UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
Albuquerque, New Mexico

WATER SOURCES FOR NESTING HABITAT OF MEXICAN DUCK AND DOUBLE-CRESTED CORMORANT, ELEPHANT BUTTE MARSH, SIERRA COUNTY, NEW MEXICO

By

T. E. Kelly

Open-file report

Prepared by the U.S. Geological Survey in cooperation with the U.S. Bureau of Land Management

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INTRODUCTION

An area of perennial water near the upper end of Elephant Butte Reservoir, in Sierra County, New Mexico, is locally known as Elephant Butte marsh (fig. 1). It is within the backwater area of the reservoir; however, impounded water has extended into the marsh area only on rare occasions since construction of the dam in 1915. The marsh is at the foot of the bluffs which mark the west edge of the Rio Grande flood plain. In 1951, the Rio Grande conveyance channel was constructed along the eastern side of the marsh. The dikes which confine this channel form an effective barrier which separates the marsh from the present Rio Grande floodway.

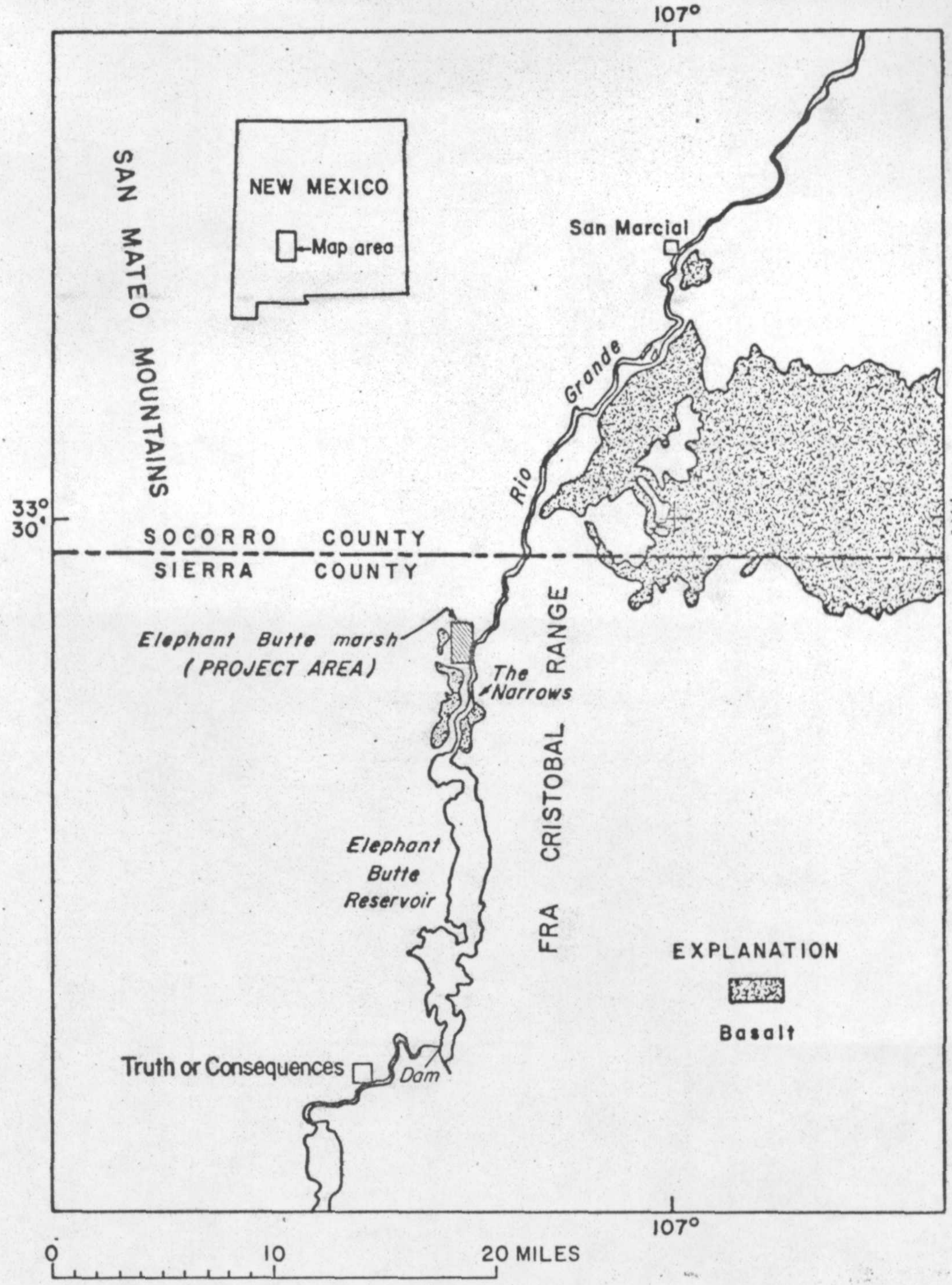

Figure 1.--Location of the project area upstream from "The Narrows" of the Rio Grande and near the base of the Fra Cristobal Range.

The perennial water in the marsh area attracts large numbers of waterfowl. Two species, in particular, which frequent the marsh are the Mexican or New Mexican Duck (Anas diazi) and the Double-crested Cormorant (Phalacrocorox auritus). The Mexican Duck is an endangered species. The Double-crested Cormorant is seen rarely within New Mexico.

Elephant Butte marsh appears to have features, which, when properly developed, would provide an attractive nesting habitat for both of these species. According to the Bureau of Land Management, the Mexican Duck prefers to nest in small water-filled potholes; the Double-crested Cormorant prefers dead trees in shallow water. Dead-tree sites exist within the marsh; suitable potholes could be excavated easily. An aerial photograph showing the differences in vegetation is shown in figure 2.

The source of the water in the marsh, its relation to waters in the Rio Grande floodway, the Rio Grande conveyance channel, and to the ground-water table, has never been investigated. Information on the origin of the water in the marsh, and its permanence under present conditions, was needed by the U.S. Bureau of Land Management, which controls the marsh area, to aid in evaluating development of the marsh as a nesting habitat.

Figure 2.--Aerial photograph showing differences in vegetation density in project area (Secs. 16, 17, 20, 21, 28, 29, T. 10 S., R. 3 W.).

