WATER RESOURCES-RECONNAISSANCE SERIES
REPORT 1
GROUND-WATER APPRAISAL OF NEWARK
VALLEY, White Pine County,
By Thomas E. Eakin

December, 1960

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White Pine County, Nevada

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Thomas E. Eakin

Prepared Cooperatively
by the
Geological Survey
U. S. Department of Interior

December
1960

FOREWORD

The 1960 Legislature authorized a special ground-water reconnaissance survey under the supervision of the State Department of Conservation and Natural Resources and in cooperation with the United States Geological Survey. This program, which should extend not over two or three years, is in addition to the regular ground-water cooperative program that has been in operation since 1945.

It was felt that there was a need for a series of such reconnaissance surveys covering all of the valleys of the state where development opportunities exist and where no information as to ground-water possibilities are available.

This report of the ground-water appraisal of Newark Valley is the first of such series. The second report will cover Pine Creek Valley and should be available in January 1961. Several additional reports will follow in the next calendar year.

I am of the opinion that this series of reconnaissance ground-water reports will be of great value to our State.

GRANT SAWYER
Governor of Nevada

December 1960

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GROUND-WATER APPRAISAL OF NEWARK VALLEY

WHITE PINE COUNTY, NEVADA

by Thomas E. Eakin

SUMMARY

The results of this reconnaissance indicate the average annual ground-water recharge to be on the order of 18,000 acre-feet and the average annual discharge to be about 16,000 acre-feet. Lack of agreement of the two estimates may be due to the fact that the estimate of discharge did not include an estimate of evaporation from the playa area. However, it is believed that the estimates are reasonable and indicate the general order of the quantity of ground water perennially circulating into and out of the ground-water system of Newark Valley. The estimates are compatible also with information developed in other valleys of Nevada where more extensive studies have been made. Refinement of the estimates, to be of value, would require a great many additional data not presently available. Substantial development of ground water in the valley would provide a means of obtaining part of the necessary data, and additional data could be obtained at such time as intensive investigation was economically warranted.

Ground water in storage has been estimated to be on the order of 15,000 acre-feet per foot of saturated thickness in the valley fill within the 150,000-acre area enclosed by the 6,000-foot contour. The large amount of water in storage provides a substantial reserve for maintaining pumping during protracted periods of drought.

Locally, water quality and soil conditions may be limiting factors in agricultural development, particularly for crops less salt tolerant than those now grown in the valley. Additionally, the growing season apparently is so short that it should be carefully considered in planning further agricultural development.

The most favorable areas for initial prospecting for large ground-water supplies appear to be in the lower parts of the alluvial apron along the west, north, and northeast sides of the valley where wells of moderate to large capacity might be developed in the upper 500 feet of the valley fill.

INTRODUCTION

To meet the rapidly increasing need for ground-water information in many areas of Nevada, the State Legislature provided by special legislation (Chap. 181 Nev. Stats. 1960) for a series of brief reconnaissances of a number of valleys in which interest in ground-water development is intense. These studies are being made by the U. S. Geological Survey in cooperation with the Nevada Department of Conservation and Natural Resources.

This report is the first of the series of reconnaissance studies made under the special legislation. It describes the general geologic, hydrologic, and climatic framework which determines the location and abundance of ground-water supplies, and presents a preliminary evaluation of the recharge to and discharge from the ground-water reservoir.

The scope of this report includes observation and evaluation of the interrelation of climate, geology, and physical conditions bearing on the occurrence, movement, recharge, and discharge of ground water.

Data on wells in Newark Valley were collected as early as 1948. However, most of the field work was done during the late summer of 1960.

The investigation was made by the Geological Survey under the administrative supervision of Omar J. Loeltz, District Engineer in charge of ground-water studies in Nevada.

The writer wishes to acknowledge his appreciation of the personnel of the district office for the constructive discussions and review of this report, which have been of substantial benefit.

This report was reviewed also by Messrs. Hugh A. Shamberger, Director, and George Hardman, Assistant Director, of the Nevada Department of Conservation and Natural Resources. Their comments and suggestions were most helpful. The writer wishes to thank them for taking the time and effort to provide this assistance.

Location and General Features

Newark Valley, in the northwestern part of White Pine County, lies within an area enclosed by lat. 39° 15' and 39° 50' N., and long. 115° 25' and 115° 55' W. (see pl. 1.) The Diamond Mountains bound the valley on the west. A divide formed by bedrock and alluvium separates the valley from Huntington Valley to the north. The eastern boundary is formed, from north to south, by Bald and Buck Mountains, the Antelope Mountains, and the White Pine Mountains. Beck Pass, altitude slightly less than 6,400 feet, provides access for a trail connecting Newark Valley with Long Valley to the east. The southern boundary of Newark Valley follows an irregular line westward from Mount Hamilton in the White Pine Mountains through the highlands of the Pancake Range.

In this report, Newark Valley is arbitrarily separated from its southwesterntributary, Little Smoky Valley, which generally is called Fish Creek Valley, by a line extending southward from the Diamond Mountains through the small hill in Sec. 14, T. 17 N., R. 54 E., to the westward extension of the Pancake Range.

As defined, Newark Valley has an area of about 800 square miles.

U. S. Highway 50 crosses the southern part of the valley and affords access to the principal trade centers -- Eureka, which is about 20 miles west of the valley and Ely, which is about 60 miles east. A good gravel road extends northward from U. S. Highway 50 along the west side of the valley and connects with State Highway 46 in Huntington Valley, thus providing good access to Elko. State Highway 20 extends southward from U. S. Highway 50 through part of Fish Creek Valley and connects with U. S. Highway 6 at Currant, in Railroad Valley. Numerous other roads and trails make most of the area accessible in fair weather.

Mining has played a very important role in the economic history of the area. The White Pine district, which is centered around Mount Hamilton, produced more than $10 million of silver, lead, copper, and gold between 1866 and 1940, according to Couch and Carpenter (1943, p. 149). The peak production was reached in 1870 when more than 33,000 tons of ore reportedly valued at more than $2 million was mined. Lincoln (1923, p. 257) reports that there were about 10,000 people in Hamilton and an additional 15,000 people in surrounding communities in the district. Hamilton was the county seat of White Pine County until a fire destroyed most of the town in 1885, after which the county seat was moved to Ely.

The Newark, or Strawberry, district is on the east flank of the Diamond Mountains and is centered in T. 19 N., R. 55 E. The smelter stack still stands in the SE 1/4 Sec. 4, T. 19 N., R. 55 E., and is visible from the gravel road along the west side of the valley. The Newark district yielded more than $400,000 in silver, lead, and copper during the period 1866-1936.

The Bald Mountain district, which is in the northeastern part of the valley, produced a few thousand dollars of silver and copper in 1869.

Mining activity declined rapidly in the early 1900's, although sporadic efforts to revive it have been made since that time. For many years, ranching and farming have formed the basis of the economy of the valley.

Currently, there are no towns within the area and the population of less than 100 is distributed among several ranches along the west and north sides of the valley.

Climate

The climate of east-central Nevada is arid to semiarid. The precipitation and humidity are low and summer temperatures and evaporation rates are high. Precipitation is very irregular in areal distribution but generally is least on the valley floor and greatest on the highest parts of the mountains. Winter precipitation occurs as snow and is moderately well distributed over several months. Summer precipitation commonly is localized as thundershowers. The range in temperature is large, both daily and seasonally. The growing season is short.

Table 1 shows average monthly and annual precipitation at three stations in and adjacent to Newark Valley. Values are arithmetic averages of monthly records published by the U. S. Weather Bureau. At Eureka the annual precipitation for the period of record has ranged from 6.13 inches in 1928 to 23.86 inches in 1941. The range in monthly precipitation has been from 0.0 (numerous times) to 5.40 inches in March 1902. The records indicate also that the maximum precipitation has exceeded 3 inches at least once in each of the months June, July, and August. On the other hand, precipitation in these months is zero in many years.

At Fish Creek Ranch the annual precipitation has ranged from 2.17 to 10.44 inches during the 16-year period of record. Monthly precipitation has ranged from zero in several months to 2.93 inches in September 1945. Monthly precipitation has exceeded 1 inch one or more times during June, July, and August during the period of record.

The Fish Creek station is about 450 feet lower than the Eureka station but higher than much of the floor of Newark Valley. The record of the Fish Creek station indicates that annual precipitation on the floor of the valley averages less than 8 inches. The records for the three stations show a general increase of precipitation with altitude. The average annual precipitation probably exceeds 20 inches in the highest parts of the mountains such as in the vicinity of Diamond Peak in the Diamond Mountains and the highest parts of Mount Hamilton.

The climatic summary of records of temperature for Eureka prior to 1931 shows an average annual temperature of 61.4° F, a maximum temperature of 110° F, and a minimum temperature of -26° F. More recent records at Eureka are within the maximum and minimum listed above.

The 16-year record for Fish Creek Ranch shows a maximum temperature of 98° F during July 1948, June 1954, and July 1959. A minimum temperature of -34° F was recorded in January 1949, and of -32° F in January 1957. No long-term mean temperature has been established by the Weather Bureau for the Fish Creek Ranch station.

