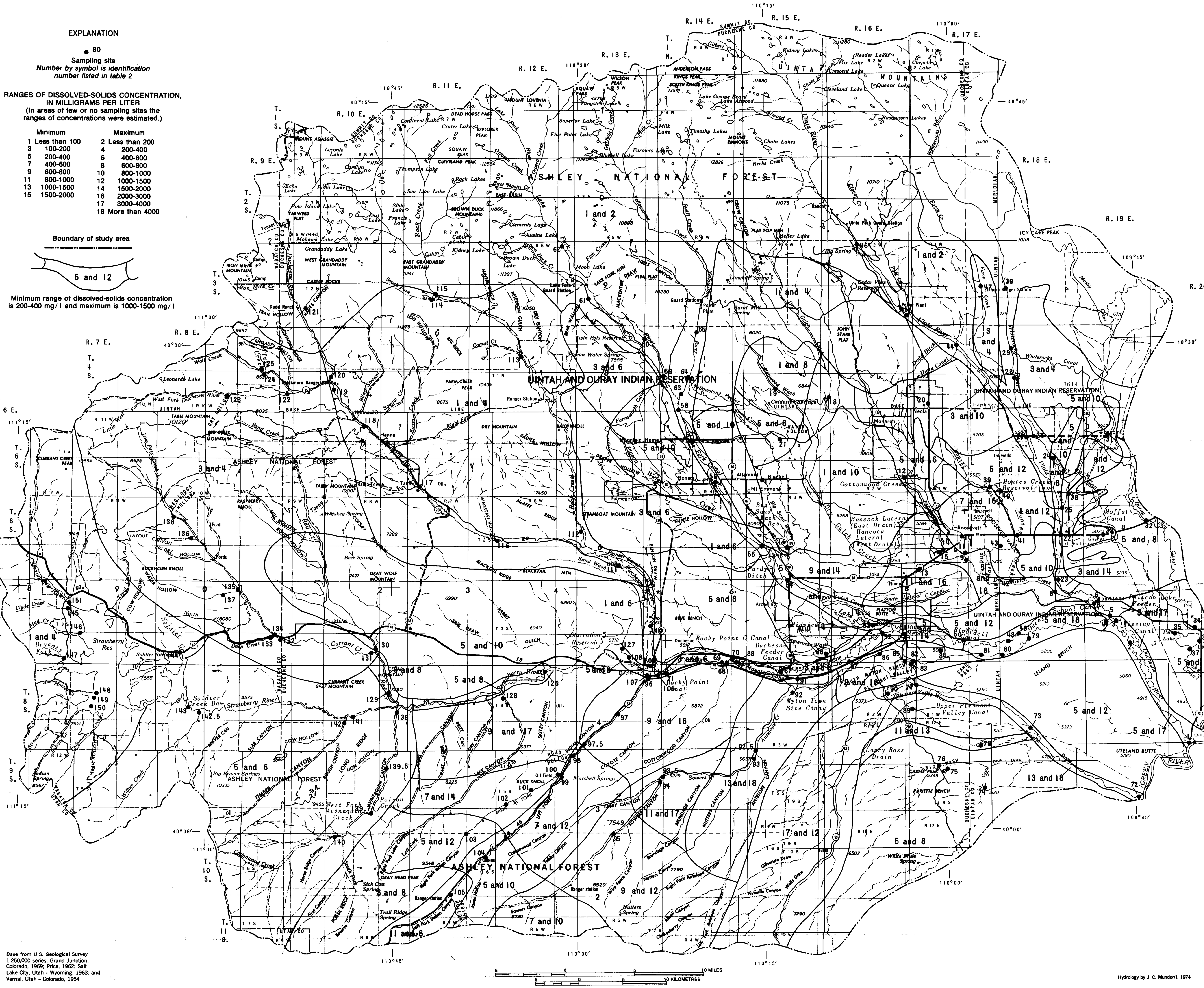
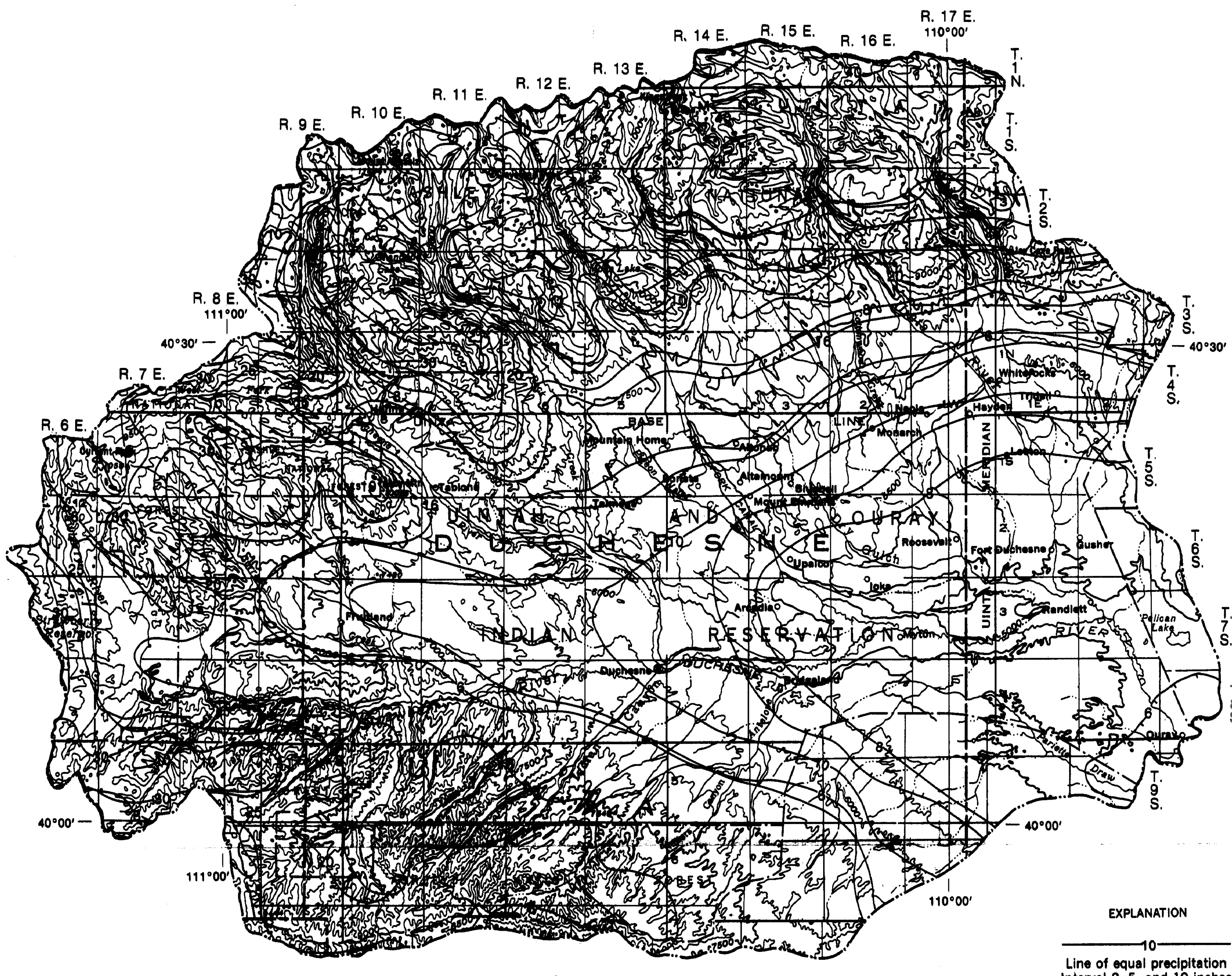


MAP SHOWING LOCATION OF WATER - QUALITY SAMPLING SITES AND THE APPROXIMATE RANGE OF CONCENTRATIONS OF DISSOLVED SOLIDS IN SURFACE WATER IN THE DUCHESNE RIVER BASIN AND SOME ADJACENT DRAINAGE AREAS, UTAH.



NORMAL ANNUAL

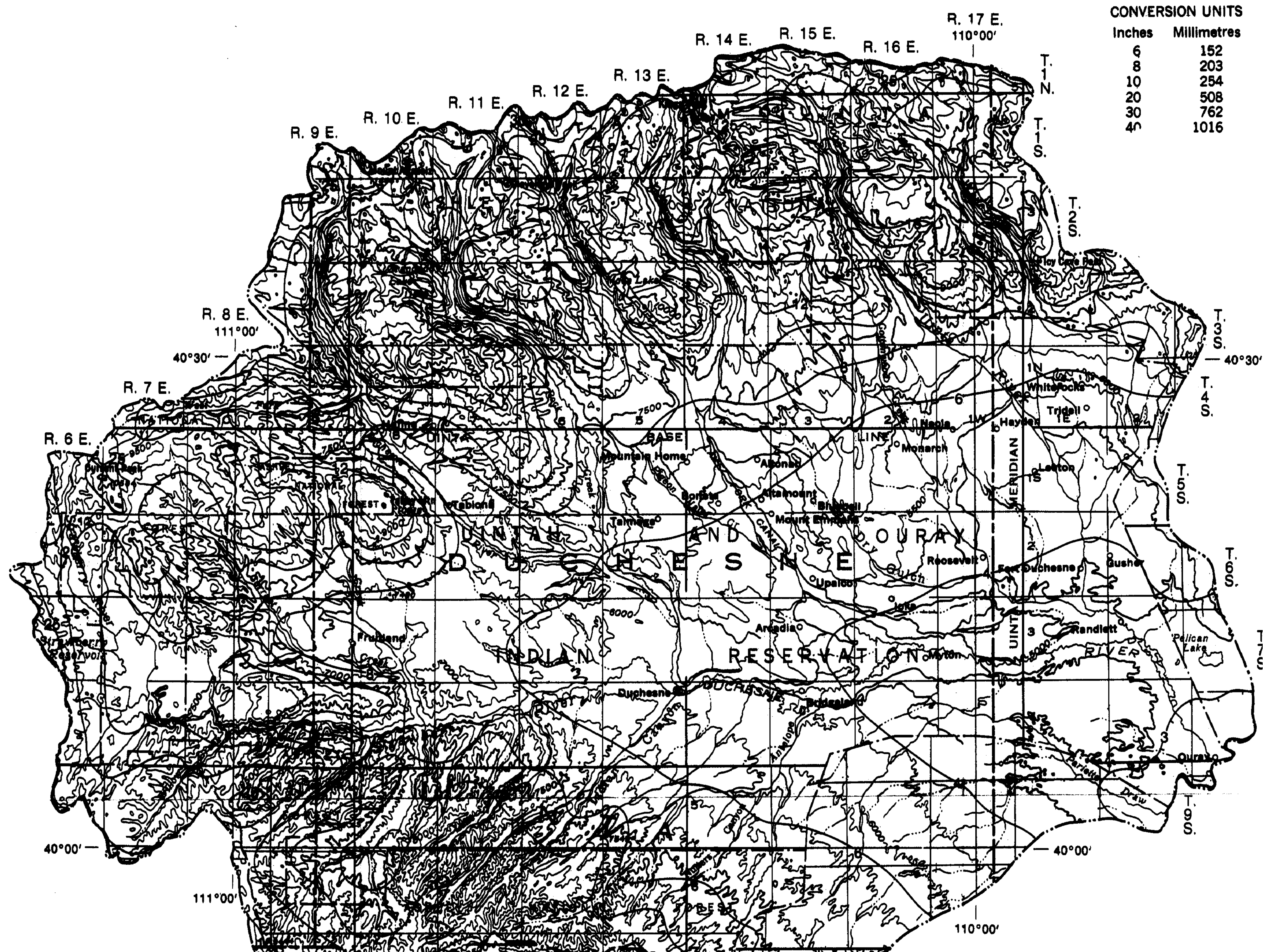
EXPLANATION

——10——
Line of equal precipitation
Interval 2, 5, and 10 inches

Boundary of study area

CONVERSION UNITS

Inches	Millimetres
6	152
8	203
10	254
20	508
30	762
40	1016



OCTOBER-APRIL

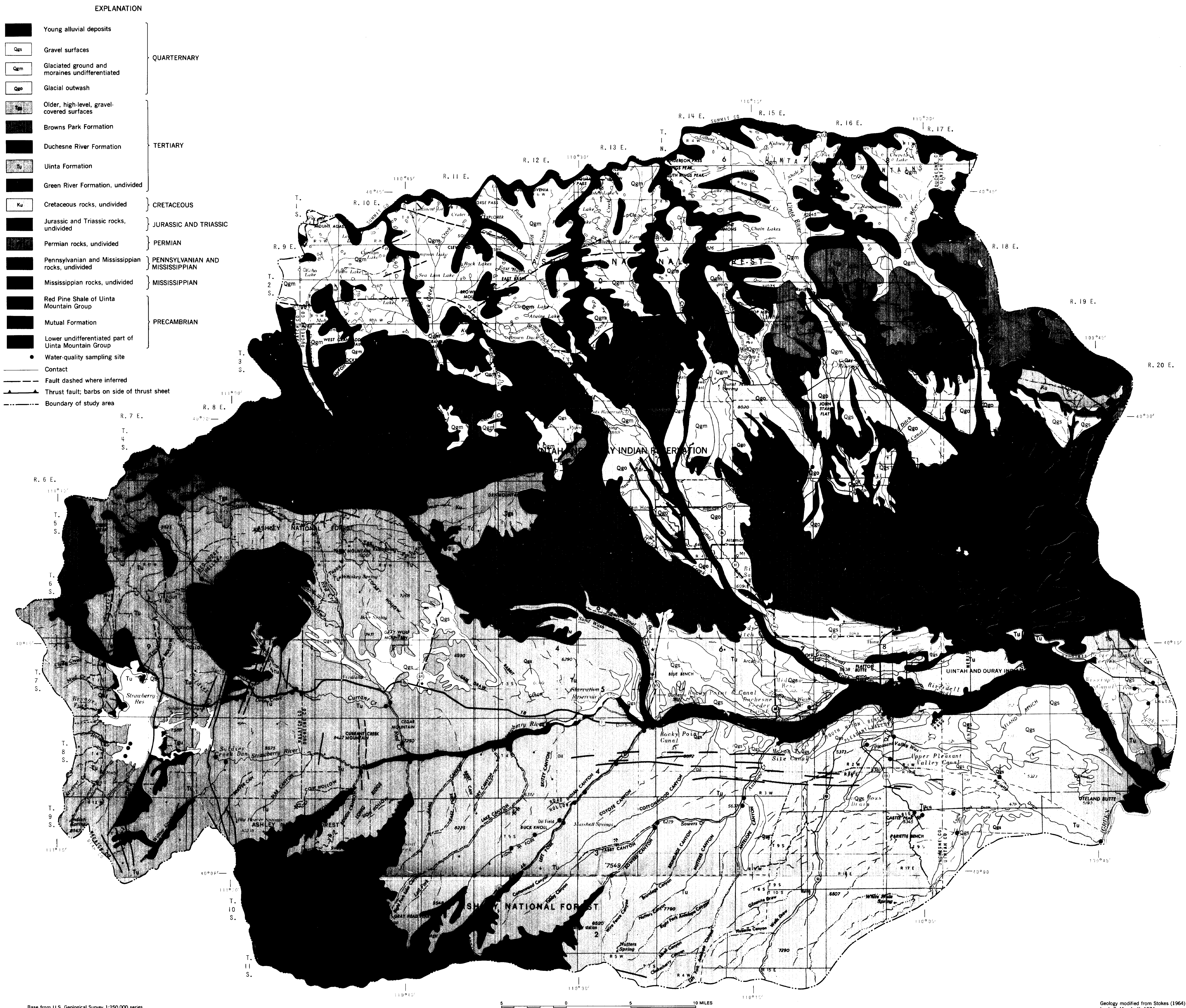
Base from U.S. Geological Survey
State base map 1959

Climatological data from
U.S. Weather Bureau (1963a)

0 10 20 MILES
0 10 20 KILOMETRES

CONTOUR INTERVAL 500 FEET (150 METRES)
DATUM IS MEAN SEA LEVEL

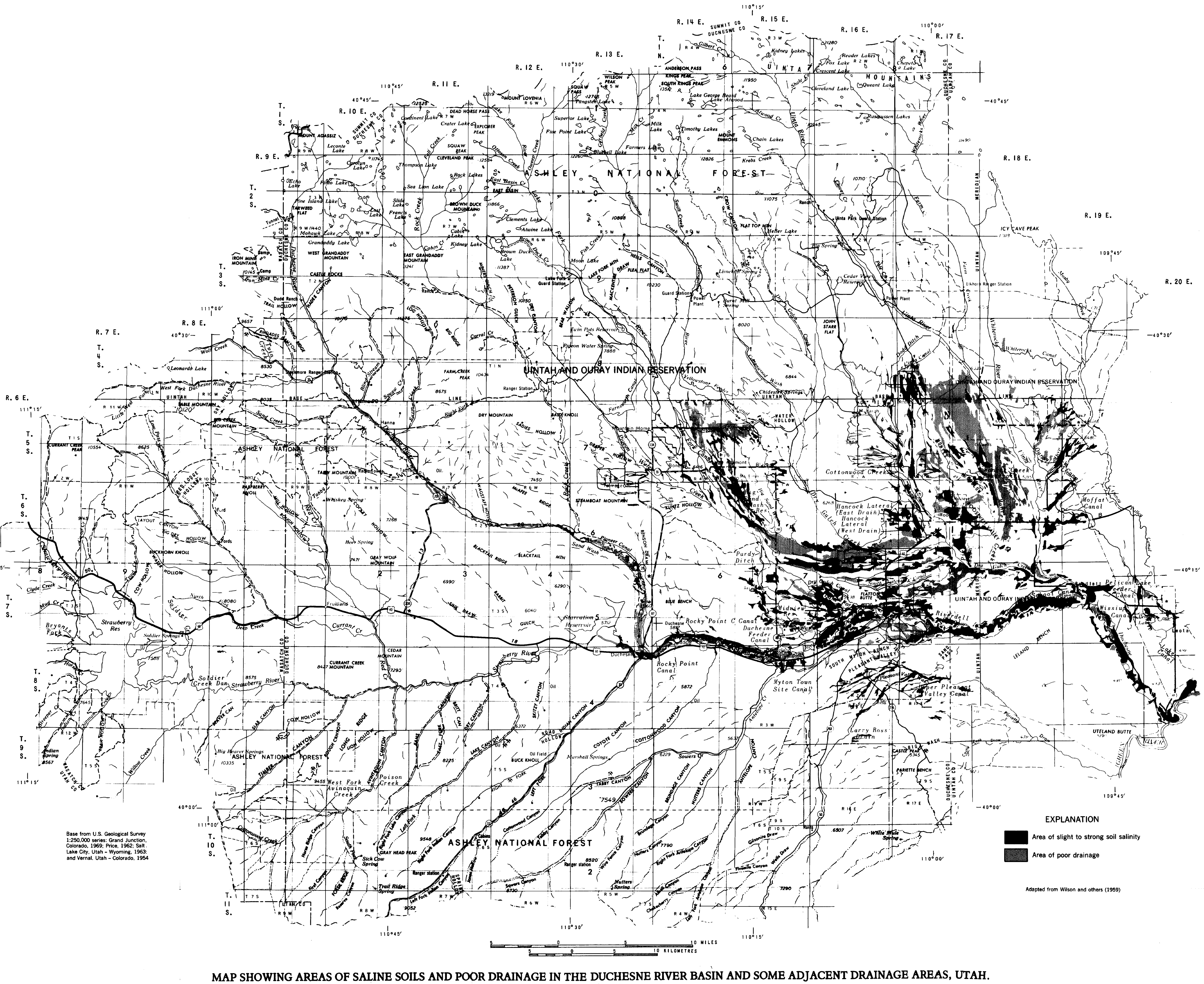
MAPS SHOWING NORMAL ANNUAL PRECIPITATION (1931-60) AND NORMAL OCTOBER - APRIL PRECIPITATION (1931-60) IN THE DUCHESNE RIVER BASIN AND SOME ADJACENT DRAINAGE AREAS, UTAH.



