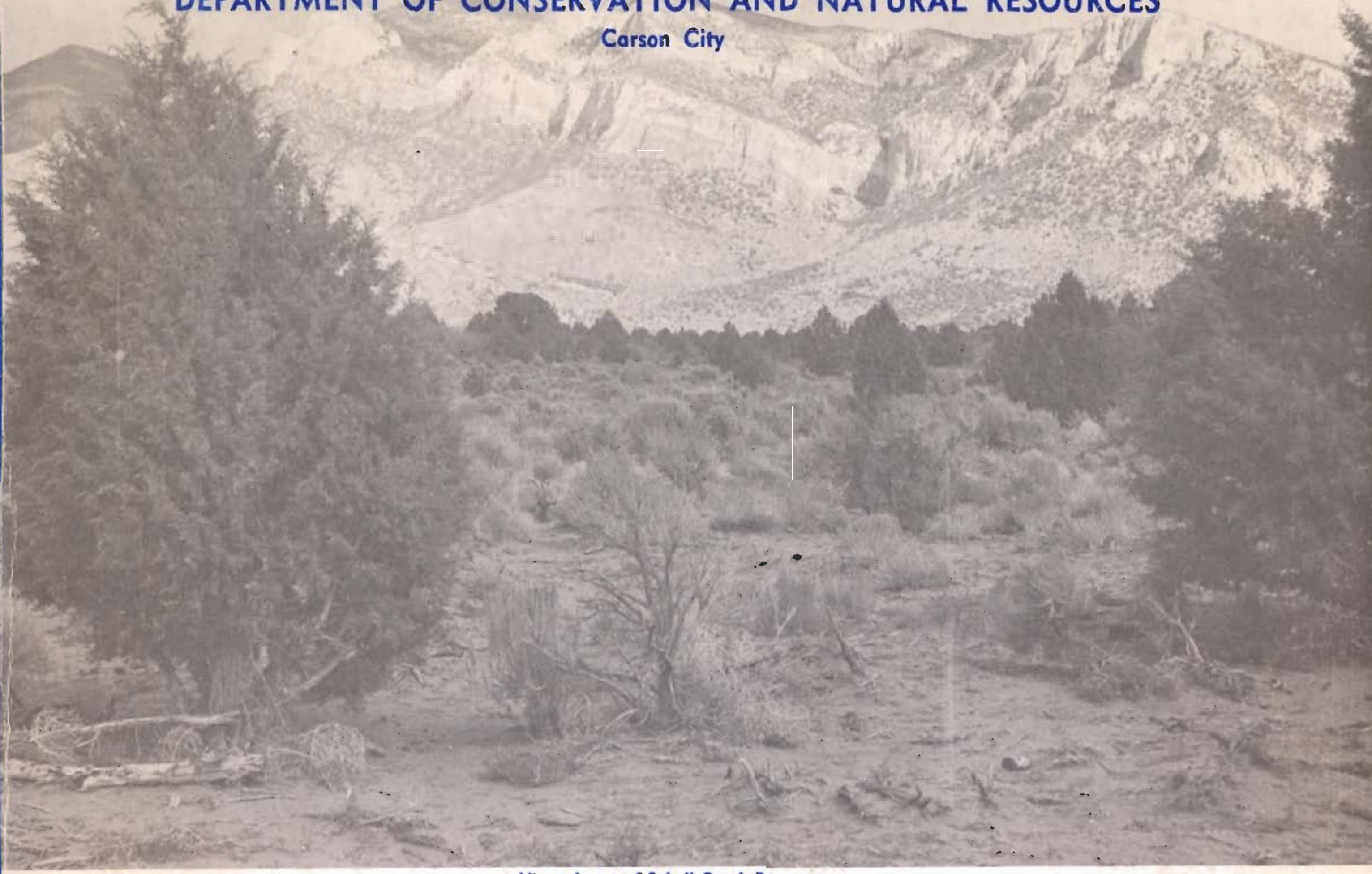
STATE OF NEVADA
DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES
Carson City



View of part of Schell Creek Range

GROUND-WATER RESOURCES - RECONNAISSANCE SERIES

REPORT 13

GROUND-WATER APPRAISAL OF CAVE VALLEY IN LINCOLN AND WHITE PINE COUNTIES, NEVADA

By
THOMAS E. EAKIN
Geologist

Price $1.00

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

DECEMBER 1962

The Tertiary volcanic rocks and older Tertiary sedimentary deposits exposed in the mountains are moderately consolidated. Although there may be some interstitial permeability probably much of the limited amount of water transmitted is through fractures. In general it is believed that the capability of the Tertiary rocks to transmit water is relatively low.

