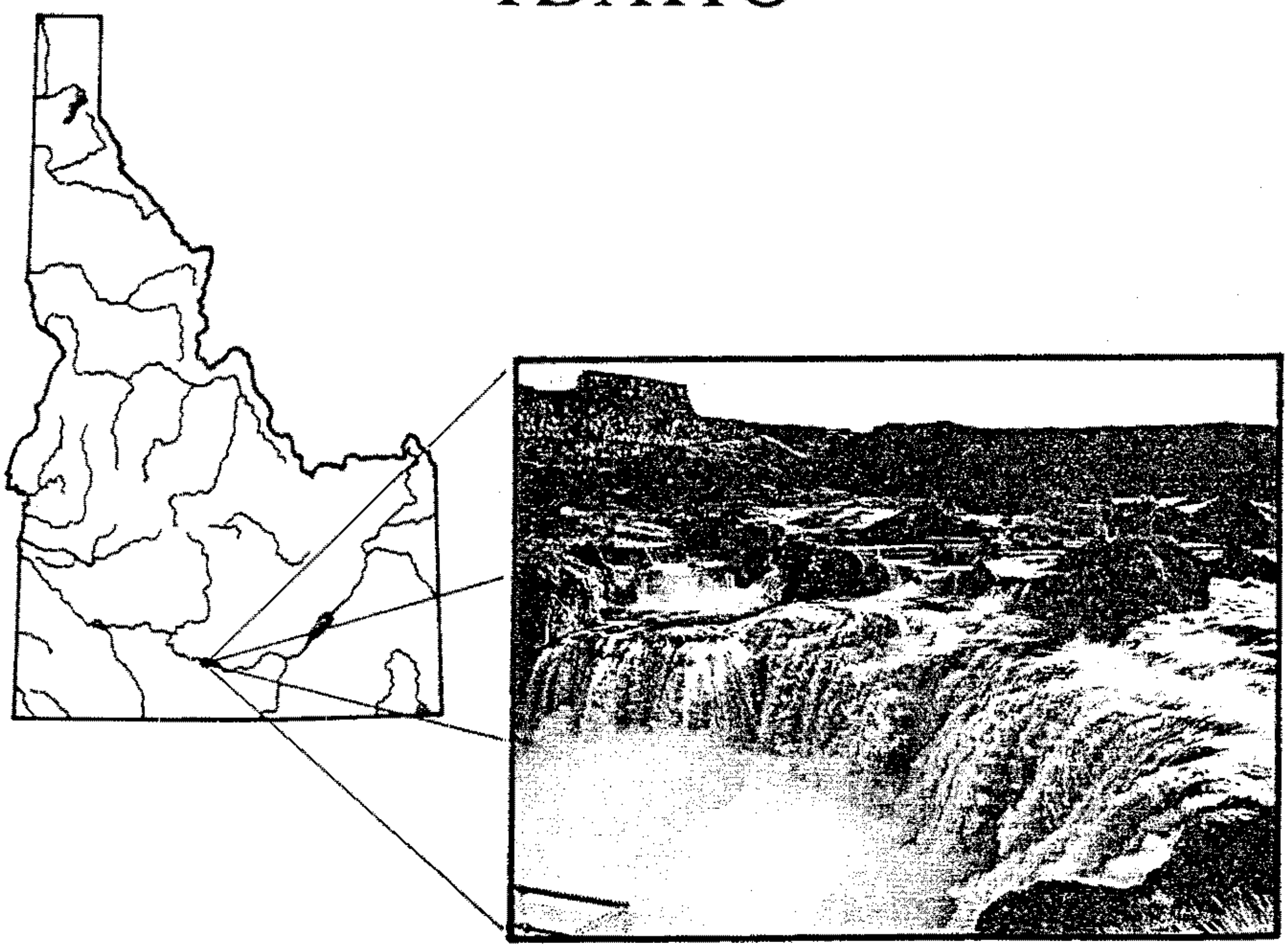
WATER RESOURCES
OF THE
TWIN FALLS TRACT, TWIN FALLS COUNTY, IDAHO



IDAHO DEPARTMENT OF WATER ADMINISTRATION

WATER INFORMATION BULLETIN NO. 22

JULY 1971

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WATER RESOURCES OF THE TWIN FALLS TRACT

TWIN FALLS COUNTY, IDAHO

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Prepared and Published by

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ABSTRACT

The water resources of the 350 square mile Twin Falls Canal Company tract are evaluated by assimilation of all available hydrologic and geologic data. The primary purpose of the study is to determine the availability of water supplies for off-the-tract development. This determination was made by analyzing the characteristics of the water resources of the entire tract.

The total inflow to the tract from all components is estimated at 1,600,000 acre-feet per annum. The quantity of water not consumed on the tract during a typical water year is estimated at 1,140,000 acre-feet. Streams and drains discharge an estimated 740,000 acre-feet per year as determined from flow records. An annual ground-water discharge from the tract of 400,000 acre-feet is estimated. The quantity of ground water stored in the top 100 feet of saturated material is estimated at 1,000,000 acre-feet. Streamflow hydrographs and ground-water levels indicate a direct relationship between the availability of both surface and ground water and the magnitude of diversions for irrigation onto the tract. Ground-water and surface-water chemical quality is uniform and suitable for irrigation of most crops

Three geologic units function as aquifers within the study area, but the productivity of existing wells indicates that a large-volume well field cannot be successfully developed on the tract. Development of the ground-water resource can probably only be achieved through numerous small-discharge wells.

Permits and licenses for over 400 cubic feet per second of surface water and 130 cubic feet per second of ground water have been recorded. The existing diversion and use of ground water is much larger than that noted by permits and licenses because few domestic use rights have been filed.

Two general methods for utilization of the available water discharged from the tract are: (1) increased efficiency of water distribution and use on the Twin Falls Tract to reduce diversions at Milner, and (2) diversion and reuse of outflow as it occurs. The large quantity of water applied to the tract in excess of that actually required for crop growth makes additional development by either method feasible, but additional information is required before specific recommendations for projects can be made.

INTRODUCTION

PURPOSE

The water resources of the State of Idaho are perhaps its most valuable natural resource. The full and safe utilization of this resource is the primary responsibility of two state agencies: the Department of Water Administration and the Water Resource Board. The Idaho Department of Water Administration is responsible for the administration and investigation of the resource because of its responsibilities for water rights, safety of dams, well driller licensing, and flood plain management. The Idaho Water Resource Board is charged with the development of a state water plan. Both agencies are interested in additional knowledge of the ground and surface-water resources in the Twin Falls area to better perform their responsibilities.

The purposes of this study are as follows:

1. To assess the ground-water and surface-water resources of the Twin Falls Tract to provide data for greater and more effective utilization of the resource.

2. To provide a greater knowledge of the water resource of the state for water-right administration by the Director of the Department of Water Administration.

3. To provide the Idaho Water Resource Board with data on the water resources in the area to aid in the preparation of a state water plan.

OBJECTIVES

The objectives of this project are to determine the quantity, quality and the occurrence of ground water, and the quantity and quality of surface-water streams within the Twin Falls Tract. The more specific objectives are to:

1. Determine the geologic control of the ground water in the area.

2. Determine the hydrologic characteristics of the aquifers.

3. Determine the recharge and discharge characteristics of those aquifers.

4. Determine the quality of ground water and its suitability for domestic and irrigation uses.

5. Determine the flow characteristics of surface-water streams in the area.

6. Outline the water rights pertinent to the ground water and surface water in the Twin Falls Tract on file with the Department of Water Administration.

7. Determine areas of potential for additional ground-water or surface-water development and the quantities of water that might be available for those developments.

LOCATION AND EXTENT

The study area includes approximately 350 square miles of land in the northern portion of Twin Falls County (fig. 1). The area is bounded on the north by the Snake River, on the west by Salmon Falls Creek, on the south by the High Line Canal of the Twin Falls Canal Company, and on the east by the intersection of the Twin Falls South Side Canal with the Snake River at Milner, and includes all lands serviced by the Twin Falls Canal Company.

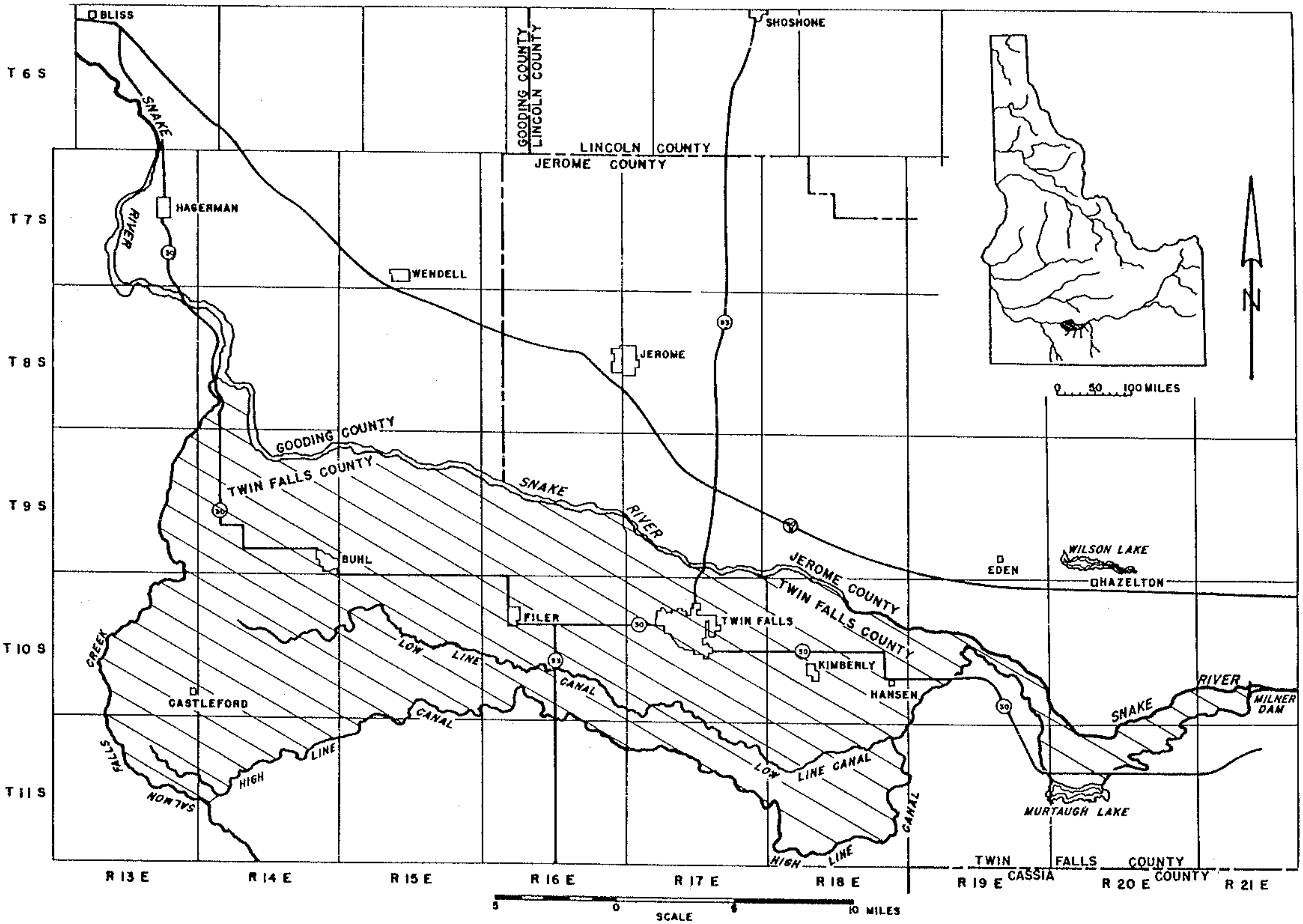

FIGURE 1. Index map showing location of area covered by this report.

The limited field work associated with this project consisted primarily of data collection trips to the offices of the Twin Falls Canal Company and the Agricultural Research Service (A.R.S.) at Kimberly. Several field samples of temperature and electrical conductivity (E.C.) were obtained from springs, drains and wells in the area.

PREVIOUS INVESTIGATIONS

The only major publication pertaining to the ground-water hydrology of the Twin Falls Tract is a study by Stearns, Crandall, and Steward (1938). This paper discussed the geology and ground-water resources of the entire Snake River Plain, but included a section on the Twin Falls Tract. Several reports have been published on the Salmon Falls Tract to the south. The most recent of these is that by E. G. Crosthwaite (1969-1) on the water resources. A report on the water resources of the Goose Creek-Rock Creek area south and east of the Twin Falls Tract was also authored by Crosthwaite (1969-2). Dr. Robert Jones of the Department of Geology, University of Idaho, has compiled water-level data on many of the wells in the Twin Falls Tract (1970). Dr. David Carter of the A.R.S. at Kimberly has headed a team of scientists collecting water discharge and water quality data of the Twin Falls Tract in connection with a study of the salt balance of the tract. The information from his studies will be presented in a series of papers to be published in the near future. Continuous discharge measurements of streams on the south side of the Snake River by the United States Geological Survey (U.S.G.S.), presented in annual reports, have been summarized in two publications by Thomas, (1968, 1969). The primary purpose of these studies was the evaluation of the north side springs in the Thousand Springs area. Miscellaneous measurements of stream discharge obtained by the U.S.G.S. in the mid-1950's and again in 1970 were also utilized in the study. Annual reports by the Twin Falls Canal Company for many of the past years, made available by Mr. Alfred Peters, General Manager, contain valuable data on water deliveries in the area as well as drain and stream discharge and ground-water levels.

ACKNOWLEDGEMENTS

The Idaho Department of Water Administration and the authors wish to acknowledge the assistance of the several organizations and individuals that provided data for this study. Included in these are: Dr. David L. Carter and Mr. James A. Bondurant, Northwest Branch, Soil and Water Conservation Research Division, Agricultural Research Service; Dr. Robert W. Jones, Idaho Bureau of Mines and Geology; Mr. Alfred Peters, Manager, Twin Falls Canal Company; and the U. S. Geological Survey, Boise, Idaho.

WELL NUMBERING SYSTEM

The well numbering system used in this study is the same as that used by the U.S.G.S. in Idaho. This system indicates the locations of wells within the official rectangular subdivisions of public land with reference to the Boise Base Line and Meridian (fig. 2). 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 respectively the quarter sections, 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 of each section. Within quarter sections 40-acre tracts are lettered in the same manner. As an example (fig. 2), well 10S 13E 30ba1, is in the northeast quarter of the northwest quarter of Section 30, Township 10 South, Range 13 East, and is the first well designated in that tract. These tracts may also be subdivided into 10-acre tracts by adding a third letter.

GEOGRAPHIC SETTING

Three major geographic features dominate the area included in the Twin Falls Tract. The first of these is a gently north to northwestward sloping plateau which includes most of the area. The slope of the land ranges from 30 to 60 feet per mile with the High Line Canal at approximately 4,100 feet and the edge of the canyon varying from 4,100 feet at Milner to 3,400 feet near Buhl.

The second major feature in the area is the deep canyon of the Snake River. The river has eroded a canyon which ranges from about 150 feet deep just downstream from Milner to 460 feet deep north of Buhl. Most of the reach of the canyon is relatively narrow but widens to approximately one-half mile north of Buhl.

The third major geographic feature, the canyon of Salmon Falls Creek, is located along the western boundary of the study area. The creek has eroded a canyon ranging from 400 to 500 feet deep, averaging approximately 1,500 feet in width. Other geographic features of interest include the deeply incised portion of the lower reaches of Cedar Draw and Rock Creek, and to a lesser extent Deep Creek and Mud Creek. Smaller streams have also cut deeply into the basalt as they near the river.

CLIMATE

The climate of the Twin Falls study area is classified as arid to semi-arid with hot summers and moderately cold winters. Weather statistics are available in annual reports from five U. S. Weather Bureau stations located on the tract and from three stations located near the tract. Most of the precipitation occurs during the late fall, winter and spring, with these months having similar average precipitation values (table 1). Average rainfall is much lower during the summer and early fall. The average annual rate of precipitation is uniformly distributed over the tract, varying from about 8 inches per year at Buhl to about 9 inches per year at the Twin Falls 2NNE station. The annual rate of precipitation for a given year can vary greatly for various locations in the tract because of localized thunderstorm activity (fig. 3). The long-term average annual precipitation for the tract was estimated at approximately 9 inches using long-term averages in the Thiessen polygon method (table 1). This level of precipitation supported only vegetation typical of a desert environment under natural conditions. Sagebrush, rabbit brush, cheat grass, and similar low water requirement vegetation predominated. Irrigation is necessary to produce nearly all of the agricultural crops grown in the area.

Average monthly temperatures vary from about 26-28° Fahrenheit (F) in January to 72-74° F in July. Areally, the average temperatures vary by only a few degrees over the Twin Falls Tract (table 1). At the Twin Falls 2NNE station, the average length of the growing season is 166 days (Stevlingson and Everson, 1968). Growing season is defined as the average number of days (or 50 percent probability) between the last 28° F temperature of spring and the first 28° F temperature of fall. The longest and shortest growing seasons

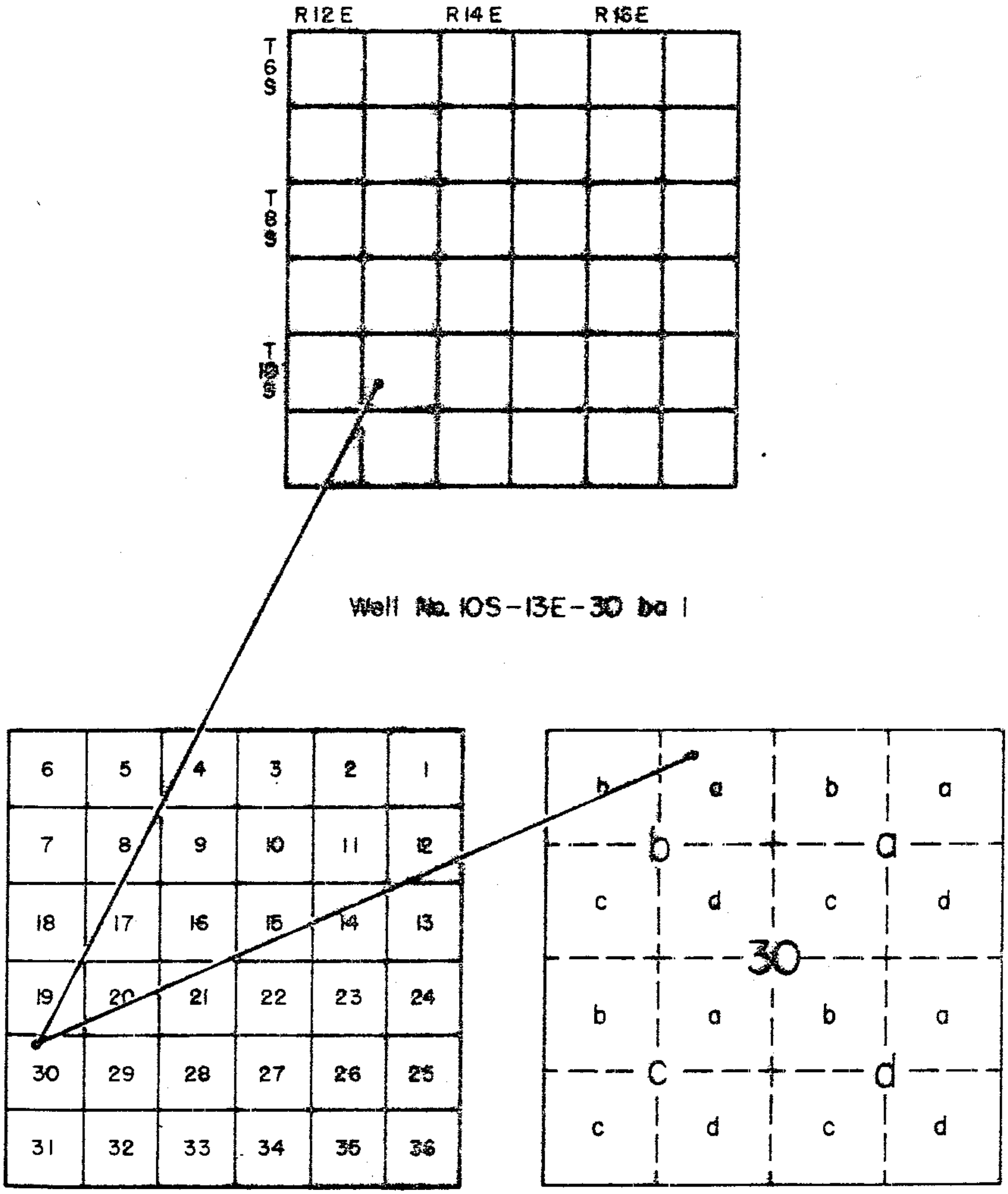

FIGURE 2. Well numbering system.

