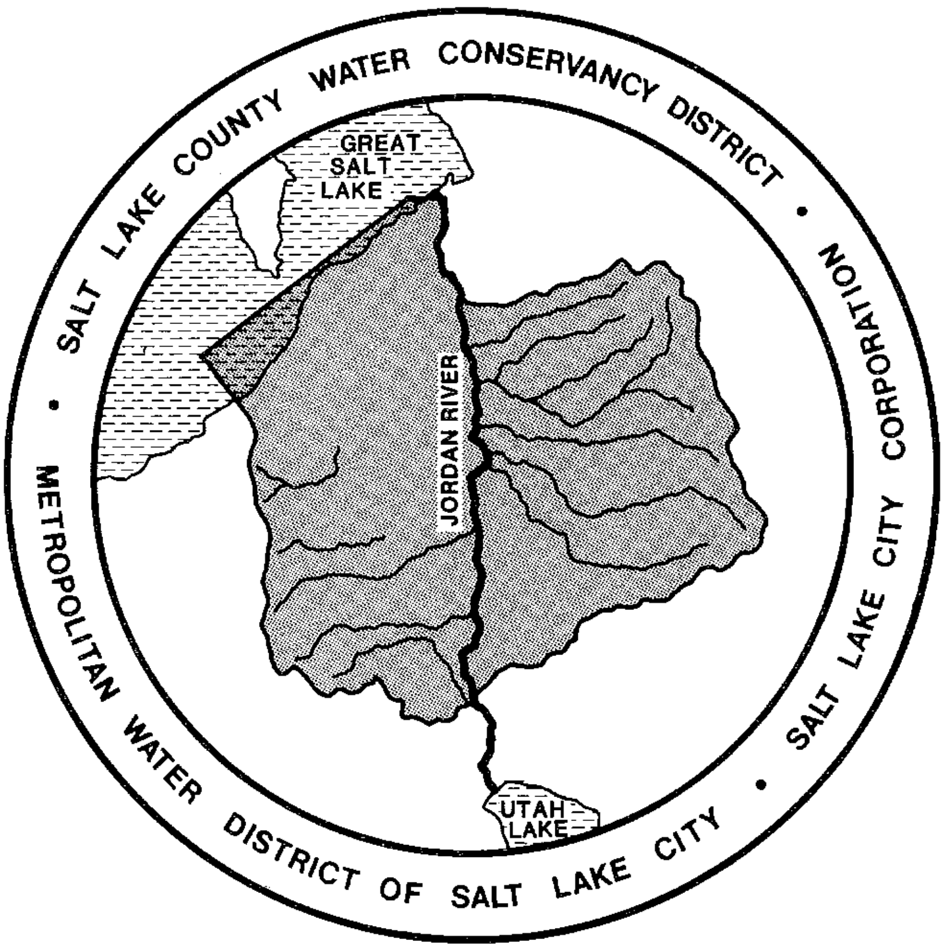
SALT LAKE COUNTY AREA-WIDE WATER STUDY



APRIL 1982

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UTAH DIVISION OF WATER RESOURCES

SALT LAKE COUNTY

AREA-WIDE WATER STUDY

METROPOLITAN WATER DISTRICT OF SALT LAKE CITY
SALT LAKE COUNTY WATER CONSERVANCY DISTRICT
SALT LAKE CITY CORPORATION

Prepared by

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Utah Division of Water Resources

April 1982

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PREFACE

The intent of this study was to identify, describe and determine the cost to develop, for culinary purposes, all surface water in Salt Lake County not presently used for this purpose. As such, the report is intended to be a surface water inventory for the county. All related topics discussed herein, such as population, water use, dual water system, conservation measures, import water, and ground water are addressed on a more cursory level, using only available data, and should not be considered a new source of information.

The study team attempted to compile into one comprehensive report all available data on each surface water source in the county. Information was obtained from available reports and personal interviews with several persons and most organizations associated with county water issues. In addition to the related topics mentioned above, and a general setting chapter, the report addresses each source individually by describing its physical features, existing water facilities, hydrologic characteristics and present water users. Costs were then developed for storage reservoirs where possible, new or expanded water treatment facilities on the larger sources, and collection and conveyance systems to other treatment facilities for the smaller sources.

The report does not prioritize or recommend development of any source nor does it address overall water management alternatives and water rights. To do so would have required analysis of each agency's system and to assume development of a source by a specific agency.

ACKNOWLEDGEMENTS

The successful conclusion of this study was made possible by the assistance, cooperation and suggestions provided by many agencies and individuals. We are grateful to all who gave so freely of their time to meet with us and to review the draft materials of this report. We are also grateful for the technical and staff support provided to us.

We are especially appreciative to Mr. Robert B. Hilbert, General Manager of the Salt Lake County Water Conservancy District; Mr Leroy W. Hooton Jr., Director of Salt Lake City Department of Public Utilities; Mr. Vaughn B. Wonnacott, General Manager of the Metropolitan Water District of Salt Lake City, for their continuous encouragement and direction during this project. Thanks is also given to Mr. Daniel F. Lawrence, Director of the Utah Division of Water Resources for his contribution to the project team and use of the Division's computer and word processor. Invaluable help was provided by Wendell E. Evensen, Dan Schenck, Gloria Bradshaw and Ed Higbee of Salt Lake City; Melvin G. Knapton and Dave Skoubye of the Metropolitan Water District of Salt Lake City and Matthew Marshall and Dave Ovard of the Salt Lake County Water Conservancy District. We are also grateful to the staffs of the three agencies for their assistance in preparing the report and especially to the staff of the Salt Lake County Water Conservancy District for their day to day support of the study team.

Assistance was provided by the U.S. Bureau of Reclamation in the form of computer time and programs for developing cost analysis, the U.S. Geological Survey in refining the method for flow projections from ungaged streams and the U.S. Army Corps of Engineers for information on dam siting and unit costs. For this help we are grateful.

Appreciation is also expressed to the members of the Advisory Panel who donated their time to provide direction to the study.

We are grateful to all those with whom we had interviews and for their subsequent review and critique of the report. Listed below are the agencies which participated in the study.

Bear Canyon water users
Bell Canyon Irrigation Company

Big Willow Creek Irrigation Company
Central Utah Water Conservancy District
City-County Health Department
Copperton Improvement District
Corner Canyon Irrigation Company
Draper Irrigation Company
East Jordan Canal Irrigation Company
Herriman Irrigation Company
Herriman Pipeline and Improvement Company
Holliday Water Company
Little Willow Irrigation Company
North Dry Creek Irrigation Company
North Jordan Irrigation Company
Riverton City
Rose Canyon Irrigation Company
Salt Lake County Department of Flood Control and Water Quality
Sandy City
South Jordan Canal Company
South Salt Lake
Spring Creek Irrigation Company
U.S. Army Corps of Engineers
U.S. Bureau of Reclamation
U.S. Geological Survey
Upper Canal Company
Utah State Department of Health
Utah State Engineer's Office
Utah State Prison

LIST OF ABBREVIATIONS

Abbreviation	Term
ac-ft	acre-feet
BOD	biochemical oxygen demand
cfs	cubic feet per second
CUP	Central Utah Project
cu. yd.	cubic yards
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
mgd or MGD	million gallons per day
mg/l	milligrams per liter
ml	milliliter
MPN	most probable number (coliform count)
psi	pounds per square inch
sq. mi.	square miles
TDS	total dissolved solids
USGS	U.S. Geological Survey
WTP	water treatment plant
WWTP	waste-water treatment plant

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CHAPTER I

INTRODUCTION

PURPOSE:

Water is undoubtedly one of the major resources of concern for the sustenance of life in Salt Lake County, Utah. The major, easily obtainable water sources in the county have been developed, and the remaining sources will require a detailed analysis to determine the availability, reliability, and cost for possible future development. In the 1960's, it was projected that the Central Utah Project (CUP) would make water available to the county by 1972. More recent projections now place receipt of water in 1990, beyond when new water supplies may be required. It is, therefore, evident that development of additional local supplies, which were originally considered as sources that could be developed by phases after the CUP capacity was reached, must now be considered.

OBJECTIVE AND SCOPE:

As the demand for high quality water increases with the increasing rate of urbanization in the valley, many concerns arise over the use of the ground and surface water supplies within the county. Will increased use of the ground water cause an overdraft? Will lower quality water west of the Jordan River or salt water intrusion from the Great Salt Lake contaminate the higher quality water east of the Jordan River with additional well development? What will happen to the artesian wells when additional ground water is developed, and should users of these artesian wells be compensated for loss of pressure? Since any surplus water from the mountain streams generally occurs during the winter and spring months, will development of these sources by constructing dams or reserving areas for artificial recharge be economically or environmentally sound? Will the capturing of the surface streams, treating them for municipal use and then discharging the majority of the water through waste-water treatment plants directly into the Jordan River greatly affect the recharge that has historically occurred from irrigation? What, if anything, should be done with the increasing amounts of water from the waste-water treatment plants? What should happen to the irrigation water rights as the irrigated land is urbanized? Will imported water from other river basins provide the additional water needs of Salt Lake County within the time frame required and within reasonable economic and environmental costs? As can be seen, supplying the growing Salt Lake County area with an adequate water supply has, is, and will be a complex and challenging undertaking.

It was not anticipated that this study would answer all of the above questions or concerns. However, the study should answer some questions, provide some basic data and information for answering some additional questions, and provide a general understanding of the supply, use, and issues concerning surface water resources in Salt Lake County.

The objectives of this study were (1) to identify all existing surface water sources within and imported into Salt Lake County, (2) to analyze these sources to determine the surplus waters now discharging to the Great Salt Lake, and (3) to estimate costs for development of all surplus sources irrespective of which agency may later develop the source.

The detailed scope of work is included in Appendix A. In general, the scope called for a source by source determination to be made of a dependable water yield, water quality, existing water treatment and supply facilities, existing water uses, excess water and costs of developing the excess water through treatment with and without storage. For the canyon streams, frequency analyses of flows were to be made using flow records, where available, and estimating flows by correlation with gaged streams where records were not available. Existing uses, where attainable, were then to be deducted from the total flows, leaving surpluses at various frequencies of occurrence.

The final determination of a reliable canyon yield is dependent on which agency develops the source and their willingness to accept a given frequency of occurrence. The costs of various storage and treatment alternatives of surplus canyon flows in this report are in the form of curves covering the range of possible sizes for each source. An attempt was made to trace surplus canyon and Utah Lake flows through the valley canal and stream network for the purpose of determining withdrawals and additions. However, actual water use records within the valley were not available. Therefore, surplus flows as outlined in the scope of work could not be determined.

The scope does not deal with water rights, nor does it include any analysis of the ground water. The U.S. Geological Survey is currently conducting a study for the water supply agencies of Salt Lake County and the Utah Division of Water Rights which will determine the quantity and quality of ground water and the effect of withdrawal. Water rights and exchange agreements, however, have been identified, where well established.

AGENCIES AGREEMENT:

Recognizing the advantages of having a comprehensive water supply inventory in Salt Lake County, the Salt Lake City Corporation, the Metropolitan Water District of Salt Lake City and the Salt Lake County Water Conservancy District entered into an agreement to equally share in the expenses of a Salt Lake County Area-Wide Water Study. The agencies contacted several consulting engineering firms for an expression of interest in the study. Four firms were selected to conduct the study. The contracts are included in Appendix A. The State of Utah, Division of Water Resources also expressed an interest in participating.

PROJECT TEAM:

The consultant portion of the project team consisted of four full-time engineers and a technical overview by principals of each firm. Additional expertise on a part-time basis was made available from the four firms as required. The Division of Water Resources furnished a full-time engineer and made available their computer and computer programs for hydrologic analyses. Salt Lake City's hydrologic personnel assisted on a part-time basis. General typing and drafting were shared by personnel from the three sponsoring agencies and the Division of Water Resources. A public advisory panel and a technical panel were established for added guidance and input. The following chart shows the organization for the study.

SALT LAKE COUNTY AREA-WIDE WATER STUDY ORGANIZATION CHART

MANAGEMENT AND FUNDING AGENCIES

METROPOLITAN WATER DISTRICT OF SALT LAKE CITY
(Vaughn Wonnacott)

SALT LAKE COUNTY WATER CONSERVANCY DISTRICT
(Robert Hilbert)

SALT LAKE CITY CORPORATION
(Leroy Hooten, Jr.)

ADVISORY PANEL

COG
(James Davis)

CITY COUNCIL
(Leigh von der Esch)

STATE NATURAL RESOURCES
(Dee Hansen)

REPRESENTATIVE FROM LEAGUE OF WOMEN VOTERS
(Grace G. Brandt)

ENVIRONMENTALLY SENSITIVE CITIZEN
(Lee Kapaloski)

HOME BUILDERS ASSOCIATION
(Cy Simon)

TWO EX OFFICIO MEMBERS
(William C. Hague and Charles W. Wilson)

CITY/COUNTY HEALTH DEPARTMENT
(Kent Miner)

CITIZEN AT LARGE
(Maurice Barnes)

TEAM LEADER

CORDELL (John) JOHNSON
(Horrocks/Carollo)

ENGINEERING TEAM

LEONARD ALLEN
(James M. Montgomery)

RICHARD BAY
(Eckhoff, Watson & Preator)

C. EUGENE BIGLER
(Division of Water Resources)

TIMOTHY PAINE
(Coon, King & Knowlton)

NORMAN STAUFFER, JR.
(Division of Water Resources)

STAFF SUPPORT

MANAGEMENT AGENCIES

TECHNICAL PANEL

COON, KING & KNOWLTON
(Charles King)

ECKHOFF, WATSON & PREATOR
(Rodney Preator)

HORROCKS/CAROLLO
David Griffith)

JAMES M. MONTGOMERY
(Alvin Anderson)

CHAPTER II

EXECUTIVE SUMMARY

SETTING:

The study area is confined basically to Salt Lake County although some consideration and discussion is given to adjacent drainages and facilities that are related to the water supply to the County. Salt Lake County covers an area of 764 square miles of which about 65 percent is valley and the remaining is mountainous terrain.

There are twelve incorporated cities in Salt Lake County which cover an area approximately equal to the unincorporated residential areas. The majority of residential expansion is occurring on irrigated agricultural land. Over 42 percent of the State's population reside in Salt Lake County.

The Wasatch Range on the east side of Salt Lake County rises to elevations over 11,000 feet; the Oquirrh Mountains on the west rise to over 9500 feet; and the Traverse Mountains on the south rise to about 6500 feet. The valley floor consists of a series of benches dropping in elevation from the mountains to the Jordan River. The valley soils consist of gravel, sand, silt, and clay to a depth of at least 2000 feet.

Salt Lake County experiences four distinct seasons with a major portion of the precipitation occurring during the winter months. Normal annual precipitation ranges from 12 to 16 inches on the valley floor to 60 inches in the high mountain areas of the Wasatch Range. Precipitation from winter storms over the Wasatch Range falls as snow which results in high runoff during the spring snowmelt period. The Oquirrh Mountains and the valley receive relatively little snow. A portion of the precipitation on both mountain ranges is absorbed into the soil and underlying bedrock during the runoff periods, resulting in recharge of the valley ground water.

Temperatures in the valley have ranged from -30^{o}F in the winter to over 100^{o}F in the summer. The mean annual temperature is approximately 50^{o}F. Evaporation in the valley for fresh water is approximately 50 inches per year. The highest monthly evaporation rate occurs in July and is approximately nine inches. The normal frost-free season for the valley area is approximately 165 days from the first of May to mid-October.

There are seven major and thirteen smaller streams with significant flows which originate in the Wasatch Range on the east side of the valley. These furnish more than 97 percent of the surface water supply originating in the Salt Lake Valley drainage. There are six streams which originate in the Oquirrh Mountains on the west side of the valley; these supply less than 3 percent of the surface water.

Water is diverted from the Weber River and from the North Fork of the Duchesne River into the Provo River where it is stored in Deer Creek Reservoir. From there it is imported to Salt Lake County via the Salt Lake Aqueduct and Provo Reservoir Canal.

Utah Lake, which lies just south of Salt Lake County, is utilized as a reservoir. It has a capacity of 830,000 acre-feet and is some 300 feet higher than the Great Salt Lake. The outflow from Utah Lake is the Jordan River. The Jordan River flows north through Salt Lake County into the Great Salt Lake, acting as the drain for the County.

Ground water occurs in surface soils throughout Salt Lake County. However, the major source of water from wells is in the valley fill. Ground water is recharged primarily from precipitation and snowmelt on the mountain watersheds. This water moves downward and laterally through open- ings in the bedrock into the valley fill. The quality of ground water east of the Jordan River is generally very good whereas ground water west of the river is generally of poorer quality.

Irrigation in the valley began in 1847 with diversions from mountain streams onto the land. Utah Lake water was brought into the valley by canals in the 1880's. Since Utah Lake water was not potable, many exchange agreements were made to substitute Utah Lake water for irrigation use so that high quality mountain streams could be used for a municipal and industrial purposes.

POPULATION:

The population in Salt Lake County has increased about 62 percent in the past 20 years and is expected to increase another 52 percent by the turn of the century. Historical and projected populations are shown in Table II-1.

TABLE II-1

HISTORICAL AND PROJECTED POPULATIONS
FOR SALT LAKE COUNTY

Year	Population	MUNICIPAL AF
1960	383,035	103,800
1970	458,607	124,300
1980	619,066	167,700
1990	780,000	211,300
2000	950,000	257,300
2010	1,121,000	303,700

WATER USE:

The 1962-75 period is considered representative of past use trends. During that period the average annual municipal withdrawal for Salt Lake County was 124,900 acre-feet and the total municipal withdrawal increased about 4500 acre-feet annually. The average withdrawal for agricultural irrigation for the same period was 299,200 acre-feet with a slight decrease of about 2500 acre-feet per year. Industrial withdrawals for this period averaged 144,300 acre-feet with a slowly increasing diversion rate of about 1000 acre-feet per year. Domestic and stock withdrawals averaged 33,700 acre-feet for this period. Total withdrawal for the 1962-75 period in Salt Lake County averaged 608,400 acre-feet. The 1962-75 average municipal withdrawal for Salt Lake County was 242 gallons per capita per day (gpcd), ranging from 204 gpcd in 1965 to 285 gpcd in 1974.

It was assumed that the 1962-75 withdrawal trends will continue for some time into the future, and that the municipal per capita use will con- tinue at the 1962-75 average of 242 gpcd. This means that the projected total municipal withdrawal for Salt Lake County will be 257,500 acre-feet by the year 2000. This is an increase in municipal withdrawals of over 50 percent in 20 years. In the year 2000, municipal withdrawals will surpass withdrawals for irrigated agriculture and will exceed estimated municipal supplies by 72,500 acre-feet. Projected water withdrawals for Salt Lake county are shown in Table II-2.

TABLE II-2

PROJECTED WATER WITHDRAWALS FOR
SALT LAKE COUNTY
(Ac-Ft)

Year	Municipal	Irrigation	Industrial	Domestic & Stock	Total
1980*	167,700	294,900	161,500	33,600	657,700
1990	211,400	269,900	171,500	31,600	684,400
2000	257,500	244,900	181,500	29,600	713,500
2010	303,800	219,900	191,500	27,600	742,800

* Base Year

EXISTING WATER RESOURCES:

Information and discussions on existing water resources are included under the following categories: Mountain Streams, Waste Water, Imported Water, Jordan River, Great Salt Lake, and Ground Water. No total summary or water budget is given.

MOUNTAIN STREAMS: On the east side of the valley, the major drainage areas which were analyzed include City Creek, Red Butte, Emigration, Parleys, Mill Creek, Big Cottonwood, and Little Cottonwood Canyons. The minor drainage areas which were analyzed include Neffs, Tolcats, Heughs, Ferguson, Deaf Smith, Bells, Middle Fork Dry Creek, South Fork Dry Creek, Rocky Mouth, Big Willow, Little Willow, Bear, and Corner Canyons. On the west side of the valley, the drainages that were analyzed include Rose, Butterfield, Bingham, Barneys, Harkers, and Coon Canyons. The physical characteristics, existing facilities, hydrologic characteristics, and water users are summarized for each canyon in Table II-3.

Because the Wasatch Range is generally much higher than the Oquirrh Mountains on the west, and are also on the windward side of major storms, the Wasatch watersheds receive more precipitation than the Oquirrh watersheds. Therefore, the majority of the surface flow into the valley originates from the Wasatch Range on the east side of the valley.

TABLE II-3

CANYON CHARACTERISTICS AND FACILITIES SUMMARY FOR SALT LAKE COUNTY

Canyon	Physical Characteristics: Stream Outlet	Fish or Stream Type	Vegetation	Wildlife	Geology	Land Use	Canyon Area (sq. mi.)	Precip. (inches)	Elev. (feet)	Existing Facilities	Hydrologic Characteristics: Ave. Peak Day	Ave. Annual Yield (Ac-Ft)	Flow Records	Water Users
City Creek	North Temple storm drain to Jordan River	Brown Trout small population	juniper, oak, maple, grasses, fir, birch, dogwood chokecherry, cottonwood	deer, porcupine, skunk, squirrel, chipmunks, small birds	limestone	picknicking, hunting, fishing, watershed	19.2	25-40	5000-9400	15 mgd WTP and two pipelines	5/21	11,749	1899-1980 continuous	S.L. City for culinary
Red Butte	ditch to 1300 So. storm drain to Jordan River	Brook & Cutthroat Trout, substantial population	scrub oak, birch, dogwood, grasses	deer porcupine, skunk, squirrel, chipmunk, rabbit, upland game & non-game birds	sandstone & shale	Research Natural Area, limited access	7.25	20-25	5000-8200	Red Butte Reservoir, pipeline, and small pond	4/30	2,450	1942-1980 continuous	Fort Douglas for lawns, and culinary
Emigration	Salt Lake City storm drain system, 1300 So. to Jordan River	some trout are stocked	oak, maple, scrub oak, box elder, cottonwood mustard, grasses	scarce or displaced	sandstone, shale, limestone	heavy residential, some recreation	18.0	20-25	5000-8900	spring from tunnel, pipeline	5/1	4,439	1901-1980 continuous	State of Utah for Pioneer Park, SLC for culinary (spring only), Mt. Olivet for cemetery sprinkler, SLC for Liberty Park Pond
Parleys	detension basin to SLC storm drain system & [illegible]	moderate trout population above Mt. Dell Res.	conifer, aspen scrub oak, birch, willow, grasses, hawthorne	deer, porcupine, rabbit, small mammals & birds	limestone, sandstone, shale	intensive recreation and transportation, watershed	50.1	20-25	4700-9400	I-80, Mt. Dell Res., 40 mgd WTP, 30" pipeline	5/12	18,131	1899-1980 continuous	SLC for culinary, and Country Club Golf Course
Corner	Corner Canyon Irr. Company Canal	perennial	grasses, shrubs, oak brush, bitterbrush	typical	volcanic plutonic quartzite	watershed, some hunting and hiking	3.5	20-25	4800-9000	diversion structure	mid May	1520	several instantaneous 1964-68	Corner Canyon Irr. Company for irrigation & stock
Rose	Utah Lake Distributing Canal and Jordan River	perennial	grasses, shrubs, bitterbrush, sage brush	deer, rabbit, squirrels, upland game birds, various small and mammals	volcanic plutonic, alluvial deposits	watershed, wildlife habitat, military reservation	10.6	10-20	5400-6900	8" pipeline, 2 concrete diversions, 110,000 gal. res., 15,000 gal. res.	late April early May	544	1964-68 infrequent instantaneous	Herriman Pipeline Co for culinary, Rose Creek Irr. Co. for irrigation & stock
Butterfield	canals, concrete ditch Jordan River	perennial,	big sage, bitterbrush, oak brush, maple, grasses	typical	quartzite, volcanic plutonic, alluvial deposits	watershed & wildlife habitat	9.6	25-30	5500-8200	many mine tunnels, concrete ditch near mouth, 100,000 gal. res. 25,000 gal. res.	4/20-5/10	809	1964-68 infrequent instantaneous	Herriman Irr. Co. for irrigation & stock; domestic for thirteen families
Bingham	natural channel to Jordan River	perennial at mouth	spruce, fir, shrubs, grasses	very limited	quartzite, volcanic plutonic, alluvial deposits	industrial, Copperton Town	18.0	25-30	5500-9000	open pit mine, many tanks, pond near mouth, mine shafts	third week of May	1524	1964 several instantaneous	Kennecott Corp. for industrial and culinary, individuals for livestock
Barneys	Utah Lake Distributing Canal	ephemeral	typical shrubs, grasses	deer, small mammals, small birds, upland game birds	quartzite, alluvial deposits	watershed & wildlife habitat, minor recreation	4.0	12-20	5300-8000	9100 gal. tank, 8" pipeline, two wells	unknown	333	single measurement 4/3/64	Kennecott Corp. for industrial and culinary, various individuals for livestock
'arkers	Coon Creek	ephemeral	typical shrubs, grasses	upland game, deer, porcupine, squirrels, various small rodents, mammals & birds	quartzite, alluvial deposits	watershed & wildlife habitat	6.5	12-20	5000-9300	none	unknown	464	single measurement 5/29/64	Kennecott Corp. for stock, Howard Haynes for stock & culinary (2 families)
Coon	lake bed terrace, gravel pit, Utah & Salt Lake Canal	ephemeral	oak brush, sage brush, bitterbrush, maple, grasses	deer, porcupine, rabbits, various squirrels and chipmunks, upland game & small birds	primarily quartzite, alluvial deposits	watershed & wildlife habitat	8.6	12-20	5000-8800	numerous springs, diversion	unknown	787	single measurement 5/6/64	Kennecott Corp. for stock & irrigation, Warner for irr. stock, culinary (1 family)

TABLE II-3
CANYON CHARACTERISTICS AND FACILITIES SUMMARY FOR SALT LAKE COUNTY

Canyon	Physical Characteristics: Stream Outlet	Fish or Stream Type	Vegetation	Wildlife	Geology	Land Use	Canyon Area (sq. mi.)	Precip. (inches)	Elev. (feet)	Existing Facilities	Hydrologic Characteristics: Ave. Peak Day	Ave. Annual Yield (Ac-Ft)	Flow Records	Water Users
City Creek	North Temple storm drain to Jordan River	Brown Trout small population	juniper, oak, maple, grasses, fir, birch, dogwood chokecherry, cottonwood	deer, porcupine, skunk, squirrel, chipmunks, small birds	limestone	picknicking, hunting, fishing, watershed	19.2	25-40	5000-9400	15 mgd WTP and two pipelines	5/21	11,749	1899-1980 continuous	S.L. City for culinary
Red Butte	ditch to 1300 So. storm drain to Jordan River	Brook & Cutthroat Trout, substantial population	scrub oak, birch, dogwood, grasses	deer porcupine, skunk, squirrel, chipmunk, rabbit, upland game & non-game birds	sandstone & shale	Research Natural Area, limited access	7.25	20-25	5000-8200	Red Butte Reservoir, pipeline, and small pond	4/30	2,450	1942-1980 continuous	Fort Douglas for lawns, and culinary
Emigration	Salt Lake City storm drain system, 1300 So. to Jordan River	some trout are stocked	oak, maple, scrub oak, box elder, cottonwood mustard, grasses	scarce or displaced	sandstone, shale, limestone	heavy residential, some recreation	18.0	20-25	5000-8900	spring from tunnel, pipeline	5/1	4,439	1901-1980 continuous	State of Utah for Pioneer Park, SLC for culinary (spring only), Mt. Olivet for cemetery sprinkler, SLC for Liberty Park Pond
Parleys	detension basin to SLC storm drain system &	moderate trout population above Mt. Dell Res.	conifer, aspen scrub oak, birch, willow, grasses, hawthorne	deer, porcupine, rabbit, small mammals & birds	limestone, sandstone, shale	intensive recreation and transportation, watershed	50.1	20-25	4700-9400	I-80, Mt. Dell Res., 40 mgd WTP, 30" pipeline	5/12	18,131	1899-1980 continuous	SLC for culinary, and Country Club Golf Course
Corner	Corner Canyon Irr. Company Canal	perennial	grasses, shrubs, oak brush, bitterbrush	typical	volcanic plutonic quartzite	watershed, some hunting and hiking	3.5	20-25	4800-9000	diversion structure	mid May	1520	several instantaneous 1964-68	Corner Canyon Irr. Company for irrigation & stock
Rose	Utah Lake Distributing Canal and Jordan River	perennial	grasses, shrubs, bitterbrush, sage brush	deer, rabbit, squirrels, upland game birds, various small and mammals	volcanic plutonic, alluvial deposits	watershed, wildlife habitat, military reservation	10.6	10-20	5400-6900	6" pipeline, 2 concrete diversions, 110,000 gal. res., 15,000 gal. res.	late April early May	544	1964-68 infrequent instantaneous	Herriman Pipeline Co for culinary, Rose Creek Irr. Co. for irrigation & stock
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Bingham	natural channel to Jordan River	perennial at mouth	spruce, fir, shrubs, grasses	very limited	quartzite, volcanic plutonic, alluvial deposits	industrial, Copperton Town	18.0	25-30	5500-9000	open pit mine, many tanks, pond near mouth, mine shafts	third week of May	1524	1964 several instantaneous	Kennecott Corp. for industrial and culinary, individuals for livestock
Barneys	Utah Lake Distributing Canal	ephemeral	typical shrubs, grasses	deer, small mammals, small birds, upland game birds	quartzite, alluvial deposits	watershed & wildlife habitat, minor recreation	4.0	12-20	5300-8000	9100 gal. tank, 8" pipeline, two wells	unknown	333	single measurement 4/3/64	Kennecott Corp. for industrial and culinary, various individuals for livestock
Parkers	Coon Creek	ephemeral	typical shrubs, grasses	upland game, deer, porcupine, squirrels, various small rodents, mammals & birds	quartzite, alluvial deposits	watershed & wildlife habitat	6.6	12-20	5000-9300	none	unknown	464	single measurement 5/29/64	Kennecott Corp. for stock, Howard Haynes for stock & culinary (2 families)
Coon	lake bed terrace, gravel pit, Utah & Salt Lake Canal	ephemeral	oak brush, sage brush, bitterbrush, maple, grasses	deer, porcupine, rabbits, various squirrels and chipmunks, upland game & small birds	primarily quartzite, alluvial deposits	watershed & wildlife habitat	8.6	12-20	5000-8800	numerous springs, diversion	unknown	787	single measurement 5/6/64	Kennecott Corp. for stock & irrigation, Warner for irr. stock, culinary (1 family)

TABLE II-3
CANYON CHARACTERISTICS AND FACILITIES SUMMARY FOR SALT LAKE COUNTY

Canyon	Physical Characteristics										Hydrologic Characteristics			
	Stream Outlet	Fish or Stream Type	Vegetation	Wildlife	Geology	Land Use	Canyon Area (sq. mi.)	Precip. (inches)	Elev. (feet)	Existing Facilities	Ave. Peak Day	Ave. Annual Yield (Ac-Ft)	Flow Records	Water Users
City Creek	North Temple storm drain to Jordan River	Brown Trout small population	juniper, oak, maple, grasses, fir, birch, dogwood chokecherry, cottonwood	deer, porcupine, skunk, squirrel, chipmunks, small birds	limestone	picknicking, hunting, fishing, watershed	19.2	25-40	5000-9400	15 mgd WTP and two pipelines	5/21	11,749	1899-1980 continuous	S.L. City for culinary
Red Butte	ditch to 1300 So. storm drain to Jordan River	Brook & Cutthroat Trout, substantial population	scrub oak, birch, dogwood, grasses	deer porcupine, skunk, squirrel, chipmunk, rabbit, upland game & non-game birds	sandstone & shale	Research Natural Area, limited access	7.25	20-25	5000-8200	Red Butte Reservoir, pipeline, and small pond	4/30	2,450	1942-1980 continuous	Fort Douglas for lawns, and culinary
Emigration	Salt Lake City storm drain system, 1300 So. to Jordan River	some trout are stocked	oak, maple, scrub oak, box elder, cottonwood mustard, grasses	scarce or displaced	sandstone, shale, limestone	heavy residential, some recreation	18.0	20-25	5000-8900	spring from tunnel, pipeline	5/1	4,439	1901-1980 continuous	State of Utah for Pioneer Park, SLC for culinary (spring only), Mt. Olivet for cemetery sprinkler, SLC for Liberty Park Pond
Parleys	detension basin to SLC storm drain system & to Jordan River	moderate trout population above Mt. Dell Res.	conifer, aspen scrub oak, birch, willow, grasses, hawthorne	deer, porcupine, rabbit, small mammals & birds	limestone, sandstone, shale	intensive recreation and transportation, watershed	50.1	20-25	4700-9400	I-80, Mt. Dell Res., 40 mgd WTP, 30" pipeline	5/12	18,131	1899-1980 continuous	SLC for culinary, and Country Club Golf Course
Corner	Corner Canyon Irr. Company Canal	perennial	grasses, shrubs, oak brush, bitterbrush	typical	volcanic plutonic quartzite	watershed, some hunting and hiking	3.5	20-25	4800-9000	diversion structure	mid May	1520	several instantaneous 1964-68	Corner Canyon Irr. Company for irrigation & stock
Rose	Utah Lake Distributing Canal and Jordan River	perennial	grasses, shrubs, bitterbrush, sage brush	deer, rabbit, squirrels, upland game birds, various small and mammals	volcanic plutonic, alluvial deposits	watershed, wildlife habitat, military reservation	10.6	10-20	5400-6900	6" pipeline, 2 concrete diversions, 110,000 gal. res., 15,000 gal. res.	late April early May	544	1964-68 infrequent instantaneous	Herriman Pipeline Co for culinary, Rose Creek Irr. Co. for irrigation & stock
Butterfield	canals, concrete ditch Jordan River	perennial,	big sage, bitterbrush, oak brush, maple, grasses	typical	quartzite, volcanic plutonic, alluvial deposits	watershed & wildlife habitat	9.6	25-30	5500-8200	many mine tunnels, concrete ditch near mouth, 100,000 gal. res. 25,000 gal. res.	4/20-5/10	809	1964-68 infrequent instantaneous	Herriman Irr. Co. for irrigation & stock; domestic for thirteen families
Bingham	natural channel to Jordan River	perennial at mouth	spruce, fir, shrubs, grasses	very limited	quartzite, volcanic plutonic, alluvial deposits	industrial, Copperton Town	18.0	25-30	5500-9000	open pit mine, many tanks, pond near mouth, mine shafts	third week of May	1524	1964 several instantaneous	Kennecott Corp. for industrial and culinary, individuals for livestock
Barneys	Utah Lake Distributing Canal	ephemeral	typical shrubs, grasses	deer, small mammals, small birds, upland game birds	quartzite, alluvial deposits	watershed & wildlife habitat, minor recreation	4.0	12-20	5300-8000	9100 gal. tank, 8" pipeline, two wells	unknown	333	single measurement 4/3/64	Kennecott Corp. for industrial and culinary, various individuals for livestock
Parkers	Coon Creek	ephemeral	typical shrubs, grasses	upland game, deer, porcupine, squirrels, various small rodents, mammals & birds	quartzite, alluvial deposits	watershed & wildlife habitat	6.5	12-20	5000-9300	none	unknown	464	single measurement 5/29/64	Kennecott Corp. for stock, Howard Haynes for stock & culinary (2 families)
Coon	lake bed terrace, gravel pit, Utah & Salt Lake Canal	ephemeral	oak brush, sage brush, bitterbrush, maple, grasses	deer, porcupine, rabbits, various squirrels and chipmunks, upland game & small birds	primarily quartzite, alluvial deposits	watershed & wildlife habitat	8.6	12-20	5000-8800	numerous springs, diversion	unknown	787	single measurement 5/6/64	Kennecott Corp. for stock & irrigation, Warner for irr. stock, culinary (1 family)

Physical factors such as watershed elevations, steepness of canyon slopes, main channel orientation, vegetation, and geology cause canyon streams to reach their peak flows at different times under the same climatic conditions. Flows at the canyon mouths increase during early spring and generally peak during May, start to recede during June and July, and reach a low stage during August and September. The average peak days are listed in Table II-3.

There are eight streams with continuous gaged records. City, Emigration, Parleys, Mill, Big Cottonwood, and Little Cottonwood Creeks have been gaged continuously since the late 1800's and early 1900's. Red Butte stream flow records span 41 years and with the other six streams were analyzed for frequency determinations by conventional methods. Bells Canyon Creek has only 10 years of partial records and was not considered for conventional frequency analysis.

The remainder of the mountain streams are ungaged with very limited random measurements available. Flows were estimated for these streams by the "area-altitude" method. This method compares the amounts of area in prescribed bands of elevation within an ungaged watershed to the areas within the same elevation bands of a gaged watershed. Average annual precipitation is then correlated to the elevation bands. Using these two variables, the average flow from the gaged watershed is correlated to the ungaged watershed to produce an estimated annual 50 percent flow. This value was then extrapolated to 80 percent and 90 percent flows as well as monthly flows, based on the pattern of the gaged watershed.

Because of similarities, Corner Canyon Creek was compared to Fort Creek which is directly south and adjacent to Corner Canyon in Utah County. All other ungaged watersheds on the east side of the valley were compared to Little Cottonwood Canyon. The ungaged streams of the Oquirrh Mountains were compared to West Canyon Creek in Cedar Valley.

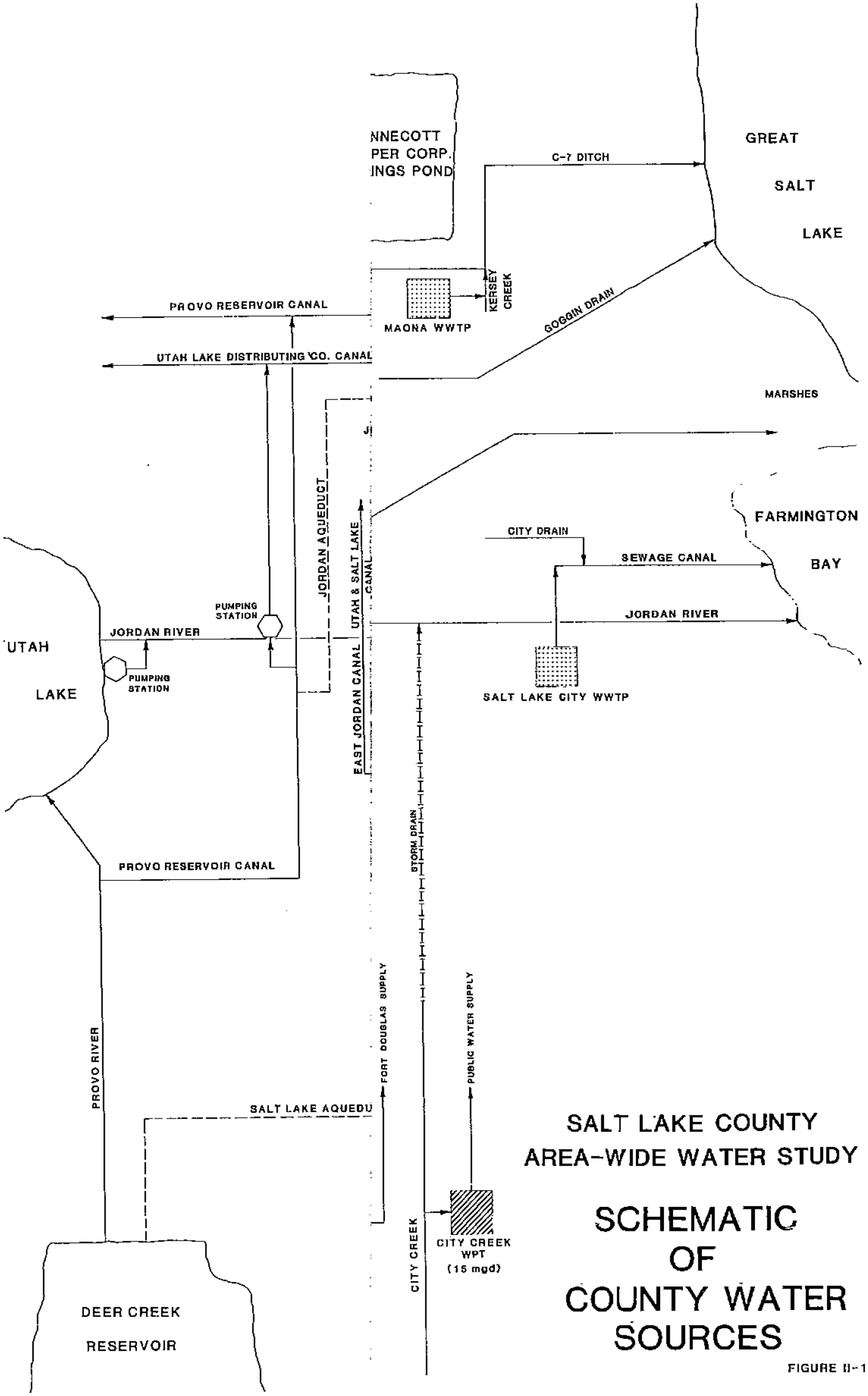
WASTE WATER: Currently, an estimated 90 mgd of water is flowing into sanitary sewer systems in Salt Lake County. This volume is expected to increase to 122 mgd by the year 2000. Waste water is being treated by nine municipal waste-water treatment plants. Seven of these discharge into the Jordan River, one into the Sewage Canal, and one into Kersey Creek.

IMPORTED WATER: Imports into Salt Lake County are from Deer Creek Reservoir on the Provo River, the Provo River downstream from the reservoir, and from springs in Tooele Valley. Deer Creek Reservoir has a usable capacity of 149,700 acre-feet and was designed to provide 100,000 acre-feet annually, of which the Metropolitan Water District of Salt Lake City is entitled to 61,700 acre-feet in a normal year. The Salt Lake Aqueduct has a capacity of 120 mgd and delivers water from Deer Creek Reservoir to the Metropolitan Treatment Plant near Little Cottonwood Canyon. The Provo Reservoir Canal also conveys Deer Creek water from the mouth of the Provo River to the Jordan Aqueduct (270 cfs capacity), which in turn supplies water to the Jordan Water Purification Plant.

Salt Lake City has preferential right to the treated water from the Metropolitan Treatment Plant but Salt Lake County Water Conservancy District is also able to purchase treated water. The treated water from the Jordan Water Purification Plant is purchased by the Salt Lake County Water Conservancy District from the Central Utah Water Conservancy District. The average annual flow of about 10,700 acre-feet from three groups of springs in Tooele County is delivered by pipeline to the Garfield/Magna area. Kennecott Copper Corporation owns and operates the pipeline from the Tooele County Springs and uses the water in smelter and concentrator operations.

JORDAN RIVER: Jordan River begins at the outlet of Utah Lake and flows north through Salt Lake County. Utah Lake was developed into a storage reservoir in 1872 and has a capacity of about 830,000 acre-feet. The annual outflow from Utah Lake is about 280,000 acre-feet. At certain times of the year the Jordan River is completely dewatered below the Jordan Narrows.

Several canals divert from the river at various points. Ten tributaries join the river as it flows through the valley. Several waste-water treatment plants also add flow to the Jordan River. At 2100 South, the Surplus Canal, with a capacity at 3300 cfs, diverts the bulk of the Jordan River flow. It was built in 1885 and enlarged in 1960 with the purpose of providing a direct route to the Great Salt Lake for Jordan River flood flows. The canals and tributaries are shown schematically in Figure II-1.



SALT LAKE COUNTY
AREA-WIDE WATER STUDY

SCHEMATIC
OF
COUNTY WATER
SOURCES

FIGURE II-1

Several gaging stations are maintained at various points on the Jordan River as well as on the Surplus Canal and other streams. Some stream flow records are continuous from as far back as 1904.

The Jordan River conveys most of the irrigation water for Salt Lake County from Utah Lake storage. Water is also delivered from the Jordan River via canals to Kennecott Copper Corporation's Magna mill and tailings ponds. Jordan River water is also used to exchange for higher quality water from other tributary streams. On the lower Jordan River the water is used for waterfowl management.

GREAT SALT LAKE: The present elevation of the Great Salt Lake is approximately 4200 feet. Since 1851, the lake has varied from a high of 4211.5 feet in 1873 to a low of 4191.6 feet in 1963. The lake is about 70 miles long and 40 miles wide with a surface area of 1500 square miles, an average depth of 13 feet, and a maximum depth of 35 feet. The volume of the lake at the present level is approximately 14.6 million acre-feet. Average annual surface inflow is 2.1 million acre-feet which is received from the Bear, Weber, and Jordan River Basins. The salinity in the north arm of the lake is fairly uniform at approximately 340,000 mg/l. The salinity of the top 20 feet in the south arm ranges between 100,000 to 250,000 mg/l. The lower layer of the south arm ranges between 250,000 to 340,000 mg/l. This high salinity prohibits direct desalting for reuse. The lake and surrounding shore area supports many types of wildlife, recreation, and mineral extraction.

GROUND WATER: The Salt Lake Valley's unconsolidated subsurface acts as a large reservoir which spills naturally through springs, into the Jordan River, and directly into Great Salt Lake. Ground water occurs throughout Salt Lake County. There were 11,823 wells in the valley registered with the Utah Division of Water Rights in 1969. Most wells are east of the Jordan River where the water quality is generally the highest. Many wells near the Jordan River and in the western and northern part of the valley do not produce water which is acceptable for culinary use. Water levels of the confined aquifer have declined in areas of relatively large withdrawals from wells.

There are many questions surrounding the potential use of the ground water in the Salt Lake Valley. The USGS, on behalf of the water supply agencies of Salt Lake County and the Utah Division of Water Rights, has begun a four-year study to answer some of these questions. Study objectives are: (1) determine the current status of the ground-water system including quality of water and recharge capability, (2) design and construct digital-computer models of ground-water reservoir, and (3) establish the potential of land subsidence as related to water-level declines.

DEVELOPABLE WATER:

Alternatives which were considered for developing the water sources previously described are summarized. Projects suggested by previous studies are included as well as those developed during this study. Estimated 1981 project costs have been computed but caution is urged in comparing alternatives since all associated costs may not be included.

Several alternatives are presented for some damsites. Use of one alternative may exclude the use of others. However, in some cases a combination of alternatives may be chosen. The known environmentally sensitive issues are mentioned but not evaluated. The selection of alternatives and the timing of development are left to the agencies wishing to develop the source.

MOUNTAIN STREAMS: Water source development alternatives including dams, reservoirs, diversion structures, water treatment plants, pipelines, and various combinations were studied for previously described mountain streams. Project costs were amortized over 20 years at 10 percent interest. Estimated costs for potential damsites are summarized in Table II-4. Estimated costs for developable water are summarized in Table II-5.

The major dam and reservoir sites within Salt Lake County have been located by previous studies, and in some cases have been analyzed extensively. Smaller dams and reservoirs have generally not been considered in earlier studies. A reconnaissance level review was made in this study to locate and analyze at least one damsite per canyon. In some canyons, several damsites were identified and studied, in others no reasonable site existed.

The basic criterion for selecting damsites for further study was topography. Other criteria such as geology and availability of borrow material were not considered in selecting damsites unless developed in previous studies. Generally, costs for each damsite were estimated for three capacities: (1) mean annual yield, (2) mean annual yield minus average constant base flow, and (3) something less than both (1) and (2). Project cost estimates considered movement of borrow, haul distance, spillway and outlet works, keyway, clearing, utility relocation, land requirements, accessibility, and environmental assessments. Annual costs for each of the three capacities were plotted against reservoir capacities. Cal- culations were made to determine the most probable reservoir capacity that would be built.

Three scenarios were assumed in sizing reservoirs and calculating water yield. They are: (1) The reservoir is an equalizing facility where mean annual stream yield is delivered in a typical annual community demand pattern, (2) The reservoir is used as a peaking facility where the 50 percent probability yield is stored from November through June and completely released during July through October in a typical demand pattern, and (3) No storage is provided but water treatment facilities are sized to process natural stream flows of an average year.

For streams which supply existing treatment plants, the criteria were changed slightly. This is because the plant or conduit capacity is known and sets the maximum water treatment rate.

The annual cost per acre-foot of water yielded, treated, and delivered to the canyon mouth was calculated. It is important to note, that in this report, the annual cost per acre-foot of <u>additional</u> water was calculated. This will be higher than the average unit cost of treatment and conveyance of <u>all</u> water from each source.

A conventional treatment plant or a conveyance pipeline to a treatment plant was considered for nearly all of the water sources studied. In some instances the flows from two smaller canyons were combined as a source for a treatment plant. Plant sizes range from 70 gpm up to the 50 percent probability peak monthly flow of the water source. Treatment plants with flows below one mgd were considered to be a complete package with many automatic control features. Both conventional treatment and direct filtration type plants were considered for plants with greater flow capacities.

TABLE II-4

ESTIMATED COSTS FOR POTENTIAL DAMSITES IN SALT LAKE COUNTY

Reservoir Site	Capacities Considered (Ac-Ft)	Capital Costs Dam(a)	Capital Costs Total Project(b)	Annual O&M Cost(c)	Total Annual Cost(d)
		($1000)			
City Creek, Site A	1000	5,029	9,533	48	1,168
	1400	4,358	6,739	34	825
	3700	11,063	15,929	80	1,950
	5600	15,602	22,279	111	2,728
Red Butte Creek	1250	1,944	3,546	18	435
	2450	3,664	6,223	31	762
Emigration Creek, Site A	2000	3,430	9,897	49	1,211
	3240	5,549	13,822	69	1,693
	4439	7,410	17,624	88	2,158
Emigration Creek, Site B	1000	3,298	8,068	40	988
	1609	3,896	9,542	48	1,169
	2205	5,640	12,491	62	1,529
Little Dell Reservoir					
a) Dell Creek Only	2750	--	14,000	70	1,714
b) With Emigration Creek Diversion	1953	--	13,978	70	1,712
	5035	--	31,678	158	3,879
c) With Parleys Creek Diversion	4152	--	21,800	109	2,918
d) With Emigration Creek and Parleys Creek Diversions	5001	--	33,128	160	4,058
	10,385	--	49,728	249	6,090
	30,000	37,912	66,207	331	8,018
e) With Parleys Creek and Mill Creek Diversions	1204	--	21,990	11	2,692
	5471	--	45,820	23	5,611
	14,413	--	77,420	39	9,481

TABLE II-4 (Con't)

Reservoir Site	Capacities Considered (Ac-Ft)	Capital Costs Dam[(a)]	Capital Costs Total Project[(b)] ($1000)	Annual O&M Cost[(c)]	Total Annual Cost[(d)]
f) With Emigration Creek,	1775	--	31,598	16	3,869
Parleys Creek, and	7234	--	56,098	28	6,869
Mill Creek Diversions	16,698	--	95,998	48	11,756
Mill Creek	1500	5,134	11,351	57	1,390
	3670	9,687	18,681	93	2,287
	9742	22,246	37,479	187	4,589
Big Cottonwood Canyon,	440	2,342	4,652	23	570
Willow Heights Site	985	3,312	6,982	35	855
	1576	7,522	11,627	58	1,424
Big Cottonwood Canyon,	1566	7,161	13,252	66	1,623
Silver Fork Site	2505	10,736	18,978	95	2,324
Big Cottonwood Creek,	10,000	11,146	28,794	144	3,426
Argenta Site	26,600	24,668	64,916	325	7,949
	35,000	40,147	84,968	425	10,405
	60,000	48,525	102,141	511	12,508
Little Willow Creek,	1000	8,478	11,944	60	1,463
(Deaf Smith Canyon)	2370	20,498	28,035	140	3,433
	4400	28,680	39,227	196	4,804
Little Cottonwood Creek,	10,000	24,240	47,907	240	5,866
Site F	21,600	48,635	91,015	455	11,149
	27,800	55,691	106,790	534	13,076
Little Cottonwood Creek,	9000	13,437	40,570	203	4,968
Site D	20,000	15,384	73,789	369	9,032
	38,400	23,797	102,550	513	12,557
Bells Canyon Creek, Site A	524	643	2,768	14	339
	697	938	3,822	19	468
Bells Canyon Creek, Site B	2000	6,071	10,104	50	1,237
	3800	12,846	18,863	94	2,260
	5228	18,213	26,266	131	3,216

TABLE II-4 (con't)

Reservoir Site	Capacities Considered (Ac-Ft)	Capital Costs: Dam[(a)]	Capital Costs: Total Project[(b)]	Annual O&M Cost[(c)]	Total Annual Cost[(d)]
		($1000)			
Bells Canyon Creek, Site C	1000	4,491	7,808	39	956
	1535	9,376	14,980	75	1,835
Corner Canyon Creek	510	6,580	8,873	44	1,086
	1080	10,578	14,289	71	1,749
Rose Creek	100	889	1,551	8	190
	160	1,209	2,018	10	247
	211	1,360	2,260	11	276
Butterfield Creek	200	748	1,446	7	177
	412	1,510	2,605	13	319
	530	1,862	3,126	15	383
Barneys Creek	100	748	1,391	7	163
	234	1,289	3,191	16	391
Harkers Canyon Creek	150	767	1,500	7	183
	328	1,307	2,495	12	305
	1040	3,226	5,668	28	694
Coon Creek	300	1,423	2,441	12	299
	544	2,246	3,636	18	445
	712	2,763	4,396	22	515

(a) Construction cost of dam only (1981)

(b) All related project costs, including dam cost, reservoir land purchase requirements, road and utility locations, etc. Also includes 25% contingency.

(c) Calculated as 0.5% of the total project cost.

(d) Sum of (1) the total project cost amortized over 20 years at 10%, and (2) the annual O&M cost.

TABLE II-5
ESTIMATED COSTS FOR DEVELOPABLE WATER

Reservoir Site	Scenario 1 - Equalizing Facility					Scenario 2 - Peaking Facility					Scenario 3 - No Storage	
	Reservoir Capacity (a)	Developable Annual Water Yield (b)	Unit Water Yield Cost For Reservoir (c)	Unit Water Yield Cost For Treatment and Conveyance (d)	Total Unit Water Yield Cost (e)	Reservoir Capacity (a)	Developable Annual Water Yield (b)	Unit Water Yield Cost For Reservoir (c)	Unit Water Yield Cost For Treatment and Conveyance (d)	Total Unit Water Yield Cost (e)	Developable Annual Water Yield (b)	Total Unit Water Yield Cost (f)
	(Ac-Ft)		($/Ac-Ft)			(Ac-Ft)		($/Ac-Ft)			(Ac-Ft)	($/Ac-Ft)
City Creek, Site A	5072	1238	1926	35	1961	5840	1238	2170	35	2205	N/A	N/A
Red Butte Creek	2011	2355	278	306	584	3114	2355	364	403	767	2355	318
Emigration Creek, Site A	4577	3928	569	249	818	6175	3928	755	314	1069	3928	314
Emigration Creek, Site B	1312	3928	260	280	540	1896	3928	338	265	603	3928	314

(a) Includes storage and carry-over capacity.

(b) Additional water developed in excess of existing annual water yield. Existing annual water yield is average annual water treatment plant production for the period 1977-1981, in the case of streams with existing treatment plants.

(c) Total annual reservoir cost (which is the sum of (1) the total project cost amortized over 20 years at 10%, and (2) the annual O&M cost) divided by the developable annual water yield.

(d) Annual treatment and conveyance cost divided by the developable annual water yield, for undeveloped streams. 1981 average treatment cost, for streams with existing water treatment plants.

(e) Sum of unit water yield costs for reservoir and treatment and conveyance.

(f) Annual treatment and conveyance cost for a new water treatment plant capable of processing unregulated stream flows during a 50% probability runoff year.

(g) Physical limitations prevent mean annual yield from being developed by this alternative.

JORDAN RIVER: Several multipurpose reservoirs on the Jordan River have been considered in past reports. All are located in the same general vicinity towards the south end of the valley. Capacities vary from 10,000 to 46,000 acre-feet with dam costs ranging up to $26 million.

For analysis purposes, treatment plants using Jordan River water were considered near the Narrows in the southern end of the valley and near 500 North in the northern end. Both plants would be conventional treatment with a reverse osmosis unit. Annual costs for various water treatment plants range from $4.6 million for a 10-mgd plant to $33.6 million for a 100-mgd plant.

GREAT SALT LAKE: The salinity in the southern arm of the Great Salt Lake adjacent to Salt Lake County ranges from 100,000 to 340,000 mg/l. With present desalination technology, it is not economicially feasible to desalt brines with concentrations greater than 50,000 mg/l.

GROUND WATER: Poor quality ground water could be used as a culinary source by reducing the concentration of dissolved solids. Desalting facilities would consist of a well, desalting unit, chlorination facility, clearwell, finished water pumping station, and reject-water pipeline. Annual costs for various desalting processes with various capacities are shown in Table II-6.

TABLE II-6

ESTIMATED ANNUAL COSTS FOR
DESALTING GROUND WATER IN
SALT LAKE COUNTY

(million dollars)

Treatment Process	Plant Capacity	
	1 mgd	5 mgd
Multistage Flash Evaporation	1.611	4.625
Reverse Osmosis	0.833	2.956
Electrodialysis	0.743	2.468

DUAL SYSTEMS: A "dual system" exists when an irrigation system is provided for watering lawns and gardens in addition to a culinary system which may also be used for watering lawns and gardens. As the demand for culinary water increases, consideration is often given to the use of dual systems as a supplement or alternative to enlarging culinary water systems. There is a wide variety of opinions on dual water systems. The experts are not in complete agreement on the role of the dual system.

Approximately 40 to 50 percent of water diverted for municipal use in Salt Lake County is applied to lawns and gardens. This means that about 56,200 acre-feet of culinary water was used annually on lawns and gardens during the 1962-75 period. By the year 2000, about 115,800 acre-feet would be used on lawns and gardens if this rate continues. Replacing all of this high quality water with low quality water using dual systems would be very difficult if not impossible. However, as new urban areas develop, dual systems could be considered for installation along with other facilities thus reducing costs.

Dual systems will not be feasible in all areas of the valley. There is no clear-cut condition where dual systems become feasible and each potential system should be reviewed on its own merits. Adequate design, installation, and management are as important for dual systems as they are for culinary systems.

A special committee is being organized by the State Safe Drinking Water Committee to study dual systems in more detail. This study is expected to begin within a year and address dual systems on a state-wide basis.

CONSERVATION MEASURES: Reduction in future water use could be affected by various conservation measures in the home, in the yard, on the farm, downtown, and around the County. Basically conservation reduces waste, increases reuse, and achieves a better balance between immediate short-range use and anticipated long-range needs. The reduction in water use from water-saving fixtures, recycling and reusing water, and changes in water use habits is variable and the total savings for Salt Lake County has not been estimated.