Weather Bureau records to 1930 indicate an average of about 103 days between killing frosts at Eureka. The record for Fish Creek Ranch indicates a

Table 1. -- Average Monthly and Annual Precipitation, in Inches, at Three Stations in and Near Newark Valley

Station		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Eureka	1/	1.12	1.08	1.50	1.33	1.51	0.86	0.73	0.66	0.66	0.91	0.64	0.83	11.83
Fish Creek Ranch	2/	.46	.25	.57	.56	.58	.38	.50	.47	.56	.39	.57	.56	5.85
Hamilton	3/	2.29	2.15	2.23	1.29	1.49	.88	.53	.99	.63	1.22	1.65	2.50	14.88

1/ Altitude, 6,550 feet. Location, sec. 13, T. 19 N., R. 53 E. Period of record, 40 years: 1889, 1891, 1902-18, 1922-30, 1939-42, 1953-59 (continuing). Partial record in 1888, 1890, 1892, 1893, 1894, 1919, 1920, and 1921.

2/ Altitude, 6,050 feet. Location, sec. 10, T. 16 N., R. 53 E. Period of record, 16 years: 1944-59 (continuing).

3/ Altitude, 7,977 feet. Location uncertain, but probably in sec. 18, T. 16 N., R. 58 E. Period of record, 4 years: 1878, 1879, 1895, 1901. Partial record in 1877, 1880, 1896, 1897, 1900, and 1902-9.

maximum of 74 days between dates of the last spring and the first fall minimum reading of 32° F or lower and an average of perhaps 28 days. Freezing temperatures have occurred in every month of the year.

A temperature of 32° F does not necessarily result in a killing frost. Because killing-frost conditions vary with crop type, the Weather Bureau records, beginning in 1948, list freeze data -- the last spring minimum and the first fall minimum for temperatures of 32° F or below, 28° F or below, 24° F or below, 20° F or below, and 16° F or below. These records show that at the Eureka station the period between spring and fall temperatures of 28° F or below ranged from 35 to 90 days and averaged about 70 days, and for 24° F or below ranged from 88 to 142 days and averaged 113 days. According to these data and to the period of 103 days between killing frosts indicated for the period before 1930, the temperature marking the beginning and ending of killing frosts at Eureka is about 26° F.

Comparison of the temperature records of the Eureka and Fish Creek Ranch stations for the period 1953-59 indicates that the Fish Creek Ranch station generally has lower minimum temperatures.

The relative topographic position of the two stations indicates that the lower parts of closed valleys have shorter growing seasons than some higher areas marginal to the valley floors. This results from the topography, which permits the heavy, cold air to flow into the lower parts of the valley during periods of little or no wind movement. This effect, to the extent that it is operative in Newark Valley, suggests the desirability of growing crops along the alluvial apron at some distance above the valley floor as an aid in obtaining a somewhat longer growing season.

Physiography and Drainage

Newark Valley is near the center of the Great Basin section of the Basin and Range Province physiographic province of Fenneman (1931, p. 328). It is a nearly closed intermontane valley of interior drainage, elongated in a northerly direction. The valley is nearly 55 miles long, is as much as 20 miles wide, and has an area of about 800 square miles.

The Diamond Mountains, the most prominent range in the area, extend northward nearly 40 miles from about the latitude of 39° 18' N. The altitude of the crest is more than 8,000 feet from Newark Mountain, about lat. 39° 31' N., to the north end of the valley--a distance of about 30 miles. Diamond Peak, near the south end of the range, is the highest point in the range and has an altitude of 10,614 feet. Diamond Peak is shown in the photograph on the cover of this report. The southern part of the Ruby Range extends southward about 20 miles along the northeast side of the valley. Throughout most of this distance the altitude of the crest averages about 8,000 feet. Bald Mountain, at the north end, is 9,306 feet above sea level. Buck Mountain has an altitude of 9,160 feet.

The White Pine Mountains, south of U. S. Highway 50, also averages about 8,000 feet in altitude. They culminate at Mount Hamilton, altitude 10,741 feet, the highest point within the area. North of U. S. Highway 50, are the Antelope Mountains, a northward extension of the White Pine Mountains. Their crest averages about 7,000 feet. The altitude of the crest of the Pancake Range within the area also is about 7,000 feet.

The lowest part of the floor of Newark Valley is in the northern part of the valley. It is occupied by a playa whose altitude is about 5,840 feet. Thus, the maximum relief in the area of study is nearly 5,000 feet.

Photographs 2 and 3 show the general physical features of Newark Valley.

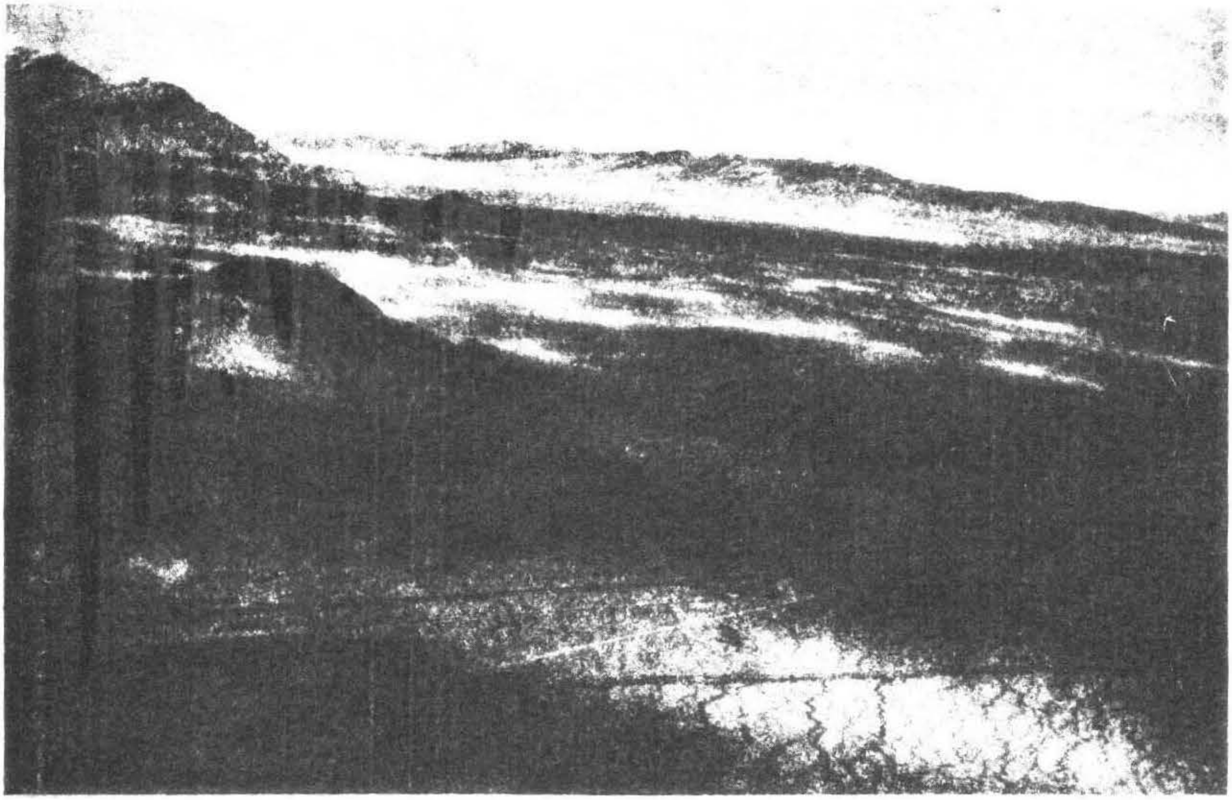
Streams within the area are ephermeral and ordinarily are dry shortly after the period of high runoff in the spring. Exceptions are streams which are fed in whole or in part by the discharge of springs. These may be perennial for some distance downstream from the spring area. Cold Creek, in the northwestern part of the valley, is an example of a spring-fed stream. Three springs supply a perennial flow which is used for irrigation.

Physiographically, the valley can be divided into three parts: the highlands area, the alluvial apron, and the valley lowland. The highlands, or mountains, are areas of erosion, having steep slopes and deeply cut canyons, and commonly are formed by the older, well-indurated rocks.

