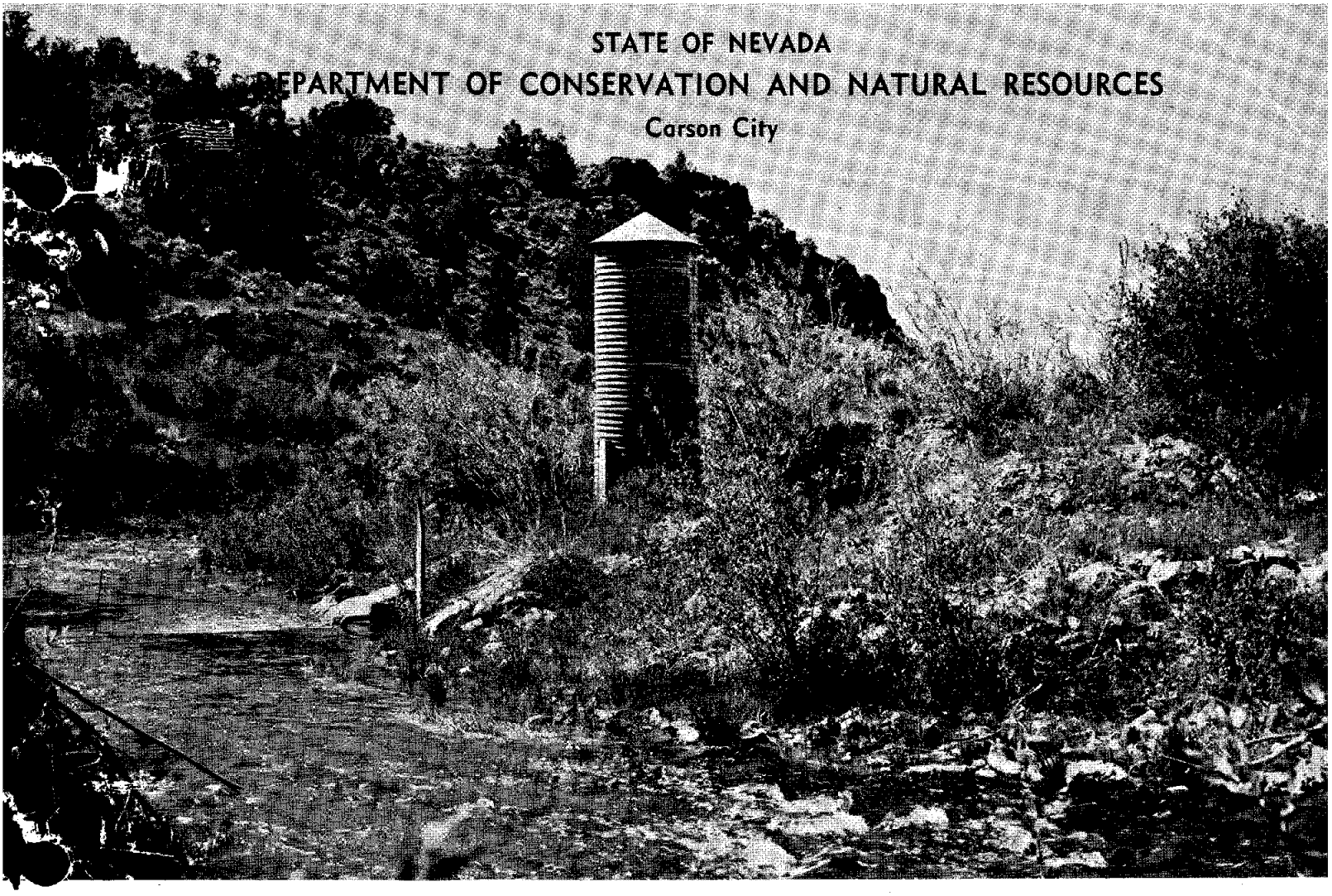
STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
Carson City



View of Reese River gaging station (near Ione). Flow is about 12 cubic feet per second.

WATER RESOURCES-RECONNAISSANCE SERIES

REPORT 31

WATER RESOURCES APPRAISAL OF THE REESE RIVER VALLEY LANDER AND NYE COUNTIES, NEVADA

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By
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Chemist

Price $1.00

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

MARCH 1965

View of a grain field in upper Reese River Valley. *Photograph by F. Eugene Rush*

WATER RESOURCES - RECONNAISSANCE SERIES

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November - 1964

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WATER RESOURCES APPRAISAL OF THE UPPER REESE RIVER VALLEY, LANDER AND NYE COUNTIES, NEVADA

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SUMMARY

The results of this investigation suggest that an average of about 37,000 acre-feet of water is discharged annually from the ground-water reservoir by evapotranspiration. The preliminary estimate of perennial yield is equivalent to the estimated natural discharge. Withdrawal of ground water by pumping was estimated to be about 3,000 acre-feet for the 1964 irrigation season. This amount was pumped largely for irrigation in Twps. 17 and 18 N. on land withdrawn under the Desert Land Act.

Using a technique still being developed, streamflow as runoff from the mountain areas of upper Reese River Valley was estimated to average about 36,000 acre-feet a year. Part of this runoff, about 11,000 acre-feet, is considered to enter the ground-water reservoir by infiltration into the valley fill after leaving the mountains. Of the remaining estimated ground-water recharge of 37,000 acre-feet, about 22,000 acre-feet is considered to infiltrate into the bedrock in the mountains from which it moves below land surface into the valley fill reservoir and about 4,000 acre-feet are derived from precipitation on the upper part of the alluvial apron.

The remaining 25,000 acre-feet of estimated runoff is lost by evapotranspiration along the stream channels and adjacent flood plain, except for an estimated 3,000 acre-feet of outflow through Reese River Canyon. Much of the streamflow is used for irrigation prior to being lost by evapotranspiration in upper Reese River Valley.

The combined average surface water and ground water discharge from upper Reese River Valley is estimated to be about 59,000 acre-feet by evapotranspiration processes in the lowlands and about 3,000 acre-feet by outflow northwest through Reese River Canyon.

Most of the runoff and ground-water recharge is derived from precipitation on the mountains, particularly the Toiyabe Range south from Austin. Most of the ground-water discharge occurs in the valley lowland from about T.17N., to the north end of the valley.

Ground water storage is estimated to be about 1.2 million acre-feet in the upper 100 feet of saturated valley fill beneath an 80,000 acre-area lying roughly between the Visbeck and Whitaker Ranches - in the central part of upper Reese River Valley. This, of course, represents only a small part of the actual ground-water storage but serves to illustrate that ground-water storage is many times the average annual natural discharge from the valley.

INTRODUCTION

Location and General Features

Upper Reese River Valley occupies the southern two-thirds of the 150-mile-long Reese River Valley, which is tributary of the Humboldt River. The nearly 1,200 square-mile area lies largely in Lander County, but the southern end extends some 20 miles into northwestern Nye county.

U. S. Highway 50 crosses the mid-latitute of upper Reese River Valley, passing through Austin. A short distance west of Austin, State highway 8A extends northward from U.S. Highway 50 through Reese River Valley to Battle Mountain and U.S. Highway 40. State Highway 21, a gravelled road, extends southward from U.S. Highway 50 through the upper part of Reese River Valley and connects with Ione on the west side of the Shoshone Range and Tonopah to the south. These roads together with many trails provide good access to much of the valley, except under adverse weather conditions.

Austin, the county seat of Lander County, is centrally located in the valley on the west slope of the Toiyabe Range.

Mining began with a silver strike in May 1862 in the vicinity of Austin and was the first substantial economic activity in the area. Although initially overshadowed by the glamour of the mining boom, livestock raising also was begun in 1862 in upper Reese River Valley by Lewis R. Bradley, who brought 500 Texas longhorn cattle into the area. Bradley later became Governor of Nevada (1870-78).

Today the principal activity in the valley is raising of cattle and sheep. Livestock graze mainly on the range but supplemental feed is supplied from irrigated meadows. With few exceptions the irrigated meadow area lies largely within the principal phreatophyte areas shown on plate 1.

Streamflow has been and is the principal source of supply for irrigation of meadow land. However, areas of rising ground water and spring flow, such as in the vicinity of the Waukine, Gondolfo, and Whitaker Ranches, provide a substantial or principal supply of the water for grasses and irrigated parts of these areas. At least as much as 50 years ago, efforts were made to obtain artesian flowing water. However,

only small flows have been obtained in parts of the lowland areas north of U.S. Highway 50 and in the vicinity of the older Carter Ranch on the lower part of the Big Creek fan.

Beginning about 15 years ago several wells were drilled for irrigation on existing ranches. The annual quantity of water pumped from these wells apparently has not been large. In the past few years farming has been tried on land withdrawn under the Desert Land Act on the west side of the valley both north and south of U.S. Highway 50. Small grains have been grown. The farming experiment seems promising although it is still in a preliminary stage of development. About 12 irrigation wells supplied water for the farming requirements during the 1964 irrigation season. The pumping rates on those wells reportedly range from about 200 to 1,500 gallons per minute.

Purpose and Scope of Report

Water-resources information, especially regarding ground water in many parts of Nevada, has been relatively meager. The deficiency of information has become more obvious as efforts toward additional water development have been intensified in recent years. The Nevada State Legislature recognized this by enacting a statute (Chpt. 181, Stats, 1960) to cooperate with the United States Geological Survey, authorizing the Nevada Department of Conservation and Natural Resources, and in conducting reconnaissance studies for preliminary evaluation of the ground water resources to aid in effective development and management of water resources throughout Nevada. This was a supplement to the regular cooperative program between the two agencies. The present report is the thirty-first in the Reconnaissance Series. Figure 1 shown the areas covered, and the titles are listed at the end of this report.

With respect to ground-water resources, the purpose of this study is to provide a preliminary evaluation of the ground-water system including estimates of the recharge to and discharge from that system as an indication of the sustainable yield.

During the course of the ground-water studies to date, it was recognized that there also is a deficiency of information on surface-water resources for other than the principal streams in the State. Techniques have been devised principally by Mr. Moore to aid in providing reconnaissance-level information on surface-water resources in ungaged areas in Nevada. Accordingly, this reconnaissance series is being broadened to include preliminary evaluations of the surface-water resources in the valleys studied. Currently, principal attention is being given to the seasonal runoff from winter precipitation, as this is the most susceptible to development.

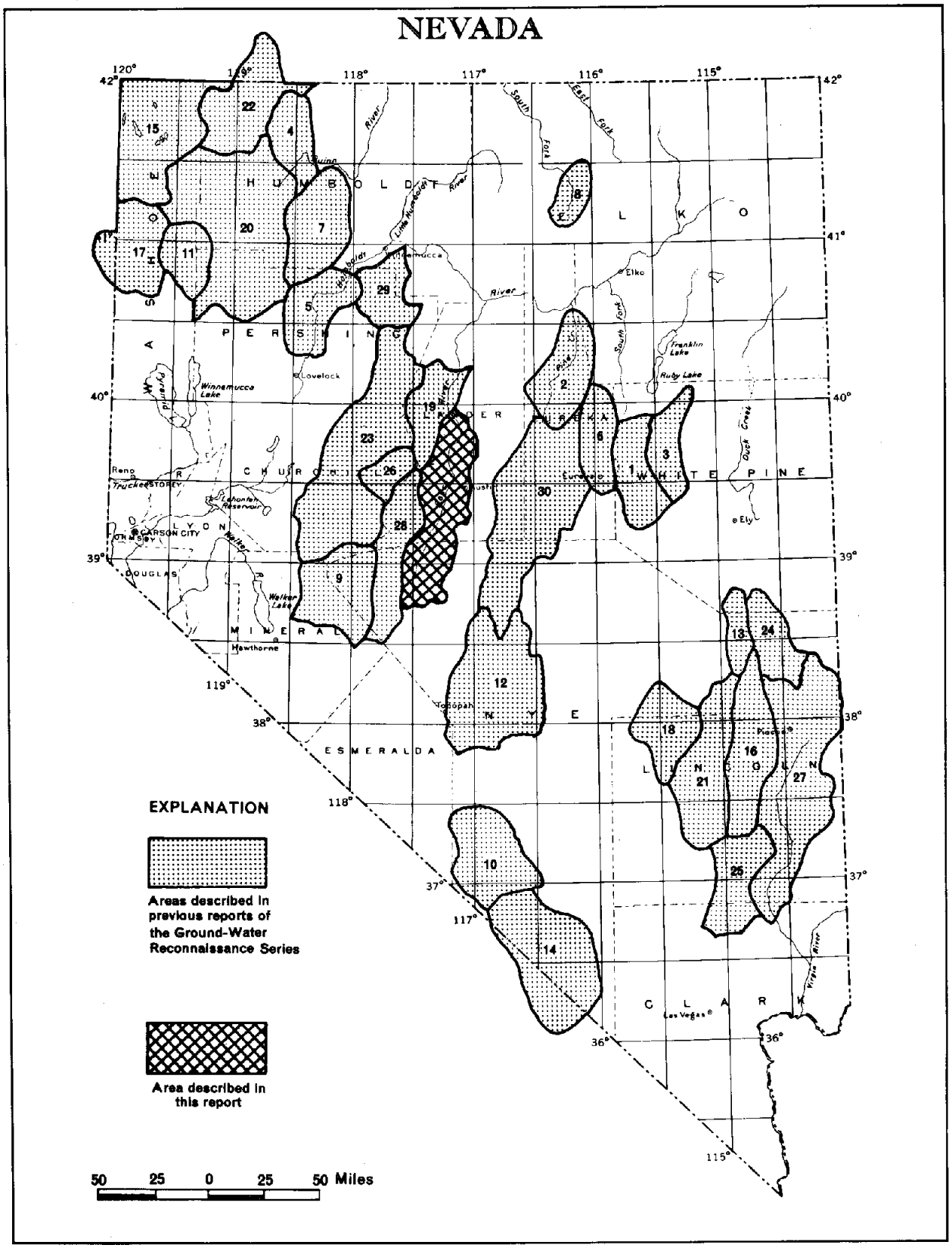

Figure 1.— **MAP OF NEVADA**

showing areas described in previous reports of the Ground-Water Reconnaissance Series and the area described in this report

PHYSICAL SETTING

Climate

The climate of upper Reese River Valley generally is characterized by a rather wide range of seasonal and daily temperature. Within the valley, temperature also varies with the relative topographic location. The mean annual temperature at Austin is about 47°F. Monthly means range from about 28°F in January to about 70°F in July. The recorded maximum temperature was 105°F on July 4, 1922, and July 20, 1931, and the minimum recorded temperature was -25°F on January 19, 1922. Average precipitation at Austin (altitude about 6,600) is about 12 inches a year; most of the precipitation occurs during the period November through May and most falls as snow. Precipitation is less in the valley lowlands and greater in the favorably situated higher parts of the Toiyabe Range, where an average annual precipitation probably exceeds 20 inches.

Hardman and Mason (1949, p. 12) show the upper Reese River Valley to be in parts of three growing-season zones: The lower Humboldt zone, which occupies the lowest parts of the valley lowland in the Lander County part of upper Reese River Valley; the upper Humboldt zone, which extends up the alluvial slopes adjacent to the valley lowland in the Lander County segiment and in the valley lowland in Nye County; and the Sierra zone, which occupies the headwaters of Reese River, Indian Valley, and the Shoshone and Toiyabe Ranges.

Hardman and Mason (1949, p. 14, 15) describe the character of the growing season of each of these three zones about as follows: The lower Humboldt zone growing season "permits the production of cereal grains, alfalfa, clover, grasses, and hardy vegetables and fruits. Corn will not mature in average seasons and, except near the lower limit of the zone, only two cuttings of alfalfa are made. This zone covers the transition area from general farming to stock ranching."

