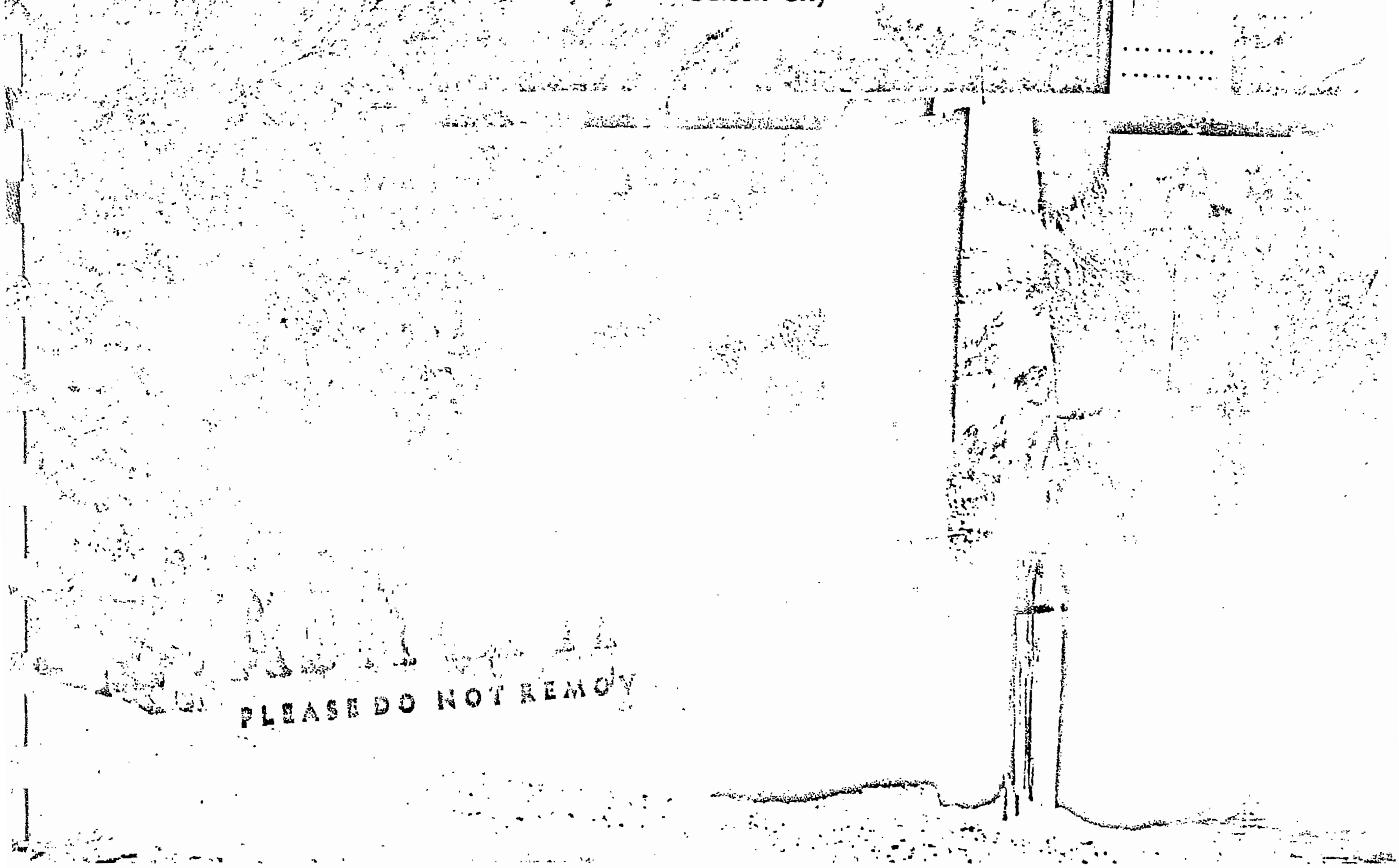
STATE OF NEVADA

DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES

Carson City



View of Muddy River at gaging station

GROUND-WATER RESOURCES – RECONNAISSANCE SERIES

REPORT 25

38 Pages
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GROUND–WATER APPRAISAL OF COYOTE SPRING AND KANE SPRING VALLEYS AND MUDDY RIVER SPRINGS AREA, LINCOLN AND CLARK COUNTIES, NEVADA

233

By

THOMAS E. EAKIN

Geologist

Price $1.00

Prepared cooperatively by the
Geological Survey, U. S. Department of Interior

FEBRUARY 1964

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February 1964

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GROUND-WATER APPRAISAL OF COYOTE SPRING AND KANE SPRING VALLEYS AND MUDDY RIVER SPRINGS AREA, LINCOLN AND CLARK COUNTIES, NEVADA

By Thomas E. Eakin

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SUMMARY

The results of this investigation indicate that the ground water discharging from the springs that supply the Muddy River is derived largely from recharge to the Paleozoic carbonate rocks, and that the area of recharge includes several valleys along and adjacent to the White River channel to the north. The mean annual streamflow of the Muddy River recorded at a gaging station near Moapa is 46.5 cfs (cubic feet per second). Preliminary analysis of the variations and magnitude of the spring flow supplying the Muddy River suggests that the spring discharge is more uniform than the recorded flow of the Muddy River, and that the mean annual discharge of the springs may approximate 50 cfs, or about 36,000 acre-feet a year.

Present development of ground water in the valley fill in the Muddy River Springs area includes about 12 wells for irrigation and several others for domestic and stock use. The annual withdrawal by wells is estimated to be in the range of 2,000 to 3,000 acre-feet.

Recharge to the valley fill in the Muddy River Springs area results principally from infiltration of the surface flow from the springs or subsurface leakage of the springs. The ground water stored in the valley fill in this area apparently might be developed and mixed with the surface flow of the Muddy River to provide additional water for beneficial use during the peak summer demands. However, extensive pumping during the summer season might result in some reduction of the flow of the Muddy River during the winter season because the total amount of water discharged from the springs cannot be increased permanently.

The chemical quality of ground water in parts of the valley fill apparently is poorer than that of the water discharged from the springs. If so, mixing in proper proportion with the spring discharge should permit reasonably satisfactory water for irrigation. The water from the springs has a dissolved-solids content of about 620 parts per million and is a mixed sodium-calcium bicarbonate-sulfate type. An analysis of the water of Muddy River near the gaging station shows that the dissolved-solids content is about 700 parts per million--a noticeable increase in a relatively short distance

downstream from the springs. Further, the dissolved-solids content continues to increase along the 25-mile river channel to Lake Mead.

Coyote Spring and Kane Spring Valleys, to the north and west, offer a contrast to the well-watered Muddy River Springs area. Both valleys are characterized by relatively meager ground-water resources that can be developed at low cost. The estimated total average annual ground-water recharge from precipitation within the drainage areas of both valleys is about 2,600 acre-feet. The depth to the main body of ground water in the valley fill probably is 300 feet or more, as indicated by an exploratory well and a stock well in the northern and southern parts of Coyote Spring Valley, respectively. However, some shallower ground water occurs in the vicinity of Coyote Springs where it is inferred to be semiperched. Most of the several springs in Kane Spring Valley issue from the flanks of the Delamar Range and partly are supplied by perched ground water in the volcanic rocks. Their combined yield is small and is used mainly for watering stock. The perennial yield of the main ground-water reservoir in the valley fill of Coyote Spring and Kane Spring Valleys is estimated to be about 2,600 acre-feet a year--the equivalent of the estimated recharge from precipitation. However, the apparent generally deep water levels suggest that the cost of pumping would be relatively high and perhaps only feasible for special purposes.

INTRODUCTION

Ground-water development in Nevada has shown a substantial increase in recent years. Part of the increased development is due to the effort to bring new land into cultivation, part is due to the effort to supplement surface-water supplies, and part is due to the general increased demands for water. In any case, as efforts to develop ground water increase, there is a corresponding increase in demand for information on the ground-water resources throughout the State.

Recognizing this need, the State Legislature enacted special legislation (Chapt. 181, Stats. 1960) for beginning a series of reconnaissance studies of the ground-water resources of Nevada. As provided in the legislation, these studies are being made by the U.S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources.

Interest in ground-water resources currently includes many areas and is expanding to additional areas almost continuously. Thus, the emphasis of the reconnaissance studies is to provide as quickly as possible a general appraisal of the ground-water resources in particular valleys or areas where information is urgently needed. Ultimately, ground-water information will be available for practically all valleys of the State, at least at a reconnaissance level. For this reason each study is limited severely in time; field work for each area generally averaging about two weeks.

The Department of Conservation and Natural Resources has established a special report series to expedite publication of the results of the reconnaissance studies. Figure 1 shows the areas for which reports have been published in this series. The titles of previous reports published in the series are given at the end of this report. This report is the twenty-fifth in the Reconnaissance Series.

The purpose of the Reconnaissance Series is to provide a general appraisal of the ground-water resources of virtually all valleys of the State for public information, and to provide preliminary estimates of the amount of ground-water development that the areas might sustain on a perennial basis as an initial guide to possible requirements for administration of the areas under the State ground-water law.

The scope of this report is limited to a general description of some of the physical conditions of Coyote Spring and Kane Spring Valleys, and Muddy River Springs area. It includes observations of the interrelations of climate, geology, and hydrology as they affect ground-water resources. Possible movement of ground water between valleys is discussed. The report also includes preliminary estimates of the average annual recharge to and discharge from the ground-water reservoir in the valleys.

Acknowledgments:

The author wishes to express his appreciation for the field assistance of D. O. Moore, D. E. Everett, F. E. Rush, and Howard Ness in this study. D. O. Moore made most of the measurements of spring discharge and D. E. Everett made the conductivity measurements. Residents of the area were most kind and helpful in providing information.

Location and General Features:

Coyote Spring Valley, Kane Spring Valley, and the Muddy River Springs area are in southeastern Nevada. Kane Spring Valley is also known locally as Kane Springs Wash. The three areas encompass a total of about 1,025 square miles and lie between about lat 36°35' and 37°26' N. and long 114°32' and 115°13' W. Almost all of Kane Spring Valley and the north half of Coyote Spring Valley are in Lincoln County. The Muddy River Springs area, a part of upper Moapa Valley, and the south part of Coyote Spring Valley are in Clark County. (See Fig. 2).

A gravel road extends northeastward from U.S. Highway 93, where it crosses the mouth of Kane Spring Wash, through the length of the valley and connects with Elgin on the railroad in Meadow Valley Wash. Trails provide moderate access to various parts of the area in fair weather.

As used herein, the Muddy River Springs area includes that part of upper Moapa Valley upstream from White Narrows; the principal area of study is the 5-mile segment of the flood plain of the Muddy River lying between the

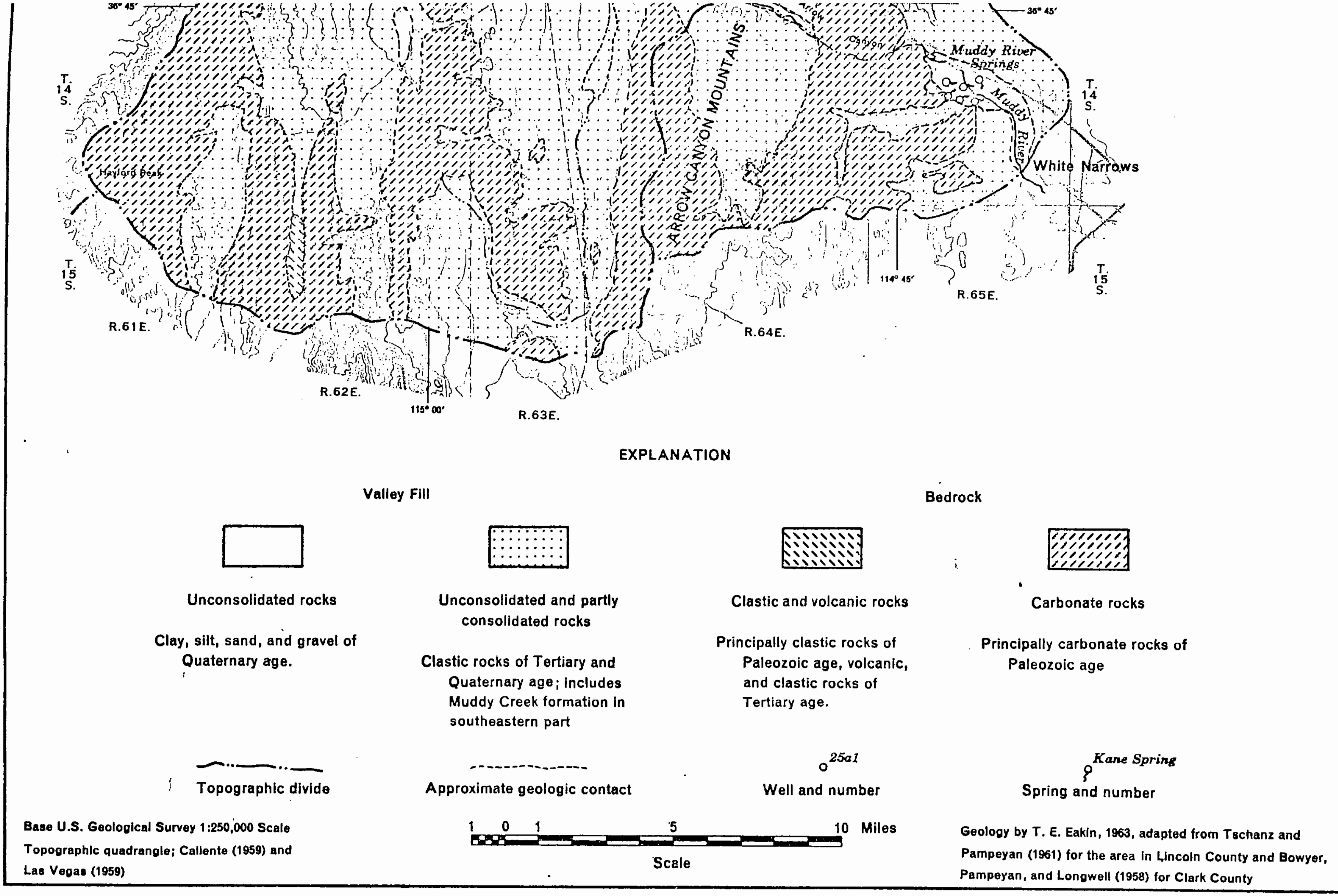
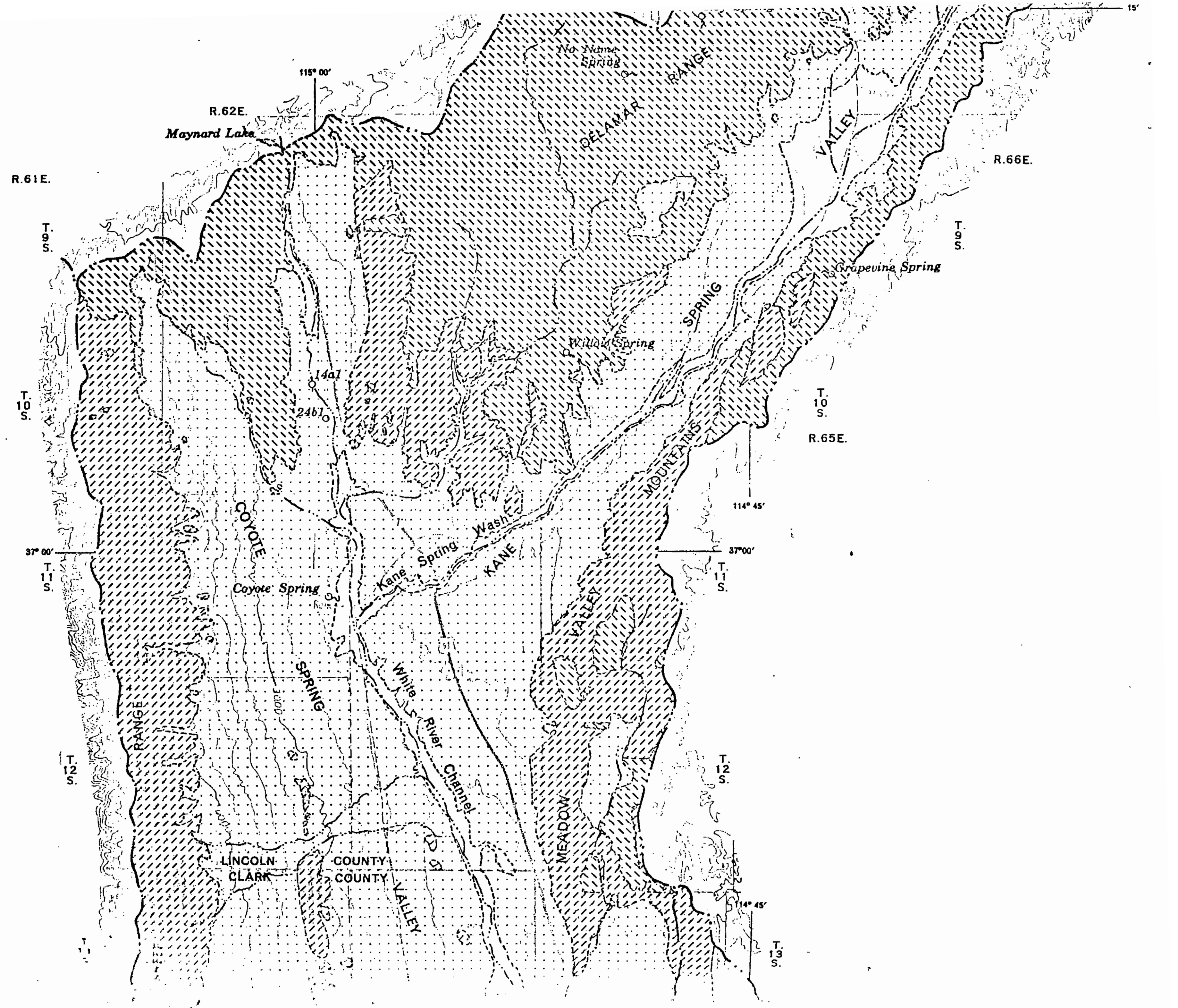