TABLE 1

AVERAGE MONTHLY PRECIPITATION AND TEMPERATURE AT STATIONS NEAR THE TWIN FALLS TRACT

Station	Buhl		Castleford		Hazelton		Hollister		Jerome		T.F. (2NNE)		T.F. (3SE)		T.F. (WBASO)	
Elevation (Ft.)	3755		3825		4060		4550		3785		3770		3765		3922	
Years of Record	44	47	7	7	50	46	54	41	53	48	64	62	45	40	7	7
Latest Year of Record Used	1963		1969		1969		1969		1969		1969		1969		1969	
Month	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)	Precip. (in.)	Temp. (°F)
January	0.96	28.1	0.64	30.4	1.35	26.3	1.09	26.6	1.26	26.5	1.04	27.3	1.02	26.9	0.69	29.6
February	0.76	33.3	0.56	32.8	1.06	31.4	0.74	31.2	0.99	31.2	0.70	32.7	0.72	31.9	0.52	32.2
March	0.78	40.6	0.57	38.9	0.98	39.2	1.01	37.1	0.93	39.0	0.84	39.9	0.87	38.9	0.64	37.4
April	0.76	49.8	0.79	46.5	0.99	48.7	1.09	46.0	0.79	49.1	0.93	50.4	0.86	48.3	0.97	45.3
May	0.98	57.6	0.63	56.6	1.09	57.0	1.23	53.9	0.87	57.4	1.00	57.4	1.01	56.5	0.74	55.3
June	0.83	64.1	2.22	62.1	.83	64.5	1.06	60.9	0.66	64.6	0.79	64.4	0.79	63.6	1.33	60.6
July	0.23	73.4	0.31	70.7	.25	73.6	0.40	71.3	0.18	74.1	0.24	72.9	0.21	72.3	0.26	69.8
August	0.17	71.0	0.76	69.0	.19	71.1	0.28	68.8	0.15	71.4	0.17	69.9	0.21	69.2	0.95	67.3
September	0.34	62.6	0.30	61.7	.39	61.9	0.43	59.9	0.41	62.4	0.49	61.3	0.46	60.5	0.47	59.6
October	0.64	52.6	0.33	49.6	.79	51.2	0.74	49.8	0.64	51.5	0.76	51.0	0.75	50.3	0.50	48.8
November	0.82	39.2	1.10	39.4	1.07	37.8	0.91	37.1	0.95	38.1	0.92	38.1	0.93	37.6	1.10	39.1
December	0.82	31.7	1.57	29.5	1.12	30.8	1.01	30.8	1.04	30.8	0.86	31.6	0.91	31.0	1.38	29.1
Total	8.09	-	9.78	-	10.11	-	9.99	-	8.87	-	8.74	-	8.74	-	9.55	-
Average	-	50.3	-	48.9	-	49.5	-	47.8	-	49.7	-	49.6	-	48.9	-	47.8

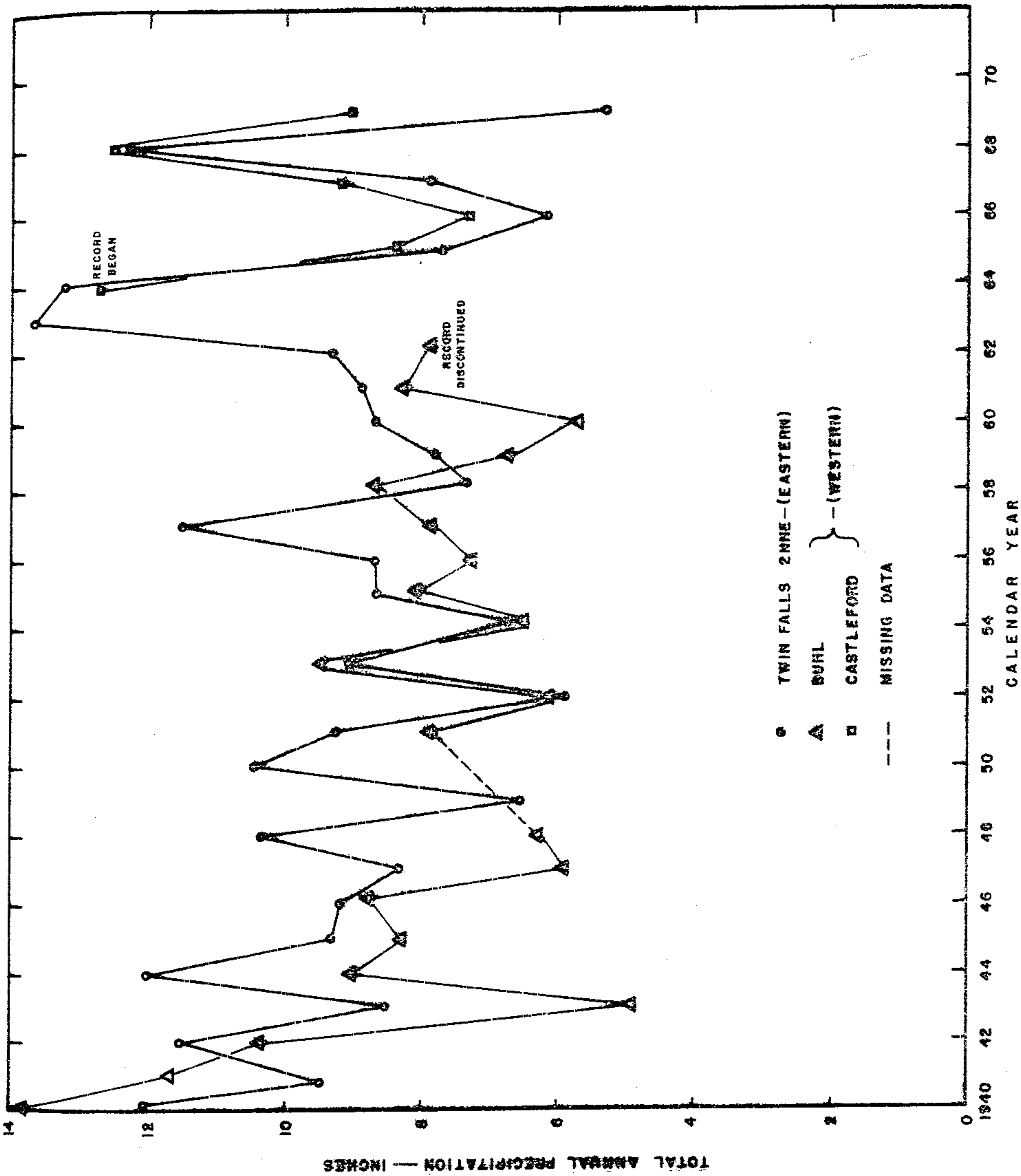

FIGURE 3. Comparison of annual precipitation of the eastern portion of the Twin Falls Tract to the western portion.

recorded at this station were 218 days and 100 days, respectively.

GROUND-WATER GEOLOGY

Three geologic units are important as aquifers in the study area and have a major effect on the characteristics of recharge, discharge and ground-water flow. The rocks vary in permeability from very low to high. Rock types include silicic latite, basalt, shale, silt, sand and gravel (Malde and Powers, 1962). A physical description of the formations and their water bearing characteristics is presented in table 2.

IDAVADA VOLCANICS

The Idavada Volcanics are the oldest rocks penetrated by wells in the Twin Falls Tract. Several wells encounter what is believed to be this formation at depths ranging from 500 to 730 feet (fig. 4). The only outcrop in the study area is in the Snake River canyon from Shoshone Falls to the Blue Lakes alcove in Sections 33-36 of Township 9 South, Range 17 East. The elevation of the top of the Idavada Volcanics in the canyon is approximately the same as that found in well 10S 17E 10bcc1, 2 miles south of the river. Very little water is presently being derived from the formation in the study area. The unit commonly yields water which is warm to hot, under sufficient artesian pressure to flow at land surface, and is characteristically high in fluorides. Well 10S 17E 10bcc1, drilled to a depth of 1,535 feet for the city of Twin Falls, yielded a small quantity of water by artesian flow at a temperature of 87^{o} F with a fluoride concentration of 6-10 parts per million (ppm). This well has since been plugged at 861 feet to exclude this water.

The permeability of the Idavada Volcanics is highly variable in southern Idaho. The formation is encountered by wells in Little Valley near Bruneau and yields large quantities of water. It is encountered in several wells in the Blue Gulch area west of Salmon Falls Creek. The yield-to-wells are highly variable depending upon the amount of fracturing (Chapman and Ralston, 1970). Crosthwaite (1969-1) also noted that the permeability is highly variable in the Salmon Falls area. The hydrologic characteristics of the Idavada Volcanics in the Twin Falls area are generally unknown as few wells have penetrated it. Its potential as an aquifer in the area is not believed to be great.

BANBURY BASALT

The Banbury Basalt is divided into three members: an upper basalt, a middle sedimentary unit, and a lower basalt. The lower basalt member, which lies on the Idavada Volcanics, is more weathered than the upper member basalt and is generally less permeable. Logs from several wells that intersect the lower basalt indicate that the unit is not productive as an aquifer. Chapman and Ralston (1970) noted that this portion of the Banbury Basalt is generally a poor aquifer in the Blue Gulch area in western Twin Falls County.

The middle sedimentary member of the Banbury Basalt is penetrated by several wells in the Twin Falls area (fig. 4). It is generally described on the drillers' logs as brown sand and silt with some gravel and is usually noted as nonproductive. Wells in the area encounter this member at depths ranging from 250 to 650 feet below land surface. This portion of the

TABLE 2

PHYSICAL AND WATER-BEARING CHARACTERISTICS OF THE GEOLOGIC FORMATIONS IMPORTANT AS AQUIFERS IN THE TWIN FALLS AREA

(After Malde, Powers & Marshall, 1963 and Crosthwaite, 1969-1)

PERIOD	EPOCH	FORMATION	PHYSICAL CHARACTERISTICS	WATER–BEARING CHARACTERISTICS
Quaternary and/or Tertiary	Pleistocene and/or Pliocene	Glenns Ferry Basalt	Olivine basalt flows, light to dark gray, dense to vesicular, porphyritic, irregularly jointed; thickness of flows ranges from about 5 to 75 ft. Fine-grained lenticular sedimentary beds as much as 15 ft. thick separate some flows. Underlies almost all the tract.	Permeability highly variable. Where joints are not filled with clay and flow contacts are permeable, yields moderate or rarely large amounts of water to wells; yields are sufficient for very small irrigation supplies at most locations.
Tertiary	Pliocene	Banbury Basalt Upper Basalt	Olivine basalt and some porphyritic plagioclase-olivine basalt generally in columnar flows as thick as 50 feet. Includes several thin sedimentary layers that are usually baked by overlying flows.	Permeability highly variable; where joints are not filled with clay and flow contacts are permeable, yields moderate or rarely large amounts of water to wells; yields are sufficient for very small irrigation supplies at most places.
		Banbury Basalt Middle Sediments	Largely brownish sand and pebble gravel in lenticular channel deposits, but includes light-colored silt, clay, and diatomite in lake deposits.	The fine grained sediments yield little water to wells, the gravel may yield moderate quantities of water.
		Banbury Basalt Lower Basalt	Lava flows mostly vesicular and less than 15 ft. thick. Vesicles commonly filled with zeolites and calcite in basin area near canyon of Snake River. Locally includes stream deposits of massive brownish sand and fine gravel, as well as basaltic pryoclastic material in vent deposits.	Permeability highly variable; where joints are not filled with clay and flow contacts are permeable, yields moderate or rarely large amounts of water to wells; yields are sufficient for very small irrigation supplies at most locations.
Tertiary	Pliocene	Idavada Volcanics	Massive, dense, reddish-brown, gray and black silicic volcanic rocks occur as thick flows and blankets of welded tuff with associated fine to coarse-grained ash and clay, silt, sand, and gravel.	Permeability highly variable. Joints and fault zones in the indurated rocks yield large quantities of water at some places, but massive nonjointed units yield little water. Sand, tuff, and ash beds yield moderate quantities of water.

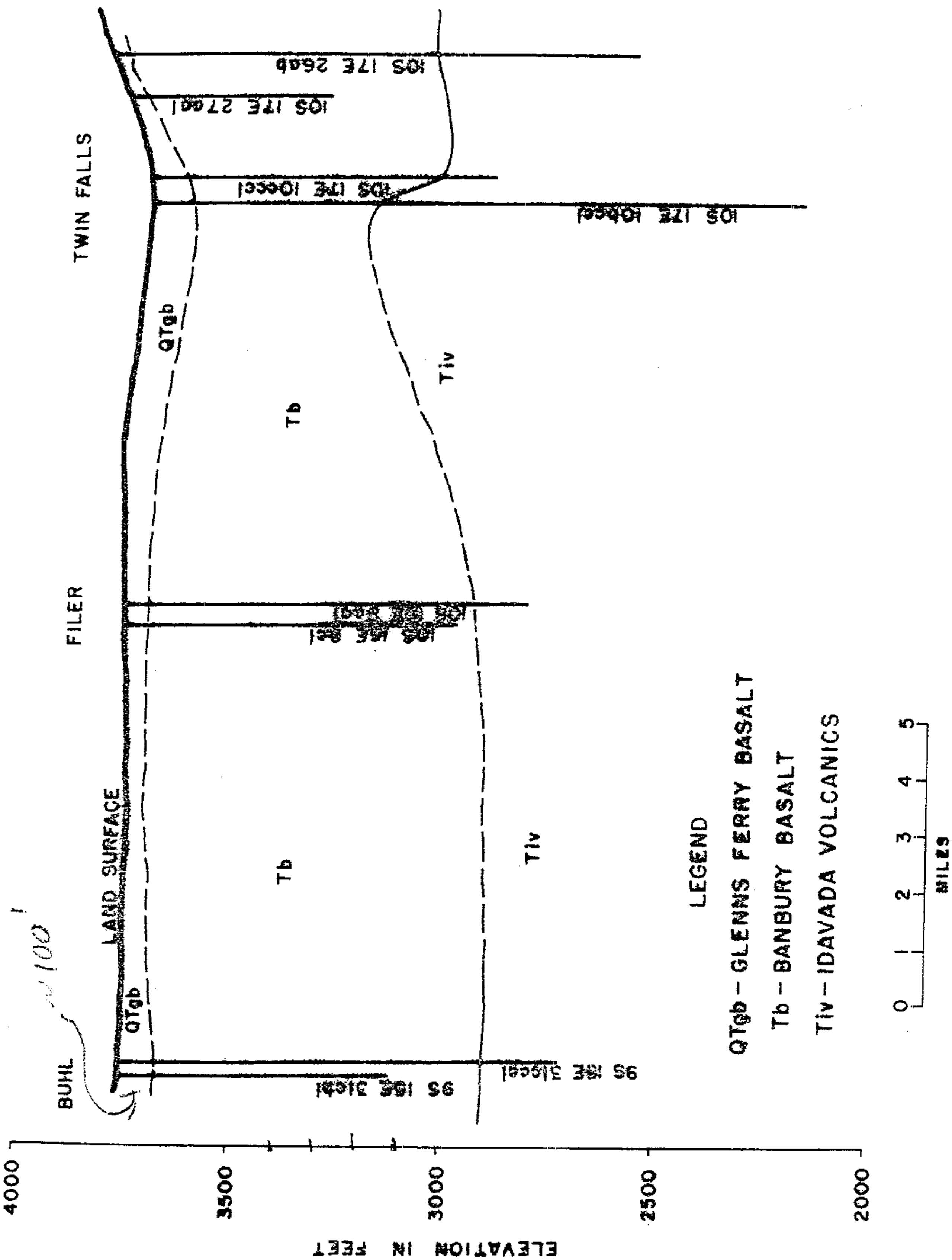

FIGURE 4. Generalized geologic cross section from Buhl to Twin Falls.

formation appears to be relatively continuous. Logs from almost all deep wells in the area note brown sediments at about 3,100 to 3,400 feet elevation.

The middle sedimentary member of the Banbury Basalt may be an important control in the recharge-discharge relationships of the ground-water system in the study area. This unit is believed to have a low vertical permeability. The water recharged from irrigation on the tract may be restricted to the overlying basalt units by the sediments. If this unit does limit the vertical movement to any significant amount, the effective depth of any recharge may be limited. Sufficient data are not presently available to determine the continuity of this zone nor its total effect on the hydrologic system.

The upper basalt member of the Banbury Basalt is difficult to differentiate from the overlying Glenns Ferry Basalt. A disconformity does exist between flows of each formation, but it is not distinctive enough to be recognizable from drillers' logs. For this reason, the discussion of the upper basalt of the Banbury Basalt is included with the discussion of the Glenns Ferry Basalt.

GLENNS FERRY BASALT

Most of the wells in the Twin Falls area derive water from the Glenns Ferry Basalt or upper member of the Banbury Basalt. The Glenns Ferry Basalt outcrops under a mantle of soil over a large portion of the Twin Falls area (Malde, Powers, and Marshall, 1963) and extends downward to an often undifferentiable contact with the upper basalt member of the Banbury Basalt. Yields from the basalts are variable with several wells exceeding 2,000 gallons per minute (gpm). Most wells, however, derive only small quantities of water for domestic uses.

STRUCTURE

Geologic structure does not appear to be a controlling factor in the movement of ground water in the Twin Falls area. Malde, Powers and Marshall (1963) noted the locations of several northwest trending faults in the lower member of the Banbury Basalt, south of the study area. Data are not available to determine the extent of any hydrologic control by structural features in the tract.

CHARACTERISTICS OF WATER FLOW

Water in the Twin Falls study area is derived from three major sources: irrigation water diverted from the Snake River into the Twin Falls South Side Canal, precipitation on the study area, and surface and subsurface inflow. A small quantity of water is also imported by the city of Twin Falls from springs to the north of the Snake River. Water occurs in the study area as both surface and ground water. The occurrence of water in these forms is closely interrelated and both are strongly affected by the rate of diversion of water from the Snake River for irrigation.

SURFACE-WATER FLOW

Salmon Falls Creek -- Salmon Falls Creek heads in the Jarbidge Mountains in Nevada and flows in a deep canyon along the western boundary of the Twin Falls Tract. The stream may be divided into three major segments: headwaters to the Salmon Falls Dam, the Salmon Falls Dam to the Roseworth Crossing, and the Roseworth Crossing to the mouth. The lower reach is of primary interest in this study.

Three major groups of streamflow data are available for the lower reach of Salmon Falls Creek. A continuously recording stream gaging station was operated 4½ miles west of Buhl for the periods July 1955 to August 1958 and December 1960 to September 1961. A similar type of station was installed at the highway crossing near the mouth in April 1970. Nine series of miscellaneous measurements of streamflow were obtained by the U.S.G.S. at five sites from Roseworth Crossing to the mouth in the period of November 1953 through July 1955. Additional measurements were obtained in February and August, 1970.

Streamflow data for calendar years 1956 and 1957 and the 1960-61 period are presented graphically in figure 5. A marked feature of the hydrograph is the large base flow component. The minimum flow at the measuring site in the 1956-57 period was 70 cubic feet per second (cfs). The minimum flow during the record of 1960-61 was 55 cfs The hydrographs for the 1956-57 record are remarkably similar (fig. 5). Generally, two peaks in streamflow are evident: one sharp peak in May and another more gentle peak in October. The spring peak is believed attributable to increased overland runoff, either from precipitation or waste water from irrigation of the Twin Falls Tract The later, more gradual increase from July through October may be attributed to larger ground-water inflows from higher water levels as a result of the surface irrigation of the Twin Falls Tract. Of particular interest is the low flow period in July. It is believed that the streamflow would gradually decrease in magnitude from October to July if the effects from overland flow were not present. The hydrograph of the 1960-61 period is somewhat different as a result of the initiation of pumping from Salmon Falls Creek for irrigation on the west side. A rating has not yet been established for the gage at the mouth installed in 1970.

The characteristics of gain and loss in the reach of Salmon Falls Creek from Roseworth Crossing to the mouth are presented in figures 6 and 7. The gain in streamflow with distance, shown in figure 6, indicates the greatest increase between the Castleford Crossing and a site west of Buhl, 1 mile upstream from the site of the stream gage. Approximately 50 cfs is gained in this 5 mile reach. Salmon Falls Creek gains from the southern edge of the Twin Falls Tract to near the mouth.

The variation of flow at each station along Salmon Falls Creek is shown in figure 7. The miscellaneous measurements of discharge at Roseworth and Castleford crossings are relatively constant. The lack of major fluctuations indicates that most of the inflow is from ground water in these reaches. The station west of Buhl exhibits a fluctuation similar to that noted in figure 5 at the gaging station, which is located approximately 1 mile downstream. The data from the miscellaneous measurement sites nearer the mouth depict progressively larger fluctuations in streamflow downstream. These data indicate a greater effect from overland flow, probably waste water from the Twin Falls Tract. Some loss in streamflow may occur near the mouth of the creek. Sufficient data are not available to analyze this loss.

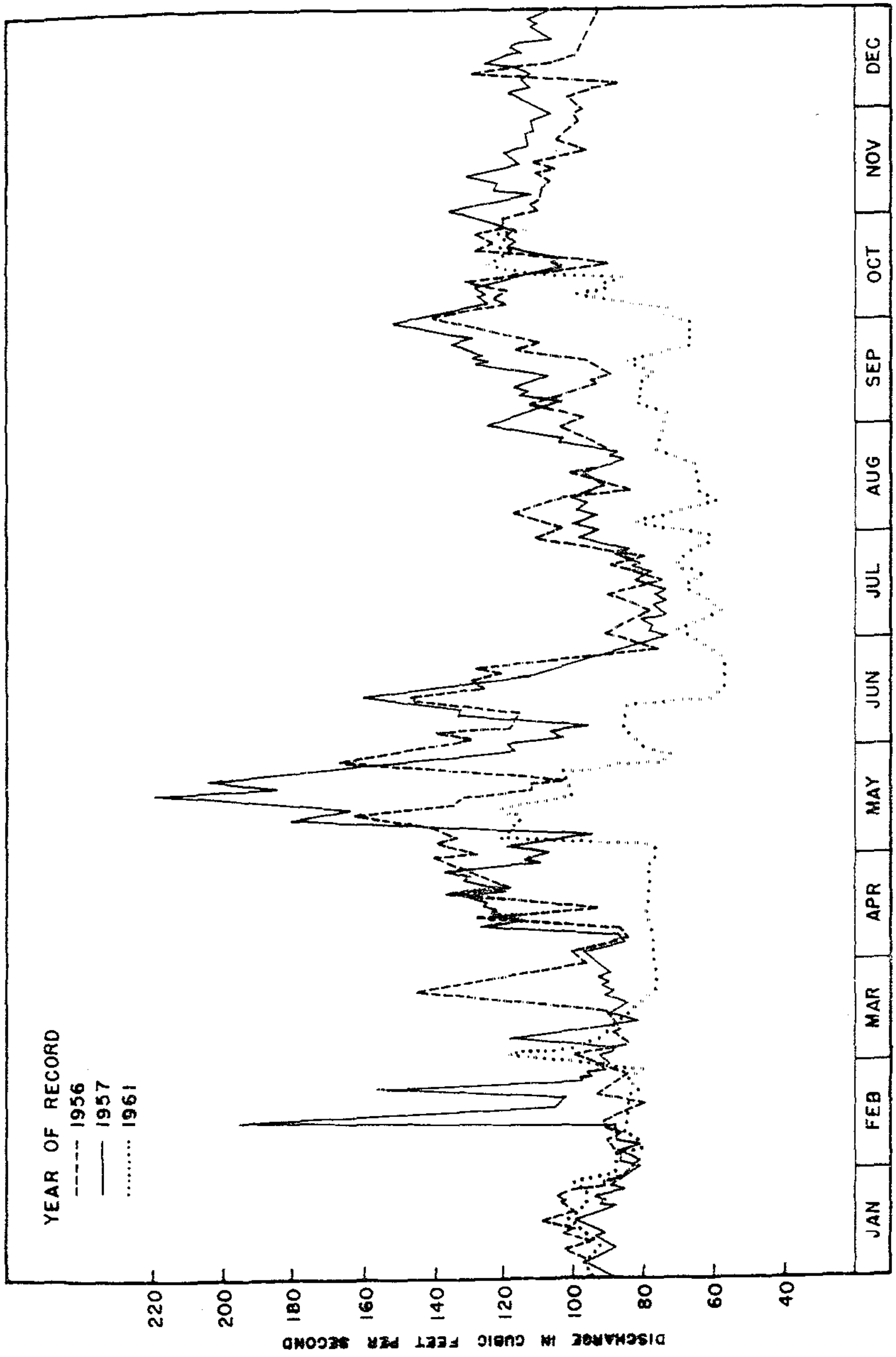

FIGURE 5. Annual discharge records on Salmon Falls Creek near Buhl.