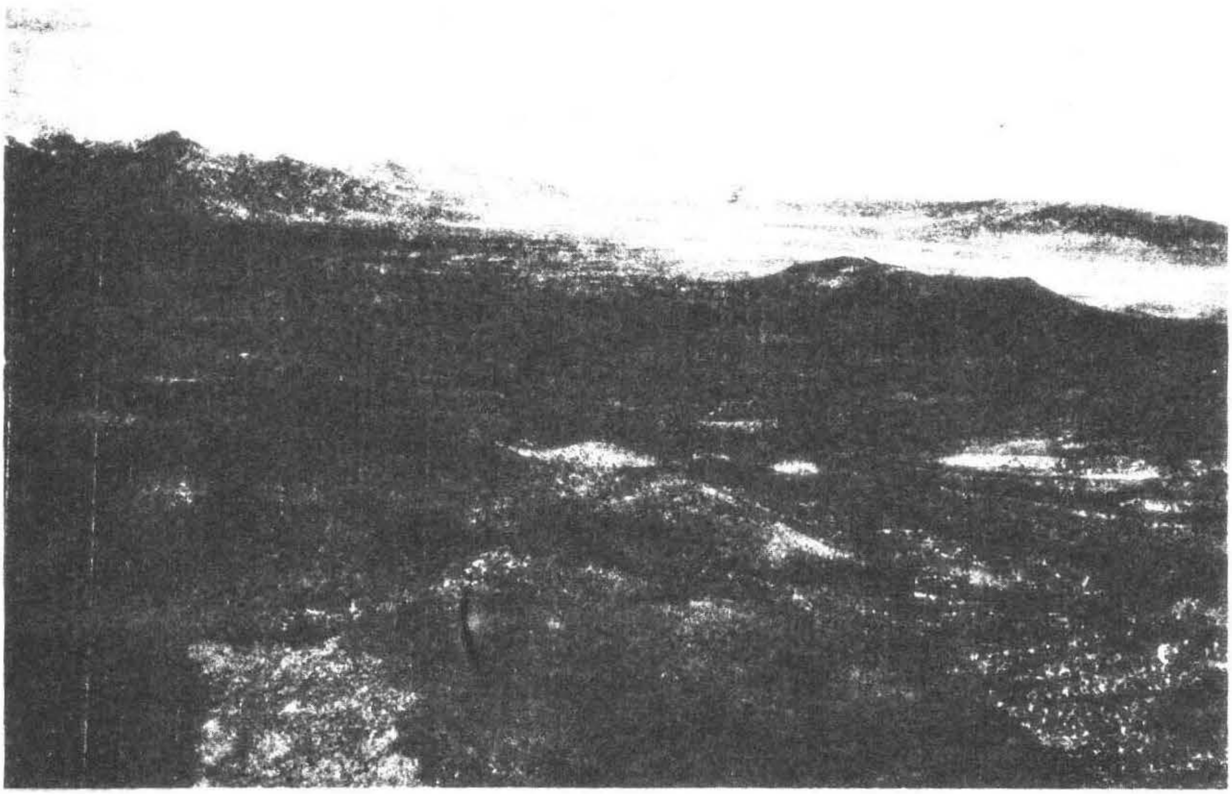
The alluvial apron, whose slopes range from 5 to 18 degrees, is principally a site of deposition of rock waste from the mountains, although in its higher parts erosion is locally dominant. Photograph 4 shows the alluvial apron in the vicinity of Strawberry Ranch, and Photograph 5 shows the apron in the vicinity of Eldridge Ranch. The sediments of the alluvial apron are fan and stream deposits consisting of lenticular beds of gravel, sand, silt, and clay, which are unconsolidated to moderately consolidated, and which generally dip toward the axis of the valley. Typical of the slopes of deposition are those developed on the lower part of the apron along the west side of the valley in Tps. 20, 21, and 22 N. and around the north end of the valley.

South and east from an imaginary line connecting the Pancake Range with Buck Mountain, the older valley fill, of Tertiary age, is eroded to a relatively smooth surface which is mantled by a veneer of younger unconsolidated sediments. However, the surface of the older valley fill adjacent to the White Pine Mountains is dissected and shows remnants of at least three erosion surfaces.

The valley lowland includes the playa and the axial lowland area extending southward from it. (See photograph 3). The surface of the playa is nearly level and extends southward from sec. 7, T. 22 N., R. 56 E., for a distance of about 14 miles. The axial lowland area rises southward at a gradient of about 20 feet per mile from the south end of the playa in sec. 19, T. 20 N., R. 56 E., a point west of Mount Hamilton--a distance of about 22 miles. The valley lowland is underlain by predominantly fine-grained alluvial and lacustrine deposits



Photograph 2. Newark Valley looking northerly. U. S. Highway 50 in foreground with county road running northerly. Eldorado Station at intersection.



Photograph 3. Newark Valley looking north. Diamond Peak on left. Buck Mt. in distance on right with Bald Mt. in distant background.

For reference a general stratigraphic sequence is given in the appendix. The sequence was compiled from Nolan, Merriam, and Williams (1956) for the Cambrian to Early Cretaceous section and from Humphrey (in press) for the Tertiary section. The section indicates a thickness of about 25,000 feet for formations of Paleozoic age and nearly 4,000 feet for rocks of Cretaceous age and younger.

Geologic History

The following tentative and general geologic history is based on the reports of Nolan, Merriam, and Williams (1956) and Humphrey (in press):

1. Deposition of dolomite, limestone, sandstone, shale, and minor amounts of coarser clastic sediments during Paleozoic time. Development of a "linear swell" west of Newark Valley in Early or Middle Ordovician time and renewal in Late Devonian to Permian time. The swell had a marked effect on the lithologic character of clastic sediments and resulted in several angular unconformities within the rock sequence of Carboniferous age.

2. Intensive diastophism in one or more periods, including folding and related extensive thrust faulting, accompanied by erosion from highland areas and continuing through much of Mesozoic time.

3. In Early Cretaceous time, erosion of highland areas and deposition in lowland areas of the Newark Canyon formation, consisting of fresh-water limestone, conglomerate, silt, sandstone, and grit.

4. Emplacement of granitic intrusions in the older rocks, probably accompanied by folding and high-angle faulting, in Late Cretaceous or early Tertiary time.

5. Deposition of fresh-water limestone, conglomerate, and interbedded tuff (Illipah formation of Humphrey) during Eocene time

6. Faulting and probable folding. The general outline of Newark Valley likely was established during Oligocene (?) to early Miocene (?) time.

7. Deposition of bedded rhyolitic tuff and pyroclastic rocks (Lake Newark formation of Humphrey) in late Miocene or Pliocene time.

8. Extrusion of basaltic lava in late Tertiary time.

9. Faulting and folding (?) involving lava flows and resulting in essentially present-day form of Newark Valley.

10. Deposition on the valley floor and marginal alluvial apron and development of a lake in Pleistocene time. The lake stood for varying periods of time at several different levels, forming beaches through a vertical range of about 300 feet.

of Quaternary age, which in turn overlie Tertiary sediments and pyroclastic rocks of unknown thickness.

Plate 1 shows the approximate boundary between the highlands and the alluvial apron and the boundary of the playa.

A lake occupied the lower part of Newark Valley in Pleistocene time. It can be identified by several levels of beaches, bars, spits, and wave-cut terraces. The highest observed beach line is at an altitude between 6,140 and 6,150 and is rather well preserved at the north end of the valley. A wave-cut nick or cliff in a bedrock spur at about the same altitude was observed in sec. 15, T. 22 N., R. 56 E. The lake developed beaches at several stands below 6,140 feet. In the north end of the valley, at least half a dozen can be seen within a vertical range of 200 feet. Beach features are prominent elsewhere also. In the northern part of T. 19 N., R. 56 E., several low-lying offshore bars were observed above and below the 6,000-foot contour. In the southern part of T. 18 N., R. 55 E., north of U. S. Highway 50, a prominent set of spits and beaches was developed from the west side of the Pancake Range. The gravel road leading northward from U. S. Highway 50 along the west side of Newark Valley cuts through several beaches and bars. The gravelly character of the bars is shown in these road cuts.