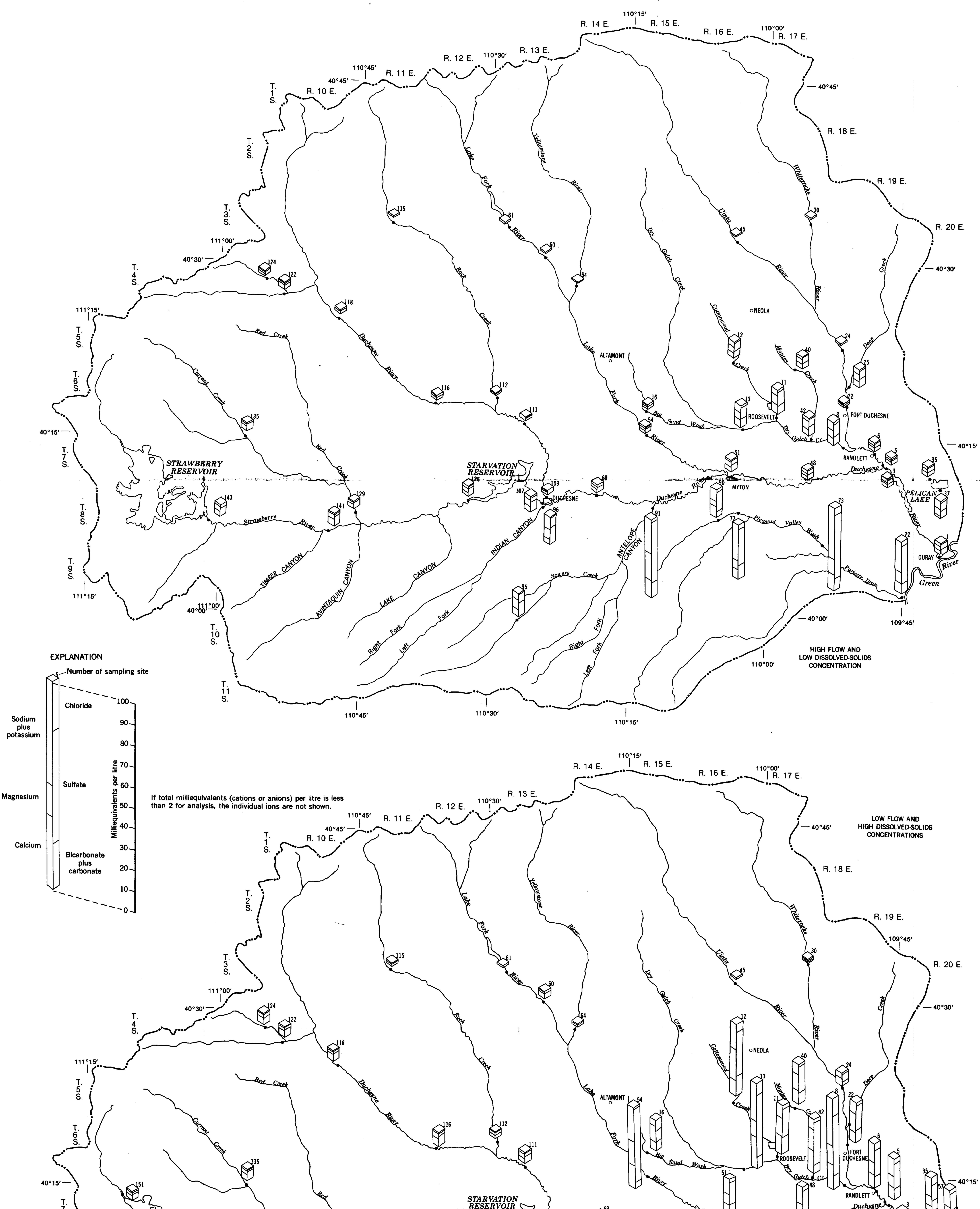
Base from U.S. Geological Survey 1:250,000 series Grand Junction, Colorado (1969), Price, (1962) Salt Lake City, Utah-Wyoming (1963), Vernal Utah-Colorado (1954)

Geology modified from Stokes (1964) by J. C. Mundorff, 1974

MAP SHOWING GEOLOGY AND LOCATION OF WATER - QUALITY SAMPLING SITES IN THE DUCHESNE RIVER BASIN AND SOME ADJACENT DRAINAGE AREAS, UTAH.



MAP SHOWING AREAS OF SALINE SOILS AND POOR DRAINAGE IN THE DUCHESNE RIVER BASIN AND SOME ADJACENT DRAINAGE AREAS, UTAH.



Base from U.S. Geological Survey 1:250,000 series
Salt Lake City, Utah; Wyoming (1963), Vernal,
Utah; Colorado (1954)

Hydrology by J. C. Mundorff, 1974

MAP SHOWING CHEMICAL CHARACTERISTICS OF SURFACE WATER DURING PERIODS OF LOW FLOW AND HIGH DISSOLVED - SOLIDS CONCENTRATIONS AND DURING PERIODS OF HIGH FLOW AND LOW DISSOLVED - SOLIDS CONCENTRATIONS AT SELECTED SITES IN THE DUCHESNE RIVER BASIN AND SOME ADJACENT AREAS, UTAH.

STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

Technical Publication No. 55

RECONNAISSANCE OF WATER QUALITY IN THE DUCHESNE RIVER BASIN AND SOME ADJACENT DRAINAGE AREAS, UTAH

by

J. C. Mundorff
Hydrologist, U.S. Geological Survey

Prepared by
the United States Geological Survey
in cooperation with
the Utah Department of Natural Resources
Division of Water Rights

1977

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ILLUSTRATIONS

[Plates are in pocket]

TABLES

ENGLISH-TO-METRIC CONVERSION FACTORS

Most numbers are given in this report in English units followed by metric units. The conversion factors used are shown to four significant figures. In the text, however, the metric equivalents are shown only to the number of significant figures consistent with the accuracy of the number in English units.

English Units (Multiply)	English Abbreviation	(by)	Metric Units (to obtain)	Metric Abbreviation
Acres		0.4047	Square hectometres	hm^2
		.004047	Square kilometres	km^2
Acre-feet	acre-ft	.001233	Cubic hectometres	hm^3
Cubic feet per second	ft^3/s	.02832	Cubic metres per second	m^3/s
Feet	ft	.3048	Metres	m
Feet per mile	ft/mi	.1894	Metres per kilometre	m/km
Gallons per minute	gal/min	.06309	Litres per second	l/s
Inches	in	25.40	Millimetres	mm
Miles	mi	1.609	Kilometres	km
Square miles	mi^2	2.590	Square kilometres	km^2
Tons		.9072	Metric tons	t

Chemical concentration and water temperature are given only in metric units. Chemical concentration is given in milligrams per litre (mg/l). For concentrations less than 7,000 mg/l, the numerical value is about the same as for concentrations in the English unit, parts per million.

Micrograms per litre (µg/l) is a unit expressing the concentration of chemical constituents in solution as weight (micrograms) of solute per unit volume (litre) of water. One thousand micrograms per litre is equivalent to one milligram per litre.

Chemical concentration in terms of ionic interacting values is given in milliequivalents per litre (meq/l). Meq/l is numerically equal to the English unit, equivalents per million.

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation: °F = 1.8(°C) + 32.

RECONNAISSANCE OF WATER QUALITY IN THE DUCHESNE RIVER BASIN AND SOME ADJACENT DRAINAGE AREAS, UTAH

by

J. C. Mundorff
Hydrologist, U.S. Geological Survey

ABSTRACT

A water-quality reconnaissance in the Duchesne River basin and some adjacent drainage areas, Utah, covered an area of about 4,400 square miles (11,400 square kilometres)--about 4,000 square miles (10,360 square kilometres) in the Duchesne River basin and the remainder in the drainage areas of Pariette Draw and Pelican Lake. Data were obtained by the U.S. Geological Survey one or more times at 108 sites during the period March 1973 to September 1974 and by the Geological Survey or other Federal agencies at 49 other sites during earlier years.

Precipitation in the study area was generally much above normal in the 1973 water year and was much below normal in the 1974 water year. Streamflow was near to appreciably above normal in 1973 and was near to appreciably below normal in 1974.

Present (1975) water developments in the Duchesne River basin include major diversions through the Strawberry and Duchesne Tunnels to the Great Basin. Essentially all the runoff from the 170-square-mile (440-square-kilometre) drainage area of Strawberry Reservoir is diverted through Strawberry Tunnel. The Duchesne Tunnel diverts water from the upper Duchesne River. The Bonneville unit of the Central Utah Project is partly completed; an average flow of about 230 cubic feet per second (6.5 cubic metres per second) would be diverted from nine streams tributary to the Duchesne and Strawberry Rivers and would be stored in the new Strawberry Reservoir Enlargement for diversion to the Bonneville Basin. The enlargement, which is the prime storage facility for the Bonneville unit and was created by Soldier Creek Dam, increases the Strawberry Reservoir capacity from 283,000 to 1,106,500 acre-feet (350 to 1,365 cubic hectometres).

Dissolved-solids concentrations are low in the surface water in the northern and western parts of the basin and increase markedly in the southeastern part of the basin. Many of the tributaries in the southern part of the basin have high dissolved-solids concentrations; but both precipitation and runoff in this part of the basin are low, and the natural discharge of these tributaries does not have a major effect on the dissolved-solids concentration of water in the Strawberry and Duchesne Rivers.

Most of the total annual runoff from the basin originates in the northern part of the basin in areas of high precipitation at altitudes greater than about 7,500 feet (2,290 metres). These areas are underlain by rocks of Precambrian, Mississippian, Pennsylvanian, and Permian age, and solution of the mineral constituents of these rocks is relatively slight. A relatively small amount of runoff originates in the southern and eastern parts of the basin where the Uinta and Duchesne River Formations of Tertiary age are predominant, the rocks in some places containing gypsum and other saline evaporites that are relatively soluble. A few observations of thunderstorm runoff in ephemeral streams in such areas indicates that dissolved-solids concentrations were less than 600 milligrams per litre and that such runoff does not have a significant adverse effect on the chemical quality of the water in the Duchesne River.

A quantitative evaluation of the effects of irrigation on the chemical quality of the Duchesne River cannot be made with available data. The coincidence is evident, however, of areas of irrigation, of areas of saline soils and poor drainage, of areas underlain by the Uinta and Duchesne River Formations, and of stream reaches of high dissolved-solids concentrations.

The large increase in dissolved-solids concentrations in a downstream direction results predominantly from large increases in the concentrations of sodium and sulfate. Coupled with this is a downstream change in chemical characteristics from a calcium bicarbonate to a sodium sulfate type water. These downstream changes generally appear to result from the diversion of large amounts of water having low dissolved-solids concentrations from upstream parts of the basin and the return to or entry into the stream of smaller amounts of water having much higher dissolved-solids concentrations.

Additional diversions of water from the upper part of the Duchesne River basin will cause an increase in weighted average dissolved-solids concentrations in downstream reaches of the river. For example, the Bonneville unit of the Central Utah Project will result in a depletion of 230 cubic feet per second (6.5 cubic metres per second) of water with a dissolved-solids concentration of 120 milligrams per litre from the present average discharge of 600 cubic feet per second (17 cubic metres per second) with an average dissolved-solids concentration of about 700 milligrams per litre at the Duchesne River near Randlett. The remaining 370 cubic feet per second (10.5 cubic metres per second) of streamflow at this point would have a discharge-weighted average dissolved-solids concentration of about 1,060 milligrams per litre, which is about 50 percent higher than the present average concentration.

During periods of low flow, several tributaries to the Duchesne and Strawberry Rivers in the southern part of the Duchesne River basin have boron concentrations that greatly exceed the limits recommended for various classes of irrigation waters. Boron concentrations as high as 20,000 micrograms per litre were observed at the mouth of Indian Canyon.

Measured suspended-sediment concentrations as high as 36,200 milligrams per litre were observed in a small amount of thunderstorm runoff in the southeastern part of the study area. Sediment concentrations greater than 100,000 milligrams per litre would not be unexpected during periods of intense thunderstorm runoff in many of the tributaries that drain areas underlain by the Uinta and Duchesne River Formations in the southern part of the study area.

An estimate of the suspended-sediment discharge of the Duchesne River near Randlett indicates that the discharge was at least 200,000 tons (181,000 metric tons) during the 1974 water year, when precipitation in the Duchesne River basin was much below normal. This discharge should not be regarded as the combined suspended-sediment discharges of all streams within the basin. A large part of these discharges is either trapped in upstream reservoirs or is removed from the Duchesne River system by the many diversions for irrigation.

INTRODUCTION

This report on the quality of surface water in the Duchesne River basin and some adjacent areas, Utah, was prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights. The purpose of the water-quality reconnaissance on which this report is based was to obtain information about (1) the general inorganic chemical characteristics of the surface water throughout the Duchesne River basin, (2) the effects of the natural environment and of present water use on the chemical characteristics of the surface water in the basin, and (3) the general characteristics of the sediment discharge from the basin.

Thus, the principal objective of the study was a general definition of water-quality characteristics in the Duchesne River basin; a secondary objective was the definition of specific problem areas or stream reaches. The reconnaissance did not include intensive study of the effects of municipal sewage, irrigation, mining, or petroleum development on water quality.

Methods of investigation

Water-quality data were obtained one or more times by the Geological Survey at 108 sites in the study area during the period March 1973 to September 1974. In addition, data were obtained one or more times by the Geological Survey or by other Federal agencies during earlier years at 49 other sites in the area. Concentrations of dissolved solids and of major ions were determined for most samples. For a few samples, only specific conductances were determined. Chemical analyses of samples obtained specifically for this investigation were made by standard methods of the Geological Survey. Data used in the preparation of this report are presented in Hood, Mundorff, and Price (1976).

Suspended-sediment data were obtained at only a few sites in the study area, and infrequently at those sites. Accurate definition of the highly variable quantities and characteristics of fluvial sediment in the study area was not possible during this reconnaissance.

Most of the data for water discharge were obtained by nonstandard methods using a greatly reduced number of sections for velocity determinations. A fairly reliable approximation of discharge was regarded as adequate for this reconnaissance.

Previous studies and acknowledgments

Streamflow records in the Duchesne River basin were first obtained in 1899 at four sites. Since then, streamflow records have been obtained by the Geological Survey for various periods at about 70 additional sites. In 1974, streamflow records were obtained at 25 sites in the basin. The U.S. Geological Survey (1971, p. 1, 20-21) gives the station names, periods of record, and information about the series of publications in which the streamflow records can be found for the period 1899-1970. Later records are given in U.S. Geological Survey (1972-75). Iorns, Hembree, Phoenix, and Oakland (1964) and Iorns, Hembree, and Oakland (1965) included the Duchesne River basin in their comprehensive study of the water resources of the Upper Colorado River Basin.

Hood (1976) investigated the water resources of the northern Uinta Basin area, with special emphasis on ground-water supply; the study area included that part of the Duchesne River basin north of the Duchesne and Strawberry Rivers and the drainage area of Strawberry Reservoir. Price and Miller (1975) made a hydrologic reconnaissance of the southern Uinta Basin; the study area included that part of the Duchesne River basin south of the Duchesne River and south of the Strawberry River as far upstream as Willow Creek. Cruff (1975) investigated methods of supplementing the stream-gaging program in providing a broader coverage of annual and monthly mean flows in the Duchesne River basin. Austin and Skogerboe (1970) made a hydrologic inventory of the "Uintah study unit," which includes all the Green River basin in Utah upstream from the gaging station "Green River at Green River, Utah."

Water-quality data have been collected periodically by the U.S. Bureau of Reclamation at many stream sites where data were needed for planning for the Central Utah Project.

V. Lambert Jensen, Dayl J. Webb, and Nick Panas gave valuable assistance in the collection of the field data on water quality and streamflow during March 1973 to September 1974.

HYDROLOGIC SETTING

The study area (pl. 1) of about 4,400 mi^2 (11,400 km^2) is about 70 percent in Duchesne County, about 15 percent in Uintah County, and about 15 percent in Wasatch County; less than 10 mi^2 (26 km^2) of the extreme southwestern part of the study area are in Utah County. Of the

Soils

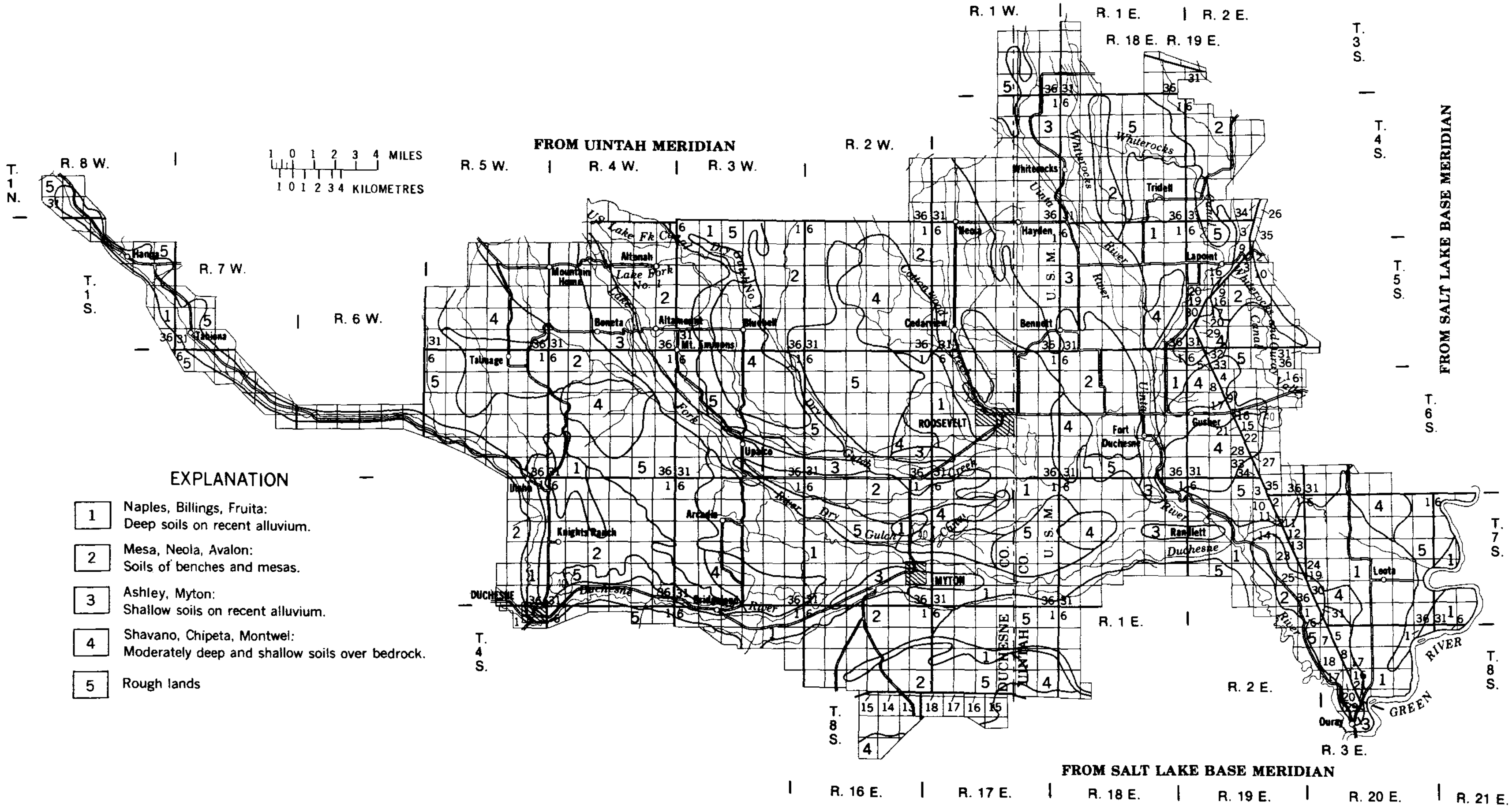
A modern detailed soil survey in the "Roosevelt-Duchesne area" includes an area of about 1,000 mi^2 (2,590 km^2) and most of the land that is irrigated or that is likely to be irrigated in the Duchesne River basin (Wilson and others, 1959). Figure 1 shows five soil associations in the Roosevelt-Duchesne area. Most of the associations consist of two or more dominant soils and generally have several other soils of lesser extent. Detailed soils maps are included in Wilson and others (1959) for the area covered by the soil association map. A reduced composite of these detailed soils maps was used in the preparation of plate 4, which shows areas of salt accumulation (slight to strong) and areas of poorly drained soils.

The areas of salt accumulation and poorly drained soils generally coincide with areas of irrigation in the Duchesne River basin. The following quotes from Wilson and others (1959, p. 56-57) are helpful in understanding some of the effects of irrigation on soils and the observed chemical characteristics of surface water in parts of the Duchesne River basin:

"Irrigation has created many agricultural problems. These include waterlogging, seepage, erosion, and the accumulation of soluble salts and alkali in the soils. * * * In some spots a stratum of bedrock extends across natural drainageways and slows the movement of the ground water. Internal drainage is blocked in many places by the bedrock of impervious shale or sandstone that underlies much of the area. * * * Excess water has accumulated in some poorly drained soils because of over-irrigation. * * * Associated with poor drainage is the accumulation of soluble salts. As the ground water rises to the surface and evaporates, it leaves soluble salts on the surface. Soluble salts have accumulated naturally in the soils of the area because they occur in the parent material and the underlying bedrock and also because the water entering the soil carries salts in solution. Even under natural conditions, some of the soils contained excessive quantities of soluble salts. In many soils, however, the high concentrations of salts have been caused or intensified by seepage of irrigation water. * * * When the fieldwork for the survey was completed in 1940, it was recognized that salinity and the content of alkali, along with drainage, were not static but were generally becoming less favorable in the area. Therefore, in 1953, another study of salinity, content of alkali, and drainage was made. This study showed that an additional 47,000 acres had become poorly drained since 1940. * * * Soil scientists found that the amount of salts in the soils had increased considerably."