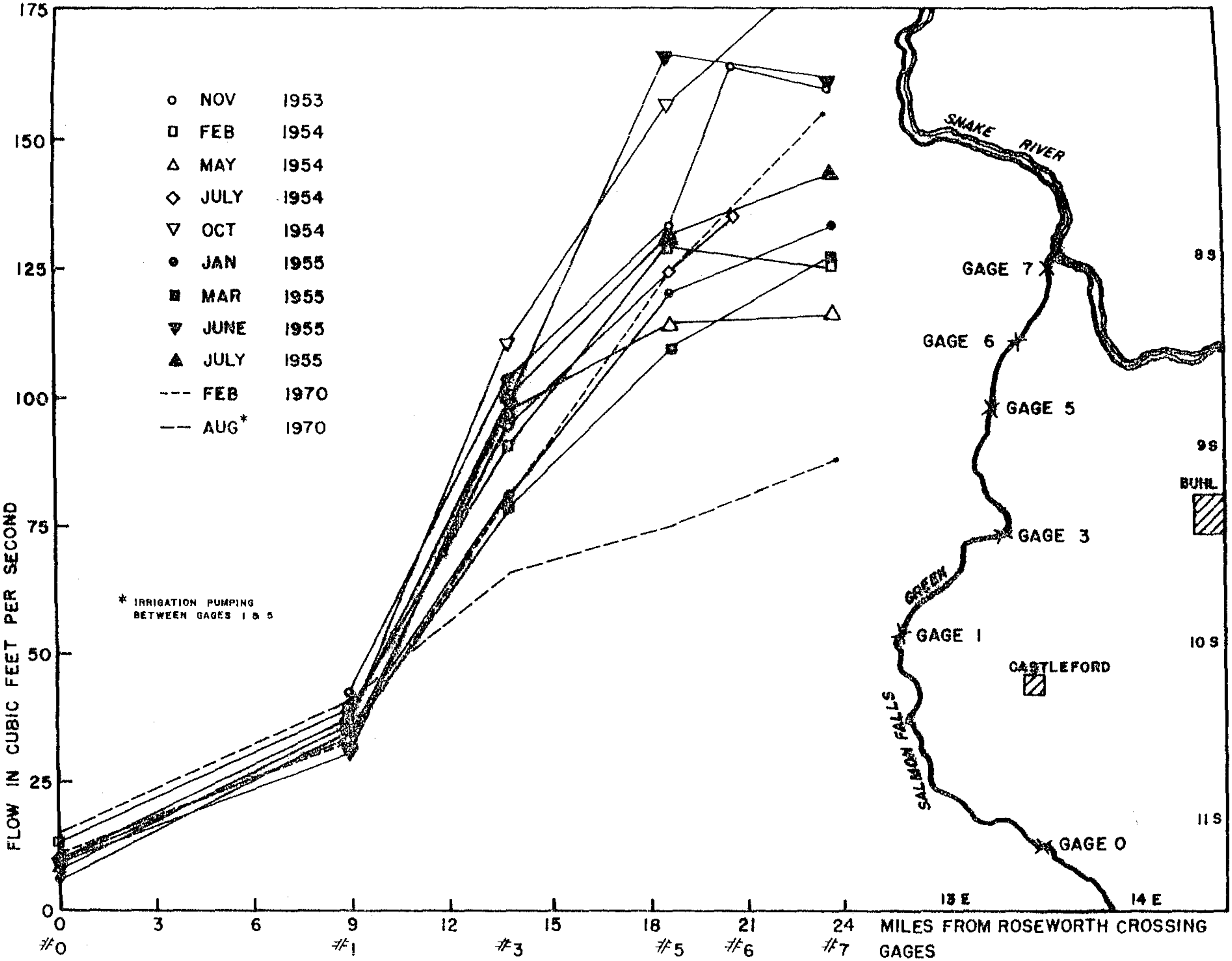

FIGURE 6. Variation of discharge with distance at miscellaneous sites on Salmon Falls Creek.

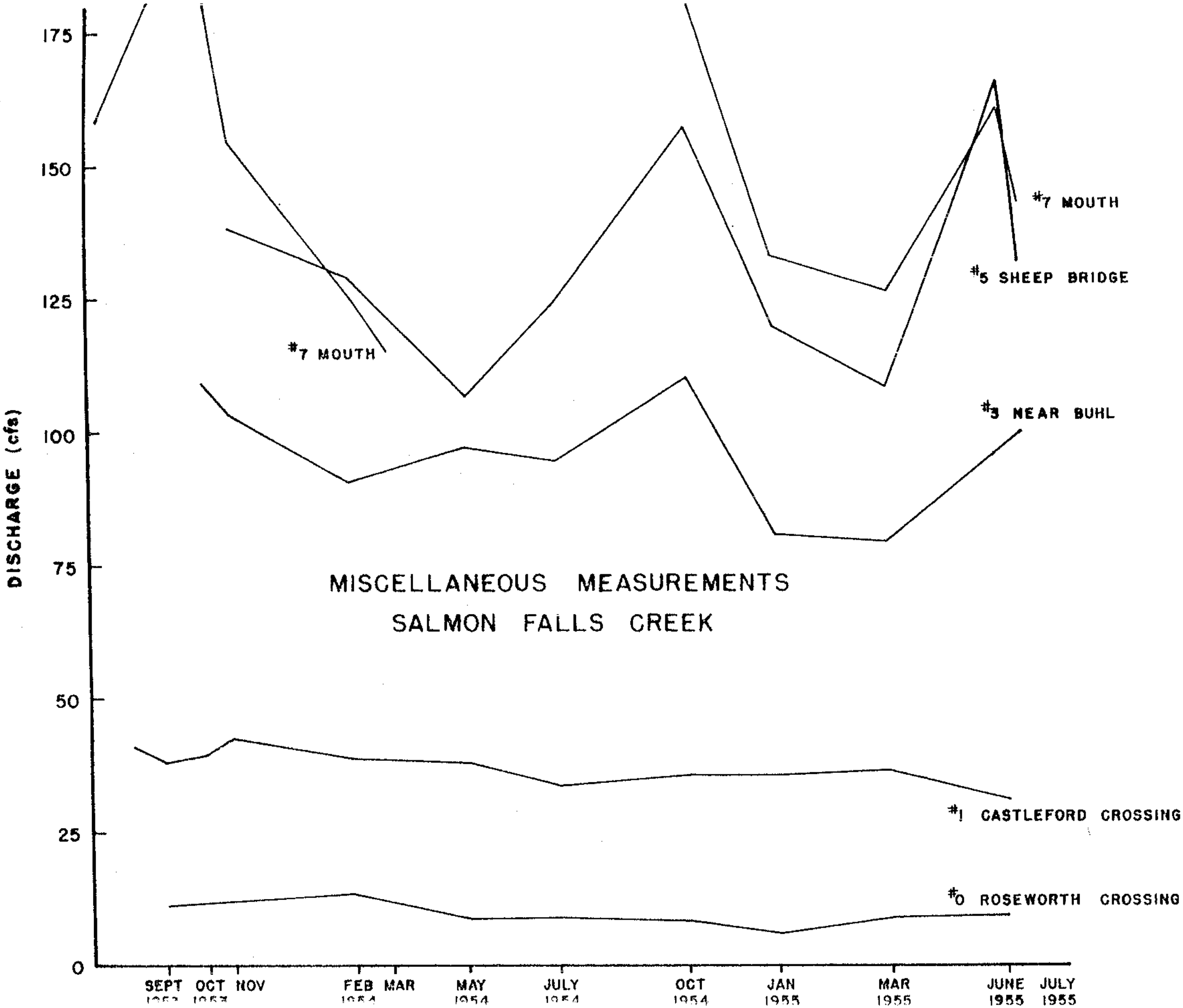

FIGURE 7. Variations in discharge with time of Salmon Falls Creek at miscellaneous sites, 1953-1955.

Most of the streamflow gain in Salmon Falls Creek from Roseworth Crossing to the mouth is believed to originate on the east or Twin Falls side of the stream. An estimate of the inflow from each side of the stream was made on the basis of the E.C. of the water. The E.C. varies in Salmon Falls Creek from 265 micro-mhos (mmhos) at Roseworth Crossing to an average of about 900 mmhos at the mouth. The average measured E.C. from the wells on the east side is 1,100 mmhos; the average E.C. measured from wells on the west side is 350 mmhos (Chapman and Ralston, 1970). Using these values and the miscellaneous streamflow data, it was estimated that approximately 90 percent of the gain in streamflow in lower Salmon Falls Creek is derived from the east side or Twin Falls Tract.

Deep Creek – Deep Creek heads as an ephemeral stream on the plateau south of Twin Falls and flows roughly parallel to Salmon Falls Creek in a northwesterly direction The stream is different from Salmon Falls Creek in that it has not eroded a deep canyon in its upper reaches. The High Line Canal ends in Deep Creek and the stream becomes part of the surface-water distribution system of the Twin Falls Canal Company in Section 19, Township 11 South, Range 14 East. After entering the tract, Deep Creek flows in a northerly direction, generally in a valley no more than 50 feet in depth until reaching the Snake River canyon.

Four major groups of data are available for Deep Creek: (1) a continuously recording stream gaging station was operated for the period July 1955 through July 1958 at a point 4½ miles northwest of Buhl and approximately 5 miles above the mouth, (2) miscellaneous measurements were obtained by the U.S G.S. at the gaging station in 1954 and at the mouth in 1958-59, (3) continuous measurements of discharge were obtained during 1968-69 by the staff of the Snake River Research Center of the A.R.S. on the flow of Deep Creek at the same site as the previous gage, and (4) miscellaneous measurements were obtained on five drains and tunnels by the same group during the 1968-69 period.

The U.S.G.S. gaging station was located immediately below a canal company diversion dam which regulates the flow. The discharge record (fig. 8) is of limited value in assessing the hydrologic characteristics of the stream. Much of the flow recorded during the nonirrigation season is water wasted by the canal company after use for watering stock. The streamflow data on Deep Creek collected by the A.R.S. at Kimberly for the 1968-69 period has the same general pattern. An estimate of the base flow characteristics of the stream may be noted from the minimum values. A low flow period appears to occur in June or July. The high base flow period cannot be determined because of the waste water from irrigation and stock watering.

The annual fluctuations in flow of several drains and tunnels in the Deep Creek drainage provide a clearer depiction of the recharge-discharge aspects (fig. 9). The period of low discharge in all five drains and tunnels measured by the A.R.S. in 1969 was April, just prior to heavy surface irrigation. The maximum discharge point ranges from July to October.

Mud Creek – Mud Creek heads on the Twin Falls Tract immediately below the Low Line Canal. It flows in a northerly direction on the plateau for about one-half of its length and in the Melon Valley for the remainder. The stream is utilized as part of the distribution system for the Twin Falls Canal Company.

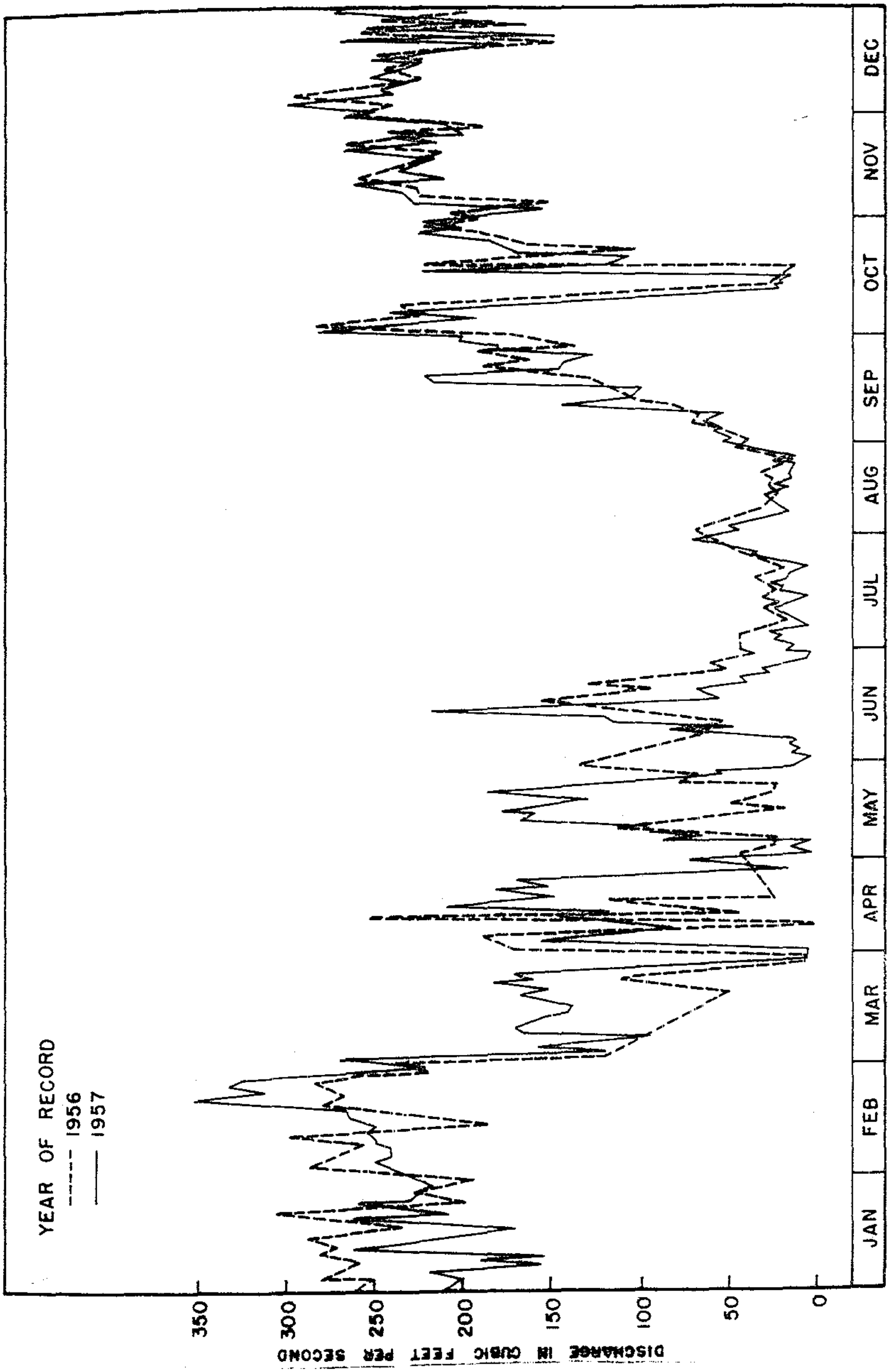

FIGURE 8. Discharge records for Deep Creek near Buhi, 1956-1957.

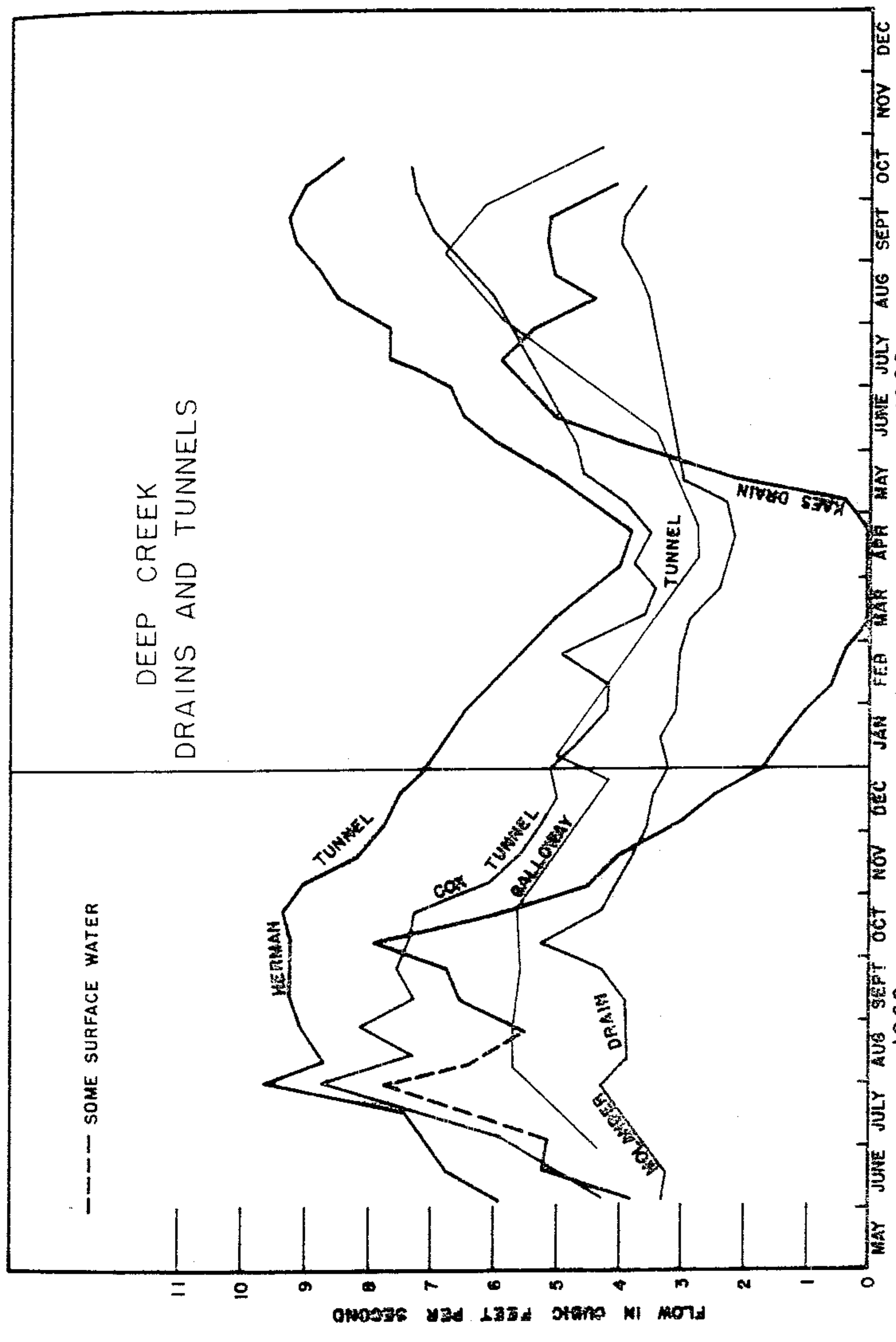

FIGURE 9. Discharge in tunnels and drains in the Deep Creek drainage, 1968-1969.

Only limited streamflow data are available on Mud Creek. Continuous measurements were obtained on the stream approximately one-half mile above the the mouth in 1968 and 1969 by the A.R.S. Miscellaneous measurements were also obtained on the stream in 1958 and 1959 by the U.S.G.S. Measurements were also obtained by the A.R.S. during 1968 and 1969 on four drains and tunnels which discharge into Mud Creek.

The partial hydrograph on Mud Creek (fig. 10) indicates a low flow in April. The abrupt changes in discharge shown by the hydrograph are caused by variations in irrigation needs and wasting of water from the tract.

The discharge data for the drain and tunnels in the Mud Creek drainage (fig. 11) indicate a pattern similar to that noted in Deep Creek. The low flow period is evident in April; the high flow ranges from July in the Hutchinson Drain and Neyman Tunnel to September in the Mendini and Love tunnels.

Cedar Draw — Cedar Draw heads as Desert Creek on the plateau northeast of Hollister. It is an ephemeral stream until it crosses the High Line Canal and enters the Twin Falls Tract. The stream flows in a valley 10 to 50 feet deep in a northwesterly direction in the tract until it nears the Snake River where it has eroded a deep canyon.

The streamflow data available on Cedar Draw include a 3-year period of continuous discharge record collected by the U.S.G.S. during 1955-58, and a 1-year record of continuous measurements collected by the A.R.S. during 1968-69, all at a site 2 3/4 miles upstream from the mouth. Three miscellaneous measurements were collected on the stream by the U.S.G.S. during 1958-59 and miscellaneous measurements were taken during 1968-69 by the A.R.S. on two tunnels and a drain feeding Cedar Draw.

The discharge record for Cedar Draw for the period July 1955 to July 1958 (fig. 12) indicates discernible base flow and overland flow components. The base flow varied from a minimum of 20 cfs to a maximum of about 70 cfs. The sharp peaks of discharge shown on the figure are the result of large changes in the waste water discharge from the Low Line Canal. Excess irrigation water is often wasted from the canal directly into the draw. The similarities of the hydrographs of the years of record are evident in figure 12. The minimum flow normally occurs in April just prior to the irrigation season. The base flow normally peaks in late September. The peaks in waste water flow occur just before and after the irrigation season with the largest discharges normally occurring in April, May, or June. The streamflow data obtained by the A.R.S. for the period 1968-69 indicate the same pattern as that data collected in the 1950's. The three miscellaneous measurements collected one-half mile from the mouth in 1958-59 indicate only a small increase in base flow below the gaging site. The single August measurement, however, indicates that significant quantities of waste water may enter the draw below the gage.

The discharge from the drain and two tunnels monitored in the Cedar Creek drainage have hydrographs similar to that of the stream (fig. 13). The drain and the Pagett Tunnel have highs in September-October and lows in April.

Cedar Draw derives essentially all of its flow from irrigation water applied to the tract and precipitation. The stream acts as a drain throughout the tract with only one lateral

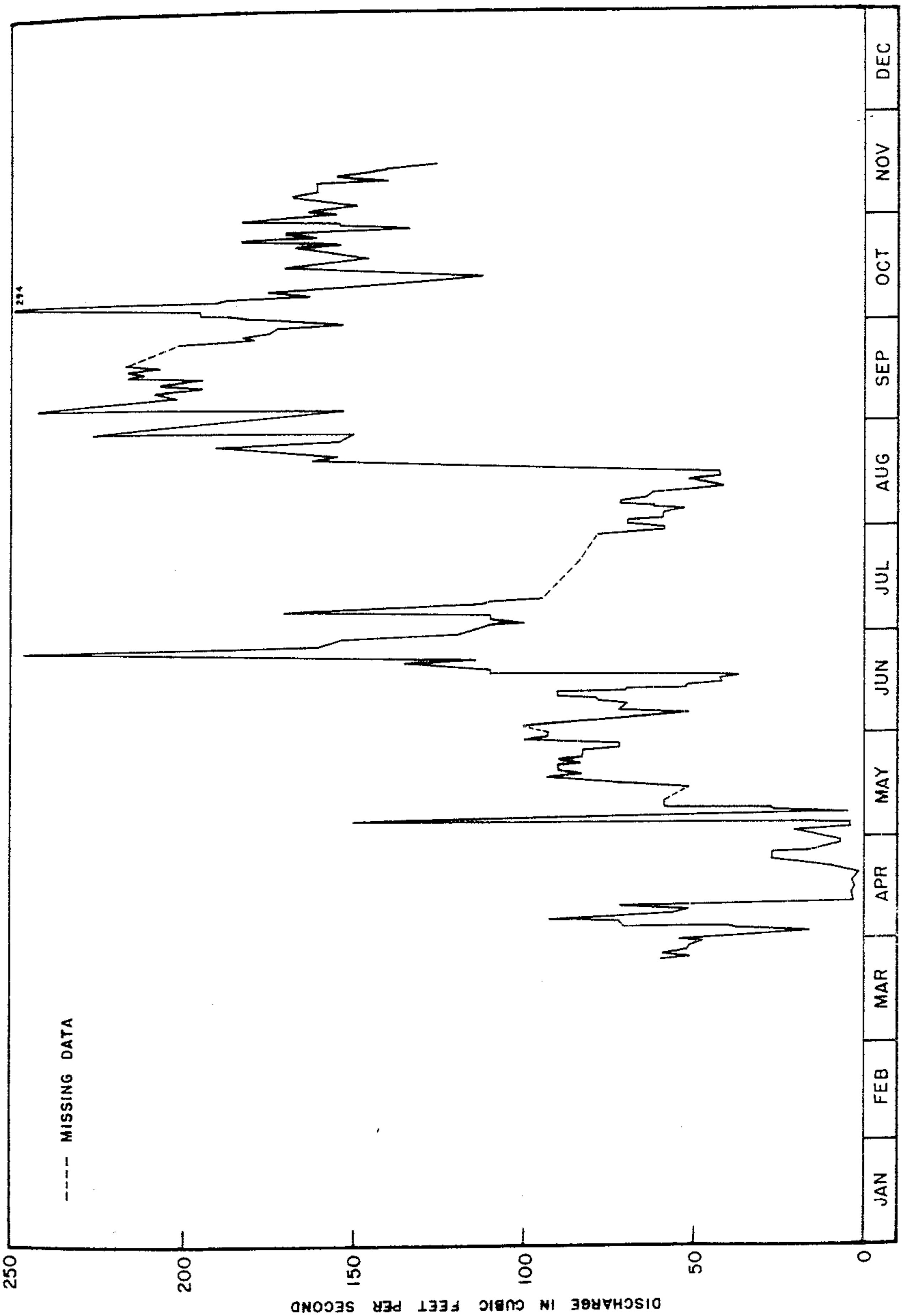

FIGURE 10. Discharge of Mud Creek at the mouth, 1969.