In July 1971, the District Office, Bureau of Land Management, Socorro, N. Mex., requested the U.S. Geological Survey to make a reconnaissance investigation of the marsh area. The objectives were to establish the origin of water in the marsh, and to determine the depth to the water table so that potholes could be excavated to proper depths in order to maintain relatively stable water levels within the potholes. The investigation was made by the Geological Survey during September 20 to October 25, 1971. A geologic reconnaissance was made, nine observation wells were installed, depth-to-water measurements were obtained, and water samples were collected and analyzed for chemical quality. Additional data on the chemical quality of water were collected on January 28, 1972 and observations were made at the southern end of the marsh.

GEOLOGIC SETTING

Elephant Butte marsh is located in a relatively narrow reach of the Rio Grande valley between the Fra Cristobal Range on the southeast and the San Mateo Mountains on the northwest. The flood plain of the river is restricted on the east by the rather extensive San Marcial basalt flow, and, on the south, by "The Narrows" of the Rio Grande, which was created by a much smaller basalt flow. Erosion by the river has cut the flood plain into sediments of the Santa Fe Group of Tertiary and Quaternary age. which forms the bluffs along the river.

The Santa Fe Group consists of deposits of red to buff clay, silt, sand, and gravel which were eroded from nearby mountains. Cementation of the Santa Fe by calcium carbonate and calcium sulfate is irregular; locally well-cemented deposits stand above the poorly cemented to unconsolidated deposits on adjacent slopes and arroyos. Volcanic deposits cap several hills west of the marsh.

Since the construction of Elephant Butte Dam, the Rio Grande has been aggrading its flood plain upstream from the dam. This has resulted in the creation of a delta where the river enters the reservoir, as well as in the deposition of large quantities of silt and clay on the flood plain itself. Happ (1948, p. 1209) estimated that between 1936 and 1941 there was an average annual accumulation of 35 acre-feet of sediment per mile of channel in the middle Rio Grande region of New Mexico.

Wind activity has been an important factor in the accumulation of sediments along the west side of the marsh. Strong winds have exerted a winnowing action on the exposed bluffs of the Santa Fe deposits; the silt and clay particles have been removed from the area and the sand has drifted into nearby arroyos and onto the flood plain. Thus, the bluffs are capped by a veneer of lag gravels that are too large for the wind to transport.