MAJOR WATER DEVELOPMENTS

A brief description of the major water developments, both present and proposed, in the Duchesne River basin, may be useful in understanding the complexities of the present surface-water system and the future modified system in the basin.



From Wilson and others (1959)

Figure 1.—Map showing soil associations in parts of the Duchesne River basin and some adjacent areas.

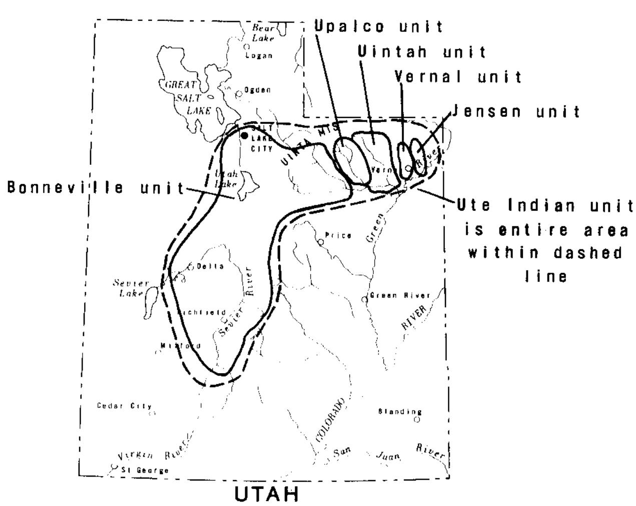
The original Strawberry Valley project, which became operational about 1915, diverted water from the Strawberry River drainage into Utah Valley in the Great Basin. Strawberry Reservoir had an active storage capacity of about 270,000 acre-ft (333 hm^3). Releases from the reservoir were rare, and essentially all the runoff from the 170 mi^2 (440 km^2) drainage area of the reservoir was diverted through Strawberry Tunnel into the Spanish Fork drainage system and into Utah Valley in the Great Basin. Strawberry Reservoir was enlarged by construction of Soldier Creek dam, which was completed in 1972. This new dam and reservoir and their role in the Central Utah project will be described in a following part of this section.

Storage in Moon Lake Reservoir began in 1937. Active capacity of the reservoir is 35,760 acre-ft (44 hm^3); total dead storage is 13,740 acre-ft (17 hm^3). The reservoir stores water from the Lake Fork River for irrigation of lands in the vicinity of Roosevelt.

The Duchesne Tunnel diverts water from the upper Duchesne River into the upper Provo River in the Great Basin. Diversions are usually during the period April-July and vary greatly from year to year. For example, during water years 1961-68, diversions ranged from about 15,500 acre-ft (19 hm^3) in 1968 to 56,000 acre-ft (69 hm^3) in 1962.

Major diversions from the Duchesne River include those into the Grey Mountain, Rocky Point, Duchesne Feeder, Myton Townsite, and Ouray School Canals. Many other diversions are made from the Duchesne and Strawberry Rivers and all their principal tributaries. Big Sand Wash Reservoir was completed in 1965 and has a storage capacity of about 12,000 acre-ft (15 hm^3), and Midview Reservoir (Lake Boreham) was completed in 1937 and has a storage capacity of about 5,800 acre-ft (7 hm^3).

The Central Utah Project, which is partly completed (1975), consists of six proposed units as shown on the sketch map below (U.S. Bureau of Reclamation, 1973). The Vernal, Jensen, Upalco, and Bonneville



units constitute the initial phase, and the Uintah and Ute Indian units constitute the ultimate phase. The Vernal and Jensen units are not within the Duchesne River basin and thus are not of direct significance to the basin. The Upalco unit (authorized) and the Uintah unit (conditionally authorized) are in the Duchesne River basin but are not under construction. The Ute Indian unit (not authorized) would be essentially an enlargement and expansion of the Bonneville unit, which is the largest and most comprehensive of the authorized units of the Central Utah Project.

The component parts of the Bonneville unit that have a direct effect on surface water in the Duchesne River basin (fig. 2) are (1) Starvation collection system, (2) Strawberry Aqueduct and collection system, and (3) Diamond Fork power system, which is dependent on inter-basin diversions from (2).

The Starvation feeder conduit delivers water from Knight Diversion Dam on the Duchesne River to Starvation Reservoir on the Strawberry River. Reservoir storage began in November 1969; total reservoir capacity is 167,300 acre-ft (206 hm^3) and active capacity is 152,320 acre-ft (188 hm^3).

The Strawberry Aqueduct and collection system would consist of Upper Stillwater and Currant Creek Reservoirs, which would serve as regulating reservoirs along the aqueduct, the Strawberry Aqueduct with its various diversion structures and feeder pipelines, and Strawberry Reservoir Enlargement. Strawberry Aqueduct, parts of which have been completed (1975) or are under construction, would intercept the flows of nine streams tributary to the Duchesne and Strawberry Rivers and convey the water to the enlarged Strawberry Reservoir, which would store the water for diversion to the Bonneville Basin. (See U.S. Bureau of Reclamation, 1973, tables A-3 and A-5 and fig. A-6.)

Strawberry Reservoir Enlargement, which is the prime storage facility for the Bonneville unit and was created by Soldier Creek Dam, increases the Strawberry Reservoir total capacity from 283,000 to 1,106,500 acre-ft (349 to 1,364 hm^3).

The final environmental impact statement for the Bonneville unit of the Central Utah Project states, "Despite the collection of a great deal of hydrological data, it is not possible to accurately and precisely predict the exact amounts of water that would be available immediately downstream from Unit structures." (U.S. Bureau of Reclamation, 1973, p. 297).

CLASSIFICATION OF WATER FOR PUBLIC SUPPLY AND IRRIGATION

The U.S. Public Health Service (1962, p. 6 and 7) established standards for drinking water and water-supply systems used by common carriers and others subject to Federal quarantine regulations. The standards state that water should contain no impurity which would cause

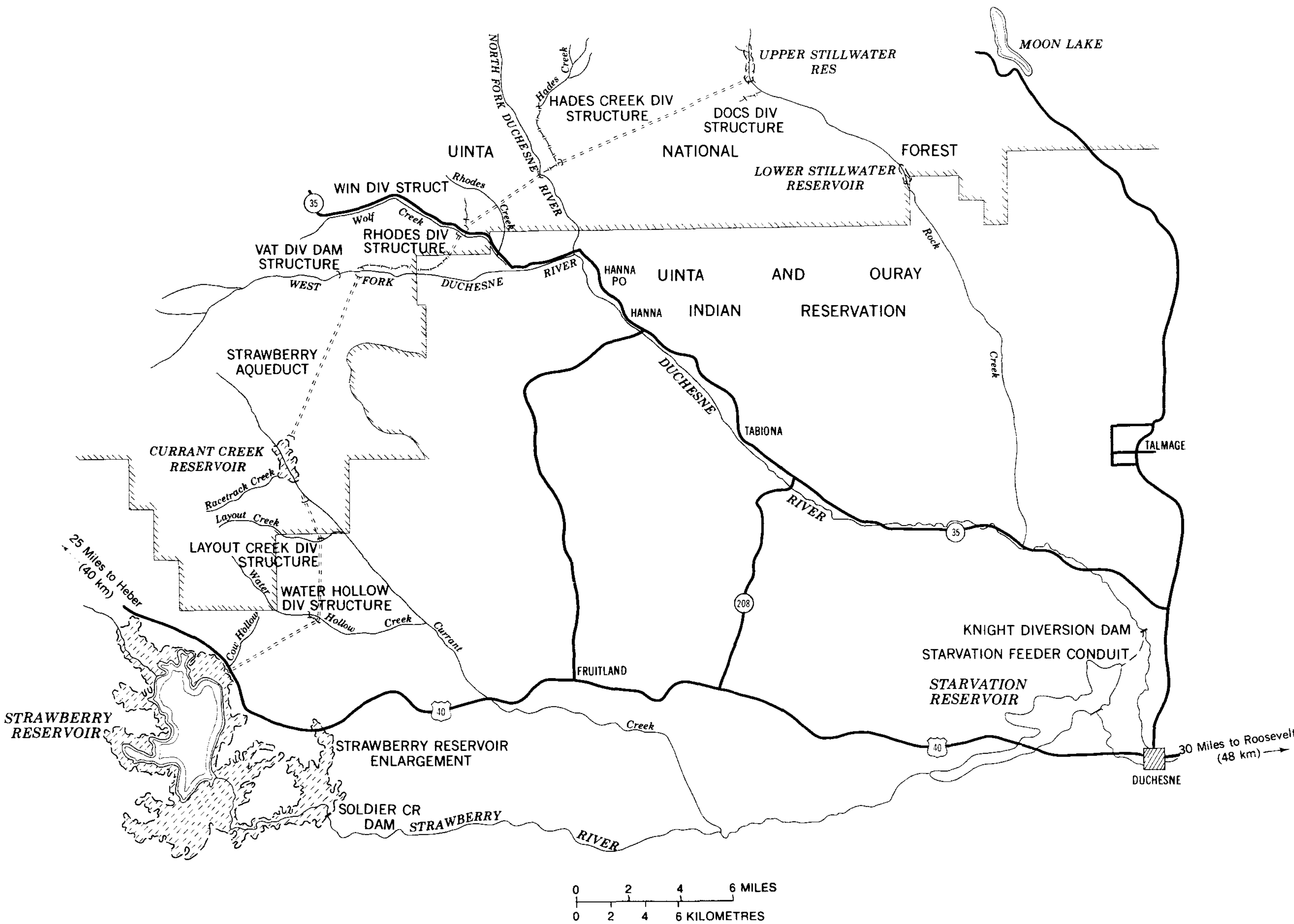


Figure 2.— Sketch map showing Starvation collection system and Strawberry Aqueduct and collection system of the Bonneville unit, Central Utah Project.

offense to the sense of sight, taste, or smell. Included in the standards are the following chemical substances which should not be present in a water supply in excess of the listed concentrations if other more suitable supplies are or can be made available:

Substance	Concentration (mg/l)
Chloride (Cl)	250
Sulfate (SO_4)	250
Total dissolved solids	500
Nitrate (NO_3)	45 (10 mg/l expressed as N)

Fluoride:

Annual average of maximum daily air temperature[1] (°F)	Recommended control limits--fluoride concentrations, in mg/l		
	Lower	Optimum	Upper
50.0-53.7	0.9	1.2	1.7
53.8-58.3	.8	1.1	1.5
58.4-63.8	.8	1.0	1.3
63.9-70.6	.7	.9	1.2
70.7-79.2	.7	.8	1.0
79.3-90.5	.6	.7	.8

[1]Based on temperature data obtained for a minimum of 5 years.

The property of hardness has been associated with effects observed in the use of soap; one might say that hardness represents the soap-consuming capacity of a water (Hem, 1970, p. 224). Because hardness is a property not attributable to a single constituent but to the presence of alkaline earths--mainly calcium and magnesium, it is usually reported in terms of an equivalent concentration of calcium carbonate. (See table below.) Hardness, as calcium carbonate, is usually computed by multiplying the sum of milliequivalents per litre of calcium and magnesium by 50. Durfor and Becker (1964, p. 27) use the following classification of hardness ranges:

Hardness range (mg/l of $CaCO_3$)	Description
0-60	Soft
61-120	Moderately hard
121-180	Hard
More than 180	Very hard

A diagram for the classification of irrigation waters was devised by the U.S. Salinity Laboratory Staff (1954, p. 80). The U.S. Salinity Laboratory Staff emphasizes that in the classification of irrigation waters, the assumption is made that the water will be used under average conditions with respect to soil texture, infiltration rate, drainage, quantity of water used, and salt tolerance of the crops. Large deviations from the average for one or more of these variables may make unsafe the use of what, under average conditions, would be good water. For example, if the water is applied to heavy-textured poorly drained soils in an area of extremely high evaporation rates, the salinity and alkali hazards would increase.

The occurrence of boron in toxic concentrations in certain irrigation waters makes it necessary to consider this element in assessing water quality. The recommended limits of boron, in milligrams per litre, for several classes of irrigation waters (U.S. Salinity Laboratory Staff, 1954, table 14) are given below.

Boron class	Sensitive crops	Semitolerant crops	Tolerant crops
1	Less than 330	Less than 670	Less than 1,000
2	330 to 670	670 to 1,330	1,000 to 2,000
3	670 to 1,000	1,330 to 2,000	2,000 to 3,000
4	1,000 to 1,250	2,000 to 2,500	3,000 to 3,750
5	More than 1,250	More than 2,500	More than 3,750

CHEMICAL QUALITY OF THE SURFACE WATER

The chemical composition of natural water depends upon many different sources of solutes, including gases and aerosols from the atmosphere, weathering and erosion of rocks and soil, solution or precipitation reactions occurring below the land surface, and cultural effects resulting from activities of man (Hem, 1970, p. 1). The streams in the study area drain terrane having markedly different geology, land use, vegetation, altitude, and climate.

Some general chemical characteristics of the water at 157 sites from which data were used in the preparation of this report are given in table 2. In this table, the columns "Dominant cations" and "Dominant anions" list the ions that, if expressed as milliequivalents per litre, are usually dominant during low and high flows. If more than one ion is shown as dominant, the order of listing indicates the commonest order of abundance. Because some of the streams have water of highly variable composition, the order of abundance is not always the same under all flow conditions.

The columns in table 2 under "Public supply" include entries for dissolved-solids concentrations greater than 500 mg/l and sulfate concentrations greater than 250 mg/l. The entries do not mean that these values are invariably exceeded in the given stream; during periods of high discharge resulting from snowmelt or rainfall, dissolved-solids and sulfate concentrations fall below 500 and 250 mg/l, respectively. Fluoride concentrations are shown only if they exceed 1 mg/l.

The columns in table 2 under "Irrigation supply" show the classification of the water relative to salinity and sodium hazards according to the method of the U.S. Salinity Laboratory Staff (1954, p. 80). The observed range in boron concentrations is also shown under "Irrigation supply." High concentrations of boron occur in only a few streams, and boron generally is not a problem in most of the study area.

Approximate ranges of dissolved-solids concentrations in the surface water in the study area are shown on plate 1. The zones shown on plate 1 are based on data obtained at the indicated observation sites, on geologic and soils data, and on probable similarities between water at the observation sites and water from similar terrain in other parts of the study area. Although the zones and zonal boundaries may be poorly defined in many places, they are of sufficient reliability to indicate a marked deterioration in the chemical quality of water in a downstream direction in the Duchesne River basin. Dissolved-solids concentrations are low in the northern and western parts of the basin and increase markedly toward the southeast. Many of the tributaries in the southern part of the basin are in zones of high dissolved-solids concentrations, but both precipitation (pl. 2) and runoff in this part of the basin are relatively low. These tributaries, therefore, do not have a major adverse effect on the dissolved-solids concentration of water in the Strawberry and Duchesne Rivers.

Variations in the chemical quality of the water

The chemical characteristics of the surface water in the Duchesne River basin vary with both time and place. Plate 5 shows graphically the major cations and anions in the water at many sites throughout the study area. It also shows the high range of dissolved-solids concentrations during periods of low flow and the low range of dissolved-solids concentrations during periods of high flow. Several factors may contribute to the increase in dissolved-solids concentrations and to the change in chemical composition of the water in a general downstream direction across the study area.

Most of the total annual runoff from the basin originates in the northern part of the basin in areas of high precipitation—mostly snow (fig. 3)—at altitudes greater than about 7,500 ft (2,290 m). These areas are underlain by rocks of Precambrian, Mississippian, Pennsylvanian, and Permian age (pl. 3), and solution of the mineral constituents of these rocks is relatively slight. A relatively small amount of runoff originates in the southern and eastern parts of the basin where the Uinta and Duchesne River Formations of Tertiary age are predominant, the rocks in some places containing gypsum and other saline evaporites that are relatively soluble. Overland flow and runoff from such areas might be expected to have higher dissolved-solids concentrations than that from the rocks in the northern part of the basin. Data obtained on the dissolved-solids content of overland runoff resulting from summer thunderstorms on August 22, 1973, however, do not indicate exceptionally high dissolved-solids concentrations from an area underlain by the Uinta Formation in the southeastern part of the study area. At Big Wash (site

74, table 1 and pl. 1), samples obtained in the flood wave advancing down the dry channel had a dissolved-solids concentration of 498 mg/l. At an ephemeral tributary (site 75) to Castle Peak Draw, thunderstorm runoff during the receding stage at this site had a dissolved-solids concentration of only 266 mg/l. At Castle Peak Draw (site 76), the runoff had a concentration of 594 mg/l. In contrast, the dissolved-solids concentration at Duchesne River at Myton (site 51) on the same day was 921 mg/l, which is appreciably greater than the concentrations observed at the three ephemeral streams. These few data suggest that overland flow and runoff in ephemeral streams in areas underlain by rocks that contain highly soluble material may not have a significant adverse effect on the chemical quality of the water in the Duchesne River.

Figure 3.— View southeast across area of Strawberry reservoir. Ice- and snow-covered reservoir is at base of hills in centerground. The Narrows at reservoir outlet at east side of the reservoir is shown by arrow. Photograph taken February 18, 1975, near site 151 at northwest side of reservoir.

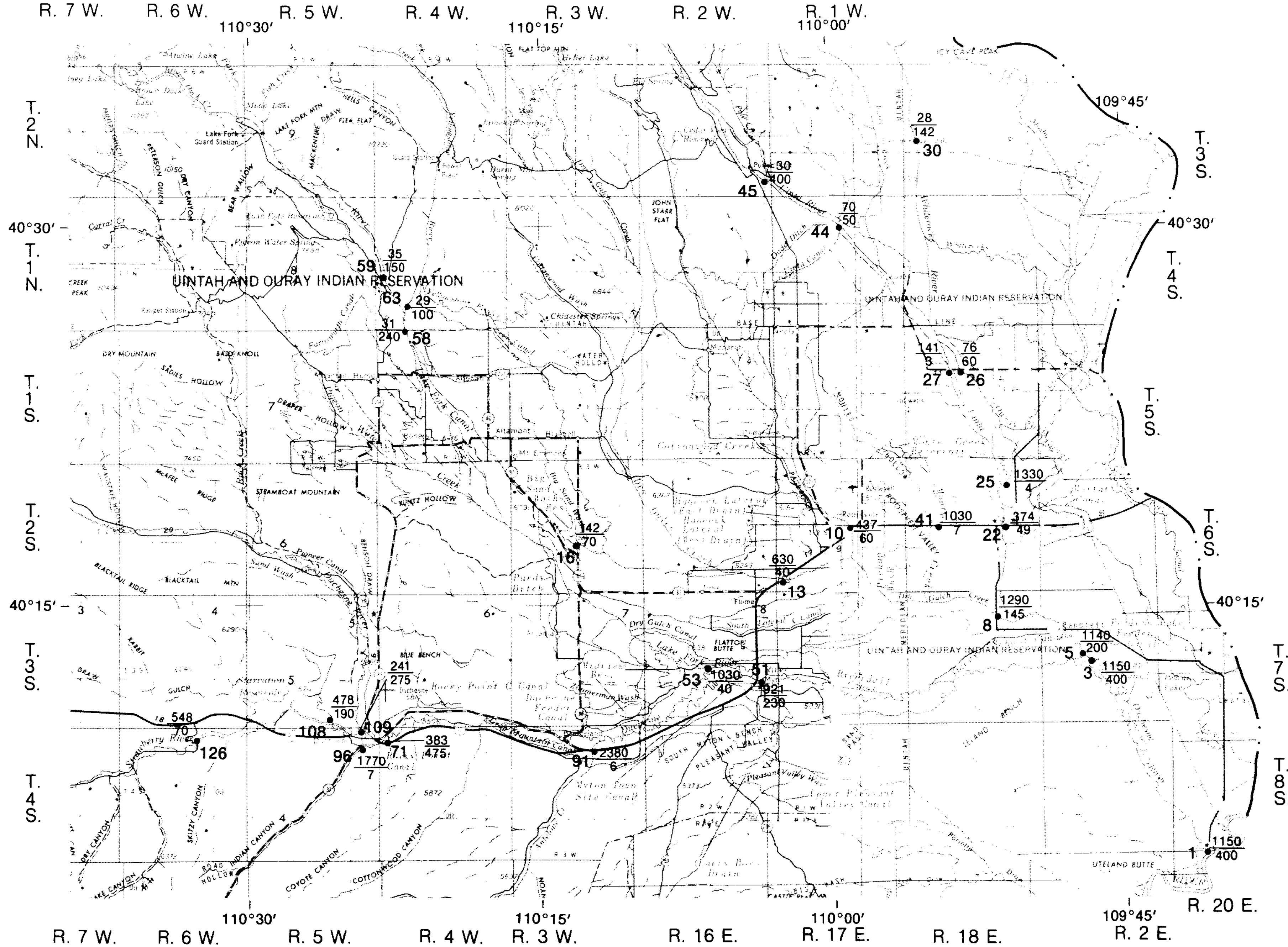
A quantitative evaluation of the effects of irrigation on the chemical quality of the Duchesne River and the downstream reaches of some of its tributaries cannot be made with the available data. Such factors as flow depletion, prolonged saturation and leaching of unfavorable soils and parent material, and the quantity and quality of return flow would have to be considered. The coincidence is apparent of areas of irrigation, of areas of saline soil and poor drainage (pl. 4), of areas underlain by the Uinta and Duchesne River Formations (pl. 3), and of stream zones and reaches of high dissolved-solids concentrations (pl. 1).