The upper Humboldt Zone is "entirely a ranching and grazing area because of low growing season temperatures and of the hazard to tender plants of killing frosts in the summer months. Cereal grains, one crop of alfalfa, and hardy vegetables can be grown in favorable locations. Meadow hay is the major harvested crop. Large areas are devoted to native pastures."

The Sierra Zone "consists of mountain tops and high plateaus and is characterized by low summer temperature and the possibility of frost or snow in any month of the year. Agriculture is limited to grazing and harvesting of a small acreage of mountain meadow hay."

Based on the record for Austin, Houston (1950, p. 16) indicates that the growing season for upper Reese River Valley averages about 117 days. However freezing temperatures may occur in any month.

Further, crops have different minimum temperature through which they may survive.

Physiography and Drainage

Upper Reese River Valley is a nearly north-trending valley in central Nevada. The Toiyabe Range forms the eastern boundary and the Shoshone Mountains form the western boundary. The two ranges merge to close the valley on the south. The Reese River Canyon is a gap cut by the Reese River across the northern part of the Shoshone Mountains and separates the upper from the middle part of Reese River Valley.

As defined, upper Reese River Valley is about 90 miles long, 15 to 20 miles wide between drainage divides and has an area of about 1,200 square miles. The valley is somewhat sinuous but has a general trend east of north. Reese River which heads in the southern end of the Toiyabe Range, flows northward through the valley but reaches the Humboldt River only on rare occasions.

The valley may be divided into three principal physiographic units -- the mountains, alluvial apron, and valley lowlands.

Mountains

The Toiyabe Range, along the east side of upper Reese River, is the dominate mountain block in the area. South from Austin the crest of the Toiyabe Range is higher than 10,000 feet above sea level for about 30 miles of the 50 mile section of the range. Much of the remaining 20 miles of crest line lies above an altitude of 9,000 feet. Several of the peaks in this section are higher than 10,000 feet, including the highest peak, Toiyabe or Arc Dome, altitude 11,788 feet, at the south end of the range. Northward from Austin the Toiyabe Range is lower, but commonly higher than 8,000 feet, and the most prominate peak is Mt. Callahan, altitude 10,202 feet.

The higher parts of the Toiyabe Range tend to have somewhat smooth and undulating slopes, suggesting a more mature surface than the deeply incised canyons and steep slopes on the margins of the range. Meinzer (1917, p. 22) observed this feature and suggested that it could be explained best by assuming two cycles of erosion separated by an interval of pronounced uplift. North of Austin the relief of the Toiyabe Range is not as bold as in the southern part of the range.

The southern part of the Shoshone Mountains, south of about latitude 39°15'N., has crest altitudes commonly near 9,000 feet and includes some peaks that are above 10,000 feet in altitude, such as Shoshone Peak North, 10,351 and Shoshone Peak South 10,066 feet. North of latitude 39°15'N., only a few peaks of the Shoshone Mountains reach an altitude of 8,000 feet.

The southern part of the Shoshone Mountains generally is rugged and has steep slopes and deeply incised canyons. North of Railroad Pass the surface commonly is less rugged, although locally canyons are deeply incised.

The mountains commonly have a relief of up to 5,000 feet above the adjacent valley lowlands from which they are separated by the alluvial apron.

Alluvial Apron

The Alluvial Apron is an area of intermediate slopes that form the transition between the mountain blocks and the valley lowland. Surface gradients commonly are 200 to 500 feet per miles. In much of the area the alluvial apron is principally an erosion surface, or pediment, cut on Tertiary deposits and volcanic rocks and thinly mantled with unconsolidated alluvium.

Opposite the principal canyons, however, alluvial fans have been formed on the older erosional surface. Deposits forming the larger alluvial fans probably are moderately thick, possibly as much as several hundred feet, adjacent to the mountain block.

Perhaps the largest alluvial fan in terms of area and bulk of deposits is that at the mouth of the canyon of Big Creek. The toe of the fan extends nearly 6 miles northwest from the mouth of the canyon. The upper surface of the fan near the mouth of the canyon is about 700 feet higher than the toe. The maximum thickness of the Big Creek fan deposits may exceed 500 feet.

A major feature of the Big Creek fan is the deeply dissected trench in which the present natural channel of Big Creek is contained. This trench is nearly 200 feet deep near the mouth of the canyon and apex of the fan. The depth decreases to a few feet at the toe of the fan. As is characteristic of similar trenches in many fans in central and eastern Nevada, the entrenchment is on the north side of the fan. The trench is almost parallel to the mountain front in the middle and lower parts of the fan.

Throughout the alluvial apron area similar entrenchment occurs adjacent to principal canyons in the mountains. The entrenchment probably has resulted from structural events and variations in the sediment transport or erosional capacity of the streams over long periods of time. Indeed, to some extent considerably entrenched channels apparently have been abandoned in favor of newer routes, as for example in the vicinity of the mouths of Marysville and New York Canyons.

Valley Lowland

The evolution of the Reese River resulted in the development of a flood plain along most of the axial part of upper Reese River Valley. Northward from the latitude of Austin and southward from the middle of T. 16 N., the width of the flood plain of the Reese River commonly is one-quarter mile or less. It is confined between bluffs which are usually a few tens of feet high but which locally may be more than 50 feet high. In the central section between the latitude of Austin and the middle of T. 16 N., marginal bluffs occur only locally and the width of the lowland increases to several miles. Similarly, the flood plains of tributary streams extend upstream from the Reese River flood plain. Collectively the flood plain areas may be called the valley lowlands.

The valley lowlands are a relatively recent product of the geological history of the valley, most likely having been developed principally during and since late Pleistocene time. They contain most of the acreage of irrigated meadows and native meadows as well as greasewood and rabbitbrush and other phreatophytes.

In some places the flood plain is modified by small Recent alluvial fans developed from minor tributary channels. Perhaps the most prominent modifications are the incised channels of the Reese River which are as much as 10 feet deep or more through most of the valley lowland. According to some reports the incision of these channels began during the 1910 floods.

The gradient of the flood plain along the axis of upper Reese River Valley generally decreases northward. In the southern part of the valley near the confluence with Indian Creek, the flood plain has a gradient of about 70 feet per mile, as indicated by the contours of the Plan of the Reese River (Welsh, 1937). Near the mouth of Clear Creek the gradient is about 40 feet per mile; from the vicinity of the Ranger Station to near the mouth of Tierney Creek, it is about 30 feet per mile. The narrows near the mouth of Cottonwood Creek and the county line is reflected by an increase in gradient to about 40 feet per mile; northward from the narrows the gradient again decreases and averages about 30 feet per mile for about 8 miles to the vicinity of the Visbeck Ranch. North of the Visbeck Ranch the gradient decreases to about 20 feet per mile for about 5 miles. At the north line of T. 17 N., the gradient is about 15 feet per mile, from which it decreases to 12 to 14 feet per mile in the vicinity of the Gondolfo Ranch. Further decrease of gradient occurs until in the vicinity of the Whitaker Ranch it is about 5 feet per mile. In the narrows in T.20 N., the gradient again increases to about 23 feet per mile where the detailed topographic control ends.

The steeper gradients occur where the flood plain is narrow. The flatter gradients occur where the flood plain is wider, upgradient from constrictions.

Drainage

Although the Reese River drains the upper Reese River Valley, continuous streamflow through the full length of the valley and through the Reese River Canyon is limited to occasional short periods during very large spring runoff or after high-intensity storms.

Reese River heads in the southwestern slopes of Toiyabe Dome near the southern end of the Toiyabe Range. It flows northwestward for a few miles, thence generally northward in the flood plain along the axis of upper Reese River Valley and leaves the area through the Reese River Canyon.

Illinois, Clear, Stewart, Marysville, Tierney, and Cottonwood Creeks are the principal tributaries draining the west slopes of the Toiyabe Range in Nye County. Big Creek is the principal tributary draining the central part of the west slope of the Toiyabe Range, and Italian, Silver, and Boone Creeks drain the northern section of the Toiyabe Range in the vicinity of Mt Callahan. At the south end of the area, Indian Creek drains Indian Valley. Bonita, Meadow, and Deep Creeks are the principal streams draining the Shoshone Mountains in the vicinity of South Shoshone peak.

The principal tributaries draining the Toiyabe Range are perennial in the canyons and on the upper parts of the alluvial apron. However, most of these actually reach the Reese River only during periods of high flow. The duration of through flow is reduced because of diversion for irrigation of the meadow areas along the streams.

Overland flow from the Shoshone Mountains rarely reaches the channel of the Reese River, except after high-intensity storms. Bonita and Meadow Creeks reach the Reese River during the spring runoff perhaps on an average of once every year or two.

Numerous dry channels periodically carry runoff for short distance and rarely debouch water into the Reese River.

GEOLOGY AND ITS RELATION TO HYDROLOGY

Reports on geologic studies for several parts of Upper Reese River Valley include those of Ferguson and Cathcart (1954) for part of the southern section of the Toiyabe Range, Feguson and Muller (1949) for the southern end of the Shoshone Mountains and Toiyabe Range, Silberling (1959) for pre-Tertiary rocks in the vicinity of Ione and Grantsville on the west side of the Shoshone Range, Hill (1915) for the Reese River (Austin area) mining district and adjacent areas, Ross (1953) for the Reese River Mining District, and others. However extensive studies for the whole of Reese River Valley have not been made. Waring (1918) in his brief study of ground water in the Reese River Valley prepared a reconnaissance map including the geology.

Available information indicates that Tertiary volcanic rocks are the most widely exposed rocks in the Shoshone Mountains and Toiyabe Range. However, according to Ferguson and Cathcart (1954), Paleozoic rocks include at least 3,000 feet of Cambrian quartzite, Quartz-mica schist with some silicious slate, and several dolomitic limestone beds; 2,500 feet or more of Ordovician rocks composed dominantly of slate and limestone; more than 3,000 feet of Permian conglomerate, grit, quartzite, slate, and a little dolimitic limestone; probably more than 5,000 feet of Permian (?) highly altered lava breccia, chert with some conglomerate, grit and slate; and Permian (?) fine-grained rhyolitic felsite rock which is largely intrusive in character. Mesozoic rocks include several hundred feet of Triassic crystalline limestone and slate, several hundred feet of Jurassic conglomerate and sandstone, and Jurassic (?) grantic intrusive rocks. The Paleozoic and Mesozoic rocks described by Ferguson and Cathcart in the southern part of the Toiyabe Range largely are exposed east of the Reese River drainage area. Other somewhat similar exposures have been described by Siberling (1959) and Ferguson and Muller (1949, p. 41-44) along the west flank of the Shoshone Mountains in the vicinity of Ione and Grantsville. Waring (1915, pl. 8) shows Paleozoic rocks for substantial parts of the west flank of the Toiyabe Range and in a few small areas of the Shoshone Mountains northwest of Austin. The Paleozoic and Mesozoic rocks commonly are much deformed and exhibit varying degrees of alteration.

Vitaliano (1963) indicates that roughly 10,000 feet of Tertiary rocks occurs in the southern Shoshone Mountains. These include about 2,500 feet of lava and associated pyroclastics, about 4,000 feet of sandstone, breccia, and lithic and ashy tuff; about 1,000 feet volcanic breccia flows and lithic tuff; about 2,000 feet of rhyolitic ignimbrite and associated volcanics; and about 300 feet of lava. The Tertiary rocks thus are dominantly volcanic with interbedded sedimentary deposits. Locally the Tertiary rocks have been altered in varying degree. They have been faulted and intensely fractured in much of the southern Shoshone Mountains. Elsewhere the fracturing generally may be less.

Ferguson and Cathcard (1954) show Quaternary basalt around part of the margins of Indian Valley. Quaternary alluvium occupies the lower parts of upper Reese River Valley. It probably is thickest, at least several hundred feet, in parts of Twps. 17, 18, and 19, where large alluvial fans occur. Commonly however, the alluvium is a thin veneer on the eroded surface of late Tertiary to early Plistocene volcanic rocks or associated rocks. The Quaternary alluvium includes clay, silt, sand, and gravel, deposited in stream channel, alluvial fan and lacustrine enviroments

On plate 1 the generalized distribution of the rocks has been shown by two major units -- consolidated rocks and valley fill. The consolidated rocks include those of Paleozoic, Mesozoic, and Tertiary age. The Paleozoic and Mesozoic sedimentary and volcanic rocks have been substantially deformed and altered by complex structural events and intrusive activity, and it is inferred that they generally have very low

permeability. The Tertiary volcanic and sedimentary rocks have been subject to fewer periods of deformation and alteration, but their general character suggests a low primary permeability. Secondary fracturing, however, such as is readily evident in the vicinity of Becker and Barrett Canyons in the Shoshone Mountains, may result in limited permeability at least in the near-surface parts of the volcanic rocks.

Because of the volume of consolidated rocks which are adjacent to and underlie Quaternary alluvium, a substantial amount of ground water may be stored in them where saturated even though their permeability is low. It is inferred, however, that the consolidated rocks have sufficiently low permeability to act principally as barriers to the movement of water in the valley fill; and further that pending specific determination, it is assumed for purposes of this report that the hydraulic divide for upper Reese River Valley is coincident with the topographic divide.

The valley fill has a wide range of permeability. Clay deposited in lakes has a very low permeability. On the other hand, sand and gravel deposited along stream channels or perhaps along shore lines of Pleistocene lakes have a high permeability. Some of the sand and gravel may be mixed with fine sand and silt which reduces its permeability. Such poorly sorted deposits commonly are deposited in alluvial fans and have less permeability than is expected for sand and gravel encountered in drilling. Cemented gravel has been reported in some of the well logs (table 9). Secondary cementation by deposition of calcium carbonate or caliche may reduce permeability to rather low values.

Generally however coarser deposits of the valley fill, where saturated, transmit water readily and contain a large volume of water in storage.

The vertical permeability of both the consolidated rocks and the valley fill and the infiltration capacity of the associated soils is an important factor in the routing of water in the hydrologic system of the valley. If the vertical permeability or infiltration rate is very low, a given amount and rate of precipitation will produce more overland flow than if the vertical permeability is high. If the vertical permeability is high, a larger proportion of the precipitation will go to supply soil moisture and ground-water recharge.

The late season streamflow in several of the canyons of the Toiyabe Range principally results from ground-water discharge derived from early-season inflow into the fractures of the consolidated rocks or associated soils. The discharge may occur as localized spring flow or as seepage along sections of the stream channel. Ground-water discharge also occurs in the floor of upper Reese River Valley, such as near the confluence of Cottonwood and Tierney Creeks, where ground water rises to the surface to sustain much of the late season flow of the Reese River. The geologic enviroment thus plays an important role in the delicate interrelations of surface and ground water.

HYDROLOGY

Precipitation supplies nearly all the water that occurs in upper Reese River Valley. Its distribution and variation form a primary control on the hydrologic system of the valley. These are governed by the meteorological enviroments in which atmospheric moisture is brought over the valley from outside source areas. Altitude, topographic slope, relief, orientation, and exposure provide further control of the amount and distribution of precipitation within the valley.

Evaporation and transpiration processes are the principal natural means of removing water from the valley. Solar radiation provides the energy for these processes to operate and is also the primary factor governing temperature in the valley.

Between the time of precipitation in the valley and the removal of water from the valley by evapotranspiration processes, the permeability of the soil and rocks provide a substantial control on the distribution and movement of ground water and surface water in the valley.

Evapotranspiration processes remove most of the precipitation at or near where it falls. Part of the precipitation makes up soil-moisture deficiency and is later returned through springs or seeps to streams or is removed from the system by evapotranspiration. Parts may move downward to recharge ground water. Part collects as streamflow and may be removed from the system by evaporation from the free-water surface of the channel, by transpiration of vegetation in or along the channel, by seepage or flooding to supply soil-moisture deficiency, or by deep percolation into the ground-water reservoir to be discharged later. Nearly all of the water discharged naturally from the valley is removed by evapotranspiration processes; a small amount leaves the valley as streamflow and underflow through Reese River Canyon.

