Arizona State Land Department

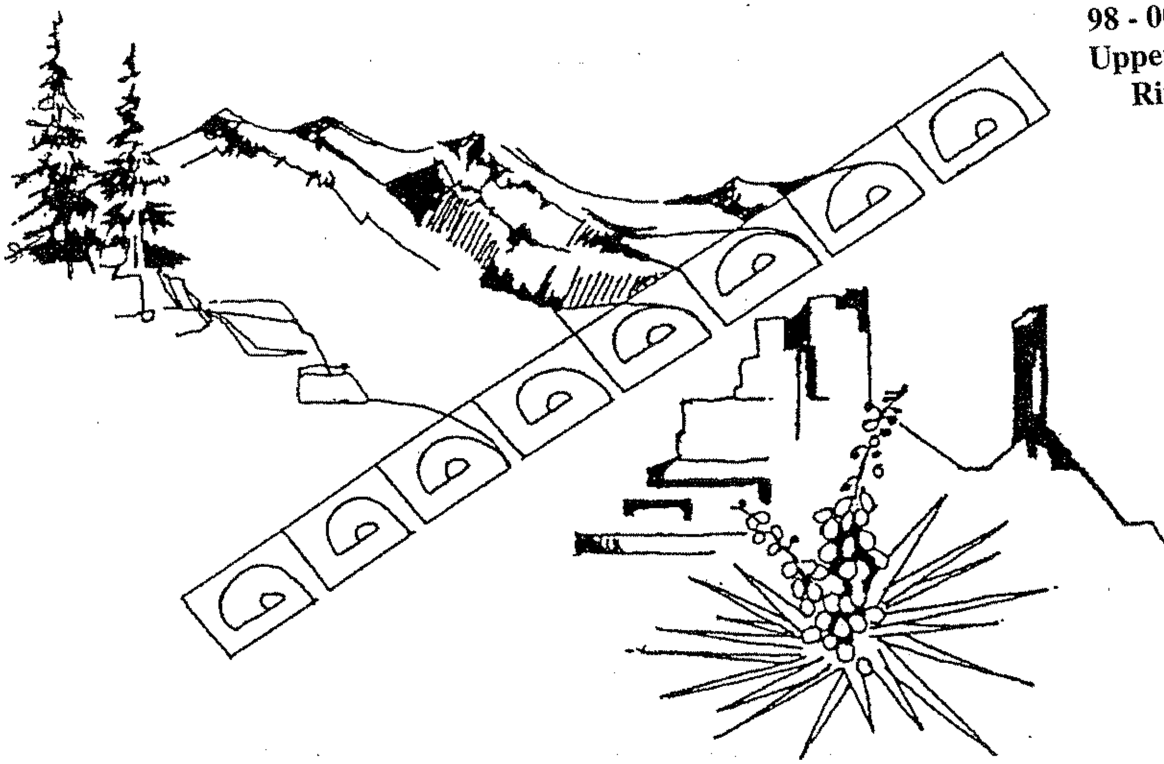
ARIZONA STREAM NAVIGABILITY STUDY

for the

UPPER SALT RIVER

Granite Reef Dam to the Confluence of the White and Black Rivers

Final Report



Prepared by
SFC Engineering Company

In Association With

George V. Sabol Consulting Engineers, Inc.,
JE Fuller/Hydrology & Geomorphology, Inc.,
and
SWCA, Inc. Environmental Consultants

March 1997

UPPER SALT RIVER PRELIMINARY REPORT

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PREFACE

This report was prepared on behalf of the Arizona State Land Department (ASLD) summarizing information relating to the navigability or non-navigability of the Upper Salt River as of the time of statehood on February 14, 1912. This report documents information relating to the Upper Salt River from the confluence of the White and Black Rivers to Granite Reef Dam. The information presented in this report is intended to provide data and evidence to the Arizona Navigable Stream Adjudication Commission (ANSAC) which will assist ANSAC to make findings and recommendations to the Arizona Legislature as to the navigability or non-navigability of the Upper Salt River. This report does not make a recommendation or conclusion regarding title navigability of the Upper Salt River.

The report consists of several related sections. First, an archaeological overview of the Upper Salt River relating to river uses is presented to set the long-term context of river conditions. Second, a historical study of the periods prior to and including statehood are discussed with respect to river uses, modes of transportation, and river conditions. Third, the historical geomorphology and hydrology of the Upper Salt River are summarized to illustrate past and potential flow conditions in the river. Fourth, information on federal boating criteria and the types of boating which have occurred historically on the Upper Salt River is provided. Finally, historical and current land use information is described and presented in a GIS format.

The Upper Salt River Navigability Study was performed by a project team consisting of SFC Engineering Company (SFC) in association with George V. Sabol Consulting Engineers, Inc. (GVSCE), JE Fuller/ Hydrology & Geomorphology, Inc. (JEF, Inc.), and SWCA, Inc., Environmental Consultants (SWCA). This study was completed on behalf of the ASLD (Contract #A5-0092) as directed by Arizona Revised Statutes §37-1124. Project staff included V. Ottozawa-Chatupron, ASLD, Project Manager; George V. Sabol, SFC, Project Principal; P. Deschamps, SFC, Project Co-Manager; J. Fuller, JEF, Inc., Project Co-Manager; R. Borkan, SWCA, team leader; D. Gilpin, SWCA, historian; D. Greenwald, SWCA, archaeologist; M. Cederholm, SWCA, GIS specialist.

EXECUTIVE SUMMARY

George V. Sabol Consulting Engineers, Inc., in cooperation with JEFuller/ Hydrology & Geomorphology, Inc., SWCA, Inc., Environmental Consultants and the Arizona Geological Survey (AZGS), was retained by the Arizona State Land Department (ASLD) to provide information to the Arizona Stream Navigability Adjudication Commission (ANSAC). ANSAC will use information provided by the project team to help make recommendations of navigability or non-navigability for the Upper Salt River to the Arizona Legislature. This report provides information on the Salt River between Granite Reef Dam and the confluence of the White and Black Rivers.

The basic approach to this study was to develop a database of information to be used by ANSAC in making a recommendation of navigability or non-navigability. Because the State's definition of navigability includes both actual navigation and susceptibility to navigation, the data collection effort was directed at two areas:

- Historical Uses of the River. Data describing actual uses of the river at the time of statehood were collected to help answer the question, "Was the river used for navigation?"

- Potential Uses of the River. Data describing river conditions at the time of statehood were collected to help answer the question, "Could the river have been used for navigation?"

Specific tasks for the study included agency contact, a literature search, summary of data collected from agencies and literature, and preparation of a summary report. The objectives of the agency contact task were to inform community officials of the studies, to obtain information on historical and potential river uses, and to obtain access to data collected by agency personnel on the Lower Salt River. For the latter task, public officials from every community, town, city, and county located within the study reach were contacted. The objective of the literature search was to obtain published and unpublished documentation of historical river uses and river conditions. Information collected from agency contacts was supplemented by published information from public and private collections.

The literature search focused on five subject areas: (1) Archaeology, (2) History, (3) Hydrology, (4) Hydraulics, and (5) Geomorphology. Archaeological data augment the historical record of potential river uses at statehood by providing an extended record of river conditions, use of river water, climatic variability, and cultural history along the rivers. Historical data provide information on actual river uses at the time of statehood, but also provide information on whether river conditions could have supported certain types of navigation. SWCA historians prepared a report summarizing use of the river and adjacent area in historic times, with special emphasis on the establishment, growth, and development of towns, irrigation systems, commercial activities, and developments. The hydrologic/hydraulic data are the primary source of information regarding susceptibility to navigation. These data include estimates of flow depths, width, velocity, and average flow conditions at statehood, based on the historical streamflow estimates, and

available modern records for natural stream conditions at statehood, as well as for existing stream conditions. Geomorphic data provide information relating to river stability, river conditions at statehood, and the nature of changes to the river since the time of statehood. Another element of the study was collection of land use information. Land use data were compiled for the Lower Salt River and were entered in a GIS database. Land use data included existing title records from county assessors offices, state and federal land leasing records from ASLD, the Bureau of Land Management, and the US Forest Service.

For the purposes of this study, the Upper Salt River was considered in three stream reaches:

- Reach 1 - White River/ Black River confluence to Roosevelt Reservoir
- Reach 2 - Roosevelt Reservoir to Stewart Mountain Dam
- Reach 3 - Stewart Mountain Dam to Granite Reef Dam

The data collected was organized into six main subject areas: archaeology, history, geology, hydrology, boating, and land use. Archaeological data indicate that the native American Hohokam civilization in central Arizona was dependent on water diverted from the Salt River to support their agricultural economy. The Hohokam built an extensive irrigation system downstream of the study reach that included about 315 miles of canals that provided water to about 140,000 acres of farmland, and supported a population of about 200,000. The water that supplied this extensive canal system flowed directly from the Upper Salt River. Within the Upper Salt River area, the prehistoric settlement pattern included small communities that relied on river flow for water supply and the river corridor for food, shelter, and building materials. In general, the pattern of settlement followed the perennial streams such as the Upper Salt River. Archaeological records also indicate that numerous fish species populated the Salt River and supplemented the diet of the Hohokam. Archaeological records indicate that climatic conditions and streamflow rates were not significantly different from conditions around the time of statehood.

The first Anglo explorers of the Upper Salt River found it in much the same condition that existed when the Hohokam and Apache settled in the area. The river had reliable streamflow, healthy beaver populations, a variety of large fish species, and dense riparian vegetation. Early Anglo residents floated canoes, flatboats, and logs down the river, although the primary mode of transportation was on foot, horseback or wagon. At least eight documented accounts of commercial and recreational boating on the Upper Salt River between 1870 and 1910 were identified as part of this study. Some types of boating occurred throughout the year during the period leading up to statehood. One successful boating expedition intended to determine if logs could be floated to Tempe from the upper watershed above Roosevelt took place during the month of June (1885), typically a month of seasonal low flows.

Use of boats on the riverine portions of the Upper Salt River was limited to shallow water, low-draft, floating boats which were used primarily in the downstream direction. Steamboats and commercial shipping operations like those found on the Colorado and lower Gila Rivers apparently were not developed on the Upper Salt River. The boats used on the Salt River sometimes encountered some difficulties in transit due to snags, boulder riffles, narrow canyons, waterfalls, or other natural hazards, and experienced difficulties at man-made obstructions such as irrigation diversions. A variety of boats were used to construct Roosevelt and Granite Reef dams, including a gas launch and boats used to haul construction materials to the dam site. Since the closure of Roosevelt Dam in 1911, recreational boating and some commercially-operated pleasure boating has been popular on Roosevelt Reservoir. Recreational and commercial rafting has been conducted on the Upper Salt River upstream of Roosevelt Reservoir since the 1950's.

By 1912, reservoir impoundments had lessened flow rates in the river channel itself, though the water supply upstream of Roosevelt Dam was no less reliable than in previous years. Documented accounts of boat use after 1911 on the Salt River downstream of Roosevelt Dam were limited to periods of high flow and floods. During the period after Roosevelt Dam was closed, and Roosevelt Reservoir was filling, streamflow in Reaches 2 and 3 of the Upper Salt River was limited to flood discharges and flow releases to downstream irrigation diversion points. However, even during this period of reduced low flow in the Salt River, winter discharges could occupy the channel for months at a time, making the river susceptible to a number of types of low-draft boating. Upstream of Roosevelt Reservoir, several commercial outfits offer recreational boating trips in Reach 1. Since 1912, three additional reservoirs have been constructed in the Upper Salt River, all of which are popular boating areas.

Review of geologic conditions in the Upper Salt River indicates that the channel geomorphology is substantially unchanged from the conditions at or before statehood, except where the river has been inundated by the reservoirs. The Upper Salt River is formed within deep canyons. Bedrock in these canyons has prevented significant channel changes from occurring. In addition, the bedrock geology of the Upper Salt River area made access to the river difficult during the period around statehood, prevented development of extensive irrigation systems, and created impediments to some forms of river travel. However, the bedrock geology of the Upper Salt River was conducive to construction of large dams and water supply reservoirs. Construction of the four reservoirs induced the only significant changes in the natural geomorphology of the study Reach. In addition to the obvious changes in downstream runoff rates caused by the reservoirs, the ordinary high watermark and ordinary low watermarks locations were changed by impounding water along the Upper Salt River system.

The Salt River Valley has a long history of reliance on the perennial flows from the Upper Salt River watershed. Without considering any disturbance by humans, the mean annual flow rate ranges from about 700 to 1,500 cfs, with relatively minor flow attenuation within the Reach due to shallow groundwater levels, narrow bedrock canyons, and perennial flow. In the year of statehood, 1912, the typical hydrologic condition of the river in Reaches 2 and 3 was, in part, a function of upstream water storage and downstream irrigation demands. For Reach 1, and for Reaches 2 and 3 prior to construction of Roosevelt Dam, periods of low flow usually occurred during the early summer months of June and July, and may have been as low as 100 to 300 cfs upstream of the Verde River confluence during the driest months of the year. Average winter flow rates typically exceeded 1,000 cfs prior to the closure of Roosevelt Dam, with annual flood discharges approaching 20,000 cfs in Reach 3. After closure of Roosevelt Dam, until it filled in 1915, winter flow rates were significantly reduced from the natural flow condition.

Typical flow depths during the lowest seasonal flows were probably one to three feet deep, with average flow widths ranging from about 50 to 100 feet depending on the channel geometry of the canyon bottom. Typical flow depths for the average annual flow were probably about three to five feet deep. At higher flow rates, such as for the 2- and 5-year flood peaks, velocities typically did not exceed 10 feet per second, which is within the range of boatable conditions for canoes, kayaks and rafts.

Under HB 2589, the Arizona Legislature defined navigability criteria that establish a presumption of non-navigability to be used by ANSAC when considering evidence for specific streams. For the Upper Salt River, the following data described in this report relate to the State's navigability criteria:

- **Commercial Trade and Travel.** As of the time of statehood, the Upper Salt River was susceptible to limited forms of commercial trade and travel. The hydrologic and historical record shows that there was sufficient water in the river that would allow use of shallow water boats during regularly occurring portions of the year. Shallow water boating in the downstream direction was most feasible, given the normal conditions of the Upper Salt River.

- **Flow Regime.** As of the time of statehood, the hydrologic record shows that the Upper Salt River was and is a perennial stream. That is, it flows at times other than in direct response to precipitation. Like all rivers, the Upper Salt River responds to excess precipitation with increased flow rates, or to periods of drought with reduced flow rates. However, even during the driest portions of the year, the entire Upper Salt River remains perennial despite impoundment of flow in four major reservoirs.

- **Sustained Trade and Travel Upstream and Downstream.** There was no evidence identified for this study that sustained trade and travel ever occurred on the Upper Salt River, nor is there evidence that trade or travel in the upstream direction ever occurred. However, the hydraulic rating curves indicate that some types of boat traffic could have occurred both upstream and downstream during regularly occurring portions of the year, although upstream travel would have been more difficult than downstream travel.

- **Profitable Commercial Enterprise.** There was no historical evidence identified for this study that any profitable commercial enterprises were conducted using the Upper Salt River for trade and travel as of the time of statehood. After the 1950's, several commercial rafting and floating outfitters have operated seasonal trips on Reaches 1 and 3 of the Upper Salt River, with numerous commercial activities occurring year-round on the reservoirs of Reach 2.

- **Types of Vessels.** The historical record indicates that canoes, flat boats, rafts, rowboats, skiffs, and floating logs were the only vessels to be used on the Upper Salt River. Historical records indicate that use of any type of boats on the river diminished by the time of statehood. Keelboats and other powered barges were used on the Upper Salt River during the construction of Roosevelt Dam from 1906 to 1911, and have been used on the Salt River reservoirs since statehood. The hydraulic rating curves prepared for the Upper Salt River study reach indicate that large keelboats, steamboats or powered barges could not have been used during the low flow conditions on the river itself as it existed in 1912. During high flows, high velocities and river conditions may have made use of these types of high-draft boats hazardous or impractical.

- **Diversions.** Irrigation diversions at Granite Reef Dam, the downstream end of the Upper Salt River study reach, removed the entire flow from the Salt River as of 1912. Some lands irrigated with water from the Upper Salt River were covered under the Desert Land Act of 1877, or were within an Indian Reservation. It is uncertain whether any of the local irrigation diversions along the Upper Salt River upstream of Granite Reef Dam were for lands covered under the Desert Land Act of 1877.

- **Recreational Boating.** Many, but not all, of the historical accounts of boating on the Upper Salt River were for recreational purposes. Today, recreational boating on the Upper Salt River is very popular.

- **Regular Flotation of Logs.** Logs or other material probably could have been floated through the entire Upper Salt River as of the time of statehood throughout the entire year, although some type of portage would have been required in some reaches and at Roosevelt Dam.

- **Impediments to Navigation.** Roosevelt Dam was the only known non-natural impediment to navigation in the Upper Salt River that existed in 1912. Waterfalls and narrow canyons were obstacles to some pre-statehood boating trips, according to the historical records.

- **Customary Modes of Transportation.** The customary mode of transportation in the region near the Upper Salt River was not by boat. By 1912, alternatives to boat travel included foot, horse, mule train, wagon, and train.

- **Rivers and Harbors Act of 1899.** The Salt River is not one of the streams listed under the Rivers and Harbors Act of 1899, although at least one newspaper account stated that the Lower Salt River should have been classified as a navigable river for the Rivers and Harbors Act appropriation.

The Upper Salt River could have and did support some types of boating during the period prior to statehood. By 1912, use of boats on the river had declined, but was still possible during most years, a condition which persists today.

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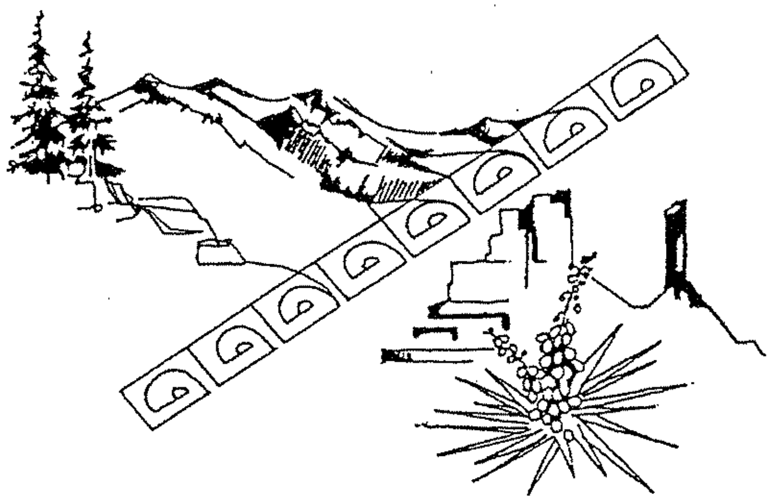

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Section 1

UPPER SALT RIVER PRELIMINARY REPORT
SECTION 1

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INTRODUCTION

George V. Sabol Consulting Engineers, Inc. (GVSCE), in association with JE Fuller/ Hydrology & Geomorphology, Inc. (JEF, Inc.), and SWCA, Inc., Environmental Consultants (SWCA) was retained by the Arizona State Land Department (ASLD) to provide information to the Arizona Navigable Stream Adjudication Commission (ANSAC). ANSAC will use the data and evidence provided by the GVSCE project team to assist their effort toward making findings and recommendations to the Arizona Legislature as to the navigability or non-navigability of the Upper Salt River as of the time of statehood.

This report documents information relating to the Upper Salt River from the confluence of the White and Black Rivers to Granite Reef Dam. No recommendation or conclusion regarding title navigability of the Upper Salt River is made in this report. The report consists of several related sections:

Section 1 - General information is provided by GVSCE as to the project background, the definition of navigability, the study reach limits, the objectives of the project, and the method of approach;

Section 2 - An archaeological overview of the Upper Salt River valley prepared by SWCA relates to river uses and sets the long-term context of river conditions;

Section 3 - A historical review by SWCA addresses the periods prior to and including statehood with respect to river uses, modes of transportation, and river conditions;

Section 4 - The historical geomorphology of the Upper Salt River evaluated by JEF, Inc. estimates river conditions and changes since statehood;

Section 5 - The hydrology of the Upper Salt River evaluated by JEF, Inc. estimates flow rates and conditions at statehood and for existing conditions;

Section 6 - A review of information on boating criteria and use of the river for various types of boating by JEF, Inc.;

Section 7 - Historical and current land use information compiled by SWCA is described and presented in a GIS format;

Section 8 - The results of the Upper Salt River study most pertinent to the legislatively mandated criteria of navigability or non-navigability are summarized.

A list of references cited, as well as an extended bibliography where appropriate, is included in each section. Appendices contain supporting documentation and the GIS work products. A glossary of terms and a list of acronyms used in the report are provided.

Project Background

Public Trust principles date back to English Common Law when the King held the beds of rivers affected by tides in Trust for the general public and for the public good. This provision was founded on the principle that there is a public need to use the waterways for commerce. When the United States gained independence from the British Crown, Public Trust principles were recognized so that the lands beneath navigable waters within the original thirteen states became the sovereign property of those states. The Equal Footing Doctrine provided that future states were entitled to sovereign ownership of riverbeds located within those new states on an 'equal footing' with the original thirteen states.

At the time of statehood on February 14, 1912, the State of Arizona received sovereign title to the beds of navigable rivers located within state boundaries. Under the Equal Footing Doctrine, the United States government previously held these lands in Trust pending the creation and admission of the State of Arizona to the Union. Although the State owned the land, in order to perfect title to the navigable streambeds, the State was required to make its claim of ownership. From statehood until the mid-1980's, Arizona claimed only the bed of the east half of the Colorado River. The State failed to act on all other claims of streambed ownership and other parties asserted title to certain streambeds lands. In assuming ownership of lands located in or near these streambeds, many of the current record title holders constructed projects and improvements to the land, paid property taxes, and altered the stream ecosystems and riparian habitat.

During recent years, the State, as well as a number of private and public entities, asserted claims of ownership of streambeds throughout Arizona. These claims turned on whether or not the streams were navigable or susceptible to being navigable at the time of statehood. The titles held by land owners whose property includes all or a portion of the streambed of potentially navigable streams are clouded. As a result of litigation addressing in-stream sand and gravel mining activities in the Verde River, the Arizona Legislature recognized the economic hardships created by the uncertainty of the State's potential future claims on streambed lands. In 1987, House Bill (HB) 2017 was passed outlining a procedure to quit claim any interest of the State in the beds of the Salt, Gila, and Verde Rivers for a nominal fee, reaffirming the State's claim to the Colorado River, and waiving any claim to all of the other streambeds in the State. A lawsuit challenging the constitutionality of HB 2017 was successful in 1991 and the Court found that one flaw in the bill was that it did not provide for an evaluation of the validity and value of the State's Public Trust interest on the individual watercourses.

In 1992, the Governor signed HB 2594 which repealed HB 2017 and established a systematic administrative procedure for gathering information and determining the extent of the State's ownership of streambeds. The main purpose of the legislation was to confirm State ownership in Public Trust lands located in the beds of streams determined to have been navigable at statehood. HB 2594 also created the Arizona Navigable Stream Adjudication Commission (ANSAC), a five member board appointed by the Governor. ANSAC was directed to establish administrative procedures, hold public hearings, and make determinations of navigability or non-navigability for specific watercourses. The legislation also directed the Arizona State Land Department (ASLD) to facilitate determination of navigability and to act as support staff for the ANSAC.

In early 1994, HB 2589, amending Arizona Revised Statutes (A.R.S.) §37-1101 through 37-1156, was adopted. HB 2589 set the criteria to be used for determination of navigability and non-navigability and established an ombudsman office to represent the interests of private property owners in proceedings involving governmental action. HB 2589 requires the ANSAC to set priorities for investigating and conducting hearings on watercourses within this state, and then to report its recommendation as to which watercourses or reaches of watercourses were navigable or non-navigable as of the time of statehood to the Legislature. The Legislature then makes a finding upon consideration of the ANSAC recommendation and enacts appropriate legislation in response to the determination. A.R.S. §37-1101 through 37-1156 are included in Appendix A of this report.

Definition of Navigability

A.R.S. §37-1101 (6) sets out the definition of "navigable" or "navigable watercourse" to be used to address the ownership of streambeds. That definition is:

> "Navigable" or "navigable watercourse" means a watercourse, or a portion or reach of a watercourse, that was in existence on February 14, 1912, and at that time was used or was susceptible to being used, in its ordinary and natural condition, as a highway for commerce, over which trade and travel were or could have been conducted in the customary modes of trade and travel on water.

The data collection effort for this study provides information that will assist ANSAC in determining if a given river meets the criteria of the statutory definition.

A.R.S. §37-1128, C. and D. itemize criteria to be considered by ANSAC in making a finding and recommendation of non-navigability:

C. The Commission shall find and recommend that a watercourse was non-navigable if, as of February 14, 1912, the watercourse either:

1) was not used or susceptible of being used for both commercial trade and travel;

2) flowed only in direct response to precipitation and was dry at all other times.

D. Unless there is clear and convincing evidence that a watercourse was navigable, it is presumed, and the Commission shall find and recommend, that the watercourse was non-navigable if, with respect to the watercourse as of February 14, 1912, any of the following applied:

1) no sustained trade and travel occurred both upstream and downstream in the watercourse;

2) no profitable commercial enterprise was conducted by using the watercourse for trade and travel;

3) vessels customarily used for commerce on navigable watercourses in 1912, such as keelboats, steamboats or powered barges, were not used on the watercourse;

4) diversions were made from the watercourse to irrigate and reclaim land by persons who made entries under the Desert Land Act of 1877, as amended (43 United States Code Sections 321 through 339), any other Federal act or to provide water to lands that are included in a Federal reclamation project or an Indian reservation that would have been inconsistent with or impediments to navigation;

5) any boating or fishing was for recreational and not commercial purposes;

6) any flotation of logs or other material that occurred or was possible on the watercourse was not and could not have been regularly conducted for commercial purposes;

7) there were bridges, fords, dikes, manmade water conveyance systems or other structures constructed in or across the watercourse that would have been inconsistent with or impediments to navigation;

8) transportation in proximity to the watercourse was customarily accomplished by methods other than by boat;

9) the United States did not regulate the watercourse under the Rivers and Harbors Act of 1899 (33 United States Code Sections 401 through 467e).

A.R.S. §37-1128, E. and F. itemizes criteria to be, and not to be, considered by the ANSAC in making a finding whether a watercourse was navigable:

E. In finding whether a watercourse was navigable, the Commission shall not consider:

1) waters that had been appropriated for beneficial uses on or before February 14, 1912 as being within the ordinary and natural condition of the watercourse;

2) the use of ferries to cross a watercourse;

3) fishing from the banks of a watercourse;

4) uses of the watercourse under flood conditions.

F. In finding whether a watercourse was navigable, the Commission shall consider the existence of dams and diversions of water and the impact of other human uses that existed or occurred at the time of statehood as part of the ordinary and natural condition of the watercourse.

Project Limits

The project team is to collect data and information relevant to the navigability or non-navigability and, hence, to title to the streambed lands of the Upper Salt River from the confluence of the White and Black Rivers to Granite Reef Dam, as shown in Figure 1.

Study Reach Lengths

The lengths of the study reaches were estimated using data reduced from the Arizona Land Resource Information System (ALRIS) GIS database. Those data were converted to an AutoCad drawing file and the lengths of the subreaches calculated using that program. The resulting total lengths of the study reaches are shown in Table 1-1.

Table 1

Study Reach Lengths

River Study Reach	Length (miles)	Length (kilometers)
Upper Salt River	153	246

Lateral Study Limits

The maximum lateral extent of the study limits for each study reach is the 100-year floodplain boundary. The identification of the lateral limits of the study reaches was conducted in two steps. First, a set of key maps was developed for all study reaches indicating sources of floodplain maps, topographic information, aerial coverage, and other pertinent information. The primary source of floodplain boundary delineations was the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM). Then, a GIS map layer was developed for each study reach showing the 100-year floodplain to establish the maximum lateral extent of the study limits for the purpose of information and data collection in subsequent work tasks. For those subreaches mapped by FEMA, the 100-year floodplain boundary was digitized in GIS format directly from the FIRM maps. No FEMA maps are available for those portions of the study reaches which are on Federally-owned or Indian reservation lands; therefore, no floodplain boundary delineations were generated or mapped for those subreaches due to budget limitations.

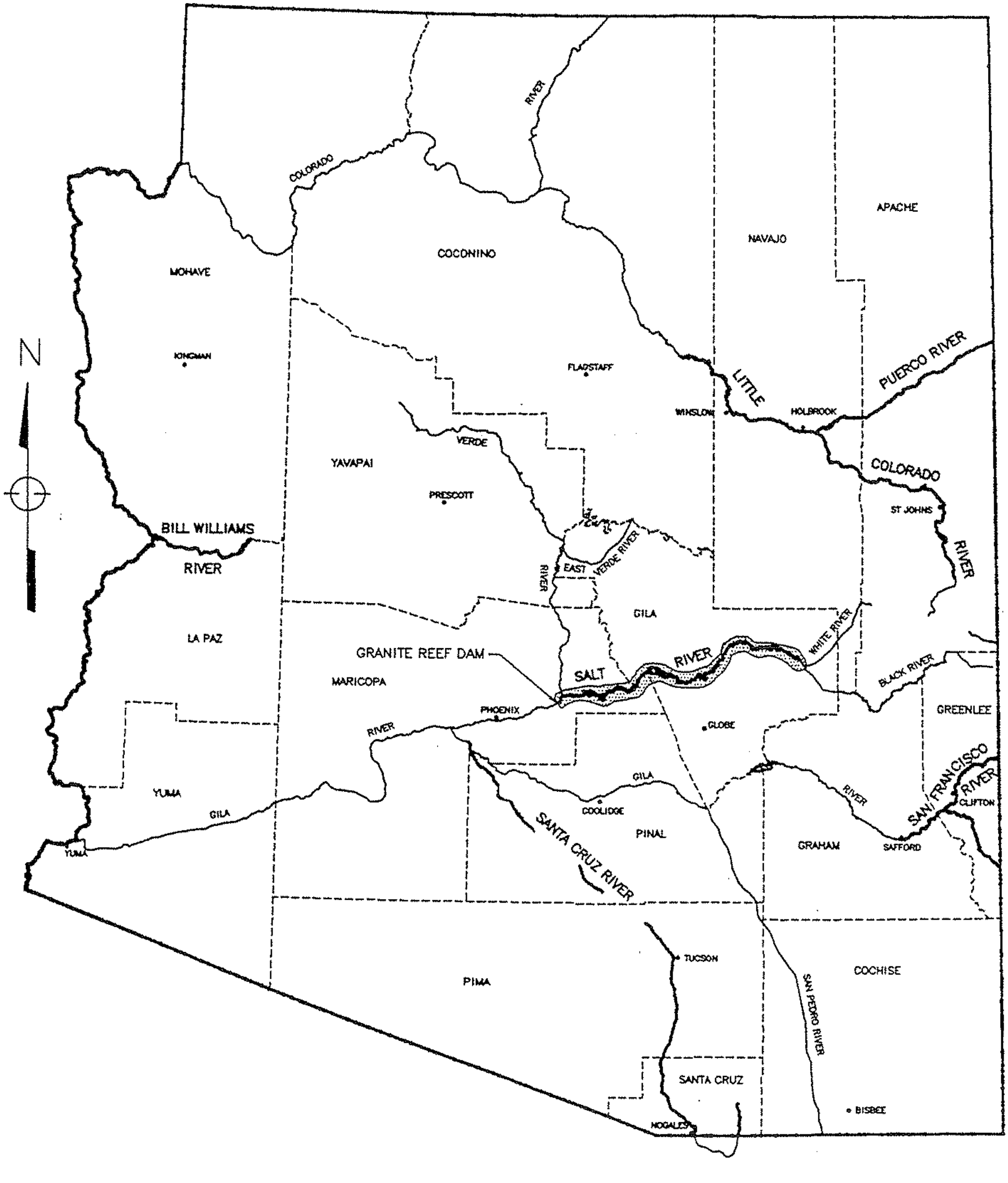

FIGURE 1

General Location Map for Arizona Stream Navigability Studies

Study Objectives

The primary objective of this project is to provide information concerning the factors addressing navigability set forth in A.R.S. §37-1101 *et seq.* to assist in the determination of navigability or susceptibility to being navigable as of statehood. Specific technical goals include the following:

- Perform a literature search to identify and catalog existing historical, archaeological, hydrologic, hydraulic, geomorphic, and land use information.
- Review existing historical, archaeological, and land use information to identify and evaluate evidence of navigable uses of the study areas.
- Review existing hydrologic, hydraulic, and geomorphic materials to identify and evaluate discharge characteristics of the study reaches.
- Identify title owners, lessees, improvements, and current uses of land located in or near the study reaches using existing information.
- Prepare reports, maps, and other information describing the results of the archaeological, historical, hydrologic, hydraulic, geomorphic, and land use investigations.
- Participate at public hearings and other public forums, as required.

In addition to the goals stated above, other identified goals that are important to the success of the streambed program include:

- Establish a cost-effective, streamlined procedure for data collection which can be used for future analyses of other Arizona streams.
- Implement quality control procedures.
- Develop data to a level sufficient to support legal surveys of the boundaries of navigable streams.

PROJECT METHODOLOGY

The basic approach to the stream navigability studies is to develop a database of information to be used by ANSAC in making navigability determinations. To that end, the scope of services for this study includes five main tasks:

- Agency Contact
- Literature Search
- Data Summaries
- Land Use
- Final Report

Because the legislative definition of a navigable watercourse includes both actual navigation and susceptibility to navigation, the data collection effort was focused on two areas:

- Historical Uses of the River - Data describing actual uses of the river at the time of statehood were collected. Specific tasks included agency contact and literature search.
- Potential Uses of the River - Data describing river conditions at the time of statehood were collected. Specific tasks included agency contact, literature search, and hydrologic, hydraulic and geomorphologic assessments.

Agency Contact

The objectives of the agency contact task were to inform community officials of the studies, to obtain information on historical and potential river uses, and to obtain access to data collected by agency personnel in regard to the study reaches. For the latter task, public officials from every community, town, city, and county located along the Upper Salt River study area were contacted. Contact consisted of an initial letter describing the stream navigability study, its potential impacts on the community, and requesting information to be used in the study. Each community official was then contacted by telephone to answer questions about the study and to provide a second opportunity to provide information for the study. In addition, officials from most local, state, and federal agencies with jurisdiction or interest in the river study areas were contacted by letter and telephone.

Historians, librarians, and archivists from public and private museums, libraries, and other collections were also contacted. Letters requesting summaries of information pertaining to historical stream uses or conditions were sent to each institution, with follow-up telephone contact. Other contacts included letter and telephone requests for information from clubs, professional organizations, special interest groups, and environmental groups. In most cases, contacts led to other persons thought to have information pertinent to the study.

Literature Search

The objective of the literature search was to obtain published and unpublished documentation of historical river uses and river conditions. Information collected from agency contact was supplemented by published information from public and private collections. The literature search focused on the following main categories:

- Archaeology
- History
- Hydrology
- Hydraulics
- Geomorphology

Historical literature searches were conducted to obtain information on the historical uses of the rivers and adjacent lands. Library research identified books, professional journals, magazine and newspaper articles, and unpublished materials that provide information on the history of the use of the rivers. City directories, Sanborne fire insurance maps, and General Land Office maps were also consulted to identify businesses located near the rivers. Literature searches in archaeology provided data on prehistoric and historic settlement patterns along the river, including evidence on paleoenvironment and irrigation agriculture. This research included published books and articles and "gray literature" or technical reports. Hydrologic, hydraulic, and geomorphic studies relating to historic navigability of each stream reach were also collected from city, county, state, and federal agencies. Published journal articles, books, and reports available from public library collections were also consulted. Bibliographies of documents and resources for each area of expertise are included in the corresponding report sections.

Data Summaries

Data collected from the agency contact and literature search tasks was organized and synthesized by these subject areas: archaeology, history, hydrology, hydraulics, geomorphology, boating, and land use.

Archaeology

Archaeological data augment the historical record of potential river uses at statehood by providing an extended record of river conditions, use of river water, climatic variability, and cultural history along the rivers. SWCA archaeologists reviewed literature and other information collected during the literature search and agency contact tasks. An overview summarizing previous archaeological work in the area, paleoenvironment, the culture history, settlement patterns, and evidence relevant to navigability of the river is presented in Section 2.

History

Historical data provide information on actual river uses at the time of statehood, and also provide information on whether river conditions would have supported navigation. SWCA historians prepared a report summarizing use of the river and adjacent area in historic times, with special emphasis on the establishment, growth, and development of towns, irrigation systems, commercial activities, and developments. The historical overview is presented in Section 3.

Geomorphology

Geomorphic data provide information on river stability, river conditions at statehood, and the nature of river changes since statehood. A summary of the geology and geomorphology of the Upper Salt River was prepared by JEF, Inc. These summaries were based on literature and other information collected during agency contact and the literature search. The objectives of these summaries were to estimate channel positions at the time of statehood, assess the possibility of and mechanism for historical channel movement from its current position, provide evidence of geologic control of flow rates, and to estimate the location of the ordinary high and low watermarks. The geomorphologic summaries are presented in Section 4.

Hydrology/Hydraulics

Hydrologic/hydraulic information is a key source of information regarding susceptibility to navigation. These data include estimates of flow depths, width, velocity, and average flow conditions at statehood, based on the available records. JEF, Inc. evaluated information collected during the agency contact and literature search tasks. Literature, stream gage records, topographic maps, aerial photographs, and other data were used to develop an estimate of natural stream conditions at statehood, as well as for existing stream conditions. Depth, velocity, and topwidth rating curves for existing and (circa) statehood channel conditions were developed from historical gaging records. Estimates of 2-year, 5-year, and average annual flow rates were obtained from gage data or other sources. Flow duration curves and average monthly flow rates were also summarized. Section 5 contains the hydrologic/hydraulic summaries.

Boating

Section 6 of the report provides information on federal boating criteria and the types of boating which have occurred historically on the Upper Salt River. Several types of information are presented including federal navigability criteria, historical accounts of boating, and modern boating records.

Land Use

Land use data were compiled for the Upper Salt River and entered in a GIS database. Land use data included existing title owner records from county assessors offices, state and federal land leasing records from ASLD, the Bureau of Land Management, and the U.S. Forest Service. Existing improvements, commercial activities, and present use of lands were identified from land use mapping and reports, aerial photographs, and in some cases, by field visits. Other data collected for the Upper Salt River, such as floodplain limits, were also entered in the GIS. The land use data summary description is presented in Section 7; the GIS work product was provided separately.

SUMMARY

A comprehensive summary is presented in Section 8 of this report which itemizes the key findings of the preceding archaeological, historical, hydrologic, hydraulic, geomorphologic, boating, and land use sections. The most pertinent findings relative to evidence of navigability or non-navigability, or evidence of susceptibility to navigation, are summarized to provide information to support a determination by others of navigability or non-navigability for each study reach. This report does not make a recommendation or conclusion regarding title navigability of the Upper Salt River.

APPENDIX A

Arizona Revised Statutes §37-1101 through §37-1156

CHAPTER 7

STATE CLAIMS TO STREAMBEDS

ARTICLE 2. DETERMINING NAVIGABILITY

The heading of Chapter 7 was changed from "Ownership of Streambeds" to "State Claims to Streambeds" by Laws 1994, Ch. 277, § 26, effective April 25, 1994.

Cross References

Ombudsman for private property rights, see § 41-1311 et seq.

ARTICLE 1. GENERAL PROVISIONS

§ 37-1101. Definitions

In this chapter, unless the context otherwise requires:

1. "Arizona navigable stream adjudication commission" or "commission" means the Arizona navigable stream adjudication commission established by § 37-1121.

2. "Bed" means the land lying between the ordinary low watermarks of a watercourse.

3. "Determination of nonnavigability in a public proceeding" means a determination that a particular watercourse was not navigable before, or as of, February 14, 1912 by a final, unappealable decision of a judicial or administrative body, including any determination of nonnavigability of:

(a) Any portion of the Salt river lying between granite reef dam and its confluence with the Gila river.

(b) The Agua Fria river.

4. "Highway for commerce" means a corridor or conduit within which the exchange of goods, commodities or property or the transportation of persons may be conducted.

5. "Man-made water conveyance system" means:

(a) An irrigation or drainage canal, lateral canal, ditch or flume.

(b) A municipal, industrial, domestic, irrigation or drainage water system, including dams, reservoirs and diversion facilities.

(c) A channel or dike that is designed, dedicated and constructed solely for flood control purposes.

(d) A hydropower inlet and discharge facility.

(e) A canal, lateral canal, ditch or channel for transporting central Arizona project water.

6. "Navigable" or "navigable watercourse" means a watercourse, or a portion or reach of a watercourse, that was in existence on February 14, 1912, and at that time was used or was susceptible to being used, in its ordinary and natural condition, as a highway for commerce, over which trade and travel were or could have been conducted in the customary modes of trade and travel on water.

7. "Ordinary low watermark" means the line on the banks of a watercourse created when the water recedes at its regularly recurring lowest stage in normal years without reference to unusual droughts.

8. "Public entity" means the United States and its agents, this state, a county, city or town, a county flood control district or any other entity established under title 48.[1]

9. "Public trust land" means the portion of the bed of a watercourse that is located in this state and that is determined to have been a navigable watercourse as of February 14, 1912. Public trust land does not include land held by this state pursuant to any other trust.

10. "Public trust purposes" or "public trust values" means commerce, navigation and fishing.

11. "Riparian area" means a geographically delineated area with distinct resource values, that is characterized by deep-rooted plant species that depend on having roots in the water table or its capillary zone and that occurs within or adjacent to a natural perennial or intermittent stream channel or within or adjacent to a lake, pond or marsh bed maintained primarily by natural water sources. Riparian area does not include areas in or adjacent to ephemeral stream channels, artificially created stockponds, man-made storage reservoirs constructed primarily for conservation or regulatory storage, municipal and industrial ponds or man-made water or effluent transportation, distribution, off-stream storage and collection systems.

12. "Watercourse" means the main body or a portion or reach of any lake, river, creek, stream, wash, arroyo, channel or other body of water. Watercourse does not include a man-made conveyance system described in paragraph 5 of this section, except to the extent that the system encompasses lands that were part of a natural watercourse as of February 14, 1912.

Amended by Laws 1994, Ch. 277, § 1, eff. April 25, 1994.

[1] Section 48-101 et seq.

Historical and Statutory Notes

The 1994 amendment deleted the definition of "groundwater"; inserted the definition of "determination of nonnavigability in a public proceeding"; in the definition of "navigable", substituted "and at that time" for "and that"; deleted the definition of "ordinary high watermark"; inserted definitions of "ordinary low watermark" and of "public trust purposes" or "public trust values"; inserted "or effluent" in the definition of "riparian area"; deleted the definition of "surface water"; and renumbered paragraphs accordingly.

Laws 1994, Ch. 277, § 27, provides:

"Sec. 27. Severability

"If a provision of this act or its application to any person or circumstance is held invalid, the invalidity does not affect other provisions or applications of the act that can be given effect without the invalid provision or application, and to this end the provisions of this act are severable."

ARTICLE 2. DETERMINING NAVIGABILITY

§ 37-1121. Arizona navigable stream adjudication commission

A. The Arizona navigable stream adjudication commission is established through July 1, 2000 as a separate agency and independent of the state land department. The commission consists of five persons, not more than three of whom shall be of the same political party, appointed by the governor pursuant to § 38-211. Persons who are appointed to the commission must be well-informed on issues relating to rivers and streams in this state. The commission shall select a presiding officer from among its members.

B. Members of the commission are public officers for purposes of title 38, chapter 3, article 8 and title 38, chapter 3.1.[1] A person who has advocated for or expressed a desire that a watercourse in this state be determined to have been navigable or nonnavigable may not serve as a commission member. A commission member who is a witness, gives evidence or makes statements of personal knowledge of the characteristics of navigability of a watercourse for the commission's consideration shall not participate as a commission member in proceedings relating to that watercourse. A commission member shall not:

1. Have any bias regarding the possible navigability of any watercourse or a portion or reach of a watercourse.

2. Own, obtain a significant portion of income from or claim any ownership or possessory interest in lands affected by this chapter.

3. Directly or indirectly receive a significant portion of income from a person who claims an ownership or possessory interest in lands affected by this chapter or from a person who obtains a significant portion of income from such lands nor have been employed by such persons within two years before, or be employed by such persons within two years after, the commission member's term of office.

C. Funding for the commission and its necessary and reasonable expenses, including contracting for private services, shall be provided from such legislative appropriations as may be necessary to permit the commission to fulfill its responsibilities.

D. The governor, on good cause shown, may remove a member for neglect of duty or misconduct or malfeasance in office. On removal, the governor shall file with the secretary of state a complete statement of all charges made against the member, the governor's findings and a complete record of the disciplinary proceedings conducted with respect to the removal.

E. Members are eligible to receive compensation pursuant to § 38-611 for service on the commission, unless a member who is otherwise employed as a public officer is prohibited from receiving additional compensation.

F. The commission shall maintain its principal office at the state capital but may hold meetings or hearings any place in this state. The commission shall meet at least once each calendar quarter, except that if the commission has completed all inquiries and hearings required under this chapter, the commission shall not be required to meet. The presiding officer or a majority of the members may call additional meetings. On termination, the commission shall transmit all of its records to the secretary of state.

G. In the event of a vacancy on the commission, the governor may appoint a replacement member pursuant to § 38-211.

H. Notwithstanding § 41-192, the attorney general shall not advise or represent the commission.

I. For purposes of subsection B of this section, "significant portion of income" means ten per cent or more of gross personal income for a calendar year.

Amended by Laws 1994, Ch. 277, § 2, eff. April 25, 1994.

[1] Sections 38-501 et seq., and 38-541 et seq.

Historical and Statutory Notes

The 1994 amendment inserted "as a separate agency and independent of the state land department" in subsec. A; inserted the second sentence in the introductory paragraph of subsec. B; deleted "from the sale and use of public trust lands and" preceding "from such legislative appropriations" in subsec. C; in subsec. F, deleted "investigations," preceding "inquiries and hearings required under this chapter", and substituted "secretary of state" for "department"; inserted a new subsec. H; and redesignated existing subsec. H as subsec. I.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

§ 37-1122. General powers and duties of the commission

A. The commission shall:

1. Adopt rules and establish procedures and services that are necessary or desirable to carry out the provisions and purposes of this chapter.

2. Assemble and distribute information to the public relating to the commission's finding and recommendation of navigability of any watercourse and the commission's other activities.

3. Conduct inquiries or hearings in performing the commission's powers and duties. The commission shall conduct its proceedings informally without adherence to judicial rules of procedure or evidence. The commission shall facilitate participation by persons who are not represented by legal counsel and shall not require a person to file documents or notices in order to be heard and participate in proceedings before the commission.

4. Exercise such other powers as may be necessary to fully carry out its responsibilities imposed by this chapter.

B. The commission may employ or contract for legal counsel, independent from the attorney general, and other professional and administrative services. Contracts for legal and professional services are exempt from § 41-192 and title 41, chapter 23.[1]

Amended by Laws 1994, Ch. 277, § 3, eff. April 25, 1994.

[1] Section 41-2501 et seq.

Historical and Statutory Notes

The 1994 amendment designated the existing provisions as subsec. A; substituted "finding and recommendation" for "determination" in par. 2 of subsec. A; rewrote par. 3 of subsec. A; and added subsec. B.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

§ 37-1123. Receiving and compiling evidence and records

A. The commission shall receive, review and consider all relevant historical and other evidence presented to the commission by the state land department and by other persons, regarding the navigability or nonnavigability of watercourses in this state as of February 14, 1912, together with associated public trust values, except for evidence with respect to the Colorado river, and, after public hearings conducted pursuant to § 37-1126:

1. Based only on evidence of navigability or nonnavigability, make findings and recommendations to the legislature pursuant to § 37-1128 as to which watercourses and portions and reaches of watercourses were not navigable as of February 14, 1912.

2. Based only on evidence of navigability or nonnavigability, make findings and recommendations to the legislature pursuant to § 37-1128 as to which watercourses and portions and reaches of watercourses were navigable as of February 14, 1912.

3. In a separate, subsequent proceeding pursuant to § 37-1128, subsection H, consider evidence of public trust values and then identify and make a public report of any public trust values that are now associated with the navigable watercourses.

B. Before receiving, reviewing or considering any evidence pursuant to subsection A of this section for a particular watercourse, the commission shall publish notice once each week for three consecutive weeks in a newspaper of general circulation in each county in which the watercourse is located. The notice shall include:

1. A statement of the intent to receive, review and consider evidence.

2. An address to which interested parties may submit evidence for the commission's review.

3. A date by which evidence must be submitted.

4. A general description of the procedures the commission will use to review the evidence.

C. Private citizens, clubs, organizations, corporations, partnerships, unincorporated associations, municipal corporations and public entities may present evidence to the commission at a hearing according to commission rules. The submission of evidence by any party pursuant to the commission's notice under subsection B of this section does not preclude that party from submitting additional evidence at any hearing before the commission.

D. The state land department shall consult and coordinate its efforts to gather evidence of navigability and public trust values with the department of water resources, the game and fish department, the state parks board and other interested persons and public and private entities. The commission shall consider the information that those persons and entities have compiled regarding the navigability of watercourses.

E. After public notice, the commission shall set priorities for investigating and conduct hearings on the navigability of the watercourses in this state. In setting the priorities, the commission shall consider:

1. The number and value of parcels of real property that are affected by a state claim of sovereign ownership to the bed of the watercourse.

2. The degree of hardship to private parties and political subdivisions due to title uncertainties relating to the bed of the watercourse.

3. The significance of the public trust values associated with the watercourse and the degree to which those values are threatened.

4. The potential viability of this state's sovereign claims to the watercourse, giving higher priority consideration to more viable claims.

F. A person who is aggrieved by the undetermined navigability status of a watercourse may petition the commission to modify the priority set under subsection E of this section and grant expedited consideration for a particular watercourse or portion or reach of a watercourse. The commission shall grant the petition if justified by the factors listed in subsection E of this section.

G. No judicial action seeking a determination of navigability of a watercourse, to establish or obtain ownership of land within the bed and banks of a watercourse or to determine any public trust values associated with a watercourse may be commenced, continued or completed unless the legislature has found that the watercourse was navigable or nonnavigable pursuant to § 37-1128. This subsection does not preclude the department from seeking a temporary restraining order or injunctive relief at any time to prevent loss or damage to public trust resources.

