UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
GROUND WATER BRANCH

GROUND-WATER AND DRAINAGE PROBLEMS IN THE WHITNEY TERRACE AREA, BOISE, IDAHO

By S. W. West

Open-file report. Not reviewed for conformance with Geological Survey editorial style and use of stratigraphic names

Prepared in cooperation with the Idaho State Department of Reclamation, M. R. Kulp, State Reclamation Engineer.

Boise, Idaho
July 1955
55-192

CONTENTS

ILLUSTRATIONS

GROUND-WATER AND DRAINAGE PROBLEMS IN THE WHITNEY TERRACE AREA, BOISE, IDAHO

By

S. W. West

ABSTRACT

Ground-water levels in the Whitney terrace area, after many years of rise owing to downward percolation of water from irrigated land, became nearly stabilized by 1935. Strong seasonal water-level fluctuations of 8 to 10 feet, however, are common in the Boise Valley. In recent years, the Whitney terrace has been changing rapidly from a farming to an urban community. The 3,200-acre area now has about 15,000 inhabitants and the land area is about 35-percent occupied by urban developments. Population trends indicate that urban expansion will continue.

Coincident with the change from rural to urban conditions on the Whitney terrace, the patterns of water use were drastically altered. The amount of irrigated land has decreased but the amount of ground-water recharge from irrigation and yard water may have increased. Liquid sewage effluent disposed in the ground also has increased the yearly volume of recharge. The estimated average yearly amount of recharge from all sources now is about 2.4 acre-feet per acre. Full urban development of the area may increase recharge from all sources to about 3.3 acre-feet per acre.

Ground-water and drainage problems can be relieved by reducing excessive recharge to the ground-water reservoir. Reduction can be accomplished by economical use of water by individuals, establishment of a water-tight public sewage system to transport all sewage to a central plant outside of the area, and by drainage works. These measures would cause a net decline of ground-water levels in the area. They can be undertaken separately or collectively.

Physical and Cultural Setting

The part of Boise and its suburbs that is locally called the Boise Bench is herein called the Whitney terrace. The Whitney terrace is one of a series of terraces which are remnants of ancient river flood plains south of Boise in T. 3 N., R. 2 E., Boise baseline and meridian (pl. 1). The area of principal concern in this report is bounded on the north and east by Emerald Street, Crescent Rim Drive, and U. S. Highway 30, on the south by the New York Canal, and on the west by Curtis Street. This area, containing about 3,200 acres, is largely residential but includes several shopping centers, a few small industrial establishments, and numerous small "spare-time farms."

Water for irrigation in the Boise Valley was first diverted from the Boise River in 1864, using simple ditch diversions to supply small lowland tracts. Agricultural development was extensive and rapid after the turn of the century. The valley and adjacent terrace uplands now are crisscrossed by a maze of irrigation canals and open drains. The Whitney terrace was a part of the irrigated area, but after about 1940 urban developments rapidly replaced agriculture and now occupy about 35 percent of the Whitney terrace east of Curtis Street.

The population trend in Boise and adjoining suburban residential and business areas is summarized in table 1. The population within the city limits in 1950 was 34,393, whereas the total urban and suburban population in Greater Boise was 48,310. The present population of Greater Boise probably exceeds 50,000, including an increase of about 32 percent in the population of Boise since 1940. Civic organizations predict that in 10 to 20 years areas like the Whitney terrace will be 80 to 100 percent occupied by nonagricultural developments.

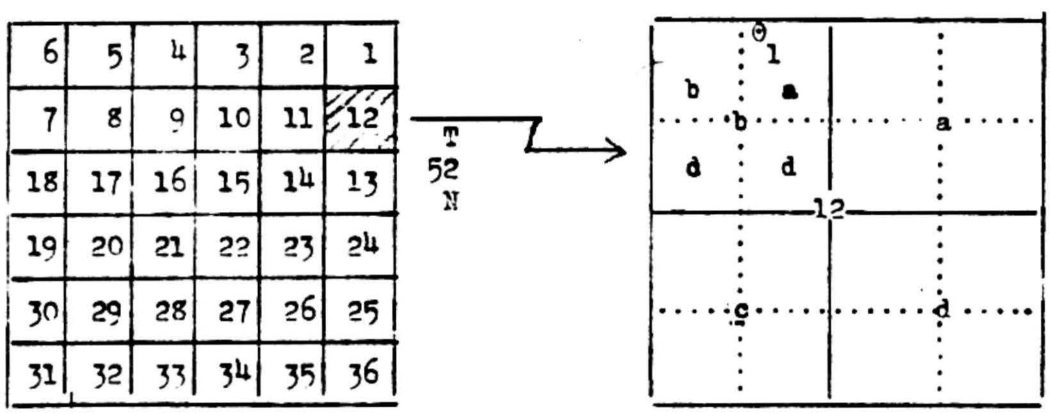
Table 1. Population increase in Boise, Idaho, 1880 to 1950

(From published reports of the U. S. Census of Population)

Year	Population	Increase	
		Number	Percent
1880	1,899	904	90.9
1890	2,311	412	21.7
1900	5,957	3,646	157.8
1910	17,358	11,401	191.4
1920	21,393	4,035	23.2
1930	21,544	151	0.7
1940	26,130	4,586	21.3
1950	34,393	8,263	31.6

System of Numbering Wells

The well-numbering system used by the Geological Survey in Idaho indicates the locations of wells within the official rectangular subdivisions of the public lands, with reference to the Boise baseline and meridian. The first two segments of a number designate the township and range. The third segment gives the section number, followed by two letters and a numeral, which indicate the quarter-section, the 40-acre tract, and the serial number of the well within the tract. Quarter sections are lettered a, b, c, and d in counterclockwise order, from the northeast quarter of each section (see diagram). Within the quarter-sections 40-acre tracts are lettered in the same manner. Thus well 2N-3W-12ba1 is in the NE¼NW¼ sec. 12, T. 2 N., R. 3 W., and is the well first visited in that tract.