After the eolian sand was deposited in the numerous arroyos west of the marsh, runoff through these channels transported the sand to the flood plain where it interfingered with the alluvial silt and clay deposited by the Rio Grande. Although most of the sand accumulated along the base of the bluffs, some may have been deposited in stream bars and subsequently transported by additional wind action.

During the present investigation nine observation wells ranging in depth from 5.2 to 18.6 feet were installed near the marsh area. Water levels were measured through 1½-inch steel pipe attached to well points, or slotted at the bottom. The locations of these observation wells are shown on figure 3, and records of the wells are given in table 1.

Five wells were installed on the west and north sides of Elephant Butte marsh. Three of these (numbers 2, 4, and 5) penetrated fine to medium quartz sand; two (numbers 1 and 3) penetrated arroyo deposits containing fine to coarse sand with interbedded gravel and boulders.

Table 1.--Records of observation wells installed near Elephant Butte marsh

Well number	Location (T. 10 S., R. 3 W.)	Depth (feet)	Date completed	Measuring point (feet above land surface)	Altitude of land surface (feet)	Construction data
1	NE¼SW¼SW¼ sec. 20	12.8	9-22-71	0.90	4,409.1	Ten feet of casing with sand-point. Well jetted and driven.
2	NE¼NW¼SW¼ sec. 20	10.9	9-23-71	2.60	4,401.0	Ten feet of casing with sand-point. Well jetted.
3	NE¼NW¼SW¼ sec. 20	18.6	9-23-71	1.75	4,403.9	Twenty feet of casing, slotted and crimped. Well driven.
4	NW¼SE¼NW¼ sec. 20	10.5	9-23-71	3.30	4,394.4	Ten feet of casing with sand-point. Well jetted.
5	NW¼NW¼NE¼ sec. 20	12.3	9-24-71	1.10	4,398.8	Ten feet of casing with sand-point. Well jetted.
6	SW¼SW¼SW¼ sec. 16	9.1	9-24-71	1.45	4,392.5	Ten feet of casing, slotted and crimped. Well driven.
7	NE¼NW¼NW¼ sec. 21	5.2	9-24-71	1.10	4,392.5	Seven feet of casing, slotted and crimped. Well driven.
8	SE¼NE¼NW¼ sec. 21	5.5	9-24-71	.20	4,396.0	Three feet of casing and sand-point. Well driven and jetted.
9	SW¼SW¼NW¼ sec. 21	12.8	9-24-71	1.30	4,392.5	Ten feet of casing with sand-point. Well driven and jetted.

Four observation wells (numbers 6-9) were installed northeast of the marsh in sections 16 and 21. None of these wells penetrated sand.

Prior to 1951 the Rio Grande conveyance channel terminated in sec. 3, T. 10 S., R. 3 W., approximately 2.5 miles upstream from the marsh. This enabled the river to meander across the flood plain, including the present marsh area where thick deposits of alluvial silt and clay were deposited. After the conveyance channel was extended to its present length south of the marsh area, test holes were bored by the U.S. Bureau of Reclamation and silt and clay were found locally to be more than 20 feet thick. No sand was encountered during the excavation of the channel in the vicinity of the marsh according to Mr. Robert Gaines (oral commun., 1971), a dragline operator for the Bureau of Reclamation.

GROUND WATER

The Rio Grande conveyance channel borders the marsh on the east; however, little or no exchange of ground water occurs between the floodway, conveyance channel, and marsh. This is due to the low permeability of the dense silt and clay strata which underlie the area.

It is possible that upstream from Elephant Butte marsh water from the conveyance channel and floodway may infiltrate permeable sand and gravel in the Rio Grande flood plain. This water could then move downstream and empty into the marsh. If this condition exists it would be an important source of recharge to the marsh. Permeable deposits have not been penetrated by test holes drilled to depths of about 13 feet in the floodway near the marsh; however, such deposits may be present at greater depths. Their presence could be confirmed or disproved by additional test drilling.

The nine observation wells that were installed (table 1) were used to determine the depth of the water table at various locations adjacent to the marsh. Two staff gages were also installed to measure the altitude of the water in the conveyance channel and marsh.

The observation wells and the staff gages were measured on three occasions (table 2). The first measurement was made within 24 hours after installation. Because some of the wells were installed by jetting, the first water-level measurement in most cases shows the effect of the water added during installation rather than the true static-water level. Subsequently, each well was measured approximately 1 week and 3 weeks after installation.