H. Notwithstanding subsection G of this section, any condemnation action by this state or a political subdivision of this state may proceed to trial and conclusion, including the payment of compensation, regardless of the potential claim of title by this state based on the navigability of the watercourse. In any action commenced or continued pursuant to this subsection, the court shall not consider or decide the navigability of the watercourse. Any judgment in any action commenced or continued pursuant to this subsection shall be subject to a potential claim of title by this state based on the navigability of the watercourse. Amended by Laws 1994, Ch. 277, § 4, eff. April 25, 1994.

Historical and Statutory Notes

The 1994 amendment rewrote the section.

Laws 1994, Ch. 277, § 25, provides:

"Sec. 25. Effect on prior proceedings

"This act does not affect proceedings taken by the state land department and the Arizona navigable stream adjudication commission before the effective date of this act to collect, assemble, compile, receive and review relevant historical and other evidence available or presented to the Arizona navigable stream adjudication commission."

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

§ 37-1124. Compiling evidence and records by department

A. Beginning on or about the date that the commission establishes priorities pursuant to § 37-1123, subsection E, but in no event later than January 2, 1993, the department shall begin the necessary investigation and inquiries to assemble the evidence relevant to finding navigability with respect to those watercourses given the highest priority by the commission. The department shall continue the investigations and inquiries as resources permit, in the order of priority set by the commission.

B. After collecting and documenting all reasonably available evidence regarding the condition and usage of a watercourse as of February 14, 1912, the present uses of the underlying land and the public trust values associated with the watercourse, if any, the department shall promptly transmit all of the evidence to the commission.

C. The department shall maintain a permanent record of the material assembled and transmitted to the commission.

Amended by Laws 1994, Ch. 277, § 5, eff. April 25, 1994.

Historical and Statutory Notes

The 1994 amendment in subsec. A substituted "finding" for "determining", and made a conforming change in statutory citation.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

§ 37-1125. Initial classification of watercourses

A. After the commission receives and reviews sufficient information to permit a preliminary finding with regard to possible navigability of any reach or portion of a watercourse, the commission shall initially classify the watercourse or portion or reach of the watercourse into one of the following categories:

1. The watercourse has characteristics of possible navigability as of February 14, 1912.
2. The watercourse has no such characteristics of navigability.

B. The commission shall make its preliminary finding under this section in an expeditious manner.

C. The commission shall maintain a permanent public record of the classifications of watercourses and portions and reaches of watercourses made under this section.

Amended by Laws 1994, Ch. 277, § 6, eff. April 25, 1994.

Historical and Statutory Notes

The 1994 amendment substituted "a preliminary finding" for "an initial determination" in the introductory paragraph of subsec. A; and substituted "a preliminary finding" for "determination" in subsec. B.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

§ 37-1126. Hearings; notice

A. After the commission completes the initial classification of any watercourse or portion or reach of a watercourse under § 37-1125, the commission shall schedule public hearings to receive additional evidence and testimony relating to navigability or nonnavigability of any such reach or portion, and, after the commission finds a watercourse is navigable, the commission shall schedule public hearings to identify and make a public report of any public trust values associated with the watercourse. The hearings shall be held at the commission's office or, in the case of a hearing concerning a watercourse located principally outside of Maricopa county, at the county seat of the county in which the predominant portion of the particular watercourse is located. The commission may schedule additional hearings at other locations at the commission's discretion.

B. At least thirty days before any public hearing under this section, the commission shall cause notice of the hearing to be published in two newspapers, one of statewide circulation and another of general circulation in the county where the hearing is to be held. In addition, the commission shall mail notice of the hearing to any person who has previously requested notice of hearings in writing from the commission.

Amended by Laws 1994, Ch. 277, § 7, eff. April 25, 1994.

Historical and Statutory Notes

The 1994 amendment substituted "after the commission finds a watercourse is navigable, the commission shall schedule public hearings to identify and make a public report of" for "if potentially navigable," in subsec. A.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

§ 37-1127. Boundary agreements; negotiations; recording; effect

A. At any time before a final judicial determination as to whether a watercourse or a portion or reach of a watercourse was navigable as of February 14, 1912, the commissioner may negotiate with any person or public entity having or claiming an interest in any land affected by this state's claim of sovereign ownership due to navigability for the purpose of reaching a boundary or exchange agreement.

B. At least thirty days before submitting a proposed boundary or exchange agreement to the board of appeals for approval under subsection C of this section, the commissioner shall provide written notice of the proposed action and an opportunity to comment to any person who has previously requested written notice of actions under this section. The commissioner shall provide contemporaneous written notice of the final decision to any person who filed a comment.

C. The board of appeals established under § 37-213 must approve each boundary or exchange agreement. In considering whether to approve a boundary or exchange agreement, the board shall consider whether the agreement is prudent and consistent with the public trust and the Constitution of Arizona.

D. The board of appeals may allow an exchange only if both of the following conditions are met:

1. The land being transferred by the state is not of material use for trust purposes.

2. The land being acquired by the state is of material use for trust purposes and has an appraised value equal to or greater than the value of the land being transferred by the state.

E. Lands that are transferred to this state in an approved boundary or exchange agreement become public trust lands.

F. An approved boundary or exchange agreement is binding on this state and other parties to the agreement but is not admissible as evidence and may not be cited as precedent in any judicial or administrative proceeding involving the navigability of any watercourse, portion or reach.

G. A boundary or exchange agreement shall be recorded in the office of the county recorder of each county in which all or part of the affected land is located.

Amended by Laws 1994, Ch. 277, § 8, eff. April 25, 1994.

Historical and Statutory Notes

The 1994 amendment substituted "judicial determination" for "determination under § 37-1128" in subsec. A; and deleted "determination of" preceding "navigability of any watercourse" in subsec. F.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

§ 37-1128. Determination of navigability; quiet title action

A. After the commission completes the public hearing with respect to a watercourse, the commission shall again review all available evidence and render its finding and recommendation as to whether the particular watercourse, or any portion or reach of the watercourse, was navigable as of February 14, 1912.

B. If any determination of nonnavigability in a public proceeding exists for a watercourse or a portion or reach of a watercourse, it is presumed that the entire watercourse was nonnavigable as of February 14, 1912, and the commission shall find and recommend that it was nonnavigable unless there is clear and convincing evidence that the watercourse was navigable.

C. The commission shall find and recommend that a watercourse was nonnavigable if, as of February 14, 1912, the watercourse either:

1. Was not used or susceptible of being used for both commercial trade and travel.

2. Flowed only in direct response to precipitation and was dry at all other times.

D. Unless there is clear and convincing evidence that a watercourse was navigable, it is presumed, and the commission shall find and recommend, that the watercourse was nonnavigable if, with respect to the watercourse as of February 14, 1912, any of the following applied:

1. No sustained trade and travel occurred both upstream and downstream in the watercourse.

2. No profitable commercial enterprise was conducted by using the watercourse for trade and travel.

3. Vessels customarily used for commerce on navigable watercourses in 1912, such as keelboats, steamboats or powered barges, were not used on the watercourse.

4. Diversions were made from the watercourse to irrigate and reclaim land by persons who made entries under the desert land act of 1877, as amended (43 United States Code §§ 321 through 339), any other federal act or to provide water to lands that are included in a federal reclamation project or an Indian reservation that would have been inconsistent with or impediments to navigation.

5. Any boating or fishing was for recreational and not commercial purposes.

6. Any flotation of logs or other material that occurred or was possible on the watercourse was not and could not have been regularly conducted for commercial purposes.

7. There were bridges, fords, dikes, man-made water conveyance systems or other structures constructed in or across the watercourse that would have been inconsistent with or impediments to navigation.

8. Transportation in proximity to the watercourse was customarily accomplished by methods other than by boat.

9. The United States did not regulate the watercourse under the rivers and harbors act of 1899 (33 United States Code §§ 401 through 467e).

E. In finding whether a watercourse was navigable, the commission shall not consider:

1. Waters that had been appropriated for beneficial uses on or before February 14, 1912 as being within the ordinary and natural condition of the watercourse.

2. The use of ferries to cross a watercourse.

3. Fishing from the banks of a watercourse.

4. Uses of the watercourse under flood conditions.

F. In finding whether a watercourse was navigable, the commission shall consider the existence of dams and diversions of water and the impact of other human uses that existed or occurred at the time of statehood as part of the ordinary and natural condition of the watercourse.

G. Subject to the specific standard of proof stated in subsection D of this section, if the evidence presented by the state land department or by any other person claiming that the watercourse was navigable does not establish that the watercourse was navigable, the commission shall issue its recommendation finding that the watercourse was nonnavigable.

H. With respect to those watercourses or portions or reaches of watercourses that the commission finds were navigable, the commission shall, in a separate, subsequent proceeding, identify and make a public report of any public trust values associated with the navigable watercourse or portion or reach of the watercourse. These findings of nonnavigability or navigability and identification of any public trust values shall be in writing and shall be supported with sufficient documentation and detail to confirm the rationale and basis for the decision. The commission's action pursuant to this section is not a final administrative decision subject to judicial review pursuant to title 12, chapter 7, article 6.[1]

I. The commission shall report its findings and recommendation to the president of the senate and the speaker of the house of representatives. The president and the speaker shall provide for legislative hearings, and if the legislature finds that the watercourse was:

1. Nonnavigable, the legislature shall enact legislation ratifying the commission's findings and recommendation and disclaiming title as provided by § 37–1130.

2. Navigable, the legislature shall enact legislation to authorize the state land department to claim the land in the bed of the watercourse and to authorize the department to file an action to quiet title to the land.

J. In an action to quiet title to land in the bed of a watercourse brought pursuant to subsection I, paragraph 2 of this section both of the following apply:

1. The commission's recommendation and the legislative finding shall not be used to support the state's claim of title.

2. The court may make a determination of any public trust values associated with the lands if title is quieted in the state.

Amended by Laws 1994, Ch. 277, § 9, eff. April 25, 1994.

[1] Section 12-901 et seq.

Historical and Statutory Notes

The 1994 amendment rewrote the section.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37–1101.

1994 Reviser's Note:

Pursuant to authority of § 41–1304.02, in subsection D, paragraph 7 the spelling of "man-made" was corrected.

§ 37–1129. Repealed by Laws 1994, Ch. 277, § 10, eff. April 25, 1994

Historical and Statutory Notes

The repealed section, added by Laws 1992, Ch. 297, § 3, related to judicial review. See, now, § 37–1128.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37–1101.

§ 37–1130. Title to bed of nonnavigable watercourse; appropriation of waters for public trust values

A. The enactment of legislation finding that a watercourse, portion or reach is nonnavigable constitutes a waiver, relinquishment and disclaimer of this state's right, title or interest in the bed of the watercourse based on its navigability.

B. This state may obtain any water that is necessary to maintain and protect public trust values that are identified by the commission pursuant to § 37–1128, subsection H only by complying with the requirements of title 45.[1]

Amended by Laws 1994, Ch. 277, § 11, eff. April 25, 1994.

[1] Section 45–101 et seq.

Historical and Statutory Notes

The 1994 amendment designated the existing provisions as subsec. A; substituted "the enactment of legislation finding" for "Subject to judicial review, the commission's determination" in subsec. A; and added subsec. B.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37–1101.

§ 37–1131. Notice to landowners

A. If the legislature enacts legislation finding a watercourse to be navigable as provided in § 37–1128, the state land department shall do the following before it files quiet title actions:

1. Collect information and perform land surveys that are necessary to determine where the department believes the exact location of the boundaries of the bed of the watercourse are located. The bed of the watercourse to which the state claim applies is the bed of the watercourse existing on the date of the legislature's finding, unless clear and convincing evidence establishes a different location. Before making this determination, the department shall provide public notice and any opportunity for comment by the private property rights ombudsman and any other person.

2. Compile a complete description of each parcel of land lying wholly or partially in the bed of the watercourse, including record title ownership by any person, and a complete title search of each parcel to show how and when the lands were first conveyed in apparent violation of the public trust.

3. If the land was conveyed in apparent violation of the public trust by an agency of the United States, bring an action against the United States for damages and prosecute the action to final judgment. Any damages collected shall be placed in the riparian trust fund established by § 37-1156.

B. Within thirty days after compiling the parcel information pursuant to subsection A, paragraph 2 of this section the department shall notify each record owner or lessee of property that is located in the bed of the navigable watercourse and each person and entity that have an interest of record in the property of the finding by the legislature and that, by virtue of the decision, all or a portion of the property will be claimed as public trust land of this state in a quiet title action. The notice shall also provide information prepared by the private property rights ombudsman explaining the person's rights and any services available from the ombudsman.

C. The state land department shall not commence an action to quiet title to land under this article without legislative authorization pursuant to § 37-1128.

Amended by Laws 1994, Ch. 277, § 12, eff. April 25, 1994.

Historical and Statutory Notes

The 1994 amendment rewrote the section.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

Administrative Code References

Show cause hearing related to boundary survey determinations, see A.A.C. R12-5-2402.

§ 37-1132. Refunds to record title owners

A. If this state's ownership of a parcel or portion of a parcel of property is confirmed in a quiet title action under this article, the state treasurer shall pay to the record title owner an amount from the state general fund to:

1. Refund all property taxes ever paid on the property.

2. Compensate the person for all improvements to the property.

3. Refund the purchase price paid for the property, plus interest at the legal rate, if the property was purchased from this state by the person or any predecessor in title.

B. The department of administration, in coordination with the department of revenue and the state land department, shall certify to the state treasurer the amounts due to the record title owner pursuant to this section.

Added by Laws 1994, Ch. 277, § 13, eff. April 25, 1994.

Historical and Statutory Notes

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

ARTICLE 3. MANAGEMENT OF PUBLIC TRUST LANDS

§ 37-1151. Petition to release public trust status

A. In responding to a petition filed by a record title owner or lessee the department shall consider the extent to which the property that has been confirmed to the state's ownership in a quiet title action, either because of its nature or because of changes, is no longer of material use for protecting public trust values. If the department concludes that the property is not of material use for protecting public trust values, the department shall consider the extent to which a release of the trust is appropriate in light of the public benefit to be derived from alternate uses, and the equitable interests or hardships of the record title holder or lessee, including each of the following:

1. The year in which the property was acquired by the record owner or lessee.

2. The entity or person from whom the property was acquired by the record owner or lessee.

3. The manner in which the record owner or lessee acquired the property.

4. The purchase price or lease terms paid by the record owner or lessee.

5. The amount of property taxes paid each year since the record owner or lessee acquired the property.

6. The profit or benefit derived from the property by the record owner.

7. The extent to which the record owner on the date of acquisition knew or should have known that the property was potentially trust land.

8. All improvements made to the property since the record owner or lessee acquired the property.

9. The public trust values identified by the commission.

10. Whether any improvements on the property impair, obstruct, promote or destroy the value of the watercourse for public trust values.

11. The existing uses of the property, its reasonable highest and best use and whether such uses impair, obstruct, promote or destroy the value of the watercourse for public trust values.

12. Whether the physical condition of the watercourse has materially changed since February 14, 1912 adversely affecting the watercourse's capability of being navigated, including changes due to construction of dams, reservoirs, dikes, levees, canals and ditches that were constructed for water conservation or flood control purposes by public entities, municipal corporations or the United States.

13. Any diminution in value to the record owner's or lessee's contiguous property caused by this state's ownership.

14. The degree of effect of continuation of the current use or any proposed change in use of the property on public trust values.

15. The impact of continuation of the current use or any proposed change in use of the property on the public trust values.

16. The impact of continuation of the current use or any proposed change in use of the property when examined cumulatively in conjunction with existing authorized impediments to full use of the public trust values.

17. The impact of continuation of the current use or any proposed change in use of the property on the public trust values if those values are considered with respect to the primary purpose to which the property is now suited.

18. The degree to which continuation of the current use or any proposed change in use requires that broad public uses be set aside in favor of more limited and private uses.

B. At least thirty days before issuing a decision that land may be released from the public trust under this section the department shall provide written notice of the proposed action and an opportunity to comment to any person who has previously requested written notice of actions under this section. The department shall provide contemporaneous written notice of the final decision to any person who filed a comment.

Amended by Laws 1994, Ch. 277, § 14, eff. April 25, 1994.

Historical and Statutory Notes

The 1994 amendment in subsec. A rewrote the introductory paragraph, substituted "values" for "or navigation purposes" in par. 10, substituted "values" for "purposes" in par. 11, substituted "values" for "uses of navigation, fishing and recreation" in par. 14, substituted "values" for "resource" in par. 15, substituted "values" for "resource" in par. 16, and rewrote par. 17.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

Administrative Code References

Release of lands from public trust status for sale, see A.A.C. R12-5-2404.

§ 37-1154. Public improvements in beds of navigable watercourses; definition

A. A determination that a watercourse or a portion or reach of a watercourse is navigable does not affect the right of a public entity to own, operate, maintain or repair a public improvement reasonably constructed in the bed of the watercourse under the public entity's powers if the improvement was constructed before the determination that the watercourse, portion or reach is navigable and does not materially impair the public trust. The public entity is considered to have obtained this state's consent to construct the public improvement and is not liable to pay compensation to this state for the land on which the public improvement is constructed if the improvement does not materially impair, obstruct or destroy the function of the watercourse for public trust purposes.

B. If the commissioner determines that the public improvement described in subsection A of this section does not, or will not if appropriate conditions are followed, materially impair the public trust uses, the department may require the public entity to obtain a permit for the improvement pursuant to § 37-1153 but shall not assess any fee for issuing the permit.

C. At least thirty days before issuing a decision under subsection D or E of this section the department shall provide written notice of the proposed action and an opportunity to comment to any person who has previously requested notice of actions under this section. The department shall provide contemporaneous written notice of the final decision to any person who filed a comment.

D. If the commissioner determines that the public improvement described in subsection A of this section destroys the function of the watercourse for public trust purposes and is not in furtherance of the public trust status of the land, the public entity may petition the department for release of public trust status pursuant to § 37-1151. In evaluating the petition, the department shall consider, in addition to the factors prescribed by § 37-1151, whether constructing the public improvement was undertaken pursuant to the public entity's authority and whether the public improvement continues to serve a public purpose.

E. If the commissioner determines that a release is appropriate under subsection D of this section, the public entity may purchase this state's interest in the land without a public auction by paying an amount to be determined by the department pursuant to § 37-1152 directly to this state pursuant to § 9-401, subsection A, § 11-251, paragraph 45 or § 48-3603, subsection C, paragraph 2, as applicable. No cause of action or claim for reimbursement accrues for the benefit of any public entity that exercises its right to purchase this state's interest pursuant to this subsection.

F. For purposes of this section, "public improvement" includes any facility established, constructed or maintained by a public entity pursuant to law and those works described in § 37-1101, paragraph 5.

Amended by Laws 1994, Ch. 277, § 15, eff. April 25, 1994.

Historical and Statutory Notes

The 1994 amendment, in the first sentence of subsec. A, deleted "by the commission" following "A determination", and deleted "commission's" preceding "determination that the watercourse,".

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

§ 37-1156. Riparian trust fund; acquisition and management of riparian lands

A. The riparian trust fund is established in the state treasury consisting of monies received from the sale or use of sovereign streambed lands and resources under this chapter, damages collected from the United States pursuant to § 37-1131 and any other appropriations, gifts, grants or donations designated by the donor for that purpose. The state treasurer shall maintain the fund separate and apart from all other funds. On notice from the commissioner the state treasurer shall invest and divest monies in the riparian trust fund as provided by § 35-313, and monies earned shall be credited to the riparian trust fund. The state treasurer shall report and maintain a separate accounting of income and other proceeds from investing trust fund monies.

B. The state land commissioner shall use the income, other proceeds and not more than seventy-five per cent of any added principal of the fund in a fiscal year pursuant to this section:

1. To acquire, from willing sellers, land or interests in land located in riparian areas in this state for public purposes consistent with conservation of wildlife and recreation.

2. For such other expenditures as promote the purposes of the public trust.

C. The state land commissioner shall consult with and receive advice from the Arizona state parks board and the Arizona game and fish department regarding the acquisition and management of land and interests in land under this section.

Amended by Laws 1994, Ch. 277, § 16, eff. April 25, 1994.

Historical and Statutory Notes

The 1994 amendment inserted ", damages collected from the United States pursuant to § 37-1131" in subsec. A; and in subsec. B, deleted par. 1, and renumbered pars. 2 and 3 as pars. 1 and 2.

For severability provisions of Laws 1994, Ch. 277, see Historical and Statutory Notes under § 37-1101.

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CONSULT GENERAL INDEX PAMPHLETS

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Arizona State Land Department

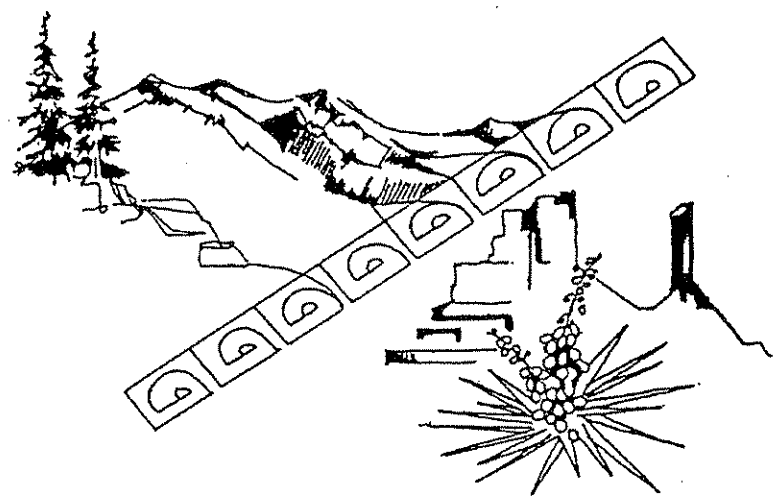
ARIZONA STREAM NAVIGABILITY STUDY

for the

UPPER SALT RIVER

Granite Reef Dam to the Confluence of the White and Black Rivers

Final Report



Prepared by

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In Association With

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JE Fuller/Hydrology & Geomorphology, Inc.,

and

SWCA, Inc. Environmental Consultants

March 1997

Section 2

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ARCHAEOLOGICAL OVERVIEW OF THE UPPER SALT RIVER VALLEY

Dawn M. Greenwald
Dennis Gilpin

Archaeology along the upper Salt River, which centers mostly around the Hohokam and Salado cultural traditions, has been fairly well documented from the confluence of the Salt and Verde rivers to just east of Roosevelt Lake (Figure 1) (Table 1). Some survey and limited excavations have been completed in the vicinity of Seneca Lake, but other portions of the study area have not been investigated and data are lacking. To compensate for this lack, the discussions below include available information from surrounding areas (Globe-Miami, Mazatzal piedmont, San Carlos) to present a more complete picture.

INTRODUCTION

Archaeological studies of the Salt River provide several lines of evidence pertaining to navigability of the river. First, such studies have permitted reconstructions of the river in its natural state. Second, archaeologists working in the area from the nineteenth century to the present have recorded information on the river, its history, and its uses. Third, archaeological studies of historic sites have yielded both historical and archaeological data on the river during the late nineteenth and early twentieth centuries. An isolated Clovis projectile point from Tonto Creek provides evidence for human use of the Tonto Basin about 9500-9000 B.C. Prior to about A.D. 100, people using the upper Salt River subsisted on wild plants and animals. From about A.D. 100 to 1450 the subsistence base was agriculture, and settlement was centered in the lower Tonto Basin, where conditions were most favorable for agriculture. Archaeological reconstructions suggest that streamflow changed little between the period from A.D. 740 to 1370 and the period from A.D. 1800 to 1979. Although a few canals have been identified in the Tonto Basin, floodwater farming was apparently more important than irrigation agriculture in the prehistoric period. The entire upper Salt River area appears to have been abandoned from about A.D. 1450 to 1540, when the Yavapai, and subsequently the Apache, began using the area. Like their predecessors, the Yavapai and Apache also practiced floodwater farming in the lower Tonto Basin. White exploration of the region began in the 1860s, followed by settlement in the 1870s; archaeologists have studied some sites dating to the period of white settlement, especially those related to twentieth-century dam construction. In the late nineteenth century, archaeologist Adolph Bandelier provided a detailed description of the Tonto Basin, as elaborated in Section 3 of this report. Although the archaeological data suggest few changes in the flow regime of the upper Salt River and little in the way of agricultural diversions or impediments to navigation, archaeological research has not documented any use of the river for commercial trade and travel or for any regular flotation of logs.

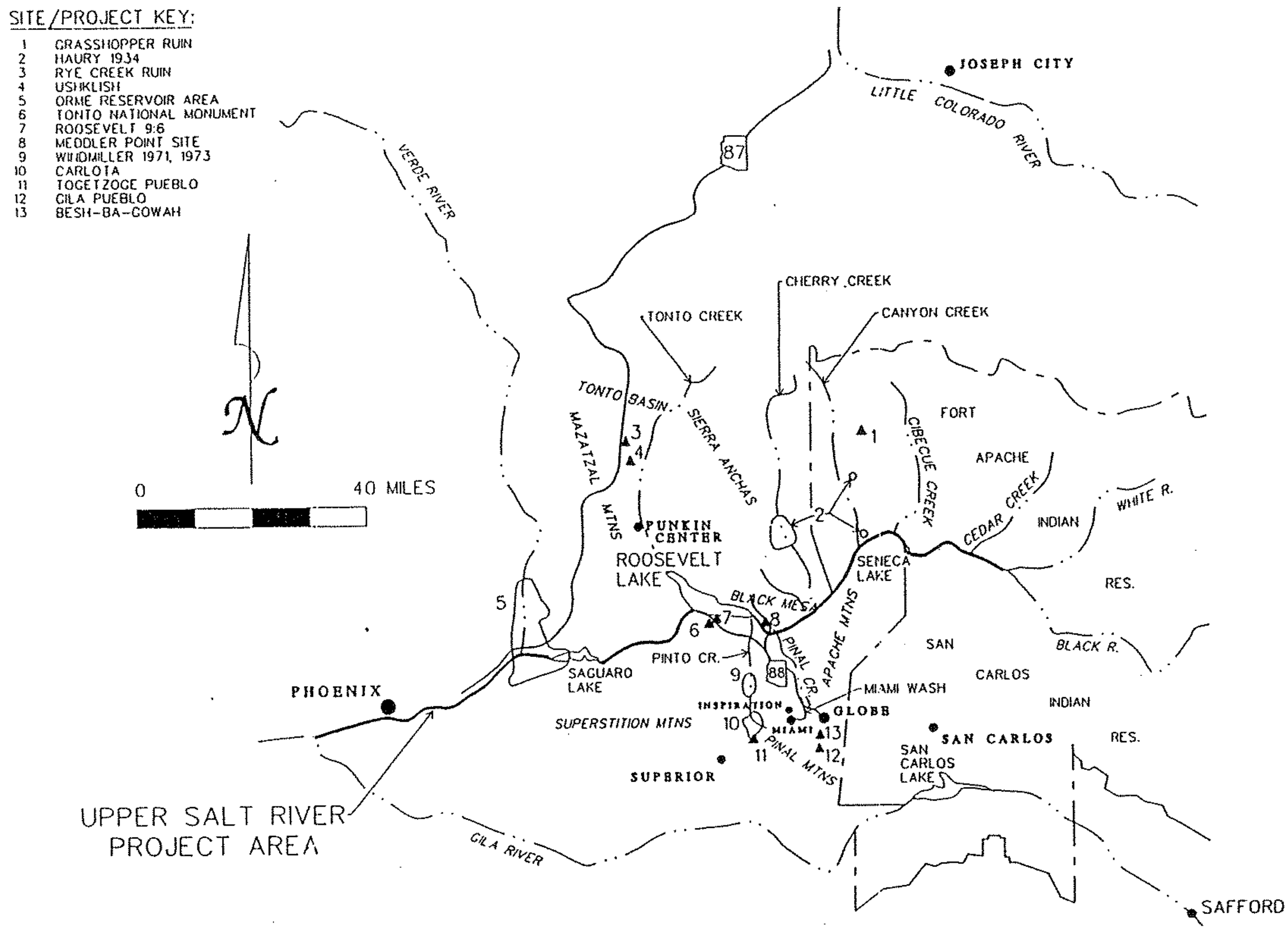

FIGURE 1

Archaeological sites in the Upper Salt River area

Table 1. Major Archaeological Projects along the Upper Salt River

Sponsor	Type of Project	Areal Extent	Number of Sites	References
Archaeological Institute of America	reconnaissance	Tonto Basin, SanCarlos, and Globe areas	ca. 32	Bandelier 1892; Lange and Riley 1970; Wood and Kelley 1987
Mrs. WilliamBoyce Thompson; American Museum of Natural History	reconnaissance and excavation	Tonto Basin and Globe	"15	Hohmann and Kelley 1988; Schmidt 1926
Gila Pueblo	reconnaissance	Central and south-central Arizona	>200	Gladwin and Gladwin 1929, 1930, 1935
Gila Pueblo	excavation	Rye Creek Ruin	1	Haury 1930
Gila Pueblo	excavation	Roosevelt 9:6	1	Haury 1932
Gila Pueblo	reconnaissance and excavation	In and east of the SierraAncha Mountains	19	Haury 1934
Works Progress Administration	excavation	Besh-ba-gowah	1	Vickrey 1939
Works Progress Administration	excavation	Inspiration I	1	Vickrey 1945
National Park Service	excavation and stabilization	Tonto National Monument cliff dwellings	2	Steen et al. 1962
University of Arizona	excavation	Grasshopper Ruin	1	Longacre and Reid 1974
Arizona State University	survey	Vosberg area	87	Morris 1970
Cities Service Company	excavation	Near Miami, Arizona	6	Grady 1974
Cities Service Company	survey	Near Miami, Arizona; 16 mi^2	50	Windmiller 1971, 1973

Table 1. Major Archaeological Projects along the Upper Salt River

Sponsor	Type of Project	Areal Extent	Number of Sites	References
Bureau of Reclamation	survey	Orme Reservoir; 24,320 acres	47 (Salt arm); 130 (Verde arm)	Canouts 1975
San Carlos Apache Tribe and U.S. Economic Development Administration	excavation	Seneca Lake area	7	Stafford 1978
Arizona Department of Transportation	excavation	Miami Wash sites	8 prehistoric	Doyel 1978
Arizona Department of Transportation	excavation	Near Punkin Center	5	Jeter 1978
Tonto National Forest	survey	610 ha; Upper Cherry Creek area	21	Wood 1980
Arizona Public Service	survey	Red Rock to Joseph City, Arizona; 15 mi^2	Total 158; Tonto-Roosevelt portion 79	Teague and Mayro 1979
San Carlos Apache Tribe and U.S. Economic Development Administration	excavation	San Carlos River Valley	40	Mitchell 1986
Arizona Department of Transportation	excavation	Mazatzal piedmont	24	Ciolek-Torrello 1987
Bureau of Reclamation	surveys	Roosevelt Lake area; approx. 12.7 mi^2	529 prehistoric	Dames and Moore 1979; Fuller,Rogge, and Gregonis 1976; Rice andBostwick 1986; Rice and Most 1984
Bureau of Reclamation	excavation	Roosevelt Platform Mound Study	64	Jacobs et al. 1992;Redman, Rice, and Pedrick 1992; Rice 1990

Table 1. Major Archaeological Projects along the Upper Salt River

Sponsor	Type of Project	Areal Extent	Number of Sites	References
Bureau of Reclamation	excavation	Roosevelt Rural Sites Study	29	Ciolek-Torrello et al. 1990; Ciolek-Torrello, Shelley, and Benaron 1994
Bureau of Reclamation	excavation	Roosevelt Community Development Study	29	Doelle et al. 1992; Elson and Swartz 1994; Elson et al. 1994
Carlota Copper Company	survey	Globe uplands, near Miami; 2600 acres	87	Ahlstrom, Euler, and Doak 1993
Carlota Copper Company	excavation	Globe uplands, near Miami; 2600 acres	51 prehistoric	Mitchell and Zyniecki 1994

ARCHAEOLOGICAL PROJECTS

Archaeological study of the upper Salt River Valley began with the travels and journal documentation of Adolph Bandelier. While Bandelier was doing research in New Mexico for the American Archaeological Institute of Boston, the territorial governor of Arizona entrusted him with writing and illustrating a history of the Southwest. In 1883 Bandelier visited the Tonto Basin and nearby areas such as San Carlos and Globe (Figure 1). He described and mapped numerous sites and conducted limited excavations and artifact collections (Wood and Kelley 1987:8). In 1925-1926, Erich Schmidt led the Mrs. William Boyce Thompson Expedition to record and excavate ruins around Globe and in the Tonto Basin. He conducted test excavations on sites around Roosevelt Lake and excavated the 120-room Togetzoge Pueblo between the towns of Superior and Miami. According to Hohmann and Kelley,

> "His research program was the first to incorporate extensive site survey and test excavations in a regional synthesis of Salado culture history. Schmidt was the first to recognize the Salado as a distinct, geographically identifiable cultural entity; the first to establish a stratigraphic and chronological relationship between the Hohokam and the Salado; and the first to identify the wide range of Salado site variability–including the presence of Hohokamlike platform mounds in selected Salado site complexes." [Hohmann and Kelley 1988:v]

In 1928 the Gila Pueblo Foundation (GPF) in Globe began a series of reconnaissance surveys throughout central Arizona to determine the extent of the Hohokam culture based on the presence of its distinctive red-on-buff pottery (Gladwin and Gladwin 1930, 1935). Between 1928 and 1930, the GPF excavated and reconstructed the site of Gila Pueblo near Globe, a large cobble and adobe pueblo of 100-150 rooms assigned to the Salado culture. In 1930-1931 GPF sponsored excavations, directed by Emil Haury, at several sites; one of them was the Roosevelt 9:6 site, for many years the type site for pre-Classic Hohokam traits (Haury 1932). Haury also conducted limited excavations at Rye Creek Ruin in the upper Tonto Basin, a cobble-masonry pueblo of 150+ rooms with a plaza and two platform mounds (Haury 1930).

Around 1931 Haury conducted a reconnaissance in and east of the Sierra Ancha Mountains to collect wood samples from cliff dwellings for dendrochronological studies. He visited 18 cliff dwellings, dating between approximately A.D. 1278 and 1348, and excavated one, Canyon Creek Ruin. Canyon Creek Ruin contained approximately 125 rooms and was occupied from circa A.D. 1350 until probably around 1400-1450 (Haury 1934:24, 152). Haury also visited and described an aboriginal turquoise quarry on the east side of Canyon Creek at its confluence with the Salt River.

During the Depression era, Irene Vickrey conducted excavations at the sites of Besh-ba-gowah and Inspiration I in the Globe-Miami area for the Works Progress Administration. Vickrey excavated 200 rooms and 300 burials at Besh-ba-gowah, a large Classic period Salado settlement near Gila Pueblo (Vickrey 1939). Inspiration I, located on a mesa overlooking Miami Wash, was a pre-Classic Hohokam/Classic period Salado site that demonstrated that the Hohokam tradition preceded the Salado tradition (Vickrey 1945).

A hiatus followed these early excavations. Then, in the 1960s, academic researchers became involved in projects that provided a regional context for the large sites. Starting in 1963, the University of Arizona (UA) Archaeological Field School began work at Grasshopper Ruin on the Salt Draw Plateau north of the Salt River and in the surrounding area. Grasshopper Ruin is a pueblo of 800+ rooms that was occupied from circa A.D. 1275 to 1400 (Longacre and Reid 1974). Approximately 300 sites have been identified by UA surveys in the area bounded by Canyon Creek, Carrizon Ridge, Cibecue Creek, and the Salt River (Effland and Macnider 1991:11). The Vosberg area (the upper reaches of Walnut Creek) of the Sierra Ancha was the focus of the Arizona State University (ASU) Field School between 1967 and 1969. ASU surveys located 87 sites in the area, and several sites, including Walnut Creek Village, were excavated (Morris 1970).

The period since the 1970s has seen an increased number of small surveys, more systematic survey methods, and the excavation of smaller sites due to the implementation of federal mandates requiring salvage and contract archaeology projects. These factors have provided archaeological studies with important information on settlement pattern, intra- and interregional interaction, cultural systems, and cultural development. One of the largest of these projects (24,320+ acres), conducted at the confluence of the Salt and Verde Rivers to assess the impact of the Orme Reservoir on cultural resources, recorded 47 historic and prehistoric sites within the Salt River arm of the proposed reservoir (Canouts 1975). The wide range of prehistoric site types included habitations, rockshelters, artifact concentrations, petroglyphs, plant procurement sites, a flaking station, and a quarry. Prehistoric cultural associations were both Hohokam and Salado, with some ceramics from the Mogollon and Anasazi areas. During the early 1970s, the Arizona State Museum (ASM) conducted survey and limited excavations in the Globe-Miami area to mitigate impacts from proposed mining projects. Recorded sites were both Hohokam and Salado and included small camps, small 1- or 2-room structures, large villages with 30-65 rooms, plazas, and compounds (Windmiller 1971, 1973). The realignment of State Highway 88 prompted the investigation of eight prehistoric sites by ASM in 1974 (Doyel 1978). The sites, located above the floodplains of Miami Wash and Pinal Creek, ranged in time from A.D. 550 to post-A.D. 1450 and included Hohokam, Salado, and Apache components. As a result of this project, a new phase, transitional between the pre-Classic Hohokam and later Salado occupations, was proposed, called the Miami phase. Several years later ASM conducted the Cholla Transmission Line Project (Reid 1982), a linear project that ran along the Little Colorado River from near

Joseph City to upper Devore Wash south of Lake Roosevelt. The majority of the 79 sites identified in the Tonto-Roosevelt portion of the corridor were within the upper Devore Wash drainage basin; the remaining 10 sites were associated with lower Cherry Creek, Coon Creek, and Black Mesa (Mitchell and Zyniecki 1994:4). ASM also surveyed a 305-m-wide corridor along State Route 87 on the eastern slopes of the Mazatzal Mountains in 1980, recording 42 new sites (Ferg and Dongoski 1980). In 1982 the Museum of Northern Arizona conducted excavations at 24 sites along a segment of the State Route 87 corridor. Most of the sites contained small pueblos dating to the twelfth and thirteenth centuries A.D. and represented seasonally occupied field houses, permanently occupied homesteads and courtyards, and agricultural features associated with the Salado and Sinagua cultures (Ciolek-Torrello 1987:xxix). In addition, Archaic and Apache occupations were investigated.

SWCA, Inc., Environmental Consultants, conducted a large block survey covering 2600 acres in the upper drainages of Powers Gulch and Pinto Creek for the proposed Carlota copper mine (Ahlstrom, Euler, and Doak 1993). The survey identified 55 sites with prehistoric components, including artifact scatters, single-room sites, sites with a small number of rooms, and a few 10-20 room pueblos, representing Archaic period, Classic period Salado, and protohistoric Apache occupations (Mitchell andZyniecki 1994:5).

The largest project to date along the upper Salt River, which is still on-going, is the Roosevelt Project. It was initiated by the U.S. Bureau of Reclamation as part of the Central Arizona Project because of potential impacts from proposed modifications to Roosevelt Dam. A number of surveys were conducted to completely inventory the area threatened by potential flooding (Dames and Moore 1979; Fuller, Rogge, and Gregonis 1976; Rice and Bostwick 1986; Rice and Most 1984), documenting a total of 529 prehistoric sites. The archaeological mitigation program was divided into three parts: (1) excavations on platform mound complexes, with 64 sites sampled (the Roosevelt Platform Mound Study, undertaken by Arizona State University) (Redman, Rice, and Pedrick 1992; Rice 1990); (2) excavations on a sample of 29 small, or rural, sites in six study areas (the Roosevelt Rural Sites Study, completed by Statistical Research) (Ciolek-Torrello et al. 1990; Ciolek-Torrello, Shelley, and Benaron 1994); and (3) excavations at 29 sites within a continuous 4-mile study area along the north side of the Salt River at the east end of Roosevelt Lake (the Roosevelt Community Development Study, undertaken by Desert Archaeology) (Doelle et al. 1992; Elson and Swartz 1994; Elson et al. 1994) (Figure 1).

CULTURE HISTORY

The history of the cultural occupation of the upper Salt River Valley is fairly well known only from approximately A.D. 800 to 1450 (Figure 2). Evidence of occupation prior to and after that time is limited; thus, interpretations must be drawn from broad regional comparisons along with the sparse data from the study area.

The Preceramic Periods

Prehistoric lifeways prior to the ceramic periods (post-A.D. 100) are represented by the Paleoindian and Archaic periods. During the Paleoindian period, circa 10,000-8000 B.C., prehistoric hunters followed large Pleistocene mammals such as mammoth and bison as their primary means of subsistence. The climate during this time was cooler and moister than today. As it became drier and the weather pattern changed from winter-dominant moisture to summer monsoon rains, the megafauna became extinct. In the Archaic period, circa 8000 B.C. - A.D. 100, hunters concentrated on smaller game such as deer, and seasonal residence patterns were based on the availability of wild plants that were gathered to supplement the diet.

Although there is no evidence of Paleoindian occupation along the upper Salt River, two Clovis projectile points (ca. 9500-9000 B.C.) have been found, one at Gila Pueblo and one on the east side of Tonto Creek near Punkin Center (Huckell 1982:Figures 2 and 7), suggesting that early big-game hunters passed through the area in pursuit of food. Evidence of the Archaic period is more widespread, although site density is low and sites often occur away from the river; however, traces of Archaic occupation are probably partially obscured by flooding, the ephemeral nature of the sites, and later occupations. Archaic manifestations have been found in the upper Tonto Basin, on the Mazatzal piedmont (Ciolek-Torrello 1987), along lower Cherry Creek (Wells 1971), near the Roosevelt Lake area (Rice 1990), and in the Payson Basin (Huckell 1978). In the Mazatzal piedmont, Ciolek-Torrello (1987:253-257) described Archaic sites as large, dense scatters of diverse lithic materials probably representing base camps and work areas. Most of these sites occurred on the upper slopes of terraces along the middle of the Corral Creek Valley (Ciolek-Torrello 1987:277).

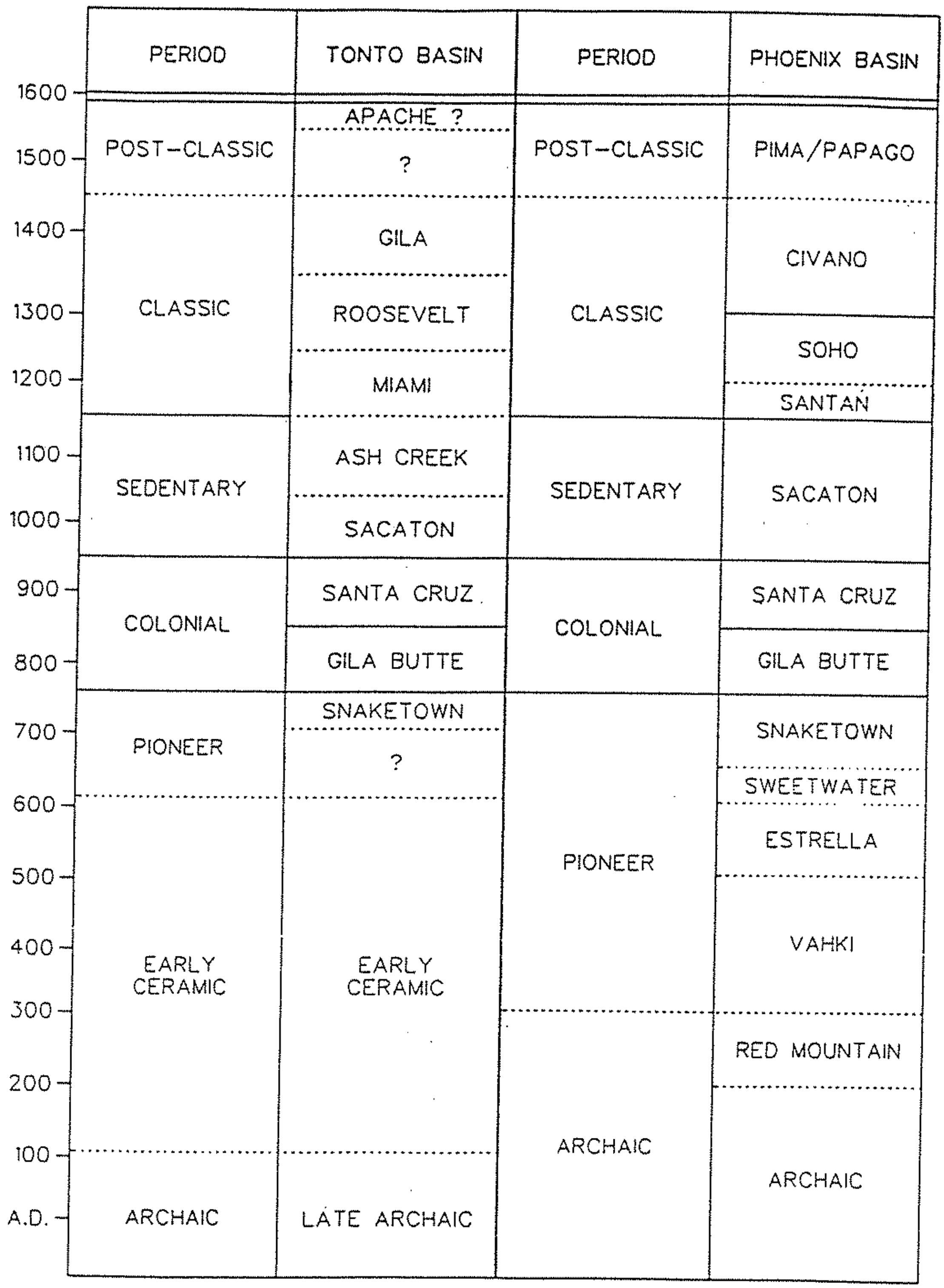

FIGURE 2

Chronological framework for the Tonto Basin compared with the Phoenix Basin

The Pre-Classic Periods

The early, or pre-Classic, periods are represented primarily by the Hohokam tradition in the western portion of the upper Salt River and by the Mogollon cultural phenomenon in the eastern portion. Recent investigations for the Roosevelt Community Development Study, however, have determined that the Eagle Ridge Site, located east of Roosevelt Lake and on a small ridge on the north side of the Salt River, "is now the earliest documented ceramic period site in the Tonto Basin, and it provides definitive evidence for an indigenous pre-Hohokam population" (Elson and Swartz 1994:vii). The initial occupation, which dates between A.D. 100 and 600, potentially includes 50-60 pit houses, with evidence of maize agriculture, wild plant gathering, and hunting (Elson and Lindeman 1994:115). Data from this early component of the site show similarities to Hohokam, Mogollon, and Anasazi culture groups, suggesting to the researchers that there was an early pan-Southwestern culture at the same time that regional differentiation was emerging. This early period represented at the Eagle Ridge Site has been termed the Early Ceramic period, since it lacks specific cultural affiliation (Elson 1994). The Hohokam, Mogollon, and Western Pueblo traditions that influenced pre-Classic populations along the upper Salt River Valley are described below.

The Hohokam Tradition

The "core" of the Hohokam tradition, which begins approximately A.D. 300-500 with the introduction of pottery, is in the Phoenix Basin, along the lower Salt and middle Gila rivers. The Pioneer period, the earliest pre-Classic period (Figure 2), is typified by pit structures with clay-lined hearths, well-defined entryways, and a roof-support configuration of 2-4 posts, both inhumation and cremation burials, and a biseasonal settlement pattern in which permanent winter villages and temporary summer hamlets co-occurred. Houses varied in size and shape from small and square to large and rectangular. Structures excavated within the original townsite of Phoenix ranged from 9.62 square meters (m^2) to 18.62 m^2 in floor area (Cable and Doyel 1984:259). Smaller, oval, bent-pole structures, thought to represent field houses during the late Pioneer period, ranged between 7 m^2 and 13 m^2 in area (Cable et al. 1985). By the late Pioneer period, population had increased, and, in the core area, settlements began to aggregate into clusters and large-scale irrigation was adopted. During the next period, the Colonial (A.D. 750-950), there was a general expansion of Hohokam traits outside of the Phoenix Basin due to growing populations and an increase in interregional interaction through trade and social functions; other cultural manifestations were probably involved as well. Large agricultural villages emerged, as well as ballcourts, new pottery styles, ritual paraphernalia, and a new association of clay figurines with cremations. House size decreased, with habitation floor areas averaging approximately 9 m^2 and field houses averaging about 4-5 m^2. The Sedentary period, A.D. 950-1150, was characterized by stability. Hohokam material culture was at its peak aesthetically, while population continued to increase and the Hohokam tradition reached its greatest spatial extent. With the expansion of settlement onto land less accessible for canal irrigation, other agricultural techniques became more widespread. The exploitation of diverse wild plant and animal resources continued with an increasing reliance on agave (Gasser 1988; Huntington 1986:268). The average house size increased, ranging from approximately 13 m^2 to 15 m^2.

The Mogollon Tradition

The Mogollon tradition was centered around the mountainous regions of western New Mexico and eastern Arizona. Although the Mogollon tradition has been divided into five different branches (Mimbres, Pine Lawn, Forestdale, Black River/Point of Pines, and San Simon [Wheat 1955]) that reflect different ecological adaptations, a number of generally consistent characteristics define this broad tradition: (1) plain brown pottery from around A.D. 300, followed at approximately A.D. 700 by painted brownwares such as red-on-brown (with black-on-white ceramics in the western area) and slightly later by a red-on-white ware in the eastern region (Mitchell 1986:7-8); (2) round to subrectangular pit houses with narrow entryways prior to approximately A.D. 1000; and (3) surface masonry or cobble-lined structures after approximatelyA.D. 1000.

The Western Pueblo Tradition

This tradition is a blending of Mogollon and Anasazi traits found in east-central Arizona and western New Mexico after about A.D. 1000; some researchers believe that Hohokam elements occur here as well (Johnson 1965). The Western Pueblo tradition is characterized by multiroom surface masonry structures, sometimes enclosed in compounds, a planned site layout, both inhumation and cremation burials, and formal kivas (ceremonial structures). It is loosely defined by excavations in the Bylas area (east of San Carlos Lake on the Gila River) and the Globe-Miami area, and may represent "a localized branch of Mogollon adapted to the riverine environment" (Mitchell 1986:8).