The unconsolidated sand and gravel deposits of Quaternary age are capable of transmitting ground water freely. However, the finer sand, silt, and clay have low permeability and transmit water slowly. These deposits occupy a large volume and have a relatively high porosity. Thus, where saturated, the Quaternary deposits contain a large volume of water in storage.

GROUND-WATER APPRAISAL

General Conditions

Most of the ground water in Cave Valley is derived from precipitation within the drainage area of the valley. Some of the precipitation on the upper parts of the alluvial apron percolates downward to the ground-water reservoir in the valley fill, but most of the recharge results from runoff in the mountains or percolation into the bedrock of the mountains and then lateral movement to the valley fill. Ground water in the valley fill moves from the areas of recharge in the northern part of the valley generally southward toward the playa.

In typical valleys in Nevada, most of the ground water is discharged naturally by evaporation and transpiration where the water table is at or near land surface. The principal means of natural ground-water discharge are transpiration by salt grass, native meadow grasses, rabbitbrush, greasewood, and other phreatophytes and evaporation from free-water surfaces and through the soil where the water table is shallow. Under ordinary conditions the area of principal evapotranspiration is in the topographically low part of the valley.

The water table is at shallow depth along the main channel and adjacent tributary channels from the middle of T. 9 N. into the northern part of T. 10 N. Here the depth to water may be nearly at land surface, as indicated by the 2-foot depth to water in well 9/63-1a1. The depth to water increases northward and is about 20 feet below land surface in well 10/63-25a1. At the playa, however, in the vicinity of T. 6 N., which is the lowest part of Cave Valley and where the principal area of natural discharge of ground water ordinarily would be found, the depth to water is substantial.

No wells were found in the immediate vicinity of the playa. However, the reported depth to water in well 7/63-15c1 and the measured depth to water in well 8/64-30c1 are both about 330 feet below land surface, and water-level altitudes are about 5,850 and 5,700, respectively. The indicated gradient of the water table between the two wells is about that of the land surface, or about 30 feet per mile. This gradient cannot be projected toward the playa because it is an apparent gradient only and the actual direction of the water-table gradient in this area is not known. It does indicate, however, that the depth to water beneath the playa is substantial and may be on the order of 300 feet. This depth to water virtually precludes any significant amount of ground-water discharge from the ground-water reservoir in this area.

Most of the ground water must be discharged from Cave Valley by underflow through bedrock. This conclusion is based on a comparison of the magnitude of recharge to the valley and the magnitude of discharge by evapotranspiration from the valley in parts of Tps. 9 and 10 N., as discussed in subsequent sections of this report.

In this area the Paleozoic carbonate rocks offer the most favorable conditions for ground-water movement between topographically closed valleys (cover photograph). Springs, such as Lund and Hot Creek Springs in adjacent White River Valley, for example, discharge from carbonate rocks. Indeed, springs discharging from or adjacent to Paleozoic carbonate rocks in this part of Nevada are commonplace. Thus, although much is unknown about the role of Paleozoic rocks in the ground-water hydrology of this area, it is evident that these rocks to large degree control the movement of ground water in this part of the State.

The discharge of ground water through bedrock from Cave Valley is not sufficient to drain completely the valley fill. Indeed, available data permit only a generalization of the system. However, on the basis of information of the few stock wells developed in the valley fill, it is evident that at least limited supplies can be obtained from the more permeable zones in the zone of saturation in the valley fill.

If the Paleozoic rocks are capable of transmitting ground-water discharge from Cave Valley by underflow, the inference is that ground-water recharge to the valley also could be accomplished by a similar mechanism. Ground water in Cave Valley occurs at a minimum known altitude of about 5,700 feet; lower water-level altitudes occur in parts of White River Valley to the west and southwest and in Dry Lake Valley to the south. Higher water-level altitudes occur in the valley fill in the northern part of Geyser (Lake) Valley to the east and Steptoe Valley to the north. Thus, based on the difference in water-level altitudes in the several valleys, the potential direction of ground-water discharge from Cave Valley is limited to the south and west.

By a similar line of reasoning it could be postulated that ground water is recharged to Cave Valley from Steptoe and Geyser Valleys. However, the principal recharge from precipitation in Cave Valley is derived from the Egan and Schell Creek Ranges, which bound the east and west sides of the valley, and most of this recharge occurs north of T. 7 N. The area of recharge probably is an area of a relative high water level compared to the ground-water levels in the adjacent valleys. Thus, it is inferred that the water-level altitudes beneath the mountains in this part of Cave Valley are sufficiently high to form a hydraulic divide and thus, to preclude ground-water underflow from Steptoe and Geyser Valleys to Cave Valley. This contrasts with the south end of Cave Valley where the mountains are much lower and recharge from precipitation is small to negligible; thus, an hydraulic barrier to underflow through the Paleozoic carbonate rocks from the valley probably does not exist.