R. 3 W.

2N-3W-12

2N-3W-12cd1

Basis for Report

A basinwide study of ground water in the Boise Valley was made by the Geological Survey in 1953 and 1954. Records of water levels obtained by that study afford a good history of ground water in the valley during the past 40 years. A brief examination of the Whitney terrace had been made several years earlier at the request of R. E. Edlefsen, Mayor of Boise, and periodic observations of water levels have been made since then. The data obtained are sufficient to delineate the nature and scope of ground-water and drainage problems in the Whitney terrace.

Field work on the Whitney terrace and the preparation of this report were part of the program of ground-water study by the Geological Survey in cooperation with the State of Idaho. Cooperative work in Idaho is directed jointly by A. N. Sayre, chief of the Ground Water Branch, Geological Survey, and Mark R. Kulp, Idaho State Reclamation Engineer. Work in Idaho is supervised by R. L. Nace, district geologist, Boise, Idaho.

Nature of the Problems

Upstream dams and storage reservoirs on the Boise River completely altered the natural flow-pattern of the river. Concurrently, surface water spread on irrigated land contributed a large volume of new ground-water recharge and drastically changed the ground-water regimen. The depth to the water table beneath the Whitney terrace and similarly situated areas in the Boise Valley originally was at least several tens of feet, and was maintained at that level by a natural balance between ground-water recharge and ground-water discharge. Discharge was by seepage into natural surface drainageways, chiefly the Boise River, and by westward underflow out of the valley. These processes still continue but, in order to discharge the increased volume of ground-water, the underground reservoir filled to a higher level, thus increasing the area of discharge and the volume of underflow. During the period of ground-water buildup, which still continues at some localities, recharge greatly exceeded discharge and water levels rose steadily (fig. 1). An approach to stability was reached in the late 1930's but there are strong seasonal water-level fluctuations. Drainage and sewage-disposal problems are chronic in parts of the Whitney terrace and are recurrent in other large parts during times of high ground water levels. Both the long-term water-level trends and seasonal fluctuations in the Whitney terrace resemble those in the Boise Valley generally, because the controlling factors are similar. Nevertheless, the ground-water reservoir in the Whitney terrace is largely independent, and satisfactery drainage and control of ground water in the terrace does not depend on drainage and control of the entire valley.

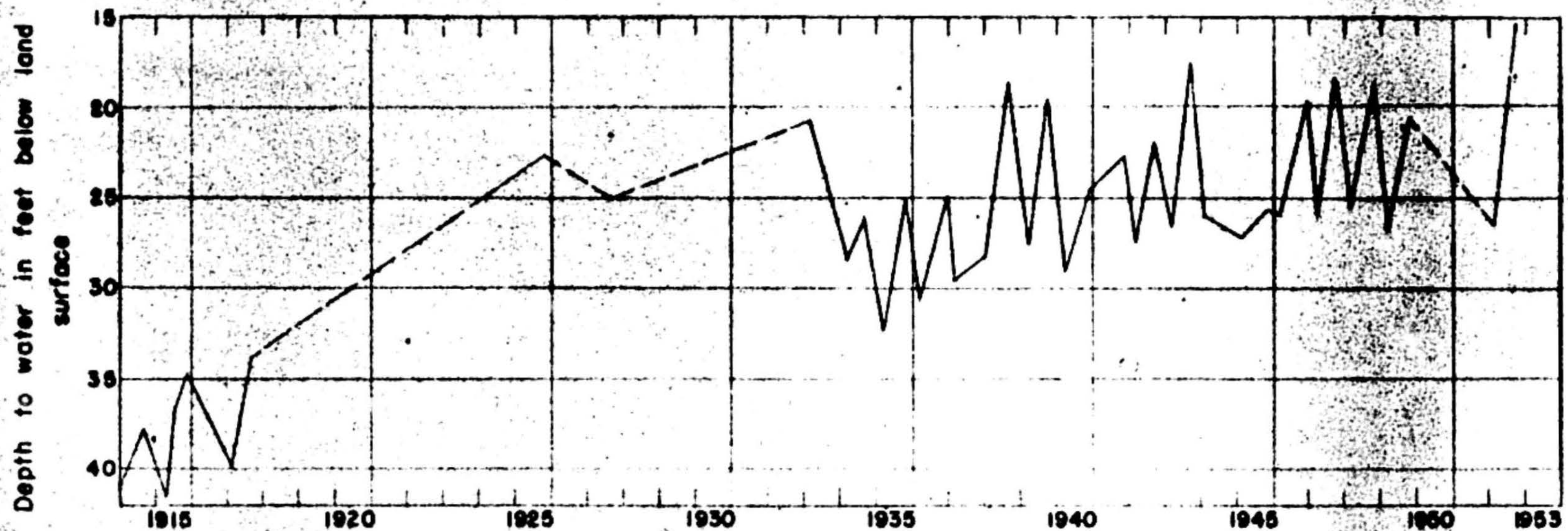


Figure 1.—Hydrograph of well 4N-2E-31cc (about 1 mile northwest of the Ada County Hospital) for the period 1914-52, showing seasonal water-level fluctuations and long-term net rise of the water table.