CHAPTER III

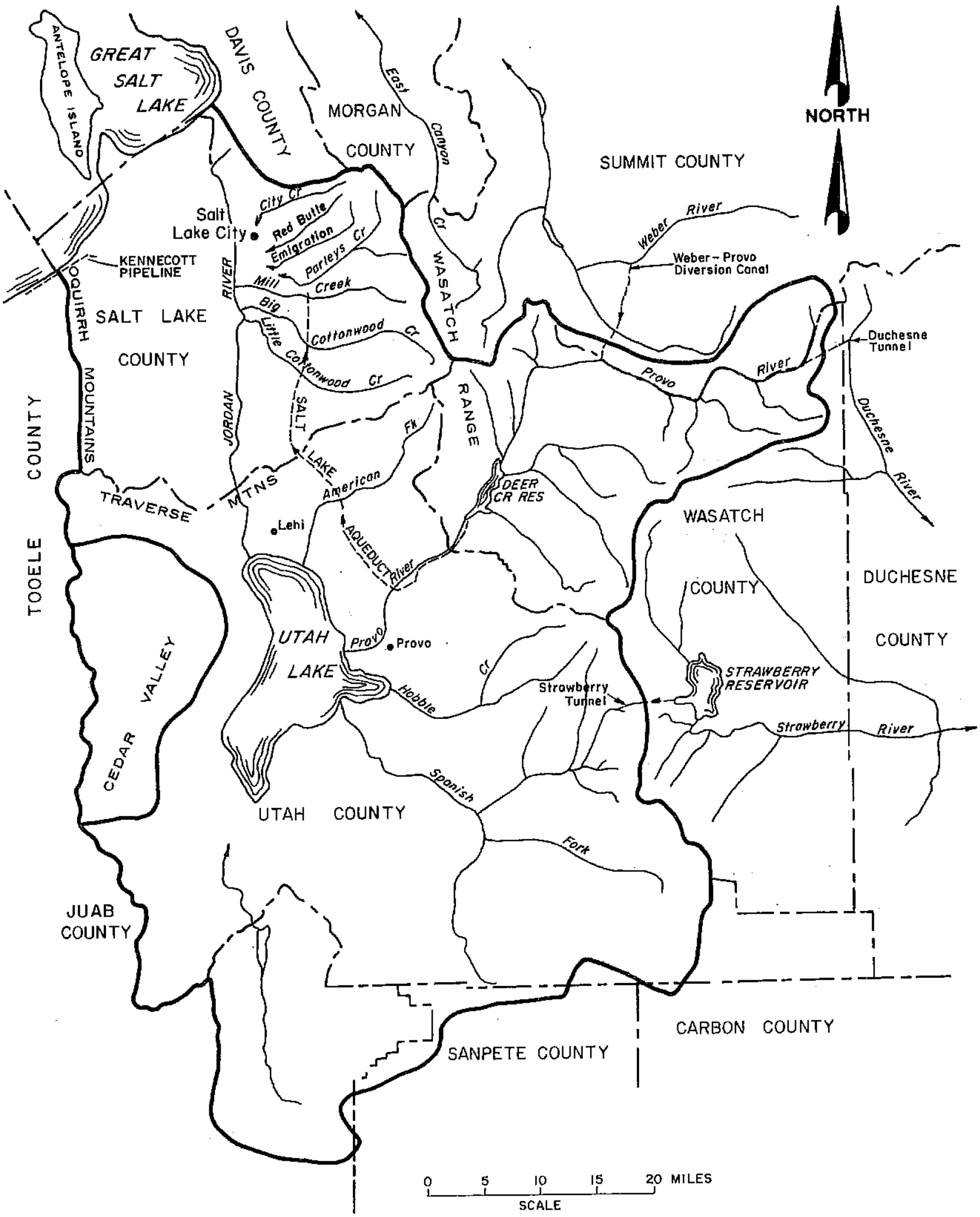
SETTING

STUDY AREA BOUNDARIES:

The study area included all of Salt Lake County, the northern Utah Lake area, and portions of the Great Salt Lake adjacent to Salt Lake County. Consideration was also given to facilities used to import water to Salt Lake County from the Central Utah Project and the Provo River Project. Salt Lake County is located in the lower portion of the Jordan River Basin. A map of the Jordan River Basin and adjacent areas is shown in Figure III-1.

Salt Lake County covers an area of 764 square miles of which approximately 65 percent is valley and the remaining is mountainous terrain. The major portion of Salt Lake County's boundaries follows the outer limits of the natural drainage areas into the valley. Only the northwestern boundary through the Great Salt Lake and the County boundary as it follows the Jordan River north of Salt Lake City for a few miles are non-drainage boundaries. A map of Salt Lake County showing the major rivers, canals and drainage areas, prominent land features, cities, and major roads is shown in Figure V-1 (inside back cover).

The incorporated municipalities within Salt Lake County include Salt Lake, South Salt Lake, Murray, Midvale, Sandy, Draper, Bluffdale, Riverton, South Jordan, West Jordan, West Valley, and the Town of Alta. The unincorporated residential areas of the county cover approximately the same amount of area as the incorporated centers. The major portion of residential expansion in the valley is occurring on irrigated agricultural land causing a change in water use. However, expansion of several large industrial areas and some residential developments is taking place on marginal non-irrigated lands creating an increasing demand for additional water. Approximately 60 percent of the state's population currently resides in the Jordan River Basin. Salt Lake County alone has over 42 percent of the state's population living within its boundaries. The Salt Lake County area is a primary industrial, political, and commercial center of the Intermountain West.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

MAP OF JORDAN RIVER BASIN

FIGURE III-1

GEOLOGIC FEATURES:

Salt Lake County is surrounded on three sides by mountains and the Great Salt Lake on the north. The Wasatch Range, reaching elevations over 11,000 feet, forms the eastern boundary. The Oquirrh Mountains, with peaks reaching elevations over 9,000 feet, form the western boundary. The Traverse Mountains with elevations reaching 6,500 feet complete the periphery. Precipitation in the mountains drains to the valley via seven major and 19 minor streams. The encircled valley floor consists of a series of benches dropping down from the mountains to the Jordan River which drains the valley flowing northward to the Great Salt Lake. The Wasatch Range is relatively steep and devoid of heavy timber. The Traverse and Oquirrh Mountains have more soil cover, are flatter and are also devoid of timber.

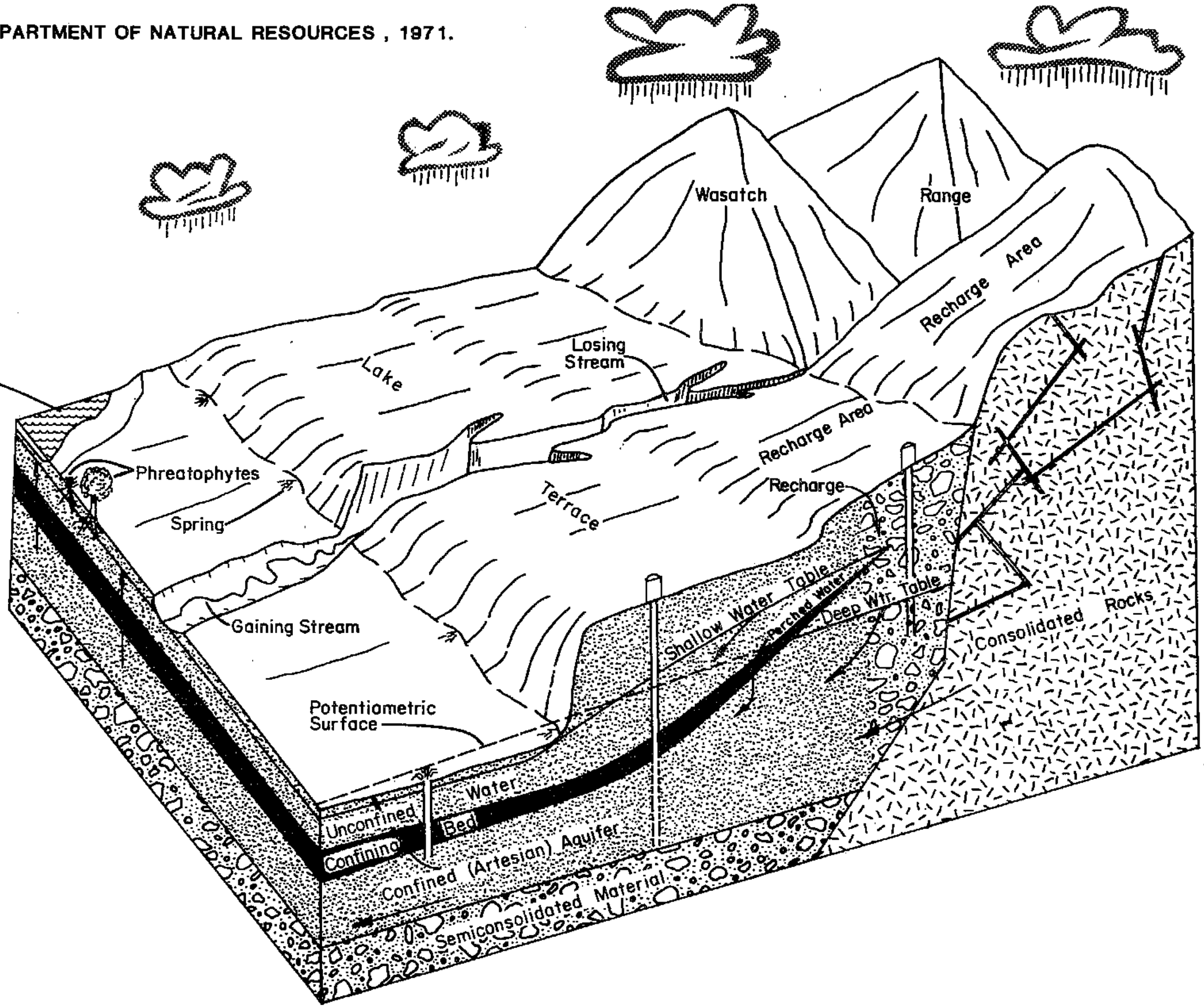
As depicted in Figure III-2, the valley is composed of deposits of loose gravel, sand, silt and clay to a depth of approximately 2,000 feet. A confining bed of clay lenses, ranging from 40 to 100 feet thick and located approximately 50 to 150 feet beneath the ground surface, separates the ground water into a relatively thin unconfined aquifer near the surface and a relatively thick deep confined (artesian) aquifer.

HYDROLOGIC FEATURES:

CLIMATE: Salt Lake County experiences four distinct seasons with the major portion of the precipitation occurring in the winter months. The normal annual precipitation ranges from 12 to 16 inches on the valley floor and bench areas to 60 inches in the high mountain areas of the Wasatch Range. The precipitation in the winter storms over the Wasatch Range falls as snow which results in high stream runoff during the spring snowmelt period. The Oquirrh Mountains and the Salt Lake Valley receive relatively little snow. A portion of the water from the mountains is absorbed into the soil during the runoff periods resulting in recharge of the valley ground water.

Temperatures in the valley have ranged from $-30^{O}F$ in the winter to over $100^{O}F$ in the summer. The mean annual temperature is approximately $50^{O}F$. Evaporation capacity in the valley for fresh water is approximately 50 inches per year. The highest evaporation rate occurs

UTAH DEPARTMENT OF NATURAL RESOURCES , 1971.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

GENERALIZED ISOMETRIC DIAGRAM OF THE SALT LAKE VALLEY AND THE WASATCH FRONT RANGE

FIGURE III-2

in July with a monthly total of approximately nine inches. The normal frost-free season for the valley area is approximately 165 days from the first of May to mid-October.

WASATCH RANGE STREAMS: The streams originating in the Wasatch Range provide more than 97 percent of the surface water supply originating in the Salt Lake Valley drainage area. These streams are shown in Figure V-1. The seven major streams listed as they are located from north to south are: City, Red Butte, Emigration, Parleys, Mill, Big Cottonwood, and Little Cottonwood Creeks. Thirteen other smaller streams with significant flow are also shown in Figure V-1. Streams in Neffs, Tolcats, and Heughs Canyons are located between Mill Creek and Big Cottonwood Creek. Ferguson Canyon Creek and Little Willow Creek (Deaf Smith Canyon) are located between Big Cottonwood Creek and Little Cottonwood Creek. Streams located south of Little Cottonwood Creek include Bells Canyon, Middle Fork Dry, South Fork Dry, Rocky Mouth Canyon, Big Willow, Little Willow, Bear Canyon, and Corner Canyon Creeks.

OQUIRRH MOUNTAIN STREAMS: The streams originating in the Oquirrh Mountains provide less than three percent of the surface water supply originating in the Salt Lake Valley drainage area. These streams listed from south to north as shown in Figure V-1 are: Rose, Butterfield, Bingham, Barneys, Harkers Canyon, and Coon Creeks.

IMPORTED WATER: Water is imported from sources outside the Jordan River drainage area to Salt Lake County. Spring runoff and winter flows from the Weber River are diverted to the Provo River through the Weber-Provo Diversion Canal. Water from the North Fork of the Duchesne River is also diverted to the Provo River, through the Duchesne Tunnel. The imported water from the Weber and Duchesne Rivers is stored in Deer Creek Reservoir on the Provo River and at times in Utah Lake. Water is then delivered to the Salt Lake County area through the Salt Lake Aqueduct, Provo Reservoir Canal, and the Jordan Aqueduct.

Another relatively small water import is from springs near the base of the Oquirrh Mountains in Tooele County used for industrial purposes in the Garfield-Magna area of Salt Lake County.

UTAH LAKE AND JORDAN RIVER: The Jordan River Basin includes the major drainage of the American Fork, Provo and Spanish Fork Rivers. These rivers originate in the mountains east of Provo and drain into Utah Lake. The outlet from Utah Lake is the Jordan River which flows north through Salt Lake County, where it is joined by tributary inflows along the Wasatch Range and Oquirrh Mountains, and terminates in the Great Salt Lake. The Jordan River Basin is shown in Figure III-1.

Utah Lake is a natural lake which is utilized as a reservoir. The lake, with a useable storage capacity of 830,000 acre-feet, lies approximately 300 feet in elevation above Great Salt Lake, and provides regulation storage for the Lower Jordan Basin. All unconsumed water of the Upper Jordan Basin eventually enters Utah Lake, where it either evaporates, is controlled and released into the Jordan River for use in Salt Lake County, or in high runoff years, is discharged into Great Salt Lake. The average annual outflow is 280,000 acre-feet.

GREAT SALT LAKE: The Great Salt Lake is a terminal lake receiving its major inflow from the Bear, Weber, and Jordan River Basins. Approximately 2.1 million acre-feet from these basins flow into the lake in an average year. The eastern portion of the Great Salt Lake area is dominated by marshlands which extend from the Jordan River marshes southeast of Antelope Island to the Bear River marshes east of the Promontory Mountains. These marshes are probably the most important single breeding ground for waterfowl in the United States.[81] In addition to wildlife, recreation and mineral extraction are other important activities associated with the Great Salt Lake.

GROUND WATER: Ground water occurs in subsurface materials throughout Salt Lake County; but only the water in the artesian aquifer in the valley fill is a major source for wells. The ground water is recharged primarily from the precipitation and snowmelt on the mountain watersheds which moves downward and laterally through surface streams and openings in the bedrock into the valley fill as shown in Figure III-2. The ground water east of the Jordan River is generally of high quality while the ground water west of the Jordan River is of lower quality. Wells producing ground water account for approximately 20 percent of the total amount diverted for public culinary water supply in Salt Lake County. The wells produce over 45 percent of the water diverted for municipal and industrial use. The extent to which additional ground-water developments can take place has been a topic of concern in the Salt Lake Valley and is currently being studied by the USGS for the water supply agencies of Salt Lake County and the Utah Division of Water Rights.

WASTE WATER EFFLUENT: Typically between 75 to 80 percent of the water delivered for indoor use through a public culinary water supply system is eventually discharged into the sanitary sewer system. Currently, in Salt Lake County the waste-water volume is estimated to be approximately 90 million gallons per day. The waste water is treated to remove the solids and organic materials, chlorinated and then discharged to a nearby stream. There are nine municipal waste-water treatment plants in Salt Lake County. Seven of these plants discharge into the Jordan River. Two regional plants are now under construction to replace these seven plants. Salt Lake City's treatment plant discharges into the Salt Lake City Sewage Canal. The Magna plant discharges to Kersey Creek. There are several industrial waste-water treatment facilities within the county which also discharge to surface waters.

WATER OVERVIEW: The majority of the precipitation that falls on the mountain watersheds surrounding the Salt Lake Valley occurs during the winter months as snow. Approximately 60 percent of the annual streamflow occurs during the spring months of April, May and June as a result of snowmelt. Part of the water from the watershed snowmelt infiltrates into the ground and percolates into the ground-water system. A small portion of the percolating water enters the unconfined aquifer above the confining clay layers. Water from this aquifer may surface below bench areas as seeps and springs as shown in Figure III-2. The larger portion of the percolating ground water enters the artesian or principal aquifer. Upward leakage from this aquifer supplies the unconfined aquifer as well as causing some seeps and springs in the lower elevations of the valley. A small amount of ground water travels northward and discharges into the Great Salt Lake.

The Jordan River receives surface runoff from the various streams as well as some ground-water inflow.

The valley was developed for irrigation initially by diverting the mountain streams onto the land. Utah Lake water was later brought into the valley by canals for municipal and irrigation use in the 1880's. Utah Lake water was not potable, so in 1888, the first of many exchange agreements was made to substitute Utah Lake water for irrigation so that the high quality mountain streams could be used as a municipal supply. Salt Lake City has now exchanged Utah Lake water for most of the summer flows from Parleys Creek, Mill Creek, and Big and Little Cottonwood Creeks. Percolating water from irrigated lands enters the unconfined aquifer providing another source of recharge to the system. The return flows from an irrigation system generally provide part of the supply of other irrigation systems, thus complicating water transfers from irrigation to other uses as urbanization rapidly occurs in the valley. The return flows from irrigation also provide late season water to the managed marshlands at the mouth of the Jordan River.

In addition to a surface water supply, the ground water has been developed through wells for municipal, industrial, and irrigation uses. Most of this development has occurred within the principal aquifer.

CHAPTER IV

POPULATION AND WATER USES

POPULATION:

HISTORICAL: The population growth in Salt Lake County for the past 20 years has been substantial. The population increased from 383,035 in 1960 to 619,066 in 1980, a 62 percent increase. Much of this increase was natural but in-migration was significant. Over 42 percent of Utah's population live in Salt Lake County. In addition to this, approximately five million people visit Salt Lake County annually.

PROJECTED: The population in Salt Lake County is expected to increase to nearly one million people by the turn of the century, a growth of over 52 percent. The baseline projections prepared by the office of the State Planning Coordinator in March 1980[86] were adjusted by the Salt Lake County Planning Commission[5] to reflect the 1980 census data. These projections are based on the existing economic structure and trends of important changes such as birth and migration rates. Population projections are shown in Table IV-1.

TABLE IV-1

HISTORICAL AND PROJECTED POPULATIONS
FOR SALT LAKE COUNTY

	Year	Population
Historic	1960	383,035
	1970	458,607
	1980	619,066
Projected	1985	696,000
	1990	780,000
	1995	866,000
	2000	950,000
	2005	1,035,000
	2010	1,121,000

WATER USES:

HISTORICAL: While several sources of data on water use are available, the water use information for the 1962-75 period given by Glenne in a 1977 water supply and use study for Salt Lake County is considered to be the most representative of existing and future conditions.[30] Data for this period are readily available, reliable, and appear to be typical of climate, hydrologic, and development patterns for the County. The major water withdrawals for various uses in Salt Lake County during 1962-1975 are summarized in Table IV-2. Three of these uses are also displayed in Figure IV-1. The actual water depleted or consumed is, of course, less than the withdrawals and is further discussed under each water use category.

Total withdrawals steadily increased during the 1962-75 period. Irrigation diversions were the largest, amounting to as much as municipal and industrial diversions combined.

Municipal: Total municipal water use consists of water delivered to domestic (indoor and out), commercial, fire fighting, public service, and potable water from the municipal system delivered to light manufacturing and the industrial sector. As illustrated in Figure IV-1, total withdrawals for municipal use for the 1962-75 period increased at the rate of about 4,500 acre-feet annually. It is interesting to note that the historical per capita rate also increased for the same period.

The 1962-75 average municipal withdrawal for Salt Lake County was 242 gpcd (0.271 ac-ft/cap/yr). The per capita use ranged from a low of 204 gpcd in 1965 to a high of 285 gpcd in 1974. The State average for the same period was 250 gpcd. Figure IV-2 illustrates the per capita withdrawal trend for Salt Lake County.[32] Using relationships developed by Hansen [32] the peak monthly and peak daily demands would be 480 gpcd and 555 gpcd respectively.

Approximately 40 to 50 percent of the annual municipal water delivered is used outdoors for lawns and gardens[41]. About half of the municipal water used outdoors is consumed by plant growth and the rest is returned to streams or aquifers via surface runoff and percolation. Of the remaining 50 to 60 percent of municipal water that is diverted for indoor culinary purposes, about 20 to 25 percent is consumed. Most of the unconsumed water is returned to a stream or aquifer via waste-water treatment plants.[33]

Industrial: Special industrial use consists of water diverted by or delivered to the larger industries in the County. There appears to have been slowly increasing industrial diversions during the 1962-75 period. This is illustrated in Figure IV-1. Most of the industrial diversions were for Kennecott Copper Corporation.[30] For most industries, less that 10 percent of the water diverted is actually consumed.[33]

Agricultural: Agricultural use includes water for irrigation of crops and water used for watering stock. Diversions for irrigation show a slight downward trend during the 1962-75 period.[30] Also, Table IV-3 shows that the land under irrigation has decreased over the past 45 years.[30] It should be pointed out that the exact quantities of water diverted for irrigation and land being irrigated in Salt Lake County are difficult to determine. The complexity of the delivery systems and the rapidly changing land use make current values rough estimates at best.

The annual potential consumptive use on irrigated cropland is about 36 inches per acre. Assuming an effective precipitation of eight inches, the irrigation water requirement would be 28 inches. The conveyance efficiency for canals is estimated to be 85 percent, and on-farm application irrigation efficiency is estimated to be 55 percent. This means the overall irrigation efficiency is 47 percent and the diversion requirement is 5.0 acre-feet per acre.[30]

Based on this diversion requirement, about 175,000 acre-feet of irrigation water would have been diverted in 1975 to irrigate the estimated 35,000 acres of irrigated cropland. However, the water actually diverted for irrigation in 1975 was estimated to be 276,600 acre-feet. The difference between the two values, 101,600 acre-feet, is apparently being used on land not identified as cropland, being by-passed as return flow to the Jordan River, or the irrigation efficiency and effective precipitation are less than estimated.

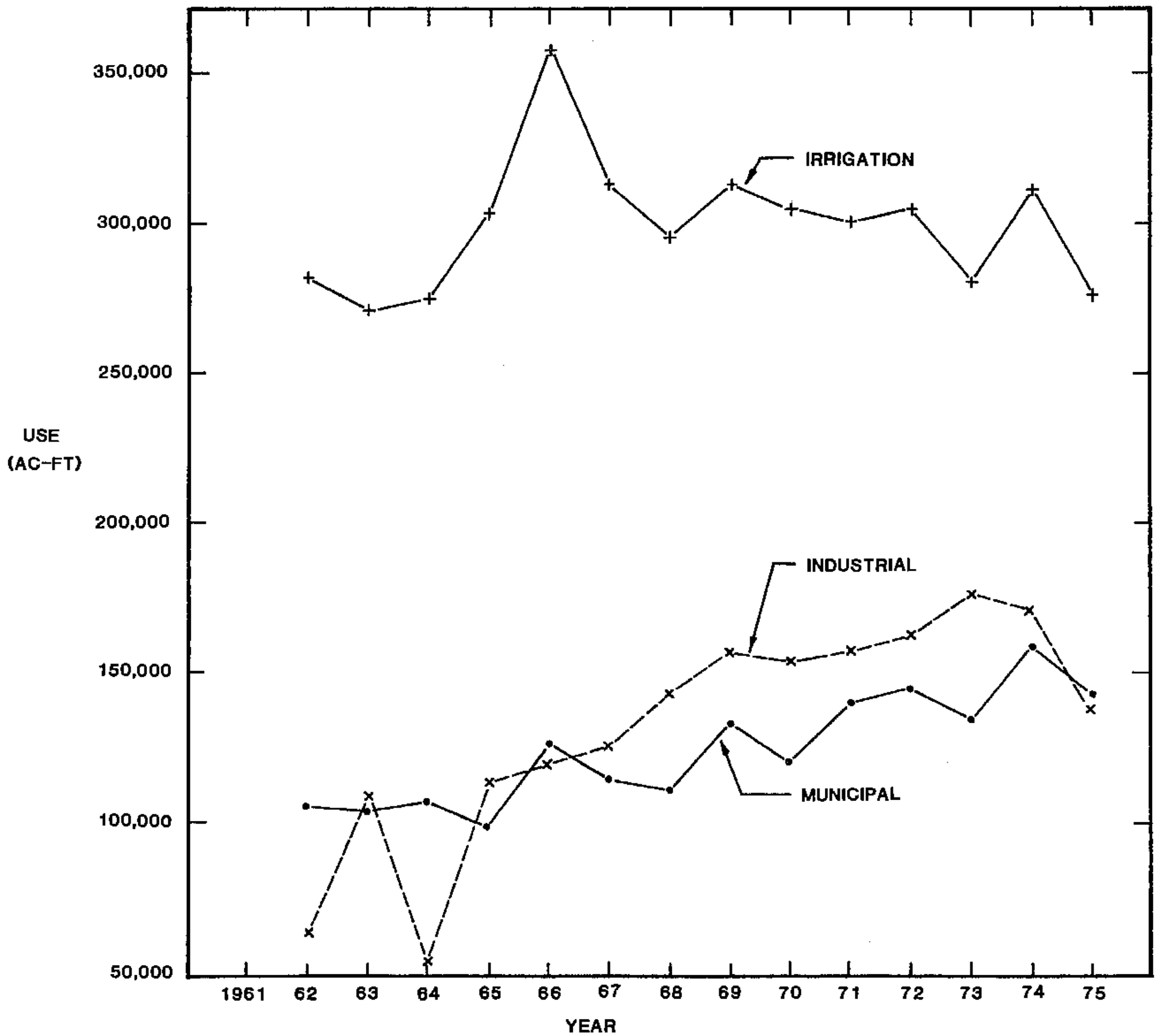
PROJECTED: Projected water withdrawals for Salt Lake County are shown in Table IV-4. These are rough estimates at best. Most values are based on historical trends which were modified somewhat to reflect estimated future conditions. The actual water withdrawals for 1980 were not used as a base for projections. A 1980 base was established using the 1971-75 average for irrigation, industrial, and stock water uses; and using the 1980 population multiplied by the 1962-75 per capita average for municipal use.

Municipal: While historically there has been a growth trend in per capita use of municipal water in Salt Lake County, it seems unlikely that this trend will continue into the future. If water becomes more expensive, delivery systems are improved, and the population density increases, the per capita demand for municipal water will probably decrease.(32) While individual water departments may have lower or higher values, the Salt Lake County average of 242 gpcd for 1962-75 appears to be a good value for estimating future demands. The total demand for municipal water will, of course, increase as the population increases. Using this value, total municipal withdrawal by the year 2000 would be 257,500 acre-feet.

Industrial: Specific information on expected industrial growth is not available so projections are difficult to estimate. However, it appears that future demand should be at least as great as the average use for the 1962-75 period, and will probably increase by 10,000 acre-feet in 20 years.(30) If past trends continue, the increase would be more like 20,000 acre-feet in 20 years.

Agricultural: The irrigated cropland is projected to decrease to approximately 22,000 acres by 1995.(30) Logically it might be expected that the amount of irrigation water diverted would decrease by a proportionate amount of 65,000 acre-feet (5 ac-ft/ac x 13,000 acres). However, historically, irrigation diversions and irrigated cropland have not decreased proportionately. As previously discussed, some of the irrigation water is apparently being used on lawns and gardens or by-passed to the Jordan River and this is expected to continue.

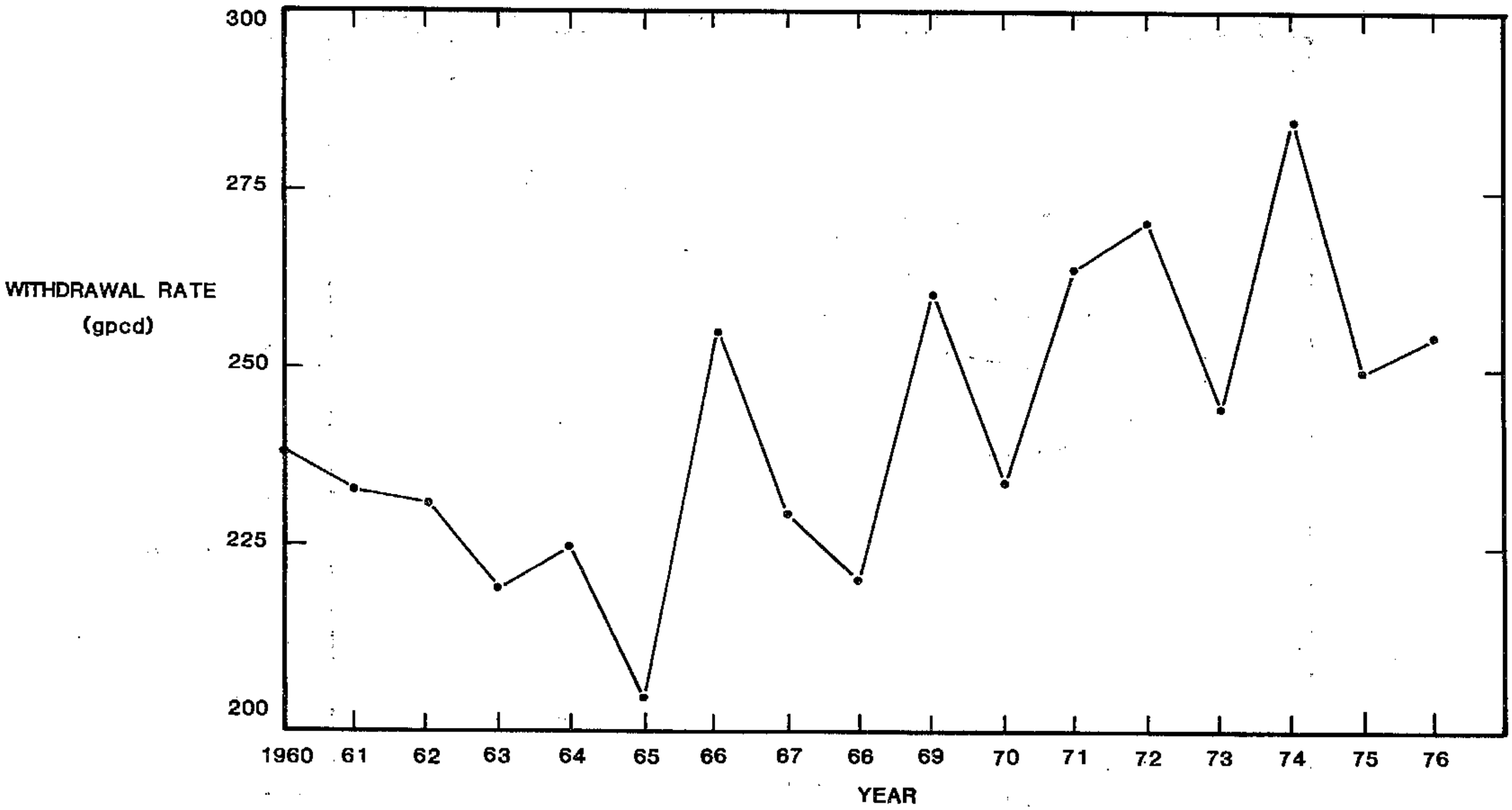
Unless there is a change in water laws or a major acquisition of irrigation water by municipal and industrial suppliers, the water withdrawals for irrigation are expected to decrease only 2500 acre-feet per year. This is 50,000 acre-feet in 20 years and allows for some continued conversion of agriculture irrigation water to use on lawns and gardens.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

HISTORICAL WATER USES FOR SALT LAKE COUNTY

FIGURE IV-1



SALT LAKE COUNTY AREA-WIDE WATER STUDY

HISTORICAL MUNICIPAL PER CAPITA WITHDRAWAL FOR SALT LAKE COUNTY

FIGURE IV-2

TABLE IV-2

HISTORICAL WATER WITHDRAWALS FOR
SALT LAKE COUNTY
(Ac-Ft)

Year	Municipal (32)	Irrigation (30)	Industrial (30)	Domestic & Stock (30)	TOTAL
1962	197,300	280,800	64,000[a]	[a]	[a]
63	104,000	270,600	109,500	37,200	521,300
64	108,300	275,900	52,400[a]	[a]	[a]
65	99,500	302,900	113,600	34,200	550,200
66	127,100	358,700	120,000	32,900	638,700
67	114,900	312,800	126,500	32,900	587,100
68	111,200	295,600	142,900	32,900	582,600
69	132,900	311,800	158,400	33,200	636,300
70	120,300	304,900	153,000	33,500	611,700
71	140,200	300,500	157,800	33,800	632,300
72	146,400	305,600	162,700	33,500	648,200
73	134,200	280,600	177,300	33,500	625,600
74	159,600	311,400	170,400	33,500	674,900
1975	142,600	276,600	139,400	33,500	592,100
1962-75 Average	124,900	299,200	144,300[b]	33,700[b]	608,400[b]
1971-75 Average	144,600	294,900	161,500	33,600	634,600

(a) incomplete data
(b) 12 year average

TABLE IV-3

HISTORICAL AND PROJECTED LAND
UNDER IRRIGATION FOR SALT LAKE COUNTY(30)
(Acres)

Year	Irrigated Land
1935	48,000
1955	44,000
1975	35,000
1996	22,000

TABLE IV-4

PROJECTED WATER WITHDRAWALS FOR
SALT LAKE COUNTY
(Ac-Ft)

Year	Municipal[a]	Irrigation[b]	Industrial[c]	Domestic[d] & Stock	TOTAL
1980*	167,700[e]	294,900[f]	161,500[f]	33,600[f]	657,700
1985	188,600	282,400	166,500	32,600	670,000
1990	211,400	269,900	171,500	31,600	684,400
1995	234,700	257,400	176,500	30,600	699,200
2000	257,500	244,900	181,500	29,600	713,500
2005	280,500	232,400	186,500	28,600	728,000
2010	303,800	219,900	191,500	27,600	742,800

*Base Year

(a) Projected population times 0.271 ac-ft/cap/yr (242 gpcd)

(b) Decrease 2500 acre-feet/yr, modified historical trend

(c) Increase 1000 acre-feet/yr, modified historical trend

(d) Decrease 200 acre-feet/yr, estimated

(e) Estimated using 1980 population times 0.271 ac-ft/cap/yr

(f) Estimated using 1971-75 average as base

CHAPTER V

EXISTING WATER RESOURCES

WASATCH RANGE WATERSHEDS:

GENERAL BACKGROUND: This section describes the major Wasatch Range watersheds and their streams that drain into Salt Lake Valley. These streams range from City Creek on the north to Corner Canyon Creek on the south. There are seven major and 13 minor streams. The natural drainage basins, hydrologic features and existing water-related structures in Salt Lake County are shown in Figure V-1 (inside back cover pocket).

The four major drainage areas of City Creek, Red Butte, Emigration and Parleys Canyons terminate as natural streams near the canyon mouths where the flows are collected into the Salt Lake City storm drain system for conveyance to the Jordan River. These drainages as discussed herein were limited to the areas upstream of the canyon mouths. The drainage area within the metropolitan area of Salt Lake City was considered as a separate area. This area is not discussed further except as it relates to inflow into the Jordan River.

The remaining three major drainage areas of Mill Creek, Big Cottonwood and Little Cottonwood Canyons still have natural drainage courses to the Jordan River. The four minor drainage areas of Neffs, Tolcats, Heughs and Ferguson Canyons, and the one minor drainage area of Deaf Smith Canyon (Little Willow Creek) drain into Big Cottonwood and Little Cottonwood basins, respectively, immediately downstream from the canyon mouths. The canyon portion of these basins are described separately in this chapter. However, the valley portions are described along with the major drainage area into which they drain.

The minor canyons from Bells south through Bear are described separately down to each canyon mouth. Downstream from their canyon mouths, all except Bear Canyon drains into the Draper Irrigation Company Canal, which eventually flows into Dry Creek and then to the Jordan River. The major portion of the valley area below these seven canyons also drains into Dry Creek via several northerly-flowing canals. The drainage area below the canyons has been treated as a single area tributary to the Jordan River. The remaining small portion of the valley area below the seven canyons drains to the Jordan River via Willow Creek.

Corner Canyon Creek has a natural drainage course along the valley floor to the Jordan River. Both the canyon and valley portions are considered jointly as a single drainage area.

Typical Wasatch Storm Characteristics: The majority of surface flow into the Salt Lake Valley originates from the rugged, mountainous canyon watersheds along the west-facing Wasatch Range. The Wasatch Range is generally much higher than the Oquirrh Mountains and is also on the windward side of the major storms. As a result, the Wasatch watersheds receive a major portion of the available precipitation, primarily in the form of snow during the winter months.(57)

Storms in the Salt Lake Valley may be classified as two general types, cloudburst storms and general storms. Cloudburst storms are high-intensity, short-duration storms normally occurring as rainfall from July through September. General storms are low-intensity storms with longer durations, sometimes lasting several days. General storms usually occur during the winter months and provide more than two thirds of the total annual precipitation along the Wasatch Range, mostly in the form of snow.(62)

Precipitation characteristics in the Great Basin have been categorized into three patterns: (1) Pacific frontal storms, (2) continental cyclone storms, and (3) convective storms associated with moist air from the Gulf of Mexico.(35) The first two types of storms occur throughout the year with varying strength and frequency. Pacific frontal storms are the major source of snowfall in the Salt Lake Valley during the winter months. Convective "Gulf" storms occur almost entirely during the summer months, and result in cloudburst rain storms. It is estimated that 80 to 90 percent of the Salt Lake Valley storms occurring from July through September are cloudburst storms originating from convective "Gulf" storm fronts.(57) They are commonly caused by uneven heating of the ground surfaces and vertical lifting of the moist air masses, leading to high precipitation intensities of short duration.[35,37] "Gulf" storms exhibit much less orographic effect(*) than the other storm patterns, primarily because they occur during the summer months when the winds aloft are light.[35,37] They can, therefore, be expected at most locations within the Salt Lake Valley.

Studies of cloudburst storms in the Salt Lake Valley report that most of the rainstorms move from a west-southwest to an east-northeast direction, with most of the rainfall occurring in the mideastern and northeastern portions of the valley.[74,91] This is attributed to the mechanical lifting of moist air over the Wasatch Range. Because of their short durations, cloudburst storms do not produce large volumes of water, although substantial peak flows are produced at the canyon mouths and on the valley floor.[15] These floods occur during the summer months when the flows at the canyon mouths are low. Cloudburst storms are usually local events within the Valley and rarely reach high intensities over large areas.[71,92]

Typical Canyon Stream Flow Characteristics: The snow in the higher elevations of the Wasatch Range, comprising the majority of the annual precipitation in the Salt Lake Valley, accumulates, settles and increases in density during the winter months as more snow falls. In the spring, warming temperatures cause the temperature of the mountain snowpack to rise until its water-holding capacity is reached, at which time the "ripe" snowpack begins to produce melt water. Much of the melt water percolates into the soil and recharges the mountain ground-water aquifer, while the rest flows downhill, alternately on the ground surface and through the shallow soil layers as interflow, until reaching a stream channel.[68]

This situation results in flows at the canyon mouths increasing during the early spring with the peak flows occurring generally during May and early June.[34,79] Physical factors such as average watershed elevations, steepness of canyon side slopes, main channel orientation and

(*)Precipitation resulting from the cooling process of lifting or deflecting of moist air currents upward as they pass over mountain ranges. Precipitation totals generally increase with an increase in elevation on the windward side of the mountains. The Leeward side is generally quite dry.[57]

geology cause the Wasatch streams to reach their peak flows at different times under the same climatic conditions. The average peak days of the eight gaged Wasatch streams including Bells Canyon, which has a one-year partial record of continuously gaged flows, are tabulated in Table V-1. The standard deviations indicate the relative amount of variation from the average date.

TABLE V-1

MEAN PEAK FLOW DATES OF GAGED WASATCH STREAMS*

Stream	Mean Peak Flow Date**	Standard Deviation (Days)
Red Butte Creek	April 30	10.7
Emigration Creek	May 1	19.2
Parleys Creek	May 12	15.9
City Creek	May 21	10.9
Mill Creek	May 27	10.1
Big Cottonwood Creek	May 28	11.3
Little Cottonwood Creek	June 4	11.5
Bells Canyon Creek	June 8	12.0

*At the gaging stations near the canyon mouths.
**Calculated from the entire period of record of mean daily flows.

During the snowmelt season, high discharge in the upper channel reaches are sustained for long periods of time. Even after most of the snow has melted the high stream flows recede slowly because of the contribution to the channels of ground-water baseflow from the early spring recharging of the mountainous aquifers. The Wasatch streams normally begin to recede during June and July, reaching relatively low flows during August and September.(79)

Peak runoff from summertime cloudburst rainstorms generally occurs rapidly near the point of incidence because of the small areal distribution of the storms.(15) When these rainfall-initiated flows reach the main channels, the peaks are rapidly dissipated by channel losses and detention.(57) The total runoff volumes from these storms are small in comparison to the snowmelt runoff volumes.

<u>Gaged Stream Analysis Procedures</u>: Of the eight gaged Wasatch streams, Bells Canyon Creek was eliminated from consideration for conventional frequency analysis because of its short period of record

(one partial year of continuous records and ten years of miscellaneous records). The seven remaining stream flow records were analyzed for frequency determinations by conventional methods. The Red Butte stream flow record, published by the U.S. Geological Survey, spans 41 years. The other six streams have been gaged by the Salt Lake City Water Department continously since the late 1800's and early 1900's, with 70 to 83-year periods of record.

For the six major streams which have been gaged by the Salt Lake City Water Department (City Creek, Emigration Creek, Parleys Creek, Mill Creek, Big Cottonwood Creek and Little Cottonwood Creek), a concurrent period of record (1963-68) is available from the U.S. Geological Survey (USGS). The USGS obtained the gage-height records from Salt Lake City at the City's normal gaging points during 1963-1968, and prepared their own rating curves to estimate the flows.

Because of the different techniques used by the USGS and Salt Lake City in preparing rating curves for the measuring points, an analysis of the concurrent period of record was performed. This was done to determine if a relationship exists between the two sets of records which could be extended over the longer period of record. Differences were evident in gaged flows by the two agencies during identical time periods. However, when the USGS gaged flows were plotted as percentages of the respective Salt lake City gaged flows, the pattern of divergence was found to be random. Even though no marked relationship was found in the concurrent records of any of the six streams, a wider divergence was found in the lower flows measured than in the higher flows. Due to the randomness of the flows and the longer term of record, the Salt Lake City flow records were used in the frequency analysis without any adjustments.

Hydrologists have found that random stream flow volumes on a given stream may be described statistically, just as many other random occurrences in nature. Several types of statistical distributions have been developed to document and predict the frequency of occurrence of given stream flows. During the present study, these distributions were calculated for each stream, and then tested statistically to choose the distribution of best fit.

The frequency analyses resulted in flows or yields of different probabilities and recurrence intervals. The probability of any given flow indicates how often one can expect that flow to be equaled or exceeded. For example, at least a 90 percent flow can be expected to occur, on the average, nine years out of ten. The recurrence interval, or the frequency of occurrence of a given flow, is expressed as the reciprocal of the probability. A 90 percent probability flow has a recurrence interval of 1.1 years, and a 50 percent probability flow has a recurrence interval of two years.

For each stream, a separate frequency analysis was performed for each month of the year, as well as a yearly total flow analysis. The results for each stream are presented in the form of a seasonal flow fluctuation bar-chart by month, or annual hydrograph, as well as a table of monthly and annual flow estimates. The product of each monthly frequency analysis is an estimate of total flow volume or yield in acre-feet. The 90 percent, 80 percent, and 50 percent probability monthly flows are presented in each case. It is felt that these probabilities represent the range of flows that will be most useful to directors, planners and designers. Flows of any other probability may be readily extracted from the reference material and flow data on file at the Salt Lake County Water Conservancy District office. Also, an annual frequency curve for flows of various probabilities, or recurrence intervals, is displayed in the description of each stream.

It was found that the sum of the monthly flow estimates for each stream did not equal the annual flow estimate. In each case the annual estimate is higher than the sum of the monthly estimates. This occurs because a lower estimate is automatically made by the statistical method for any month with a high variance, which is the case during the spring months for each stream. The annual estimate indicates that there is more water yielded annually by a given stream than is predicted by the monthly estimates, but there are not enough data to justify which, or to what extent, the monthly estimates should be adjusted. Both estimates are significant, however, and are included in the table of flow estimates for each stream. The annual estimate becomes useful when planning any facility with a detention time of several months or greater, such as a large reservoir. On the other hand, the individual monthly estimates are most useful for planning and design of facilities with little or no detention time, such as culinary water treatment plants.

A further breakdown of past flows has been made, which is useful for planning facilities with small detention times, such as one day. This additional breakdown is a table of historical "flow-duration" values for each stream. The flow-duration table for any given month (or year) shows the amount of flow rate fluctuation experienced during that month, while the monthly frequency analysis estimate represents the total stream yield for the month. The flow-duration values have been calculated by the U.S. Geological Survey. Unfortunately, they are generally based on only six years of record, rather than the entire period of record, and should not be used for design purposes without correlation with the longer stream flow records.

Ungaged Stream Analysis Procedures: A comparison method has been used to estimate the flows or yields from the major ungaged watersheds along the Wasatch Range. This method, known as the area-altitude method, compares the amounts of area in prescribed bands of elevation within an ungaged watershed to the areas within the same elevation bands of a gaged watershed. A second variable, average annual precipitation, is also related to the elevation bands. Using these two variables, the average, or mean annual flow from the gaged watershed is correlated to the ungaged watershed to estimate a mean annual (50 percent probability) flow. This value has then been extrapolated to 80 percent and 90 percent probability flows, as well as monthly flows, based on the pattern of the gaged watershed. However, no confidence limits have been estimated, since the monthly estimates are extrapolations themselves.

Corner Canyon Creek differs from the other ungaged Wasatch streams in Salt Lake County due to its large southerly slope and was, therefore, compared to the watershed of Fort Creek. Fort Creek Canyon is located directly south and adjacent to Corner Canyon but discharges into Utah Lake. Fort Creek is the nearest canyon with similar characteristics, such as large southerly exposure, similar vegetation and elevation range, and a record of stream flows. The eight-year record of stream flows for Fort Creek was correlated with the Little Cottonwood Creek record to extend the record and improve its accurracy.

All the other ungaged Wasatch watersheds in Salt Lake County were compared to Little Cottonwood Canyon, due to its proximity, east-west configuration, elevation range and similar geology. However, since Little Cottonwood Canyon is so much larger than the ungaged watersheds, a search was made to locate a nearby small gaged watershed which could be used for comparison. Two smaller canyons were considered. The first, Burr Fork in Upper Emigration Canyon, was rejected because of its limited elevation range and its typical limestone geology. The second, Elbow Fork in Upper Mill Creek Canyon, was also rejected as only a five-year period of flow records is available. No other nearby, gaged small watersheds were found which could be used for comparison. Little Cottonwood Canyon therefore, appeared to be the best alternative.

CITY CREEK CANYON:

Physical Description: City Creek Canyon is comprised of low-lying mountains with the highest peaks not more than 9400 feet in elevation and has a drainage area of 19.2 square miles. The canyon is approximately 12 miles in length from the headwaters to just below the state capital where the creek flows into the Salt Lake City storm drain system.

A natural confined basin has formed in the high headwaters area of the canyon. This basin stores the surface flow and forms two small temporary lakes during the spring. These lakes are believed to be recharge areas for the springs located further down the canyon. Side slopes as well as the canyon floor are moderately steep in the upper four miles of the canyon below the natural confined basin. The lower canyon area, however, has more gradual side slopes and the gradient of the floor is relatively flat.

Subsurface conditions in the upper portion of the canyon are cavernous. Soils in this area range from deep to very shallow and are derived from sedimentary rocks.(70) These soils tend to be well drained and runoff varies from slow to rapid depending primarily on slope and localized soil type.

City Creek Canyon consists of two major ecosystems. The upper area of City Creek Canyon is mostly a lower montane ecosystem with some small areas of upper montane on the mountain tops. Juniper trees, oak and grasses are found on the slopes with the streamside vegetation consisting of fir, maple, birch, dogwood, chokecherry and currant.(60)

The lower parts of the canyon are characterized by a change to a valley grassland type of environment. The principal vegetative growth in the lower section of City Creek is oak and grasses on the slopes and cottonwoods, maple, birch, boxelder and grasses along the stream.

Throughout the entire creek, fish populations are small and dominated by Brown Trout.(37) The wildlife of this area are typical of the Wasatch Range canyons with Rocky Mountain Mule Deer, porcupine, skunk, pika, squirrels, chipmunks, and various small birds such as woodpeckers, junco, robin and flycatcher.

Land use in City Creek Canyon is restricted because it is a primary water supply for Salt Lake City. The watershed is owned by the City, thus there are no permanent or summer residences or even overnight camping allowed. The primary uses of this canyon, other than as a watershed, include hiking, picnicking, hunting and fishing. Most of these activities are done on a controlled basis.

Rainfall in the upper areas of City Creek Canyon range from 25 to 40 inches per year. Snowpack is moderate due to the low elevations of the mountains.

The stream originates in the small basin areas below Grandview and Lookout Peak. Approximately one mile downstream from where the headwater tributaries join, a spring supplements the stream flow substantially. Another third of a mile down the canyon a stream from Cottonwood Gulch flows into the main stream. Two other substantial tributaries to City Creek are North Fork and Barneys Hollow which enter five and three miles, respectively, from the canyon mouth. From the headwaters area to immediately above Barneys Hollow where the City Creek Water Treatment Plant is located, the gradient is steep to moderate with a slight decrease in slope from this point down to the storm drain diversion. Just upstream from the diversion the creek runs through a small park.

Existing Facilities: The City Creek Water Treatment Plant began operation in 1955 and was the first water purification plant in the Salt Lake Valley. The plant is located about four miles up City Creek Canyon. The design capacity of the plant is 15 mgd. Its facilities include chemical treatment, coagulation, sedimentation, filtration and chlorination. Treated water is delivered through two pipelines to Salt Lake City.

Hydrologic Characteristics: The City Creek watershed does not react quickly and violently to climatic conditions as do other watersheds in the Wasatch Range. A review of the flow records for City Creek shows typically a gradual rise in stream flows during April, with a marked increase as temperatures rise in early May. After the peak flow is reached a gradual recession of flows then extends for well over a month through June and into July.

The physical makeup of the watershed is the main reason for these moderate flow fluctuations. The gradual canyon side slopes allow for nearly constant exposure of the snowpack on the south-facing slopes to radiation energy from the sun. Also, because of the cavernous nature of limestone formations, the watershed is particularly conducive to ground-water recharge and spring flow. Several springs within the watershed contribute water to the main channel. The greater than average recharge rate produces a large ground-water reservoir whose later discharge accounts for the gradual recession of flows at the mouth of City Creek Canyon following the peak discharge late in the spring.

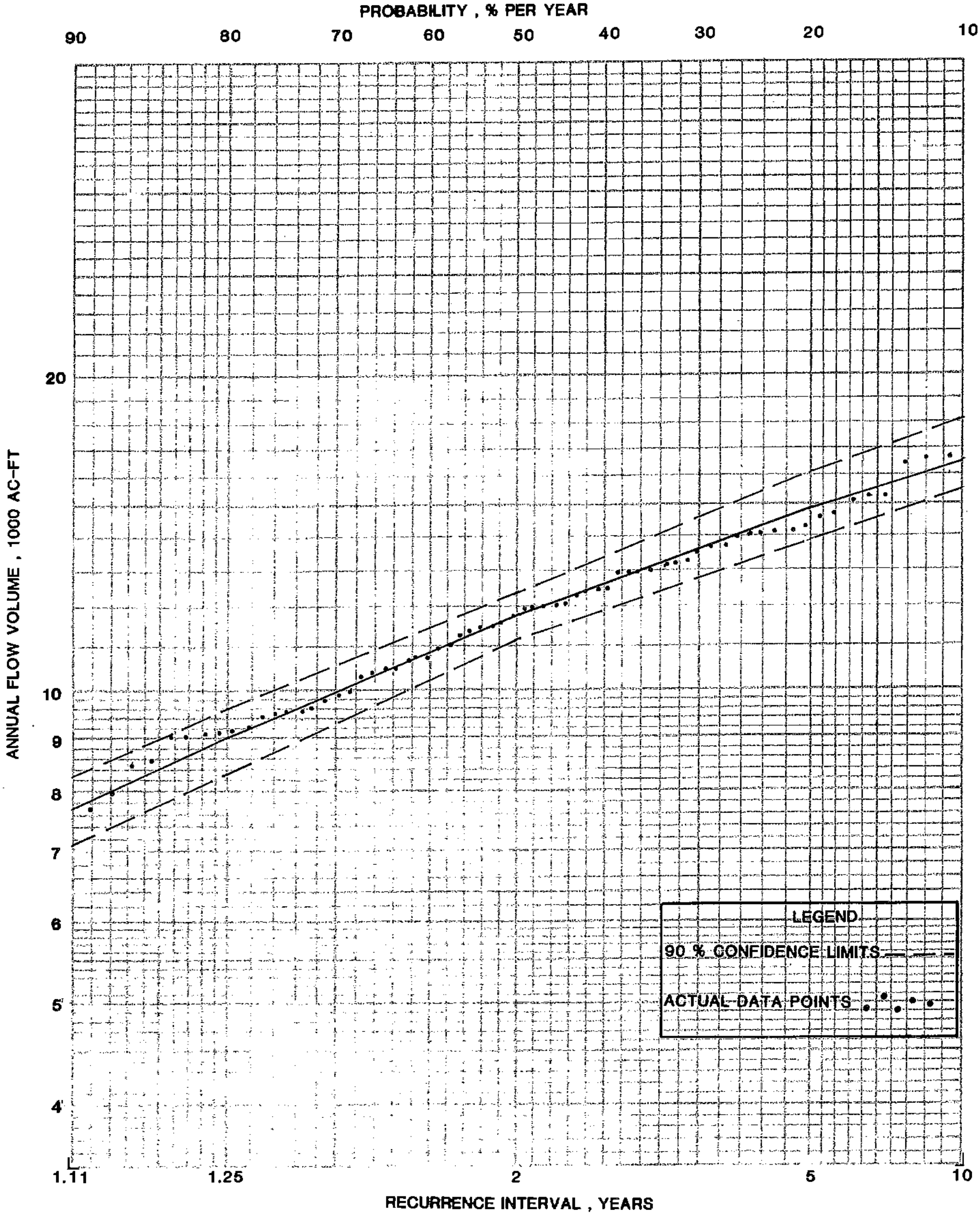
The major cause of stream flow peaks on City Creek is spring snowmelt.[34] Because the drainage basin is not a particularly high in elevation (5000 feet to 9400 feet) the peak daily discharge is reached fairly early in the snowmelt season. The average peak day is May 21.

A frequency analysis of the 82-year period of record (1899-1980) for monthly and annual total flow volumes was performed. A frequency curve for annual flow volumes is shown in Figure V-2. The City Creek annual hydrograph representing flows at the mouth of the canyon for 90 percent, 80 percent and 50 percent probabilities, is displayed in Figure V-3. These same results, including the 90 percent confidence limits, are tabulated in Table V-2. As may be seen from the table, the average annual yield estimate from the City Creek watershed is 11,749 acre-feet.

Tabulated flow-duration values for each month, as well as on an annual basis, are tabulated in Appendix E. These values provide additional information concerning daily and weekly flow rate fluctuations.

Water Users: Salt Lake City asserts rights to 100 percent of the flow in City Creek. The City diverts the portion of the flow that is needed for culinary purposes into the City Creek Water Treatment Plant. Any remaining water in the stream flows down the canyon and into a storm drain which runs along North Temple Street to the Jordan River.

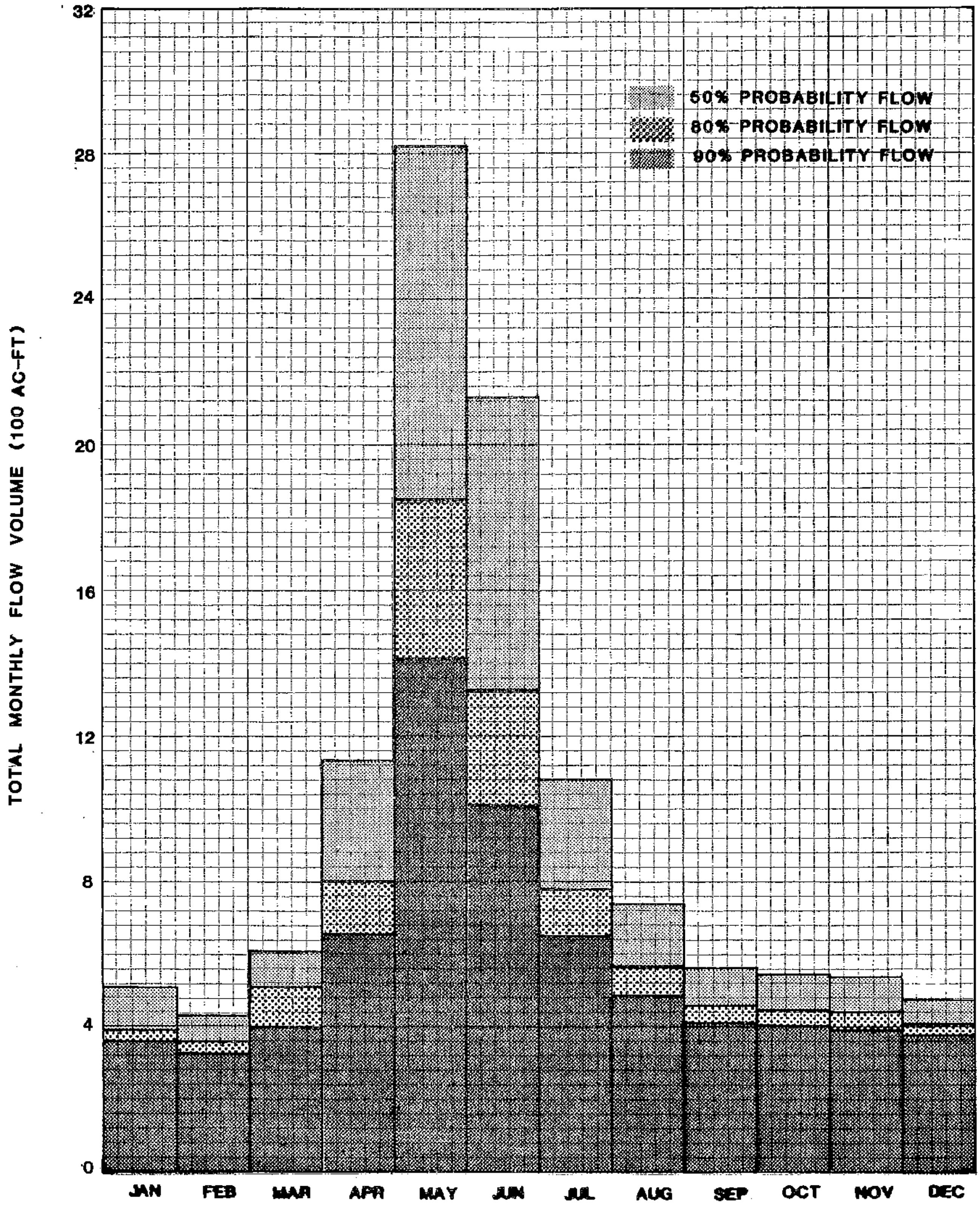
Table V-3 shows the percentage of the City Creek stream flow that was diverted for culinary use during 1977-81.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL FREQUENCY CURVE

CITY CREEK



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

CITY CREEK

FIGURE V-3

TABLE V-2
CITY CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)					
	90% Probability	90% Confidence Limits	80% Probability	90% Confidence Limits	50% Probability	90% Confidence Limits
January	357	339 - 372	388	370 - 404	452	437 - 468
February	327	307 - 345	354	334 - 372	421	403 - 440
March	394	359 - 425	456	418 - 490	602	565 - 641
April	659	588 - 724	797	716 - 872	1,133	1,048 - 1,225
May	1,402	1,234 -1,557	1,844	1,638 -2,038	2,812	2,579 - 3,066
June	1,002	864 -1,132	1,322	1,152 -1,485	2,125	1,922 - 2,350
July	649	581 - 711	772	697 - 842	1,076	998 - 1,160
August	488	448 - 523	567	524 - 606	740	699 - 784
September	411	383 - 435	458	429 - 484	564	538 - 591
October	405	381 - 426	449	424 - 471	544	522 - 567
November	395	371 - 416	440	415 - 462	534	512 - 557
December	376	358 - 391	406	388 - 422	472	457 - 488
Annual Sum	6,865		8,253		11,475	
Annual Yield Estimate	7,728	7,105 - 8,280	9,002	8,327 - 9,616	11,749	11,098 - 12,438
Deviation**	11.2%		8.3%		2.3%	

*From Frequency analyses of the 1899-1980 period of flow record at gaging station No. 1725 near the canyon mouth.
**Assuming the estimated annual yield to be the most correct.