Table 2.--Water-level measurements of observation wells and staff gages

Well number or name	Altitude of land surface (feet)	Measured 9-23/24-71		Measured 9-29-71		Measured 10-14-71	
		Depth to water[1] (feet)	Altitude of water (feet)	Depth to water[1] (feet)	Altitude of water (feet)	Depth to water[1] (feet)	Altitude of water (feet)
1	4,409.1	8.91	4,400.19	9.00	4,400.10	9.12	4,399.98
2	4,401.0	9.41	4,391.59	9.51	4,391.49	9.49	4,391.51
3	4,403.9	12.12	4,391.78	11.99	4,391.91	11.96	4,391.94
4	4,394.4	2.25	4,392.15	2.25	4,392.15	2.26	4,392.14
5	4,398.8	4.14	4,394.66	4.21	4,394.59	4.24	4,394.56
6	4,392.5	Dry	--	Dry	--	Dry	--
7	4,392.5	Dry	--	Dry	--	Dry	--
8	4,396.0	Dry	--	Dry	--	Dry	--
9	4,392.5	Dry	--	Dry	--	Dry	--
Staff[2] gage conveyance channel	--	--	4,395.1	--	4,394.0	--	4,395.6
Staff gage Elephant Butte marsh	4,392.35[3]	--	4,390.09	--	4,390.05	--	4,390.27

1/ Below land surface
2/ Staff destroyed
3/ Top of staff

Measurements obtained on September 29 and October 14, 1971 probably represent the true static-water level; the difference between the two measurements in each well reflects the change in ground-water storage which occurred between the two dates. Wells 6 through 9 remained dry throughout the period of study indicating that the silt and clay penetrated by these wells is nonpermeable and that little or no ground water moves through them.

The small fluctuations of the water level in the marsh, measured during this investigation, actually represent large changes in the total amount of water in the marsh area (table 2). Between September 23 and 29, the water level in the marsh declined 0.04 foot, a water loss of 2.5 million gallons. However, a net gain of 13.8 million gallons occurred when the water level in the marsh rose 0.22 foot between September 29 and October 14 when several rains were recorded near the site.

Figure 3 shows the configuration of the water table along the northwestern side of the marsh area, based on measurements made October 14, 1971. The contours indicate that ground water, moving eastward in the Santa Fe Group, discharges into the marsh. The principal discharge points are characterized by a line of seeps and springs which supports a dense growth of native grasses at an altitude of 4,391 feet.

It is important to note that during the summer months immediately preceding this investigation, precipitation was more than 2 inches below normal. Undoubtedly this reduced precipitation has resulted in a lowered water table in sediments of the Santa Fe Group and reduced the amount of spring discharge. During periods of normal precipitation in the area, water levels in the observation wells could be expected to be higher than those measured during this study.

Owing to the limitations of time and money, this investigation did not include a detailed evaluation of the ground-water regimen. However some data are available from nearby areas which allow an approximation to be made of the amount of ground-water recharge to the marsh.

According to Conover and others (1955, p. 113), the aquifer in the Santa Fe Group contributes approximately 1 cubic foot of water per second per mile to the Rio Grande. This is about 450 gallons per minute per mile of river channel. The estimate by Conover and others was based on several different methods of calculating ground-water movement. The Santa Fe Group is exposed along a distance of approximately 1.5 miles from the north end of the marsh to its mouth. Assuming a uniform discharge rate throughout this distance, and that there is no contribution of ground water to the marsh from the east side of the valley, the aquifer in the Santa Fe would contribute approximately 180 million gallons of ground water per year.

The marsh area contains about 0.3 square mile of open water. With an average annual evaporation of about 100 inches per year (New Mexico State Engineer, 1956a, p. 259), about 520 million gallons of water per year would be evaporated from the open-water surface. This is approximately 300 percent of the estimated total amount of ground-water recharge based on the calculations of Conover and others. Although transpiration by the dense growth of salt cedar also must be a major factor in water loss, no accurate figures are available on which to base a reasonable approximation.

SURFACE WATER

There are three sources of runoff to Elephant Butte marsh: (1) surface runoff through the arroyos which empty into the marsh from the north and west, (2) inundation by water from Elephant Butte reservoir, and (3) overflow and backwater from the Rio Grande conveyance channel and floodway.

