between surging and airlifting episodes. Well development continued for a total of 8 hours.

Aquifer Testing

A 24-hour aquifer test was conducted on May 9-10, 1992. The test was conducted at three progressively larger pumping rates or steps. Discharge from the well was piped approximately 100 ft from the well to a baffle box with a flume outlet. Water level fluctuations in the flume box (and thus discharge variation) were recorded using a pressure transducer and data logger. Water levels in the well were determined from a pressure transducer placed just above the submersible pump. Measurements were also made with an M-Scope for the first 320 minutes of the test. After that time, the M-Scope probe could not be lowered to the water level in the well due to an obstruction in the well at about 205 ft below the top of the

casing. Water level measurements were made from the top of the drill string, approximately 3.7 ft above land surface.

Water level drawdown data are presented graphically in Figures 4 and 5. Figure 4 has a normal arithmetic scale for time on the x-axis. On Figure 5, the x-axis is a logarithmic scale.

The first step of the aquifer test was conducted at an average pumping rate of 20 gpm for a period of 60 minutes. Water levels stabilized at 14.25 ft below static level within about 5 minutes after starting the test. Initial drawdown measurements in the first 2-4 minutes of the test are slightly larger because the pumping rate was higher than 20 gpm. The water level at this pumping rate will be about 126 ft below land surface.

The second step of the aquifer test was conducted at an average pumping rate of 39 gpm for 120 minutes. Water levels dropped an additional 38.25 ft during this step for a total drawdown of about 52.5 ft below the static water level. The water level in the well did not reach a constant level during this period, but continued to fall at a decreasing rate. It appears from the data plot that an equilibrium water level for long-term pumping at this rate would be about 166 ft below land surface.

The third step of the aquifer test was conducted at an average pumping rate of 46 gpm for 21 hours. Water levels dropped an additional 42 ft during this step for a total drawdown of about 96 ft below the static water level. The water level in the well reached a constant level about 208 ft below land surface during this period. Water levels during this period show some blips and variation from a gradual leveling off of the water level decline. These blips correspond to periods when it was noted that the generator sputtered and the pumping rate slowed for brief periods of time.

A pumping rate of 50 gpm was desired for the third step of the aquifer test. Initially, the well was producing about 49 gpm during the third step. Production gradually decreased until it had fallen to about 46-47 gpm 140 minutes into this step (320 minutes into the test). At that time, the control valve was opened wider in an attempt to bring the discharge back up to about 50 gpm. Discharge increased only slightly and water level in the well dropped about 3 ft. This incident can be seen as a small step down between two upward blips on the graph.

The graph of drawdown versus time (Figures 4 and 5) at varying pumping rates shows that this well can probably produce 20 gpm indefinitely with only a small (14 ft) amount of drawdown. The water level in the well would be about 126 ft below land surface.