The above discussion of the regional ground-water system in the carbonate rocks in the vicinity of Cave Valley is greatly simplified. However, the system actually has a much greater complexity. For example, locally there are perched ground-water bodies which tend to obscure the regional system to some extent. Thus, many of the small springs issuing in the mountains probably are related to perched ground-water bodies and do not reflect the position of the regional ground-water system in that locality. Indeed, it is not unlikely that the ground-water system in the valley fill in the vicinity of Cave Valley playa might appropriately be classified as semiperched with respect to the underlying regional ground-water system in the bedrock.

Estimated Average Annual Recharge

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

The precipitation map of Nevada (Hardman and Mason, 1949, p. 10) has been modified by Hardman (oral communication, 1962) in part to adjust to recent topographic base maps for the region. This is the same base used for plate 1 of this report. Five precipitation zones were selected: the boundary between the zones of less than 8 inches and 8 to 12 inches was delineated at the 6,000-foot contour; between 8 to 12 inches and 12 to 15 inches at the 7,000-foot contour; between 12 to 15 inches and 15 to 20 inches at the 8,000-foot contour; between 15 to 20 inches and more than 20 inches at the 9,000-foot contour.

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

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

Table 3 summarizes the computation of recharge. The approximate recharge (column 5) for each zone is obtained by multiplying the figures in columns 2, 3, and 4. Thus, for the zone receiving more than 20 inches of precipitation, the computed recharge is 3,500 acres x 1.75 feet x 0.25 (25 percent) = about 1,500 acre-feet. The estimated average annual recharge to the ground-water reservoir in Cave Valley is about 14,000 acre-feet.

Table 3.--Estimated average annual ground-water recharge from precipitation in Cave Valley

(1) Precipitation zone (inches)	(2) Approximate area of zone (acres)	(3) Average annual precipitation (feet)	(4) Percent recharged	Estimated recharge (acre-feet) (2 x 3 x 4 + 100)
20+	3,500	1.75	25	1,500
15 to 20	19,500	1.46	15	4,300
12 to 15	69,000	1.12	7	5,400
8 to 12	114,000	.83	3	2,800
8-	29,000	--	-	--
	235,000	Estimated average annual recharge (rounded)		14,000

Estimated Average Annual Discharge

Some ground water is discharged from Cave Valley by transpiration of water-loving vegetation (phreatophytes) and by evaporation along stream channels and a smaller amount is discharged from wells. However, most ground-water discharge from the valley probably is by underflow through bedrock to the west, southwest, or south. The quantity of this underflow could not be estimated directly, because the hydrologic and geologic data are inadequate. However, an indirect estimate of the average annual underflow from Cave Valley can be made, based on the fundamental concept that over the long term, assuming no change in storage, recharge must equal discharge.

Ground-water discharge by evapotranspiration probably does not exceed a few hundred acre-feet a year. Evapotranspiration of ground water is limited to the area along the main drainage channel in the valley fill in Tps. 9 and 10 N.

adjacent tributary channels, and along channels in the upper parts of the alluvial apron where the water table is at shallow depth, such as in the vicinity of stock wells 9/62-1a1 and 10/63-25a1, and to the spring areas in sec. 9, T. 9 N., R. 64 E. and near the Gardner Ranch. Pumpage from stock wells probably does not exceed 100 acre-feet a year. Thus, the estimated average annual discharge of ground water by evapotranspiration and pumpage from wells is not more than several hundred acre-feet. In contrast, the estimated average annual recharge to ground water is about 14,000 acre-feet (table 3). If the values of recharge and discharge are of the correct magnitude, then by difference the discharge of ground water by underflow through the bedrock is only several hundred acre-feet less than the 14,000 acre-feet estimated for annual recharge.

Inasmuch as the estimate of discharge is based on the estimate of recharge, the estimated discharge in no way provides an independent check on the accuracy of the estimate of recharge.

Perennial Yield

The perennial yield of a ground-water system is limited ultimately by the average annual recharge to and natural discharge from the ground-water system. It is the upper limit of the amount of water than can be withdrawn from the system for an indefinite period of time without causing a permanent depletion of ground water in storage. The average recharge from precipitation and the average discharge by evapotranspiration, discharge to streams, and underflow from a valley are measures of the natural inflow and outflow from the ground-water system.

In an estimate of perennial yield, consideration should be given to the effects that ground-water development of wells may have on the natural circulation in the ground-water system. Development by wells may or may not 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 from wells theoretically is offset eventually by a reduction of the natural discharge. In practice, however, it is difficult to offset fully the discharge from wells by a decrease in the natural discharge, except when the water table has been lowered to a level that eliminates both underflow and evapotranspiration in the area of natural discharge. The numerous pertinent factors are so complex that, in effect, specific determination of perennial yield of a valley 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.