The New York and Ridenbaugh canals once were a principal source of ground-water recharge in the Whitney terrace, because infiltration losses from these canals were large. Much of the canals on the terrace now is lined or sealed and the principal remaining sources of recharge are domestic sewage and irrigation water spread on fields and yards. Recharge from irrigation is clearly shown by strong seasonal water-level fluctuations, ranging from about 3 to 15 feet. The smaller fluctuations are at places where the water table is very shallow.

Surface drainage of the relatively flat Whitney terrace formerly was along several shallow natural drainageways. These are blocked at many places by road grades and earth-fill for other construction, and surface water tends to pond and sink into the ground rather than to run off. Surface drainage now is largely through artificial ditches. The earliest occurrence of undesirably high ground-water levels reportedly was near places where the natural drains were artificially blocked.

The approximate average minimum depth to water in several segments of the Whitney terrace is shown in plate 1. The depth-to-water zones represent the highest recorded recent water levels in numerous wells. The depth to water in these zones varies somewhat from year to year and from season to season, and the representation necessarily is generalized and approximate. Local deviations from the depth to water shown on the map occur and the map, therefore, does not accurately show the depth to water at any specified point at a given time of the year.

Physical Factors That Influence The Ground Water

The ground-water and drainage conditions in the Whitney terrace are influenced by both natural and artificial physical factors. Climate strongly affects ground-water recharge. Topographic features affect surface runoff, the amount of water that percolates into the ground, the direction of ground-water movement, and the places at which ground water is discharged from springs and seeps. Geologic features affect the rate of ground-water recharge, the storage capacity of the ground-water reservoir, and the direction and speed of ground-water movement. The principal artificial effects on ground water in the Whitney terrace area are from water use, chiefly pumping, surface-water irrigation, and sewage disposal.

Climate

Precipitation in the area is highly seasonal, being heaviest in winter and lightest in summer. The average annual precipitation at Boise was 11.48 inches during the period 1921 to 1950. Only a relatively small amount of the precipitation recharges ground water by direct infiltration. The amount of recharge from other sources is relatively large and induces relatively large water-level fluctuations that tend to obscure the effects of recharge from precipitation (fig. 2). The influence of climatic factors other than precipitation is relatively small in this area. Temperature, of course, affects precipitation as rain or snow and, when the temperature is low, freezing of the ground impedes infiltration.