PLATE 1. MAP OF COYOTE SPRING AND KANE SPRING VALLEYS, AND MUDDY RIVER SPRINGS AREA, LINCOLN AND CLARK COUNTIES, NEVADA

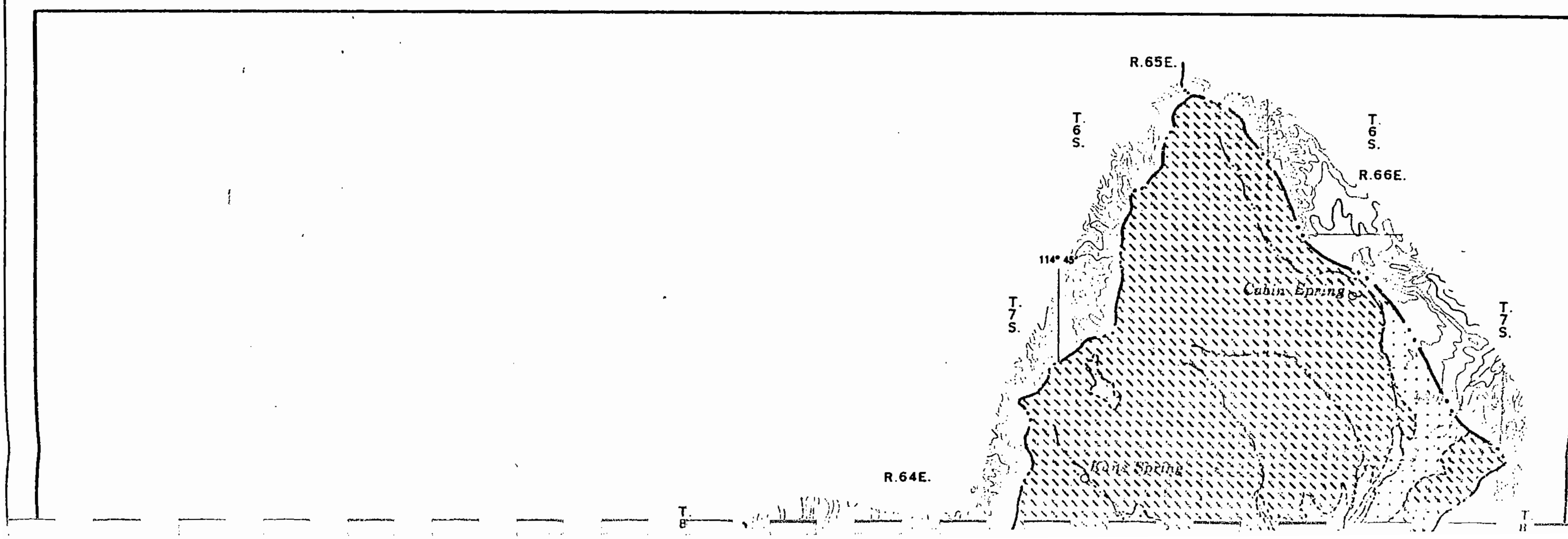
SHOWING AREAS OF BEDROCK, VALLEY FILL, SELECTED WELLS AND SPRINGS



R.61E.
R.62E.
115° 00'
Maynard Lake
No Name Spring
DELAMAR RANGE
VALLEY
R.66E.
T. 9 S.
T. 9 S.
Grapevine Spring
SPRING
Willow Spring
14a1
24b1
T. 10 S.
T. 10 S.
R.65E.
MOUNTAINS
114° 45'
COYOTE
Wash
Kane Spring
KANE
37° 00'
37°00'
T. 11 S.
T. 11 S.
Coyote Spring
VALLEY
SPRING
White River Channel
RANGE
T. 12 S.
T. 12 S.
MEADOW
LINCOLN COUNTY
CLARK COUNTY
VALLEY
114° 45'
T. 13 S.
15'

UNITED STATES DEPARTMENT OF INTERIOR
GEOLOGICAL SURVEY

STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES



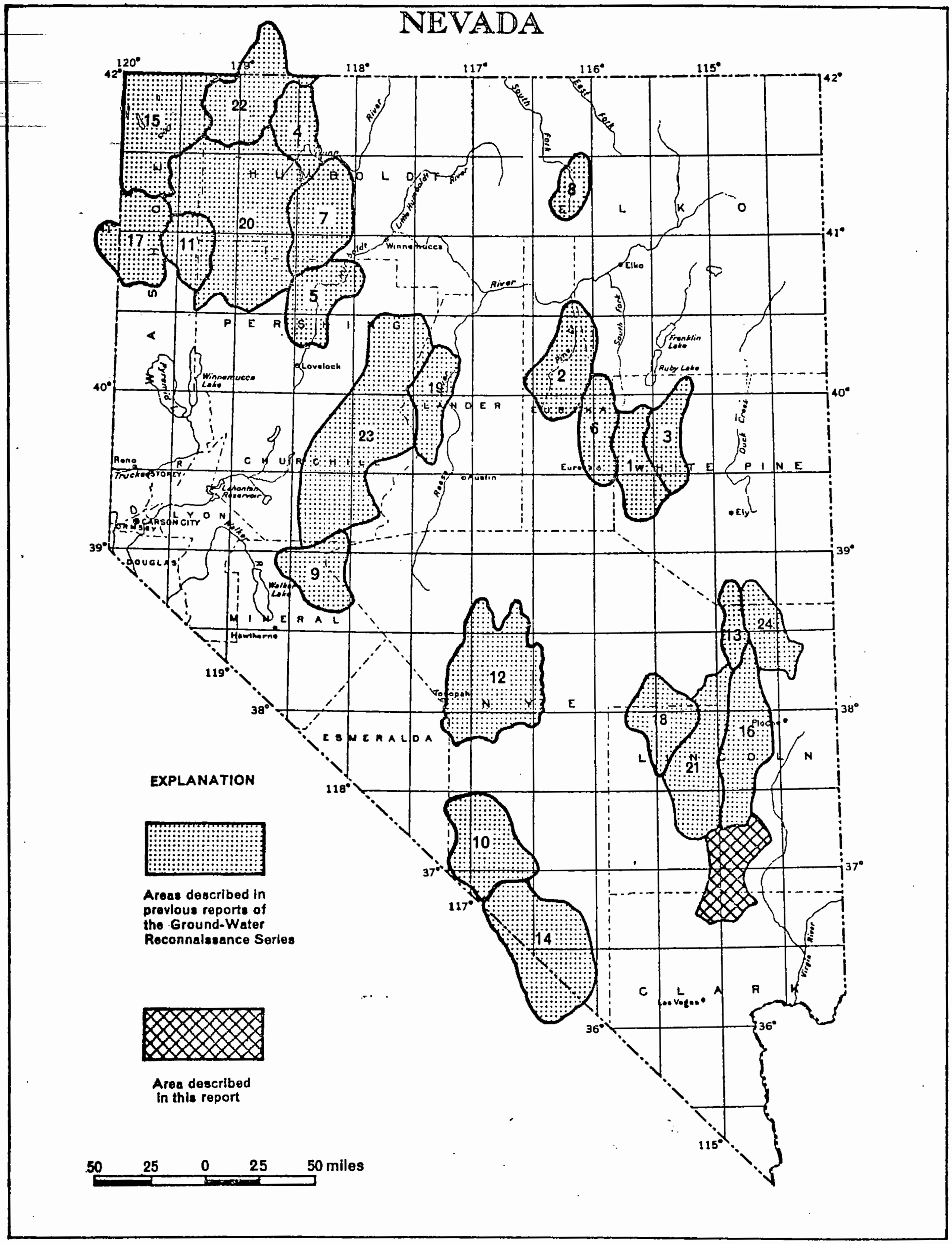


Figure 1. MAP OF NEVADA

showing areas described in previous reports of the ground-water reconnaissance series and the area described in this report.

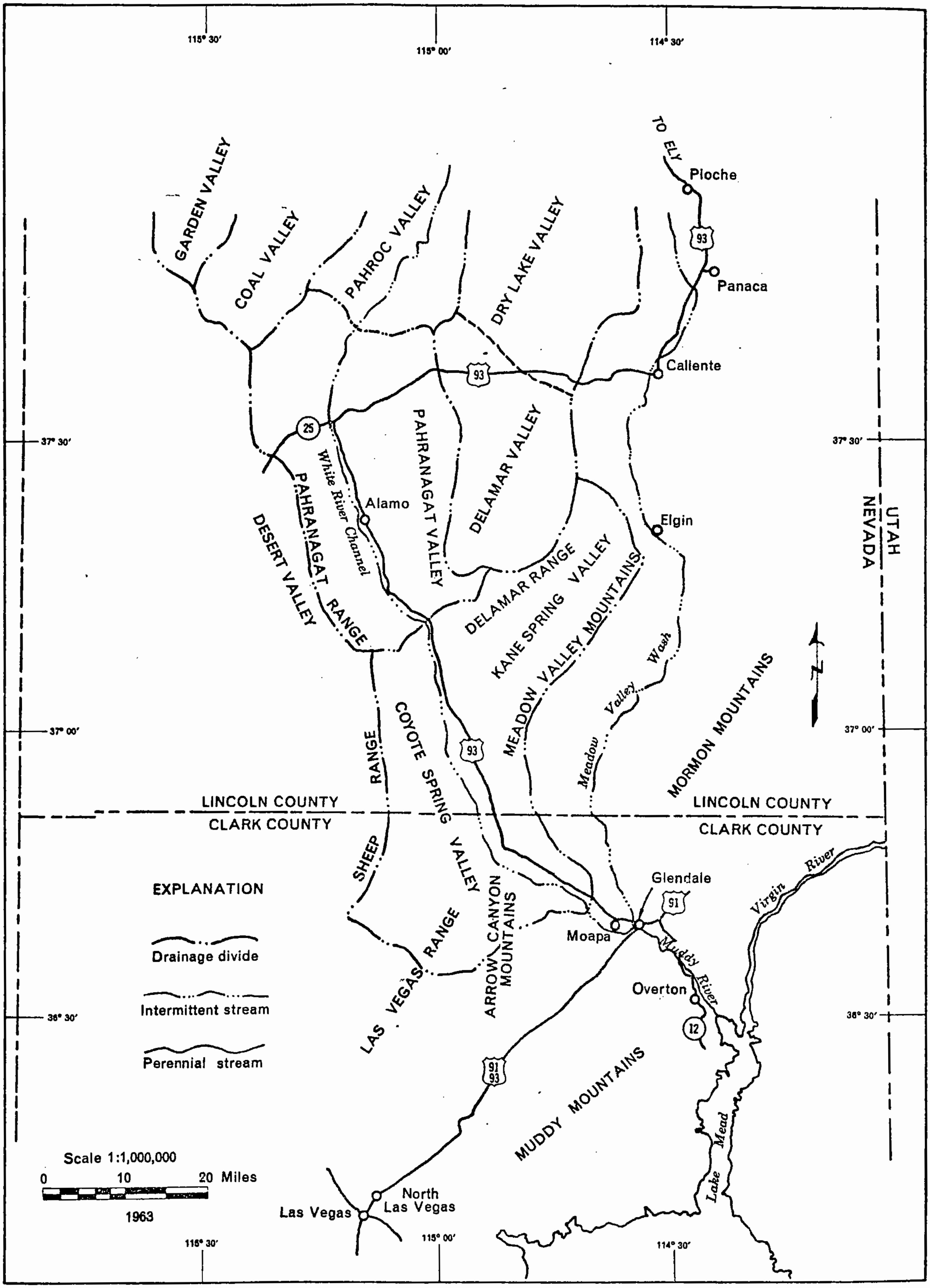


Figure 2.—Sketch map showing relation of Coyote Spring and Kane Spring Valleys and Muddy River Springs area to adjacent areas

mouth of Arrow Canyon and the White Narrows. Arrow Canyon is also known locally as Arrowhead Canyon.