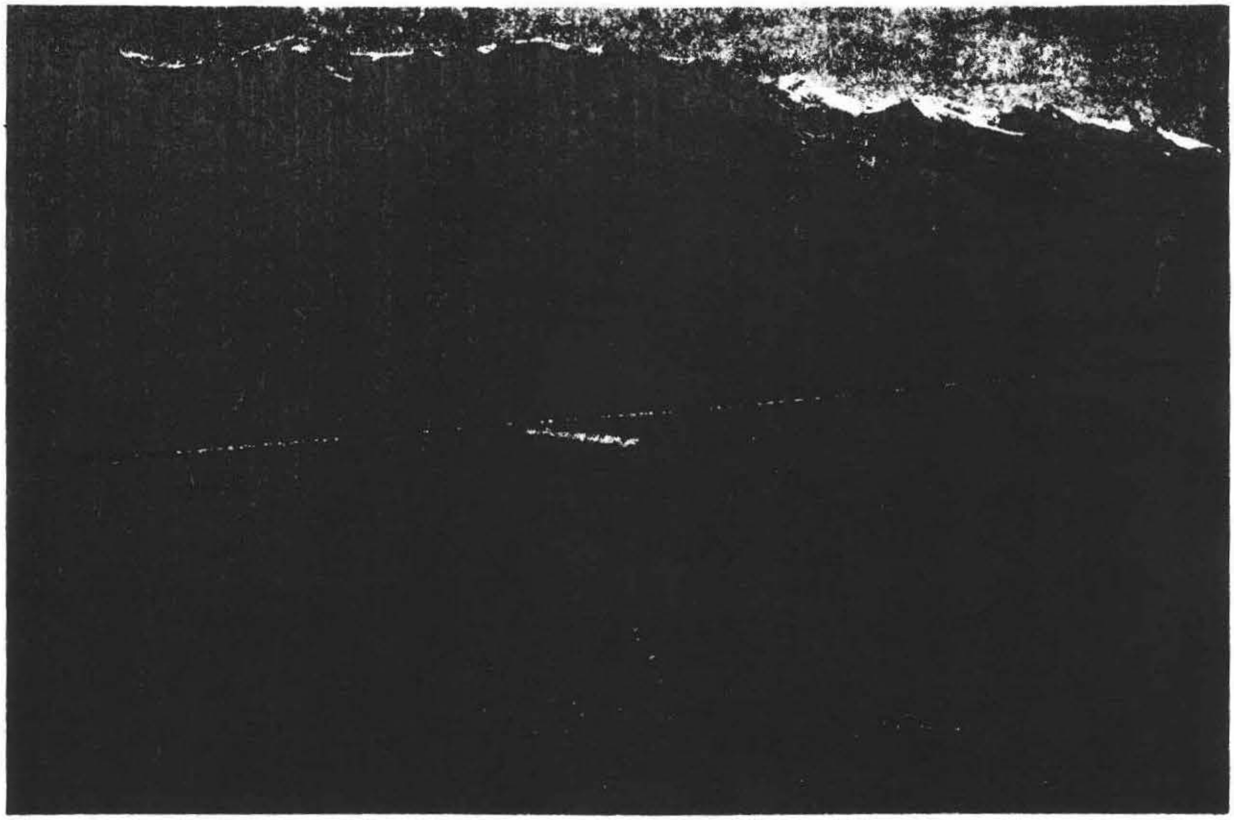
GENERAL GEOLOGY

Bedrock in the Mountains

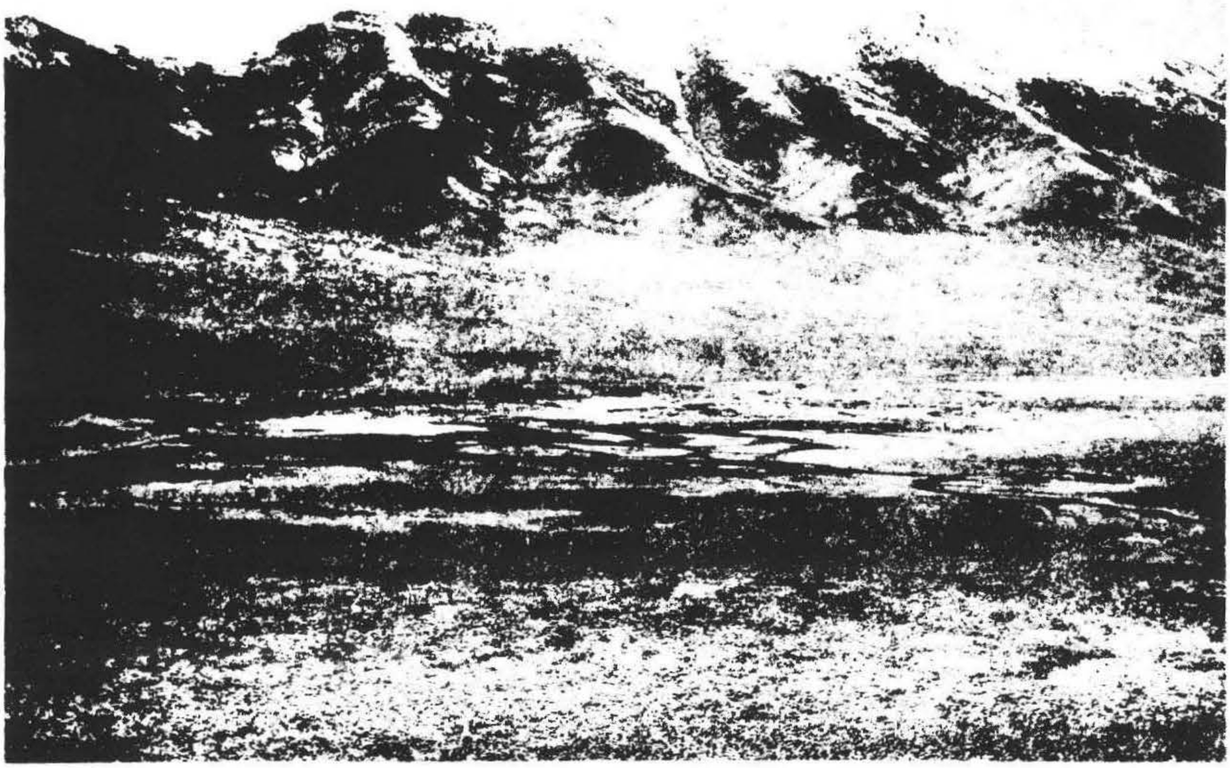
Nolan, Merriam, and Williams (1956) discuss the stratigraphy of the Paleozoic rocks in the nearby Eureka area. Humphrey (in press) reports on the geology in the vicinity of Mount Hamilton. Rocks of Paleozoic age, including dolomite, limestone, and lesser amounts of quartzite and shale, crop out principally in the Diamond Mountains, Bald and Buck Mountains, and White Pine Mountains. Clastic rocks, fresh-water limestone, rhyolitic pyroclastic rocks, and basaltic lavas, ranging in age from Early Cretaceous to late Tertiary, also crop out in the mountains enclosing Newark Valley. Granitic intrusions of Late Cretaceous to early Tertiary age are exposed in parts of the mountain areas.

Valley Fill

The valley fill of Newark Valley consists of deposits which probably range in age from early Tertiary to Recent, but which at depth may include sediments of Mesozoic age, such as those of the Newark Canyon formation as described by Nolan, Merriam, and Williams (1956, p. 68). The valley-fill deposits of Tertiary age may have the same character as the Tertiary formations exposed in the mountains, which were described by Humphrey (in press). Unconsolidated gravel, sand, silt, and clay of Quaternary age form the uppermost part of the valley fill.



Photograph 4. Strawberry Ranch on west side of Newark Valley. Diamond Mountains in background.



Photograph 5. Eldridge Ranch on west side of Newark Valley. Diamond Mountains in background.

11. Desiccation of the lake in late Pleistocene time.

12. Continued erosion of highlands and deposition in lowlands in Recent time.

Water-bearing Properties of the Rocks

Paleozoic rocks in the area generally have a low primary permeability, or ability to transmit water, because they are dense and contain few pores. However, because they have been faulted, folded, weathered, and otherwise altered, they contain many secondary openings, mainly joint cracks. These fractures, which locally have been enlarged by solution, have created substantial permeability in some of the limestone and dolomite of Paleozoic age. Ore deposition in the Paleozoic rocks commonly was localized by this secondary permeability. Deposition in the Eldorado dolomite (Middle Cambrian) in the Eureka district is an example. Deposition associated with hydrothermal alteration and emplacement of intrusive rocks generally reduces any secondary permeability that may have developed. Later faulting, folding, erosion, and cementation or solution may either increase or decrease the permeability developed previously.

Numerous small springs issue from Paleozoic rocks in the mountains. The general character of the Simonsen warm springs in the northeastern part of Newark Valley (near the NE cor. T. 22 N., R. 56 E.) suggests that the springs are related in part to conduits in carbonate rocks of Paleozoic age. In the Eureka district, attempts to develop new ore bodies have involved pumping substantial amounts of water in the vicinity of the ore bodies. From the Fad shaft as much as 10,000 gpm (gallons per minute) had to be lifted more than 1,500 feet during several extended periods of pumping. Thus, the Paleozoic rocks, at least locally, are capable of transmitting water readily.

Intrusive rocks in the mountains probably transmit very little ground water, although weathered zones and joint systems supply small amounts of water locally to springs.

Lava flows, such as those which crop out in the Pancake Range, are generally above the zone of saturation. Locally, intermittent springs issue at the base of these flows where they rest on fine-grained sediments or pyroclastic units. Present information does not indicate the extent or distribution of such flow rocks in the valley fill.

The Tertiary rocks (Illipah and Lake Newark formations of Humphrey (in press)) in general are inferred to have a fairly low permeability. Where saturated, these rocks may provide considerable ground-water storage but probably would yield rather small supplies to wells. However, sand, gravel, and possibly limestone of the Tertiary formations locally might yield moderate to large supplies of water to properly constructed wells. Well 16/53-10D1 1/

1/ The well numbering system is described in the section entitled "Designation of wells".

at Fish Creek Ranch, was drilled to a depth of 539 feet, largely in these deposits. The pumping rate was reported to be 800 gpm, the water apparently being supplied from two zones of sand and gravel--one at a depth of less than 50 feet and the other below 400 feet. The lower water-yielding zone probably is in rocks of Tertiary age.

The gravel and sand strata of Quaternary age beneath the water table probably will yield water to wells in moderate amounts. One example is the sand and gravel in the upper 50 feet of the irrigation well at Fish Creek Ranch. Well 17/54-2D1, used for highway construction, reportedly yielded 300 to 400 gpm. Incomplete information for this well suggests that the principal aquifer is in deposits of Quaternary age.

GROUND-WATER APPRAISAL

General Conditions

Ground water in Newark Valley is presumed to originate largely or entirely in precipitation within the drainage basin. Precipitation on the flanks of the Diamond Mountains, White Pine Mountains, and Bald and Buck Mountains undoubtedly supplies most of the recharge to the ground-water reservoir. Fish Creek (Little Smoky) Valley, which is higher than, and tributary to, Newark Valley, must provide some recharge to the ground-water reservoir in Newark Valley. Precipitation on the valley floor is small and probably is mostly evaporated or transpired before it can reach the water table. The valley fill is the principal ground-water reservoir. Some water occurs also in bedrock, where continuity of openings permits. Locally ground water is perched above the regional water table in the bedrock and is the source of supply for some of the small springs at high altitudes in the mountains. Perched or semiperched ground water occurs also along a north-south line about at the middle of R. 57 E. in Tps. 18 and 19 N. Here the water seems to be held up by relatively impermeable rock units of Tertiary age.

The ground water in the valley fill is the most favorable for economical development. However, existing wells in Newark Valley have been limited primarily to providing small supplies for stock or domestic use. Currently, springs supply most of the water for irrigated pasture or meadowland in the lower parts of the valley.

Recharge to the ground-water reservoir in the valley fill is derived principally from the infiltration of precipitation and of surface water on the upper parts of the alluvial apron; but also, to an unknown but perhaps considerable extent, by underflow from bedrock.

From the areas of recharge, ground water moves toward the lower parts of the valley--that is, toward the playa. The configuration of the water table, the upper surface of the zone of saturation, conforms generally with the slope of the land surface but has less relief. Thus, the depth to water tends to increase away from the playa toward the mountains.

Ground water is discharged by evaporation and transpiration in the areas where the water table is at or near the land surface. Transpiration by meadow grasses, greasewood, and rabbitbrush, and direct evaporation from the soil where the water table is very near the land surface, are the principal means of ground-water discharge at present.