Archaeological Evidence around the Upper Salt River Valley

In the area near the confluence of the Verde River, Hohokam habitation sites occur along the Salt River throughout the pre-Classic sequence. Orme Reservoir survey data indicated that all but one of the 30 habitation sites were located on the first terrace of the river, and of the 14 smaller plant procurement sites, 2 were on the floodplain, 9 were on the river terrace, and 3 were in other zones (Canouts 1975:233, 244). The location of plant-procurement sites was thought to be based on water availability and maximum access to a variety of vegetation types (Canouts 1975:244). The largest sites and the greatest site density occurred during the Sedentary period. During this time sites were located at regular intervals along the Salt River (Canouts 1975:266), and other sites, including large habitations, were located in nonriverine settings; the Apache Trail Site, for example, is a large habitation site on the bajada of the Superstition Mountains (Greenwald 1987). It was occupied during the entire pre-Classic sequence and contained trash mounds, hornos (roasting pits), pit houses, burials, miscellaneous pits, and rock piles (Greenwald 1987).

In the Tonto Basin, Pioneer period occupation is represented by the Roosevelt 9:6 site (Haury 1932), Ushklish (Lekson, Elson, and Craig 1992:24), and the Deer Creek Site (Swartz 1992). Colonial period sites occur throughout the lower Tonto Basin (Elson 1994) and in the Globe-Miami area (Doyel 1978). Some of these sites, such as AZ V:11:11(ARS), which is near San Carlos, include a substantial number of Hohokam ceramics, while at others, such as the Deer Creek Site, the frequencies are low (Lekson, Elson, and Craig 1992:24-25). The Roosevelt studies have found that during the Sedentary period Cibola whitewares (Anasazi) replaced Hohokam-derived buffwares. This change, which occurred some time after A.D. 1025, in the late Sedentary period, identifies the Ash Creek phase (Figure 2). At the Meddler Point Site, ceramic affiliation was the only characteristic that appeared to change significantly. The site layout and material culture seemed to retain the Hohokam "look" (Craig and Clark 1994:196-198). Pre-Classic period structures excavated as part of the Roosevelt Rural Sites Study (RRSS) were larger than similar sites in the Phoenix Basin, averaging 19.5 m^2, and were usually subrectangular. In contrast, Sedentary period structures averaged 25.9 m^2 and were oval or subrectangular. The RRSS also found that during the Pioneer and Colonial periods, only a few, widely scattered small hamlets were located on the lower terraces of the floodplain (Ciolek-Torrello 1994a:669-670). During the Sedentary period, there is evidence that occupation expanded onto the higher terraces that form the bajada zone, although along the Salt River inhabitants continued to exploit the prime agricultural land in the floodplains of the Salt River and its tributaries.

East of the Tonto Basin, pre-Classic sites reflect Mogollon characteristics (Stafford 1978:25), although to the south, near the town of San Carlos, there is evidence for pre-Classic occupation by people whose settlements may exhibit predominantly Hohokam or Western Pueblo characteristics as well (Mitchell 1986). One habitation site displayed typical Hohokam traits such as pit houses, hornos, cremations, buffware pottery, and a canal segment. A late Colonial/Sedentary site contained two cobble-foundation rooms, similar to Mogollon field houses, and a Sedentary period site contained both pit house and roomblock (adobe-encased cobble-foundation rooms) occupations, the latter postdating the former. Ceramics indicated that the pit houses were of Mogollon affiliation; the architecture of the roomblock, with room floor areas ranging between 18 m^2 and 22 m^2, indicated that is was Western Pueblo (Mitchell 1986:57).

The Classic Period

The Classic period is best known for changes in architecture, from pit architecture to above-ground dwellings, and in material culture, although changes also occurred in demography, settlement pattern, and social organization. The Classic period is divided into the Miami, Roosevelt, and Gila phases (Figure 2), with the first phase representing a transitional time with mixed cultural patterns, including puebloan elements, and the other two phases reflecting the dominant Salado tradition. The Salado tradition, first identified by a series of pottery types such as Pinto, Gila, and Tonto polychromes, was represented by a complex of characteristics centered around the Tonto-Globe area. Other traits include puebloan architecture of coursed masonry or solid adobe, cliff dwellings, compounds or defense walls, and inhumation burials. There is considerable disagreement among archaeologists whether the tradition represents in situ development of earlier indigenous Hohokam populations (Doyel 1976:254), the migration of Puebloan people to the area (Gladwin and Gladwin 1935:27), a peripheral Hohokam manifestation of a distinct group that comprised the Hohokam regional tradition (Wood 1985; Wood et al. 1981), the migration of people from the Gila Valley near Safford (Steen et al. 1962), or in situ development from indigenous Mogollon populations (Whittlesey and Reid 1982). Since there is no commonly accepted view, the following discussion will treat the Salado phenomenon as a series of cultural characteristics that forms a tradition without emphasizing derivation.

The Miami phase is typified by large permanent settlements with up to five above-ground cobble-lined rooms and an enclosing wall. It is represented by AZ V:9:57(ASM), a site located on a ridge above Pinal Creek (Doyel 1978), sites in the Mazatzal piedmont (Ciolek-Torrello 1987), and sites excavated as part of the RRSS (Ciolek-Torrello 1994b). During this phase, habitation sites were dispersed throughout all environmental zones of the

Tonto Basin and adjacent areas. Along the Salt River, population was distributed in farmsteads and small hamlets on the terraces above the floodplain. Upland areas away from the river were associated with large numbers of field houses and agricultural features. Field-house data examined during the RRSS indicate that these sites served a variety of functions, including temporary storage associated with cultivation or extraction of wild plant foods and native cultivars and seasonal habitations associated with corn agriculture (Ciolek-Torrello 1994b:666). Most habitation sites were contained within small rectangular compounds, with functionally distinct rooms and granaries.

During the Roosevelt phase, Salado traits became a well recognized and distinctive regional tradition. The Roosevelt phase is marked by Pinto Polychrome and Roosevelt Black-on-white ceramics and generally small sites, with a maximum range of from 6 to 20 low-walled, boulder-outlined rooms, often surrounded by a compound wall. Rooms were scattered throughout the compound, and some were placed against the compound wall. Most sites were located on the floodplain terraces (Ciolek-Torrello et al. 1990:13). The Roosevelt Community Development (RCD) project investigations discovered that the platform mound and most of the compounds at the Meddler Point Site were occupied during the Roosevelt phase (Craig and Clark 1994:60). Residential compounds at this site were arranged in a dispersed rancher's pattern around a central plaza and platform mound complex (Craig and Clark 1994:175-176). Site data also showed an overlap in architectural styles during this phase, which included oval pit rooms and other structures, constructed of either upright cobbles with post-reinforced adobe or stacked cobbles with adobe.

During the Gila phase, population aggregated into large and compact multistory pueblos (often 150+ rooms) and compounds. Sites were larger than ever before, and Gila and Tonto polychromes were the hallmark ceramics of this phase. Sites representing the Gila phase include the Tonto Cliff Dwellings (Steen et al. 1962), Rye Creek Ruin (Gladwin 1957; Haury 1930), Gila Pueblo, Besh-ba-gowah, and Togetzoge. Smaller pueblos and specialized sites also contributed to the settlement pattern, which included abandonment of many areas such as the uplands, in favor of populations centralized into a few very large, nucleated pueblos.

The Protohistoric Period

After approximately A.D. 1450 there is no evidence for prehistoric occupation along the upper Salt River. The cause(s) for the abandonment of sites is unknown, although explanations for the collapse of the cultural system have included pressure from Apache raiders (Gladwin 1957), population decimation by disease, environmental degradation, and over-stressing of a complex and probably fragile social system (Wood 1986:11-12). Little information is available for the timespan between the collapse and the Historic Period, termed the Protohistoric Period (Wood 1989:29).

Protohistoric Western Apache and possibly Yavapai are thought to have occupied this general region (Ciolek-Torrello et al. 1990:15). Ferg (1992) believes that the Tonto Basin was used exclusively by the Yavapai from about A.D. 1540 to 1750, when the Apache also began to use the area. By about A.D. 1850, the Southern Tonto Apache controlled the Tonto Basin. Horticulture (small-scale irrigation and dry farming), hunting, and wild plant gathering were practiced, and small settlements comprised households whose members were related by extended family ties (Basso 1970:24). Sites contain wickiups (circular, perishable residential structures usually 3-5 m in diameter) and roasting pits; ceramics are occasionally present, and manos and metates (often salvaged from prehistoric sites) are infrequently present. An Apache camp site excavated in the Payson area consisted of three wickiups, a sweat lodge, and a wind break (Hohmann and Redman 1988). Other evidence of Apache occupation has been found in the Globe-Miami area (Doyel 1976, 1978), and in the Mazatzal Piedmont (Ciolek-Torrello 1987:335).

The Historic Period

Historic documentation of the upper Salt River basin began with the Coronado Expedition in 1540, but until the 1870s Euroamericans visited the river only to trap or follow the trails along the river. Historic sites thus are considered to date after about 1970. Historical archaeology on the upper Salt River has focused on dam construction camps, although a few other site types (including ranches, corrals, historic roads, and trash dumps) have been identified. The archaeology of the construction camp at Granite Reef Dam is described in Brown (1978). Hantman and McKenna (1985) describe the archaeology of O'Rourke's Camp, the construction camp of the private contractor at Roosevelt Dam; Ayres et al. (1994) describe the other Roosevelt Dam construction camps. The construction camps associated with Mormon Flat, Horse Mesa, and Stewart Mountain dams are described by Douglas et al. (1994). Each of these studies summarizes historical information about the construction of the dams and the ethnicity and daily lives of the workers. One of the most interesting conclusions of these studies is that a large number of the construction workers were Apaches; less than twenty years after the end of the Apache wars, most of the Western Apache were working on one of the largest, most technologically advanced construction projects in U.S. history.

ENVIRONMENTAL RECONSTRUCTIONS

Within recent years, enormous strides have been taken toward interpreting the prehistoric natural environment, particularly in the form of retrodictions and reconstructions. These studies have included the paleoclimatic and hydrological conditions of the lower Colorado Plateau, the paleobotanical and paleofaunal taxa native to the Salt River Valley that were used by prehistoric inhabitants, and the annual streamflow of the Salt River for the years A.D. 740 to 1370.

Euler et al. (1979) produced a paleoenvironmental record for the American Southwest by plotting geoclimatic and bioclimatic indicators for the Colorado Plateau. Data from tree rings, pollen records, and alluvial sediments were analyzed within a temporal framework, and fluctuations through time were noted (Table 2). Dean et al. (1985) used similar data to produce a model of interaction between the cultural system (prehistoric populations) and the natural system (environment) and to identify periods of stress. In general, low water tables and channel entrenchment, or degradation, would have had an adverse effect on agriculture; on the other hand, high effective moisture and aggradation, or surface stability, would have been favorable to the development of irrigation systems and other agricultural technologies. Variability in the dendroclimatic record might have produced some short-term responses to accommodate unusually high or low precipitation, such as relocation of agricultural fields or the expansion of irrigation systems (Dean et al. 1985:542-543).

The geomorphological data provided in Table 2 for the annual discharge of the Salt River were reconstructed from a series of tree rings from the Salt and Verde river drainages for the period A.D. 740-1370 (Graybill 1989). The tree-ring series were calibrated with gaged records of Salt River flow (A.D. 1914-1979) and Verde River flow (A.D. 1895-1979). It was found that the average flow from A.D. 740-1370 was somewhat less than modern average flows, due to a larger number of extremely high flow events after A.D. 1800. The statistics for Salt River reconstructed flows are presented in Table 3. Tree-ring series used in the reconstructions are referred to as AZNOF, those taken from archaeological sites within the N and O Arizona geographic quadrangles and from the Flagstaff area, and as GRCMN, tree rings from archaeological sites near Grasshopper Ruin and from data published (Dean and Robinson 1978:19-20) as the Central Mountain North Chronology. According to reconstruction statistics, the summer flows were less variable than the winter flows and thus were more predictable in terms of average amount of flow.

Table 2. Environmental Reconstructions Applicable to the Salt River Valley

Year A.D.	Effective Moisture*	Depositional and Erosional Cycles*	Dendroclimatic Variability*	Salt River Geomorphic Processes**
1500				
		degradation	frequent oscillations	
1400				Marked lateral erosion and channel widening (A.D. 1356-1370)
				Stable conditions; trend toward island-braided channel (infrequent high-magnitude flows); some channel avulsion probable; deepening of channel (A.D. 1197-1355)
1300	low			
		aggradation		
1200			infrequent oscillations	
		degradation		Trend toward bar-braided channel (infrequent high-magnitude flows); some channel avulsion possible (A.D. 1052-1196)
1100				
				Trend away from bar-braided channel toward island-braided conditions; channel narrowing (A.D. 900-1051)
1000	high	aggradation		
900				
				Establishment of bar-braided channel; channel widening and bank erosion (A.D. 798-899)

Table 2. Environmental Reconstructions Applicable to the Salt River Valley

Year A.D.	Effective Moisture*	Depositional and Erosional Cycles*	Dendroclimatic Variability*	Salt River Geomorphic Processes**
800	low	degradation	frequent oscillations	
				Channel stabilization (A.D. 740-797)
700				
	high	aggradation	Infrequent oscillations	
600				

*From Masse 1991, after Dean et al. 1985 and Euler et al. 1979.
**From Gregory 1991, after Nials, Gregory, and Graybill 1989.

As part of the Roosevelt Rural Sites Study, Statistical Research, Inc., developed Palmer Drought Severity Indices for local soils in the Tonto Basin (Rose 1994). Soil moisture conditions for early summer in the Tonto Basin from A.D. 740-1370 were reconstructed by using historic tree-ring width indices to derive the prehistoric tree-ring sequence and predict crop yield values per arable soil type. This information was then used to calculate an estimate of maximum annual maize supply potentially available from various agricultural techniques and the maximum yearly population size that could be supported by the annual maize supply (Van West and Altschul 1994:365). Using a model of non-canal irrigation systems, it was determined that there were 71 extremely dry years and 49 extremely wet years in the lower Tonto Basin between A.D. 740 and 1370, with a total of 38 extremely wet or dry years in the Colonial period (A.D. 750-949), 27 during the Sedentary period (A.D. 950-1149), 34 in the early Classic (A.D. 1150-1299), and 15 during the late Classic (A.D. 1300-1370). The authors interpret the data to mean that "the Sedentary period, particularly between A.D. 1042 and 1134, was likely the era of greatest predictability in agricultural production in the Tonto Basin" (Van West and Altschul 1994:404). This time period corresponds to apparent population expansion in the lowerTonto Basin.

Prehistorically, the floodplain and terraces of the Salt River contained a wide variety of plant and animal species. In recent times desertification and reduction in this habitat (Crosswhite 1981:67; Hastings and Turner 1965; Rea 1983) have decreased species diversity and changed some of the types of flora and fauna that characterize the Sonoran Desert landscape. Man's influence over only the past 100 years has created changes along the river in the amount of groundwater, erosion, and depletion of native vegetation. The riparian forest is mostly gone or replaced by feral salt cedar, and weedy species proliferate. The water table, previously a few feet below the surface, now averages hundreds of feet underground (Rea 1983:3). The archaeological and historic records document the change in riparian and desert scrub communities from historic to modern times, yet the natural resources used prehistorically by the Hohokam have remained relatively constant. Data from pollen, macrobotanical, and faunal remains from archaeological sites indicate that there were no radical differences in the natural environment prehistorically.

Table 3. Statistical Description of Actual and Reconstructed Flows for the Salt River: July-June, October-April, and Summer (Estimated)

	A.D. 1914-1979			A.D. 1800-1979	A.D. 740-1370
Statistic	Actual	Reconstructed		Reconstructed	Reconstructed
		GRCMN	AZNOF	GRCMN	GRCMN and AZNOF
Jul-Jun					
mean	626.42	554.63	556.83	568.24	537.91
s.d.	497.34	291.66	318.57	339.56	237.25
Oct-Apr					
mean	458.63	399.21	393.29	408.10	376.82
s.d.	413.13	243.89	261.04	289.78	192.60
Statistic	Actual		Estimated	Estimated	Estimated
Summer[1]					
mean	167.79		160.41	160.14	161.09
s.d.	103.56		49.65	53.87	45.93

Note: FromGraybill 1989
[1]Summer flow in thousands of acre-feet. Actual summer flow includes the values for July, August, and September plus May and June of the succeeding year. Estimated summer flow is the simple remainder resulting from subtraction of the October-April reconstructed values from the July-June reconstructed values.
s.d. = standard deviation

PREHISTORIC AGRICULTURAL POTENTIAL

The potential for prehistoric agriculture along the upper Salt River Valley was highest in the lower Tonto Basin. From the confluence of the White and Black rivers, the Salt River descends rapidly through a rugged, bedrock-confined canyon before discharging into Lake Roosevelt. The river emerges from its narrow canyon about 17 miles above Roosevelt Dam (Welch 1994:32), and, according to Gregory (1979:2), the alluvial floodplain around Roosevelt Lake is the first place where water from the upper Salt River would have been available for canal irrigation. Although floodwater farming and farming with the aid of rock features such as alignments and rock piles for collecting runoff are evident in many areas excavated to date, there are very few examples of canal irrigation. Five examples of prehistoric canals are given by Van West and Altschul (1994:362-363): (1) multiple canals in the vicinity of the Tonto Cliff Dwellings that are now inundated by Lake Roosevelt (Tagg 1985:31); (2) a possible canal segment east of the Armer Ruin complex on the north side of the Salt River (Wood 1986:Figure 4); (3) a canal off of Tonto Creek one mile upstream from the VIV Ruin (Wood 1989:36); (4) a canal segment in the Livingston Group study area near a residential compound (Jacobs et al. 1992:16); and (5) a canal on the south side of the Salt River being investigated as part of the Roosevelt platform mound study (Van West and Altschul 1994:363). All of these canals date to the Classic period. A Colonial period canal was reported by Mitchell (1986) on the San Carlos River, and although pre-Classic canals have not been identified along the upper Salt River to date, there is good reason to assume that some were probably in use. Wood (1986) has pointed out that before Lake Roosevelt was formed, 44 miles of irrigable perennial stream coursed along the Salt River and Tonto Creek, and according to Van West and Altschul (1994:404), there were years during the A.D. 740-1370 period when climates were so extreme as to have encouraged the development of and dependence on irrigation systems in the lower Tonto Basin.

SUMMARY AND CONCLUSIONS

In summary, archaeological studies in the upper Salt River area have documented some 11,000 years of human use of the region. People began practicing agriculture in the study area about A.D. 100, and most agricultural settlements were in the lower Tonto Basin, which provided the best conditions for agriculture. Archaeological reconstructions of streamflow suggest that although streamflow changed little between A.D. 740-1370 and A.D. 1800-1979, floodwater farming was apparently more important than irrigation agriculture in the prehistoric period. Archaeological research has not documented any use of the river for commercial trade and travel or for any regular flotation of logs.

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Arizona State Land Department

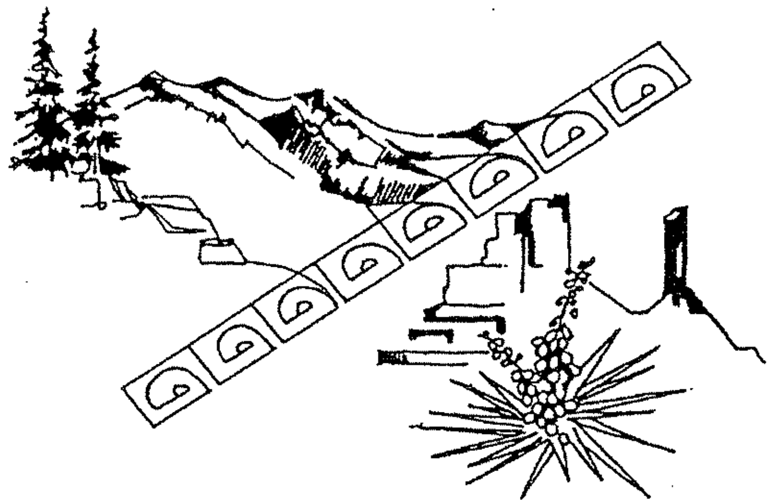
ARIZONA STREAM NAVIGABILITY STUDY

for the

UPPER SALT RIVER

Granite Reef Dam to the Confluence of the White and Black Rivers

Final Report



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Section 3

HISTORICAL OVERVIEW OF THE UPPER SALT RIVER, ARIZONA

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HISTORICAL OVERVIEW OF THE UPPER SALT RIVER

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INTRODUCTION

Historical accounts of the upper Salt River provide abundant evidence about the flow regime of the river, uses of the river, diversions from the river, impediments to boating on the river, examples of boating and floating logs down the river, types of vessels used on the river, and customary modes of transportation in the region. Although Spanish accounts of the river may date as early as A.D. 1540, most historical accounts of the river and the surrounding region date to the nineteenth and twentieth centuries.

Prior to the 1860s, the upper Salt River area was occupied exclusively by the Yavapai and Apache. Fort McDowell, on the Verde River 7 miles above its confluence with the Salt, was established in 1865, and farms quickly sprang up around it to supply the soldiers. Camp Ord (Fort Apache) was established in 1870. Crook's campaign of 1872-1873 subdued the Apaches of the Tonto Basin and opened the area to white settlement. Mining south of the Salt River led to development of the salt works on the river at the mouth of Salt River Draw (below the mouth of Cibecue Creek). Ranching and limited farming were practiced throughout the Tonto Basin, and a few small communities (including Armer, Livingston, Cline, and Catalpa) were established along the Salt. In 1885 the Arizona Diversion Dam, located approximately three-quarters of a mile downstream from the confluence of the Verde and the Salt rivers, was completed and began to supply water to fields in the Salt River valley on the north side of the river. Between about 1903 and 1911, Roosevelt Dam was constructed just below the confluence of Tonto Creek and the Salt River. In 1905 floods damaged the Arizona Dam, and in 1908 it was replaced by Granite Reef Dam 3 miles below the Salt-Verde confluence. In the 1920s, three additional dams (Mormon Flat, Horse Mesa, and Stewart Mountain) were completed along the Salt River.

Historic accounts of the upper Salt River describe it as flowing year-round, although fluctuating seasonally. Many early writers emphasized the almost impenetrable canyons of the Salt River, which opened up in only a few places, such as the Tonto Basin, Mormon Flat, and the mouth of the Verde River.

Historical accounts also provide evidence for boating on the river, both commercial and recreational. The Boy Scouts of America and the Sierra Club initiated modern recreational rafting on the upper Salt River in the late 1950s.

HISTORICAL OVERVIEW/CHRONOLOGY

Historical documentation of the upper Salt River began with the Spanish, who provided brief descriptions that are often vague about the exact locations being discussed. During the Mexican period (1821 to 1848), the upper Salt River was described by trappers from the United States, whose accounts are also vague. With the establishment of Fort McDowell on the lower Verde River in 1865, the U.S. Army began to subdue the Indian occupants of the region, in the process providing more detailed information on the upper Salt. A chronology of the principal historical events along the upper Salt River can be found at the end of this report. Historical maps showing the principal localities mentioned in the text are in Appendix A.

Historic Indian Use

Historically, the upper Salt River was the homeland of the Yavapai and the Western Apache. Although the Yavapai and Apache spoke different languages, the two groups had similar cultures, with a subsistence pattern based on hunting, gathering wild plants, and limited farming and a settlement pattern of scattered, extended-family rancherías. They were thus often confused with each other by early explorers, military expeditions, and colonists.

The Yavapai are upland Yuman speakers, probably descended from the Cerbat archaeological culture that occupied southern California and northwestern Arizona south of the Colorado River from about A.D. 700 to 1850 (Khera and Mariella 1983). From about A.D. 1300 to 1850, the Cerbat apparently evolved into the historic Pai (Hualapai, Havasupai, and Yavapai). Ferg (1992) argues that the Yavapai controlled the Tonto Basin until about A.D. 1750. In the mid-nineteenth century, a band of Yavapai lived along the Salt River below the Tonto Basin. Most members of this band were massacred by the U.S. Army at Skeleton Cave in 1872. Their way of life prior to the massacre was described by Mike Burns, a Yavapai who at age seven was captured shortly before the battle and raised by Captain James Burns (Corbusier 1971:49-85). Mike Burns wrote that in the winter his family camped in cave houses in the box canyon of the Salt River farther downstream, near the mouth of Fish Creek (Corbusier 1971:62). Their summer camp was "just below the present site of the Roosevelt Dam...[in a] place that no enemy would dare to enter as we could kill every one" (Corbusier 1971:61, 65). An Apache leader named Delche "camped on the rocky banks of the Salt River about 6 miles away" (Corbusier 1971:62).

The Apaches are Southern Athapaskan speakers descended from Athapaskans who began migrating south from the western subarctic approximately 1000 years ago (Wilcox 1981). Anthropologists recognize seven groups of Southern Athapaskan speakers: the Navajo; the Western, Chiricahua, Mescalero, Jicarilla, and Lipan Apache;

and the Kiowa-Apache. Scholars have not yet settled the debate about when the Southern Athapaskans arrived in the Southwest. Some have argued for an early arrival date, circa A.D. 1000. Gunnerson's (1956, 1974) reconstruction suggests that the Southern Athapaskans arrived on the southern Great Plains about A.D. 1525 and spread into the Southwest between about A.D. 1540 and 1582. According to Gunnerson, when Coronado passed through the Southwest in 1540-1542 (see below), he did not describe any groups that historians can identify as Apacheans. When he explored the Southern Great Plains in 1541, however, he observed a group of nomadic bison hunters who lived in conical skin tents that they transported on dog travois. Coronado's Pueblo Indian guides said that this group had arrived on the southern Great Plains about 15 years before. Gunnerson thought that these nomadic bison hunters were the Southern Athapaskans. In 1582 the Espejo expedition reported a group of nomadic peoples in the vicinity of Acoma Pueblo in western New Mexico. Gunnerson interpreted this group as Southern Athapaskan, possibly ancestors of the modern Navajo. Based on these accounts and her interpretation of them, Gunnerson argued that the Southern Athapaskans had reached the Southern Plains by about A.D. 1525 but had not yet entered the Southwest in 1540, although they were living in the region by A.D. 1582.

Historically, the Southern Athapaskans practiced both hunting and gathering and farming, although the emphasis was different in each group. Raiding and warfare were also significant components of the Southern Athapaskan subsistence pattern. Southern Athapaskan mobility was largely a function of the degree of emphasis on hunting and gathering, farming, and raiding. The mobility of the Southern Athapaskans resulted in indistinct boundaries between bands and rendered each of the different Southern Athapaskan languages mutually intelligible into the historic period. Spanish colonists began to distinguish differences among the Southern Athapaskans as early as 1598 (Gunnerson 1974:57) but used a large number of different terms for the Apaches (Opler [1983:387-392] lists many of these.) Only after the conquest of the Apaches in the late nineteenth century did the loosely organized Apachean groups crystallize into formal bands and tribes.

Basso (1983) divides the Western Apache into five bands: Northern Tonto Apache, Southern Tonto Apache, Cibecue Apache, White Mountain Apache, and San Carlos Apache. The San Carlos Apache are further divided into numerous local groups, including the Aravaipas, Pinaleños, and Coyoteros, among others (Thrapp 1967:viii). Hohmann and Rink (1990:57) state that "the upper Salt River was home to the 'Coyotero' Apaches." They add that the Cibecue bands resided in the vicinity of upper Cibecue Creek, the Pinaleño lived in and around the Pinal Mountains, and the southern Tonto bands lived within the Tonto Basin. Granger (1960:111) says that the Pinal Mountains were occupied by the "Pinal Coyoteros, a tribe of Apaches, who were also referred to as the Pinaleños." "Yavapai people migrated from the lower Colorado River Basin and intermarried with the southern Tonto Apache" (Hohmann and Rink 1990:57). Hohmann and Rink describe how the Apache followed a seasonal round of food gathering, growing, and hunting. In late spring, they moved to farming sites along the White River, Carrizo Creek, and Cibecue Creek, where they planted corn, beans, and pumpkins. Young, old, and disabled people stayed with the crops to protect them from destructive birds and animals while others hunted or gathered wild plants such as cactus fruits, mesquite beans, yucca, and acorns. In the fall, they harvested their fields and gathered pinon nuts and juniper berries. During the winter, when food was scarce, some groups resorted to raiding [Hohmann and Rink 1990:57].

Fort Apache was established in 1870 as Camp Ord to protect the Euroamerican settlers from Indian raids (Granger 1960:233; Walker and Bufkin 1986:37). The San Carlos and Fort Apache (or White Mountain) Indian reservations were established by Executive Order in 1872 (Thrapp 1967:111). In the late fall of 1872, General George Crook launched his campaign against the Apaches of the Tonto Basin and by the following spring had rounded up most of the Apaches (Thrapp 1967). In 1875, 1600 White Mountain Apache were relocated to San Carlos (Nelson 1990:58).

By 1906 the Apaches on the nearby reservations constituted, in the eyes of Euroamericans, a large work force and were enlisted for construction of Roosevelt Dam. Their work camps and their role in this extraordinary engineering feat are described by Ayres et al. (1994), Rogge, Keane, and McWatters (1994), and Rogge et al. (1996).

Spanish Exploration

In February of 1540, Francisco Vázquez de Coronado set out from Compostela, Mexico, leading an expedition of over 230 mounted men, 62 foot soldiers, and over 800 Indian allies to explore what is now the southwestern United States (Winship 1892-3, 1990). The expedition's route has been variously reconstructed (for a summary see National Park Service 1991), some scholars suggesting that they crossed the Salt River in the vicinity of the study reach, others that they traveled somewhere along the Arizona-New Mexico border. Byrkit (1984:223) suggests that the Salt River was the river Coronado crossed using rafts, the Rio de las Balsas of Captain Juan Jaramillo (one of the chroniclers of the Coronado Expedition). Haak (1991:107-108) agrees with this interpretation, but most reconstructions ofCoronado's route place this crossing to the east of the study area.

Once the Spanish began to missionize southern Arizona in 1691, they reached the lower Salt River on a number of occasions but apparently never ventured above the confluence of the Salt and the Verde. The Spanish recognized the Salt (or Salado), the Verde, and the Rio de la Asunción (the Salt River below the confluence of the Salt and the Verde), but they also applied other names to these rivers.

On March 1, 1699, Father Eusebio Kino climbed to the top of the Estrella Mountains, south of present-day Phoenix, where guides pointed out the major rivers of the region. Kino called the Gila the Río de los Apóstoles and named branches of the Gila after the four evangelists (Bolton 1936:422; Coues 1900:136n), including the Salt, which he named for Matthew (Bolton 1936:422). By 1701, however, Kino was referring to the Salt River as the Río Azúl (Coues 1900:137n).

Padre Luis Velarde's 1716 description of the Pimería Alta states that the major rivers of the region were the Gila and the Colorado but also mentions "two others, called the Salado and the Verde, the first because it is salty, and the latter perhaps because it runs among greenish shapes or rocks. And these rivers run, the Salado from the east to the west and to the south from Moqui [Hopi]; and the Green or Verde from the northeast of the said province to where they are joined, as has been said" (Wyllys 1931:116).

According to Granger (1960:115), "In 1736 or 1737, Padre Ignacio Xavier Keller viewed the Verde and Salado Rivers and apparently named their union point and the stream below there, the Asunción ("Assumption")."

Father Jacobo Sedelmayr, who reached the Salt in 1744, called it the Rio de la Asunción (Granger 1960:115). According to Sedelmayr, at the confluence of the Salt and Gila "a very pleasant country surrounds this fork of the rivers. Here the eye is regaled with creeks, marshes, fields of reed grass and an abundant growth of alders and cottonwood" (Dunne 1955:24).

Father Ignaz Pfefferkorn mentioned the Salt River in 1763 (Pfefferkorn 1949), noting that the Gila unites with the large Río de la Asunción, which flows from north to south-west, and into whose great volume pour two little streams, the Río Salado (salty river) and the Río Verde (green river), some miles before the Río de la Asunción joins the Gila [Pfefferkorn 1949:28].

Granger (1960:115) says that "the writer of the Rudo Ensayo" ("Rough Essay," an eighteenth century account by an anonymous Jesuit priest) called the section of the Salt below the confluence with the Verde the Rio Compuesto (Put-Together River). Coues (1900:140n) dates the Rudo Ensayo to 1762 (but see Guiteras [1951], who gives a date of 1763) and quotes page 129 as follows:

"[T]he Gila...receives the waters of the Assumption River, which, eight or nine leagues farther up to the northwest is formed by two other rivers, taking their rise, according to an account of Father James Sedelmayr [of his travels to the Yumas in 1748], in an extensive ridge of mountains in the land of the Apaches, on the other side of the Gila, farther up towards the east. Of these two branches, one is called Verde, owing to the verdure of the groves which adorn its banks, and the other Salado, because it is salty to such a degree, that after its union with the Verde, and even after joining the Gila, the water for some distance is unpalatable." [Coues 1900:140].

In November of 1775, Father Francisco Garcés, arriving at the confluence of the Gila and Salt rivers, described the rivers of southern Arizona and mentioned that the Río de la Asumpción [sic] was composed of the Verde and the Salado (Garcés 1900:139). Garcés wrote that the Río de la Asumpción "is much larger than the Gila, which becomes much (*muchisimo*) swollen in the summer by reason of the snows that there are in the sierras in which it rises and through which it flows" (Garcés 1900:110-111). Garcés reiterated that the Gila River "receives the principal volume of its waters from the Rio de la Asumpción, which is very much increased by the melting of the snows of the sierra through which it flows" (Garcés 1900:139-140).

American Trappers

Mexico won its independence from Spain in 1821. Despite Mexico's attempts to discourage incursions into its territories by citizens of the United States, fur trappers began exploring the Southwest while it was still part of Mexico. Contrary to their popular image, the mountain men generally rode horseback through the Southwest and did not normally use boats. James Ohio Pattie canoed the lower Gila in 1827, however, and on at least two occasions (Ewing Young's party in 1826 and James Ohio Pattie's group in 1827), trappers canoed the lower Colorado River.

The mountain men began trapping the Gila and its tributaries in 1826, when James Ohio Pattie and his father Sylvester Pattie made an illegal trip to the Gila. The Patties approached the Gila by way of the Santa Rita copper mines, near what is now Silver City, New Mexico, and returned by the same route. In the summer of 1826, they returned to pick up their caches of furs, but they were gone (Weber 1971:95-97).

Ewing Young and William Wolfskill also organized an expedition to the Gila in the summer of 1826, but Ewing Young became ill, and William Wolfskill led the group of 11 to 16 men (Weber 1971:124). This group went to the Santa Rita mines, then down the Gila to the Salt, where they were attacked by Indians and forced to retreat.

In the fall of 1826, four groups of trappers went to the Gila. William Sherley ("Old Bill") Williams and Ceran St. Vrain led a group of 20 men. A second group, led by John Rowland, consisted of 18 men, Antoine Robidoux led a group of 30 men, including James Ohio Pattie, and Ewing Young led a party of 18 (Weber 1826:119-120). The Robidoux party went to the Santa Rita Mines, then went down the Gila to the Salt River, where Indians killed all the men except for Robidoux, Pattie, and an unnamed French trapper (Weber 1971:123). The survivors joined Ewing Young's party. George C. Yount was with Ewing Young's 1826 group. Like Robidoux's group, Young's party had gone through the Santa Rita Mines on their way to the Gila. They had then gone through San Francisco Hot Springs and trapped up the San Francisco River, returning to the Gila. The combined Young and Robidoux parties next traveled up the Salt, trapping beaver along the way. At the Verde River (which they called the San Francisco River), the party split, and Ewing Young went up the Verde, while Pattie continued up the Salt. Young followed the Verde to its headwaters, then returned to the Salt (Byrkit 1978:34; Davis 1982; Pattie 1831). The entire group then continued on down the Salt and the Gila to the Colorado. Yount wrote:

> In trapping the Colorado it was found convenient to construct small water-craft, which was done by scooping out logs of Cottonwood, after the method practiced by the Indians--With these canoes our trappers ascended the River till they reached the nation of the Mohavies [Camp 1966:33).]

The group went upstream to the bend in the Colorado River, then back to the Mohave villages (Camp 1966:38). At the mouth of the Virgin River, the group divided up again (Weber 1971:125). Young and most of the rest of the group may have gone to California in early 1827 before returning to Santa Fe. Pattie and others went east and returned to Santa Fe by traveling down the Rio Grande (Weber 1971:125). George Yount returned to Santa Fe via Zuni Pueblo (Weber 1971:126). Thomas ("Pegleg") Smith, S. Stone, and Alexander Branch may have taken a still different route back to New Mexico; Humphreys (1966:318) says that after they left the main group at the mouth of the Virgin River, they built rafts and crossed the Colorado River.

In 1827 George Yount led a party of 24 men "including servants and campkeepers" (Camp 1966:43) to the Gila and Colorado rivers, returning by way of the Grand Canyon, Grand Falls, Hopi, and Zuni. Sylvester and James Ohio Pattie were on this trip, as far as the Colorado River, and James described building a canoe and floating the Gila (Pattie 1831:136). At the Colorado River, the Patties and six others "became insubordinate, and parted from the main body, above the mouth of the Gila, built canoes, and descended the Colorado to try their fortunes alone" (Camp 1966:43). (See Pattie [1831:136-151] for his description of the situation.) The Patties traveled across Baja California to Santa Catalina, where they were arrested for traveling outside the area specified in their permit. Sylvester Pattie died in jail, but James was finally released and returned to Kentucky in 1830 (Weber 1971:139-140). After the Patties left the expedition, the remaining 16 men under Yount went up the

Colorado, then headed east, between the Grand Canyon and the San Francisco Peaks, to Zuni and the Rio Grande (Camp 1966).

In his 1850 report on the 1849 Navajo expedition (see below), Lieutenant James H. Simpson (1850:137) reported that in 1827 Richard Campbell led 35 men to San Diego via Zuni Pueblo; a substantial amount of historical research has been done on the route of this group (Camp 1966:x; Maloney 1939; Roberts 1931:12; Simpson 1850:137; Templeton 1965:57, 62; Wallace 1984: 326 n.2; Weber 1971:135-136). Roberts (1931:12) cites Simpson (1850:137) as reporting that this group went down the west bank of the Zuni River, crossed the Zuni east of Twin Buttes, continued southwest, crossed the Little Colorado, and went on to the upper Salt, following an Indian trail. Camp (1966:x) and Weber (1971:135-136) seem to suggest that this expedition went from Zuni to Hopi to the Crossing of the Fathers, then west. Templeton (1965:57, 62) argues convincingly, however, that Campbell was with Ewing Young's 1826-1827 group (described above), a conclusion supported by Wallace (1984:326 n.2).

According to Wallace (1984:332), Ewing Young and Kit Carson were familiar with a trail down the Zuni River from Zuni to the Little Colorado River, thence down the south side of the Little Colorado River to the first creek on the east side of Volcanic Mountain, which was followed to the Mogollon Rim, where the trail descended to the Salt River. In August of 1829, Young led a group of 40 American, Canadian, and French trappers (including Kit Carson on his first trapping expedition) from Taos to Zuni, and then to the head of the Salt River (Carter 1968:42-44). The group followed the Salt River to the mouth of the Verde River, then went up the Verde to its headwaters, where the group split up, some of the men going back to Taos, while Young, Carson, and others went to California (Byrkit 1978:35, 46; Weber 1971:142-143). Young and Carson returned in the fall of 1830, traveling from Los Angeles to the Colorado River, up the Gila to the Santa Rita mines and back to Taos, arriving in Taos in April of 1831.

The trappers and traders of the Mexican Period thus acquired a familiarity with the upper Salt River, but few descriptions of their expeditions were published, and the accounts that did appear in print rarely describe the rivers (as ironic as that may seem, given the importance of the rivers to the fur trade). One exception is Pattie's description of the Salt River (Pattie 1831). The fragmentary accounts of the trappers do suggest, however, that the Palatkwapi Trail (from Hopi to the Verde Valley, perhaps taken by those members of Young's 1829 expedition who did not go on to California and by Leroux in 1854) (Byrkit 1988) and the Zuni-Salt River Trail followed by Young and Carson in 1829 (and by Lt. Beckwith in 1849) (Carter 1968:42-44; Foreman 1937, 1941a:220; Wallace 1984:332) were both in use during the Mexican Period. Antoine Leroux, who later guided the Sitgreaves and Whipple expeditions along the 35th parallel and returned to Taos via the Salt and Verde in 1854, apparently acquired his knowledge of the area during six or seven years of trapping in the 1830s (although he first arrived in Taos in 1824 [Foreman 1941b; Parkhill 1965, 1966]).

United States Military Exploration

In 1849 James Collier, the first customs collector of the Port of San Francisco, was guided to California by mountain man John Hatcher (Foreman 1937 cited by Wallace 1984:332). They went down the Zuni River to the Little Colorado, then went on to the upper Salt River by the trail described above. According to Roberts (1931:12), who cites Amiel Weeks Whipple (1851:15) and Sitgreaves (1853:6), Collier was accompanied by a military detachment led by Brevet Captain Herman Thorne, who drowned October 16, 1849, while crossing the Colorado River (Whipple was present, having made the trip from San Diego [Whipple 1851]). At that point, Lieutenant Edward G. Beckwith took command, and later maps of the Military Department of New Mexico (1859, partially revised and corrected in 1867) show Beckwith's trip. (Foreman [1941c:15] also describes this event.) A number of old maps show a route labeled "Beckwith 1849" running west from Zuni, crossing the Little Colorado River west of its confluence with the Zuni River, Silver Creek, and the head of Chevelon Creek, then passing over the Mogollon Rim, skirting the headwaters of the "San Carlos River" (probably Carrizo Creek), passing through the vicinity of present-day Cibecue, and reaching the Salt River between the mouth of what appears to be Canyon Creek and Tonto Creek (which is labeled as such). Based on information from Beckwith and Dr. Randall, another member of the expedition, Whipple described this route through the Salt River canyon, comparing it to the canyon of the Bill Williams River and the Gila Box:

> "The Salinas also, according to the accounts of Lieutenant Beckwith and Dr. Randall, who tried to follow its course, on their way from Zuñi to the Gila, in 1849, treads a chasm of the same nature, and is as impassable with pack-mules as that near Mount Turnbull. They were obliged to leave the stream, and make their way over high and rough mountains [Foreman 1941a:220]."

From July of 1853 to March of 1854, Whipple surveyed a railroad route from Fort Smith, Arkansas, to Los Angeles, California, via the Colorado Plateau to the north of the study area. Upon reaching Los Angeles, Antoine Leroux (the mountain man who guided the expedition) returned to New Mexico via the Gila and the Verde, a route that became known as Leroux's Trail (Foreman 1941c:13). In their *Report Upon the Indian Tribes*, Whipple, Ewbank, and Turner (1855:14-15) provided an excerpt from Leroux's journal from May 16 through 24, describing Leroux's trip from the mouth of the Salt River to Beaver Creek.

In late summer of 1870, General George Stoneman (Military Commander of the Department of Arizona) and 24 other men (including 1 officer, 1 surgeon, 12 enlisted men, 4 teamsters, 3 servants, 1 cook, and 2 civilians) toured the military posts of Arizona (Marion 1965). Leaving Fort Whipple on August 29, 1870, they went north to the Leroux Valley, then east past Leroux Springs, Cosnino Caves, and Canyon Diablo, arriving at the Little Colorado on September 4 (Marion 1965:18). The group forded the Little Colorado River at Sunset Crossing on September 4 and crossed to the south side again at Leroux Crossing, near the confluence of the Puerco and the Little Colorado, on September 6 (Marion 1965:19). They then traveled up Silver Creek and over the Mogollon Rim to Camp Mogollon. The rest of their trip took them to Camp Goodwin, Camp Bowie, Tucson, Camp Grant, Fort McDowell, and back to Fort Whipple, which they reached on October 5. Traveling south from Camp Mogollon (Fort Apache is on the south side of the East Fork of the White River) to Camp Goodwin, the Stoneman party crossed the Black River and avoided the Salt River entirely.

Hostilities with the Apaches

In the 1860s, the United States military presence in the Southwest was greatly reduced because of the need for manpower to fight the Civil War back east. Until troops were again posted in the area following the war, some settlers took matters into their own hands.

Vigilante Actions

In 1864, King S. Woolsey of Prescott led three vigilante campaigns against the Apaches of the Tonto Basin (Goff 1981:33; Haak 1991:3). In January of 1864, Woolsey led 15 to 60 men from Fort Whipple at Prescott down the Agua Fria, east to the Verde, and into the Tonto Basin (Goff 1981:33). Somewhere in the area, perhaps near Fish Creek, Woolsey and his vigilantes murdered a group of Apaches who had been invited to a council, an event known variously as the Bloody Tanks Massacre or the Pinole Treaty (after the food served to the doomed visitors) (Faulk 1970; Goff 1981:33; Welch and Ciolek-Torrello 1991:57). In March, Woolsey and approximately 100 men "surprised Apache occupants and annihilated a village of 60 wickiups, killing 14 warriors and many women and children" (Ogle 1940:49 cited by Welch and Ciolek-Torrello 1991:57).

According to Welch and Ciolek-Torrello (1991:57), "Woolsey's third expedition failed to locate any Indians, but the group named Tonto Creek after the group of Apaches they had been pursuing." "On June 1, 1864, Woolsey and 93 men left Agua Fria Ranch and traveled down Tonto Creek, finding an abandoned village of 50 Apache wickiups at the mouth of Tonto Creek" (LeCount 1976:2). In his report to Territorial Governor John M. Goodwin, Woolsey described following Sycamore Creek "about twelve miles to its mouth, finding Indian corn and wheat fields all the way. At the mouth of the creek the Salt River flows southward for some miles and then turns to the west" (Goff 1981:45). Woolsey's group then crossed the Salt River and followed the left bank 6 miles to the Salt River Canyon and then went overland to Pinal Creek, where he camped in the Indian wheat fields on June 13 (Granger 1960:111). Woolsey then went down Pinal Creek and camped on the Salt River before returning to Wheatfields on Pinal Creek. Grapevine Spring, on the south side of the Salt River and east of the mouth of Tonto Creek, was named by Woolsey in June of 1864 during his third expedition. His expedition used this spring for water instead of the Salt River, which was too brackish to be potable (Granger 1960:104). In his report to Governor Goodwin, Woolsey wrote, "The road from Grape Vine springs is about fourteen miles S.E. to some springs and tanks, and then turning east for about five miles, where it reaches Pinal creek at our camping ground" (Goff 1981:46). Woolsey led his men to Fort Goodwin on the San Pedro River, then back to the Wheatfields camp in August of 1864, and "found an extensive Indian wheat field ready for harvesting" [Granger 1960:119]), then to Grapevine Spring along the Salt River, then up Tonto Creek to the Verde River, the Agua Fria River, and home, arriving at Prescott 87 days after starting (Goff 1981:47-51).

Some other military records also mention the Salt River. George M. Wheeler's Army survey of the American West began in 1869 and lasted until 1879; Arizona was mapped in 1871 (Bartlett 1962). Granger (1960:115) says that "Capt. George M. Wheeler in 1873 refers to [the Salt River] by two names: The Prieto ("Black") and the Salt River." Army wife and diarist Martha Summerhayes mentioned crossing the Salt River several times, but never described the river (Summerhayes 1911:195, 212). Summerhayes was at Fort Apache from October of 1874 to April of 1875, but she did not describe the Salt River below the camp. In December of 1876, she crossed the Salt on her way to Fort McDowell, and she crossed it again on her trip from FortMcDowell to Fort Lowell in 1878.

Military Presence and Campaigns

In 1865 Camp (later Fort) McDowell was established on the Verde River 8 miles above its confluence with the Salt. Soldiers at Camp McDowell dug an irrigation ditch and put in gardens, "becoming the first Euro-American irrigators of central Arizona" (Rogge, Keane, and McWatters 1994:7). Soon after, civilian farmers settled in the area. In 1867 a site for Camp Reno was selected on Tonto Creek (Haak 1991:4) approximately 15 miles above the confluence of Tonto Creek and the Salt River (Reicker 1879). In 1868 a wagon road running northeast from Fort McDowell to Camp Reno was completed, and Camp Reno was constructed (Haak 1991:4-5). The road from Fort McDowell to Camp Reno avoided the Salt River (Reicker 1879).

The military post that later became Fort Apache began in 1870 with the establishment of Camp Ord. Within a year the name changed from Camp Ord to Camp Mogollon to Camp Thomas and, in 1871, to Camp Apache. The camp was finally named Fort Apache in 1879 (Granger 1960:233). In November of 1870, Captain Netterville established Infantry Camp in "Mason's Valley, near the head of Queen Creek on the western edge of the Pinal Mountains" and began construction of a road to "Picket Post near the present town of Superior" (Bigando 1990:6). In 1871, Infantry Camp was renamed Camp Pinal, but later that year it was abandoned at the order of newly arrived General George Crook (Bigando 1990:6). Von Greenw.'s (n.d.) map circa 1870 shows Fort Badger on the south bank of the Salt River just below the mouth of the Rio San Francisco (Verde River), the community of Ash Grove just south of Fort Badger, and Grapevine Spring above the mouth of Tonto Creek.

The purpose of all this activity was protection of the growing Euroamerican population from incursions by the Yavapai and Apache. In 1869, Major Andrew Alexander of Fort McDowell led a "campaign of extermination" against the Apaches (Haak 1991:5). In the winter of 1872-3, Crook cleared the Tonto Apaches from the Tonto Basin and forced them to the San Carlos Reservation, which had been established in 1872 (Woody and Schwartz 1977:20). This campaign is described in Bourke (1891) and Corbusier (1971). Major William Brown attacked a group of Yavapais at Apache Cave (also called Skull Cave or Skeleton Cave) on December 27, 1872 (Granger 1960:176, 1983:23; Thrapp 1967:127-130). In January, Crook's troops defeated a band of Apaches on Turret Mountain (Woody and Schwartz 1977:21).

Welch and Ciolek-Torrello (1994:58) say that "By 1870, the only Apache group still free-ranging in the basin was led by Del Shay (Peace 1981:8). Del Shay fiercely resisted Euroamerican efforts to subjugate his people and remained a threat to basin settlers until the army bribed his nephew, who betrayed his uncle and presented Del Shay's head to the cavalry on July 29, 1874" (Peace 1981:80). Welch and Ciolek-Torrello (1994:58) state that after 1873, the Apaches had been subdued and were no longer a threat to settlement of the Tonto Basin, but drought and Apache discontent on reservations kept the basin from being fully colonized.