Precipitation

Records of precipitation have been maintained at Austin for more than 70 years. Since 1942, three snow courses have been maintained in Big Creek Canyon and two courses have been maintained at the south end of Reese River Valley. Discontinuous records of precipitation have been obtained from storage gages at Kingston Summit, Yomba School, and near the confluence of Reese River and Indian Creek.

The relatively long record of precipitation at Austin is of much value to demonstrate the seasonal distribution and variations of precipitation in a given locality. The records are published by the United States Weather bureau in monthly and annual summaries and are not repeated here. Precipitation at Austin in the form of maximum, minimum, upper quartile, lower quartile, and median values by months is summarized numerically in table 1 and graphically in figure 2. Similar values are given for annual precipitation, based on the water year

October 1 to September 30. This results in annual values somewhat different than those based on the calendar year. The water-year basis is preferable in hydrologic studies, because precipitation and temperature conditions in the fall and winter months commonly have an important effect on runoff conditions the following spring.

Table 1. --Maximum, minimum and quartile distribution of precipitation by months and water year for period of record (1877-1963) at Austin, Nevada.

Austin, Altitude 6,600 feet, Location, T. 19 N., R. 44 E., Sec. 19.

Month	Maximum	Upper Quartile	Median	Lower Quartile	Minimum	No. of Months of record
Oct.	3.72	1.18	0.62	0.24	0.00	74
Nov.	2.13	1.26	.76	.39	.00	76
Dec.	4.31	1.50	.99	.55	T	75
Jan.	4.00	1.60	1.06	.60	T	76
Feb.	4.14	1.50	1.07	.66	.05	75
Mar.	5.36	1.99	1.49	.84	.12	75
Apr.	4.56	2.09	1.39	.87	.03	74
May	5.03	1.91	1.20	.56	T	74
June	3.26	1.15	.50	.05	.00	74
July	2.53	.76	.36	.10	.00	76
Aug.	2.70	.95	.32	.06	.00	75
Sept.	3.03	.81	.34	.06	.00	75
Sum of months	44.77	16.70	10.10	4.98	0.20	
Recorded Complete water-years	18.37	14.09	11.91	10.28	5.35	70 years

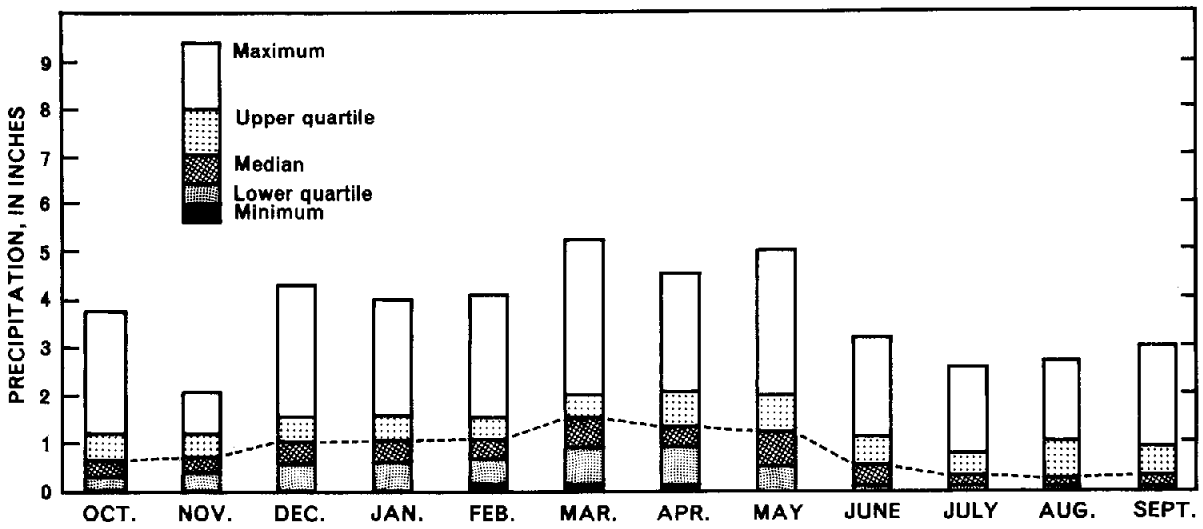

Figure 2.— Distribution by months of precipitation at Austin, Nev., for the period of record between 1877 and 1963

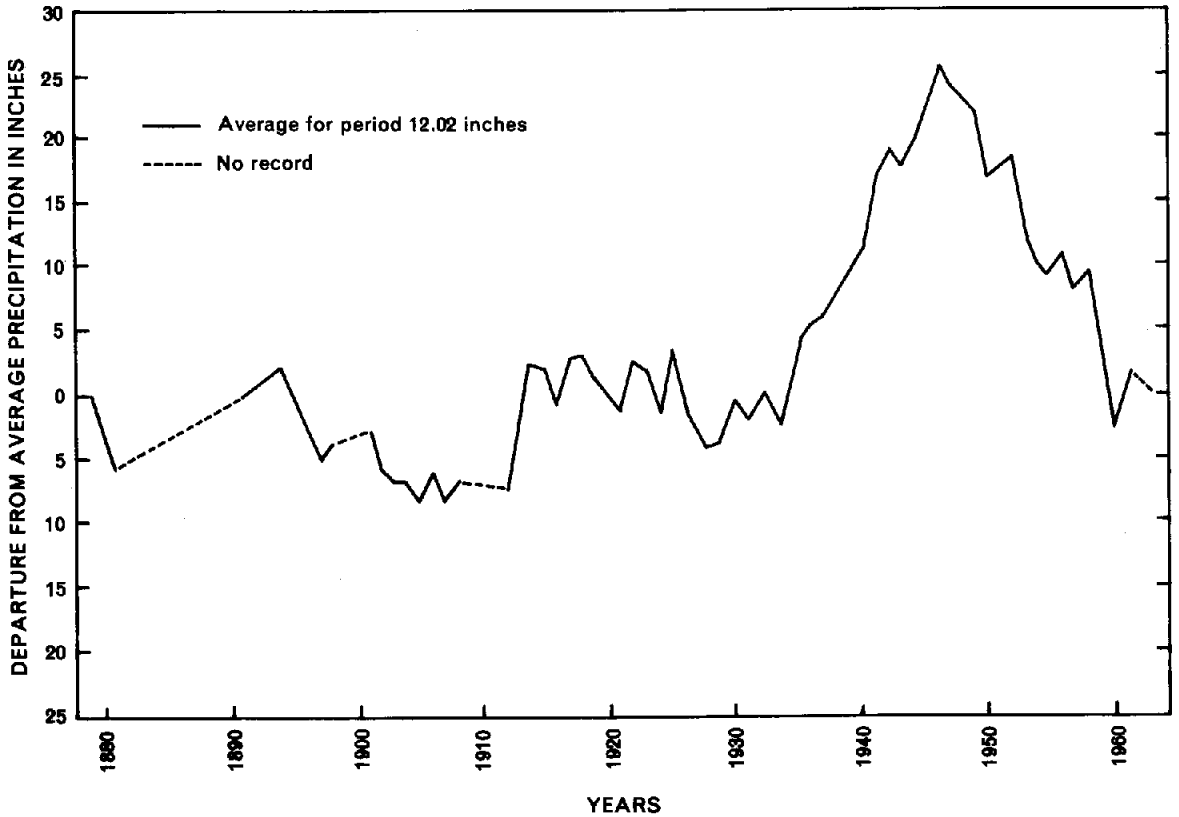

Figure 3.—Cumulative departure from average precipitation at Austin, Nev.; based on 70-year period of record for the water-year ending September 30

Table 1 shows that the maximum precipitation for a water year was 18.37 inches and the minimum was 5.35 inches. These values are lower than the recorded calendar-year maximum of 21.07 inches and the minimum of 5.90 inches for the period of record. For the 70 complete water-years of record the median precipitation is 11.91 inches --that is 50 percent, or 35 years, had precipitation greater than the median and 50 percent of the years of record had less than the median value. The upper quartile of 14.09 inches is the amount for which 25 percent of the years were greater than that value and 75 percent of the years were less than that value. The lower quartile of 10.28 inches is that amount in which only 25 percent of the years had lesser amounts of precipitation and 75 percent of the years had more precipitation. Stated another way, precipitation ranged between 10.28 and 14.09 inches (lower and upper quartile) in 35 of the 70 years of record.

Table 1 also shows the grouping of precipitation by months. The sum values for each of the 12 months describe what might be called a statistical year rather than a recorded water year. Thus, the values shown for the maximum in each month occurred in different years. These values, however, are instructive. For example, the sums of the maximum-monthly precipitation produces a value about 2 1/2 times the actual maximum precipitation for a given water year; the value for the sum of monthly upper quartile values is about 1.2 times the upper quartile of actual water years; the sum of monthly median values is about 0.85 times the median of actual water years; the sum of monthly lower quartile values is about half the lower quartile of actual water-years, and the sum of monthly minimum values is only about 0.04 times the actual water year minimum.

The maximum and minimum values recorded for individual water years fall relatively close to the upper and lower quartiles of the "statistical" year. These relations between the actual and statistical values suggest that, in a given year, months of substantially below median precipitation tend to be at least partly compensated for by other months in which precipitation is above the median.

Most of the annual precipitation occurs during the winter months. As represented by the median monthly values, about 70 percent of the annual precipitation occurs in the 6-month period, December through May. Most of this precipitation occurs as snow and tends to accumulate to supply the spring runoff. This characteristic is favorable for producing usable run-off and aids in accomplishing ground-water recharge. This characteristic is further indicated by a similar distribution in the other precipitation groups. Thus, in table 1, all of the precipitation shown in the column of minimum monthly precipitation occurred during the period December through May. Similarly about 60 percent of the precipitation shown in the maximum monthly precipitation occurred during the same period.

In addition to variations in precipitation from year to year and seasonally within the year, short-term variations occur from individual storms or high-intensity showers. The variations of precipitation result in an annual precipitation which tends to be distributed about a median

value of 11.91 inches a year and which 50 percent of the time falls between 10.28 and 14.09 on the basis of the long period of record at Austin. Of this annual amount, on the order of 70 percent occurs, largely as snow, during the 6-month period December through May. Figure 3 shows the cumulative departure from average precipitation at Austin, and indicates that variations from year to year provide trends of wet and dry intervals. As shown by the graph, years of above average precipitation, upward trend, commonly are followed by years of below average precipitation, downward trend. However prominate exceptions are the succession of above average years from the mid-1930's to the mid-1940's followed by a deficient period from 1946 to 1961 in which 12 of 15 years had below average precipitation.

As the record for Austin shows, precipitation at a given site varies with time. Similarly, precipitation at a given time varies geographically. Records of precipitation are not available for a good comparison of this feature for upper Reese River Valley. However, it generally is recognized that average precipitation on the mountains tends to be greater than on the valley floor. Native vegetation tends to be grouped in general zones of precipitation where their water requirements can be met and where other factors are favorable. Further, precipitation zones have relation to altitude zones where slopes, exposure, and orientation are comparable. In part this gross generalization was utilized by Hardman and Mason (1949, p. 11) to prepare a precipitation-zone map of Nevada, which recently has been modified by Hardman because of the availability of improved topographic control for the State. In this area precipitation zones of less than 8 inches, 8 to 12 inches, 12 to 15 inches, 15 to 20 inches, and over 20 inches may be approximately represented by altitude zones of less than 6,000 feet, 6,000 to 7,000, 7,000 to 8,000, 8,000 to 9,000, and more than 9,000 feet, respectively. The areas of the respective altitude zones are 217,000 acres, 264,000 acres, 144,000 acres, 92,000 and 45,000 acres. Then if average annual precipitation for these successive zones is 10, 13.5 17.5 and 21 inches, respectively, the total average annual precipitation on upper Reese River Valley would be about 700,000 acre-feet.

The actual value of total average annual precipitation, of course, may be greater or less than the estimate of 700,000 acre-feet. The analysis of surface-water runoff, discussed in the next section, suggests that, at least locally, precipitation may be somewhat less than that computed empirically above for the several precipitation zones.

Variations in annual precipitation, as was indicated by the record of precipitation at Austin, also are to be expected throughout the upper Reese River Valley. Further, time or space variations in the distribution of precipitation within a given year may result in any two years, with about the same annual precipitation, having quite different runoff conditions However, the general character of the hydrologic system may be illustrated, based on nominal average conditions, and for present purposes the value of 700,000 acre-feet may be used as a measure of the average annual precipitation in upper Reese River Valley.

Surface Water

Part of the precipitation in Upper Reese River Valley moves from the place it falls by overland flow which first collects in swales and rills, into minor channels, and then into the principal channel of the canyon in which it occurs. In this manner, water from snowmelt and precipitation collects in the headwater area of the Reese River in the southern Toiyabe Range on the southern flanks of Toiyabe Dome. The river leaves the canyon and flows on to the alluvial apron and thence into the lowland, flowing northward toward Reese River Canyon and the Humboldt River, about 50 miles north of the area. Similarily, tributary streamflow, such as in Illinois, Clear, Stewart, Tierney, Cottonwood, Big, Italian, Silver, and Boone Creeks, develops in the Toiyabe Range,

and crosses the alluvial fans or apron toward the Reese River. Other streams, especially most of those draining the canyons of the Shoshone Mountains, only rarely and under the most optimum conditions develop sufficient flow to reach the Reese River. Still others, such as Bonita and Meadow Creeks, reach the Reese River for short periods in most years.

Even on the alluvial apron localized streamflow occasionally develops for short periods as the result of high-intensity storms or cloudbursts. Generally, however, this type of streamflow is so erratic in frequency and duration as to have a low susceptibility to economic development.

Almost from the first overland movement, runoff is subject to evapotranspiration. However, in a given stream or creek there is a reach or section along its course at which the maximum mean flow occurs. This ordinarily is at the lower end of the area producing runoff for that particular basin. If all the drainage basin of the stream is runoff producing, then the point of maximum flow of that stream will be at its mouth or where it joins a larger stream. In the study area this generally occurs only in the mountains where several small tributaries may join to form a larger stream or creek, and all the area of the tributaries receive enough precipitation to produce runoff. Downstream from the mountain front, stream losses generally increase substantially, and the flow is dimished by natural evapotranspiration or seepage to the ground-water reservoir. Under most conditions in this region the point of maximum runoff of streamflow of individual stream or creek systems commonly occurs near the division between the mountains and the alluvial apron. Local conditions may shift this point upstream or downstream in given streams, and the point of maximum flow may shift along the stream course during the year or from year to year. Ordinarily the most identifiable normal location of the point of maximum flow is where the stream leaves the mountains. Commonly too, this point approximately represents the upstream location where diversions are made and thus is of good reference value in consideration of possible development.

Available Records

The Reese River is the principal stream in the upper Reese River Valley. The river is gaged in the NE1/4 sec.3, T.11N., R.40E., at a point about 2 1/2 miles upstream from the confluence of Indian Creek. The gaging station, Reese River near Ione, was installed in August 1951 and streamflow records have been continuous to the present time. The present gaging site is about at the point of maximum flow of the headwater area of the Reese River.

A short partial record of Reese River streamflow (Reese River near Berlin) was obtained between June 1913 and September 1916 about 5 miles downstream from the present gage and just upstream from the confluence of Illinois Creek. Only one complete water-year, 1914, was obtained.

The drainage area above these lower sites is more than twice that of the present site and includes Indian Valley.

A partial record of the flow of Big Creek (Big Creek near Austin) was obtained during the interval July 1913 to September 1916 near the mouth of the canyon.

A gaging station was established on the Reese River at the head of Reese River Canyon, SW1/2 sec.21, T.24 N., R.43E., in July 1963. This gage will provide a measure of the streamflow leaving upper Reese River Valley.