A drainage area of about 50 square miles contributes surface runoff to the marsh. This area extends from the river flood plain, where the average annual precipitation is about 10 inches per year, westward to the crest of the San Mateo Mountains which receive about 20 inches of precipitation annually (New Mexico State Engineer, 1956b, p.7). Although this represents a potential surface runoff of nearly 11 billion gallons per year, only a very small quantity ever reaches the marsh as surface flow, and the actual amount has not been measured. Some of the arroyos which drain this area can, on occasion, produce relatively high instantaneous peak discharge; however, none of those which empty into the marsh has been accurately measured. The San Jose arroyo, which is located about 2 miles north of the marsh, has a drainage area of only 17.6 square miles. Yet on June 26, 1954 a surge of water with a peak discharge of 5,890 cubic feet per second (2.6 million gallons per minute) was measured near the mouth of the arroyo. Such flows are quite rare, however, and most of the water in this drainage basin is either lost through evapotranspiration or infiltrates into the underlying deposits.

The study area is subject to infrequent flooding by water from Elephant Butte reservoir. When the reservoir fills to the sill of the overflow structure, the marsh area is inundated by 16 feet of water; the most recent such occurrence was from June 1941 to May 1943. The study site had been flooded previously in 1920-22, 1924-26, 1928, 1930, 1932, 1933, and 1937-39.

Under normal conditions there is no exchange of water between the marsh and Rio Grande conveyance channel and floodway. However, during periods of high runoff the dikes of the conveyance channel are breached and floodwaters empty into the marsh. This has occurred almost annually in recent years. Mr. Robert Gaines (oral commun., 1971) also reports that during winter months ice jams sometimes form in the conveyance channel and cause water from the channel to spill into the marsh area.

A narrow divide separates the marsh from the conveyance channel and floodway in the southeast quarter of section 29 (fig. 3). This natural dam, which is composed primarily of silt and clay, has a minimum altitude of 4,391 feet. Several witnesses have reported that water flows from the marsh into the floodway across this divide.

On January 28, 1972 the area was examined for evidence which would indicate the direction of movement of water across this divide. A considerable amount of debris was found which verifies that surface water has moved in both directions. The most recent direction of movement was in a westerly direction from the conveyance channel into the marsh. The fact that this evidence is contrary to all eye-witness accounts suggests that such a direction of flow probably occurs only on occasions when the conveyance channel is in flood and accessibility to the area is severely limited.

Stream-gaging stations located along this reach of the Rio Grande have been maintained by the Geological Survey for a number of years. A continuous record of the amount of water flowing through the conveyance channel and floodway at San Marcial is available. However the channel and floodway form a single channel approximately a half mile upstream from the marsh outlet (fig. 2); no data are available for this reach of the unconfined channel.

The water level in the Rio Grande appeared to be about a foot or more below the lip of the divide on January 28, 1972. According to Geological Survey records, the discharge through the conveyance channel at that time was 750 cubic feet per second or about 340,000 gallons per minute at San Marcial; there was "no flow" in the floodway. This is approximately 30 percent of the channel capacity. However this water is widely distributed across the unconfined flood plain after leaving the conveyance channel, and data are not available to predict the minimum amount of water needed to inundate the marsh-flood plain divide.

CHEMICAL QUALITY

Water samples were collected from various sources in the project area (fig. 3) and analyzed for major chemical constituents (table 3). In addition specific conductance of the water was measured at 18 sites (fig. 4). One spring sample (table 3, sample 3) collected in September 1971 was highly mineralized. This spring was later re-sampled and found to be much lower in dissolved constituents (table 3, sample 3a). The specific conductance measurements substantiated the accuracy of this later sample. Consequently it is probable that the original sample collected in 1971 was not representative of the water quality of the springs near the marsh. The source of contamination is unknown; the sample is considered unreliable.

Data given in table 3 indicate that water in the marsh itself (sample 2) is similar to the springs (sample 3a) which empty into the marsh. Both of these waters are more closely related to water in the conveyance channel (sample 1) than to the water (sample 4) collected from a well in the Santa Fe Group. Water from the well reflects the gypsum ($CaSO_4 \cdot H_2O$) which has been found at various localities in the Santa Fe Group (Kottlowski, 1955, p. 88).