The large increase in dissolved-solids concentrations in a downstream direction results predominantly from large increases in the concentrations of sodium and sulfate. Although calcium, magnesium, bicarbonate, and chloride also increase somewhat, the increases in sodium and sulfate result in a general change from dilute calcium bicarbonate type water in the upper part of the basin to concentrated sodium sulfate type in the lower part. At many sites in the lower part of the Duchesne River basin, the water at low discharges may be a sodium sulfate type, whereas at high discharges it may be a complex calcium magnesium sodium sulfate bicarbonate type (table 1 and pl. 5).

The change in dissolved-solids concentrations and in chemical characteristics of the water in a downstream direction across the study area (pls. 1 and 5) appears to result from the diversion of large amounts of water having low dissolved-solids concentrations from upstream reaches of the Duchesne River and its major tributaries and the entry into or return to the stream of much smaller amounts of water having much higher dissolved-solids concentrations. Part of the increase in dissolved solids in the depleted flow of the Duchesne River results from the natural contribution of such perennial tributaries as Antelope Creek and Indian Canyon, which carry relatively small amounts of runoff having high dissolved-solids concentrations. But most of the increase is probably caused by relatively large amounts of return flow and seepage, which have high dissolved-solids concentrations and enter the stream system in reaches of depleted flow.

Figure 4 illustrates the marked depletion of flow and increase in dissolved-solids concentrations in a downstream direction at selected sites upstream from and within areas of major irrigation in the Duchesne River basin. The combined flow of the Uinta River near Neola (site 45) and Whiterocks River near Whiterocks (site 30) was about 540 ft^3/s (15 m^3/s), and the concentration of the combined flow was about 30 mg/l. At the East and West Channels of the Uinta River near Whiterocks (sites 26 and 27), the depleted flow was only about 63 ft^3/s (1.8 m^3/s), and the concentration of the combined flow was about 80 mg/l. Diversions upstream from sites 26 and 27 are almost entirely for irrigation of lands downstream from the sites. At Uinta River at Fort Duchesne (site 22), the discharge was 49 ft^3/s (1.4 m^3/s) and the dissolved-solids concentration was 374 mg/l, or nearly 300 mg/l greater than the 80 mg/l for the combined flow at sites 26 and 27. At Uinta River at mouth, near Fort Duchesne (site 5), the discharge had increased to 200 ft^3/s (5.7 m^3/s) and the dissolved-solids concentration was 1,140 mg/l. The major increase in both discharge and concentration between sites 22 and 5 resulted from the inflow of Dry Gulch Creek.

Figure 4 shows that the discharge at Big Sand Wash below Big Sand Wash Reservoir (site 16) was 70 ft^3/s (2.0 m^3/s) and the concentration was only 142 mg/l. At Dry Gulch Creek at U.S. Highway 40 near Roosevelt (site 13), the discharge was reduced to 40 ft^3/s (1.1 m^3/s) and the concentration had increased to 640 mg/l. At Cottonwood Creek at U.S. Highway 40 at Roosevelt (site 10), the discharge was 60 ft^3/s (1.7 m^3/s) and the concentration was 437 mg/l. Thus, the combined flow at sites 10



Base from U.S. Geological Survey 1:250,000 series
Salt Lake City, Utah; Wyoming (1963), Vernal,
Utah; Colorado (1954)

0 1 2 3 4 5 MILES
0 1 2 3 4 5 KILOMETRES

EXPLANATION

70/50 — Dissolved-solids concentration, in milligrams per litre. / Water discharge, in cubic feet per second.

44• Sampling site

Figure 4.—Dissolved-solids concentration and water discharge at selected sites in part of the Duchesne River basin during period August 22-24, 1973.

and 13 was 100 ft^3/s ($2.8 m^3/s$) and the concentration of the combined flow was 514 mg/l. At Montes Creek at U.S. Highway 40 near Roosevelt (site 41), the discharge was 7 ft^3/s ($0.20 m^3/s$) and the concentration was 1,030 mg/l. The combined flow at sites 10, 13, and 41, therefore, was 107 ft^3/s ($3.0 m^3/s$). This compares to the 145 ft^3/s ($4.1 m^3/s$) of flow having a concentration of 1,290 mg/l observed at Dry Gulch at State Highway 88, near Fort Duchesne (site 8). Thus, 38 ft^3/s ($1.1 m^3/s$) of water having a concentration of 3,380 mg/l entered the system along the relatively short reaches downstream from sites 10, 13, and 41 and upstream from site 8. No other natural tributaries contribute to the stream system in this area, but several large canals and drains that receive drainage from areas outside the natural drainage area downstream from sites 10, 13, and 41 terminate in Dry Gulch Creek downstream from these sites. Thus, an unknown part of the 38 ft^3/s ($1.1 m^3/s$) of inflow undoubtedly came from irrigated areas outside the natural drainage area downstream from these sites. This 38 ft^3/s of inflow was mainly responsible for the large increase in the dissolved-solids concentration of the Uinta River between site 22 (374 mg/l) and site 5 (1,140 mg/l).

The overall downstream flow depletion and water-quality degradation in the Duchesne River basin are apparent in figure 4. The combined flow at upstream sites on the Duchesne River (475 ft^3/s or 13 m^3/s at site 71), Lake Fork River (240 ft^3/s or 7.0 m^3/s at site 58), Big Sand Wash (70 ft^3/s or 2.0 m^3/s at site 16), Uinta River (400 ft^3/s or 11.3 m^3/s at site 45), and Whiterocks River (142 ft^3/s or 4.0 m^3/s at site 30) was about 1,330 ft^3/s ($38 m^3/s$). The dissolved-solids concentration of the combined flow would have been about 160 mg/l. The discharge at the mouth of the Duchesne River (site 1) was 400 ft^3/s (11 m^3/s) and the dissolved-solids concentration was 1,150 mg/l. Thus, the discharge at site 1 was less than one-third the combined discharge at selected upstream sites, and the dissolved-solids concentration was about seven times greater than the concentration of the combined discharge.

Diversions from the Duchesne and Uinta Rivers are made for irrigation of land adjacent to but outside the Duchesne River basin. Irrigation of South Myton Bench and Pleasant Valley in the southern part of the study area and of the Pelican Lake drainage area in the extreme eastern part is with water diverted from the Duchesne and Uinta Rivers. Nearly all the irrigation return flow from these areas, however, enters the Green River directly. For example, on August 22, 1973, the discharge of the Duchesne River near Randlett was about 480 ft^3/s ($14 m^3/s$), and the dissolved-solids concentration was about 1,150 mg/l. On the same date, the discharge of Pariette Draw below Pleasant Valley Wash was 75 ft^3/s ($2.1 m^3/s$)—nearly all of which was return flow from lands irrigated near Pleasant Valley Wash with water diverted from the Duchesne River—and the concentration was 2,640 mg/l. If this return flow had entered the Duchesne River upstream from Randlett, the resultant flow of about 555 ft^3/s ($16 m^3/s$) would have had a dissolved-solids concentration of about 1,350 mg/l. Thus, the adverse effects of such diversions out of the Duchesne River basin on the average dissolved-solids concentration of the lower Duchesne River result from the diversion of good quality water from upstream reaches. The adverse effects do not result from the return of poor quality water to downstream reaches of the Duchesne River. The irrigation return flow with relatively high dissolved-solids concentration does not re-enter the basin; it discharges directly to the Green River.

Effect of additional diversions on the dissolved-solids content of the Duchesne River

Average flow in downstream reaches of the Duchesne River will be reduced by diversions for the Bonneville unit of the Central Utah Project. Data presented by the U.S. Bureau of Reclamation (1973, table B-9) indicate that the average flow of the Duchesne River near Randlett for the period 1941-66 was about 603 ft^3/s (17 m^3/s), and the average flow adjusted to present modified conditions was about 572 ft^3/s (16.2 m^3/s) for the same period. Streamflow data obtained by the Geological Survey during the period October 1942 to September 1973 show that the average discharge was about 596 ft^3/s (17 m^3/s).

Data presented by the U.S. Bureau of Reclamation (1973, table B-9) for the period 1941-66 indicate that the weighted average dissolved-solids concentration of the Duchesne River near Randlett was 676 mg/l, and the average concentration adjusted to present modified condition was 713 mg/l. Chemical-quality data obtained by the Geological Survey from December 1950 to September 1951 and from November 1956 to December 1966 were used to compute these average concentrations. Data for the remaining periods between 1941 and 1966 were obtained by correlation.

The preceding data can be used to calculate the general effect of diversions for the Bonneville unit of the Central Utah Project on the dissolved-solids content of the Duchesne River downstream from Myton, specifically at Duchesne River near Randlett (site 3 on pl. 1):

1. The present average discharge of the Duchesne River near Randlett is about 600 ft^3/s (17 m^3/s) and the weighted average dissolved-solids concentration is about 700 mg/l.

2. The Bonneville unit will result in a depletion of 166,000 acre-ft (205 hm^3) of water and 27,000 tons (24,494 t) of dissolved solids from the Duchesne River system (U.S. Bureau of Reclamation, 1973, p. 399). This is the equivalent of an average flow of about 230 ft^3/s (6.5 m^3/s) with a dissolved-solids concentration of 120 mg/l.

3. For calculation purposes, it is assumed here that the Bonneville unit depletion is diverted from the present discharge of about 600 ft^3/s (17 m^3/s) with a dissolved-solids concentration of about 700 mg/l at the Duchesne River near Randlett. The remaining 370 ft^3/s (10.5 m^3/s) of streamflow at the Duchesne River near Randlett would have a discharge-weighted average dissolved-solids concentration of about 1,060 mg/l, which is about 360 mg/l, or 50 percent higher than the present average concentration of about 700 mg/l.

Areas of saline soils

Runoff or seepage from areas of soils having slight to strong salinity (pl. 4) may have high dissolved-solids concentrations. A seepage sample was obtained on August 23, 1973, from an area of saline soils in the SW¼NW¼NW¼ sec. 35, T. 3 S., R. 4 W., Uintah base and meridian. This seepage point (fig. 5), which is immediately downslope

Figure 5.— Salt efflorescence in area of saline soil in the SW¼NW¼NW¼ sec. 35, T. 3 S., R. 4 W., Uintah base line and meridian. Rocky Point C Canal is near top of slope in center of picture. The salt is predominantly sodium sulfate.

from the Rocky Point C Canal and about 0.75 mi (1.2 km) north of the Duchesne River, had an estimated discharge of about 5 gal/min (0.32 l/s). The dissolved-solids concentration of the water was 40,800 mg/l, sulfate concentration was 30,000 mg/l, and sodium concentration was 9,600 mg/l. The source of the seepage water was probably the canal immediately upslope from the seepage area. The water diverted from the Duchesne River into the Rocky Point Canal on August 23, had a dissolved-solids concentration of about 250 mg/l. If the source of the seepage water was the upslope canal, then the dissolved-solids concentration of the water increased more than 150-fold as a result of its movement from the canal to its point of issue in the area of saline soils.

A sample of salt efflorescences was prepared by compositing small samples of efflorescences from many of the saline areas shown on plate 4. Distilled water was added to the composite sample, and a chemical analysis was made of the filtrate. The dissolved-solids concentration of the filtrate was about 44,000 mg/l. Duplicate analyses of the filtrate indicate that sodium concentration was about 12,000 mg/l, sulfate concentration was about 31,000 mg/l, and the highly soluble salt efflorescences are sodium sulfate. The relative concentrations of sodium and sulfate in the soluble material from the salt efflorescences were nearly identical to those in the seepage water obtained from the area of saline soils near the Rocky Point C Canal.

The small amount of data obtained about soil salinity during this project suggests that overland flow or subsurface seepage that enters the stream system from many areas of saline soils might have a very high dissolved-solids concentrations.

Areas of high boron concentrations

During periods of low flow, several tributaries to the Duchesne and Strawberry Rivers in the southern part of the Duchesne River basin have boron concentrations that greatly exceed the limits recommended by the U.S. Salinity Laboratory Staff (1954) for various classes of irrigation waters. (See section on "Classification of water for public supply and irrigation.") Table 1 gives some hydrologic data, including concentrations of boron, obtained at selected sites in the study area. Indian Canyon at mouth (site 96) and Lake Canyon at mouth (site 128) had the highest observed boron concentrations—20,000 and 17,000 μg/l, respectively. Data in table 1 and in Hood, Mundorff, and Price (1976) were the basis for the delineation of the area of high boron concentration shown in figure 6.

High boron concentrations may result from solution of both surface and subsurface rocks. A chemical analysis of streambed material at the mouth of Right Fork Indian Canyon showed 65,000 μg of boron per 1,000 grams of material. The material at the mouth of Antelope Creek contained 40,000 μg of boron per 1,000 grams of material.

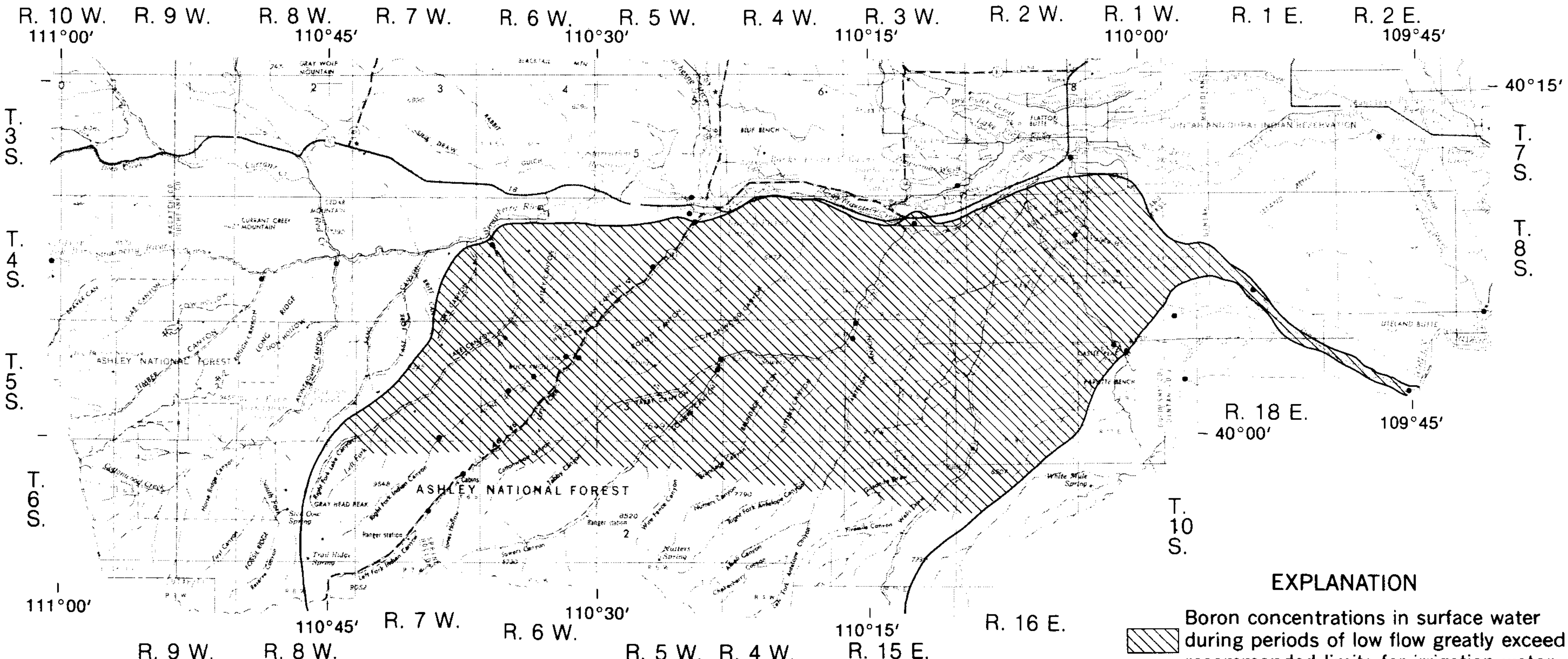
In Indian Canyon (fig. 7), the streambed at any given time may alternate between dry reaches and reaches in which flow occurs. On July 18, 1974, the channel of Left Fork Indian Canyon was dry upstream from site 105. A large spring in the channel at site 105 was discharging about 0.6 ft^3/s (0.017 m^3/s) of water, which maintained flow in the channel for several miles downstream. This water had a dissolved-solids concentration of 598 mg/l and a boron concentration of 1,100 μg/l. At site 104, which is about 3.5 mi (5.6 km) downstream from site 105, the discharge was slightly greater and the dissolved-solids concentration appreciably greater than those at site 105 (table 1). Boron concentration increased from 1,100 μg/l at site 105 to 3,900 μg/l at site 104. This increase may indicate appreciable interchange of surface water and ground water in the channel between sites 104 and 105. At site 99, which is immediately upstream from the junction with Right Fork Indian Canyon, the dissolved-solids and boron concentrations were greater than those at site 104 although the water discharge was only 0.1 ft^3/s (0.003 m^3/s).

Table 1.--Water discharges, dissolved-solids concentrations, and boron concentrations at selected sites

Site No.	Sampling site	Date	Discharge (ft^3/s)	Dissolved solids (mg/l)	Boron (μg/l)
1	Duchesne River at mouth, near Ouray	7-18-74	225	1,280	1,400
3	Duchesne River near Randlett	7-18-74	240	1,180	1,300
51	Duchesne River at Myton	7-18-74	180	790	710
66	Midview Reservoir outflow near Bridgeland	7-18-74	53	494	350
72	Pariette Draw near mouth, near Ouray	3-16-72	10	4,690	2,200
73	Pariette Draw below Pleasant Valley Wash	8-22-73	75	2,640	1,300
74	Big Wash near Myton	8-22-73	1.5	522	530
75	Unnamed tributary to Castle Peak Draw nr Myton	8-22-73	1	266	320
76	Castle Peak Draw near Castle Peak	8-22-73	.5	594	1,600
77	Pleasant Valley Wash 3 mi south of Myton	7-18-74	11	1,910	1,100
78	Pariette Draw below small reservoir	7-18-74	8	960	580
91	Antelope Creek near mouth, at U.S. Highway 40, near Bridgeland	6- 4-74	3	3,750	6,300
		7-18-74	10	2,740	5,200
92.5	Antelope Creek below Sowers Creek	6- 4-74	3.5	2,250	4,900
93	Sowers Creek above Antelope Creek	7-18-74	5	2,250	4,400
93.5	Sowers Creek below Tabby Canyon	6- 4-74	2	1,590	3,600
		6- 4-74	1.5	1,590	4,600
94	Sowers Creek above Tabby Canyon	7-18-74	1	1,730	3,900
96	Indian Creek at mouth, at Duchesne	6- 4-74	1	2,340	12,000
		7-18-74	.4	2,350	12,000
		9-25-74	1	2,220	20,000
97	Indian Canyon 4.2 mi above mouth	7-18-74	.2	2,340	11,000
		9-25-74	.4	2,290	4,900
99	Left Fork Indian Canyon above Right Fork	7-18-74	.1	1,010	4,900
100	Right Fork Indian Canyon above Left Fork	7-18-74	.25	1,690	6,500
101	Right Fork Indian Canyon 1.9 mi above mouth	7-18-74	.75	1,580	5,700
102	Right Fork Indian Canyon 3.7 mi above mouth	7-18-74	.75	1,530	5,500
103	Right Fork Indian Canyon 9.0 mi above mouth	7-18-74	.5	1,160	4,400
104	Left Fork Indian Canyon below Jones Hollow	7-18-74	.7	847	3,900
105	Left Fork Indian Canyon above Spring Hollow	7-18-74	.6	598	1,100
107	Strawberry River above Indian Canyon, at Duchesne	7-18-74	2.40	480	380
109	Duchesne River above Strawberry River, at Duchesne	7-18-74	13	285	100
128	Lake Canyon at mouth, at Strawberry River	9-25-74	2	3,460	17,000
139	Avintaquin Creek at mouth, at Strawberry River	6- 4-74	15	347	300
142	Timber Canyon at mouth, at Strawberry River	6- 4-74	8	334	270
142.5	Willow Creek at mouth, at Strawberry River	6- 4-74	20	296	30

Flow was observed for at least 1 mi (1.6 km) downstream from the junction of the two forks of Indian Canyon; but the channel was dry for at least 1 mi (1.6 km) upstream from site 97, where another spring issues at the base of a channel scarp about 20 ft (6 m) high (fig. 8). The water issuing from this channel spring had a dissolved-solids concentration of 2,340 mg/l and a boron concentration of 11,000 μg/l, which is much higher than that observed at any upstream site. Flow was continuous between site 97 and site 96 at the mouth of Indian Canyon, and the dissolved-solids and boron concentrations showed little change between the sites, although the small water discharge doubled between sites 97 and 96.