Some 10,000 years ago in Pleistocene time, the White River flowed through Coyote Spring Valley entering the valley through the gap at Maynard Lake in the north end. It flowed through Arrow Canyon between the Arrow Canyon Range and Meadow Valley Mountains and continued southeastward along the present course of Muddy River. The altitude of the White River channel in the vicinity of the gap at Maynard Lake is about 3,120 feet. At the White Narrows (pl. 1) in the lower end of the area of this report the altitude is about 1,660 feet. The average gradient of the channel is about 32 feet per mile. The channel of the White River is a prominent topographic feature of the region extending southward from the latitude of Preston in White River Valley to Lake Mead, a distance of roughly 150 miles. It is a significant factor in the ground-water hydrology of the region.

The Sheep Range is the dominant mountain block in the area. It bounds Coyote Spring Valley on the west. The crest of the Sheep Range is higher than 7,000 feet above sea level for 15 miles and for half of this distance is higher than 8,000 feet above sea level. Hayford Peak, altitude 9,920 feet, at the south end of the range is the highest point in the area.

The Delamar Range forms the northwest side of Kane Spring Valley. About 4 miles of the crest of the Delamar Range is higher than 7,000 feet. An unnamed peak, altitude 7,720 feet, is the high point of the range.

Meadow Valley Mountains form the southeast side of Kane Springs Valley. Only a few short segments of the mountains are higher than 5,000 feet above sea level. The highest peak, unnamed, has an altitude of 5,676 feet. A high divide between the Meadow Valley Mountains and the Delamar Range separates the northeast end of Kane Spring Valley from Meadow Valley Wash in the vicinity of Elgin.

The Arrow Canyon Range bounds the southeast part of Coyote Spring Valley. Its highest points rise only a little more than 5,000 feet above sea level. The Range is separated from the Meadow Valley Mountains to the north by Arrow Canyon, a topographic low between the ranges.

The south end of Coyote Spring Valley is topographically closed by a bedrock and alluvial divide extending eastward from Hayford Peak to the Arrow Canyon Range.

The Muddy River Springs area drains southeastward from Arrow Canyon through upper Moapa Valley. Muddy River is joined by Meadow Valley Wash in the vicinity of Glendale. Meadow Valley Wash drains a very large area to the east and northeast of the area of this report.

Coyote Spring and Kane Spring Valleys are used principally for livestock range. Only one ranch is in Coyote Spring Valley, and several ranches and farms are in the Muddy River Springs area. Here the residents are engaged principally in dairying and other farming activities. Also, two resort areas have been developed around springs which form a part of the supply of Muddy River.

Climate:

The climate of the lowlands of Coyote Spring Valley, Kane Spring Valley, and Muddy River Springs area is arid to semiarid. Precipitation and humidity ordinarily are low and summer temperatures and evaporation rates are high. Precipitation is irregularly distributed within the valleys but generally is least on the valley floors and greatest in the mountains. Snow commonly occurs during the winter in the higher parts of the Sheep and Delamar Ranges and only rarely elsewhere. Localized storms, principally in July and August, provide most of the summer precipitation. The daily and seasonal range in temperature is large.

No long-term records of precipitation are available for the area of this report. However, records for Overton in lower Moapa Valley to the southeast and for Alamo in Pahranagat Valley to the north provide useful reference. The record of precipitation was begun at Overton in 1939 and in Alamo in about 1921. Additionally, records are available for Elgin in Meadow Valley Wash, about 3 miles northeast of Kane Spring Valley. Table 1 gives average monthly and annual precipitation at Alamo and Overton for the 20-year period 1941-60. The average given for Elgin is based on the 10-year period 1953-62 and therefore may not be directly comparable to the other two stations. The annual precipitation also is listed in table 1 for the available data from 1941. Locations of the stations are shown in figure 2.

Table 2 lists temperature data at Alamo and Overton for the period 1941-60. Maximum and minimum temperatures recorded are: at Alamo, 115°F. on August 11, 1940, and -9°F on January 9, 1937; and at Overton 122°F on June 23, 1954, and 8°F on January 3, 1954.

Table 1.--Summary of precipitation at Alamo, Elgin, and Overton, Nevada

(from published records of the U.S. Weather Bureau)

Average monthly and annual precipitation, in inches, (1941-60)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Alamo	.56	.55	.68	.51	.46	.10	.69	.55	.27	.62	.46	.38	5.80
Elgin 1/	1.27	1.01	.61	.47	.49	.12	.79	.85	.60	.81	.94	.56	8.50
Overton	.59	.47	.43	.29	.16	.05	.21	.41	.28	.52	.43	.57	4.41

1/ Average precipitation for Elgin 1953-62.

Annual precipitation, in inches, (1941-62)

Year	Alamo	Elgin	Overton	Year	Alamo	Elgin	Overton
1941	14.91	--	12.37	1952	6.88	10.47	5.89
1942	2.94	--	1.26	1953	1.98	3.55	.71
1943	--	--	5.88	1954	5.96	12.06	4.74
1944	--	--	3.63	1955	5.65	11.19	3.22
1945	10.65	--	3.91	1956	1.23	2.03	.87
1946	--	--	5.24	1957	7.43	13.06	6.73
1947	--	--	3.14	1958	6.47	10.14	6.03
1948	2.75	--	2.07	1959	4.42	6.01	5.39
1949	6.09	--	4.35	1960	6.02	11.06	5.71
1950	5.32	--	1.11	1961	3.63	7.69	2.25
1951	4.89	12.81	5.47	1962	--	8.21	1.22

Table 2.--Average monthly and annual temperature, in degrees Fahrenheit, at Alamo and Overton, Nevada, 1941-60

(from published records of the U. S. Weather Bureau)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Alamo	37.1	42.0	46.7	55.8	62.2	71.0	78.0	75.2	68.6	57.6	45.9	38.9	56.6
Overton	44.6	49.7	55.9	66.6	74.2	82.1	89.6	87.8	80.2	67.4	53.1	46.2	66.1

Low humidity and high temperature and wind movement result in high evaporation rates. The evaporation rate is known to be high, although records of evaporation are not available for this area. However, according to a regional interpretation by Kohler, Nordenson, and Baker (1959, pls. 1, 2) average annual pan evaporation would be on the order of 115-120 inches and average annual lake evaporation would be on the order of 75 inches.

Houston (1950, p. 19, 20) lists the average growing season in Pahranagat Valley as 167 days and in Moapa Valley as 237 days. The area of this report lies between the two areas referred to above. Accordingly, it is inferred that the growing season in the north part of Coyote Spring Valley may approach, but be somewhat longer than, the growing season in Pahranagat Valley. In the Muddy River Springs area, however, the growing season probably would more nearly approach the growing season in Lower Moapa Valley. Variations of average growing season may occur within short distances, depending on local conditions of topography and exposure, as well as the variations that occur from year to year.

In recent years the U.S. Weather Bureau records list freeze data rather than killing frosts; the dates are listed for the occurrence of the last spring minimum and the first fall minimum for temperatures of 32°F or below, 28°F or below, 24°F or below, 20°F or below, and 16°F or below. From these data, the number of days between the last spring minimum and the first fall minimum occurrence for the respective temperature groups are given. The following tabulation lists the number of days for three of the temperature groups recorded at Alamo and Overton for the period 1952-62.

Number of days between the last spring minimum temperature and the first fall minimum temperature for Alamo and Overton for the period 1952-62

	32°F or below		28°F or below		24°F or below	
Year	Alamo	Overton	Alamo	Overton	Alamo	Overton
1952	177	243	212	265	227	319
1953	117	221	150	221	208	267
1954	219	234	230	256	257	338
1955	141	198	178	227	208	227
1956	134	205	183	226	202	253
1957	163	238	169	247	238	298
1958	173	207	176	252	222	300
1959	151	243	184	243	228	291
1960	144	207	164	274	198	295
1961	129	208	156	260	188	301
1962	--	214	--	245	--	244
Average	155	220	180	247	217	285

Physiography and Drainage:

Coyote Spring Valley and Muddy River Springs area are segments of a topographic trough that includes from north to south White River Valley, Pahroc Valley, Pahranagat Valley, Coyote Spring Valley, and Moapa Valley. The ancestral White River flowed in this trough in late Pleistocene time, some 10,000 years ago, when it was tributary to the Virgin and Colorado Rivers. Under present climatic conditions, streamflow in most of the White River and tributary channels only occurs for short intervals after high-intensity storms. One exception to this is Muddy River, supplied by springs southeast of Arrow Canyon, and which is perennial to Lake Mead, about 25 miles downstream. The present-day lowland of Coyote Spring Valley and Muddy River Springs area is the former flood plain of the White River, which forms the topographic axis of the two valleys.

The floor of the channel slopes southward in Coyote Spring Valley from the gap at Maynard Lake, altitude about 3,120 feet. About 30 miles south of the gap the channel is about 1,000 feet lower. In this area, about the southeast quarter of T. 13 N., R. 63 E., the channel swings eastward, near a low north-trending spur of the Arrow Canyon Range. In its eastward course, the White River cut a narrow gap in Paleozoic rocks as it crossed a bedrock divide between the Meadow Valley Mountains and the Arrow Canyon Range. From this gap, named Arrow Canyon, the channel follows a more southeastward course to present Lake Mead. In this area the channel has been cut generally into the Muddy Creek Formation of Pliocene age, and overlying younger gravel deposits. Between the mouth of Arrow Canyon and White Narrows the flood plain has a gradient of 30 to 35 feet per mile.

The White River channel provides the main drainage line for the area of this report. Kane Spring Wash is the major tributary. Numerous other tributary channels or washes are relatively minor and drain relatively small segments or basins within Coyote Spring Valley, Kane Spring Valley, and the Muddy River Springs area. These tributaries dissect otherwise rather smooth alluvial slopes that rise with increasing gradients to the mountain blocks, primarily the Sheep Range and to a lesser extent the Delamar Range, Meadow Valley Mountain, and the Arrow Canyon Range.

GENERAL GEOLOGY

The geology shown on plate 1 is based largely on the reconnaissance geologic map of Lincoln County prepared by Tschanz and Pampeyan (1961) and on the reconnaissance geologic map of Clark County (1958) prepared by Bowyer, Pampeyan, and Longwell.

Reso (1963, p. 902) in his study of the Pahranagat Range indicates that nearly 90 percent of the rocks in the Paleozoic section, which he estimates to be about 18,200 feet thick, are limestone and dolomite. Langenheim and others (1962) describe over 10,000 feet of Paleozoic rocks in the Arrow Canyon Range. The Paleozoic section is dominantly composed of carbonate rocks. Farther south in the Muddy Mountains, Longwell (1928, p. 21) describes a Paleozoic section of more than 7,400 feet of which two-thirds is carbonate rocks. North of the Pahranagat Range in the south Egan Range Kellog (1960, p. 189) notes that about 80 percent of the rocks in the Paleozoic section, which is about 30,000 feet thick, are limestone and dolomite (carbonate). As the area of this report lies more or less between the Pahranagat and Arrow Canyon Ranges, it is a reasonable inference that Coyote Spring and Kane Spring Valleys and the Muddy River Springs area are underlain generally by relatively thick sections of Paleozoic rocks, and further that a large proportion of the Paleozoic section consists of carbonate rocks. Exposures of the Paleozoic carbonate rocks are common in the vicinity of the Muddy River Springs area, Arrow Canyon, and the Arrow Canyon Range to the west, the Sheep Range, and elsewhere.

In this report, the rocks of Coyote Spring and Kane Spring Valleys and Muddy River Springs area are divided into two major groups, designated bedrock and valley fill, and further, each group is divided into two units. The distribution of the four units is shown on plate 1. The Paleozoic carbonate rocks have been identified as a separate unit of the bedrock group because of their significance in the ground-water hydrology of the region. The second unit of the bedrock groups includes Paleozoic shale, sandstone, quartzite, and conglomerate, and Tertiary volcanic rocks composed of welded tuff, tuff, lava flows, and some sedimentary units.

The second group of rocks is designated valley fill and is divided into two units--older and younger valley fill. The older unit consists of unconsolidated to partly consolidated silt, sand, and gravel derived from adjacent highland areas, but includes some rocks of volcanic origin. It ranges in age from late Tertiary to Quaternary. The unit was deposited largely under subaerial and lacustrine environments. Although data are not available to determine the maximum thickness of the unit, it probably is at least several hundred feet thick and may exceed a thousand feet in the area of report. In addition, this unit includes the Muddy Creek Formation in the vicinity of Muddy River Springs. Longwell (1928, p. 90-96) describes the Muddy Creek Formation more fully from observations in and adjacent to lower Moapa Valley. He indicates that 1,700 feet does not seem excessive for the thickness in the center of the basin. It is likely that somewhat similar deposits of similar age and lithology occur in Coyote Spring and Kane Spring Valleys.

The younger valley fill includes clay, silt, sand, and gravel of late Quaternary age and occurs along the White River channel and a few tributary channels. Obviously, deposits along numerous active channels are of Recent age, although these are not shown on plate 1. As defined, the maximum thickness of younger valley fill generally may be less than 100 feet along the White River channel. The valley fill probably is underlain by bedrock similar to that exposed in the mountains.

Water-Bearing Properties of the Rocks:

The rocks of Paleozoic age generally have had their primary permeability, that is, permeability at the time of deposition, considerably reduced by consolidation, cementation, or other alteration. However, because they subsequently have been fractured repeatedly by folding and faulting, secondary openings have developed through which some ground water may be transmitted. Further, the fractures or joints in the Paleozoic carbonate rocks locally have been enlarged by solution as water moved through them. Solution openings developed near sources of recharge where carbon dioxide carried by rain water penetrated the rocks, or where organic and other acids derived from decaying vegetation and other sources were carried by water into contact with the carbonate rocks. Solution openings are not necessarily restricted to the vicinity of present day recharge areas and outcrops of these rocks. Rather, they may occur wherever the requisite conditions have occurred anytime since deposition of the carbonate rocks. The principal significance of solution openings is that they greatly facilitate movement of ground water through carbonate rocks.

That the existing fractures or solution openings have extensive hydraulic connection throughout the area is demonstrated by the regional hydrology. In the absence of detailed information, it is presumed that ground-water movement through carbonate rocks in this region occurs through both fractures and solution openings. Muddy River Springs, though issuing from alluvial deposits, occur near surface exposures of carbonate rocks and are considered to be supplied largely by ground water in carbonate rocks.