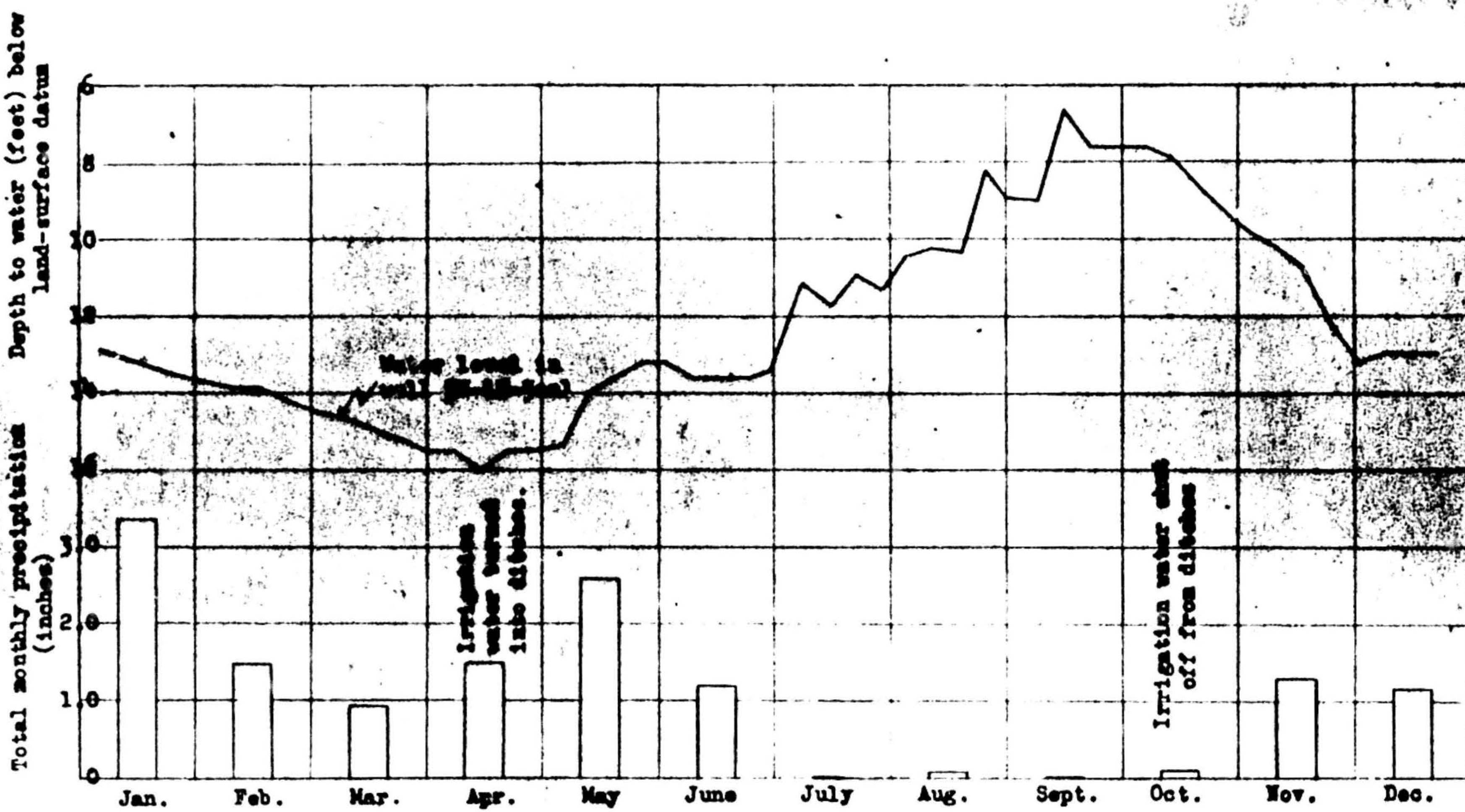


Figure 2.—Graphic comparison of total monthly precipitation at Boise Airport with water-level fluctuations in well 3N-1E-5aa1 ~~for~~ 1953. Shows lack of discernible correlation between precipitation and water-level fluctuations, owing to dominating masking effect of ground-water recharge from surface-water irrigation.

Topographic Factors

In areas where recharge of ground water is by downward percolation to homogeneous water-bearing material, the water table tends to be a subdued replica of the land-surface configuration. Commonly, however, the rate of downward percolation is not uniform, owing to horizontal and vertical variations in the ability of materials to transmit water. In general, within a limited area, the higher the land surface, the greater the depth to water, but this relation is modified by other factors. For example, the Broadway terrace is about 60 feet lower than the Whitney terrace (fig. 3), but the depth to water on each along the line of Roosevelt Street is 5 to 15 feet. The ground water in the terraces is affected strongly by local geology and by rapid local recharge. The influence of topography is shown, however by the rise of the water table towards the Sunrise terrace. Southward from the Sunrise terrace, however, the water table drops, though the land surface continues to rise. Recharge in the non-irrigated area to the south is not sufficient to maintain the water table as high as that beneath the Whitney terrace.

In general, the depth to water on individual terraces is greater near the terrace fronts (pl. 1), owing to loss in hydraulic head by ground-water discharge at the base of the terrace (fig. 3). Ground-water seeps are common along the base of the steep front of the Whitney terrace, where the land surface intersects the water table.

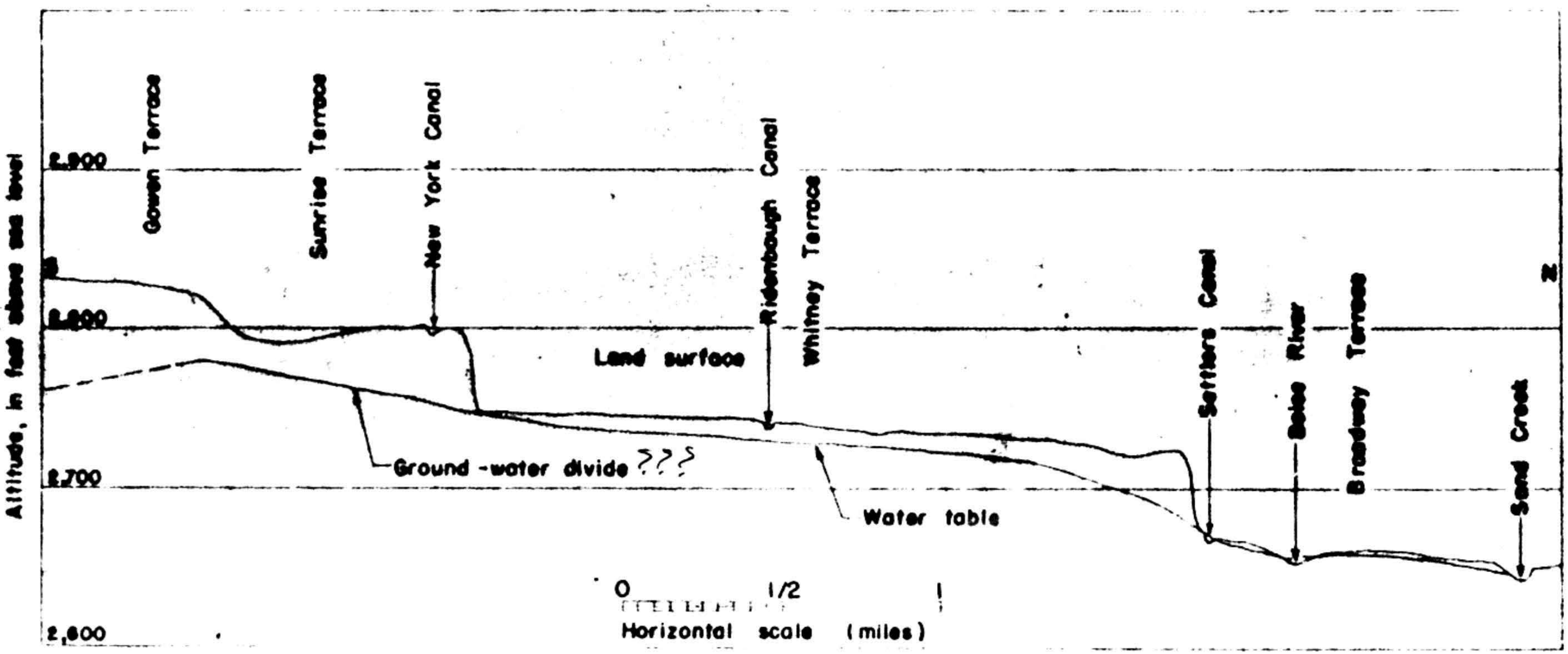


Figure 3.—Generalized profile and cross-section south of Boise River at Boise, Idaho, showing relation of water table and land surface in summer of 1953. Profile is approximately along the line of Roosevelt st.