EL MALPAIS NATIONAL MONUMENT

AQUIFER TEST, MAY 9-10, 1992

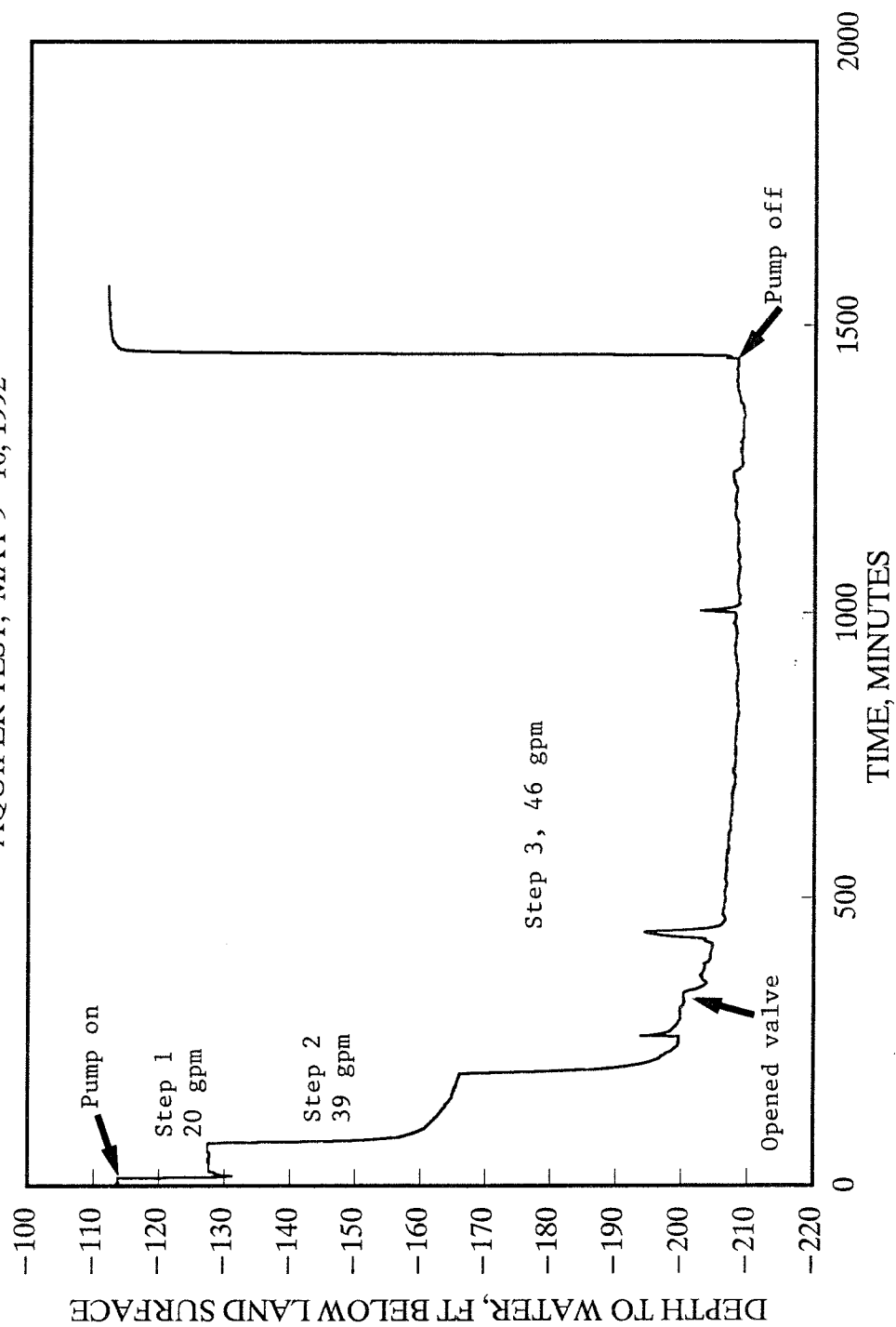


Figure 4. Water level response to the aquifer test. Arithmetic time scale.