During the present investigation, miscellaneous measurements of streamflow were made on Boone, Italian, Big, Cottonwood, Tierney, Stewart, Clear, and Reese River gage in the Toiyabe Range, and Deep, Bonita, and Riley Creeks in the southern Shoshone Range. Additionally, estimates of flow of the Reese River were made at several points along its course in the valley. Current gaging stations and miscellaneous measurement sites are shown on Plate 1.

Table 2 summarizes the discharge of the Reese River near Ione for the period 1952-63. Average annual streamflow was about 10.5 cubic feet per second (cfs), and the flow ranged from 27.6 cfs in 1958 to 2.35 cfs in 1960. Principal runoff occurs in the April to June period from snowmelt in the mountains, during which time about 59 percent of the annual runoff occurs. May has the highest monthly average runoff, 42.2 cfs. The September to January runoff is low with monthly averages of between 2 and 3 cfs.

The lower graphs in figure 4 show the annual streamflow pattern for Reese River at the gaging station. The monthly plot points are shown as a percentage of the average annual streamflow. The middle line of the graph represents the median distribution of the monthly mean discharge for each month; that is, for each month, 50 percent of the monthly flows of record were less than and 50 percent were more than the proportional amount shown by the graph. The upper line of the graph, the upper quartile, is a plot of the proportional monthly flow for which only 25 percent of the monthly flows of record were higher than and 75 percent were less than the proportions indicated. The lower line of the graph, the lower quartile, is a plot of the monthly proportion of annual flow for which 75 percent of the monthly flows of record were greater than and 25 percent were less than the proportion indicated by the line.

Table 2. --Summary of streamflow of the Reese River at the gaging station, near Ione for the water-year period 1952-63.

(Discharge in cfs.)

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Year
Average	2.32	2.13	2.22	2.14	3.10	4.82	26.3	42.2	26.0	7.60	3.00	2.23	10.5
Max. month	4.40	3.68	3.97	3.58	9.01	9.59	82.6	154.	73.5	22.4	7.44	4.99	27.6 1/
Min. month	1.02	0.88	1.04	1.02	1.44	2.35	3.99	3.85	1.96	.30	.10	.59	2.35 2/

1/ Average for maximum recorded water year.

2/ Average for minimum recorded water year.

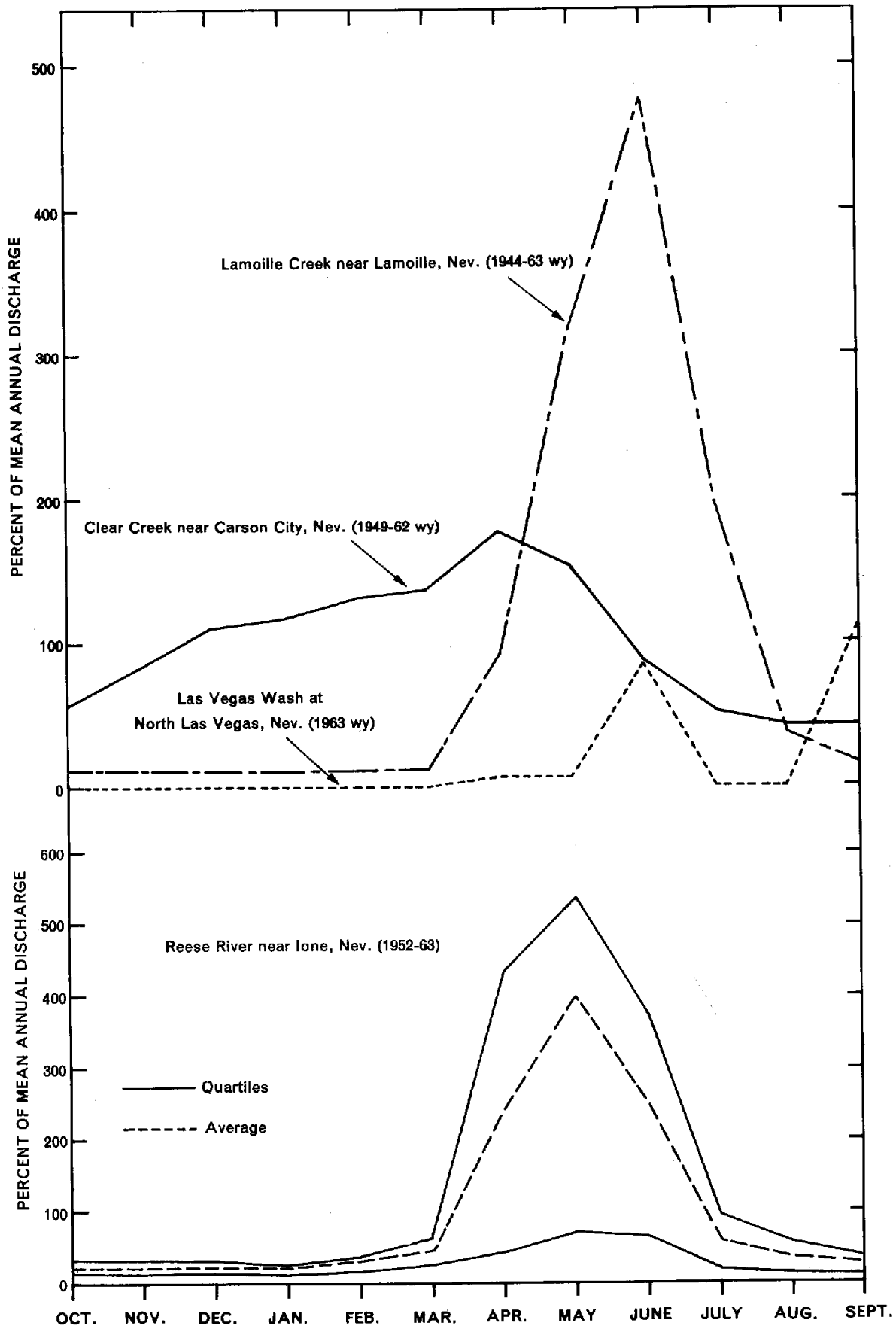

Figure 4.—Graphs of monthly discharge in percent of mean annual discharge of Reese River, Lamoille Creek, Clear Creek, and Las Vegas Wash, Nevada

As noted above, the characteristic annual hydrograph of the flow of Reese River reflects a dominant influence of snowmelt runoff. In Nevada there are three general types of runoff. One is characterized by spring snowmelt runoff, such as the Reese River. In the upper graphs in figure 4, the graph for Lamoille Creek, in northeastern Nevada, also represents the spring snowmelt runoff which forms the greater proportion of the annual streamflow. It shows a peak occurring later than that of Reese River. The graph for Clear Creek in western Nevada represents another type in which the principal runoff is distributed through several months, resulting from a prompt response in runoff from fall and winter precipitation. Snowmelt occurs even through the winter months, which reduces peak runoff during the spring. The graph for North Las Vegas Wash, although based on a short record, illustrates the flash runoff resulting from high-intensity storms or cloudbursts. It is characterized by short periods of possibly very high rates of runoff separated by long periods of little or no flow. The peaks in this graph, which occur in June and September, represent flash runoff of 2-day duration or less which occurs most frequencly in the summer months but in fact may occur in almost any month of the year. Although this type of runoff is characteristic of the southern part of the State, it also occurs to some extent throughout the State.

Many streams may reflect a combination of the three types of streamflow Flash floods occur on occasion in upper Reese River Valley. Austin has been subject to local flooding from high intensity storms, partly because it occupies the floor of Pony Canyon. Perhaps one of the worst of the flash floods occurred early in its history on August 15, 1878. Flash floods were reported on July 28, 1952, along several of the canyons of the Toiyabe Range south of Austin. In any locality flash floods may be widely spaced in time or they may be closely spaced, such as the three cloudbursts on July 1, July 31 and August 1, 1953, which flooded Washington Canyon.

Estimated Runoff in Upper Reese River Valley

Streamflow is measured on most of the principal and some of the smaller streams in Nevada. There remains, however, numerous small streams that locally and collectively are important to the hydrology and economy of the State. In the past assessing such streamflow tended to be hampered by the apparent need for measurements over a considerable period of time.

A method recently has been devised to estimate runoff in Nevada, particularly for application to areas where little or no streamflow record is available. The method still is in the development stage and is subject to further field checking and adjustment. It is a reconnaissance method only, and in no way should it be construed that the method necessarily produces results of equivalent reliability to those based on extensive data. Nevertheless, it presently provides a means of making preliminary estimates that can be useful if used with caution.

As surface-water runoff is subject to some variation in interpretation, its use here refers approximately to runoff from the mountain block to the alluvial apron or slightly beyond, which is inferred to represent the approximate point of maximum flow, previously discussed, from each mountain drainage basin. Because the method utilizes general altitude zones for reference, these do not coincide precisely with the contact between the mountains and alluvial apron. As these are classed as rather general estimates, it seems likely that the actual difference that would result from using the mountain block instead of altitude zones probably is small. For upper Reese River Valley the 7,000-foot contour is used as the assumed lower altitude limit for producing significant and potentially manageable runoff. Referring to the contours on plate 1, it may be seen that the 7,000 foot contour reasonably represents the division between the mountains and the alluvial apron through most of the area. The contour locally is out on the alluvial apron along the front of the Toiyabe Range and near the south end of the valley and is in the mountain block in parts of the Shoshone Mountains. However, for the valley as a whole it probably is reasonably representative.

The method used for synthesizing the surface -water runoff is based on the fact that through the State the precipitation usually increase with elevation and that precipitation in a given altitude zone may vary in different parts of the State. This same relation was assumed in estimating the surface-water runoff.

Using the drainage areas supplying the natural flow to streams where gaging stations had been or are operated, recorded runoff was prorated by altitude zones with due regard to the proportional areas of the several zones and with increasing unit values of runoff for increasing altitude. Runoff for particular altitude zones was found to change within the State but more important apparently were rather consistant for large areas. Thus, relations were established between runoff, altitude and precipitation. This permits estimating runoff in ungaged areas on the basis of th altitude-precipitation relation, which can be extended by precipitation station records.

The runoff for each 1,000-foot zone was estimated for the entire State In a given general area a set of runoff values, in inches, for the successive 1,000-foot zones was obtained. Eight different sets were sufficient to provide coverage for the entire State by large areal units, termed runoff zones. As the runoff values are in inches of runoff, a factor was used to convert to cubic feet per second per square mile. This coversion factor is multiplied by the evaluated runoff, in inches, for each altitude zone; the product of which is a general runoff coefficient for that zone.

As the different physical characteristics, such as vegetation, amounts of precipitation, geology, and types of soil mantle, vary locally within the large areas, the general runoff coefficients were adjusted accordingly. The adjustment of the runoff coefficients for local conditions was based

on miscellaneous streamflow measurement. The miscellaneous measurements were adjusted to a long-term average by adjusting the actual measurement to the average for that year by using the ratio of the discharge at a control stream at the time of the miscellaneous measurement, to the average for the year. This value then is further adjusted by the ratio of the current year discharge to the long-term average annual discharge of the control stream.

The upper Reese River Basin was entirely within one of the general runoff zones (B). Ten miscellaneous measurements were made. (See plate 1 for locations.) Relating these measurements to the streamflow record of the Reese River, it was found that two areas had lower runoff coefficients than the rest of the valley. The runoff coefficient was about 50 percent lower than the general runoff coefficient in one subzone, B-1 in table 3, along the west flank of the Toiyabe Range, about between Porter and Marysville Canyons. The coefficient was about 70 percent lower than the general coefficient in the other subzone, B-2 in table 3, on the east flank of the Shoshone Mountains from about Barrett Canyon northeastward for about 11 miles.

Table 3 summarizes the surface-water runoff computations. The approximate synthesized runoff in column 5 for each altitude zone is obtained by multiplying the figures in columns 3 and 4. Thus, the estimated average annual runoff for the 10,000- to 11,000-foot altitude zone in runoff zone B-1 is 0.339 x 5.56 = about 1.88 cfs. The estimated average annual runoff in the upper Reese River Valley is about 50 cfs, or roughly 36,000 acre-feet a year, and is generated mainly in an area of approximately 400 square miles in the mountains.

As defined, the estimated average annual runoff of about 36,000 acre-feet roughly represents the amount of annual runoff from the mountains to the alluvial apron. It does not include runoff generated from precipitation directly on the alluvial apron and valley lowland, which is very erratic in occurrence and generally minor by comparison.

Table 3. --Estimated average annual runoff from mountains in Upper Reese River Valley.

Altitude zone 1/ (feet)	Runoff Zone	Runoff coefficient	Area Sq. mi.	Synthesized runoff (cfs)
Column 1	2	3	4	5
	2/			
7,000-8,000	B	.030	171	5.13
8,000-9,000	B	.185	92.6	17.1
9,000-10,000	B	.414	24.0	9.94
10,000-11,000	B	.622	10.4	6.47
11,000-12,000	B	1.18	1.33	1.57
	3/			
7,000-8,000	B-1	.017	33.8	0.57
8,000-9,000	do	.109	34.7	3.78
9,000-10,000	do	.237	15.1	3.58
10,000-11,000	do	.339	5.56	1.88
	4/			
7,000-8,000	B-2	.002	19.8	.04
8,000-9,000	do	.013	16.4	.21
9,000-10,000	do	.029	0.89	.03
			407.76	50.30
				or
		Total (rounded)	408	36,000 acre-feet

1/ Area below 7,000 feet assumed not to contribute to surface-water run off, except after local intense storms, resulting in short duration runoff.

2/ General zone applicable to most of upper Reese River Valley.

3/ Local zone comprising west flank of Toiyave Range about between Porter and Marysville Canyons.

4/ Local zone comprising east flank of Shoshone Mountains northeastward for about 11 miles from Barrett Canyon.

Disposition of runoff

Runoff from the mountains, which supplies Reese River and its tributaries, is dissipated largely by evapotranspiration within the valley. Only a small part actually leaves the valley as streamflow through Reese River Canyon. Most of the runoff from the mountains supplies water for the irrigation of natural meadows and associated irrigated areas as well as other natural vegetation along the stream, floodplains, and valley lowlands. Some replenishes soil moisture along the floodplain in the valley lowlands to be discharged later in the season by evapotranspiration of vegetation. Some recharges the ground-water reservoir from which discharge subsequently occurs by evaporation and transpiration of phreatophytes. Thus, a large fraction of this streamflow is discharged from the valley by evapotranspiration.

Many areas of grasses or meadow which utilize streamflow also derive part of their supply from the underlying ground water when streamflow is inadequate. For convenience, the estimates of surface-water discharge by evapotranspiration and outflow are listed in table 5 in the section on ground-water discharge. Of the estimated 36,000 acre-feet of average annual runoff from the mountains, an estimated 22,000 acre-feet is consumed by evapotranspiration in the valley lowlands.

Although most of the streamflow from the mountains is dissipated by evapotranspiration within the valley, occasionally high stages of runoff occur for sufficient periods of time so that streamflow may discharge through Reese River Canyon. The Reese River reportedly has flowed from the upper Valley to the Humboldt River 7 times in about 100 years (U.S. Department of Agriculture, 1962). An indirect measurement, made near the gaging station at the head of Reese River Canyon, indicated that a peak discharge of about 740 cfs occurred during the floods of mid-February, 1962. In addition to the occasional large floods, high-water years resulting in substantial peak flow through the Reese River Canyon occurs but does not necessarily reach the Humboldt River. Apparently, too, at least a small flow related to the spring snowmelt period probably discharges into Reese River Canyon most years.

The above information suggests the general order of the nature and frequency of flow through the Reese River Canyon, about as follows: Flood flow of sufficient amount and duration to discharge water from the upper Reese River Valley into the Humboldt River may average as frequently as 1 in 15 years; high flow may occur once in several years; and some flow occurs nearly every year. Although there is no satisfactory way of closely estimating the amount of streamflow leaving upper Reese River Valley, very rough calculations suggest that the average annual outflow probably is not more than 5,000 acre-feet and most likely is on the order of 3,000 acre-feet a year. (See table 5.) Most of the flow, of course, actually occurs during short periods after high-intensity rain or very high runoff from snowmelt.