The specific conductances measured on springs ranged from 440 to 1,600 micromhos and average about 1,060 micromhos (fig. 4). The water in the marsh is more highly mineralized in the shallow, restricted areas where aquatic plants are abundant than in areas where the open water is deeper and more exposed to wave action.

Table 3.--Chemical analyses of water samples collected in project area

[Analyses by U.S. Geological Survey. Chemical constituents are in milligrams per liter]

Sampling site*	Date collected	Sample No.	Silica (SiO_2)	Calcium (Ca)	Magnesium (Mg)	Sodium plus Potassium (as Na)	Bicarbonate (HCO_3)	Sulfate (So_4)	Chloride (Cl)	Fluoride (F)	Dissolved solids (residue at 180°C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25°C)	pH
Rio Grande conveyance channel at marsh	9-29-71	1	25 (est.)	85	18	101	217	248	48	—	654	284	106	955	7.4
Elephant Butte marsh	9-29-71	2	25 (est.)	42	20	156	212	210	96	—	678	188	14	1,070	7.4
Spring near marsh	9-30-71	3	25 (est.)	540	91	439	240	1,880	370	—	3,670	1,720	1,520	4,170	7.4
Spring near marsh	1-28-72	3a	22	97	17	103	289	180	66	1	627	310	75	988	7.8
Pete well	1-26-72	4	23	86	6.8	46	101	150	84	.2	458	240	170	749	7.5

* See figure 1.