TABLE V-3

CITY CREEK STREAM FLOWS AND DIVERSIONS

	1977				1978				1979				1980				1981			
	Stream Flow @ Canyon Mouth (Ac-Ft)	Stream Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)	Stream Flow @ Canyon Mouth (Ac-Ft)	Stream Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)	Stream Flow @ Canyon Mouth (Ac-Ft)	Stream Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)	Stream Flow @ Canyon Mouth (Ac-Ft)	Stream Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)	Stream Flow @ Canyon Mouth (Ac-Ft)	Stream Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)
January	458	412	412	100	381	329	329	100	457	396	396	100	411	342	342	100	401	368	368	100
February	412	364	364	100	878	318	318	100	388	343	343	100	444	347	347	100	361	324	324	100
March	475	391	383	98	1795	671	649	97	521	448	448	100	533	382	363	95	438	377	377	100
April	647	567	567	100	1795	1298	677	52	890	716	705	98	968	785	699	89	816	662	654	99
May	843	729	727	100	4148	2289	873	38	2500	1823	1342	74	2710	1867	1104	59	1773	1297	1081	83
June	919	879	879	100	4159	2523	1347	53	1599	1421	1330	94	2503	1902	1392	73	1713	1350	1201	89
July	605	596	596	100	1689	1518	1414	93	836	830	830	100	1161	1128	1107	98	1027	810	810	100
August	471	464	464	100	977	943	943	100.	605	602	602	100	729	[illegible]	726	100	777	566	566	100
September	396	387	387	100	702	677	677	100	455	452	452	100	538	534	534	100	553	436	436	100
October	383	362	362	100	588	541	541	100	422	401	401	100	473	450	450	100	520	403	403	100
November	366	337	337	100	518	456	456	100	385	345	345	100	427	399	399	100	491	355	355	100
December	381	341	341	100	499	434	434	100	380	346	346	100	416	388	388	100	476	364	364	100
Total	6356	5829	5819	100	18,129	11,997	8,658	72	9,438	8,1[illegible]	7,540	93	11,360	9,250	7,851	85	9,346	7,312	6,939	95

RED BUTTE CANYON:

Physical Description: From the headwaters area, including Knowltons Fork, to the canyon mouth the total size of the drainage area is 7.25 square miles. The stream flows for a short distance below the canyon before being partially diverted into a ditch and then eventually entering the Salt Lake City 1300 South storm drain conduit.

Watershed elevations range from 5000 feet to 8200 feet. The canyon is characterized by moderately steep slopes with the north-facing slopes generally being steeper than the south-facing slopes. The canyon floor is wide and has many side drainage ways entering it.

The canyon area consists of sandstone and shale deposits. The streambed is heavily silted in places. In the upper areas of the canyon the soils are shallow, well-drained, and usually derived from mixed sedimentary rock. At the mouth of the canyon the stream crosses a lake terrace with excessively drained soils. Runoff in this area tends to be very rapid.(70)

At the mouth of the canyon a foothill-type watershed exists with elm, scrub oak and various grasses prevalent. Above this area exists a lower montane ecosystem with scrub oak, birch, dogwood, and grasses likely to be found. The stream is well shaded and the banks are well stabilized.

Because of limited access to Red Butte Canyon, wildlife in this area is plentiful. Brook and Cutthroat Trout populations are substantial above Red Butte Reservoir. Deer, porcupine, Snowshoe Rabbit, squirrels, pika, chipmunks, skunk, shrews and various rodents as well as upland game birds and nongame birds inhabit this area. Since this canyon has been officially designated as a "Research Natural Area", land use is strictly for research and as a watershed. Access to the area is controlled by the U.S. Forest Service.

Precipitation in this area averages 20 to 25 inches per year with snowpack being relatively light. Surface flow originates in two head-water areas, the main fork of Red Butte Canyon and Knowltons Fork. These two streams flow separately for about two miles before joining to begin the main flow of Red Butte Creek. Two miles beyond this point another sizable tributary enters from the north. At this point the canyon floor becomes even wider than above and the gradient lessens. Less than a mile below this is the Red Butte Reservoir at an elevation of 5380 feet. Below the reservoir the stream flows for about 2000 feet in a culvert into a small pond from which water is diverted for culinary uses. The stream remaining then combines with spilled water from the reservoir and flows out of the pond to the canyon mouth and southwest to its entrance in the storm drain system at about 1100 East and 1100 South. This storm drain system eventually enters the 1300 South conduit which then drains to the Jordan River.

Existing Facilities: The Red Butte Reservoir was built in 1928.[57] The capacity of the reservoir is approximately 430 acre-feet.[41] Overflow from the reservoir is controlled by weir boards being placed at the outlet. Water is conveyed through a pipe from the reservoir to a small pond approximately 2000 feet down the canyon. The water is treated with chlorine and ammonia.[41]

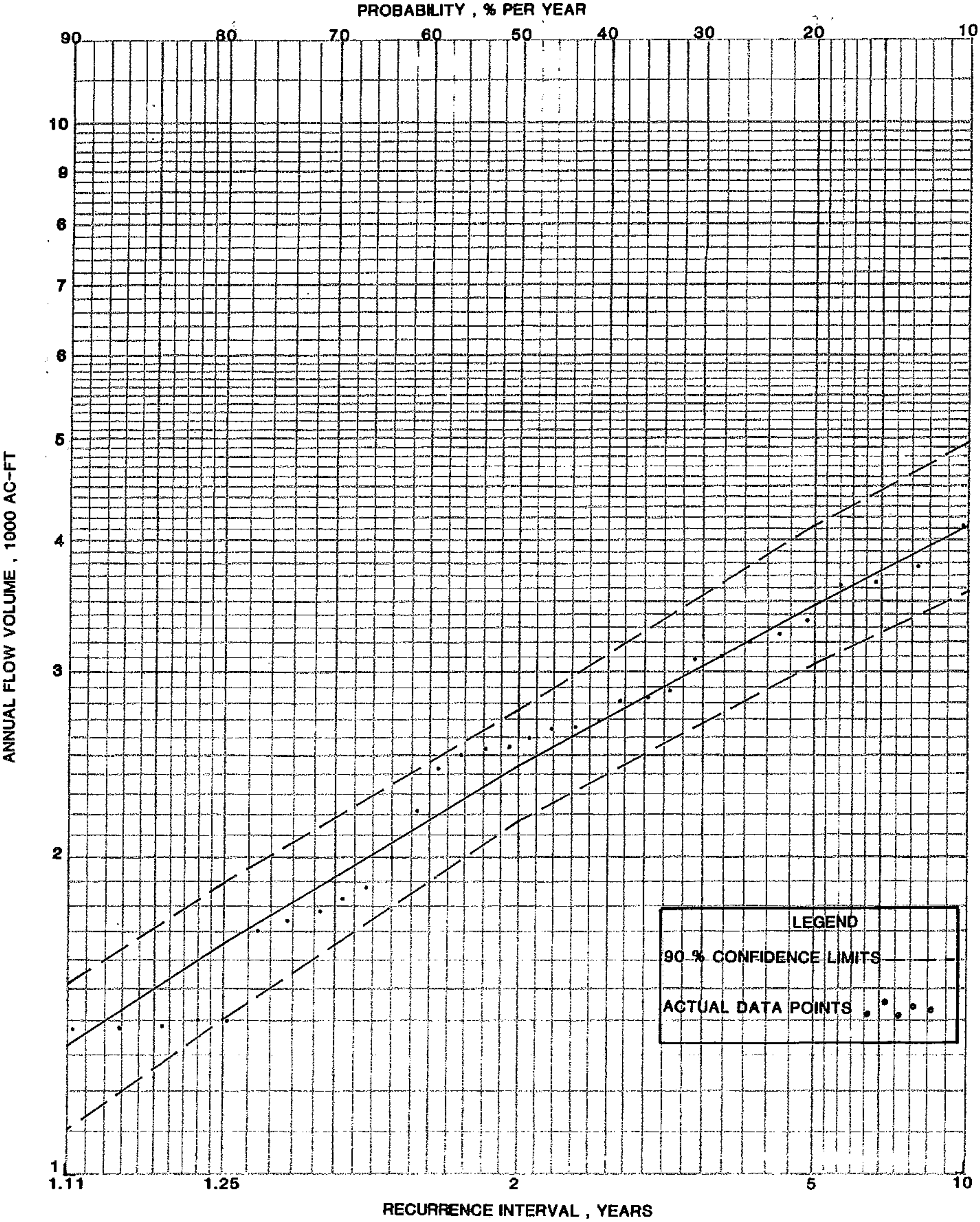
Hydrologic Characteristics: Red Butte Creek flows originate mostly from snowmelt, with only a minor portion contributed by summer rainstorms.[83,84] Snowmelt is also the chief cause of annual flow peaks.[57,78]

Red Butte Creek attains its seasonal peak flows earlier than any other Wasatch gaged stream, its average peak date being April 30. This is due to its low elevation range and its wide canyon floors.

Daily streamflow fluctuations are very gradual in Red Butte Creek during the snowmelt season. The seasonal fluctuation is also quite gradual. An average flow of one to three cfs occurs from about July to February, with flows gradually increasing in March and April to about five to ten cfs. The reservoir overflows from about the middle of January to the first of August.

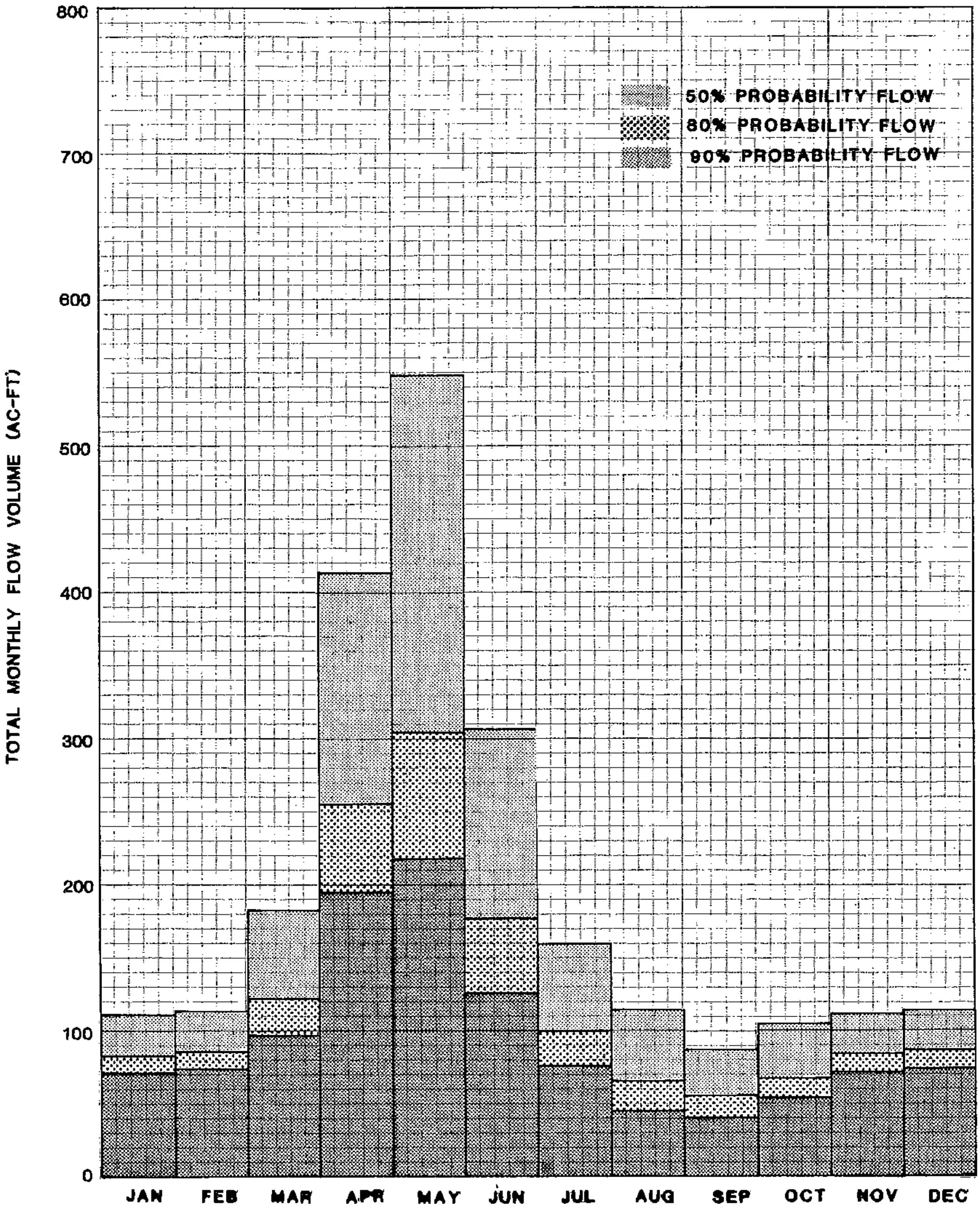
A frequency analysis of annual and monthly yields near the canyon mouth during the 1942-1980 period of record was performed. The resulting average annual yield estimate is 2450 acre-feet. An annual frequency curve is shown in Figure V-4. The monthly yield estimates are shown graphically in Figure V-5, and are tabulated in Table V-4. A further breakdown of flows, a daily flow-duration table, is included in Appendix E.

Water Users: Water from the canyon is used for irrigation of the lawns and as a culinary supply at Fort Douglas. Below the canyon, the stream contributes to the small pond in Liberty Park.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL FREQUENCY CURVE



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

RED BUTTE CREEK

FIGURE V-5

TABLE V-4
RED BUTTE CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)					
	90% Probability	90% Confidence Limits	80% Probability	90% Confidence Limits	50% Probability	90% Confidence Limits
January	70.4	60 - 78	82.9	73 - 91	111	102 - 121
February	73.3	64 - 81	85.0	73 - 91	112	102 - 121
March	97.9	80 - 114	121	101 - 140	181	159 - 206
April	194	153 - 231	254	205 - 301	413	355 - 481
May	217	164 - 267	303	235 - 371	549	458 - 658
June	125	96 - 151	175	138 - 211	306	259 - 362
July	75.8	61 - 89	99.6	82 - 117	159	138 - 183
August	44.6	35 - 53	65.4	52 - 78	113	96 - 132
September	39.8	32 - 47	54.2	45 - 63	87.3	76 - 100
October	53.6	45 - 61	68.8	58 - 78	102	91 - 114
November	70.4	62 - 78	82.8	73 - 91	110	101 - 120
December	73.4	64 - 81	85.5	76 - 94	112	103 - 122
Annual Sum	1,135		1,477		2,355	
Annual Yield Estimate	1,326	1,101 - 1,522	1,660	1,402 - 1,896	2,450	2,173 - 2,762
Deviation**	14.4%		11.0%		3.9%	

*From frequency analyses of 1942-1980 streamflow data from USGS gaging station No. 1722 near the canyon mouth.
**Assuming the annual yield estimate to be the most current.

EMIGRATION CANYON:

Physical Description: Emigration Canyon drainage area is 18.0 square miles in size and is approximately 10.5 miles long. Below the canyon mouth Emigration Creek flows 2.6 miles before entering the same Salt Lake City storm drain system as City Creek and Red Butte.

Two canyons, Killyon and Burr Fork empty into a small open valley in the upper Emigration Canyon headwaters area. This is characterized by low lying rolling hills with steeper mountains to the north. Elevations of these mountains are relatively low ranging from 5000 to 8900 feet.

Further down the canyon the side slopes remain moderate until near the mouth, where they become narrow and steep. From the mouth, the drainage area is typical East Bench terrain which gently slopes to the west.

Emigration Canyon consists mostly of sandstone, shale and limestone formations with a high percentage of rock outcrop in the higher elevations.(83) Soils tend to be shallow, well-drained, and derived from sedimentary rocks. Essentially all soils in the upper third of the watershed are rated either very high or high in erosion hazard.(25) Below this point, erosion hazard is still high, but for a lesser percentage of the area.

Below the canyon mouth the drainage area consists of a lake bed terrace with very well drained soils having medium to slow runoff potential.

On the north-facing slopes of Emigration Canyon oak and maple are present, and on the south-facing slopes scrub oak prevails. Along the banks of the stream, box elder and cottonwood trees, mustard, clover and grasses exist in a semi-residential environment. Emigration Creek is not considered an important fishery, but some trout are stocked by the Utah Division of Wildlife Resources. Because of the heavy residential use of Emigration Canyon many species typically found in the lower and upper montane ecosystems are scarce, or totally displaced.

The drainage area outside of the canyon has been residentially developed for a long time with very little of the natural habitat left intact.

Land use in the canyon along the creek is primarily residential. Very few recreational activities occur. Below the canyon the primary land use is residential, although some commercial and recreational development exist. There are shopping centers, a golf course and a zoo in close proximity to the canyon mouth.

The average precipitation in Emigration Canyon is 20 to 25 inches per year. This is relatively low compared to other canyons.

Emigration Creek originates as stream flow from Killyon Canyon and Burr Fork. There is some supplemental water from springs in this upper area. Small tributaries feed Emigration Creek for most of its length with two of the larger ones being Pioneer Fork and Perkins Hollow entering approximately half way down the canyon. The stream gradient in the canyon is moderate.

Just below the mouth of the canyon there is the Mount Olivet diversion ditch. Below this diversion there have been many areas of stream channelization. The stream eventually flows into a storm drain near Westminister College and is then conveyed to the 1300 South conduit and to the Jordan River.

Existing Facilities: Salt Lake City diverts water from an independent spring located in a tunnel near the canyon mouth built by the City to develop water.(8) From this point it is conveyed through a 12-inch cast iron and steel pipeline which has a capacity of 2.77 mgd. It ends west of Wasatch Boulevard and north of the Bonneville Golf Course where it is used for the golf course and the Hogle Zoo. Any excess flows into the Sunnyside conduit.

Warner Springs are in a small side canyon to the north of the main canyon. Water is impounded in a large storage tank, and part of it is used in the Rotary Park at the mouth of the canyon and in the maintenance of the grounds of the "This is the Place" Monument. Unused water is allowed to overflow the reservoir, and contributes to the creek.

Hydrologic Characteristics: Snowmelt is the chief component of flow in Emigration Creek, with rainfall runoff being only a minor component.(83,84) The annual peak flows are normally caused by snowmelt during the spring, rather than summer cloudburst runoff peaks.(57,78)

Emigration Creek reaches its peak flows relatively early in the season, and is generally the second gaged stream to peak each year. Its annual average peak date is May 1, only one day after the average peak date of Red Butte Creek. This is probably due to the low elevations in the watershed and the wideness of the canyon.

Emigration Creek flows also recede fairly early in the season. Flows normally recede quickly during July and August, reaching a yearly minimum flow of one to two cfs generally in mid-September. Flows then increase gradually through the winter, until rising again in March of the next snowmelt season.

A frequency analysis of monthly and annual yields at the canyon mouth during the 1901-1980 period of record was performed. The average annual yield estimate is 4439 acre-feet. A frequency curve of annual yields is displayed in Figure V-6. Also, the monthly flows for 90 percent, 80 percent and 50 percent probabilities are shown graphically in Figure V-7, and are tabulated in Table V-5. A daily flow-duration table is included in Appendix E.

Water Users: The water rights on Emigration Creek are shown below:

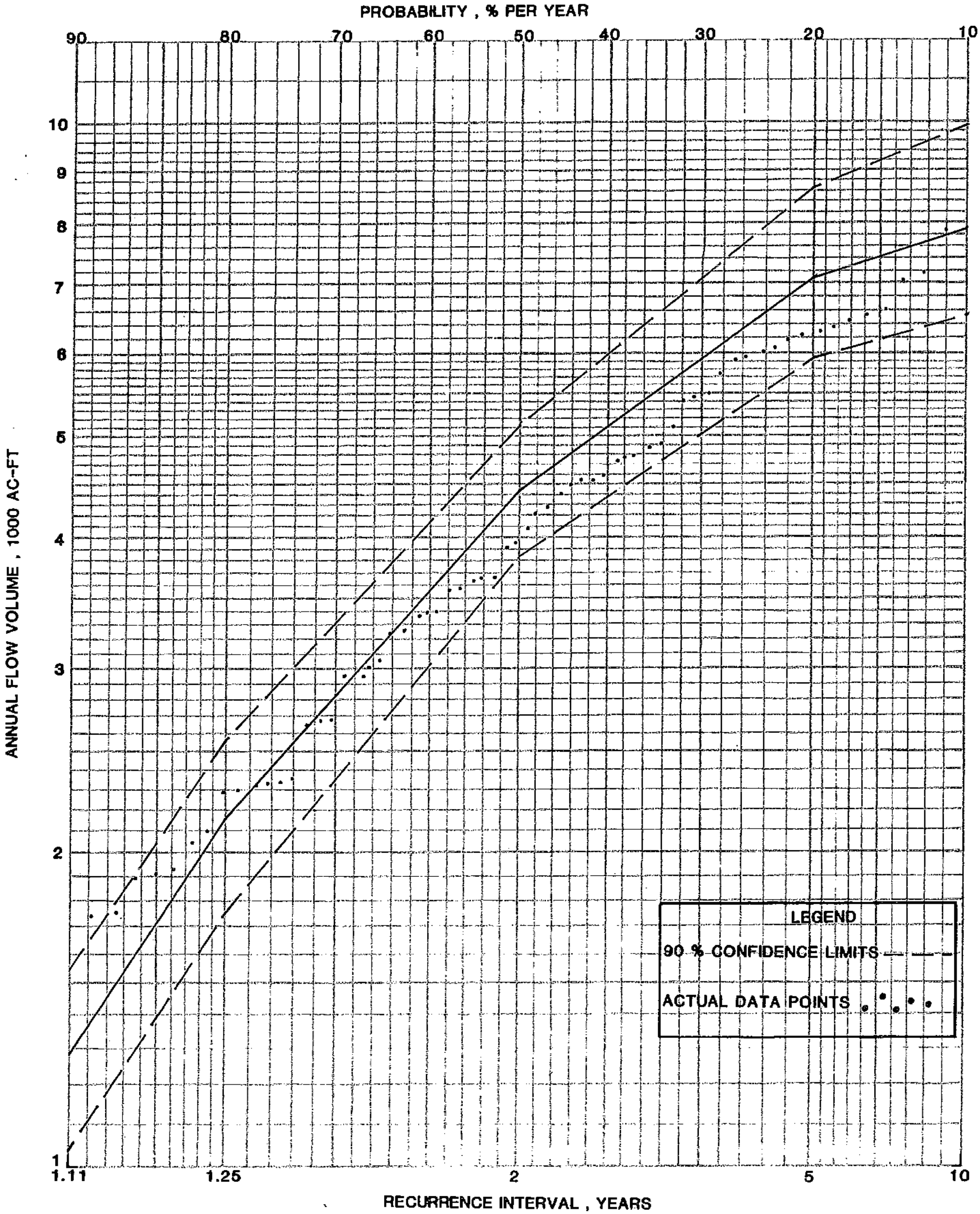
J. A. Hogle	0.208 cfs
B. R. Shurtliff	0.203 cfs
W. T. Plumb	0.203 cfs
Mount Olivet Cemetery	1.000 cfs
Salt Lake City (all flow in excess of)	1.614 cfs

In addition to the above, the State of Utah claims some water for Pioneer Park.(34)

Salt Lake City does not use any of the water from the creek for culinary purposes. The City uses Emigration Creek water for the Liberty Park pond and sometimes the creek water is used in the Parley's Exchange for irrigation purposes. The City diverts water from the Emigration Tunnel spring which enters the City's supply system untreated.

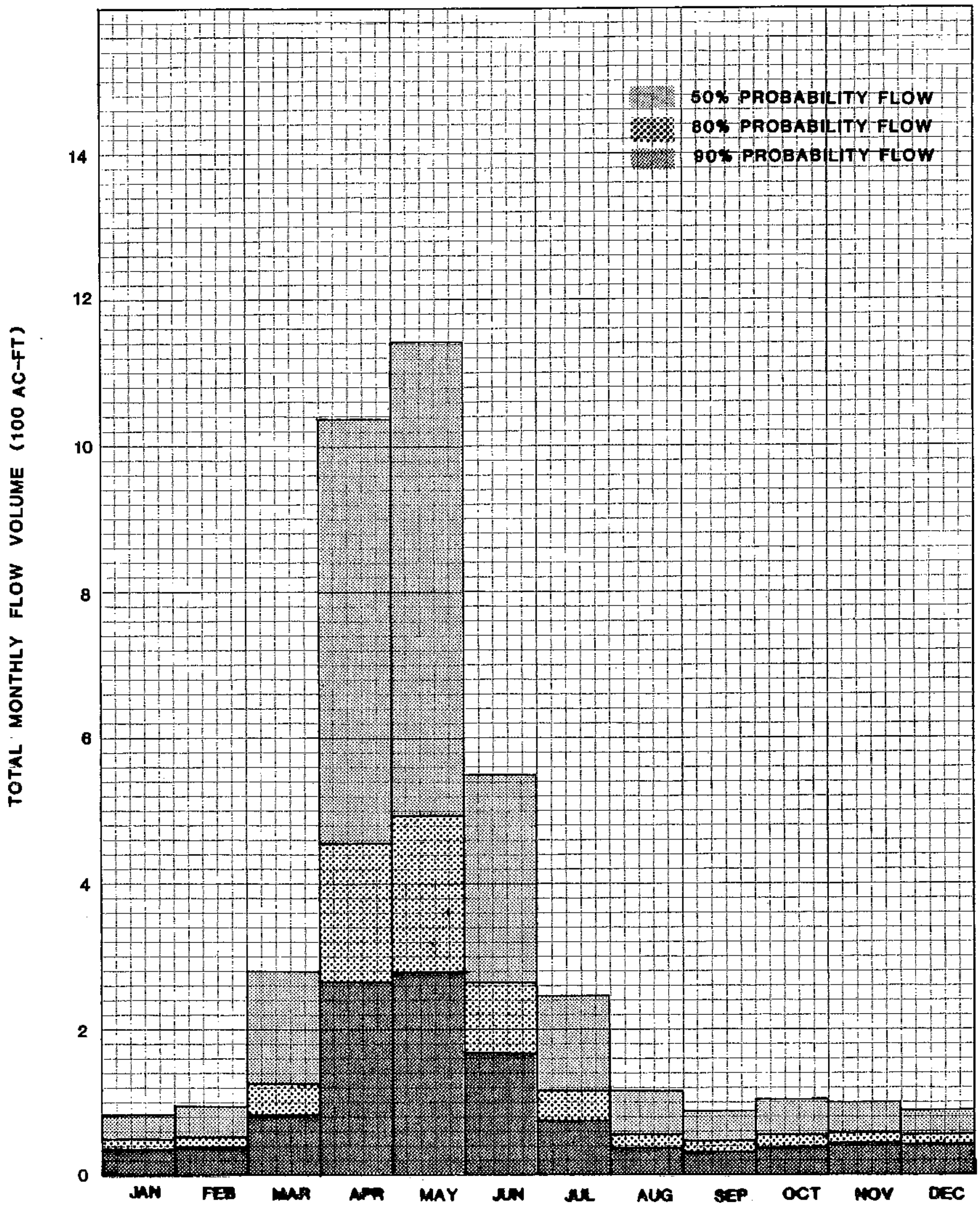
The Mount Olivet Cemetery diverts water from Emigration Creek for irrigaion. The water is diverted from the creek near Hogle Zoo and is transported through the Mount Olivet Ditch to a reservoir near the cemetery. The water is pumped from the reservoir into the cemetery sprinkling system.(89)

The Metropolitan Water District of Salt Lake City has filed on surplus flood flows which may be diverted to the proposed Little Dell Lake Project.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL FREQUENCY CURVE



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

EMIGRATION CREEK

FIGURE V-7

TABLE V-5
EMIGRATION CREEK FLOW ESTIMATE*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)					
	90% Probability	90% Confidence Limits	80% Probability	90% Confidence Limits	50% Probability	90% Confidence Limits
January	37	31 - 42	50	43 - 57	83	74 - 93
February	39	32 - 46	52	43 - 61	94	82 - 107
March	82	63 - 101	126	99 - 154	280	235 - 333
April	264	206 - 324	454	360 - 553	1,039	877 - 1231
May	279	216 - 344	492	389 - 601	1,143	962 - 1358
June	169	136 - 202	266	217 - 316	550	464 - 638
July	72	57 - 87	115	93 - 138	243	208 - 284
August	37	29 - 45	56	45 - 68	118	100 - 139
September	30	24 - 36	44	36 - 52	88	76 - 102
October	38	31 - 45	54	45 - 63	102	89 - 117
November	42	35 - 48	58	49 - 66	100	89 - 112
December	41	35 - 47	54	47 - 61	88	79 - 98
Annual Sum	1,130		1,821		3,928	
Annual Yield Estimate	1,287	1,034 - 1,540	2,160	1,763 - 2,565	4,439	3,827 - 5,149
Deviation**	12.2%		15.7%		11.5%	

*From the 1901-1980 period of streamflow records at the SLC gaging station near Hogle Zoo.
**Assuming the annual estimate to be the most correct.

PARLEYS CANYON:

Physical Description: Parleys Canyon is the largest mountain drainage area in Salt Lake County with an area above the canyon mouth of 50.1 square miles. It also differs physically from the other canyons as it has a tee shape, with Mountain Dell Canyon and Lambs Canyon forming the north and south tee bar ends, respectively.

The elevation range of Parleys Canyon is 4700 feet to 9400 feet, with much of the canyon area lying at a mid-elevation level. Where Mountain Dell Canyon and Lambs Canyon join Parleys Canyon there exists an open valley area surrounded by rolling foothills and moderate mountain slopes.

Mountain Dell Canyon has steep slopes and a narrow drainage way in the upper half. However, the lower area near Parleys Canyon is more open and surrounded by moderate slopes. Mountain Dell Reservoir is located where Mountain Dell Canyon enters Parleys Canyon approximately 5.2 miles from the mouth of Parleys Canyon. Lambs Canyon is consistent throughout its length with moderate to steep side slopes and a fairly abrupt opening to Parleys Canyon. From the large basin area down to the mouth, Parleys Canyon becomes narrower with steeper side slopes.

Most of the canyon drainage area has a limestone substrata with sandstone and shale formations found near the canyon mouth. The primary soils tend to be well-drained, deep to shallow and allow rapid runoff.

The terrain in the three miles from the mouth of the canyon to where the stream enters the storm drain has been altered drastically due to the construction of the I-80 Freeway, Salt Lake Country Club Golf Course and Sugarhouse Park. This area consists of lake terrace alluvial deposits which are cobbly, very well drained and runoff is moderate. Vegetation in the high mountain peaks is mostly conifer and aspen. Slope vegetation in the lower canyon drainage area consists of scrub oak, and various grasses, with birch, willow, hawthorne and grasses as the principle streamside vegetation except where disturbance by urbanization has occurred.[60]

The upper basin area has some moderate trout populations. Below Mountain Dell Reservoir, there are none. Wildlife in the canyon is similar to most other mid-elevation canyons with Rocky Mountain Mule Deer, Yellow Haired Porcupine, Snowshoe Rabbit and various species of small mammals and birds present.

In the upper area of Parleys, Lambs and Mountain Dell Canyons there is intensive use for recreation, and transportation. As a major transportation artery for Salt Lake City, six lanes of I-80 follow the entire length of the Canyon. Recreation includes picnicking, golf, hiking, and cross country skiing. Much of the canyon is in public ownership and is managed as a municipal watershed.

Average precipitation in the upper drainage area of the three canyons, ranges from 20 to 25 inches per year. The lower elevations have a normal annual rainfall of 16 inches. Snowpack is moderate, with much of it occurring in the Mountain Dell and Lambs Canyon areas.

The stream flow from Lambs Canyon originates from numerous springs as well as surface runoff. It joins Parleys Creek two miles upstream from Mountain Dell Reservoir. Alexander Creek enters Parleys Creek a mile downstream while Dell Creek flows directly into the reservoir. These two tributaries also rely upon springs for much of their stream flow.

From the reservoir down to Sugarhouse Park, the creek is severely channelized. Much of this channel has been replaced by culverts down to the canyon mouth where it again becomes an open channel. This channel continues through the Salt Lake Country Club Golf Course and finally into a detention basin at Sugarhouse Park. This basin drains into the Salt Lake City storm drain system, which connects to the 1300 South conduit and ultimately drains to the Jordan River.

<u>Existing Facilities</u>: Just below Mountain Dell Reservoir is the Parleys Water Treatment Plant. These two facilities supply water to Salt Lake City via the Mountain Dell Conduit, a 30-inch concrete-lined steel pipe that can deliver water to the East Bench high-level tanks. The pipeline terminates at Suicide Rock at the mouth of the canyon where the flow is transported by other conduits to the distribution system.[7]

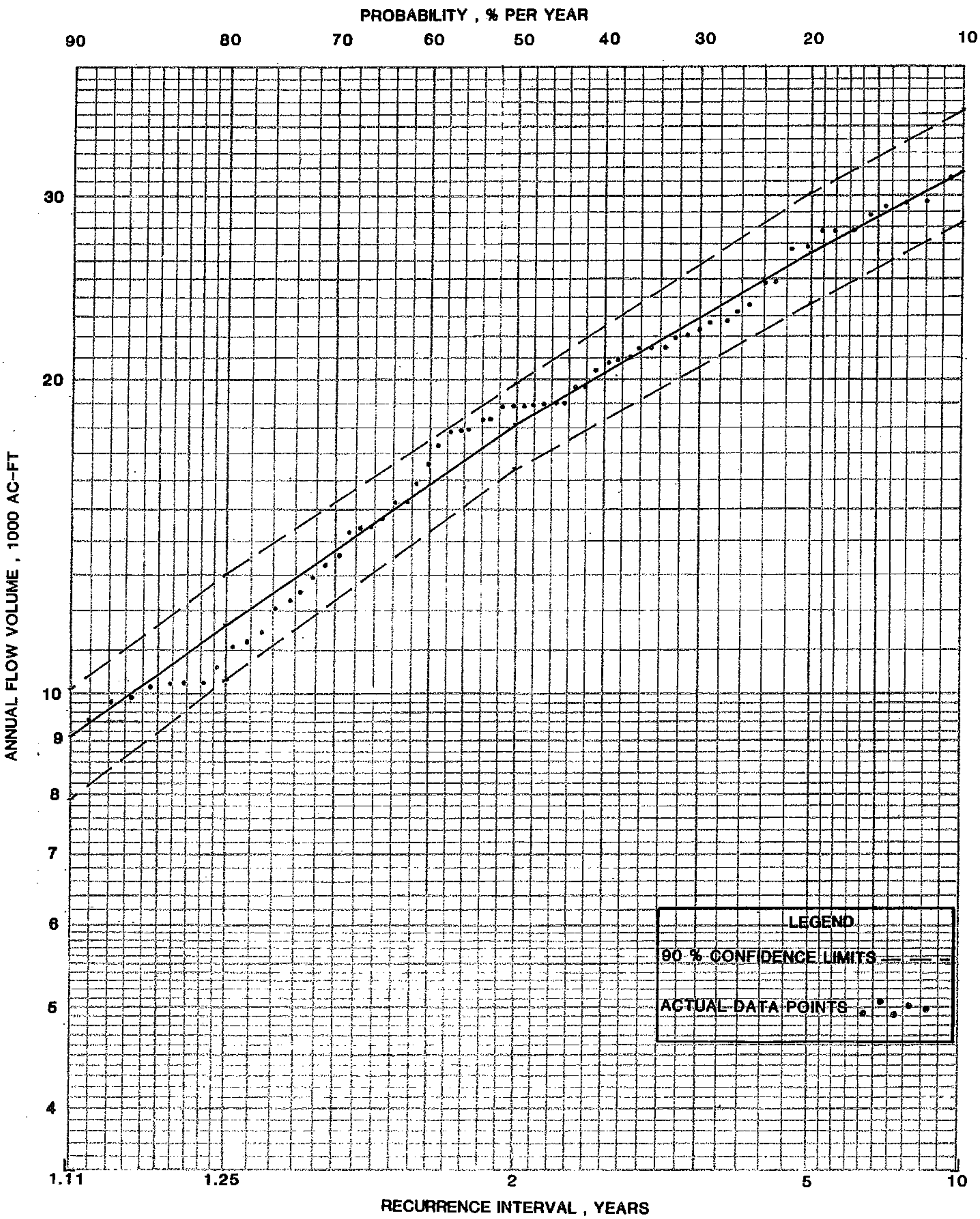
Mountain Dell Reservoir has a capacity of about 3200 acre-feet with a detention time of 63 days.[30] The dam was built in 1917 and raised to its present height in 1925.

The water treatment plant was built in 1965 and uses the Mountain Dell Conduit that was built prior to that time. The plant design capacity is 40 mgd and the conduit capacity is 32 mgd.

Hydrologic Characteristics: Parleys Creek reaches its peak flows fairly early in the season. Its average peak date is May 12. This is due, in part, to the low elevation range of the canyon and to its wideness. However, the south ridges bounding the watershed are 800 to 1000 feet higher than the north ridges, minimizing the radiation energy from the sun on the snowpacks of both slopes. This delays the seasonal peak flows from the earlier date on which they would occur in a more evenly distributed watershed.

Despite the shading effect of the south ridges and the Mountain Dell Reservoir flood attentuation capabilities, dramatic stream flow fluctuations occur at the canyon mouth. Flows commonly increase tenfold within a matter of days, usually during June.[78] However, the maximum flows seldom exceed 200 cfs. The main source of these flows is snowmelt. (83,84)

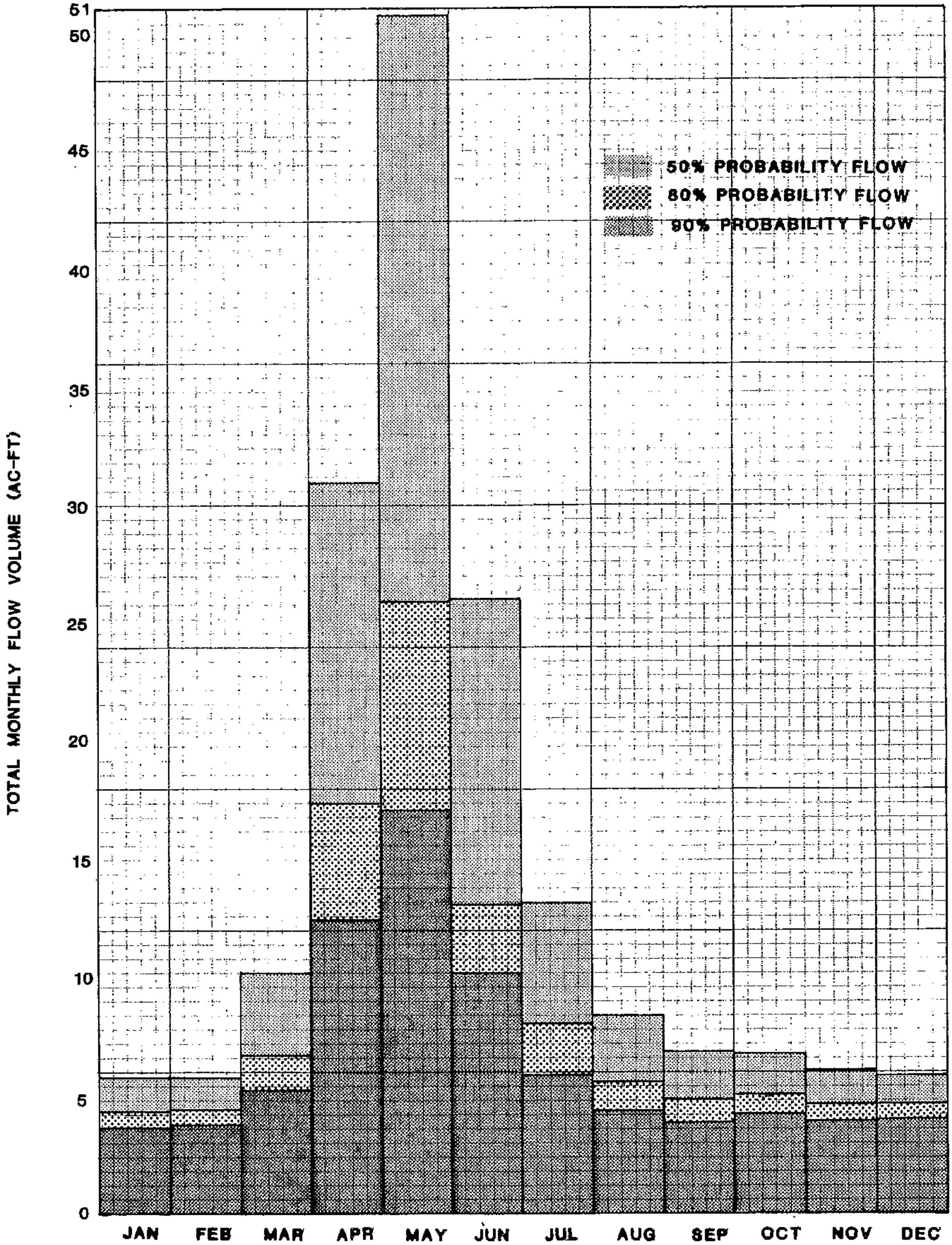
Frequency analyses of annual and monthly yields from Parleys Canyon, as recorded by the Salt Lake City Water Department from 1899-1980, were performed. The monthly flows were adjusted for diversions and change in reservoir storage to reflect natural flow amounts at the canyon mouth. An annual yield frequency curve is shown in Figure V-8. Monthly yield estimates for probabilities of 90 percent, 80 percent and 50 percent are displayed graphically in Figure V-9, and are tabulated in Table V-6. A further breakdown in flow estimates on a daily basis is included in Appendix E as flow-duration tables for each month. However, these values cannot be compared directly to the frequency analysis values without correlation because they are based only on the records from 1912 and 1913.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL FREQUENCY CURVE

PARLEYS CREEK



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

PARLEYS CREEK

FIGURE V-9

TABLE V-6
PARLEYS CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)					
	90% Probability	90% Confidence Limits	80% Probability	90% Confidence Limits	50% Probability	90% Confidence Limits
January	375	342 - 405	434	398 - 467	573	538 - 610
February	383	351 - 412	440	405 - 472	573	540 - 608
March	537	466 - 603	671	588 - 750	1027	933 - 1131
April	1248	1040 - 1449	1740	1470 - 2007	3093	2734 - 3499
May	1707	1393 - 2017	2599	2152 - 3049	5068	4415 - 5818
June	1016	830 - 1199	1305	1082 - 1529	2590	2259 - 2970
July	591	508 - 670	804	698 - 906	1311	1183 - 1453
August	435	383 - 483	556	494 - 615	840	770 - 916
September	390	350 - 426	483	437 - 525	685	637 - 736
October	426	387 - 461	504	461 - 543	680	637 - 726
November	399	366 - 429	465	429 - 498	610	575 - 647
December	406	376 - 433	461	429 - 490	586	556 - 618
Annual Sum	7913		10,462		17,636	
Annual Yield Estimate	9090	7922 - 10,177	11,705	10,302 - 13,041	18,131	16,516 - 19,904
Deviation**	12.9%		10.6%		2.7%	

*From the 1899 - 1980 period of streamflow records at the Salt Lake City canyon mouth gaging station.
**Assuming the annual estimate to be the most correct.

Water Users: Salt Lake City has a right to 100 percent of the flows in Parleys Creek. By cooperative agreement the Metropolitan Water District of Salt Lake City filed on any excess flows that could not be used by Salt Lake City.

Salt Lake City's water is drawn from Mountain Dell Reservoir and treated in the Parleys Water Treatment Plant. The city also uses water from Parleys Creek for the Parleys Exchange area and this water is also used for the Country Club Golf Course. Table V-7 shows the stream flow that was treated during 1977-81.

TABLE V-7

PARLEYS CREEK STREAM FLOWS AND DIVERSIONS

	1977					1978					1979					1980					1981				
	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Flow into Reservoir (Ac-Ft)	Bypass @ Treatment Plant (Ac-Ft)	Treatment Plant Production (Ac-Ft)	% of Available Flow Treated (%)	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Flow into Reservoir (Ac-Ft)	Bypass @ Treatment Plant (Ac-Ft)	Treatment Plant Production (Ac-Ft)	% of Available Flow Treated (%)	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Flow into Storage (Ac-Ft)	Bypass @ Treatment Plant (Ac-Ft)	Treatment Plant Production (Ac-Ft)	% of Flow Available Treated (%)	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Flow into Storage (Ac-Ft)	Bypass @ Treatment Plant (Ac-Ft)	Treatment Plant Production (Ac-Ft)	% of Available Flow Treated (%)	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Flow into Storage (Ac-Ft)	Bypass @ Treatment Plant (Ac-Ft)	Treatment Plant Production (Ac-Ft)	% of Flow Availab Treate (%)
y	250	277	0	339	149	259	287	0	834	291	169	447	0	1270	284	183	435	0	5	1	196	349	0	508	146
ry	287	260	0	49	19	368	266	0	883	332	224	332	0	798	240	331	493	0	263	53	149	337	0	0	0
	187	310	0	0	0	2015	1556	913	875	56	1259	591	925	619	105	1445	672	1163	321	48	197	452	0	0	0
	251	549	0	52	9	7512	4438	4502	1186	26	2832	2139	1682	371	17	3683	3386	2533	1355	40	283	1191	0	588	49
	562	860	196	0	0	7325	6781	4576	1239	18	1087	3564	426	939	26	4165	5039	2609	796	16	2130	1822	717	9	0
	367	596	62	534	90	2841	3563	1628	1892	53	400	1403	31	1865	133	1150	2447	467	2103	86	930	1214	479	926	76
	178	347	0	347	100	320	1436	0	2050	143	335	687	0	1499	218	206	1158	0	1649	142	265	508	0	1134	223
	220	194	0	724	373	238	704	0	1102	157	240	465	0	1095	235	182	588	0	1421	242	267	248	0	1136	458
ber	295	210	0	1126	536	297	546	0	384	70	340	228	0	1407	617	123	465	0	915	197	275	266	0	808	304
.	296	284	0	847	298	234	495	0	1097	222	241	292	0	613	210	195	452	0	931	206	309	394	0	640	162
r	126	282	0	218	77	229	464	0	843	182	88	336	0	671	200	257	417	0	599	144	318	364	0	1003	276
r	233	294	0	540	184	268	439	0	505	115	211	337	0	116	34	296	398	0	727	183	354	369	0	704	181
	3,252	4,363	258	4,776	109	21,906	21,025	11,619	12,890	61	7,426	10,821	3,064	11,263	104	12,216	15,950	6792	11,085	69	5,673	7534	1196	7456	99

MILL CREEK CANYON:

Physical Description: From the headwaters area of Mill Creek Canyon to the canyon mouth there are 18.0 square miles of drainage area. Below the canyon mouth to the Jordan River there are 19.0 square miles of drainage area resulting in a total drainage area for Mill Creek of 37.0 square miles.

Ten miles upstream from the canyon mouth, at an elevation of about 8700 feet, exists an open valley area which is the headwaters area for Mill Creek Canyon. The valley is bordered on the north and south by steep mountain slopes and to the east by a low ridge. Below this valley area the canyon floor becomes narrower bordered by moderately steep side slopes. The surrounding mountain ridges range from 8000 to 9000 feet with one exception, Gobblers Knob, reaching 10,200 feet. The gradient for most of the canyon length is moderate with occasional flat and steep sections.

The Mill Creek drainage area downstream of the mouth is characterized by an east bench sloping strongly westward. This eventually gives way to the gradual slopes of the valley floor terminating in the flood plain of the Jordan River.

The canyon geologic profile is composed of quartzite on the south slopes, shale to the north and limestone deposits in the headwater region.(61) Soils are strongly sloping, well drained and range from deep to shallow with considerable rock outcropping.

The valley portion of Mill Creek drainage area is essentially composed of lake bed deposits with soils ranging from well-drained lake terraces to the east, to poorly drained flood plain deposits near the Jordan River. Runoff is highly variable in this portion.

The lower elevation areas of the canyon are characterized by oak and aspen on the slopes and box elder, birch, dogwood, maple, willow and grasses along the stream. However, the banks are damaged or denuded in many of the numerous picnic areas.(60) Conifers and aspen cover the slopes in the higher elevations with White and Douglas Fir, dogwood, cow parsnip and grasses along the stream banks. This upper area is in excellent condition whereas the lower area has been used extensively thus causing significant damage in various places.

Cutthroat and Rainbow Trout are present in lower Mill Creek due to both natural reproduction and planting. Rainbow Trout are found in modest populations in the upper reaches of Mill Creek. Because the canyon sees heavy use, wildlife is scarce in the lower areas near picnic sites. Inhabitants of the canyon include deer, rabbit, raccoon, skunk, and small mammals and birds. Below the canyon mouth there has been heavy urbanization thus the natural habitat has been almost entirely displaced.

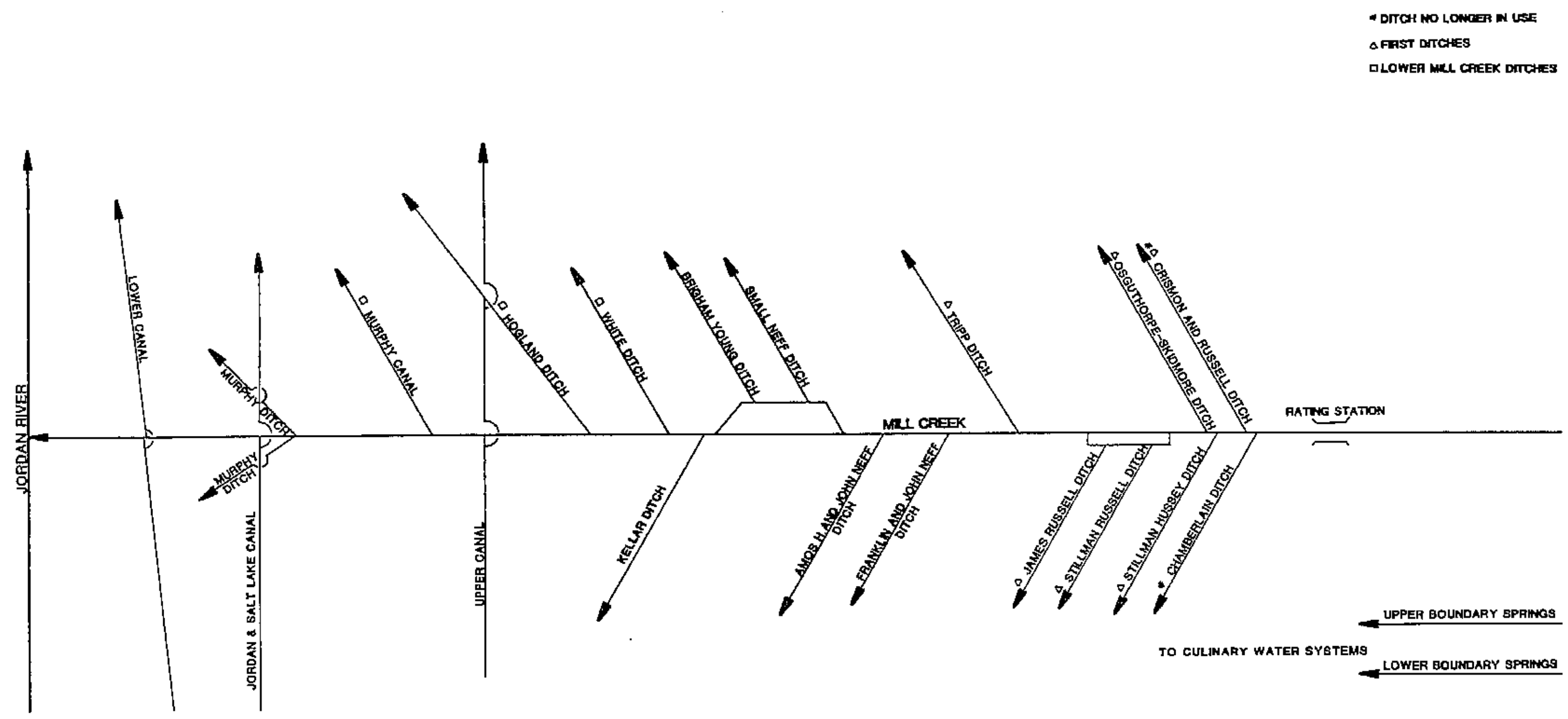
Land use for the canyon includes heavy summer recreational, some winter recreational and a limited amount of summer residential uses. Picnicking is the primary summer use with over 1900 designated picnic spaces in numerous picnic sites available.(37) The use in the valley portion of the drainage area is primarily residential with some commercial development along the east bench. This gives way to a greater percentage of commerical and industrial uses as it nears the Jordan River.

In the headwaters area and mountain ridges of Mill Creek Canyon the precipitation is 30 to 35 inches per year with snowpack being fairly heavy.(83) The creek originates as three short tributaries which join together in the high valley area. From here the stream flows approximately five miles without major tributaries adding any stream flow. At this point, however, two streams, Porter Fork and Bowman Fork Creeks, join together and then flow into Mill Creek from the south. Except for the headwaters area the stream gradient remains fairly constant at a gradual slope.

As the stream leaves the canyon it flows for about six miles through mostly residential area before entering heavily urbanized South Salt Lake. At this point, the stream starts to meander for about a mile until it enters a channel which takes it to the Jordan River.

<u>Existing Facilities</u>: There are many irrigation ditch diversions on Mill Creek. These are shown schematically in Figure V-10.

Mill Creek has three gaging stations. Each station has a water-stage recorder. The first station is located 100 ft. upstream from Elbow Fork. The gage near the mouth of the canyon is approximately 0.7 of a mile east of Wasatch Boulevard. The last station is about 2.5 miles downstream from the mouth of the canyon. A propeller-type totalizing meter has also been installed in the line from the Boundary Springs. The



SALT LAKE COUNTY AREA-WIDE WATER STUDY

SCHEMATIC OF MILL CREEK

FIGURE V-10

adjusted natural flow from the canyon is the sum of the flows from the springs and the creek just east of Wasatch Boulevard.[78]

The Boundary Springs are located about 1,500 feet upstream from the Mill Creek gaging station at the mouth of the canyon. There are two areas of springs which are known as the Upper and Lower Boundary Springs. The Lower Boundary Spring have been developed by the Boundary Springs Water Users Association. Two 12-inch corrugated metal pipes approximately 70 feet long have been extended into the spring. The pipes are covered with layers of gravel and clay and a sheet of plastic to prevent surface runoff contamination. A pipe conveys the water to the mouth of the canyon.[65] The Upper Boundary Spring has been developed by Salt Lake City.

Hydrologic Characteristics: Mill Creek normally peaks fairly late in the season, its average peak date being May 27. This is mainly attributable to the steepness of the canyon side slopes and the fact that the south ridge bounding the watershed is 1000 to 1800 feet higher than the north ridge. Also, elevations on the south ridge extend to about 10,000 feet, which also contributes to a late peak date due to late snow-pack melting.

A major hydrologic characteristic of Mill Creek Canyon is the uniformity of stream flows at its mouth. The stream flows do not fluctuate dramatically, as do many other Wasatch streams, but vary gradually. Flood peaks from snowmelt in the upper reaches of the water-shed are greatly attenuated by the time they reach the canyon mouth.[34,44] This is mainly due to the "shading" effect of the steep, high south ridges of the watershed on the snowpack. Because of this shading, radiation energy from direct snowpack exposure to the sun is limited, and snowmelt takes place mainly due to heat transfer from the atmosphere by convection.[68]

Snowmelt is the major component of Mill Creek stream flows through-out the year, although in the fall and winter months the watershed subsurface aquifer, recharged by spring snowmelt, contributes most of the flow.[44] This flow is generated from springs and seeps above Elbow Fork. Rainfall runoff contributes relatively little volume to the annual watershed yield.[83,84]

A frequency analysis of annual and monthly yields at the canyon mouth for the 1899-1980 period of record was performed. The resulting average annual yield estimate from Mill Creek is 10,762 acre-feet. An annual yield frequency curve is shown in Figure V-11.