The Paleozoic clastic rocks and the Tertiary volcanic and clastic rocks exposed in the mountains generally have little primary permeability. Secondary fractures probably are the principal means by which limited amounts of ground water are transmitted through them. Favorably disposed fractures probably provide the network of openings through which water moves and is discharged at small springs in the mountains. The several small springs in Kane Spring Valley are considered to be of this type. Apparently all of these springs issue from or closely adjacent to volcanic rocks. Under favorable conditions the distribution of fractures in welded tuff, lava flows, or Paleozoic clastic rocks, where saturated, may permit the development of small to moderate yields of water from wells. However, these occurrences are likely to be so localized that the odds of a well encountering them are very small indeed.

The partly consolidated fine-grained deposits of the older valley fill probably would yield water slowly to wells. Locally, either fractures or gravel and sand beds may yield water freely. Coyote Spring and the area to the west is an area where some ground water occurs in these and perhaps in the younger deposits. The general location of the springs is such as to suggest that the ground water is perched--that is, sustained above the main ground-water body by faults or units of relatively low vertical permeability. The main ground-water body in the older valley fill apparently is at substantial depth and has been encountered in wells 10S/62-14a1 and 13S/63-25a1 at depths of 416 and 332 feet, respectively.

In the Muddy River Springs area, the older valley fill contains ground water, but it is inferred that these deposits generally have a relatively low permeability.

The younger valley fill in Coyote Spring and Kane Spring Valleys generally is above the main ground-water body and is not saturated. An exception to this is in the vicinity of Coyote Spring where ground water moving in the older valley fill from recharge areas in the Sheep Range discharges into the younger valley-fill deposits beneath the White River channel. For some distance in this vicinity the younger valley fill probably is saturated to within a few feet or a few tens of feet of land surface.

Most of the unconsolidated sand and gravel of the younger valley fill is capable of transmitting ground water freely, as is demonstrated by several moderate-capacity wells in the Muddy River Springs area. However, much of the valley fill apparently is composed of deposits of fine sand and silt having relatively low permeability and, where saturated, transmit water much more slowly than coarse sand and gravel. Younger valley-fill deposits in the Muddy River Springs area can provide small supplies of water readily, even to wells that penetrate only the upper few feet of saturated deposits. However, the chemical quality may not be entirely satisfactory for some purposes.

GROUND-WATER APPRAISAL

Occurrence and Movement of Ground Water:

The dominant feature of ground water in the area of this report is uniformity and magnitude of discharge of the Muddy River Springs. These springs, with an average discharge of somewhat more than 46 cfs, are the source of Muddy River and are the base of the agricultural economy of the Moapa Valley. The springs occur in a relatively dry region of Nevada. Along the Muddy River flood plain from the mouth of Arrow Canyon to White Narrows, ground water generally occurs within 10 to 15 feet of land surface. The ground water in the valley fill is supplied largely by return flow from the springs or by subsurface seepage from the springs.

In Coyote Spring Valley, ground water in the valley fill generally is at a substantial depth below land surface. At Maynard Lake at the extreme north end of the valley, the depth to water apparently is within about 10 feet of land surface. Southward, however, the depth to water generally is much greater. Well 10S/62-14a1 in the northern part of the valley was drilled to a depth of 510 feet and the depth to water reportedly was about 416 feet. In the southern part of the valley well 13S/63-25a1 was drilled to a depth of 353 feet in 1944, and the reported depth to water was about 332 feet. The depth to water in these wells apparently is indicative of the depth to water of the main ground-water body in the older valley fill.

The gradient of the main ground-water body along the axial part of Coyote Spring Valley is southward, as indicated by the following: The water level in the Maynard Lake area at the north end of the valley is about 3,100 feet above sea level; 10 miles to the south the water level in well 10S/62-14a1, as reported, is at an altitude of about 2,175 feet; and about 22 miles farther south, the water level in well 13S/63-25a1 is at an altitude of about 1,875 feet. Thus, the gradient averages about 92 feet per mile between Maynard Lake and well 10S/62-14a1 and roughly 13.5 feet per mile between well 10S/62-14a1 and well 13S/63-25a1. The southward gradient along the axial part of the valley is indicative of a general southward movement of ground water in Coyote Spring Valley.

The exception to this substantial depth to water is adjacent to Coyote Spring near the Butler (formerly) Ranch in sec. 24, T. 11 S., R. 62 E. Coyote Spring, prior to development, issued from the bluffs on the west side of White River Channel. Seemingly the springs derived their supply from a semiperched water-bearing zone in the older valley fill. In turn, this zone receives recharge from precipitation in the Sheep Range to the west. Ground water is discharged from this zone partly by the spring, partly by transpiration of phreatophytes, partly by movement into the younger valley fill beneath the White River channel, and partly by downward movement toward the principal water-bearing zone in the valley fill. The part that moves into the younger deposits beneath the White River channel then moves southward for some distance because of greater permeability of these deposits compared to that of the older valley fill. However, as the wetted area at the base of these deposits is increased sufficiently most of the ground water in them also will drain by vertical leakage into the main ground-water reservoir. Thus the relatively low vertical permeability results in a partial perching of the ground water in part of the older valley fill.

No well information is available for Kane Spring Valley. It is inferred from general geologic and hydrologic conditions that the depth to water in the principal water-bearing zone in the valley fill along Kane Spring Wash is substantial and generally comparable to that in Coyote Spring Valley. That is, in lower Kane Spring Valley the depth to water may be on the order of 300 to 400 feet below land surface. To the extent that ground water occurs in the older valley fill in Kane Spring Valley, the general direction of ground-water movement is southwestward along the axial part of the valley into Coyote Spring Valley.

Several small-yield springs in Kane Spring Valley occur along the Delamar Range and Meadow Valley Mountains. All of the six springs shown on plate 1 issue from or adjacent to volcanic rocks. It is considered that these springs are supplied by ground water moving through fractures in the volcanic rocks and that the ground water is partly perched as the result of either differential permeability between volcanic rock units or faulting.

Beneath the valley fill, ground water also is stored and transmitted in Paleozoic carbonate rocks. The occurrence of ground water in carbonate rocks is evident from the springs in Pahranagat Valley to the north of Coyote

Spring Valley and in the Muddy River Springs area. The storage and transmission of ground water in carbonate rocks beneath the valleys is inferred from the fact that the Sheep Range is an area where carbonate rocks are exposed extensively and also that the Sheep Range is a favorable area for receiving recharge from precipitation. Additionally, the relatively deep water level of the main ground-water body in the valley fill, in the vicinity of well 13S/63-25a1, is suggestive that some ground water moves downward from the valley fill into the Paleozoic carbonate rocks. Well 13S/63-25a1, which is a short distance northwest of the Arrow Canyon, is in an area where a shallow depth to water would be expected because of a decrease of transmissibility in the valley fill due to a substantial reduction in cross section of the valley fill in the gap.

Ground water occurs in the younger valley fill beneath the flood plain in the Muddy River Springs area. For most of the area the depth to water in the younger valley fill is within a few feet of land surface. However, it increases in depth to 25 to 35 feet in the northwestern part of the area beyond the springs. The thickness of the younger valley fill in this part of the area has not been determined, but based on the late geologic history of the region, its maximum thickness probably is not more than several tens of feet. Most of the ground water developed by wells in the area apparently comes from water in the younger valley fill.

Ground water also occurs in the older valley fill in this area. The depth to water varies considerably, largely due to variations in altitude of the land surface. The water surface in the older valley fill probably is consistent with that in the younger valley fill and has a general southeastward slope.

Although some recharge to the ground-water reservoir in the valley fill is derived from local precipitation, most is derived from surface and subsurface discharge of the Muddy River Springs. The water supplying the springs is derived from ground water that largely moves through Paleozoic carbonate rocks, which in turn is supplied by recharge derived from precipitation in favorable areas generally north and west of the springs.

<u>Muddy River Springs:</u> The Muddy River Springs are the dominant hydrologic feature of this area. The average annual discharge is 46.5 cfs for 25 complete years of records as measured at the Muddy River gaging station near Moapa. Monthly and annual mean discharge is given in table 3. Annual mean discharge has ranged from 43.5 cfs in 1930 to 49.6 cfs in 1958. The least monthly mean discharge is 43.2 cfs in June and the greatest monthly mean discharge is 49.6 cfs in January, according to the record. Thus the range in annual fluctuation is small with the minimum annual mean discharge being nearly 88 percent of the maximum annual mean discharge. The minimum monthly mean discharge is nearly 87 percent of the maximum monthly mean discharge. It should be noted that a small part of the measured streamflow is contributed by runoff from local precipitation. Most of this is contributed by high-intensity storms which occur most frequently in July and August.

The fact that local storms contribute only a small part of the total flow past the gaging station is shown by making a simple adjustment of the detailed gaging-station records for storm runoff, which only reduces the mean annual discharge from about 46.5 cfs to about 46.4 cfs. This adjustment, however, does shift the low monthly flow from June to July. The remaining flow measured at this gaging station represents discharge from springs.

Table 3.--Monthly and annual mean discharge, in cubic feet per second, of Muddy River, near Moapa, for 25 years during the period 1914-62

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Annual
1914	47.6	48.9	49.7	50.3	58.7	46.8	45.4	44.0	44.3	43.9	43.5	43.9	47.2
1915	44.8	47.1	48.8	50.5	54.3	50.2	48.7	46.8	42.5	45.3	44.3	48.0	47.6
1917	46.7	49.7	49.1	48.2	49.2	48.3	46.7	44.5	44.9	44.3	44.8	44.5	46.7
1918	47.1	48.2	49.2	49.0	50.0	49.5	47.0	46.0	44.3	44.9	43.5	46.1	47.0
1929	42.4	44.1	46.7	47.5	47.0	45.7	44.7	42.7	42.0	42.9	42.5	43.2	44.3
1930	43.9	44.1	44.8	47.0	46.6	46.2	44.7	43.0	40.3	40.7	41.2	39.8	43.5
1931	43.7	44.3	45.8	46.8	46.8	45.5	42.8	42.5	40.7	41.7	40.7	45.6	43.9
1945	45.9	47.0	48.8	47.4	47.2	46.1	43.7	42.0	41.7	44.5	47.7	45.8	45.6
1946	49.7	49.4	50.1	50.8	49.7	49.2	46.6	42.7	40.6	42.5	46.0	45.9	46.9
1947	49.6	51.2	50.6	50.1	49.6	48.3	48.6	46.9	44.7	44.4	44.6	45.2	47.8
1948	46.5	48.2	50.4	48.2	48.3	47.3	46.5	45.4	44.6	42.6	43.2	44.1	46.3
1949	47.0	47.0	49.5	53.5	50.9	47.6	46.9	45.7	45.5	43.1	43.7	44.6	47.1
1950	47.2	46.8	49.8	49.0	47.5	47.8	45.9	45.0	42.8	44.5	43.1	45.2	46.2
1951	46.5	47.2	47.5	48.8	48.1	48.0	48.4	48.3	44.6	44.8	45.1	45.0	46.9
1952	46.6	48.0	49.3	49.3	47.5	50.1	47.5	45.6	45.1	44.7	42.2	43.4	46.6
1953	44.4	50.5	52.1	49.6	47.6	45.2	44.7	43.5	42.6	45.9	42.9	43.4	46.0
1954	46.6	49.0	50.3	48.9	48.5	46.5	46.1	45.6	42.4	41.7	42.4	44.4	46.0
1955	45.1	50.3	48.7	52.5	52.1	47.6	45.6	45.8	43.7	42.7	48.5	44.3	47.2
1956	46.1	46.3	48.0	49.5	50.9	47.2	46.0	44.8	43.7	41.8	41.7	43.3	45.8
1957	43.7	47.1	48.8	49.5	50.9	47.3	46.8	47.7	46.1	43.4	54.5	46.5	47.7
1958	52.9	54.2	53.6	52.5	56.2	53.5	50.6	48.5	42.8	44.0	43.3	43.8	49.6
1959	44.7	47.9	52.1	52.7	52.3	52.1	48.8	47.1	44.6	45.2	52.3	46.9	48.9
1960	47.3	53.0	54.9	55.4	51.7	51.5	47.7	45.7	41.2	40.2	41.1	43.4	47.8
1961	45.2	61.6	51.4	48.6	44.2	44.5	44.6	42.1	41.9	45.1	43.3	42.5	46.3
1962	42.8	46.2	48.3	48.2	46.3	49.9	44.0	42.7	43.5	40.6	39.0	42.4	44.5

To analyze further the gaging-station record as a means of evaluating the characteristics of the actual discharge of the springs, a set of measurements and estimates of discharge were made at 40 points in September 1963. These measurements are listed in table 4. The locations of springs and measuring points are shown in figure 3. The springs rise within a distance of two miles north of the gaging station. When the measurements were made, all except 1.4 cfs of the flow was passing the gaging station. The flow at stations 2 and 3 was the only water from the springs that did not pass the gaging station in the main channel. It is noted that the flow of 1.35 cfs past station 3 actually resulted from pumping of well 14S/65-15bb1, which is in a spring area. A special study of the discharge of the springs has been started and involves periodic measurements at selected stations. These will form the basis for a more detailed analysis of the spring flow.

Preliminary information indicates that the spring discharge has less variation than shown by the record for the gaging station on Muddy River near Moapa. Inspection of the continuous gage height record indicates that a slight daily fluctuation, on the order of a few thousandths of a foot, occurs in the summer season but not in the coldest part of December and January. This fluctuation apparently is due to evapotranspiration along the channel and ditches between the gaging station and the springs.