Geologic Factors

The occurrence and behavior of ground water in the Whitney terrace is somewhat variable because the water-bearing materials range from highly permeable to nearly impermeable. The area is underlain at great depth by a "basement" or floor of ancient granitic rocks. Overlying the basement rock are interbedded fine sediments and volcanic ash, permeable to impermeable volcanic rocks, and a thick accumulation of lake beds, chiefly clay and sand. Materials in the upper 15 to 40 feet are alluvial clay, sand, and gravel, which were deposited in former channels and on earlier flood plains of the Boise River (fig. 4). Characteristically, the stream deposits consist of discontinuous stringers of gravel and sand in flood plain silt and clay. Thin beds of well-sorted clay, sand, and gravel occur locally at shallow depth. Beds of well-sorted clay are nearly impervious to water, owing to the small size of interstitial openings. Ground water moves readily through clean coarse sand and gravel, but much of the Whitney terrace sand and gravel contains clay and silt that partially fills the interstices and impedes ground-water movement. Moreover, where sand and gravel overlie relatively impermeable beds of clay, silt, and fine sand in the Whitney terrace, the fine-grained sediments impede downward percolation of water from the gravel, causing high water levels, especially during the irrigation season, when recharge exceeds underflow from the area.

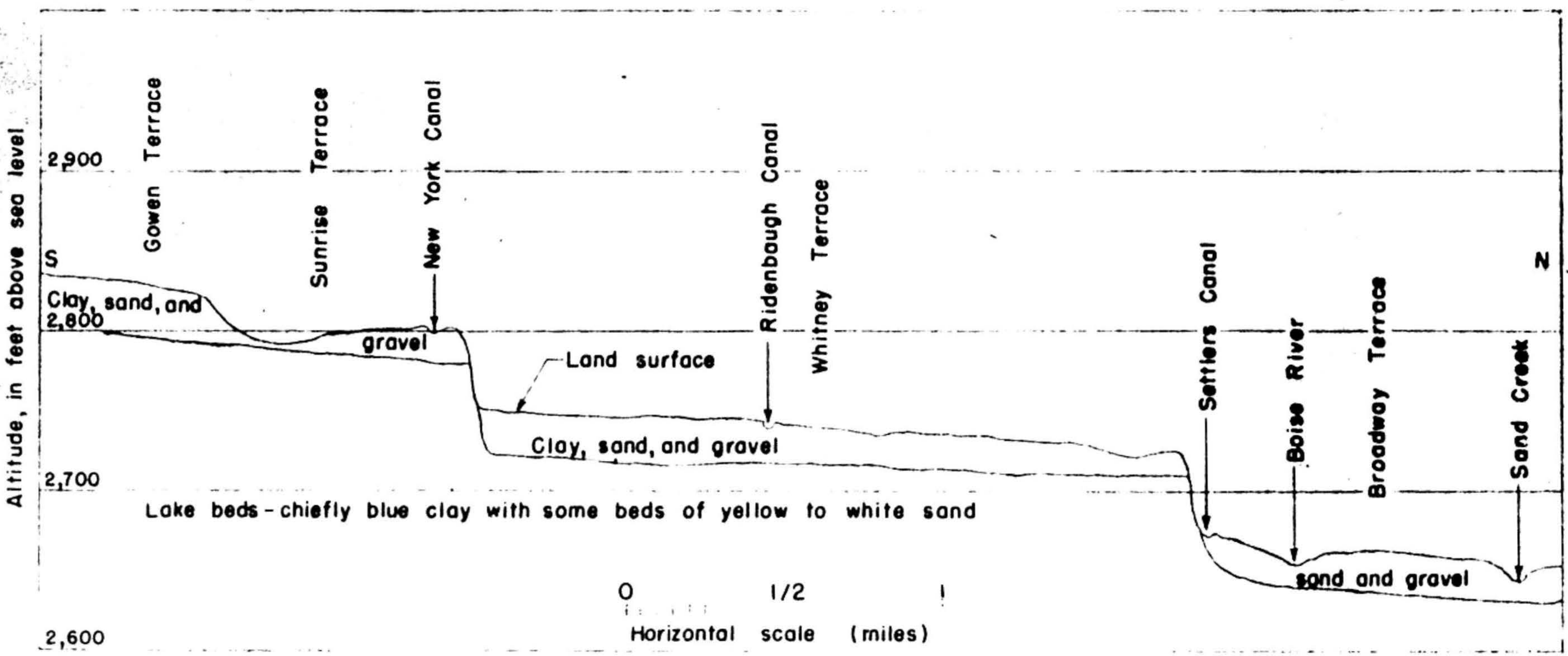


Figure 4.—Generalized profile and cross-section south of Boise River at Boise, Idaho, showing the relation of river flood plain deposits to the older lake beds of the Idaho formation. Profile is approximately along the line of Roosevelt st.

Artificial Factors

The principal artificial factors that influence ground water in the Whitney terrace are irrigation, yard watering, and liquid-sewage discharge. The contribution of each to ground-water recharge is large.

Unconsumed irrigation water and yard water enter the ground from unlined canals, irrigated farms, gardens, and lawns. The influence of canal losses on ground-water levels is illustrated by water-level fluctuations in well 3N-2E-25bb2, on Apple Street a few hundred feet north of the Ridenbaugh canal. Shortly after water is turned into the canal in the spring the water level in the well rises sharply (fig. 5).