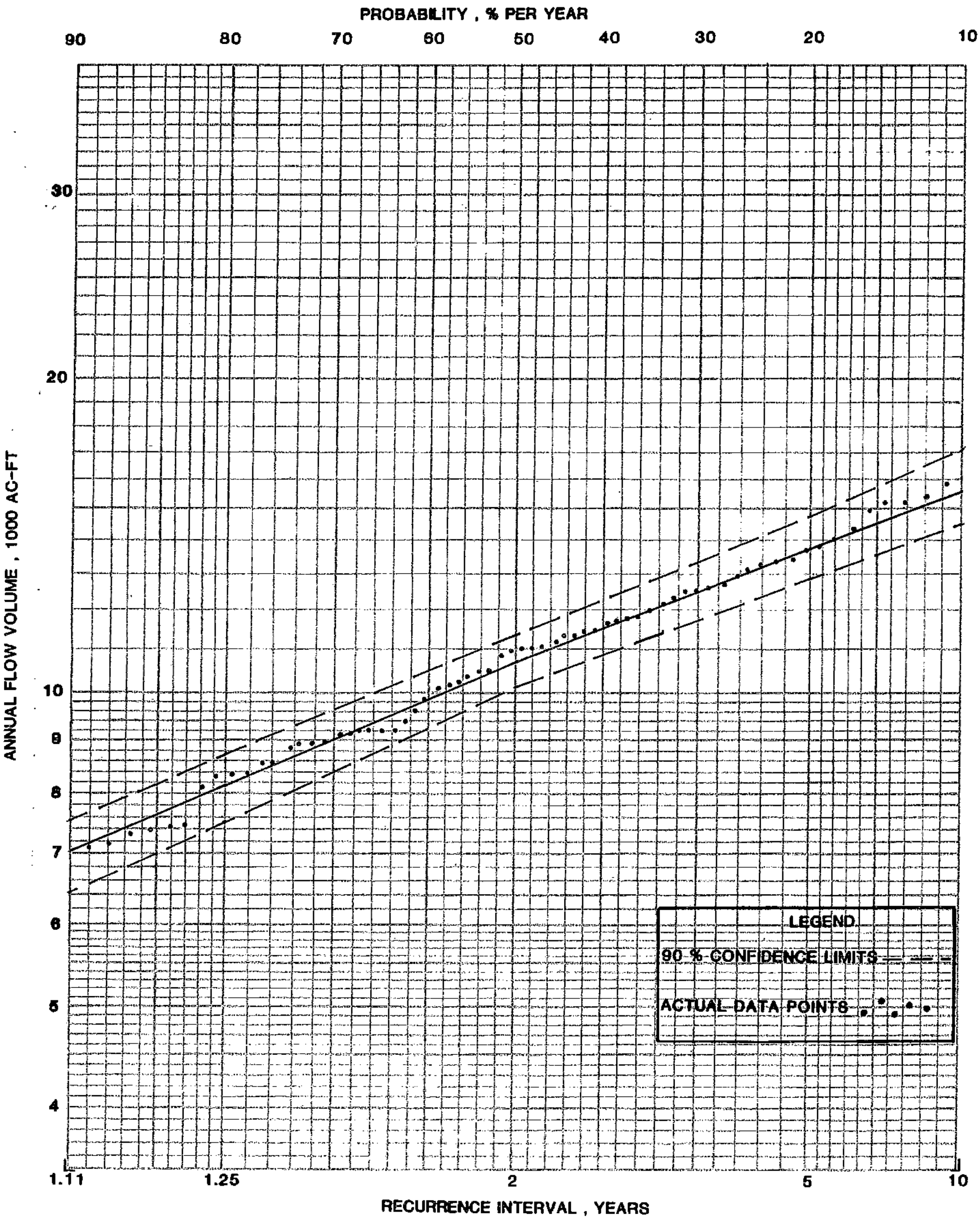
Monthly yield estimates are displayed graphically in Figure V-12, and are tabulated in Table V-8. A further breakdown of flows on a daily basis is included in Appendix E as flow-duration tables for each month. However, these values cannot be compared directly to the frequency analysis values because they only represent stream flows recorded during 1963-1967 and 1979.

Water Users: The stream flow is diverted into irrigation ditches for watering lawns and gardens. Salt Lake City has obtained rights to a large portion of the stream flow through exchange agreements with the irrigation companies. These exchange agreements are summarized in Table V-9. The City is currently not utilizing the creek water from these exchange agreements. The Utah Lake water is not yet being supplied except to the lower Mill Creek water users through the Upper Canal.

The Lower Boundary Spring supplies water to about 40 families. The water is used for culinary purposes, livestock watering and lawn and garden watering. Salt Lake City has rights to about 40 percent of the flow from the spring and has leased some of the remaining flow from the individual owners. The City's share is used directly in their distribution system.

The Upper Boundary Spring water is totally controlled by Salt Lake City. However, the Boundary Springs Water Users Association has a right to some of the water if the Lower Boundary Spring does not produce a sufficient quantity to supply the needs of the users. This water is also used directly in the City's distribution system.

The Metropolitan Water District of Salt Lake City has filed on any excess flows in the creek that Salt Lake City can not use.

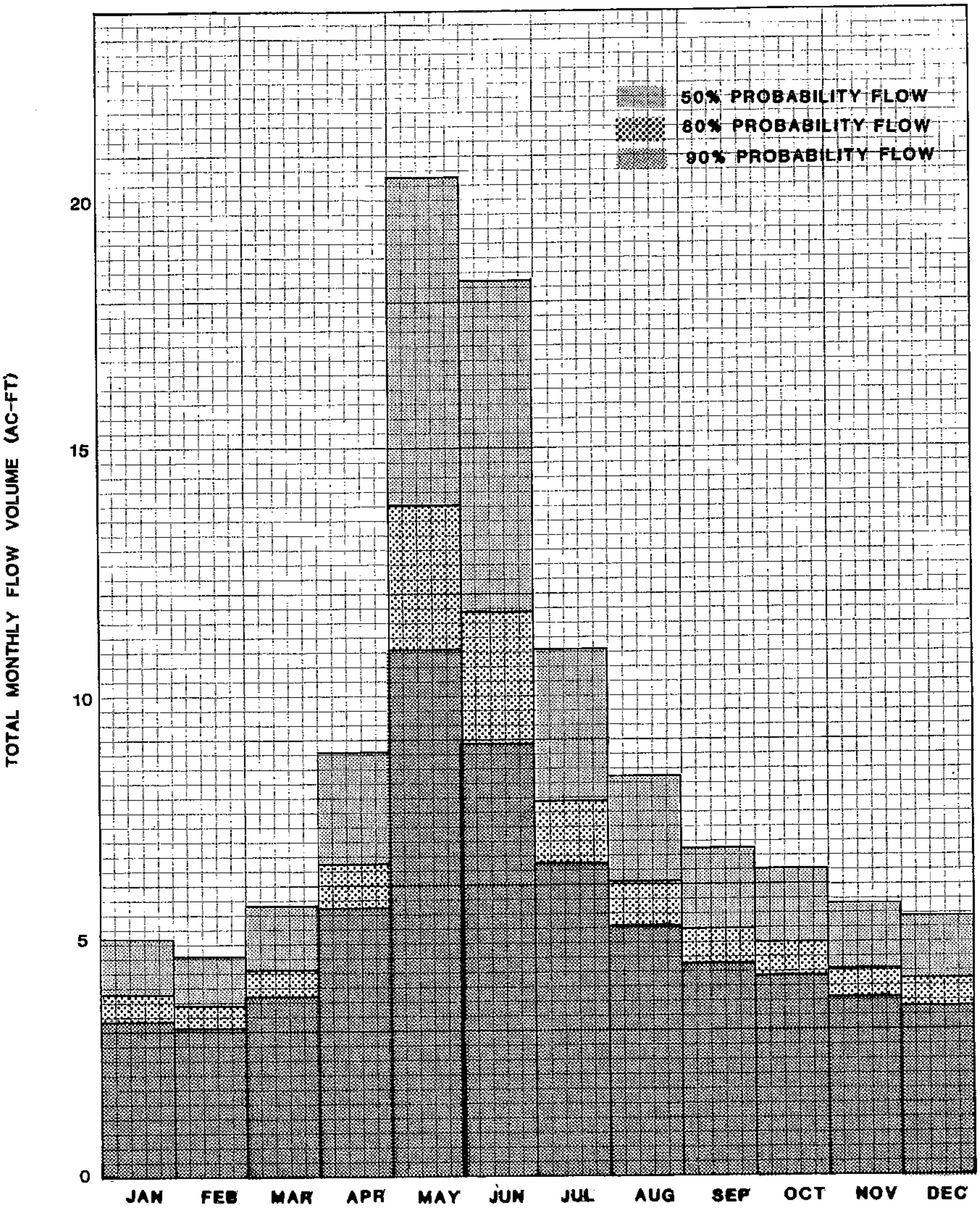


SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL FREQUENCY CURVE

MILL CREEK

FIGURE V-11



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

MILL CREEK

FIGURE V-12

TABLE V-8
MILL CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)					
	90% Probability	90% Confidence Limits	80% Probability	90% Confidence Limits	50% Probability	90% Confidence Limits
January	325	298 - 349	376	347 - 402	490	462 - 519
February	310	285 - 332	355	329 - 379	457	432 - 483
March	373	340 - 402	427	392 - 459	559	525 - 595
April	553	497 - 604	643	582 - 700	875	813 - 941
May	1086	961 - 1201	1381	1232 - 1521	2058	1893 - 2237
June	891	771 - 1004	1162	1016 - 1302	1843	1670 - 2033
July	634	570 - 692	772	699 - 839	1084	1009 - 1165
August	512	465 - 554	608	556 - 656	822	770 - 877
September	437	399 - 471	508	467 - 545	565	532 - 600
October	411	377 - 442	480	443 - 514	632	596 - 671
November	366	335 - 394	428	394 - 459	565	532 - 600
December	349	320 - 375	406	375 - 434	532	502 - 564
Annual Sum	6247		7546		10,588	
Annual Yield Estimate	7019	6428 - 7545	8178	7537 - 8763	10,762	10,139 - 11,424
Deviation**	11.0%		7.7%		1.6%	

*From the 1899-1980 period of streamflow records at the Salt Lake City canyon mouth gaging station.
**Assuming the annual estimate to be the most current

TABLE V-9

WATER RIGHTS FOR MILL CREEK

DITCH	NON-IRRIGATION SEASON 0 to 1.88 cfs (%)	NON-IRRIGATION SEASON 1.88 to 29.03 cfs (%)	NON-IRRIGATION SEASON 29.03 to 41.93 cfs (%)	NON-IRRIGATION SEASON above 41.93 cfs (%)	IRRIGATION SEASON 0 to 1.88 cfs (%)	IRRIGATION SEASON 1.88 to 29.03 cfs (%)	IRRIGATION SEASON 29.03 to 41.93 cfs (%)	IRRIGATION SEASON above 41.93 cfs (%)
Franklin & John Neff (a)	0	4.43	7.45	6.04	0	4.43	7.45	6.04
Amos H.Neff (a)	0	5.74	6.55	5.88	0	5.74	6.55	5.88
Brigham Young (a)	0	22.95	22.32	17.94	0	22.95	22.32	17.94
Hoagland & Murphy (a)(b)	0	41.67	35.24	28.32	0	41.67	35.24	28.32
White (c)	0	8.33	8.81	7.08	0	8.33	8.81	7.08
First Ditches		9.83	13.05	29.46		9.83	13.05	29.46
Kellar		7.05	6.58	5.28		7.05	6.58	5.28

(a) Culinary water required for exchange is 450 gallons per day per acre with a daily maximum of 288,000 gallons per day from April 1 to October 1. 225 gallons per day per acre is required from October 1 to April 1.

(b) From April 15 to October 15 deduct 11.65% from the Hoagland and Murphy Ditches to get the City's share.

(c) Culinary water required for exchange is a maximum of 144,000 gallons per day.

NEFFS CANYON:

Physical Description: Neffs Canyon has a drainage area of 3.5 square miles and ranges in elevation from 5600 to 9000 feet with an average elevation of 7800 feet.(87) This canyon's stream flow is essentially the combination of two distinct drainage areas, Neffs Canyon and North Fork. The headwaters of both drainage areas are at approximately 8600 feet.

Slopes in this canyon are steep with very steep cliffs at the base of Mount Olympus to the south and in the upper headwaters area to the east. Slopes lessen slightly below these cliffs in the upper areas.

Limestone, shale, quartzite and some glacial till make up the geologic structure of Neffs Canyon.(61) Soils are deep to shallow, well drained with significant rock outcropping. Runoff is generally rapid.

Scrub oak and brush type vegetation exists throughout most of this canyon. However, there are extensive areas of rock outcropping with no vegetation growth at all. Wildlife in this canyon is probably more scarce due to the close proximity of the Mount Olympus Cove residential subdivision. Land use is limited to watershed and wildlife habitat with extensive residential development at the canyon mouth. Some recreational activities may occur in the summer.

Precipitation in this canyon reaches a high of 45 inches with snowpack being heavy in the upper areas. Along with surface runoff as a source, springs and seeps add a substantial amount of water to the stream flow. Two of the larger springs are Neffs Spring and Mount Olympus Spring.

Several separate flows contribute to the mainstream flow with the largest, North Fork Creek, entering the drainage way very near the canyon mouth. The stream gradient ranges from moderate to very steep in various parts of the canyon. Drainage ways in Neffs Canyon are well-defined while the North Fork drainage ways are vague. The total length of the longest and most identifiable stream channel is approximately three miles. At the canyon mouth the surface flow enters the Canyon Cove residential subdivision storm drain.

Existing Facilities: Salt Lake City has constructed a concrete box to collect water from Mount Olympus Spring. The water is collected below the surface by a pipe extended into the mountain. From the box, the water is piped to a 640,000 gallon reservoir. The water is chlorinated prior to entering the reservoir. Mount Olympus Water Company buys water from Salt Lake City and has a two-inch connection on the pipeline for filling their trucks.

The surface runoff from the canyon is diverted into the Canyon Cove storm drain system which discharges into Big Cottonwood Creek.

Hydrologic Characteristics: Neffs Canyon Creek is an ephemeral stream at the canyon mouth that rarely flows for more than a month.[34] Most of the water yield from Neffs Canyon emerges as springs. Neffs Spring is intermittent and Mount Olympus Spring is perennial.[34] Casto Springs, Dry Creek Spring, and Spring Creek are also supplied from the Neffs Canyon watershed[1]. These three springs are further discussed in the section on Big Cottonwood Canyon.

No continuous flow record is available for Neffs Canyon Creek. However, the USGS has published two instantaneous measurements downstream from the canyon mouth as follows:[78]

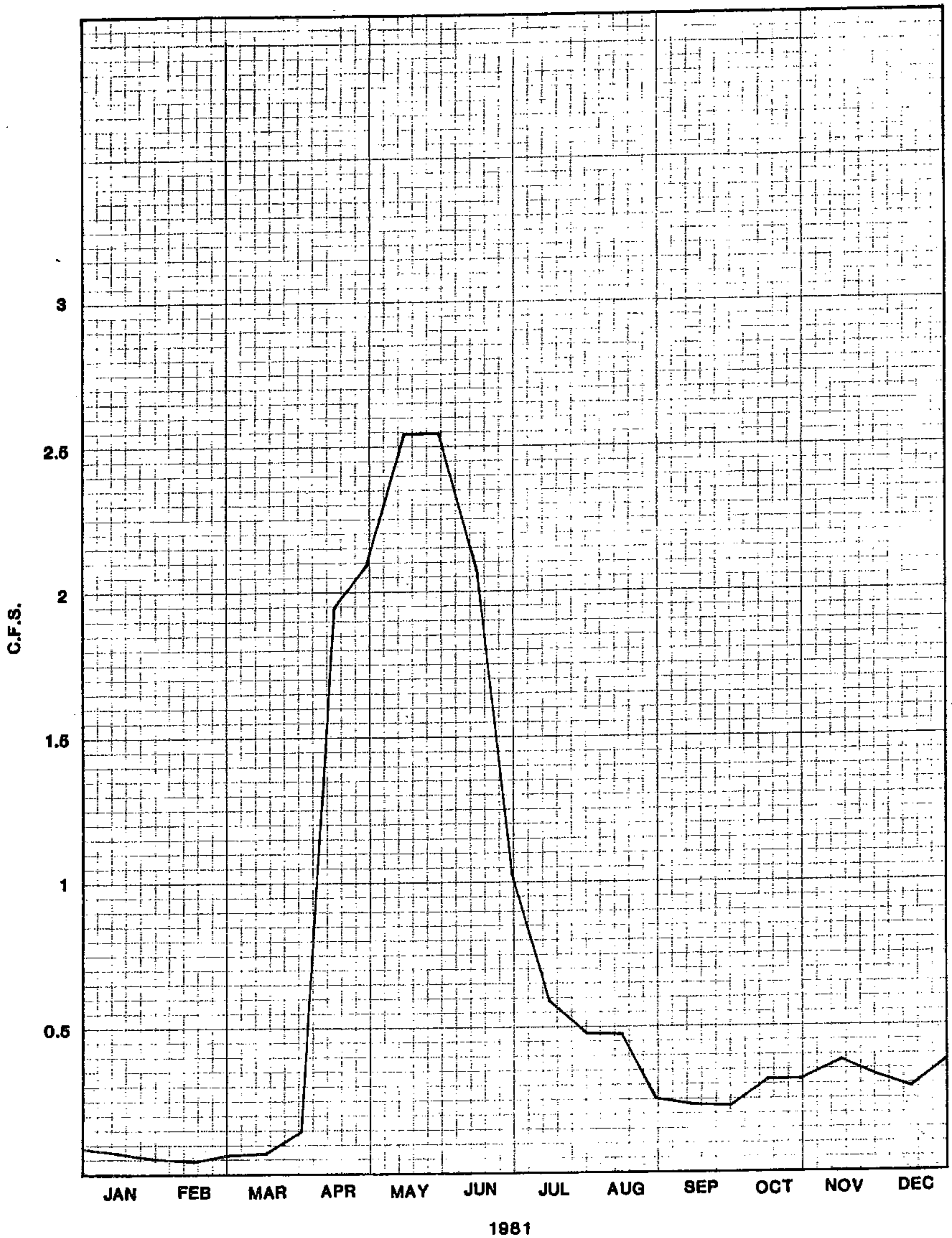
May 22, 1964 ----- 6.3 cfs

June 18, 1965 ---- 0.1 cfs

Continuous measurements for Mount Olympus Spring are available from the Salt Lake City Water Department. The estimated peak flow from the spring is four mgd. However, due to an insufficient intake box capacity at the spring, records do not represent the total spring flow. The 1981 pipe flow record is shown graphically in Figure V-13.

An annual yield estimate for Neffs Canyon Creek was made by correlation with Little Cottonwood Canyon. This annual yield estimate was then extrapolated to monthly values of several probabilities, based on the Little Cottonwood Creek flow pattern. Only the May yield estimate is shown, since the surface flow is negligible during April and June. These May estimates may be too high, since the recharge rate is relatively high in Neffs Canyon. The estimates should be used with caution, since their accuracy cannot be verified by continuous measurements. Flow estimates are shown in Figure V-14 and Table V-10.

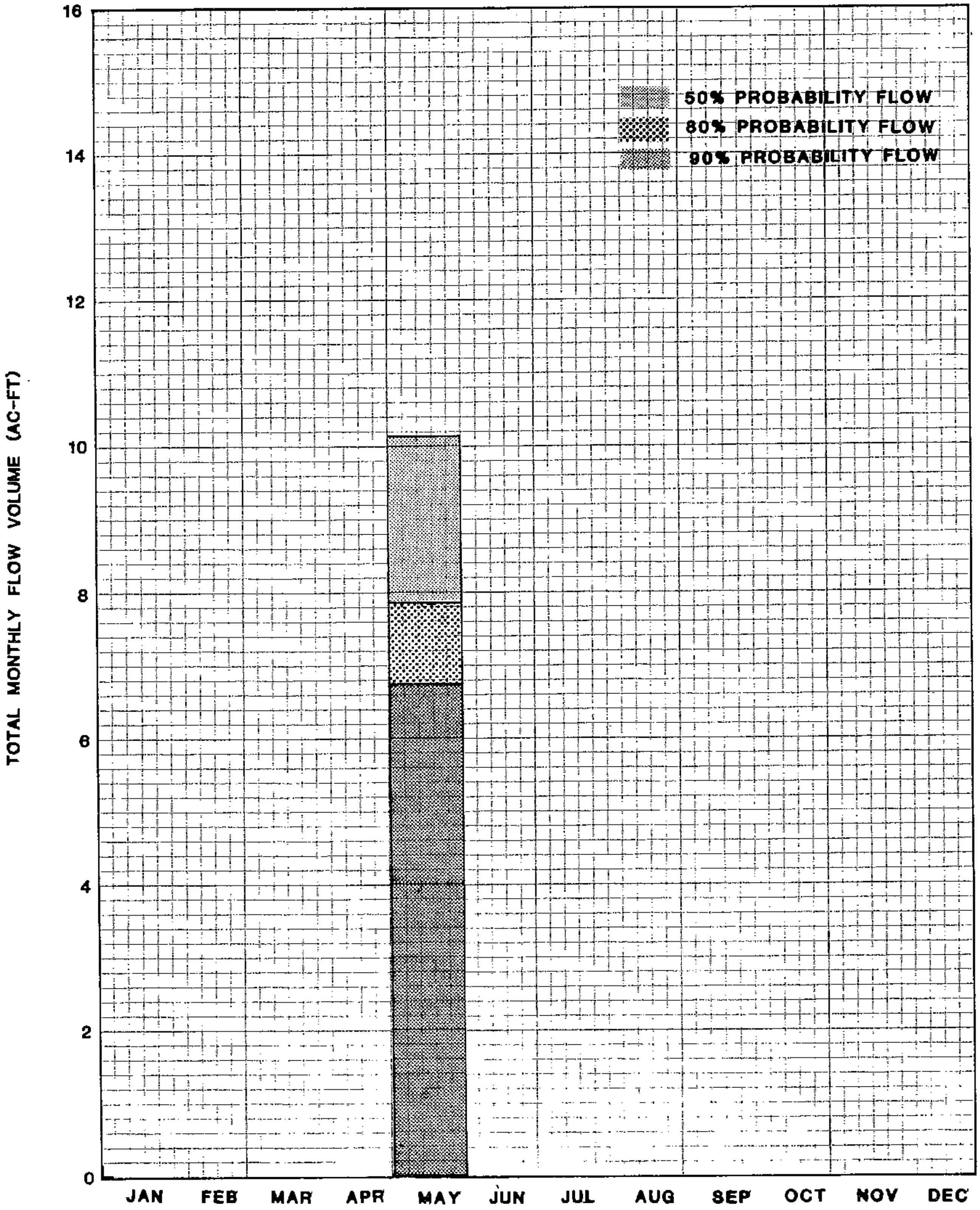
The surface flow estimates in Table V-10 are not meant to reflect the entire watershed yield. In reality, most of the yield emerges from Springs. The Mount Olympus Spring flow shown in Figure V-13 is included only to demonstrate the seasonal flow fluctuations, since the actual spring yield from Neffs Canyon is much greater than that shown.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

1981 ANNUAL HYDROGRAPH – OLYMPUS SPRINGS

FIGURE V-13



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

NEFFS CANYON CREEK

FIGURE V-14

Water Users: Salt Lake City owns the entire water right to Mount Olympus Spring and the water is placed into the City's distribution system. Mount Olympus Water Company uses some of the water for their bottled water. Currently, the surface runoff from the canyon is not being utilized. Casto Springs, Dry Creek Springs, and Spring Creek water users are discussed in the Big Cottonwood Canyon section.

TABLE V-10

NEFFS CANYON CREEK SURFACE FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	--	--	--
February	--	--	--
March	--	--	--
April	--	--	--
May	677	786	1014
June	--	--	--
July	--	--	--
July	--	--	--
August	--	--	--
September	--	--	--
October	--	--	--
November	--	--	--
December	--	--	--
Annual Sum	677	786	1014
Annual Yield Estimate**	2501	3061	4278

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern. Only the May estimates are included.

**Values are the actual "area-altitude" results, and do not reflect the true surface flow yields, since the stream is ephemeral.

TOLCATS CANYON:

Physical Description: The entire drainage area to the mouth of Tolcats Canyon consists of 0.8 of a square mile of canyon terrain. Existing in the shadows of Mount Olympus, Tolcats Canyon has an elevation range of 5000 to 9000 feet. The canyon is characterized by extremely steep walls eventually becoming more gradual near the canyon mouth.

Tolcats Canyon is in an area of extensive quartzite formations with a rockland soil association type. These are mixed soils with areas of greater than 40 percent barren rock.(70) Runoff is very rapid for this small, steep drainage area.

Vegetation consists of grasses, scrub oak and shrubs in the lower areas with small areas of conifers and aspen in the higher elevations. At the mouth of the canyon some change in the natural environment has occurred due to a residence and Wasatch Boulevard. Land use is limited to some hiking during the summer and a year-round residence at the mouth.

The normal annual rainfall is 25 to 35 inches.(83) The flow at the canyon mouth is made up of three tributary drainage ways, two of which are 1.0 mile long and the third is 0.5 of a mile long.

Existing Facilities: The flow from Tolcats Canyon enters the Salt Lake County storm drain system which discharges to Big Cottonwood Creek. There are no other facilities in the drainage area.

Hydrologic Characteristics: Tolcats Canyon is a relatively low-elevation watershed, which results in an early snowmelt peak flow date during the end of April. Tolcats Canyon Creek is ephemeral, flowing only two to three months during the spring.(34)

No continuous flow measurements are available for the stream in Tolcats Canyon. However, a few instantaneous measurements were taken near the canyon mouth by the USGS during the snowmelt seasons of 1966 and 1968.(78) These measurements show peak flows of about one to one and a half cfs during the end of April peak period, with 0.1 to 0.2 cfs during early April, and during May and June. Snowmelt volumes from Tolcats Canyon are relatively small.(34)

An estimate of the average annual yield from Tolcats Canyon has been made by correlation with Little Cottonwood Canyon. The annual yield estimate was extended to estimate the 80 percent and 90 percent probability flows. Monthly flows were then extrapolated from the annual yield estimates. Since the stream is ephemeral, only the predicted flows for March through June have been considered. The flow estimates are displayed graphically in Figure V-15, and are tabulated in Table V-11.

Water Users: The water from the canyon is not used until after it combines with other streams. Tolcats Canyon water currently flows to the Jordan River via Big Cottonwood Creek.

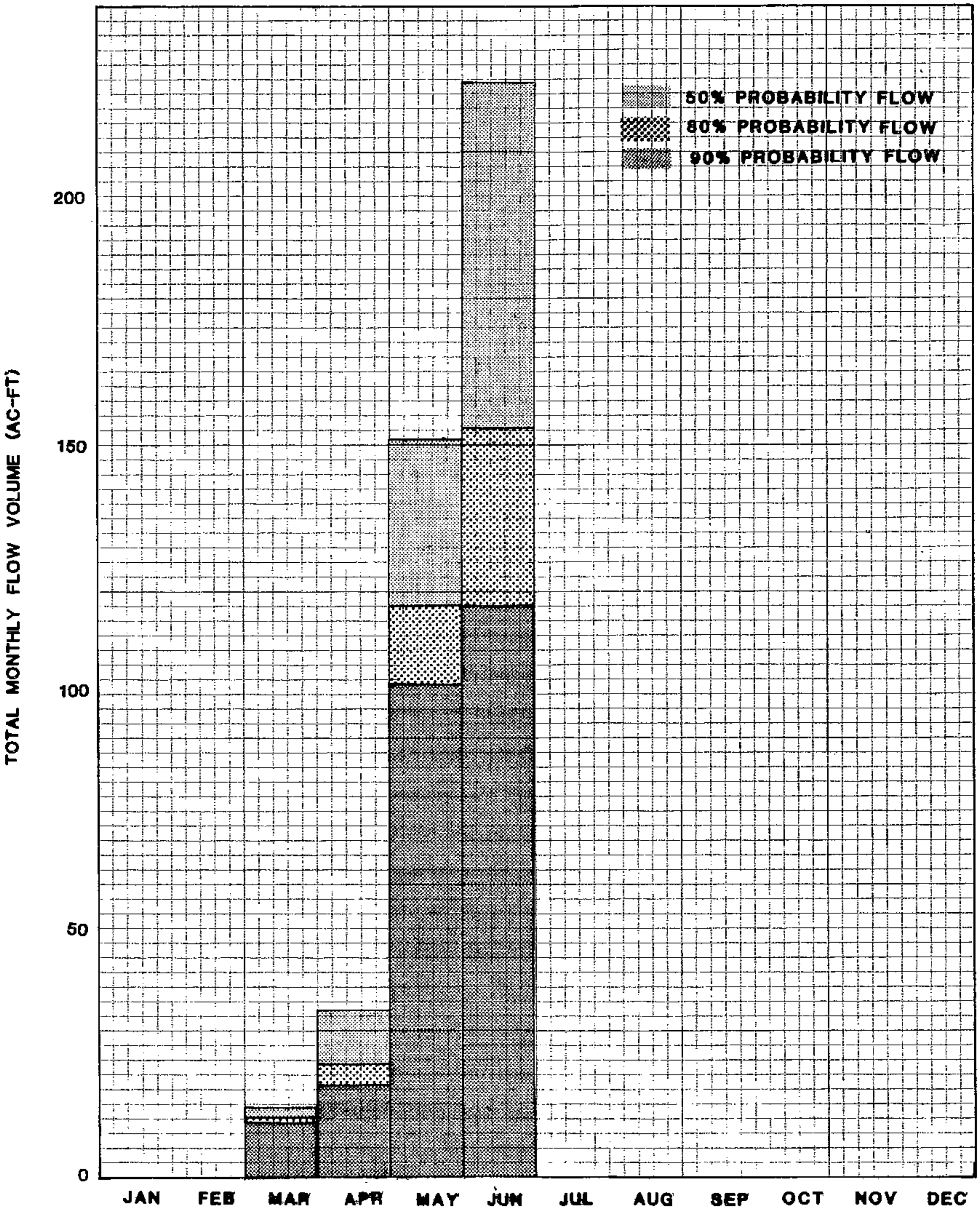
TABLE V-11

TOLCATS CANYON CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	--	--	--
February	--	--	--
March	11	12	14
April	19	23	34
May	101	117	151
June	117	153	224
July	--	--	--
August	--	--	--
September	--	--	--
October	--	--	--
November	--	--	--
December	--	--	--
Annual Sum	248	305	423
Annual Yield Estimate**	465	528	651

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern. Only the March-June flows are included.

**Values are the actual "area-altitude" results, and do not reflect the true surface flow yields, since the stream is ephemeral.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

TOLCATS CANYON CREEK

FIGURE V-15

HEUGHS CANYON:

Physical Description: The canyon drainage area is 1.9 square miles. This is considered to be the total drainage area since Heughs Canyon is a tributary to the valley portion of the Big Cottonwood Creek drainage area. Elevation ranges from 5000 to 9400 feet. Side slopes as well as the canyon floor are moderately steep throughout the canyon. These slopes are very consistent with the various small drainage ways appearing to be homogeneous.

Quartzite formations are overlain by rockland type soils which tend to be well-drained, very rocky and have a rapid runoff.[70]

Slope vegetation consists of scrub oak, shrubs and grasses changing to conifers and aspen in the high reaches of the drainage area. Typical wildlife species occur in this canyon in the upper areas away from residential development at the mouth of the canyon.

Besides the residential development at the canyon mouth the principal land uses of the canyon are watershed and wildlife habitat.

Normal annual precipitation in this area is 20 to 25 inches. Stream flow in Heughs Canyon comes from three drainage ways. Two of them join together half way down the canyon after approximately one mile of separate flow. The third tributary enters the main drainage way three-quarters of a mile downstream at a point about one-half mile from the canyon mouth.

Existing Facilities: The flow from Heughs Canyon enters the storm drain system in the subdivision east of Wasatch Boulevard. The storm drain system discharges to Big Cottonwood Creek. There are no other facilities in the drainage area.

Hydrologic Characteristics: No continuous flow record is available for the Heughs Canyon ephemeral stream.[34] However, the USGS has published a series of instantaneous measurements taken during the snowmelt seasons of 1964-1968 at the mouth of Heughs Canyon.[78] These measurements show that the stream flows from April through June, with flows ranging from 0.5 cfs to 13.8 cfs. The peak flows appear to normally occur during the middle of May. Although no flow measurements were taken before April or after June, it is likely that the stream flows at times during March and July.

An estimate of the average annual water yield of Heughs Canyon has been made by correlation with Little Cottonwood Canyon. This estimate was then extrapolated to monthly yield estimates for probabilities of 50 percent, 80 percent and 90 percent, based on the Little Cottonwood Creek pattern. In each case, only the estimates for March through July are included, since the USGS instantaneous readings indicate this is the probable period of flow.

These estimates should be used with caution, and should not be considered accurate, since no continuous flow data are available for verification. Based on miscellaneous measurements, the peak flow of Heughs Canyon Creek is probably reached earlier than is shown in the Little Cottonwood-based estimates. The monthly flow estimates are shown in Figure V-16 and are tabulated in Table V-12.

Water Users: Salt Lake County has a small pipeline and storage tank to use Heughs Canyon water for their gravel pit operations.

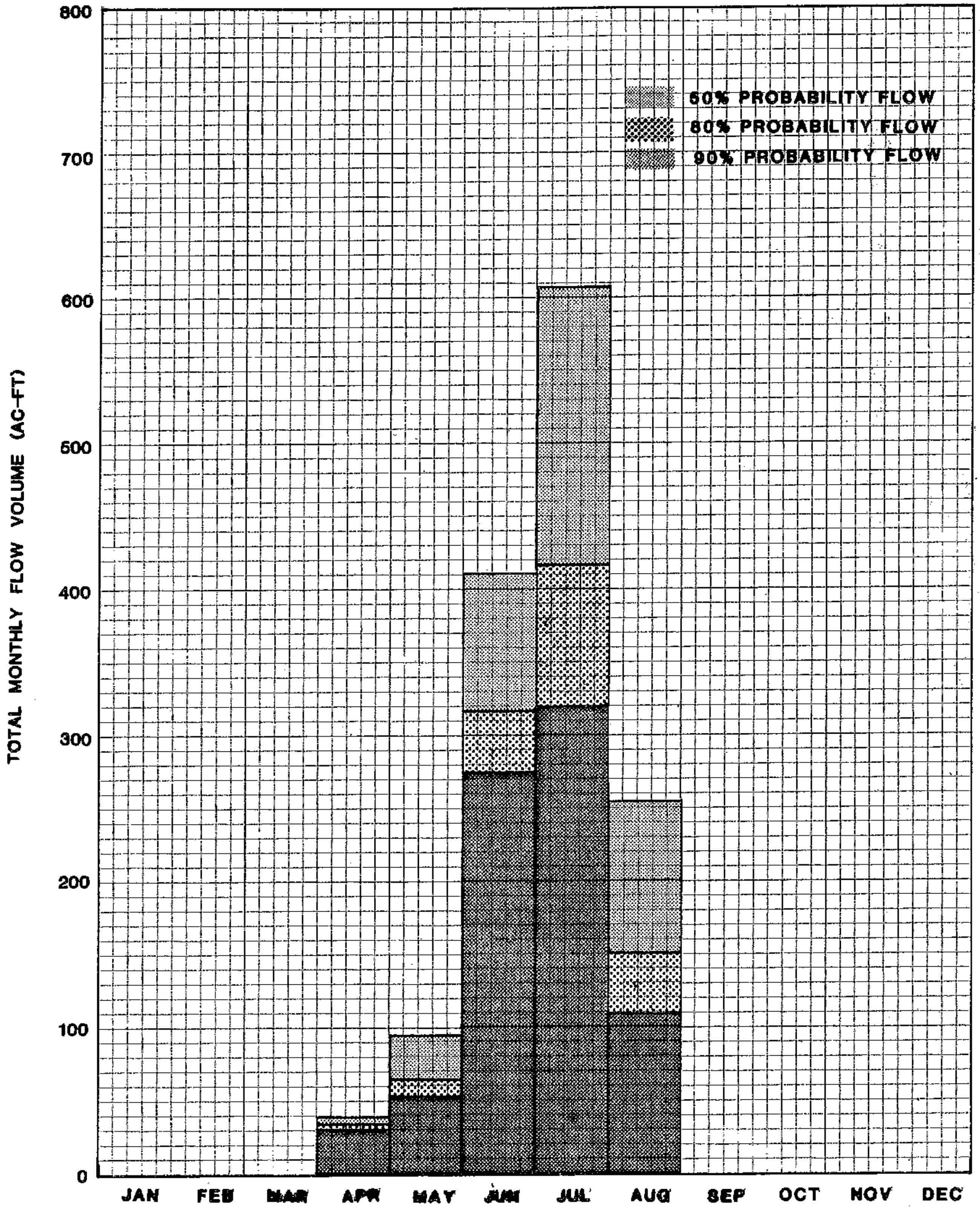
TABLE V-12

HEUGHS CANYON CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	--	--	--
February	--	--	--
March	30	32	38
April	52	64	93
May	274	318	410
June	319	417	607
July	109	150	253
August	--	--	--
September	--	--	--
October	--	--	--
November	--	--	--
December	--	--	--
Annual Sum	784	981	1401
Annual Yield Estimate**	1262	1435	1769

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern. Only the March-July estimates are included.

**Values are the actual "area-altitude" results, and do not reflect the true surface flow yields, since the stream is ephemeral.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH
HEUGHS CANYON CREEK

FIGURE V-16

BIG COTTONWOOD CANYON:

Physical Description: Big Cottonwood Canyon, with a drainage area of 50 square miles, is second only to Parleys Canyon in size within Salt Lake County. The contributing canyons of Neffs, Tolcats and Heughes to the north and Ferguson to the south add 3.5, 0.8, 1.9 and 1.3 square miles, respectively, of canyon drainage. The valley portion, from the canyon mouth to the Jordan River, contributes 19.8 square miles comprising a total drainage area of 69.8 square miles for Big Cottonwood Creek.

In the upper one third of Big Cottonwood Canyon the canyon floor is wide and runs in a relatively straight course due to the extensive glacial activity. This area includes a large basin, where Brighton ski area is located, which has surrounding mountains of moderate to steep slopes. The elevations of this upper area range from 7400 feet to over 10,000 feet. The lower two thirds of the canyon consists of a narrower meandering floor with steep mountain sides crowding down to the creek bed and road side. Elevations in this part of the drainage area range from 5000 feet to over 10,500 feet. The Big Cottonwood Creek drainage area from the mouth of the canyon to the Jordan River is an area characterized by ancient lake bed terraces to the east and a gently sloping flood plain westward to the river.

The upper area of Big Cottonwood Canyon is composed of glacial till and talus slopes.(61) A large portion of this area has a soil cover which tends to be well-drained, mostly deep but shallower on the steep slopes, resulting in a rapid runoff. The lower canyon area, starting from below Reynolds Flat which is the lower boundary of glacial action, to the mouth, has extensive quartzite and limestone formations with soil characteristics similar to the upper canyon area. However, since slopes are steeper in this part of the canyon, there is a greater percentage of rock outcropping. Flood plain deposits and alluvial sands and gravel characterize the valley portion of the Big Cottonwood Canyon drainage area. The soils in this area are well-drained and deep, having a rapid water intake and a slow runoff.(70)

Vegetation and wildlife in the upper canyon areas above 7500 feet belong to the upper montane and subalpine ecosystems. The dominant vegetation is aspen, fir and spruce trees, mountain lover, mountain juniper and several species of alpine herbs. Below 7500 feet down to the elevation at the mouth of the canyon exists the lower montane ecosystem which is dominated by conifers, aspen, maple, sage brush, scrub oak and various grasses.

Animals are likely to migrate throughout the entire canyon area. Wildlife species include deer, porcupines, rabbits, squirrels, chipmunks, shrews, pikas and various rodents and small birds. There are also some excellent trout populations throughout the canyon area which consist of Brook, Rainbow, and Brown Trout.

The natural habitat of the valley floor drainage area has been encroached upon by man so that few native species of vegetation or wildlife still exist. There are, however, moderate trout populations in this part of Big Cottonwood Creek.

Big Cottonwood Canyon has intense recreational use year-round. The peak use times are in July and February. Summer uses include picnicking (greater than 1,500 picnic sites), hiking, rockclimbing and summer residents (with over 440 cabins). Winter activities are primarily downhill and cross country skiing, tubing and tobogganing. Land use from the mouth of Big Cottonwood Canyon to the Jordan River is primarily residential with some small industrial activities.

Average precipitation in the Big Cottonwood Creek drainage area ranges from over 50 inches in the mountains to less than 16 inches in the valley floor area. In the canyon area the high mountain peaks receive much of this precipitation as snow, thus snowpack and snowmelt become important hydrologic factors.

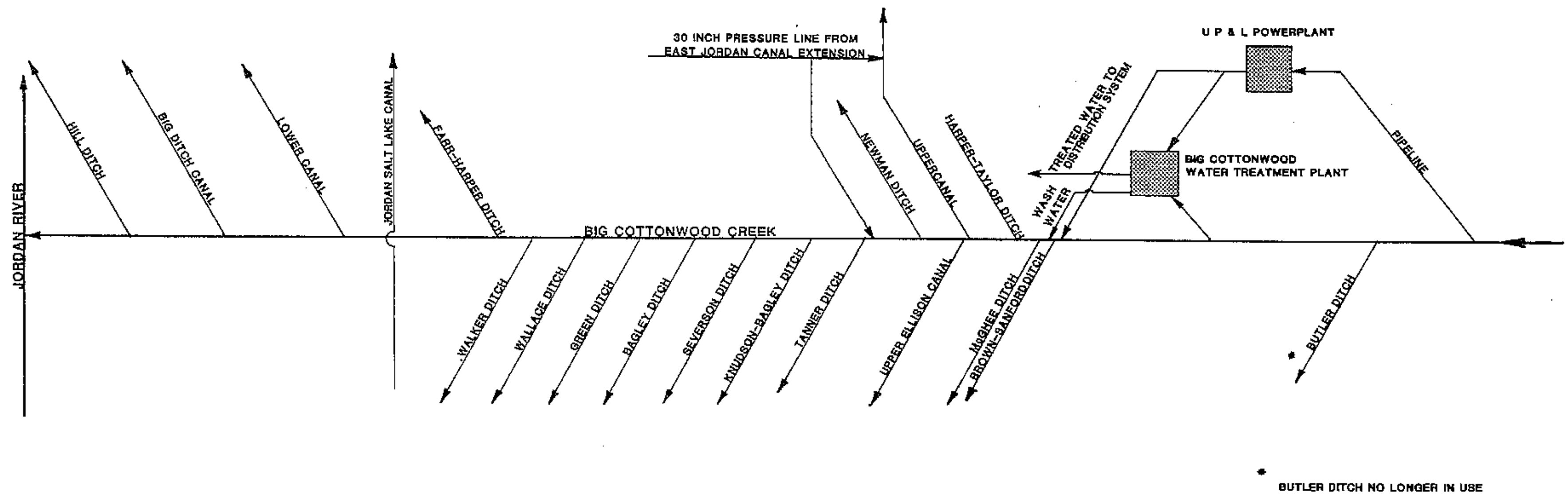
The headwaters for Big Cottonwood Creek originate in the basin area where Brighton Ski Resort is located. The initial sources for Big Cottonwood Creek are Twin Lakes and Lake Mary Reservoirs. Since this upper canyon area has been glaciated, the channel is relatively straight with a moderate gradient, until it reaches Reynolds Flat approximately 6.5 miles downstream from Lake Mary. In this distance, Big Cottonwood Creek picks up some side canyon streams of considerable size. These streams are: Silver Fork, three miles downstream; Bear Trap Fork, 3.5 miles; Days Fork and Mill D Creek, five miles; and Mill D South Fork and Butler Fork located at Reynolds Flat. From this point down to the mouth of the canyon, Big Cottonwood Creek has several bends, and a variable gradient. Approximately 9.5 miles from the headwaters, Mineral Fork joins Big Cottonwood Creek with Mill B South and North Forks both entering another mile further downstream. Lillian, Florence, and Blanche Lakes are located about 2.5 miles to the south of the headwaters of Mill B South Fork. From this point Big Cottonwood Creek continues down, picking up Wipple Fork and Broads Fork a mile further. A small reservoir at Storm Mountain, which has since been filled, existed about 2.5 miles upstream from the canyon mouth. When the creek leaves the canyon it flows approximately nine miles through the valley area to the Jordan River.

The channel gradient in the valley is gentle with much meandering. No major streams enter Big Cottonwood Creek in the valley via a natural stream course. However, Neffs, Tolcats, Heughs and Ferguson Canyon Creeks are tributaries to Big Cottonwood Creek through the storm drain system. Often this valley portion of Big Cottonwood Creek is dewatered by Salt Lake City's Big Cottonwood Water Treatment Plant at the canyon mouth. Stream flow is augmented by water received through exchange agreements, urban runoff, springs, and other small tributaries.

Existing Facilities: In the Big Cottonwood Creek drainage area the existing hydrologic facilities include two reservoirs, the water supply system for Brighton, two hydroelectric power plants, the Big Cottonwood Water Treatment Plant, and several irrigation ditch diversions. Figure V-17 shows a schematic diagram of the sources and uses of the water in the lower canyon and valley portions of the drainage area.

Several reservoirs have been constructed in Big Cottonwood Canyon to impound water during the spring runoff, but only two remain in use today. These were constructed in 1915 by Salt Lake City and are Lake Mary (740 acre-feet capacity, elevation 9550) and Twin Lakes (940 acre-feet capacity, elevation 9580). Lakes Katherine, Blanche, Lillian, and Florence were constructed as irrigation reservoirs, but their dams have since been breached.[34] The remnants of these reservoirs and many other natural depressions form small lakes throughout the upper portions of the canyon.

A mine tunnel in the Brighton area has been sealed and is used to collect ground water for the culinary water supply. Big Cottonwood Canyon residences have holding vaults for sewage, and septic tanks and drain fields for other domestic waste water.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

SCHEMATIC OF BIG COTTONWOOD CREEK

FIGURE V-17

Located approximately two miles up the canyon is the Stairs Power Plant which is owned by Utah Power and Light Company. The intake for the plant is located about a half mile further up the canyon near the Storm Mountain picnic area. The water is conveyed to the plant via a tunnel and a pipeline. A second power plant is located near the mouth of the canyon. Water is conveyed to this plant through the Granite Flume which originates immediately downstream from the Stairs Power Plant.

The Big Cottonwood Water Treatment Plant is located downstream from the second power plant. The treatment plant is owned and operated by Salt Lake City. The plant design capacity is 42 mgd. Its facilities include screening, chemical treatment, mixing, coagulation, sedimentation and filtration.[8] Consideration is currently being given to expansion of the plant capacity.

Below the power plant intake are several irrigation ditch diversions. The ditches which receive water from Big Cottonwood Creek and the types of measuring devices for each of the gaging stations are listed in Table V-13.

<u>Hydrologic Characteristics</u>: The reservoirs in the upper Big Cottonwood drainage basin, Lake Mary and Twin Lakes, serve as detention facilities for the Salt Lake City Water Department. These dammed basins

TABLE V-13

BIG COTTONWOOD CREEK GAGING STATIONS

Station	Measuring Device
Big Cottonwood Creek	20-ft Parshall Flume
Butler Ditch	Rectangular Weir
Water Treatment Plant Intake	48-inch Sparling Meter
Power Plant Creek Discharge	4-ft Parshall Flume
Brown & Sanford Ditch	5-ft Rectangular Weir
Upper Canal	10-ft Lyman Weir
Newman Ditch	30-inch Cipolletti Weir
Tanner Ditch	3-ft Parshall Flume
Knudson-Bagley Ditch	
Severson Ditch	
Bagley Ditch	
Green Ditch	5-ft Cipolletti Weir
Wallace Ditch	
Farr-Harper Ditch	2-ft Lyman Weir
Lower Canal	3-ft Cipolletti Weir
Big Ditch Canal	3-ft Parshall Flume
Hill Ditch	2-ft Parshal Flume

begin to fill with water early in May each year from snowmelt. Twin Lakes, the larger reservoir, fills to capacity nearly every year. However, Lake Mary does not often fill, even though the drainage basin is larger and higher in elevation than that of Twin Lakes. The reasons for this lack of captured water in Lake Mary appear to be: (1) upstream detention of snowmelt by two natural lakes, Katherine and Martha; and (2) fracturing of the granite bedrock in the drainage area.[34]

Big Cottonwood Creek does not experience extreme fluctuations in flow rate as does the neighboring Little Cottonwood Creek. Even though the Big Cottonwood Canyon watershed is much larger than that of Little Cottonwood Canyon (50.0 square miles compared to 27.4 square miles), Big Cottonwood Creek usually has a lower peak flow at the canyon mouth than Little Cottonwood Creek under the same climatic conditions.[34,79] This greater attenuation of flood peaks is due to a much larger watershed lag time and flatter canyon side slopes. Also, since most of the watershed is covered with vegetation and soil, with exposed rock only in the upper elevations, soil percolation rates are substantial.

The major cause of flooding in the canyon is snowmelt during the late spring months of May and June. Some annual peaks are initiated by cloudburst rain storms on ripe snowpacks during the spring months. No annual peak flows at the canyon mouth during the period of record (1899-1980) have been caused by rainstorms alone during the late summer or fall.[34] However, some major summer flash floods have occurred in the canyon, such as the Storm Mountain flash flood in 1981 where the peak flow was estimated to be approximately 500 cfs. The mean peak day is May 28, with a standard deviation of 11 days, indicating a narrow band of springtime occurrences.

A frequency analysis was performed on the 82-year period of record (1899-1980) at the Big Cottonwood Creek gaging station near Wasatch Boulevard for monthly and annual flow volumes. The recorded flows have been adjusted to reflect natural conditions. A frequency curve for annual flow volumes is shown as Figure V-18. The Big Cottonwood Creek annual hydrograph, representing estimated flows at the mouth of the canyon for 90 percent, 80 percent and 50 percent probabilities, is displayed in Figure V-19. These same results, including the 90 percent confidence limits, are tabulated in Table V-14. As may be seen from the table, the average annual yield estimate from Big Cottonwood Creek is 51,238 acre-feet of water.

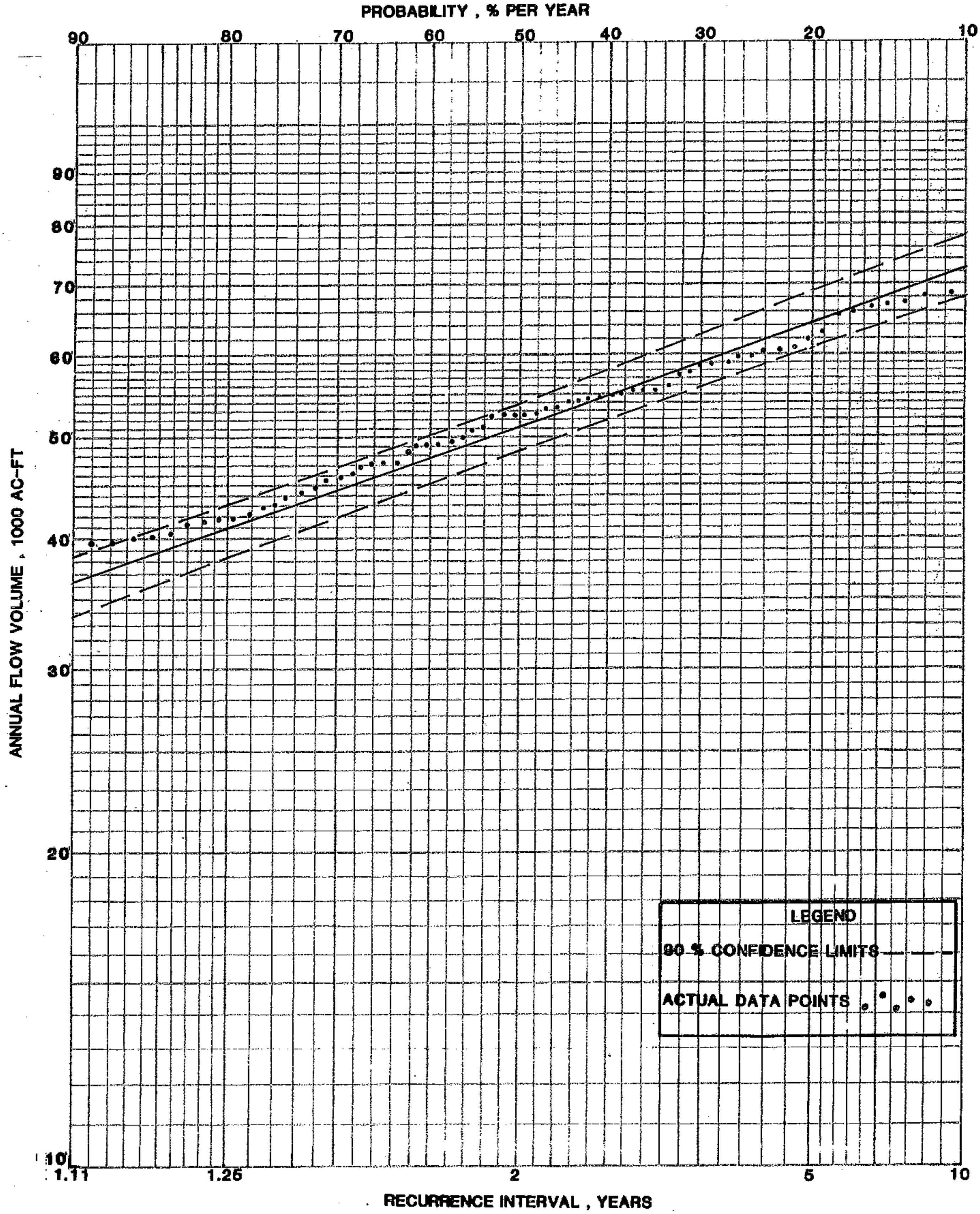
In the valley, the creek flows in a northwesterly direction towards the Jordan River. The stream is generally a "losing stream" east of Highland Drive and a "gaining stream" the remaining distance to the Jordan River. Numerous storm water drains discharge into the stream channel.

Below Neffs, Tolcats and Heughs Canyons in the Big Cottonwood Creek drainage area is an area with several springs. Casto, Spring Creek and Dry Creek Springs are the most prominent and are perennial. Springs are also prevalent along Highland Drive and near Big Cottonwood Creek. The source for these springs is ground-water flow from the above mentioned canyons.

The water quality of Big Cottonwood Creek is very good in the canyon. The average annual coliform concentrations are below 100 MPN/100 ml and monthly summer peaks are usually below 150 MPN/100 ml. These values reflect the good waste-water and watershed management program maintained in the canyon.(37) Below the water treatment plant, the quality deteriorates due to urban and storm water runoff. The lower reaches of the creek have mean BOD values in excess of 5.0 mg/l, mean TDS values of over 500 mg/l and coliform counts in excess of 5000 per 100 ml. Also, measureable amounts of oil and grease have been found in the creek.(39)

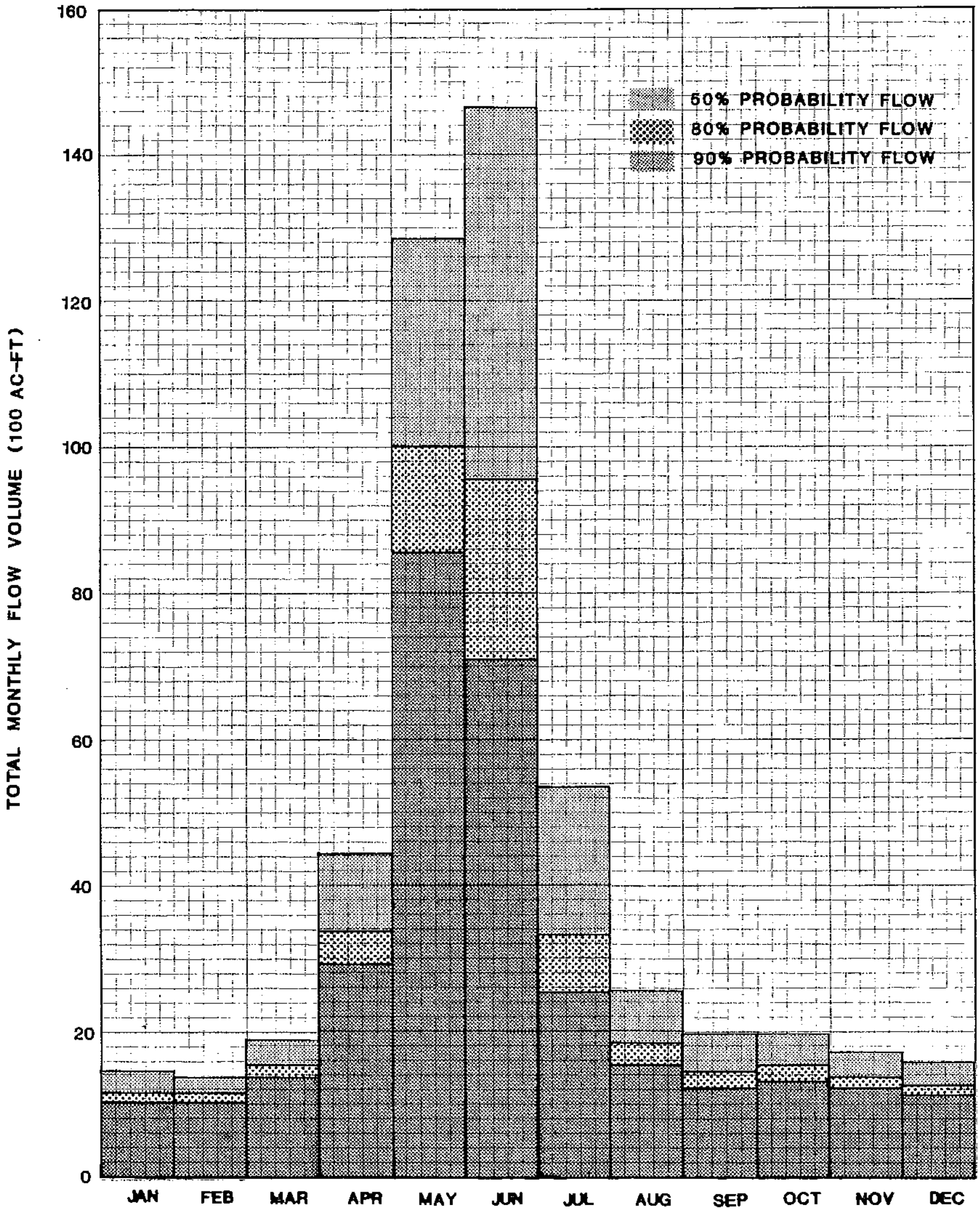
Water Users: Utah Power and Light Company diverts water from the creek for power generation at two hydroelectric power plants. This is a non-consumptive use of the water and the water is discharged back to the stream and/or to the Big Cottonwood Water Treatment Plant. The water treatment plant also has a direct intake from the stream channel. Big Cottonwood Creek stream flows and diversions to the water treatment plant during 1977-81 are shown in Table V-15.

Salt Lake City has obtained rights to a large portion of the stream flow through exchange agreements. During the non-irrigation season, the City has rights to over 98 percent of the flow. During the irrigation season, the City has rights to almost 92 percent of the first 120 cfs and over 72 percent of the flows over this amount. The water rights on Big Cottonwood Creek are shown in Table V-16 along with a description of the exchange agreements.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL FREQUENCY CURVE



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

BIG COTTONWOOD CREEK

FIGURE V-19

TABLE V-14

BIG COTTONWOOD CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)					
	90% Probability	90% Confidence Limits	80% Probability	90% Confidence Limits	50% Probability	90% Confidence Limits
January	1,038	963 - 1,104	1,168	1,089 - 1,239	1,465	1,392 - 1,542
February	1,010	945 - 1,067	1,121	1,054 - 1,181	1,369	1,309 - 1,432
March	1,388	1,278 - 1,485	1,521	1,409 - 1,623	1,884	1,782 - 1,992
April	2,937	2,694 - 3,153	3,381	3,120 - 3,619	4,403	4,152 - 4,669
May	8,575	7,931 - 9,143	10,008	9,308 - 10,641	12,870	12,206 - 13,570
June	7,097	6,237 - 7,891	9,546	8,467 - 10,565	14,647	13,418 - 15,988
July	2,534	2,175 - 2,872	3,315	2,877 - 3,737	5,347	4,821 - 5,930
August	1,518	1,363 - 1,659	1,829	1,655 - 1,991	2,560	2,379 - 2,754
September	1,205	1,082 - 1,316	1,427	1,291 - 1,553	1,971	1,832 - 2,120
October	1,315	1,205 - 1,413	1,509	1,391 - 1,616	1,961	1,848 - 2,081
November	1,220	1,133 - 1,297	1,371	1,280 - 1,453	1,713	1,629 - 1,801
December	1,122	1,042 - 1,192	1,261	1,177 - 1,337	1,575	1,498 - 1,656
Annual Sum	30,959		37,457		51,765	
Annual Yield Estimate	36,305	33,673 - 38,621	40,863	38,104 - 43,353	51,238	48,687 - 53,923
Deviation**	14.7%		8.3%		-1.0%	

*From frequency analyses of the 1899-1980 period of flow records at the Salt Lake City gaging station near Wasatch Boulevard.