The estimated 22,000 acre-feet estimated to be lost by evapotranspiration and the about 3,000 acre-feet flow through the Reese River Canyon account for 25,000 of the 36,000 acre-feet of runoff. The remainder, 11,000 acre-feet, is inferred to recharge the ground-water reservoir. Obviously, as this latter amount is obtained by difference, any errors in the estimates of evapotranspiration and outflow would be incorporated in the estimate of recharge from runoff.

Ground Water

The source of virtually all of the ground water in upper Reese River Valley is precipitation within the drainage area of the valley. Most of the recharge is derived from the precipitation in the mountains, and most of that resulting from the spring melting of the snowpack accumulated during the winter. Precipitation on the alluvial apron probably does not result in material direct recharge to the ground-water reservoir, but that which falls on phreatophyte areas during the growing season temporarily may reduce the draft on ground water by that vegetation and indirectly contribute to the ground-water reservoir by reduction of discharge.

Precipitation may percolate directly to ground water or may have an intermediate stage as runoff or streamflow prior to reaching the ground-water reservoir.

Water in the mountains moves downgradient, whether as streamflow or ground water, toward the lower parts of the valley. The gradient of the water surface and consequent movement from the mountains to the valley axis is illustrated by wells 19/43-15dl and 19/43-16dl, (see P 11) which have depths to water blow land surface of 105 and 64 feet, respectively. Well 16dl is about a mile west and toward the valley axis from well 15dl and at substantially lower land-surface altitude. Water level in the flood plain another mile west is about at land surface. The water level in this part of the valley slopes westward toward the valley axis at a gradient of about 40 feet per mile less than the gradient of the land surface.

Along the axis of the valley, which is consistent with the alinement of the Reese River, water-level gradients are about parallel to northward land surface grandients for the shallow-water segments which are found along most of the length of the river. In the several-mile section where the river is dry most of the time, that is northward from about the Visbeck Ranch, the depth to water is deep, about 70 feet at well 17/42-28al. In this section the water-level gradient along the axis of the valley is less than that of land surface. This flatter water-level gradient may reflect an increase in transmissibility of the valley fill or increased cross-sectional area of the valley fill. The water that is not consumed by evapotranspiration moves northward and is joined by lateral inflow, particularly from the Toiyabe Range. The northward movement is restricted by the bedrock narrows in T.20N., R.43E., where the transmissibility and the cross-sectional area of the valley fill is less. The

most prominent constriction is the Reese River Canyon, which is cut through the Shoshone Range at the north end of the valley. Another is in the vicinity of the Lander-Nye County line, just north of the Waukine Ranch.

Additionally, localized inflow along many of the principal tributary stream channels results in a water table that is at or near land surface up-gradient from the restrictions. The areas of grasses shown in the valley lowlands on Plate 1 are also areas of shallow water table. The successive occurrences of these conditions along the Reese River channel results in the alternate sections of flow and no flow or larger and smaller rates of flow along the course of the Reese River northward from its confluence with Indian Creek. For example, on June 24, 1964, stream flow at the Ranger Station was estimated to be 8 to 10 cfs; about 2 miles down stream the flow was estimated to be 6 to 7 cfs; about 6 miles downstream near the Heath Ranch, the flow was estimated to be about 3 cfs; 5 miles downstream, near the narrows at the county line, the estimated flow was about 6 cfs; 3 miles farther, the estimated flow was 4 to 5 cfs; about 2 miles beyond, estimated flow was 2 to 3 cfs; another 3 miles farther, the estimated flow was 1 to 1 1/2 cfs and this was deverted to the nearby fields east of the Visbeck Ranch. The channel was dry north of the Visbeck ranch for about 10 miles where the springs on the Gondolfo Ranch opposite Big Creek Canyon sustained some flow for about 10 miles to the vicinity of the Whitaker Ranch. The relation of the shallow water table to sections of increased flow point to the close interrelation and inter-dependence of ground water and surface water.

Estimated Average Annual Recharge

Only a small percentage of the precipitation within the drainage area of upper Reese River Valley actually recharges the ground-water reservoir. A method described by Eakin and others (1951) may be used to derive a preliminary estimate of average annual recharge from precipitation in the drainage area. The method is based on the assumption that zonal distribution of precipitation generally increases with altitude and does so more or less regularly, and that the sum of fixed percentages of the average precipitation of each zone represents the equivalent volume of water that is recharged to the ground-water reservoir on the average year.

Hardman and Mason (1949, p. 10) prepared a map of zonal distribution of precipitation in Nevada which indicates a general relation of precipitation increasing with altitude. For Upper Reese River Valley, table 4 lists the several zones of precipitation, the area of each zone, the assumed percentage of precipitation that becomes recharge, and estimated amount of water that ultimately recharges the ground-water reservoir. The table shows that the estimated average annual recharge is about 58,000 acre-feet. The relation of runoff to precipitation to altitude, discussed in a previous section, suggests these relations vary in different parts of the State. The general zone in which upper Reese

River Valley lies is in one of the lower of the eight general zones of runoff-precipitation- altitudes developed for the State. Even though the valley is in a lower runoff zone, about 30 percent of the mountain area above 7,000 feet was found to have substantially deficient runoff compared to the valley as a whole (see table 3). This deficiency is sufficient to reduce the runoff for the whole mountain area by 20 percent of the value that would be obtained by using the regular coefficients for the general zone for the whole valley. If a similar reduction were applicable to the estimated recharge to the ground-water reservoir for the precipitation zones at and above 7,000 feet altitude, the combined recharge from those zones would be decreased from about 51,000 acre-feet (table 4) to about 41,000 acre-feet. Deficiency of precipitation in the mountain area probably would imply also a deficiency of precipitation in the valley, of which the 6,000-7,000-foot recharge zone is a part. In turn a lesser recharge would result in that zone, so that the combined effect of lesser precipitation as indicated by the runoff-precipitation-altitude relations might reduce the average annual recharge from the estimated 58,000 to perhaps about 45,000 acre-feet. This still is higher than the estimated average annual discharge, about 37,000 acre-feet, discussed in the following section (table 5). The foregoing material illustrates the possibility that anomalous estimates may be made when assumed conditions do not satisfactorily represent actual conditions. It also points to the need for additional study and investigation to improve the method of estimating recharge and to obtain fully adequate control data on which to base such estimates.

Table 4. --Estimated average annual ground-water recharge from precipitation in Upper Reese River Valley, Nevada.

Precipitation zone				Estimated recharge		
Precipitation range (inches)	Average annual precipitation (feet)	Altitude range (feet)	Area (acres)	Assumed percentage of average annual precipitation	Acre-feet per year	Adjusted
20+	1.75	above 9,000	45,000	25	19,700 2/	12,500
15 to 20	1.46	8,000 to 9,000	92,000	15	20,100	12,800
12 to 15	1.12	7,000 to 8,000	144,000	7	11,300	7,200
8 to 12	.83	6,000 to 7,000	264,000	3	6,600	4,200
8-	--	below 6,000	217,000	0	- ---	
				Total	57,700	36,700
				Estimated average annual recharge (rounded)	a/ 58,000	37,000

a/ See text discussion which indicates that this value probably is too high by a substantial amount, as shown in adjusted column.

For this report reliance will be placed on the estimate of natural ground-water discharge, as that appears to represent more closely the actual conditions than does the recharge estimate for upper Reese River Valley. For the purpose of the illustrative hydrologic budget discussed beyond, the value of the estimated discharge of 37,000 acre-feet also is used as the estimated recharge. This amount of recharge is distributed by zones in about the same proportion as 37,000 is to 58,000 acre-feet values. This in effect reduces the recharge of the upper three zones from about 51,000 to about 33,000 acre-feet and the lower zone from nearly 7,000 to about 4,000 acre-feet. Of the recharge 33,000 acre-feet derived from precipitation in the mountains above an altitude of 7,000 feet, 11,000 acre-feet are inferred to leave the mountains as streamflow and then infiltrate to the ground-water reservoir in the valley fill as discussed previously. The remaining 22,000 acre-feet thus are assumed to infiltrate into the bedrock of the mountains and thence move to the ground-water reservoir in the valley fill by subsurface flow.

Of the total estimated recharge, most apparently is derived from precipitation in the mountains at the south end of the valley; that is the part more or less lying in Nye County. The Toiyabe Range in Lander County, particularly the section from Big Creek to Austin and the west flank of Mt. Callahan, also produce considerable recharge.

Discharge

Under natural conditions most ground water is discharged by evapotranspiration processes from upper Reese River Valley. A small fraction of the total is discharged by underflow through Reese River Canyon. Discharge of ground water by evapotranspiration occurs to some extent in the mountains, especially in mountain meadows, such as in Indian Valley, and along stream channels in the canyons. Most, however, is discharged in the valley lowland or floodplain of the Reese River and the lower parts of its tributary streams. Further, most of that ground-water discharge occurs in the valley lowland from about T. 17 N., northward.

Table 5 shows that the estimated average annual natural ground-water discharge is 37,000 acre-feet, which is considerably less than the unadjusted estimate of average annual ground-water recharge of 58,000 acre-feet. The methods of estimating both recharge and discharge are only approximate techniques and may not result in close agreement of values in a given area. As mentioned in the previous section, the estimated average annual ground-water discharge is believed to represent more closely the actual conditions.

The areas of natural ground-water discharge by evapotranspiration occur in the floodplains of the streams and valley lowlands which also are the areas of evapotranspiration of surface-water runoff. The estimated evapotranspiration from surface and ground water is in part interrelated. Therefore, table 5 summarizes the estimates of evapotranspiration and outflow of both surface water and ground water from upper Reese River Valley

Table 5.--Estimated average annual discharge of ground water and surface water by evapotranspiration and outflow from Upper Reese River Valley.
(values rounded)

Method of discharge	Estimated discharge (acre-feet)	
	Surface water	Ground water
Evapotranspiration of phreatophytic vegetation in flood plains of streams and valley lowland.		
a. Largely grass areas; includes saltgrass, seep grass, irrigated pasture, meadow, and other grasses; also includes some wild rye and locally willows, aspen, and similar vegetation. Depth to water ranges from 0 to 30 feet and averages about 10 feet. Consumptive use requirements supplied by surface water and ground water locally ranging from almost entirely surface water to almost entirely ground water. Estimated average annual rate of 0.5 foot from surface water and 0.7 foot from ground water for about 28,000-acre area.	14,000	20,000
b. Largely greasewood and rabbitbrush areas, but including grasses in favorable locations. Depth to water ranges from about 10 to 35 feet; and averages about 20 feet, in 26,000-acre area. Water partly supplied from surface water and ground water. Estimated average annual rate of ground-water use, 0.5 foot; surface water supplied locally and during some years; estimated average annual rate about 0.2 foot.	5,000	13,000
Evaporation from free-water surfaces within area (a) above and additional to estimated vegetative use above.		
(1). Rising ground water and spring areas, estimated rate of about 2 feet in area of about 2,000 acres.	--	4,000
(2). Along Reese River in southern half of valley and tributary streams, estimated rate of about 1 foot of surface water evaporated on about 2,000 acres, in excess of vegetative use.	2,000	--
(3). Evaporation in flood plain in northern part of valley, largely resulting from flooding during years of high runoff and floods. Estimated average annual amount.	1,000	--
Outflow		
(1). Average annual surface-water outflow through Reese River Canyon largely from years of high runoff and flooding.	3,000	--
(2). Ground-water outflow in Reese River Canyon; small, probably does not exceed	--	500
Estimated average annual surface-water discharge by evapotranspiration and outflow	25,000	
Estimated average annual discharge of ground water.		37,000
Estimated average annual discharge of surface water and ground water.	62,000	

Until the last few years, ground water withdrawn by wells has been minor in quantity and used for stock, domestic, or supplemental irrigation,. Some of this water was consumed, returned to the ground-water reservoir, but probably most was discharged by evapotranspiration. Generally the net effect was that ground water was routed for useful purposes prior to evapotranspiration, and because the total amount involved was small, the use had a negligible effect on the natural system.

Recently, however, ground-water withdrawals have increased with the commencement of well irrigation for farming on land withdrawn under the Desert Land Act. Most of the development is in parts of T. 17 N., R 41 E., and T. 18 N., R. 42 E. Pumpage from 12 wells in the 1964 irrigation season is estimated to be roughly 3,000 acre-feet. To this date, pumping in this area probably has had little affect on the natural discharge.

Storage

The quantity of ground water stored in the valley fill of upper Reese River Valley is many times the average annual recharge to and discharge from the ground-water reservoir. Although the total volume in storage is not known, some concept of the magnitude is indicated by the following illustrations. Between the Visbeck and Whitaker Ranches an area of at least 80,000 acres probably is underlain by more than 100 feet of saturated valley fill. Well logs from the few wells in the area suggest that the drainable pore space or specific yield is about 15 percent; that is, the volume of water that will drain by gravity from a given volume of saturated deposits is estimated to be about 0.15 of the volume of dewatered material. Thus the quantity of water stored beneath an area of 80,000 acres in a saturated thickness of 100 feet and with a specific yield of 15 percent is 1.2 million acre-feet. Although this represents only a small portion of the total volume of the saturated valley fill, it still is on the order of 20 to 25 times the estimated average annual recharge and discharge to the ground-water reservoir of upper Reese River Valley and is 1.7 times the estimated average annual total precipitation. The very large volume of ground water in storage provides a substantial reserve to sustain with-drawals during protracted droughts.

Perennial Yield

The perennial yield of a ground-water system is the maximum amount of water that can be withdrawn from the system for an indefinite period of time without causing a permanent and continuing depletion of ground water in storage and without causing deterioration of the quality of water. It is limited ultimately by the amount of natural discharge of water 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 a closed hydrologic system, the average natural recharge equals the average natural discharge over a long-time period. As previously discussed, the estimate of discharge from upper Reese River Valley is considered to approach more closely the actual value of recharge to and discharge from the ground-water system. For this preliminary estimate of perennial yield, a value equivalent to the estimated average discharge of 37,000 acre-feet is used.

Recovery of this amount by wells with minimum disruption of the natural ground-water system would require a distribution of wells in or adjacent to the natural areas of discharge--principally in and along the valley lowland in the north half of the valley. Locally, though, water quality may not be suitable for the intended use.

The development in other parts of the ground-water system would have varying effects on salvaging natural discharge, depending upon the relative position of the development in the ground-water system. For example, the present irrigation-well development in the vicinity of the northwest part of T. 17 N., R. 42 E., is along the west margin of a natural discharge area. Little recharge is derived from the low mountains on the west side of the valley in this area. Most of the withdrawals in this area must come from ground water in storage until water levels in the pumped area are lowered sufficiently to divert water now being discharged by evapotranspiration in the adjacent phreatophyte area. To accomplish this, water levels in the pumped area probably would have to be lowered an average of 100 feet or more and be maintained at a low level for a number of years before a significant amount of water could be salvaged by diversion from the phreatophyte area.

Chemical Quality

Eighteen water samples were analyzed as part of the present study (table 6) to make a generalized appraisal of the suitability of the ground water for agricultural use and to help define potential water quality problems.

Suitability for Agricultural Use

According to the Salinity Laboratory Staff, U.S. Department of Agriculture (1954. p.69), the most significant factors with regard to the chemical suitability of water for irrigation are dissolved-solids content, the relative proportion of sodium to calcium and magnesium, and the concentration of elements and compounds that are toxic to plants. Dissolved-solids content commonly is expressed as "salinity hazard", and the relative proportion of sodium to calcium and magnesium as "alkali hazard."

The salinity Laboratory Staff suggests that salinity and alkali hazards should be given first consideration when appraising the quality of irrigation water, then consideration should be given to boron or other toxic elements and bicarbonate, any one of which may change the

quality rating.