EL MALPAIS NATIONAL MONUMENT

AQUIFER TEST, MAY 9-10, 1992

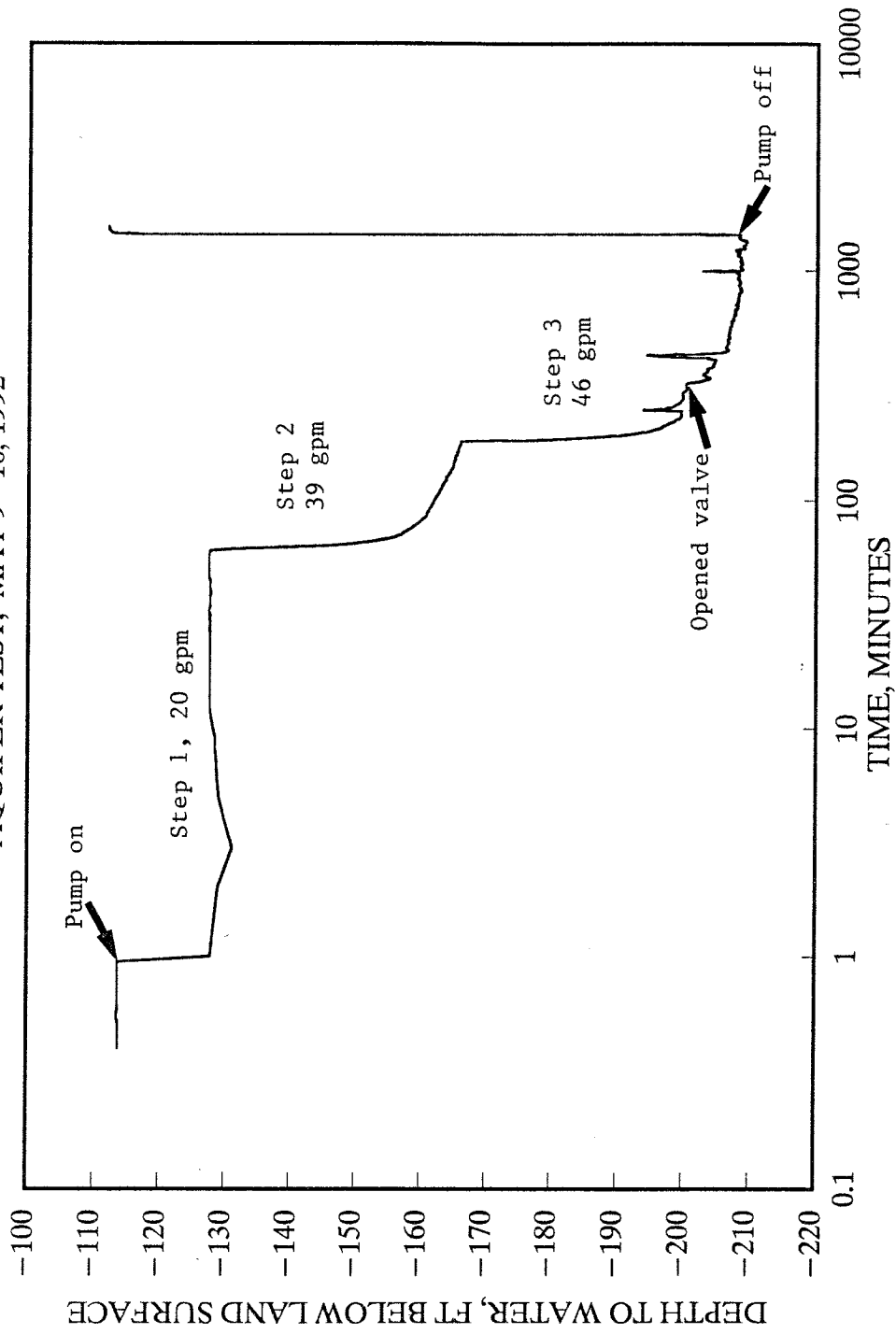


Figure 5. Water level response to the aquifer test. Logarithmic time scale.

Increasing the pumping rate to about 39 gpm will probably draw the water level in the well down to about 166 ft below land surface. Increasing the pumping rate to about 46 gpm draws the water level down to about 212 ft below land surface. Thus, it appears that the efficiency of the well decreases rapidly at pumping rates above about 40 gpm.

The screen in this well was placed 273-283 ft below land surface. A permanent pump can be placed in the well just above the screened interval. This would allow the water level in the well to be drawn down to about 250 ft below land surface while still maintaining some safety factor for maintaining submergence of the pump.

The generator used during the aquifer test was not running at 100% of rated capacity. When the well is supplied with a permanent electrical supply, it may be capable of producing 50 gpm or more. At this rate, the water level in the well may be drawn down to about 250 ft below land surface. Results of the aquifer test indicate that this pumping rate and drawdown level could probably be maintained for at least several days of continuous operation and that the water level in the well will recover quickly after pumping.

Water level in the well recovered very quickly after the pump was turned off. This situation is indicative of artesian conditions for the aquifer in this area. Water level in the well rose to within about 1.5 ft of the static water level 10 minutes after the pump had been turned off (94 ft of recovery). Artesian conditions are further indicated by the rise in water level in the well after first encountering water. The well was dry until a fracture zone was encountered at about 270-275 ft. The water level in the well then rose to about 120 ft below land surface.

Chemical Quality

Specific conductivity and temperature of the water from the well were checked several times during the aquifer test. Conductivity remained about 390 microsiemens/centimeter (us/cm) and temperature about 11.5°C for the duration of the 24-hour test. Water samples were collected after 23.5 hours of pumping for analysis of chemical quality. These samples were kept cool in an ice chest and taken to the Bureau of Indian Affairs (BIA) laboratory in Gallup the following day. Results of the analyses are shown on the attached table. Water from this well meets EPA drinking water standards. The water had no objectionable taste or odor.