**Assuming the annual estimate to be the most current.

Several irrigation ditches divert water along the creek. Water exchanged with Salt Lake City is replaced by pumping from the East Jordan Canal Extension or diverting from the Jordan and Salt Lake City Canal. Figure V-17 shows a schematic flow diagram of the water use of Big Cottonwood Creek.

The Upper Canal is supplied exchange water from the East Jordan Canal Extension via a pumping station near 6200 South 2100 East. The service area is west of the canal to the Lower Canal and from Big Cottonwood Creek to Mill Creek (2700 South). The area is largely urbanized and the water is used mainly for garden plots.

The Holliday Water Company supplies culinary water to about 3200 connections in the area between Highland Drive and the Upper Canal and between Mill Creek and 5800 South. The water sources are the Big Cottonwood Conduit, the 3900 South supply line, and three 16-inch wells within the area. The 1980 production from the three wells was 2156 acre-feet. The water is pumped directly from the wells into the distribution system. Additional water, 1.95 cfs, is available through an exchange agreement with Salt Lake City for Big Cottonwood Creek water. This amount is in addition to the total for the Upper Canal in Table V-16.

Spring Creek Irrigation Company has developed the Spring Creek Spring which is located just west of Wasatch Boulevard near Neffs Canyon. The spring is fed by ground water from Neffs Canyon. The springs produced 565 acre-feet during 1980. The spring supplies most of the company's needs. Additional water may be purchased from the Holliday Water Company. The Spring Creek Irrigation Company provides culinary water to approximately 540 connections in the area along the Murray-Holladay Road between Wasatch Boulevard and the Cottonwood Mall. The company provides some irrigation water which is supplied from the Upper Canal.(1)

Approxmately 800 feet south of Spring Creek Spring is Casto Spring. The Salt Lake County Water Conservancy District owns much of the stock in the Casto Springs Irrigation Company and has an exchange agreement for the entire flow from the spring, which is about 600 acre-feet annually. The flow is collected and piped to a nearby reservoir for distribution in the Conservancy District's system. In return for the spring water, the Conservancy District supplies purchased treated water from the Salt Lake Aqueduct during the irrigation season.(47)

Salt Lake County Water Conservancy District also owns all of the stock in the Dry Creek Springs Irrigation Company. Dry Creek Springs are located about a thousand feet south of Casto Spring. The annual flow from Dry Creek Springs is approximately 670 acre-feet and is collected and piped to the same reservoir as the water from Casto Spring.[47]

TABLE V-15

BIG COTTONWOOD CREEK STREAM FLOWS AND DIVERSIONS

	1977				1978				1979				1980				1981			
	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Bypass Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Bypass Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Bypass Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Bypass Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)	Actual Stream Flow @ Canyon Mouth (Ac-Ft)	Bypass Flow @ Treatment Plant (Ac-Ft)	Diversion to Treatment Plant (Ac-Ft)	% of Flow Diverted (%)
January	1176	0	1176	100	1113	0	1113	100	1456	264	1192	82	1345	10	1335	99	1335	0	1335	100
February	1043	0	1043	100	1196	0	1196	100	1238	0	1238	100	1369	106	1263	92	1198	0	1198	100
March	1261	0	1261	100	2577	1268	1309	51	1747	337	1410	81	1662	99	1563	94	1565	52	1513	97
April	3416	1038	2378	70	5383	4471*	912	17	3455	1370	2085	60	4399	3054	1345	31	4459	2543*	1916	43
May	5744	3447*	2297	40	11,048	9130	1918	17	11,885	9354*	2531	21	10,925	9513*	1412	13	9267	7097*	2170	23
June	7345	4193*	3152	43	18,618	15,748*	2870	15	10,157	7380*	2777	27	15,148	12,907*	2241	15	8918	5677*	3241	36
July	1981	6	1975	100	7208	3921*	3287	46	3971	1194	2777	70	6970	3610*	3360	48	3064	343*	2721	89
August	1482	78	1404	95	3501	686*	2815	80	2503	206	2297	92	3291	195*	3096	94	2426	18	2408	99
September	1418	71*	1347	95	3501	1063*	2438	70	2523	121*	2402	95	2640	202*	2438	92	1476	10	1466*	99
October	1680	69	1611	96	2604	420	2184	84	1870	210	1660	89	2017	51	1996	97	1630	109*	1521	93
November	1267	0	1267	100	1753	178	1575	90	1343	0	1343	100	1630	55	1575	97	1833	411*	1422	78
December	1184	0	1184	100	1628	460	1168	72	1275	2	1273	100	1555	0	1555	100	1902	353*	1549	81
Total	28,997	8,902	20,095	69	60,130	37,345	21,672	36	43,423	20,438	22,985	53	52,951	29,802	23,149	44	39,073	16,613	22,460	57

*Adjusted values

TABLE V-16

WATER RIGHTS FOR BIG COTTONWOOD CREEK

Ditch	October 1 to April 1 0 - 50 cfs (%)	April 1 to October 1 0 - 120 cfs (%)	April 1 to October 1 120 - 351.59 cfs (%)
Bagley	0	0	0.87
Big Ditch (a)	26.25	28.50	17.05
Brown & Sanford (b)	10.42	6.00	14.20
Butler (k)	1.11	0.83	2.85
Farr & Harper	0.72	0.83	1.15
Green (c)	12.17	8.83	6.82
Harper & Taylor	0	0	1.15
Hill (d)	3.27	3.55	2.02
Knudson	0.07	0	0.13
Knudson & Bagley (e)	0.05	0.07	0.28
Lower Canal (f)	8.90	9.67	8.53
Lower Ellison	0	0	2.28
McGhie	0	0	2.85
Newman	0	0.50	1.15
Severson	0	0	1,15
Tanner (g)	19.00	22.02	17.05
Upper Canal (h)	16.05	17.50	17.05
Upper Ellison (i)	0	1.17	2.57
Walker (j)	2.00	0.53	0.85

(a) Irrigation water required for exchange is 35.5% of creek flow from April 1 to October 1 and 1.67% of creek flow from October 1 to April 1. Maximum flow is 35.0 cfs.

(b) Irrigation water required for exchange with Salt Lake City from March 15 to May 15 is their creek share. From May 15 to November 1 the required quantity is 10 cfs when creek flow is 100 to 150 cfs and 6 cfs when the creek flow is 60 to 100 cfs.

(c) Irrigation water required for exchange with Salt Lake City is as shown below.

April	8.0 cfs	August	12.0 cfs
May	14.0 cfs	September	10.0 cfs
June	19.0 cfs	October 1-15	6.0 cfs
July	16.0 cfs		

Culinary water required for exchange is as follows:

April 1 to October 1	900 gallons per day per acre or 0.8 cfs
October 1 to April 1	500 gallons per day per acre or 0.44 cfs

TABLE V-16 (con't)

(d) Irrigation water required for exchange with Salt Lake City is 4.67% of creek flow from April 1 to October 1.

(e) Irrigation water required for exchange with Salt Lake City from April 1 to October 1 is 0.28% of creek flow to 120.0 cfs plus 0.105% of creek flow above 120.0 cfs.

(f) Irrigation water required for exchange with Salt Lake City from April 1 to October 1 is 12.92% of the creek flow with a maximum flow of 20.0 cfs. The minimum flow shall not be below 10.0 cfs from July 1 to September 15 and 6.0 cfs from September 15 to October 1.

(g) Irrigation water required for exchange with Salt Lake City for April, May and June is the creek share less the culinary supply. Other months are shown below:

July	27.36 cfs	September	23.36 cfs
August	25.36 cfs	October 1-15	13.56 cfs

Culinary water required for exchange is as follows:

April 1 to October 1	2.64 cfs
October 1 to April 1	1.438 cfs

(h) Irrigation water required for exchange with Salt Lake City for April, May and June is the creek share less the culinary supply. Other months are shown below:

July	25.0 cfs	September	18.0 cfs
August	21.0 cfs	October 1-15	8.0 cfs

Culinary water required for exchange is as follows:

April 1 to October 1	1.95 cfs
October 1 to April 1	1.083 cfs

(i) Irrigation water required for exchange with Salt Lake City during April, May and June is equal to their creek share. During July, August and September the quantity supplied by the City is 30% more than their creek share.

(j) Irrigation water required for exchange with Salt Lake City during April, May and June is equal to their creek share less the amount of culinary water supplied. Culinary water required is as follows:

April 1 to October 1	36,000 gallons per day
October 1 to April 1	20,000 gallons per day

(k) Salt Lake City has purchased all of the rights owned by Butler Ditch.

FERGUSON CANYON:

Physical Description: Ferguson Canyon Creek is a tributary to the valley portion of the Big Cottonwood Creek drainage area. The total drainage area to the valley is 1.3 square miles of canyon land. Elevations in the canyon range from 5200 feet to 10,000 feet.

Side slopes are steep to very steep particularly along the southern ridge. The headwater area is wide with abruptly rising steep side slopes. The lower part of the canyon is narrower yet still has steep side slopes.

The upper half of the canyon has been subject to glacial action with glacial till and talus present while the lower half is mostly volcanic plutonic in structure.[61] Soils in the area are extremely rocky, well-drained and have much rock outcropping. Runoff is medium to rapid.

Grasses and shrubs are the primary vegetation of this canyon. The inhabitants are those typical to the smaller Wasatch Range canyons such as deer, Snowshoe Rabbit, various small mammals, rodents and upland game birds. Human encroachment upon this canyon is minimal.

Land use as a watershed and wildlife habitat are the two primary uses for this canyon.

Precipitation ranges from 25 to 30 inches per year in this canyon. Surface runoff collects in the upper area where snowpack is moderate. The stream gradient is moderate in this upper area. From this point to near the canyon mouth, the gradient is fairly steep with it becoming more gradual right at the mouth again. There the stream flow is diverted into a subdivision storm drain system which eventually travels north along the west side of Wasatch Boulevard into Big Cottonwood Creek.

Existing Facilities: The water from Ferguson Canyon Creek previously flowed into the Butler and the Brown & Sanford Ditches. After Salt Lake City bought the Butler Ditch, the Brown & Sanford Ditch relinquished their claim to the water in exchange for the County's installing a storm drain for the canyon runoff. Frequently during peak flows the irrigation ditch dikes would be severly eroded. Now the water enters the storm drain and discharges to Big Cottonwood Creek.

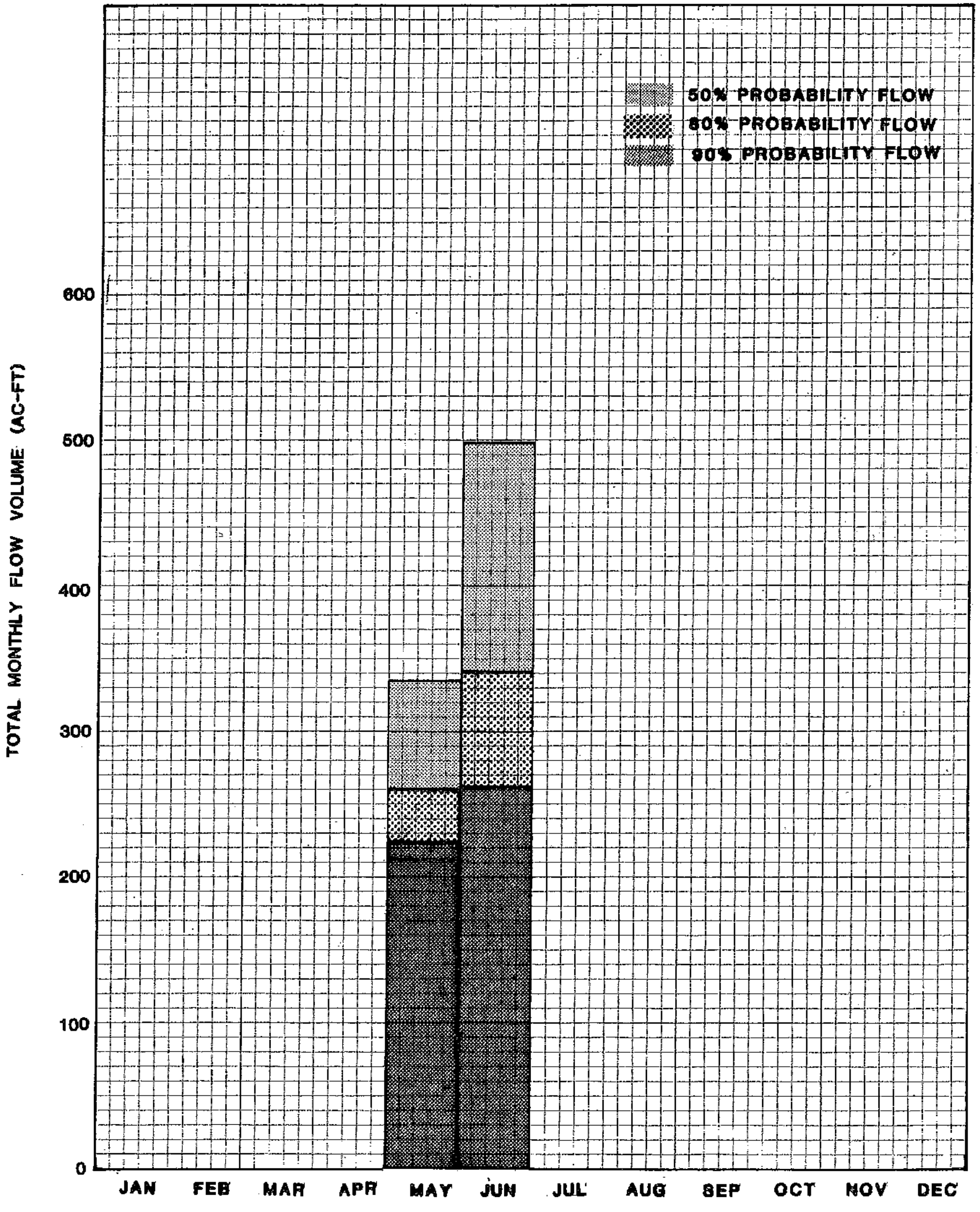
Hydrologic Characteristics: The upper reach of Ferguson Canyon Creek is perennial, but at the canyon mouth the stream is ephemeral.[44] The stream normally flows for only about four weeks in the spring due to snowmelt. The stream reacts quickly to summer cloudburst rainstorms due to its steepness, and large summertime flow peaks are attained.[44]

No continuous flow record is available for Ferguson Canyon. However, a few instantaneous readings at the canyon mouth above Wasatch Boulevard were taken during the spring snowmelt seasons of 1965, 1966 and 1968 by the USGS. These records show flows during May and June of 0.1 cfs to 2.2 cfs. No indication of when the stream normally reaches its peak flow is made by the records.

An estimate of the average annual watershed yield of Ferguson Canyon has been made by correlation with Little Cottonwood Canyon. From this quantity, the monthly yields of May and June for different probabilities have been extrapolated. This results in an estimated average annual snowmelt yield of 1448 acre-feet. These estimates should be used with care and should not be considered as accurate, since no substantial flow data are available for verification.

The estimated flows are shown graphically in Figure V-20, and are tabulated in Table V-17.

Water Users: Since the flow has been diverted into Big Cottonwood Creek, it has become part of the decreed rights for that stream. The Big Cottonwood Creek water users are discussed elsewhere in this chapter.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

FERGUSON CANYON CREEK

FIGURE V-20

TABLE V-17

FERGUSON CANYON CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	--	--	--
February	--	--	--
March	--	--	--
April	--	--	--
May	224	260	335
June	261	341	497
July	--	--	--
August	--	--	--
September	--	--	--
October	--	--	--
November	--	--	--
December	--	--	--
Annual Sum	485	601	832
Annual Yield Estimates**	1032	1174	1448

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern. Only May and June estimates included.

**Values are the actual "area-altitude" results, and do not reflect the true surface flow yield, since the stream is ephemeral.

DEAF SMITH CANYON:

Physical Description: Deaf Smith Canyon is made up of two branches, one being North Fork Deaf Smith, the other being Deaf Smith. Sometimes the streams in both branches are referred to as Little Willow Creek. The total drainage basin is 3.6 square miles. The creek flows into the Big Willow Creek Irrigation Company Ditch just below the canyon mouth and eventually into Little Cottonwood Creek.

This canyon has steep side slopes with an elevation range from 5300 feet to over 11,000 feet.

Quartzite and volcanic plutonic subsurface conditions are overlain by well drained, cobbly, steep soils with much rock outcropping. Runoff tends to be slow to medium. Vegetation consists of grasses and shrubs below 7500 feet with confiers and aspen prevelant above that level.

There is not an identifiable land use for the Deaf Smith Canyon area other than as a wildlife habitat. However, residential development is fairly dense immediately below the mouth.

The normal annual precipitation for this canyon is 20 to 30 inches. The stream flow from North Fork Deaf Smith originates just below Twin Peaks. It joins the flow from Deaf Smith Canyon about one tenth of a mile above the canyon mouth. The North Fork is approximately three miles long, which is twice the length of the Deaf Smith tributary to the south. The stream gradient for both forks is moderate to steep.

Existing Facilities: The only facility on the stream from Deaf Smith Canyon is the concrete irrigation diversion structure at the mouth of the canyon. This structure diverts water into the Big Willow Creek Irrigation Company Ditch.[4]

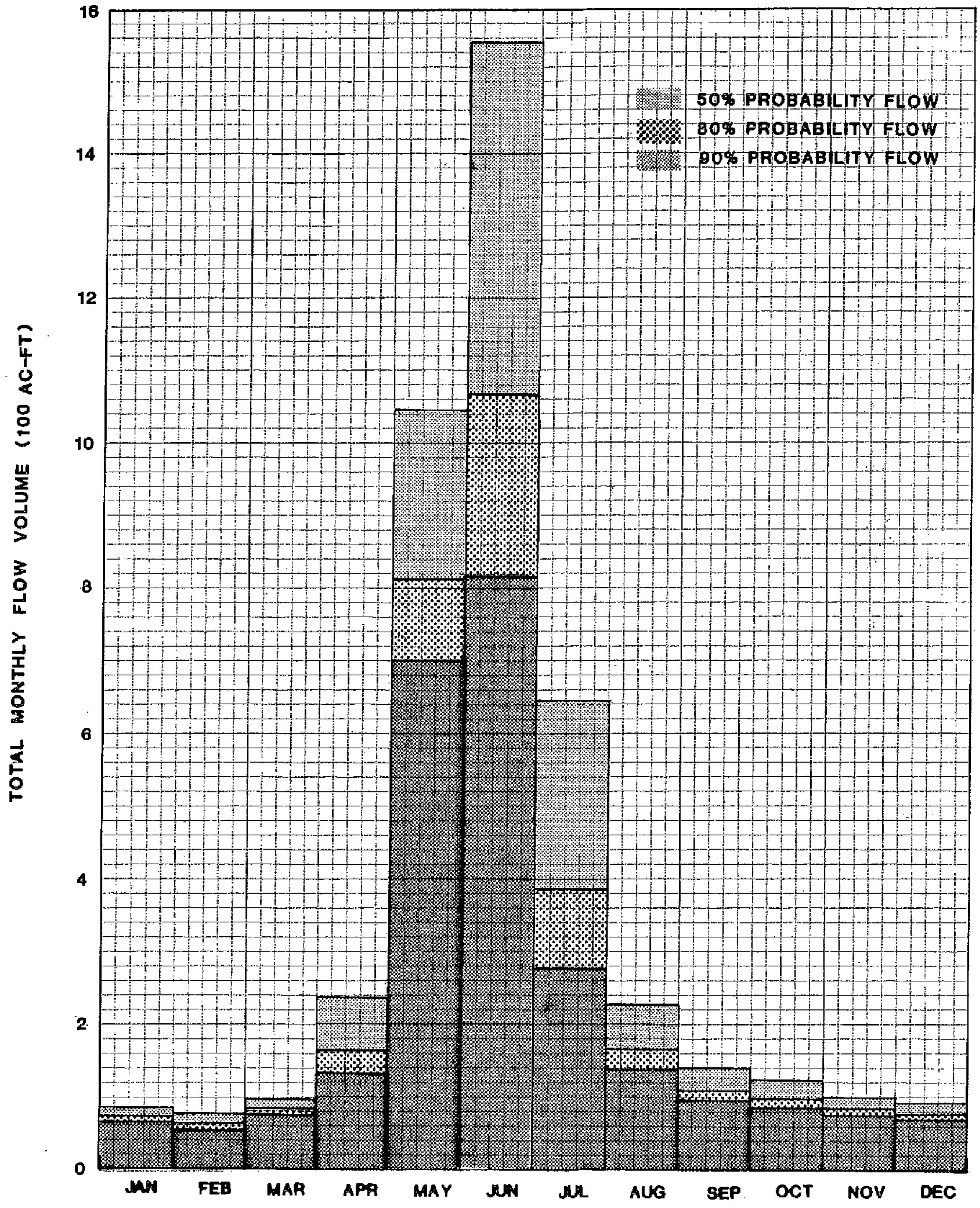
Hydrologic Characteristics: Little Willow Creek, originating in Deaf Smith Canyon, is a perennial stream at the canyon mouth.[8] The stream is intermittent in its upper reaches before becoming perennial at lower elevations. Because of the high elevations in Deaf Smith Canyon, the snowmelt flows reach their peak relatively late in the snowmelt season. The peak flows usually occur during the last weeks of May or early in June.[78]

Although no continuous gaging record of flows is available, several instantaneous measurements near the canyon mouth were made by the USGS from 1964 to 1968 during the spring snowmelt seasons. Also, the Big

Willow Creek Irrigation Company has taken several flow measurements near the canyon mouth during the summer months in recent years. These measurements, assuming they are representative, indicate that the canyon normally yields less than one cfs during the late winter and early spring. Flows increase through April until reaching a peak of about 10 to 30 cfs during late May or early June. The flows then recede during June and July to about one and a half to two cfs by the end of August. By the end of September, about one cfs is flowing in Little Willow Creek, with further decreases in flow during the winter.

The average annual yield of Deaf Smith Canyon has been estimated by correlation with Little Cottonwood Canyon. From this value, 80 percent and 90 percent probability annual yields have been estimated, based on the Little Cottonwood Creek frequency analysis. A further extrapolation was made to estimate the monthly flows, based on the Little Cottonwood Creek pattern. Although only a second order extrapolation, the estimated monthly pattern should be fairly accurate, with respect to time, since Little Willow Creek reaches its seasonal peak flows about the same time as Little Cottonwood Creek. The estimated flows are displayed graphically in Figure V-21, and are tabulated in Table V-18.

Water Users: The Big Willow Creek Irrigation Company owns all the rights to the water from Deaf Smith Canyon. The water is mainly used for irrigation purposes, but approximately twelve families use the water as a culinary supply. The irrigation company's service area is from 2700 East to the edge of the mountains and from Little Cottonwood Creek to 7400 South. Any excess flow discharges at the end of the company's ditches into the Little Cottonwood Creek streambed.[4]



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

LITTLE WILLOW CREEK

(DEAF SMITH CANYON)

FIGURE V-21

TABLE V-18

LITTLE WILLOW CREEK (DEAF SMITH CANYON) FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	64	70	83
February	55	61	75
March	76	81	96
April	133	163	238
May	700	812	1047
June	815	1065	1552
July	278	383	645
August	138	165	227
September	94	108	139
October	86	96	122
November	75	83	101
December	70	77	92
Annual Sum	2584	3164	4417
Annual Yield Estimate	3225	3668	4522

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern.

LITTLE COTTONWOOD CANYON:

Physical Description: There are 27.4 square miles of drainage area from the Albion Basin,[79] which forms the upper reaches of Little Cottonwood Canyon, to the canyon mouth. A sizable tributary, Little Willow Creek (Deaf Smith Canyon), which enters the Little Cottonwood basin below the canyon mouth, is 3.6 square miles. The valley portion of the drainage area is 34.7 square miles, which makes the total basin area for Little Cottonwood Creek 62.1 square miles.

The canyon portion of Little Cottonwood Creek has been extensively glaciated, resulting in a wide and moderately steep canyon floor following a relatively straight course. In the headwaters area, the 2.5-square mile Albion Basin has a flat floor and is surrounded by moderately sized mountain peaks ranging in elevation from 9200 feet to over 10,400 feet.

From the basin area to the mouth, the canyon has steep walls to the north and some rugged side canyons to the south. The closer to the mouth the steeper the walls become on both sides of the canyon. The steep walls and the flat floor give the canyon a "U" shape which is typical of glaciated canyons. The elevation range for the canyon is from 5200 feet at the mouth to over 11,200 feet at Twin Peaks located on the north side.

The drainage area from the mouth of the canyon to the Jordan River has a moderate slope and is comprised first of lake bed terraces followed by flood plains. The valley elevations range from 4250 feet at the Jordan River to 5200 feet near the canyon mouth.

The entire canyon area is characterized by glacial till and talus.[61] Soils in the canyon are a stony loam with extensive rock outcropping. They are generally well-drained and moderately deep to deep, except where steep slopes result in more shallow soils. Runoff in the canyon area is moderate to rapid.[61] The valley portion of Little Cottonwood drainage area is made up of lake bed and flood plain deposits which are sandy and gravely in nature. They are well drained and deep resulting in slow runoff.[70]

The upper canyon area is characterized by conifers, aspens, low growing shrubs and grasses. Streamside vegetation in the canyon is characterized by fir, dogwood, cottonwood, aspen and various grasses.

Much of the native vegetation in the valley portion of the Little Cottonwood Creek drainage area has been displaced due to the heavy urbanization.

Because of the poor shading and the steep, fast-flowing nature of Little Cottonwood Creek above the mouth of the canyon, fish population and size are small, with Rainbow and Cutthroat Trout the dominant species. There are some Brown Trout populations in the creek near the Jordan River.

Inhabitants of Little Cottonwood Canyon include Rocky Mountain Mule Deer, Yellow Haired Porcupine, Snowshoe Rabbit, skunk and various species of squirrels, chipmunks, and small birds.[60] Because of the urbanization, few native species of wildlife inhabit the valley area.

Land use in Little Cottonwood Canyon is primarily recreational and is the most heavily used of all the canyons in Salt Lake County.[37] Hiking, rock climbing, camping, picnicking, resort activities and sightseeing are the most common summer activities with cross country and downhill skiing occurring in the winter and spring. In addition to the Alta and Snowbird Ski Resorts with overnight lodging for well over 2,000 guests,[37] there are some summer cabins and permanent residences in the canyon. Recreational use was dramatically increased when Snowbird Ski Resort was built in the early 1970's. Because of this growth and the fact that Little Cottonwood Creek water is used for municipal purposes, a sewer pipe leading to the Salt Lake County Cottonwood Sanitary District system was installed in 1971. By 1973 all but the upper canyon summer cabins, which still use holding vaults, were connected to the sewer.

The valley portion of the Little Cottonwood Creek drainage area is under heavy pressure for urbanization, with much of the land already used for residential housing. There are areas of commerical use and industrial use near the Jordan River.

Precipitation in the high mountain areas of Little Cottonwood Canyon reaches as high as 60 inches per year, while the valley floor averages about 16 inches per year.[83] The mountains also have a very heavy snowpack.

In the Albion Basin area there is a small reservoir, Secret Lake, which is the headwaters for Little Cottonwood Creek. After the streams from this basin combine, they flow at a moderate gradient through channels constructed by Alta and Snowbird Ski Resorts. At approximately five miles downstream, Little Cottonwood Creek receives stream flow from the south that originates at another reservoir, White Pine Lake. Two thirds of a mile later it receives a similar stream flow from Red Pine Lake. The last two major contributors to stream flow are Hogum Fork and Coal Pit Gulch Creek which are three and two miles, respectively, upstream from the mouth of the canyon. For the entire length of the canyon, the channel is relatively straight with the gradient ranging from moderate to steep. The canyon channel from the headwaters to the water treatment plant near the mouth is approximately 12 miles long.

From the canyon mouth, as the stream flows towards the valley, the creek traverses the east bench for a short distance until it reaches the water treatment plant. There it is dewatered in several segments for up to six months of the year due to irrigation and domestic withdrawals. For the remaining nine miles to the Jordan River much of the streambed has been channelized and has a moderate slope. The Little Willow Creek (Deaf Smith Canyon) tributary enters Little Cottonwood Creek downstream from the water treatment plant.

Near the mouth of the canyon there are springs known as the Beaver Pond Springs. These springs nearly ceased flowing in August, 1963, and four wells were drilled to replace them. The quantity of water pumped is somewhat greater than the natural spring flow.[78] Because the wells are above the fault, the water from the wells is considered as part of the natural stream flow in compiling flow records.

Up the canyon from the Beaver Pond Springs is the Granite Spring. Information on this spring was not available. Also, there are several other springs in the Little Cottonwood Creek valley drainage area, but very little information is available on them.

Existing Facilities: The existing hydrologic facilities in the Little Cottonwood drainage area include three reservoirs, water distribution and waste-water collection systems for Alta and Snowbird, the Metropolitan Water Treatment Plant near the mouth of the canyon, a hydroelectric power generation plant, and several irrigation ditch diversions. Figure V-22 is a schematic diagram of the water sources and diversion locations in the lower canyon and valley portions of Little Cottonwood drainage area.

The three reservoirs which are located in the higher elevations of the canyon are Secret Lake, Red Pine Lake and White Pine Lake. The first two were built by the Little Cottonwood Water Company and the latter was built by South Despain Extension Company. Their capacities and elevations are(34):

Secret Lake	60 acre-feet, 10,000 feet
Red Pine Lake	280 acre-feet, 9,400 feet
White Pine Lake	318 acre-feet, 10,000 feet

The water supply for the Town of Alta and the Snowbird Ski Resort is spring water from mines located in the area. These mines are closed off by concrete structures. The sanitary waste water from both areas is transported down the canyon through a 10-inch sewer main.

Located approximately one mile above the mouth of the canyon is the dam and diversion for the Murray City hydroelectric power plant. At the present time, a 30-inch penstock conveys the water to the power plant located near the Metropolitan Water Treatment Plant. The hydraulic capacity of the power plant is approximately 34 cfs.(8) Plans are currently being finalized to expand the penstock and plant capacity to 185 cfs.

The Metropolitan Water Treatment Plant is located on a bench near the mouth of the canyon. The plant treats water which is then sold to Salt Lake City and others within the County. The plant treats water from Little Cottonwood Creek, to which Salt Lake City is entitled, and Deer Creek Reservoir. The water from Little Cottonwood Creek enters the plant from the Murray City hydroelectric power plant tailrace or directly from the creek via a 36 x 40 inch intake pipe downstream of the Beaver Pond Spring area. The water from Deer Creek Reservoir is delivered via the Salt Lake Aqueduct which is a 69-inch pipeline. The design capacity of the plant is 100 mgd with treatment processes including screening, grit collection, aeration, chemical treatment, mixing, coagulation, sedimentation, filtration, and chlorination. Treated water from the plant may either flow by gravity into the northern section of the Salt Lake Aqueduct and the 18-inch line along 9400 South street or be pumped into the Little Cottonwood Conduit, an older pipeline constructed and owned by Salt Lake City.

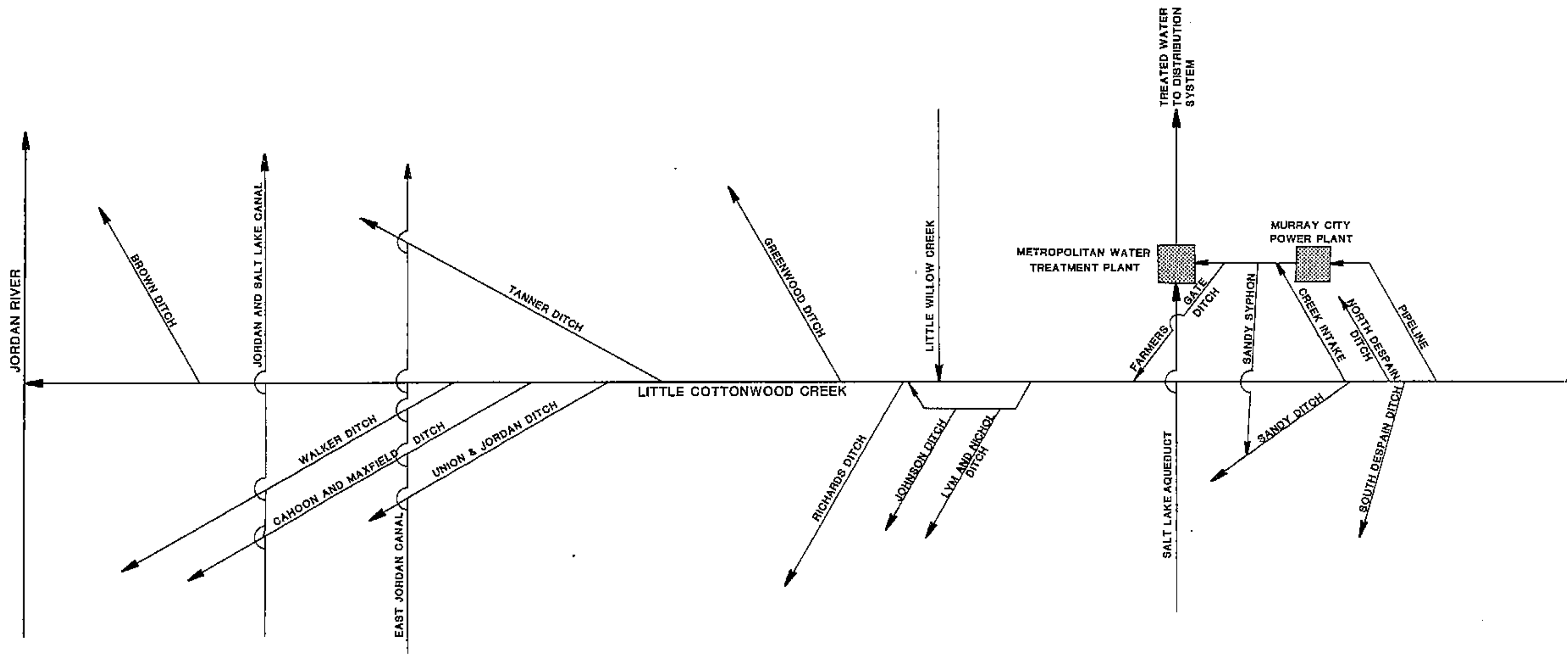
Downstream from the power plant diversion are several irrigation ditch diversions. These are shown schematically in Figure V-22 and listed in Table V-19 along with the gaging stations and types of measuring devices.

Hydrologic Characteristics: Because of the physical characteristics of the watershed, Little Cottonwood Creek undergoes extreme fluctuations in flow. The stream flows at the Wasatch Boulevard gaging station have experienced a 24-hour fluctuation in excess of 200 cfs.[34] The large percentage of impervious rock area and steep side slopes in the canyon decrease the reaction time of the watershed and the degree of flood peak attenuation. Even though the neighboring gaged Big Cottonwood Canyon watershed has a much larger drainage area (50.0 square miles compared to 27.4 square miles at the canyon mouths), Little Cottonwood Creek often has a higher peak instantaneous discharge than Big Cottonwood Creek under the same climatic conditions.[34,74]

Records also show that in general, instantaneous snowmelt peaks reach the canyon mouth around 10:00 p.m. During the 1910-1980 concurrent period of record for Big Cottonwood and Little Cottonwood Creeks at the canyon mouths, a maximum daily peak flow of 762 cfs occurred on Little Cottonwood Creek with a corresponding peak of 721 cfs on Big Cottonwood Creek.[79] The stream flow records also show that Little Cottonwood Creek flows normally reach their peak at the canyon mouth several hours before those of Big Cottonwood Creek in reaction to the same storm.

Of all the continuously gaged streams in Salt Lake County, Little Cottonwood Creek experiences its seasonal peak flows the latest in the spring.[34] This is apparently due to the large percentage of high elevation area in the watershed. The mean peak day is June 4, with a standard deviation of 11.5 days, indicating a fairly consistent, narrow range of springtime occurrences.

The major cause of peak flows in Little Cottonwood Canyon is spring snowmelt, while summer cloudburst rain storms cause the greatest flood peaks on the valley floor.[57] During the period of record, no annual maximum peak discharges due to summer cloudbursts have occurred, as recorded at the canyon mouth. Snowmelt flood volume yields from the canyon are greater than rain storm volumes.[57]



SALT LAKE COUNTY AREA-WIDE WATER STUDY

SCHEMATIC OF LITTLE COTTONWOOD CREEK

FIGURE V-22

TABLE V-19

LITTLE COTTONWOOD CREEK GAGING STATIONS

Station	Measuring Device
Little Cottonwood Creek	15-ft Parshall flume with continous recorder
South Despain Ditch	V-notched weir
South Despain Ditch Extension	5-ft broad-crested weir
North Despain Ditch	estimated
Sandy Siphon	4-ft Lyman weir
Farmers Pipeline	24-inch rated gate
Metropolitan WTP	Venturi meters with continuous recorders
Sandy Ditch	7-ft Lyman weir
Thompson Ditch	
Lym Ditch	estimated
Johnson Ditch	
Richards Ditch	9-ft Cipolletti weir
Greenwood Ditch	Cipolletti weir
Tanner Ditch	3-ft Parshall flume
Union & Jordan Ditch	estimated
Cahoon & Maxfield Ditch	4-ft Parshall flume
Walker Ditch	5-ft Cipolletti weir
Murray Irrigation Ditch	
Union & East Jordan Ditch	7-ft Cipolletti weir
Brown Ditch	
Hansen Ditch	
Last Chance Ditch	
Erickson & Baker Ditch	
Beaver Springs Pipeline	30-inch Cipolletti weir
Sandy City Wells	

Little Cottonwood Creek flows have been gaged at the canyon mouth since 1898, with a continuous record available since 1910. The recorded flows have been adjusted to reflect natural conditions.

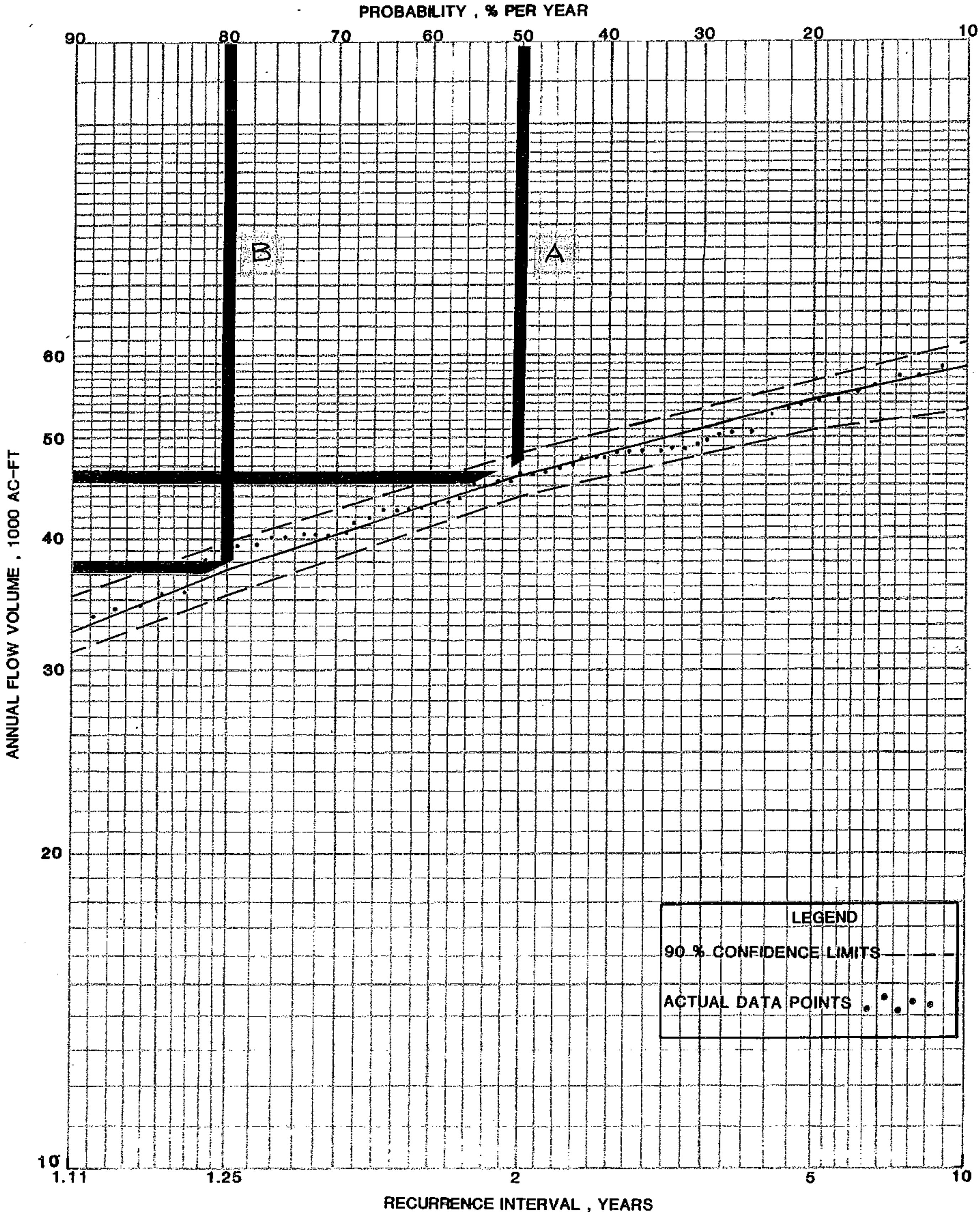
A frequency analysis of the 71-year period of record (1910-1980) for monthly and annual total flow volumes at the Wasatch Boulevard gaging station, was performed. A frequency curve for annual flow volumes is shown in Figure V-23. The Little Cottonwood Creek annual hydrographs for 90 percent, 80 percent and 50 percent probabilities are displayed in Figure V-24. These same results, including the 90 percent confidence limits, are tabulated in Table V-20. Also, monthly flow-duration tables may be found in Appendix E.

Little Cottonwood Creek is dewatered below the Metropolitan Water Treatment Plant for approximately nine months each year. The water treatment plant diverts the entire creek flow for municipal use during the winter. Even during the spring runoff, very little of the creek water reaches the Jordan River because of irrigation diversions.

The water quality of Little Cottonwood Creek varies throughout the year. The quality is lower during the period of spring runoff because of the debris that is transported by the stream. Generally speaking, Little Cottonwood Creek has very high quality water.

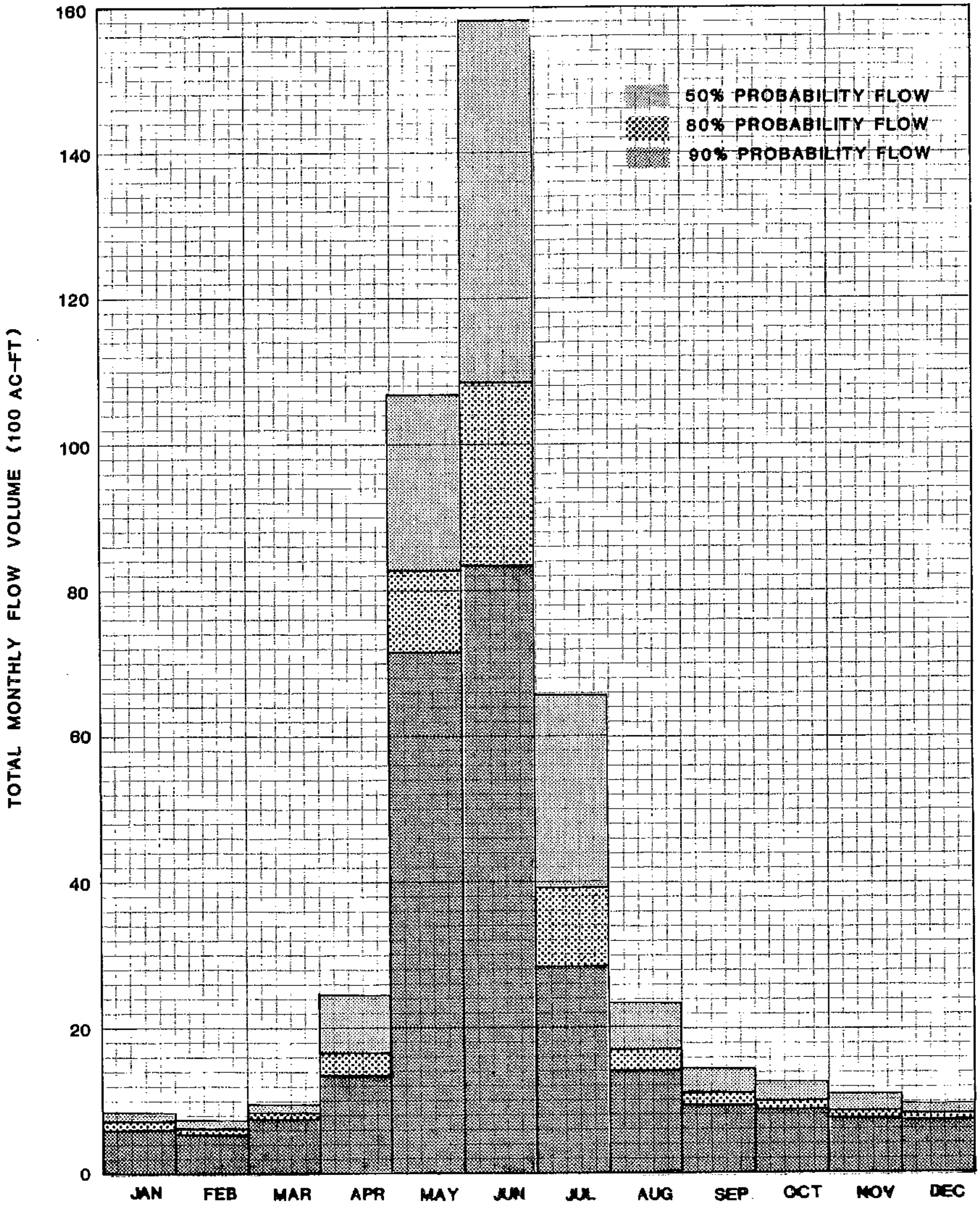
Water quality is obviously impacted by the increased recreational use of Little Cottonwood Canyon. However, it appears that the most severe impact was caused by the actual construction of Snowbird rather than the increase in skier usage.[37] This was a short term impact. Future land use and water quality trends will probably continue as they are at present, with growth in canyon use held to a moderate pace since limitations have been put on Snowbird's development. Additional residential developments in the canyon could adversely affect the water quality.

The valley portion of Little Cottonwood Creek is impacted by point and nonpoint pollution.[60] Urban runoff, canal water inflow from exchange agreements and irrigation return flow deteriorate the water quality. The lower reaches of the creek show coliform counts in excess of 5,000 MPN/100 ml, nitrates in excess of 0.5 mg/l and phosphates in excess of 0.5 mg/l.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL FREQUENCY CURVE



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

LITTLE COTTONWOOD CREEK

FIGURE V-24

TABLE V-20
LITTLE COTTONWOOD CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)					
	90% Probability	90% Confidence Limits	80% Probability	90% Confidence Limits	50% Probability	90% Confidence Limits
January	650	610 - 683	713	672 - 748	850	815 - 886
February	557	517 - 591	621	580 - 657	765	728 - 804
March	781	721 - 833	831	771 - 883	985	934 - 1,039
April	1,356	1,193 - 1,521	1,664	1,467 - 1,845	2,428	2,219 - 2,656
May	7,147	6,562 - 7,653	8,293	7,657 - 8,854	10,699	10,107 - 11,326
June	8,324	7,371 - 9,174	10,880	9,713 - 11,943	15,856	14,622 - 17,195
July	2,836	2,389 - 3,253	3,913	3,334 - 4,463	6,593	5,881 - 7,391
August	1,407	1,258 - 1,539	1,680	1,513 - 1,831	2,324	2,156 - 2,505
September	959	874 - 1,033	1,099	1,008 - 1,180	1,424	1,339 - 1,515
October	882	803 - 951	982	899 - 1,056	1,246	1,170 - 1,327
November	761	708 - 806	846	791 - 894	1,036	987 - 1,087
December	712	667 - 750	784	737 - 824	942	902 - 984
Annual	26,381		32,306		45,148	
Annual Yield* Estimate	32,948	31,183 - 35,295	37,464	35,539 - 39,949	46,194	44,122 - 48,363
Deviation**	19.9%		13.8%		2.3%	

*From frequency analyses of the 1910-1980 period of flow records at the Salt Lake City Wasatch Boulevard gaging station.

**Assuming annual estimate as most correct.

Water Users: Murray City diverts water from the stream to supply their power generating turbines. This is a non-consumptive use of the water and the water is returned to the stream, discharged to the Metropolitan Water Treatment Plant, or diverted into the Sandy siphon. When the plant and penstock capacities are expanded to 185 cfs, the creek could be effectively dewatered below the plant diversion for longer periods of the year.

The Metropolitan Water Treatment Plant can receive its water from the power plant or from the stream directly through a 36 x 40 inch intake pipe. During the non-irrigation season the plant may remove all the water from the creek. Also, during the irrigation season, the plant will take up to 10 cfs over Salt Lake City's share and replace it with water from Deer Creek Reservoir. This is done because Little Cottonwood Creek water is better suited as a culinary supply than Deer Creek Reservoir water.

The irrigation companies have established rights for all of the stream flow. The cities of Salt Lake, Murray and Sandy have purchased and/or have exchange agreements for a large portion of this water. The Metropolitan Water Treatment Plant treats the above cities' shares.

The legal distribution of the water from the Little Cottonwood Creek as established in the Morse Decree of 1910 is shown in Table V-21. With the limited time and budget for this study, it was impossible to define the actual distribution and use of the water.

The Beaver Pond Springs, prior to 1963, served as part of the water supply for Midvale, Sandy City and the Union and Jordan Irrigation Company. At that time, four wells were drilled to replace the springs. Currently, the Beaver Pond Springs provide culinary water for only one resident.

TABLE V-21

WATER RIGHTS FOR LITTLE COTTONWOOD CREEK (b) 1910

Ditch	0 to 2.29 cfs % of 2.29 cfs	2.29 to 94.79 cfs % of 92.50 cfs	94.79 to 111.86 cfs % of 17.07 cfs	111.86 cfs to 159.09 cfs % of 47.23 cfs	159.09 to ~~298~~ 308.57 cfs % of ~~199~~ 149.48 cfs (b)
South Despain	10.91	0	0.67	0	0.174
Brady #1 (h)	17.90	0	0.93	0	0.27
Brady #2 (1)	4.36	0	0.64	0	0.18
Richards (a) (e)	0	11.11	8.26	0	2.20
Tanner (a) (f)	0	22.22	13.83	0	3.62
Cahoon & Maxfield (a) (c) (d)	0	27.78	38.72	0	10.26
Walker (g)	0	11.11	8.26	0	2.20
Greenwood (j)	43.66	0	4.15	0	1.10
North Despain	8.73	0	0.67	0	0.174
Bissinger (k)	3.49	0	1.40	0	0.36
Van Valkenberg (k)	10.91	0	1.69	0	0.45
Union & Jordan (a)	0	27.78	20.73	0	5.50
16 Other Ditches	0	0	0	100	73.432

Footnotes on following page

TABLE V-21 (con't)

(a) Sandy City is entitled to 10 percent of the water rights of these ditches when the flow of the creek ranges between 2.29 and 94.79 cfs, but never less than a total of 1.5 cfs except in August.

(b) When the flow of the stream is in excess of 159.09 cfs, all flow in excess of 94.79 cfs is allocated in accordance with the percentages shown in the last column.

(c) The Cahoon & Maxfield ditches retain the following rights which have been sold to Murray:

April 1 to September 30	1.25 cfs
October 1 to March 31	0.625 cfs

(d) Irrigation water required for exchange with Salt Lake City is as shown below. The exchange water is Jordan River water provided through the Jordan and Salt Lake City Canal and the East Jordan Extension Canal.

April 1-15	12.0 cfs	July	40.0 cfs
April 15-30	25.0 cfs	August	35.0 cfs
May	30.0 cfs	September	25.0 cfs
June	40.0 cfs	October 1-15	10.0 cfs

(e) Irrigation water required for exchange with Salt Lake City is equal to their creek share plus 1.0 cfs extra during July, August and September if the city is taking their total creek share. The exchange water is Deer Creek or well water.

(f) Irrigation water required for exchange with Salt Lake City is equal to their creek share plus 2.0 cfs during July, August and September. The exchange water is Jordan River water provided through the Jordan and Salt Lake City Canal.

(g) Irrigation water required for exchange with Salt Lake City is equal to their creek share plus 1.0 cfs during July, August and September. The exchange water is Jordan River water provided through the East Jordan Extension Canal. Culinary water required for exchange is as follows:

April 1 to September 30	36,000 gpd
October 1 to March 31	20,000 gpd

(h) The Taylorsville-Bennion Improvement District [& West Jordan City] has purchased the rights of this ditch. [TB - 55% WJ - 45%]

(i) Midvale City has purchased the rights of this ditch when the stream flow is below 94.79 cfs.

(k) Midvale City has purchased the rights of this ditch.

(l) Owned by Salt Lake City.

BELLS CANYON:

Physical Description: The Bells Canyon drainage area to the lower reservoir at the mouth of the canyon is 3.9 square miles. Bells Canyon is very steep with a 5000-foot elevation range in a length of approximately four miles. Some peaks in the drainage basin reach over 10,000 feet. The side slopes of the canyon are also very steep. The upper headwaters area has three basins, one of which has a small natural reservoir. Normal annual precipitation ranges from 20 to 60 inches.

Geologically the canyon is volcanic plutonic with glacial till and talus evident near the mouth. The soils near the lower reservoir are deep and well-drained with stony or boulder-strewn material that is intermixed with sandy loam material.(70) This is typical of glacial moraines. Above this area soils tend to be shallow, well-drained and extremely rocky. Runoff for this entire area ranges from moderate to rapid.

In the upper basin area conifers and aspen are prevalent up to elevations that reach high alpine conditions. Here vegetative growth is sparse and consists mainly of small shrubs and herbs. The mid elevations of the canyon are characterized by birch, heavy undergrowth and grasses. In the lower areas scrub oak, shrubs and grasses are the dominant vegetation.

Trout populations are substantial in the upper reservoir, probably supplemented by planting. There is very little human encroachment in this area. Dominant wildlife species include Rocky Mountain Mule Deer, Yellow Haired Porcupine, and Snowshoe Rabbit. Small animals characteristically found here are various species of squirrels, chipmunks, shrews, skunk, pika and various rodents.(60) Smaller birds exist throughout this area while upland game birds are prevalent in the lower areas of the canyon.

Land use in Bells Canyon includes some hiking and limited fishing, hunting and camping, although not near the level of use that Little Cottonwood Canyon receives.

Stream flow originates in the three upper basins. These basins are rather steep and each is approximately 0.8 of a mile in length. From the point where these basins join, the stream channel is very steep for 1.3 miles, eventually becoming more gradual for the remaining mile to the lower reservoir. A short distance upstream from the reservoir the stream flow is divided equally with half of the flow going into the reservoir and the other half being diverted into the Draper Irrigation Company Ditch.

Existing Facilities: There are three principal hydrologic facilities in Bells Canyon, a lower reservoir, a diversion into an irrigation canal and an upper reservoir.

The lower reservoir is located at the mouth of Bells Canyon at a maximum elevation of 5578 feet.[38] Bells Canyon Creek now flows into the reservoir, although one half of the creek flow is diverted into the Draper Ditch. The Lower Bells Canyon Reservoir has a capacity of 420 acre-feet.

The diversion into the Draper Irrigation Company Ditch is about 1000 feet above the lower reservoir. From this point the ditch flows in a southerly direction for a distance of almost three miles before entering the Draper Irrigation Canal. The Draper Irrigation Company Ditch presently collects a portion of flows from Bells Canyon Creek, Middle Fork Dry Creek, South Fork Dry Creek, Rocky Mouth Canyon Creek, and Big Willow Creek.[38] Part of this flow is used as supply to the Draper Irrigation Company Water Treatment Plant.

The Upper Bells Canyon Reservoir Dam was built in the late 1800's in the high basin area at an elevation of about 9400 feet. This dam was breached in the 1950's due to safety concerns. There is still a substantial reservoir existing in the basin below the breach level. Approximate capacity of this reservoir is 220 acre-feet.

Hydrologic Characteristics: Bells Canyon has a large percentage of its drainage area at relatively high elevations. Because of this, the Bells Canyon Creek reaches its peak flows later in the snowmelt season than the seven continuously gaged canyon streams, with a mean peak date of June 8.[46]

The channel is very steep in the upper reaches, causing the watershed to have a very short response time to individual rainstorms or high snowmelt periods. However, the majority of the Bells Canyon annual water yield is from melting snowpacks and ground-water baseflow, with only a minor portion of water contributed by summer cloudburst rain storms.

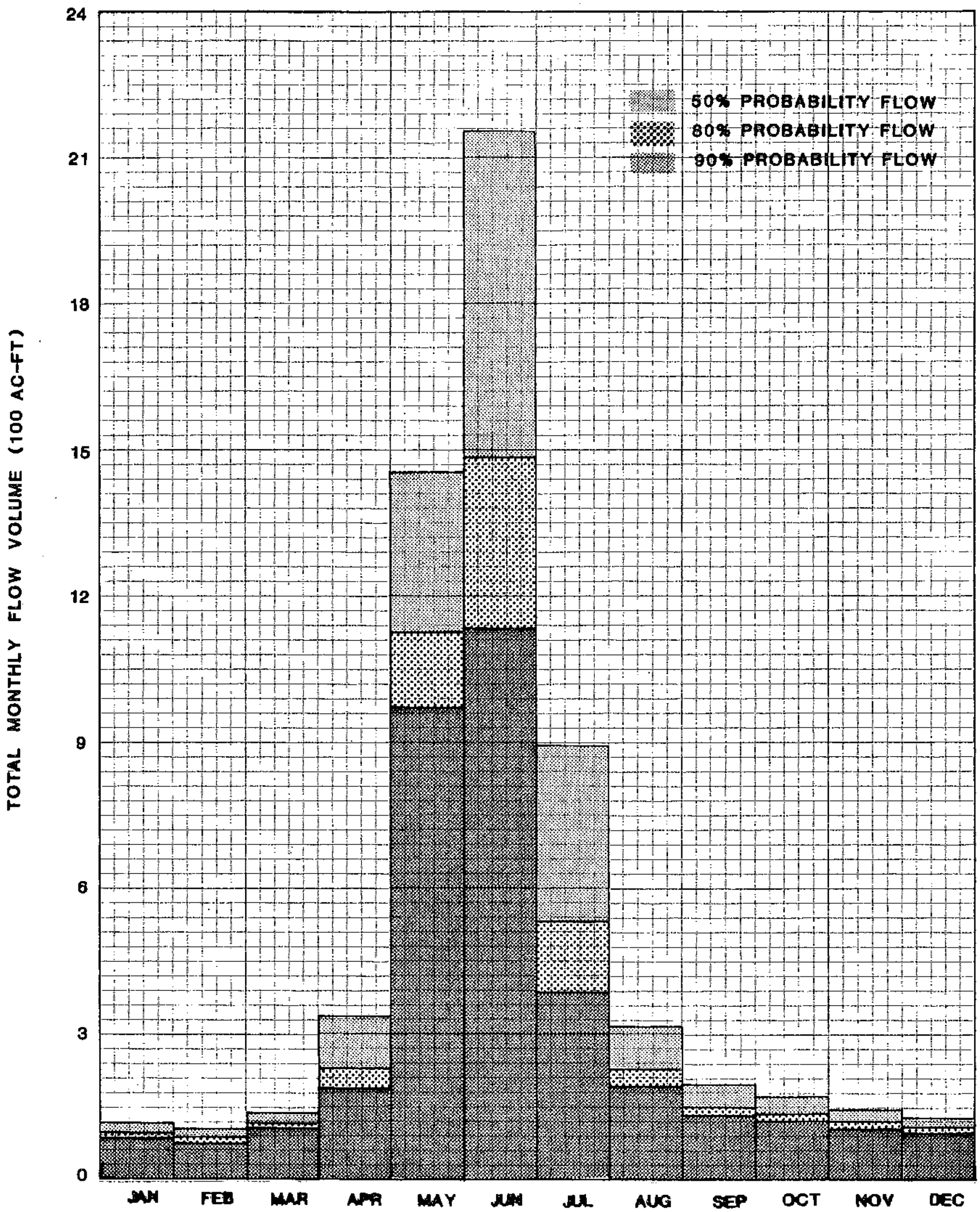
A continuous record of stream flows near the canyon mouth is available from the Salt Lake County Water Conservancy District for the period from April 8 to July 30 of 1980. A previous record of instantaneous canyon flows measured by the Bells Canyon Irrigation Company during the snowmelt seasons of 1971 through 1979 is also available. These measurements were taken approximately biweekly from April through August for each year. The measurements show typically a dramatic increase in flows during May until reaching the peak early in June, with a gradual recession during June, July and August.