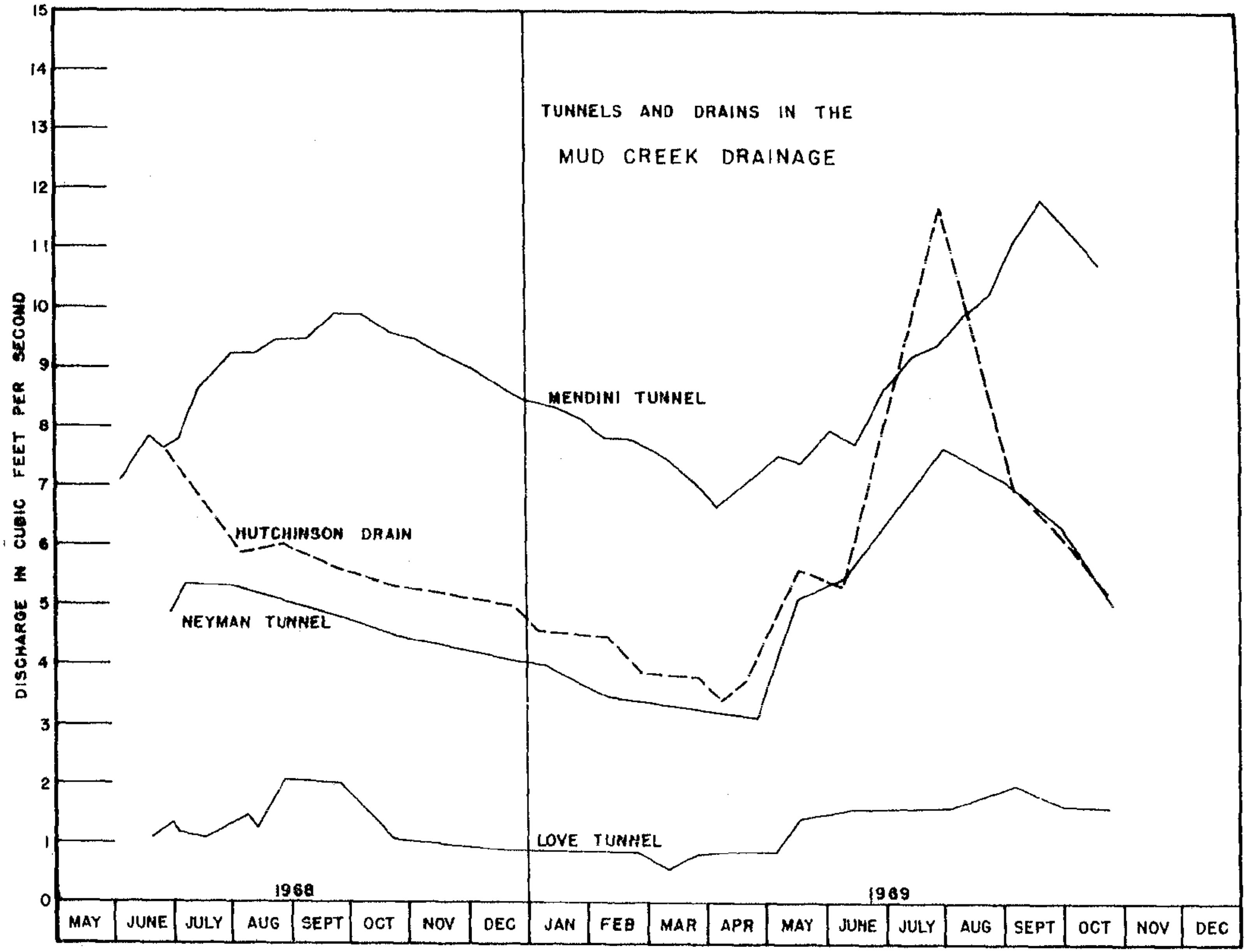

FIGURE 11. Discharge of tunnels and drains in the Mud Creek drainage, 1968-1969.

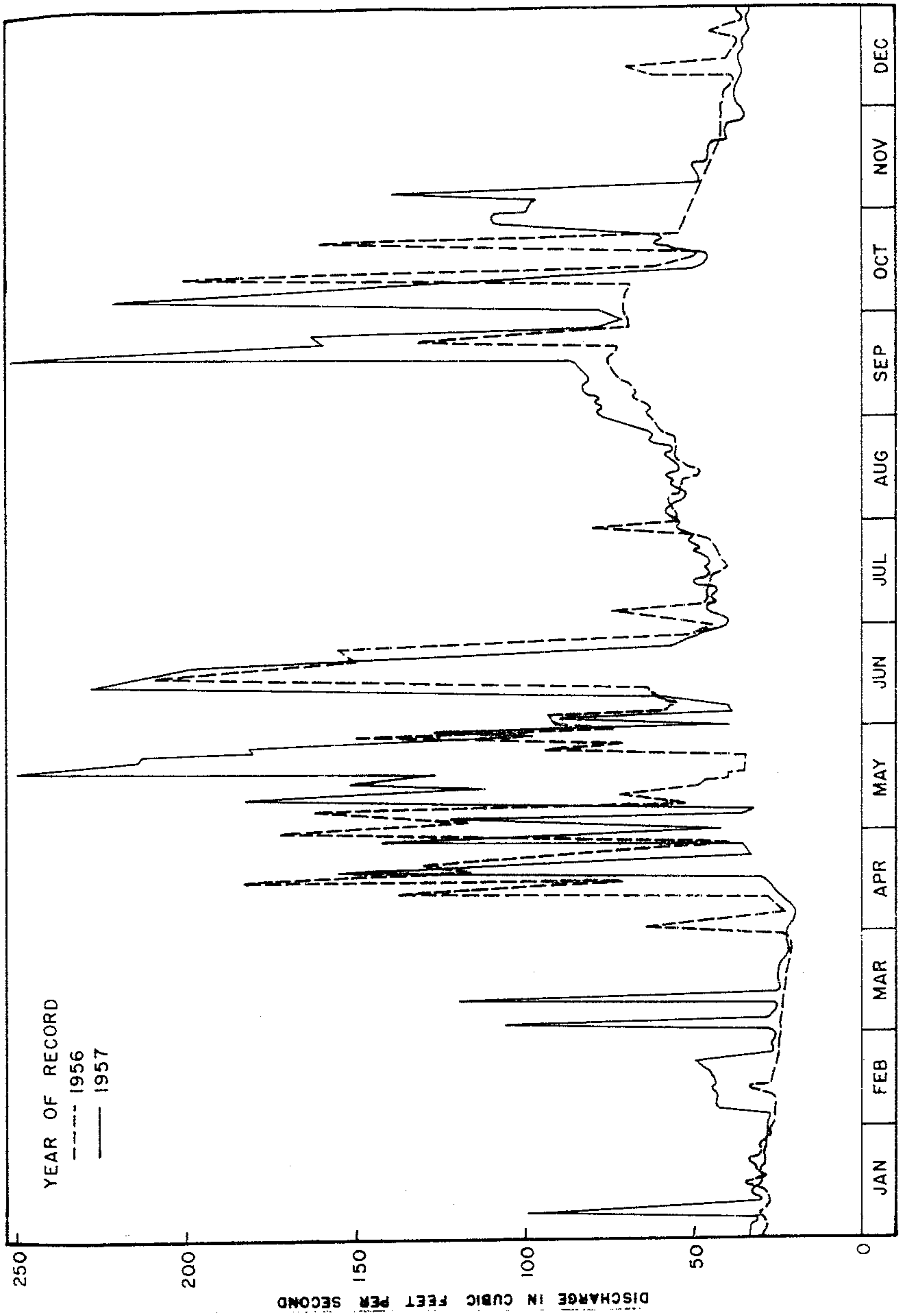

FIGURE 12. Discharge records on Cedar Draw near Filer, 1956-1957.

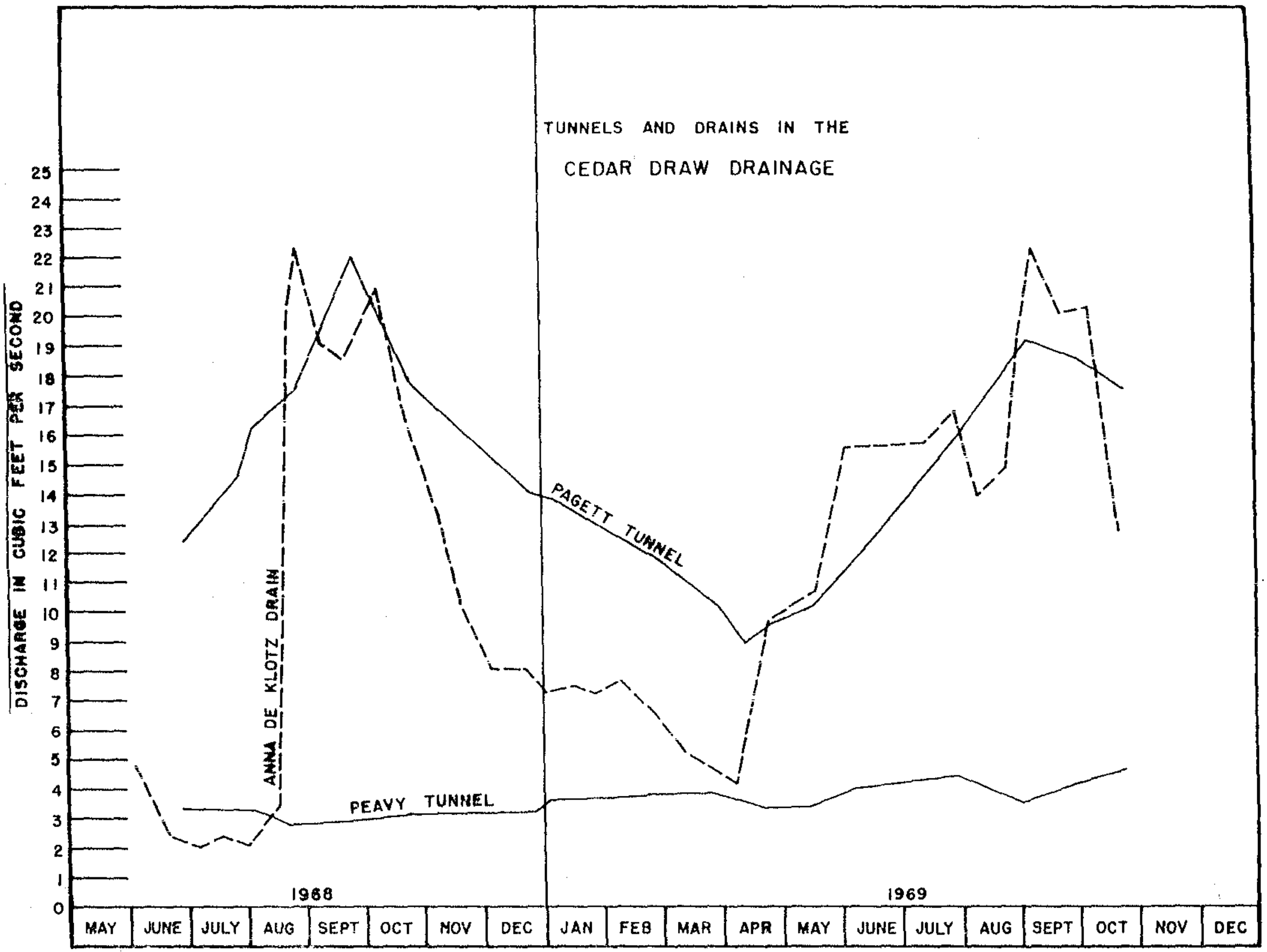

FIGURE 13. Discharge of tunnels and drains in the Cedar Draw drainage, 1968-1969.

diverting water from it.

Rock Creek – Rock Creek, the largest stream discharging from the tract, heads in the Rock Creek Hills south of Twin Falls. The stream may be divided into three reaches: (1) the upper drainage down to the town of Rock Creek, (2) Rock Creek to the High Line Canal, and (3) the High Line Canal to the mouth. The lower reach is of particular interest to this study.

Two gaging stations have been operated on Rock Creek by the U.S.G.S. A station has been operated continuously at a site approximately 5 miles south of the town of Rock Creek since 1943. The record is of little value in this study because Rock Creek is normally completely diverted above the High Line Canal. A second station was operated on Rock Creek at a site west of Twin Falls 3 miles above the mouth for the period 1922-47. Continuous record was obtained at the same site by the A.R.S. for the period 1968-70. In addition to this record, miscellaneous measurements were obtained on the stream at the mouth by the U.S.G.S. in 1958-59, and on drains and tunnels by the A.R.S. in 1968-69.

The average annual flow of Rock Creek near Twin Falls for the 1922-46 period is presented graphically in figure 14. The average annual flow varied from a low of 163 cfs in 1926 to a high of 254 cfs in 1930. The more detailed characteristics of the hydrograph are shown in figure 15 by the combined daily plots of the period 1944-46. The average monthly flows range from 100 to 400 cfs with lows generally in March and highs in June or September. The detailed hydrograph is similar to those noted for the other streams on the tract. A base flow component can be noted with two distinct overland flow peaks. The base flow reaches a minimum in March just prior to the irrigation season and a maximum near the end of heavy irrigation in September. Peak flows are noted at the start and end of the season when flows diverted at Milner are not needed for crop production and are wasted into the stream. The record obtained for 1968-70 indicates a similarly shaped hydrograph.

Miscellaneous measurements of discharge on eight drains and tunnels presented in figure 16, indicated a wide variance in magnitude of flows. Maximum and minimum flows occurred on approximately the same dates for all records. Low flows were recorded in late March and early April with highs in September.

Most of the flow of Rock Creek is derived from precipitation and irrigation water applied to the tract. Some flow enters the tract from upper Rock Creek during periods of high runoff. Some flow probably enters the stream from the city of Twin Falls supply.

South Side Twin Falls Canal – A gage has been maintained on the South Side Twin Falls Canal just below Milner since 1909. The average discharge for the 42-year period 1926-68 was 1,745 cfs or 1,263,000 acre-feet per year. This diversion allowed an average application of 6.25 acre-feet per acre for project lands. The total annual diversion in acre-feet per year for the period of record is presented in figure 17. The annual discharge varied from 841,000 acre-feet for 1910, the first water year of record, to 1,560,000 acre-feet for 1917. The variation in flow for the period 1926-68 was from a low of 1,147,000 acre-feet in 1961 to 1,370,000 acre-feet in 1933. Hydrographs of daily flow during these years, along with the hydrograph for a year with average discharge, are presented in figure 18. Typically, water is turned in the canal in April and out in October.

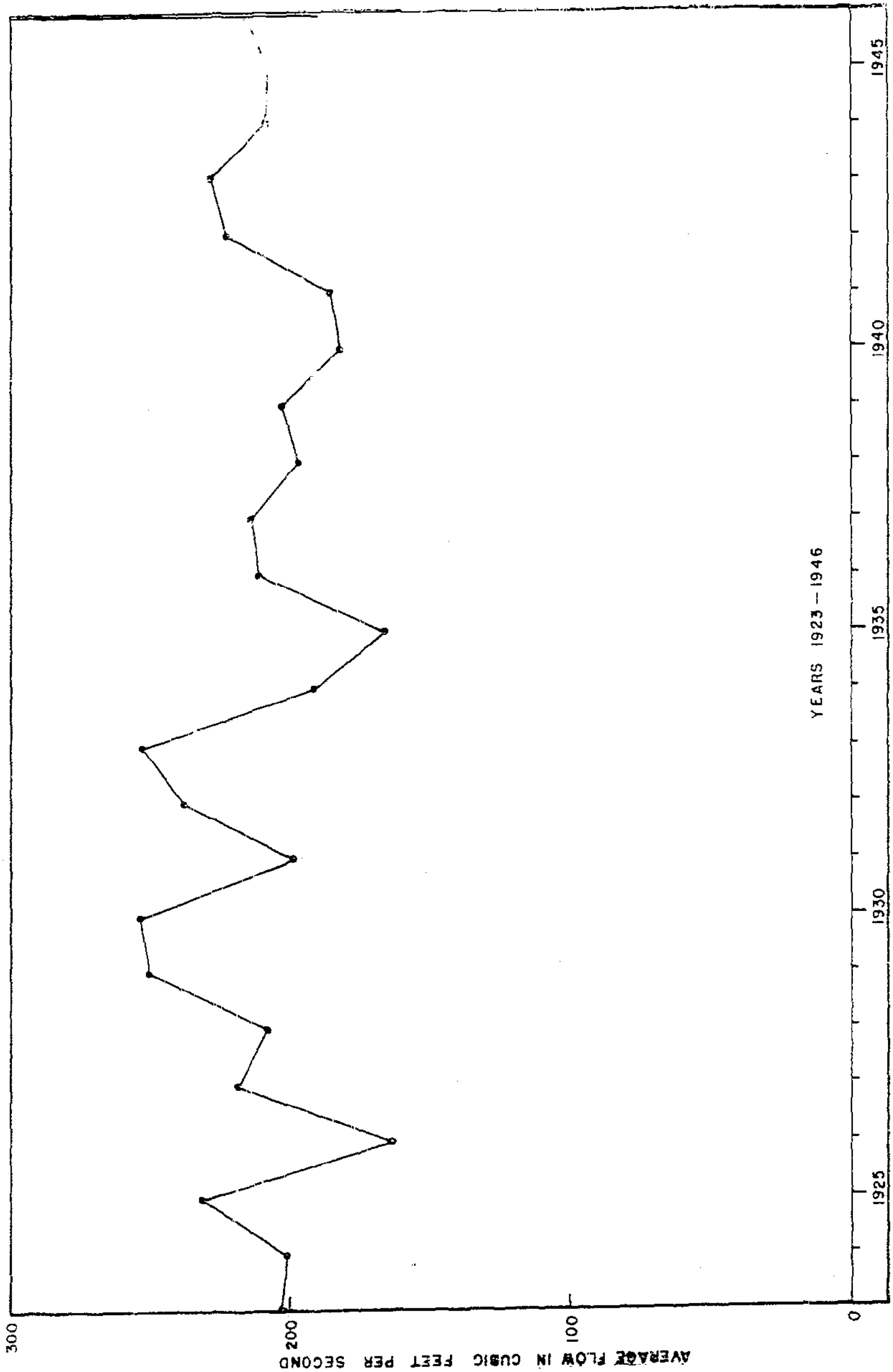

FIGURE 14. Average annual flow of Rock Creek near Twin Falls, 1922-1946.

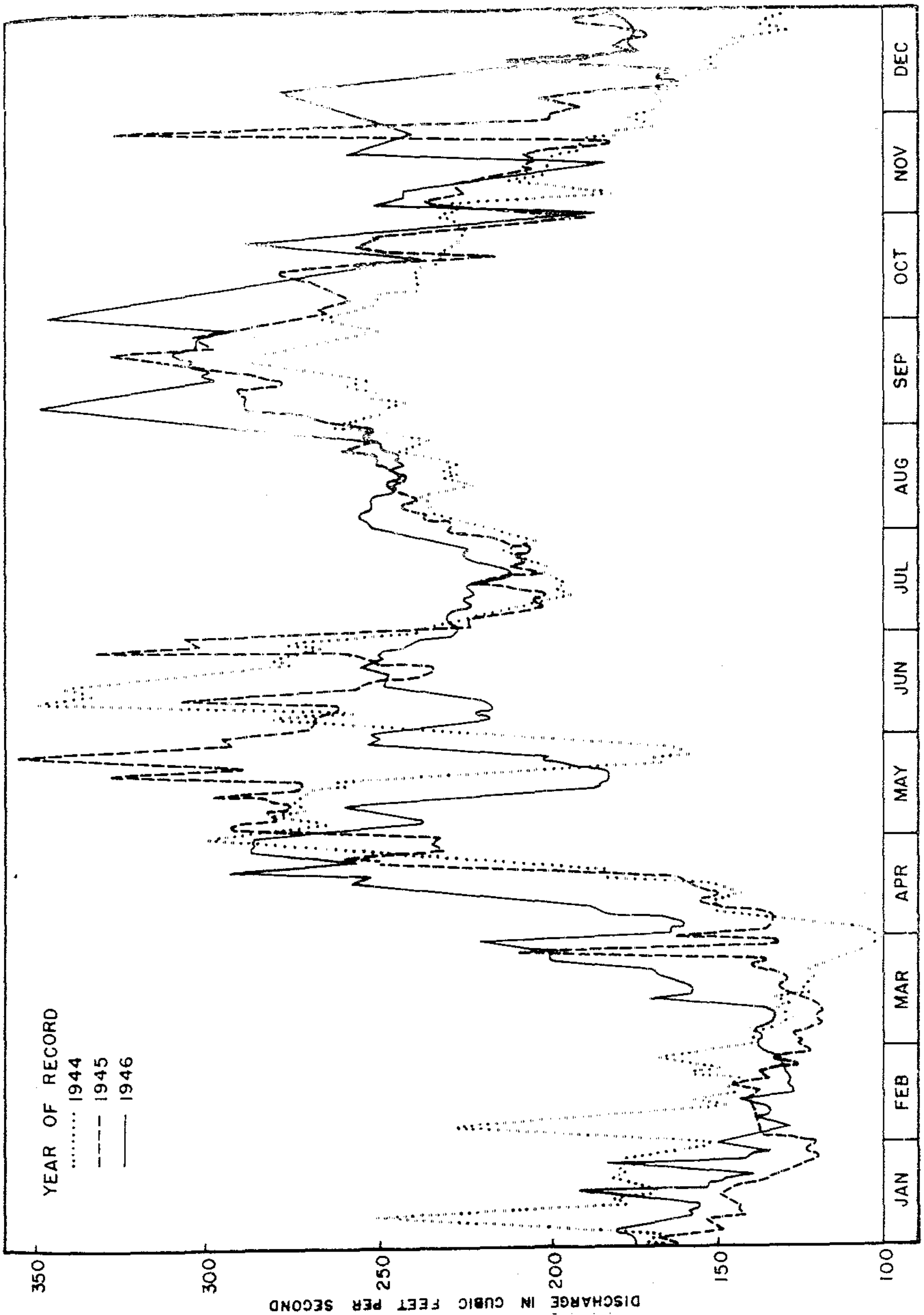

FIGURE 15. Typical annual hydrographs of Rock Creek near Twin Falls.