On September 25, 1974, samples were again obtained at sites 96 and 97. Discharges at the two sites were about double those observed on July 18. At the channel spring at site 97, the doubling of the discharge resulted in no significant change in dissolved-solids concentration; but the boron concentration of 4,900 μg/l was less than half that observed on July 18 (table 1).



Base from U.S. Geological Survey 1:250,000 series
Salt Lake City, Utah; Wyoming (1963), Vernal,
Utah; Colorado (1954)

0 5 10 15 MILES
0 5 10 15 KILOMETRES

EXPLANATION

Boron concentrations in surface water during periods of low flow greatly exceed recommended limits for irrigation water (U.S. Salinity Laboratory Staff, 1954).

• Sampling site

Figure 6.—Map showing area where boron concentrations in the surface water during periods of low flow greatly exceed recommended limits for irrigation water.

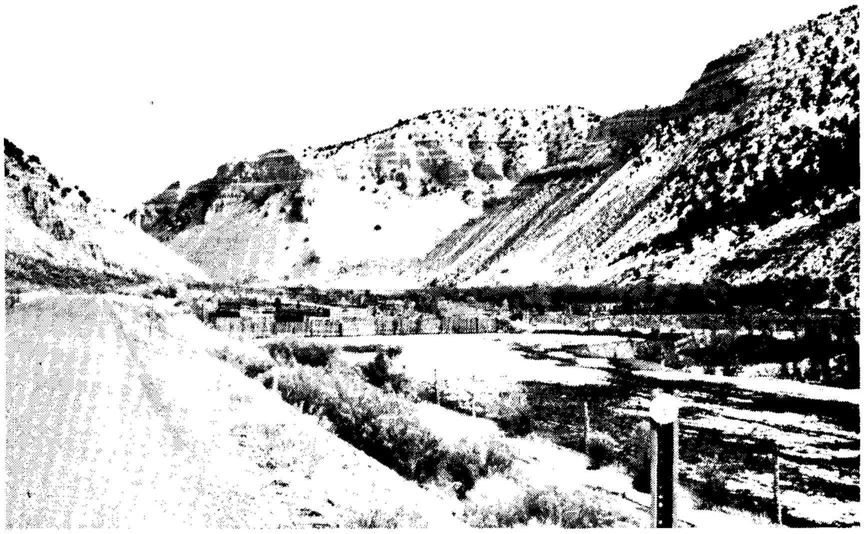


Figure 7.—View north in Indian Canyon about 10 miles (16 kilometres) upstream from mouth of canyon. The Uinta Formation forms the canyon walls. Photograph taken February 18, 1975.

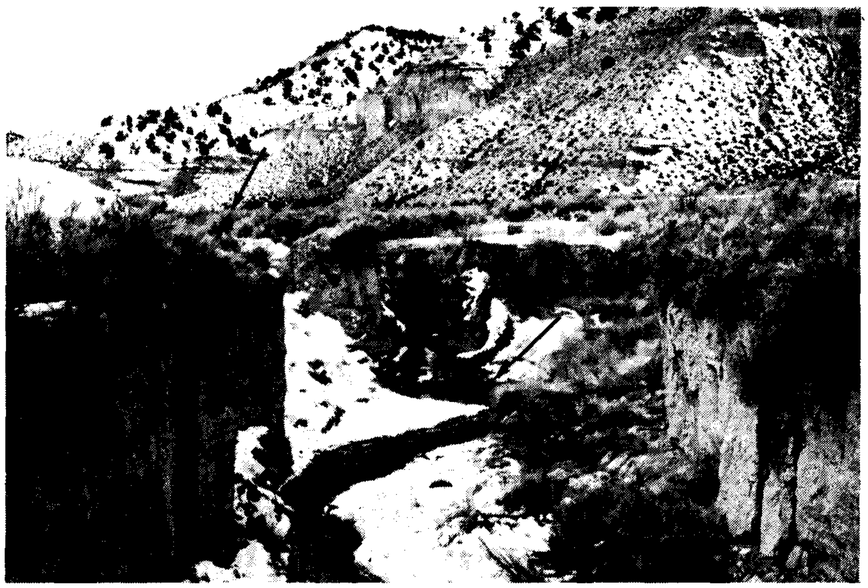


Figure 8.—View south (upstream) in Indian Canyon at site 97, about 4.5 miles (7.2 kilometres) above mouth of canyon. Spring issues from pool (arrow) at base of channel scarp. Figure of man is near edge of vertical bank at left center of picture (arrow). Depth of channel is 30-35 feet (9-11 metres) in foreground.

At the mouth of Indian Canyon at site 96, the doubling of the discharge resulted in no significant change in dissolved-solids concentration, but the boron concentration was almost 70 percent greater than that observed on July 18. If it is assumed that the 0.4 ft^3/s (0.011 m^3/s) of water with a boron concentration of 4,900 µg/l at site 97 was part of the 1.0 ft^3/s (0.028 m^3/s) of water with a boron concentration of 20,000 µg/l at site 96 at the mouth of Indian Canyon, then 0.6 ft^3/s (0.017 m^3/s) of water with a boron concentration of about 30,000 µg/l must have entered the stream between sites 97 and 96. The mineralogic source of these high concentrations of boron is not known.

The relatively high boron concentration of 1,600 µg/l in Castle Peak Draw (site 76, table 2) during thunderstorm runoff indicates that the area of high boron concentrations extends eastward from the Antelope Creek drainage area as shown in figure 6. The low boron concentrations of 530 and 320 µg/l at sites 74 and 75 during thunderstorm runoff suggest that the extreme southeastern part of the Pariette Draw drainage area does not contribute water having high boron concentrations.

Trace elements

A few determinations of concentrations of zinc, selenium, arsenic, mercury, cobalt, lead, and strontium were made for the water from the Duchesne and Strawberry Rivers and from selected tributaries (Hood and others, 1976). Concentrations of all these elements except strontium were very low. The observed range in concentrations, in micrograms per litre, at 14 sites was:

Zinc	0 to 20
Selenium	0 to 6
Arsenic	1 to 20
Mercury	0.0 to 0.7
Cobalt	0 to less than 1
Lead	0 to 11
Strontium	380 to 9,600

Strontium is an alkaline-earth element that is chemically similar to calcium and magnesium. Skougstad and Horr (1963) found that the strontium concentrations of samples from 75 major rivers of the United States ranged from 7 to 13,700 µg/l. The strontium concentrations in the study area ranged from 380 µg/l at Duchesne River at Duchesne (site 109) to 9,600 µg/l at Antelope Creek near mouth (site 91). An area of high strontium concentration appears to coincide with the area of high boron concentrations described in the preceding section. The source of the high strontium concentration appears to be ground water issuing in springs and seeps which maintain the perennial base flow in such tributaries as Antelope Creek and Indian Canyon. For example, the strontium concentration of the water issuing from the channel spring that maintains the low flow in Indian Canyon between sites 97 and 96 was 7,000 µg/l on September 25, 1974.

FLUVIAL SEDIMENT

Most of the sediment discharge by streams in arid and semiarid areas is transported during short periods of time each year. The highest suspended-sediment concentrations and discharges are characteristic of high-intensity runoff and usually occur as a result of runoff from thunderstorms. Snowmelt runoff may result in sediment concentration and discharge that are significantly larger than concentrations and discharges during periods of base flow. The snowmelt runoff, however, results in sediment yields that are small compared to that during high-intensity runoff from thunderstorms. The reconnaissance of the quality of surface water in the Duchesne River basin, however, was designed primarily to define the chemical quality at selected times during the year. The investigation did not include special efforts to obtain water-quality data--either chemical quality or sediment--during thunderstorm runoff.

In general, suspended-sediment concentrations increase with increasing water discharge of a stream, but dissolved-solids concentrations decrease with increasing water discharge. Thus, the quality of water, relative to its sediment content, generally is best during periods of low flow; and the quality of water, relative to its salt content, generally is best during periods of high flow. Further, the range in sediment concentrations generally is much greater than the range in dissolved-solids concentrations; sediment concentrations may range from a few hundred to more than 100,000 mg/l during a short period.

Visual observations during many trips to the study area indicated that suspended-sediment concentrations were low during base-flow periods. The water in most streams was clear to slightly turbid, and suspended sediment concentrations were estimated to be less than 100 mg/l. An exception was Red Creek below Currant Creek, near Fruitland (site 129); four measurements during August-November 1973 at discharges of 35, 38, 36, and 32 ft^3/s (0.99, 1.08, 1.02, and 0.91 m^3/s) showed suspended-sediment concentrations of 359, 247, 140, and 672 mg/l. These concentrations, however, are low relative to suspended-sediment concentrations that could be expected as a result of thunderstorm runoff in the large areas underlain by the Uinta and Duchesne River Formations in the southern and western parts of the basin (fig. 9).

Suspended-sediment data representative of thunderstorm runoff were obtained only once during this study. On August 22, 1973, sediment samples were obtained from a small amount of thunderstorm runoff advancing down the channel of Big Wash (site 74) in the southeastern part of the study area. At a discharge of about 1 ft^3/s (0.028 m^3/s) immediately behind the front of the advancing flow down the dry channel, the suspended-sediment concentration was 36,200 mg/l. About 10 minutes later at a peak discharge of only about 1.5 ft^3/s (0.042 m^3/s), the sediment concentration had decreased to 24,600 mg/l.

Sediment concentrations greater than 100,000 mg/l would not be unexpected during periods of intense thunderstorm runoff in many of the tributaries that drain areas underlain by the Uinta and Duchesne River

Formations in the southern part of the study area. Concentrations ranging from 100,000 to 230,000 mg/l have been measured in areas of similar terrain in the Price River and Spanish Fork basins, which are adjacent to the Duchesne River basin to the south.

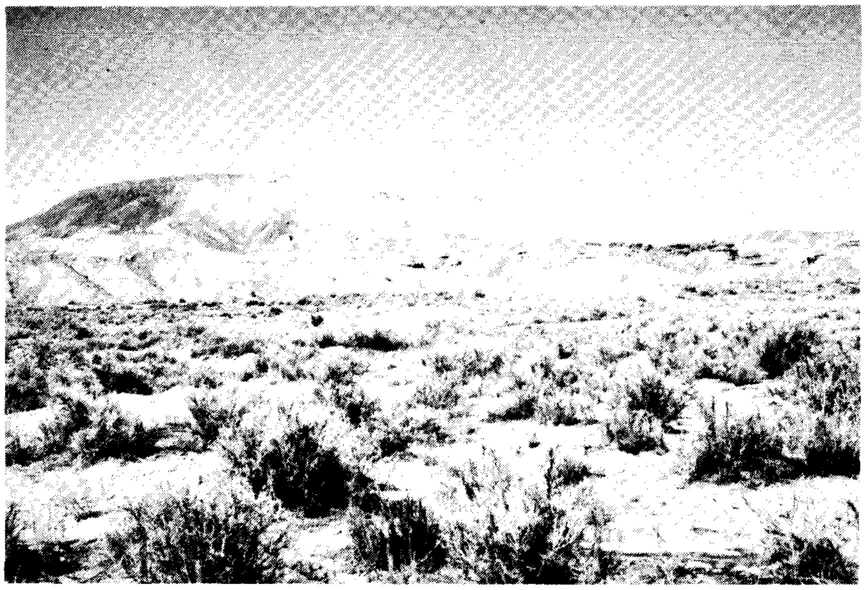


Figure 9.—Flattop Butte in an area of the Uinta Formation about 3 miles (4.8 kilometres) northwest of Myton.

Standard sediment investigations, including the collection of daily or more frequent data, were not a part of this reconnaissance. Samples for the determination of specific conductance of water are collected daily at Duchesne River near Randlett (site 3), however, as part of continuing programs of the Geological Survey. The sediment content of these samples obtained during the period July 1973 to September 1974 was determined in order to make an estimate of sediment discharge of the Duchesne River near Randlett. The samples were surface samples collected at only one vertical section of the stream; a sediment sampler was not used, and intake velocities were not representative of stream velocities. Estimates based on these nonstandard suspended-sediment samples indicate that the sediment discharge at site 3 during the 1974 water year (October 1973-September 1974) was at least 200,000 tons (181,000 t). Precipitation during 1974 was much below normal (see section on "Hydrologic setting"); thus, the sediment discharge during 1974 was probably much below normal. For example, during the 3-month period July-September 1973, the estimated sediment discharge was about 50,000 tons (45,360 t); whereas during July-September 1974, the estimated discharge was only 4,000 tons (3,629 t).

The estimated sediment discharge at the Duchesne River near Randlett should not be regarded as indicative of the intensity of erosion within the Duchesne River basin or as the combined suspended-sediment discharges of all streams within the basin. Nearly all the sediment discharge from about 900 mi^2 (2,330 km^2) of the drainage area is deposited in Strawberry Reservoir, Strawberry Reservoir Enlargement, or Starvation Reservoir. Part of the sediment discharge from about 670 mi^2 (1,740 km^2) of the Duchesne River basin upstream from Knight diversion is deposited in Starvation Reservoir as a result of diversions from the Duchesne River. The sediment discharge from many areas upstream from small reservoirs such as Big Sand Wash, Midview, and Montes Creek Reservoirs is deposited in the reservoirs. Furthermore, during the irrigation season, part of which coincides with the period of thunderstorm activity, a large part of the sediment that discharges from tributaries that drain highly erodible surface material probably leaves the Duchesne River in many diversions for irrigation. Hundreds of thousands of tons of suspended sediment probably are diverted from the Duchesne River and its major tributaries, and the sediment is deposited on the lands on which the water is applied.

CONCLUSIONS

Conclusions resulting from the reconnaissance of water quality in the Duchesne River basin are:

1. Dissolved-solids concentrations are low in the surface water in the northern and western parts of the basin and increase markedly in the southeastern part of the basin.

2. The large increase in dissolved-solids concentrations in a downstream direction results mainly from large increases of sodium and sulfate. The downstream changes generally appear to result from the diversion of large amounts of water having low dissolved-solids concentrations from upstream parts of the basin and return to or entry into the stream of smaller amounts of water having much higher dissolved-solids concentrations.

3. Additional diversions of water from the upper part of the basin will cause an increase in weighted average dissolved-solids concentrations in downstream reaches of the river. The Bonneville unit of the Central Utah Project will result in a depletion of 230 ft^3/s (6.5 m^3/s) of water with a dissolved-solids concentration of 120 mg/l from present average discharge of 600 ft^3/s (17 m^3/s) with an average dissolved-solids concentration of about 70 mg/l at the Duchesne River near Randlett. The remaining 370 ft^3/s (10.5 m^3/s) of streamflow at this point would have a discharge-weighted average dissolved-solids concentration of about 1,060 mg/l, which is about 50 percent higher than the present average concentration.

4. During periods of low flow, several tributaries to the Duchesne and Strawberry Rivers in the southern part of the basin had boron concentrations that greatly exceeded the limits recommended by the U.S. Salinity Laboratory Staff (1954) for various classes of irrigation waters.

5. An estimate of the suspended-sediment discharge of the Duchesne River near Randlett indicates that the discharge was at least 200,000 tons (181,000 t) during the 1974 water year, when precipitation was much below normal. A large part of the sediment discharge from upstream areas, however, is either trapped in upstream reservoirs or is removed from the Duchesne River system by the many diversions for irrigation.

REFERENCES CITED

Austin, L. H., and Skogerboe, G. V., 1970, Hydrologic inventory of the Uintah study unit: Utah Water Research Lab., Utah State Univ. Rept. PRWG 40-5.

Cruff, R. W., 1975, Estimating mean streamflow in the Duchesne River basin, Utah: Utah Dept. Nat. Resources Tech. Pub. 48.

Durfor, C. N., and Becker, Edith, 1964, Public water supplies of the 100 largest cities in the United States, 1962: U.S. Geol. Survey Water-Supply Paper 1812.

Hem, J. D., 1970, Study and interpretation of the chemical characteristics of natural water, 2nd ed.: U.S. Geol. Survey Water-Supply Paper 1473.

Hood, J. W., 1976, Characteristics of aquifers in the northern Uinta Basin area, Utah and Colorado: Utah Dept. Nat. Resources Tech. Pub. 53.

Hood, J. W., Mundorff, J. C., and Price, Don, 1976, Selected hydrologic data, Uinta Basin, Utah and Colorado: U.S. Geol. Survey open-file release (duplicated as Utah Basic-Data Release 26).

Iorns, W. V., Hembree, C. H., Phoenix, D. A., and Oakland, G. L., 1964, Water resources of the Upper Colorado River Basin--Basic data: U.S. Geol. Survey Prof. Paper 442.

Iorns, W. V., Hembree, C. H., and Oakland, G. L., 1965, Water resources of the Upper Colorado River Basin--Technical report: U.S. Geol. Survey Prof. Paper 441.

Price, Don, and Miller, L. L., 1975, Hydrologic reconnaissance of the southern Uinta Basin, Utah and Colorado: Utah Dept. Nat. Resources Tech. Pub. 49.

Skougstad, M. W., and Horr, C. A., 1963, Occurrence and distribution of strontium in natural water: U.S. Geol. Survey Water-Supply Paper 1496-D.

Stokes, W. L., ed., 1964, Geologic map of Utah: Utah Univ.

U.S. Bureau of Reclamation, 1973, Final environmental statement, Authorized Bonneville unit, Central Utah Project, Utah: U.S. Bur. Reclamation report INT FES 73-42.

U.S. Geological Survey, 1971, Index of surface-water records to September 30, 1970, Part 9, Colorado River Basin: U.S. Geol. Survey Circ. 659.

_____ 1972-75, Water resources data for Utah, Part 1, Surface-water records: Water Resources Div.

U.S. Public Health Service, 1962, Drinking water standards: U.S. Public Health Service Pub. 956.

U.S. Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Dept. Agriculture Handb. 60.

Wilson, Le Moyne, and others, 1959, Soil survey of Roosevelt-Duchesne area, Utah: U.S. Soil Conserv. Service.

Table 2.--Summary of

Dominant cation(s): Ca, calcium; Mg, magnesium; Na, sodium.
Dominant anion(s): HCO3, bicarbonate; SO4, sulfate.
Dominant geologic influence on water quality: Ku, Cretaceous rocks undivided; Mz, Mesozoic rocks undivided: Mu, Mississippian rocks undivided; PCm, Mutual Formation; PCrp, Red Pine Shale; Ppc, Park City Formation; Qay, relatively younger alluvial deposits; Qgm, glaciated ground and moraines undifferentiated; Qgo, glacial outwash; Qgs, gravel surfaces; Tdr, Duchesne River Formation; Tgu, Green River Formation; Tu, Uinta Formation.
Water-use problems: A blank entry indicates that no problem is known to exist; salinity and sodium hazard from classification by U.S. Salinity Laboratory Staff (1954, p. 80); Cl, chloride; SO4, sulfate.