The depth to water in and adjacent to the playa area ranges from zero to perhaps 5 feet. In areas where springs occur on the lower parts of the west and east slopes of the valley this same depth range may be expected. At U. S. Highway 50, in the SW cor. T. 18 N., R. 54 E., the depth to water is about 35 feet. The depth to water in the well 19/57-19B1 is about 110 feet, and at the stock well 18/56-2B1 it apparently is about 145 to 150 feet. Several miles east of these two wells, in the middle of R. 57 E., there is a north-trending line of springs and wells, used for stock. The shallow water in this area is believed to be held up by Tertiary rocks of low permeability.

Numerous springs, used for irrigation along the west and east sides of the valley in Tps. 20, 21, and 22, issue from the lower parts of the alluvial apron. (See Photograph 5). Their tendency to discharge in elongate seeps, areas, and pools along the toes of alluvial fans strongly suggests that they are gravity springs--that is, they represent simply an intersection of the gently sloping water table with the more steeply sloping land surface. The Simonsen warm springs, which issue from the alluvium near the NE cor. T. 22 N., R. 56 E., probably is supplied with water moving through bedrock and rising from moderate depth through valley fill. The temperature of water entering the pool is about 74° F, which is about 20 degrees higher than that of unconfined ground water in the valley. The discharge is 2 to 3 cfs (cubic feet per second) and probably varies somewhat seasonally and annually.

A sulfur spring in the SW $\frac{1}{4}$ sec. 16, T. 18 N., R. 56 E., has a small discharge of unpalatable water. It is closely associated with volcanic rocks, which crop out nearby.

Estimated Average Annual Recharge

An estimate may be made of the average annual recharge to the ground water as a percentage of the average annual precipitation within the basin. The general method is described briefly in an earlier report (Eakin and others, 1951, p. 79-80).

For Newark Valley, the precipitation map of Hardman and Mason (1949, p. 10) was compared with the topographic map (pl. 1). Precipitation zones were modified slightly to fit the better controlled topographic map. The division between the zones of less than 8 inches and 8 to 12 inches of precipitation was selected at the 6,000-foot contour; that between the zones of 8 to 12 and 12 to 15 inches at 7,000 feet; that between the zones of 12 to 15 and 15 to 20 inches at 8,000 feet; and that between the zones of 15 to 20 and more than 20 inches at

9,000 feet. The average precipitation assumed for the respective zones, beginning with the 8- to 12- inch zone, is 10 inches (0.83 ft.), 13.5 inches (1.12 ft.), 17.5 inches (1.46 ft.), and 21 inches (1.75 ft.).

The recharge estimated as a percentage of the average precipitation for each zone is as follows: less than 8 inches, 0 percent; 8 to 12 inches, 3 percent; 12 to 15 inches, 7 percent; 15 to 20 inches, 15 percent; more than 20 inches, 25 percent.

Table 2 summarizes this computation. The approximate recharge (column 4) for each zone is obtained by multiplying the figures in columns 1, 2, and 3. Thus, for the zone receiving more than 20 inches, the computed recharge is 3,000 acres x 1.75 feet x 0.25 (25 percent) = 1,300 acre-feet.

Table 2.--Estimated Average Annual Ground-Water Recharge to Newark Valley

Precipitation zone (inches)	(1) Approximate area of zone (acres)	(2) Average Precipitation (feet)	(3) Percentage Recharged	(4) Estimated Recharge (ac.-ft.) (1)x(2)x(3)
20	3,000	1.75	25	1,300
15-20	19,000	1.46	15	4,200
12-15	70,000	1.12	7	5,500
8-12	270,000	.83	3	6,500
8	150,000	---	---	---
	512,000 (800 sq. mi.)		Total	17,500
Underflow from Fish Creek Valley (estimated)...............				1,000
Estimated total recharge, on order of......................				18,000

In addition to the recharge from precipitation in the valley, ground-water underflow from Fish Creek Valley contributes recharge to Newark Valley. No precise data are available from which to estimate the underflow. However, a rough estimate can be made on the basis of generalized information and reasonable assumptions. The formula Q = 0.00112 TIW provides the basis for computation, where Q = the quantity of underflow, 0.00112 converts gallons per day to acre-feet per year, T = the transmissibility 1/ of the water-bearing deposits, I= the ground-water gradient, and W = the width of the section through which the ground water moves. The above terms are given in the following units: Q, in acre-feet per year; W, in miles; I, in feet per mile; and T, in gallons per day per foot times 0.00112.

The width of the valley-fill section in the vicinity of the arbitrary boundary between Fish Creek and Newark Valley is about 2.5 miles (pl. 1), normal to the general direction of ground-water movement. The gradient as determined from the altitude of the water level of stock well 17/54-22A1 and well 17/55-6B1 at the Eldorado Station on U. S. Highway 50 is about 4 feet per mile. In this area, the general geologic and hydrologic conditions suggest that a value of 100,000 gpd per foot might be reasonable for the transmissibility. Substituting these values in the formula (0.00112 x 100,000 x 4 x 2.5), a value of roughly 1,000 acre-feet per year is the indicated average annual underflow from Fish Creek Valley to Newark Valley.

Fish Creek is an ephemeral stream. Surface flow from Fish Creek Valley into Newark Valley may occur for a short time during the period of spring runoff. On the average, however, the annual runoff is relatively small, and therefore the average recharge by seepage loss from the stream is believed to be negligible.

The estimated recharge from precipitation and by underflow from Fish Creek Valley add up to a figure of approximately 18,000 acre-feet for the average annual recharge to the ground-water reservoir in Newark Valley.

Estimated Average Annual Discharge

Ground water is discharged from Newark Valley by transpiration of water-loving vegetation (phreatophytes) and by evaporation from the soil and from free water surfaces. Almost all the discharge from springs and wells is eventually evaporated or transpired. Present stock and domestic consumption is very small.

Obviously, the scope of this reconnaissance precluded any detailed study of the ground-water discharge by evapotranspiration. Rather, the basis used for estimating the discharge by phreatophytes was developed from studies in the Great Basin by Lee (1912) and White (1932) and elsewhere as reported by Young and Blaney (1942). Table 3 summarizes the estimated average annual discharge of ground water from Newark Valley.

1/ The transmissibility may be expressed in terms of gallons per day through a strip of the aquifer 1 foot wide extending the full height of the aquifer under unit hydraulic gradient, or through a section of the aquifer 1 mile wide under a hydraulic gradient of 1 foot per mile.

Table 3. --Estimated Average Annual Ground-Water Discharge from Newark Valley

Vegetation	Area (acres)	Estimated rate of ground-water use (feet per year)	Estimated discharge by evapo-transpiration (acre-feet)
Meadowland and pasture 1/	3,600	1.0	3,600
Native vegetation 2/ by zones of average depth to water:			
5 feet	13,400	.5	6,700
15 feet	21,800	.2	4,360
25 feet	11,800	.1	1,180
Playa area 3/	25,000	(a)	(a)
Estimated discharge by evapotranspiration, rounded			16,000

1/ Mixed grasses, depth to water 0-5 feet. Largely irrigated by spring discharge and shallow ground water. Excludes part supplied by occasional streamflow or direct precipitation.

2/ Greasewood, rabbitbrush, salt grass, in varying proportions, density generally moderate to low but locally moderate to heavy.

3/ Generally bare saline flat, local sand dunes. Depth to water generally less than 10 feet. Rate of annual evaporation unknown.

a.. Not estimated, but assumed negligible.

Although ground water is being evaporated in all or part of the playa area, the average annual rate could not be estimated within reasonable limits. Therefore, no estimate has been made for evaporation from the playa. If the estimates of recharge (table 2), and of transpiration by phreatophytes (table 3) are correct, the difference of 2,000 acre-feet a year should be the amount evaporating directly from the playa area. However, the estimates of recharge and discharge are too crude to assume that the difference between them is equal to the discharge by evaporation. Accordingly, it is assumed that the discharge is small to negligible and that the estimated discharge by phreatophytes includes virtually all the natural discharge from Newark Valley.

However, a rate of evaporation of 0.1 foot would amount to a discharge of 2,500 acre-feet a year and would closely balance the estimates of recharge and discharge. In valleys such as Newark Valley where playa areas are large, evaporation could be an important element of ground-water discharge. For this reason, a recommendation is made in a later section of the report to study evaporation from playas.

Perennial Yield

The perennial yield of a ground-water system is ultimately limited by the average annual recharge and discharge circulating into and out of the system. It is the upper limit of the amount of water that can be withdrawn for an indefinite period of time from a ground-water system without permanent depletion.

In a closed basin, the average recharge from precipitation and the average discharge by evapotranspiration are measures of the natural circulation of the ground-water system.

In an estimate of perennial yield, consideration should be given to the effects that ground-water development by wells may have on the natural circulation of the ground-water system. Development by wells may induce recharge in addition to that received under natural conditions. Part of the water discharged by wells may re-enter the ground-water reservoir by downward percolation, especially if the water is used for irrigation. Ground-water discharged by wells usually is offset eventually by a reduction of the natural discharge. In practice, however, it is difficult for well discharge to offset the natural discharge fully, except when the water table has been lowered to a level that eliminates transpiration in the natural area of discharge. The complexities of the numerous pertinent factors are such that, in effect, specific determination of perennial yield requires a very extensive investigation based in part on data that can be obtained economically only after there has been substantial development of ground water for several years.