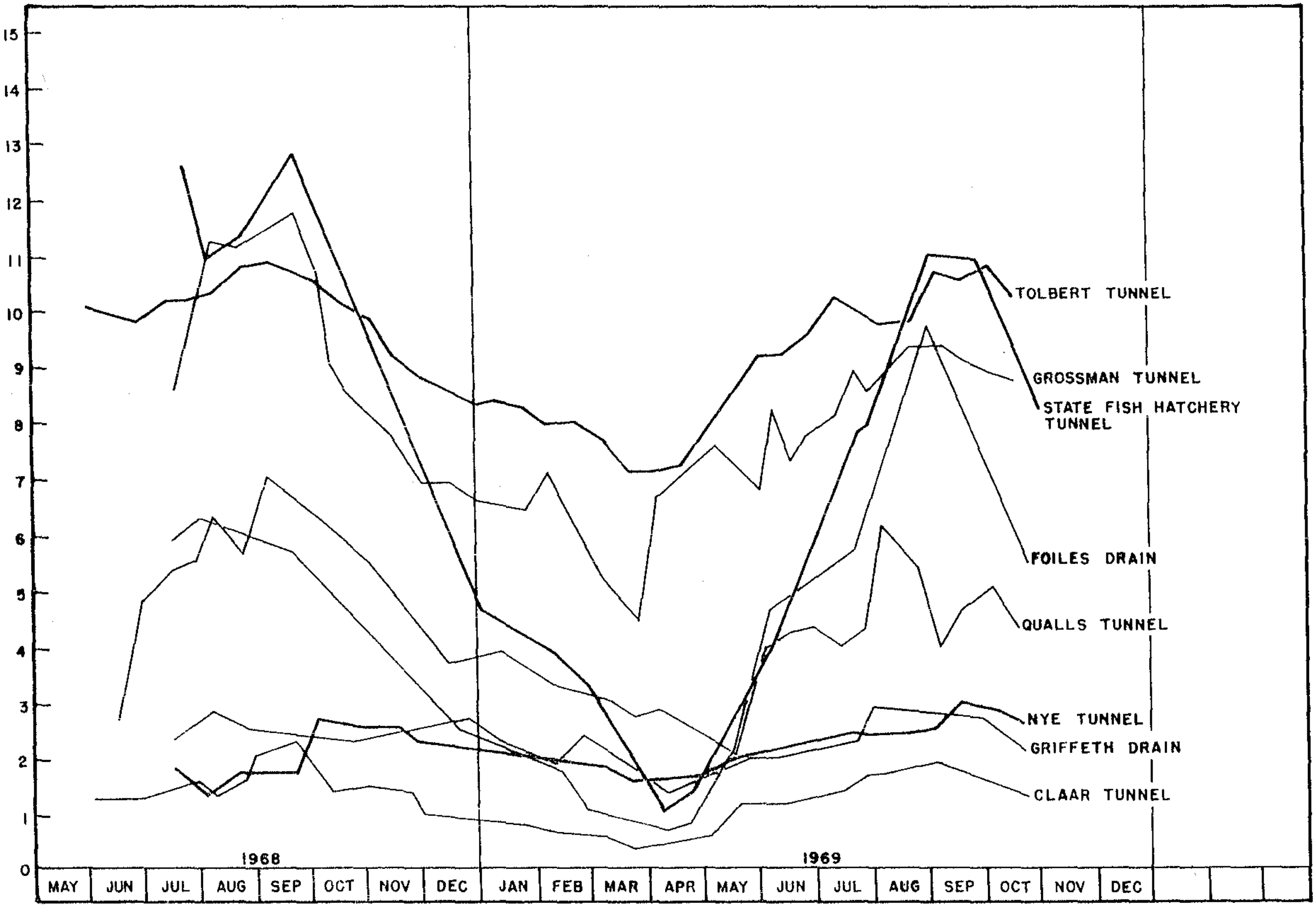

FIGURE 16. Discharge of the tunnels and drains in the Rock Creek drainage, 1968-1969.

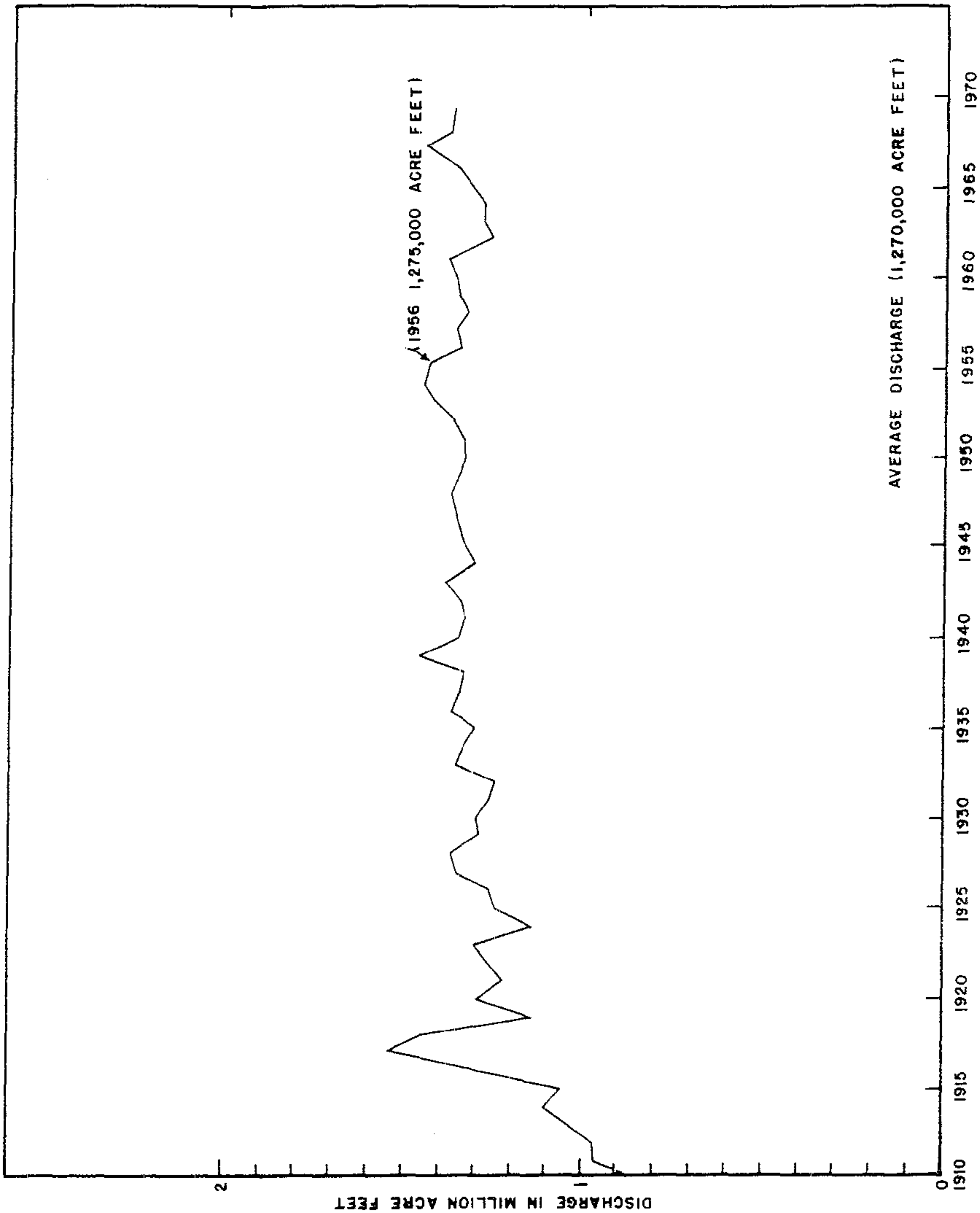

FIGURE 17. Annual discharge of the South Side Twin Falls Canal, 1910-1967.

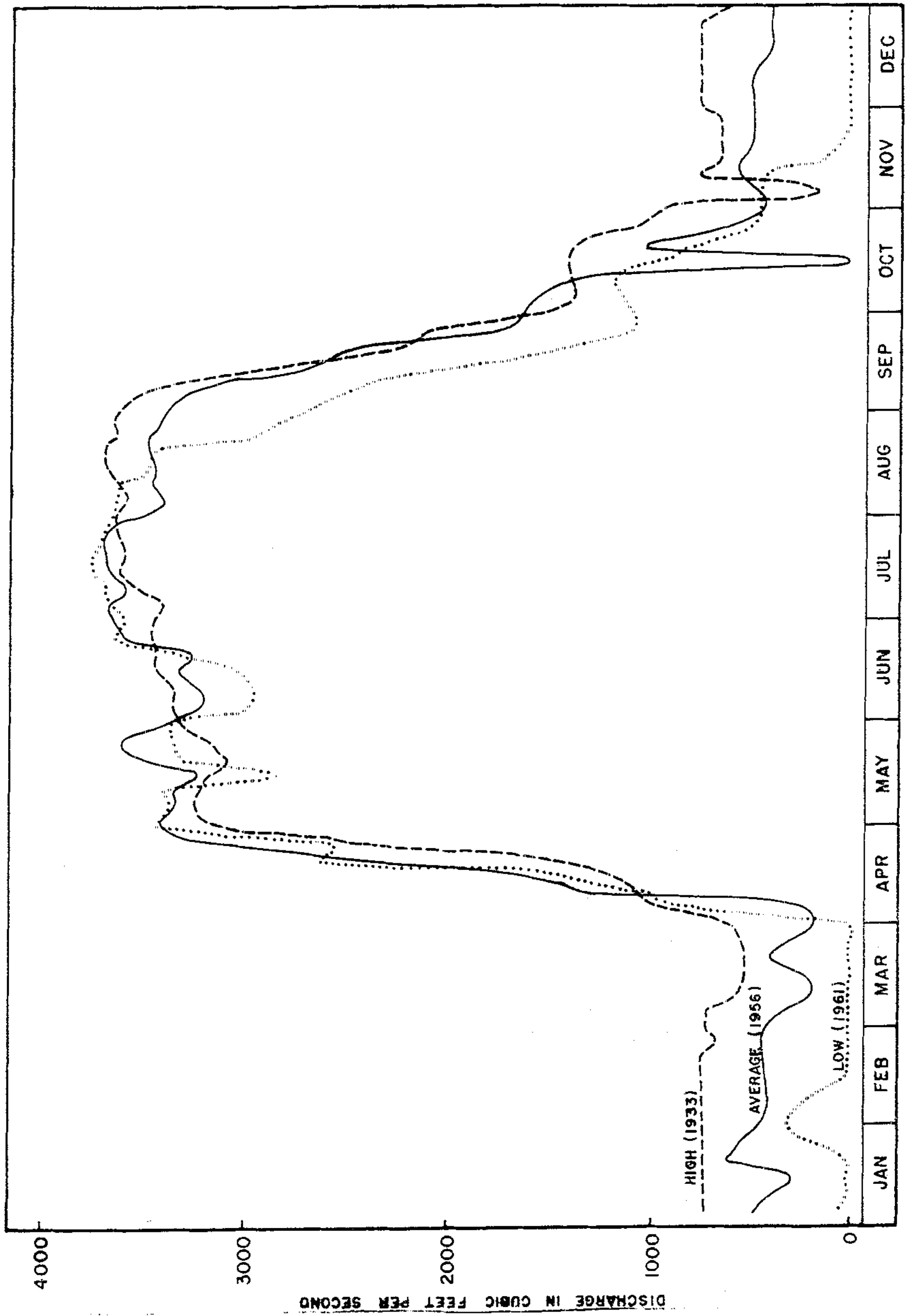

FIGURE 18. Typical hydrographs of annual flow in South Side Twin Falls Canal at Milner.

Winter flow averaging 300-400 cfs during January, February, and March were discontinued in 1960.

The gage near Milner provides the only published data on water distribution on the tract. Some data are available from watermasters' reports, but are not sufficiently detailed for hydrologic analysis.

Inflow to the Snake River from the Twin Falls Tract – The U.S.G.S. performed three sets of measurements of accessible surface-water flow and spring flow on the south side of the Snake River between Milner and King Hill (Thomas, 1968). All of the measurements were of water from the Twin Falls Tract. A tabulation of these measurements indicated a measured flow of 1,650 cfs on September 15-19, 1958; 1,160 cfs on March 24-26, 1959; and 1,280 cfs on August 3-10, 1959. Thomas estimated that an additional 150 cfs of water discharges from the south side as seeps, small springs and unmeasured wastes (1968, p. 17). The low flow in March and high flow in September is similar to streamflow characteristics throughout the tract.

Snake River – Stream gaging stations have been operated at five sites bordering the Twin Falls Tract: at Milner (1909-present), near Kimberly (1923-present), near Twin Falls (1911-1917, 1919-47), near Buhl (1946-present), and below Salmon Falls near Hagerman (1937-present). The Snake River gains between each of the stations. This gain is of interest as it represents discharge from the north and south banks of the river

The average annual gains between Milner and Kimberly are presented in figure 19 for the period 1924-68. The long-term average inflow is 476 cfs; the last 15-year and 5-year inflows are 371 cfs and 352 cfs, respectively. The inflow has decreased with time since about 1959. The average monthly gains for the combined period 1955-65 are presented in figure 20. The gain hydrograph has a shape similar to that shown for the south side discharges. Thomas (1968, p. 17) considered that all inflow in the Milner-Kimberly reach of the Snake River originated from the south side. This assumption was based on the opinion that the river is above the Snake Plain aquifer almost throughout the reach. Only a few springs, including Devils Washbowl Spring, are known to issue from the north side.

The average gain between the Kimberly gage and the gage at Twin Falls was 275 cfs for the period 1925-45. A number of surface discharges are present on both sides of the river in this reach.

A large gain exists between the Kimberly and Buhl gages on the river; 1,752 cfs for the period 1947-62. Thomas (1969, p. 18) estimated that about one-third of this inflow is from surface return flow from the south side.

The reach from Buhl to below Lower Salmon Falls near Hagerman received the largest inflow in the Milner-King Hill portion of the river. Of the average inflow of 4,658 cfs, Thomas (1969, p. 18) noted about 10 percent was from measured wasteways from the south side.

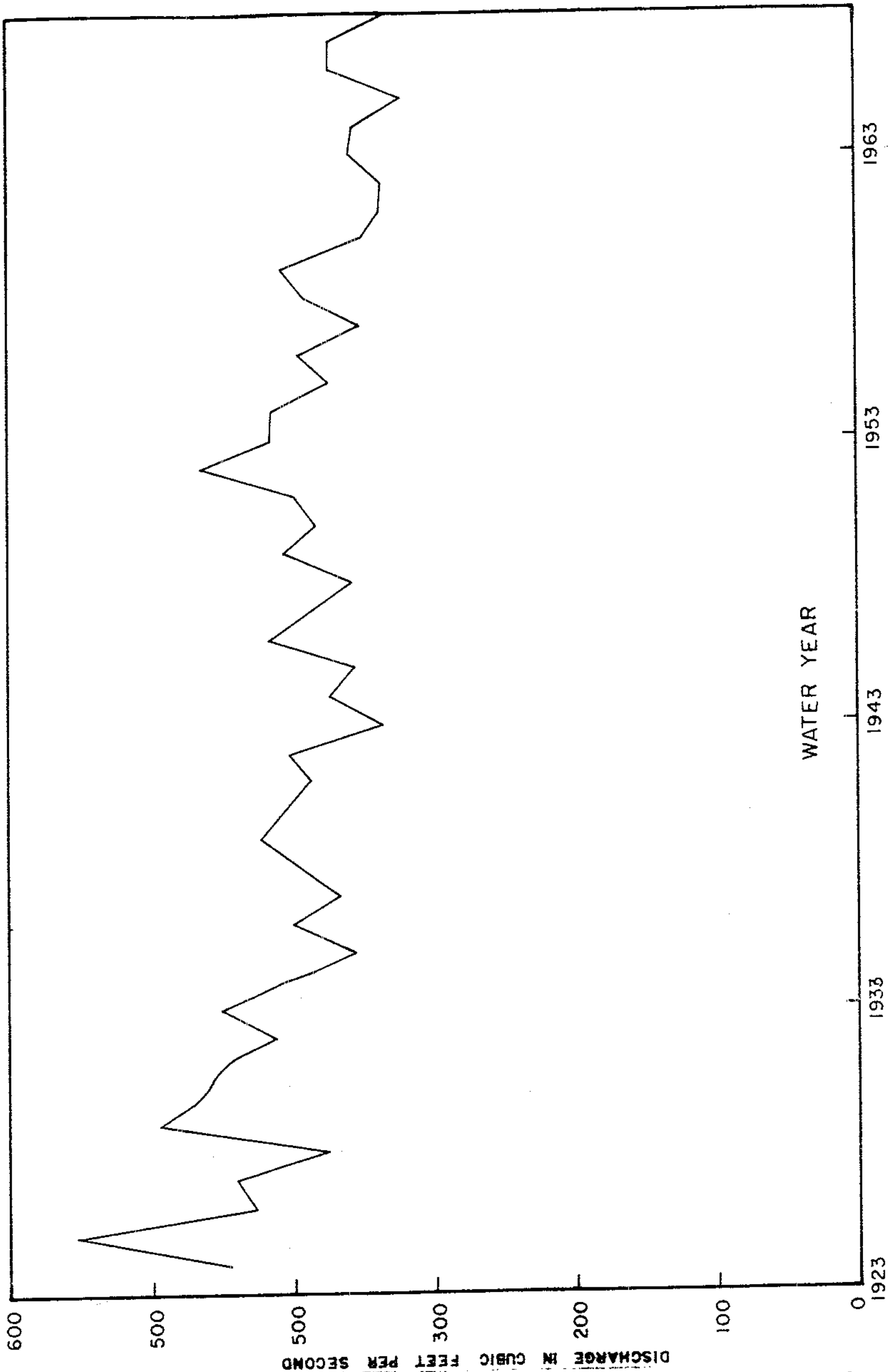

FIGURE 19. Records of annual inflow to the Snake River between Milner and Kimberly, 1924-1968.

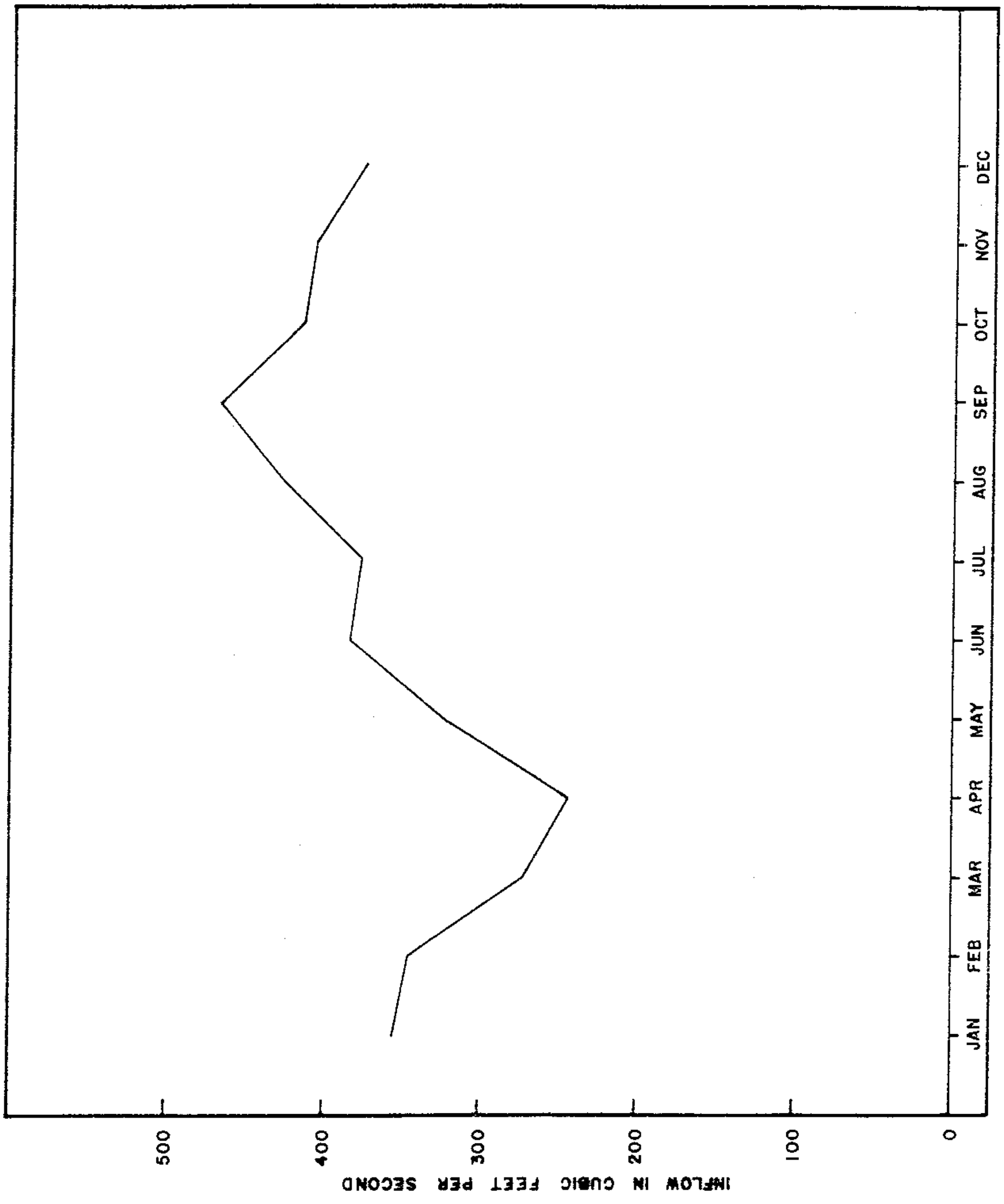

FIGURE 20. Average monthly inflow to the Milner-Kimberly reach of the Snake River, 1955-1964.

GROUND-WATER FLOW

A large quantity of water is present as ground water under the Twin Falls Tract. This water is derived from excess irrigation water applied to the tract, precipitation, and ground-water inflow. The ground-water system is believed to discharge either into the Snake River or the Snake Plain aquifer north of the river.

Direction of Ground-Water Flow – The direction of ground-water movement is shown in figure 21 by contours of water-level elevation. The contours are based on 1946 data published by Jones (1970) and checked by more recent data from well logs and specific measurements. The figure was constructed assuming the streams to be gaining and directly connected to the ground-water system. The general direction of ground-water flow is north and northwest. Locally near streams, the flow may be northeast, west or southwest. The slope of the ground-water surface varies from 50 feet per mile to several hundred feet per mile near the streams and the Snake River. The water surface roughly parallels the land surface. The contours presented in figure 21 tie in reasonably well with those published previously for the adjacent Salmon Falls Tract (Crosthwaite, 1969-1) and the Goose Creek-Rock Creek area (Crosthwaite, 1969-2).