Sampling sites were chosen in upper Reese River Valley to achieve the widest possible areal coverage. Samples were collected from streams, from wells on the alluvial slopes, and from wells along the axix of the valley. The analyses are shown in table 6. All but one of the wells sampled yield water which probably is suitable for irrigation. Water from well 24/43-35cl, at the north end of the valley, has a high salinity and alkali hazard and a very high bicarbonate content. Accordingly, this water is at best marginal and probably is unsuitable for irrigation. The streams which were sampled contain water that probably is suitable for irrigation most of the time.

Water Quality and its Relation to the Ground-Water System

The quality of ground water in upper Reese River Valley varies from place to place. However, in general, the dissolved-solids content is low in the recharge areas in the mountains and increases in the area of discharge in the lower parts of the valley. Water from well 13/40-15al has a specific-conductance of 575 micromhos per centimeter. The source of much of this water probably is recharge derived from precipitation on the Toiyabe Range and Shoshone Mountains. Some concentration of the water may result from local evapotranspiration in the lowland area upgradient from this well. About 9 miles farther north, water from well 15/41-28cl has a specific-conductance of 363 micromhos. Although some of the chemical constituents in the water in this area probably are derived from ground-water underflow from the south, the decrease in specific-conductance suggests that the concentration principally reflects local recharge from the Shoshone Mountains just west of the well. Farther north, the specific-conductance of water from wells 17/42-6cbl, 18/42-30cbl and 18/42-31ccl averaged 286 micromhos. These wells are on the alluvial slope and are close to the nearby limited recharge area in the Shoshone Mountains. Ground water in this area probably has moved mostly through volcanic rocks or detritus derived largely from volcanic rocks and deposits which favor a relatively low accumulation of calcium and magnesium. As would be expected, water from these wells is less highly mineralized than water from well 18/42-26cl which has a specific conductance of 545 micromhos. As the well is in a discharge area, this higher specific conductance probably is due largely to the concentration resulting from evapotranspiration processes. At the northern end of the valley, water from well 24/43-35cc2 has a specific conductance of 1,440 micromhos. As the well is near the downstream end of the ground-water system in the valley, this relatively high specific conductance probably is due to further concentration by evapotranspiration processes. To some extent the higher concentration may result in part from additional mineral matter which is dissolved as the ground-water moves northward.

Most of the ground water in the area is a calcium-bicarbonate type. However, water from wells 20/43-33dl and 16/42-19ddl is a mixed sodium-calcium bicarbonate type, and water from wells 15/41-28cl and 24/43-35cc2 is a sodium-bicarbonate type.

Hydrologic Budget

The full and detailed accounting of the water in a given hydrologic system requires intensive study and substantial data. However, a generalized picture can be obtained for preliminary reference through the use of the rough estimates available from reconnaissance studies. This, in turn, may serve the purpose of indicating the general magnitude of the hydrologic system in upper Reese River Valley, its principal parts, and the areas where additional data and information may be required. The tentative hydrologic budget is given in table 7.

Table 6.--Chemical analyses, in parts per million, of water from selected wells, springs, and streams in Upper Reese River Valley, Nev.

(Field analyses by the U.S. Geological Survey)

Location (township, range, and section)	Date of collection	Calcium (Ca)	Magnesium (Mg)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Chloride (Cl)	Sulfate (SO_4)	Hardness as $CaCO_3$		SAR 1/	RSC 2/ <1 (epm)	Specific conductance (micromhos at 25°C)	pH
								Calcium Magnesium	Noncarbonate				
Wells													
13/40-15a1	8-05-64	60	12	316	0	16	29	199	0	1.6	1.20	575	8.1
15/41-28c1	8-05-64	27	5.2	173	0	15	24	89	0	1.4	1.06	363	7.6
16/42-19dd1	8-05-64	43	7.9	280	0	6.6	44	140	0	2.3	1.63	562	8.0
17/42-6cb1	8-05-64	35	5.0	137	0	9.6	20	108	0	.7	.09	280	8.0
18/42-26c1	6-23-64	61	11	265	0	19	38	196	0	1.2	.42	545	7.7
18/42-30cb1	6-24-64	19	1.8	136	0	10	20	55	0	2.5	1.13	294	7.8
18/42-31cc1	8-05-64	34	4.4	139	0	11	24	103	0	1.0	.22	284	8.1
18/43-17b1	8-05-64	59	27	268	0	7.8	59	259	39	0.4	.00	526	7.8
20/43-33d1	8-05-64	37	3.8	155	0	31	44	108	0	2.0	.38	432	8.2
21/42-1c1	8-06-64	3.2	.5	108	13	14	36	10	0	9.9	2.00	337	8.8
24/43-35cc2	8-05-64	62	6.4	775	0	33	76	181	0	8.6	9.08	1,440	7.2
Spring													
18/42-22c1	8-05-64	20	14	97	17	19	64	109	1	1.8	.00	385	8.9
Streams (Reese River)													
13/40-15a	8-05-64	37	7.4	216	0	9.2	15	123	0	1.5	1.08	385	8.0
14/41-8a	8-05-64	46	13	280	0	16	34	168	0	1.8	1.23	540	8.0
15/41-22b	8-05-64	33	7.4	188	0	11	32	113	0	1.7	.82	385	8.1
16/41-13dd	8-05-64	12	3.2	64	24	13	32	43	0	3.1	.99	282	9.3
18/42-11b	8-05-64	32	19	211	4	20	52	157	0	1.7	.45	502	8.5
(Cottonwood Creek)													
15/41-22a	8-05-64	47	7.7	196	0	4.0	23	149	0	.7	.23	357	8.0

1/ Sodium-adsorption ratio equals sodium $/\sqrt{\text{calcium + magnesium / 2}}$ in which concentration of ion are expressed in milliequivalents per liter (U.S. Dept. Agri., 1954, p. 72).

2/ Residual sodium carbonate equals carbonate plus bicarbonate minus the sum of calcium plus magnesium in which concentrations of ions are expressed in milliequivalents per liter (Eaton, 1950).

Although the values given in tab le 7 are subject to a number of qualifications, the relative distribution illustrates several important features.

1. Most of the precipitation, on the order of 90 percent, is lost by evapotranspiration, probably without having become either streamflow or ground water.

2. About 50 to 55 percent of the total precipitation occurs in the mountains, which occupy about one-third of the total drainage area of nearly 1,200 square miles.

3. Most of the runoff and ground water is derived from precipitation in the mountains.

Of substantial importance, though not shown in table 7, is the large volume of ground water in storage. According to the estimate for only a fraction of the saturated valley fill, storage is many times the average annual ground-water discharge. In the example used to illustrate ground-water storage, the volume of water in storage was 1.7 times the estimated 700,000 acre-feet of average annual precipitation.

DEVELOPMENT

For many years most of the runoff from the mountains has been utilized principally for the production of hay for livestock feed. Ditches have been used to divert the water more effectively on native meadows, or developed land. Locally, lined ditches, as on Big Creek, have been constructed to reduce water losses as the stream flows across the alluvial apron. Overall, this is a relatively minor change in the natural regimen of the valley.

Ground-water development occurred rather early in the history of the valley in the sense that springs supplying the low flow of streams were used. Springs in the Gondolfo Ranch area also have long been utilized as the principal seasonal supply for irrigation in that area. Wells and small springs have been used to provide water for livestock. In the lowland area mostly north from the Gondolfo Ranch and at the old Carter Ranch in section 17 near the lower part of Big Creek flowing wells have been obtained throughout most of the area.

In about 1950 several large diameter wells were drilled for irrigation at and south from the Visbeck Ranch. Partly these were to supplement surface water supplies and possibly permit additional acreage to be irrigated. Annual pumpage was relatively small. Beginning in 1963 several irrigation wells were drilled in conjunction with withdrawals of land under the Desert Land Act in a segment on the west side of the valley and north and south of U.S. Highway 50. About 12 wells were pumped during the 1964 irrigation season. The combined pumpage for the 1964 season is estimated to be on the order of 3,000 acre-feet. The pumping rates for individual wells ranged from about 200 to 1,500 gallons per minute. Pumping rates were observed to range somewhat during the season. To a large extent this appears to result from throttle adjustment of the fuel driven engines as a means of adjusting the supply for irrigating different parts of the fields. It was noted that some yields apparently were not enough. Late in the season a well was being drilled seemingly to replace 18/42-31bbl. The water from this well is used for irrigation mostly of small grains. Although this farming experiment is in the early stages of development it seems promising. However, additional time is needed to determine the degree of success that can be sustained in this area.

For many years the City of Austin has obtained most of its water supply from springs above town. Commonly however, even though much effort has been made to develop the springs as well as mine tunnels and wells above town, a seasonal shortage frequently occurs. Part of the difficulty apparently relates to natural conditions and part probably relates to increasing demand for water both for the permanent population and to provide increasing services for tourists.

Past experience suggests that developing springs in this area may reduce local evapotranspiration losses and make a higher proportion of the discharge subject to control. Commonly though, the "development"

Table 7.--Generalized hydrologic budget for upper Reese River Valley, Nevada

		Average annual amount (acre-feet)	
Inflow to mountains			
Precipitation above 7,000-foot contour (see precipitation section).			374,000
Outflow from mountains			
Streamflow - runoff from precipitation in the mountains. (See table 3; includes 11,000 acre-feet which becomes recharge to ground water, see ground water section).		36,000	
Ground-water underflow equivalent to the ground-water recharge from precipitation in the mountains (33,000 acre-feet) minus the ground-water recharge (11,000 acre-feet) by infiltration from streamflow noted above (see estimated average annual recharge section).		22,000	
	Subtotal	58,000	
Evapotranspiration from precipitation in the mountains (precipitation minus estimates of runoff and ground-water underflow: 374,000 - 58,000).		316,000	
	Total outflow from mountains		374,000
Inflow to valley			
Precipitation below 7,000-foot contour (see precipitation section) (of this amount, 4,000 acre-feet are estimated to recharge the ground-water reservoir).		328,000	
Runoff from precipitation in mountains (see above)		36,000	
Ground-water underflow from the mountains (see above)		22,000	
	Total inflow to valley		386,000
Outflow from valley			
Evapotranspiration of surface-water runoff (table 5)		22,000	
Evapotranspiration from ground water (table 5)		37,000	
Discharge through Reese River Canyon - surface water and ground water (table 5)		less than 3,500	
Evapotranspiration from precipitation in valley. (Inflow minus evapotranspiration of surface water, ground water, and discharge through Reese River Canyon; 386,000 - 22,000 - 37,000 - 3,500 = 324,000)		324,000	
	Total outflow from valley		386,000

also tends to increase the flow by reduction in storage upgradient from the springs. When equilibrium is again established, the flow may be about the same as before the last "development" activity.

The high-level springs have relatively small intake areas and comparatively small storage areas upgradient from them. Thus the flow responds relatively rapidly with precipitation in the mountains near Austin. The cumulative departure graph, for rainfall (fig. 3) shows a pronounced deficient period of precipitation at Austin since the water year ending September 30, 1946. Except for precipitation in the 1963 water year, which closely approximated the precipitation of 1946, only four other years had above-average precipitation. The substantial proportion of years of below-average precipitation undoubtedly has had an adverse effect on the discharge of the high altitude springs in the Austin area.

Potential development: Increased utilization of streamflow can be achieved in upper Reese River Valley by reduction of losses or by increasing the efficiency of handling the water under existing conditions of streamflow. Further utilization of streamflow could be achieved by providing storage reservoirs to permit adjusting natural flow to better meet the particular needs. To a large extent the problem is an economic one --that is, does the increased income or benefit more than offset the cost of obtaining increased efficiency and control of streamflow.

With respect to potential development of ground water, the indicated perennial yield is about 37,000 acre-feet. To withdraw this amount on a sustained base with minimum affect on the ground-water system would require that wells be distributed in or marginal to the principal areas of natural discharge. If the wells were to be drilled marginal to the discharge area, they preferably should be placed on the side toward the principal recharge to that area. In this way, the salvage of natural discharge would start to occur soon after the development. Should development be located elsewhere, the farther the area of development is from the natural discharge area, the longer time it would take for the development to affect natural discharge. At a distance of several miles, water levels in the developed area maybe lowered beyond the limits of economic operation before an equivalent reduction in natural discharge would occur. Thus, for practical purposes most of the discharge by pumping in the developed area would be from storage.

The present area of irrigation wells is on the west side of the main area of natural discharge of ground water in upper Reese River Valley. Recharge from precipitation in the Shoshone range to the west and southwest of pumping is considered to be very minor. Pumping in this area therefore initially will be almost entirely from ground water in storage. Under continued pumping, water levels will be lowered at increasing distance from the well field until inflow equaled the rate of pumping. In this area, drawdown east of the well field will gradually extend into the adjacent area of natural discharge. The extent to which ground water is salvaged by this well field can be indicated by the extent to which ground water is diverted from the phreatophyte area to the wells.

Continued pumping at the rate and seasonal pattern as used in 1964 probably will require several years before measurable drawdown will occur in the unconfined shallow ground water in the natural discharge area. Probably an additional several years pumping will be required before the drawdown and area included are sufficient to significantly reduce natural ground-water discharge in these areas. How soon, or whether pumping in this area would affect the discharge of the principal springs on the Gondolfo Ranch cannot be indicated with any assurance at this time. Until variations due to natural conditions can be demonstrated, it would be difficult to compute any effect due to pumping in the new well field.

DESIGNATION OF WELLS

The number system for wells and springs in this report is based on the rectangular subdivisions of the public lands, referenced to the Mount Diablo base line and meridian. It consists of three units: the first is the township north of the base line; the second unit, separated from the first by a slant, is the range east of the meridian; and the third unit, separated from the second by a dash, designates the section number. The section number is followed by a letter that indicated the quarter section; the letters a, b, c, and d designating the northeast, northwest, southwest and southeast quarters, respectively. Following the letter, a number indicates the order in which the well or spring was recorded within the 160 acre tract. For example, well 17/40-8c1 is the first well recorded in the southwest quarter of section. 8, T. 17 N., R. 40 E., Mount Diablo base line and meridian.

Because of the limitation of space, wells and springs are identified on plate 1 only by the section number, quarter section letter, and number, indicating the order in which they are located. Township and range numbers are shown along the margins of the area on plate 1.