As an initial guide for the development of Newark Valley, the preliminary estimates of ground-water recharge and discharge, previously discussed, can be used. Thus, the respective preliminary estimates of 18,000 and 16,000 acre-feet (tables 2 and 3) suggest that the upper limit of the perennial yield is on the order of 18,000 acre-feet a year. The crude data and assumed values used in reaching the estimates make it apparent that the actual perennial yield of the natural ground-water system may be several thousand acre-feet a year more or less than this estimate.

Storage

A large amount of ground-water is stored in the valley fill in Newark Valley. Some concept of the magnitude of the ground-water in storage may be gained by the following calculation: The alluvial area below the 6,000-foot contour is about 150,000 acres. If a value of 10 percent is assumed for the specific yield (drainable pore space) of the saturated portion of the valley fill in that area, 15,000 acre-feet of water is theoretically available from storage in each foot of saturated valley fill. This amount is of the same magnitude as the estimates for average annual recharge and discharge, as has proved to be true for several other valleys investigated in Nevada.

Naturally, uniform lowering of water level over such a large area is not possible by means of localized pumping. However, the illustration serves to show that a relatively large volume of water is available in storage for maintaining an adequate supply for pumping during extended periods of drought or for limited periods of high demand under emergency conditions.

Quality

The chemical quality of ground water in interior valleys, such as Newark Valley, generally varies considerably as the water moves through the ground-water system. Sufficient sampling points are not presently available in Newark Valley to describe the chemical quality of the ground water. In general, the concentration of dissolved chemical constituents is least in the areas of recharge and greatest in the areas of discharge--that is, they are lowest in the mountain areas and greatest in the lowland, or playa, area. Variation from this simple assumption is common, and has been observed in many valleys in Nevada. It generally is the result of variations in mineral constituents of the different geologic units. Thus, for any one valley a completely satisfactory identification of the range and variations in chemical characteristics requires analysis of samples from sources distributed adequately as to geologic source and geographic location. These are not available in Newark Valley at this time. However, long-term use of the springs along the northern part of the west and east sides of the valley indicates that the water is suitable for the crops now grown in the valley.

The gravity springs in these areas probably discharge water that is of the bicarbonate type and is not strongly mineralized. This conclusion is based on the type of rocks through which the water moves and the short distance to the areas of recharge. The water of the warm springs near the NE cor. T. 22 N., R. 56 E., is used for irrigation also, although it may be somewhat higher in dissolved constituents than the water from the principal gravity springs on the west side of the valley.

Well 17/55-6B1, at Eldorado station supplies water for domestic use and garden irrigation. The water has been used for several years and the owner reports it to be very good.

An analysis (laboratory files, University of Nevada, Department of Food and Drugs) of water from a well (probably 16/53-10D1) at Fish Creek Ranch showed 3.90 epm (equivalents per million) of calcium, 1.72 epm of magnesium, 2.65 epm of sodium, 6.28 epm of bicarbonate, 0.56 epm of chloride, and 1.44 epm of sulfate. Electrical conductivity was 903 micromhos (at 25° C). According to the classification of Wilcox (1948), this water is in class II, which is good to permissible for irrigation of crops having an average tolerance for salts. This class of water may be harmful to some crops that are sensitive to salt concentration and to some soils that are not well drained. For the higher ranges of concentration, harmful quantities of salts may accumulate in soils of medium and heavy texture. Water of this class may occur beneath the valley lowland and possibly in the deeper aquifers.

The fact that water of intermediate or poor chemical quality may occur locally in Newark Valley need not be a generally discouraging factor. Rather, it suggests that new water supplies developed in the valley should be analyzed for suitability for the proposed use. For agricultural use the chemical quality, texture, and drainage characteristics of the soil may be as important as the chemical quality of the water in determining whether a venture will be successful. Each of these items, therefore, should be considered.

Development

Present development of ground water by wells in Newark Valley is virtually limited to stock and domestic use. The withdrawals are negligible compared to the average amount of water recharged to and discharged from the ground-water reservoir. Well 17/54-2D1, which was used for highway construction purposes, reportedly supplied water at a rate between 300 and 400 gpm from a water-bearing zone or zones which were less than 100 feet deep. Upon completion, irrigation well 16/53-10D1 at Fish Creek Ranch reportedly was capable of yielding 800 gpm from two water-bearing zones--one less than 50 feet below the land surface and the other between about 400 and 500 feet. The latter well is outside Newark Valley. However, both wells indicate that productive water-bearing zones are to be expected in the valley fill in favorable areas of Newark Valley.

Presently available data are not adequate to designate specific depths or areas at which yields sufficient for irrigation or other large-use purposes can be developed. General geologic conditions suggest that sand and gravel zones capable of yielding moderate to large supplies to wells might occur within the upper 500 feet of fill underlying the middle and lower parts of the alluvial apron along the west and north sides and the northern part of the east side of the valley. Favorable water-bearing zones may occur also for several miles north and south of U. S. Highway 50 in the lowland area leading to Fish Creek Valley (See

Photographs 2 and 3). Other areas in the valley also may be susceptible to the development of moderate supplies of water from wells. However, the area south from the north line of T. 18 N., R. 56 E., probably would be limited for irrigation development on the basis of economics because the depth to water is more than 140 feet and increases southward.

In addition to the occurrence of favorable water-bearing zones, it should be noted that success in obtaining wells of moderate to large yield may be dependent to a large extent on proper construction and development.

RECOMMENDATIONS FOR ADDITIONAL GROUND-WATER STUDIES

At the request of the Director of the Department of Conservation and Natural Resources, recommendations for additional ground-water studies are presented below. These proposals are based on observations made during this brief investigation, and are made to facilitate the planning of future work under the cooperative program of ground-water investigations.

1. Investigation of ground-water discharge by evaporation from the playa area of the valley. Qualitatively, it is known that the rate of evaporation may range from zero to several feet per year under different geohydrologic environments of areas that are called "playas." Obviously, the depth to the water table is important. However, the importance of other factors, such as the chemical and physical character of the earth materials between the land surface and a level some distance below the lowest seasonal stage of the water table is imperfectly understood. In Nevada, increasing accuracy is greatly needed for estimating ground-water discharge. As playa areas are very extensive throughout the State and as many are in areas of ground-water discharge, these studies should be started at an early date.

2. Investigation of the Cenozoic geology and history. Ground-water development by wells in Nevada is intimately related to the Cenozoic (Tertiary and Quaternary) geology. Indeed, the valley fill is of principal importance to the occurrence, movement, storage, and chemical quality of ground water. The nature and distribution of the valley fill are, in turn, primarily the result of erosion, sedimentation, and structural deformation in Cenozoic time. Throughout the State, knowledge of this geologic era must be greatly improved if an optimum understanding of ground water is to be obtained. Improved knowledge and more extensive data on ground-water resources in Nevada can aid greatly in the development, conservation, and management of this valuable resource. Investigation of the Cenozoic geology of the Newark Valley area would be desirable because parts of the Tertiary formations are exposed for direct study in the Pancake Range and along the east side of the valley. Also, substantial work has been done on the Paleozoic sequence in the nearby Eureka area, and this provides an excellent framework for the investigation of the younger formations. Further, valley-fill areas to the north and northwest have been investigated, and these studies would assist in extending geologic correlation.

3. Investigation of precipitation and runoff from small drainage basins in the mountains. Data are not available through a satisfactory range of geologic, climatologic, and topographic conditions in Nevada to provide adequate control for determining recharge to ground water. As ground-water development increases, it will be necessary to strengthen substantially the basic knowledge of the effect of geology and topography on ground-water recharge from precipitation and runoff. Data are required through a range of conditions of each of the principal factors. As a first step, it is recommended that either the Cold Creek basin, in the southeastern part of T. 23 N., R. 55 E., or the drainage basin west of Strawberry, which is largely in the northwestern part of T. 21 N., R. 55 E., be selected for study. In addition to a detailed investigation of the geologic and topographic conditions, it will be necessary to install a stream-gaging station to obtain several years of record. Precipitation records should be obtained for the same period. This could be accomplished by the use of several standard storage gages placed strategically in the basin, a control record being obtained at a nearby ranch.

DESIGNATION OF WELLS

Wells and springs in Nevada are designated by the U. S. Geological Survey by a single numbering system. The number assigned to a well or spring in this report is both an identification and a location number. It is based on the Mt. Diablo base line and meridian of the General Land Office network.

A typical number usually consists of three units. The first unit of wells in Newark Valley is the number of the township north of the Mt. Diablo base line. The second unit, separated from the first by a slant, is the number of the range east of the Mt. Diablo meridian. The third unit, separated from the second by a dash, is the number of the section in the township. The section number is followed by a letter, which designates the quarter section, and finally by a number designating the order in which the well was recorded in that quarter section. The letters A, B, C, and D designate, respectively, the northeast, northwest, southwest, and southeast quarters of the section.

Thus, the well number 19/56-30D2 indicates that this well was the second well recorded in the southeast quarter of sec. 30, T. 19 N., R. 56 E.

Owing to limitation of space on plate 1, wells are identified by the section number, quarter-section letter, and serial number. Individual townships are shown on plate 1. For example, well 19/56-30D2 is shown on plate 1 by the symbol 30D2 and is in T. 19 N., R. 56 E.

RECORD OF SELECTED WELLS IN NEWARK VALLEY

Table 4 contains drillers' logs, water-level measurements, descriptions of pumping equipment, and other data for 24 wells in Newark Valley. The locations of these wells are shown on plate 1.