Water-Level Fluctuations – The ground-water resource in the Twin Falls area has been grossly affected by development of irrigation on the tract. Stearns, Crandall and Steward (1938, p. 129) noted that the water level prior to irrigation averaged more than 250 feet below land surface. With the introduction of irrigation from the Snake River, water levels rose rapidly. The average rise in 29 wells in the tract in the period 1909-12 was 25 feet per year. The rise slowed to about 4 feet per year in the period 1913-28. The water levels have stabilized and remained relatively constant in the last several decades.

The Twin Falls Canal Company collected annual water-level records on many wells through 1946. Since few new seepage problems were occurring, the measurement program was gradually discontinued. The canal company data provide insight to the long-term fluctuations and the basis for the concept of little change.

Three observation wells are presently operated by the U.S.G.S. in the Twin Falls Tract. The longest record of water-level fluctuations (1951-present) is from a 1,200-foot well in Kimberly. The other two wells are shallower (347 and 352 feet) and were first measured in 1960.

The well hydrographs, presented in figure 22, all indicate a low in the spring and a high in the fall. This fluctuation is a direct result of the annual cycle of irrigation on the tract. Prior to irrigation development, the cycle would have included a high in the spring as a result of natural recharge and a low in the fall. A difference may be noted in the timing of the high and low peaks on the figure. Well 11S 17E 25ddd2 has a low in late March or early April and a high in late August or early September. These peaks are very close to the times when water is turned in and out of the canal. This well is located close to the High Line Canal and is constructed to obtain water from 145 feet to 352 feet. Well 10S 18E 20ddd1, in Kimberly, has a low in May or June and a high in October or November. The fluctuation in this well thus lags that in well 11S 17E 25ddd2 by 1 to 2 months. The Kimberly well, although drilled to a depth of 1,200 feet, is constructed to obtain water from 300 to 500

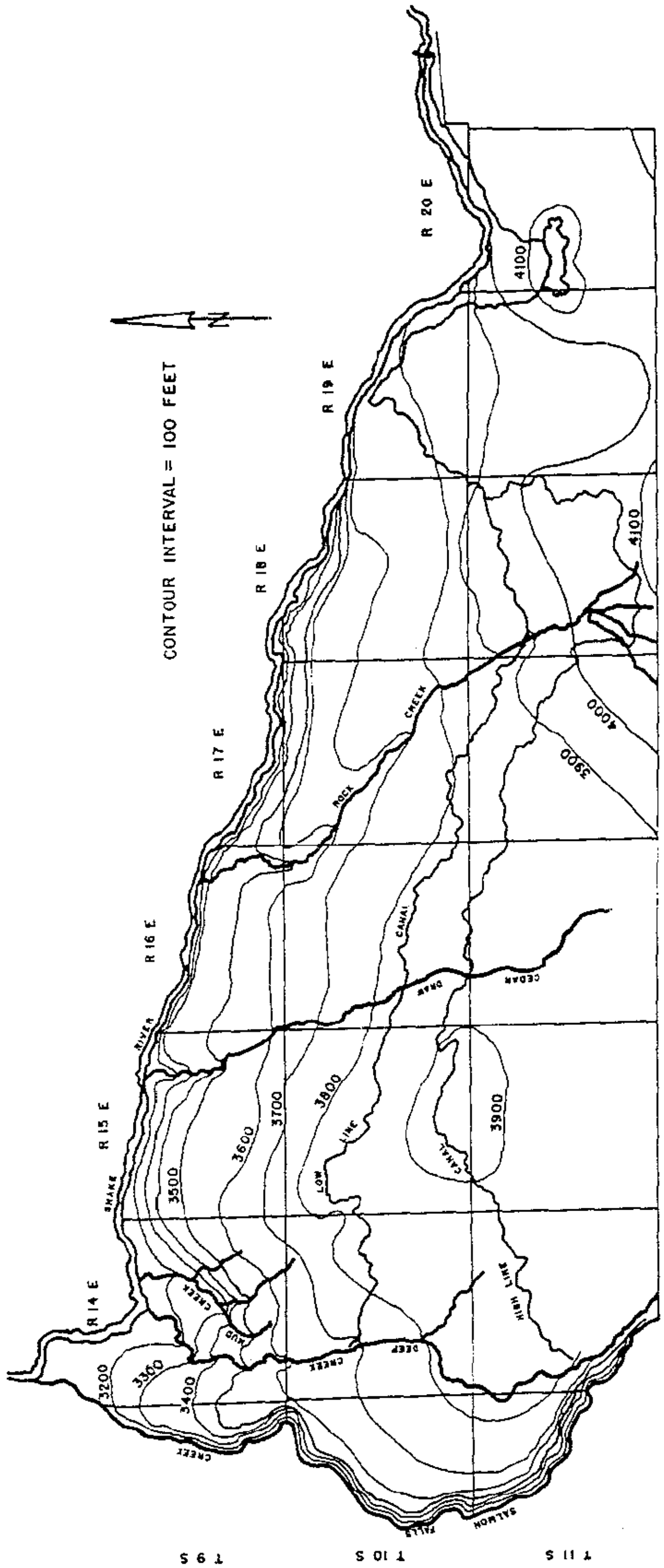

FIGURE 21. Spring water-level contours of the Twin Falls Tract.

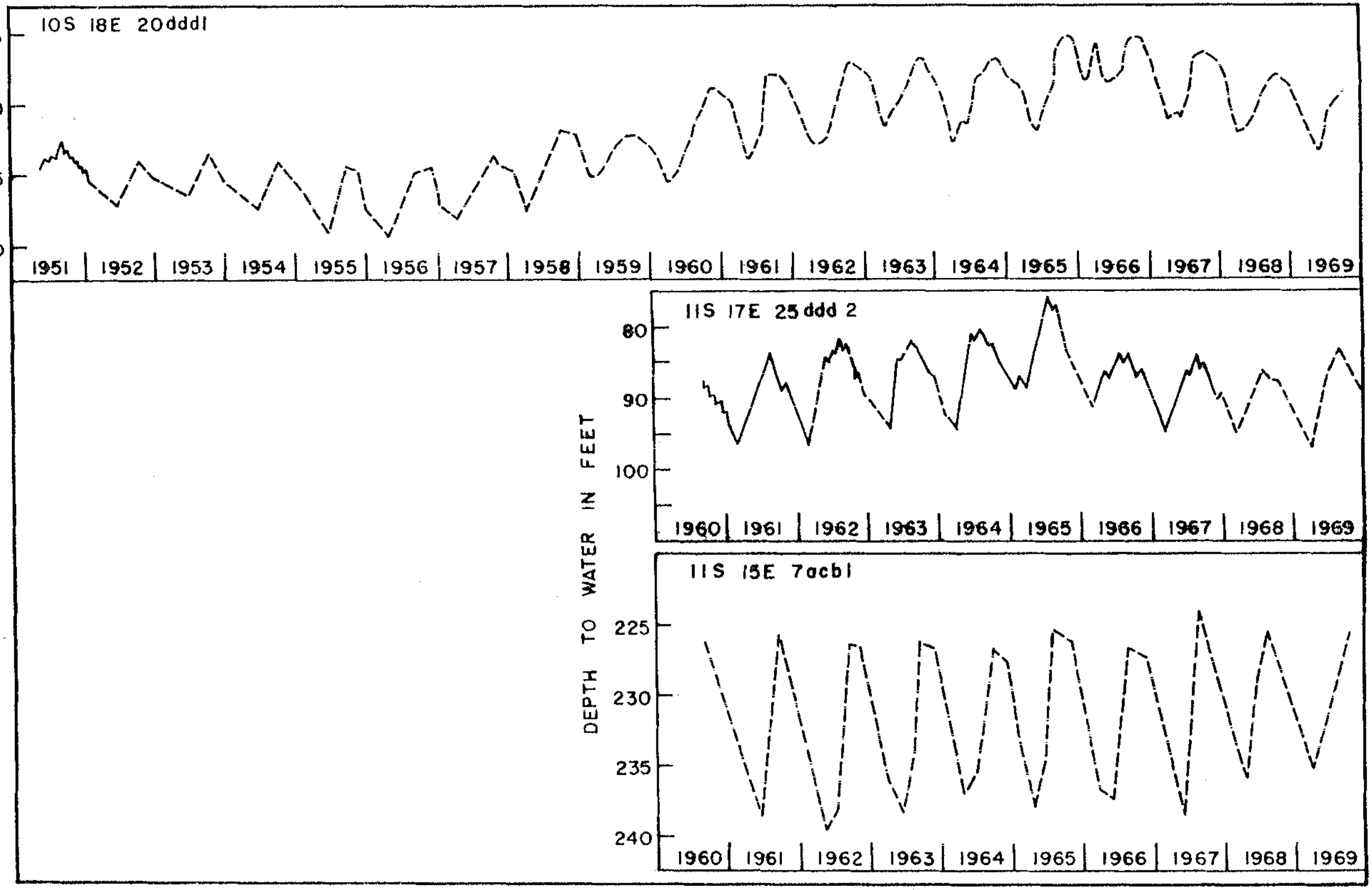

FIGURE 22. Hydrographs of wells 10S 18E 20ddd1, 11S 17E 25ddd2 and 11S 15E 7acb1.

feet. The deeper perforations and greater distance from the primary canals are believed to account for the lag. The third observation well in the tract, 11S 15E 7acb1, has a similar lag in high and low peaks. This well is located slightly south of the High Line Canal in the western portion of the tract.

The hydrographs of three wells located to the east of the tract in Sections 17 and 18 of Township 11 South, Range 19 East are presented in figure 23. These wells have reported depths of 860 feet (17aab1), 527 feet (18dcd1), and 290 feet (18aaa1). All of these hydrographs have a normal annual fluctuation; a high occurs in the spring and a low occurs in the fall. These wells thus do not indicate an influence in the area from irrigation or leakage from the Twin Falls South Side Canal.

Several of the hydrographs presented in figures 22 and 23 have similar long-term fluctuations. A peak in water levels can be noted in 1965-66 in the hydrographs of wells 10S 18E 20ddd1, 11S 17E 25ddd2, 11S 19E 18dcd1, and 11S 19E 17aab1. Crosthwaite (1969, p. 48-50) noted this pattern and stated several factors that might have caused the change: (1) changes in the annual diversion in the Twin Falls South Side Canal and thus leakage in the Murtaugh Lake area, (2) variation in precipitation, and (3) abandonment of some irrigation wells to the south and east. It is important to note that both wells with normal and "irrigation" annual fluctuations indicated this general change. Since this long-term fluctuation is not noted in the hydrograph of well 11S 15E 7 acb1, it is believed that the fluctuation is associated with the general ground-water inflow into the tract from the southeast from the Goose Creek-Rock Creek area. Contours of water-level elevation (Crosthwaite, 1969-2, p. 28) indicate this ground-water flow enters the tract from the southeast.

Ground-Water Storage – A large quantity of water is in storage in the aquifers underlying the Twin Falls Tract. An accurate estimate of this storage, however, has not been made to date because of a lack of quantitative data on the storage capability of fractured basalt, the primary aquifer material. Stearns, Crandall and Steward (1938, p. 129) estimated that 6,000,000 acre-feet of water went into storage underground during the period 1906 to 1928, the early development of the tract. It is believed that this estimate is based on a water-level rise of about 200 feet over an area of 200,000 acres with a storage coefficient of 0.15. This estimate would require that about 27 percent of the total diversion in the 1906-28 period would have been recharged, an average of 272,000 acre-feet per year.

The estimated storage coefficient of 0.15 is believed to be high for the geologic formations of the Twin Falls Tract. This may be shown by the quantity of recharge needed to cause the estimated 25-feet per year rise in water levels noted in the 1909-12 period. A 25-foot rise over the 147,000-acre tract irrigated in 1912 with an 0.15 storage coefficient would require 551,000 acre-feet of recharge, over 56 percent of the total diversion. Ten (10) to 20 percent of the total diversion is believed to be a more logical recharge from experience gained on other projects of a similar type in southern Idaho. This would require a storage coefficient in the range of 0.03 to 0.06. Qualitatively, this range of storage coefficient would better explain the large rise in water levels during the development of the project.

If a storage coefficient of 0.05 is assumed for the aquifers underlying the tract, the total quantity of water in storage may be estimated. The top 100 feet of the saturated

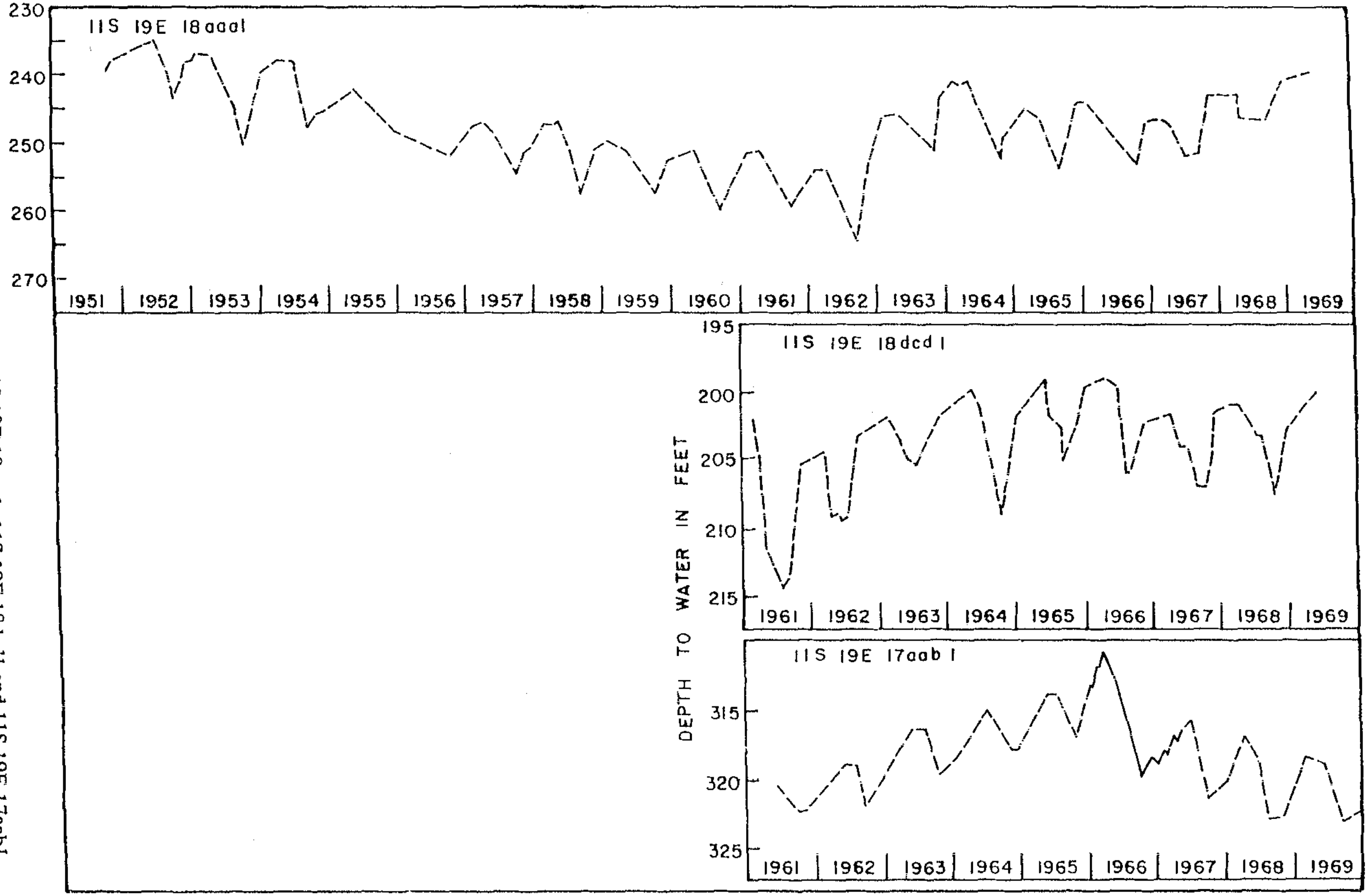

FIGURE 23. Hydrographs of wells 11S 19E 18aaa1, 11S 19E 18dcd1 and 11S 19E 17aab1.

material would thus contain approximately 1,000,000 acre-feet of water under the 200,000-acre tract. The average 10-foot annual water-level fluctuation shown in figures 22 and 23 thus indicates an annual storage and dissipation of 100,000 acre-feet of water, or approximately 7 percent of the average annual diversion.

The above estimates of ground-water storage must be treated only as general estimates because of the gross uncertainties in the estimation of a single storage value and application of this value to an area as large as the Twin Falls Tract. The storage capabilities of the saturated geologic materials are very complex and variable, both horizontally and vertically. Because of the nature of fractured rock, little data are available to improve the estimates.

INTERRELATIONSHIP OF GROUND WATER AND SURFACE WATER

As stated previously, the ground water and surface water are closely interrelated in the Twin Falls Tract. The use of one form of the resource cannot be considered without evaluation of the effect of this use on the other form. Two possible exceptions exist from this cause-effect relationship in the tract. It is believed that deep supplies of ground water may be developed, without measurably affecting the flows of the surface streams. A well depth of at least 750-1,000 feet is believed necessary for this type of development. Diversion can be accomplished from the Snake River below Milner without appreciably affecting the ground-water or the surface-water conditions in the tract. The analysis of any other modification of the present hydrologic system in the tract should include both surface and ground-water aspects.

WATER BALANCE

One of the primary objectives of this study is to determine the quantity of water leaving the Twin Falls Tract that may be usable for additional development. The quantity of water leaving the tract in surface streams and drains can be adequately evaluated from existing measurements available from the U.S.G.S. and other agencies. However, the quantity of ground water or subsurface flow from the tract is not directly measurable and can only be estimated. The available data make the water balance method the most practical of several possible methods of estimating this quantity of ground water leaving the tract.

Quantitative data are either available for each inflow source or can be estimated with reasonable accuracy. Quantitative data are also available or can be estimated for each outflow source except subsurface outflow. Thus the magnitude of the subsurface outflow can be estimated as the difference between the total inflow and the known outflow factors, assuming no change in either surface or subsurface storage occurs during the period for which the balance is calculated. Surface storage on the tract is limited to Murtaugh Lake. Its relatively small capacity makes it unnecessary to consider surface storage in the water balance. Subsurface storage changes could be significant; however, records of depth-to-water made by the Twin Falls Canal Company and the U.S.G.S. indicate that the underground aquifer is in dynamic equilibrium. The quantity of water in storage changes throughout the year. The water levels rise when irrigation water is applied and fall during the winter and early spring months, but are essentially the same on any given date, year after year. Therefore, water balance calculations can be made on an annual basis without considering storage changes.

The boundaries of the study area were used as the boundaries for the water balance. The block defined by these boundaries contains more area than the 202,700 acres serviced by the Twin Falls Canal Company. The remaining acreage, approximately 12,000 acres, can be omitted from the water balance assuming that it is waste ground from which the net water gain or loss is negligible.

The 1956 water year was chosen as the period for the water balance because of the availability of outflow data for the major streams. Because the discharge in the major streams accounts for approximately three-fourths of the measurable surface outflow, it is desirable to calculate the balance for a year in which discharge data is available for them. Comparison of the streamflow records for 1956 with long-term records for these same streams is not possible. Comparison of the two major inflow factors, precipitation and diversions from Milner into the South Side Canal, however, indicates that 1956 can be described as a typical year with respect to water supply. The precipitation at the Twin Falls 2NNE station for 1955-56 corresponds almost exactly to the 47-year mean (fig. 3). Diversions into the South Side Canal at Milner for the water years 1955-56 corresponded to the 34-year mean (fig. 17). The diversions from Milner are almost the same each year, less than 10 percent maximum variation from the mean. The water balance should be similar in magnitude each year because these diversions account for about 80 percent of the inflow to the tract.

INFLOW

The estimated total inflow in the water year 1956 from the combined sources of precipitation, irrigation diversions from Milner, and stream inflow was 1,446,000 acre-feet (table 3). Subsurface inflow from the Rock Creek-Milner Low Lift area, Salmon Falls, and Blue Gulch areas was estimated at 165,000 acre-feet. Each of these inflow sources is discussed in detail in the following sections.

Precipitation — The contribution to the water supply from precipitation on the tract was estimated as 144,000 acre-feet. This value was obtained from estimated precipitation of 8.52 inches for the 1956 water year. The weighted average precipitation was calculated by the Thiessen polygon method, using U. S. Weather Bureau stations in and adjacent to the area (fig. 24). Precipitation for each of the stations for the 1956 water year and the long-term average for each station is shown in table 4. The total input would have been increased by only 8,000 acre-feet had the precipitation been calculated using the long-term average precipitation for each station.

Surface Inflow — Surface inflow into the Twin Falls Tract is almost exclusively derived from irrigation diversions from the Snake River. Reservoirs on the streams that enter the tract allow utilization of most of the water on lands south of the Twin Falls Tract. Of the eight streams entering the tract, only Rock Creek and Salmon Falls Creek carry significant quantities during normal water years.

The total surface inflow for the 1956 water year from all streams and canals was 1,302,000 acre-feet. Included in this value are the following: 1,275,000 acre-feet diverted from the Snake River at Milner as measured by the U.S.G.S., 18,000 acre-feet from Rock Creek (measured by the U.S.G.S. near Rock Creek, Idaho, and reduced for surface irrigation

TABLE 3

SUMMARY OF WATER BALANCE – TWIN FALLS TRACT

(1956 Water Year)

INPUTS		Acre-Feet
Precipitation		144,000
Canal Diversions		1,275,000
Stream Inflow		26,000
Twin Falls City		1,000
Total (Surface)		1,446,000
Ground Water (Rock Creek-Milner Lowlift)		58,000
Ground Water (Salmon Falls)		100,000
Ground Water (Blue Gulch)		7,000
Total		1,611,000
Total (rounded)		1,600,000
OUTPUTS		
Evapotranspiration		460,000
Major Streams		
Rock Creek	= 167,000	
Cedar Draw	= 56,000	
Mud Creek	= 84,000	
Deep Creek	= 161,000	
Salmon Falls	= 112,000	580,000
Major Drains		110,000
Minor Streams and Drains		50,000
Unmeasured Surface and Subsurface Outflow		400,000
Total (rounded)		1,600,000

diversions below the gaging site), 7,000 acre-feet from Salmon Falls Creek (estimated from U.S.G.S. miscellaneous measurements at Roseworth Crossing), 1,000 acre-feet as combined flow from ephemeral streams entering the tract (Crosthwaite, oral communication), and approximately 1,000 acre-feet from Blue Lakes by the city of Twin Falls.