Permanent Euroamerican Settlement

Soon after Camp McDowell was established, the soldiers cleared 150 acres of bottomland for cultivation and irrigated it with Verde River water brought by an acequia from four miles upriver. At first, the farm was worked by employees of the Quartermaster Department but later was leased to private citizens who produced grain for the quartermaster and cavalry animals (Surgeon General's Office 1870:459-460). Recognizing a market for agricultural produce at Fort McDowell and in the gold fields around Wickenburg and Prescott, Jack Swilling and others formed the Swilling Irrigation and Canal Company in Wickenburg in 1867. Later that year, the Swilling group attempted to clear out an old Hohokam canal on the north side of the Salt River opposite Tempe Butte, but they encountered too much rock. Nevertheless, the following spring they completed the Swilling Ditch with its headgate in Section 7, Township 1N, Range 4E (near present-day Tempe). At roughly the same time, Joseph Davis built a canal with its headgate in the same section. The community that grew up around these canals was named Phoenix. In 1870 a formal townsite for Phoenix was established in Section 8, Township 1N, Range 3E, just to the west of the original site, and the old community of Phoenix became known as Mill City (Cable and Doyel 1986:7-10).

Rowe's Station, which was later supplanted by Marysville, was established in 1865, just after the founding of Camp McDowell. According to Granger (1960),

> "In 1868 William Rowe established a place known as Rowe's Station. Here in 1865 Charles Whitlow had settled with his family in order to be near the newly established Camp McDowell (cf. Fort McDowell). Whitlow kept a general store and supplied the post animals and forage. In 1874 Whitlow moved to Florence. Rowe was still a resident of Marysville in 1875. Meanwhile a little community had grown up at the former Rowe's Station. To honor his daughter, Mary Elizabeth Whitlow (b. Kentucky, 1853), Whitlow named the place Marysville. In 1877 Mormons from Utah crossed the Salt River at this point (cf. Lehi). Their use of the name Maysville is a corruption of the true name of the place [Granger 1960:186]."

In 1885 the Arizona Diversion Dam on the Salt River below the mouth of the Verde was completed, the beginning of major efforts to control the flow of the Salt (see below).

Mining

Stories of mineral deposits in the Tonto Basin were in circulation throughout Arizona Territory as early as the 1860s (Haak 1991:7-9). Bigando (1990:2) and Haak (1991:7-8) report that a New Mexico military surgeon named "Doc" Thorn (or Thorne) found silver deposits near a hat-shaped butte (probably Sombrero Butte) during the 1860s. Thorn told Corydon E. Cooley, a Quartermaster, about the find, and in the summer of 1869, Cooley, Albert F. Banta, Henry W. Dodge, and Coyotero Apache guides prospected along the Salt River in the Sombrero Butte vicinity, but they were ordered out of the area by Pinal Apaches (Bigando 1990:2; Haak 1991:8). The group went upriver until they met a cavalry unit, which escorted them to Fort McDowell. From there they went to Jack Swilling's ranch and organized another expedition (Bigando 1990:2). Another group of 29 prospectors, led by Calvin Jackson, set out at the same time from Prescott (Bigando 1990:3). Both groups got into scrapes with the Apaches, and at the request of Colonel George B. Sanford, commandant of Fort McDowell, they combined forces between the mouth of Canyon Creek and Sombrero Butte and prospected about 30 miles up the Salt without finding anything (Bigando 1990:3). Cooley returned to Phoenix, but Jackson went on to the Pinal Mountains, where he found silver ore about two miles north of the future site of the Old Dominion Mine at Globe (Bigando 1990:4). Later that fall, Jackson returned to the site under protection of the military, but the group never developed their claim (Bigando 1990:4-6).

In 1871 a prospector named Thomas Miner reportedly found silver near a hat-shaped peak, prompting formation of the Safford expedition. (Note that Bigando [1990:6] and Woody and Schwartz [1977:14] say that Miner claimed he had found gold in the Pinal Mountains ten years earlier, and that in 1871 he led an advance party for the Safford expedition [Bigando 1990:6].) Led by Territorial Governor Anson P. K. Safford, 250 men (according to Haak [1991:8]; Woody and Schwartz [1977:14] say 280 men, Bigando [1990:6] says over 300) calling themselves the Mogollon Mining and Exploration Company explored the area around Sombrero Butte and much of the Tonto Basin without success (Bigando 1990:6-9; Haak 1991:8; Woody and Schwartz 1977:14). That same year, General George Stoneman established Camp Pinal and began construction of a road from Picket Post to the new camp (Haak 1991:8-9). During the construction of Stoneman's grade, a soldier named Sullivan found a piece of silver ore, which prompted unsuccessful prospecting in the area (Haak 1991:9). (Bigando [1990:9] says that the Silver Queen Ledge was discovered in 1871 by William A. "Hunkydory" Holmes, E. J. "Doc" O'Dougherty, the Anderson twins [David and Robert], T. B. Kerr, and others. "By February, 1872, the Silver Queen was preparing to ship twenty tons of ore to San Francisco for refining" [Bigando 1990:10].)

In 1873 two silver deposits, the most famous of which was the Globe Ledge, were discovered in Alice Gulch, near present-day Globe (Granger 1960:103; Haak 1991:10). Because of Apache hostilities, however, the deposit was not developed immediately. The Globe mineral deposits were known as early as 1875 (Hodge 1877:115). In that year four men hauling ore from the Globe Ledge to Florence found the silver deposit first reported by Sullivan in 1871, and this became the Silver King Mine (Bigando 1990:13-14; Haak 1991:9).

On November 25, 1875, miners in the area around Globe organized the Globe Mining District, which ran from the Gila to the Salt and from the San Carlos Reservation to Pinal Creek (Woody and Schwartz 1977:26). In 1876, the Globe area experienced a mineral rush (Hodge 1877:115), and Globe City was founded (Haak 1991:10; Woody and Schwartz 1977:27). Charlie McMillan and Theodore ("Dore" or "Dory") Harris found the Stonewall Jackson silver deposit and established McMillanville about 15 miles south of Gleason Flat (Haak 1991:12-13; Nelson 1990:58; Woody and Schwartz 1977:26). The town and the mines were originally located on the San Carlos Apache Indian Reservation but were removed from the reservation once the value of the mineral deposits was recognized (Bigando 1990:15; Haak 1991:14; Woody and Schwartz 1977:26). McMillanville grew to a town of 1700 people by 1877; by 1884 it had been abandoned (Haak 1991:12, 14, 16).

From 1876 until his death in 1879, King Woolsey operated a salt works at the confluence of the Salt River and Salt River Draw where the river acquires its load of salt (Granger 1983:541-542). Nelson (1990:59) says that this salt was used in silver milling at McMillanville. Anderson and Anderson (1976:8) say that Woolsey "had several men working at the mines to gather the Salt which was packed out of the Salt River Canyon and freighted to larger markets." Granger (1983:541-542) says that 1879 military maps show this salt works (see Reicker 1879), and he describes this area, noting that "Water flowing over the lip of the cliff leaves salt on the cliff face and gives a brackish taste to the stream."

Reicker (1879) shows two mining districts on the south side of the Salt River. On the east, along Pinal Creek, was the Globe Mining District, which included Globe City, McMillanville (Tulwelle Mill Post Office), Wheatfields, and the Richmond Basin. The northwest corner of the Globe Mining District extended to the north side of the Salt River below the mouth of Cherry Creek. On the west, along Pinto, Pine, and Smelter creeks, was the Pioneer Mining District, which included only one town, Silver City, among the Surprise, Empire, Esber, Silver Belle, Arco, Silver Quarry, Silver King, Crown P., and Belcher mines.

Silver deposits began to play out in the 1880s, and copper mining replaced silver mining as the predominant industry (Haak 1991:11). Asbestos mining began in earnest on the Salt River about 1911, although prospectors had discovered asbestos deposits there in 1872 (Nelson 1990:59). The asbestos mining community of Chrysotile, located 5 miles southwest of the Highway 60 bridge, was occupied from 1911 to 1933 (Granger 1960:99; Nelson 1990:59). The Regal Mine, located on the canyon wall above "Mule Hoof Bend, became the largest and best developed asbestos mine in the U.S., producing steadily from 1912 to 1948" (Nelson 1990:60). Other mines in the Salt River Canyon included the Fiber King above the Salt Banks and the Apache below the mouth of Cibecue Creek (Nelson 1990:60). Manganese was also mined in the canyon, "warranting the operation of a mill...at Gleason Flat during the 1950s" (Nelson 1990:60).

Ranching

David Harer moved his family into the Tonto Basin in 1875 and began raising cattle and hogs (Trimble 1986:212). Welch and Ciolek-Torrello (1994) report that this and "several [other] successful...livestock operations were established by 1875" in the Tonto Basin:

"David Harer began hog farming on Greenback Creek...and Florence Packard, Harer's son-in-law, drove the first cattle herds into the area. David D. Gowan and his partners set up ranching operations in the upper basin in 1876. Lewis Robinson moved 2,000 sheep into the basin to establish an outfit on the Mazatzal piedmont. Large-scale cattle ranching began by 1876, when Christian Cline brought 1,600 head from California [Welch and Ciolek-Torrello 1994:65]."

Granger (1960:118) says that the Tonto Basin was reconnoitered in July of 1876 by William C. Allen, John Bushman, Pleasant Bradford, and Peter Hansen, who thought that it was not suitable for settlement. However, in "March 1878, John H. Willis herded cattle into the upper part of the basin" (Granger 1960:118).

James Stinson settled in Pleasant Valley in 1881 but had a second headquarters "in the Valley of the Salt River from which he could send his stepson Thomas Flannigan to school (there were no schools in Pleasant Valley as yet)." Stinson resided on the Salt River and hired a resident manager for the Pleasant Valley headquarters (Woody and Schwartz 1977:109). A family named Gordon lived on Canyon Creek just above its mouth (Woody and Schwartz 1977:109), and "the Haigler family established a ranch below them" (Woody and Schwartz 1977:110).

In the 1880s, Mormons from the Salt River valley grazed livestock at the confluence of the Salt River and La Barge Creek, an area that later became known as Mormon Flat (Granger 1983:422). "On August 14, 1890, the Mormons were authorized to abandon all their Tonto Basin settlements" (Granger 1960:118).

Nelson (1990:58) estimates that perhaps 2000 head of cattle grazed in the vicinity of the Salt River in the early 1900s. Among the principal brands used by ranches in the area were the "X Four, Bar Eleven, Flying V, Straight Y, Five Rail, T Four E, HE Over T, Rocking K, and X Diamond" (Nelson 1990:58). Nelson (1990:58) says that Rockinstraw Mountain was named after a German immigrant named Roggenstroh. The stone cabin at the mouth of Cherry Creek was built by cowboys in the early 1900s, and the corral at Gleason Flat was made of surplus barbed wire from World War I (Nelson 1990:58). Ayres et al. (1994:405) identify at least one site (the Lee-Cooper Ranch) in the Roosevelt Dam area that was in use as a ranch in the early 1900s. This site continued to be occupied until the 1950s.

Granger (1960:105) mentions that Hayes Mountain was named after W. C. Hayes, who "ran cattle on the San Carlos Indian Reservation from the early 1890's until reservation cattle leases were cancelled and the land turned to use by Indian cattle." Jack Stewart, for whom Stewart Mountain and Stewart Mountain Dam were named, was a cattleman in that area from 1880 to about 1900 (Granger 1960:194). An 80-mile sheep driveway ran from Blue Point on the Salt River to Spring Creek in the SierraAnchas (LeCount 1976:16).

Haak (1991) notes that:

> " [s]ome of the ranches in early Gila County were large enough to allow for the establishment of a school or a Post Office. If such a settlement was given a name it was considered to be a town. There were Myrtle, Angora, Gordon, and Holder in northern Gila County. Armer, Livingston, Cline, and Catalpa were located near the Salt River [Haak 1991:73]."

Henry and Lucinda Armer originally settled at Grapevine Spring but later homesteaded on the north side of the Salt River near the mouth of Tonto Creek, where the little community of Armer grew up (Anderson and Anderson 1976:25, 72). Armer had a post office from 1884 to 1895 (Welch and Ciolek-Torrello 1994:65).

In the late 1870s, Charles Livingston began ranching at the mouth of Pinto Creek, homesteading there in 1888. Livingston originally called his property the Flying V Ranch, but when Gila County expanded to the north by annexing a portion of Yavapai County, Livingston had to relinquish the name to Jerry Vosburg, who had a Flying V Ranch in the newly annexed lands. The small community (including a school and several businesses) around Livingston's ranch took the name Livingston, and a post office was established there in 1896. This community was eventually flooded by Roosevelt Lake (Granger 1960:107, 1983:367;Haak 1991:110).

Catalpa was a community at the mouth of Tonto Creek (LeCount 1976:28) that was also flooded by Roosevelt Lake (Granger 1983:127).

> "Catalpa, according to Will C. Barnes, was a town and Post Office three miles south of the Armer ranch. George Danforth settled there in 1876. A year later a man named Robinson began to raise sheep nearby, and in 1880 a Post Office was opened on his land. The Post Office closed in 1888, but county records show that there was a school there as late as 1891 [Haak 1991:109]."

Welch and Ciolek-Torrello (1994) describe Cline:

> "By 1886, the extended-family settlement of Cline was a local gathering place with a church, cemetery, and post office, all of which were abandoned in 1912 after the land was condemned by the federal government and the waters of Roosevelt Lake began to rise for the first time [Welch and Ciolek-Torrello 1994:65]."

Most of the ranchers along the Salt River were bought out by the U.S. government in 1903 when construction of Roosevelt Dam began; however, some of these ranchers were allowed to stay on their lands through 1906 (Anderson and Anderson 1976:128 cited by Welch and Ciolek-Torrello 1994:66). The construction of Roosevelt Dam "provided abundant local markets for cattle, produce, labor, services, and supplies" (Welch and Ciolek-Torrello 1994:65). In the Tonto Basin as a whole, ranching reached its peak in the 1920s, when 82,000 cattle grazed the region (LeCount 1976:18 cited by Welch and Ciolek-Torrello 1994:65).

A 1904 map of the Salt River valley (U.S. Reclamation Service 1904:Plate V; Zarbin 1984:frontispiece) shows three ranches along the Salt River between Roosevelt Reservoir and Granite Reef Dam. The Coffin Ranch was on the north side of the river below the mouth of Pine Creek, and Stewards Ranch was also on the north side of the river, below the mouth of Cottonwood Creek. Monroy's Ranch was on the south side of the river above the mouth of the Verde. Within the Tonto Basin, the H. Z. Ranch and Plunkett's Ranch date to this period. The H. Z. Ranch at Livingston was established before 1905 and by 1905 was within the community of Livingston (Zarbin 1984:96). Plunkett's Ranch was 1 mile east of the mouth of Pinto Creek (Zarbin 1984:108). A Mrs. Harvey Morris operated a ranch 3 miles east of Roosevelt.

Farming in the Tonto Basin

Welch and Ciolek-Torrello (1994:64) argue that the Tonto Basin was exploited primarily for ranching, but "virtually all ranchers had a hand in schemes to deliver surface water to their homes and best pastures. Many of these ranching outfits maintained gardens and orchards for domestic use, and a handful experimented with farming on a larger scale. Several small cultivation operations persist in the basin today."

Welch and Ciolek-Torrello (1994:66) further state, "Farming did achieve some importance in the Tonto Basin prior to dam construction, but it was not comparable to other agricultural centers in Arizona. In particular, the Tonto Basin never attracted large-scale irrigation farmers or sustained many of the small-scale irrigators that did invest in irrigation system development." Welch and Ciolek-Torrello (1994:66-67) cite Forbes (1916:8) as saying, "It is very doubtful if a dozen individuals on the Tonto make what would be termed by a farmer in a real agricultural region a good living out of their land. The ranchers...are stockmen first of all and only secondarily farmers."

Welch and Ciolek-Torrello (1994:Figure 4.2) used notes on locations of irrigation ditches from the 1881 cadastral survey of the Tonto Basin (General Land Office [GLO] 1881) to create a map of ditches and fields in the Tonto Basin. The area around Livingston was used by both Apaches and Euroamerican farmers. Welch (1994:237) speculates that the 1890 or 1905 floods shifted the active channel of the Salt River to the north, "opening up the area to south-bank farmers and obliterating some of the north-bank fields abandoned by the Apache and taken over by early basin settlers." Welch also argues that the north side of the Salt River, opposite Grapevine Spring, was farmed historically: "The alluvial fans of the Cottonwood and Armer drainages were probably farmed using ditch irrigation in the years before the construction of Roosevelt Dam" (Welch 1994:237). On the other hand, the Apache farms around Grapevine Spring, reported by King Woolsey in 1864, were apparently not farmed by Euroamericans (Welch 1994:233), perhaps because the farming of spring-fed gardens was an unfamiliar technique.

When Adolph Bandelier visited the Tonto Basin in 1883, he mentioned a number of ranches along the Salt River. On May 23, Bandelier stopped by "Mr. Kenton's ranch" (Lange and Riley 1970:111) and "the ranches of Mr. Danforth and of Mr. Robertson," which were in fields of grain (Lange and Riley 1970:111). On May 24, on his way to the cliff dwellings now preserved as Tonto National Monument, Bandelier wrote, "We rode down the river, past Archie McIntosh's house, and about four miles in all, then turned sharply to the south" (Lange and Riley 1970:112). (Bandelier [1892:425] further describes McIntosh as "the well-known scout.") Later that day, he passed the Fisk and Walbridge ranches (Lange and Riley 1970:112). On May 26 Bandelier went to the Armour Ranch (Lange and Riley 1970:115). On May 28, Bandelier crossed Tonto Creek to the ranch of Mr. Vineyard and continued on to Mr. Flippen's ranch (Lange and Riley 1970:116). On May 29 and 30, Bandelier worked in the vicinity of the ranches of "Tobe" and Frank Cline nine miles north of the Salt River and across Tonto Creek from each other (Bandelier 1892:429; Lange and Riley 1970:116-119).

Stone and Ayres (1984) conducted a preliminary study of the potential effects that raising Roosevelt Dam would have on historic sites. They identified five homesteads (all dating from about 1880 to 1920), one ranch (dating from about 1915 to present), a corral (1880-1920), and a trash dump (1905-1911). The earliest homestead was shown on the 1881 GLO map and was patented in 1892 by Jemina Hargrave (Welch and Ciolek-Torrello 1994:Table 4.2). The John L. Cline homestead was dated to roughly the same period and was patented in 1891 (Welch and Ciolek-Torrello 1994:Table 4.2). A third homestead consisted of a cobble house, canals, and fields (Welch and Ciolek-Torrello 1994:Table 4.2).

An 1896 study of water supply and water appropriations on the Salt River (Stewart and Bicknell 1896) described 1670 acres of irrigated fields at a location that Welch and Ciolek-Torrello (1994:72) interpret as the Salt River above the future site of Roosevelt Dam. According toStewart and Bicknell (1896):

> "As there is an abundance of water in the river and the land lies very low any one can take out a ditch for himself. As none of the land irrigated is over one mile from the river, and the land is very porous, it is probable that a large portion of the water taken out finds its way back again. They build no dams, but take out water by natural sloughs or by slight wings or boulders and brush. We found ditches of say 80 inches running continuously on 35 or 40 acres of land. Crops are an equal acreage of grain and alfalfa." [Stewart and Bicknell 1896:2 cited by Welch and Ciolek-Torrello 1994:72].

"Egyptian Corn" (similar to Milo Maize) was another important crop grown in the Tonto Basin (Croxen 1926:7 cited by Welch and Ciolek-Torrello 1994:69).

A 1901 map of irrigated areas in Arizona (Bureau of the Census 1901) shows irrigated farming along the Salt River in the Tonto Basin but not elsewhere on the upper Salt. Welch and Ciolek-Torrello (1994:Figure 4.2) show the locations of historic irrigation ditches and fields in theTonto Basin.

When Roosevelt Dam was constructed, only a few farms needed to be purchased. According to Welch and Ciolek-Torrello (1994:67), Greely and Glassford (1891:34) estimated that only about 12,000 acres of "arable and irrigable land" was present in Gila County, and it was located "in patches and small strips in the narrow valleys of Salt River and Tonto Creek." During the planning of Roosevelt Dam, a similar estimate was obtained:

> "The surveys show about 740 acres of cultivated land that will be submerged by the reservoir. The improvements on these lands consist mainly of small frame or adobe houses, fences, and irrigation ditches....About 4,400 acres of unimproved land is also in private hands, and has little or no value." [Davis 1902:51 cited by Welch and Ciolek-Torrello 1994:67].

Welch and Ciolek-Torrello (1994) continue:

> "Roedenbeck's (1907) estimation that the government needed to purchase only 500 to 700 acres to have clear title to the reservoir is in close agreement with these figures....Forbes (1916:11) documents a total of 1,130 acres cultivated in the lower Tonto Basin and estimates that only slightly more arable land was available....Of these 1,130 acres, 207 acres in 14 parcels were dry farmed. Two of the 14 dry-farmed

parcels had been cultivated for many years, with an average of one good crop of grain hay per three years. Typical per-acre yields in this area are reported as 1,200 to 1,500 pounds of corn, 2 to 3 tons of sorghum, 1 ton of wheat hay, and 800 pounds of beans (Forbes 1916:11) [Welch and Ciolek-Torrello 1995:67].

Welch and Ciolek-Torrello (1994:72) speculate that a number of individuals established homesteads along lower Tonto Creek and the Salt River after plans for construction of Roosevelt Dam became known and soon thereafter sold their land to the government. However, Dr. Ralph Palmer, the doctor at the Roosevelt Dam construction camps, mentions a "Charley Hill who had a small pasture up the Salt River" and provided milk to the town of Roosevelt (Palmer 1979:106).

Dam Construction

In 1885 the New York-based Arizona Water Company completed the Arizona Diversion Dam, located three-quarters of a mile below the confluence of the Verde and Salt rivers (Rogge, Keane, and McWatters 1994:7; Zarbin 1986:51). The Arizona Diversion Dam "directed water into the Arizona Canal to serve lands under the Arizona, Grand, Maricopa, and Salt River canals north of the river" (Zarbin 1986:51). The Arizona Diversion Dam was:

> "a rock-filled, heavy plank crib structure substantially sturdier than the earlier diversion dams made simply of stacked brush and rock. The Arizona Diversion Dam was completed in 1885 and functioned admirably for two decades until it was damaged in 1905 by floods. It was replaced shortly thereafter by the concrete Granite Reef Diversion [Dam] built in 1906-1908 by the U.S. Reclamation Service in conjunction with the construction of Roosevelt Dam" [Rogge, Keane, and McWatters 1994:7]

In 1889 William M. Breakenridge, James H. McClintock, and John R. Norton surveyed locations for dams along the Salt River and identified locations of Roosevelt, Stewart Mountain, Mormon Flat, and Horse Mesa dams (Peplow 1979:52-54, 58-59; Zarbin 1984:24-25).

Construction of Roosevelt Dam was funded through the Reclamation Act of 1902 (Nelson 1990:59). Mapping of the Tonto Basin site for the proposed dam began that year (Rogge, Keane, and McWatters 1994:12). Prior to construction of the dam itself, construction was completed on a diversion dam, a 19-mile power canal, a power house, a 146-mile access road from Globe to Mesa, a telephone line from Globe to Mesa, a machine shop, a blacksmith shop, a carpenter shop, a domestic water supply system, and other facilities (Rogge, Keane, and

McWatters 1994:12). Lumber, bricks, lime, fuel oil, and other supplies had to be transported to the site (Rogge, Keane, and McWatters 1994:12). In the early years of preparation, workers lived at Livingston, the existing farm and ranch community (Rogge, Keane, and McWatters 1994:208). As the number of workers increased, three construction camps were built: O'Rourke's Camp, a tent city for 400 employees of the contractor; Government Hill, a community for employees of the Reclamation Service; and Roosevelt, a town that provided housing for independent workers and services for all three of the construction camps (Hantman and McKenna 1985; Rogge, Keane, and McWatters 1994:59, 208).

"The town of Roosevelt came into existence during the construction of Roosevelt Dam. The first building went up in 1904. By 1906 there were 400 people and ten businesses in the community. It continued to grow until 1908, when the entire town was moved to higher ground. The waters of the reservoir flooded over the old townsite. The new town of Roosevelt thrived until the dam was completed in 1911 [Haak 1991:110]."

Roosevelt Dam was constructed between 1905 and 1911. Granger (1960:114) says, "The first stone in the masonry dam was laid on September 20, 1906, and nearly five years later on February 5, 1911, the structure was completed. Theodore Roosevelt dedicated the dam on March 18, 1911" (Granger 1960:114). The dam did not fill until April 15, 1915, when water flowed over the spillway for the first time (Granger 1960:114).

The Granite Reef Diversion Dam, constructed 3 miles below the confluence of the Salt and Verde rivers to replace the flood-damaged Arizona Diversion Dam, was completed in 1908 (Brown 1978; Lacy et al. 1987:19; Zarbin 1986:67). A large work camp was constructed at the location of the dam (Brown 1978; Zarbin 1986:69), a footbridge was built across the river upstream from the dam (Zarbin 1986:68), and a "cableway was erected spanning the river directly over the line of the dam and was used for handling materials, and at times, during floods when bridges were washed away, the men were transported to the north side of the river in this manner" (Brown 1978:38). Even with the footbridge and cableway, boats were used to transport men across the river, and on February 17, 1909, three men drowned when one of two boats crossing the lake capsized (Zarbin 1984:195, 1986:83).

Although Roosevelt Dam had been built primarily to store water for irrigation, power production turned out to be an important secondary benefit. In the 1920s, the Salt River Project built three additional dams below Roosevelt to increase power production. Preliminary work on Mormon Flat Dam was begun in 1923 and construction was completed in 1925, impounding Canyon Lake (Rogge, Keane, and McWatters 1994:15). Engineering surveys for Horse Mesa Dam were conducted in 1924, with engineers and surveyors camping in small rock overhangs along the Salt River (Rogge, Keane, and McWatters 1994:15). Work on the road to Horse

Mesa Dam started that same year (Rogge, Keane, and McWatters 1994:15). The spillways and road were completed in 1926; the dam was completed in 1927, creating Apache Lake (Rogge, Keane, and McWatters 1994:16). Stewart Mountain Dam was built in 1928 and 1929, creating Saguaro Lake (Rogge, Keane, and McWatters 1994:16).

HISTORICAL DOCUMENTATION

Early Descriptions

A number of explorers and travelers described the upper Salt River in the late nineteenth and early twentieth centuries; however, because of the remoteness of the location, the rugged terrain, and the Apache threat, such descriptions are not as common as for the San Pedro, Santa Cruz, lower Salt, Gila, and Little Colorado Rivers. In general, these observers saw a perennial stream, although its flow was highly variable, both seasonally and annually.

As noted above, in 1716 Padre Luís Velarde recorded that the major rivers of the Pimeria Alta were the Gila and the Colorado, but he also mentioned "two others, called the Salado and the Verde" (Wyllys 1931:116).

On February 1, 1826, James Ohio Pattie, who called the Salt River the Black River, described the stream at its confluence with the Verde: "It affords as much water at this point as the Helay....We found it to abound with beavers. It is a most beautiful stream, bounded on each side with high and rich bottoms" (Pattie 1831:91 cited by Davis 1982). In 1867 the physician and naturalist Elliot Coues described beaver as still being "very abundant" along the Rio Salado and San Francisco (Verde) rivers (Coues 1867 cited by Davis 1982:169).

Mike Burns, the Yavapai who was captured at age seven shortly before the Skeleton Cave massacre of 1872, has left his impressions of what the Salt River was like in the 1860s and 1870s, before the conquest of the area by the United States military (Corbusier 1971:49-85). Burns wrote that during the winter his family lived in cave homes in the rugged country between Fish Creek and the Salt River near the head of the box canyon of the Salt River. Burns described this canyon as:

> "about 10 miles long and 3 miles wide, high, and surrounded by rocks and precipices on all sides, with only two places where it can be climbed on foot, but not on a horse. One path was on the west and the other on the northeast side....From the neck we could see the *che-wa-kees* [camps] on the other side of the river, but it took all day to get to them, as the country was rough, the canyons deep and the rocks in

the river very slippery. In winter the river was very difficult to cross on account of the high water from White River and Tonto Creek, tributaries of Salt River into which also comes Fish Creek [Corbusier 1971:62]."

After the Skeleton Cave massacre, the troops proceeded about 25 miles downstream and camped in a place also familiar to the seven-year-old captive:

"[T]he soldiers...followed the Salt River below where is now the great dam (Roosevelt) for about 25 miles where they crossed and made camp opposite *ha-cha-wa-wa-tay-dis-ka-la-ha* (enemy's big wash), the mouth of a big tributary of the Salt River. There, all sorts of green grass and trees grew in the springtimes and the scent of the wild flowers is so sweet, and which was a great sporting place for the Indians. The bottom lands are level for camping places and all kinds of game and other food were plentiful [Corbusier 1971:62]."

In 1871 A. A. Humphrey's survey of the Southwest left Prescott on November 10 and went to Sunset Crossing on the Little Colorado, followed the Little Colorado to Leroux Fork, and then went on to Camp Apache. Lieutenant Daniel Lockwood commented on the Salt River Canyon to the southwest of the camp, describing the Army's understanding of the terrain from which they would have to remove Apaches the following year.

"The country to the southwest of the camp is rough, and broken by deep cañons, which have their outlets in the Salt, or Prieto, River; the latter is the name given to the Salt River above the point where its course lies through the salt-beds that completely change its character. At the point where the trail crosses it, the river breaks through a deep cañon, the southern bank being 1,950 feet above the water; reaching the summit, a broad rolling plateau is seen, which is a continuation of the Natanes Mountains. To the west, the irregular line of the opposite wall of an extensive box cañon was readily discerned, where the river's course is extremely tortuous. The walls appeared to be red sandstone; the country beyond, to the west, was very much broken and cut up by vast cañons, which headed off in the direction of the Sierra Ancha, and particularly near Sombrero Butte. The confusion created by nature was truly wonderful [Lockwood 1872:69]."

In 1874 Dr. William Corbusier, the surgeon at Camp Verde, accompanied a scouting party of 30 men commanded by Lieutenant Walter S. Schuyler. Leaving Camp Verde in February of 1874, the group went to Fort McDowell, then Camp Grant (on the San Pedro River), then back to the Salt River and Fort McDowell, returning to Camp Verde in May. Corbusier described crossing the Salt River on their return trip, near the future site of Roosevelt Dam:

"When we reached the Salt River, the water was so high and turbulent that we could not cross, and it was some time before we found a fording place. We camped about a mile above the present site of the Roosevelt Dam in a grove of cottonwoods, now many feet under the water of the artificial lake [Corbusier 1971:25]."

In 1875, 1400 Apache Indians were moved from the Rio Verde Indian Reservation to the San Carlos Indian Reservation, and Indian Commissioner L. E. Dudley described forcing them to cross the Salt River during the spring run-off near the mouth of the Verde River:

"No further matter of particular interest occurred until Saturday the 3rd of March when we reached the Salt River. We fortunately found that the stream could be forded, but running as swiftly as it does in the month of March, it was a sad duty to compel men, women and children to wade through cold water, even though they were Indians. The water was about waist deep to a tall man, and the crossing was a pitiful sight [Dudley 1875-6 cited by Corbusier 1971:262]."

Hiram Hodge (1877:38), author of a guidebook to Arizona, said of the Salt, "At low water it is a clear, beautiful stream, having an average width of two hundred feet for a distance of one hundred miles above its junction with the Gila, and a depth of two feet or more."

Ciolek-Torrello and Welch (1994) quote a 1926 description of conditions onTonto Creek in the 1870s:

"There were perennial grasses on the mesas...where only brush grows at the present time.... Tonto Creek was timbered...from bluff to bluff, the water seeped rather than flowed....Most of the old trees are gone, some have been washed away during the floods that have rushed down this stream nearly every year since the range started to deplete [Croxen 1926 cited by Ciolek-Torrello and Welch 1994:38]."

Pioneer archaeologist Adolph Bandelier visited the Tonto Basin from May 23 to June 1, 1883, and described ruins and existing conditions (Bandelier 1892:419-428; Lange and Riley 1970:110-121). Bandelier (1892:419) described the Salt River as "a broad, blue, rushing stream, wider than the Gila, with clear and very alkaline waters," and called it "the finest large river in the Southwest." According to Bandelier (Lange and Riley 1970:111), the Salt flowed through a "beautiful green valley, planted with grain, emerald green, where the ranches of Mr. Danforth and of Mr. Robertson lie." On May 25, Bandelier explored ruins from the Danforth and Robertson ranches to the cliff dwellings now preserved in Tonto National Monument, and once again compared the Salt River to the Gila, noting that, "On the whole, this Salt river is a much handsomer spot than the Gila. Vegetation is stronger, rank, but equally thorny. Snakes begin to appear. Lizards are quite frequent" (Lange and Riley 1970:114).

On May 26 Bandelier explored the area near the mouth of Pinto Creek and wrote:

"Chico did not like to cross Salt River, which is very swift, and as broad as the Gila at San Carlos, but only "belly deep." The bottom on the other side is not as wide as that of the south bank, and it rises more rapidly. There is also a dense growth of mesquite, and the foothills, higher and more steep, are studded with *Cactus pitahaya* as with huge pillars [Lange and Riley 1970:115]."

On May 28 Bandelier crossed Tonto Creek ("a limpid stream, not deeper than two feet, and very firm bottom") and visited Mr. Flippen's (or Flippin's) ranch (Lange and Riley 1970:116). Bandelier (Lange and Riley 1970:116) wrote that Flippen's Ranch "lies in the flat about one-third-of-a-mile southwest of Tonto, and at the foot of high, steep slopes, which descend abruptly from the Mazatzal Range. The ranch is but one grove of cottonwood and of giant mesquite."

Mr. Flippen described Salt River floods to Bandelier: "Salt River is known to have risen to ten feet above its present level" (Lange and Riley 1970:117). On May 29, still examining the ruins at the mouth of Tonto Creek, Bandelier wrote, "The [Tonto] creek, as well as Salt River, is alive with trout" (Lange and Riley 1970:118). On May 30, Bandelier followed a road that ran along the Salt River near the mouth of Tonto Creek. "I then descended into the river bottom, which is narrow and very gravelly, totally unfit for cultivation, and has the usual growth of cottonwoods" (Lange and Riley 1970:119). On May 30, Bandelier wrote, " 'Tobe' Cline told me last night that within a few years, old springs have suddenly reappeared on Salt River."

Bandelier (1892:416) heard that the Salt River ran through deep canyons above and below theTonto Basin. "The course of the Upper Salt River is almost without interruption through such clefts, and the impression was conveyed to me that it was generally uninhabitable for sedentary natives. A little west of the mouth of the Pinal, however, begins the beautiful valley of Upper Salt River, and extends as far as the mouth of theTonto" (Bandelier 1892:416-417).

Impacts of Cattle, Floods, and Dam Construction

Ciolek-Torrello and Welch (1994:38) summarize environmental changes in the Tonto Basin beginning in the 1870s, when cattle were introduced, noting that recent analyses have indicated that grazing is not the sole cause of the arroyo cutting that began throughout the Southwest in the 1880s. Changes in the amount and timing of precipitation and natural processes of streams are now thought to result in arroyo cutting even in the absence of grazing.

Vegetation removal is the most important single source of both generalized topsoil erosion and the degradation of fertile alluvial terraces. Widespread overgrazing is the obvious source of most of the vegetation loss and has caused floristic degradation and stream channel entrenchment as described in additional quotations from Croxen (1926):

> "The first real flood to come down the Tonto Creek was in 1891 after it had rained steadily for twelve days and nights. At this time the country was fully stocked, the ground had been trampled hard, much of the grass was short, or gone, gullies had started and the water came rushing down. This flood took a good deal of the agricultural land from the ranches along the creek and was so high that it filled the gorge where it entered Salt River at the present site of Roosevelt Dam....There were no washes at all in those days, where at present arroyos many feet deep are found and at places cannot be crossed.
>
> All the men interviewed state that there was little brush in the country at the time stock was first brought in, and it was possible to drive a wagon nearly anywhere one desired [Ciolek-Torrello and Welch 1994:39]."

Welch and Ciolek-Torrello (1994:65) write that "One observer (Anonymous n.d.) documented the desperate situation in 1892: ' Most of the basin's water holes had dried up, and cattle carcasses littered the landscape; Tonto Creek was dry, and the Salt was a mere trickle.'"

Ciolek-Torrello and Welch (1994:38) also note that, "Before construction of Roosevelt Dam, the Salt River floodplain supported a mature gallery forest dominated by cottonwood and willow." Obviously, the construction of Roosevelt Dam to control flooding also radically changed the environment of the Tonto Basin. Ciolek-Torrello and Welch (1994) note the changes from Bandelier's (1892:428) description of the pre-dam floodplain:

" 'From Armour's Ranch to the mouth of Tonto Creek the river continues to be lined with cottonwoods and groves of mesquite, no longer a shrub but a fair-sized tree.' Mesquite also thrived along stretches of the Salt River and Tonto Creek prior to dam construction, but the genus does not tolerate prolonged inundation. In consequence, mesquite has been eliminated from some areas while being encouraged by the reservoir's artificially elevated water table on gently sloping benches with moisture-retentive soils (e.g., the fluvial terrace east of Pinto Creek). Early European settlers removed large areas of the bottomland mesquite bosques and riparian gallery forests to open the land for pastures and farms and to obtain wood for fuel and construction. At the same time, cattle carried mesquite seed and deposited it in many nonmesic environments, encouraging expansion of its habitat away from the floodplain [Ciolek-Torrello and Welch 1994:38-39]."

According to Randall (1993), the first recorded flood on the Salt River occurred in February 1890. Presumably this refers to the first flood that was measured, since Bartlett (1854:240-241) noted the propensity of the river to flood in 1852, and General James Rusling (1877:381-383) witnessed a flood in 1867. Lacy et al. (1987:24) found citations for floods on the Salt or Gila in 1833, 1862, 1869, 1880, 1883, 1884, 1889, 1891, 1895, and 1896. The 1890 flood reported by Randall occurred somewhat later than the time other streams in southern Arizona began to flash flood and cut arroyos. Other major floods on the Salt occurred in 1891-2, 1905, 1909, 1911, and 1916 (Lacy et al. 1987:24).

Ciolek-Torrello and Welch (1994:Table 2.5) present a table listing severe weather events affecting irrigation on the Salt River. Major floods occurred in February 1874, December 1879, August 1881, February 1884, September 1887, December 1889, February 1890, February 1891 (the largest recorded flood in the Euroamerican history of Arizona), April 1895, August 1904, February 1905, April 1905, November 1905, November 1906, December 1907, February 1908, December 1909 to January 1910, July 1910, Summer 1914, February 1915, July 1915, January 1916, February 1920, and so forth. Major droughts occurred from September to November 1898, July to November 1901, and in May 1910.

According to Behan (1988a:7), historian James H. McClintock provided a summary description of the Salt River in a 1901 promotional pamphlet on the Phoenix area. "For the greater part of the year the Salt River is a river only in name. Yet it is one of the most considerable of the flood streams in the nation. It has an average volume ten times that of the Gila (McClintock 1901:25 cited by Behan 1988a:7).

Ayres et al. (1994:6) state, "Heavy rains fell in 1908 and the reservoir began to fill behind the rising dam, forcing residents of the town of Roosevelt to relocate uphill to a place that was known [as] Newtown for a while before the name of Roosevelt was again adopted."

Dr. Ralph Palmer, the doctor for the Roosevelt Dam construction camps, provided a number of descriptions of the Salt River circa 1905-1906 (Palmer 1979:84, 92-93, 137-139). One of his descriptions is" of a ride down the Salt River from Roosevelt to Harpham's Camp at Government Wells (2.3 miles from Apache Junction):

> The water in the river was low, and except in the box canyons, we could usually find good going on one side or the other. In one of the boxes extending from what is now the Horse Mesa Dam to just above the Mormon Flat Dam, a distance of some eight miles, the walls were so precipitous we had to keep in the bed of the river. In this stretch we encountered a number of pockets of quicksand [Palmer 1979:92-93]."

In another passage, Palmer mused on different perceptions of the rivers of Arizona:

> "I remember when I first came to Arizona I had a letter from my father who wrote that he had been studying a map of the country and noticed a great many rivers and wanted to know what kind of fish were in them and if they were navigable. As a matter of fact we do have a few rivers such as the Colorado, the Salt and the Tonto; the Verde and the Gila which always carry some water in parts of their courses, but for the most part the "rivers" on the map are dry washes and only carry water on the surface during those cloud bursts which fill them for a short time till the water runs off [Palmer 1979:137-138]."

Palmer (1979:84) also mentions riding up the Salt River hunting for ducks.

Historical Uses

The most prominent uses of the upper Salt River have been ranching, farming, mining, and hydroelectric power production. Ranching, farming, and mining have been discussed above. Historical accounts also mention minor uses of the river for such activities as recreation. According to Rogge, Keane, and McWatters (1994),

> "Roosevelt residents swam in several locales, including Tonto Creek, the Salt River, a hot springs near the base of the new dam, and the new reservoir. In 1905 and 1906, E. E. Bacon operated the hot springs for both laundry and bathing customers, but the operation was flooded out in 1906 (Zarbin 1984:90). As the reservoir began to fill, new tourists began to join residents in swimming in Roosevelt Lake (Arizona Republican 30 May 1909[a](2):1, 6 Jun 1909[b](2):1) [Rogge, Keane, and McWatters 1994:236]."

Douglas et al. (1994) describe the history of hydroelectric power production on the Salt River:

> "The first use of hydroelectric power generated by harnessing the flow of the Salt River was for construction of Roosevelt Dam, the first dam built on the river. A temporary power house provided sufficient electricity for construction. During the course of constructing Roosevelt Dam, the Reclamation Service engineers realized there was a continuing need for cheap electricity for pumping ground water to augment the surface water supply in the Salt River Valley. The Reclamation Service installed a permanent power plant at Roosevelt in 1909 [Douglas et al. 1994:50]."

Mormon Flat, Horse Mesa, and Stewart Mountain dams were built in the 1920s, primarily for hydroelectric power production.

Regional Transportation

As mentioned above, the earliest travels through the upper Salt River region (by Coronado in 1540, by early American trappers after 1825-6, and by the American military after 1849) were all overland. However, on several occasions trappers constructed canoes or rafts to float the Gila and Colorado rivers.

In their 1849 trip down the Zuni River to the Little Colorado and on to the upper Salt River below the mouth of Canyon Creek, James Collier, John Hatcher, Brevet Captain Herman Thorne, and Lieutenant Edward G. Beckwith found the Salt River Canyon to be impassable with pack mules and had to travel over the mountains away from the stream (Foreman 1937, 1941a:220).

In 1870 mail to Fort McDowell went by way of Maricopa Wells (Surgeon General's Office 1870:459). Reed (1977:131) describes this route in more detail. It ran from Drum Barracks to Fort Yuma, up the south bank of the Gila (with camps at Gila City, Filibuster, Stanwix, Oatman's Flat, and Gila Bend), then went 45 miles across the desert to Maricopa Wells, then across another 35 miles of desert to the Salt River crossing at Maryville (across the Salt River from present-day Lehi), then 15 miles through McDowell Canyon to the fort. Reporting on Fort McDowell in 1870, the Surgeon General stated that "the floods of the Gila and Salt River have cut the post off from communication with the outside world for three and four weeks at a time (Surgeon General's Office 1870:459).

Reed (1977) mentions instances in which packtrains of mules passed through the Salt River valley on their way to Fort McDowell. "On January 19, 1871, a packtrain belonging to W. B. Hellings and Company, loaded with grain for Camp McDowell, was attacked fifteen miles south of the upper Salt River crossing" (Reed 1977:56). As discussed above, in the 1870s salt from King Woolsey's salt works was packed out of the Salt River Canyon (Anderson and Anderson 1976:8; Granger 1983:541-542).

Hinton (1878:281) mentions a road from Fort McDowell to Camp Reno, near Tonto Creek. Reicker's (1879) map shows the wagon road from Fort Reno to Fort McDowell running southwest, avoiding the Salt River between the mouths of Tonto Creek and the Verde River. A wagon road also ran down the east side of Tonto Creek, crossed the Salt River, and continued along the south side of the Salt River, then up the east side of the Salt River Mountains to Pinal Creek, which it followed to Miami and Globe (Reicker 1879). A road ran east from Globe City to the San Carlos River. From there another road ran northwest to McMillanville, then continued northeast to the Timber Camp (Reicker 1879).

> "A wagon road wound its way to the camp by a tortuous route leading from Globe City through Copper Hills and Richmond Basin, and on around the southeastern slope of the Apaches. Supplies of various sorts were brought by wagon into the camp to be sold by a number of merchants who had established branches of their Globe City and Silver City stores. The same road carried wagons loaded with rich silver ore bound for the reduction works located along Pinal Creek [Bigando 1990:20-21]."

Reicker's (1879) map shows that four roads radiated out from Camp Apache (renamed Fort Apache that year). One went north up the North Fork of the White River, then forked at the Mogollon Rim, with one branch going to Snowflake and the other to Springerville and St. Johns. Another road (the General Crook Trail) ran east from Camp Apache to Camp Verde. A third road ran southeast from Camp Apache to the Black River, then over the east side of the San Carlos Mountains to the San Carlos River. The fourth road ran straight south to the mouth of Bonita Creek, then on to the Gila River, midway between San Carlos and Camp Thomas.

Ayres et al. (1994:385) suggest that the Tonto Creek road was probably built in the mid 1870s, at the time of the first white settlement of the area. According to Ayres et al. (1994:385), the road is shown on the 1881 General Land Office map. Granger (1983:609) notes that the mouth of Tonto Creek has long been a ford across the Salt River. "From at least 1882 ranchers and farmers called this place The Crossing" (Granger 1983:609).

The Apache Trail and its antecedents were long the key means of transportation through the upper Salt River region. The Apache Trail automobile road "was built in connection with the construction of Roosevelt Dam in 1905, when the Reclamation Service cleared a road from Mesa to connect with the settlement of Roosevelt at the dam" (Granger 1960:95). The road was built by Apache laborers "under the direction of Louis C. Hill, supervising engineer" (Granger 1960:95). By 1904, a stage traveled daily between Globe and Roosevelt (Rogge, Keane, and McWatters 1994:234). In 1905, when the Apache Trail was completed, stages ran between Globe and Mesa through Roosevelt (Rogge, Keane, and McWatters 1994:234). The first automobile trip from Tempe to Roosevelt over the Apache Trail was in 1906 (Zarbin 1984:146). The Apache Trail Stage Company, which was chartered from October 8, 1914, to October 8, 1939, provided transportation from the railroad at Globe to the railroad at Phoenix over the Apache Trail (Granger 1960:95). Bigando (1990) writes:

> "As important to the community [of Globe] as the construction work [on Roosevelt Dam], however, was the road that had recently been completed between the dam site and Mesa. The Roosevelt-Mesa road provided Globe with a much shorter wagon route to Phoenix than the existing road over the Pinal Mountains [Bigando 1990:72]."

Old State Route 188, from Roosevelt north to Punkin Center, was built from 1905 to 1910 to replace dirt roads leading to the north, including the old Tonto Creek Road (Ayres et al. 1994:385).

By 1910 the route from Magdalena, New Mexico, through Springerville was well-enough established that it was incorporated in the first transcontinental automobile route. In 1910 Mr. A. L. Westgard of the National Highways Association made a coast-to-coast trip by automobile. He followed the Santa Fe Trail to Albuquerque and followed the railroad west to McCartys. Finding no reliable roads west of Grants, he went down the east side of El Malpais to Zuni Salt Lake, thence west to Springerville. From Springerville, he went on to Fort Apache, Rice, Globe, Phoenix, Yuma, and Los Angeles (Wilhelm and Wilhelm 1982:181-183). In 1911 or 1912, Westgard made a second coast-to-coast automobile trip, this time traveling south from Albuquerque to Socorro, then west through Magdalena, Datil, Quemado, and Springerville (Wilhelm and Wilhelm 1982:183). In 1913 Westgard made a third trip, following the same route as his second trip as far as Springerville, but then heading northeast through St. Johns, Concho, and Holbrook, and taking the future route of Route 66 to Los Angeles (Wilhelm and Wilhelm 1982:183). Circa 1910-1911, the Ocean to Ocean Highway was designed, passing through Springerville. In 1912, the *Los Angeles Times* sent a car over this road, traveling through Yuma, Phoenix, Miami, Globe, Rice, Fort Apache, and Whiteriver to Springerville (Wilhelm and Wilhelm 1982:184). Applewhite (1979:56) states that in 1910, Westgard went through Springerville, Cooley, Cooley's Ranch, Fort Apache, San Carlos, Globe, Yuma, and

Los Angeles. The first Ocean to Ocean Highway Convention was held in Springerville in 1913 (Applewhite 1979:57).

In the 1910s the trip from Phoenix to Greer took two and one-half days, going up the Roosevelt Road ("Apache Trail") to Globe (60 miles), then through Rice (22 miles), Casadora Springs on Sycamore Creek (15 miles), Government Sawmill (7 miles), to the confluence of the Black and White rivers. From there the road ran to Fort Apache and the White River Indian Agency, crossing the White River on the only covered bridge in Arizona. From Whiteriver to Cooley's Ranch (near present-day Indian Pine) was 21 miles; from there the road went to Sheep's Crossing and then to Greer (Applewhite 1979:62). The bridge across the Salt River in Salt River Canyon was completed in 1934 (Applewhite 1979:80).

Boating

Downstream boating on the upper Salt River is documented by at least eight accounts of attempts, successful or otherwise, to boat or to transport goods down the Salt River between about 1873 and 1910. Photographs provide further evidence that boating on the Salt was not uncommon. Furthermore, boats of various sorts were used in constructing the dams along the river.

In 1873 Charles Hayden attempted to float logs down the Salt River and to establish a lumber mill in Tempe, but he could not get the logs through the canyons upstream (*Arizona Weekly Miner* 1873a, 1873b, 1873c).

> "The Hayden party, left up Salt River to come down in a canoe and drive some logs with them, have returned, and pronounce the scheme a failure. With much toil and difficulty, on account of rapids and boulders in the river, they descended a long way, when, having lost their arms, ammunition and provisions, excepting flour, they arrived in a canon so narrow as not to admit of the passage of a log, and were compelled to abandon their boat and foot it. Mr. Hayden is still sanguine of getting sufficient timber on this side of the canons [*Arizona Weekly Miner* 1873c]."

A successful boat trip from Livingston to Tempe by Jim Meadows and three other men was described in the *Arizona Republican*:

"In 1883 Jim made the first attempt, with success attending him, to navigate the waters of the Salt river between Livingstone and Tempe, accompanied by two white men and a negro. In passing through the first box canyon the negro was scared stiff. In passing through the second box they got hung upon the rocks and had to roll more rocks into the water to raise the water high enough to float the boat clear [*Arizona Republican* 1909c]."

At least two newspaper accounts describe soldiers boating down the Verde River from Fort McDowell to Phoenix.