The amount of ground-water recharge from irrigation depends on the permeability of the soil, the amount of water applied, and the amount of water retained above the water table as soil moisture. The amount of water applied to the land and the portion of that water that reaches the water table have not been determined accurately for the Whitney terrace. The average yearly farm delivery of irrigation water in the Whitney terrace is assumed to be about 4 acre-feet per acre. Watermaster records indicate that farm delivery of water in the terrace is appreciably more than 4 acre-feet per acre, and canal diversions may be as much as 6 acre-feet per acre in some years. However, in the urban area many landowners do not use the water to which they are entitled, but divert it into drains which ultimately carry it back to the canal. For the purpose of this report, and to illustrate the effects of irrigation, the farm-delivery figure of 4 acre-feet per acre is sufficiently accurate. The estimated average depletion of the irrigation water by consumptive use is assumed to be 2 acre-feet per acre. Assuming that there is little or no surface runoff of unconsumed water, the average yearly net recharge from irrigation on the terrace is about 2 acre-feet per acre of irrigated land. Infiltration from unlined canals contributes an additional but unknown amount of recharge. Recharge from irrigation temporarily raises the water levels an average of 8 to 10 feet in much of the Boise Valley (see hydrographs of wells), and comparable rises probably occur in the Whitney terrace, saturating the ground all the way to the surface at some places.

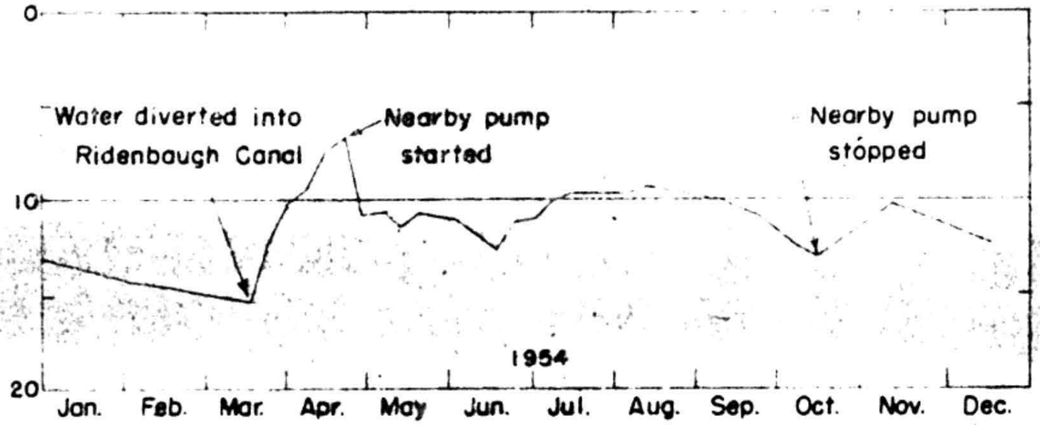


Figure 5.—Hydrograph of well 3N-2E-25bb2 (on Apple st. near Ridenbaugh Canal), ~~for~~ 1954, showing the changes in water level caused by canal leakage and pumping from nearby drainage well.

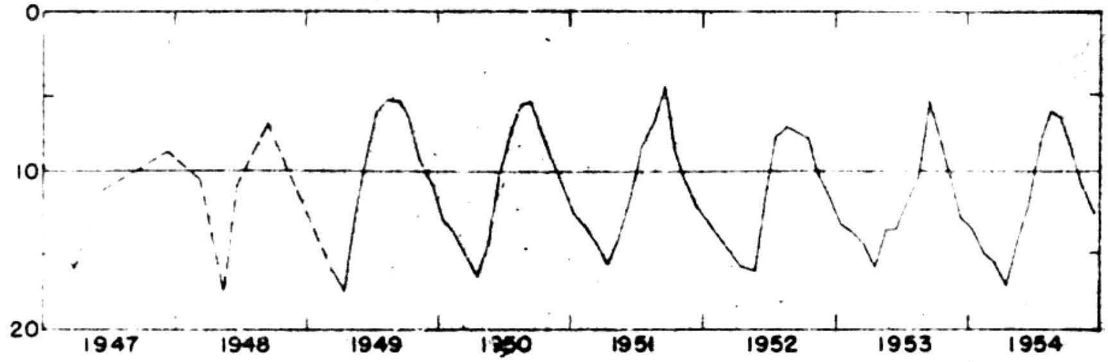


Figure 6.—Hydrograph of well 3N-1E-5aa1 (5 miles west of Boise on Ustick Road), ~~for the period~~ 1947-54, showing the changes in water levels caused by surface-water irrigation