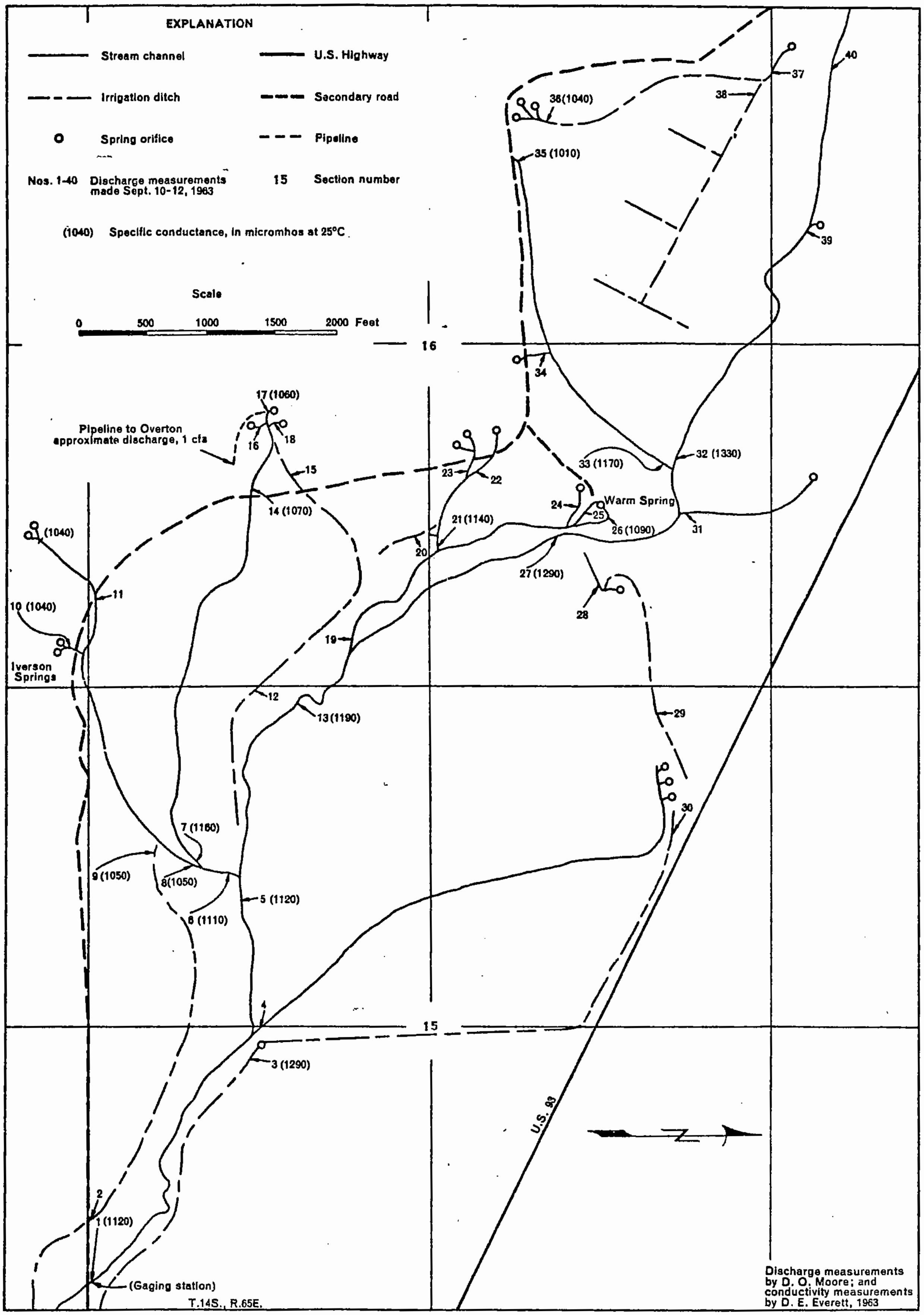


Figure 3.—Sketch map of Muddy River Springs area, showing location of springs and points where discharge measurements were made in September 1963

TABLE 4.--Measurements of flow between springs and Muddy River gaging station, September 10-12, 1963

Measurement number 1/	Discharge in cfs	Measurement number 1/	Discharge in cfs
1	42.8 at gaging station	21	0.15 estimated
2	0.05 estimated	22	0
3	1.35	23	0
4	0.02 estimated	24	0.05 estimated
5	43.0	25	3.95
6	11.1	26	3.26
7	2.94	27	19.5
8	8.37	28	0.94
9	0.74	29	0.84
10	2.26	30	2.30
11	3.78	31	0.30 estimated
12	0.80 estimated	32	4.16
13	31.8	33	9.21
14	1.63	34	0
15	1.37	35	0.48
16	1.0 estimated	36	0.48
17	1.23	37	0.1 estimated
18	0.6 estimated	38	0.77
19	8.32	39	0.03 estimated
20	0.05 estimated	40	0

1/ Corresponds to measuring site on fig. 2.

Inspection of the monthly mean discharge indicates that the lowest flow occurs in the summer months and the highest flow occurs about in January. This reflects the seasonal variation due to evapotranspiration in the area upgradient from the gaging station. This effect also reflects some diversion for irrigation in the area upgradient from the gaging station where most of the water diverted for irrigation is dissipated by evapotranspiration. If this effect is adjusted out of the gaging station record, the average annual discharge of the springs might closely approach the average discharge of nearly 50 cfs for January recorded at the gaging station.

Several simple preliminary adjustments of the gaging record result in the removal of local effects of evapotranspiration and surface runoff from high-intensity storms. The resultant adjusted discharge indicates a long-time variation in annual mean discharge. The inference may be made that such long-time variation in annual mean discharge is a response to the effects of long-time variations in precipitation. To examine this thesis, a comparison was made by plotting the cumulative departure from average discharge of the gaging record with the cumulative departure from average annual precipitation at Adaven about 100 miles north-northwest of the Muddy River Springs (fig. 4). This precipitation station was used because it is within the drainage area believed to supply water to the Muddy River Springs and because it has a relatively long period of record. There are considerable minor variations between the two graphs. However, the two curves seemingly fit best by matching the sharp rise in the precipitation graph during the period 1935-41 with the sharp rise in the discharge graph during the period 1956-60. The substantially above-average precipitation shown for the reference period also was in part a period of above average precipitation regionally in eastern Nevada and western Utah. Accordingly, it is inferred that throughout the drainage area that may supply Muddy River Springs, precipitation was substantially above average. If this was the case, then above-average recharge during the reference period probably was well distributed throughout the area and should be reflected, in time, in the discharge from the system. The tentative interpretation that the above-average discharge of Muddy River Springs during the period 1956-60 was in response to above average recharge during the period of 1935-41 obviously cannot be proven conclusively with the data at hand. Positive correlation with less than major conditions of precipitation--that is, excessively wet or dry periods--undoubtedly will be difficult and will require much additional information. Besides the need for a more vigorous analyses, substantially more data are required over a considerable period of time to determine if the response and lag-time is repetitive. At present the tentative interpretation only suggest that the lag-time response is on the order of a number of years which is consistent with the general concept of the dimension and character of the carbonate system.

Ground-water system supplying Muddy River Springs.--Under long-term conditions and prior to development, the average annual recharge to the ground-water reservoir in a hydrologically-closed ground-water system equals the average annual discharge. However, if a ground-water system in a topographically-closed valley is hydrologically open, recharge derived from

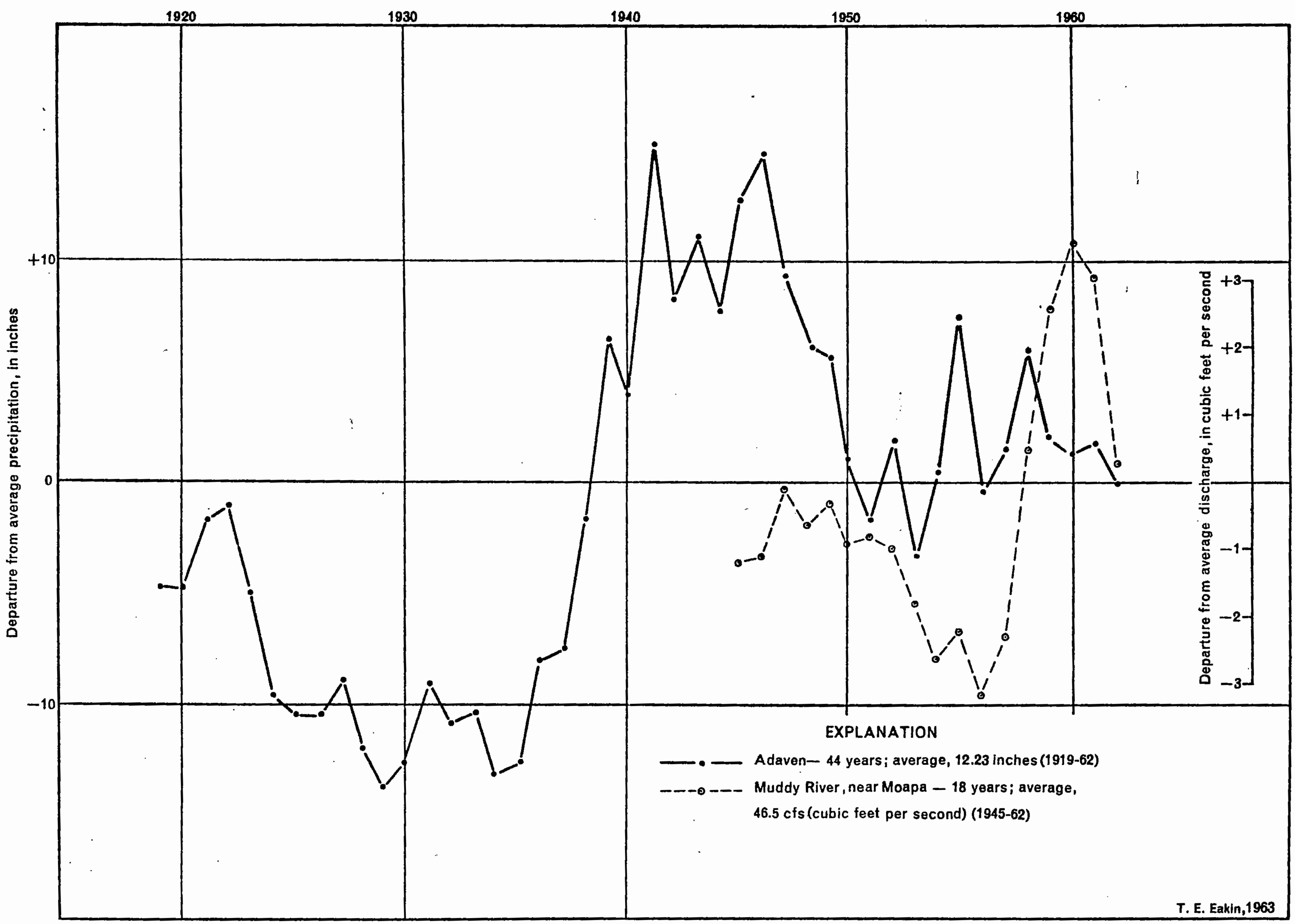


Figure 4.—Graphs of cumulative departure from average annual precipitation at Adaven for the period 1919-62 and from average annual discharge of Muddy River near Moapa for the period 1945-62

precipitation in the valley may be more or less than the natural discharge by evapotranspiration within the valley. Where the long-term recharge derived from precipitation within the valley is more than the long-term discharge in the valley and there is no net change in ground-water storage, ground water must be discharging from the valley by underflow to an area or areas of lower hydraulic head. Conversely, where the long-term recharge derived from precipitation within the valley is less than the long-term discharge in the valley, recharge must be entering the valley by underflow from an area or areas having a higher hydraulic head beyond the topographic divide.

In addition to hydraulic head potentials, the hydrologic properties of the rocks affect the movement of ground water. Where bedrock in the mountains enclosing a topographically-closed valley is relatively impermeable, ground water in the valley normally is part of a closed hydrologic system. Where the bedrock is at least locally permeable, the ground-water system may be hydrologically open.

The chemical quality of the ground water is another factor that may be an aid in evaluating the nature of a ground-water system. Ordinarily, the concentration of chemical constituents shows considerable variation in different parts of a ground-water system. However, the concentration generally is least in recharge areas and greatest in natural-discharge areas. Despite the common variations that may be expected in the chemical constituents in ground water in a given system, the character and concentration of one or more constituents may aid in identifying whether or not the system is closed.

In summary, closed or open ground-water systems may be identified by potential hydraulic gradients between the reference valley and adjacent valleys, by the relation of recharge to discharge within the valley, by the water-bearing character of geologic formations, including modifications by structural deformation, and by the chemical quality of the ground water.

The potential hydraulic gradient along the White River channel is southward. This trend continues southward from Muddy River Springs along the White River channel extending through Moapa Valley to Lake Mead (fig. 2). The altitude of the Muddy River Springs ranges from about 1,760 to 1,800 feet. Farther north in Coyote Spring Valley the water-level altitude in well 10S/62-14a1 is roughly 2,175 feet. At Maynard Lake, the water-level altitude is about 3,110 feet. Finally, the altitude of Ash Springs, southern group of the major springs in Pahranagat Valley, is about 3,605 feet. Thus, generally a southward hydraulic gradient is indicated which is generally consistent with the gradient of the White River channel. Moreover, the southward gradient indicates that the principal sources of ground water issuing from Muddy River Springs are upgradient or in a generally northward direction from the springs.

Possible sources of recharge for the Muddy River Springs are precipitation in or adjacent to the several mountain ranges generally north of the springs. Some of the lower altitude ranges have relatively small recharge potential and therefore would have little effect on the system. The more prominent ranges proportionally should have a greater effective recharge. Within the area of this report, the Sheep Range along the west side of Coyote Spring Valley probably is the dominant area of recharge. It extends from Hayford Peak, about due west of Muddy River Springs, to the north end of the area, a distance of about 35 miles. Precipitation apparently decreases northward in the range. Therefore, the more favorable area for recharge is in the southern part or about west from Muddy River Springs. This area then may provide some recharge to the Muddy River Springs, although the amount could be only a small fraction of the total spring discharge. The intervening Arrow Canyon Range probably has insignificant recharge to afford a hydraulic barrier to underflow from the Sheep Range. Also the altitude of the water level, about 1,875 feet in well 14S/63-25a1 in southern Coyote Spring Valley, is compatible with possible movement of ground water from the Sheep Range toward Muddy River Springs. Further, recharge from precipitation in the Sheep Range probably is sufficient to maintain a hydraulic divide along the range, thereby separating the ground-water system supplying Muddy River Springs from the ground-water systems west of the Sheep Range.

Elsewhere in the area, the Delamar Range probably produces some recharge to the ground-water system supplying Muddy River Springs. Farther north, valleys tributary to the White River channel and adjacent valleys, such as Garden, Coal, White River, Cave, Dry Lake, and Delamar probably contribute recharge in some degree to the system ultimately supplying Muddy River Springs. These areas have been discussed in several prior reports of the reconnaissance series (Eakin, 1962, 1963a, b, c).

To the northeast, ground water derived from the Meadow Valley Wash drainage area, at least theoretically, may supply part of the water discharged from Muddy River Springs. Potential gradients exist for the upper part of that area. However, quantitative evaluation of recharge and discharge by evapotranspiration of ground water within that basin has not been made at this time.

The capability of the Paleozoic carbonate rocks to transmit ground water in quantity has been discussed by Eakin (1962, 1963, 1963b). Drilling at the Nevada Test Site, about 65 miles west of Muddy River Springs, has shown that the Paleozoic carbonate rocks commonly transmit ground water more readily than the Paleozoic clastic rocks and Tertiary tuff (Winograd, 1962, p. 110). Thus, the Paleozoic carbonate rocks probably afford the best opportunity for ground-water movement between valleys. It should be recognized, however, that ground water is transmitted largely through fractures or solution openings in the Paleozoic carbonate rocks. Potential lateral movement of ground water through the carbonate rocks for distances of many miles is favored by the relatively high proportion of carbonate rocks in the Paleozoic section, which may be 10,000 to 18,000 feet thick in this region. Several periods of faulting and erosion provide the mechanisms for the development of extensive systems of fractures and solution openings. Although faulting may have offset or separated individual carbonate formations, it very likely may provide connection with other carbonate formations and thus result in hydraulic continuity over considerable distances.