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Table 8.--Records of selected wells in Upper Reese River Valley

Well number and location	Owner and name	Date drilled (month and year)	Depth (feet)	Diameter of casing (inches)	Principal water-bearing zone (feet)	Measuring point: Description	Measuring point: Above(+) or below(-) land surface (feet)	Water level: Below measuring point (feet)	Water level: M or R	Water level: Date	Use	Log No.	Yield (gpm)	Remarks
11/40-27b1	Willie Bill	8-59	55	6	48-52	T.C.	--	20	R	8-07-50	D	1457		
12/40-11c1	Willie Bobb	8-50	50	6	35-38	T.C.	--	18	R	8-03-50	D	1458		
13/40-4d1	Casey Berchum	9-50	60	6	56-60	T.C.	--	20	R	9-27-50	D	1456		
13/40-15a1	U.S. Gov't.	--	--	36	--	T.C.	-3.0	12.33	M	6-24-64	D			
13/40-15c1	Yomba Indian Reservation	9-50	90	6 1/4	85-89	T.C.	+0.5	26.26	M	6-24-64	D	1449		
13/40-21b1	Dunron Hooper	10-50	60	6	35-38	T.C.	--	22	R	10-16-50	D	1459		
13/40-34c1	John Jay Casey	7-50	200	12	--	T.C.	--	12	R	7-02-50	I	1356	R1,000	
14/41-18a1	Mabel Jackson	7-50	65	6	46-48	T.C.	--	22	R	7-31-50	D	1448		
14/41-18b1	--	--	--	6	--	T.C.	+0.5	26.12	M	6-24-64	D			
14/41-19c1	--	--	--	8	--	T.C.	+1.0	16.79	M	6-24-64	S			
14/41-19d1	Bart and Joe O'Toole	10-50	268	14	140-145	T.C.	--	28	R	10-13-50	I	1455	R 500	
15/41-8c1	Jim Bobb	7-50	50	6	8-50	T.C.	--	10	R	7-24-50	D	1447		
15/41-28c1	--	--	--	6	--	T.C.	+1.0	15.30	M	6-24-64	D			
16/42-8ca1	Roy Visbeck	5-50	1,000	16,12,10	--	T.C.	--	47.43	M	5-22-50	I	1343		
16/42-8cb1	Roy Visbeck	11-56	143	8	114-125	T.C.	--	110	R	11-30-56	S	3612		
16/42-9b1	Roy Visbeck	12-56	146	10	138-144	T.C.	+0.3	108.40	M	6-23-64	S	3613		
16/42-19bb1	--	--	20M	48	--	T.C.	+1.0	14.20	M	6-09-48	U			
16/42-19dd1	Alice O'Toole	9-50	146	8	141-146	T.C.	+1.0	108.90	M	6-23-64	U	1454		
16/42-19dd2	Alice O'Toole	--	--	8	--	T.C.	+1.0	82.00	M	6-23-64	U			
16/42-30ad1	Alice O'Toole	9-50	250R	14	178-184	T.C.	+0.3	64.40	M	6-23-64	I	1438	R 600	
17/41-12ab1	A. Linder	--	--	16	--	T.C.	+0.5	78.83	M	6-25-64	I			Well pumping 400 gpm est.
17/41-13ab1	A. Linder	--	--	16	--	--	--	--	-	--	I			Well pumping 1,000 gpm est.
17/41-13dc1	A. T. Linder	6-61	216	--	80-216	T.C.	--	41	R	6-08-61	I	6026	1,700	Well pumping 1,200 gpm est.
17/41-24bb1	James B. Meyer	3-62	287	16	--	T.C.	--	98.90	M	6-25-64	I,D	6507		
17/41-24cc1	Joseph A. Meyer	3-48	118M	6	--	T.C.	+1.3	80.77	M	6-09-48	S			
17/41-24cc2	Joseph Meyer	--	265	16	--	T.C.	--	110	R	6-25-64	I,D	6508		
17/42-3c1	Roy Visbeck	12-56	70	8	55-70	T.C.	+0.5	21.71	M	6-23-64	S	3616		
17/42-6cb1	W. J. Rogers	5-62	332	16 1/2,14	290-332	T.C.	--	43	R	5-04-63	I	7032	R1,700	from 120 feet.
17/42-28a1	Roy Visbeck	12-56	104	8	85-93	T.C.	--	- 70.66	M	6-23-64	S	3611		
17/42-34c1	Roy Visbeck	12-56	115	8	95-115	T.C.	+1.0	- 92.60	M	6-23-64	S	3615		
18/41-36dc1	Robert Miller	3-62	325	16 1/2	178-196	T.C.	--	- 83.23	M	6-25-64	I	7031	600	est.
18/42-9bb1	Grady Rogers	8-61	240	16	163-167	T.C.	--	- 41.77	M	6-24-64	I	6114	R 450	from 200 feet. Not pumping. Temperature 58°F.
18/42-9cb1	Ed Revelle	1960	--	16	--	H.C.	--	- 40.76	M	5-01-63	I			
18/42-14c1	I. Gondolfo	--	12	--	--	T.C.	--	- 4.25	M	6-24-64	D			
18/42-17ba1	Alton Singer	1960	--	--	--	T.C.	--	- 46.89	M	5-01-63	I			
18/42-17bb1	William R. Hastings	1-60	318	16	165-213	T.C.	+0.5	- 50-52	M	6-24-64	I	5571	1,300	Not pumping
18/42-20b1	Frank Zinzer, Jr.	3-62	490	16,14	--	T.C.	--	- 63.40	M	6-24-64	I,D	6506		Well pumping 200-300 gpm est.
18/42-26c1	Roy Visbeck	12-56	47	8	31-37	T.C.	+0.5	- 9.05	M	6-24-64	S	3618		Well pumping
18/42-28b1	--	--	--	10	--	T.C.	+0.3	- 7.90	M	6-24-64	S			
18/42-28c1	Roy Visbeck	12-56	20	10	6-18	T.C.	+0.5	- 10.70	M	6-25-64	S	3614		
18/42-30cb1	T. Works	--	--	16	--	H.C.	+0.8	- 94.00	M	6-25-64	I		750	est.
18/42-31bb1	H. Beyer	12-49	221	16	47-90	T.C.	-0.5	48.00	M	6-24-64	I		R1,380	from 80 feet
18/42-31cc1	L. Renfro	--	--	16	--	T.C.	1.5	- 65.89	M	6-25-64	I			Pumping 500 gpm est.
18/42-34c1	Roy Visbeck	12-56	39	8	14-19	T.C.	--	17.24	M	6-24-64	S	3617		
18/42-35c1	Roy Visbeck	--	450R	8	--	T.C.	1.0	8.07	M	6-25-64	D,S			
18/43-6d1	Darrell Blanton	7-59	241	16	65-241	T.C.	-1.0	7.71	M	6-25-64	I	5574	R1,880	from 38 feet
18/43-17b1	Roy Visbeck	--	71M	4	--	T.C.	--	Flowing	-	6-24-64	D,I			
19/43-15dd1	City of Austin	5-63	400	16,12,10	370-385	T.C.	--	105	R	8-13-63	P.S.	7326	550	from 220 feet
19/43-16d1	W. W. Whitaker	8-47	110	6	85-110	T.C.	--	64.86	M	6-24-64	S	106		
19/43-17d1	--	1921	365	4	--	--	--	--	-	--	--	--		Oil test; plugged 2 ft. below land surface
19/43-20d1	W. W. Whitaker	9-47	345	8	326-329	T.C.	--	Flowing	-	6-24-64	S	105		
20/42-35d1	W. W. Whitaker	10-47	225R	6	170-180	--	--	160	R	10-22-47	S	262		
20/43-14a1	Bob Burton	3-53	306	6	222-306	T.C.	-1.5	206.0	M	6-22-64	S	2169		
20/43-33d1	W. W. Whitaker	--	--	6	--	T.C.	--	Flowing	-	6-24-64	S			
20/43-35c1	W. W. Whitaker	--	--	6	--	T.C.	-1.0	83.88	M	6-23-64	U			
21/42-1c1	W. W. Whitaker	8-47	190	6	--	T.C.	--	Flowing	-	6-23-64	S			
21/42-25a1	W. W. Whitaker	8-47	177M	6	--	T.C.	+4.0	--	M	6-07-48	S			
21/42-25a2	W. W. Whitaker	--	9	48	--	T.C.	-0.5	- 4.85	M	6-07-48	U			
21/42-36b1	W. W. Whitaker	8-47	185R	6	--	--	--	Flowing	-	6-08-48	S	93		Flowing 3 gpm est. Temperature 56°F
22/43-2a1	--	--	--	36	--	T.C.	--	- 9.65	M	6-22-64	U			
22/43-11b1	W. W. Whitaker	8-47	485R	6	--	T.C.	0.3	- 5.00	M	6-22-64	S			
22/43-31c1	--	--	--	3x6 ft.	--	T.C.	2.0	- 17.91	M	6-22-64	S			
23/43-7	J. Ansolabere	1948	220R	6	180-185	T.C.	--	-180	R	2-21-63	S	547		
23/43-25b1	--	--	37M	3x6 ft.	--	T.C.	1.0	- 8.67	M	6-22-64	U			
24/43-26c1	--	--	--	6	--	T.C.	1.4	- 22.5	M	6-22-64	S			
24/43-35cc1	Stienen Ranch	2-50	202R	12	128-174	T.C.	--	- 4	R	7-06-61	I			
24/43-35cc2	Stienen Ranch	--	--	48 dug	--	T.C.	0	- 5.5	M	6-22-64	D			

Table 9. --Selected drillers' logs of wells in upper Reese River Valley, Lander and Nye Counties, Nevada

Material	Thickness (feet)	Depth (feet)
11/40-27bl Willie Bill		
Topsoil	15	15
Clay, yellow	10	25
Gravel, loose	2	27
Clay, yellow	13	40
Gravel, loose	2	42
Clay, yellow	6	48
Gravel, loose	4	52
Clay, yellow	3	55
Total		55
12/40-11cl Willie Bobb		
Topsoil	9	9
Gravel, cemented	12	21
Gravel, loose	1	22
Gravel, cemented	13	35
Gravel, loose	3	38
Gravel, cemented	6	44
Gravel, loose	2	46
Gravel, cemented	4	50
Total		50
13/40-4dl Casey Berchum		
Topsoil	6	6
Clay	14	20
Gravel	5	25
Clay	10	35
Gravel	3	38
Clay	18	56
Gravel	4	60
Total		60
13/40-21bl Dunron Hooper		
Topsoil	6	6
Clay	16	22
Gravel	3	25
Clay	10	35
Gravel	3	38
Gravel, cemented	17	55
Gravel	5	60
Total		60

Material	Thickness (feet)	Depth (feet)
13/40-15cl Yomba Indian Reservation		
Topsoil	22	22
Gravel	1	23
Clay	17	40
Gravel	1	41
Clay	19	60
Gravel	1	61
Clay	24	85
Gravel	4	89
Clay	1	90
Total		90
13/40-34cl John Jay Casey		
Topsoil	15	15
Boulders	15	30
Clay, yellow	25	55
Gravel	5	60
Clay, yellow	20	80
Clay, brown	15	95
Gravel	10	105
Clay, Brown	35	140
Gravel	10	150
Clay, yellow	30	180
Gravely	10	190
Clay, yellow	10	200
Total		200

Material	Thickness (feet)	Depth (feet)
14/41-18dl Mabel Jackson		
Topsoil	6	6
Clay	16	22
Gravel, loose	1	23
Gravel, cemented	23	46
Gravel, loose	2	48
Gravel, cemented	14	62
Gravel, loose	1	63
Gravel, Cemented	2	65
Total		65
14/41-19dl Bart and Joe O' Toole		
Topsoil	12	12
Sand and Gravel	13	25
Clay	45	70
Sand	70	140
Gravel	5	145
Volcanic ash	123	268
Total		268
15/41-8cl Jim Bobb		
Topsoil	8	8
Gravel	42	50
Total		50

Material	Thickness (feet)	Depth (feet)
16/42-19dl Billie and Alice O'Toole		
Topsoil	6	6
Clay	24	30
Gravel, cemented	48	78
Gravel	4	82
Clay, yellow	96	178
Gravel	6	184
Clay, yellow	56	240
Gravel	3	243
Clay, yellow	7	250
Total		250
17/41-13dcl A. T. Linder		
Topsoil	7	7
Gravel	22	29
Clay and gravel	12	41
Sand, fine	32	73
Gravel	3	76
Clay	4	80
Sand and gravel	90	170
Gravel	46	216
Total		216

Material	Thickness (feet)	Depth (feet)
17/41-24bbl James B. Meyer		
Topsoil	6	6
Gravel	16	22
Clay, sandy	36	58
Sand and Gravel	73	131
Clay, sandy	11	142
Sand and Gravel	21	163
Clay	13	176
Gravel and sand	18	194
Sand, gravel, clay	22	216
Gravel, cement	8	224
Sand and gravel	24	248
Gravel, cement	5	253
Sand and gravel	34	287
Total		287
17/41-24ccl Joseph A. Meyer		
Clay and gravel	74	74
Gravel and sand	16	90
Gravel and sand	62	152
Clay and cemented gravel	138	290
Total		290

Material	Thickness (feet)	Depth (feet)
17/41-24cc2 Joseph A. Meyer		
Topsoil	16	16
Gravel	4	20
Sand, brown	51	71
Gravel and sand	38	109
Gravel	7	116
Clay	6	122
Sand and gravel	18	140
Gravel, cement	8	148
Gravel and sand	33	181
Clay, sandy	27	208
Sand and gravel	26	234
Clay	7	241
Sand and gravel	24	265
Total		265

Material	Thickness (feet)	Depth (feet)
17/42-6cb1 W. J. Rogers		
Topsoil, sandy	12	12
Clay and gravel	27	39
Clay	20	59
Gravel, loose	9	68
Clay, sandy	22	90
Gravel, loose, fine	50	140
Sand and Gravel	16	156
Gravel, fine	32	188
Clay, sandy	42	230
Gravel, loose, fine	24	254
Gravel and sand	14	268
Sand	22	290
Gravel, loose	42	332
Total		332

Material	Thickness (feet)	Depth (feet)
17/42-34cl Roy Visbeck		
Silt	12	12
Gravel	73	85
Clay	10	95
Gravel	20	115
Total		115
18/41-36 dcl Robert Miller		
Soil, sandy	13	13
Clay, sandy	27	40
Sand and gravel	7	47
Clay	32	79
Gravel, fine	11	90
Clay, sandy	20	110
Gravel, fine	36	146
Clay, sticky	32	178
Gravel	18	196
Clay, gravel, sand	52	248
Clay & Sand	72	320
Gravel, large, loose	5	325
Total		325

Material	Thickness (feet)	Depth (feet)
18/42-9bbl Grady Rogers		
Topsoil	4	4
Gravel, sandy	4	8
Sand and gravel, cemented	25	33
Gravel	9	42
Clay, tan	10	52
Sand and Clay	22	74
Sand	18	92
Sand and clay	11	103
Sand	9	112
Clay, brown	4	116
Sand	10	126
Clay, tough	6	132
Sand, coarse	6	138
Clay, brown	4	142
Sand & Clay	10	152
Clay, brown	11	163
Sand	4	167
Clay & Sand	5	172
Sand, coarse	4	176
Clay, brown	1	177
Gravel, fine	12	189
Clay, brown	13	202
Gravel, fine	15	217
Clay, Brown	15	232
Sand, coarse	6	238
Clay, brown	2	240
Total		240

Material	Thickness (feet)	Depth (feet)
18/42-17bbl William R. Hastings		
Topsoil	7	7
Gravel & Sand	14	21
Clay, sandy	21	42
Sand & Gravel	42	84
Clay, tight	40	124
Sand, hard	41	165
Sand, loose, fine	48	213
Clay, sticky	2	215
Gravel & sand	26	241
Sand, fine	75	316
Clay, soft, white	31	347
Sand, fine	85	432
Total		432