Site No.	Site name	No. of chemical analyses	No. of additional specific conductance determinations	Discharge range (ft^3/s)	Average: No. of years of record	Average: ft^3/s	Dissolved solids range (mg/l)	Specific conductance range (mhos/cm at 25°C)	Dominant cation(s): Low flow	Dominant cation(s): High flow
1	Duchesne River at mouth, near Ouray	18	0	10-2,400	-	-	257-2,900	399-4,080	Na	Na,Ca,Mg
2	Duchesne River at Wissiup Canal, near Randlett	26	0	10-500	-	-	556-3,180	810-3,920	Na	Na,Ca,Mg
3	Duchesne River near Randlett	-	-	2.2-10,300	31	596	209-3,330	291-4,490	Na	Na,Ca,Mg
4	Duchesne River above Uinta River, near Randlett	7	0	65	-	-	733-1,660	1,040-2,100	Na	-
5	Uinta River at mouth, near Randlett	32	0	15-2,500	-	-	183-2,930	283-3,650	Na	Ca,Na
6	Uinta River at State Highway 88, at Randlett	37	0	8-1,000	-	-	136-3,700	215-4,680	Na	Ca,Na
7	Ouray School Canal at mouth, at Randlett	2	0	6	-	-	911-1,580	1,400-1,960	Na	-
8	Dry Gulch at State Highway 88, near Fort Duchesne	112	0	6-300	-	-	724-3,150	985-4,230	Na	Na,Ca
9	Dry Gulch below Cottonwood Creek, near Roosevelt	12	0	15-300	-	-	1,040-3,550	1,410-4,420	Na	Na,Ca
10	Cottonwood Creek at U.S. Highway 40, at Roosevelt	4	0	6-60	-	-	437-706	704-981	Ca,Mg,Na	Ca,Mg,Na
11	Cottonwood Creek above Dry Gulch, near Roosevelt	23	0	0.5-25	-	-	454-1,580	651-1,960	Ca,Mg,Na	Ca,Mg,Na
12	Cottonwood Creek near Cedar View	20	0	3-20	-	-	264-2,170	410-2,640	Na,Mg,Ca	Na,Mg,Ca
13	Dry Gulch at U.S. Highway 40, near Roosevelt	35	0	3-45	-	-	630-2,840	961-3,400	Na,Ca	Na,Ca
14	Hancock Lateral (east drain) at U.S. Highway 40, near Roosevelt	30	0	0.1-8	-	-	361-4,170	545-5,190	Na	Ca,Na,Mg
15	Hancock Lateral (west drain) at U.S. Highway 40, near Roosevelt	30	0	1-8	-	-	700-4,460	994-4,820	Na,Mg,Ca	Na,Mg,Ca
16	Big Sand Wash at State Highway 199, below Big Sand Wash Reservoir	56	0	1-70	-	-	66-940	119-1,300	Ca,Mg	Ca,Mg
17	Big Sand Wash at State Highway 199, near Altamont	1	0	8	-	-	415	659	Ca,Mg	-
18	Dry Gulch near Neola	5	0	4-52	8	3.1	67-137	98-204	Ca	Ca
19	Cottonwood Wash at Yellowstone Feeder Canal, near Neola	10	0	0.1-0.25	-	-	474-740	783-1,190	Na,Ca,Mg	Na,Ca,Mg
20	Yellowstone Feeder Canal at terminus, near Neola	14	0	0.1-20	-	-	28-280	41-445	Ca,Mg	Ca
21	Water Hollow 4.5 mi east of Altonah	11	0	0.1-15	-	-	240-485	401-722	Ca,Na	Ca,Na
22	Uinta River at Fort Duchesne	69	0	0.9-1,000	21	117	84-1,600	130-1,930	Mg,Na,Ca	Ca
23	Uinta River above Dry Gulch, near Fort Duchesne	27	0	1-500	-	-	108-1,510	158-2,150	Na,Mg,Ca	Ca
24	Uinta River at Park Canal heading, near Lapoint	62	0	3-800	-	-	35-516	47-736	Ca	Ca
25	Deep Creek at mouth, near Fort Duchesne	28	0	1-15	9	7.1	513-1,450	753-1,780	Mg,Ca,Na	Mg,Ca,Na
26	East Channel Uinta River at State Highway 121, near Whiterocks	2	0	60-93	-	-	76-79	127-136	Ca	Ca
27	West Channel Uinta River at State Highway 121, near Whiterocks	2	0	2-3	-	-	90-141	159-250	Ca	Ca
28	Whiterocks River 1 mi east of Whiterocks	2	0	30-85	-	-	29-38	46-57	Ca	Ca
29	Whiterocks River at Whiterocks Canal, near Whiterocks	12	0	60-900	-	-	14-50	26-77	Ca	Ca
30	Whiterocks River near Whiterocks	79	18	25-900	66	125	18-69	30-240	Ca	Ca
31	Ouray Valley Canal at State Highway 121, at Lapoint	1	0	15	-	-	134	236	Ca	-
32	Ouray Valley Canal at U.S. Highway 40, near Gusher	1	0	15	-	-	113	193	Ca	-
33	Ouray Park Canal at U.S. Highway 40, near Gusher	1	0	20	-	-	546	830	Ca,Mg,Na	-
34	Ouray Park Canal at State Highway 88, near Pelican Lake	2	0	14-24	-	-	263-334	430-549	Ca,Mg,Na	Ca,Mg,Na

selected hydrologic data

Dominant anion(s) ow low	Dominant anion(s) High flow	Significant upstream storage	Significant upstream diversions	Significant upstream irrigation	Dominant geologic influence on water quality	Water use problems: Public supply: Dissolved solids (mg/l)	Public supply: Specific ions (mg/l)	Public supply: Fluoride (mg/l)	Irrigation supply: Salinity hazard	Irrigation supply: Sodium hazard	Irrigation supply: Boron (μg/l)	Hardness	Remarks
.	S04,HC03	Yes	Yes	Yes	Tdr,Tu	>500	S04>250	-	medium to high	low to high	150-1,400	very hard	Present (1974) upstream reservoir storage capacity is about 1,600,000 acre-ft.
4	S04,HC03	Yes	Yes	Yes	Tdr,Tu	>500	S04>250	-	high to very high	low to high	350-1,500	-	
4	S04,HC03	Yes	Yes	Yes	Tdr,Tu	>500	S04>250	-	medium to very high	low to medium	10-1,300	very hard	Average discharge is for 1942-73. Site 3 has been a daily water-quality station during 1951, 1956-74.
4	-	Yes	Yes	Yes	Tdr,Tu	>500	S04>250	-	high to very high	low to medium	1,200	very hard	Present upstream reservoir storage capacity is about 1,600,000 acre-ft.
4	S04,HC03	No	Yes	Yes	Qay,Tdr	>500	S04>250	-	medium to very high	low to medium	<500	very hard	
4	S04,HC03	No	Yes	Yes	Qay,Tdr	>500	S04>250	-	medium to very high	low to high	30-650	very hard	
4	-	Yes	Yes	Yes	Tdr,Tu	>500	S04>250	-	high	low	820	very hard	Diversion is from Duchesne River at site 49 about 6 mi upstream from site 7.
4	S04	No	Yes	Yes	Qay,Tdr	>500	S04>250 Cl>250	-	high to very high	low to high	200-960	very hard	
4	S04	No	Yes	Yes	Tdr	>500	S04>250 Cl>250	-	high to very high	low to high	-	-	
4,HC03	S04,HC03	No	Yes	Yes	Tdr	>500	S04>250	-	medium to high	low	210-240	very hard	
4,HC03	S04,HC03	No	Yes	Yes	Tdr	>500	S04>250	-	high	low	230-370	-	
4,HC03	S04,HC03	No	Yes	Yes	Tdr	>500	S04>250	-	medium to high	low	-	-	
4	S04,HC03	No	Yes	Yes	Tdr	>500	S04>250	-	high to very high	low to medium	-	very hard	
4	S04,HC03	No	Yes	Yes	Tdr	>500	S04>250 Cl>250	-	high to very high	low to very high	-	-	Cl ranges from 17 to 420 mg/l.
4	S04,HC03	No	Yes	Yes	Tdr	>500	S04>250	-	high to very high	low to medium	-	-	
03	HC03	Yes	No	No	Qgo,Tdr			-	low to medium	low	0-400	soft to very hard	Dissolved-solids concentrations are less than 500 mg/l during most years.
03	-	No	No	No	Qgo			1.2	medium	low	130	very hard	
03	HC03	No	No	No	Qgo			-	low	low	0	soft	
03	HC03	No	No	No	Tdr	>500		-	medium to high	low	-	-	
03	HC03	No	Yes	No	Qgo,Tdr			-	low to medium	low	-	-	
03	HC03	No	No	No	Tdr			-	medium	low	30-350	-	
4,HC03	HC03	No	Yes	Yes	Qay,Tdr	>500	S04>250	-	low to high	low	10-260	very hard	
4,HC03	HC03	No	Yes	Yes	Qay,Tdr	>500	S04>250	-	medium to high	low	50-380	-	
03	HC03	No	Yes	No	Qay				low to medium	low	0-160	-	
4,HC03	S04,HC03	No	Yes	Yes	Qay,Tdr,Ku	>500	S04>250		medium to high	low	20-470	very hard	
03	HC03	No	Yes	Yes	Qay				low	low	-	soft to mod. hard	
C03	HC03	No	Yes	Yes	Qay				low	low	-	mod. hard	
C03	HC03	No	Yes	No	Qgo,Qgm				low	low	50	soft	
C03	HC03	No	No	No	Qgm			-	low	low	-	-	
C03	HC03	No	No	No	Qgm				low	low	10-40	soft	
C03	-	No	Yes	Yes	Qgm			-	low	low	-	mod. hard	
C03	-	No	Yes	Yes	Qgm			-	low	low	-	mod. hard	
C03,S04	-	No	Yes	Yes	Qay	>500			high	low	260	mod. hard	See site 24.
C03,S04	HC03,S04	No	Yes	Yes	Qay				medium	low	110-140	hard to very hard	

Table 2.--Summary of selected

Site No.	Site name	No. of chemical analyses	No. of additional specific conductance determinations	Discharge range (ft^3/s)	Average: No. of years of record	Average: ft^3/s	Dissolved solids range (mg/l)	Specific conductance range (µmhos/cm at 25°C)	Dominant cation(s): Low flow	Dominant cation(s): High flow
35	Pelican Lake Feeder Canal at Pelican Lake	32	0	0.5-20	-	-	243-1,070	402-1,610	Na	Ca,Na,Mg
36	Pelican Lake at State Highway 88, at east side of lake	2	8	-	-	-	572-583	900-950	Na,Mg	Na,Mg
37	Pelican Lake outlfow into Lake Canal	44	0	0.5-15	-	-	427-1,070	677-1,450	Na,Mg	Na,Mg
38	Moffat Canal at State Highway 246, near Cusher	1	0	17	-	-	507	816	Mg,Ca	-
39	Montes Creek above Montes Creek Reservoir	1	0	10	-	-	777	1,100	Ca,Mg,Na	-
40	Montes Creek below Montes Creek Reservoir	37	0	0.2-50	-	-	194-1,340	323-1,610	Ca,Mg,Na	Ca,Mg,Na
41	Montes Creek at U.S. Highway 40, near Roosevelt	2	0	7	-	-	690-1,030	1,160-1,410	Ca,Mg,Na	-
42	Montes Creek at mouth, near Fort Duchesne	52	0	1-30	-	-	513-1,920	736-2,370	Ca,Mg,Na	Ca,Mg,Na
43	Pickup Wash near Roosevelt	1	0	3	-	-	2,440	2,810	Na,Ca,Mg	-
44	Uinta River 3.5 mi northwest of Whiterocks	1	0	50	-	-	70	123	Ca	-
45	Uinta River near Neola	81	20	1.5-1,900	45	181	15-91	27-147	Ca	Ca
46	Uinta River at power diversion, near Neola	14	0	30-800	-	-	11-36	20-55	Ca	Ca
47	Farm Creek near Whiterocks	5	16	2.4-26	24	6.3	150-238	175-380	Ca	Ca
48	Duchesne River at Ouray School Canal, near Randlett	50	0	5-3,600	-	-	209-4,040	346-4,560	Na	Ca,Na,Mg
49	Ouray School Canal at head, near Randlett	6	0	18-49	-	-	773-1,480	1,090-1,890	Na	Na,Ca,Mg
50	Riverdell Canal at SW¼NE¼NW¼ sec. 27, T. 3 S., R. 1 W., Uintah meridian	2	0	2-3	-	-	1,040-1,310	1,510-1,790	Na	-
51	Duchesne River at Myton	95	17	8-2,770	65	532	209-1,810	270-2,350	Na	Ca,Na
52	Duchesne River at Myton Townsite Canal, near Myton	20	0	15	-	-	142-1,480	223-1,820	Na	Ca,Mg,Na
53	Lake Fork River near mouth, near Myton	8	0	40	-	-	536-1,070	796-1,500	Na,Ca	-
54	Lake Fork River at State Highway 86, near Upalco	15	0	0.7-50	-	-	79-2,860	128-3,160	Na,Ca,Mg	Ca,Mg
55	Lake Fork River at Purdy Ditch, near Altamont	10	0	30-1,400	-	-	69-460	98-691	Ca,Mg,Na	Ca
56	Lake Fork River at State Highway 87, near Altamont	1	0	130	-	-	57	99	Ca	Ca
57	Lake Fork at C Canal head, near Altonah	51	0	4-1,200	-	-	25-193	46-331	Ca	Ca
58	Lake Fork River below Yellowstone River, near Altonah	5	0	75-240	-	-	16-162	33-260	Ca	Ca
59	Lake Fork River above Yellowstone River, near Altonah	2	0	100-150	-	-	29-35	54-57	Ca	Ca
60	Lake Fork River at Lake Fork damsite	26	0	5-900	-	-	18-215	33-336	Ca	Ca
61	Lake Fork River below Moon Lake, near Mountain Home	5	6	8-372	31	128	19-26	22-33	Ca	Ca
62	Lake Fork River above Moon Lake, near Mountain Home	3	6	17-410	23	115	16-30	18-55	-	-
63	Yellowstone River at mouth, near Altonah	14	0	40-450	-	-	22-88	34-124	Ca	Ca,Mg
64	Yellowstone River at Yellowstone Feeder Canal head, near Altonah	27	0	20-900	-	-	20-88	37-151	Ca	Ca
65	Yellowstone River near Altonah	34	22	44-900	29	141	25-176	35-279	Ca	Ca
66	Midview Reservoir (Lake Boreham) outflow near Bridgeland	3	0	35-53	-	-	494-712	882-1,040	Na,Ca,Mg	-
67	Duchesne River at State Highway 86, at Bridgeland	13	1	135-170	-	-	168-940	289-1,340	Na,Ca,Mg	Ca,Na
68	Duchesne River above Grey Mountain Canal, near Bridgeland	3	0	250	-	-	309-426	510-668	Ca,Na,Mg	Ca,Na,Mg
69	Duchesne River above Duchesne Feeder Canal, near Bridgeland	85	0	15-4,000	-	-	143-1,280	226-1,660	Ca,Na,Mg	Ca,Na,Mg
70	Duchesne Feeder Canal at head, near Bridgeland	1	0	90	-	-	387	662	-	Ca,Na
71	Duchesne River below Strawberry River, near Duchesne	6	4	200-2,100	-	-	456	205-755	Ca,Na,Mg	-
72	Pariette Draw near mouth, near Ouray	3	0	6-20	-	-	1,580-4,690	2,090-5,730	Na	Na

ydrologic data--Continued

Dominant anion(s) Low flow	Dominant anion(s) High flow	Significant upstream storage	Significant upstream diversions	Significant upstream irrigation	Dominant geologic influence on water quality	Water use problems: Public supply: Dissolved solids (mg/l)	Public supply: Specific ions (mg/l)	Public supply: Fluoride (mg/l)	Irrigation supply: Salinity hazard	Irrigation supply: Sodium hazard	Irrigation supply: Boron (μg/l)	Hardness	Remarks
,HCO3	SO4,HCO3	No	Yes	Yes	Qay	>500	SO4>250	-	medium to high	low	-	-	
	SO4	No	Yes	Yes	Qay,Qgs	>500	-		high	low	300	very hard	
,HCO3	SO4,HCO3	Yes	Yes	Yes	Qay,Qgs	>500	SO4>250		high	low	170-310	very hard	
3	-	No	Yes	Yes	Qay	>500			high	low	-	very hard	
,HCO3	-	No	No	Yes	Qay,Tdr	>500	SO4>250	-	high	low	360	very hard	
,HCO3	SO4,HCO3	Yes	No	Yes	Qay,Tdr	>500	SO4>250		high	low	310	very hard	
,HCO3	-	Yes	Yes	Yes	Qay,Tdr	>500	SO4>250	-	high	low	-	very hard	
	SO4,HCO3	Yes	Yes	Yes	Qay,Tdr	>500	SO4>250	-	high	low	-	very hard	
	-	No	Yes	Yes	Tdr	>500	SO4>250	-	very high	low	-	-	
)3	-	No	Yes	No	Qgm			-	low	low	-	soft	
)3	HCO3	No	No	No	Qgm			-	low	low	0-40	soft	
)3	HCO3	No	No	No	Qgm			-	low	low	-	soft	
)3	HCO3	No	No	No	Tdr,Mun				low	low	-	mod. hard to very hard	
	SO4,HCO3	Yes	Yes	Yes	Tdr,Tu	>500	SO4>250	-	medium to very high	low to high	120-6,150	very hard	
	SO4	Yes	Yes	Yes	Tdr,Tu	>500	SO4>250	-	high	-	-	-	See site 7.
	-	Yes	Yes	Yes	Tdr,Tu	>500	SO4>250	-	high	low to medium	-	-	
	HCO3,SO4	Yes	Yes	Yes	Tdr,Tu	>500	SO4>250		medium to very high	low to medium	380-970	very hard	
	HCO3,SO4	Yes	Yes	Yes	Tu	>500	SO4>250	-	medium to high	low	880	-	
	-	No	Yes	Yes	Tdr	>500	SO4>250		medium to high	low	310-370	very hard	
	HCO3,SO4	No	Yes	Yes	Tdr		SO4>250	-	low to high	low	40	mod. hard to very hard	
)3,SO4	HCO3	No	Yes	Yes	Qgo,Tdr			-	low to medium	low	-	-	
)3	HCO3	No	Yes	No	Qgo,Qgm			-	low	low	20	soft	
)3	HCO3	No	Yes	No	Qgm			-	low	low	0-80	-	
)3	HCO3	No	Yes	No	Qgm			-	low	low	20-50	soft	
)3	HCO3	Yes	No	No	Qgm,PCm			-	low	low	-	soft	
)3	HCO3	Yes	No	No	Qgm,PCm			-	low	low	-	-	
)3	HCO3	Yes	No	No	Qgm			-	low	low	-	soft	
	-	Yes	No	No	Qgm			-	low	low	-	soft	
)3,SO4	HCO3	No	Yes	No	Qgm,Tdr				low	low	20-180	soft	
)3,SO4	HCO3	No	No	No	Qgm,Tdr			-	low	low	0-80	-	
)3,SO4	HCO3,SO4	No	No	No	Qgm,Tdr			-	low	low	-	soft to mod. hard	
4,HCO3	-	Yes	Yes	Yes	Tdr,Tu,Qgs	>500	SO4>250		high	low	350-430	very hard	
4,HCO3	HCO3	Yes	Yes	Yes	Tdr,Tu				medium to high	low	310-350	mod. hard to very hard	
)3,SO4	HCO3	Yes	Yes	Yes	Tdr,Tu	-			-	low	260-420	hard to very hard	
)3,SO4	HCO3	Yes	Yes	Yes	Tu,Tgu			-	medium	low	0-350	-	The observed maximum dissolved-solids concentration and specific conductance were in March 1970 at a discharge of 15 ft^3/s when nearly all upstream flow was being stored in the new Starvation Reservoir. 81 of 82 observed concentrations were less than about 500 mg/l.
	HCO3	Yes	Yes	Yes	Tu,Tgu			-	medium	low	-	very hard	
)3,SO4	-	Yes	Yes	No	Tu,Tgu				low to medium	low	160-350	very hard	
4	SO4	No	No	Yes	Tu	>500	SO4>250		very high	medium to very high	2,200	very hard	