"The Salt River is a navigable stream and should be included in the river and harbor appropriation. North Willcox and Dr. G. E. Andrews, U.S.A., of McDowell, landed at Barnum's pier, on the Salt River Valley Canal, at three o'clock yesterday afternoon, direct from McDowell, having accomplished the voyage from that point to this port, in a canvas skiff. The running time proper was about eighteen hours, and the trip would have been thoroughly pleasant, had rain not fell upon them, during the night in which they camped out. The jolly mariners are now enjoying a good time among their friends in this city [*Arizona Gazette* 1883]."

"The death of Major E. J. Spaulding, which occurred on Monday at the Mesa dam on Salt River is to be deeply regretted for a good man, a thorough and brave officer, has come to his too early grave. While coming down to Phoenix with Capt. Hatfield in a canoe and shooting as they came, they were about to lift their boat over the Mesa dam, when the major attempted to remove his gun from the boat, and in doing so it was discharged, killing him almost instantly. He was Commandant at Ft. McDowell, Major of the 4th Cavalry and an officer highly esteemed by his superiors and men under him [*Phoenix Herald* 12 December 1888]."

Reed (1977:140) also mentions the death of Major Spaulding, and cites both the *Phoenix Herald* and the *Post Return* for December 1888. Reed (1977:140) makes it clear that Major Spaulding "left the garrison with Captain Charles A. P. Hatfield bound for Phoenix in a canoe."

In 1885 William Burch, John Meaders, John Meadows, Lew Robinson, and James Logan successfully boated the Salt from four miles above the Tonto Creek confluence to Phoenix. The men described their voyage in a series of articles in the *Arizona Gazette* (1885a, 1885b, 1885c, 1885d).

"A party of five men, including William Burch, John Meadows and Lew Robinson, started in a boat from near Eddy's ranch, yesterday morning, to explore Salt river canyon, said to be about 60 miles long and through which a boat was never known to pass. The rapids with numerous projecting boulders make the trip a hazardous one, but the party have a staunch craft, 18 feet long by five feet wide, and are confident of accomplishing the passage of the canyon without any mishaps. The object of the trip is to ascertain if logs could be floated through the canyon. If practical, Mr. Burch intends erecting a saw mill at the foot of the Sierra Anchas and floating the logs down the river to Phoenix [*Arizona Gazette* 1885a]."

"Yesterday James Logan, Wm. Burch, John Meaders and Wm. Robinson, composing the party of daring adventurers arrived in this city, having landed their craft at Tempe and coming into this city in six days after launching their boat. They report having enjoyed a most exciting and interesting trip. Through the box canon of the Salt river the banks frequently towered above them over 1,000 feet, and on one occasion they were wrecked, losing provisions, fire arms, etc. The object of the trip was to determine whether saw logs could be rafted to the lower Salt river, and the undisputed conclusion is that such work can be successfully carried on. In fact Mr. Burch, who is a sawpull man on the upper Salt river has partially contracted for the delivery at Tempe of over one thousand railroad ties. If experience should demonstrate that saw logs can be successfully floated from the timber regions to this portion of the Salt river, then the benefits derived from this exploration cannot be over-estimated [*Arizona Gazette* 1885b]."

The June 6 article was an interview with John Meaders, describing the adventures of the voyage.

"Timber exists in the Four Peak range in large quantities. Game and fish are most plentiful, the party having killed one mountain sheep and several deer, while they caught large quantities of Salt river trout--called by some white salmon. These fish closely resemble the lake trout of California but are not so game. Several of these fish, weighing eight and ten pounds, were caught by the explorers, but in previous instances fish of this species weighing forty pounds have been caught. The boat on one occasion shot under a cave, but a few feet high, and where its inmates commenced to fear that the end had come; here the fish were so thick that the boat floated on their backs.

They expected every minute to strike a waterfall and have their boat dashed to pieces, as they feared when they shot the cave. On one occasion their boat upset and much of their supplies were lost. In case of losing their vessel in the canon but one recourse would be left, that of swimming down the stream to a break in one bank or another and that might not be encountered for a distance of twenty miles [*Arizona Gazette* 1885c]."

The stream was described as being six to twenty feet deep, with no driftwood or other debris in it. The success of the voyage demonstrated to the *Gazette* that "it will open to this valley the timber belt of the Sierra Anchas which is undoubtedly the best and most extensive in the territory."

On June 8 the *Gazette* reported that, according to Postmaster Mowry, a trip through the canyons of the Salt (this one on foot, during a period of low water) had been made eight to ten years before by Frank Middleton and his brother in-law, George Shute (*Arizona Gazette* 1885d).

According to Scott Soliday, research historian at the Tempe Historical Museum, an article in the *Mesa Free Press* of 1890 or 1891 describes how, after Fort McDowell was abandoned, A. J. Chandler had logs or sawn timber from the fort floated down the Verde and then used in the headgates of the Consolidated Canal (Scott Soliday, personal communication to Douglas Mitchell, 12 August 1993). (This article has not been located.)

In 1910 Roy Thorpe and James Crawford took a rowboat trip from Roosevelt Dam to Mesa. They boated the Salt River until they arrived at Granite Reef, after which they floated the South Canal and the Mesa Canal. According to the *Arizona Republican*,

> "The row boat which was used throughout the journey was in a very dilapidated condition at the end of the trip. Before the start was made three bottoms had been placed in the craft and one of these had been worn through by the constant friction with the boulders and sands found in shallow waters. Many times the men were compelled to lift their craft from the water and carry it over obstacles and at other times had to haul it along the stands....The men are well pleased with their adventure, but have no serious intention of attempting to go into competition with the stage company, nor did they attempt to break any speed regulations [*Arizona Republican* 1910)."

Behan (1988a:18, Figures 2 and 3) contains two photographs that illustrate recreational boating on the Salt River, although neither one is identified as to location. Figure 2, which was taken from Seargeant (1960:94-95), shows a boy in a canoe. According to Behan's (1988a) notes, Seargeant describes swimming in the Salt before the construction of the dams. A postcard (CP CTH 2064) postmarked December 17, 1918, in the Carl Hayden Photograph Collection (1918), Arizona State University, Hayden Library, Special Collections, shows three people in a rowboat on the Salt River, Arizona. The same photograph was published in the early 1900s magazine *Arizona* (1910). It is also reproduced in Behan (1988a:Figure 2). The general terrain pictured suggests that it was taken above Granite Reef Dam, perhaps in the Roosevelt area. The Barry Goldwater Collection in the Arizona Historical Foundation contains a photograph (G-554) from about 1900 that shows four people on a boat at the confluence of the Salt River and the Verde River. A dog on shore is watching them. This photograph was published in Beasley (1908:4) with the caption "At the Junction of the Verde and the Salt."

Boats were commonly used in the construction of dams and canals. Photographs CP MCL 97342.A3 and CP MCL 97343.A3 in the Herb and Dorothy McLaughlin Photographs (1885), Arizona State University, Hayden Library, Special Collections, show a flatboat being used in the river during construction of the Arizona Canal, circa 1885. (The original photograph is in the Arizona Department of Library and Archives Collection, Archives 3 [Rothrock and Barnett file]). The dredge used by the U.S. Reclamation Service to enlarge the Arizona Canal is depicted in a published photograph in Brown (1978:79). This photograph shows a steam dredge floating down the canal with the Salt River in the background.

On February 17, 1909, during construction of Granite Reef Dam, three men drowned. Sixteen men were crossing the lake in two boats, and one of the boats capsized (Zarbin 1984:195, 1986:83).

During construction of Roosevelt Dam, boats were used to transport workers, materials, and equipment, as well as to cross the stream. Although a suspension bridge was built across the river, boats were still used, and when the bridge was destroyed by flood on November 27, 1906, boats had to be used to cross the stream until the bridge was rebuilt (Zarbin 1984:118). In October of 1908, dry weather left boats grounded on the banks of Tonto Creek (Zarbin 1984:187-188), but later that year, S. S. Thompson, the Roosevelt correspondent for the *Arizona Republican* reported:

> "The government launch has been kept busy, and Mr. Depew, who has been finding time hanging heavily on his hands on account of the lack of water to run his boat, has had to work overtime to fill all demands that have been sprung upon him. A boom has been stretched across the river above the dam to impound lumber, houses and driftwood...from going over the dam [Thompson 1908 cited in Zarbin 1984:190]."

In December, "The gasoline launch on the lake was kept busy carrying people and mail across the lake" (Zarbin 1984:191).

In 1908 George Greenwald was drowned while rafting down the Salt River toward Roosevelt Dam (Rogge, Keane, and McWatters 1994:229). The reservoir had begun to fill during the February floods of that year (Rogge, Keane, and McWatters 1994:235).

> "In February 1908, the head carpenter for the Reclamation Service at Roosevelt floated a raft of lumber down the Salt River with two other men. As they approached the half-finished dam, they intended to guide the raft through the tunnel at the south end of the dam. Instead, the raft drifted too far north, into the main current of the Salt River. Two men jumped off the raft and swam to safety, but 33-year old

George Greenwald stayed on the raft and attempted to save the lumber. The rushing current swept the raft and Greenwald downriver, between the northern edge of the dam under construction and the canyon wall. Greenwald made no attempt to reach for a rope thrown to him from a bridge suspended between the dam and the north wall of the canyon. As the raft tipped over the stones at the downstream side of the dam, Greenwald lost his footing and drowned. The California man had been employed at Roosevelt for several years where he married Selma Johnson of Phoenix, and had been living with her and a child in Roosevelt (Arizona Republican 12 Feb 1908[a]:10, 19 Feb 1908[b]:3; Zarbin 1984:169) [Rogge, Keane, and McWatters 1994:229]."

In 1909 one of two engineers using a boat to inspect tunnels in Roosevelt Dam drowned. In this case, the boats were floating on a temporary impoundment created by constructing a dam across the mouth of the tunnel (Zarbin 1984:200).

Prior to construction of the Salt River Bridge at Roosevelt Lake, a barge was used to cross the lake at the upper end. This barge is illustrated in Anderson and Anderson (1976:30). During the construction of Horse Mesa Dam (1924-1927), floating "clamshell" derricks were used to dredge sand and gravel, which were dumped into scows and towed by tugboats to the dam site (Douglas et al. 1994:55). Douglas et al. (1994) provide a little more detail on this process:

"A method unique to Horse Mesa, however, was the use of "clamshell" derricks to gather sand and gravel from upstream beds to use in mixing concrete for the dam (Figure 2-8). Excavated sand and gravel was dumped onto large scows that were towed to the dam site by tugboats purchased by the [Salt River Water Users'] Association in San Francisco [Douglas et al. 1994:55]."

Recreational rafting of the Salt River Canyon above the Tonto Basin appears to have begun after World War II, when rubber rafts became available to the public. According to Nelson (1990),

"The Theodore Roosevelt Council of the Boy Scouts of America and the Sierra Club began organizing Salt River trips in the late 1950s....The early adventurers used Army or Air Force surplus rafts, running the river at water levels as low as 400 and as high as 3000 cubic feet per second [Nelson 1990:60]."

Current floating of the Salt River is described in a number of guidebooks (Anderson and Hopkinson 1987:121-122; Rink 1990) and articles (Annerino 1983; Jackel 1986; Johnston 1994; *Outdoor Arizona* 1976; Parker 1973; Plachecki 1990). Anderson and Hopkinson (1987:121) state that the section above U.S. Route 60 is suitable for kayaks and recommend putting in where Arizona Route 9 crosses the Black River, 5 miles above the confluence of the Black and White rivers. Anderson and Hopkinson (1987:121-122) consider the section from U.S. 60 to Roosevelt Reservoir to be one of the premier floats in the Southwest. Anderson and Hopkinson (1987:122) do not recommend floating the Salt River below Roosevelt Lake, noting, "Below Roosevelt Reservoir the river is almost back-to-back dams all the way to the Phoenix suburbs....Boaters living in the immediate vicinity sometimes play the out-wash eddies of the dam spillways for an hour or so in the afternoon when the dams are releasing." Weir (1981:275) describes inner-tubing the Salt River from Stewart Mountain Dam to Granite Reef Dam, a popular enough route to support at least one commercial outfitter.

In late 1993 eight men blew up Quartzite Falls on the Salt River above the mouth of Cherry Creek (Dean 1994; Yozwiak 1994a, 1994b). All were indicted and later pleaded guilty of destruction of government property or to being an accessory after the fact (*Arizona Republic* 1994; Yozwiak 1994b).

SUMMARY AND CONCLUSIONS

Historical accounts of the upper Salt River indicate that it flowed year-round, although it fluctuated seasonally. The canyons above and below the Tonto Basin were generally viewed as difficult of access. Settlers began to establish small farms and ranches, primarily in the Tonto Basin, in the 1870s. Major diversions from the stream began in 1885, when the Arizona Diversion Dam was completed. Roosevelt Dam was constructed between 1903 and 1911. Despite these diversions and impediments to navigation, Charles Hayden attempted (unsuccessfully) to float logs down the upper Salt River in 1873, and at least seven other instances of boating (in canoes, a canvas skiff, a rowboat, and other small craft) on the upper Salt River during the period from 1883 to 1910 have been documented. Moreover, boats and rafts were commonly used in dam construction. Nonetheless, most transportation along the river and in the region surrounding the river was overland throughout the historic period.

A NOTE ON SOURCES

Many of the primary sources on upper Salt River history are published and are available at the three major research libraries in the state: the University of Arizona library, the Hayden Library at Arizona State University, and the Cline Library at Northern Arizona University. The Flagstaff Public Library also has many of the key references and a good collection of community histories from towns along the river. Each of the research libraries has useful photographic collections (see Appendix B). The Special Collections of the Cline Library include photographs owned by Northern Arizona University as well as the photographic collections of the Northern Arizona Pioneers Historical Society. The Hayden Library houses photograph collections of Arizona State University and the Arizona

Historical Foundation. The Salt River Project maintains archives that are important in documenting the history of the Salt and other rivers. The Cline Library at Northern Arizona University and the library of the Museum of Northern Arizona have secondary sources, but with regard to the Salt River, duplicate the holdings of the libraries at the University of Arizona and Arizona State University. It should be noted that the computerized card catalog at the Cline Library at NAU can access the collections of the other university libraries in Arizona.

General histories of Arizona (Bancroft 1888, 1889; Farish 1915; Hamilton 1928; Lockwood 1932; McClintock 1916a, 1916b; Wallace W. Elliott & Co. 1884) began to appear in the 1800s. At about the same time, promotional literature and guidebooks (Guild 1891; Hamilton 1884; Hinton 1878; Hodge 1877; James 1917) were published that provide contemporary descriptions of rivers, towns, mining, agriculture, transportation, and so forth.

More recent histories of Arizona include Faulk (1970), Trimble (1977, 1986), Wagoner (1970, 1975, 1977). Walker and Bufkin's (1986) historical atlas is extremely useful. Granger (1960, 1983, 1985) provides histories of Arizona place names. Often inaccurate, these books are nonetheless useful introductions to general historical patterns in a region. Davis (1982) is a good summary of the wildlife encountered by the earliest explorers of various parts of Arizona. The history of Mormon settlement in Arizona is covered by McClintock (1921).

General works on the history of the Salt River include Behan (1988a, 1988b), Lacy et al. (1987), Myers (1956), and Nelson (1990). Perhaps the two most thoroughly researched themes in the history of the upper Salt River are the Apache wars and the construction of dams.

The ethnography and history of the Apache are recounted in Basso (1983), Gunnerson (1956, 1974), Opler (1983), and Wilcox (1981); Gifford (1936) and Khera and Mariella (1983) discuss the Yavapai. Ferg (1992) and Hohmann and Rink (1990) summarize both groups.

The Spanish period is discussed generally in Officer (1987). Winship (1892-3, 1990) published the primary sources on the Coronado Expedition. The National Park Service (1991) completed a study of Coronado's route. Other references specific to the history of the Salt River during the Spanish period include Bolton (1936) on Kino, Coues (1900) and Garcés (1900) on Garcés, Dunne (1955) and Sedelmayr (1955) on Sedelmayr, Pfefferkorn (1949, 1989), and Wyllys (1931) on Velarde.

The history of the fur trade in the Southwest has many students, although the primary documents are almost hopelessly inexact about dates and personnel. Hafen (1965) edited a ten-volume set of biographical sketches of individual mountain men involved in the fur trade. Weber (1971) is a general history of the fur trade in the Southwest. Pattie (1831, 1905, 1930, 1988) is the primary source on James Ohio Pattie's story of his years in the

Southwest. Pattie is also discussed in Hill (1923a) and Kroeber (1964). Hill (1923b) and Holmes (1967) are biographies of Ewing Young. Carter (1968) is a biography of Kit Carson. Biographies of George C. Yount include Camp (1936, 1966), Wood (1941), and Yount (1923). Foreman (1941b, 1941c) and Parkhill (1965, 1966) have published biographies of Antoine Leroux. Templeton (1965) has published a biography of Thomas "Pegleg" Smith.

The Apache wars have an immense bibliography. Among the sources used in this study are Ball (1970), Bourke (1891), Corbusier (1971), Crook (1946), Goff (1981), Ogle (1940), Reed (1977), Stein (1984), Thrapp (1964, 1967), Woodward (1961), and Woody (1962).

Contemporary accounts of the construction of Roosevelt Dam include Barrows (1913), Beasley (1908), Fitch (1914), Palmer (1979), and Snyder (1905). Histories of Roosevelt Dam and the Salt River Project include Row and Sonnichsen (1977), Peplow (1979), Pollard (1945), Robinson (1979), Salt River Project (1966), C. Smith (1972), K. Smith (1981, 1986), Worster (1985), and Zarbin (1984, 1986). Zarbin (1984) used newspaper articles from the early 1900s to construct an almost day-by-day account of the construction of Roosevelt Dam. Brown (1978) discusses the history of the construction of Granite Reef Dam. Zarbin (1986) also has a good section on Granite Reef Dam. Prior to the raising of Roosevelt Dam, numerous historical and archaeological studies were conducted to document the dams and sites associated with dam construction. All of these studies are synthesized in Rogge, Keane, and McWatters (1993) and Rogge et al. (1994). The construction of Roosevelt Dam is described by Ayres et al. (1994), Hantman and McKenna (1985), and McKenna and Hantman (1985). Douglas et al. (1994) discuss the construction of the Mormon Flat, Horse Mesa, and Stewart Mountain dams.

Community histories have been written about Globe (Anderson and Anderson 1976; Bigando 1990; Haak 1991; Woody and Schwartz 1977) and the Tonto Basin (Anonymous n.d.; Croxen 1926; Hazelton n.d.; LeCount 1976). Ciolek-Torrello and Welch (1994) summarize general historical information on the Tonto Basin. The history of ranching in Arizona is summarized in Haskett (1935, 1936).

Modern boating along the Salt River is described by Anderson and Hopkinson (1987), Annerino (1983), Jackel (1986), Johnston (1994), *Outdoor Arizona* (1976), Parker (1973), Plachecki (1990); Rink (1990), and Weir (1981). The story of the destruction of Quartzite Falls is told in *Arizona Republic* (1994), Dean (1994), and Yozwiak (1994a, 1994b).

Newspapers are an extremely important source of information on the history of river use. Newspapers are on microfilm at the State Library and Archives (as well as at the University of Arizona library, the Hayden Library at Arizona State University, and the Cline Library at Northern Arizona University). The State Library and Archives has a listing of all of the newspapers published in the state. Earl Zarbin has examined Arizona newspapers published between 1859 and 1918 and compiled an index of articles relating to water in Arizona (Zarbin n.d.). Mary Lu Moore, historian with the State Attorney General's Office, has a copy of this index. The *Arizona Gazette, Arizona Republic, Arizona Republican, Mesa Free Press, Phoenix Gazette, Phoenix Herald, Tempe News, Tombstone Daily Prospector*, and *Arizona Weekly Miner* were among the newspapers found to have articles relevant to the history of the use of the Salt River.

Many of the museums and libraries around the state maintain collections of photographs. Among the most extensive are those of the libraries of the state universities, the state historical societies, the state library and archives, and the Salt River Project, mentioned above. The Arizona Historical Foundation has a separate catalog of photographs in its collection.

UPPER SALT RIVER CHRONOLOGY

1540 Coronado may have crossed the Salt River within the study reach (National Park Service 1991).

1698 Fr. Eusebio Kino calls the river the Rio Salado, but also says that he was naming it after the evangelist Matthew (Bolton 1936:422).

1736-7 Fr. Ignacio Xavier Keller calls the junction of the Salt and the Verde the Rio de la Asunci\n (Granger 1983:541).

1744 Fr. Jacobo Sedelmayr also uses term Rio de la Asunci\n (Granger 1983:541).

1766 Salt River called Rio Compuesto (Put-Together River) by an anonymous Jesuit priest (Granger 1983:541).

1775 Fr. Francisco Garcés called the Salt the Rio de la Asumpci\n (Coues 1900:139; Garcés 1900:110-111, 139-140).

1821 Mexican Independence

1820s Fur trappers along the Salt

1846-8 Mexican War

1849 Collier, Thorne, and Beckwith pass through the upper Salt River valley on what would later be known as Beckwith's Route (Foreman 1941c:12).

1851 "Lt. Parke mapped it as Rio Salines" (Granger 1983:541).

1852 "By 1852 it was called the Salado, Salinas or Salines River" (Granger 1983:541).

1864 "Battle" of Bloody Tanks, January 24, 1864, in which King S. Woolsey and party massacre a group of Apaches after treacherously inviting them to dinner (Granger 1960:97). Haak (1991:3) says that this occurred on June 8, 1864, at the confluence of the Salt River andTonto Creek.

1864 King S. Woolsey's third expedition, June 1864 (Granger 1960:104).

1865 Camp McDowell established (Granger 1960:187).

1867 Camp McDowell renamed Fort McDowell (Granger 1960:187).

1867 Site selected for Camp Reno on Tonto Creek (Haak 1991:4) approximately 15 miles above confluence of Tonto Creek and Salt River (Reicker 1879).

1868 Road completed from Fort McDowell to Camp Reno and camp constructed (Haak 1991:4-5).

1869 Major Andrew Alexander of Fort McDowell leads a "campaign of extermination" against the Apaches (Haak 1991:5).

1869 A. F. Banta prospects in the Globe area (Haak 1991:8).

1870 Camp Ord established, renamed Camp Mogollon, then Camp Thomas later that year (Granger 1960:233; Walker and Bufkin 1986:37).

1870 General George Stoneman establishes Picket Post Camp and has his men make bricks from a nearby clay deposit (Woody and Schwartz 1977:12).

1871 Camp Thomas renamed Camp Apache (Granger 1960:233; Walkerand Bufkin 1986:37).

1871 Prospector named Miner reportedly finds silver near a hat-shaped peak, prompting the Safford expedition. Led by Territorial Governor Anson P. K. Safford, 250 men explore the area around Sombrero Butte and much of the Tonto Basin without success (Haak 1991:8; Woody and Schwartz 1977:14).

1871 General George Stoneman establishes Camp Pinal (Haak 1991:8).

1871 General George Crook leads cavalry from Camp Apache to Prescott over route that later (1872-4) becomes the General Crook Trail (Weir 1981:181).

1872 White Mountain and San Carlos Indian reservations established (Thrapp 1967:111; Woody and Schwartz 1977:19).

1872-3 Crook's campaign against the Tonto Basin Apaches (Thrapp 1967).

1872 Major William Brown attacks Yavapai Apache at Apache Cave (also called Skull Cave or Skeleton Cave) on December 27, 1872 (Granger 1983:23).

1873 George M. Wheeler calls the Salt the Prieto (Black) River and the Salt River (Granger 1983:541).

1873 Globe Ledge silver deposit discovered in Alice Gulch, near present-day Globe (Granger 1960:103; Haak 1991:10).

1875 1500 Yavapai Indians concentrated at Camp Verde, then marched to San Carlos.

1875 Four men hauling ore from the Globe Ledge to Florence find the silver deposit first reported by Sullivan in 1871 that becomes the Silver King Mine (Haak 1991:9).

1876 Charlie McMillan and Dore Harris discover Stonewall Jackson silver deposit, establish McMillanville (Nelson 1990:58).

1879 Camp Apache renamed Fort Apache (Granger 1960:233).

1880 Gila County created from portions of Maricopa and Pinal counties. Globe selected as county seat (Haag 1991:1).

1881 Apache uprising following arrest of mystic Noch-ay-del-Klinne at Cibecue (Woody and Schwartz 1977:51-64).

1883 Adolph Bandelier visits the Tonto Basin from May 23 to June 1 and describes ruins and existing conditions (Bandelier 1892:419-428; Lange and Riley 1970:110-121).

1885 Arizona Diversion Dam, at the future site of Granite Reef Dam, completed (Rogge, Keane, and McWatters 1994:7).

1889 1500 square miles of land north of Salt River transferred from Yavapai County to Gila County (Haag 1991:2).

1889 William M. Breakenridge, James H. McClintock, and John R. Norton survey locations for dams along the Salt River and identify locations of Roosevelt, Stewart Mountain, Mormon Flat, and Horse Mesa dams (Salt River Project 1979:52-54).

1891 Fort McDowell abandoned (Granger 1960:187).

1896 President McKinley creates Black Mesa Forest Preserve (Haskett 1936:36). By 1908 divided into Apache National Forest (Greer, Springerville, Blue River, and Clifton) and Sitgreaves National Forest (everything north) (Applewhite 1979:52).

1903 Salt River Water Users' Association formed (K. Smith 1986:38).

1905 Roosevelt Dam begun (Lacy et al. 1987:19). (Nelson [1990:59] says from 1907 to 1911.) Granger (1983:609) dates the construction of Roosevelt dam from 1906 to 1911. Salt River Project (1979:137) give dates of September 20, 1906, to February 6, 1911 (first stone to last stone).

1908 Granite Reef Diversion Dam constructed (Lacy et al. 1987:19).

1911 Roosevelt Dam completed (Salt River Project 1979:137).

1912 Statehood

1913 Fort McDowell Indian Reservation created by Executive Order (Granger 1960:187).

1915 Water goes over Roosevelt Dam Spillway for the first time (Granger 1983:609).

1917 Salt River Project created from Salt River Valley Water Users' Association (C. Smith 1972:17).

1923 Mormon Flat Dam begun (Granger 1983:422).

1924 Fort Apache turned over to the Indian Service (Granger 1960:233).

1925 Mormon Flat Dam completed, impounding Canyon Lake (Granger 1983:422).

1927 Horse Mesa Dam completed, creating Apache Lake (Granger 1983:308).

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1965 *The Lame Captain: The Life and Adventures of Pegleg Smith.* Westernlore Press, Los Angeles.

Thrapp, Dan L.
1964 *Al Sieber, Chief of Scouts.* University of Oklahoma Press, Norman.

1967 *The Conquest of Apacheria.* University of Oklahoma Press, Norman.

Trimble, Marshall
1977 *Arizona: A Panoramic History of a Frontier State* Doubleday, Garden City, New York.

1986 *Roadside History of Arizona* Mountain Press Publishing Company, Missoula, Montana.

U.S. Reclamation Service
1904 *Second Annual Report of the Reclamation Service.* House Document 44, 58th Congress, 2nd Session. U.S. Government Printing Office, Washington, D.C.

von Greenw., Westl. L.
n.d. Portion of historic map of the American Southwest, circa 1870. *Stieler's Hand_Atlas, No. 84.* Photocopy on file, SWCA, Inc., Environmental Consultants, Flagstaff.

Wagoner, Jay J.
1970 *Arizona Territory, 1863-1912: A Political History* University of Arizona Press, Tucson.

1975 *Early Arizona: Prehistory to the Civil War* University of Arizona Press, Tucson.

1977 *Arizona's Heritage.* Peregrine Smith, Santa Barbara, California.

Walker, Henry P., and Don Bufkin
1986 *Historical Atlas of Arizona* 2nd ed. University of Oklahoma Press, Norman.

Main theme: Excellent atlas based on the history of Arizona. Good maps show the location and dates for trails and railroads.

Wallace, Andrew
1984 Across Arizona to the Big Colorado: The Sitgreaves Expedition of 1851. *Arizona and the West* 26(4):325-364.

Wallace W. Elliot & Co.

1884 *History of Arizona Territory Showing its Resources and Advantages with Illustrations: Descriptive of its Scenery, Residences, Farms, Mines, Mills, Hotels, Business, Houses, Schools, Churches, Etc.* Wallace W. Elliot & Co., San Francisco.

Main theme: Detailed description of Arizona history from the first Spanish entradas to a description of its natural resources, early expeditions, missions, pioneers, Spanish territories, military campaigns, civil war in Arizona, public lands, counties, metals, Indians.

Weber, David J.

1971 *The Taos Trappers: The Fur Trade in the Far Southwest, 1540-1846.* University of Oklahoma Press, Norman.

Weir, Bill

1981 *Arizona Handbook.* Moon Publications, Chico, California.

Not to be trusted for historical information. Used primarily as a source of references on the General Crook National Recreation Trail. On page 275 Weir describes tubing the Salt River from Stewart Mountain Dam to Granite Reef Dam.

Welch, John R.

1994 Archaeological Studies of Agricultural Contexts. In *The Roosevelt Rural Sites Study: Changing Land Use in the Tonto Basin*, edited by Richard Ciolek-Torrello and John R. Welch, pp. 223-251. Statistical Research Technical Series No. 28, Vol. 3. Tucson.

Welch, John R., and Richard Ciolek-Torrello

1994 Nineteenth- and Twentieth-Century Land Use in the Tonto Basin. In *The Roosevelt Rural Sites Study: Changing Land Use in the Tonto Basin*, edited by Richard Ciolek-Torrello and John R. Welch, pp. 57-78. Statistical Research Technical Series No. 28, Vol. 3. Tucson.

Whipple, Amiel Weeks

1851 *Journal of an Expedition from San Diego, California to the Rio Colorado, from Sept. 11 to Dec. 11, 1849.* Senate Executive Document No. 19, 31st Congress, 2nd Session. Reprinted 1961, Westernlore Press, Los Angeles.

Describes the Collier-Thorne-Beckwith group, which traveled from Zuni to the Salt River, then went down the Salt and Gila to the Colorado.

Whipple, Amiel Weeks, Thomas Ewbank, and William Turner

1855 *Report Upon the Indian Tribes.* Part 3 of U.S. War Department Reports of Explorations and Surveys to Ascertain the Most Practical and Economical Route for a Railroad from the Mississippi River to the Pacific Ocean. U.S. Congress. Senate, 33rd Congress, 2nd session, Senate Executive Document No. 78 (Serial No. 752). Beverley Tucker, Washington, D.C.

Wilcox, David R.

1981 The Entry of Athapaskans into the American Southwest: The Problem Today. In *The Protohistoric Period in the North American Southwest, A.D. 1450-1700*, edited by David R. Wilcox and W. Bruce Masse, pp. 213-256. Anthropological Research Papers No. 24. Arizona State University, Tempe.

Wilhelm, C. LeRoy, and Mabel R. Wilhelm

1982 *A History of the St. Johns Arizona Stake: The Triumph of Man and His Religion over the Perils of a Raw Frontier.* Historical Publications, Orem, Utah.

Winship, George P.
1892-3 *The Coronado Expedition, 1540-42.* Fourteenth Annual Report of the Bureau of American Ethnology. U.S. Government Printing Office, Washington.

1990 *The Journey of Coronado, 1540-1542, translated and edited by George Parker Winship; introduction by Donald C. Cutter.* Reprinted. Fulcrum Publishing, Golden, Colorado. Originally published 1904 as *The Journey of Coronado, 1540-1542, from the City of Mexico to the Grand Canon of the Colorado and the Buffalo Plains of Texas, Kansas, and Nebraska, as told by himself and his followers*, translated by George Winship.

Wood, Ellen Lamont
1941 *George Yount, the Kindly Host of Caymus Rancho.* Grabhorn Press, San Francisco.

Woodward, Arthur
1961 Sidelights on Fifty Years of Apache Warfare, 1836-1886. *Arizoniana* 2(3):3-14.

Woody, Clara T.
1962 The Woolsey Expedition of 1864. *Arizona and the West* 4:167-176.

Woody, Clara T., and M. L. Schwartz
1977 *Globe, Arizona: Early Times in a Little World of Copper and Cattle* Arizona Historical Society, Tucson.

Worster, Donald
1985 *Rivers of Empire: Water, Aridity and the Growth of the American West.* Pantheon Books, New York.

Main theme: History of water in the West. In this book Worster shows how elites of wealth and technological power have controlled water in the West. An examination of the politics and development of water projects.

Wyllys, Rufus K.
1931 Padre LuRs Velarde's Relaci\n of PimerRa Alta, 1717. *New Mexico Historical Review* 6(2):111-157.

Yount, George C.
1923 The Chronicles of George C. Yount. *California Historical Society Quarterly* 2(1):3-66.

Yozwiak, Steve
1994a Outrage in the Wilderness: Salt River's Quartzite Falls Blown Up in "Vigilante Action." *Arizona Republic* 5 May:1, 10.

1994b 8 Indicted in Blasting of Falls on Salt: River-Rafting Guide, Others All from Valley. *Arizona Republic* 14 October:1, 19.

Zarbin, Earl

n.d. Index to Water-Related Articles in Early Central Arizona Newspapers, 1859 thru 1918. Ms. in possession of author and Mary Lu Moore, Historian, Arizona State Attorney General's Office, Phoenix.

1984 *Roosevelt Dam: A History to 1911.* Salt River Project, Tempe, Arizona.

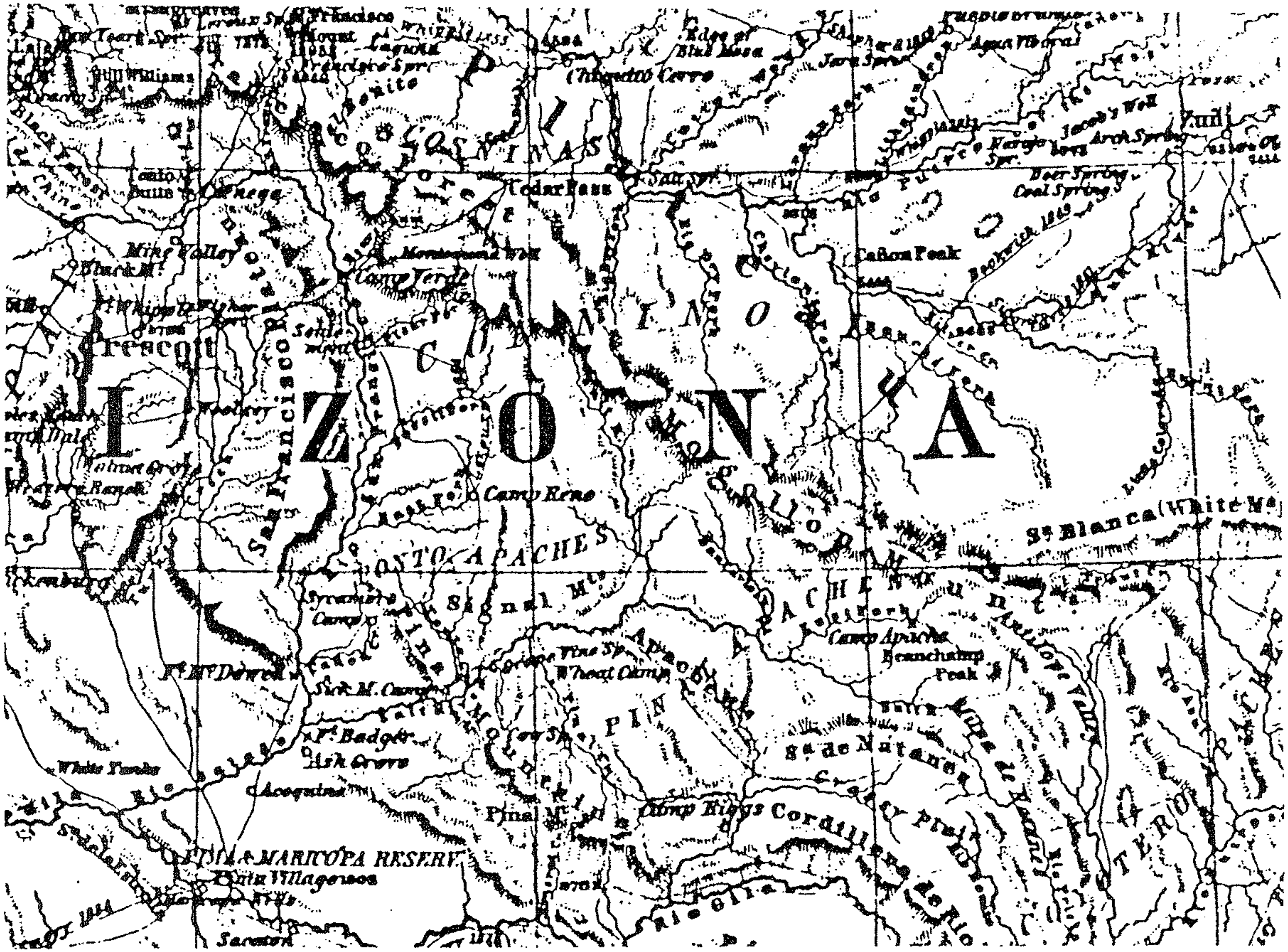
This history is based largely on newspaper stories and provides almost a day-by-day account of the construction of Roosevelt Dam.

1986 *Salt River Project: Four Steps Forward, 1902-1910* Salt River Project, Tempe, Arizona.

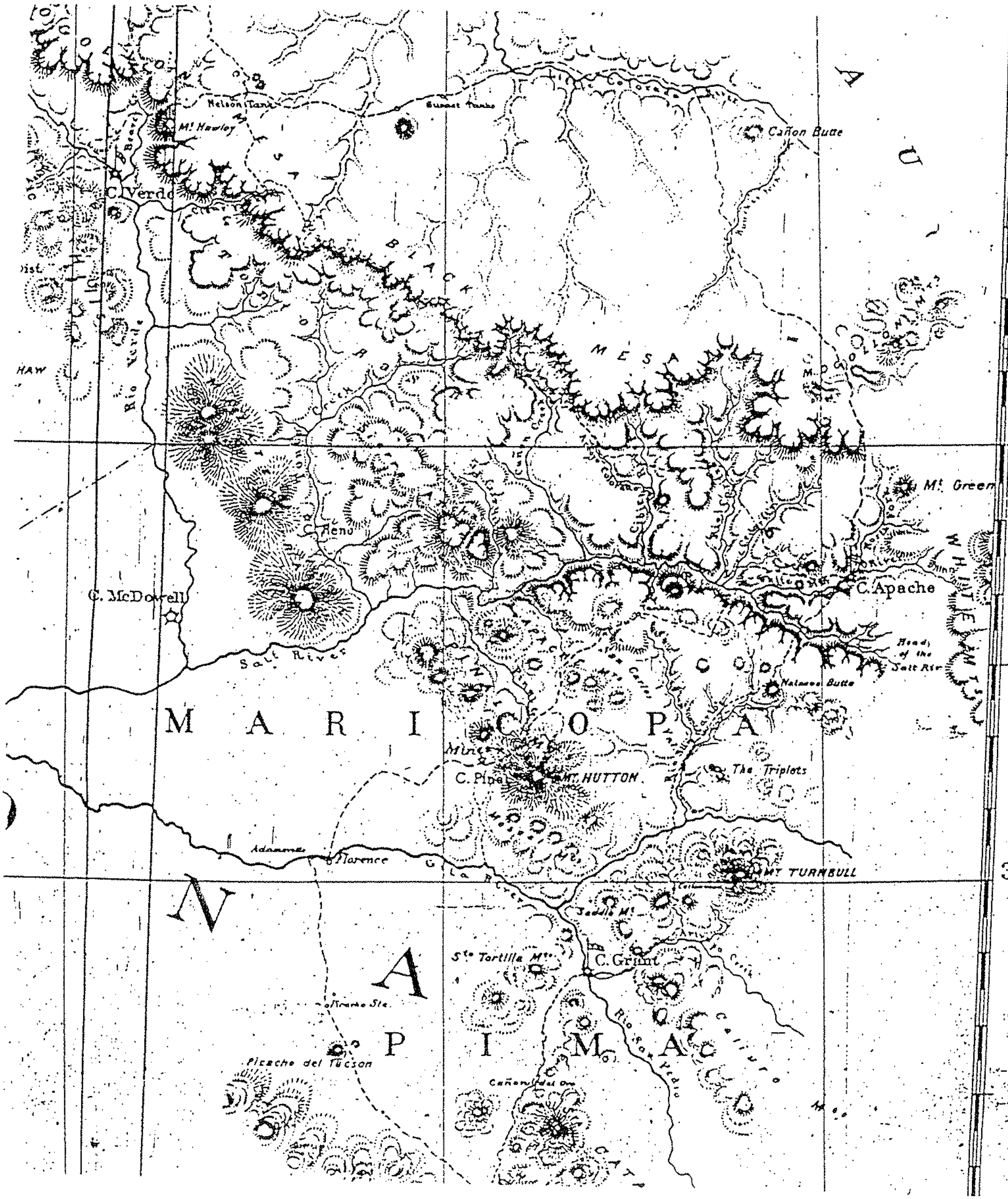
This is a detailed history of the Salt River Project with a section on the construction of Granite Reef Dam.

APPENDIX A

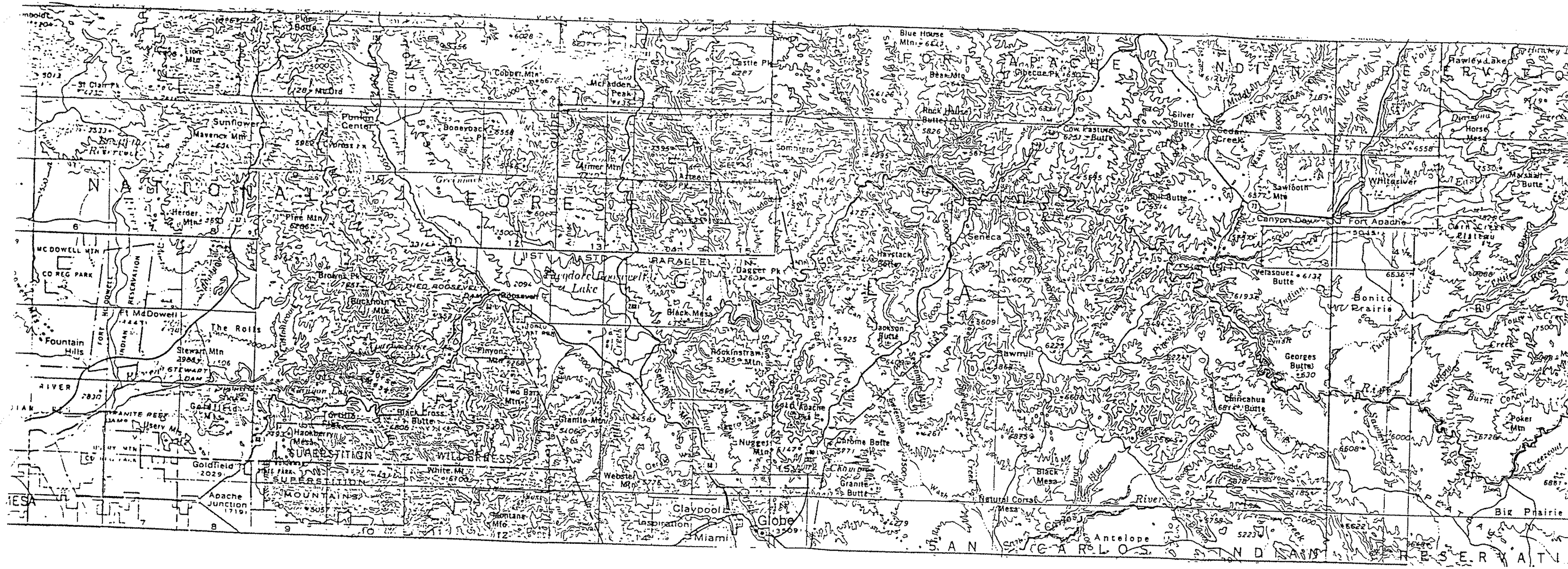
HISTORICAL MAPS OF THE UPPER SALT RIVER



Portion of historic map, circa 1870, showing upper Salt River (from Westl. L. von Greenw. n.d.).



Portion of historic map showing upper Salt River (from Reiker 1879).



Scale 1:500,000

1 inch equals approximately 8 miles

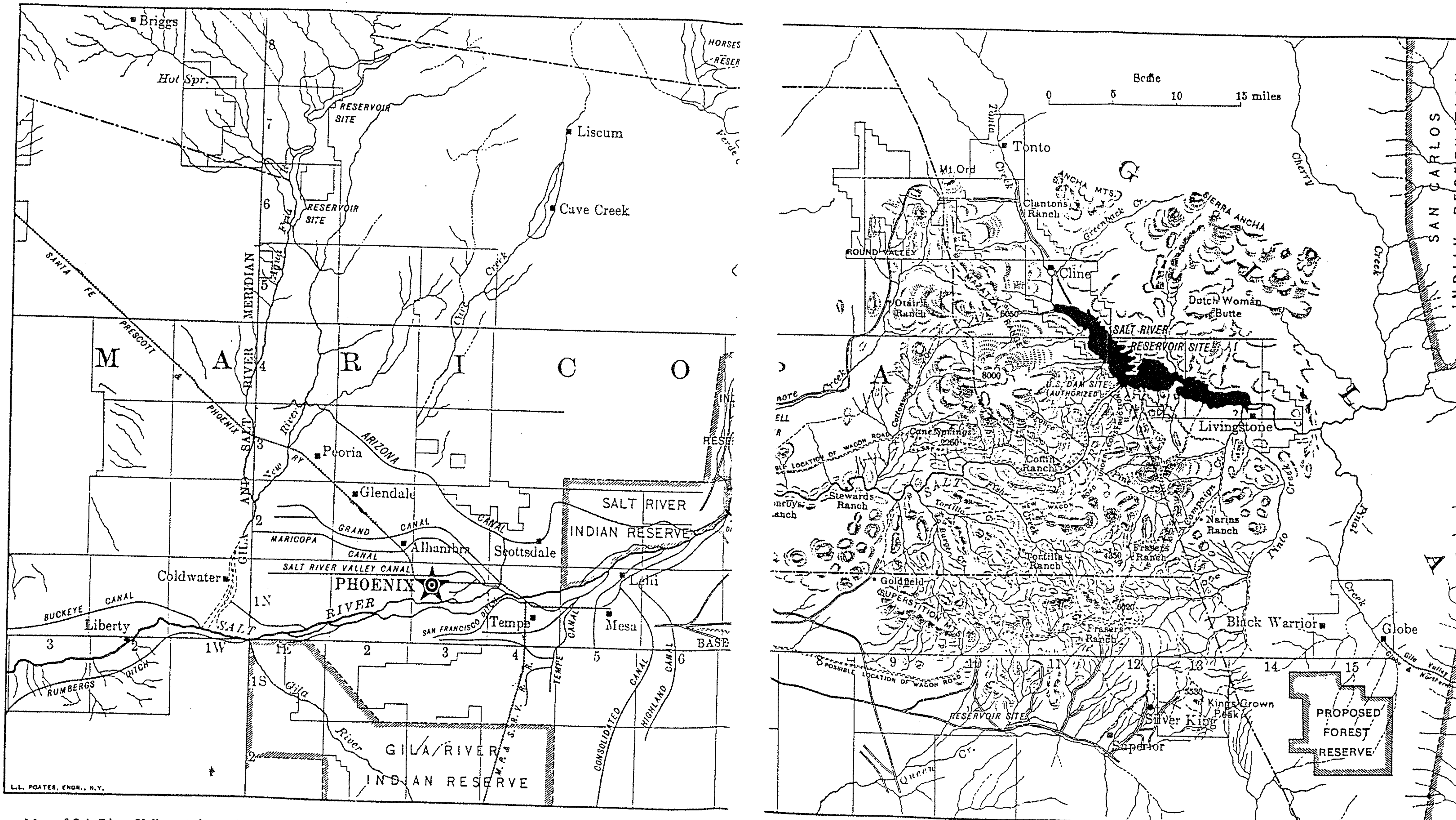
10 0 10 20 30 40 Miles

10 0 10 20 30 40 50 Kilometers

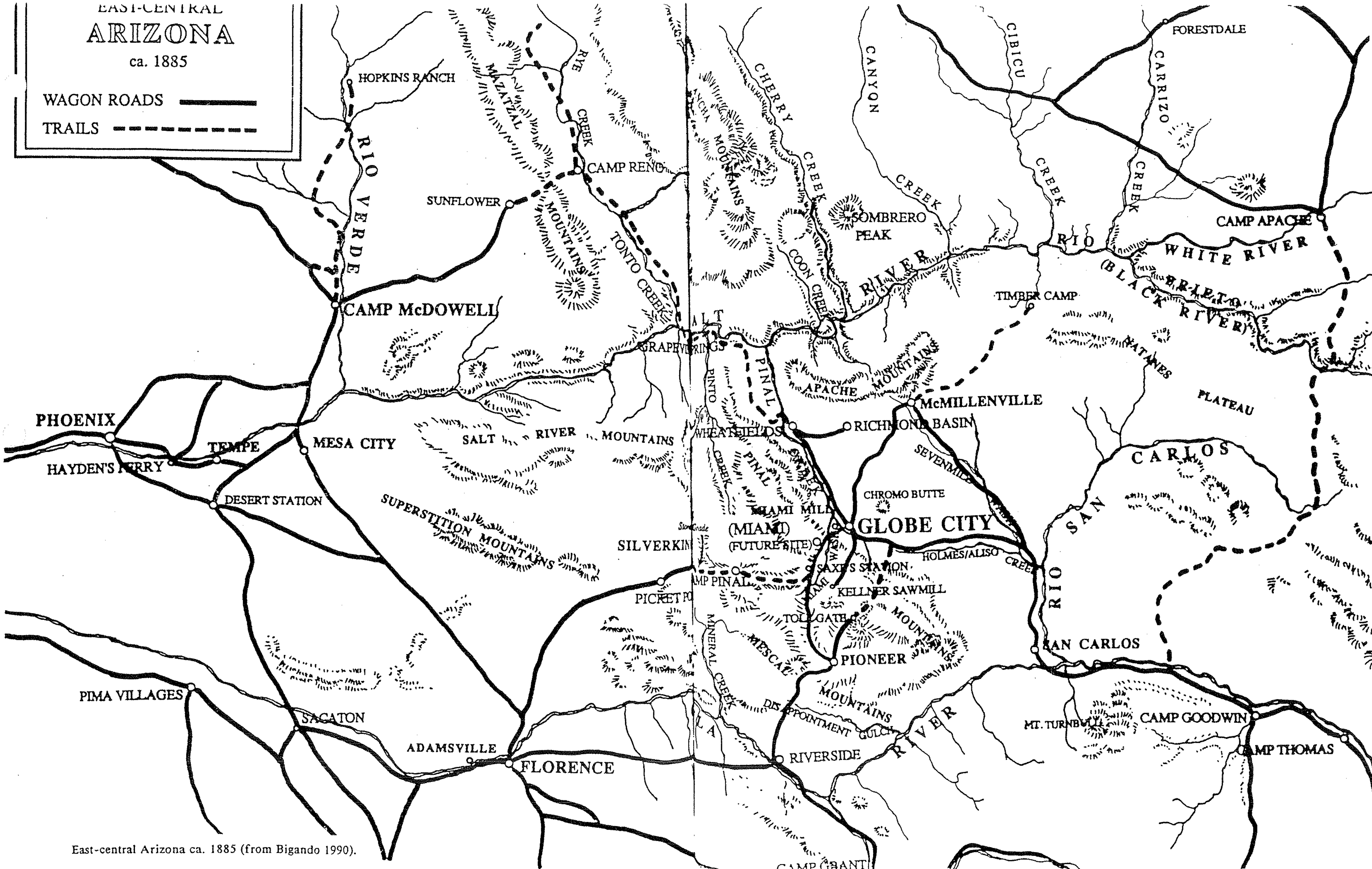
Contour interval 500 feet

Datum is mean sea level

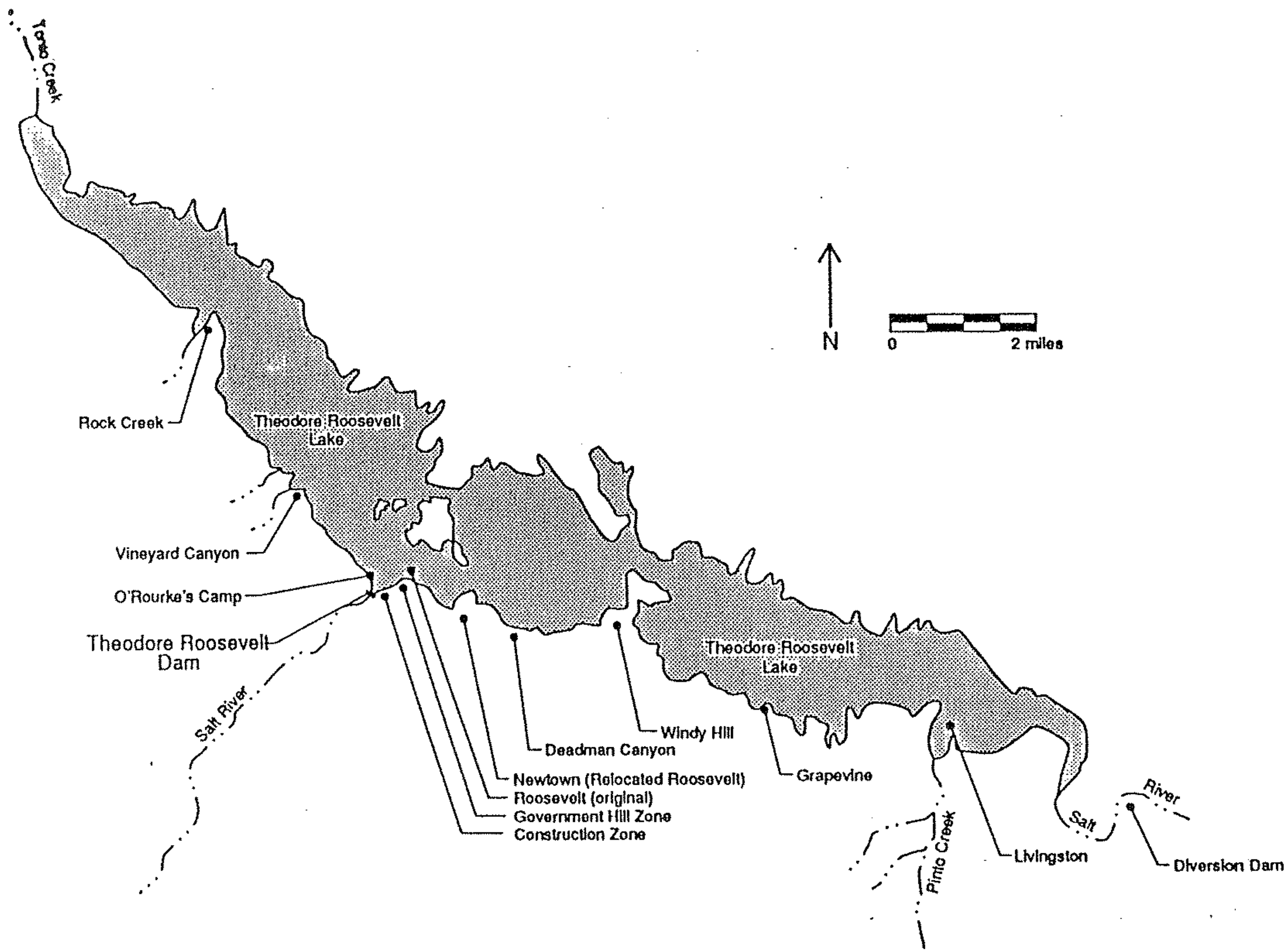
Detail of modern map showing upper Salt River (from State of Arizona, USGS, revised 1981).