The apparent substantial ground-water underflow out of Cave Valley further complicates the evaluation of perennial yield. Pumping from wells might not salvage much of this discharge unless the wells were drilled so as to intercept the discharge or unless pumping resulted in the removal of a substantial part of the ground water in storage in the valley fill. To accomplish the required lowering of water levels in the valley fill, pumping lifts probably would have to be considerably in excess of present economic pumping lifts for irrigation.

However, to the extent that ground water occurs in the valley fill, development is possible in Cave Valley. On a perennial basis the amount would be limited to the ground water actually recharging the permeable water-yielding zones in the valley fill and in which the depth to water is shallow enough to pump economically. The rate at which ground water in Cave Valley could be pumped perennially under the above conditions is not known but may not exceed a few thousand acre-feet per year. The extent to which the yield could be increased above this amount is related largely to the amount of underflow from the valley that could be salvaged. In any event, assuming that all natural discharge could be salvaged, the yield could not exceed the average annual recharge on a continuing basis.

Storage

A considerable amount of ground water is stored in the valley fill in Cave Valley. It is many times the volume of the average annual recharge to the ground-water reservoir. The magnitude of this stored ground water may be estimated by the following calculation: The surface area of the valley fill below the 7,000-foot contour is a little more than 143,000 acres. If it is assumed that only about 100,000 acres overlies a reasonably thick section of valley fill that is saturated, and if a value of 10 percent is assumed as the specific yield (drainable pore space) of the saturated deposits, then about 10,000 acre-feet of water is in storage for each foot of saturated valley fill. Thus, the amount of water in storage in the upper 100 feet of saturated valley fill would be about 70 times the estimated average annual recharge to the ground-water reservoir. Because the depth to water commonly may be 300 feet or more in this part of the valley, pumping in quantity from this area probably would not be economically feasible for most uses.

The principal point to be recognized is that the volume of ground water in storage provides a reserve for maintaining an adequate supply for pumping during protracted periods of drought or for temporary periods of high demand under emergency conditions. This reserve, in effect, increases the reliability of ground water as a dependable source of supply and is an important asset in semiarid regions where surface-water supplies vary widely from year to year.

Chemical Quality

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

No samples of water were collected for chemical analysis, and as a matter of fact there are not yet sufficient sampling points available in Cave Valley to determine the general chemical character of the ground water in the various parts of the valley. On the basis of the general chemical character of water associated with Paleozoic limestone and dolomite rocks elsewhere in eastern Nevada, the ground water in Cave Valley, at least in the marginal parts of the valley fill adjacent to the area of recharge, probably is a calcium-magnesium bicarbonate type and probably slightly to moderately mineralized. To the writer's knowledge, no serious effort to raise crops by irrigation has been attempted in Cave Valley, but should an attempt be made, the water developed for irrigation should be analyzed to determine its chemical suitability for the proposed crop.

Development

Ground water presently is used to a minor extent for stock supplies in Cave Valley, and well 9/63-1a1 is equipped with a small turbine pump. Water from this well may have been used to a limited extent for the irrigation of native meadow grasses. The volume of water discharged from wells and springs probably is less than 100 acre-feet a year. Although data are not available to indicate where moderate-to large-capacity wells might be developed, yields of a few hundred gallons a minute probably could be developed along the principal channel and its tributaries in the latitude of T. 9 N., and the southern part of T. 10 N. Initial efforts to develop ground water in Cave Valley might well take advantage of the shallow depth to water in this area; that is, carefully constructed wells or infiltration systems may result in development of moderate supplies at a reasonable cost.

Moderate supplies also might be developed locally in the middle segment of the alluvial apron on both sides of the main channel north of the playa, although the water-yielding character of the water-bearing zones is not known. Adjacent to principal canyons ground water may locally be within 100 feet of land surface, but for much of the alluvial apron and in the immediate vicinity of the playa the water table probably is in excess of 200 feet. Before extensive development is attempted, it would seem prudent to put in one or more test holes in favorable localities to determine whether moderate to large supplies can be obtained from wells.

PROPOSALS FOR ADDITIONAL GROUND-WATER STUDIES

In compliance with the request of Hugh A. Shamberger, Director, Nevada Department of Conservation and Natural Resources, the special studies listed below are suggested as necessary for obtaining basic data for a better understanding of the factors that influence or control ground water in Cave Valley and other areas in Nevada. These studies are separate from the normal areal investigations that commonly are needed after development of ground water in a given valley becomes substantial.