NATURAL RESOURCES AND ENGINEERING LABORATORY
Navajo Area Office, Gallup, NM 87301

Lab Sample Number: 92P831
Date Received: 05/11/92
Date Analysis Reported: 09-11-92
Checked By: *RW-M*

Date Collected: 05/10/92
Field Number: ***
Submitter : DOI-NPS
Location: El Malpais, NM
Collector's Name: Larry Martin
Authorized By :

SEND REPORT TO : El Malpais National Monument
: PO Box 939
: Grants, NM 87020
: Phone: (505) 285-4641

ATTENTION : Doug Emry

ANALYSIS SHEET

TEST NO.1	UT	EPA	TEST NO.2	UT	EPA	TEST NO.4	UT	EPA
	mg/l			mg/l			ug/l	
Spc Cond.	: 440	5,500 uohms	Phos Rec:	0.11	50 **	Endrin :		0.20
pH	: 7.59	6.5-8.5	Nitrat/N:	0.65	10.0 *	Lindane:		4.00
Res. Total	: 237	---	Nitrit/N:	0.00	1.0 **	Methoxy:		100
Res. Filt.	: ---	500				Toxaphe:		5.00
Res. Susp.	: ---	---	TEST NO.3	UT	EPA	2,4,D :		100
Calcium	: 59	75-2000**		ug/l		Silvex :		10.0
Magnesium	: 9.0	50-150**	Arsenic :	13.8	50.0*	PCB :		0
Sodium	: 12	20-250**	Barium :	250	2000*			
Potassium	: 13	1000-2000**	Cadmium :	<0.1	5.0 *	TEST NO.5	UT	EPA
Carbonates	: 0	---	Chromium:	<1.0	100 *		pCi/l	
Bicarbonates:	216	150**	Copper :	180.0	---	Gr Alph:	2	15
Boron	: 77.0	1.0**	Lead :	<1.0	50.0*	Gr Beta:	5	50
Chlorides	: 50.05	250**	Mercury :	<0.2	2.00*	Ra 226 :	0.35	
Fluorides	: 0.60	4.0 *	Selenium:	<1.0	50.0*	Ra 228 :	<0.50	
Sulfates	: 22	250**	Silver :	<0.2	100 *	Uranium:	15	

OTHER TESTS

	mg/l		ug/l		ug/l
Hrdn CaCO3 :	12	0-50	Aluminum:	50-200	Molybde:
Alk.as CaCO3:	177	---	Iron Dis:	40.0	Nickel :
S.A.R.	:	---	Lithium :	---	Silica :
Turbidity :		OTU	Manganes:	6.0	Stronti:
				50	Zinc :
					10.0
					5000

OTHER TESTS-TEST 4

Chlordane :		Dieldrin:		Endosul II :
Heptachlor :		4,4'DDD :		Endosul SO4:
Heptachlo Ep:		4,4'DDT :		Endrin Aldh:
4, 4' DDE :		Endosul I:		Aldrin :

Cation - Anion Balance: $0.03/8.47 \times 100 = 0.35 \%$

*** LOCATION: SW 1/4, NW 1/4, NW 1/4, Sec. 19, Twp 9, Rge 11

* THIS IS EPA STANDARDS.

** UNOFFICIAL STANDARD.

TOTAL P. 82

Conclusions

A hydrogeologic investigation of the project area was conducted to determine the favorable locations for constructing test holes. The first test hole was located in an area with a thick sequence of sedimentary rock. This hole was dry. The second test hole was located in an area where drilling would encounter alluvium, lava, and granitic rocks, three potential aquifers. A water supply was found and developed from a fracture zone in the granitic rocks.