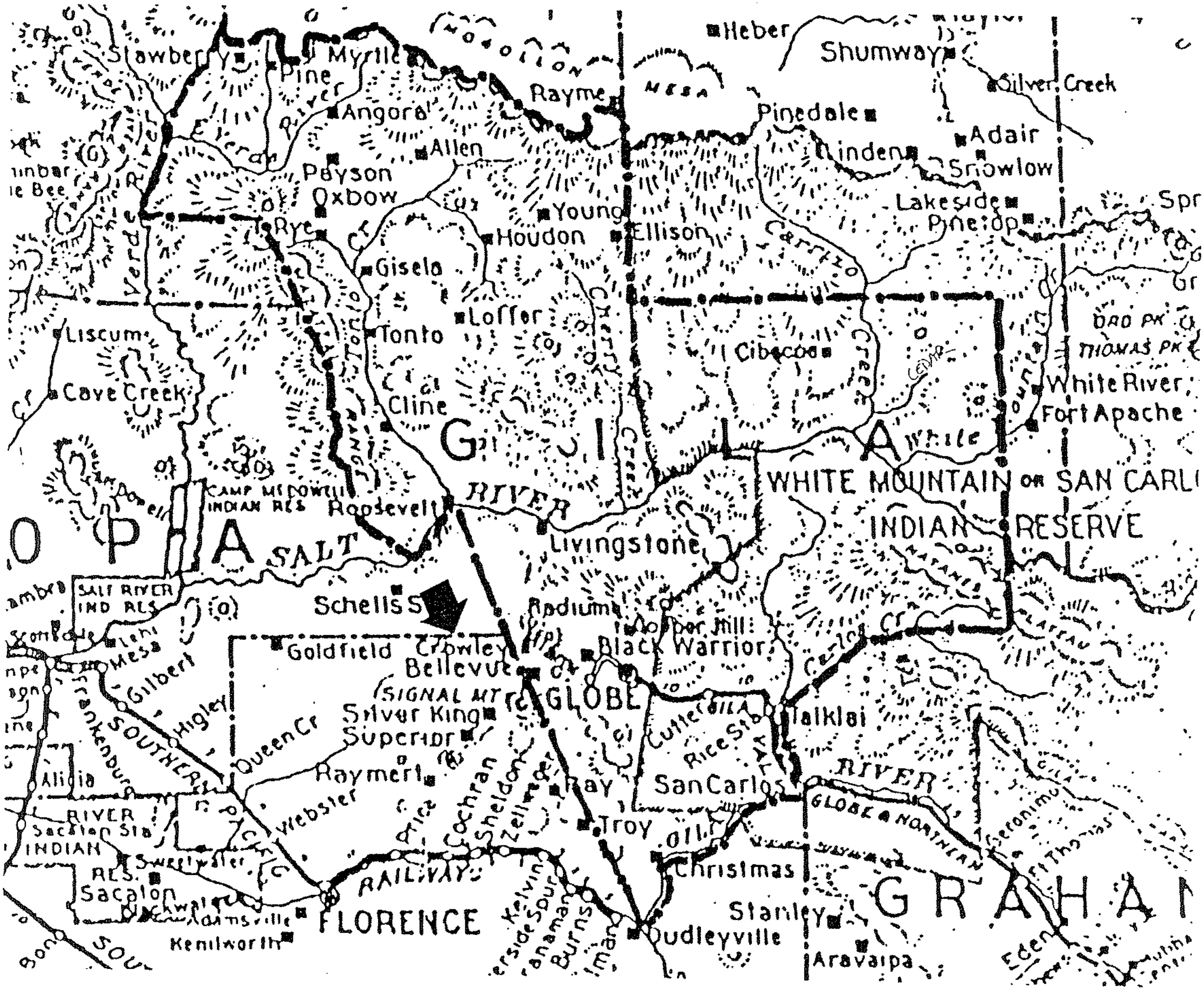
Map of Salt River Valley, Arizona (Zarbin 1984:frontispiece).



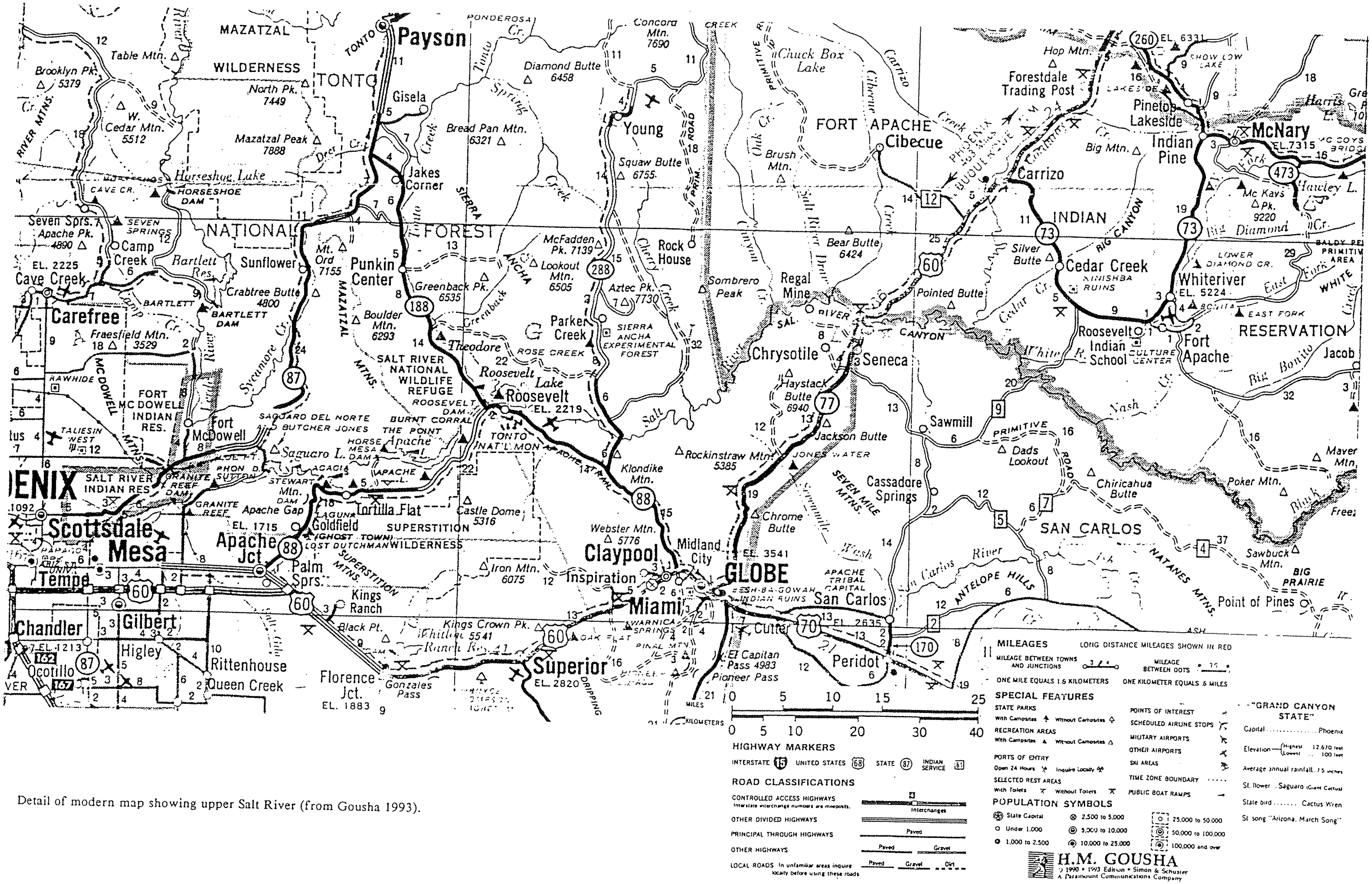
East-central Arizona ca. 1885 (from Bigando 1990).



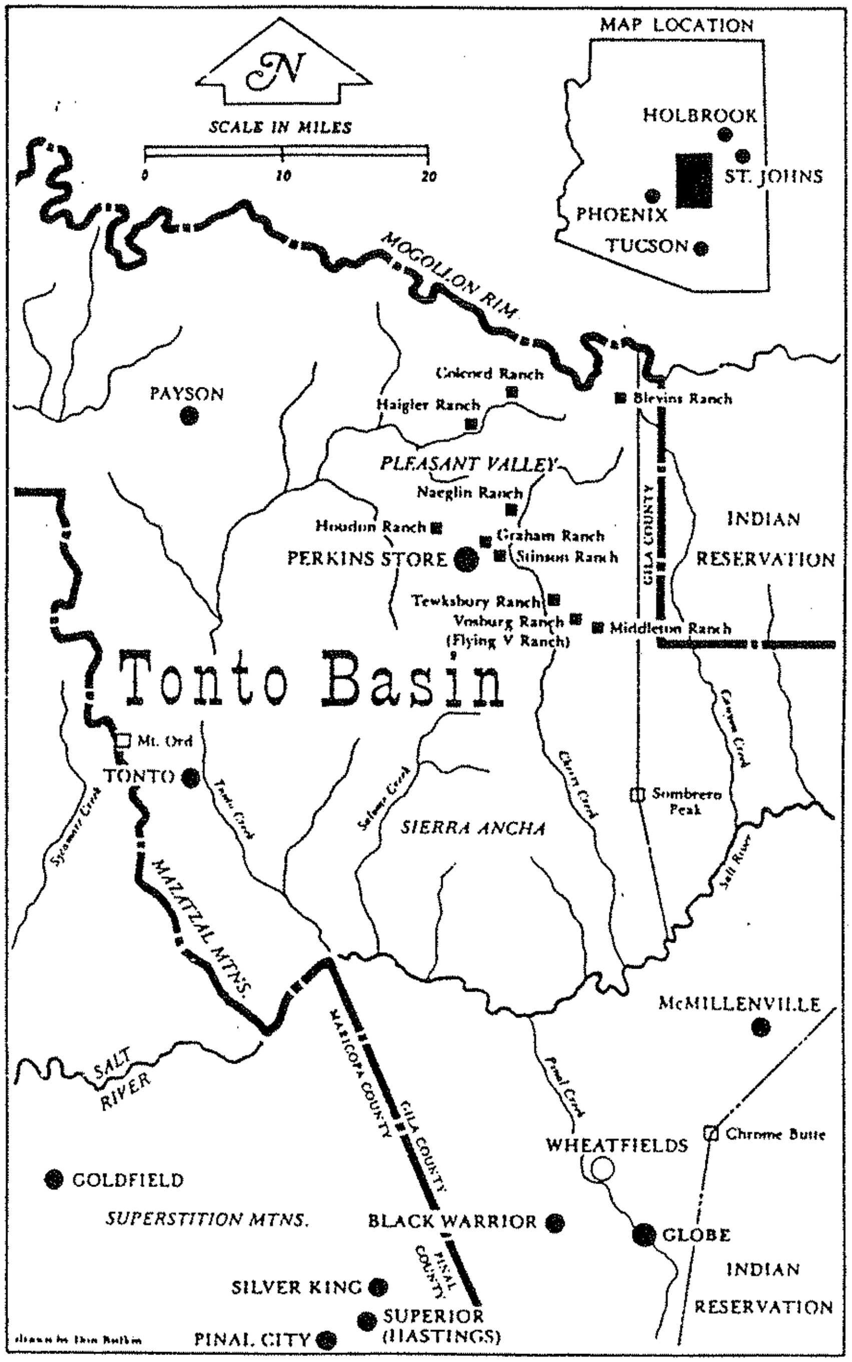
Historic site locations in Roosevelt Dam locale (Ayres et al. 1994:Figure 1-2).



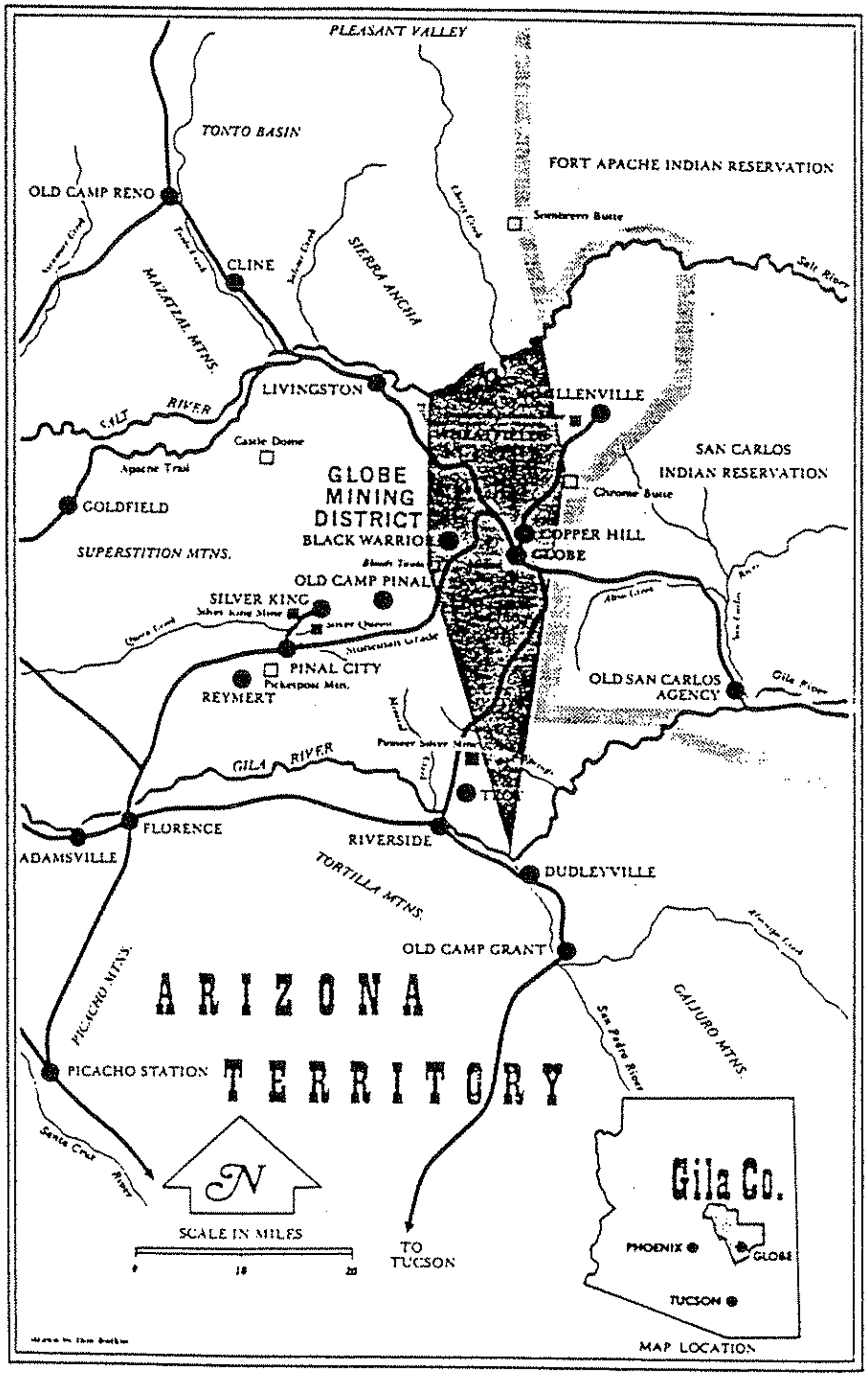
Gila County map, circa 1910 (from Haak 1991).



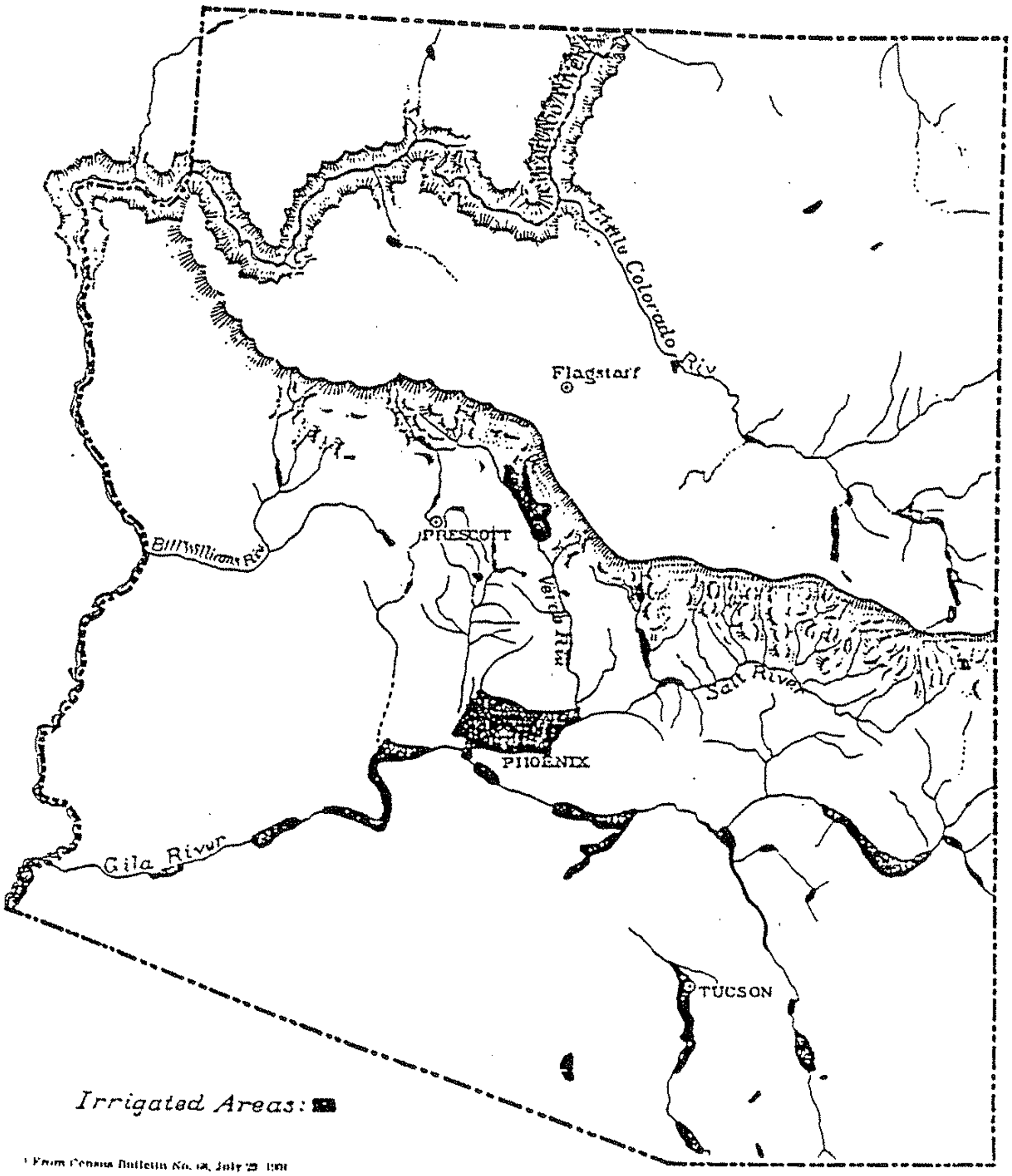
Detail of modern map showing upper Salt River (from Gousha 1993).



Map of the Tonto Basin (Woody and Schwartz 1977:100).

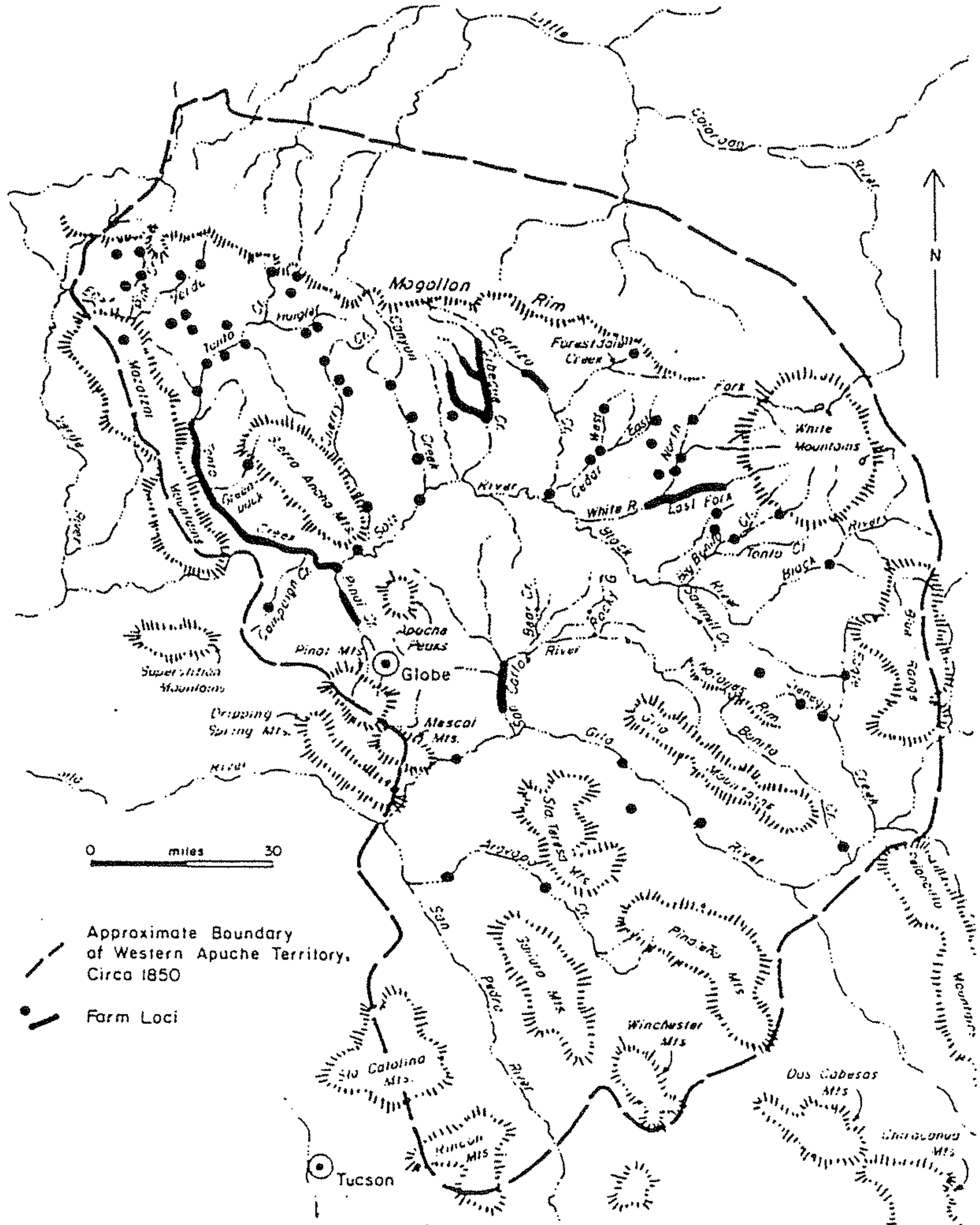


Map of Globe Mining District (Bigando 1990:10).



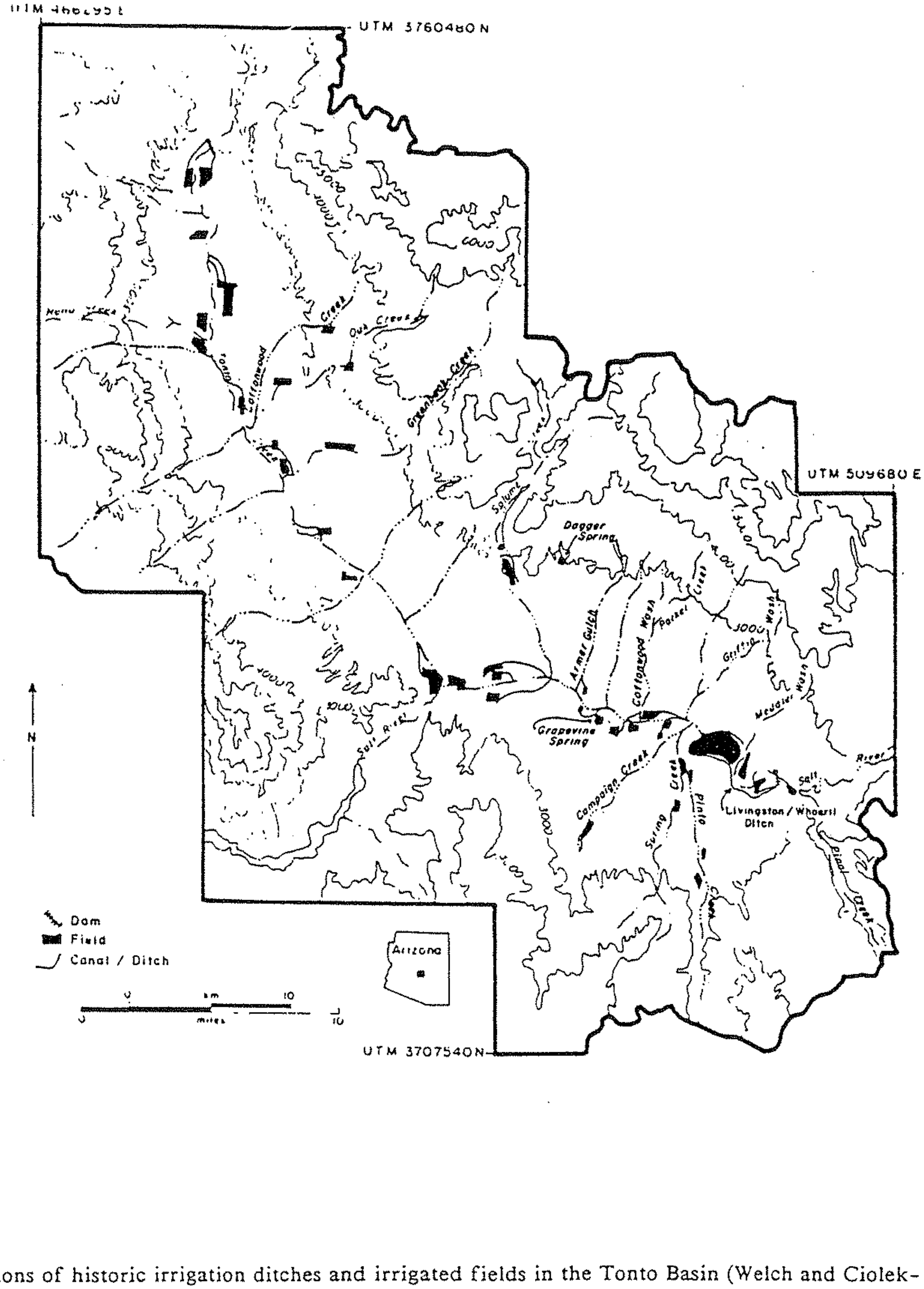
[1] From Census Bulletin No. 68, July 29, 1901

Map of irrigated areas in Arizona from Census Bulletin No. 68, July 29, 1901.



(After Pool 1985. Sources: Aschmann 1974; Bushkirk 1986; Goodwin 1942)

Locations of Western Apache farms in the Tonto Basin and adjacent areas (Welch and Ciolek-Torrello 1994:Figure 4.1).



Locations of historic irrigation ditches and irrigated fields in the Tonto Basin (Welch and Ciolek-Torrello 1994:Figure 4.2).

APPENDIX B

INVENTORY OF HISTORICAL PHOTOGRAPHS OF THE UPPER SALT RIVER

INVENTORY OF HISTORICAL PHOTOGRAPHS OF THE UPPER SALT RIVER

BOATING

Title: At the Junction of the Verde and the Salt
Location: Published photograph
Number: none
Description/Comments: In Al Beasley (editor), 1908, *Twentieth-Century Phoenix, Illustrated*, Phoenix, Arizona, p. 4. Another copy of this photograph is in the collections of the Arizona Historical Foundation, Hayden Library, Arizona State University, under call number G-554.

Title: Boating on Salt River
Location: Arizona Historical Foundation, Hayden Library, Arizona State University
Number: G-554
Description/Comments: Published as "At the Junction of the Verde and the Salt" in Al Beasley, editor, 1908, *Twentieth-Century Phoenix, Illustrated*, Phoenix, Arizona, p. 4.

Title: Three People in a Row Boat on the Salt River, Arizona, Circa 1918.
Location: Arizona State University, Hayden Library, Special Collections
Number: CP CTH 2064
Description/Comments: Carl Hayden Photograph Collection, 1918. This postcard is postmarked Dec. 17, 1918. The same photograph was published in the early 1900s magazine *Arizona*, Vol. 1, No. 1 (February 1910), p. 16. It is also reproduced in Barbara Behan, 1988, *An Historical Analysis of the Salt River*, 1830-1912, Figure 2. The general terrain pictured suggests that it was taken above Granite Reef Dam, perhaps in the Roosevelt area.

Title: Arizona Canal Under Construction, Phoenix, Arizona, Circa 1885
Location: Arizona State University, Hayden Library, Special Collections
Number: CP MCL 97342.A3
Description/Comments: Herb and Dorothy McLaughlin Photographs, 1885. Original in Arizona Department of Library and Archives Collection, Archives 3 (Rothrock and Barnett). Shows flatboat being used in river for dam construction.

Title: Arizona Canal Under Construction, Phoenix, Arizona, Circa 1885
Location: Arizona State University, Hayden Library, Special Collections
Number: CP MCL 97343.A3
Description/Comments: Herb and Dorothy McLaughlin Photographs, 1885. Original in Arizona Department of Library and Archives Collection, Archives 3 (Rothrock and Barnett). Shows flatboat being used in river for dam construction.

Title: The Dredge Used by the U.S. Reclamation Service to Enlarge the Arizona Canal
Location: Published photograph in Brown, Patricia E., 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 79.
Number: Published
Description/Comments: Shows steam dredge floating down the canal with the Salt River in the background.

Title: Barge Crossing Roosevelt Lake on the Upper End, Prior to Construction of the Salt River Bridge
Location: Published photograph in Guy Anderson and Donna Anderson, editors, 1976, *Honor the Past, Mold the Future: Gila Centennials, Inc. Historical Celebration and Pageant, September 10-19, 1976*, Gila Centennials, Inc., Globe, Arizona, p. 30.
Number: Published
Description/Comments: Shows barge on the lake.

Title: Photograph of Clamshell Derrick, Horse Mesa Dam, ca. 1926
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Turnmire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-8.
Number: Published
Description/Comments: Photograph of clamshell derrick operating in the impounded river.

GRANITE REEF DAM

Title: Panoramic View of the Granite Reef Construction Camp Circa 1907
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, Plate 1.
Number: Published
Description/Comments: Caption reads, "Panoramic view of the Granite Reef work camp circa 1907. Looking north toward Mt. McDowell. Photograph obtained from Salt River Project." Shows work camp in foreground, wooden tower on left, river flowing as a braided stream in middle ground, Mt. McDowell in background.

Title: General View of Granite Reef Diversion Dam Construction, October 31, 1907
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 72.
Number: Published
Description/Comments: Shows wooden tower with river in background.

Title: Construction of Granite Reef Diversion Dam from North Shore; Arizona Canal, Foreground
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 79.
Number: Published
Description/Comments: Shows dam and river flowing bank to bank.

Title: Snapshot of Building at Granite Reef Dam, Maricopa County, Arizona, 1917
Location: Arizona State University, Hayden Library, Special Collections
Number: CP GM 56
Description/Comments: Gertrude Muir Photographs. View of spillway and office, lake full, water going over dam.

Title: Old Boat Landing on Salt River at Headgate Tender's Residence, Maricopa County, Arizona, 1913
Location: Arizona State University, Hayden Library, Special Collections
Number: CP GM 58
Description/Comments: Gertrude Muir Photographs. Old boat landing on Salt River in front of headgate tender's house, Granite Reef, Arizona, April 1913.

Title: Granite Reef Dam, Arizona, 1917-1932
Location: Arizona State University, Hayden Library, Special Collections
Number: CP GM 59
Description/Comments: Gertrude Muir Photographs. Granite Reef Dam in floodtime.

Title: Snapshot of Building at Granite Reef Dam, Maricopa County, Arizona, 1917.
Location: Arizona State University, Hayden Library, Special Collections
Number: CP GM 62
Description/Comments: Muir Photographs. Same as GM 56 but slightly to the left.

Title: SS Gates, Granite Reef Dam
Location: Arizona State University, Hayden Library, Special Collections
Number: CP SPC 53:17
Description/Comments: Crowd on hand, office on right of dam, slack water in foreground.

OTHER

Title: Salt River-Maricopa County
Location: Arizona Pioneers Historical Society, Tucson
Number: 91796; File: Places, Pictures-Salt River, Maricopa County
Description/Comments: Rothrock Collection. Shows canal dam.

Title: Salt River by Moonlight, Near Phoenix Arizona
Location: Arizona Pioneers Historical Society, Tucson
Number: 10191; File: Pictures-Places-Salt River Valley
Description/Comments: Original from the Arizona Governor's Report, 1896. Duplicate print #24381 from Sylvia Kennedy Hawkins. Holliday Collection #160. Same as CP MCL 98056.A3. Published as CP MCL 98056.PHX39 in Herb McLaughlin and Dorothy McLaughlin, 1970, *Phoenix 1870-1970 in Photographs*, Arizona Photographic Consultants, Phoenix, p. 39. This was a popular photograph at the turn of the century. It was reproduced as a tinted postcard (University of Arizona Library, Special Collections Salt River [Ariz.] Photographs, Postcards, Folder 1) and can also be found in the Pickrell Collection, University of Arizona Library, Special Collections (Salt River [Ariz.] Photographs, Postcards, Folder 1).

Title: Moonlight on Salt River, Near Phoenix
Location: University of Arizona, Special Collections
Number: None; File: Salt River (Ariz.): Photographs, Postcards, Folder 1
Description/Comments: From Charles U. Pickrell Collection. Same as CP MCL 98056.A3. Published as CP MCL 98056.PHX39 in McLaughlin, Herb, and Dorothy McLaughlin, 1970, *Phoenix 1870-1970 In Photographs*, Arizona Photographic Consultants, Phoenix, p.39. This was a popular photograph at the turn of the century. It was used in the Governor's Report of 1896 (Arizona Pioneers Historical Society, Tucson, Photograph 10191), and reproduced as a tinted postcard (University of Arizona Library, Special Collections Salt River [Ariz.] Photographs, Postcards, Folder 1).

Title: Salt River, Arizona, On the Line of the S.P.R.R.
Location: University of Arizona, Special Collections
Number: None; File: Salt River (Ariz.): Photographs, Postcards, Folder 1
Description/Comments: Tinted postcard, Published by Newman Postcard Co., Los Angeles and San Francisco, No. AR27. Same as CP MCL 98056.A3. Published as CP MCL 98056.PHX39 in Herb McLaughlin and Dorothy McLaughlin, 1970, *Phoenix 1870-1970 in Photographs*, Arizona Photographic Consultants, Phoenix, p.39. This was a popular photograph at the turn of the century. It was used in the Governor's Report of 1896 (Arizona Pioneers Historical Society, Tucson, Photograph 10191). It can also be found in the Pickrell Collection, University of Arizona Library, Special Collections (Salt River [Ariz.] Photographs, Postcards, Folder 1).

Title: Sunset on the Salt
Location: Arizona Pioneers Historical Society, Tucson
Number: 19206; File: Pictures-Places-Salt River Project
Description/Comments: On back of photograph: "As we looked forward just before crossing the river we could see a most remarkable sunset just ready to drop behind the low hills that were gradually tapering down towards the desert in the direction of Granite Reef, where the construction of a great irrigation enterprise was being undertaken by the Reclamation Service to reclaim part of this vast desert that lies in the direction of the setting sun."

Title: Sheep Crossing Salt River with McDowell Butte Beyond, Circa 1918
Location: Arizona Historical Foundation, Hayden Library, Arizona State University
Number: DC COO:14
Description/Comments: Dane Coolidge Collection, 1918

Title: Beaver Dams, Salt River, Circa 1915
Location: Arizona Historical Foundation, Hayden Library, Arizona State University
Number: DC COO 1191-1192
Description/Comments: Dane Coolidge Collection, 1915. There is no way to determine where these dams were located, although other photographs in the Dane Coolidge Collection were taken around Granite Reef Dam.

Title: Mormon Flat, Salt River, 1920
Location: Arizona Pioneers Historical Society, Tucson
Number: 77057; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer. This is a good view of Mormon Flat, but the river is barely visible.

Title: Salt River, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77087; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77088; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77089; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, ca. 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77090; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River near Diversion Dam & Pinal Creek, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77107; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77108; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77111; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77112; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77113; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77114; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77115; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77116; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River Canyon, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77097; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River Canyon, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77098; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Apache Trail and Salt River, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77099; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, August 20-Oct 20, 1920
Location: Arizona Pioneers Historical Society, Tucson
Number: 77049; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Sections of Canal Built to Develop Electricity with Falling Water, March 6, 1906
Location: Published photograph in Earl Zarbin, 1984, *Roosevelt Dam: A History to 1911*, Salt River Project, Phoenix, p. 128.
Number: Published
Description/Comments: Shows canal in foreground with Salt River (through Tonto Basin) as braided stream in background.

Title: Looking Upstream at Site of Roosevelt Dam on the Salt River, April 16, 1906
Location: Published photograph in Earl Zarbin, 1984, *Roosevelt Dam: A History to 1911*, Salt River Project, Phoenix, p. 134.
Number: Published
Description/Comments: Shows Salt River flowing canyon wall to canyon wall with a few beaches on either side.

Title: Main Street at Roosevelt, February 1907
Location: Published photograph in Earl Zarbin, 1984, *Roosevelt Dam: A History to 1911*, Salt River Project, Phoenix, p. 147.
Number: Published
Description/Comments: Shows town of Roosevelt from above with Salt River as a braided stream on a sandy bed in background.

Title: The West End of the Town of Roosevelt, Arizona, March 1906
Location: Published photograph in Karen L. Smith, 1986 *The Magnificent Experiment: Building the Salt River Reclamation Project, 1890-1917*, University of Arizona Press, Tucson, p. 71.
Number: Published
Description/Comments: Caption reads, "The west end of the town of Roosevelt, Arizona, as it was in March, 1906, during construction of the dam. Located on the south side of Salt River approximately one-half mile upstream from the damsite, the town had a population of about 500 during the peak of construction. After the dam was completed and the reservoir began to fill, the town was abandoned and eventually inundated." The Salt River, covering about half of its broad, sandy bed is shown in the foreground; the town of Roosevelt is on the opposite bank in the background.

Title: Downstream View of Salt River Prior to Roosevelt Dam's Construction.
Location: Published photograph in Palmer, Ralph F., 1979, *Doctor on Horseback: A Collection of Anecdotes Largely but Not Exclusively Medically Oriented* Mesa Historical and Archaeological Society, Mesa, Arizona.
Number: Published
Description/Comments: Salt River flowing canyon wall to canyon wall.

Title: Tonto Basin, Prior to Construction of Roosevelt Dam
Location: Published photograph in Guy Anderson and Donna Anderson, editors, 1976, *Honor the Past, Mold the Future: Gila Centennials, Inc., Historical Celebration and Pageant, September 10-19, 1976*, Gila Centennials, Inc., Globe, Arizona, p. 65.
Number: Published
Description/Comments: Caption reads, "Tonto Basin, prior to construction of Roosevelt Dam. Catwalk across the point is about where the dam was later built." Shows the Salt River as a braided stream running across a broad, sandy river bed and entering the canyon.

Title: Arizona Dam Destroyed by Flood, April 13-16, 1905
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 8.
Number: Published
Description/Comments: Caption reads, "Most of the Arizona Dam was carried away by floods April 13-16, 1905." Upper photograph is closeup of the top of the dam.

Title: Arizona Dam Destroyed by Flood, April 13-16, 1905
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 8.
Number: Published
Description/Comments: Caption reads, "Most of the Arizona Dam was carried away by floods April 13-16, 1905." Lower photograph shows the area behind the dam after the dam was breached.

Title: Flood Damage to Arizona Dam, 1905
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 9.
Number: Published
Description/Comments: Caption reads, "Photographs show washed out sections of the Arizona Dam and the Arizona Canal head." Two similar views.

Title: Photograph of Mormon Flat Construction Camp, 1923
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Turnmire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 1-4.
Number: Published
Description/Comments: Shows Mormon Flat in foreground with a glimpse of the Salt River in the middle ground.

Title: Photograph of Surveyors' Rock Shelter at Horse Mesa, October 1924
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Turnmire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-2.
Number: Published
Description/Comments: Shows Salt River in foreground with rocky beach and rock shelter on opposite bank in background.

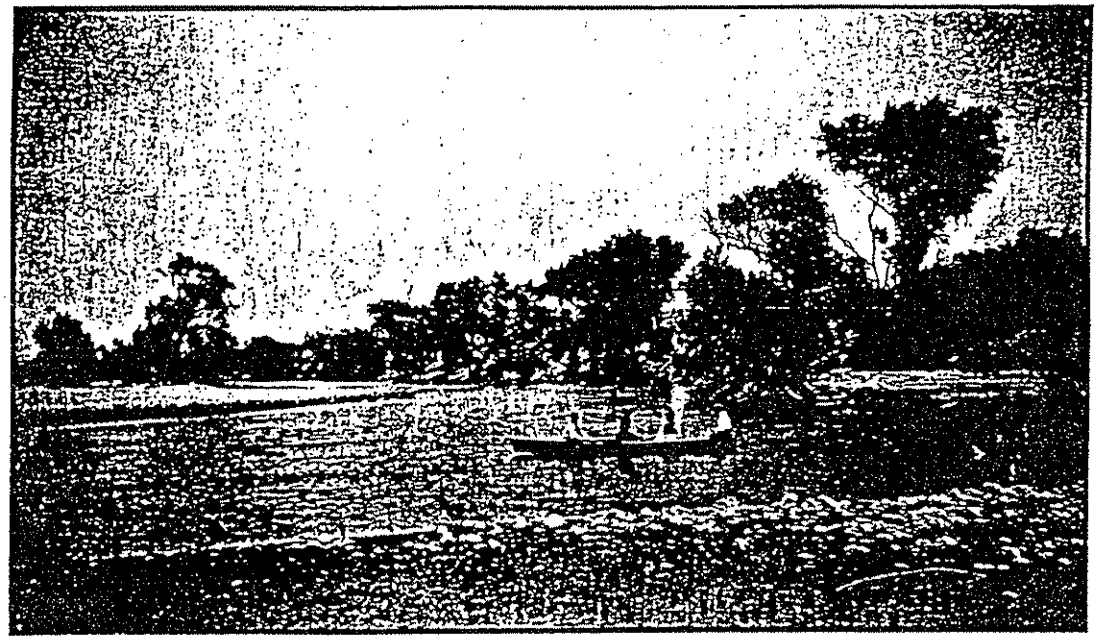
Title: Photograph of Horse Mesa Dam Construction Camp, ca. 1926
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Turnmire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-5.
Number: Published
Description/Comments: Caption reads, "Photograph of Horse Mesa Dam Construction Camp, ca. 1926 (view of northern portion of the northern section of camp." View from above shows Salt River flowing through canyon on lower right.

Title: Photograph of Horse Mesa Dam Construction Camp, ca. 1926
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Turnmire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-6.
Number: Published
Description/Comments: Caption reads, "Photograph of Horse Mesa Dam Construction Camp, ca. 1926 (view of central portion of the northern section of camp." View from river shows Salt River flowing through canyon on lower right.

Title: Photograph of Horse Mesa Dam Construction Camp, ca. 1926
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Turnmire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-7.
Number: Published
Description/Comments: Caption reads, "Photograph of Horse Mesa Dam Construction Camp, ca. 1926 (view of southern portion of the northern section of camp." View from above shows Salt River flowing through canyon from upper left to lower right.