Table 2.--Summary of selected

Site No.	Site name	No. of chemical analyses	No. of additional specific conductance determinations	Discharge range (ft^3/s)	Average: No. of years of record	Average: ft^3/s	Dissolved solids range (mg/l)	Specific conductance range (mhos/cm at 25°C)	Dominant cation(s): Low flow	Dominant cation(s): High flow
73	Pariette Draw below Pleasant Valley Wash	1	0	75	-	-	2,640	3,300	Na	Na
74	Big Wash near Myton	2	0	1-1.5	-	-	498-522	749-781	Na,Ca	Na,Ca
75	Unnamed tributary to Castle Peak Draw near Myton	1	0	1	-	-	266	406	Na	Na
76	Castle Peak Draw near Castle Peak	1	0	0.5	-	-	594	962	Na	Na
77	Pleasant Valley Wash 3 mi south of Myton	3	0	9-20	-	-	1,690-2,440	2,280-3,090	Na	Na
78	Pariette Draw below small reservoir	1	0	8	-	-	960	1,390	Na	-
79	Myton Townsite Canal near terminus, near Randlett	8	0	5-16	-	-	417-1,070	676-1,410	Na,Ca	Na,Ca,Mg
80	Myton Townsite Canal 7 mi east of Myton	1	0	-	-	-	454	709	-	Na,Ca
81	Myton Townsite Canal near Sand Pass	1	0	-	-	-	1,050	1,400	Na,Ca	-
82	Myton Townsite Canal below Grey Mountain Canal	8	0	30-90	-	-	384-930	616-1,270	Na,Ca,Mg	Na,Ca,Mg
83	Drain below unnamed pond 2 mi south of Myton	7	0	2-4	-	-	1,480-2,030	1,820-2,410	Na,Ca	Na,Ca
84	Drain 2.5 mi east and 1 mi south of Myton	7	0	10-20	-	-	1,790-2,360	2,280-2,880	Na,Ca,Mg	Na,Ca,Mg
85	Grey Mountain Canal at mouth, at Myton Townsite Canal	1	0	8	-	-	873	1,290	Na,Ca	-
86	Drain into Grey Mountain Canal at State Highway 53, near Myton	5	0	0.05-4	-	-	1,000-1,820	1,340-2,230	Na,Ca	Na,Ca
87	Drain at U.S Highway 40, 4.5 mi west of Myton	4	0	1-2	-	-	668-1,750	962-2,030	Na,Ca,Mg	-
88	Grey Mountain Canal at diversion, at Duchesne River	1	0	160	-	-	413	653	-	Ca,Na,Mg
89	Upper Pleasant Valley Canal at NE¼NE¼SE¼, sec. 24, T. 3 S., R. 2 W., Uintah meridian	1	0	75	-	-	551	853	-	Ca,Na
90	Larry Ross Drain near Myton	11	0	0.05-0.2	-	-	888-6,740	1,230-7,840	Na	Na,Ca
91	Antelope Creek near mouth at U.S. Highway 40, near Bridgeland	13	0	1-10	-	-	2,260-3,750	2,590-4,060	Na,Mg,Ca	Na,Mg,Ca
92	Antelope Creek near Bridgeland	3	0	0.5-3	-	-	2,400-4,040	3,180-4,320	Na,Mg,Ca	-
92.5	Antelope Creek below Sowers Creek	1	0	3.5	-	-	2,250	2,680	-	-
93	Sowers Creek above Antelope Creek	1	0	5	-	-	2,250	2,820	-	Ca,Na,Mg
93.5	Sowers Creek below Tabby Canyon	1	0	2	-	-	1,590	2,010	-	-
94	Sowers Creek above Tabby Canyon	2	0	1-1.5	-	-	1,590-1,730	2,060-2,210	Ca,Mg,Na	-
95	Sowers Creek near Duchesne	5	23	0.5-42	9	4.3	635-879	800-1,525	Mg,Na,Ca	Mg,Ca,Na
96	Indian Canyon at mouth, at Duchesne	19	2	0.4-35	-	-	644-2,370	1,000-3,230	Na,Mg	Mg,Na,Ca
97	Indian Canyon 4.2 mi above mouth	2	0	0.2-0.4	-	-	2,290-2,340	3,130-3,170	Na,Mg	-
97.5	Indian Canyon below Road Hollow	1	0	2.5	-	-	1,640	2,320	-	-
98	Indian Canyon 8.4 mi above mouth	1	0	5	-	-	733	1,080	-	Na
99	Left Fork Indian Canyon above Right Fork	2	0	0.1-0.5	-	-	998-1,010	1,460	Na	-
100	Right Fork Indian Canyon above Left Fork	2	0	0.2-0.25	-	-	1,690-1,700	2,380-2,450	Na	-
101	Right Fork Indian Canyon 1.9 mi above mouth	1	0	0.75	-	-	1,580	2,230	Na	-
102	Right Fork Indian Canyon 3.7 mi above mouth	1	0	0.75	-	-	1,530	2,180	Na	-
103	Right Fork Indian Canyon 9.0 mi above mouth	1	0	0.5	-	-	1,160	1,670	Na	-
104	Left Fork Indian Canyon below Jones Hollow	2	0	0.7-1.3	-	-	819-847	1,250	Na,Mg	-
105	Left Fork Indian Canyon above Spring Hollow	1	0	0.6	-	-	598	929	Na,Mg,Ca	-
106	Strawberry River at mouth, below Indian Canyon at Duchesne	8	5	35-375	-	-	486-625	500-940	Na,Ca,Mg	Na,Ca,Mg

Dominant anion(s) Low flow	Dominant anion(s) High flow	Significant upstream storage	Significant upstream diversions	Significant upstream irrigation	Dominant geologic influence on water quality	Water use problems: Public supply: Dissolved solids (mg/l)	Public supply: Specific ions (mg/l)	Public supply: Fluoride (mg/l)	Irrigation supply: Salinity hazard	Irrigation supply: Sodium hazard	Irrigation supply: Boron (µg/l)	Hardness	Remarks
4	SO4	No	No	Yes	Tu	>500	SO4>250		very high	high	1,300	very hard	
4,HCO3	SO4,HCO3	No	No	No	Tu				high	low	530	hard to very hard	Ephemeral stream; thunderstorm runoff. Site is in SW¼SE¼NE¼, sec. 12, T. 9 S., R. 17 E.
03,SO4	HCO3,SO4	No	No	No	Tu				medium	low	320	soft	Ephemeral stream; thunderstorm runoff. Site in is SW¼SE¼NE¼, sec. 4, T. 9 S., R. 17 E.
4,HCO3	SO4,HCO3	No	No	No	Tu	>500		3.0	high	high	1,600	soft	Ephemeral stream; thunderstorm runoff.
4	SO4	No	No	Yes	Tu	>500	SO4>250		very high	medium to high	990-1,100	very hard	
4	-	No	No	Yes	Tu	>500	SO4>250		high	low	580	very hard	
4,HCO3	SO4,HCO3	Yes	Yes	Yes	Qay,Tu	>500	SO4>250		medium to high	low	-	-	
	SO4,HCO3	Yes	Yes	Yes	Qay,Tu			-	medium	low	-	-	
4	-	Yes	Yes	Yes	Qay,Tu	>500	SO4>250	-	high	low	-	-	
4,HCO3	SO4,HCO3	Yes	Yes	Yes	Qay,Tu	>500	SO4>250	-	high	low	1,000	very hard	
4	SO4	No	No	Yes	Tu	>500	SO4>250	-	high to very high	low to medium	-	-	Irrigation return flow.
4	SO4	No	No	Yes	Qay,Tu	>500	SO4>250	-	very high	low to medium	-	-	Do.
4,HCO3	-	Yes	Yes	Yes	Qay	>500	SO4>250	-	high	low	-	very hard	
4	SO4	No	No	Yes	Qay,Tu	>500	SO4>250	-	high	low	-	-	Irrigation return flow.
4	-	No	No	Yes	Qay	>500	SO4>250	-	high	low	-	-	
	HCO3,SO4	Yes	Yes	Yes	Tdr,Tu			-	medium	low	-	very hard	See site 85 data collected on same day.
	HCO3,SO4	Yes	Yes	Yes	Tu	>500		-	high	low	-	-	
4	SO4	No	No	Yes	Tu	>500	SO4>250	-	high to very high	low to very high	-	-	Canal seepage and irrigation return flow.
4	SO4	No	Yes	Yes	Tu,Tgu	>500	SO4>250	1.8-2.4	very high	medium to high	4,200 6,600	very hard	Strontium 9,600 µg/l, Aug. 18, 1974.
4	-	No	No	No	Tu,Tgu	>500	SO4>250	1.4	very high	medium to high	7,200-8,400	very hard	Strontium 9,200 µg/l, Aug. 18, 1974.
4	-	No	No	No	Tu,Tgu	>500	SO4>250	-	very high	-	4,900	-	
	SO4	No	No	No	Tu,Tgu	>500	SO4>250	1.7	very high	low	4,400	very hard	Strontium 8,400 µg/l, Aug. 18, 1974.
4	-	No	No	No	Tu,Tgu	>500	SO4>250	-	high	-	3,600	-	
4	-	No	No	No	Tu,Tgu	>500	SO4>250	1.5	high	low	3,900-4,600	very hard	
03,SO4	HCO3,SO4	No	No	No	Tgu	>500	SO4>250	-	high	low	2,600	very hard	
4,HCO3	HCO3,SO4	No	Yes	Yes	Tu,Tgu	>500	SO4>250	2.0-2.4	high to very high	low to high	1,800-20,000	very hard	Strontium 6,200 µg/l, Aug. 18, 1974.
4,HCO3	-	No	Yes	Yes	Tu,Tgu	>500	SO4>250	2.0-2.4	very high	medium	4,900-11,000	very hard	In July and September 1974, flow at this site originated from channel spring at base of channel scarp; channel was dry for at least a mile upstream from spring.
	-	No	Yes	Yes	Tu,Tgu	>500	SO4>250	-	very high	-	7,300	-	
	HCO3,SO4	No	No	No	Tu,Tgu	>500		-	high	low	2,800	-	
4,HCO3	-	No	No	No	Tu,Tgu	>500	SO4>250	1.7	high	medium	4,800-4,900	very hard	
4,HCO3	-	No	No	No	Tu,Tgu	>500	SO4>250	1.8	high	medium	6,500	very hard	
4,HCO3	-	No	No	No	Tu,Tgu	>500	SO4>250	1.8	high	medium	5,700	very hard	
03,SO4	-	No	No	No	Tu,Tgu	>500	SO4>250	1.8	high	medium	5,500	very hard	
03,SO4	-	No	No	No	Tu	>500	SO4>250	1.4	high	medium	4,400	very hard	
03,SO4	-	No	No	No	Tgu	>500	SO4>250	1.5	high	low	3,500-3,900	very hard	
03	-	No	No	No	Tgu	>500		1.1	high	low	1,100	very hard	Flow in channel on July 18, 1974, began at channel spring at this site; no flow between this site and the headwaters several miles upstream.
03,SO4	HCO3,SO4	Yes	Yes	No	Tu	>500			high	low	390-950	very hard	

Table 2.--Summary of selected

Site No.	Site name	No. of chemical analyses	No. of additional specific conductance determinations	Discharge range (ft³/s)	Average: No. of years of record	Average: ft³/s	Dissolved solids range	Specific conductance range (mhos/cm at 25°C)	Dominant cation(s): Low flow	Dominant cation(s): High flow
107	Strawberry River above Indian Canyon at Duchesne	107	1	25-1,000	54	151	262-629	414-997	Na,Ca,Mg	Na,Ca,Mg
108	Strawberry River below Starvation Reservoir	20	5	50-375	-	-	420-710	681-1,040	Na,Ca,Mg	Na,Ca,Mg
	do	2	0	1-3	-	-	789-1,250	1,160-1,660	Na,Mg,Ca	-
109	Duchesne River above Strawberry River, at Duchesne	135	6	13-3,400	52	360	92-563	170-859	Ca	Ca,Mg
	do	1	0	6	-	-	1,030	1,300	Na,Mg,Ca	-
110	Duchesne River above Rocky Point Canal, near Duchesne	1	0	150	-	-	223	382	Ca	Ca
111	Duchesne River above Knight Diversion	93	20	37-3,000	-	-	78-335	150-530	Ca,Mg	Ca
112	Rock Creek near Talmage	26	29	43-1,710	10	197	34-187	60-380	Ca	Ca
113	Rock Creek near Mountain Home	38	20	20-1,740	36	173	24-227	37-361	Ca	Ca
114	South Fork Rock Creek near Hanna	12	18	3-114	20	13	18-316	29-519	Ca,Mg	Ca
115	Rock Creek above South Fork, near Hanna	13	14	10-1,650	8	148	12-68	20-250	Ca	Ca
116	Duchesne River near Tabiona	43	21	70-1,510	55	201	106-399	170-604	Ca,Mg	Ca
117	Duchesne River at Tabiona	2	0	80-88	-	-	233-256	396-434	Ca,Mg	-
118	Duchesne River at Hanna	48	0	35-1,230	7	153	95-300	170-482	Ca,Mg	Ca
119	Duchesne River below West Fork, near Hanna	2	0	105	-	-	105-132	164-233	Ca	-
120	Duchesne River above West Fork, near Hanna	3	0	29-378	-	-	200	73-273	Ca	Ca
121	Hades Creek near Hanna	6	0	3-60	-	-	28-91	44-148	Ca,Mg	Ca,Mg
122	West Fork Duchesne River near Hanna	11	17	13-352	29	49	185-343	280-520	Ca	Ca
123	West Fork Duchesne River below Dry Hollow, near Hanna	3	0	25-145	19	38	162-269	276-428	Ca	Ca
124	Wolf Creek above Rhodes Canyon, near Hanna	11	14	3.4-35	28	7.6	133-334	225-505	Ca	Ca
125	Twin Creek near Win Diversion, near Hanna	2	0	5	-	-	148-169	263-298	Ca	-
126	Strawberry River near Duchesne	30	33	32-1,250	5	150	271-622	430-962	Na,Mg,Ca	Ca,Mg,Na
127	Strawberry River at Starvation damsite, near Duchesne	9	0	40-415	-	-	287-610	453-975	Na,Mg,Ca	Ca,Mg,Na
128	Lake Canyon at mouth, at Strawberry River	4	0	0.75-2	-	-	3,220-3,510	4,120-4,810	Na	-
129	Red Creek below Currant Creek, near Fruitland	6	32	17-380	10	61	180-541	310-840	Na,Ca,Mg	Ca
130	Red Creek above Currant Creek, near Fruitland	7	6	0.1-87	-	-	239-812	408-1,390	Na	Ca
131	Currant Creek at mouth, near Fruitland	1	0	28	-	-	309	514	Ca,Mg	-
132	Currant Creek near Fruitland	2	31	16-343	39	46	251-261	280-490	Ca	-
133	Deep Creek at mouth, near Fruitland	1	0	-	-	-	368	575	Ca,Mg,Na	-
134	Currant Creek above Deep Creek, near Fruitland	1	0	-	-	-	287	468	Ca,Mg	-
135	Currant Creek above Water Hollow, near Fruitland	12	0	13-260	-	-	177-286	302-540	Ca,Mg	Ca

hydrologic data--Continued

Dominant anion(s) Low flow	Dominant anion(s) High flow	Significant upstream storage	Significant upstream diversions	Significant upstream irrigation	Dominant geologic influence on water quality	Water use problems: Public supply: Dissolved solids (mg/l)	Public supply: Specific ions (mg/l)	Public supply: Fluoride (mg/l)	Irrigation supply: Salinity hazard	Irrigation supply: Sodium hazard	Boron (µg/l)	Hardness	Remarks
CO_3,SO_4	HCO_3,SO_4	Yes	Yes	No	Tu				medium to high	low	650-850	very hard	102 of 107 chemical analyses were made prior to storage in Starvation Reservoir that began in 1969.
CO_3,SO_4	HCO_3,SO_4	Yes	Yes	No	Tu,Tgu	>500			medium to high	low	260-400	-	
04,HCO_3	-	Yes	Yes	No	Tu,Qay	>500	SO_4>250	-	high	low	470	-	Data for March-April 1970 obtained when all flow of Strawberry River was being stored in new Starvation Reservoir. These two analyses represent channel seepage.
CO_3,SO_4	HCO_3	No	Yes	No	Qgm,PCm				low to medium	low	0-300	mod. hard to very hard	
04	-	-	-	-	Qay	-	-	-	high	low	-	-	Channel seepage in March 1970 when nearly all flow of Duchesne River was diverted to Starvation Reservoir.
CO_3	HCO_3	No	Yes	No	Qgm,PCm				low	low	80	hard	
CO_3	HCO_3	No	Yes	No	Qgm,PCm				low to medium	low	0-370	mod. hard to very hard	
CO_3,SO_4	HCO_3	No	No	No	Qgm,Tdr				low to medium	low	30	soft to hard	
CO_3	HCO_3	No	No	No	Qgm				low to medium	low	0	soft to mod. hard	
CO_3	HCO_3	No	No	No	Qgm,PCm			-	low to medium	low	-	soft to hard	
CO_3	HCO_3	No	No	No	Qgm			-	low	low	-	soft	
CO_3	HCO_3	No	Yes	No	Qgm,Mz			-	low to medium	low	0-150	mod. hard to very hard	
CO_3	-	No	Yes	No	Qgm,Mz				medium	low	60	very hard	
CO_3,SO_4	HCO_3	No	Yes	No	Qgm,Mz				low to medium	low	0-100	hard to very hard	
CO_3	-	No	Yes	No	Qgm			-	low	low	-	mod. hard	
CO_3	HCO_3	No	Yes	No	Qgm			-	low	low	-	mod. hard	
CO_3,SO_4	HCO_3	No	No	No	Qgm,PCrp			-	low	low	0-30	-	
CO_3	HCO_3	No	No	No	Mz			-	medium	low	0-50	very hard	
CO_3	HCO_3	No	No	No	Mz			-	medium	low	20	-	
CO_3	HCO_3	No	No	No	Mz			-	low to medium	low	0-50	hard to very hard	
CO_3	-	No	No	No	Ppc			-	medium	low	-	-	
CO_3	HCO_3	Yes	Yes	No	Tu,Tgu	>500			medium to high	low	390-710	very hard	
CO_3	HCO_3	Yes	Yes	No	Tu,Tgu			-	medium to high	low	-	-	
04	-	No	No	No	Tu	>500	SO_4>250	1.8	very high	very high	9,700-17,000	very hard	
CO_3	HCO_3	No	Yes	No	Tu,Tdr				medium to high	low	100-160	very hard	
CO_3	HCO_3	No	Yes	No	Tu,Tdr	>500		-	medium to high	low	50-110	very hard	
CO_3	-	No	Yes	No	Tu,Tdr	-	-	-	medium	low	40	very hard	
CO_3	-	No	Yes	No	Tu,Tdr			-	medium	low	-	very hard	
CO_3	-	No	No	No	Tu,Tdr	-		-	medium	low	140	very hard	
CO_3	-	No	Yes	No	Tu,Tdr	-		-	medium	low	70	very hard	
CO_3	HCO_3	No	Yes	No	Tdr,Ku				medium	low	0	hard to very hard	

Table 2.--Summary of selected

Site No.	Site name	No. of chemical analyses	No. of additional specific conductance determinations	Discharge range (ft^3/s)	Average: No. of years of record	Average: ft^3/s	Dissolved solids range	Specific conductance range (µmhos/cm at 25°C)	Dominant cation(s): Low flow	Dominant cation(s): High flow
136	Layout Creek near mouth	3	0	2-10	-	-	184-188	349-351	Ca	Ca
137	Water Hollow near Fruitland	11	9	0.3-8	25	5.7	152-318	270-544	Ca,Mg	Ca
138	Currant Creek below Red Lodge Hollow, near Fruitland	7	8	4-150	23	25	185-285	290-430	Ca	Ca
139	Avintaquin Creek at mouth, at Strawberry River	4	0	15-500	-	-	319-587	519-898	Na	Ca,Mg,Na
139.5	Avintaquin Creek above Lion Hollow	1	0	16	-	-	340	541	-	-
139.7	Avintaquin Creek above Poison Creek	1	0	14	-	-	315	540	-	-
140	West Fork Avintaquin Creek near Fruitland	3	31	2-273	9	16	316-413	420-644	Ca,Na,Mg	Ca,Mg,Na
141	Strawberry River above Red Creek, near Fruitland	6	35	25-1,250	10	60	-	460-800	Ca,Mg	Ca,Mg
142	Timber Canyon at mouth, at Strawberry River	3	0	3-10	-	-	334-430	574-674	Ma,Ca,Na	Mg,Ca,Na
142.5	Willow Creek at mouth, at Strawberry River	1	0	20	-	-	296	578	-	-
143	Strawberry River near Soldier Springs	11	16	15-230	23	31	257-361	380-580	Ca,Mg,Na	Ca,Mg
		1	10	0.2-14	-	-	357	460-600	Ca,Mg	-
144	Soldier Creek at U.S. Highway 40, at Strawberry Reservoir	1	0	3	-	-	227	-	Mg,Ca	-
145	Clyde Creek at mouth, at Strawberry Reservoir	1	0	1.5	-	-	207	368	Ca	-
146	Mud Creek at mouth, at Strawberry Reservoir	1	0	1	-	-	247	450	Ca,Mg	-
147	Bryant Fork at mouth, at Strawberry Reservoir	1	0	2	-	-	236	430	Ca,Mg	-
148	Indian Creek diversion canal near terminus	1	0	20	-	-	323	520	Ca,Mg	-
149	Horse Creek below Indian Creek diversion canal	1	0	0.1	-	-	262	454	Ca,Mg	-
150	Indian Creek below Indian Creek diversion canal	1	0	1	-	-	248	410	Ca,Mg	-
151	Strawberry River above Strawberry Reservoir	1	0	12	-	-	221	365	Ca,Mg	-

Dominant anion(s)		Significant upstream storage	Significant upstream diversions	Significant upstream irrigation	Dominant geologic influence on water quality	Water use problems						Hardness	Remarks
						Public supply			Irrigation supply				
Low flow	High flow					Dissolved solids (mg/l)	Specific ions (mg/l)	Fluoride (mg/l)	Salinity hazard	Sodium hazard	Boron (μg/l)		
03	HCO3	No	No	No	Tdr,Ku			-	medium	low	-	-	
03	HCO3	No	Yes	No	Tdr,Ku				medium	low	0-70	very hard	Diversion to Strawberry Reservoir through Water Hollow Tunnel began Dec. 9, 1971.
03	HCO3	No	Yes	No	Ku			-	medium	low	0-50	very hard	
03	HCO3	No	No	No	Tgu	>500			medium to high	low	300-890	very hard	
	-	No	No	No	Tgu	-	-	-	medium	-	260	-	
	-	No	No	No	Tgu	-	-	-	medium	-	150	-	
03	HCO3	No	No	No	Tgu			-	medium	low	-	very hard	
03	HCO3	Yes	Yes	No	Tu,Tgu				medium	low	160-200	very hard	
03	HCO3	No	No	No	Tgu				medium	low	290	very hard	
	-	No	No	No	Tu,Tgu				medium	-	30	-	
03	HCO3	Yes	Yes	No	Tu			-	medium	low	20-170	very hard	Site 143 is immediately downstream from new Soldier Creek Dam; storage began June 30, 1973. Minimum-release requirement to Strawberry River is 4 ft^3/s. The 31 ft^3/s shown as average discharge for 23 years is for pre-1973 conditions.
03	-	Yes	Yes	No	Tu				medium	low	80	very hard	
03	-	No	No	No	Tu				medium	low	20	very hard	
03	-	No	No	No	Tu				medium	low	20	very hard	
03	-	No	No	No	Tu				medium	low	10	very hard	
03	-	No	No	No	Tu				medium	low	20	very hard	
03	-	No	Yes	No	Tu				medium	low	50	very hard	
03	-	No	Yes	No	Tu				medium	low	20	very hard	
03	-	No	Yes	No	Tu				medium	low	20	very hard	
03,SO4	-	No	No	No	Qay,Tu				medium	low	20	very hard	

PUBLICATIONS OF THE UTAH DEPARTMENT OF NATURAL RESOURCES,
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(*)-Out of Print

TECHNICAL PUBLICATIONS

*No. 1. Underground leakage from artesian wells in the Flowell area, near Fillmore, Utah, by Penn Livingston and G. B. Maxey, U.S. Geological Survey, 1944.