The average annual yield estimate of 6288 acre-feet was determined by correlation with Little Cottonwood Canyon. Estimates of the 80 percent and 90 percent probability annual yields were extended from the average annual yield estimate based upon the Little Cottonwood Creek frequency analysis. Monthly yields were then extrapolated from the annual yield estimates. The 50 percent probability monthly yield estimates compare quite well with the actual April to July flows measured in 1980. The annual and monthly estimates are shown graphically in Figure V-25, and are tabulated in Table V-22.

Water Users: The Draper Irrigation Company diversion is located approximately 1,000 feet above the Lower Bell Canyon Reservoir. The Draper Irrigation Company is entitled to 50 percent of the stream flow. Their share of the water is diverted into the Draper Irrigation Company Ditch which transports the water to the Draper area. The water may be used for culinary or irrigation purposes.[48] A diversion is located on the Draper ditch to direct the water into the lower reservoir if the water is not needed in the Draper area.

The water in the lower reservoir is used by the North Dry Creek Irrigation Company and the Bells Canyon Irrigation Company. The North Dry Creek Irrigation Company is entitled to one-seventh of the flow entering the reservoir (7.14 percent of the total stream flow). The Bells Canyon Irrigation Company has rights to the remaining 42.86 percent.[48] The North Dry Creek diversion is located downstream of the lower reservoir.

The North Dry Creek Irrigation Company supplies irrigation water to the area between 9500 South and 10000 South and between 2300 East and 3500 East. They also supply culinary water to approximately 45



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

BELLS CANYON CREEK

FIGURE V-25

TABLE V-22

BELLS CANYON CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	89	97	116
February	76	84	104
March	106	113	134
April	185	226	331
May	973	1129	1456
June	1133	1481	2158
July	386	533	897
August	192	229	316
September	131	150	194
October	120	134	170
November	104	115	141
December	97	107	128
Annual Sum	3592	4398	6145
Annual Yield Estimate	4485	5100	6288

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern.

families. The company buys water from the Salt Lake County Water Conservancy District if the demand exceeds their capabilities.[45]

The Bells Canyon Irrigation Company supplies mountain irrigation water to the area between Dry Creek and Willow Creek and between 700 East and the mountains. Utah Lake water from the Draper Irrigation Company Canal is supplied to an area between 700 East and State Street and between Dry Creek and the Draper Cross Roads. Culinary water is supplied through an exchange and purchase from the Salt Lake County Water Conservancy District.

Crowten Springs, located south of Bells Canyon mouth on the west-facing slope, originates just west of the Draper Irrigation Company Ditch. The spring water was formerly conveyed west along 10600 South in a four-inch diameter pipeline for use in schools of the Jordan School District. The spring water and pipeline are no longer in use.[48]

Bells Canyon Irrigation Company water is diverted to the Draper Irrigation Company Ditch in exchange for culinary water.

Metro bought Bell Cyn [illegible]
& is expanding [illegible]

MIDDLE FORK DRY CREEK CANYON:

Physical Description: Middle Fork Dry Creek Canyon is 0.65 of a square mile in size and is one of the smallest drainage areas considered in the study. Just below the canyon mouth the stream enters the Draper Irrigation Company Ditch.

The elevation range from the canyon mouth to the highest peak is 5200 to 9400 feet. Slopes are very steep throughout most of this drainage area particularly just above the mouth. The canyon floor is very steep and has many bends in it. The geologic formation of this canyon is volcanic plutonic. Surface conditions are characterized by shallow soils which tend to be well-drained and have medium to rapid runoff. Rock outcrops occur as protrusions along ridges and side ledges in the upper areas.

Oakbrush, big sage brush, shrubs and grasses exist in the lower elevations, whereas conifer and aspen are found in small areas at higher elevations. Wildlife in this area consists of the typical species found in canyons along the Wasatch Range. Minimal watershed and wildlife habitat are the only identifiable land uses.

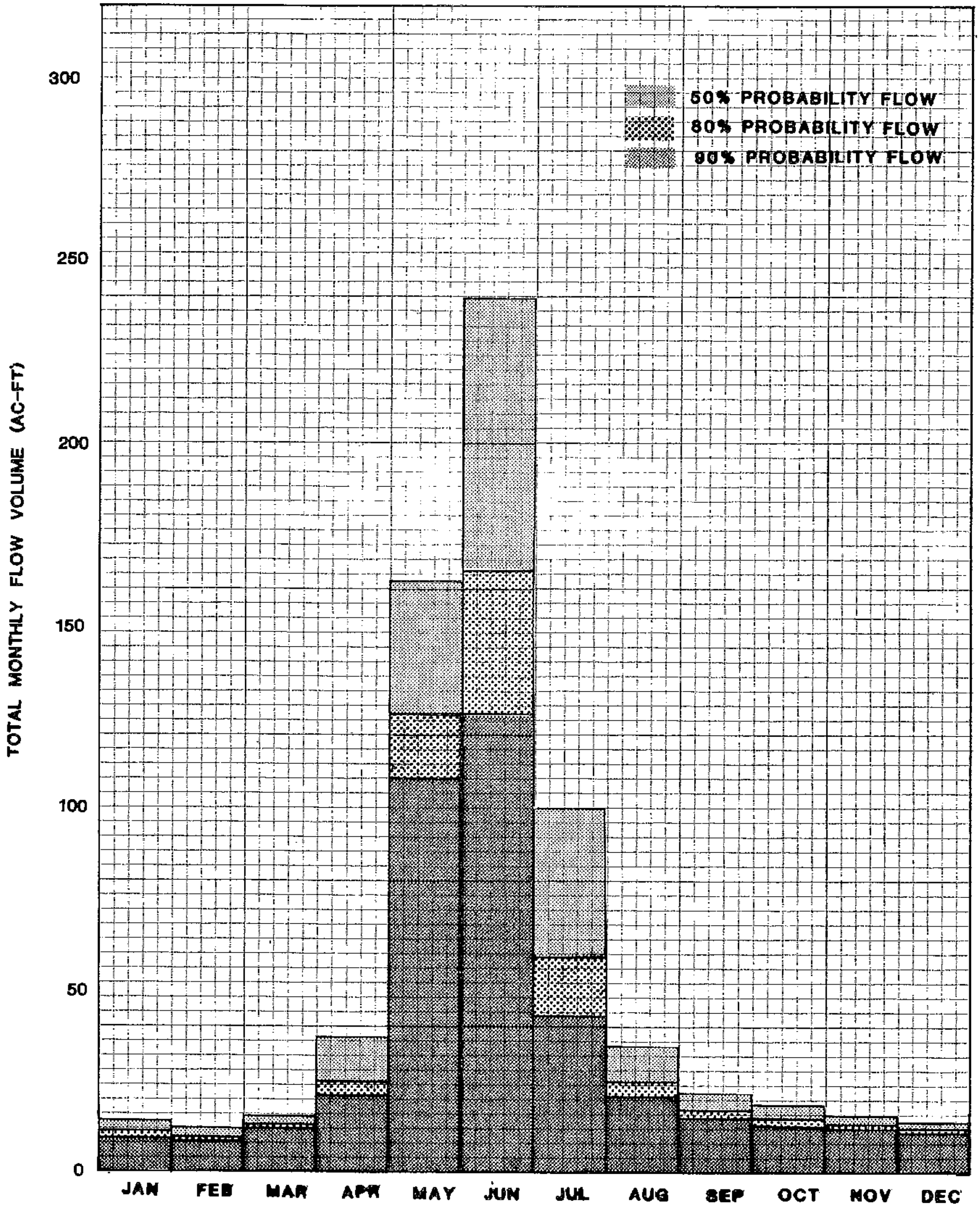
Snowpack is moderate in Middle Fork Dry Creek Canyon. Average precipitation is 20 to 30 inches per year. The stream channel for the entire canyon is indirect and generally steep.

Existing Facilities: There are no facilities on this stream. The creek discharges into the Draper ditch.[27]

Hydrologic Characteristics: No continuous flow record is available for Middle Fork Dry Creek. The stream is believed to be perennial.

An estimate of the mean annual yield of Middle Fork Dry Creek watershed was made by correlation with Little Cottonwood Canyon. The average annual yield estimate is 699 acre-feet. From this value, monthly yields for probabilities of 50 percent, 80 percent and 90 percent have been extrapolated. Figure V-26 and Table V-23 show these monthly estimates.

Water Users: The Draper Irrigation Company owns the rights to the water from Middle Fork Dry Creek. The water is combined with the water from Bells Canyon in the Draper ditch and is used for irrigation.[38]



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

MIDDLE FORK DRY CREEK

FIGURE V-26

TABLE V-23

MIDDLE FORK DRY CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	9.9	11	13
February	8.5	9.4	12
March	12	13	15
April	21	25	37
May	108	126	162
June	126	165	240
July	43	59	100
August	21	25	35
September	15	17	22
October	13	15	19
November	12	13	16
December	11	12	14
Annual Sum	400	490	~~672~~ 685
Annual Yield Estimate	498	567	699

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern.

SOUTH FORK DRY CREEK CANYON:

Physical Description: South Fork Dry Creek Canyon has a drainage area of 1.1 square miles and an elevation range of 5,200 feet at the mouth to over 10,000 feet on mountain peaks.[38] This represents the total drainage area since the creek flows into the Draper Irrigation Company Ditch just below the canyon mouth. There is an upper valley area which is wide with a moderate gradient surrounded on three sides by very steep cliffs. This valley eventually becomes more narrow with a steeper gradient. Side slopes are very steep, however, they do lessen somewhat at the canyon mouth.

Volcanic plutonic is the geologic formation of this canyon. Soil types in this area are generally shallow, well-drained and have a high percentage of rock outcrops. Runoff is moderate to rapid.

Vegetation in the lower elevations is limited to grasses and shrubs with conifers and aspens dominant in areas over 8,500 feet. Wildlife consists of deer, rabbit, skunk, porcupine, various small marmots and small birds with some upland game birds.

Other than its use as a watershed and wildlife habitat, South Fork Dry Creek Canyon is subject to very little use. Only an occasional hunter or hiker may visit this area.

Average precipitation in this area is 20 to 30 inches per year with snowpack being medium. The stream forms in various ill-defined drainage ways and is identifiable for about one mile above the canyon mouth. The stream gradient is steep in the upper areas, but becomes more gradual near the ditch at the canyon's mouth.

Existing Facilities: A diversion structure near the mouth of the canyon is used to divert part of the flow into an eight-inch pipe which conveys the water to the Draper Irrigation Company Water Treatment Plant. Excess water discharges into the Draper Irrigation Company Ditch. (47)

Hydrologic Characteristics: No continuous flow record is available for South Fork Dry Creek. However, a current meter measurement of 2.0 cfs was made on July 16, 1980, by representatives of the Salt Lake County Water Conservancy District and Nielsen, Maxwell and Wangsgard Consulting Engineers. The stream is believed to be perennial at the canyon mouth. The main water source for the creek is snowmelt, with rainfall runoff being of minor importance.[83,84]

An estimate of the average annual watershed yield was made, based on a comparison of South Fork Dry Creek Canyon with Little Cottonwood Canyon. From this estimate, monthly flows, as well as flows of higher probabilities, have been extrapolated. These estimates are shown graphically in Figure V-27, and are tabulated in Table V-24.

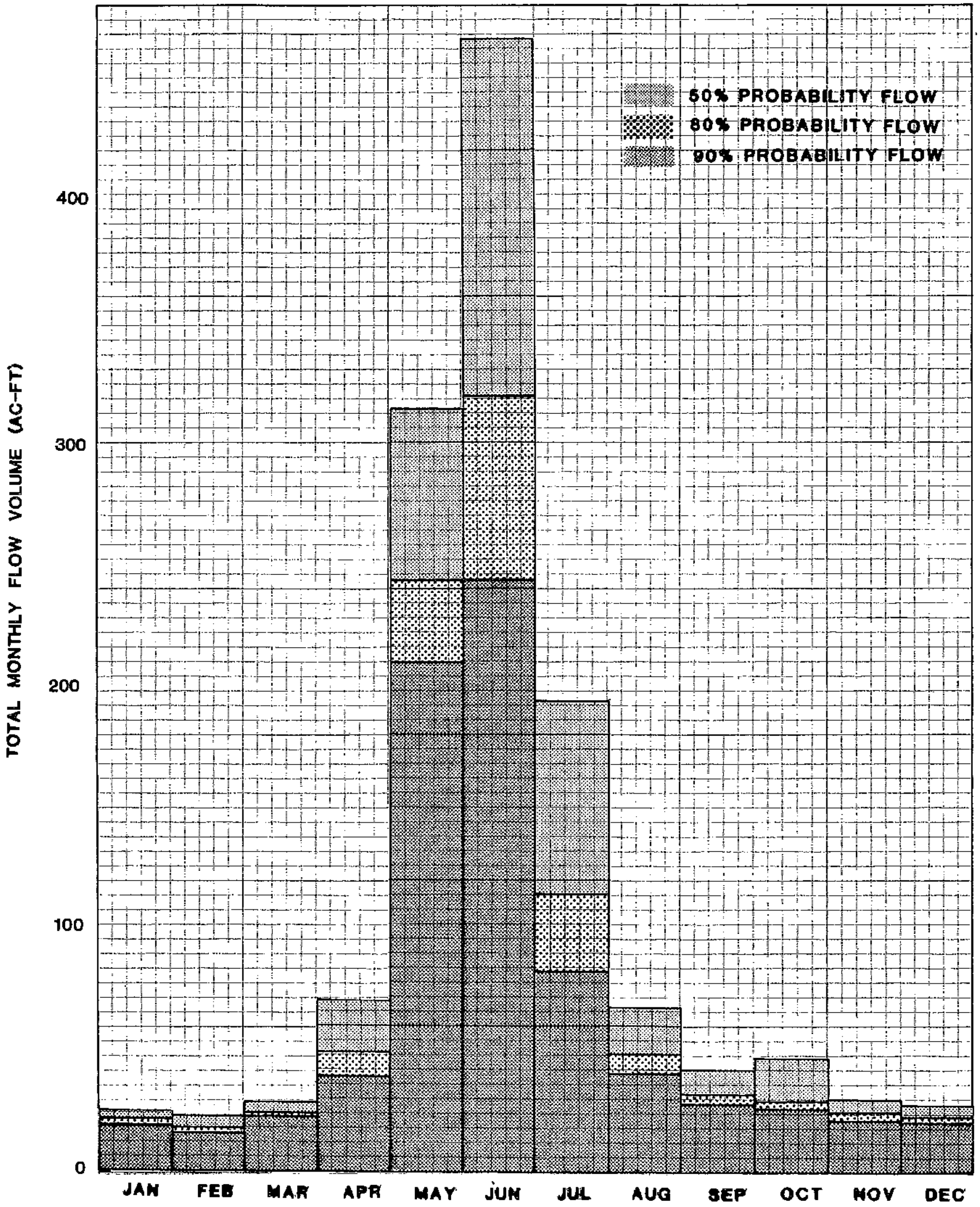
Water Users: The Draper Irrigation Company owns the rights to the water from South Fork Dry Creek. The water can be combined with the water from Bells Canyon and used for irrigation or as a culinary supply. (38)

TABLE V-24

SOUTH FORK DRY CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	19	21	25
February	16	18	23
March	23	24	29
April	40	49	71
May	210	244	314
June	244	320	466
July	83	115	194
August	41	49	68
September	29	32	42
October	26	29	37
November	22	25	30
December	21	23	28
Annual Sum	773	949	1327
Annual Yield Estimate	968	1100	1357

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

SOUTH FORK DRY CREEK

FIGURE V-27

ROCKY MOUTH CANYON:

Physical Description: Rocky Mouth Canyon has a drainage area of 0.74 of a square mile.[38] Elevation variation in this canyon ranges from 5,400 feet to over 10,000 feet. Slopes in this canyon are very steep, lessening slightly in the headwaters area.

Subsurface conditions are volcanic plutonic overlain by shallow, well-drained soils. There is much rock outcropping with low permeability. Runoff is rapid in areas with steep slopes, which exist in most of this canyon.

Shrubs and grasses exist at lower elevations but give way to scrub oak and eventually to conifers and aspen as elevation increases. Typical wildlife species exist in this area. Use as a watershed is essentially the only identifiable use for Rocky Mouth Canyon.

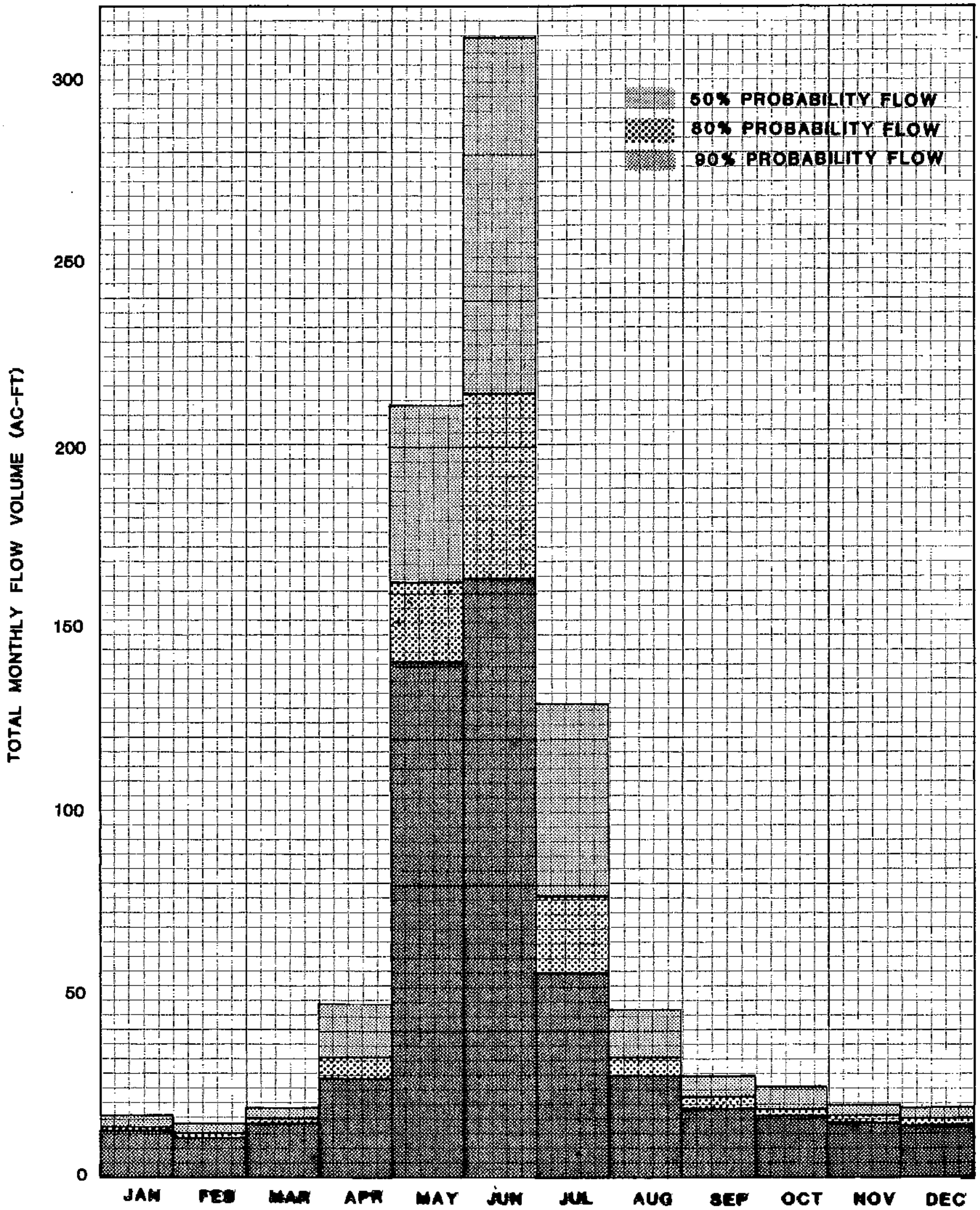
Normal annual precipitation in this canyon is 20 to 30 inches. Snowpack is moderate. The headwaters area of Rocky Mouth Canyon is not as steep as the rest of the canyon. From this point the stream channel is very steep down to the canyon mouth. Below the mouth of the canyon the stream is diverted into the Draper Irrigation Company Ditch.

Existing Facilities: Other than the diversion, there are no facilities on this stream. The creek comingles with Big Willow Creek before entering the Draper Irrigation Company Ditch.[47]

Hydrologic Characteristics: Although no continuous flow record is available for Rocky Mouth Canyon Creek, a current meter measurement of 2.5 cfs was made on June 17, 1980 by representatives of the Salt Lake County Water Conservancy District and Nielsen, Maxwell and Wangsgard Consulting Engineers. The stream is believed to be perennial.

An estimate of the average annual yield of Rocky Mouth Canyon was made by comparison with Little Cottonwood Canyon. This average annual yield estimate has been extrapolated to calculate monthly flows, based on the Little Cottonwood Creek pattern. Estimates for flows of 90 percent, 80 percent and 50 percent probabilities are shown graphically in Figure V-28, and are tabulated in Table V-25.

Water Users: The Draper Irrigation Company owns the rights to the water from Rocky Mouth Canyon Creek. The water is combined with the water from Bells Canyon and other canyons in the Draper Ditch and is used for irrigation.[38]



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

ROCKY MOUTH CANYON CREEK

FIGURE V-28

TABLE V-25

ROCKY MOUTH CANYON CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	13	14	17
February	11	12	15
March	15	16	19
April	27	33	48
May	141	163	211
June	164	214	312
July	56	77	130
August	28	33	46
September	19	22	28
October	17	19	25
November	15	17	20
December	14	16	19
Annual Sum	520	636	890
Annual Yield Estimate	649	738	910

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern.

BIG WILLOW CREEK CANYON:

Physical Description: Big Willow Creek Canyon has a drainage area of 1.4 square miles. Like most of the canyons in this area the stream is diverted near the canyon mouth. Elevation ranges from 5300 feet at the canyon mouth to a peak of over 10,500 feet. Over half of this drainage lies above 8000 feet. This upper headwaters area consists of a fairly wide glaciated valley surrounded by abruptly rising very steep slopes. The lower part of the canyon is much narrower with a well-defined drainage way. The floor is steep and is bordered by steep side slopes.

Geologic formation of this canyon consists of volcanic plutonic. Soils are generally shallow, well-drained, rocky and are fairly steep. Much rock outcropping is evident, particularly in the areas with the steep side slopes.

Vegetation and wildlife is typical of the other southeastern Salt Lake County canyons. Shrubs and grasses occur at the lower elevations, then scrub oak at middle elevations and eventually up to conifer and aspen which exist in the high elevations. Land use as a watershed and wildlife habitat are the only identifiable uses in Big Willow Creek Canyon.

Average annual precipitation ranges from 20 to 40 inches. Snowpack in the upper regions is quite heavy. Because there is no well-defined drainage way in the upper regions of this canyon the channel is identifiable for only about 1.25 miles in the lower portion of the canyon. The channel gradient is very steep at first, becoming more gradual as it nears the canyon mouth.

Existing Facilities: A diversion structure near the mouth of the canyon is used to divert the flow to the Draper Irrigation Company Water Treatment Plant or to the Draper Irrigation Company Ditch. The structure has a v-notch weir to measure the stream flow and an eight-inch headgate upstream to divert the water into a six-foot diameter pit. An eight-inch pipe conveys the water to the treatment plant. A screen has been provided over the eight-inch outlet in the pit. Excess water also discharges into the Draper ditch.[27]

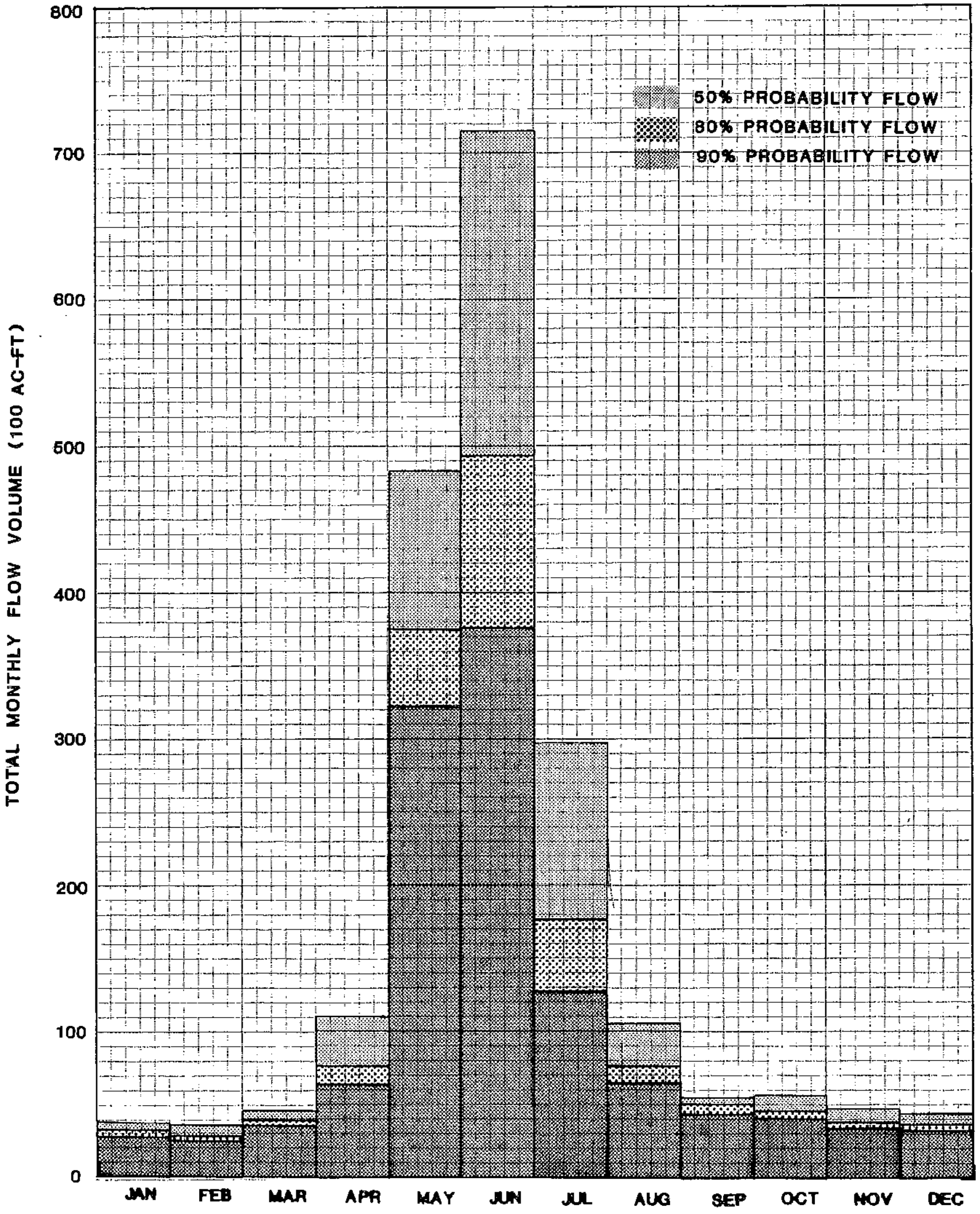
Hydrologic Characteristics: Big Willow Creek Canyon is similar to Bells Canyon and Little Cottonwood Canyon with respect to its range and areal distribution of elevations. It normally reaches peak snowmelt flows during the first two weeks of June, which corresponds with the average peak dates of Bells and Little Cottonwood Canyons and is relatively late in the snowmelt seasons.(27)

The major source of flow in Big Willow Creek Canyon is snowmelt water.(83,84) Snowmelt flows respond quickly to warming temperature changes in the spring, often peaking at the canyon mouth in as little as 24 hours following the warm temperatures.(48) Diurnal flow fluctuations are marked during the spring snowmelt season, with peaks normally attained during the early evening of each day.(48)

No continuous flow record is available for Big Willow Creek. However, one measurement of 3.9 cfs was made on June 17, 1980, by representatives of the Salt Lake County Water Conservancy District and Nielsen, Maxwell and Wangsgard Consulting Engineers. The stream flows perennially.(48)

An estimate of the average annual watershed yield of Big Willow Creek Canyon was made, using the "area-altitude" method, by comparison with Little Cottonwood Canyon. Estimates of flows of higher probabilities, as well as monthly flows, were extrapolated from the average annual yield estimate. These values are shown graphically in Figure V-29, and are tabulated in Table V-26.

Water Users: The Draper Irrigation Company owns the rights to the water from Big Willow Creek. The water can be combined with the water from Bells Canyon and used for irrigation or used as a culinary supply for the Draper Irrigation Company Water Treatment Plant.(38)



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

BIG WILLOW CREEK

FIGURE V-29

TABLE V-26

BIG WILLOW CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	29	32	38
February	25	28	35
March	35	38	45
April	62	75	110
May	323	375	483
June	376	492	716
July	128	177	298
August	64	76	105
September	43	50	64
October	40	45	56
November	34	38	47
December	32	36	43
Annual Sum	1191	1462	2040
Annual Yield Estimate	1489	1683	2087

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern.

LITTLE WILLOW CREEK CANYON:

Physical Description: The total drainage area for Little Willow Creek lies in the canyon and is 1.3 square miles in size. Elevation ranges from over 10,400 feet at the highest peaks down to 5200 feet at the canyon mouth. Slopes vary in the upper third of the canyon with steep cliffs and gradual valleys existing there. Below this the slopes are consistently steep.

Geologic conditions are volcanic plutonic overlain by soils that are generally shallow, well-drained and have extensive rock outcropping. Runoff is medium to rapid.

Vegetation consists primarily of shrubs and grasses in the lower elevations with conifer and aspen trees the dominant species found in the higher areas of the drainage way. Wildlife consists of the typical species found in adjacent canyons. Land use consists mainly of watershed and wildlife habitat.

With the high elevations and 20 to 35 inches of precipitation per year, snowpack is fairly heavy in parts of Little Willow Creek Canyon. The stream channel is 3.25 miles long in the canyon. The stream gradient is moderately steep in the headwaters area, eventually becoming steeper down to the canyon mouth. There are no significant side tributaries in this canyon.

Existing Facilities: The flow from Little Willow Creek discharges directly into the Little Willow Irrigation Company Ditch. In addition, a six-inch pipeline has been constructed to transport water from the creek to the Utah State Prison. A storage tank which is owned by the Division of State Land and Forestry is located above the prison and is used to store the water. A branch line is available to bypass the tank and bring the water directly to the prison.[17]

Hydrologic Characteristics: Little Willow Creek Canyon has a relatively high elevation range, although not quite as high as its neighboring Big Willow Creek watershed. Because of this, the snowmelt flows in Little Willow Creek normally reach their peak late in the snowmelt season, during the first part of June. The stream flows perennially.[16]

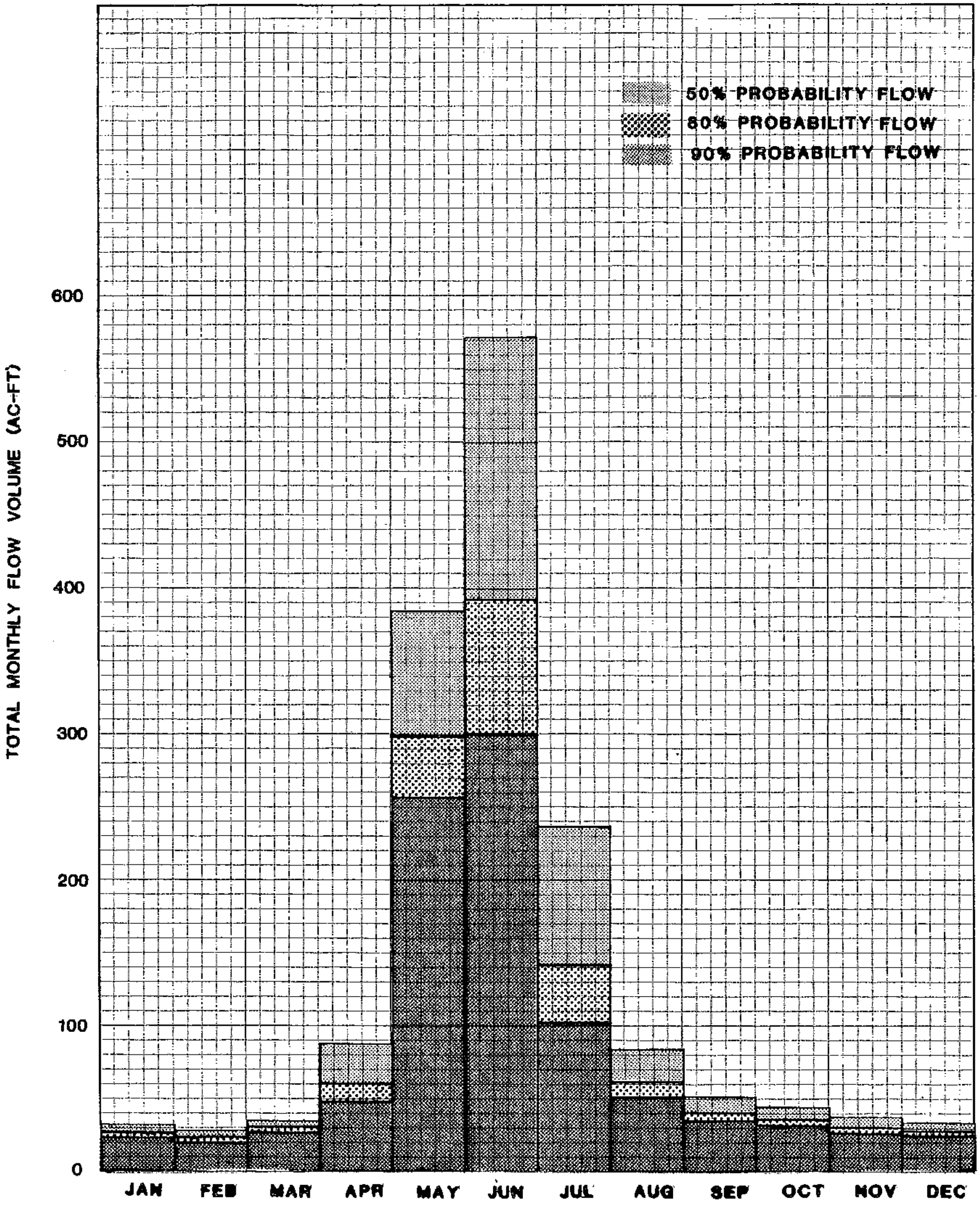
The major source of water in the canyon is snowmelt.[83,84] The melt water surfaces in springs in many locations within the canyon, and flows into the main channel.[16]

No continuous flow record is available. However, several measurements were made in 1941 by A.Z. Richards during preparation of a diligence claim.[16] These measurements revealed flows of 0.4 cfs to more than 5.5 cfs from April 1 to October 1, with the peak flow being reached in June. The November to May flow remains fairly constant at about 0.6 cfs, according to a representative of the Little Willow Irrigation Company. A single measurement of 1.2 cfs was also made on July 1, 1957.[16]

An estimate of the average annual watershed yield from Little Willow Creek Canyon was made by correlation with Little Cottonwood Canyon. From this estimate, annual yields of higher probabilities and monthly flows were extrapolated, based on the Little Cottonwood Creek pattern. These estimates are displayed graphically in Figure V-30, and are tabulated in Table V-27.

Water Users: The rights to the water from Little Willow Creek are divided between the Utah State Prison and the Little Willow Irrigation Company. The prison owns 0.3 cfs and leases an additional 0.3 cfs. The prison's share is stored in a tank owned by the Utah Division of State Land and Forestry. In return for use of the tank the Division uses some of the water for irrigation of a small tree farm. The prison uses the water in their pressure irrigation system. Culinary water for the prison is supplied from a well.[17]

The Little Willow Irrigation Company uses their share of the water for irrigation of land owned by their stockholders and sells any excess water to the prison and the Hidden Valley Golf Course. Also, a connection for these three users has been provided on the Salt Lake Aqueduct to supply additional water.[16]



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

LITTLE WILLOW CREEK

FIGURE V-30

TABLE V-27

LITTLE WILLOW CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	23	26	31
February	20	22	28
March	28	30	35
April	49	60	88
May	257	299	385
June	300	392	571
July	102	141	237
August	51	61	84
September	35	40	51
October	32	35	45
November	27	30	37
December	26	28	34
Annual Sum	950	1164	1626
Annual Yield Estimate	1186	1348	1663

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern.

BEAR CANYON:

Physical Description: Bear Canyon has a drainage area of 1.0 square mile. Near the mouth it has fairly steep slopes becoming more gradual in the upper drainage area which extends to an elevation of 9500 feet.

Similar to other canyons in this region, Bear Canyon is volcanic plutonic. The lower half of the canyon has shallow, well-drained soils that tend to have a moderate runoff. The upper half of the canyon has a greater percentage of rock outcropping, thus runoff is more rapid.

Some conifer and aspen exist in the upper areas of this canyon, but the predominant vegetation consists of shrubs and grasses. Land use is essentially watershed and wildlife habitat.

Average precipitation is 20 to 30 inches per year and snowpack is moderate. The stream flow originates in an area with vague drainage characteristics but eventually flows into a well defined and very steep canyon. Near the canyon mouth much of the stream seeps into the ground.

Existing Facilities: Riverton City has developed a spring near the mouth of the canyon. A tunnel has been drilled horizontally 200-feet into the mountain to collect the ground water. A pipe conveys the water from the canyon to the city. A meter has been installed on the pipe near its crossing of the Jordan River.

Hydrologic Characteristics: Bear Canyon Creek is a perennial stream which is supplied mainly by snowmelt water.[64] Although no continuous flow record is available, an individual water user near the canyon mouth reports a fairly constant winter flow of about 0.4 cfs, with an average peak of 12 cfs being attained during the period of April 20 to May 10. The flows at the mouth respond very quickly to temperature changes.[64]

An estimate of the average annual surface flow yield from Bear Canyon was made by correlation with Little Cottonwood Canyon. From this estimate, higher probability yields and monthly flows have been extrapolated. The monthly flow pattern should be used with caution, since the peak date may be as much as four weeks earlier than shown. The flow estimates are displayed graphically in Figure V-31, and are tabulated in Table V-28.

The spring developed by Riverton City yields a nearly constant rate of 155 to 165 gallons per minute, according to Riverton City records.[6]

Water Users: The runoff from Bear Canyon is used by five individuals and Riverton City. The individuals use the water for irrigation of crops and livestock watering.

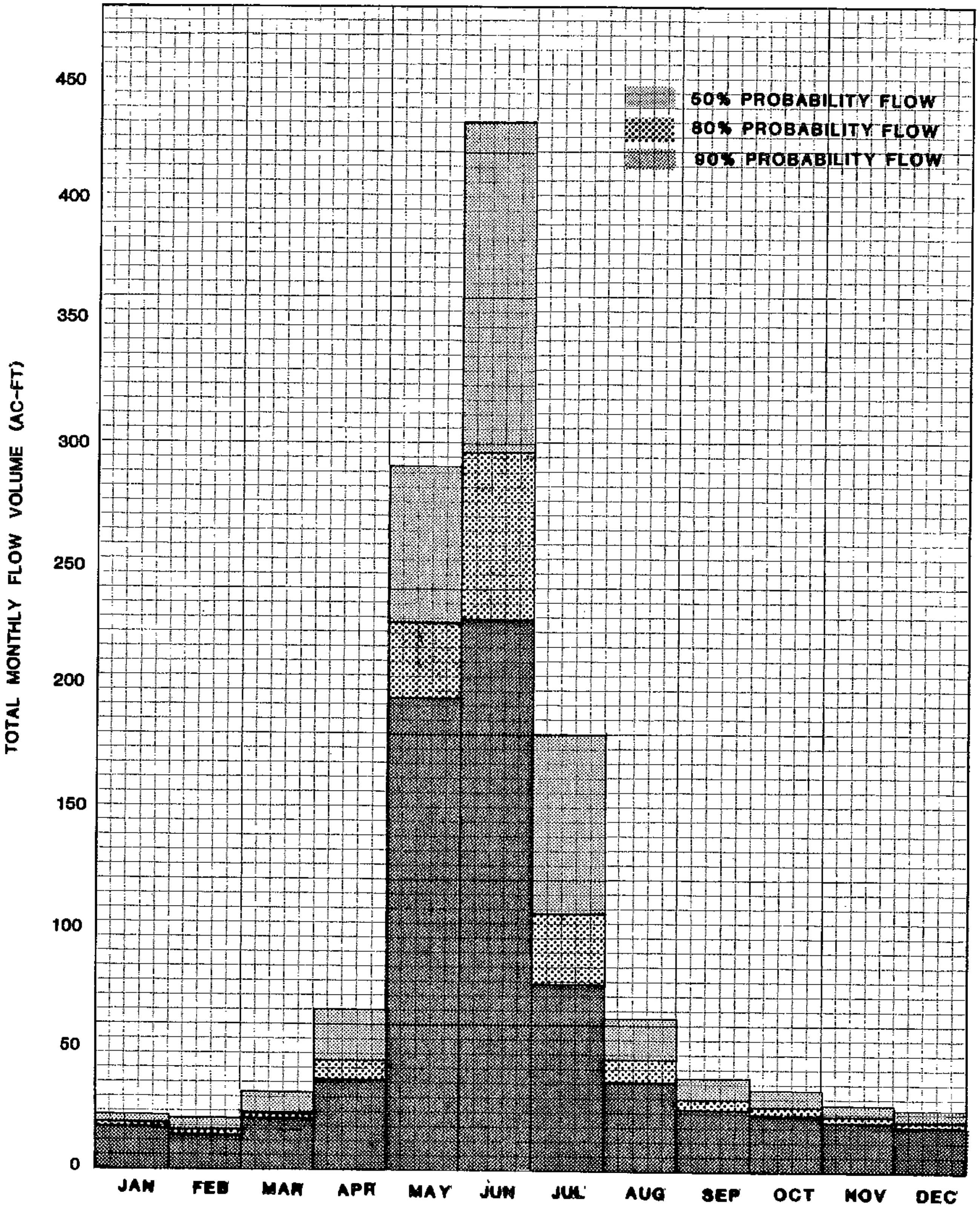
Riverton City has not diverted their share of the surface water for several years. Instead, they have developed a spring which provides them with a constant flow all year long. The spring water is piped directly into their distribution system.[64]

TABLE V-28

BEAR CANYON CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescried Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	18	19	23
February	15	17	21
March	21	23	27
April	37	45	66
May	195	226	291
June	227	296	432
July	77	106	180
August	38	46	63
September	26	30	39
October	24	27	34
November	21	23	28
December	19	21	26
Annual Sum	718	879	1239
Annual Yield Estimate	898	1021	1259

*Extrapolated from the result of an "area-altitude" correlation with Little Cottonwood Canyon, based on the Little Cottonwood Creek pattern.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

BEAR CANYON CREEK

FIGURE V-31

CORNER CANYON:

Physical Description: Stream flow out of Corner Canyon is actually the combination of three distinct drainage ways with a total area of 3.5 square miles. The canyon has an elevation range of 4800 to 9000 feet with a high percentage of it lying in the 6000 to 7000 foot range.

Slopes vary from steep to moderate with much of the steep slope areas existing in the northern part of this wide drainage area. The southern part of the canyon is characterized by moderately steep slopes rising to low elevation flat top mountains.

Subsurface geologic conditions are mostly volcanic plutonic with quartzite formations near the canyon mouth. The mouth is made up of sandy terrace escarpment, which is deep, well-drained, and has a moderate runoff. In the drainage area itself the soils are deep, well drained, with steep slopes and slow permeability.[70] Runoff is moderate.

Vegetation is grass and shrubs, composed in part of bunch wheat grass, bluegrass, oakbrush and bitterbrush.[70] Corner Canyon is used as a watershed area with some hiking and hunting.

Because of the low elevations and the southerly orientation, average precipitation in the Corner Canyon area is only 20 to 25 inches per year. Of the three drainage ways in Corner Canyon, the center one is the largest. The gradient of the stream channel is steep in the headwaters area eventually becoming more gradual near the canyon mouth.

The other two drainage ways have no significant side tributaries. The largest of the two is located to the north of Corner Canyon the other to the south. They both enter the main stream approximately one half mile upstream from the canyon mouth.

Existing Facilities: There are no facilities on Corner Canyon Creek other than the diversion into the Corner Canyon Irrigation Company Canal.

Hydrologic Characteristics: Corner Canyon Creek is a perennial stream whose major source of water is snowmelt.[58] Although no continuous flow record is available, the USGS recorded several measurements at the canyon mouth during 1964-1968. These measurements show a flow range of 0.6 to 16.2 cfs, with the peak flows reached in mid May. The stream flow decreases to a nearly constant low flow relatively early in the summer. This is probably due to the large amount of southerly exposure of the snowpack to the sun. By the middle of July the flow has decreased to a near minimum, which is then sustained through the fall and winter until beginning to increase late in March.[78]

An estimate of the average annual yield of Corner Canyon was made by correlation with a frequency analysis performed for Fort Creek, which flows south into the town of Alpine. The Fort Creek watershed was chosen for comparison because of its proximity and its large portion of south-facing slopes. From the annual estimate, yields of higher probabilities and monthly flows were extrapolated, based on the Fort Creek pattern. The Fort Creek monthly flow pattern seems to correspond well with the Corner Creek flow pattern, based on the limited amount of flow records available. The flow estimates are shown graphically in Figure V-32, and are tabulated in Table V-29.

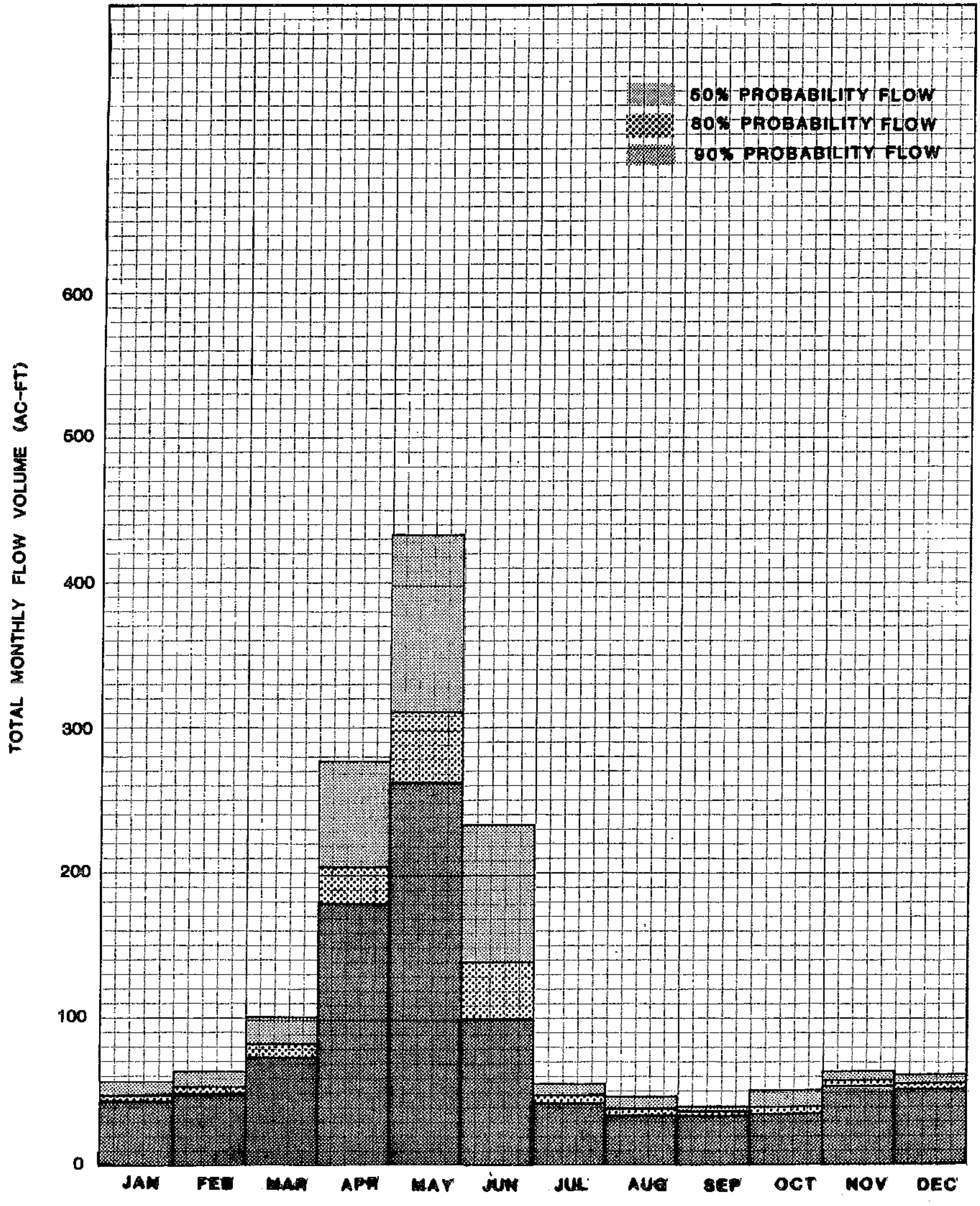
Water Users: The water from Corner Canyon is used by the Corner Canyon Irrigation Company for irrigation and livestock watering.

TABLE V-29

CORNER CANYON CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	45	48	58
February	49	54	64
March	74	83	101
April	180	206	279
May	263	313	435
June	101	140	236
July	43	47	56
August	35	39	48
September	34	36	40
October	35	40	51
November	53	56	63
December	51	55	61
Annual Sum	913	1117	1442
Annual Yield Estimate	1166	1258	1520

*Extrapolated from the result of an "area-altitude" correlation with Fort Creek Canyon, based on the Fort Creek pattern.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

CORNER CANYON CREEK

FIGURE V-32

OQUIRRH MOUNTAINS:

GENERAL BACKGROUND: This section provides background information concerning the major Oquirrh streams which drain into Salt Lake Valley. Six streams are considered in this report. From south to north they are: Rose Creek, Butterfield Creek, Bingham Creek, Barneys Creek, Harkers Canyon Creek and Coon Creek.

Rose Creek drains into the South Jordan Canal near the Jordan River. The area from the headwaters to the river is considered as a single drainage basin in this report.

Butterfield Creek and Midas Creek comprise a single drainage course to the Jordan River. Both channels flow separately in their upper valley reaches. The channels join to form a single stream about half a mile upstream from the Jordan River.

Barneys Creek and Bingham Creek flow separately in their upper valley reaches but are considered as a single drainage area in the lower valley. Bingham Creek has a well-defined channel to the river. However, Barneys Creek drains easterly across the valley floor to just beyond the Utah Lake Distributing Canal where the channel fades and becomes indistinguishable.

Coon Creek and Harkers Canyon Creek are included as a single drainage basin. Coon Creek extends northeasterly from the canyon mouth to the Utah and Salt Lake Canal, which marks its termination point. Harker Canyon Creek joins the Coon Creek channel just below the mouth of Coon Canyon. Coon Creek does not have a natural channel to the Jordan River.

Typical Oquirrh Storms: A discussion of the general characteristics of the three typical storm patterns is included in the "Typical Wasatch Storms Characteristics" subsection of this report. A brief discussion of the particular effects of these storms on the precipitation received on the east-facing slopes of the Oquirrh Mountains follows.

Pacific frontal storms and cyclonic storms occur throughout the year with varying strength and frequency. Snowfall during the winter months is primarily from Pacific frontal storms.[57] The frontal storms generally develop in the Gulf of Alaska and move across the Great Basin in an easterly direction.[88]

Frontal storms exhibit a marked orographic effect when moving easterly across mountain ranges.[35] That is, precipitation results from the cooling process of lifting of moist air currents upward as they pass over mountain ranges.[57] Snowfall depths increase with higher elevations on the windward, or Tooele side of the Oquirrh Mountains. The leeward or Salt Lake County side of the Oquirrh Mountain receives very little winter precipitation because the descending air has been depleted of its moisture.

Convective "Gulf" storms are confined entirely to the summer season, and become cloudburst events.[57] They characteristically reach high rainfall intensities for short durations over relatively small areas.[62] "Gulf" storms exhibit much less orographic effect than winter frontal storms,[33] and can be expected to occur with high intensities on both the east and west slopes of the Oquirrh Mountains. This fact is evidenced by the common reports of flashfloods during the summer months in the intermittent valley reaches of the east-draining Oquirrh streams.

Ungaged Stream Analysis Procedures: None of the Oquirrh streams draining into Salt Lake County are continuously gaged. Some infrequent USGS instantaneous flow measurements at the canyon mouths are available for all six of the major Oquirrh streams. These few measurements, although useless from a statistical approach, are helpful in estimating the range of typical flow magnitudes.

The "area-altitude" method has been used to estimate the average annual yield from the six Oquirrh watersheds. By this method an ungaged watershed annual water yield may be estimated by correlation with a nearby similar gaged watershed. In this method, both the gaged or base station, and the ungaged watershed areas are separated into bands of elevation on a topographic map and measured. A relationship between average annual precipitation and elevation is interpolated from a state-wide precipitation atlas. Also, a relationship of runoff as a percentage of precipitation at various elevations is obtained. The ungaged watershed is then correlated with the base station by relating the three variable (elevation band area, precipitation, and percentage of runoff) to elevations within the ungaged watershed.

Two similar gaged watersheds, which appeared to exhibit the characteristics of the leeward side of the Oquirrh Mountains, were identified for possible use in the area-altitude method. These two watersheds are West Canyon in Cedar Valley and South Willow Canyon in the Stansbury Mountains west of Tooele Valley. Both are on east-facing slopes and have been continuously gaged for at least ten years.

Upon closer examination, however, it was found that South Willow Canyon is more comparable to the Wasatch canyons than to the Oquirrh Mountains. South Willow Canyon yields about twice the annual amount of water than West Canyon, even though West Canyon is six times the size of the Stansbury watershed. South Willow Canyon's large stream flows and dense vegetation are apparently caused by higher elevations and local climatological conditions that are not typical of the leeward Oquirrh Mountain slopes.

West Canyon was found to be much more similar to the Salt Lake County Oquirrh slopes in terms of geology, vegetation, elevation range and runoff, and was therefore selected for use in the area-altitude computations. A frequency analysis of the gaged West Canyon flows was performed. Unfortunately, only a ten-year period of record was available. However, no other suitable watershed with flow records was found.

The result of the area-altitude computations for each watershed on the west side of Salt Lake County was a single number, the estimated average annual yield. This value for each canyon was extrapolated to 80 percent and 90 percent probability annual yields, based on the pattern of West Canyon Creek. A further extrapolation, also based on the West Canyon Creek pattern, was made to distribute each annual yield estimate into monthly yields.

While these extrapolations are useful for preliminary planning purposes, they should not be regarded as completely accurate, and should be used with caution. The higher probability flows and the monthly patterns have questionable accuracy for several reasons: (1) there is no gaged stream on the Oquirrh Mountains which can be used to check the accuracy of the estimating method; (2) they are based on a frequency analysis of West Canyon Creek with only a ten-year period of record; (3) the extrapolation of monthly flows from the West Canyon Creek pattern does not allow for shifting of the seasonal peak flow data of watersheds with much lower elevations, which occurs in reality; (4) the method predicts perennial flows for all of the ungaged streams at the canyon mouths, which is not the case; and (5) the method does not take into account man-made changes in watershed characteristics, such as those due to mining activities. It is recommended that a program of continuous stream gaging be initiated on the Oquirrh Mountain streams to obtain more reliable data.

ROSE CANYON:

Physical Description: The canyon drainage area of Rose Creek is 10.6 square miles and the valley portion is 22.0 square miles, resulting in a total drainage area to the Jordan River of 32.6 square miles.

Rose Canyon is the lowest of all the Oquirrh canyons with its headwaters area at approximately 6900 feet. This area is characterized by low-lying mountains and foothills with moderately steep north-facing slopes and gradual south-facing slopes. Rose Canyon is very broad and eventually opens into the valley with no well-defined canyon mouth.

The drainage area from the mountains to the Jordan River slopes gently eastward. Gully erosion along Rose Creek and other small streams is characteristic of this area.

The canyon area subsurface is volcanic plutonic with the canyon floor consisting of alluvial deposits.(61) Soils tend to be well-drained, very cobbly, and have a rapid runoff.(70)

The geologic substrata of the valley drainage area consists of lakebed deposits with the Jordan River corridor made up of flood plain deposits. Soils are well-drained to poorly drained with runoff generally being slow.

Vegetation in the canyon area is mainly grasses and shrubs, composed in part of bitter brush, big sage brush, bluegrass and wheat grass. While not as abundant as in the eastern canyons, typical wildlife species found in this area are deer, rabbit, squirrels, upland game birds, and various small birds and mammals. Land use in the canyon area is watershed, wildlife habitat, grazing and as a military reservation.

Much of the valley area in the Rose Creek drainage area is used for irrigated and non-irrigated cropland. Natural vegetation and wildlife have been essentially displaced. Crops in this area include alfalfa and small dryland grains.

Precipitation in this area ranges from 10 inches in the valley area to 20 inches in the headwaters area. Because the mountain elevations are relatively low, snowpack is light.

Upper Rose Creek flows for about 1.5 miles before it is joined by Yellow Fork Creek which is actually larger in drainage area and flow. There are no other major tributaries in the canyon area, although shortly after Rose Creek leaves the canyon it is supplemented by Wide Hollow

Creek. From here it flows out of the west bench area into the valley where it eventually enters the Utah Lake Distributing Canal approximately three miles east of the Jordan River.

Rose Creek has a distinguisable natural channel to the South Jordan Canal. Rose Creek flows annually in its lower reaches and is fed by return flows and ground water.