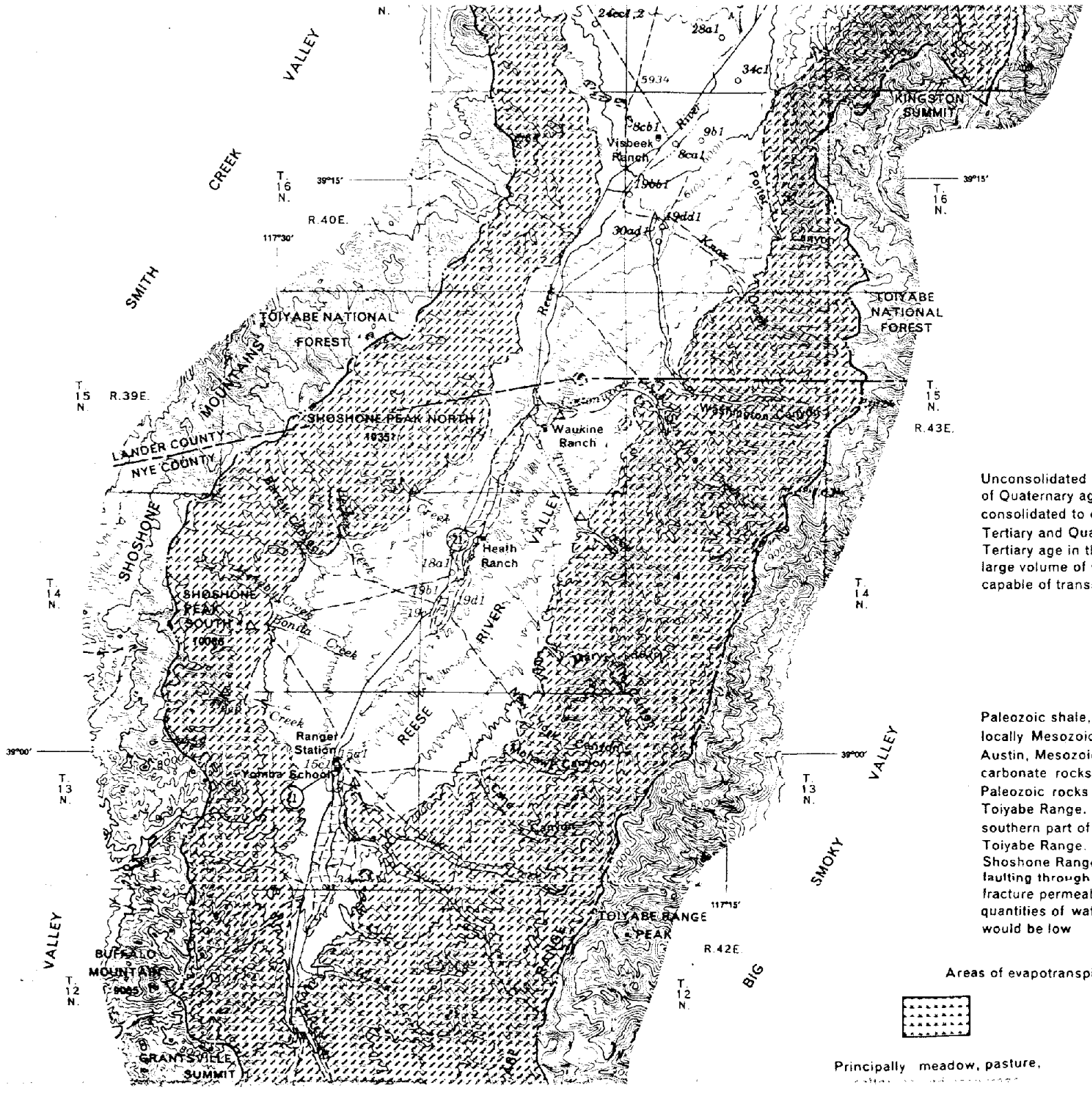
Material	Thickness (feet)	Depth (feet)
18/42-20bal Frank Zinzer, Jr.		
Topsoil	2	2
Sand, crusted	4	6
Sand, white	14	20
Clay, Blue	8	28
Sand, brown	55	83
Sand & clay	7	90
Sand	22	112
Clay	12	124
Sand	19	143
Clay	6	149
Sand	6	155
Clay	15	170
Sand	40	210
Clay	5	215
Sand & Clay	15	230
Clay	10	240
Sand	20	260
Clay	6	266
Sand	19	285
Clay	5	290
Sand	14	304
Clay	50	354
Sand & Clay	136	490
Total		490

Material	Thickness (feet)	Depth (feet)
18/43-6dl Darrell Blanton		
Topsoil	3	3
Clay	11	14
Clay & gravel streaks	51	65
Gravel	13	78
Clay & Gravel streaks	26	104
Sand & Gravel	7	123
Clay	8	131
Sand & Gravel	3	134
Clay	6	170
Sand & gravel	12	182
Clay, brown	4	186
Sand, water bearing	15	201
Sand & gravel, cemented	6	207
Gravel	5	212
Clay, blue, with gravel streaks	29	241
Total		241

Material	Thickness (feet)	Depth (feet)
19/43-15ddl City of Austin		
Topsoil	15	15
Sand & Gravel	5	20
Clay	24	44
Sand, fine	12	56
Granite, decomposed	240	296
Clay	74	370
Sand & Gravel	15	385
Clay	15	400
Total		400
19/43-16dl W.W.Whitaker		
Topsoil	5	5
Clay & Gravel	80	85
Sand & Gravel	25	110
Total		110

Material	Thickness (feet)	Depth (feet)
19/43-20d1 W.W. Whitaker		
Silt	15	15
Gravel	42	57
Clay	93	150
Sand	5	155
Clay	8	163
Sand	2	165
Clay	18	183
Sand	6	189
Clay	91	280
Sand	4	284
Clay	42	326
Sand	3	329
Clay	16	345
Total		345

Material	Thickness (feet)	Depth (feet)
20/43-33d1 W.W. Whitaker		
Silt	5	5
Gravel	73	78
Clay, brown	29	107
Sand	20	127
Clay	18	145
Gravel	9	154
Total		154



EXPLANATION

Valley fill

Unconsolidated to partly consolidated clay, silt, sand, and gravel of Quaternary age in valley lowlands and in alluvial fans; partly consolidated to consolidated clay, silt, sand, and gravel of Tertiary and Quaternary age, and locally volcanic deposits of Tertiary age in the alluvial apron. Fine-grained deposits store large volume of water where saturated; sand and gravel generally capable of transmitting water freely to wells

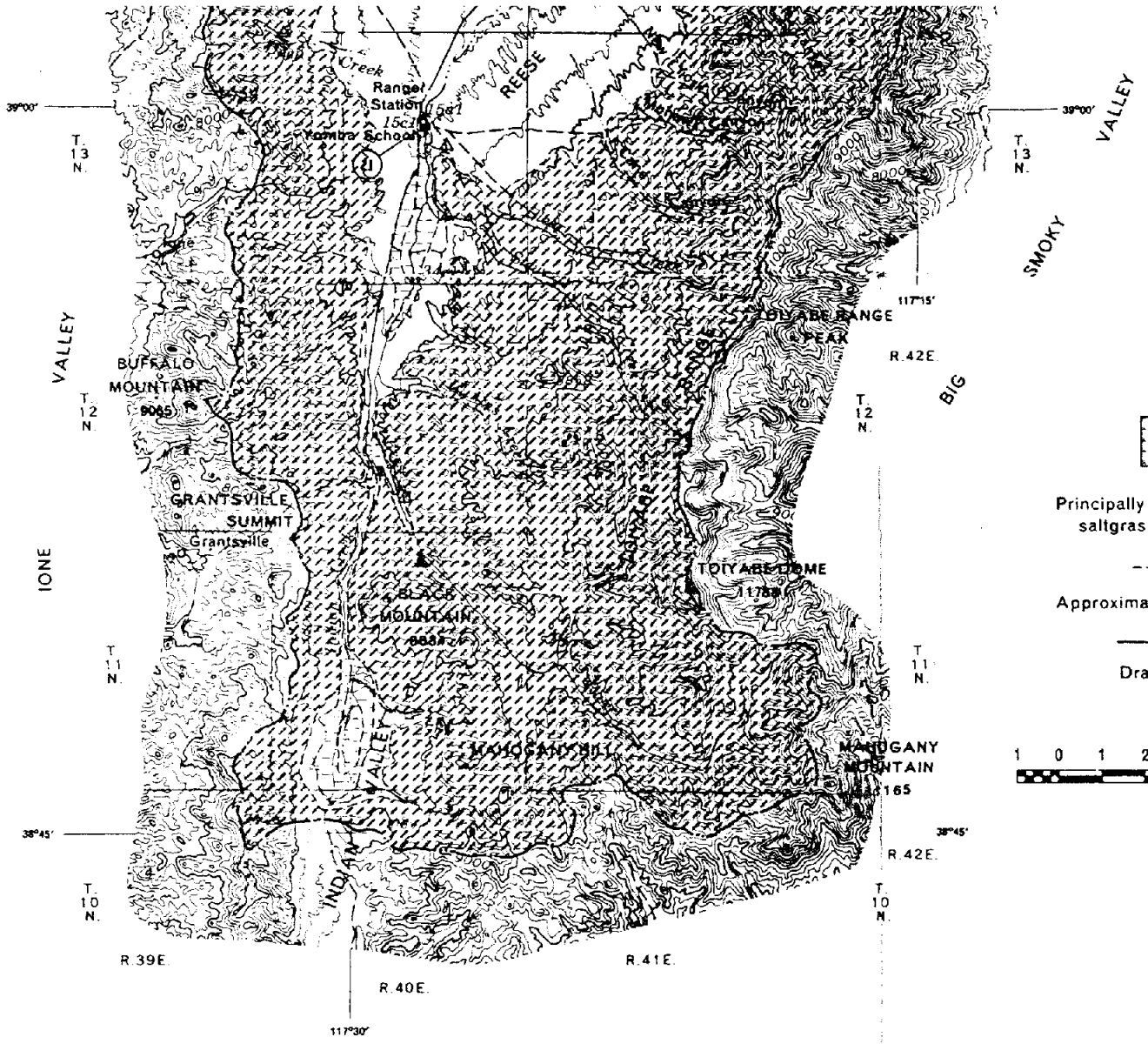
Consolidated rocks

Paleozoic shale, sandstone, carbonate, and volcanic rocks; locally Mesozoic(?) granitic intrusive rocks as in the vicinity of Austin, Mesozoic shale, sandstone, conglomerate, and carbonate rocks and Tertiary volcanic and sedimentary rocks. Paleozoic rocks and Mesozoic intrusive rocks largely exposed in Toiyabe Range. Mesozoic sedimentary rocks occur locally in southern part of Shoshone Range (Union district) and southern Toiyabe Range. Tertiary volcanic rocks extensively exposed in Shoshone Range and southern Toiyabe Range. Substantial faulting through several periods has developed considerable fracture permeability that may store and transmit considerable quantities of water, however, yields to wells commonly would be low

Areas of evapotranspiration of ground water

Principally meadow, pasture,

Principally greasewood



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Areas of evapotranspiration of ground water

Principally meadow, pasture, saltgrass and seepgrass

Principally greasewood and rabbitbrush

Approximate geologic contact

Well and number

Drainage divide

Stream gaging station

Scale

1 0 1 2 3 4 5 Miles

Miscellaneous stream measuring site

1964

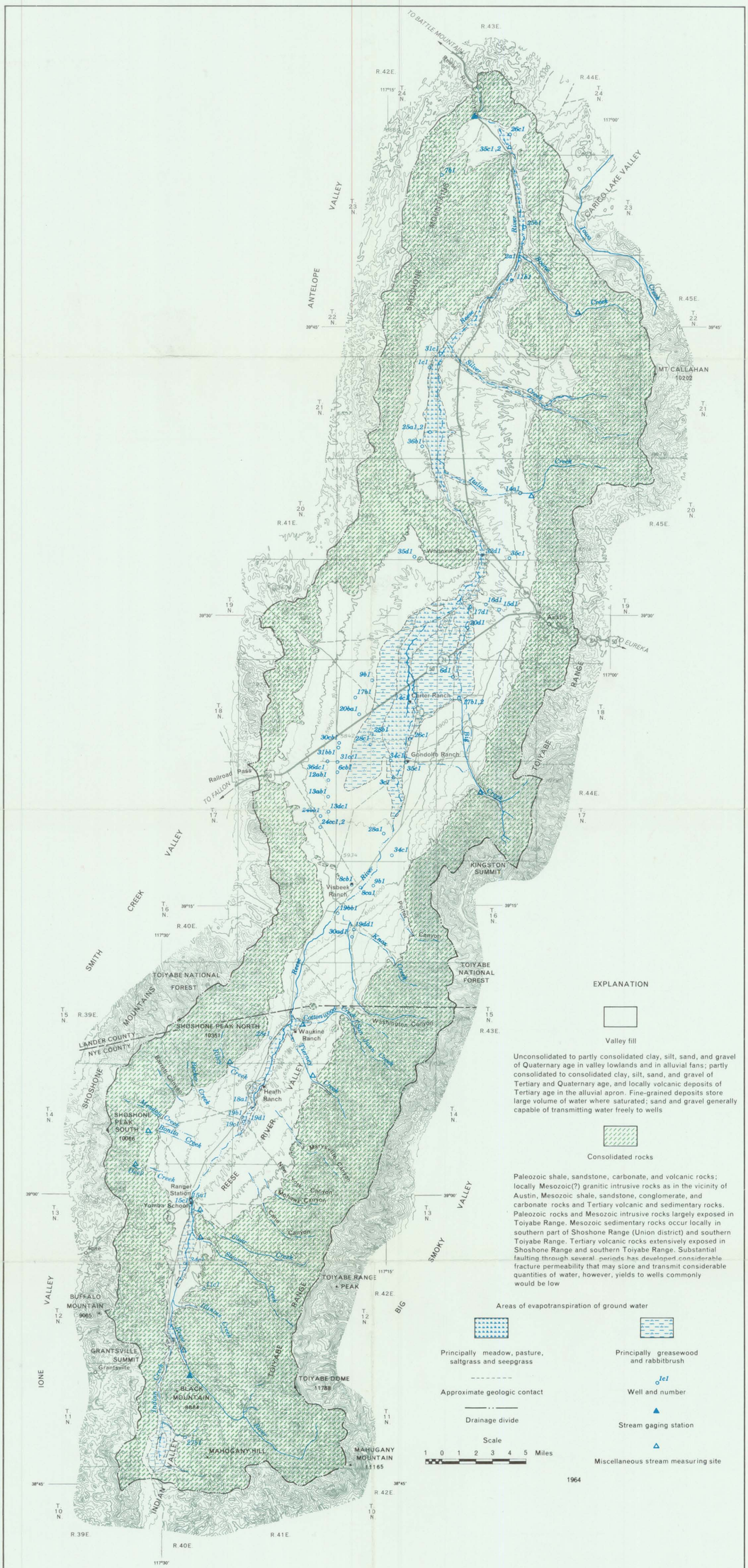
Base U.S. Geological Survey 1:250,000 Topographic quadrangles; Millett (1959) and Tonopah (1959)

Hydrogeology by T. E. Eakin (1964) geology adapted from Waring (1918), Ferguson and Muller (1949), and Ross (1953)

PLATE 1.—GENERALIZED HYDROGEOLOGIC MAP OF UPPER REESE RIVER VALLEY, LANDER AND NYE COUNTIES, NEVADA

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

THE STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES



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Unconsolidated to partly consolidated clay, silt, sand, and gravel of Quaternary age in valley lowlands and in alluvial fans; partly consolidated to consolidated clay, silt, sand, and gravel of Tertiary and Quaternary age, and locally volcanic deposits of Tertiary age in the alluvial apron. Fine-grained deposits store large volume of water where saturated; sand and gravel generally capable of transmitting water freely to wells

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Paleozoic shale, sandstone, carbonate, and volcanic rocks; locally Mesozoic(?) granitic intrusive rocks as in the vicinity of Austin, Mesozoic shale, sandstone, conglomerate, and carbonate rocks and Tertiary volcanic and sedimentary rocks. Paleozoic rocks and Mesozoic intrusive rocks largely exposed in Toiyabe Range. Mesozoic sedimentary rocks occur locally in southern part of Shoshone Range and southern Toiyabe Range. Tertiary volcanic rocks extensively exposed in Shoshone Range and southern Toiyabe Range. Substantial faulting through several periods has developed considerable fracture permeability that may store and transmit considerable quantities of water, however, yields to wells commonly would be low

Areas of evapotranspiration of ground water

Principally meadow, pasture, saltgrass and seepgrass

Principally greasewood and rabbitbrush

Approximate geologic contact

Drainage divide

1c1 Well and number

Stream gaging station

Miscellaneous stream measuring site

Scale

1 0 1 2 3 4 5 Miles

1964

Base U.S. Geological Survey 1:250,000 Topographic quadrangles; Millett (1959) and Tonopah (1959)

Hydrogeology by T. E. Eakin (1964)
geology adapted from Waring (1918), Ferguson and Muller (1949), and Ross (1953)

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