No. 2. The Ogden Valley artesian reservoir, Weber County, Utah, by H. E. Thomas, U.S. Geological Survey, 1945.

*No. 3. Ground water in Pavant Valley, Millard County, Utah, by P. E. Dennis, G. B. Maxey and H. E. Thomas, U.S. Geological Survey, 1946.

*No. 4. Ground water in Tooele Valley, Tooele County, Utah, by H. E. Thomas, U.S. Geological Survey, in Utah State Eng. 25th Bienn. Rept., p. 91-238, pls. 1-6, 1946.

*No. 5. Ground water in the East Shore area, Utah: Part I, Bountiful District, Davis County, Utah, by H. E. Thomas and W. B. Nelson, U.S. Geological Survey, in Utah State Eng. 26th Bienn. Rept., p. 53-206, pls. 1-2, 1948.

*No. 6. Ground water in the Escalante Valley, Beaver, Iron, and Washington Counties, Utah, by P. F. Fix, W. B. Nelson, B. E. Lofgren, and R. G. Butler, U.S. Geological Survey, in Utah State Eng. 27th Bienn. Rept., p. 107-210, pls. 1-10, 1950.

No. 7. Status of development of selected ground-water basins in Utah, by H. E. Thomas, W. B. Nelson, B. E. Lofgren, and R. G. Butler, U.S. Geological Survey, 1952.

*No. 8. Consumptive use of water and irrigation requirements of crops in Utah, by C. O. Roskelly and Wayne D. Criddle, 1952.

No. 8. (Revised) Consumptive use and water requirements for Utah, by W. D. Criddle, K. Harris, and L. S. Willardson, 1962.

No. 9. Progress report on selected ground-water basins in Utah, by H. A. Waite, W. B. Nelson, and others, U.S. Geological Survey, 1954.

*No. 10. A compilation of chemical quality data for ground and surface waters in Utah, by J. G. Connor, C. G. Mitchell, and others, U.S. Geological Survey, 1958.

*No. 11. Ground water in northern Utah Valley, Utah: A progress report for the period 1948-63, by R. M. Cordova and Seymour Subitzky, U.S. Geological Survey, 1965.

*No. 12. Reevaluation of the ground-water resources of Tooele Valley, Utah, by Joseph S. Gates, U.S. Geological Survey, 1965.

*No. 13. Ground-water resources of selected basins in southwestern Utah, by G. W. Sandberg, U.S. Geological Survey, 1966.

*No. 14. Water-resources appraisal of the Snake Valley area, Utah and Nevada, by J. W. Hood and F. E. Rush, U.S. Geological Survey, 1966.

*No. 15. Water from bedrock in the Colorado Plateau of Utah, by R. D. Feltis, U.S. Geological Survey, 1966.

*No. 16. Ground-water conditions in Cedar Valley, Utah County, Utah, by R. D. Feltis, U.S. Geological Survey, 1967.

*No. 17. Ground-water resources of northern Juab Valley, Utah, by L. J. Bjorklund, U.S. Geological Survey, 1968.

No. 18. Hydrologic reconnaissance of Skull Valley, Tooele County, Utah, by J. W. Hood and K. M. Waddell, U.S. Geological Survey, 1968.

No. 19. An appraisal of the quality of surface water in the Sevier Lake basin, Utah, by D. C. Hahl and J. C. Mundorff, U.S. Geological Survey, 1968.

No. 20. Extensions of streamflow records in Utah, by J. K. Reid, L. E. Carroon, and G. E. Pyper, U.S. Geological Survey, 1969.

No. 21. Summary of maximum discharges in Utah streams, by G. L. Whitaker, U.S. Geological Survey, 1969.

No. 22. Reconnaissance of the ground-water resources of the upper Fremont River valley, Wayne County, Utah, by L. J. Bjorklund, U.S. Geological Survey, 1969.

No. 23. Hydrologic reconnaissance of Rush Valley, Tooele County, Utah, by J. W. Hood, Don Price, and K. M. Waddell, U.S. Geological Survey, 1969.

No. 24. Hydrologic reconnaissance of Deep Creek valley, Tooele and Juab Counties, Utah, and Elko and White Pine Counties, Nevada, by J. W. Hood and K. M. Waddell, U.S. Geological Survey, 1969.

No. 25. Hydrologic reconnaissance of Curlew Valley, Utah and Idaho, by E. L. Bolke and Don Price, U.S. Geological Survey, 1969.

No. 26. Hydrologic reconnaissance of the Sink Valley area, Tooele and Box Elder Counties, Utah, by Don Price and E. L. Bolke, U.S. Geological Survey, 1969.

No. 27. Water resources of the Heber-Kamas-Park City area, north-central Utah, by C. H. Baker, Jr., U.S. Geological Survey, 1970.

No. 28. Ground-water conditions in southern Utah Valley and Goshen Valley, Utah, by R. M. Cordova, U.S. Geological Survey, 1970.

No. 29. Hydrologic reconnaissance of Grouse Creek valley, Box Elder County, Utah, by J. W. Hood and Don Price, U.S. Geological Survey, 1970.

No. 30. Hydrologic reconnaissance of the Park Valley area, Box Elder County, Utah, by J. W. Hood, U.S. Geological Survey, 1971.

No. 31. Water resources of Salt Lake County, Utah, by Allen G. Hely, R. W. Mower, and C. Albert Harr, U.S. Geological Survey, 1971.

No. 32. Geology and water resources of the Spanish Valley area, Grand and San Juan Counties, Utah, by C. T. Sumsion, U.S. Geological Survey, 1971.

No. 33. Hydrologic reconnaissance of Hansel Valley and northern Rozel Flat, Box Elder County, Utah, by J. W. Hood, U.S. Geological Survey, 1971.

No. 34. Summary of water resources of Salt Lake County, Utah, by Allen G. Hely, R. W. Mower, and C. Albert Harr, U.S. Geological Survey, 1971.

No. 35. Ground-water conditions in the East Shore area, Box Elder, Davis, and Weber Counties, Utah, 1960-69, by E. L. Bolke and K. M. Waddell, U.S. Geological Survey, 1972.

No. 36. Ground-water resources of Cache Valley, Utah and Idaho, by L. J. Bjorklund and L. J. McGreevy, U.S. Geological Survey, 1971.

No. 37. Hydrologic reconnaissance of the Blue Creek Valley area, Box Elder County, Utah, by E. L. Bolke and Don Price, U.S. Geological Survey, 1972.

No. 38. Hydrologic reconnaissance of the Promontory Mountains area, Box Elder County, Utah, by J. W. Hood, U.S. Geological Survey, 1972.

No. 39. Reconnaissance of chemical quality of surface water and fluvial sediment in the Price River Basin, Utah, by J. C. Mundorff, U.S. Geological Survey, 1972.

No. 40. Ground-water conditions in the central Virgin River basin, Utah, by R. M. Cordova, G. W. Sandberg, and Wilson McConkie, U.S. Geological Survey, 1972.

No. 41. Hydrologic reconnaissance of Pilot Valley, Utah and Nevada, by Jerry C. Stephens and J. W. Hood, U.S. Geological Survey, 1973.

No. 42. Hydrologic reconnaissance of the northern Great Salt Lake Desert and summary hydrologic reconnaissance of northwestern Utah, by Jerry C. Stephens, U.S. Geological Survey, 1973.

No. 43. Water resources of the Milford area, Utah, with emphasis on ground water, by R. W. Mower and R. M. Cordova, U.S. Geological Survey, 1974.

No. 44. Ground-water resources of the lower Bear River drainage basin, Box Elder County, Utah, by L. J. Bjorklund and L. J. McGreevy, U.S. Geological Survey, 1974.

No. 45. Water resources of the Curlew Valley drainage basin, Utah and Idaho, by Claud H. Baker, Jr., U.S. Geological Survey, 1974.

No. 46. Water-quality reconnaissance of surface inflow to Utah Lake, by J. C. Mundorff, U.S. Geological Survey, 1974.

No. 47. Hydrologic reconnaissance of the Wah Wah Valley drainage basin. Millard and Beaver Counties, Utah, by Jerry C. Stephens, U.S. Geological Survey, 1974.

No. 48. Estimating mean streamflow in the Duchesne River Basin, Utah, by R. W. Cruff, U.S. Geological Survey, 1974.

No. 49. Hydrologic reconnaissance of the southern Uinta Basin, Utah and Colorado, by Don Price and Louise L. Miller, U.S. Geological Survey, 1975.

No. 50. Seepage study of the Rocky Point Canal and the Grey Mountain-Pleasant Valley Canal systems, Duchesne County, Utah, by R. W. Cruff and J. W. Hood, U.S. Geological Survey, 1975.

No. 51. Hydrologic reconnaissance of the Pine Valley drainage basin, Millard, Beaver, and Iron Counties, Utah, by J. C. Stephens, U.S. Geological Survey, 1976.

No. 52. Seepage study of canals in Beaver Valley, Beaver County, Utah, by R. W. Cruff and R. W. Mower, U.S. Geological Survey, 1976.

No. 53. Characteristics of aquifers in the northern Uinta Basin area, Utah and Colorado, by James W. Hood, U.S. Geological Survey, 1976.

No. 54. Hydrologic Evaluation of Ashley Valley, northern Uinta Basin area, Utah, by James W. Hood, U.S. Geological Survey, 1977.

WATER CIRCULARS

No. 1. Ground water in the Jordan Valley, Salt Lake County, Utah, by Ted Arnow, U.S. Geological Survey, 1965.

No. 2. Ground water in Tooele Valley, Utah, by J. S. Gates and O. A. Keller, U.S. Geological Survey, 1970.

BASIC-DATA REPORTS

*No. 1. Records and water-level measurements of selected wells and chemical analyses of ground water, East Shore area, Davis, Weber, and Box Elder Counties, Utah, by R. E. Smith, U.S. Geological Survey, 1961.

No. 2. Records of selected wells and springs, selected drillers' logs of wells, and chemical analyses of ground and surface waters, northern Utah Valley, Utah County, Utah, by Seymour Subitsky, U.S. Geological Survey, 1962.

No. 3. Ground-water data, central Sevier Valley, parts of Sanpete, Sevier, and Piute Counties, Utah, by C. H. Carpenter and R. A. Young, U.S. Geological Survey, 1963.

*No. 4. Selected hydrologic data, Jordan Valley, Salt Lake County, Utah, by I. W. Marine and Don Price, U.S. Geological Survey, 1963.

*No. 5. Selected hydrologic data, Pavant Valley, Millard County, Utah, by R. W. Mower, U.S. Geological Survey, 1963.

*No. 6. Ground-water data, parts of Washington, Iron, Beaver, and Millard Counties, Utah, by G. W. Sandberg, U.S. Geological Survey, 1963.

No. 7. Selected hydrologic data, Tooele Valley, Tooele County, Utah, by J. S. Gates, U.S. Geological Survey, 1963.

No. 8. Selected hydrologic data, upper Sevier River basin, Utah, by C. H. Carpenter, G. B. Robinson, Jr., and L. J. Bjorklund, U.S. Geological Survey, 1964.

*No. 9. Ground-water data, Sevier Desert, Utah, by R. W. Mower and R. D. Feltis, U.S. Geological Survey, 1964.

No. 10. Quality of surface water in the Sevier Lake basin, Utah, by D. C. Hahl and R. E. Cabell, U.S. Geological Survey, 1965.

*No. 11. Hydrologic and climatologic data, collected through 1964, Salt Lake County, Utah, by W. V. Iorns, R. W. Mower, and C. A. Horr, U.S. Geological Survey, 1966.

No. 12. Hydrologic and climatologic data, 1965, Salt Lake County, Utah, by W. V. Iorns, R. W. Mower, and C. A. Horr, U.S. Geological Survey, 1966.

No. 13. Hydrologic and climatologic data, 1966, Salt Lake County, Utah, by A. G. Hely, R. W. Mower, and C. A. Horr, U.S. Geological Survey, 1967.

No. 14. Selected hydrologic data, San Pitch River drainage basin, Utah, by G. B. Robinson, Jr., U.S. Geological Survey, 1968.

No. 15. Hydrologic and climatologic data, 1967, Salt Lake County, Utah, by A. G. Hely, R. W. Mower, and C. A. Horr, U.S. Geological Survey, 1968.

No. 16. Selected hydrologic data, southern Utah and Goshen Valleys, Utah, by R. M. Cordova, U.S. Geological Survey, 1969.

No. 17. Hydrologic and climatologic data, 1968, Salt Lake County, Utah, by A. G. Hely, R. W. Mower, and C. A. Horr, U.S. Geological Survey, 1969.

No. 18. Quality of surface water in the Bear River basin, Utah, Wyoming, and Idaho, by K. M. Waddell, U.S. Geological Survey, 1970.

No. 19. Daily water-temperature records for Utah streams, 1944-68, by G. L. Whitaker, U. S. Geological Survey, 1970.

No. 20. Water-quality data for the Flaming Gorge area, Utah and Wyoming, by R. J. Madison, U.S. Geological Survey, 1970.

No. 21. Selected hydrologic data, Cache Valley, Utah and Idaho, by L. J. McGreevy and L. J. Bjorklund, U.S. Geological Survey, 1970.

No. 22. Periodic water- and air-temperature records for Utah streams, 1966-70, by G. L. Whitaker, U.S. Geological Survey, 1971.

No. 23. Selected hydrologic data, lower Bear River drainage basin, Box Elder County, Utah, by L. J. Bjorklund and L. J. McGreevy, U.S. Geological Survey, 1973.

No. 24. Water-quality data for the Flaming Gorge Reservoir area, Utah and Wyoming, 1969-72, by E. L. Bolke and K. M. Waddell, U.S. Geological Survey, 1972.

No. 25. Streamflow characteristics in northeastern Utah and adjacent areas, by F. K. Fields, U.S. Geological Survey, 1975.

No. 26. Selected hydrologic data, Uinta Basin area, Utah and Colorado, by J. W. Hood, J. C. Mundorff, and Don Price, U.S. Geological Survey, 1976.

No. 27. Chemical and physical data for the Flaming Gorge Reservoir area, Utah and Wyoming, by E. L. Bolke, U.S. Geological Survey, 1976.

INFORMATION BULLETINS

*No. 1. Plan of work for the Sevier River Basin (Sec. 6, P. L. 566), U.S. Department of Agriculture, 1960.

*No. 2. Water production from oil wells in Utah, by Jerry Tuttle, Utah State Engineer's Office, 1960.

*No. 3. Ground-water areas and well logs, central Sevier Valley, Utah, by R. A. Young, U.S. Geological Survey, 1960.

*No. 4. Ground-water investigations in Utah in 1960 and reports published by the U.S. Geological Survey or the Utah State Engineer prior to 1960, by H. D. Goode, U.S. Geological Survey, 1960.

*No. 5. Developing ground water in the central Sevier Valley, Utah, by R. A. Young and C. H. Carpenter, U.S. Geological Survey, 1961.

*No. 6. Work outline and report outline for Sevier River basin survey, (Sec. 6, P.L. 566), U.S. Department of Agriculture, 1961.

*No. 7. Relation of the deep and shallow artesian aquifers near Lynndyl, Utah, by R. W. Mower, U.S. Geological Survey, 1961.

*No. 8. Projected 1975 municipal water-use requirements, Davis County, Utah, by Utah State Engineer's Office, 1962.

No. 9. Projected 1975 municipal water-use requirements, Weber County, Utah, by Utah State Engineer's Office, 1962.

*No. 10. Effects on the shallow artesian aquifer of withdrawing water from the deep artesian aquifer near Sugarville, Millard County, Utah, by R. W. Mower, U.S. Geological Survey, 1963.

*No. 11. Amendments to plan of work and work outline for the Sevier River basin (Sec. 6, P.L. 566), U.S. Department of Agriculture, 1964.

*No. 12. Test drilling in the upper Sevier River drainage basin, Garfield and Piute Counties, Utah, by R. D. Feltis and G. B. Robinson, Jr., U.S. Geological Survey, 1963.

*No. 13. Water requirements of lower Jordan River, Utah, by Karl Harris, Irrigation Engineer, Agricultural Research Service, Phoenix, Arizona, prepared under informal cooperation approved by Mr. William W. Donnan, Chief, Southwest Branch (Riverside, California) Soil and Water Conservation Research Division, Agricultural Research Service, U.S.D.A., and by Wayne D. Criddle, State Engineer, State of Utah, Salt Lake City, Utah, 1964.

*No. 14. Consumptive use of water by native vegetation and irrigated crops in the Virgin River area of Utah, by Wayne D. Criddle, Jay M. Bagley, R. Keith Higginson, and David W. Hendricks, through cooperation of Utah Agricultural Experiment Station, Agricultural Research Service, Soil and Water Conservation Branch, Western Soil and Water Management Section, Utah Water and Power Board, and Utah State Engineer, Salt Lake City, Utah, 1964.

*No. 15. Ground-water conditions and related water-administration problems in Cedar City Valley, Iron County, Utah, February, 1966, by Jack A. Barnett and Francis T. Mayo, Utah State Engineer's Office.

*No. 16. Summary of water well drilling activities in Utah, 1960 through 1965, compiled by Utah State Engineer's Office, 1966.

*No. 17. Bibliography of U.S. Geological Survey water-resources reports for Utah, compiled by Olive A. Keller, U.S. Geological Survey, 1966.

*No. 18. The effect of pumping large-discharge wells on the ground-water reservoir in southern Utah Valley, Utah County, Utah, by R. M. Cordova and R. W. Mower, U.S. Geological Survey, 1967.

No. 19. Ground-water hydrology of southern Cache Valley, Utah, by L. P. Beer, 1967.

*No. 20. Fluvial sediment in Utah, 1905-65, A data compilation by J. C. Mundorff, U.S. Geological Survey, 1968.

*No. 21. Hydrogeology of the eastern portion of the south slopes of the Uinta Mountains, Utah, by L. G. Moore and D. A. Barker, U.S. Bureau of Reclamation, and James D. Maxwell and Bob L. Bridges, Soil Conservation Service, 1971.

*No. 22. Bibliography of U.S. Geological Survey water-resources reports for Utah, compiled by Barbara A. LaPray, U.S. Geological Survey, 1972.

No. 23. Bibliography of U.S. Geological Survey water-resources reports for Utah, compiled by Barbara A. LaPray, U.S. Geological Survey, 1975.