Subsurface Inflow – Subsurface inflow enters the study area from three surrounding areas. Estimates of ground-water outflow from previous hydrologic studies on these areas were summed to calculate the total subsurface inflow into the Twin Falls study area. Subsurface outflow from the Rock Creek-Milner Low Lift area has been estimated at approximately 58,000 acre-feet (Crosthwaite, 1969-2). Water-level contours presented in the same report indicate that most of this outflow enters the extreme eastern portion of the Twin Falls study area. The outflow from the Salmon Falls Tract also appears to enter the Twin Falls study area and has been estimated at 100,000 acre-feet (Crosthwaite, 1969-1).

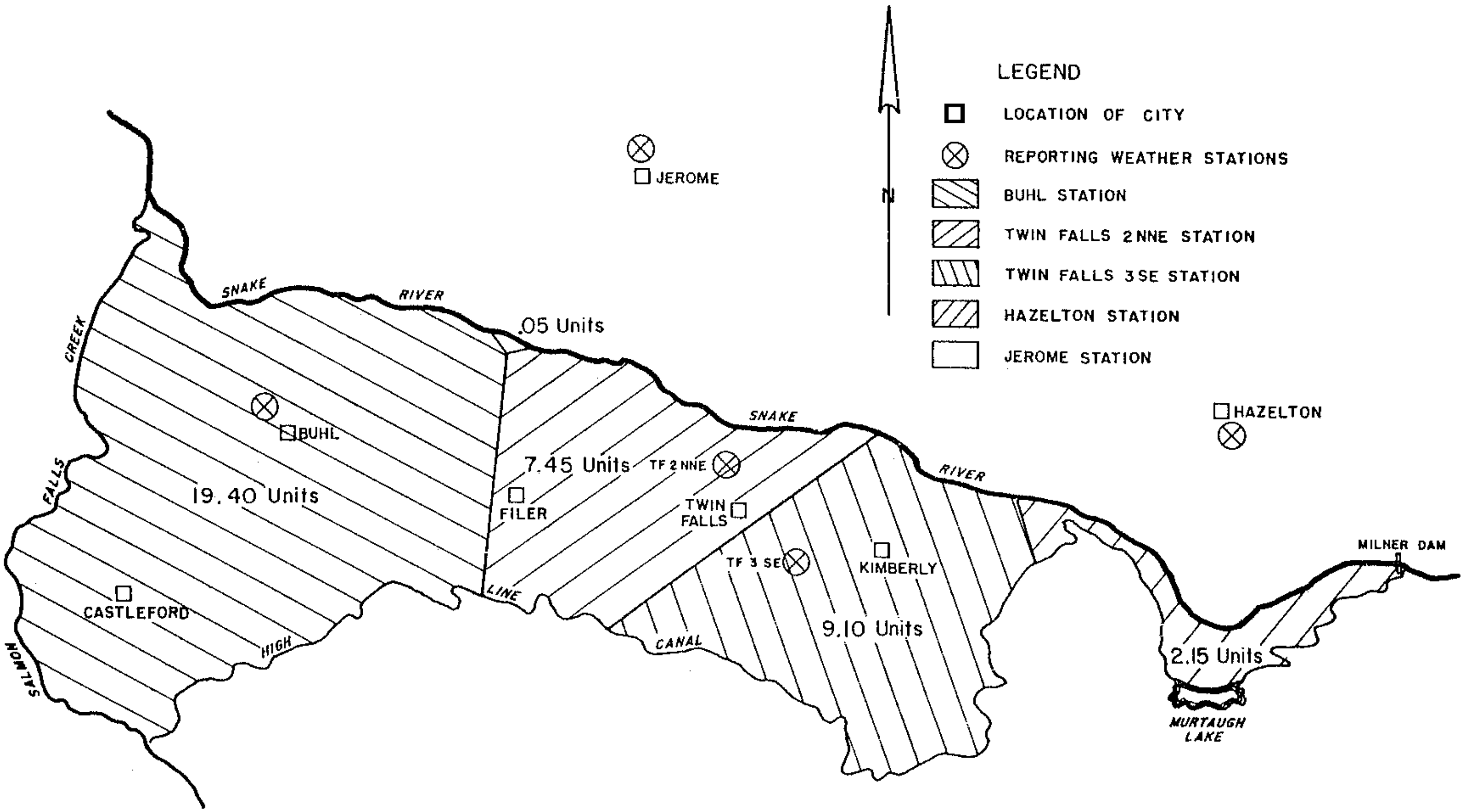

FIGURE 24. Thiessen polygons for 1955-1956 precipitation.

TABLE 4

COMPUTATION OF PRECIPITATION ON TWIN FALLS TRACT

(1956 Water Year)

Station	Precipitation 1956 W.Y. (Inches)	Area Affected (Acres)	Product (Acres-Inches)	Long-term Average Precipitation (Inches)
Buhl	8.53	103,100	879,443	8.09
Hazelton	10.43	11,400	118,902	10.11
Jerome	10.05	300	3,015	8.87
Twin Falls 2NNE	8.09	39,600	320,364	8.74
Twin Falls 3SE	8.39	48,300	405,237	8.74
Total	8.52 (Average)	202,700	1,726,961 (Or approxi. 144,000 A-F)	9.03 (Average)

Ground-water discharge from the Blue Gulch area west of Salmon Falls Creek enters Salmon Falls Creek below Roseworth Crossing and thus must be considered in the water balance calculation. The annual discharge from this area has been estimated at 7,000 acre-feet (Chapman and Ralston, 1970). Each of these three estimates are the result of a number of assumptions, and are not known to the same precision as the estimates of surface-water inflow. The estimate of the average quantity of water available to the tract is rounded to 1,600,000 acre-feet per year because of the lack of the precision of the data.

OUTFLOW

Water leaves the study area by three methods: consumptive use, surface outflow entering the Snake River, and subsurface outflow which also probably enters the Snake River in the form of seeps and springs. Consumptive use was estimated at 460,000 acre-feet for the 1956 water year, and measurable surface outflow was measured at 740,000 acre-feet for the 1956 water year, leaving a residual of 400,000 acre-feet to be accounted for as unmeasurable surface outflow and subsurface outflow. Each of these items are discussed in the following sections.

Consumptive Use – The quantity of water consumptively used on the tract by evaporation and plant transpiration was estimated using crop consumptive use data for the 1956 crop growing season (Sutter and Corey, 1970) adjusted to a full calendar year basis using estimated evaporation rates for the nonirrigation season months. Acreages for the principal crops (table 5) grown in the study area were estimated for 1956 using irrigated acreage data from the 1959 Census of Agriculture and the total cropped acreage reported by the Twin Falls Canal Company (202,700 acres). It was assumed that the percentage of

TABLE 5

COMPUTATION OF CONSUMPTIVE USE FOR TWIN FALLS TRACT

(1956 Water Year)

Crops	Acreage	Consumptive Use Crop Season (Ft.)	50% of Non-Crop Season Evapotranspiration (Ft.)	Total Annual Consumptive Use (Ft.)	Total Annual Water Use (A-F)
Corn, grain	608	1.76	.22	1.98	1,204
Corn, silage	3,243	1.79	.34	2.13	6,908
Fall grain	405	1.73	.59	2.32	940
Spring grain	38,513	1.46	.59	2.05	78,952
Beans, peas	52,094	1.50	.47	1.97	102,625
Hay, alfalfa	54,526	2.52	.21	2.73	148,856
Potatoes	7,500	2.07	.59	2.66	19,950
Sugar beets	11,554	2.23	.21	2.44	28,192
Vegetables	3,446	1.07	.59	1.66	5,720
Orchards	406	2.11	.21	2.32	942
Pasture	10,135	1.94	.21	2.15	21,790
Misc. (Roads, Towns)	20,270	1.94	.21	2.15	43,581
Total	202,700			2.27 Average	459,660

acreage of each crop and of the noncrop land acreage would be the same for the Twin Falls Tract in 1956 as for Twin Falls County in 1959. Crop season consumptive use for each principal crop was calculated by Sutter and Corey using climatic data for the Twin Falls 2NNE weather station for 1956 in the modified Blaney-Criddle equation. The resulting value was increased for evaporation during the winter months by adding 50 percent of the potential evaporation computed for Lake Walcott (Walker and others, 1970) for each month of the nongrowing season for each crop (table 5). The crop acreage reported by the Twin Falls Canal Company includes noncropped areas such as towns, roads, canals, fences, and farmsteads. This area was arbitrarily assigned a consumptive use equivalent to irrigated pasture.

A weighted average consumptive use of 2.27 acre-feet per acre was calculated for the Twin Falls Tract. The A.R.S. has estimated a weighted average consumptive use for 1969 of 2.58 acre-feet per acre for the same area. This value was obtained using the modified Penman equation (David Carter, written communication, 1970). The A.R.S. estimate is 14 percent greater than the value obtained in this study. The results are considered reasonably comparable because the estimates were developed using different methods and for different years.

Surface Outflow – The estimate of the surface outflow from the tract of 740,000 acre-feet for 1956 is based upon several types of stream records and measurements made by several agencies. All of the surface outflow from the tract has not been measured during the same year by any one agency and sufficient overlap in records is not available to allow adequate correlation between measurements. The continuous discharge records available for three of the major streams for 1955-58 provide the best available basis for evaluating total runoff. Therefore, estimates of discharge from the other streams, drains, and springs were adjusted to 1956 after being calculated for the year in which the most complete data was available for their discharge.

The outflows were separated into three classifications to make the calculations as consistent as possible: major streams, major drains entering the Snake River, and minor streams, drains, and springs entering the Snake River. The runoff from Cedar Draw, Deep Creek, and Salmon Falls Creek was evaluated from the continuous records available for them for 1956. Because the gage on each of these creeks is located several miles upstream from the mouth, corrections were made to increase the discharge to that at the mouth. Mud Creek was not gaged in 1956 by the U.S.G.S., but a continuous record is available for 1969 from the A.R.S. The discharge for Mud Creek was calculated for 1969 from data collected by the A.R.S. and corrected to 1956 using a factor developed from data for Deep Creek and Salmon Falls Creek which were gaged in both years. A similar method was used for Rock Creek which was also not gaged in 1956. The resulting value was corrected to the mouth. The total discharge for these streams in 1956 is presented in table 3.

Outflow from the major drains was calculated using the miscellaneous measurements made by the A.R.S. in the summer of 1969 and the spring measurement made by the U.S.G.S. in 1959 as a basis. A drain was assumed to have a hydrograph similar in shape to that of the nearest major stream. The discharge obtained from the four miscellaneous measurements was utilized to estimate the 1969 runoff for these drains. This runoff was corrected to agree with the discharge that would have resulted if the four measurements had been from a hydrograph similar in shape to that of the nearest major stream. The result was corrected to 1956 using the ratio of the 1956 discharge to 1969 discharge for the nearest major stream.

Outflow from the minor streams, drains, and springs was estimated assuming that the average of 1959 spring and late summer measurements made by the U.S.G.S. was the average discharge in 1956. Because the combined outflow from these sources accounted for only 7 percent of the total estimated surface outflow, detailed corrections for 1956 were not justifiable.

Unmeasured Surface and Subsurface Outflow – The 400,000 acre-foot estimate of unmeasured surface and subsurface outflow was obtained by subtracting the estimated consumptive use and surface runoff from the estimated total input. An estimate obtained in this manner is subject to inaccuracies from many sources. This is particularly true because the residual would be smaller if the less reliable estimates of subsurface inflow were not considered. If subsurface inflow were not included, the residual would be reduced by 40 percent to 235,000 acre-feet.

The gain in the flow of the Snake River between Milner and Lower Salmon Falls is sufficient to allow the above noted outflows to occur. Estimates of gain in each of three reaches between gages can be obtained by subtracting the annual runoff at successive gages. It should be emphasized, however, that these estimates are subject to error because they are the difference of two large numbers. These estimates are given in the following table:

Gages	1956 Total Gain Acre-Feet	1956 Unaccounted For Gain Acre-Feet
Milner to Kimberly	287,000	237,000
Kimberly to Buhl	1,250,000	70,000
Buhl to Lower Salmon Falls	3,292,000	450,000

The total unaccounted for increase in flow of Snake River between Milner and Lower Salmon Falls in 1956 was approximately 760,000 acre-feet. This value cannot be entirely attributed to south side inflow because not all of the surface and subsurface water entering from the north side was measured. Also, the estimates of north side inflow were based upon single annual measurements. The unaccounted for gain is sufficiently large, however, to allow a residual south side inflow of the magnitude estimated by the water balance.

WATER QUALITY

Data on the quality of the water in the Twin Falls Tract is available from three major sources. The A.R.S. collected bimonthly samples from 26 drains and tunnels and 7 stream sites in the Twin Falls Tract in 1968-69 (table 6). Several quality analyses are available from the U.S.G.S. on streams and tunnels on the tract, collected during the period 1962-69. The Idaho Department of Health has collected samples from public supply wells in the area and have analyses available for these sites.

TABLE 6

ANALYSES OF WATER QUALITY FROM TWIN FALLS COUNTY

COLLECTION DATE OF SAMPLES - DECEMBER 30, 1968 - UNLESS OTHERWISE NOTED

	Drains & Tunnels	Location	Temp. (°F)	E.C. x 10^{-6}	pH	Cations (ppm) Ca^{++}	Na^{+}	K^{+}	Mg^{++}	Anions (ppm) Cl	HCO_3	SO_4	NO_3	F	SAR
	Collecting Agency - A.R.S.														
1.	Foiles	NW¼NW¼ 7-11S-18E	56	767	8.03	106.2	55.6	6.3	21.8	51.8	296.5	48.0	1.2	-	1.28
2.	Griffeth	SW¼SW¼ 17-10S-17E	57	923	7.92	80.2	80.2	4.3	32.8	50.0	328.2	47.1	1.9	-	1.97
3.	Brown	NE¼SW¼ 21- 9S-16E	57	1112	8.01	104.2	96.3	6.3	28.6	60.3	372.2	65.8	3.1	-	2.16
4.	Hutchinson	SW¼SE¼ 7- 9S-15E	57	1112	7.99	105.2	103.4	7.8	28.6	60.3	467.4	51.9	3.7	-	2.32
5.	Kaes	SW¼NW¼ 8-10S-14E	57	1112	7.86	124.2	63.0	7.0	34.0	67.4	377.1	64.8	3.7	-	1.29
6.	Molander	NW¼SE¼ 7-10S-14E	57	1090	8.08	114.2	63.0	8.2	40.1	75.9	350.2	66.8	-	-	1.29
7.	Anna De Klotz	SE¼NE¼ 2-10S-15E	54	956	8.26	108.2	92.0	5.5	38.3	52.1	386.8	51.9	3.1	-	1.94
8.	Harvey Drain	NE¼NW¼ 33- 9S-15E	55	1012	8.08	100.2	92.0	5.1	38.3	57.4	396.6	51.9	4.3	-	1.82
9.	Claar	SW¼SW¼ 32-10S-17E	54	1179	8.19	104.2	83.9	3.9	40.1	49.6	389.8	69.2	3.1	-	1.77
10.	Fish Hatchery	SE¼NE¼ 21-10S-17E	55	856	7.90	98.2	65.1	5.1	36.5	47.9	311.8	50.0	1.9	-	1.43
11.	Grossman	NW¼NE¼ 19-10S-17E	57	912	8.05	78.2	69.0	3.9	32.8	44.7	351.4	51.9	2.5	-	1.66
12.	Nye	SE¼NE¼ 13-10S-16E	57	1001	7.94	82.2	81.6	3.9	32.2	58.9	333.1	63.9	2.5	-	1.94
13.	Qualls	SE¼SW¼ 11-10S-16E	55	990	8.13	88.2	77.7	3.9	26.8	54.3	343.5	65.8	2.5	-	1.87
14.	Tolbert	NE¼NE¼ 12-10S-16E	56	1156	8.05	107.2	94.0	4.3	37.7	63.5	391.1	68.2	3.7	-	1.98
15.	Walters	NE¼SE¼ 20- 9S-16E	57	1112	8.29	87.2	89.2	5.5	48.7	58.2	351.4	66.8	3.7	-	1.90
16.	Mendini	NE¼SW¼ 24- 9S-14E	57	1090	8.31	60.1	110.3	8.2	28.6	59.2	341.7	50.9	5.0	-	2.94
17.	Neyman	NW¼SW¼ 28- 9S-14E	56	1134	8.30	114.2	92.0	4.7	32.8	58.9	413.7	57.2	3.1	-	1.96
18.	Love	SE¼SW¼ 34- 9S-14E	56	1201	8.10	107.2	92.0	9.0	36.5	71.3	453.9	61.0	4.3	-	1.96
19.	Galloway	SE¼NE¼ 9-10S-14E	54.5	1012	8.18	92.2	89.2	4.7	37.7	48.6	429.5	44.2	3.7	-	1.98
20.	Cox	SW¼SE¼ 8-10S-14E	54.5	1001	8.11	75.2	75.4	4.7	32.8	51.1	389.9	43.2	4.3	-	1.83
21.	Herman	SE¼SE¼ 17-10S-14E	54.5	1101	8.05	130.3	64.8	4.3	31.6	58.2	439.3	55.2	2.5	-	1.32
22.	Harvey Tunnel	NE¼NW¼ 33- 9S-15E	55	956	8.00	77.2	81.6	9.0	31.6	58.9	411.2	36.2	3.7	-	1.98
23.	Peavy	NW¼SW¼ 1-10S-15E	57	979	8.05	70.1	86.9	5.1	37.7	55.0	386.2	41.8	3.1	-	2.09
24.	Pagett	SW¼SW¼ 7-10S-16E	56	979	8.04	70.1	86.9	5.1	40.7	61.7	367.9	45.1	3.1	-	2.04
25.	Hankins	SE¼NE¼ 2-10S-17E	56	1090	7.99	87.2	103.4	6.6	35.3	59.2	381.9	52.8	3.7	-	2.30
	Surface														
26.	Rock Creek - High Line	SW¼ 25-11S-18E	32	245	8.07	29.1	8.7	4.7	7.9	11.0	115.3	7.2	0.0	-	.37
27.	Rock Creek - Mouth	SE¼NW¼ 25- 9S-16E	45	979	7.93	97.2	69.0	9.4	31.6	71.6	387.4	51.9	0.0	1.0	1.55
28.	Cedar Draw	SE¼SE¼ 23- 9S-15E	45	1023	8.05	69.1	89.2	5.1	37.7	59.9	395.4	55.2	2.5	1.0	2.14
29.	Mud Creek	SW¼NW¼ 11- 9S-14E	46	1045	8.04	86.2	96.3	7.4	26.8	65.6	431.4	50.9	3.1	-	2.33
30.	Deep Creek	NE¼NW¼ 29- 9S-14E	48	979	8.10	89.2	75.4	9.0	37.7	53.2	374.0	59.6	2.5	1.0	1.69
31.	Snake River at Milner		32	567	8.27	61.1	25.7	5.5	16.4	33.0	249.5	-	18.6	-	-
	Collecting Agency - Idaho Department of Health														
	Twin Falls Well	SW¼NW¼ 10-10S-17E													
	Three different depths														
32.	895 ft. - date sampled 6/ 9/59		-	-	7.7	95.0	128.0	-	36.0	92.0	135.3	252.0	-	.8	-
33.	1195 ft. - date sampled 6/18/60		-	-	7.8	104.0	96.0	-	25.9	90.0	299.9	126.0	-	6.9	-
34.	1535 ft. - date sampled 8/10/60		-	-	8.2	36.8	66.0	-	4.8	39.0	175.6	49.8	-	6.8	-

Pattern diagrams of water quality are presented in figure 25 for data collected from drains, tunnels, and streams in the tract on December 30, 1968. In general, calcium is the predominant cation with sodium second, and magnesium third. Bicarbonate is dominantly the major anion. The water in the tract is relatively uniform. Some variation is noted between the concentrations of sodium and calcium, especially in the Cedar Draw drainage.

The chemical data presented is typical of winter discharge of the tunnels and streams. The variation of water quality with time of streams on the tract is shown by a plot of E.C. data for the period 1968-69 (fig. 26). The variations in E.C. values may be compared to the relative proportions of ground-water and surface-water discharges entering the streams. During the winter period when most of the streamflow is derived from ground-water outflow, the E.C. values average 1,000 mmhos, which is believed to be the common value for the ground-water system. Spring and summer values are variable depending on the relative magnitudes of overland flow and waste flow. The lowest values occur in the early spring when the greatest magnitude of surface flow is wasted and ground-water inflow is near the minimum. These values approach the minimum of the Snake River at Milner, the source of the irrigation water.

The variation of the quality of ground water with depth may be seen from three analyses from well 10S 17E 10bcc1 during contruction (table 6). Water samples were obtained when the well was 895 feet, 1,195 feet, and 1,535 feet deep. Several marked features are present. The concentrations of total dissolved solids changes from about 885 ppm, common for most shallow ground water in the Twin Falls Tract, to 350 ppm. The fluoride concentration changes markedly from less than 1 ppm to 6.8 ppm. The water obtained by this well from about 1,400 to 1,535 feet is chemically different from other water intercepted by wells or streams in the area. The temperature also increased from 60^{o} to 87^{o} F when this water was encountered. The high fluoride concentrations encountered are typical of the Idavada Volcanics found in the western Snake Plain (Ralston and Chapman, 1969).

Most of the ground water and surface water in the Twin Falls Tract is suitable for irrigation of most crops. A plot of the sodium adsorption ratio (SAR) versus E.C. (fig. 27) indicates the water has a low sodium hazard and a high salinity hazard. Care should be taken with the use of this water on saline sensitive plants such as green beans and clover.

WATER RIGHTS

The primary water rights associated with the study area are those held by the Twin Falls Canal Company. The flow rights allow the diversion of 3,000 cfs with a priority date of 1900 and 600 cfs with a priority date of 1915.

Use of water under these rights include the original application and reuse within the established collection and distribution system. Waste water below the last existing company diversion is thus not included under this right.