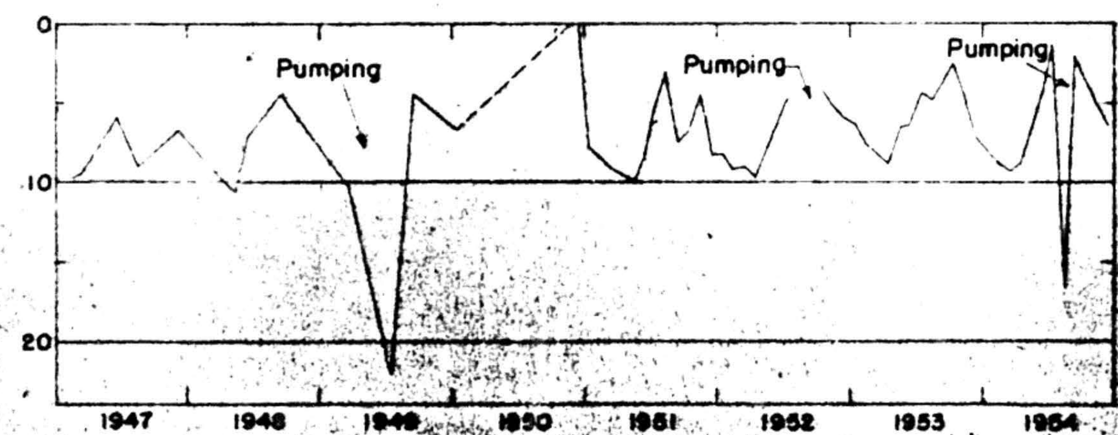


Figure 7.—Hydrograph of well 3N-2E-21bc1 (near west end of Lemhi St.), ~~for the period 1947-54~~, showing the changes in water levels caused by seasonal surface-water irrigation and temporary pumping of ground water from this well.

The part of the Whitney terrace between Curtis Street and U. S. Highway 30 contains about 3,200 acres, of which about 35 percent (1,120 acres) is residential area. The percentage of the residential area that actually is occupied by streets and buildings is not known but it is here assumed that fully developed urban tracts are 50 percent covered. Evidence suggests, however, that application of yard water is much heavier than that in irrigated fields. Thus, urban development probably does not cause much decrease in the artificial recharge. The total loss of irrigation and yard water to the ground probably is about 6,400 acre-feet a year, or an average of 2 acre-feet per acre. Full urban development of the terrace area might change the total of recharge from irrigation and yard watering, but the change cannot be estimated.

Effluent sewage from most houses and establishments on the terrace is released directly to the ground and essentially all of the liquid effluent from cesspools and septic tanks is added to the ground water. The estimated population in the area here reported on is about 15,000. The average per capita volume of sewage effluent is about 85 gallons a day[1/] and the aggregate volume is about 1,275,000 gallons a day or 465,375,000 gallons (1,400 acre-feet) yearly. Essentially all of the domestic water now used is imported from outside of the area or is pumped from deep aquifers that are unrelated to the shallow aquifers in which the drainage problem occurs. The yearly volume of sewage effluent is equivalent to 0.44 acre-foot per acre per year in the 3,200-acre area. Full urban development would increase the amount to 1.26 acre-feet per acre.

1/ Andrew Wahl, Superintendent, Sewage Dept., City of Boise. (Personal communication, 1955).

Assuming that the estimated amounts of recharge from irrigation and sewage systems are reasonably accurate, the total volume of ground-water recharge from both sources is about 2.4 (2.0 plus 0.44) acre-feet per acre a year, or 0.4 acre-foot per acre more than when the entire area was irrigated farms. Full urban development would increase the yearly ground-water recharge to about 3.26 acre-feet per acre from both sources, or 1.26 foot more than the current amount. The net amount of recharge then would be 65 percent greater than in irrigated fields. A further rise in ground-water levels, and aggravation of the drainage problem, therefore, is anticipated with continued urban development if the practice of disposing of sewage in the ground is continued.

Rising water levels would be accompanied by increased ground-water underflow from the area, and the net cumulative yearly water-level rise might be small. Seasonal fluctuation of water levels would become smaller, owing to the larger proportion of recharge from sewage effluent, which does not vary markedly in seasonal volume. Proposed future irrigation on the Hillcrest Unit of the Mountain Home Project may increase annual recharge by underflow to the Whitney terrace, and aggravate the drainage problem.

Methods of Controlling Ground-Water Levels

Several means are available for abating the ground-water and drainage problems. The Whitney terrace east of Curtis Street is so situated that its water problems can be largely isolated from those of adjoining areas. At present there is no nearby irrigated area at higher altitude than the terrace. The water table in the lower Broadway terrace is well below that on the Whitney terrace.

Possible remedies for excessive recharge of ground water include (1) economical water use, (2) insulating leaky canals, (3) establishing a water-tight public sewage system to conduct sewage effluent out of the area, and (4) construction and operation of drainage works. These remedies could be applied separately or collectively. The sewage system would become increasingly important as urban development continues. In addition to alleviating the drainage problem a closed public sewage system would reduce a potentially serious health hazard.1/

1/ H. C. Clare, Idaho State Sanitation Engineer. (Personal communication, 1955.

Drainage ditches and drainage wells merit special mention. Properly constructed wells commonly are more effective than ditches where the zone of saturation is sufficiently thick and permeable to yield large amounts of water to wells. In areas where permeable materials extend only to shallow depth and overlie less permeable materials, interception drains extending normal to the direction of ground-water movement help prevent the rise of water levels. Surface drains are less desirable in residential areas because they are unsightly, are a hazard to small children, take up a large amount of space, and commonly lower water levels only slightly.

The effect of drain ditches and wells on water levels is illustrated in figure 8. Pumping from a well causes a depression in the water table around the well in the general shape of an inverted cone. The dimensions of the cone of depression (the area of influence) depend on the ability of the water-bearing material to store and transmit water and on the rate of pumping. The amount of drawdown in a well and the size of its area of influence increase as the pumping rate and duration of pumping increase. Where the cones of depression around two or more pumping wells overlap, drawdown is increased throughout the areas of influence (fig. 9).

A considerable amount of field and laboratory study would be necessary to determine the desirable number and spacing of wells needed for satisfactory drainage.