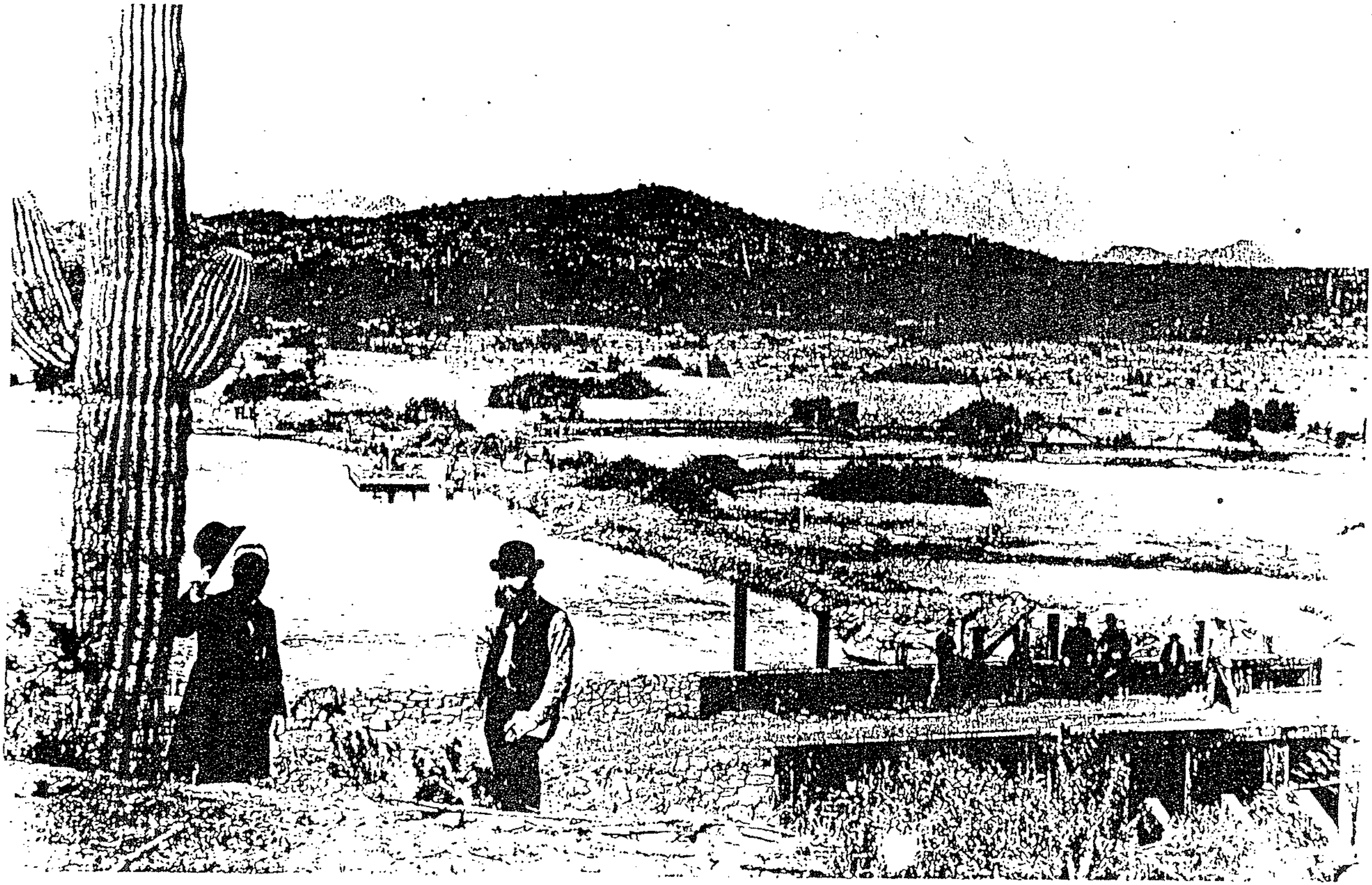
Title: Photograph of Lake Roosevelt During Flood, February 4, 1908
Location: Published photograph in James E. Ayres, A. E. Rogge, Melissa Keane, Diane L. Douglas, Everett J. Bassett, Diane L. Fenicle, Cindy L. Myers, Bonnie J. Clark, and Karen Turnmire, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2A: Sites in the Roosevelt Dam Area*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 11, Phoenix, Figure 3-41.
Number: Published
Description/Comments: Shows impounded waters with town of Roosevelt in middle ground.

Boating on the Salt River (G-554, Arizona Historical Foundation, Hayden Library, Arizona State University).

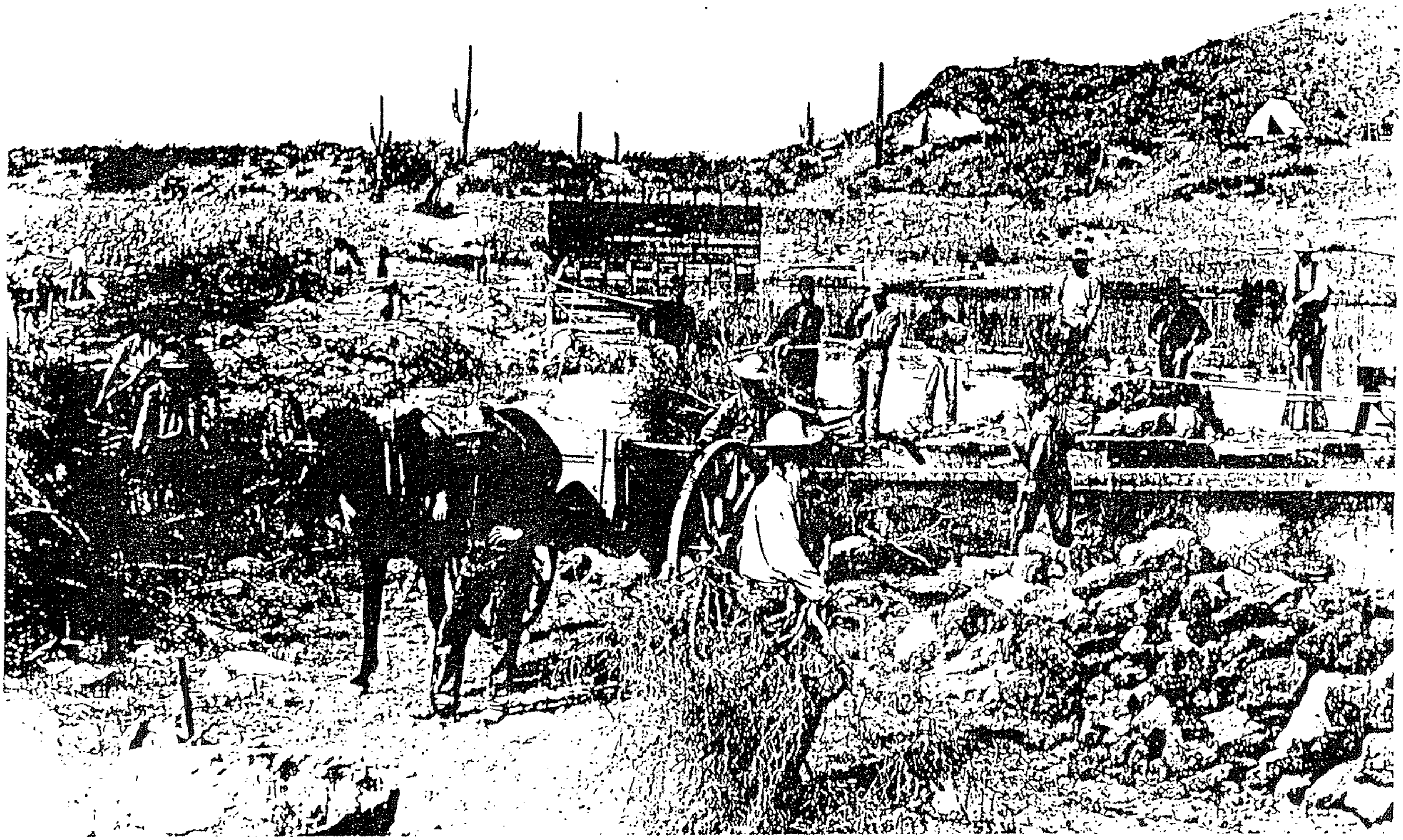


At the Junction of the Verde and the Salt (from Beasley 1908:4).

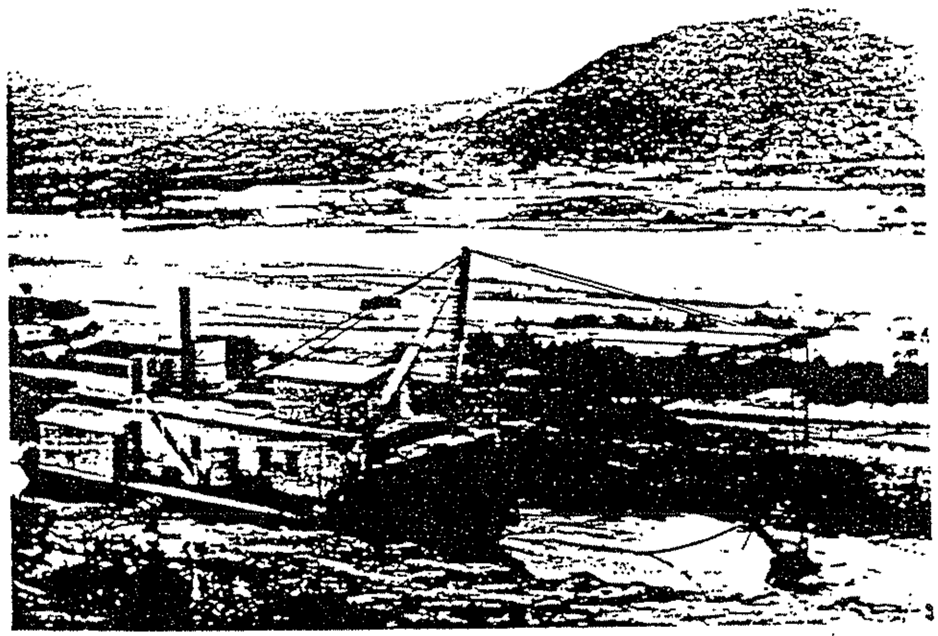
Boating on the Salt River (CP CTH 2064, Arizona State University, Hayden Library, Special Collections).



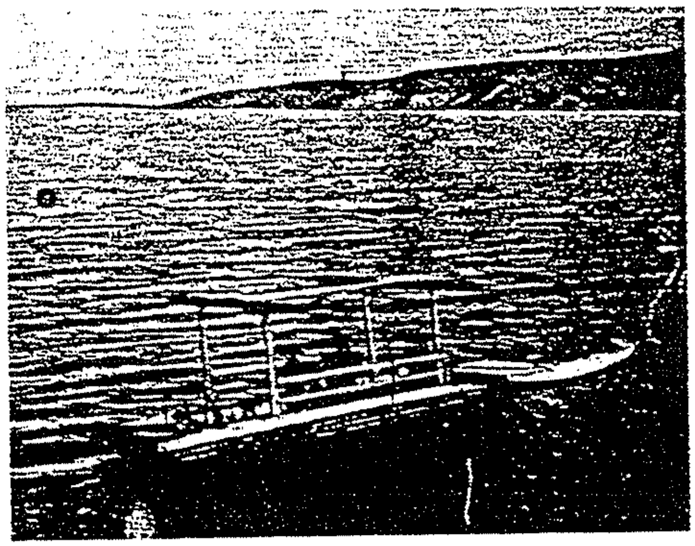
Arizona Canal under construction, Phoenix, Arizona, circa 1885 (CP MCL 9742.A3, Arizona State University, Hayden Library, Special Collections



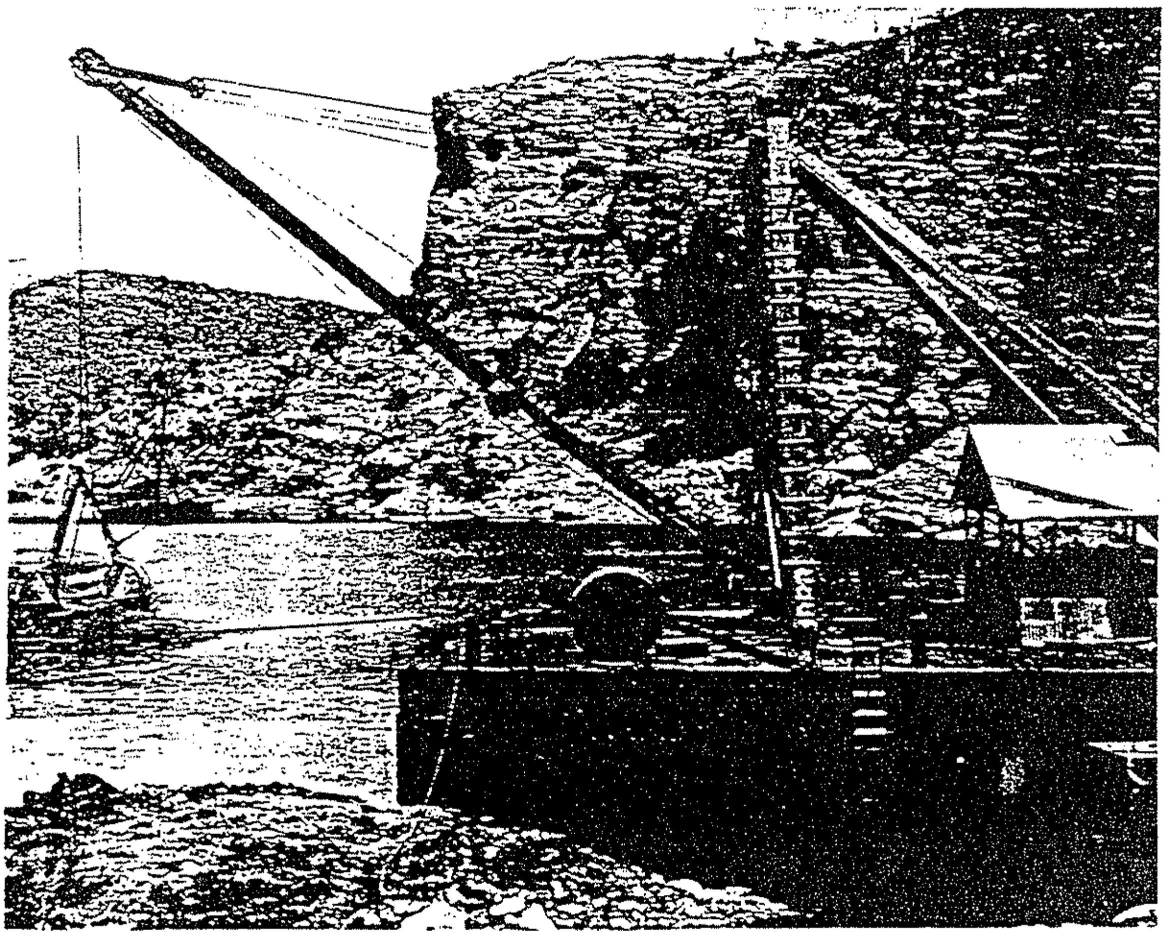
Arizona Canal under construction, Phoenix, Arizona, circa 1885 (CP MCL 9743.A3, Arizona State University, Hayden Library, Special Collections)



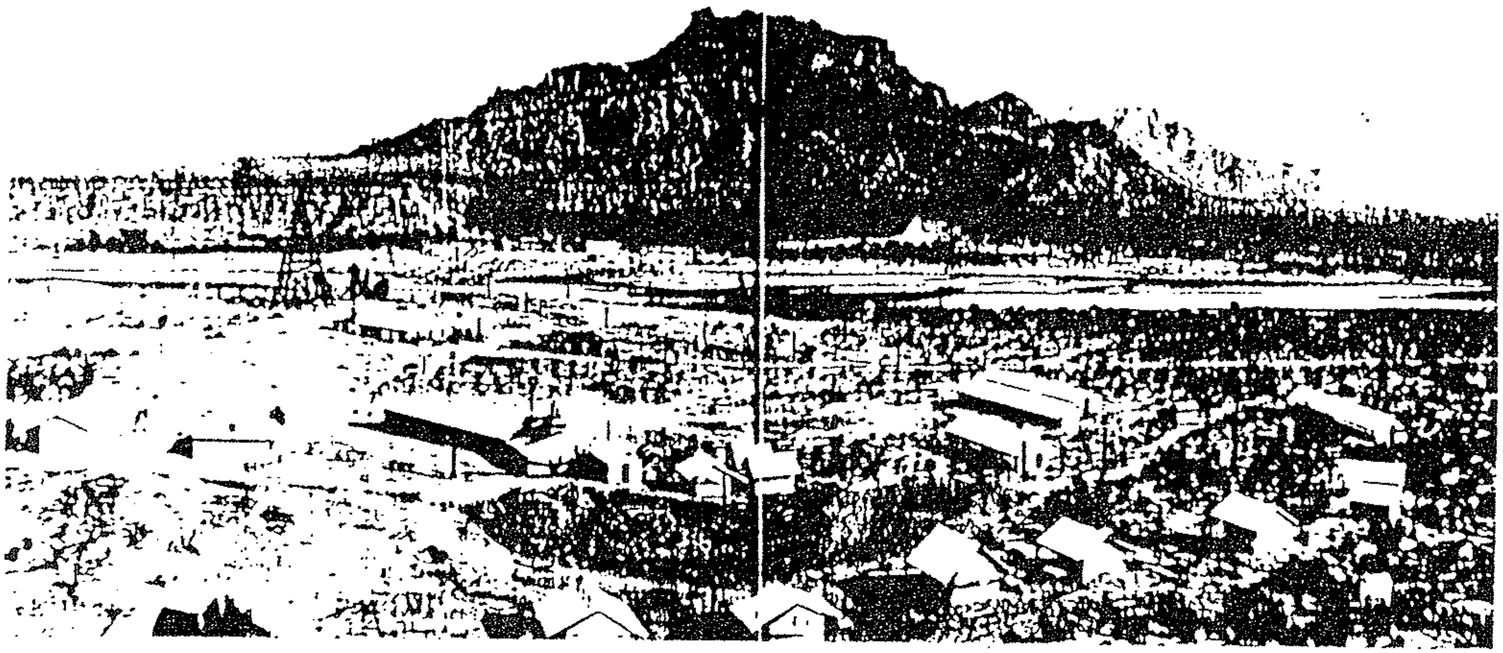
The dredge used by the U.S. Reclamation Service to enlarge the Arizona Canal (Brown 1978:79).



Barge crossing Roosevelt Lake on the upper end, prior to construction of the Salt River Bridge (Anderson and Anderson 1976:30).

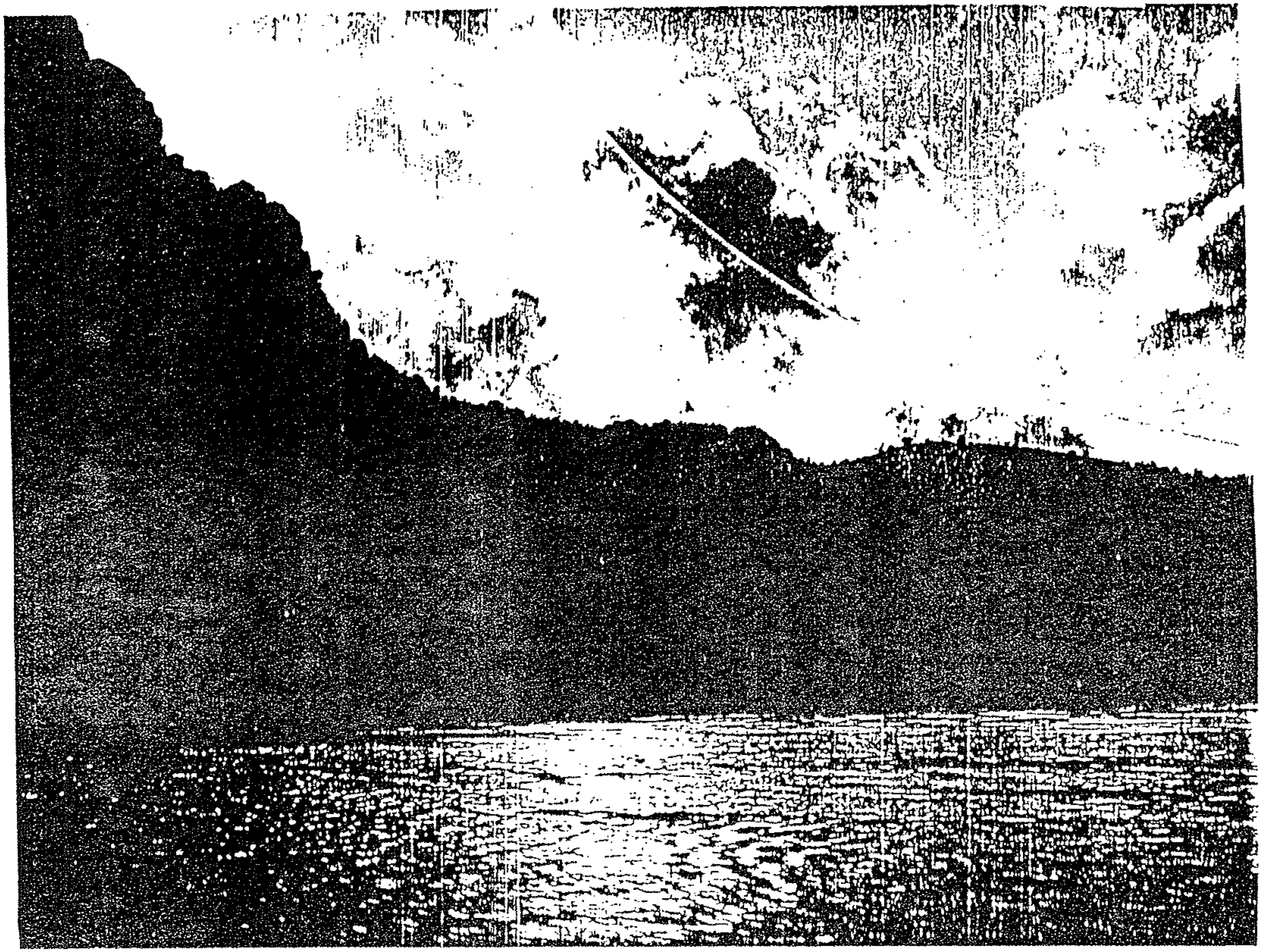


Photograph of clamshell derrick, Horse Mesa Dam, circa 1926 (Douglas et al. 1994:Figure 2-8).



Panoramic view of the Granite Reef work camp circa 1907. Looking north toward Mt. McDowell. Photograph obtained from Salt River Project (Brown 1978:Plate 1).

General view of Granite Reef Diversion Dam construction October 31, 1907 (Brown 1978:72).



Sunset on the Salt (#19, 206, Arizona Pioneers Historical Society, Tucson).

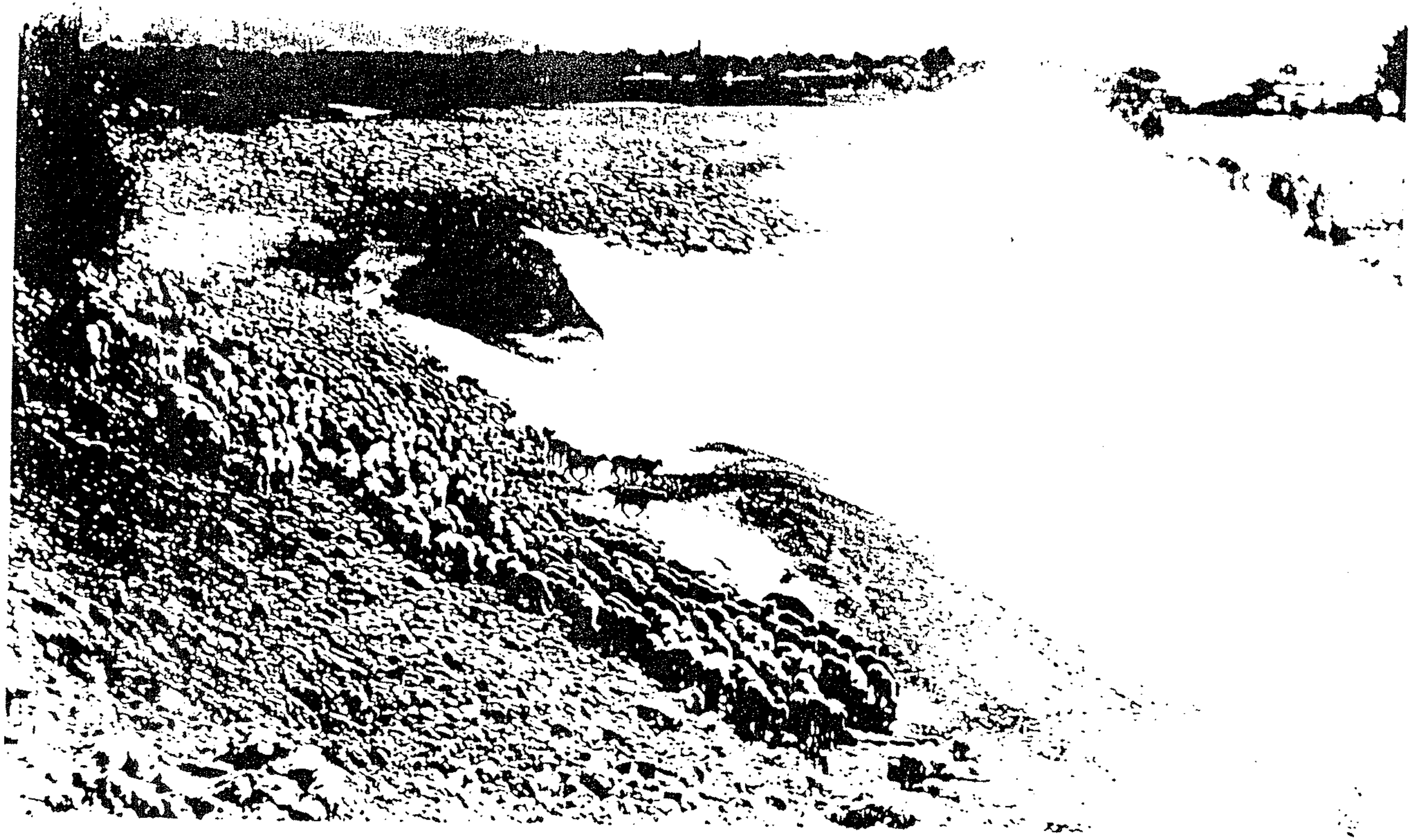
"Sunset on the Salt." As we looked forward just before crossing the river we could see a most remarkable sunset just ready to drop behind the low hills that were gradually tapering down towards the desert in the direction of Granite Reef, where the construction of a great irrigation enterprise was being undertaken by the Reclamation Service to reclaim part of this vast desert that lies in the direction of the setting sun.

2710 Salt River Project, Arizona

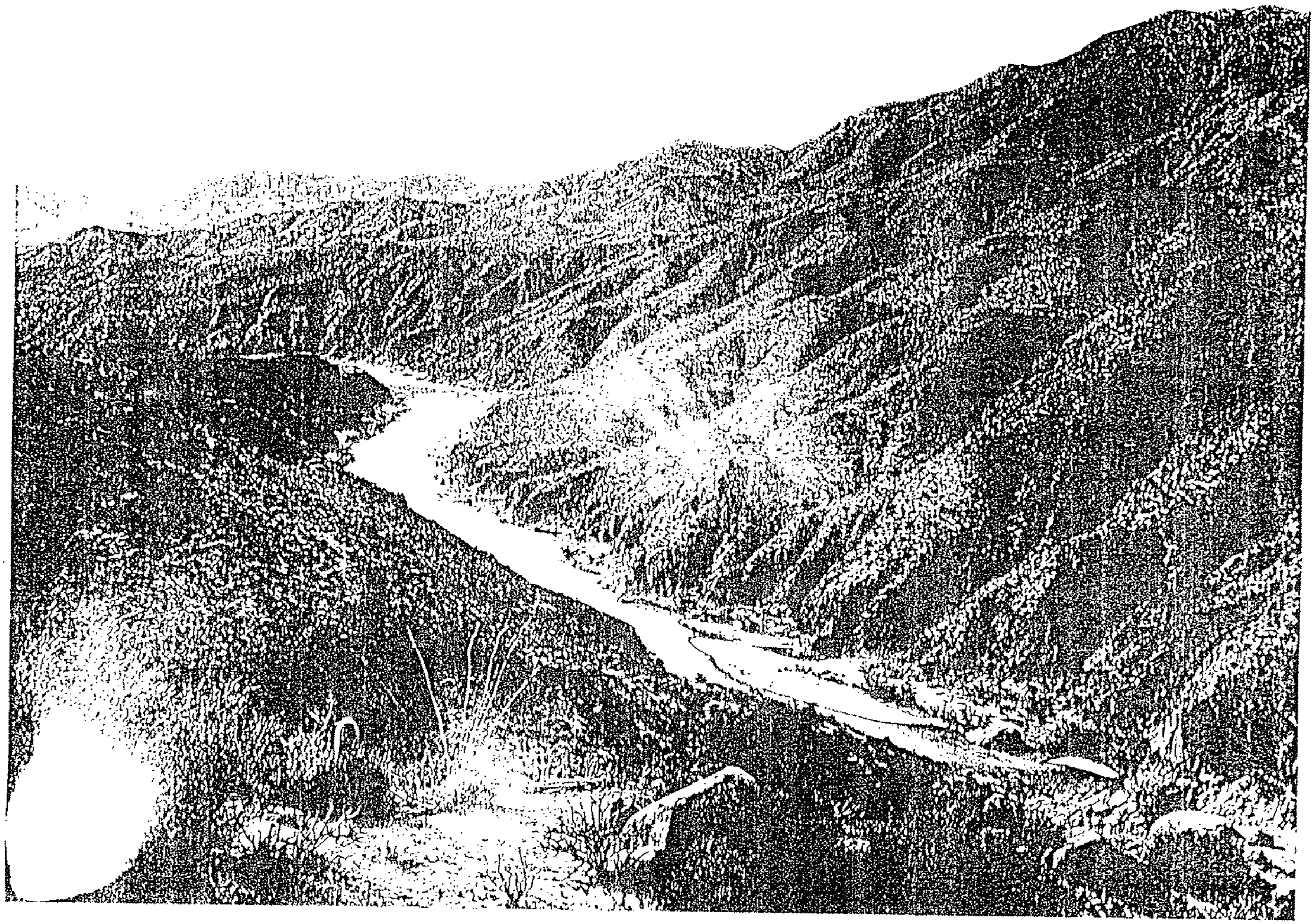
19,206

Pictures - Places - Salt River Project

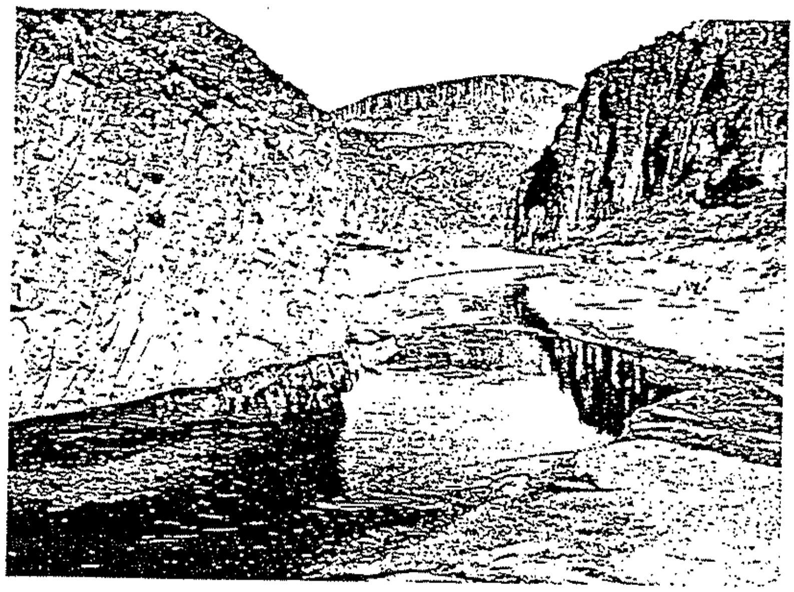
Writing on back of Photograph #19, 206, Arizona Pioneers Historical Society, Tucson.



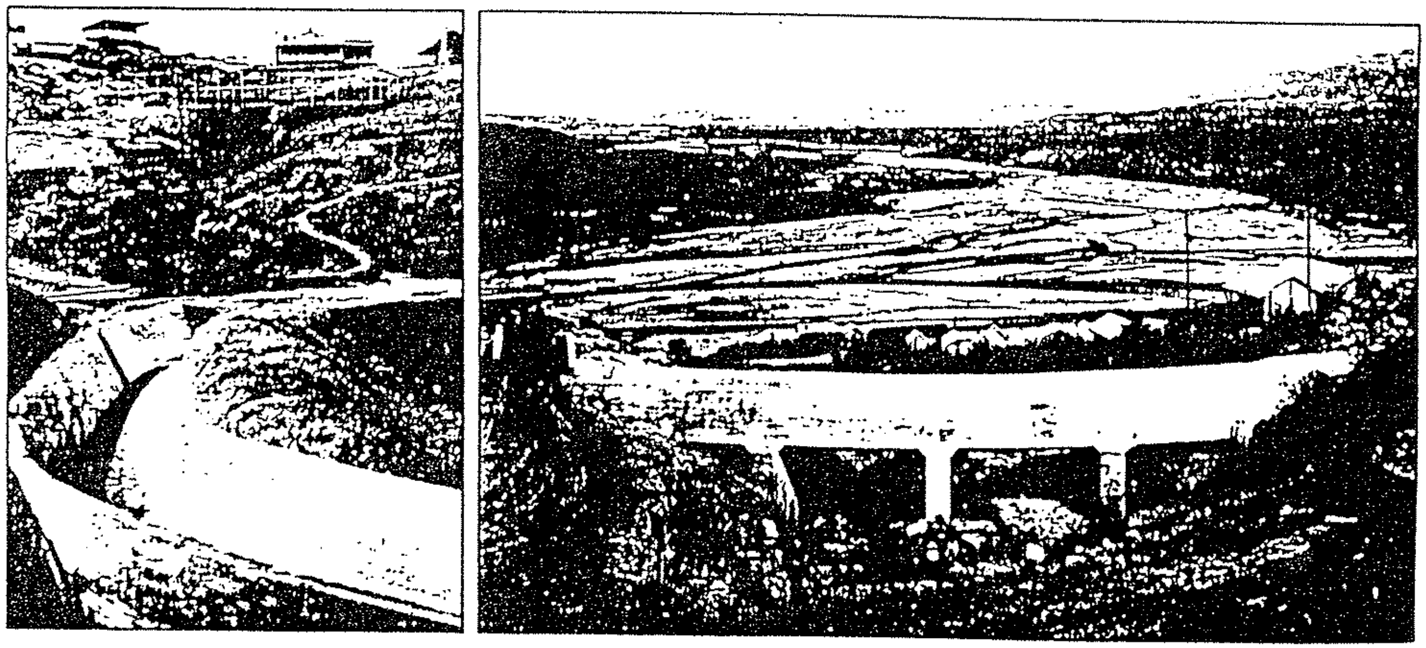
Sheep crossing Salt River with McDowell Butte beyond, circa 1918 (DC C00:14, Arizona Historical Foundation, Hayden Library, Arizona State University).



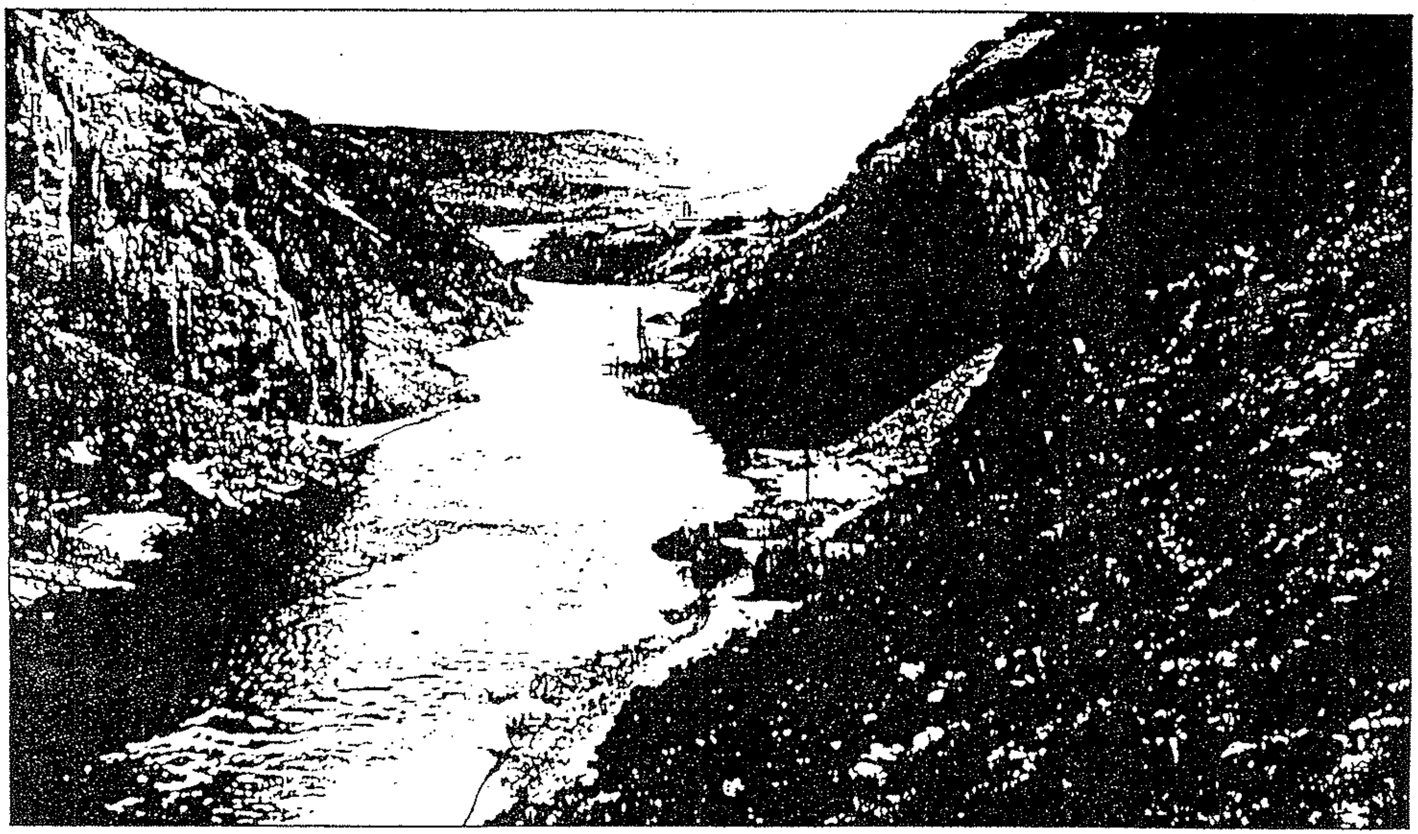
Salt River, circa 1921 (#77090, Arizona Pioneers Historical Society, Tucson).



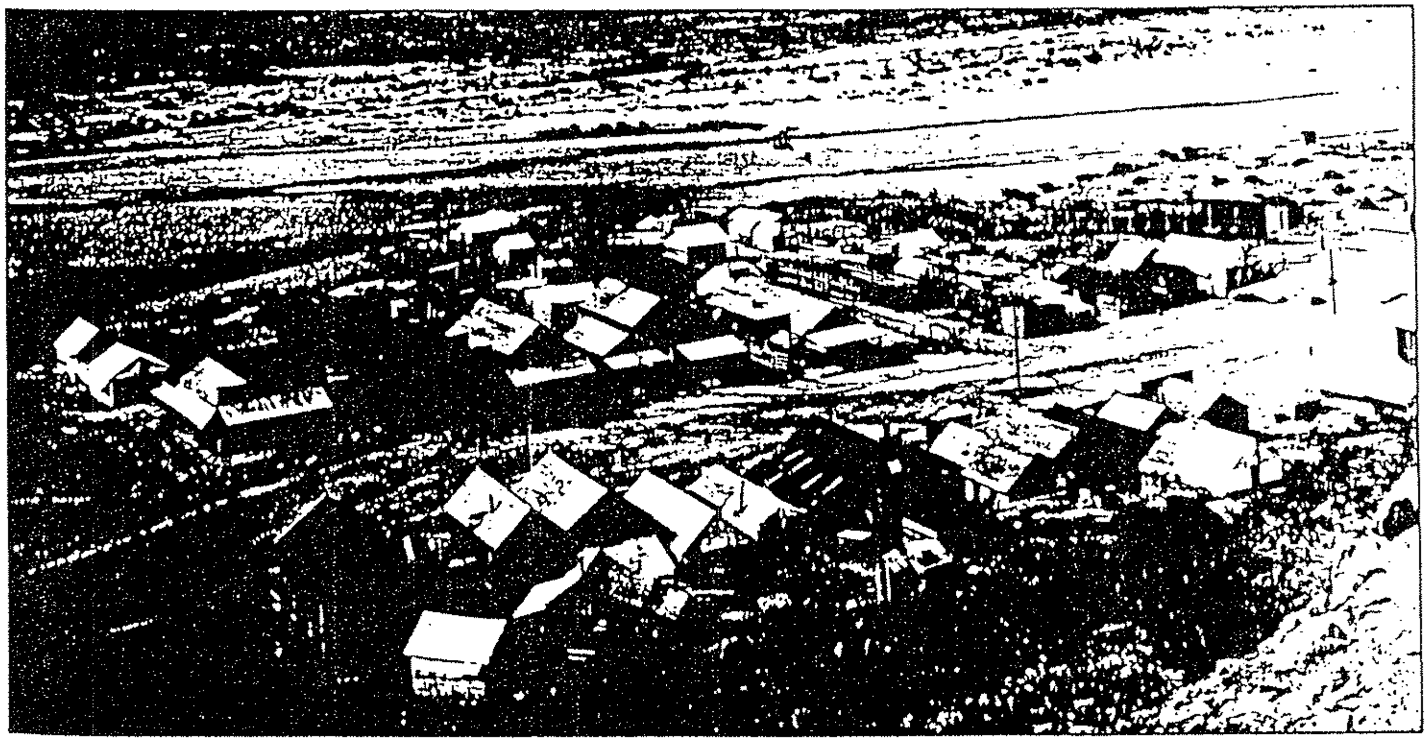
Salt River near diversion dam and Pinal Creek, February 1921 (#77107, Arizona Pioneers Historical Society, Tucson).



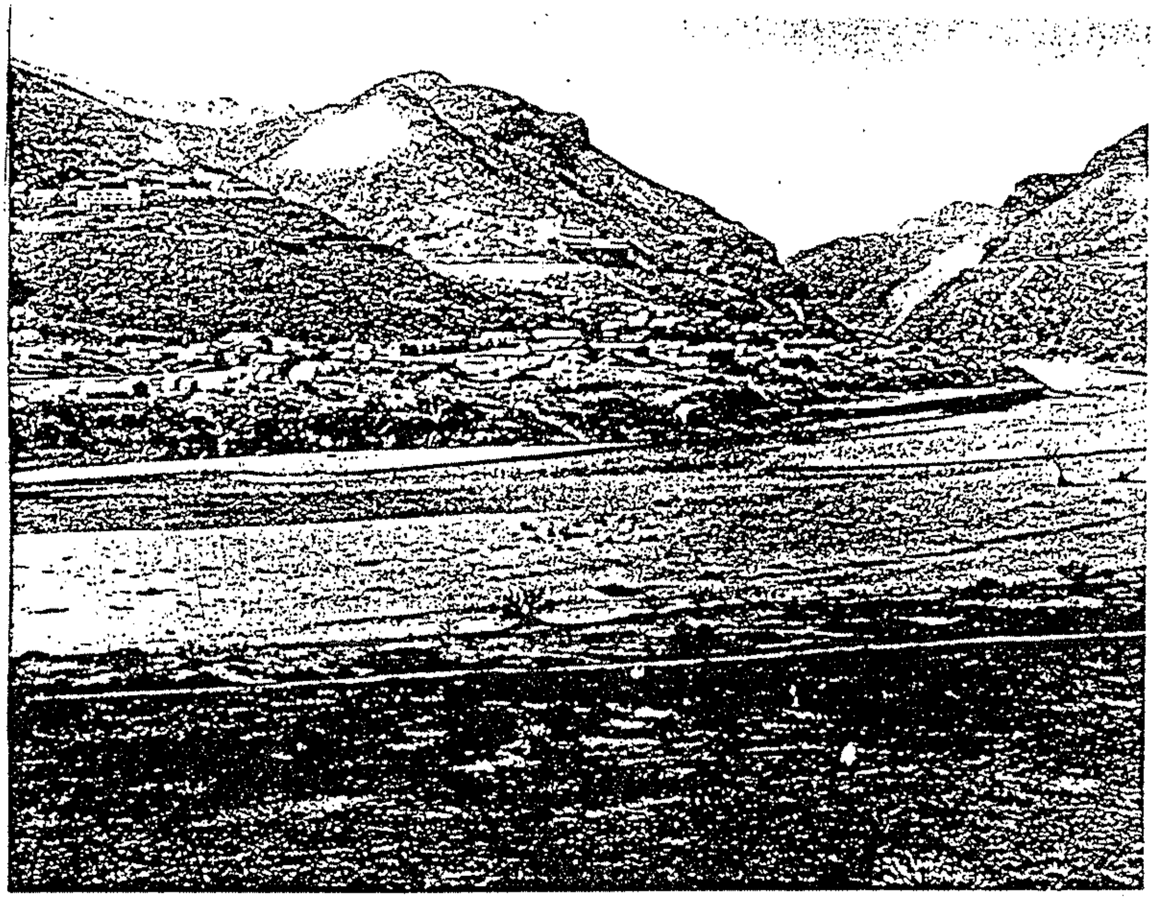
Sections of canal built to develop electricity with falling water, March 6, 1906 (Zarbin 1984:128).



Looking upstream at site of Roosevelt Dam on the Salt River, April 16, 1906 (Zarbin 1984:134).



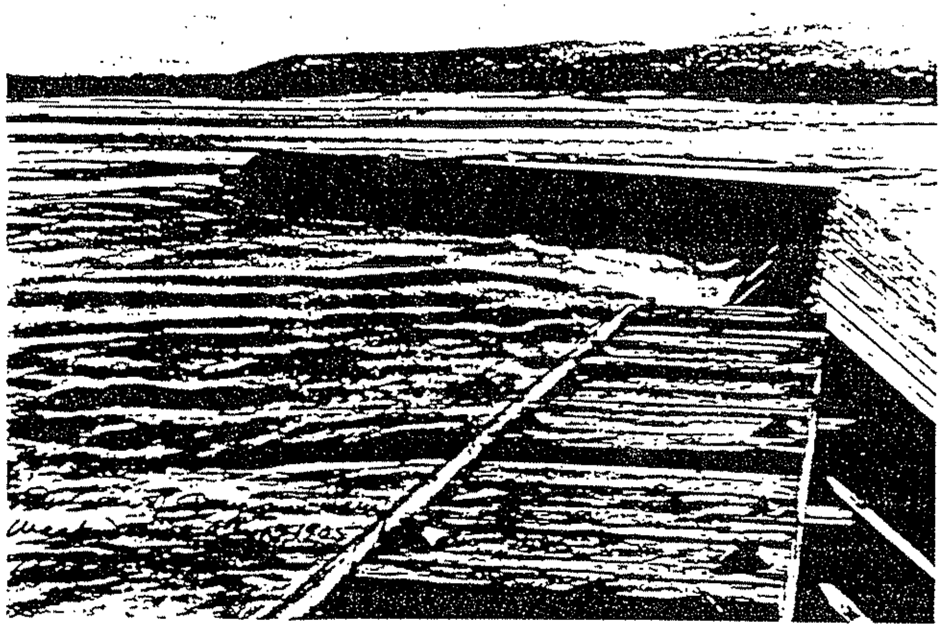
Main street at Roosevelt, February 1907 (Zarbin 1984:147).

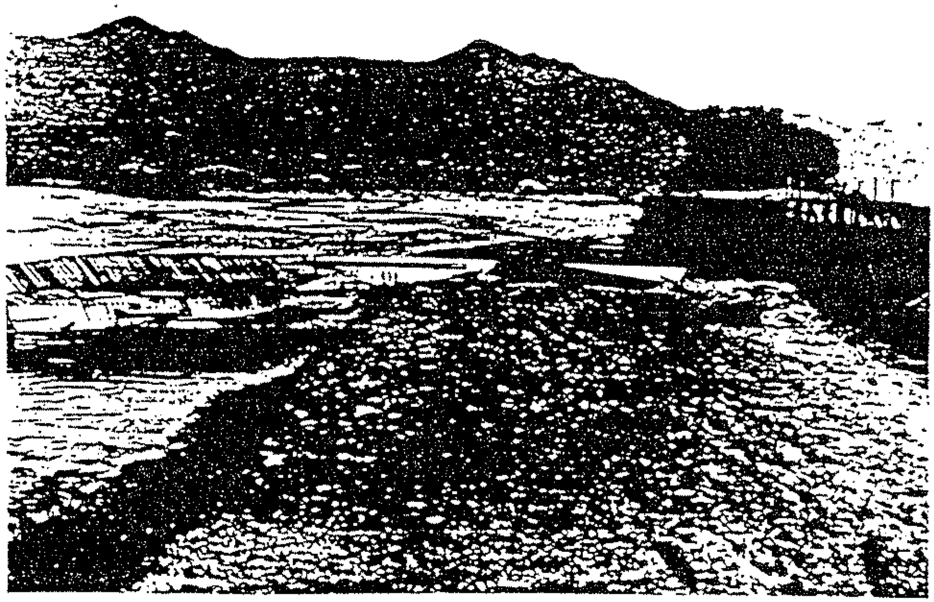


The west end of the town of Roosevelt, Arizona, as it was in March 1906, during construction of the dam. Located on the south side of Salt River approximately one-half mile upstream from the dam site, the town had a population of about 500 during the peak of construction. After the dam was completed and the reservoir began to fill, the town was abandoned and eventually inundated (K. Smith 1986:71).

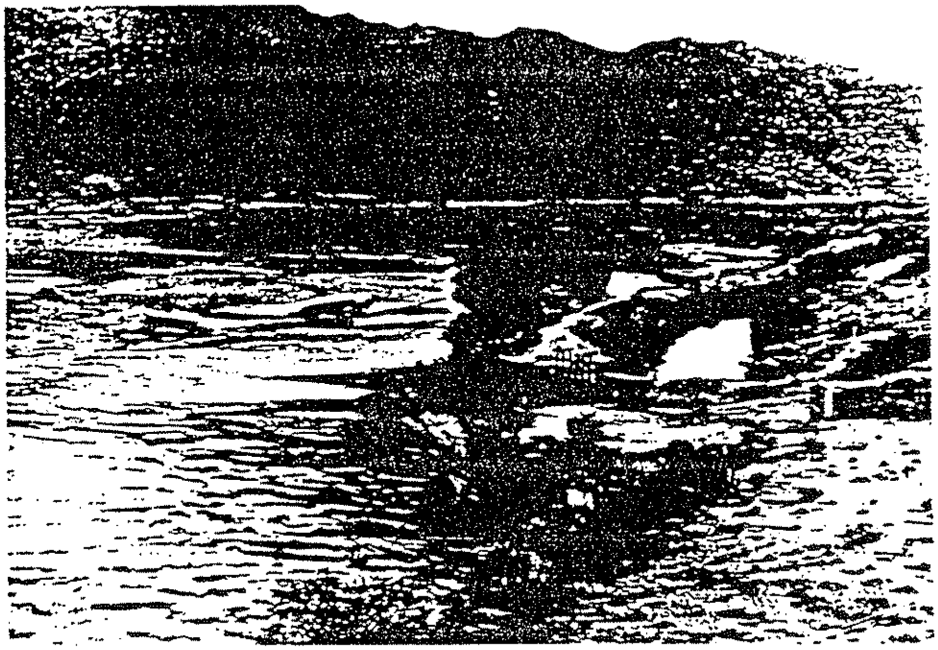
Downstream view of Salt River prior to dam's construction (Palmer 1979).