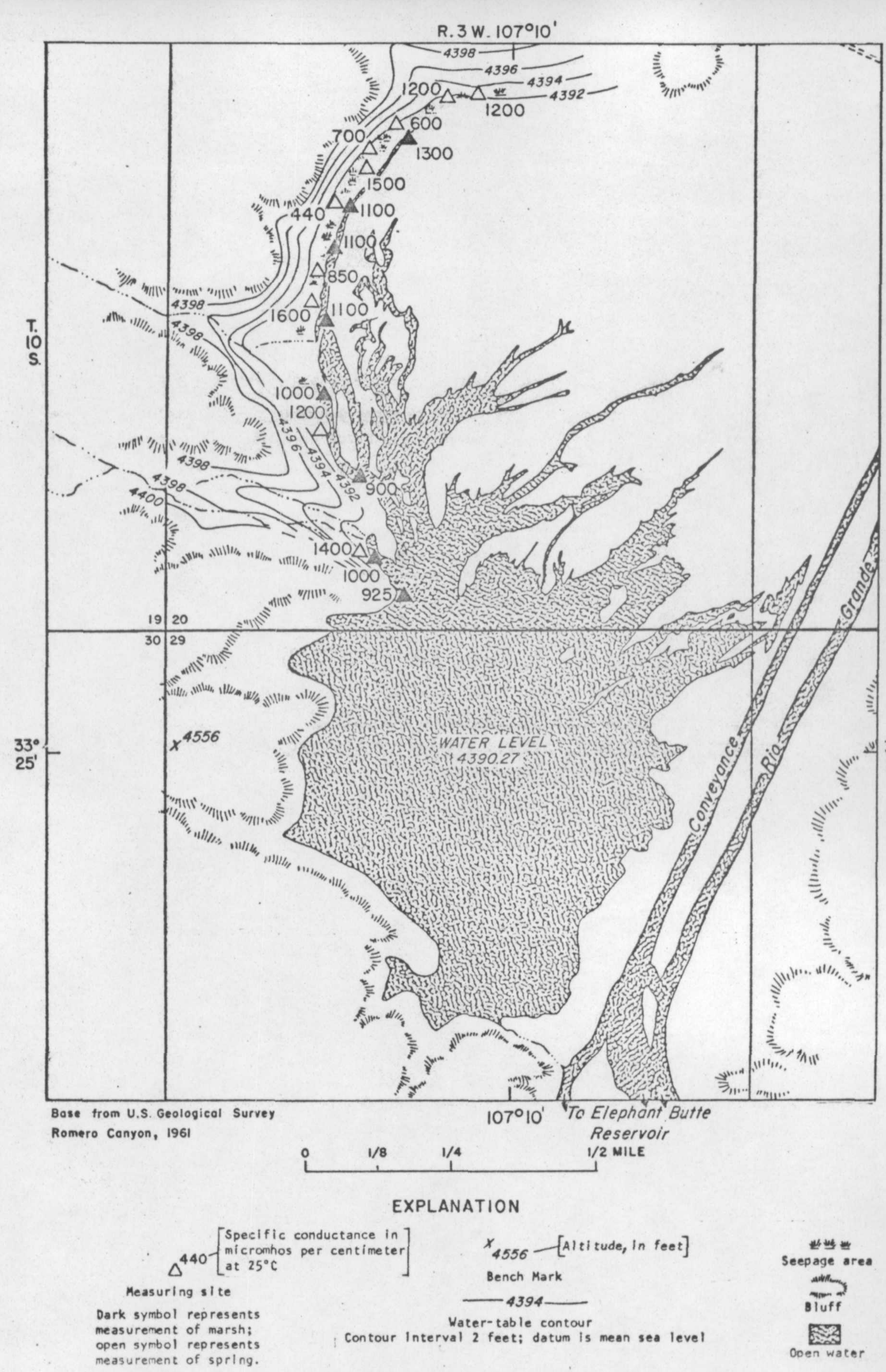

Figure 4.--Location of sites where specific conductance of water was measured, January 28, 1972.

SUMMARY AND CONCLUSIONS

Ground water in the area west of Elephant Butte marsh moves eastward through sediments in the Santa Fe Group and discharges into the marsh. Along the northwestern side of the marsh ground water discharges from numerous springs and creates a seepage area with a high water table. Calculations of ground-water discharge indicate that approximately 180 million gallons of water per year enters the marsh from these springs.

The drainage area west of the marsh, approximately 50 square miles in extent, receives about 11 billion gallons of water per year as precipitation. At infrequent intervals, large flows of surface water have discharged into the marsh. Such flows are rare, however, and most of the water from the drainage basin is either lost through evapotranspiration or infiltrates into the underlying deposits.

Evaporation from the open-water surface of the marsh (transpiration from vegetation not considered) is about 520 million gallons of water per year. However the lack of salt deposits and the low mineralization of the marsh water indicate that there must be overflow from the river and (or) conveyance channel frequently enough to flush the marsh and thereby prevent a salt buildup.

Ground-water discharge into the marsh could be lessened if there is an appreciable increase in withdrawal from aquifers in the Santa Fe Group north and west of the marsh; such occurrences seem unlikely within the foreseeable future.

The main source of water in Elephant Butte marsh probably is overflow and backwater from the conveyance channel and Rio Grande floodway. It is reported that water from the conveyance channel sometimes empties into the marsh when ice jams form in the channel and force the water to overflow the dikes. Also physical evidence at the mouth of the marsh shows that during periods of high runoff, backwater tops the natural divide which separate the channel and the marsh. Water levels in the marsh also are supported by surface runoff from the west, however the amount of water that enters the marsh from these sources is not known.

It is possible that upstream from Elephant Butte marsh water from the conveyance channel and floodway may infiltrate permeable sand and gravel in the Rio Grande flood plain. This water could then move downstream and empty into the marsh. If this condition exists it would be an important source of recharge to the marsh. Permeable deposits have not been penetrated by test holes drilled to depths of about 13 feet in the floodway near the marsh; however, such deposits may be present at greater depths. Their presence could be confirmed or disproved by additional test drilling.

RECOMMENDATIONS

Potholes for nesting habitat of the Mexican Duck, which require a relatively stable water level, could be excavated below the level of the springs and the seepage area on the northwestern side of the marsh. Potholes excavated east of the seepage area probably would remain dry except when filled by surface runoff; evapotranspiration would result in a rapid water loss.

Bureau of Land Management personnel are encouraged to measure water levels in the observation wells on a monthly or quarterly basis in order to observe the natural fluctuations. This could provide an advance warning of water-level decline in the seepage area which might be detrimental to nesting habitat.

It would be advantageous to establish a temporary gaging station at the mouth of Elephant Butte marsh. This would provide the necessary data to determine at what stage, or gage height, the river will flow into the marsh. By comparison of these data with existing long-term record at San Marcial, the frequency of flow from the conveyance channel to the marsh could be established.

In order to insure an adequate supply of water in the marsh during the waterfowl-nesting season, water could be diverted from the conveyance channel in an amount sufficient to maintain the desired depth of water in the marsh.