Existing Facilities: The Herriman Pipeline Company developed three springs in Rose Canyon and its tributaries from which they divert water. A six-inch pipeline, constructed in 1969, conveys water from these springs to a chlorination facility southwest of Herriman. The chlorinated water is stored in a 110,000-gallon reservoir.[15]

Two wells west of Herriman also supply water to the Herriman Pipeline Company. Water from these wells is stored in a 15,000-gallon reservoir.[85]

The Rose Creek Irrigation Company has constructed two concrete diversion structures on the creek. These structures divert the flow into the Company's ditches.

Hydrologic Characteristics: Rose Creek is a perennial stream in the canyon.[14] The surface stream originates as springs in the upper reaches.[13] Since the watershed does not extend to very high elevations, excessive snowmelt flows do not usually occur. Also, because of the low elevations the snowmelt peak flows occur fairly early in the spring, usually during the last part of April or early in May.[13,78] These snowmelt flows are normally sustained for about two weeks before beginning to recede noticeably.[13] Flows decrease during the summer to a minimum in August, and then remain fairly constant throughout the winter months.

Infrequent instantaneous flow measurements taken by the USGS at the canyon mouth during 1964-1968 show flows of less than one cfs during the fall and winter months, with flows ranging from 0.6 to 1.6 cfs during the spring peak runoff season.[78] Other measurements show peak flows during the spring from 6 to 12 cfs.[28]

The average annual yield from the Rose Canyon watershed has been estimated by comparison to a frequency analysis performed for West Canyon Creek in Cedar Valley. From this annual yield estimate, higher probability flows and seasonal flow fluctuations have been extrapolated.

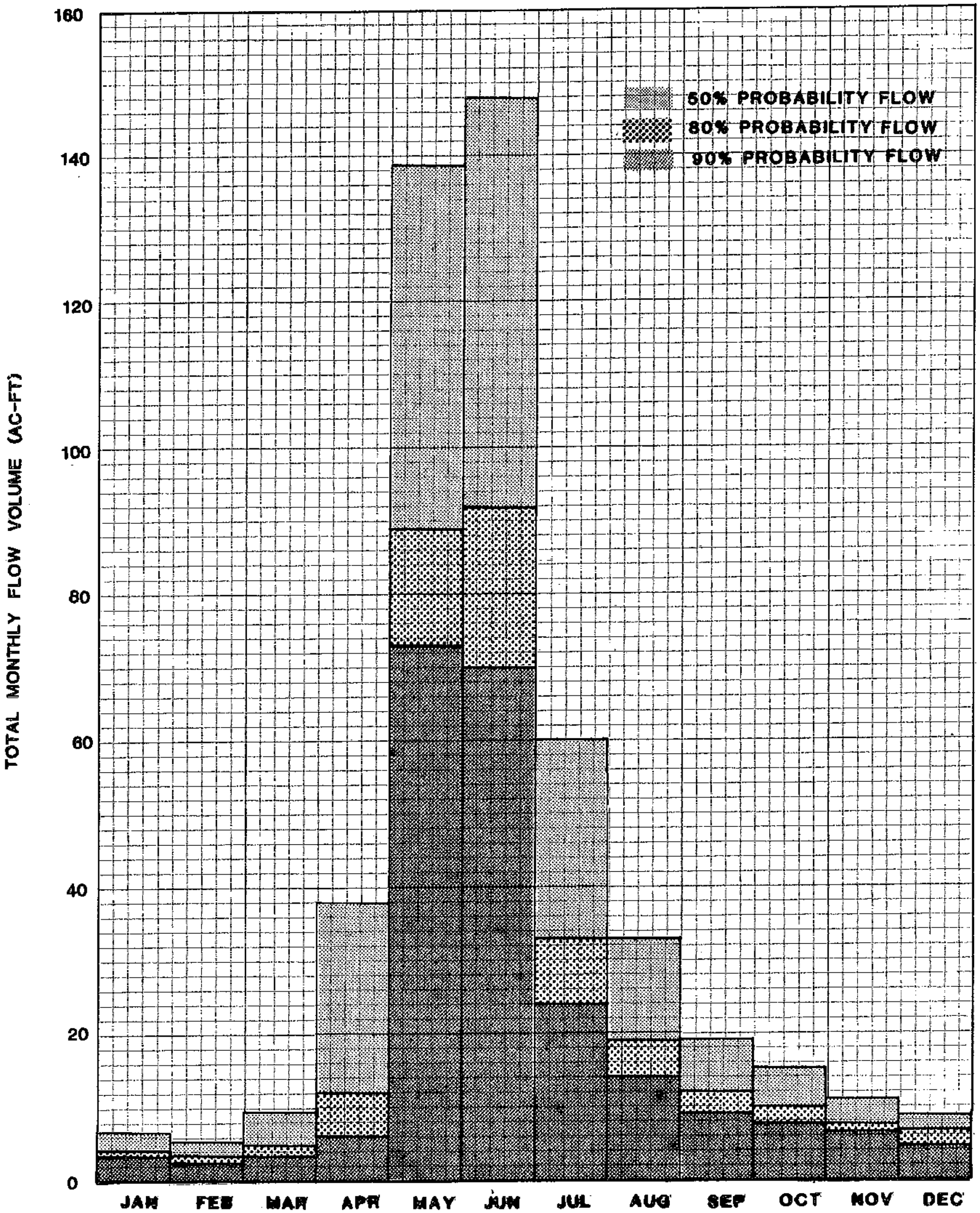
These values are displayed graphically in Figure V-33, and are also tabulated in Table V-30. Caution should be taken when using these values for planning or designing purposes. Oral communications and infrequent measurements have indicated that the average snowmelt peak flows on Rose Creek may occur as much as a month earlier than predicted from the West Canyon Creek seasonal pattern. However, there is not sufficient information available to make an accurate adjustment of the predicted seasonal pattern at this time.

Water Users: Rose Canyon supplies water for agricultural, irrigation, stock watering and culinary use in and around the Herriman area.

The Herriman Pipeline Company supplies culinary water to approximately 510 people. The water is distributed through the Company's system which was constructed in 1946. The pipeline company has rights to a total of 0.14 cfs from springs.(85)

The Rose Creek Irrigation Company provides water for irrigation and stock watering. The company has established rights for 5.5 cfs.(85)

Two of the springs in the canyon have been filed upon by parties other than the two companies already mentioned. One spring is located in Farmers Hollow and has an established right of 0.0067 cfs. The other spring is in Wide Hollow and has an established right of 0.027 cfs. The water from both of these springs is used for stock watering.(85)



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

ROSE CREEK

FIGURE V-33

TABLE V-30

ROSE CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	3.2	4.0	6.5
February	2.4	3.2	5.3
March	3.4	4.8	9.3
April	6.1	12	38
May	73	89	139
June	70	92	148
July	24	33	60
August	14	19	33
September	9.1	12	19
October	7.5	9.8	15
November	6.1	7.6	11
December	4.4	5.7	8.8
Annual Sum	223	292	493
Annual Yield Estimate	288	359	544

*Extrapolated from the result of an "area-altitude" correlation with West Canyon, based on the West Canyon Creek pattern.

BUTTERFIELD CANYON:

Physical Description: The canyon drainage area for Butterfield Creek is 9.6 square miles. There are also 42.9 square miles of valley drainage area east of Butterfield Canyon which generates a substantial stream flow in Butterfield and Midas Creeks.

Butterfield Canyon has an elevation range of 5500 feet to 8200 feet. Slopes are moderately steep, becoming more gradual near the canyon mouth.

The drainage area from the canyon mouth eastward consists of the western Lake Bonneville terrace with moderate slopes, leveling out eventually to the valley floor with a slight slope towards the Jordan River. Erosion-caused gullies such as Midas Creek and some of the small streams are found throughout this area.

Quartzite deposits are extensive throughout the canyon headwaters area and to the north, while volcanic plutonic formations exist in the southern slopes of Butterfield Canyon. The canyon floor and west bench area are made up of alluvial deposits. Soils in the canyon area are deep to shallow, usually well-drained with rapid runoff.

The valley portion of the drainage area consists of lake bed deposits overlain by well to poorly-drained soils which have a medium to slow runoff.

Vegetation in the canyon area consists mainly of grasses and shrubs some of which are big sage, wheatgrass, bitter brush, oak brush, maple, bluegrass and mountain brome.[70] Land use in the canyon is primarily watershed and wildlife habitat.

Since land use in the valley drainage area is primarily agricultural, the vegetation consists mainly of irrigated and dry crops. Much of the natural vegetation has been displaced by farming activities or residential development.

Rainfall in the canyon area averages 25 to 30 inches per year.[83] Elevations in the headwaters area are moderate, therefore, snowpack is light.

Four small tributaries, Stockings Fork, Left Hand Fork, Tooele Fork and Spring Gulch Creek combine in the upper canyon area to form much of the Butterfield Creek flow. The creek flows at a moderate gradient out of the canyon on to the west bench. Shortly after the creek leaves the bench it is diverted into a concrete irrigation ditch.

Stream flows in the lower reaches of the valley drainage area consist of Midas Creek and Butterfield Creek. Both are fed by ground-water sources and occasional overflows. Both cross and are diverted into various irrigation canals. However, their natural drainage channels combine and continue to the Jordan River.

Existing Facilities: Many mine tunnels have been dug and are now abandoned in this portion of the Oquirrh Mountains. Flows from these tunnels are now used as water sources to Butterfield Creek. One such tunnel is the Butterfield Tunnel which is located approximately two miles up the canyon. This old mine shaft has been sealed and a portion of the collected ground water is diverted into the creek bed. Another such mine shaft is the Bingham Tunnel.(85) This mine is located in the northwest section of the old Lark town site.

A concrete lined irrigation ditch conveys the water from Butterfield Creek to the Herriman area. The ditch was constructed in 1913 by the Herriman Irrigation Company.(12)

Some of the water from the Bingham Tunnel is stored in two tanks in the Lark area, The capacities of the tanks are 100,000 and 25,000 gallons. The tanks are owned by Kennecott Copper Corporation.(85)

Hydrologic Characteristics: Butterfield Creek is a perennial stream in its canyon reaches whose flow characteristics have been altered due to mining activities within the watershed. Before the mine tunnels in the Butterfield-Bingham area were constructed in the early 1900's, Butterfield Creek was a perennial stream with very low winter flows, according to longtime area residents.(12) Currently a constant flow of one cfs enters Butterfield Creek through the old Butterfield Tunnel. It is not otherwise known to what extend the mining activities have altered the natural watershed yield characteristics.

No continuous flow record is available for Butterfield Creek. However, discussions with the Herriman Irrigation Company president have indicated that snowmelt flows are large in some years, with peak flows being reached normally from April 20 to May 10. These high flows are sustained normally for one to two weeks, and then recede during May and the first days of June.(12) The USGS has infrequently taken instantaneous flow measurements at the canyon mouth. Published measurements taken from 1964-1968 show July-March flows of about 1.5 cfs, and springtime flows as high as six cfs, which are reached during April and May.[78] A very gradual seasonal fluctuation is characteristic of this watershed, partly due to the constant inflow from Butterfield Tunnel. Also, flashfloods caused by canyon runoff from cloudburst storms occur often in the Butterfield watershed during the summer.[12]

An estimate of the average annual Butterfield watershed yield was made by correlation with a frequency analysis performed for West Canyon Creek in Cedar Valley. From this estimate, higher probability flows and seasonal fluctuations have been extrapolated. These flow estimates are displayed graphically in Figure V-34 as an annual hydrograph, and are also tabulated in Table V-31. These flow estimates should be used with care, since they represent the watershed under natural conditions, which is not the case in reality. Because of the many unknowns, no attempt has been made to adjust the flows to represent the current conditions. However, it is felt that the estimated flows are conservative, especially during the winter months.

Butterfield Creek becomes an intermittent stream in its upper valley reach, due mainly to irrigation diversions. However, in its lower valley reach it becomes a gaining perennial stream due to ground water and subsurface irrigation return flows. The Butterfield Creek channel is joined by the perennial lower reach of Midas Creek about a half mile upstream from the Jordan River. The single stream then flows to the river.

A perennial spring is located in Saints Rest Gulch. This gulch is a side drainage area near the mouth of Butterfield Canyon. However, flows from this spring do not reach Butterfield Creek because of diversions near the spring.

<u>Water Users</u>: The water from Butterfield Creek is used primarily for irrigation by the stockholders of the Herriman Irrigaton Company. The water is delivered through the company ditch to the area surrounding the town of Herriman.

During the late 1940's the Herriman Irrigation Company filed a lawsuit against the United States Smelting, Refining and Mining Company and Kennecott Copper Corporation concerning the ground water being collected in the mine shafts. The irrigation company felt much of the water which naturally drained into Butterfield Creek was being diverted through the mines. Since records were not available to substantiate the previous creek flows, the irrigators lost the suit. However, as a result, Decree C-236-64 gave the irrigation company a right to use water from the Bingham Tunnel.[85] It is felt that this mine drains ground water from the Butterfield Creek drainage area. The Decree does not guarantee the irrigators quantity or quality. The water from this source is used for irrigation.[12]

The Decree also gave the irrigation company the right to 1.0 cfs from the Butterfield Tunnel. This water enters Butterfield Creek and is considered as part of the creek flow.

The spring in Saints Rest Gulch is used for irrigation and as a domestic supply for thirteen families. Water rights for the spring amount to 0.038 cfs (approximately 17 gpm).

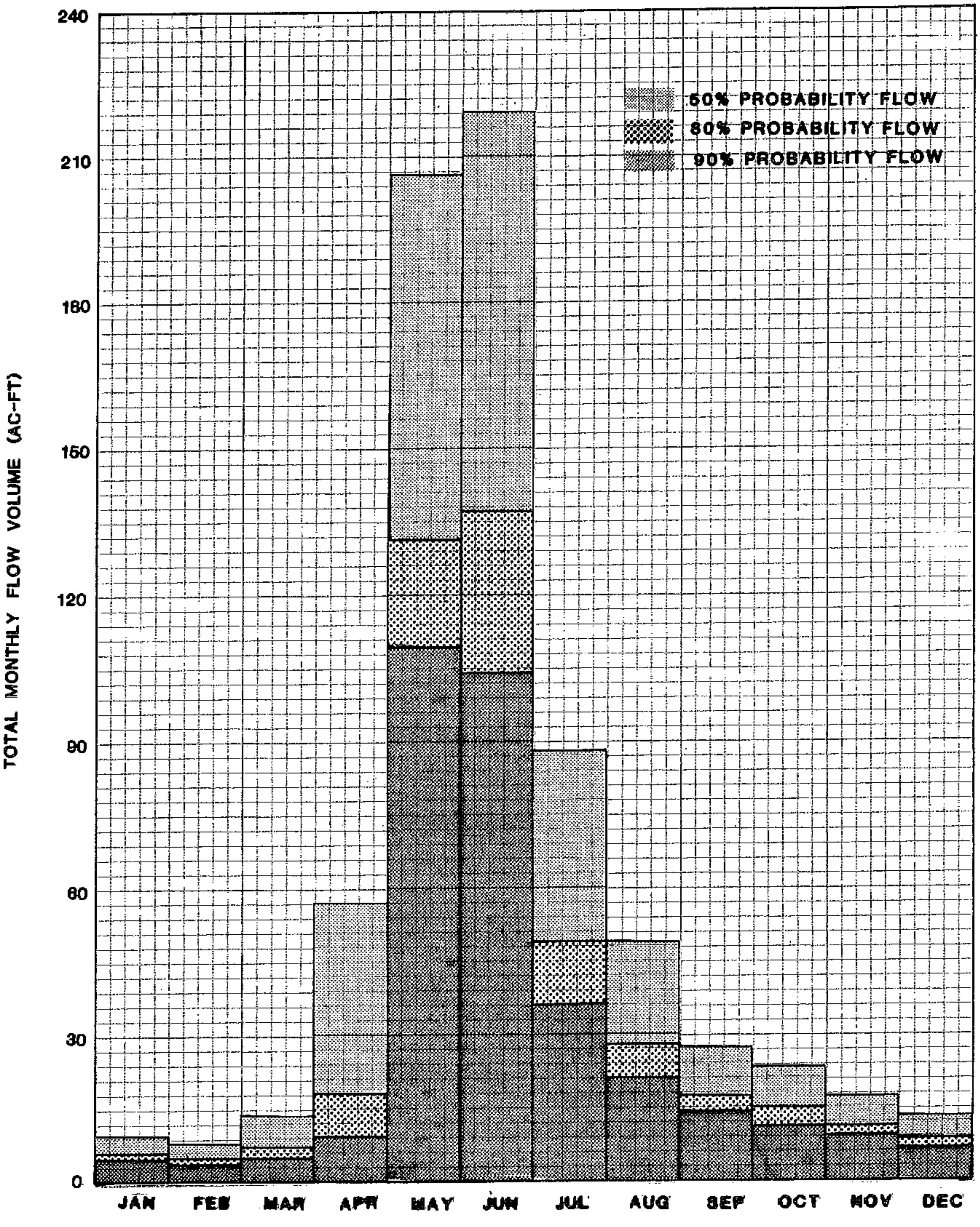
The surface flow from Copper Gulch is used for irrigation on land north of Herriman. This source does not flow all year and a well is used to furnish the required additional water.

TABLE V-31

BUTTERFIELD CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
Jaunary	4.7	6.0	9.6
February	3.6	4.7	7.8
March	5.1	7.2	13.8
April	9.1	18	57
May	109	131	206
June	104	137	219
July	36	49	88
August	21	28	49
September	14	17	27
October	11	15	17
November	9.1	11	17
December	6.5	8.4	13
Annual Sum	333	432	730
Annual Yield Estimate	428	532	809

*Extrapolated from the result of an "area-altitude" correlation with West Canyon, based on the West Canyon Creek pattern.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

BUTTERFIELD CREEK

FIGURE V-34

BINGHAM CANYON:

Physical Description: Bingham Canyon has a drainage area of 18.0 square miles which includes the Kennecott Copper Pit Mine. The valley drainage area below both Bingham and Barneys canyon is 67.4 square miles in size. The total drainage area for Bingham Creek is 85.4 square miles. Elevations in the canyon drainage area range from 5500 to over 9000 feet.

Slopes and drainage ways in this canyon have been severely modified due to the mining activities. The only natural drainage way in the canyon is Dry Fork which lies three miles to the north of the copper pit mine. This natural drainage way is characterized by several small tributaries entering into a short, narrow canyon. Slopes in this area are moderately steep.

The remaining portion of the canyon consists of the copper pit mine and various waste disposal areas. Slopes are steep to very steep in the mine with some level fill areas existing around the mine perimeter. The canyon, from the mine to its mouth, is characterized by steep consistent man made slopes to the south and moderate naturally developed slopes to the north. The canyon floor has a slight gradient with almost no meandering.

From the canyon mouth to the Jordan River, the drainage area consists of a small western bench where slopes are slightly steeper than in the gentler sloping valley region. Erosion-caused gullies are prevalent in this area. There is a bluff which consists of some steep slopes located in the southern portion of this drainage way.

Quartzite deposits are abundant in the canyon area except for the mine pit which consists of volcanic plutonic formation. A narrow strip along the canyon floor is made up of alluvial deposits. Soils in the canyon which have been undisturbed by mining generally tend to be well-drained with rapid to slow runoff. The soils of the open pit mine and much of the canyon area have been disturbed and no identification has been performed by the U.S. Soil Conservation Service.

The valley drainage area is essentially lake bed deposits overlain by well to poorly drained soils with medium to slow runoff.[70]

Much of the vegetation and wildlife within the canyon has been displaced because of the mining activities. However, there are some areas where spruce and fir trees along with shrubs and grasses remain undisturbed. Land use in the canyon is obviously industrial since this mining operation is one of the largest of its kind in the world.

Below the canyon, irrigated and dry cropland prevail with much of the west bench area under agriculture. The town of Copperton is located near the mouth of the canyon. Residential development has occured in the central valley portion of the Bingham Canyon drainage area.

Precipitation ranges from 25 to 30 inches in the canyon areas. Stream flow origins appear to be very complex. Much of the flow is contributed by various mine shafts draining into the creek. Also contributing to the creek is the natural runoff as well as the open pit mining discharge. At the canyon mouth the water is used for mining processes, after which it eventually flows through an aqueduct to a retention pond. Flows occasionally occur in the original stream channel for Bingham Creek during periods of high runoff. Also in the valley portion, Bingham Creek derives flow from various ground-water sources.

Existing Facilities: The mining activities in the canyon have resulted in many facilities which affect the natural water supply and flow patterns, the greatest being the Kennecott Copper Corporation's open pit mine. With the mine still in operation, the effects of the facility are continually changing.

There are many old mine shafts in the canyon which collect ground water. In Dry Fork an old mine collects ground water which is used as a culinary supply. Near the mouth of Pine Canyon in Tooele Valley, the Elton Tunnel extends over 23,000 feet into the mountain and drains the ground water. The end of the mine is under the Bingham Creek drainage area.(69)

In 1910, the Utah Metal Mining Company drilled a tunnel from Middle Canyon on the western slope of the Oquirrh Mountains to Carr Fork in Bingham Canyon. Drainage of the ground-water seepage in the tunnel is toward Middle Canyon. Kennecott Copper Corporation has constructed a pipeline in the tunnel to bring spring water in Middle Canyon to their mining operations.[29] Many tanks have been constructed by Kennecott Copper Corporation to collect the ground water in Bingham Canyon. These range in size from 60,000 gallons to 215,000 gallons. The water is chlorinated prior to storage in these tanks.[19]

Kennecott Copper Corporation has constructed a large pond near the mouth of the canyon below Copperton. The pond is part of their leaching operations.

Hydrologic Characteristics: The Utah Metals Tunnel drains ground water to Middle Canyon. It has not been determined whether the water developed originates in the Middle Canyon or the Bingham Canyon drainage area. The water flows into the tunnel at a point 7,400 feet from the Middle Canyon portal which is north of the overlying surface drainage divide. For this reason it is assumed that the tunnel water originates from precipitation in the Bingham Canyon area. However, water moving into the tunnel may have traveled north along solution channels or bedding-plane joints out of the Middle Canyon drainage basin, following the dip of the sedimentary strata. Also, the water may be moving in various directions according to the local hydraulic gradient along fault zones or joints not parallel to bedding. Due to the lack of information, it is difficult to determine whether Bingham Canyon water is being transferred to Middle Canyon.[29]

Even though it is unknown to what degree the natural drainage characteristics of Bingham Canyon have been altered by the Utah Metals Tunnel, the surface mining activities have definitely changed the natural conditions. Construction of the Kennecott Copper Corporation open pit mine, the largest open pit copper mine in the world, has substantially changed the flow patterns and the size of the drainage area of Bingham Canyon. The east portion of the pit lies on slopes that originally formed the upper Midas Creek watershed. Surface drainage is now into the pit rather than the natural canyon slopes. The ground water has been lowered and large areas of vegetation removed resulting in the drainage characteristics of the area being altered. Runoff from the area is collected in the mine and thus concentrated into smaller areas. The runoff from within the pit is drained through a tunnel to the Bingham Creek channel at a point upstream from the canyon mouth.

Bingham Creek is a perennial stream at the canyon mouth.(35) Although no continuous gaging has been done, several instantaneous measurements were made during 1964.(78) These measurements show flows lower then one cfs during the early spring, with flows increasing to a peak of about 11 cfs during the latter portion of May. The flow at the mouth then recedes to low flows (about one cfs) by October.

The Bingham watershed is capable of producing high peak flows following cloudburst storms. Flashfloods have occurred at times, being produced from canyon runoff in the upper reaches of the stream, and have followed the natural channel to the Jordan River.

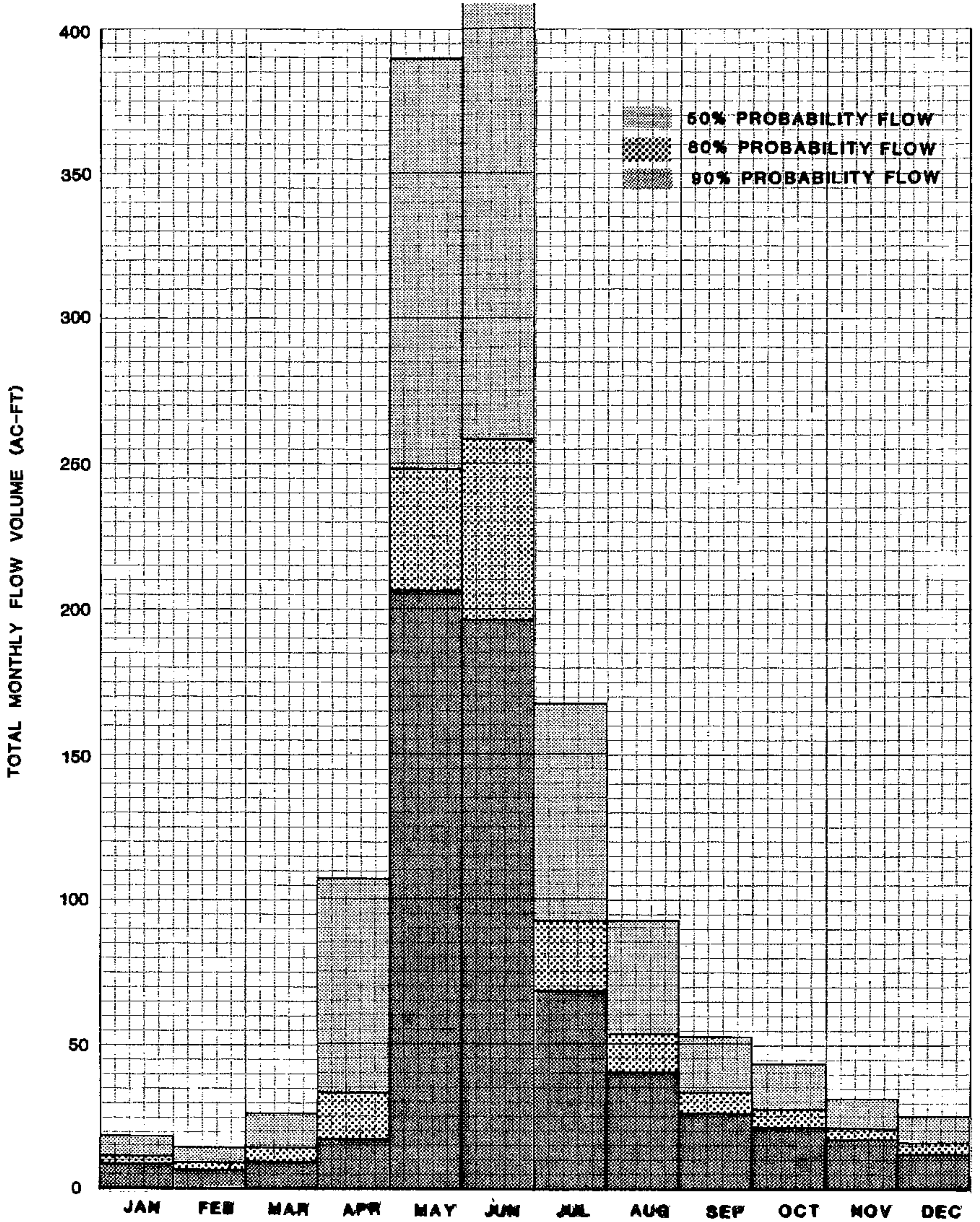
The total average annual runoff from Bingham Canyon at the canyon mouth has been estimated by the area-altitude method by comparison to West Canyon in Cedar Valley. From this value, both seasonal fluctuations and flows with higher probabilities (80 percent and 90 percent probabilities) have been extrapolated. The estimated annual hydrograph is displayed in Figure V-35, with the flow values tabulated in Table V-32.

The perennial stream is diverted from the Bingham Creek natural channel about four miles downstream from the canyon mouth, and is then conveyed by an aqueduct to tailings ponds nearby. The natural channel below the diversion point is now an intermittent stream, flowing during the spring snowmelt season and during cloudburst activities. The lower valley reach of Bingham Creek becomes a perennial stream from ground water and subsurface irrigation return flows. This gaining perennial stream then flows into the Jordan River.

Water Users: The water from Bingham Creek is used for domestic and sanitation supplies, irrigation and industrial uses. The industrial uses include leaching and precipitation operations, dust suppression, drilling, washing, cleaning and fire control.

Kennecott Copper Corporation owns the rights to most of the water in Bingham Canyon. The corporation has rights for flows of over 70 cfs from Bingham Creek as well as the water from the tunnels in Dry Fork. Also, the corporation has rights to water in Barneys Canyon which is piped into Bingham Canyon.(19)

Some private individuals have rights to some of the springs in the canyon. They use the water for stock watering. Approximately 60 people at Lead Mine use some of the water from Barneys Canyon as a domestic supply.(19)



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

BINGHAM CREEK

FIGURE V-35

TABLE V-32

BINGHAM CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	8.8	11	18
February	6.7	8.8	14
March	9.6	14	26
April	17	33	107
May	206	248	389
June	196	258	414
July	68	92	167
August	40	53	92
September	26	33	52
October	21	27	43
November	17	21	31
December	12	16	25
Annual Sum	628	815	1378
Annual Yield Estimate	806	1004	1524

*Extrapolated from the result of an "area-altitude" correlation with West Canyon, based on the West Canyon Creek pattern.

Kennecott Copper Corporation owns the rights to the water seeping into the Utah Metals tunnel. They traded these water rights to the Middle Canyon Irrigation Company for the right to take an equivalent amount of water from the White Pine and Hansen drainage basins of Upper Middle Canyon. The water is piped through the tunnel to the mine's culinary water system.[69]

Kennecott Copper Corporation also has several deep wells which supply industrial water. The well water has a lower quality than the canyon stream and ground water.

The town of Copperton receives its culinary water from two wells in the Barneys Canyon drainage area.

BARNEYS CANYON:

Physical Description: Barneys Canyon has a total drainage area of 4.0 square miles. The valley drainage area below the mouth of the canyon is discussed in the Bingham Canyon section. The headwaters area lies at about 8000 feet and the canyon mouth is at about 5300 feet. Slopes throughout the canyon are moderately steep, especially along the western perimeter of the headwaters area. The canyon floor is fairly wide with the exception of a one-mile stretch where it narrows just above the canyon mouth.

This canyon is characterized by quartzite deposits as the main substrata with alluvial deposits in the canyon bottom and the west valley bench. This is overlain by well-drained soils that are deep to shallow with variable runoff characteristics.

Vegetation and wildlife are typical of other canyons in the Oquirrh Mountains. Shrubs and grasses dominate the vegetation species while deer, small mammals, small birds, and upland game birds are the common wildlife found here. Land use is essentially watershed and wildlife habitat. However, some minor recreation may take place because of a road providing easy access.

The stream flow in Barneys Canyon originates as surface runoff in the headwaters region which averages 20 inches of precipitation per year. The flow is supplemented by three small tributaries entering the main channel in the upper two thirds of the canyon. The stream gradient is moderate for this portion of the canyon.

Near the canyon mouth the stream is augmented by a significant tributary from the north. This tributary is 2.8 miles long with Bancroft Spring making up much of its flow. Another small intermittent tributary enters Barneys Creek just below the canyon mouth. From here the creek flows over the valley and eventually into an irrigation canal.

Existing Facilities: Copperton has two deep wells near the mouth of Barneys Canyon. The wells were drilled in 1942 by Kennecott Copper Corporation and later given to the town. Water from the wells discharges to a 9,100 gallon tank before being pumped through an eight-inch pipeline to a million-gallon reservoir for distribution.[50]

There are no other facilities known to be located in the drainage area. The springs in the canyon are discussed later with the water users.

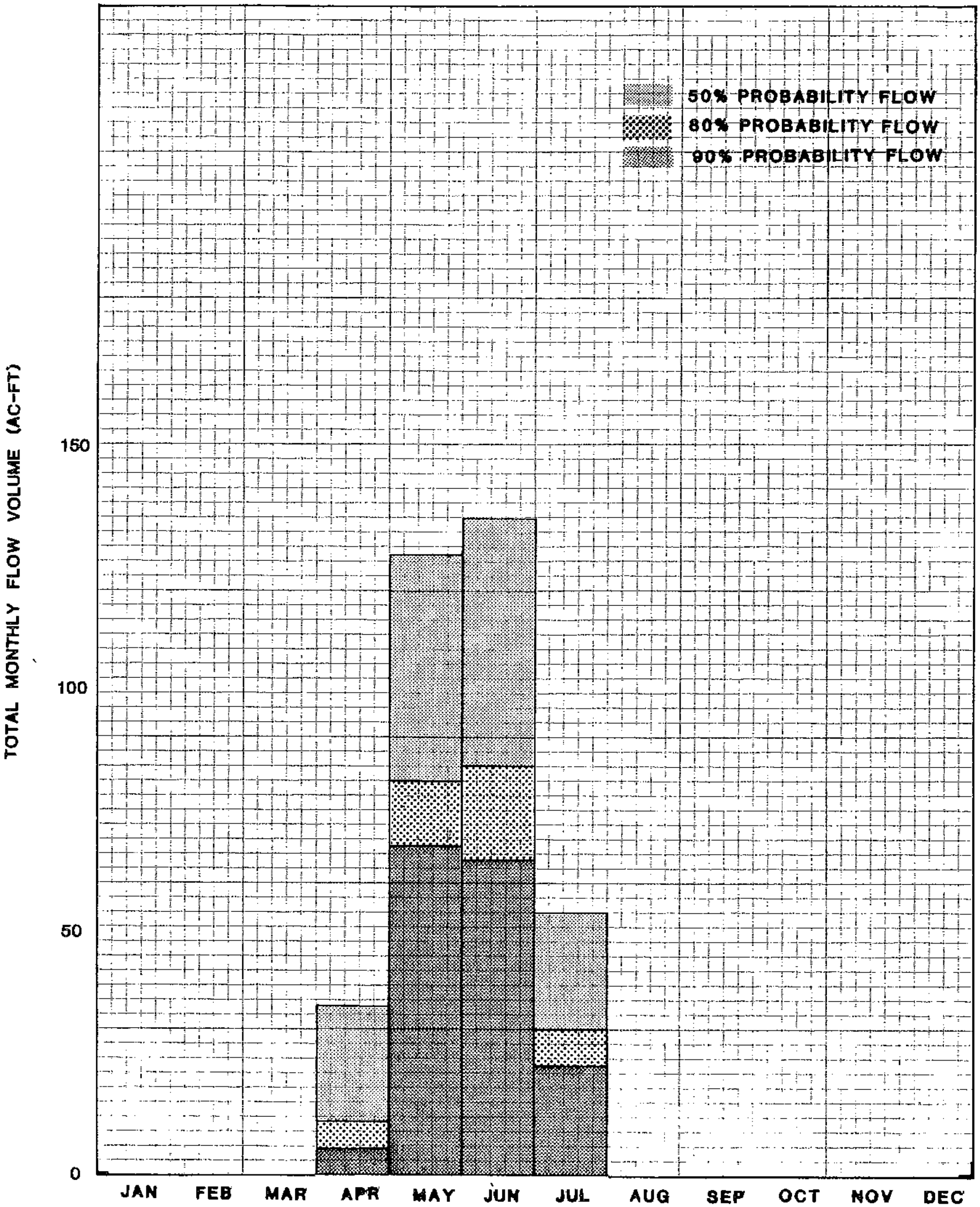
Hydrologic Characteristics: No flow measurements are available for the stream in Barneys Canyon except for a single instantaneous measurement of 0.2 cfs at the canyon mouth taken by the USGS on April 3, 1964. This value may be representative of the range of low flows during winter and early spring.

An estimate of the average annual yield from the Barneys Canyon watershed has been made by correlation with West Canyon. Additional estimates of higher probability flows and seasonal fluctuations have been made, based on the pattern of West Canyon. These results are shown graphically in Figure V-36 and are tabulated in Table V-33. Because of the many unknowns, these values should be used with caution.

Water Users: The surface water from Barneys Canyon has been appropriated for watering of livestock. The owners of the rights are listed below. Kennecott Copper Corporation also has rights to water which is used for industrial and culinary uses. Several other water rights have recently been disallowed by the State Engineer's Office because of abandonment.(85)

Owner	Source	Flow Right (cfs)
Kennecott Copper Corporation	Gray Spring	0.487
Calvin J & Wm. Spratling	Bancroft, Lohman Dorton Springs	0.1
	Dugway Springs Creek	0.01
	Dorton Springs Branch	0.111
	Spring Area	0.056
Howard Haynes	Lambert Spring	0.15
	Spring	0.02 cfs

Copperton has two deep wells in Barneys Canyon which furnish the culinary water for the town. The appropriated right of the wells is 1.939 cfs.(85)



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

BARNEYS CREEK

FIGURE V-36

TABLE V-33

BARNEYS CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	--	--	--
February	--	--	--
March	--	--	--
April	3.7	7.2	23
May	45	54	85
June	43	56	90
July	15	20	36
August	--	--	--
September	--	--	--
October	--	--	--
November	--	--	--
December	--	--	--
Annual Sum	107	137	234
Annual Yield Estimated	176	219	333

*Extrapolated from the result of an "area-altitude" correlation with West Canyon, based on the West Canyon Creek pattern. Only the April to July estimates are included to reflect the ephemeral nature of the stream.

HARKERS CANYON:

Physical Description: Harkers Canyon is 6.5 square miles in size. This is the total drainage area since the stream joins Coon Creek a short distance below the mouth of the canyon. The elevation range in this canyon is from 5000 at its mouth to 9300 feet at its highest peak.

Slopes in the canyon are moderate in the headwaters area around Crystal Spring. Side slopes are steeper below this point and again become more gradual near the canyon mouth. The canyon floor is more open in the upper half of the drainage area. Below, it becomes narrow and then opens up into the valley.

Quartzite deposits are the principal geologic structure of this region with alluvial deposits collecting in the canyon floor and valley bench areas. Soils tend to be deep to shallow, well-drained with runoff varying from medium to very rapid depending upon localized slope and soil association.

Vegetation is typically shrubs and grasses in most areas of this canyon. Wildlife is made up of species typically found in other Oquirrh canyons such as deer, porcupine, squirrels, various small rodents and mammals, as well as upland game and small bird species. Land use is limited to watershed and wildlife habitat.

Rainfall in this canyon ranges from 12 to 20 inches per year. Along with surface runoff, springs contribute to the stream flow of Harkers Canyon Creek. The stream gradient is steep in the headwaters area where two streams join together. Below this point there are only a few minor tributaries to the stream, one of which is a spring located about half way down the canyon. Just below the canyon mouth another spring flows into the stream and a short distance later Harkers Canyon Creek enters Coon Creek.

Existing Facilities: There are no known facilities in Harkers Canyon.

Hydrologic Characteristics: The only flow measurement available for the Harkers Canyon stream is one measurement of 0.1 cfs at the canyon mouth taken by the USGS on May 29, 1964. An estimate of the average annual watershed yield at the canyon mouth has been made by correlation with flows in West Canyon in Cedar Valley. From this estimate, higher probability flows and seasonal fluctuations have been extrapolated, and are shown in Figure V-37 and Table V-34. It was assumed that the stream normally flows from April through July.

Water Users: The water from Harkers Canyon Creek and an unnamed spring has been appropriated by Kennecott Copper Corporation for stock watering. The right is for 14.0 cfs. Stock watering is directly on the stream without any diversions.[85]

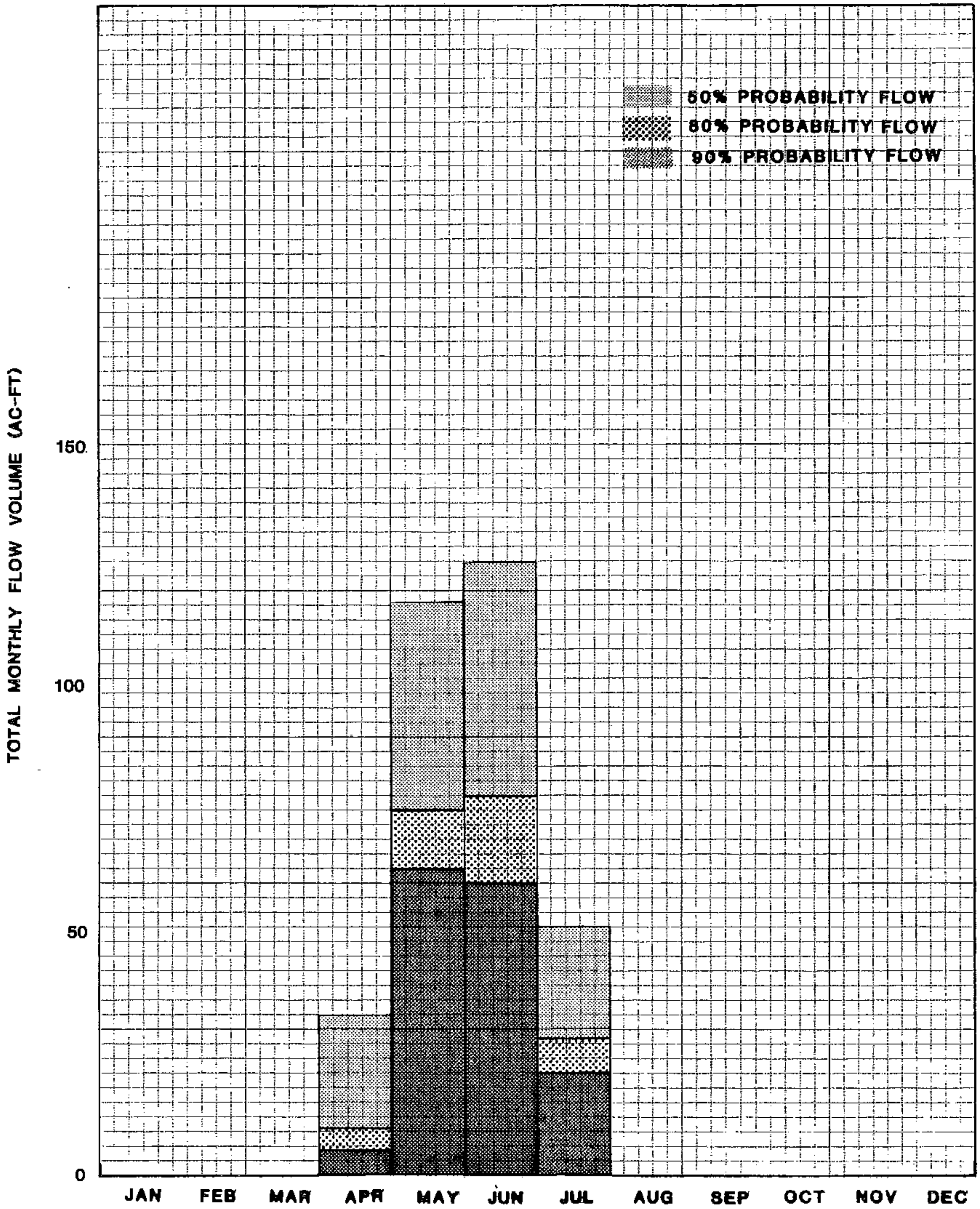
Howard Haynes owns the rights to the water from Rock Spring and Crystal Spring. The water is appropriated for stock watering and for culinary purposes for two persons.[85]

TABLE V-34

HARKERS CANYON CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	--	--	--
February	--	--	--
March	--	--	--
April	5.2	10	33
May	63	75	118
June	60	78	126
July	21	28	51
August	--	--	--
September	--	--	--
October	--	--	--
November	--	--	--
December	--	--	--
Annual Sum	149	191	328
Annual Yield Estimate	245	305	464

*Extrapolated from the result of an "area-altitude" correlation with West Canyon, based on the West Canyon Creek pattern. Only the April to July estimates are included to reflect the ephemeral nature of the stream.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

HARKERS CANYON CREEK

FIGURE V-37

COON CANYON:

Physical Description: The canyon drainage area for Coon Canyon is 8.6 square miles. The stream is partially diverted near the canyon mouth and the remainder only flows for a short distance beyond that point. The elevation ranges from 5000 to 8800 feet with much of the area lying at the 6000 to 7000-foot level.

In the upper headwaters area along the western perimeter of this drainage area the slopes are very steep from the 8500-foot peaks down to about the 7000-foot level. This area is characterized by several smaller drainage ways feeding together from a fan shape formation. Side slopes in this area are moderately steep except for a large open, gently sloping area, where two of the largest tributaries come together. The canyon floor is fairly narrow throughout most of its length. The lower portion of the canyon has several small side drainages with moderately steep side slopes entering it throughout the area. The canyon mouth opens onto the lake bed terrace of western Salt Lake Valley.

The canyon floor substrata is made up of alluvial deposits while the canyon side slopes are primarily quartzite deposits. Soils in this canyon area are generally deep to shallow with some rock outcropping. Runoff is medium to very rapid depending upon localized slope and soil conditions.

Vegetation common to the Coon Canyon area is oak brush, sage brush, bitterbrush, mountain brome, maple and various grasses. Wildlife of this canyon includes deer, porcupine, rabbits, various squirrels and chipmunks along with upland game and small bird species. Land uses of Coon Canyon are limited to wildlife habitat and watershed.

Precipitation in this area ranges from 12 to 20 inches per year with snowpack being relatively light. Supplementing this source of surface water are several springs which surface throughout the canyon.

There are three main streams from Lewis Canyon, Left Hand Fork and Right Hand Fork which are the sources of stream flow for Coon Creek. They join at approximately 3.5 miles from the canyon mouth. Stream flow gradients for these three tributaries are steep in the headwaters area, becoming moderately steep down to where they join together. From this point on, the gradient is moderate.

Along this portion of the stream there are three smaller tributaries of significant flow. Porters Hollow enters the main stream channel one-quarter mile down from the point where the three major streams converge. Willow Creek is spring-fed and enters Coon Creek just below Porter Hollow. Deadmans Wash is a long narrow drainage way to the south of Coon Creek that joins the main stream approximately one mile up from the canyon mouth. At this point there is a partial diversion for irrigation purposes. Harkers Canyon Creek joins Coon Creek just below the canyon mouth. The remaining combined stream flows only a short distance below the canyon mouth before it terminates in a gravel pit.

Existing Facilities: Numerous springs are in the Coon Canyon drainage area. They have not been developed but contribute to the creek flow. Listed below are the major springs within the canyon and near the canyon mouth.

Maple Spring	Tabitha Spring
Mud Spring	Coon Spring
Willow Spring	Seven unnamed Springs

A right of diversion on Coon Canyon Creek has been established at a point just upstream from Deadmans Wash.[85]

An old mine which now collects ground water is located about 2200 feet west of Utah Highway 111 along the Kennecott Copper Corporation railroad. The water which is collected is combined with the above diversion and transported to an area south of Magna according to the appropriation.[85]

Hydrologic Characteristics: No flow measurements are available for the stream in Coon Canyon except for a single measurement of 0.2 cfs at the canyon mouth taken by the USGS on May 6, 1964. An estimate of the average annual yield from Coon Canyon has been made by correlation with West Canyon flows in Cedar Valley. Also, 80 percent and 90 percent probability flows, as well as seasonal fluctuations, have been extrapolated. These values are shown graphically in Figure V-38 and are tabulated in Table V-35. The creek was assumed to flow only from April through July.

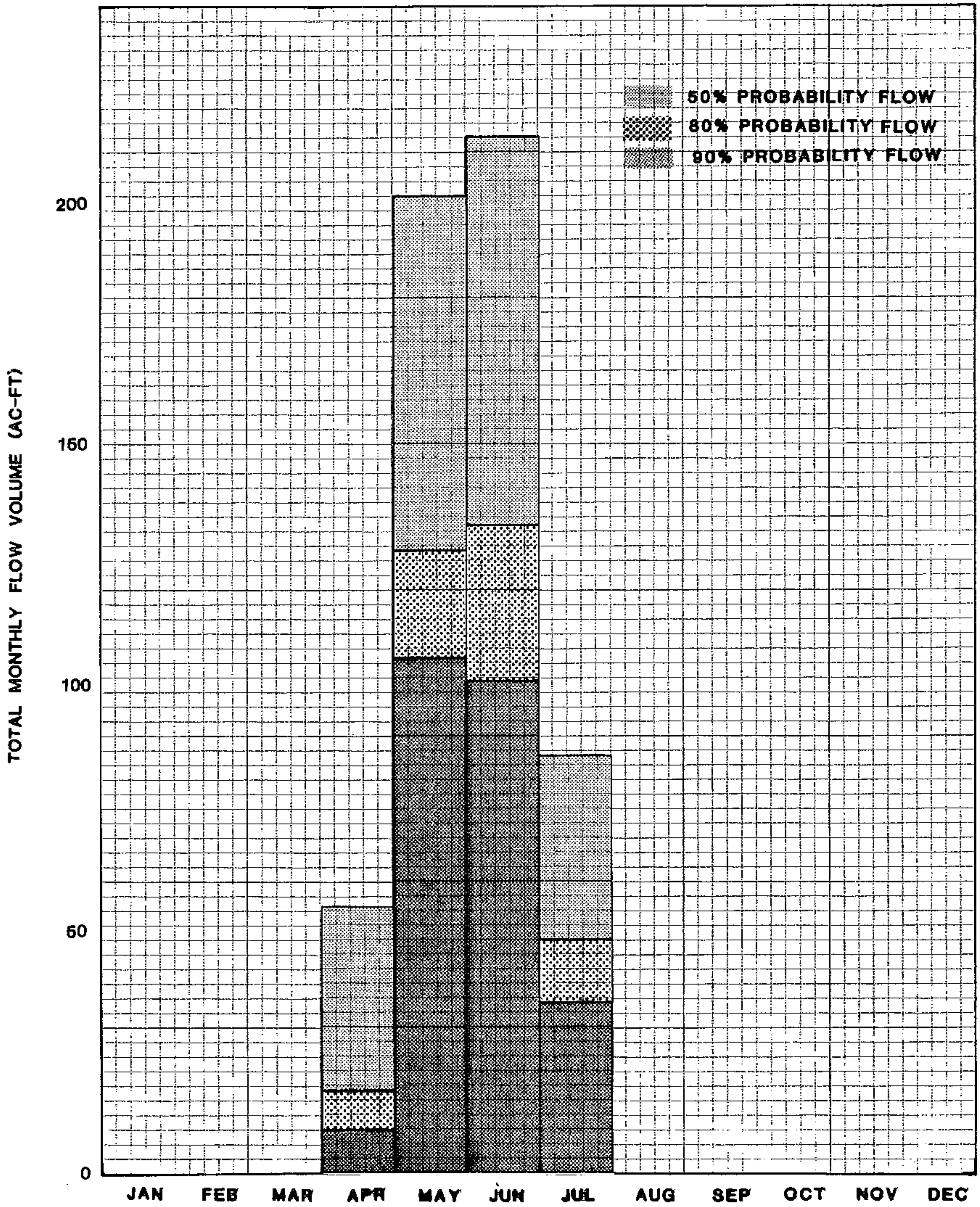
Water Users: Kennecott Copper Corporation owns most of the water rights for Coon Canyon. The water was appropriated mostly for stockwatering and irrigation. Dean M. and Rosana H. Warner own the only other rights to the surface water from Coon Canyon. The uses specified by their appropriation are for irrigation, stockwatering, and culinary purposes for a single family.(85)

TABLE V-35

COON CREEK FLOW ESTIMATES*

Period	Expected Total Flow Volumes at Prescribed Probabilities (Ac-Ft)		
	90% Probability	80% Probability	50% Probability
January	--	--	--
February	--	--	--
March	--	--	--
April	8.8	17	55
May	106	128	201
June	101	133	213
July	35	48	86
August	--	--	--
September	--	--	--
October	--	--	--
November	--	--	--
December	--	--	--
Annual Sum	251	326	555
Annual Yield Estimate	416	518	787

*Extrapolated from the result of an "area-altitude" correlation with West Canyon, based on the West Canyon Creek pattern. Only the April to July estimates are included to reflect the ephemeral nature of the stream.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

ANNUAL HYDROGRAPH

COON CANYON CREEK

FIGURE V-38

IMPORTED WATER:

Imported water referred to in this report is water that is derived from sources outside of the natural drainage basin of the Jordan River or that reaches Salt Lake County by man-made conveyances. Community leaders had begun plans for importing water to the Salt Lake Valley prior to the 1920's. The Provo River Project and the Central Utah Project are the results of those many years of planning and effort.

SOURCES: Water imports into Salt Lake County are from Deer Creek Reservoir and the Provo River downstream from the reservoir as part of the Provo River Project, and from springs (Donnes Pond, Mill Pond and Six Mile Creek) in Tooele Valley west of the Oquirrh Mountains. The Central Utah Project does not as yet supply any water to Salt Lake County. However, the Jordan Aqueduct, an element of the plan, is used in conveying Deer Creek Reservoir water to Salt Lake County.

The Provo River drains about 680 square miles of both the eastern slopes of the Wasatch Range and the southern slopes of the Uinta Mountains. The natural stream flow has been augmented by trans-mountain diversions from the Strawberry River since 1915, from the Weber River since 1932, and from the Duchesne River since 1952.[33] The flow is regulated by several small reservoirs in the headwaters and by Deer Creek Reservoir.

FACILITIES: Deer Creek Reservoir was completed in 1941. Most of the runoff from the Provo River Basin was appropriated prior to that time. Therefore, the reservoir's water supply in most years is chiefly from the Weber River and Duchesne River diversions.[33] The total capacity of the reservoir is 152,600 acre-feet. The usable capacity is 149,700 acre-feet with the water surface at the top of the radial spill-way gates.[33] The usable content sometimes exceeds this amount by a few thousand acre-feet because of the water which backs up above the top of the gates during periods of high flow. The reservoir was designed to provide an annual yield of 100,000 acre-feet and does so in most years. The difference between the annual yield and the capacity provides for evaporation losses and some carryover storage.

The Salt Lake Aqueduct, operated by the Metropolitan Water District of Salt Lake City, commences at the reservoir and delivers some of the District's share of stored water in Deer Creek Reservoir to the urban areas of Salt Lake County. The aqueduct is a 69-inch reinforced concrete pipeline about 42 miles long. It has a capacity of 120 mgd. The first section, about 32 miles in length, conveys water from the reservoir to the Metropolitan Water Treatment Plant near Little Cottonwood Canyon. From the treatment plant, the aqueduct carries treated water northward a distance of about eight miles to terminal reservoirs near 3300 South Street.

Below Deer Creek Reservoir, the Provo River flows southwest through Provo Canyon to Utah Lake. There are isolated developed areas along the canyon ranging from restaurants to private cabins. The canyon is popular for fishing and picnicking.

The river has been channelized primarily from highway construction and high summer flows. There are several faults which cross the canyon. Ground water contributes to the stream flow in Provo canyon. The average annual flow immediately below Deer Creek Dam is 237,800 acre-feet. Diversions below Deer Creek Dam reduce the flow to 92,300 acre-feet near the mouth of Provo Canyon. Natural accretions from tributary sources and return flow from irrigated croplands produce an average annual flow of 135,500 acre-feet at a point about two river miles upstream from Utah Lake.(11)

Water is diverted from the river near the mouth of the canyon into the Provo Reservoir Canal. This canal conveys the water approximately twenty miles, crosses the Jordan River at the Jordan Narrows and supplies water to the western part of Salt Lake and Utah Counties.

The Provo Reservoir Canal currently conveys water provided by the Metropolitan Water District of Salt Lake City to the Jordan Aqueduct, which in turn conveys raw water to the Jordan Water Purification Plant. The design capacity of the canal is 550 cfs at the head and 350 cfs at the Jordan Narrows, whereas the capacity of the Jordan Aqueduct is 270 cfs.(7) The aqueduct is currently being extended to 2100 South Street so that treated water can be delivered to the west side of Salt Lake City.

The Jordan Water Purification Plant is owned and operated by the Central Utah Water Conservancy District. To date, the 60 mgd plant has only been operated during the summer when the Salt Lake Valley's water needs are the greatest. The treatment process is of the conventional type utilizing flash mixing, flocculation, sedimentation, filtration and disinfection.

The discharges of the three groups of springs in Tooele County are delivered to the Garfield/Magna area by pipeline. The average annual flow is about 10,700 acre-feet.[33]

WATER USERS: The Metropolitan Water District of Salt Lake City owns 46,500 shares of stock acquired under a subscription contract with the Provo River Water Users Association, and 15,200 additional shares acquired under an exchange agreement with the Utah Lake Distributing Company. This entitles the Metropolitan Water District of Salt Lake City to use 61.7 percent of the total annual yield of the Deer Creek Reservoir.[7] The District also has the right to carry over any of its unused water in the reservoir from one year to another, to the extent that space is available to do so. However, during years of high flow, the carry-over water may be lost when the reservoir fills with water of the Provo River Water Users Association.

There are several connections along the first section of the Salt Lake Aqueduct for users to whom the Metropolitan Water District of Salt Lake City sells surplus raw water.

Salt Lake City has preferential rights to all of the water owned by the Metropolitan Water District of Salt Lake City. The Metropolitan Water Treatment Plant supplies water to Salt Lake City, Murray, and Sandy. The Salt Lake County Water Conservancy District purchases excess treated water.

The treated water from the Jordan Water Purification Plant is purchased by the Salt Lake County Water Conservancy District.

Kennecott Copper Corporation owns and operates the pipeline from the Tooele County Springs, and uses the water in the smelter and the Arthur and Magna concentrators.

The average annual flows for the three sources of imported water is shown below.

Salt Lake Aqueduct	32,234 acre-feet (1978-81)
Jordan Aqueduct	8,425 acre-feet (1977-81)
Tooele Valley Springs	10,700 acre-feet (estimated)

QUALITY: The reason for developing means of importing water is to maintain a high quality of available water. The Jordan River, into which most of Salt Lake Valley water eventually drains, has both biological and chemical water quality problems which essentially prohibit its use for municipal water supply. Therefore, many dollars have been spent to collect water in the upper reaches of the drainage area before its quality is deteriorated and to convey it to the urbanized areas.

UTAH LAKE AND JORDAN RIVER:

PHYSICAL DESCRIPTION: The Salt Lake Valley is about 18 miles wide and 33 miles long. The valley is surrounded on three sides by mountains; the Wasatch Range on the east, the Traverse Mountains on the south, and the Oquirrh Mountains on the west. The valley floor has considerable relief with elevations ranging from 4,200 at the Great Salt Lake to about 5,200 where it joins the bordering mountains. The valley is characterized by a series of terraces left by the recession of prehistoric Lake Bonneville. The terraces along the east side of the valley are much more pronounced than the terraces along the west side.(72)

The geologic composition of the valley floor is very complex. Soils vary from clay or clay-like gravels on the valley floor; to loams on the lake terraces; to sands, silts and clays on the higher terraces.(72)

Native vegetation on the valley floor has been drastically modified by agricultural operations and urbanization. In undisturbed areas, vegetation consists predominantly of grasses and sagebrush. Cottonwood trees grow along the stream courses.

The climate of the Salt Lake Valley is temperate and semiarid with four well-defined seasons. Precipitation amounts vary with elevation. Normal annual values range from about 12 inches near the southern end of the valley to 20 inches near the base of the mountains. Precipitation normally occurs throughout the year with the majority falling during the winter and spring months.