Table 4.--Records of Selected Wells in Newark Valley

16/53-10D1. Owner, Bartholomae Corp., Fish Creek Well No. 1 (Fish Creek Valley), drilled irrigation well, depth 539 feet, casing diameter 12 inches to 127 feet, and 440 feet of 8 5/8-inch, presumably from 99 to 539 feet. Equipped with electric-driven vertical turbine pump. Reported pumping rate, 800 gpm. Measuring point, top edge of 3/8-inch hole in plate over well casing, west side. Depth to water below measuring point, 4.90 feet, August 13, 1948. Reported driller's log:

Material	Thickness (feet	Depth (feet)
Soil	2	2
Gravel (water)	9	11
Clay	2	13
Gravel (water-perforated 14-50 ft.)	36	49
Clay, gray	48	97
Clay, blue	13	110
Clay, sandy, blue	11	121
Hardpan	1	122
Clay, gumbo, sticky	148	370
Sand	16	386
Shale, brown (perforated 405-539 ft.)	116	502
Gravel	31	533
Bedrock quartzite	6	539
Total depth		539

18/55-23B1. Owner, unknown. "Lagari" well. Dug stock well, 4 by 4 feet, depth 58.0 feet. Equipped with gasoline engine and cylinder pump. Measuring point, top of plank well cover. Depth to water below measuring point: 54.11 feet, May 28, 1954; 54.92 feet, August 24, 1960.

18/55-31C1. Owner, U. S. Government. Dug stock well, depth 43.2 feet, diameter 3 feet, concrete casing. Equipped with windmill and cylinder pump. Measuring point, top of concrete casing. Depth to water, in feet, below measuring point, which is 1.0 foot above surface:

Depth	Date	Depth	Date
35.65	Dec. 21, 1946	34.54	Mar. 15, 1951
35.25	Apr. 19, 1947	34.42	Sept. 11, 1951
35.14	Jan. 4, 1948	34.38	Oct. 1, 1952
35.20	Mar. 16, 1948	34.67	Mar. 3, 1953
34.89	Mar. 24, 1949	34.25	Sept. 15, 1953
34.98	June 16, 1949	34.20	Mar. 9, 1954
34.81	Sept. 12, 1949	34.19	Sept. 15, 1954
34.63	Dec. 16, 1949	34.45	Sept. 19, 1955
34.76	Mar. 16, 1950	34.6	Sept. 11, 1957
34.74	June 19, 1950	34.64	Dec. 18, 1959
34.57	Sept. 19, 1950		

18/56-2B1. Owner, unknown. Dug stock well, 3 by 4 feet, wood cribbed, depth 143 feet (possibly drilled deeper). Equipped with gasoline engine and cylinder pump. Depth to water estimated at 145 to 150 feet.

18/56-21D1. Owner, unknown. Dug, stock (unused?) well, depth 41 feet. Measuring point top of well curbing. Depth to water below measuring point, 24.85 feet, August 27, 1957.

18/56-33A1. Owner, unknown. Dug stock well, depth 20.3 feet. Measuring point top of well curbing. Depth to water below measuring point, 7.9 feet, August 22, 1957.

18/57-15B1. Owner, unknown. Dug stock well, 3 by 3 feet, depth 14.0 feet. Apparently siphons to stock tank down slope. Measuring point, top of well curbing. Depth to water below measuring point, 10.4 feet, August 22, 1957.

19/56-30D1. Owner, Bureau of Land Management (?). "Valley" well No. 1. Dug stock well, diameter 4 feet, depth 35 feet. Measuring point, top of concrete curbing. Depth to water below measuring point, 32.78 feet, April 30, 1948.

19/56-30D2. Owner, Bureau of Land Management (?). "Valley" well No. 2. Dug stock well, diameter 3.5 feet, depth 37 feet, concrete casing. Equipped with windmill and cylinder pump. Measuring point, top of concrete curbing. Depth to water, in feet, below measuring point, which is 1.5 feet above land surface.

Depth	Date	Depth	Date
33.55	Apr. 30, 1948	33.29	Sept. 11, 1951
33.50	June 16, 1949	33.13	Oct. 1, 1952
33.25	Sept. 12, 1949	33.48	Mar. 3, 1953
33.63	Dec. 16, 1949	33.21	Sept. 15, 1953
33.24	Mar. 16, 1950	33.18	May 28, 1954
34.88	June 19, 1950	33.38	Sept. 16, 1954
33.23	Sept. 19, 1950	33.40	Sept. 19, 1955
33.23	Mar. 15, 1951	34.17	Aug. 28, 1960

19/57-5A1. Owner, unknown. "Dry Mountain" well. Stock well, 5 by 5 feet and 6-inch diameter casing, dug to 31 feet, drilled to 61 feet. Equipped with gasoline engine and cylinder pump. Measuring point, top of 6-inch casing. Depth to water below measuring point, 24.68, April 30, 1948.

19/57-19B1. Owner, Goicoechea. "Goicoechea" well. Unused, dug stock well, 4 by 4 feet, wood-cribbed, depth 112± feet. Equipped with cylinder pump. Measuring point, top of wood curbing. Depth to water, in feet, below measuring point, which is 0.5 feet above land surface:

Depth	Date	Depth	Date
108.58	Apr. 29, 1948	108.43	Sept. 15, 1953
108.86	June 16, 1949	108.43	May 28, 1954
109.04	Sept. 12, 1949	108.02	Sept. 16, 1954
108.75	Mar. 16, 1950	108.60	Sept. 19, 1955
108.42	Sept. 19, 1950	(measuring point changed=	
108.54	Mar. 15, 1951	3.0 feet above land surface)	
108.35	Sept. 11, 1951	111.31	Dec. 21, 1959
108.43	Oct. 1, 1952	111.47	Sept. 28, 1960
108.42	Mar. 3, 1953		

20/55-10D1. Owner, Bureau of Land Management. Dug stock well, diameter 3 feet, depth 21.7 feet, concrete casing. Formerly equipped with windmill and cylinder pump. Measuring point, top of plank well cover. Depth to water, in feet, below measuring point which is 1.0 foot above land surface:

Depth	Date	Depth	Date
9.17	Jan. 14, 1948	9.52	Mar. 15, 1951
9.29	Apr. 30, 1948	9.45	Sept. 11, 1951
9.08	Mar. 24, 1949	9.45	Oct. 1, 1952
9.53	June 16, 1949	9.38	Mar. 3, 1953
9.66	Sept. 12, 1949	9.95	Mar. 9, 1954
9.13	Dec. 16, 1949	10.29	Sept. 15, 1954
9.42	Mar. 16, 1950	10.43	Sept. 19, 1955
9.73	June 19, 1950	10.48	Dec. 21, 1959
9.48	Sept. 19, 1950		

20/55-34D1. Owner, unknown. Drilled stock well, diameter 6 inches. Equipped with windmill and cylinder pump. Measuring point, top of collar on casing. Depth to water, in feet, below measuring point, which is 2.0 feet below land surface.

Depth	Date
23.85	Jan. 14, 1948
22.22	Apr. 30, 1948
22.18	June 16, 1949

21/55-3D1. Owner, R. W. Hooper. Dug stock well, diameter 3.5 feet, depth 8.5 feet, concrete casing. Equipped with windmill and cylinder pump. Measuring point, top of plank well cover. Depth to water below measuring point: 4.78 feet, April 30, 1948; 6.94 feet, December 18, 1959.

21/55-10C1. Owner, R. W. Hooper. Dug domestic well, 5 by 5 feet, depth 33.5 feet, wood cribbed. Equipped with bucket and windlass. Measuring point, top of wood cribbing. Depth to water, in feet, below measuring point, which is 3.5 feet above land surface.

Depth	Date	Depth	Date
21.29	Jan. 14, 1948	17.60	Mar. 15, 1951
17.78	Apr. 30, 1948	22.10	Sept. 11, 1951
15.25	Mar. 24, 1949	20.19	Oct. 1, 1952
17.22	June 16, 1949	16.79	Mar. 3, 1953
21.81	Sept. 12, 1949	22.65	Sept. 15, 1953
20.12	Dec. 16, 1949	17.36	Mar. 9, 1954
16.05	Mar. 16, 1950	22.56	Sept. 15, 1954
19.65	June 19, 1950	22.61	Sept. 19, 1955
22.65	Sept. 19, 1950		

21/55-22C1. Owner, Bureau of Land Management (?). Unused, dug stock well, diameter 3.5 feet, depth 18 feet, concrete casing. Measuring point, top of plank well cover. Depth to water below measuring point, 8.26 feet, April 30, 1948.

22/55-27B1. Owner, unknown. Unused, dug stock well, diameter 3 feet, concrete casing. Measuring point, top of plank well cover. Depth to water below measuring point, 10.24 feet, August 24, 1960.

22/55-34C1. Owner, unknown. Dug stock well, depth 9.5 feet. Equipped with windmill and cylinder pump. Depth to water below measuring point, 9.2 feet, September 21, 1957.