The chemical quality of the water issuing from the Muddy Creek Springs is represented by an analysis of water from the Warm Spring and Iverson Spring, given in a subsequent section. The chemical character is that of a mixed water. However, this does not preclude the possibility that the water is a part of the carbonate ground-water system. If it is, the chemical concentration and character have been modified by contact with non-carbonate rocks, such as the Tertiary volcanic rocks or the Muddy Creek Formation. Certainly, part of the water supplied to the carbonate system has moved through volcanic rocks in various parts of the extensive system supplying the springs, if the present understanding of that system is correct. Field measurements of conductivity were made at 19 of the 40 points at which discharge measurements were made, as shown in figure 3. Field conductivity for the water from the Warm Spring was 1,150 micromhos as compared with the laboratory measurement of 985. The field conductivity ranged from 1,010 at station 6 in figure 2 to 1,330 at station 32. Of the 19 conductivity measurements, 15 were in the range from 1,010 to 1,090 micromhos. It is inferred, though not proved, from these measurements that the water quality from the various springs generally is similar to that of the Warm Spring and Iverson Springs with minor variations in concentration. The analyses of the water from the Warm Spring and Iverson's Springs therefore probably are closely representative of the distribution and proportion of chemical constituents for all the Muddy Creek Springs.

Estimated Average Annual Recharge:

The average annual recharge to the ground-water reservoir is estimated as a percentage of the average annual precipitation within the valley (Eakin and others, 1951, p. 79-81). A brief description of the method follows: Zones in which the average precipitation ranges between specified limits are delineated on a map, and a percentage of the precipitation is assigned to each zone which represents the assumed average recharge from the average precipitation in that zone. The degree of reliability of the estimate so obtained, of course, depends on the degree to which the values approximate the actual precipitation in the several zones and the degree to which the assumed percentages represent the actual proportion of recharge to ground water. Neither of these factors is known precisely enough to assume a high degree of reliability of the recharge estimate for any one valley. However, the method has proved useful for reconnaissance estimates, and experience suggests that in many areas the estimates probably are relatively close to the actual long-term average annual recharge.

The precipitation map of Nevada (Hardman and Mason, 1949, p. 10) has been adjusted (Hardman, oral communication, 1962) to the improved topographic base maps (scale 1:250,000) now available for the whole State. The base map for plate 1 of this report was prepared from the same series of topographic maps. The several zones of precipitation applicable to Coyote

Spring and Kane Spring Valleys and Muddy River Springs area are: The boundary between the zones of less than 8 inches and 8 to 12 inches of precipitation was delineated at the 6,000-foot contour; between 8 to 12 inches and 12 to 15 inches, at the 7,000-foot contour; between 12 to 15 inches and 15 to 20 inches at the 8,000-foot contour; and between 15 to 20 inches and more than 20 inches at the 9,000-foot contour.

The average precipitation used for the respective zones, beginning with the zone of 8 to 12 inches of precipitation, is 10 inches (0.83 foot), 13.5 inches (1.12 feet), 17.5 inches (1.46 feet), and 21 inches (1.75 feet).

The percentages of the average precipitation assumed to represent recharge for each zone are: less than 8 inches, 0; 8 to 12 inches, 3 percent; 12 to 15 inches, 7 percent; 15 to 20 inches, 15 percent; more than 20 inches, 25 percent.

Table 4 summarizes the computation of recharge for Coyote Spring and Kane Spring Valleys. The recharge (column 5) for each zone is obtained by multiplying the figures in columns 2, 3, and 4. Thus, for the zone of 12 to 15 inches of precipitation the computed recharge is 13,000 (acres) times 1.12 (feet) times .07 (7 percent), which is about 1,000 acre-feet. The estimated total average annual recharge derived from precipitation within the defined drainage basin of Coyote Spring and Kane Spring Valleys is about 2,600 acre-feet. Recharge from precipitation within the immediate drainage area tributary to Muddy River Springs area by comparison would be negligible.

In a general way the Sheep Range probably provides nearly 80 percent of the estimated average recharge and the Delamar Range most of the remainder. On this basis the Meadow Valley Mountains and the Arrow Canyon Range apparently supply a negligible amount of recharge to the overall ground-water system.

Table 5.--Estimated average annual ground-water recharge from precipitation in Coyote Spring and Kane Spring Valleys

Precipitation zone (inches)	Approximate area of zone (acres)	Average annual precipitation (feet)	Percent recharged	Estimated recharge (acre-feet) (2 x 3 x 4 ÷ 100)
20+	450	1.75	25	200
15-20	2,500	1.46	15	550
12-15	13,000	1.12	7	1,000
8-12	36,000	.83	3	900
8-	527,000	--	--	--
	605,500 (about 950 sq. mi.)	Estimated average annual recharge (rounded)		2,600

Estimated Average Annual Discharge:

Ground water is discharged naturally from the Coyote Spring and Kane Spring Valleys and the Muddy River Springs area principally by Muddy River Springs. A minor amount of ground water is discharged from the springs in Coyote Spring and Kane Spring Valleys.

Much of the spring flow in Coyote Spring and Kane Spring Valleys is discharged finally from the valleys by evapotranspiration processes. In Muddy River Springs area some of the spring flow is discharged finally by evapotranspiration within the area but most leaves the area by surface flow in the Muddy River. Thus the bulk of the ground water discharged from the area of this report can be estimated by the amount of water discharged by the Muddy River Springs.

The flow of the Muddy River, near Moapa, has been recorded for the periods July 1913-September 1915, May 1916-September 1918, June 1928-October 1931, April-July 1932, and from October 1944 to the present. Monthly and annual mean discharge is listed in preceding table 3. This station is just upstream from the paved road crossing in the SE 1/4 SE 1/4 sec. 15, T. 14 S., R. 65 E., and downstream from the several springs supplying the base flow of the Muddy River (see fig. 3). The record of streamflow at this station represents the actual discharge of the springs, except as follows: (1) streamflow at the station may be higher than spring discharge during periods of surface runoff, particularly from high intensity rains within the adjacent drainage area, and (2) streamflow at the station will be lower than spring discharge when water is diverted above the gaging station for irrigation and when evapotranspiration along the channels and in the fields irrigated by water from the springs between the station and the springs depletes the flow to the gaging station.

Although the scope of this investigation does not permit a detailed analysis of the record and the necessary additional field work, the effects of adjusting for the above factors can be shown roughly as follows:

The mean and median monthly and annual discharge, in cfs, for 25 complete water years of record are:

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Year
25-year mean	46.1	48.7	49.5	49.8	49.7	48.1	46.8	45.0	43.2	43.4	44.2	44.4	46.5
25-year median	46.5	48.0	49.3	49.3	49.2	47.6	46.5	45.4	43.4	43.9	43.3	44.4	46.7
Mean--adjusted for effect of surface water runoff	46.0	48.2	49.5	49.8	49.4	48.0	46.8	44.9	43.2	43.0	43.5	44.4	46.4

It may be noted that the relatively close values between the means and medians are indicative of the relatively uniform flow of the springs.

A partial adjustment to correct out the effects of streamflow from surface runoff due to local rainfall was made for the period 1945-62 in which records were conveniently available. The adjustment was made by reducing the high flow shown for short intervals to values consistent with the immediately preceding and succeeding periods for daily streamflow. During the 18-year period, adjustments were made for a total of 24 intervals. These were distributed by months as follows: one in October, three in November, two in December, two in February, one in March, one in May, two in June, six inJuly, and six in August.

If the 25-year mean discharge, 46.5 cfs, of Muddy River at the gaging station near Moapa is used for convenience to represent the discharge of the springs, the indicated mean discharge of the springs is about 33,700 acre-feet a year. The actual spring discharge is greater, due to some losses by irrigation diversion and evapotranspiration, and may approach a mean of 50 cfs or about 36,000 acre-feet a year. The annual mean discharge, however, has ranged from a low of 43.5 cfs in 1930 to a high of 49.6 cfs in 1958 for the period of record at the gaging station.

In addition to the spring discharge in the Muddy River Springs area several wells pump water for irrigation from the valley fill. These wells irrigate 400 to 500 acres of land. If about 5 feet of water per year is applied to this acreage, the yearly pumpage would be 2,000 to 3,000 acre-feet. Actual pumpage was not evaluated for the current year, and it is believed that acreage irrigated and acreage in various crops varies somewhat from year to year. Therefore the 2,000 to 3,000 acre-feet a year is considered to be a reasonable estimate for the "average" year.

Natural discharge of ground water by evapotranspiration in Coyote Spring and Kane Spring Valleys is relatively minor. In the vicinity of Coyote Spring, ground-water discharge probably is not more than a few hundred acre-feet a year, including that used for irrigation at the ranch. The flow of the springs in Kane Spring Valley is discharged finally by evapotranspiration from the valleys. The magnitude of this discharge is smaller than that in Coyote Spring Valley, probably less than 100 acre-feet a year.

In summary, it is estimated that ground water discharged naturally from the area of this report amounts to roughly 36,000 acre-feet a year from the springs that supply Muddy River. Of this, an average of 33,700 acre-feet, or 46.5 cfs, leave the area as streamflow past the Muddy River gaging station near Moapa. Most of the remainder apparently is used by irrigated crops or native vegetation upstream from the gaging station, and a very small amount may leave the area as underflow.

Whether part of the ground water discharged by irrigation wells subsequently leaves the area as streamflow in the Muddy River has not been determined. If it does, it can be only a small fraction of the total average pumpage of 2,000 to 3,000 acre-feet a year.

Additionally a few hundred acre-feet a year of ground water is discharged by evapotranspiration from the springs in Coyote Spring and Kane Spring Valleys.

Perennial Yield:

The perennial yield of a ground-water system is the upper limit of the amount of water that can be withdrawn economically from the system for an indefinite period of time without causing a permanent and continuing depletion of ground water in storage and without causing a deterioration of the quality of water. It is limited ultimately by the amount of natural discharge of suitable quality that can be salvaged for beneficial use from the ground-water system. The average recharge derived from precipitation and streams and from underflow into a valley are measures of the natural inflow to the ground-water system. The average discharge by evapotranspiration, discharge to streams flowing from the valley, and underflow from the valley are measures of the natural discharge from the ground-water system.

In the area of this report, natural discharge from the Muddy River Springs area is estimated to be on the order of 36,000 acre-feet a year. The estimated average annual recharge from precipitation in the immediate drainage area of the springs is negligible and indeed for the whole of Coyote Spring and Kane Spring Valleys and Muddy River Springs area is estimated to be only about 2,600 acre-feet. The source of most of the discharge of the Muddy River Springs is considered to be from valleys upgradient from the springs and hydrologically connected with them. These include the valleys along the White River channel and adjacent valleys that are ground-water tributaries to them. Although not demonstrated as yet, allowance must be made for a possible contribution to the springs from the ground-water system in carbonate rocks within the Meadow Valley drainage area.

As a substantial part of the natural discharge of the region is concentrated in the Muddy River Springs area, the discharge of the springs closely approximates the long-time perennial yield of the regional ground-water system.

The total discharge of the springs cannot be increased permanently. A temporary increase probably could be achieved by lowering the outlet levels of the sppings. This would increase the flow for perhaps several months and would be accomplished largely by the removal of some water stored in a limited area of the ground-water system adjacent to the springs. After this is removed the discharge rate would diminish gradually to about the previous natural rate. This is because the amount that the discharge points might be lowered probably is only a few feet and this would have an insignificant effect on the gradient distribution for the whole system.

It is noted, however, that an apparent long-time increase might be accomplished by developing the springs in such a way as to minimize surface and subsurface seepage losses that may now exist. However, this would represent a salvage of water for beneficial use rather than increasing the long-time yield of the springs. Also, much of the ground water in the valley fill in the Muddy River Springs area is the result of downward percolation of spring flow from diversion ditches on irrigated fields and subsurface seepage from the spring system. Part of the ground water in the valley fill is pumped from wells for irrigation and thus constitutes a beneficial use of at least part of the water that otherwise might be lost by transpiration from nonbeneficial vegetation and by evaporation.

The extent to which this process might be used more effectively without measurably influencing the total natural discharge of the springs cannot be evaluated at this time. Several factors of the natural system are not yet sufficiently known. Additionally there would be several possible patterns of such development, each of which would have different net effects on ground water in the area.

The combined perennial yield of ground water in Coyote Spring and Kane Spring Valleys may be on the order of 2,600 acre-feet--the estimated average annual recharge derived from precipitation within the area. The average annual ground-water discharge cannot be estimated directly because most of it apparently occurs by underflow from the valleys. Ground water discharged by evapotranspiration is estimated to be a few hundred acre-feet a year in the vicinity of Coyote Spring and probably not more than 100 acre-feet a year in the vicinity of the several springs in Kane Spring Valley. Presumably most of the ground water discharged by evapotranspiration in the vicinity of Coyote Spring could be intercepted for at least one-time use, but it is uncertain from present information how much of the ground water in the valley fill, presently discharged by underflow, could be intercepted for use in the valley.

Ground Water in Storage:

The amount of ground water in storage in the valley fill and underlying carbonate rocks in Coyote Spring and Kane Spring Valleys and the Muddy River Springs area is substantial. The relatively large volume in storage provides a reserve for maintaining withdrawals during protracted periods of drought. The reserve, in effect, increases the dependability of ground water as a source of supply and is an important asset in semi-arid and arid regions where surface-water supplies vary widely from year to year.

The stabilizing influence of a large amount of stored ground water is well illustrated by the flow of the springs supplying Muddy River. The relative uniformity of flow of the springs in large measure depends on the large volume of water in storage in the carbonate ground-water system. The water stored in this system greatly dampens the effect of variations in recharge from year to year. Thus, as shown by the 25-year period of record of flow of the Muddy River near Moapa, the extreme values of annual mean discharge fall within plus or minus 3.3 cfs of the mean of 46.5 cfs. Although this record is not an absolute measure of the discharge at the several spring orifices, it demonstrates the small range of fluctuation of the spring discharge, and is suggestive of a proportionally large volume of water stored in the carbonate system.

In the Muddy River Springs area, the magnitude of ground water stored in the valley fill may be illustrated by the following calculation. The surface area of the flood plain is about 2,000 acres between White Narrows and the mouth of Arrow Canyon. This area overlies a substantial thickness of sedimentary deposits. If a value of 15 percent is assumed as the specific yield (drainable pore space) of saturated deposits, then about 15,000 acre-feet of ground water are stored in the upper 50 feet of saturated valley fill. This is roughly 40 percent of the average annual discharge of the springs in that area, or roughly 5 to 6 times the amount of water now pumped for irrigation annually. This volume is equivalent to more than twice the amount of surface storage for the proposed "Warm Springs reservoir" under the U.S. Bureau of Reclamation "Moapa Valley Pumping Project" (1962). However, the ground water in the valley fill apparently has a somewhat higher chemical concentration than that of the springs and may not be entirely suitable for all irrigation uses without treatment or mixing with the spring water.