The Department of Water Administration has a number of permits and licenses on file for the diversion of surface and ground water within the tract. The locations of these points of diversion are shown in figure 28. Many of the surface-water rights and permits are for

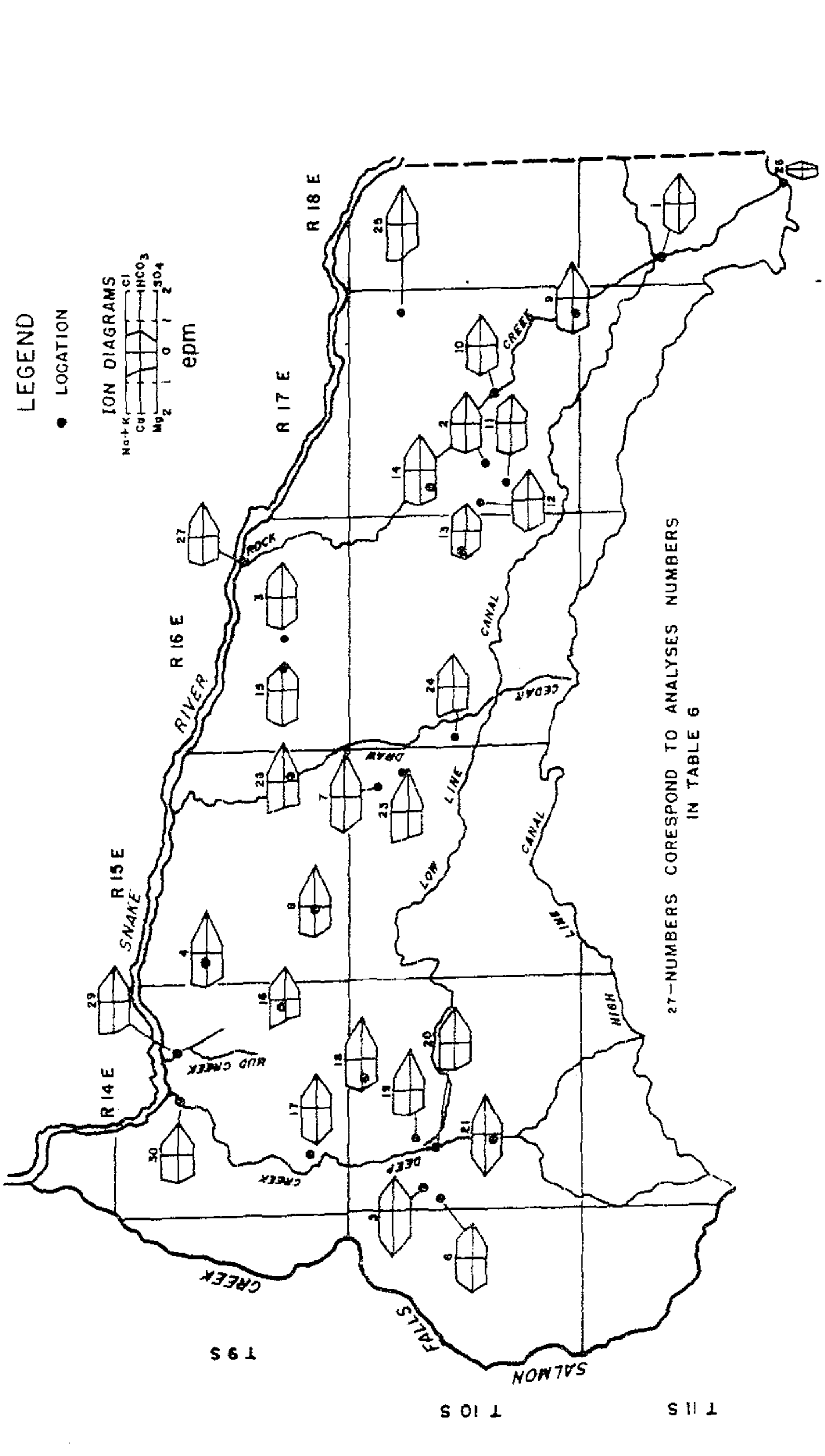

FIGURE 25. Pattern diagrams of water quality in the Twin Falls Tract.

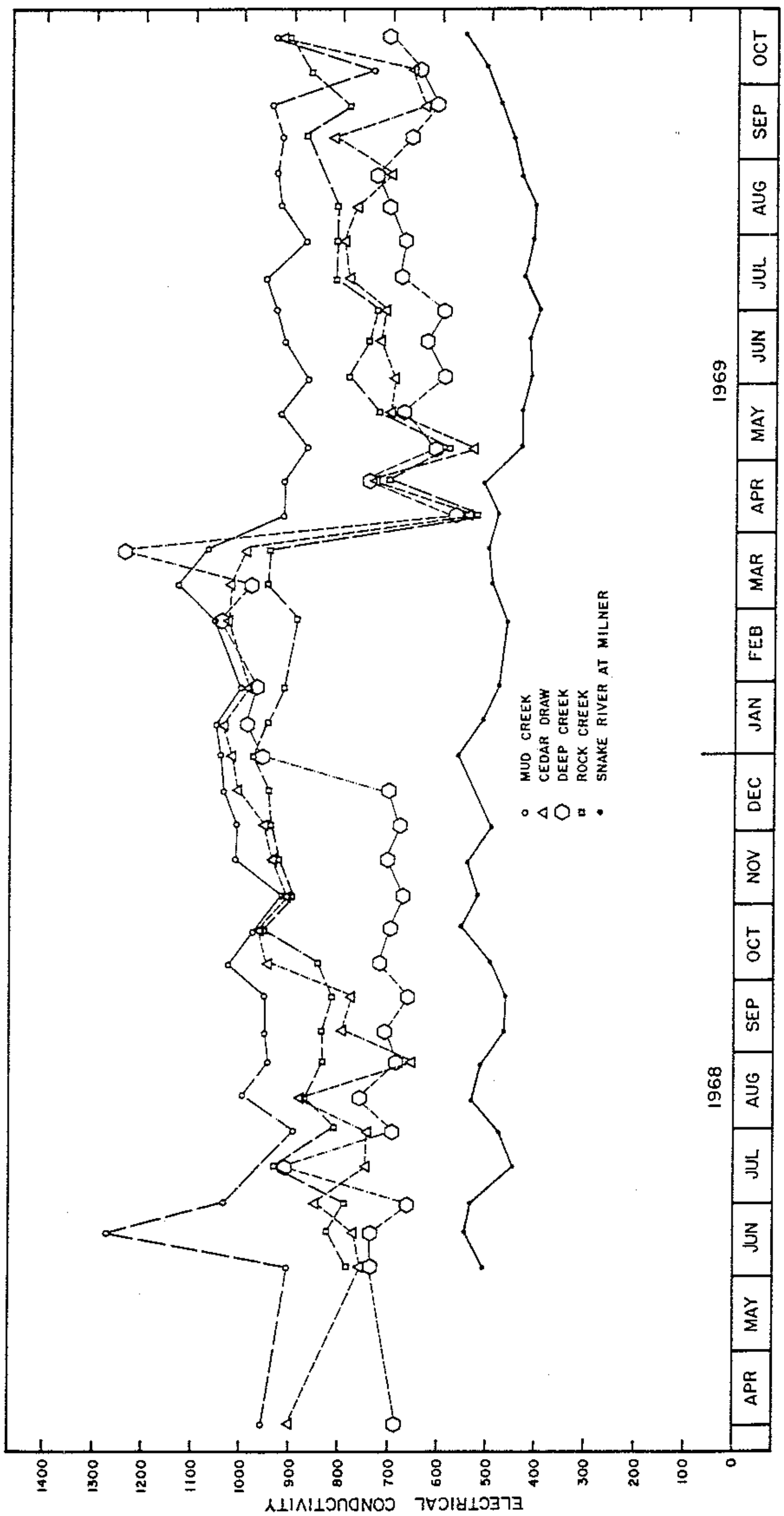

FIGURE 26. Variations in electrical conductivity (E.C.) with time in streams on Twin Falls Tract.

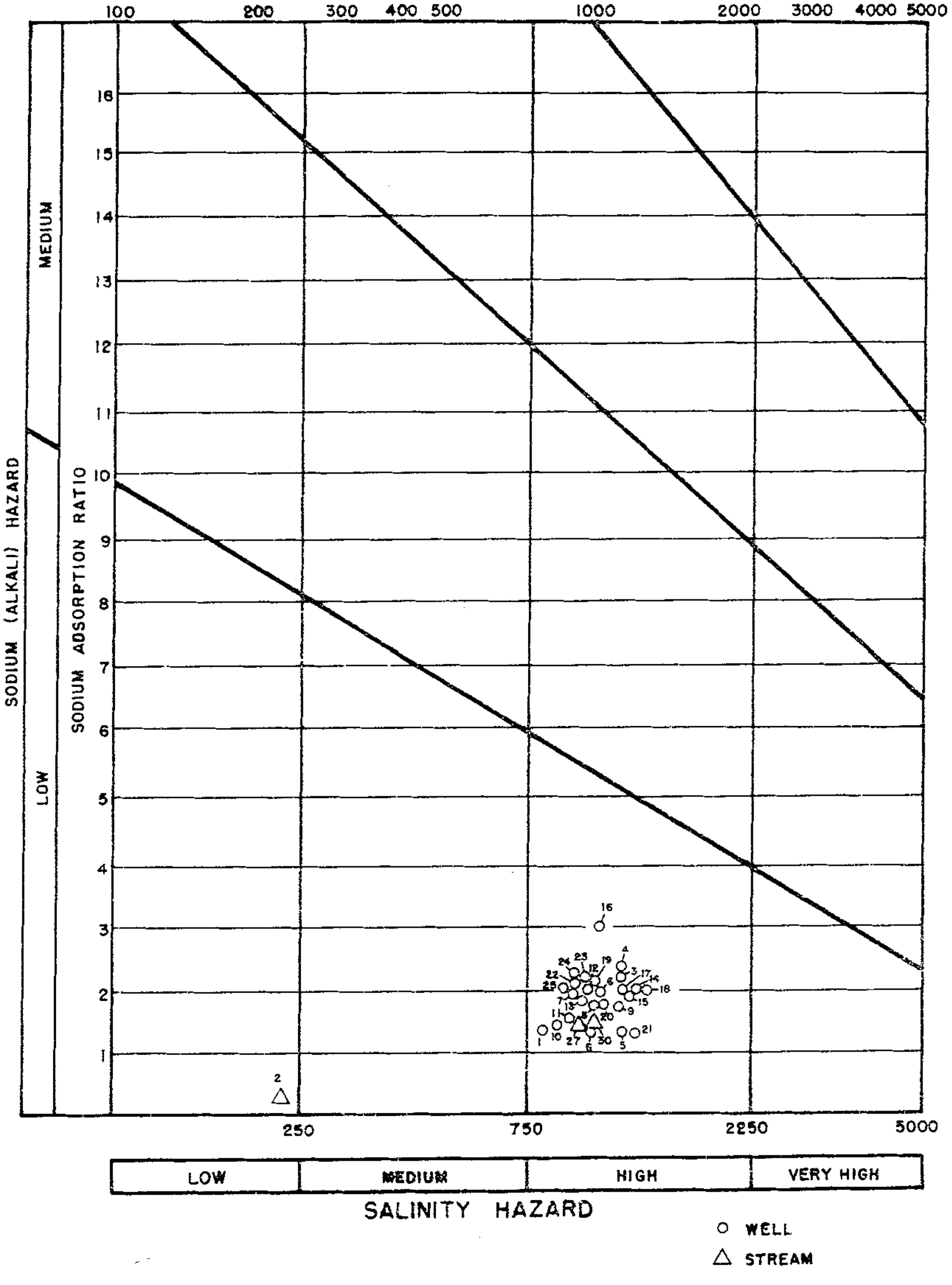

FIGURE 27. Classification of water for irrigation.

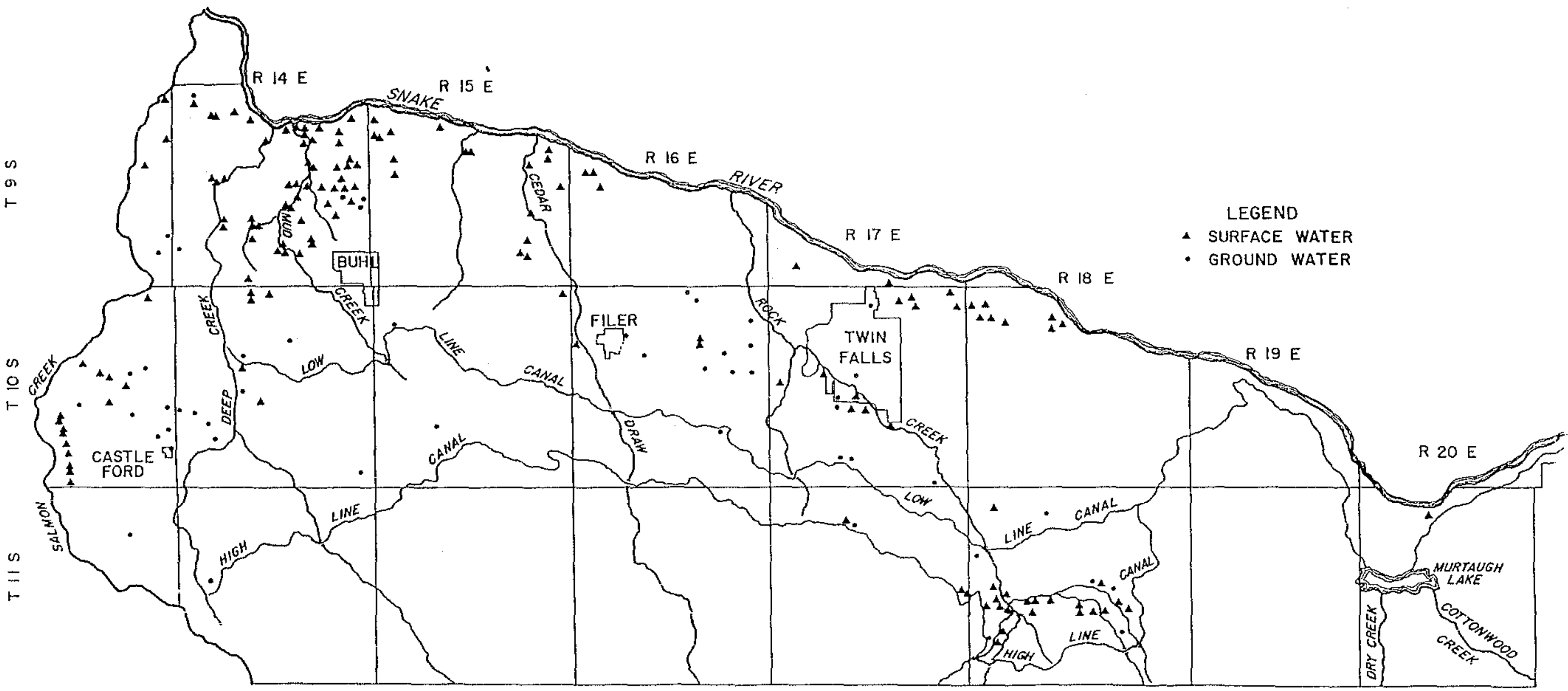

FIGURE 28. Licenses and approved applications to appropriate water on the Twin Falls Tract.

miscellaneous drains and ditches in the area northwest of Buhl. The potential diversion from surface sources as noted by the permits and licenses total over 400 cfs. Diversions totaling 262 cfs are noted from unnamed streams and drains. The recorded rights on streams total 10.4 cfs on Deep Creek, 27.6 cfs on Mud Creek, 1.8 cfs on Cedar Draw, and 96.2 cfs on Rock Creek. Many of the recent rights developed are for fish propagation and are thus essentially nonconsumptive.

A total of 72 permits or licenses are on file with the department for the diversion of ground water for a potential total diversion of 134 cfs. The centers for this development are near Twin Falls and Castleford. Many permits, not included in the tabulation, are located in Township 11 South, Range 20 East, east of the tract. Most ground water in the tract is utilized for small irrigation or supplemental uses. This is shown by the small average filing of 1.86 cfs. Most of the wells obtain water from the shallow aquifers.

Almost all domestic water supplies are derived from ground water. Many small wells have been drilled by the Twin Falls Canal Company for domestic usage. Very few water rights have been recorded for this use. The existing diversion and use of ground water is thus much larger than that noted by the permits and licenses on file.

SUMMARY

The Twin Falls Tract may be considered a hydrologic unit. Although the southern boundary is arbitrarily located, the magnitude of unmeasured surface or subsurface flow crossing this boundary is small compared with the annual diversion of water from the Snake River for irrigation. The effect of this diversion is of primary importance in the tract, as most characteristics of both ground-water and surface-water flow are dependent upon it.

The ground-water resource is closely interrelated with the surface water and water applied for irrigation. Three geologic units are important as aquifers in the study area: Idavada Volcanics, Banbury Basalt and Glenns Ferry Basalt. The Idavada Volcanics, the lowest unit penetrated in the area, has not been developed extensively in the tract. The change in water quality in this unit at about 1,400 feet noted from well 10S 17E 10bcc1 is believed to denote the effective limit of influence from surface-water irrigation diversions. The upper unit of the Banbury Basalt and Glenns Ferry Basalt supply water for most wells in the tract.

Well yields are highly variable from any of the aquifers in the study area. Several wells have yields exceeding 2,000 gpm; most wells derive only small quantities for domestic use. The aquifer transmissibility is believed to be low.

The effective storage coefficient for this area is believed to be approximately 0.05. This value is considerably lower than that previously estimated, but helps to explain the rapid water-level rises that occurred in the area with the initiation of irrigation. Approximately 1,000,000 acre-feet of water is estimated to be in storage in the top 100 feet of the saturated aquifer system. About 100,000 acre-feet is believed involved in the average annual water-level fluctuation.

Each of the five major surface streams draining the tract has the same general annual fluctuation. This fluctuation is a combination of effects from surface waste water from irrigation and ground-water inflow. A base flow component may be noted from each stream typical of the ground-water fluctuations in the area. A low is noted in the spring and high in the fall. Superimposed on this base flow are major individual fluctuations associated with surface-water irrigation. Large flows are noted from surface wastes at the start and end of the irrigation season. Most of the streams have direct turnouts from the major canals. The total south side inflows to the Snake River, as measured in three mass measurements by the U.S.G.S., show the same general fluctuations: a low in the spring and a high in the fall.

The water balance of the Twin Falls Tract indicates that about 80 percent of the total water input to the tract is from diversion from the Snake River. The remainder of the input is divided approximately equally between precipitation and subsurface inflow. The precision of the latter value is believed to be the lowest of all the data on water inputs to the tract. Stream inflow to the tract accounts for only a small percentage of the total input.

Measured surface outflow is the dominant component of the discharge portion of the water balance. Approximately 45 percent of the total water supply of the tract is discharged as measured surface water, mostly in the five main streams. About 30 percent of the total outflow is discharged by consumptive use on the tract. The remaining 25 percent of the outflow is discharged by ungaged surface streams and ground water. This latter discharge is estimated at 400,000 acre-feet per year. The gain in streamflow noted in the Snake River gages between Milner and Lower Salmon Falls is more than sufficient to include inflows of the magnitude presented in the water balance.

The data on water quality provide support data for the postulated base and overland flow components of the streamflow. Levels of E.C. average 1,000 mmhos for the ground-water system. Calcium and sodium are the primary cations and bicarbonate is the primary anion in the ground water in the tract. The ground water is generally uniform in chemical composition. Most of the ground water has a low sodium hazard, a high salinity hazard, and is suitable for irrigation of most crops.

The Department of Water Administration has on file permits and licenses which total over 400 cfs of surface water and 134 cfs of ground water. Applications for permit have not been filed for most of the domestic wells in the tract.

UTILIZATION OF THE OUTFLOW

Approximately 70 percent (1,151,000 acre-feet) of the total annual supply of the Twin Falls Tract leaves the area as surface or ground water. If it is assumed that this water is not needed to fill existing rights downstream in the Snake River, this large outflow is a potential source of water for existing and future irrigation projects. Additional utilization of this outflow is difficult, however, as it is not confined to any single area. Two general methods exist to utilize the outflow from the Twin Falls Tract: (1) increased efficiency of water use on lands already irrigated, and (2) diversion and reuse of outflow as it occurs.

EFFICIENCY OF DISTRIBUTION AND APPLICATION

An analysis of the efficiency of water distribution and use on an irrigation project as large and complex as the Twin Falls Project presupposes knowledge far beyond that gained in the preparation of this report. The problem of location of specific sections of the distribution system causing major losses must be the responsibility of the canal company itself. Perhaps additional canal lining projects can be undertaken in areas of need. Additional study is needed to evaluate the efficiency of the distribution system.

The utilization of better field irrigation techniques is an important tool in the prevention of waste and outflow from the tract. Work is being done by research personnel and others on improving irrigation efficiency. Application of new irrigation methods should be a policy of the canal company as a water conservation method.

The length of the distribution system is a major problem in the efficient operation of the Twin Falls Canal Company. Periods of low water need must be anticipated approximately 24 hours in advance to prevent the wasting of unneeded water. This is particularly a problem at the start and end of the irrigation season when major quantities of water are wasted. This flow may be seen in the hydrographs presented in figures 8, 12 and 14. Regulating storage is needed to provide a damping effect on these fluctuations. Murtaugh Lake is used for this purpose in the present distribution system. Additional reservoirs of this type are needed at locations in the middle and lower sections in the canal network. Sites for these types of structures should be investigated.

The day of plentiful water is past in southern Idaho. Water conservation attitudes must replace attitudes of sectionalism and water competition. This change in attitude is thus a very real method of waste prevention.

DIVERSIONS OF OUTFLOWS

A large outflow has been identified from the Twin Falls Tract, but primarily in forms not conducive to major utilization. Approximately three-fourths of the measured surface outflow is concentrated in the five major streams on the tract: Rock Creek, Deep Creek, Salmon Falls Creek, Mud Creek and Cedar Draw. Nearly 500,000 acre-feet of flow was estimated in these streams in 1956. Utilization of discharge from all but Salmon Falls Creek is possible by either diversion and reuse within the irrigated tract or by storage and diversion in the canyons near the Snake River. Potential sites appear to exist on Rock Creek, Deep Creek and Cedar Draw for the construction of small dams and pumping stations to relift water either into laterals or the main canals. These structures would not allow utilization of the complete discharges of these streams, as they gain considerably downstream from any potential sites. The cost for this supply, however, would generally be low, as lifts would not exceed several hundred feet. These reservoirs would also act as regulation structures in locations where the creeks are utilized as part of the distribution system.

Higher, more major structures can be constructed on the lower reaches of several of the streams. These dams would intercept essentially all of the streamflow for pump utilization on the lower reaches of the tract. Pump lifts in this option might exceed 300 feet to irrigate major portions of land. It is anticipated that the storage behind these structures would be confined to the deep canyon portions of the streams. Study is needed of potential sites to determine the feasibility of either size of structures.

Utilization of measured surface outflows in other than the five major streams is limited to minor changes in the distribution system. Effort should be made to continue the practice of including wasteways into the canal and lateral system whenever possible. Incentive might be given to pumping and reusing waste water in lower sections of the tract.

Approximately one-quarter of the total discharge from the Twin Falls Tract is denoted as *unmeasured surface and subsurface outflow*. This quantity, approximately 400,000 acre-feet in 1956, is the residual of the water balance and is thus the least reliable. Significant discharge does occur in this form, however, and represents a potential for future development. The ability of the aquifers to yield water, however, has and will limit the utility of this resource. Yield-to-wells have been low, to date, with most wells producing less than 500 gpm. The greatest potential for development of the ground-water resource in the tract is probably the continued construction of shallow, small-diameter wells that both aid drainage and provide additional irrigation water. Some potential for larger well development appears likely in the extreme southeast portion of the tract. This area, however, has suffered water-level declines and has been partially included in a critical ground-water area, thus limiting future development.

OPTIMUM UTILIZATION OF OUTFLOW

The optimum utilization of the outflow from the Twin Falls Tract is believed to be a combination of preventive measures to increase the efficiency of the present water usage and full reuse of the return flows that do occur. This type of program would result in a lower annual rate of diversion to the canal system from the Snake River, thus creating a supply for additional application and use.

Detailed study is needed of many phases of the water cycle in the Twin Falls Tract. Evaluation of each part of the water balance is necessary to better qualify the components of input and output. Feasibility studies are needed for the surface-water storage structures needed for return flow reuse. Evaluation of the aquifer characteristics are also needed to determine the optimum development of the ground-water resource.

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