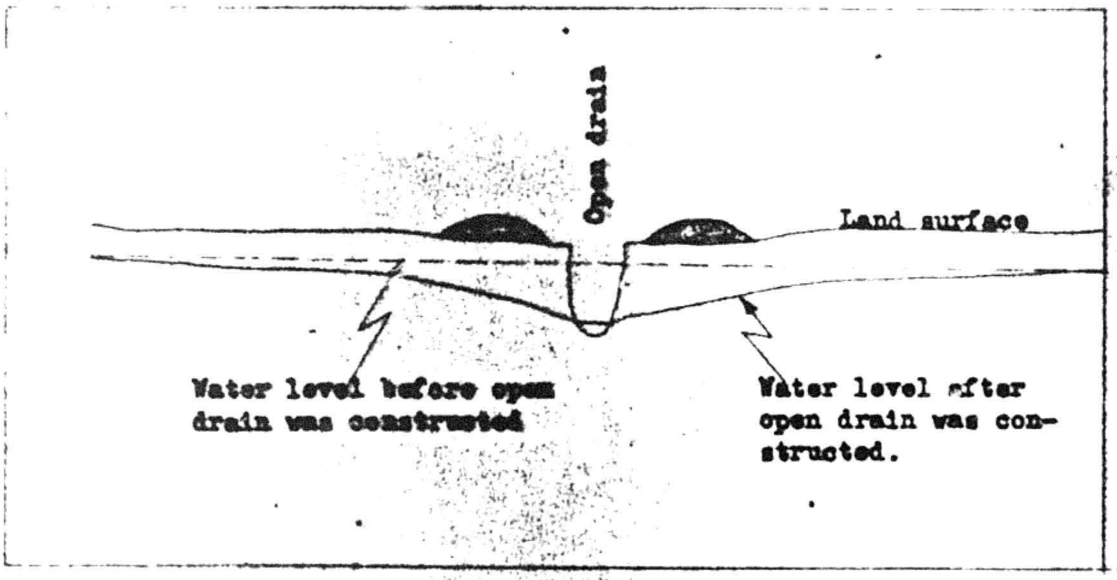


Figure 8.—Hypothetical sectional view of an open-ditch drain, showing effect on water table.

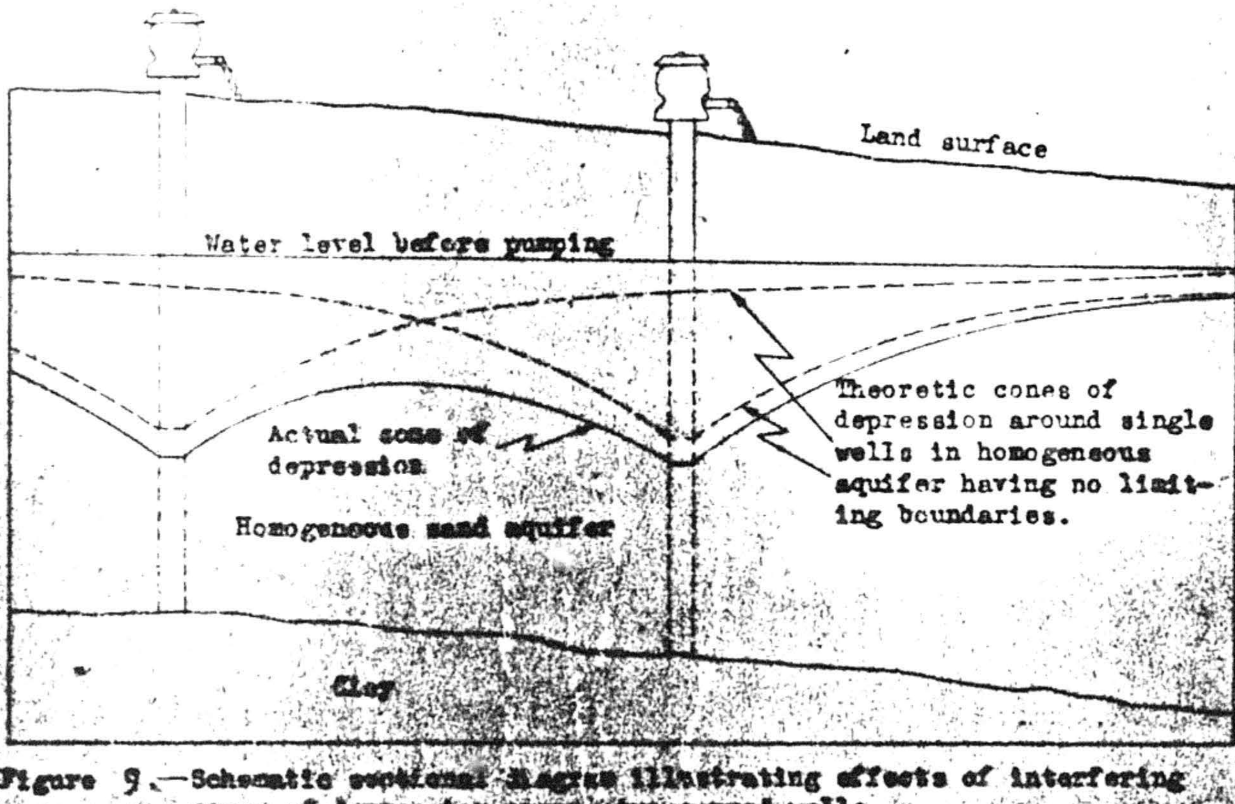


Figure 9.—Schematic sectional diagram illustrating effects of interfering cones of depression around two pumped wells.