Chemical Quality:

The chemical quality of the water in most ground-water systems in Nevada varies considerably from place to place. In recharge areas the chemical concentration of the water normally is very low. However, as the ground water moves through the system to discharge areas, it comes into contact with soluble rock materials for long periods of time. The extent to which the water dissolves chemical constituents from the rock materials is governed in large part by the solubility, volume, and distribution of the rock materials, by the time the water is in contact with the rocks, and by the temperature and pressure in the ground-water system.

Table 6 lists the results of three analyses. Analysis 14S/65-15d is for a sample of water from the Muddy River at the gaging station (fig. 3). Analysis 14S/65-16acb is for a sample of water as it issued from Warm Spring, and analysis 14S/65-21a is for a sample of water issuing from Iverson Springs. The water at the Muddy River gaging station shows a small increase in concentration in all major constituents compared with the water from Warm Spring and Iverson Spring. This is as would be expected for water flowing on or through the flood-plain deposits which are composed in part of re-worked material from the Muddy Creek Formation.

[illegible] Chemical analyses of water from three sampling points in Muddy River Springs area, Clark County, Nev.

(in parts per million)

	Muddy River 14S/65-15d	Warm Spring 14S/65-16acb	Iverson Spring 14S/65-21aa
Date of collection	3-9-62	4-15-63	9-12-63
Temperature (°F)	71°	90°	89°
Silica (Si)	32	31	29
Calcium (Ca)	71	65	70
Magnesium (Mg)	33	28	26
Sodium (Na)	125	99	101
Potassium (K)	14	10	11
Carbonate (CO_3)	0	0	0
Bicarbonate (HCO_3)	303	288	274
Sulfate (SO_4)	216	174	179
Chloride (Cl)	75	60	64
Fluoride (F)	2.4	2.4	2.3
Nitrate (NO_3)	1.5	2.3	2.2
Boron (B)	0.4	0.3	0.3
Hardness as $CaCO_3$			
Calcium and Magnesium	248	236	225
Noncarbonate	65	43	55
Specific conductance Micromhos at 25°C)	1090	985	964
Dissolved solids - Sum	---	614	620
Sodium adsorption ratio (SAR)	3.1	2.57	2.62
Residual sodium carbonate (RSC) in equivalents per million	0.00	0.00	0.00
pH	--	--	--

During this investigation, field conductivity measurements were made at 25 points, 19 of which are shown on figure 2, at and upstream from the gaging station. Conductivities ranged from 1,010 to 1,330 micromhos. Of the 25 measurements, 15 were within the range of 1,010 to 1,090 micromhos. The field conductivities should not be compared directly with the laboratory conductivities listed in table 5 because the field measurements are subject to larger error. However, comparison between the several field conductivity measurements may be made for relative differences.

With respect to use, the water from the Muddy River Springs is classed as hard. The reported concentration of 2.4 ppm (parts per million) fluoride in the water is relatively high and exceeds the upper limits for average concentration recommended by the U. S. Public Health Service (1962, p. 8). Continual use of an excess of fluoride in water commonly has adverse effects on the permanent teeth of children.

For irrigation use, the analyses indicate that the water is classed as having a high salinity hazard and low sodium (alkali) hazard--that is, class C3-S1 according to the diagram for the classification of irrigation waters (U.S. Department of Agriculture, 1954, fig. 25). The concentration of boron is small and should not result in adverse effects even for most boron sensitive crops. As the spring water flows down the Muddy River and is diverted for irrigation or infiltrates into the younger valley fill deposits, the concentration of most of the chemical constituents tend to increase. The increase in concentration generally may be due either to evaporation, which leaves a higher proportion of constituents in the remaining water, or to solution from the soils, soil amendments, or vegetal matter with which the water may be in contact. Thus, downgradient from the springs, the spring water increases in concentration, but the quality remains suitable for all ordinary purposes.

Development:

The major development of ground water in the area of this report is based on the springs that supply Muddy River. Irrigation utilizing the Muddy River extends from the vicinity of the springs through upper Moapa Valley to the Narrows near Glendale and in lower Moapa Valley southward to within about a mile of Lake Mead.

Shamberger (1940, p. 14) indicated that the decreed rights of the Muddy River provided for irrigation supply for about 500 acres of land in upper Moapa Valley plus about 87 acres within the Indian Reservation. Of this acreage, about 186 acres are upstream from the Muddy River gaging station near Moapa. For the lower Moapa Valley the decree provided irrigation supply for 2,670 acres (summer irrigation season) and 4,541.56 acres during the winter season. According to the U.S. Bureau of Reclamation (1962), presently irrigated land includes 840 acres in the upper valley and 2,870 acres in the lower valley. In the upper valley 526 acres were within the Moapa Indian Reservation and 314 acres were outside the Reservation.

In the lower valley additional water (2,150 acre-feet per year) from Muddy River was used for industrial and public supply and about 1,400 acre-feet was used on 410 acres of the Overton Wildlife management area.

Additional development in the Muddy River Springs area probably would not increase the total natural water supply. However, careful consideration of the physical factors relating to the occurrence of the springs undoubtedly could lead to some development that would result in an increased availability of water for beneficial use. For example, ground water in the valley fill, which is a natural reservoir, is recharged largely from the springs. The recharge is accomplished by infiltration from the surface flow of the springs along natural channels and irrigation ditches, and from the fields irrigated by the spring water, and also by subsurface leakage from the springs. During the summer season of peak demand, ground water pumped from the valley fill could be mixed with the existing Muddy River and provide additional water. On a seasonal pumping operation, peak demand requirements probably could be maintained for a long period. Obviously, if the pumping is substantial, some reduction in winter discharge of the Muddy River should be expected. In effect, the natural regimen of the springs is one of relatively constant flow year around. A seasonal pumping regimen would provide a better means of adjusting that regimen to the uneven demand for water during the year. The quality of the well water is reportedly poorer than that of Muddy River. However, it seems likely that this adverse factor might be offset, at least in part, by mixing the pumped water with that of Muddy River.

Controls to reduce natural losses by evaporation and transpiration by nonbeneficial vegetation also could be of value in making more water available for beneficial use.

Ground water also is withdrawn by wells in the Muddy River Springs area. About 12 wells are used for irrigation and several others are used for domestic or stock requirements. Most of the larger-yield wells are shown on figure 5, and additional information for them is listed in tables 7 and 8. Although pumpage for irrigation probably varies from year to year, the estimated annual pumpage generally is in the range of 2,000 to 3,000 acre-feet. For the Muddy River Springs area, pumpage apparently has not resulted in a significant lowering of water levels. Figure 6 shows hydrographs for five wells in the Muddy River Springs area. Most of the fluctuations shown suggest prominent lowering of water levels in the wells during pumping, but that water levels recover about to previous levels after periods of nonpumping.

Water-level fluctuations also occur in response to recharge from nearby irrigation ditches, downward seepage in areas of irrigation and springs, recharge from local precipitation, discharge by evapotranspiration, and discharge into drainage ditches. The water levels for wells in this area are not measured more than a few times during any one year. Accordingly, the resulting hydrographs do not show the details of fluctuations resulting from the affects of the several factors given above.

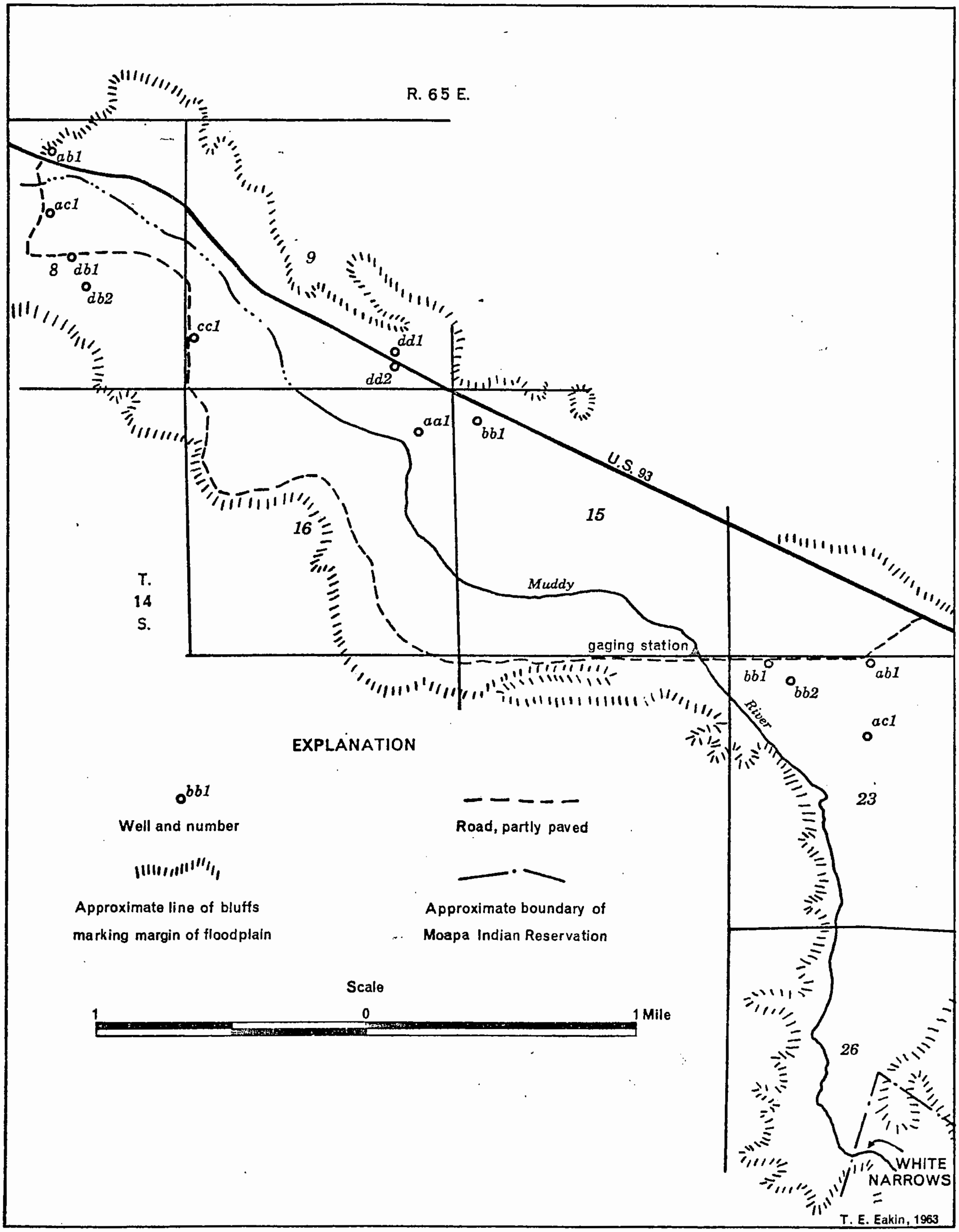


Figure 5. Sketch map of Muddy River Springs area showing locations of selected wells

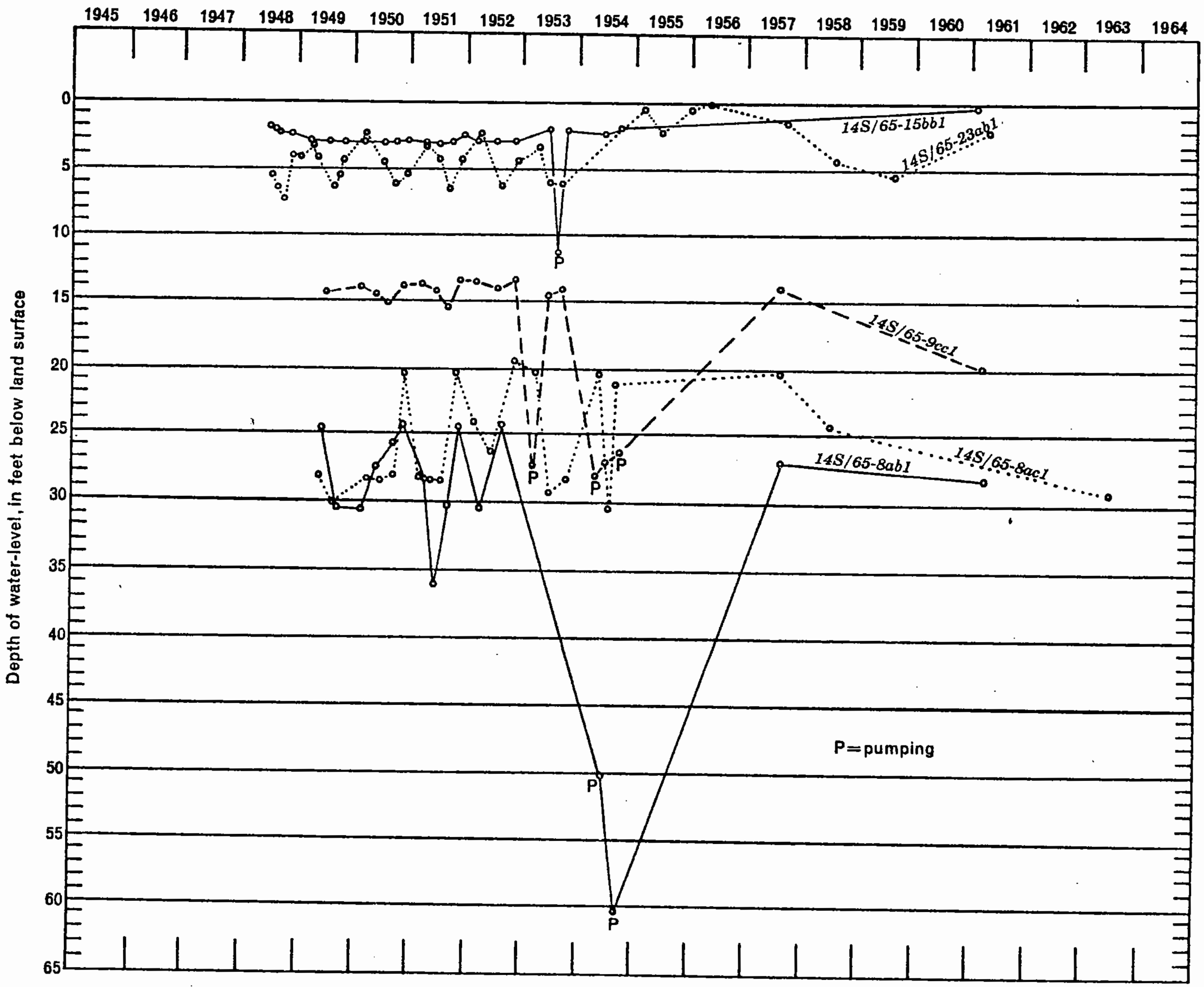


Figure 6.—Hydrographs for five wells in Muddy River Springs area

Coyote Spring has been developed to supply irrigation water for several acres of orchard. The development consists of a tunnel about 550 feet long, excavated in fine-grained lake beds. Some water seeps into the walls and floor of the tunnel. Most of the supply is derived from several uncased wells, about 100-feet deep, that were drilled in the floor of the tunnel, and from a number of small diameter holes bored laterally from the tunnel. Initially the flow from this tunnel system reportedly was about half a second-foot. However, variations in flow probably occur in response to variations in precipitation in the Sheep Range to the west which provides the recharge to ground water in the valley fill in this area. Variations in the discharge of the tunnel system probably occur also from time to time due to partial closing by caving or sloughing of the uncased wells and bored holes in the tunnel.