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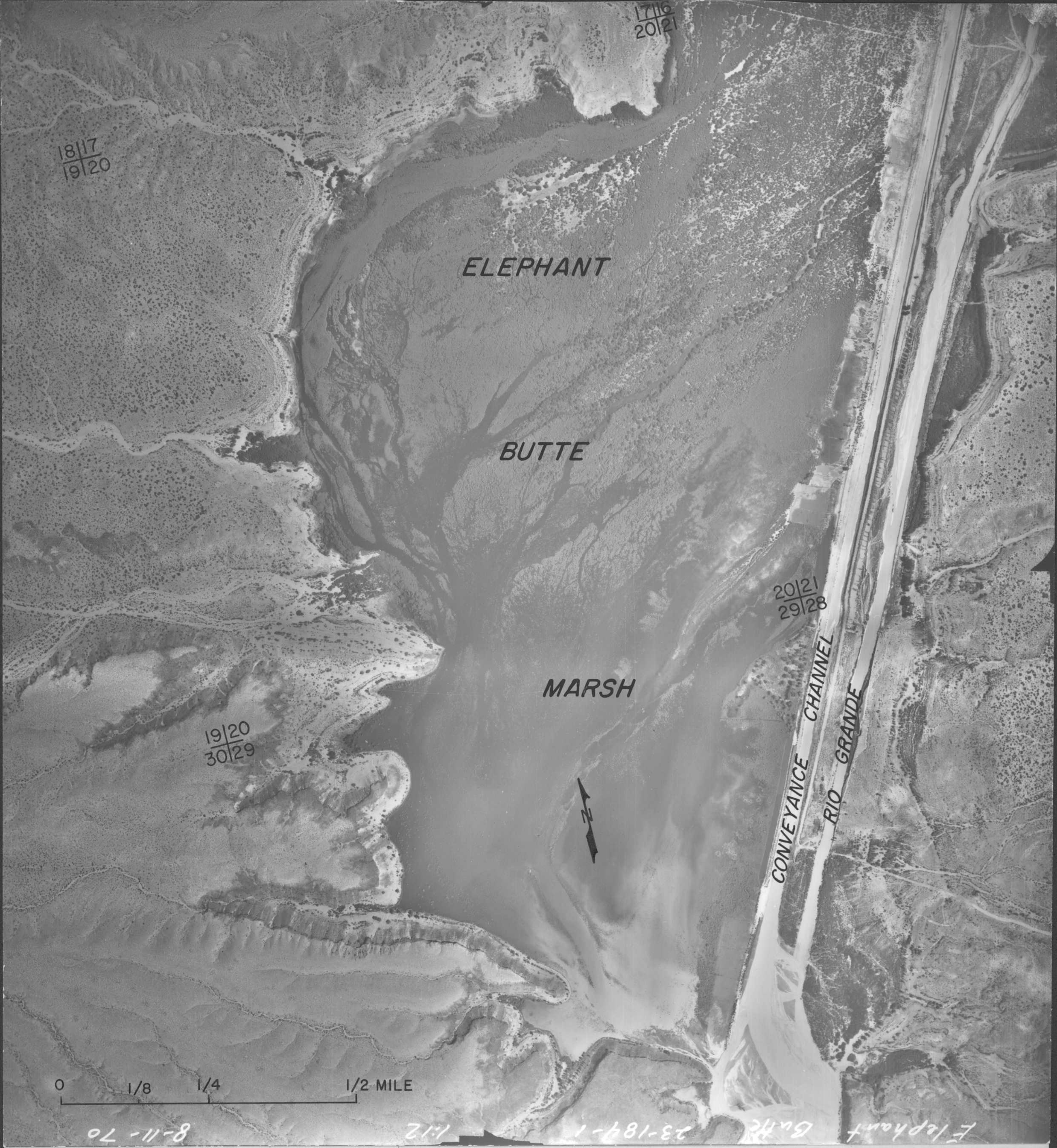

Figure 2.--Aerial photograph showing differences in vegetation density in project area (Secs. 16, 17, 20, 21, 28, 29, T. 10 S., R. 3 W).

Label: Rio Grande
Conveyance channel
Elephant Butte marsh

GME/WRP

WATER SOURCES FOR NESTING HABITAT OF
MEXICAN DUCK AND DOUBLE-CRESTED CORMORANT,
ELEPHANT BUTTE MARSH, SIERRA COUNTY, NEW MEXICO

Figure 3