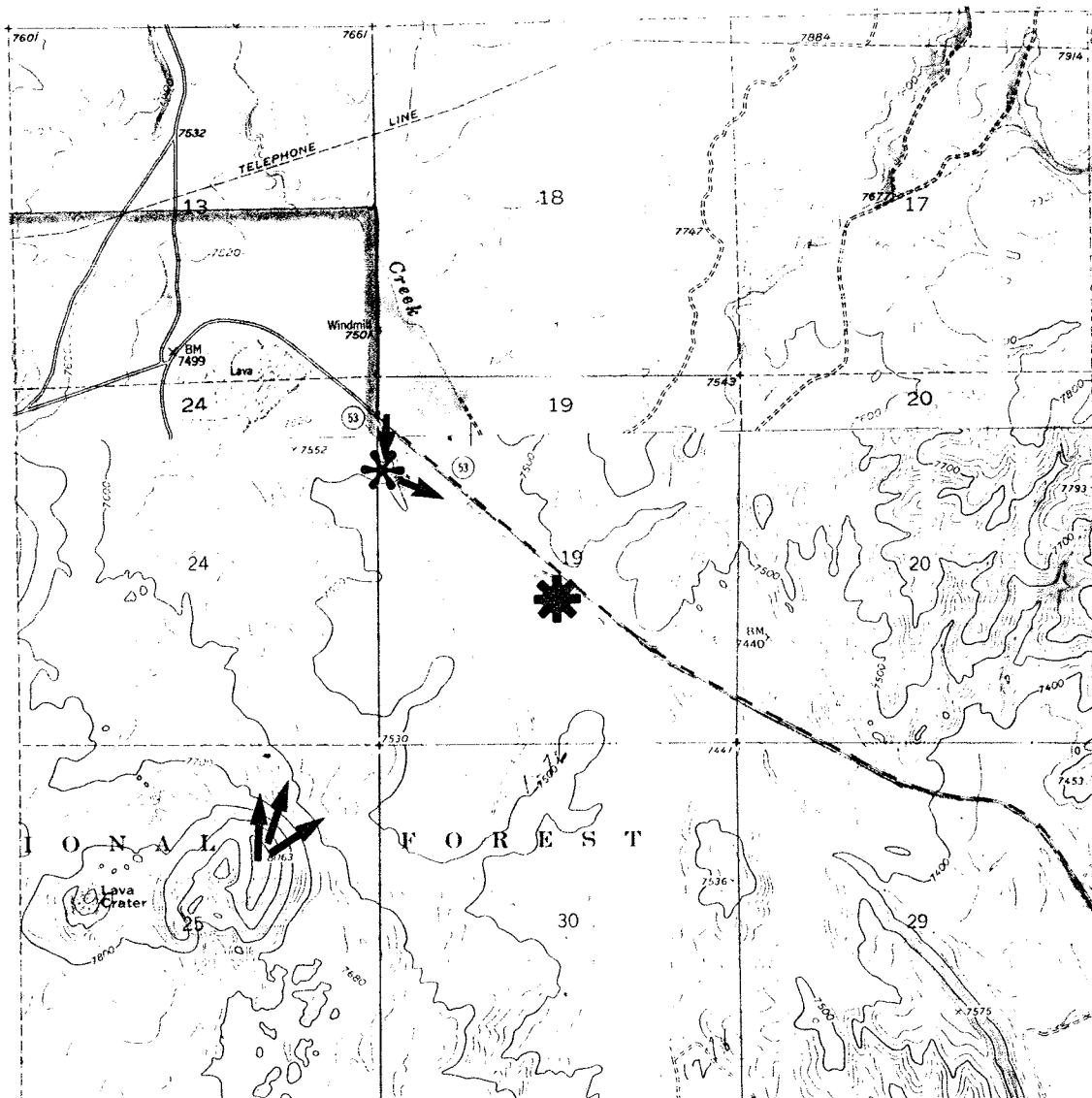
An aquifer test was conducted at the second test hole to determine yield, drawdown, and chemical quality. Water supply from the second test hole was determined to be adequate to warrant converting the test hole to a production well. The well was constructed with a 6-inch inside diameter screen and casing. Ten feet of stainless steel wire-wound well screen (Johnson-type) was placed at a depth of 273-283 ft below land surface. When a pump is installed in this well, it should be placed just above the screen (bottom of the pump at about 270 ft).

The well will produce a steady supply of 20 gpm with about 14 ft of drawdown. Water level in the well will be about 130 ft below land surface at a pumping rate of 20 gpm. A pumping rate of 50 gpm is attainable and will probably result in about 100 ft of drawdown. The water level in the well would be drawn down to about 215 ft below land surface, still well above the top of the well screen and recommended pump setting.

Water quality from the well meets all drinking water standards. It has no objectionable taste or odor.

References

Maxwell, Charles H. 1986. Geologic Map of El Malpais Lava Field and Surrounding Areas, Cibola County, New Mexico. U.S. Geological Survey Map I-1595, One Sheet.



Map showing location of test holes and photographs on the following pages. The first 3 photos on the following pages were taken from on top of the cinder cone in the NE 1/4 of section 25.

- * Test Hole 1
- * Test Hole 2 (Water Supply Well)
- ↑ Photo site and view direction