In Kane Spring Valley ground-water development consists of improvement of some of the springs to supply stock requirements.

The depth to water for most of Coyote Spring and Kane Spring Valleys is relatively great and commonly is believed to be in excess of about 300 feet. Additionally, the degree to which suitable water-yielding zones in the valley fill occur below the water table is not known. Thus, the possibility of developing ground water for irrigation within economically feasible limits would be considered speculative. However, where cost would not be the limiting factor, some development should be possible. The perennial yield presently estimated at about 2,600 acre-feet is based on the estimated average annual recharge derived from precipitation in the two valleys.

PROPOSAL FOR ADDITIONAL GROUND-WATER STUDY

In compliance with the request of Hugh A. Shamberger, Director, Department of Conservation and Natural Resources, State of Nevada, suggestions for a special study are given below. This study would provide needed basic data and a better understanding of the factors that influence or control ground water in Muddy River Springs area and somewhat similar areas in Nevada. The proposed study is separate from the usual areal investigations which commonly are needed after the development of ground water in a given area has become substantial. A limited start has been made in this study.

In addition to continued operation of the gaging station of Muddy River near Moapa, periodic measurement and observation of the discharge of the springs, and the distribution and pattern of natural loss in the area upstream from the gaging station should be made to define more accurately the amount and variation of the spring discharge as compared with the discharge record of the gaging station. Such a study would permit a detailed reconstruction of spring discharge from the gaging station record for better control in analyzing the hydrologic system supplying the springs. It also would provide valuable information for determining possible means of increasing utilization of the natural water supply of the area.

DESIGNATION OF WELLS

In this report the number assigned to a well is both an identification number and a location number. It is referenced to the Mount Diablo base line and meridian established by the General Land Office.

A typical number consists of three units. The first unit designates the township; "N" after the number identifies the township as north of the Mount Diablo base line; "S" after the number identifies the township as south of the Mount Diablo base line. The second unit, a number separated by a slant line from the first, is the range east of the Mount Diablo meridian. The third unit, separated from the second by a dash, is the number of the section in the township. The section number is followed by a lower case letter, which designates the quarter section, this letter may be followed by another letter which designates the quarter-quarter section, and finally, a number designating the order in which the well was recorded in the quarter section. The letters a, b, c, and d, designate, respectively, the northeast, northwest, southwest, and southeast quarters or quarter-quarter of the section.

Thus, well number 14S/65-8ab1 indicates that this well was the first well recorded in the northwest quarter of the northwest quarter of sec. 8, T. 14 S., R. 65 E.

Wells on plate 1 are identified only by the section number, quarter-section letter, and quarter-quarter section letter and serial number. The township in which the well is located can be ascertained by the township and range numbers shown on the margin of plate 1. For example, well 14S/65-8ab1 is shown on plate 1.as 8ab1 and is within the rectangle designated as T. 14 S., R. 65 E. On plate 2, the full townships are not shown, but appropriate identification is given on the margins.

Table 8. --Selected well logs in Coyote Spring Valley and Muddy River Springs area, Nev.

Coyote Spring Valley

10S/62-14a1. Owner, E. Van Horn. Drilled test well. Test hole No. 1. Depth 510 feet; casing diameter 10 inches: Reported depth to water below land surface 416 feet, April 23, 1958. Driller's log:

Material	Thickness (feet)	Depth (feet)
Sand	4	4
Gravel, cemented	8	12
Gravel, cemented	3	15
Boulders	3	18
Gravel, cemented	4	22
Boulders	3	25
Gravel, cemented	15	40
Boulders	3	43
Gravel, cemented	11	54
Gravel, cemented	88	142
Clay and gravel	2	144
Gravel, cemented	14	158
Gravel and clay	2	160
Gravel, cemented	64	224
Clay and gravel	2	226
Gravel, cemented	144	370
Gravel, cemented; sand	10	380
Gravel, cemented	50	430
Gravel, cemented; sand	10	440
Sand, red	5	445
Sand, red; water	3	448
Sand, red	9	457
Sand, black and red	10	467
Sand, black and white; water	27	494
Clay, white, sandy	8	502
Clay, sandy	8	510
Total Depth		510

Table 8 -- continued

10S/62-24b1. Owner, E. Van Horn. Drilled test well. Test well No. 2. Depth 231 feet; casing diameter 10 inches. Completely dry, May 2, 1958. Driller's log:

Material	Thickness (feet)	Depth (feet)
Soil and sand	16	16
Gravel	19	35
Gravel and sand	20	55
Clay and gravel	2	57
Gravel	2	59
Clay, gravelly	11	70
Gravel, cemented; boulders	5	75
Gravel, cemented	50	125
Clay and gravel	4	129
Gravel, cemented	11	140
Clay and gravel	3	143
Gravel, cemented	47	190
Clay and gravel	6	196
Gravel, cemented	35	231
Total depth		231

13S/63-25a1. Owner, Lawrence W. Perkins. Double Canyon well. Drilled stock well; depth 353 feet; casing diameter 6 inches. Reported depth to water below land surface 332 feet, May 4, 1944. Driller's log:

Material	Thickness (feet)	Depth (feet)
Clay, sandy	55	55
Clay, sandy	175	230
Lime, white	30	260
Rock and gravel, cemented	85	345
Water-bearing	8	353
Total depth		353

Muddy River Springs area

14S/65-8ab1. Owner Clarence Lewis. Dug and drilled irrigation well. Reported depth 57 1/2 (?) feet; casing diameter 11 feet to 12 inches. Equipped with turbine pump. Temperature of water 80°F. Pumped 260 gpm with 10.3-foot drawdown on June 29, 1949. Measuring point top of 12" casing which is 0.5' above land surface.

Measurements of water level, in feet, below land surface

Date	Depth	Date	Depth
June 15, 1949	24.90	Dec. 18, 1951	24.59
Sept. 21, 1949	30.66	Mar. 30, 1952	30.86
Mar. 21, 1950	30.79	Sept. 10, 1952	24.23
June 23, 1950	27.58	Sept. 11, 1952	70.10 pumping
Sept. 12, 1950	25.96	Sept. 16, 1952	44.09
Dec. 12, 1950	24.14	July 1, 1954	50.40 pumping
Mar. 28, 1951	28.55	Oct. 17, 1954	60.66 pumping
June 6, 1951	36.20	Oct. 22, 1957	27.10
Sept. 13, 1951	30.10	Mar. 8, 1961	28.25

Driller's log:

Material	Thickness (feet)	Depth (feet)
Silt	7	7
Clay and rocks	24	31
Gravel, coarse	24	55
Clay	2 1/2	57 1/2
Total depth		57 1/2

14S/65-8db2. Owners, Woodruff and Owen Perkins. Drilled irrigation well. Depth 52 feet; casing diameter 14 inches. Equipped with turbine pump. Pumped 498 gpm from 40 feet on March 28, 1951. Measuring point top of 14-inch casing which is 3.0 feet above land surface. Depth to water below land surface 21.55 feet, June 18, 1963. Driller's log:

Material	Thickness (feet)	Depth (feet)
Silt, sandy	12	12
Gravel with water from 21'	23	35
Sand and gravel; water	17	52
Total depth		52

14S/65-9dd1. Owner P. H. Godfrey. Drilled irrigation and domestic well. Depth 65 feet; casing diameter 12 inches. Reported depth to water below land surface 10 feet, July 15, 1959. Driller's log:

Material	Thickness (feet)	Depth (feet)
Topsoil	5	5
Sand	5	10
Sand, gravel; water	16	26
Clay, red	39	65
Total depth		65

14S/65-9dd2. Owner F. Taylor. Drilled irrigation well. Depth 60 feet; casing diameter 12 inches. Reported depth to water 14 feet, June 10, 1957. Driller's log:

Material	Thickness (feet)	Depth (feet)
Silt, sandy	21	21
Sand, boulders	3	24
Gravel	8	32
Sand	4	36
Gravel	9	45
Gravel, boulders	15	60
Total depth		60

Table 7.--Records of selected wells in Coyote Spring Valley and Muddy River Springs area

Measuring point: Above land surface; L, land surface; Tc, top of casing.
Water level: In feet and tenths if measured by U.S.G.S.; in feet only if reported.
Status or use: Ir, irrigation; Obs, observation; D, domestic; U, unused.
Remarks: Dl, driller's log; Wl, water level.

Well number and location	Owner	Year completed	Depth (feet)	Casing: Diameter (inches)	Casing: Perforated zone (feet)	Measuring point: Description	Measuring point: Height (feet)	Water level: Below land surface (feet)	Water level: Date	Temperature (°F)	Status or use	Remarks
						Coyote Spring Valley						
10S/62-14a1	Mr. Van Horn	--	510	10	--	Tc	+3.5	Dry	--	--	Abd	Reported depth to water, 416 feet, when drilled. Plugged at 68.5 feet.
13S/63-25a1	L. W. Perkins	1944	353	6	--	--	--	332	4- -44	--	--	Dl.
						Muddy River Springs area						
14S/65-8ab1	Clarence Lewis	1949	57.5	11 (ft) to 12 in.	--	Tc	+0.5	28.75	3-08-61	80	Ir, Obs	360± gpm, Dl, Drawdown - 10.3 feet. Dug and drilled.
14S/65-8ac1	Clarence Lewis	--	44	16	--	edge of 12x12 timber	+1.0	30.08	6-08-63	--	Ir, Obs	502 gpm, 1952.
14S/65-8db1	Woodruff and Oran Perkins	--	Open dug well	5x5 (ft)	--	Top of cover	+0.5	23.28	9-19-53	81.5	Ir, Obs	285 gpm, 1950; well caved.
14S/65-8db2	Woodruff and Oran Perkins	1950	52	14	24-28	Tc	+3.0	24.55	6-18-63	--	Ir	498 gpm, 1951; Dl.
14S/65-9cc1	Howard Lewis	1949	75	12	--	Tc	+0.5	20.50	3-08-61	--	Ir, Obs	420 gpm, 1949.
14S/65-9dd1	P. H. Godfrey	1959	65	12	--	Tc	--	10	7-15-59	--	D, Ir.	125 gpm, reported Wl, Dl.
14S/65-9dd2	F. Taylor (?)	1957	60	12	--	--	--	14	6-10-57	--	Ir	Dl.
14S/65-15bb1	F. Taylor	1948	80	20	--	L	0.0	18.90	6-08-63	--	Ir	1,400 gpm, 9-12-63.
14S/65-16aa1	F. Taylor	--	80(?)	14	--	Tc	+1.0	Flowing	9- -63	--	Ir	Flow about 75 gpm.
14S/65-23ab1	Lawrence W. Perkins	--	50	6	--	Tc	+1.9	2.48	3-08-61	--	Obs, U	
14S/65-23ac1	Lawrence W. Perkins	1948	82	16	--	Tc	0.0	2.35	6-18-63	--	Ir	440 gpm. Drawdown, 23 feet.
14S/65-23bb1	D. B. and G. M. Perkins	--	60	10	--	L	0.0	13.94	6-18-63	--	Obs	270 gpm, 1948; Drawdown 18.5 feet. Wl, 2.41, 6-15-48.
14S/65-23bb2	Dale and Lawrence Perkins	--	--	--	--	--	--	--	--	--	D, Ir	300 gpm.

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FOREWORD

This report, the 25th in the series of reconnaissance ground-water studies which were initiated following authorization by the 1960 Legislature, gives the results of a study of the Coyote Spring and Kane Spring Valleys and Muddy River area. The Kane Springs Valley is situated in Lincoln County, while the southern end of Coyote Springs Valley extends into Clark County. The Muddy River Springs area lies in Clark County.

This study was made and report prepared by Thomas E. Eakin, geologist for the U. S. Geological Survey.

These reconnaissance ground-water resources surveys make available pertinent information of great and immediate value to many State and Federal agencies. As development takes place in any area, demands for more detailed information will arise and studies to supply such information will be undertaken. In the meantime these reconnaissance type studies are timely and adequately meet the immediate needs for information on the ground-water resources of the areas covered by the reports.

Hugh A. Shamberger
Director
Department of Conservation
and Natural Resources

February 1964

PREVIOUSLY PUBLISHED REPORTS OF THE
GROUND-WATER RESOURCES - RECONNAISSANCE SERIES

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Report
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1. Ground-Water Appraisal of Newark Valley, White Pine County, Nevada. Dec. 1960, by Thomas E. Eakin. (Supply Exhausted)

2. Ground-Water Appraisal of Pine Valley, Eureka and Elko Counties, Nevada. Jan. 1961, by Thomas E. Eakin. (Supply Exhausted)

3. Ground-Water Appraisal of Long Valley, White Pine and Elko Counties, Nevada. June 1961, by Thomas E. Eakin. (Supply Exhausted)

4. Ground-Water Resources of Pine Forest Valley, Humboldt County, Nevada. Jan. 1962, by William C. Sinclair.

5. Ground-Water Appraisal of the Imlay Area, Humboldt River Basin, Pershing County, Nevada. Feb. 1962, by Thomas E. Eakin.

6. Ground-Water Resources of Diamond Valley, Eureka and Elko Counties, Nevada. Feb. 1962, by Thomas E. Eakin. (Supply Exhausted)

7. Ground-Water Resources of Desert Valley, Humboldt County, Nevada. April 1962, by William C. Sinclair.

8. Ground-Water Appraisal of Independence Valley, Western Elko County, Nevada. May 1962, by Thomas E. Eakin.

9. Ground-Water Appraisal of Gabbs Valley, Mineral and Nye Counties, Nevada. June 1962, by Thomas E. Eakin.

10. Ground-Water Appraisal of Sarcobatus Flat and Oasis Valley, Nye County, Nevada. Oct. 1962, by Glenn T. Malmberg and Thomas E. Eakin.

11. Ground-Water Resources of Hualapai Flat, Washoe, Pershing and Humboldt Counties, Nevada. Oct. 1962, by William C. Sinclair.

12. Ground-Water Appraisal of Ralston and Stonecabin Valleys, Nye County, Nevada. Oct. 1962, by Thomas E. Eakin.

13. Ground-Water Appraisal of Cave Valley in Lincoln and White Pine Counties, Nevada. Dec. 1962, by Thomas E. Eakin.

14. Ground-Water Resources of Amargosa Desert, Nevada-California. March 1963, by George E. Walker and Thomas E. Eakin.