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Appendix--Generalized Stratigraphy of Newark Valley and Vicinity

/After Nolan, Merriam, Williams (1956) and Humphrey (1960)/

Age	Formation	Lithology	Thickness (feet)
Quaternary	Alluvium	Unconsolidated sand, gravel, silt, and clay in fanglomerate, stream, lake, beach, playa, and dune deposits	0-200 or 300
Unconformity			
Pliocene (?)	Belmont fanglomerate of Humphrey (in press)	Chiefly unbedded gravel and fanclomerate	?
Unconformity			
Late Miocene or Pliocene	Lake Newark formation of Humphrey (in press)	Bedded rhyolite tuff and coarser pyroclastics; in part lacustrine	430
Unconformity			
Eocene	Illipah formation of Humphrey (in press)	Fresh-water limestone, conglomerate, and interbedded tuff	1,500±
Unconformity			
Early Cretaceous	Newark Canyon formation	Heterogeneous assemblage of fresh-water limestone, conglomerate, silt, sandstone, and grit	1,800
Unconformity			

Age	Formation	Lithology	Thickness (feet)
Permian	Carbon Ridge formation	Heterogeneous, predominatly calcareous rocks including abundant bedded sandy limestone; many beds of brown, yellow, or purple sandstone near base	1,750
Early and Middle Pennsylvanian	Ely limestone	Massive bedded blue-gray limestone with some sandstone and rarely conglomerate beds near base . . .	1,500
Late Mississippian	Diamond Peak formation	Quartzite with large but varying portions of shale, conglomerate, and limestone; abundant fossils	420
Late Mississippian	Chainman shale	Black shale with some thin beds of sandstone. Rather siliceous in Diamond Mountains	5,000
	Unconformity		
Early Mississippian	Joana limestone	Dense, porcelaneous limestone, coarseley crystalline limestone locally conglomeratic, nodular cherty limestone, black platy shale, thin quartzite or sandstone beds, and subordinate black chert	0-135

Age	Formation	Lithology	Thickness (feet)
Mississippian and Devonian	Pilot shale	Platy generally calcareous shale, tan to black in color on fresh fracture; approaches 1,000 feet in thickness in Pancake Range . .	420
Middle and Late Devonian	Devils Gate limestone	Thick-bedded gray to blue-gray hard, dense, brittle limestone; few thinner beds of platy, flaggy limestone; some dolomite or dolomitic limestone near base; divided into Hayes Canyon and Meister members	1,200
Early and Middle Devonian	Nevada formation	Dominantly dolomite but appreciable thickness of sandstone and limestone; divided into five members in which a sandstone unit and a dominantly limestone unit separate three dolomite units; members, younger to older, are Bay State domomite, Woodpecker limestone, Sentinel Mountain dolomite, Oxyoke Canyon sandstone, and Beacon Peak dolomite	2,900

Unconformity

Age	Formation	Lithology	Thickness (feet)
Silurian	Lone Mountain dolomite	Characteristically heavy-bedded to massive finely granular to coarsely saccharoidal light-gray dolomite; some beds of coarse crinoidal dolomite near base	1,500-2,200
Unconformity			
Late Ordovician	Hanson Creek formation	Dark-gray to black dolomite, intensely fractured and brecciated in Eureka area; mostly limestone and calcareous shale in Roberts Mountains	300+
Unconformity			
Middle and Late (?) Ordovician	Eureka quartzite	Typically vitreous fine-to medium-grained sugary gleaming white quartzite, much fractured, brecciated, and locally recrystallized.	500-
Unconformity			

Age	Formation	Lithology	Thickness (feet)
Pogonip group (eastern facies), composed of Antelope Valley limestone, Ninemile formation, and Goodwin limestone			
Early and Middle Ordovician	Antelope Valley limestone	Thick-bedded or massive medium or light-blue-gray fine-grained limestone; tends to be flaggy or platy, with argillaceous partings, in upper part	430
Early Ordovician	Ninemile formation	Platy, thin-bedded fine-grained to porcelaneous olive-green or greenish blue limestone. Some light-gray crystalline, sandy limestone, limy sandstone, and shale partings	540
Early Ordovician	Goodwin limestone	Dominantly well-bedded, fairly massive light-gray to blue-gray limestone; much very fine grained, asphanitic, locally platy light-gray to white chert in lower 350 feet	1,000±

Age	Formation	Lithology	Thickness (feet)
Late Cambrian	Windfall formation	Includes: Catline member, massive limestone beds and thinner sandy or silty limestone beds (250 feet); and Bullwhacker member, thin-bedded platy sandy or shaly limestone between units characterized by massive limestone (400 feet) . .	650
Late Cambrian	Dunderberg shale	Approximately equal thicknesses of shale and zones of interbedded shale and thin nodular, lenticular limestone beds	265
Middle and Late Cambrian	Hamburg dolomite	Mostly composed of light-to medium-dull-gray coarsely crystalline dolomite, porous and vuggy, considerable local variation in bedding, texture, color, and composition	1,000

Age	Formation	Lithology	Thickness (feet)
Middle Cambrian	Secret Canyon shale	Includes: Clarks Spring member, thin-bedded fine-grained silty blue-gray limestone with prominent yellow and red argillaceous partings (425-450 feet); lower shale member, argillaceous shale with little interbedded limestone; unweathered shale is massive blocky silstone with little or no fissility (200-225 feet)	650
Middle Cambrian	Geddes limestone	Well bedded, flaggy blue limestone with thin shale partings and some nodular black chert	330
Middle Cambrian	Eldorado dolomite	Massively bedded carbonate rock, ranging from nearly pure limestone to nearly pure dolomite; common type is light-gray rather coarsely crystalline dolomite, generally textureless but locally porous and vuggy; considerably modified by hydrothermal alteration	2,500±

Age	Formation	Lithology	Thickness (feet)
Middle Cambrian	Pioche shale	Commonly micaceous sandy shale; includes some micaceous sandstone quartzite and white and black limestone beds	400-500
Early Cambrian	Prospect Mountain quartzite	White to gray fairly well sorted quartzite; micaceous sandy shale interbeds make up less than 5 percent of formation and tend to be more numerous in lower part	1,500±

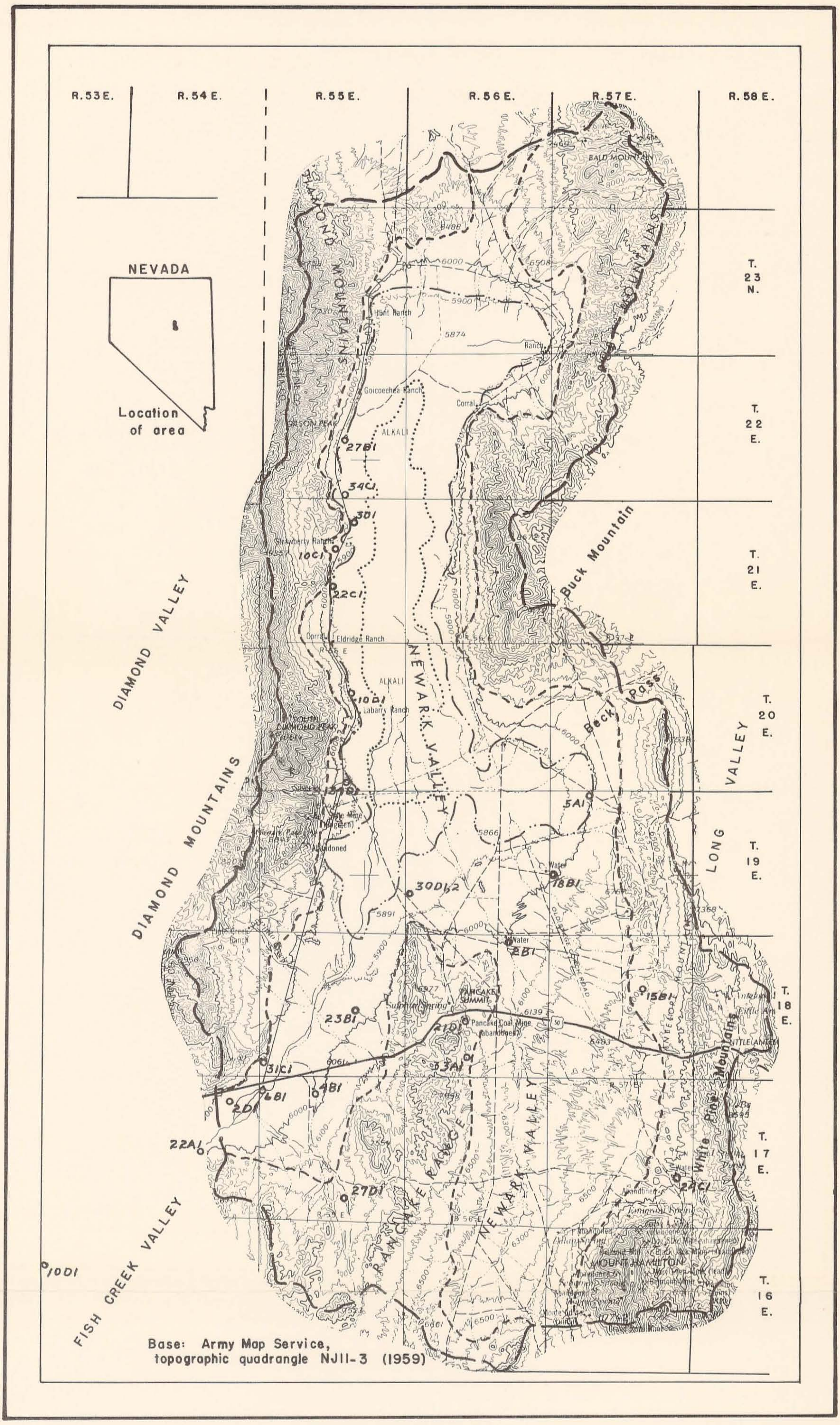

PLATE I. MAP OF NEWARK VALLEY, WHITE PINE COUNTY, NEVADA

SHOWING AREAS OF VALLEY FILL, TRANSPIRATION, AND PLAYA AND LOCATIONS OF WELLS

EXPLANATION

Drainage divide

Outer boundary of transpiration area (approximate)

Contact between valley fill and bedrock (approximate)

Outer margin of playa

Well

Scale 1:250,000

5 0 5 10 15 20 MILES

Contour interval 100 and 200 feet

December 1960