The Jordan River begins as the natural outlet for Utah Lake which covers about 150 square miles of Utah Valley. The lake collects surface runoff and irrigation return flows from a 2,950 square-mile tributary area.(75) Utah Lake has a usable storage capacity of about 830,000 acre-feet and a surcharge capacity of about 100,000 acre-feet per foot rise.(72)

The lake was developed into a storage reservoir in 1872 by the construction of a low dam across the outlet. Gates were provided in the dam to control the flow from the lake. In 1902 a pumping station was built so that the lake could be lowered below the outlet elevation. The pumping station has been modified and enlarged several times. Its present capacity is about 1,050 cfs.(36)

The Jordan River meanders 16 miles northward from Utah Lake through northern Utah County to Salt Lake County. The river enters Salt Lake County at the Jordan Narrows, a gap in the low Traverse Mountains, and meanders another 41 miles through Salt Lake Valley to the Great Salt Lake. The river flows through the middle of the valley draining both subsurface and surface runoff. All but the northwest portion of the county is drained by the Jordan River. The average gradient at the river is only 5.2 feet per mile resulting in a slow-moving stream. The stream gradients for various segments of the river are summarized below.[72]

Stream Reach	Gradient (feet per mile)
Utah Lake to Little Cottonwood Creek	12.6
Little Cottonwood Creek to Mill Creek	2.3
Mill Creek to Surplus Canal	3.0

At the Jordan Narrows, several canals originate which wind along the east and west benches of the valley. Some of these canals divert from the Jordan River by gravity and others require pumping.

North of the Narrows the river meanders, commencing with a relatively narrow, deep channel and gradually widening into a broad flood plain, gaining flow from ground water, irrigation return flows, several waste-water treatment plants, and streams from the mountain canyons. Southwest of the City of Murray the river passes through several areas of marshland. North of Bennion the flood plain broadens and the meandering of the river increases.

As the river flows through the county, ten tributaries add to the stream flow. These tributaries are listed in Table V-36. In addition, the Jordan River acts as a drain for the shallow aquifer. This aquifer and the geology of the Salt Lake Valley are discussed in greater detail in the section on Ground Water in this chapter.

EXISTING FACILITIES: Water enters the Jordan River from Utah Lake through a flow-control structure. When the lake is too low to discharge the required volume, water is pumped from the lake into the river.[75]

TABLE V-36
JORDAN RIVER TRIBUTARIES IN SALT LAKE COUNTY

Stream	Distance Below Jordan Narrows (approx. river miles)	Remarks
Corner Canyon Creek	7	Drains runoff from canyon
Butterfield Creek	10 3/4	Midas Creek is a tributary
Willow Creek	10 1/2	Fed from ground water
Dry Creek	13	Drains surface flow from Bells Canyon & South Fork Dry Creek
Bingham Creek	16 1/4	Only channel maintained from canyon mouth to river on the west side
Little Cottonwood Creek	20	Controlled flow below canyon, drains runoff from canyon
Big Cottonwood Creek	21	Controlled flow below canyon, drains runoff from canyon
Mill Creek	24 3/4	Drains runoff from canyon
Parleys, Emigration & Red Butte Creeks	27 3/4	Canyon runoff drained through 1300 South storm drain
City Creek	30 1/2	Canyon runoff drained through North Temple storm drain

At the Jordan Narrows, a dam has been constructed to divert the water into two canals and to provide a pool from which to pump into a third canal. The two gravity-fed canals are the East Jordan Canal, which transports water to the east side of the valley, and the Utah and Salt Lake Canal, which traverses the west side. The East Jordan Canal supplies water to the Draper Irrigation Canal, the Sandy Irrigation Canal, and the East Jordan Canal Extension. A meter has been installed at about 7350 South 900 East to measure the flow to the East Jordan Canal Extension.(68) The East Jordan Canal Extension ends at Walker Lane and the end of Cottonwood Lane. Tailwater drains from the canal into a small garden ditch and a street drain ditch.(60)

The Provo Reservoir Canal crosses the Jordan River at the Narrows. The canal then splits on the west side of the Jordan River and supplies water to the western portion of north Utah County and to Salt Lake County. The Provo Reservoir Canal ends in a field at approximately 4600 West and 7200 South.(68) Utah Lake water also enters Salt Lake County through the Utah Lake Distributing Canal. The Metropolitan Water District of Salt Lake City owns a pumping station at the Narrows which lifts water from the Jordan River into the Utah Lake Distributing Canal. The station has a turbine-powered pump which is turned by water in the Provo Reservoir Canal supplied from the Provo River. Normal operation is to use the turbine, but a standby electric-powered pump was installed in 1962.(63) The Utah Lake Distributing Canal supplies water to an area east of the Provo Reservoir Canal service area in north Utah County and Salt Lake County. The Utah Lake Distributing Canal terminates in a field at approximately 4000 West and 5300 South.(68)

Approximately 1.3 miles downstream from the Jordan Narrows dam on the Jordan River is the intake for the South Jordan and the Jordan and Salt Lake City Canals. The intake is on the east side of the river. The South Jordan Canal crosses over the river in a flume to the west side about a third of a mile downstream. The South Jordan Canal ends at 4000 West and 4400 South. Tailwater flows into a pipe which connects to the Decker Lake drainage channel. The channel discharges to the Kearns-Chesterfield storm drain which flows into the Jordan River.(68) The Jordan and Salt Lake City Canal supplies water for Salt Lake City exchange agreements to an area east of the river. The water flows in an open canal through most of the rural and metropolitan areas of the County until it reaches approximately 3000 South at Elgin Avenue where it enters a 48-inch concrete pipe and a rectangular concrete conduit. Continuing north it crosses to the Parleys, Emigration and Red Butte Creeks and supplies water to the Parleys Canyon water users in an area from 2700 South to 900 South and west of the canal. When irrigation water is not being used it can flow into the Jordan River through any of the above mentioned creeks or into the 600 South storm drain.

The Galena Canal diverts water from the river 4.8 miles below the Jordan and Salt Lake City Canal. The canal was originally constructed to convey water to an industrial facility near Midvale. The industrial facility is no longer in operation, but the canal is being used for irrigation water conveyance.

The Beckstead Ditch diverts water from the river 1.6 miles below the Galena Canal. The ditch provides irrigation water for the bottom lands on the west bank between 12300 South and 9500 South.

The North Jordan Canal branches from the river 4.6 miles below the previously named canal at about 9600 South. A dam has been constructed across the river to divert water into the canal. The North Jordan Canal supplies water to the Riter Canal.

At 2100 South, the Surplus Canal diverts the bulk of the Jordan River flow. The Surplus Canal was constructed in 1885 and enlarged in 1960. The purpose of the Surplus Canal is to provide a short, direct route to the Great Salt Lake for Jordan River flows in excess of those that can pass down the natural channel without flooding. The capacity of the canal is 3,300 cfs from 2100 South to North Temple and 2,000 cfs below that point. Some of the water in the canal is diverted into the North Point Consolidated Canal and the remaining water is spilled to the Goggin Drain which discharges to the Great Salt Lake.

The City Drain was constructed in the western part of Salt Lake City to drain storm water runoff and ground water. The drain combines with the Sewage Canal. The Salt Lake City Water Reclamation Facility discharges treated waste water to the Sewage Canal. The Sewage Canal flows into Farmington Bay.

A gaging station is maintained at the Jordan Narrows Dam by the USGS. The gage is a water-stage recorder as are other gages along the river. Records at this station are available since 1904. Recorded flows represent the combined flows of the Jordan River, the Utah and Salt Lake Canal and the East Jordan Canal.

Another station is located on the river near 5800 South. Measurements at this station were taken between July 1965 and September 1968, and from 1974 to present. Currently, water quality data are obtained at this station.

A third station is located at approximately 1700 South. Flow records are available since 1943 for this station. Water quality data have been kept since 1974.

The furthest downstream gaging station on the Jordan River in Salt Lake County is located near 500 North Street. Flow records for this station have been kept on a continuous basis since 1975.

Currently, the Salt Lake County Flood Control and Water Quality Division is conducting a water quality sampling program. In addition to the stations mentioned above, an additional station on the river has been established at 9000 South for water quality sampling.

There are two gaging stations on the Surplus Canal. The first is located near the beginning of the canal at 2100 South Street. The second is located downstream from North Temple Street. Records are available for these stations since 1942 and 1976, respectively.

Three additional gaging stations are maintained on other streams in the valley. These are the Goggin Drain, Lee Creek, and the C-7 Ditch. Records for these stations were kept during the periods from October 1963 to September 1967 and from October 1971 to date.

HYDROLOGIC CHARACTERISTICS: Utah Lake is utilized to regulate water supply for irrigation. Therefore, the water users are interested in storing as much water as possible. However, the owners of land bordering the lake are interested in limiting damage from high lake levels. As a result of this conflict of interests, a compromise level (4489.34 feet above mean sea level at the head of the Jordan River) was established by a "Compromise Agreement" in 1885. The lake rises above this level at times, but no water may be held in the lake above compromise level by artificial means.[33]

The pumping station can be used to lower the level of Utah Lake nearly 10 feet below the compromise level. At this level, there is no natural outflow and the Jordan River must be totally fed by pumping. Historically, the lake has been drawn as low as 12 feet below the compromise level by emergency pumps installed on the west shore in 1934. (75)

Because of the large area and shallow depth of the lake, the evaporation loss per unit of storage capacity is very high. The Utah Lake and Jordan River Water Commissioner has computed the average annual rate of evaporation as 3.9 feet or 47 inches.[33] The annual inflow to Utah Lake averages about 600,000 acre-feet and the outflow is about 280,000 acre-feet. The remaining 320,000 acre-feet is lost to evapotranspiration each year.[75]

The Jordan River is a controlled stream. At certain times of the year, the river is completely dewatered immediately below the Jordan Narrows. Ground water and stream runoff replenish the river as it flows northward through Salt Lake County. At 2100 South, head gates can be used to divide flows between the natural channel and the Surplus Canal.

Water quality data for Utah Lake and the Jordan River are shown in Tables V-37 through V-40. The water quality of Utah Lake has the greatest influence on the quality of the Jordan River. When the lake is the lowest, during the late summer, the TDS concentration of the lake and river is the highest. Figure V-39 illustrates the approximate relation of dissolved solids content to the level and volume of Utah Lake from June 1959 to November 1966. Other than a seasonal change in quality, there does not appear to be any pattern of change in the quality of the Jordan River. A check of pre-1970 water quality data indicated the quality has remained fairly stable during the last twenty years. It is expected that the biological quality of the water will improve with the beginning of operation of the two regional waste-water treatment plants and the closing of the seven existing plants.

WATER USERS: The Jordan River conveys most of the irrigation water for Salt Lake County from Utah Lake storage. The water is delivered in Salt lake County through a series of canals which flow northerly throughout the valley. These canals are shown in Figure V-1 (inside back cover pocket).

The East Jordan Canal delivers water to the Draper Irrigation Company and to Salt Lake City through the East Jordan Canal Extension as well as to its own stockholders. Salt Lake City uses the water for its exchange agreements on Big Cottonwood and Little Cottonwood Creeks.

Approximately 2.8 miles downstream from the Jordan Narrows, water is pumped from the East Jordan Canal into the Draper Irrigation Company Canal. The pumping begins about the first of May each year and continues to the middle of October. The Draper Irrigation Company supplies irrigation water to the Bells Canyon Irrigation Company.(48) The continuation of the Draper Irrigation Company Canal beyond Dry Creek is called the Sandy Irrigation Canal. Tailwater from the canal flows into the East Jordan Canal.

The Utah and Salt Lake Canal also receives water from the Jordan River at the Jordan Narrows. This canal delivers water to Kennecott Copper Corporation's Magna mill and tailings pond as well as to various irrigators. Excess water not used by Kennecott flows into the C-7 Ditch which discharges into the Great Salt Lake.(68)

Water that is pumped from the river at the Jordan Narrows into the Utah Lake Distributing Canal is delivered to northern Utah County and Salt Lake County for irrigation of crops. The water pumped into the canal is part of an exchange agreement between the Metropolitan Water District of Salt Lake City and the Utah Lake Distributing Canal Company. The District provides an equal amount of Jordan River water in exchange for Deer Creek Reservoir water.(42)

The Jordan and Salt Lake City Canal provides water to Salt Lake City. The City uses the water in its exchange agreements for the water in Little Cottonwood, Big Cottonwood, Mill, and Parleys Creeks.

The South Jordan Canal provides irrigation water to the area between the canal and the Jordan River.

The North Jordan Canal supplies water for agricultural uses and Kennecott Copper's milling process. The canal flows into the Riter Canal. Water not used by Kennecott flows into the C-7 Ditch which discharges into the Great Salt Lake.(68)

The water users on the lower Jordan River include irrigators, private duck clubs, and the state-operated Farmington Bay Waterfowl Management Area. The Utah Division of Wildlife Resources and the private clubs have constructed a complex system of dikes for controlling and managing the water that flows into and within the marsh lands at the mouth of the Jordan River. These marsh lands are an integral part of the Great Salt Lake marshes, which are considered to be one of the most important waterfowl breeding grounds in the United States.

TABLE V-37
UTAH LAKE WATER QUALITY(88)

Date	Hardness $CaCO_3$ (mg/l)	TDS (mg/l)	TKN (mg/l)	Total Phosphorus (mg/l)	NH_3 (mg/l)
Jun. 7, 1977	389	879	--	0.034	0.09
Aug. 8, 1977	390	996	--	0.185	0.12
Dec. 6, 1977	405	1000	--	0.083	0.22
May 9, 1978	385	890	--	0.065	--
Jul. 28, 1978	410	930	0.9	0.270	0.07
Aug. 31, 1978	--	--	1.5	0.350	0.34
Sep. 22, 1978	389	1005	--	0.070	0.04
Mar. 10, 1979	430	967	0.5	0.040	0.38
May 12, 1979	432	858	--	0.100	0.02
Jun. 16, 1979	399	913	2.6	0.050	0.01
Jul. 10, 1979	402	950	0.9	0.075	0.02
Aug. 24, 1979	355	943	--	0.140	0.34
Sep. 22, 1979	361	981	2.7	0.090	0.65
Nov. 1, 1979	--	972	--	--	--
Mar. 13, 1980	375	870	--	0.095	0.06
Apr. 28, 1980	394	877	--	0.018	0.09

TABLE V-3[illegible]
JORDAN RIVER WATER QUALITY
5800 SOUTH

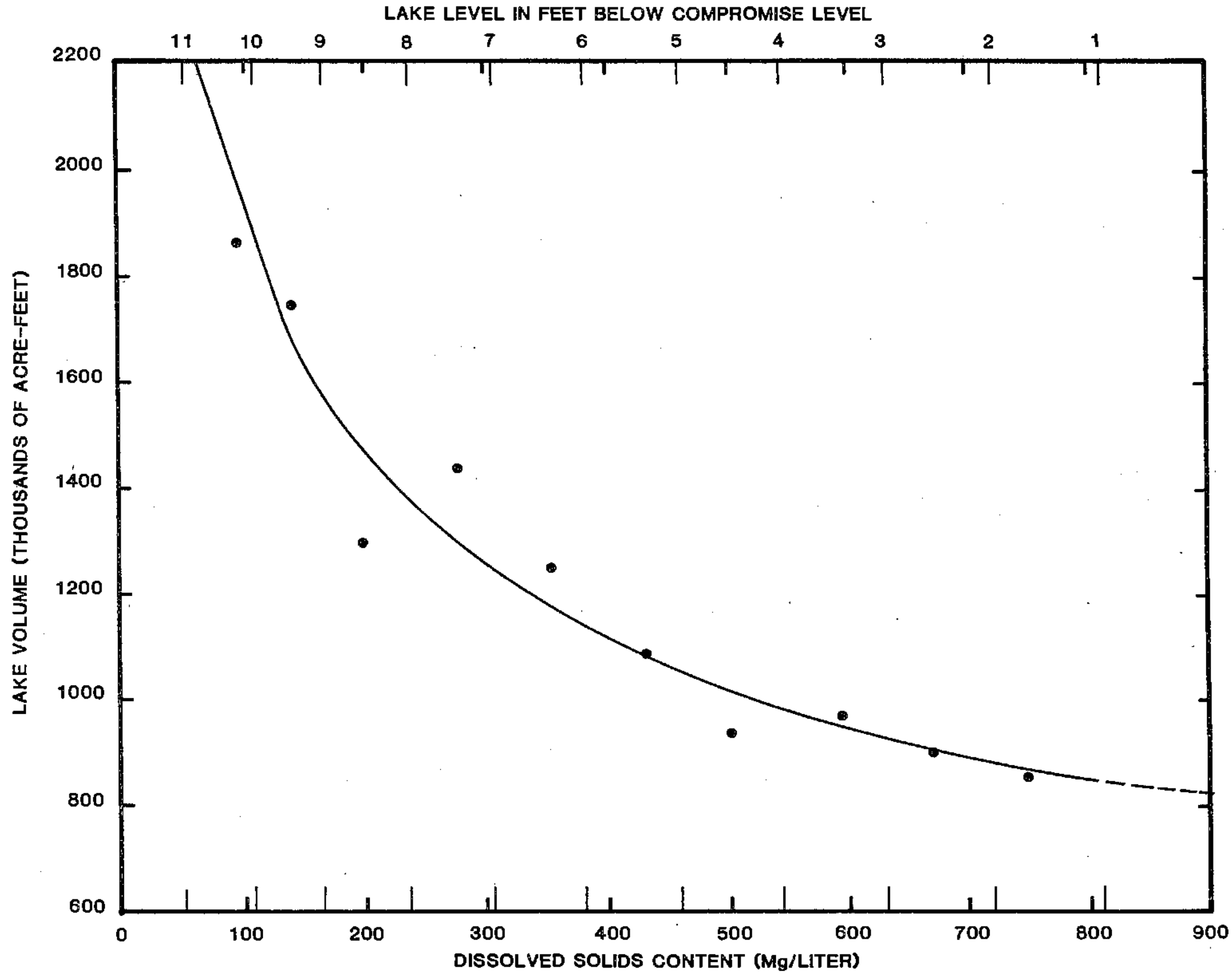
Month	Criteria	1976	1977	1978	1979	1980	1981
Jan.	Hardness(mg/l)	410	680	695	650	690	410
	TDS(mg/l)	930	1400	1430	1390	--	780
	Total Coliform	160	4500	95,000	130	--	
Feb.	Hardness	420	660	680	470	690	420
	TDS	930	1400	1440	1020	--	950
	Total Coliform	2100	71,500	220	11,150	--	190
Mar.	Hardness	380	680	680	420	510	420
	TDS	880	1420	1370	930	--	940
	Total Coliform	700	5100	1800	615	--	4800
Apr.	Hardness	390	650	555	420	450	450
	TDS	880	1340	1170	940	--	1170
	Total Coliform	110	12,550	2300	90	--	--
May	Hardness	640	650	560	550	430	530
	TDS	1310	1400	1200	1230	--	1190
	Total Coliform	260	3200	41,000	830	--	12,000
June	Hardness	640	670	570	620	450	470
	TDS	1310	1400	1170	1310	1030	1130
	Total Coliform	4500	130,000	21,000	22,750	--	35,000
July	Hardness	660	640	640	590	450	
	TDS	1340	1390	1350	1310	--	
	Total Coliform	24,000	3000	680	66,000	--	
Aug.	Hardness	660	640	600	670	580	
	TDS	1350	1450	1410	1360	740	
	Total Coliform	1450	4550	21,700	34,000	--	
Sept.	Hardness	590	650	650	610	650	
	TDS	1270	1360	1410	1380	--	
	Total Coliform	4100	2810	840	39,000	--	
Oct.	Hardness	660	680	660	710	550	
	TDS	1380	1420	1430	1460	1050	
	Total Coliform	1	550	1350	42	--	
Nov.	Hardness	680	705	710	730	450	
	TDS	1430	1410	1440	--	--	
	Total Coliform	17,700	30,400	3600	--	--	
Dec.	Hardness	680	680	630	720	440	
	TDS	1430	1430	2800	--	1000	
	Total Coliform	6500	400	1410	--	--	
Ave.	Hardness	570	670	640	600	510	
	TDS	1230	1400	1350	1230	--	
	Total Coliform	5100	22,400	16,000	17,500	--	

TABLE V-39
JORDAN RIVER WATER QUALITY
1700 SOUTH STREET

Month	Criteria	1976	1977	1978	1979	1980	1981
Jan.	Hardness (mg/l)	420	550	580	510	510	420
	TDS (mg/l)	946	1140	1240	1080	1110	420
	Total Coliform	--	--	--	--	--	--
Feb.	Hardness	410	550	580	470	460	415
	TDS	910	1100	1150	970	990	900
	Total Coliform	--	--	--	--	--	3500
Mar.	Hardness	400	575	610	460	480	390
	TDS	890	1190	1190	960	1030	880
	Total Coliform	--	--	--	--	--	12,000
Apr.	Hardness	370	530	450	380	440	360
	TDS	820	1130	870	840	1090	780
	Total Coliform	--	--	--	--	--	32,400
May	Hardness	370	540	420	240	340	420
	TDS	750	1110	850	460	780	770
	Total Coliform	--	--	--	--	--	2400
June	Hardness	370	520	210	400	290	190
	TDS	780	1040	375	820	610	500
	Total Coliform	--	--	--	--	--	144,000
July	Hardness	540	570	490	470	330	510
	TDS	1150	1140	1020	1080	530	1060
	Total Coliform	--	--	--	--	3700	1000
Aug.	Hardness	530	530	510	--	490	
	TDS	1120	1200	1090	--	990	
	Total Coliform	--	--	--	--	--	
Sept.	Hardenss	510	530	510	--	460	
	TDS	1050	1130	1090	--	1040	
	Total Coliform	--	--	--	--	--	
Oct.	Hardness	570	560	550	520	435	
	TDS	1170	1110	1140	1160	925	
	Total Coliform	--	--	--	--	--	
Nov.	Hardenss	550	570	530	550	540	
	TDS	1130	1120	1160	1150	1120	
	Total Coliform	--	--	--	--	--	
Dec.	Hardness	520		550	560	435	
	TDS	1090		1130	1110	985	
	Total Coliform				--	--	
Ave.	Hardness	465	550	500	460	422	
	TDS	983	1140	1025	960	910	
	Total Coliform						

TABLE V-40
JORDAN RIVER WATER QUALITY
CUDAHY LANE

Month	Criteria	1976	1977	1978	1979	1980
Jan.	Hardness (mg/l)	410	530	535	480	
	TDS (mg/l)	915	1160	1080	1040	
	Total Coliform	1450	1780	940	2450	
Feb.	Hardness	410	515	480	415	
	TDS	970	1070	1380	990	
	Total Coliform	1360	11,500	580	3700	
Mar.	Hardness	400	525	410	425	
	TDS	845	1170	770	850	
	Total Coliform	390	2900	10,300	1320	
Apr.	Hardness	320	520	310	400	
	TDS	610	1050	470	730	
	Total Coliform	1500	9950	7600	1040	
May	Hardness	300	435	340	310	
	TDS	560	915	560	590	
	Total Coliform	2340	14,000	10,000	400	
June	Hardness	400	490	270	420	
	TDS	835	1070	430	1680	
	Total Coliform	1800	52,000	45,800	55,500	
July	Hardness	530	520	450	410	
	TDS	1120	1130	910	1010	
	Total Coliform	7600	2900	7300	180,000	
Aug.	Hardness	520	510	490	490	
	TDS	1100	1125	1095	1080	
	Total Coliform	5590	34,500	101,500	20,000	
Sept.	Hardness	550	500	480	490	
	TDS	1200	1050	1060	1120	
	Total Coliform	16,100	1800	59,000	17,000	
Oct.	Hardness	560	540	520		
	TDS	1100	1110	1070		
	Total Coliform	0	37,000	50,500		
Nov.	Hardness	545	550	495		
	TDS	1125	1090	1050		
	Total Coliform	3600	5000	29,000		
Dec.	Hardness	525	460	500		
	TDS	1125	930	1090		
	Total Coliform	1070	9600	1420		
Ave.	Hardness	455	510	440		
	TDS	960	1070	910		
	Total Coliform	3570	15,240	27,000		



SALT LAKE COUNTY AREA-WIDE WATER STUDY

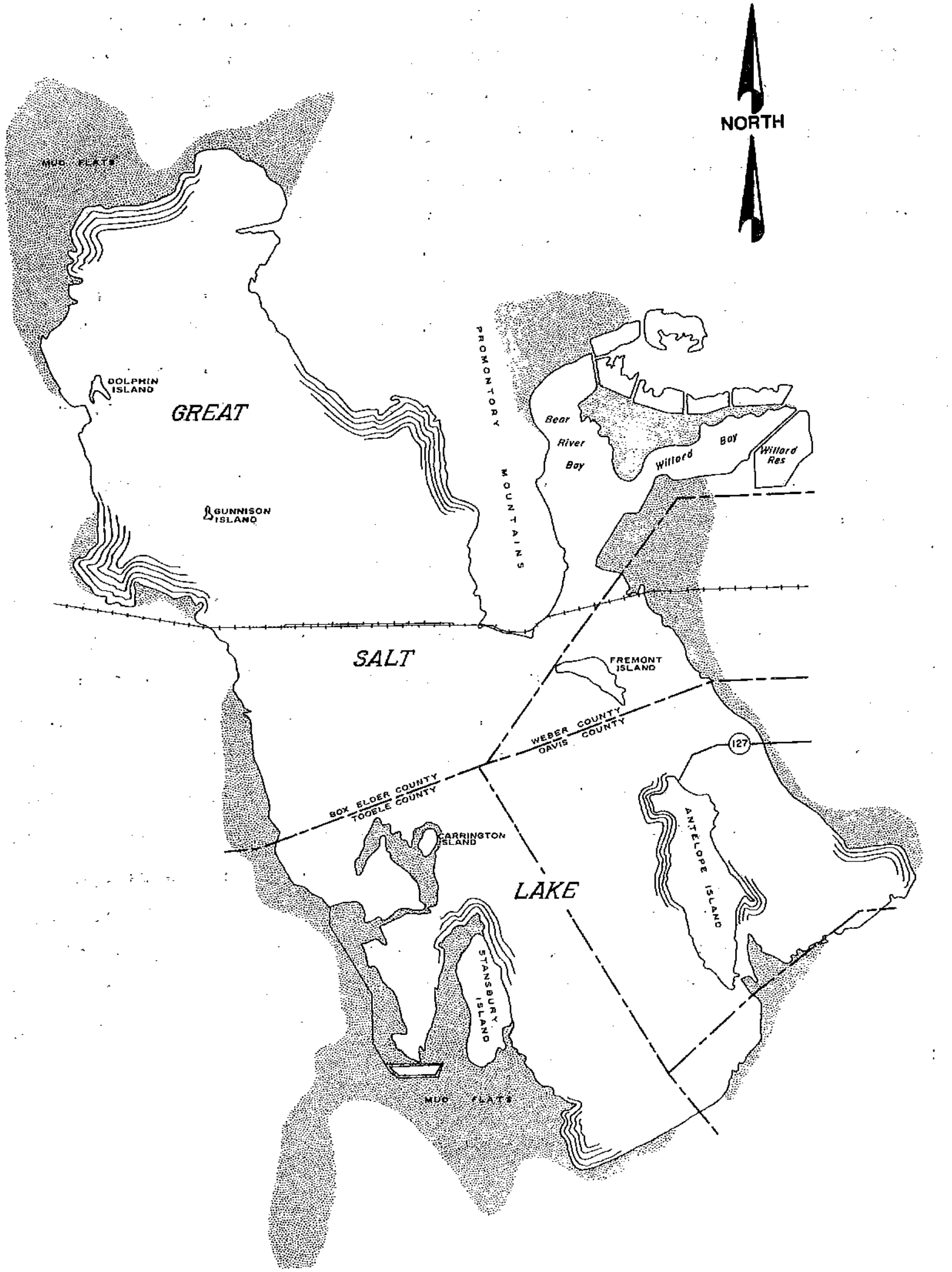
DISSOLVED SOLIDS CONTENT OF UTAH LAKE WATER

FIGURE V-39

GREAT SALT LAKE:

PHYSICAL DESCRIPTION: Great Salt Lake is the eastern remnant of ancient Lake Bonneville. The Lake at its present elevation of approximately 4200 feet is about 70 miles long and 40 miles wide. It has a surface area of approximately 1,500 square miles and an average depth of 13 feet, the maximum depth being about 35 feet. At the present elevation the total volume of the Lake is approximately 14.6 million acre-feet. There are many islands in the Lake, the largest are: Antelope, Carrington, Fremont, Bird, Gunnison, Cub, and Dolphin. The natural features of the Lake have been significantly affected by the Southern Pacific Railroad causeway and the Syracuse causeway. A map showing the Great Salt Lake, its major islands, and the causeways is shown in Figure V-40.

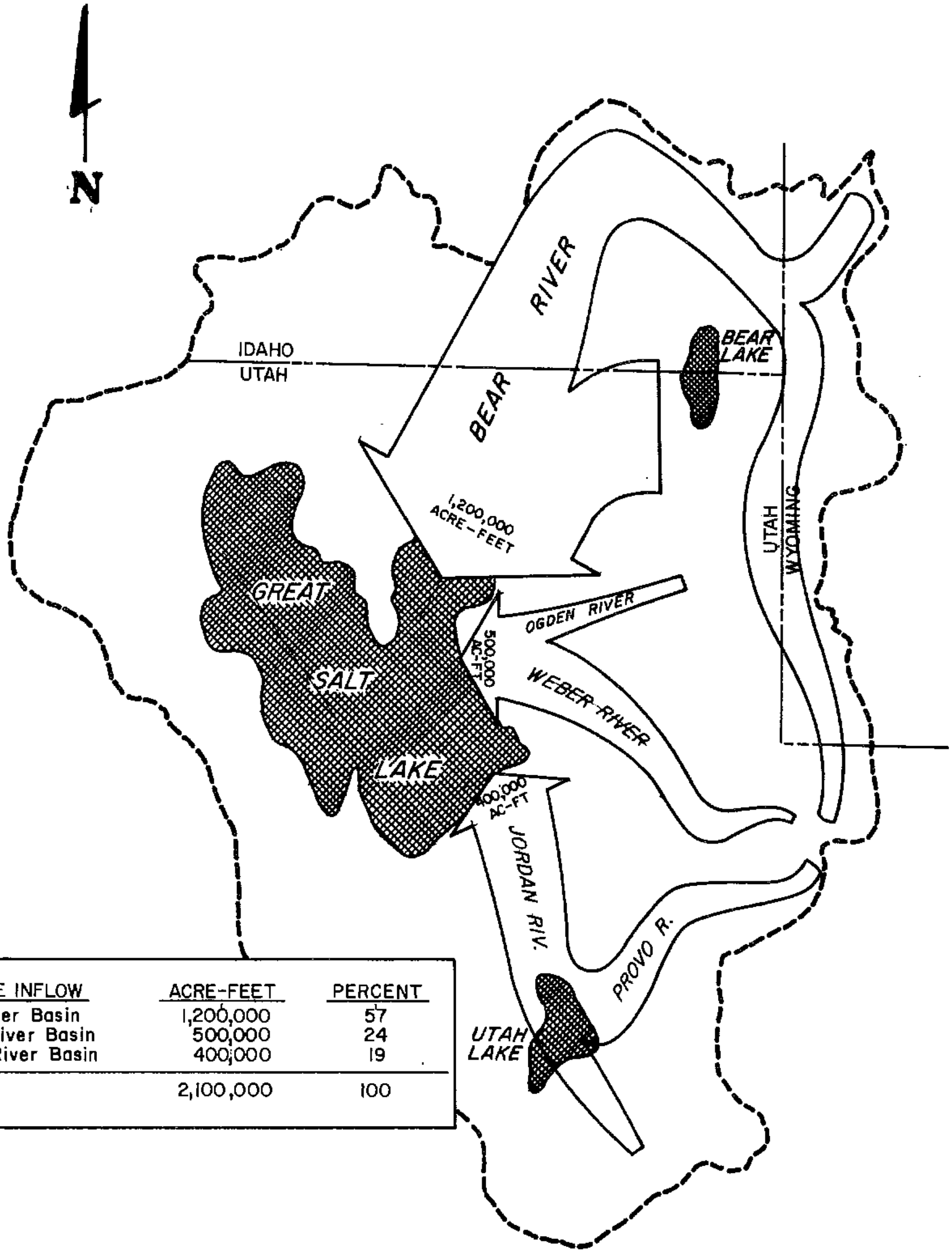
HYDROLOGY: The Great Salt Lake is a terminal lake receiving its inflow from the Bear, Weber, and Jordan Rivers. The Lake has a large fluctation in surface elevation due to the wide variation of inflow (including precipitation), which ranges from 1.5 to 7.5 million acre-feet, with an average annual inflow of 3.0 million acre-feet. The precipitation accounts for approximately 0.9 million acre-feet, or one-third of the inflow. As the lake is a terminal lake, the outflow consists solely of evaporation. Since 1851, the lake elevation has varied from a maximum of 4211.5 feet in 1873 to a minimum of 4191.6 feet in 1963. The present level of the lake is at an elevation of approximately 4200 feet. A sketch of the Great Salt Lake drainage area showing the mean annual surface inflow from each of the three major drainage basins is shown in Figure V-41. A historical hydrograph of the Great Salt Lake is shown in Figure V-42. Lake stage probabilities for present water uses and for additional water depletions of 250,000 and 500,000 acre-feet are shown in Figure V-43.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

GREAT SALT LAKE AREA MAP

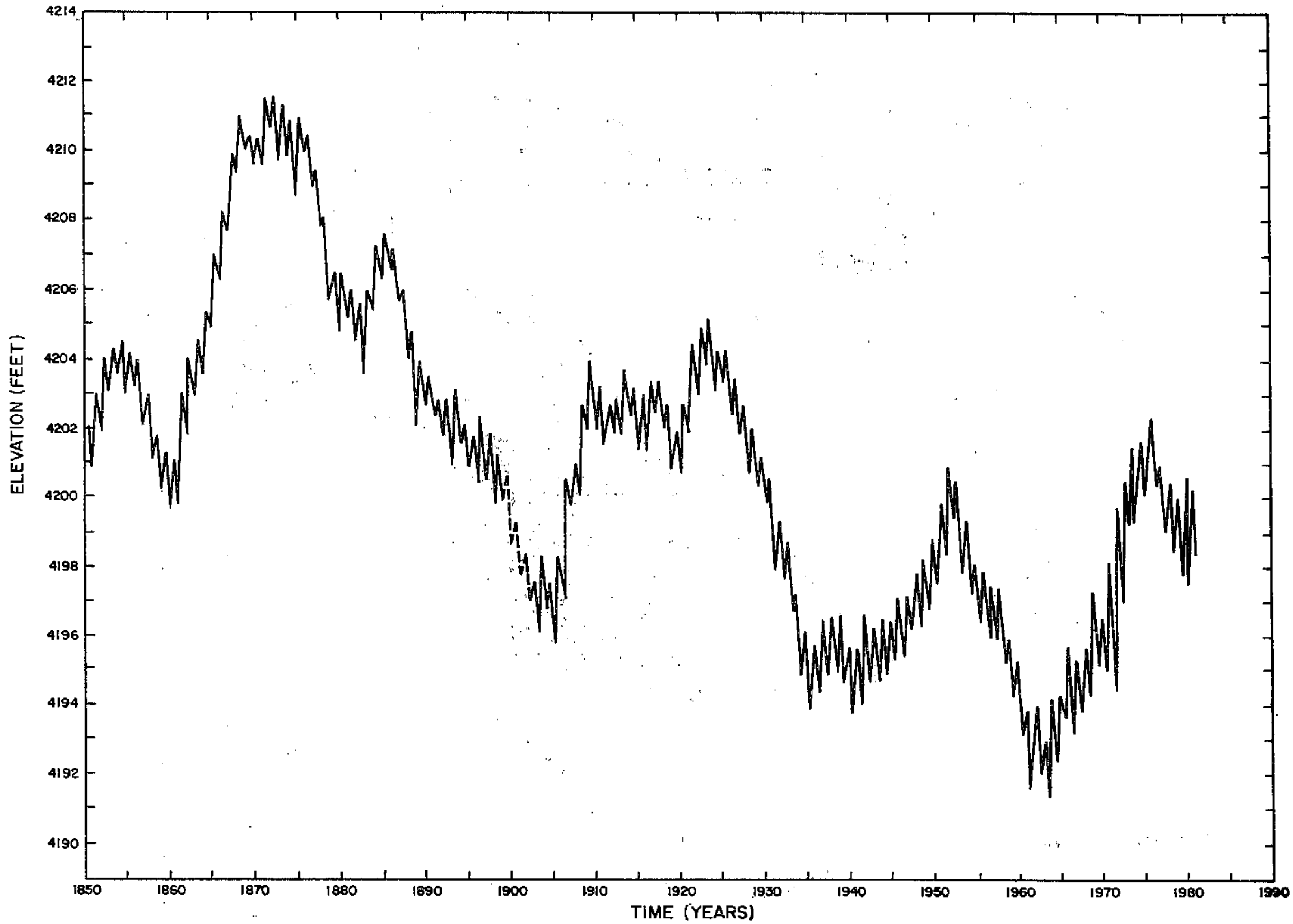
FIGURE V-40



SURFACE INFLOW	ACRE-FEET	PERCENT
Bear River Basin	1,200,000	57
Weber River Basin	500,000	24
Jordan River Basin	400,000	19
Total	2,100,000	100

SALT LAKE COUNTY AREA-WIDE WATER STUDY

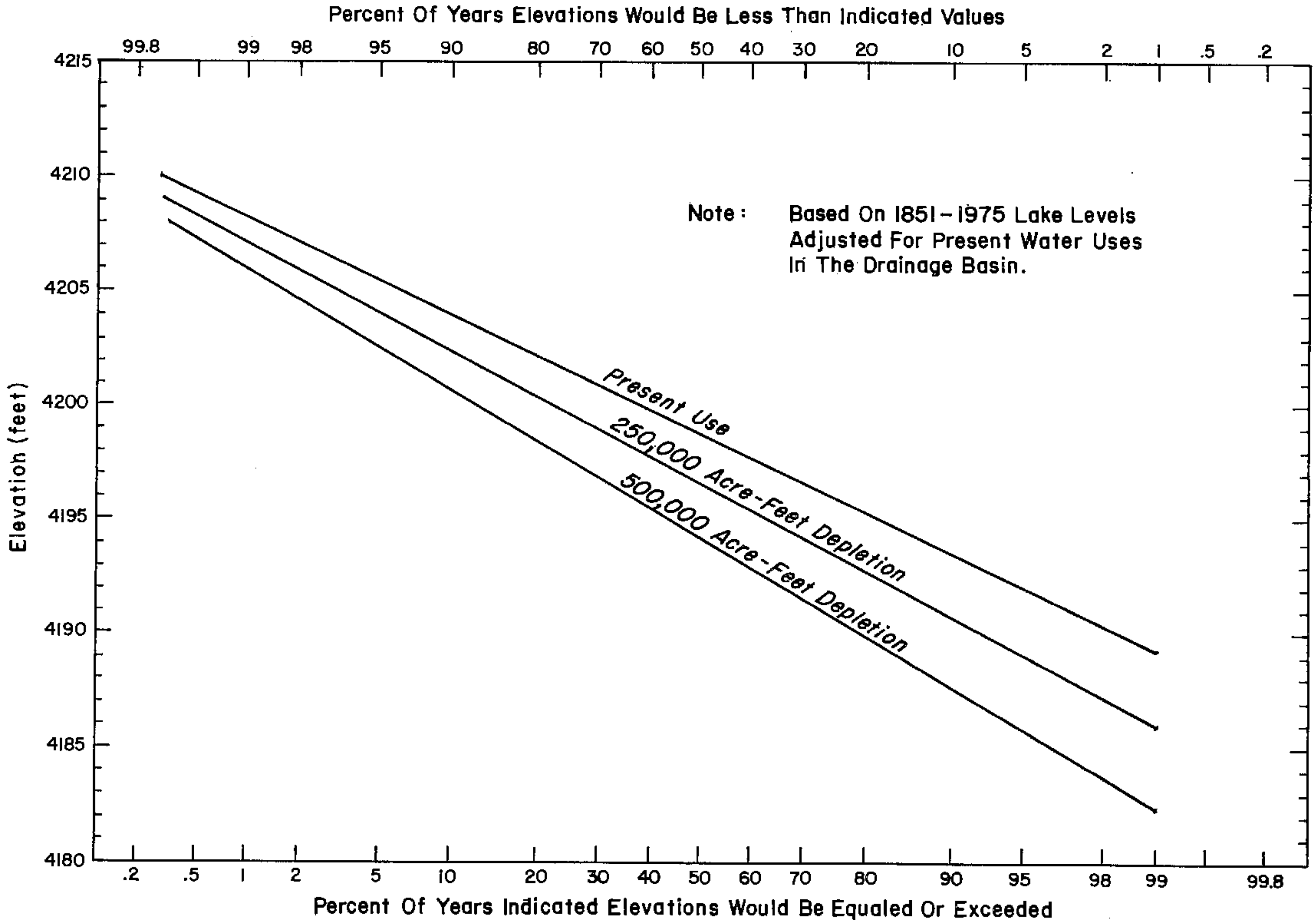
FLOW CHART FOR THE GREAT SALT LAKE DRAINAGE AREA



SALT LAKE COUNTY AREA-WIDE WATER STUDY

HISTORICAL HYDROGRAPH OF THE GREAT SALT LAKE

FIGURE V-42



SALT LAKE COUNTY AREA-WIDE WATER STUDY

PROBABILITY CURVE FOR GREAT SALT LAKE SURFACE ELEVATIONS

FIGURE V-43

WATER QUALITY: Construction of the Southern Pacific Railroad causeway across the Great Salt Lake was completed in 1959. Restricted bi-directional flow through the two culverts in the causeway resulted in the lake becoming two distinct bodies of water, the North Arm and the South Arm. Most of the surface inflow to the lake is into the South Arm. The salinity in the South Arm is significantly lower than the salinity in the North Arm. The lake elevation in the South Arm generally ranges from 0.5 feet to 2.5 feet higher than the North Arm elevation.

The salinity of the brine in the North Arm remains fairly uniform at approximately 340,000 mg/l. The salinity in the South Arm is highly dependent on the total volume of water in the lake. The brine in the South Arm is stratified into two distinct layers. The top layer extends to a depth of approximately 20 feet. The salinity of the brine in the top layer ranges between 100,000 and 250,000 mg/l. The brine in the lower layer in the South Arm ranges in salinity between 250,000 and 340,000 mg/l.

Recent sampling of water in the Farmington Bay has shown the salinity to vary between 25,000 and 100,000 mg/l. Computer models of the Great Salt Lake have predicted that the salinity of the water in the bay will drop below 5000 mg/l after several years due to the Syracuse causeway separating the bay from the Great Salt Lake.

The high salinity of the Great Salt Lake brines prohibits the direct desalting of this water resource for reuse. Presently only the tributary inflows could be used in a desalting process. A summary of the mean monthly total dissolved solids of the three primary tributaries to Great Salt Lake are shown in Table V-41. These values range from about 500 mg/l to 6000 mg/l. If the salinity in Farmington Bay continues to drop as predicted, this source could be considered for desalting. Since Farmington Bay has received large amounts of sewage in past years, and is currently receiving the waste water from the Salt Lake City Water Reclamation Facility through the sewage canal and the waste water from three treatment plants in Davis County, the Bay may not be a suitable source for a municipal water supply.

TABLE V-41

SUMMARY OF MEAN MONTHLY WATER QUALITY
OF PRIMARY TRIBUTARIES TO GREAT SALT LAKE[22]

Month	TOTAL DISSOLVED SOLIDS - ppm					
	Bear River		Weber River		Jordan River	
	Above Refuge	Below Refuge	Above Refuge	Below Refuge	Above Refuge	Below Refuge
Jan.	910	1050	580	690	1400	1690
Feb.	840	980	550	640	1300	1630
Mar.	710	970	540	580	1240	1620
Apr.	520	850	540	610	1300	1560
May	710	910	600	700	1400	1500
June	1820	1175	730	880	1260	1490
July	3600	2600	760	1170	1760	1820
Aug.	3450	4150	780	1630	2040	2540
Sept.	2860	5400	800	1980	1960	3380
Oct.	1430	3180	780	1690	1860	2730
Nov.	1040	2080	720	1170	1700	2080
Dec.	970	1240	650	860	1580	1690

WATER USES: The lake and surrounding shore area supports many types of wildlife, recreation, and mineral extraction. Birds are the most abundant wildlife in the area, with 247 species having been identified. The marshes assume a position of international importance since, due to their strategic position on the Pacific and Central fly-ways, they serve as a line between the United States, Mexico, Canada, and Central America. Some three million game birds stop over from these fly-ways each year. Recent and current development of marinas and other recreation facilities on Antelope Island and the South Shore are providing needed recreational opportunities near the populous Wasatch Front area. Mineral extraction from the lake includes common salt, salt cakes, sulfate of potash (fertilizer), and magnesium chloride. The potential for additional development of the recreational, wildlife and mineral resources is enormous.

GROUND WATER:

Ground water occurs in subsurface materials throughout Salt Lake County. In the mountainous areas, the ground water is recharged from rainfall and snowmelt through surface soils and rock fractures and discharges either to evapotranspiration, streams, or into the unconsolidated fill in Salt Lake Valley. The Salt Lake Valley unconsolidated subsurface acts as a large reservoir which spills naturally through springs, into the Jordan River, and directly into the Great Salt Lake.

Ground water in the valley occurs in four zones as shown in Figure III-2: (1) a deep unconfined aquifer adjacent to the mountains, (2) a confined (artesian) aquifer below the clay layer further into the valley, (3) an unconfined aquifer overlying the artesian aquifer, and (4) shallow unconfined perched aquifers throughout the valley. The aquifers described under (1) and (2) above compose the principal aquifer of the valley.[33]

The confined aquifer consists of deposits of clay, silt, sand and gravel, all hydraulically interconnected. There are many relatively thin beds and lenses of fine-grained material which tend to confine water in each of the many individual beds of sand and gravel. Underlying the confined aquifer are relatively impermeable consolidated and semi-consolidated deposits. Overlying the confined aquifer are relatively impermeable deposits of clay, silt, and fine sand, which act collectively as a single bed that ranges from about 40 to 100 feet in thickness. The top of the confining bed generally lies between 50 and 150 feet below the land surface.[33]

The confined aquifer generally yields water readily to wells. The most productive of these wells are around the edge of the aquifer, nearest the mountains, where it contains thick coarse-grained deposits. Most of the least productive wells are in the northern and central parts of the valley, where the aquifer consists largely of fine-grained deposits.[33]

The deep unconfined parts of the ground-water reservoir near the mountains generally have yielded little water to wells. In some places, the water-bearing materials are so thin that they cannot yield large quantities to wells; in other places, the depth to water is too great (more than 500 feet) for economical pumping. A few public-supply and industrial wells with moderate to high yields have been constructed in the unconfined part of the reservoir near the mountains, but a larger number of wells with yields too low to be considered successful have been drilled. Most of the low-yield wells are between stream channels; whereas most of the productive wells are along or near stream channels, where the deposits are better sorted and more recharge is available.[33]

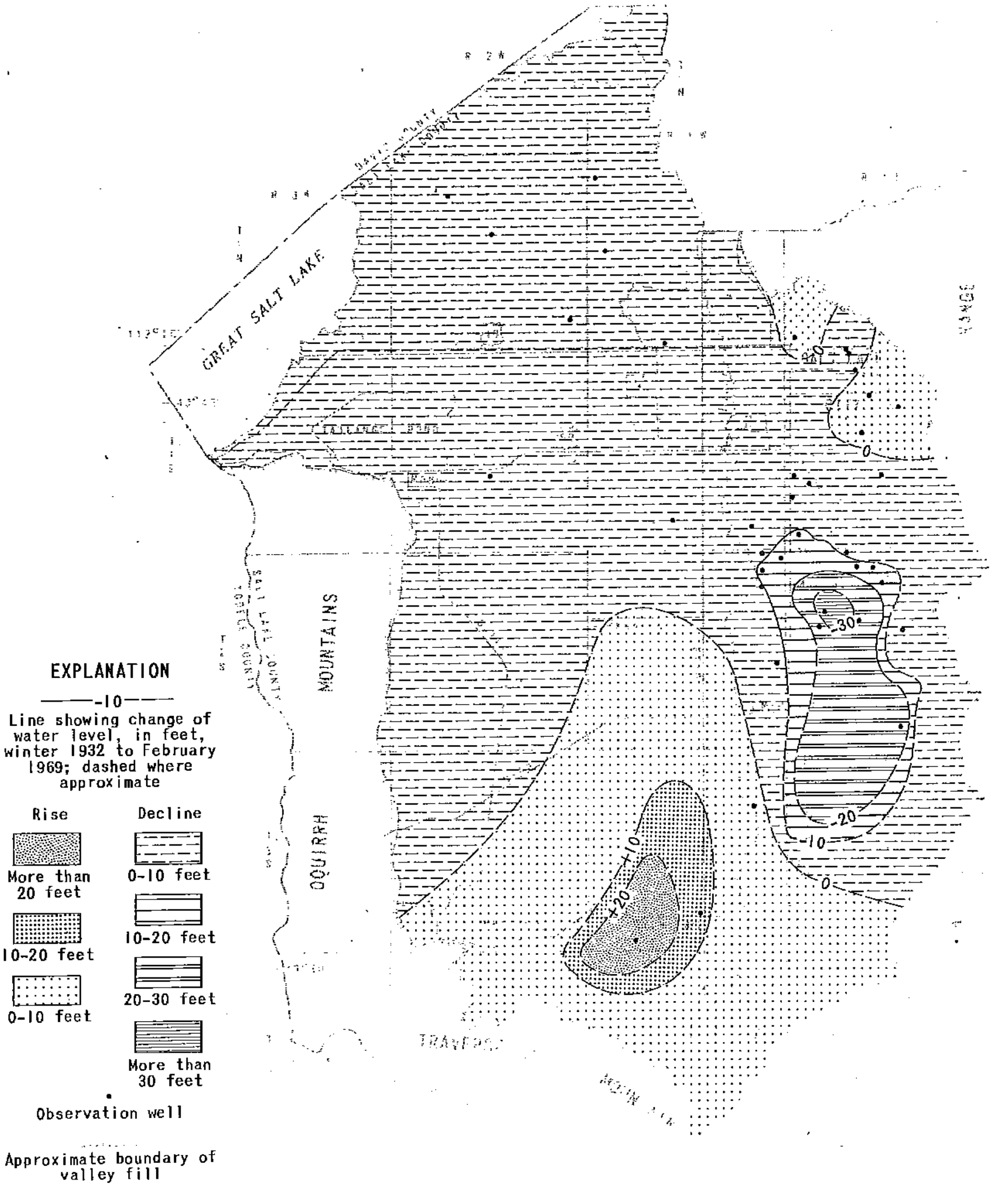
The shallow unconfined aquifer overlies the bed of low permeability that confines water in the artesian aquifer and extends over approximately the same area as the confined aquifer. The shallow aquifer is fed by water moving upward from the confined aquifer and by seepage of irrigation water, streams and rainfall. This aquifer is seldom used for water supply because of the poor chemical quality and low yield to wells.[33]

The perched water is where the bottom of the confining bed lies above the deep water table. Thus, an unsaturated zone exists between the deep water table and the body of perched water above it. Although water moves slowly down through the fine-grained bed supporting the body of perched water, most perched bodies never drain completely. They form or enlarge during periods when the rate of infiltration from the surface exceeds the rate at which water moves downward through the fine-grained bed, and they shrink during periods of little or no recharge. The principal areas of perched water are east of Midvale and between Herriman and Riverton, but smaller bodies of perched water are scattered around the county.[33]

In 1969 there were 11,823 wells in Jordan Valley registered with the office of Utah Division of Water Rights.[33] Most of the wells are located in the area east of the Jordan River. The quality of the ground water is highest in this area and is lower in the western and northern part of the valley. Many wells near the Jordan River and in the western part of the valley do not produce water which is acceptable for culinary use.[47]

Since 1932 the static water level of the confined aquifer has risen in 28 percent of the Salt Lake Valley and declined in the remaining 72 percent. This rise occurred in the southern part and along the north-central edge of the valley as shown in Figure V-44. Most of the rise is in areas where return flow from irrigation recharges the principal aquifer. The decline is in areas of relatively large withdrawals from wells and little or no increase in recharge from irrigation. In the Murray area the decline has been on the order of thirty feet.[33] The map in Figure V-45 shows the change in the water level from February 1980 to February 1981.

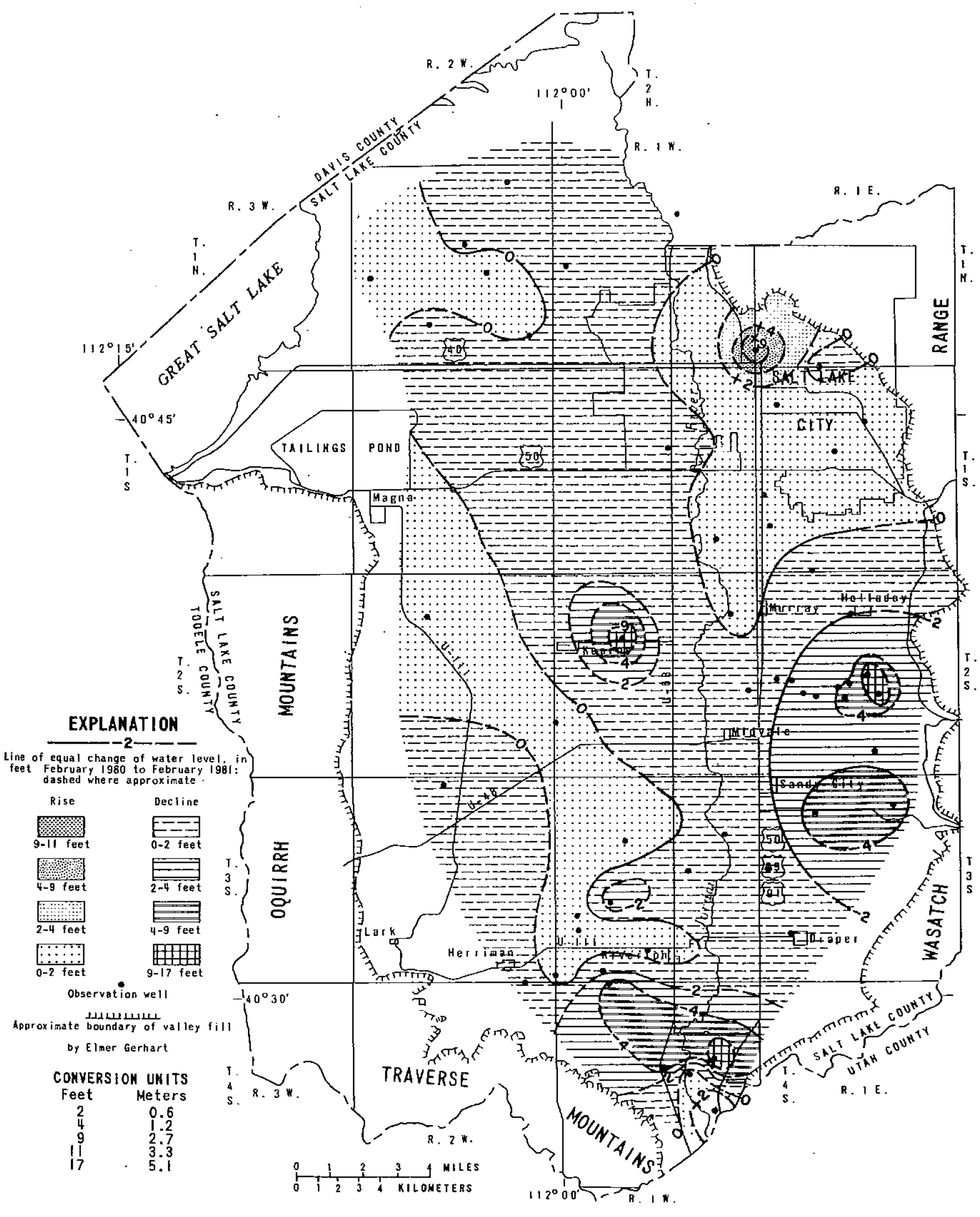
There are many questions surrounding the potential use of the ground-water reservoir in the Salt Lake Valley, i.e. subsidence and infiltration of poor quality water into areas of presently good quality water. The U.S. Geological Survey, on behalf of the water supply agencies of Salt Lake County and the Utah Division of Water Rights, has begun a four-year study to answer some of these questions. The objectives of the study are: (1) determine the current state of the ground-water system, (2) design and construct digital-computer models of the ground-water reservoir, and (3) establish the potential of land subsidence as related to water-level declines. The study is expected to be completed in October, 1984.



SALT LAKE COUNTY AREA-WIDE WATER STUDY

CHANGE IN WATER LEVEL FOR THE PRINCIPAL AQUIFER FROM WINTER 1932 TO FEBURARY 1969

FIGURE V-44



SALT LAKE COUNTY AREA-WIDE WATER STUDY

CHANGE OF WATER LEVELS FROM FEBURARY 1980 TO FEBURARY 1981

FIGURE V-41

WASTE WATER:

Typically 75 to 80 percent of the water delivered for indoor use through the culinary water system finds its way into the sanitary sewer system.[18] Currently, this volume of water is estimated to be 90 million gallons per day in Salt Lake County. By the year 2000, this volume is expected to increase to 122 million gallons per day.[60] Present practice is to process the waste water to "secondary treatment" standards and discharge it to a surface water source. "Secondary treatment" as defined by the Utah Division of Public Health is as follows[82]:

Parameter	Monthly Mean
BOD (mg/l)	25
Suspended Solids (mg/l)	25
Coliform (MPN/100 ml)	2,000
Fecal Coliform (MPN/100 ml)	200
pH	6.5 -9.0
BOD Removal (%)	85
Suspended Solids Removal (%)	85

In Salt Lake County there are nine municipal waste-water treatment plants. Seven of these discharge to a 14 mile reach of the Jordan River between 9400 South and 2100 South. Salt Lake City's treatment plant discharges to the Sewage Canal. The Magna plant discharges to Kersey Creek. The capacity of each of the plants is shown in Table V-42 along with the current flows.

Several studies have been made within the last ten years as to how the waste water from the county should be handled. The 208 Area-Wide Water Quality Management Project recommended that the seven plants along the Jordan River be combined into two regional plants.[60] A "201 Facility Plan" was then prepared for each plant to further evaluate its cost effectiveness. These plants are now under construction and are expected to be "on line" by 1984. The larger of the two plants will be located immediately north of 3300 South near the Jordan River. The other plant will be at about 7600 South on the west bank of the Jordan River. Effluent requirements for these plants are shown below and are known as

"Polished Secondary" standards[60]:

Parameter	Monthly Mean
BOD (mg/l)	10
Suspended Solids (mg/l)	10
NH_3 (mg/l)	5.0 summer 10.0 winter
Coliform (MPN/100 ml)	200
Fecal Coliform (MPN/100 ml)	20
pH	6.5 to 9.0
Chlorine Residual (mg/l)	0.0

Reuse of the treated waste-water effluent was considered in the respective "201 Facility Plans". At the present time, reuse of the effluent is not economically feasible.

TABLE V-42

SALT LAKE COUNTY WASTE-WATER TREATMENT PLANTS

(mgd)

Plant	Design Capacity	Current Average Flows
Magna	1.3	1.2
Salt Lake City	45.0	36.0
South Salt Lake	4.55	4.3
Granger-Hunter	7.0	8.7
SLC Suburban No. 1	16.0	15.7
Murray	5.0	3.0
Cottonwood	8.0	8.0
Tri-Community w/lagoon	7.8	7.7
Sandy	4.0	2.6