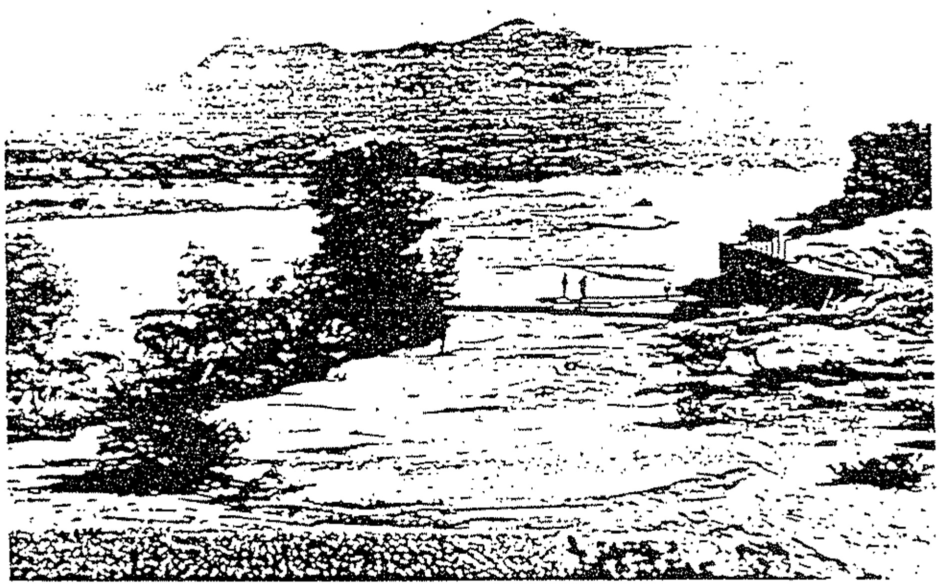
Tonto Basin, prior to construction to Roosevelt Dam. Catwalk across the point is about where the dam was later built (Anderson and Anderson 1976:65).





Most of the Arizona Dam was carried away by floods April 13-16, 1905 (Brown 1978:8).



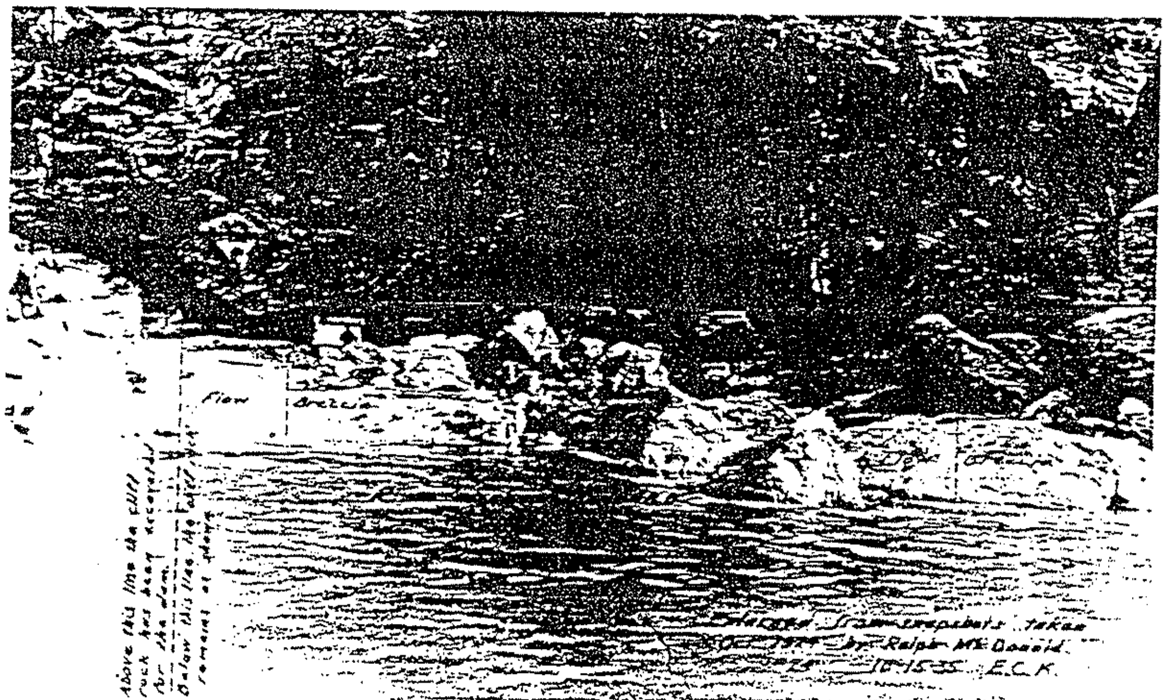


Photographs show washed out sections of the Arizona Dam and the Arizona Canal head (Brown 1978:9).

Source: Salt River Project

Photograph of Mormon Flat Construction Camp, 1923
Figure 1-4

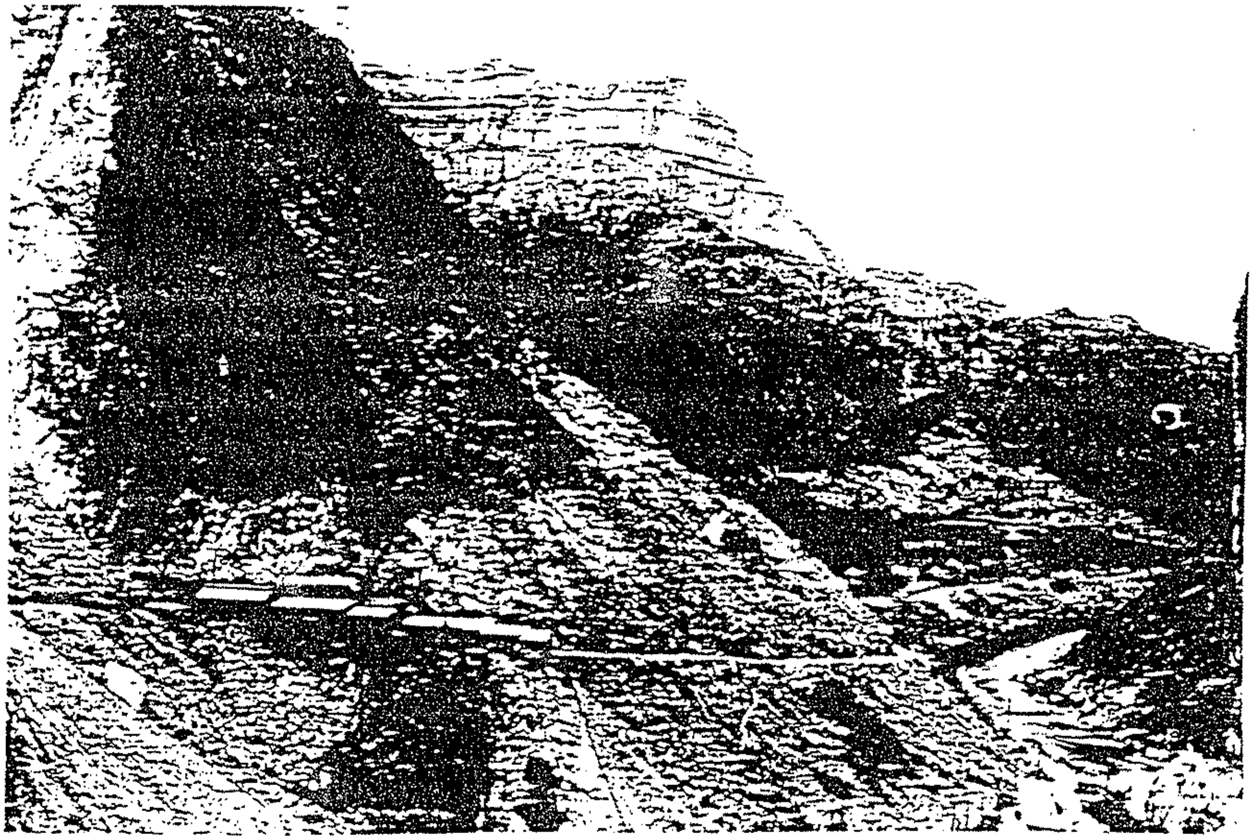
(Douglas et al. 1994:17).



Source: Arizona Department of Library, Archives and Public Records

Photograph of Surveyors' Rock Shelter at Horse Mesa, October 1924
Figure 2-2

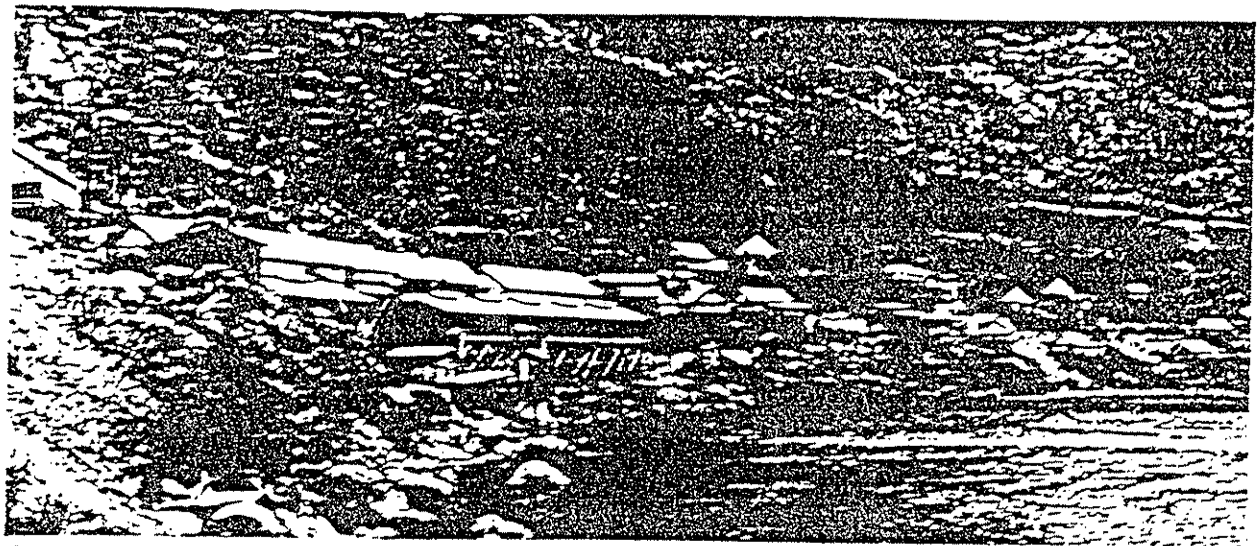
(Douglas et al. 1994:51).



Source: Salt River Project

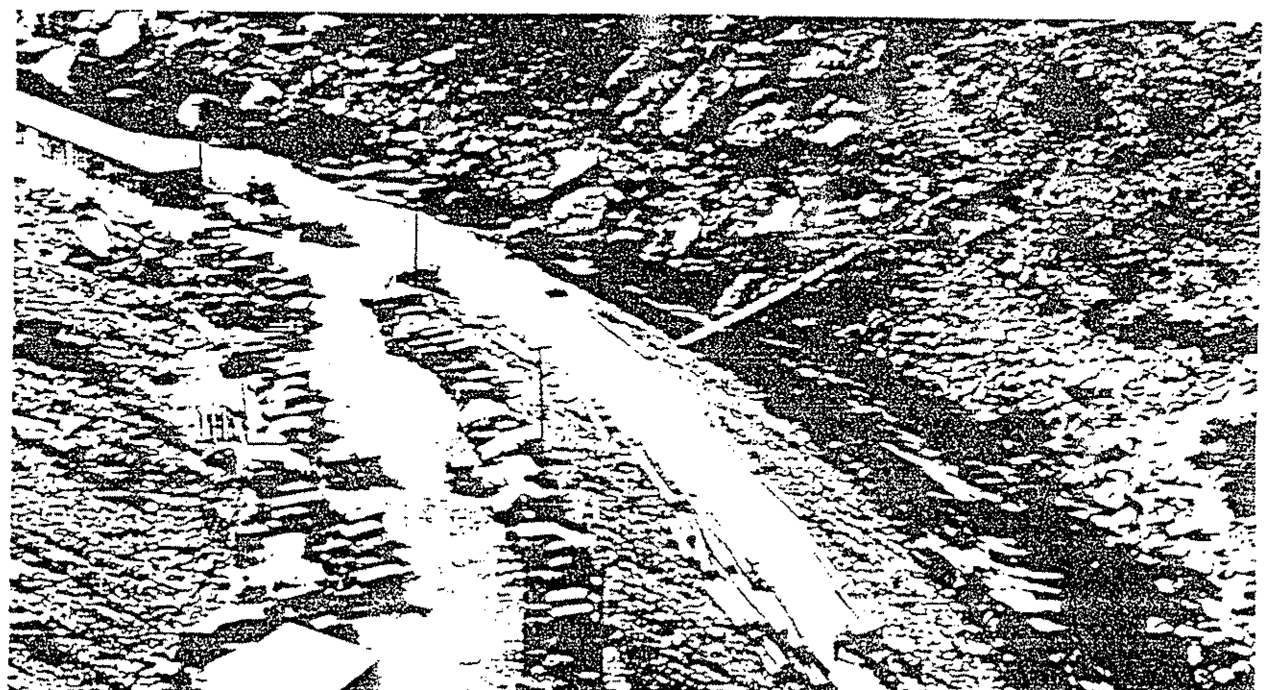
Photograph of Horse Mesa Dam Construction Camp, ca. 1926
(view of northern portion of the northern section of camp)
Figure 2-5

(Douglas et al. 1994:53).



Source: Salt River Project

Photograph of Horse Mesa Dam Construction Camp, ca. 1926
(view of central portion of northern section of camp)
Figure 2-6



Source: Salt River Project

Photograph of Horse Mesa Dam Construction Camp, ca. 1926
(view of southern portion of northern section of camp)
Figure 2-7

(Douglas et al. 1994:54).

Arizona State Land Department

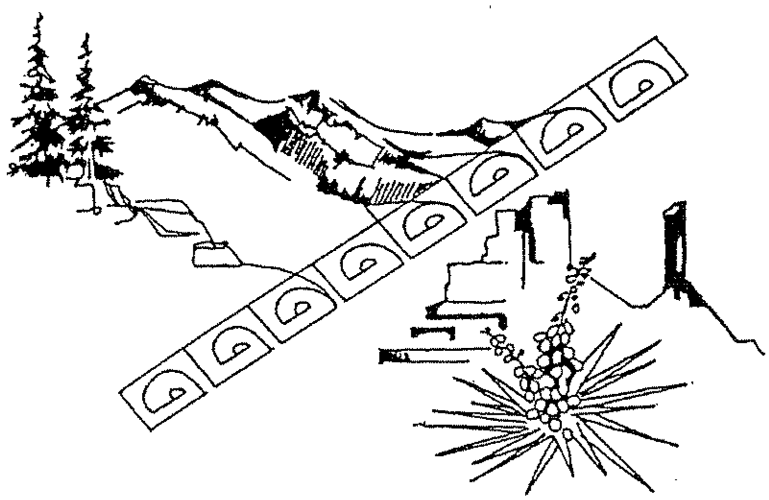
ARIZONA STREAM NAVIGABILITY STUDY

for the

UPPER SALT RIVER

Granite Reef Dam to the Confluence of the White and Black Rivers

Final Report



Prepared by

SFC Engineering Company

In Association With

George V. Sabol Consulting Engineers, Inc.,

JE Fuller/Hydrology & Geomorphology, Inc.,

and

SWCA, Inc. Environmental Consultants

March 1997

Section 4

Geomorphology of the Upper Salt River

Prepared for

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February 14, 1997

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Section 4:
Geomorphology of the Upper Salt River

Introduction

This section describes the regional geology and fluvial geomorphology of the Upper Salt River. The objectives of this section are to:

- Describe potential geologic impacts on streamflow
- Describe channel changes, if any, that occurred since statehood
- Provide a geologic context for discussion of historical stream conditions
- Describe the location of the ordinary high watermark and ordinary low watermark

Resources used to support this overview of the Upper Salt River geology included summaries of regional geologic history, aerial photographs, detailed geomorphic mapping published for limited portions of the study area, field observations, and topographic maps.

Stream Reaches

The study reach extends from the confluence of the Black River and the White River near Fort Apache to Granite Reef Dam near Phoenix (Figure 1), a distance of approximately 153 miles. For the purposes of the geomorphic investigation, the Upper Salt River may be considered in three stream reaches (Figure 2):

- Reach 1 - White River/ Black River confluence to Roosevelt Reservoir
- Reach 2 - Roosevelt Reservoir toStewart Mountain Dam
- Reach 3 - Stewart Mountain Dam to Granite Reef Dam

The geomorphology of these three reaches is described in the following sections.

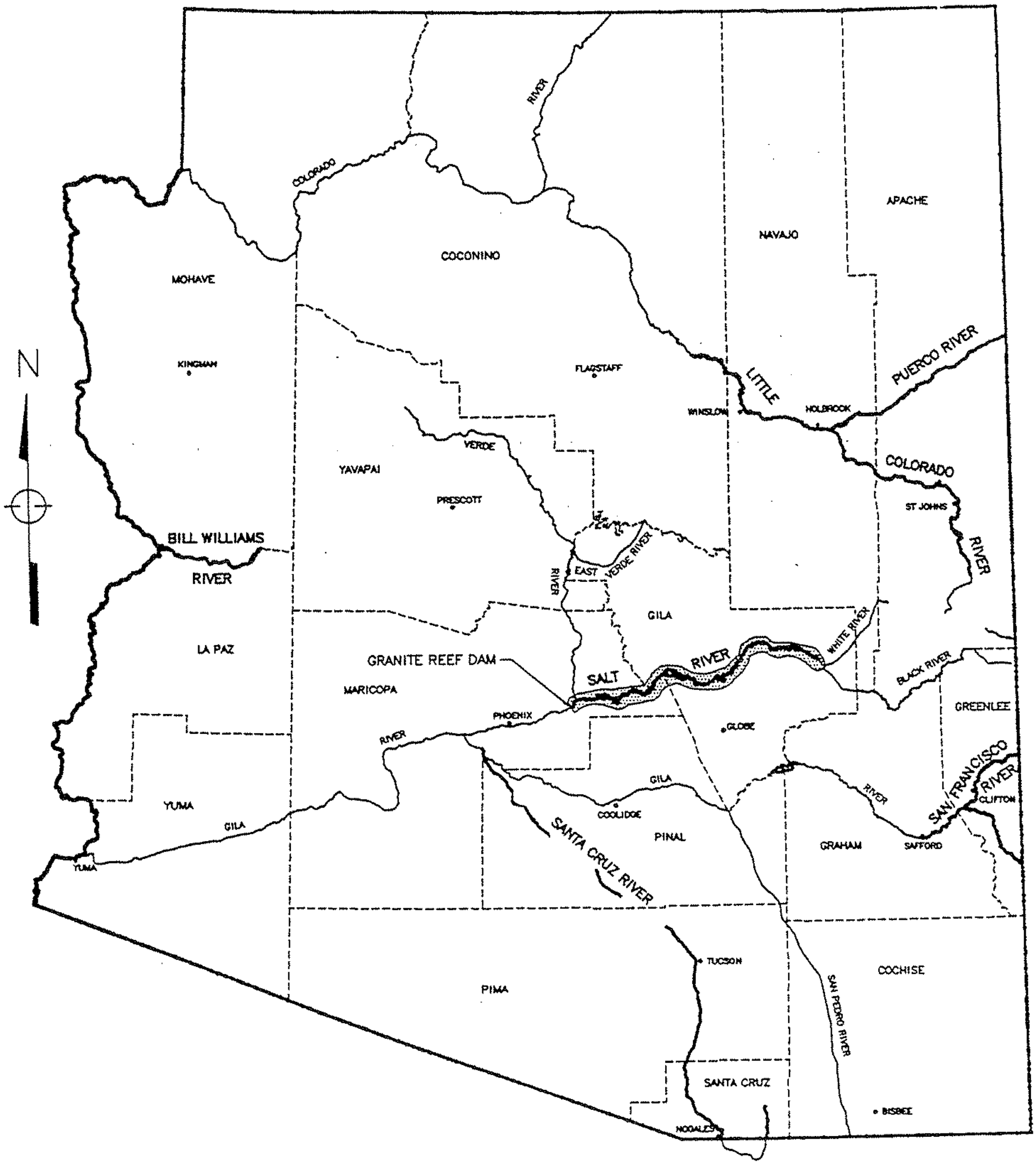

FIGURE 1

Study Reach Location Map

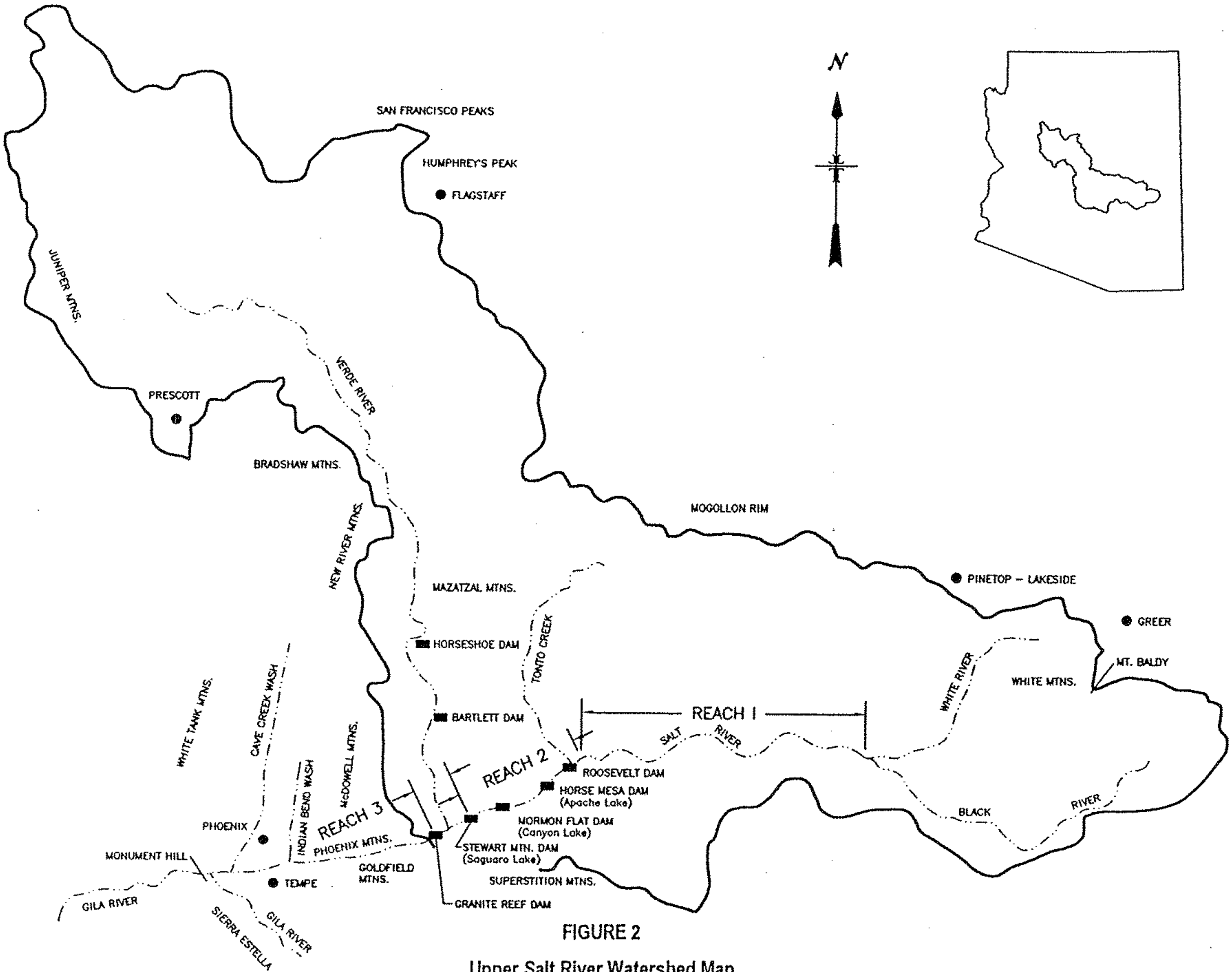

FIGURE 2

Upper Salt River Watershed Map

Physiography

The 153-mile Upper Salt River study reach is located entirely within Maricopa and Gila Counties, although the Salt River watershed extends through about 12,000 square miles of central and eastern Arizona (Figure 2). The watershed ranges in elevation from 12,643 feet at Humphrey's Peak north of Flagstaff (11,590 ft. at Mt. Baldy near Greer) to 1,300 feet at the base of Granite Reef Dam. The Upper Salt River watershed is bounded by the Mogollon Rim to the north, the Mazatzal Mountains to the west, the Superstition Mountains and the Gila River watershed to the south, and the White Mountains to the east. The Verde River portion of the upper watershed is bounded by the Mogollon Rim and San Francisco Peaks to the north, the Juniper, Bradshaw, and New River Mountains to the west, and the Mazatzal Mountains to the east. Major perennial tributaries to the upper watershed include the White, Black, and Verde Rivers, and Tonto Creek.

The study reach experiences a hot, dry climate typical of the upper Sonoran Desert. Mean precipitation and temperature does not vary significantly within the study limits, although climate varies significantly with elevation within the watershed of the study reach (Table 1). Precipitation occurs during two major seasons: in late summer as intense, localized orographic thunderstorms; and in winter as large-scale cyclonic storms which originate over the Pacific Ocean (Sellers and Hill, 1974). Winter storms tend to produce the largest (peak and volume) flows on the Salt River, with over 90 percent of the largest storms occurring in winter months.

Table 1
Climatic Data for the Upper Salt River Watershed.

Average Annual Statistic	Granite Reef 1938-1967 elev.=1,325 ft.	St. Johns 1902-1957 elev.=5,725 ft.	Show Low 1933-1955 elev.=6,382 ft
Precipitation (in)	8.9	11.4	18.4
Max. Temperature	86	70	65
Min. Temperature	54	35	36

Vegetation in the study area is dominated by Sonoran Desert Scrub-Lower Colorado River Subdivision communities which include grasses, low shrubs, and saguaro cacti (Randall, 1993). Since the 1940's, the dominant riparian vegetation species is tamarisk, although previously some reaches were lined by cottonwood, seepwillow, and mesquite trees (Randall, 1993), particularly in Reach 3 and within the flats in Reaches 1 and 2. The upper watershed extends through several climatic-vegetation zones, including areas above the tree line on the highest peaks in the drainage area.

Historically, sources of runoff in the study reach included discharge from springs, snowmelt from higher elevation areas in the upper watershed, and direct runoff from precipitation. Long-term and/or historical streamflow records are available for the entire study reach upstream of Granite Reef Dam. Additional estimates of long-term flow rates for the study reach have been developed based on indirect data such as climatic reconstruction using tree-ring records (cf. Smith and Stockton, 1981), short-term stream gage records made prior to statehood (cf. Davis, 1897), reconstruction of pre-development flows derived from modern stream gage records (cf. Thomsen and Porcello, 1991), accounts of early explorers (cf. Bartlett, 1854), or extrapolations based on irrigation capacity (cf. Kent, 1910). Some of these flow data are summarized in Tables 2 and 3. Hydrologic data for the study reach are discussed in more detail in Section 5 of this report. Historical and hydrologic data indicate that the Salt River was perennial throughout the study area as of the time of statehood, as it is today.

Table 2

Flow Statistics, Salt River Sites Upstream of Reservoirs [a] (cfs).

Month	Salt River above Roosevelt 1914-1989	Verde nr. Tangle Creek 1946-1989
Average Annual Flow	896	559
10% Flow Rate	157	120
50% Flow Rate	343	238
90% Flow Rate	2,040	917

[a] Roosevelt and Tangle Ck. gages located upstream of Salt-Verde confluence.

Table 3 Some Estimates of Average Annual Flow, Salt River at Granite Reef Dam(cfs)		
Average Annual Flow	50% Flow Rate	Source/Methodology
1,045	n.a.	Smith and Stockton, 1981; Tree-ring records
1,689	1,230	Thomsen and Porcello, 1991; Modem Gage Records
2,844	n.a .	Powell, 1893; Short-Term Records
Note: Includes runoff from Verde River.		

Geologic Setting

Arizona is comprised of two great geologic regions: the Colorado Plateau Province, and the Basin and Range Province; with a transition zone, or Central Mountain Province, dividing them (Figure 3). The Upper Salt River drains the Central Mountain Region, and drains into the northern portion of the Basin and Range Province. The Central Mountain Region is characterized by mountains of Precambrian igneous, metamorphic rocks, capped by remnants of Quaternary and Late Tertiary volcanics. Regional uplift of the entire state, including the Central Mountains, is thought to have occurred during the Laramide Orogeny in late Cretaceous/early Tertiary time (65 Ma[1]). Volcanic activity in the study area generally occurred about 29 million years before present (b.p.) during the Tertiary Period. The mountains of the transition zone generally experienced longer periods of erosion, resulting in generally lower elevations than the mountains of the two other provinces (Nations and Stump, 1981). Central Mountain Region ranges within the Upper Salt River basin include the White, Bradshaw, Superstition, and Mazatzal Mountains. These ranges consist primarily of Precambrian metamorphic and igneous rock with some more recent volcanics.

[1]My = 1,000,000 years; 1 Ma = 1 My before present; 1 ky = 1,000 years; 1 ka = 1 ky before present (North American Commission on Stratigraphic Nomenclature, 1983).

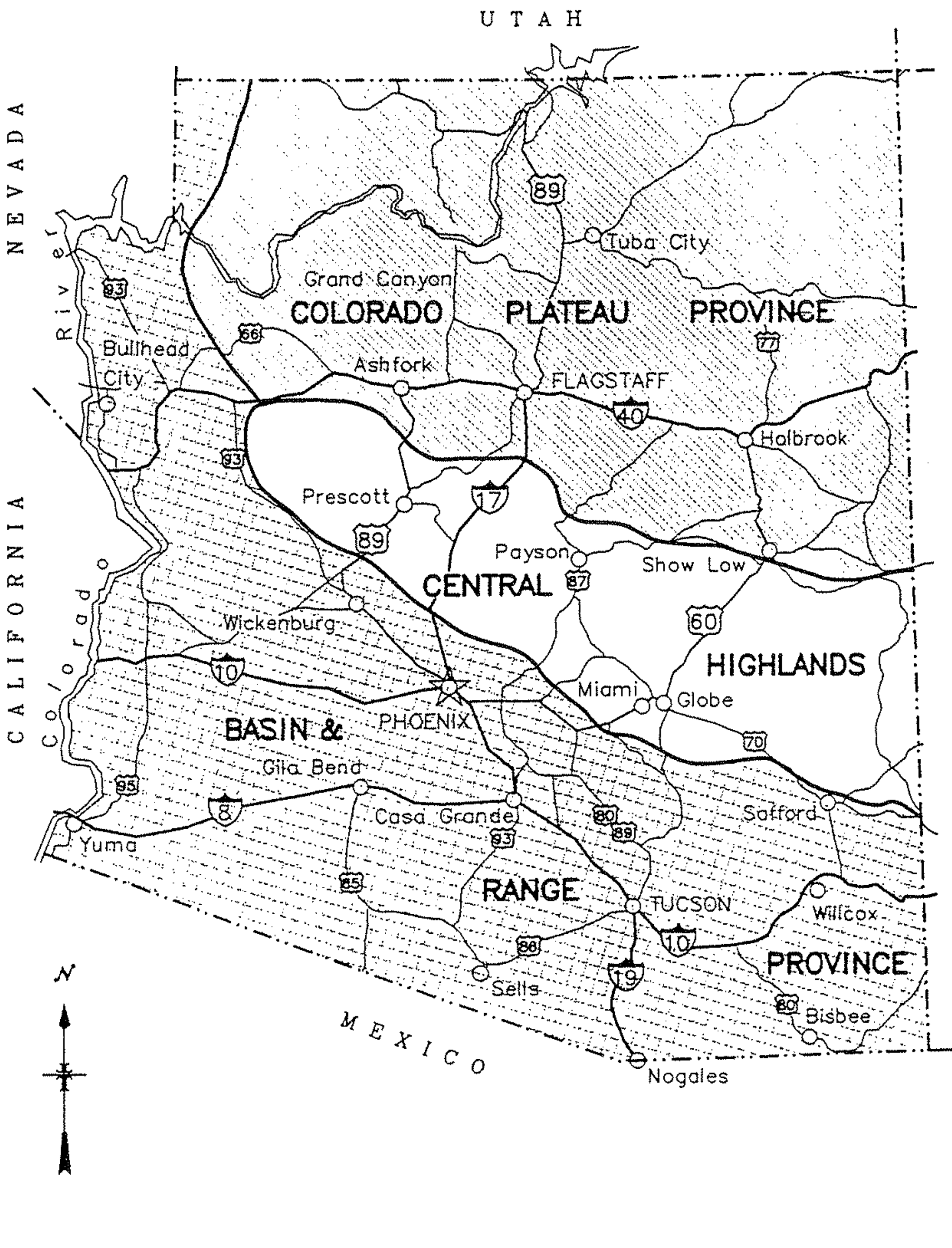

FIGURE 3

Physiographic Province Map

The Upper Salt River study area is located mostly within the narrow confined bedrock canyons of the Central Mountain Province. The geomorphology of most of the Upper Salt River is dictated by the bedrock cropping out in these narrow canyons. Several broader valleys, or "flats," existed along portions of the Upper Salt River in the Central Mountain Province prior to construction of the reservoir system, but have since been inundated by the reservoir storage pools. A few small flats are still found upstream of Roosevelt Reservoir within the Tonto National Forest and Fort Apache Indian Community, including locations such as Redmon Flat and Gleason Flat. No evidence of river instability or significant channel changes during (or since) the historical period was identified in any of the remaining flats.

West of the Central Mountain Region, at the downstream end of the study reach, near Granite Reef Dam and the Verde River confluence, the river enters the Basin and Range Province. The Basin and Range Disturbance (8-15 Ma) was the most recent tectonic event to affect Arizona (Nations and Stump, 1981). This event consisted of tensional stress resulting in steep, normal block faulting which formed a series of northwest-southeast trending mountain blocks. Uplift of mountain blocks was accompanied by downdropping of basin areas and subsequent filling of the intermountain basins by alluvium eroded from the mountains. Most of Reach 3 is formed within a deep alluvial basin at the margin of the Basin and Range Province.

Four sets of distinct geomorphic terraces have been described along the Salt River, within the Basin and Range Province portion of Reach 3. These terraces extend as far upstream as the Blue Point Ranger Station near Saguaro Lake, where the highest (and oldest) terrace is located more than 200 feet above the existing streambed. The elevations of the four terraces converge in the downstream direction until disappearing in the alluvial fill of the Salt River Valley near Tempe. The two highest (and oldest) terraces do not impact the geomorphology of the Upper Salt River study reach. The second youngest of these terraces, the so-called Blue Point terrace, forms the boundaries of the alluvial (geologic) floodplain in Reach 3 near Granite Reef Dam (Kokalis, 1971; Pewe, 1978; 1987). The margins of the Blue Point Terrace constrain the maximum extent of prehistoric river movement during recent geologic time (+/-10,000 years b.p.) in Reach 3. Channel movement during the historic period since the time of statehood was confined well within the Blue Point Terrace margins, near or at the existing channel boundaries. The lowest (and youngest) terrace is the geologic floodplain of Reach 3, an infrequently flooded surface located topographically above the existing stream channel. The active channel and ordinary high (and low) watermark is confined by this lowest terrace.

Geologic Impacts on Streamflow

Bedrock crops out in the bed and banks of most of the Upper Salt River study reach. The bedrock geology of the study reach exerts strong control on river conditions in the Upper Salt River study reach in several ways:

- First, bedrock limits the potential for lateral movement of the stream channel and prevents significant modifications of the channel cross sections with time (OConnor et. al., 1985). The natural erosion rate of bedrock is slow enough to be considered insignificant within the historical period. Within the bedrock-confined canyons of Reaches 1 and 2, no significant changes in channel geomorphology were identified during the period since statehood. In these canyon reaches, the exact locations or geometry of specific pools and riffles may fluctuate in response to large floods, but the overall channel pattern and reach-averaged width-depth-velocity relationships remain essentially unchanged.

- Second, bedrock cropping out in the bed of the river forms small waterfalls and rapids that would have created obstacles for some types of boating at the time of statehood, such as large-draft keel boats, steamboats, or powered barges. Large rapids and low flow riffles are also formed by large cobble and boulder deposits. These riffles could have been local impediments to navigation during some annual low flow periods, for even the most shallow-draft boats available as of the time of statehood.

- Third, bedrock canyons provided a favorable environment for construction of dams and impoundment of water upstream of the dams. Construction of these reservoirs has altered the natural river conditions downstream. Nearly all of the Upper Salt River between State Route 288 and Stewart Mountain Dam (Reach 2) is within a reservoir ponding area, or is affected by backwater from a reservoir. Runoff in Reach 3 is controlled entirely by releases from reservoirs constructed in these bedrock canyons.

- Fourth, narrow bedrock canyons do not provide favorable environments for extensive agricultural operations. Therefore, irrigation diversions as of the time of statehood were limited to very small ditches used for small ranches on the flats and for local water supply. The largest flat and agricultural area along the Upper Salt River located near Roosevelt was submerged by the reservoir prior to statehood.

- Fifth, discharges from springs in bedrock aquifers provide a significant source of streamflow, in addition to the dissolved solids that give the Salt River its name. Discharge from springs provides a constant base flow, making the Upper Salt River a perennial stream, with an average discharge greater than 350 cfs [2] during the driest months of the year (in Reach 3).

- Sixth, given that changes in channel geometry since the time of statehood are generally insignificant, rating curves for existingstreamflow gaging stations and rating curves prepared from recent channel surveys may be used to estimate channel characteristics as of the time of statehood.

- Finally, the rugged terrain and remoteness of the bedrock canyons of the Upper Salt River minimized the potential for human impacts on the watershed and channel as of the time of statehood. Few towns and no significant cities were located on the Upper Salt River. Therefore, transportation routes, including ferries, roads and railroads, almost completely avoided the Upper Salt River. The few transportation routes in the study area are described in Section 3 of this report.

Channel Geomorphology

Descriptions of Historical River Conditions. The early explorers and residents of Arizona record river conditions in the Upper Salt River that are similar to the conditions that may be observed today. These historical accounts, provided elsewhere in this report, describe steep, inaccessible bedrock canyons (except in the flats now inundated by the reservoirs), perennial flow, and narrow canyon bottoms that generally prevented travel by foot or wagon, except during periods of low water. Historical accounts of boating the Upper Salt River describe waterfalls and rapids, and sheer canyon reaches that lacked beaches or bars on which to land. No physical or anecdotal evidence was identified that suggests that the geomorphology of the Upper Salt River has significantly changed during the period since statehood, except for the reaches altered by reservoir construction and by reservoir operation practices.

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[2] Salt River above Roosevelt - USGS Station #09498500 (1914-1989). See Section 5 of this report.

Existing Conditions. In its current condition, the Upper Salt River is a slightly sinuous, moderately steep, entrenched bedrock stream. The channel consists of cobble and boulder riffle sequences, interspersed with shallow, sand- and gravel-bed pools. The channel slope averages about 0.4 ft./ft. (0.4 percent). The average sinuosity is less than 1.5. The channel margins are composed of bedrock and geologically older[3] alluvial terraces, with inset silty sand terraces formed in low energy slackwater zones. Descriptions of some geomorphic characteristics of the three reaches of the Upper Salt River are provided in Table 4.

Table 4.
Reach Geomorphology Description for the Upper Salt River - Existing Conditions

Characteristic	Reach 1	Reach 2	Reach 3
Slope	0.2 ft/ft	0.4 ft/ft*	0.2 ft/ft
Sinuosity	1.6	1.5*	1.3
Channel Pattern	Pool & Riffle	Pool & Riffle*	Riffles, Minor Braiding
Bed Material	Bedrock; Boulders	Bedrock; Boulders*	Gravel-Boulders
Bank Material	Bedrock	Bedrock*	Alluvium
Flow Condition	Perennial	Perennial	Perennial
Human Impacts	Minimal	Reservoir Ponding	Reservoir Releases Flow Regulation
Lateral Stability	Stable	Stable	Stable, Local Erosion

* Note: Characteristic assumed due to reservoir impoundment obscuring data

In general, the geomorphology of the Upper Salt River reflects the bedrock geology of the reach. Minor changes in channel geomorphology can occur, typically occur during the extreme floods. During extreme floods, there is sufficient energy to transport the large diameter bed sediments (boulders) that form the riffles and bars in the canyons. The high-energy floodwater also transports large amounts of finer sediments which are left as thin deposits along the margins of the bedrock canyons (O'Connor et. al., 1986). Streambank riparian vegetation, if it occurs along the channel, grows predominantly on these deposits of finer material. While these finer deposits and

[3] Late Pleistocene to Early Holocene age.

the boulder bars and riffles are subject to erosion during large floods, the net changes in overall channel characteristics typically are minor for an extended river reach. That is, erosion of a bar or riffle in one location generally is balanced by deposition elsewhere in the reach. The overall stream characteristics are preserved, although the exact channel dimensions at any given location may change with time.

In the alluvial portions of Reach 3, large floods flow across the broader geologic floodplain and have the potential to cut new channels within the active channel area. The active channel area is inset within the geologic floodplain. However, like the erosion and deposition in the canyon reaches, any local changes in low flow channel geometry are generally balanced when considered from a reach-wide perspective. No evidence of any significant changes in overall channel geomorphology since the time of statehood was identified for Reach 3.

Ordinary High Watermark

Methodologies for defining the ordinary high watermark are not rigorously defined. In practice, the ordinary high watermark is identified by a marked change in vegetation or soil characteristics between the channel bottom and the overbank area. Occasionally, this change is accompanied by a break in slope between the flat bottom of the active channel and a steep or vertical bank. At one time, several review agencies recommended using the floodplain limits of the 20-year flood to map the ordinary high watermark. The 20-year floodplain limit is generally not used in Arizona at the present time, and was not used for this study.

For the stream navigability studies, House Bill 2594 (1991) defined the ordinary high watermark as:

> ...the line on the shore of a watercourse established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of the soil, destruction of terrestrial vegetation or the presence of litter or debris, or by other appropriate means that consider the characteristics of the surrounding areas. Ordinary high watermark does not mean the line reached by unusual floods.

In Reach 1, lacking evidence to the contrary, it is assumed that the existing river conditions are substantially unchanged from river conditions as of the time of statehood. Therefore, ordinary high watermarks observed in the field probably are very similar to the ordinary high watermarks at statehood. In the narrow bedrock canyons of Reach 1, the canyon walls form the limits of the ordinary high watermark. In the flats, and in areas of larger bars or other alluvial deposits, there are generally readily-identified vertical cut banks that form the ordinary high watermark.

In Reach 2, historical changes to the river preclude use of the normal identifying characteristics of the ordinary high- or low-water marks along the river today. Specifically, inundation of the natural channels by the reservoir impoundment areas have transformed the Salt River into a series of adjacent reservoir pools. The ordinary and natural condition of the river as of the time of statehood is no longer visible. It is interesting to note that as of the time of statehood, in its ordinary and natural condition, the shoreline of Roosevelt Reservoir was the ordinary high watermark. The shoreline of Roosevelt Reservoir, if used as the ordinary high watermark, would greatly widen the limits of the (riverine; pre-statehood) ordinary high watermark along the Salt River upstream of Roosevelt Dam.

In Reach 3, it is possible that alteration of the natural flow regime due to water and power supply concerns, has led to some change in the ordinary and natural condition of the river as of the time of statehood. However, Reach 3, which is located within the Tonto National Forest, has not been extensively developed or channelized, or been subject to other major human modifications. Therefore, it is assumed that the physical characteristics of Reach 3 below the ordinary high watermark have not significantly changed since 1912. Like Reach 1, the ordinary high watermark can be identified in the field by the location of vertical cut banks, the onset of riparian vegetation such as mesquite bosques, and presence of fine-grained soil materials in direct contrast to the very coarse active channel sediments.

Ordinary high watermarks were estimated from the most recent 7.5 minute USGS topographic maps using the break in slope at the main channel indicated by the contour lines. If the State makes any future claim to the bed of the Upper Salt River, it will be necessary to refine the delineation of the ordinary high watermark using more detailed topographic mapping and/or field survey techniques. Ordinary high water flow rates, according to information presented elsewhere, probably exceeded 20,000 cfs (cf. Powell, 1893), a rate which occurred nearly every year prior to completion of the Salt-Verde Reservoir system, and which would fill the channel of the Upper Salt River. In general, the ordinary high water area follows the blue and stippled zone along the main channel on the topographic maps.

Ordinary Low Watermark

HB 2589 limited the State's claim to navigable watercourses to the land within the ordinary low watermark. The ordinary low watermark is defined in HB 2589 as:

> ...the line on the banks of a watercourse created when the water recedes at its regularly recurring lowest stage in normal years without reference to unusual droughts.

In practice, the ordinary low watermark may be difficult to identify on Arizona rivers, but is generally identified in conjunction with delineation of the high watermark, or is defined on the basis of site-specific or hydrologic characteristics. Unlike high watermarks, low watermarks are more ephemeral and may be erased by subsequent high flows. Case histories for application of a low watermark standard in Arizona are lacking.

The following general statements can be made in regard to delineation of the ordinary low watermark for the Upper Salt River:

- The Upper Salt River is a perennial stream. Therefore, an ordinary low watermark exists for the study reach. It was assumed for purposes of delineating the ordinary low watermark that no unusual drought conditions currently exist, or existed at the time the USGS topographic maps were prepared.

- Portions of Reach 2 are within the impoundment areas of the Salt River reservoir system. Any physical evidence of the riverine ordinary low watermark as of the time of statehood in these reservoir areas is now buried under the surface of the reservoir. The existing ordinary low watermark for Reach 2 reflects the normal storage pool elevation of each reservoir, which represents a much larger land area than the pre-reservoir riverine ordinary low watermark. One of these reservoirs, Roosevelt, was in existence at the time of statehood.

- Within the narrow bedrock canyon portions of the Upper Salt River, there is very little difference in land area between the ordinary high watermark and the ordinary low watermark, especially at the scale of mapping used for this study. This land area between the two marks generally consists of narrow bouldery channel bars and sandy deposits devoid of vegetation.

- For the purposes of this study, the limits of the blue river symbol on the USGS topographic map may be taken as the limits of the ordinary low watermark. Should a claim of ownership based on the ordinary low watermark be made by the state, a more detailed delineation is recommended using detailed topographic mapping and/or field survey.

Regardless of whether the ordinary low watermark is delineated for existing (1996) conditions or for conditions as of the time of statehood (1912), the entire Upper Salt River was perennial in its ordinary and natural condition, as defined by HB 2589.

Summary

Review of the geology of the Upper Salt River indicates that the channel geomorphology is substantially unchanged from its condition at or before statehood, except where the river has been inundated by reservoir impoundments. Most of the Upper Salt River is formed within deep bedrock canyons. Bedrock along the channel margins in these canyons precludes significant movement of the river channel or other channel changes. In addition, the bedrock geology of the Upper Salt River area made access to the river difficult during the period around statehood, prevented development of extensive irrigation systems, and prevented the development of large population centers near the river. Bedrock outcrops in the channel created waterfalls, rapids, and narrow canyons which may have been potential impediments to navigation for some types of boats such as keel boats, steamboats, and powered barges.

However, the bedrock geology of the Upper Salt River was also conducive to construction of large dams and water supply reservoirs. Construction of the four reservoirs induced the only significant changes in the natural geomorphology of the study reach. In addition to the obvious changes in runoff rates caused by the reservoirs, the location of the ordinary high water and ordinary low watermarks were changed by impounding water along the Upper Salt River system. The bedrock geology is also responsible for the large number of springs which discharge into the river, giving it a reliable source of perennial base flow runoff.

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Arizona State Land Department

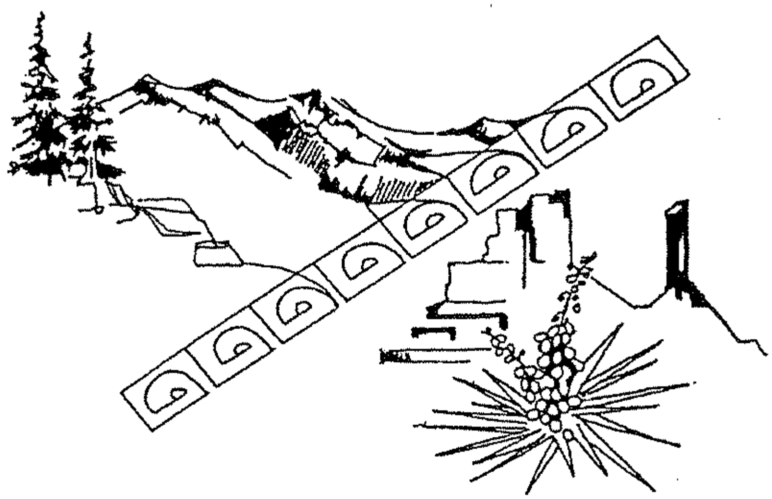
ARIZONA STREAM NAVIGABILITY STUDY

for the

UPPER SALT RIVER

Granite Reef Dam to the Confluence of the White and Black Rivers

Final Report



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Section 5

Hydrology of the Upper Salt River

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Hydrology of the Upper Salt River

Introduction

The objective of this section is to evaluate the ordinary and natural discharge of the Upper Salt River. The hydrology of the Salt River upstream of Granite Reef Dam was significantly altered by human activities beginning with the construction of Roosevelt Dam in the early 1900's. Therefore, the ordinary and natural hydrologic condition of the Salt River depends on which changes are considered non-natural. So that the range in potentially "natural" conditions is presented, this section summarizes information that describes the hydrology of the Upper Salt River for the following time periods:

- Pre-Settlement - Flow conditions for the period leading up to statehood
- Statehood - Flow conditions in 1912, the year of Arizona statehood
- Post-Statehood - Long-term flow conditions, including the period after 1912

For stream conditions during each of these time periods, estimates of monthly and annual flow rates, anecdotal information regarding the appearance and character of the stream, and flood data will be summarized. Hydraulic rating curves relating discharge to stream depth, width, and velocity for existing and historical river conditions will also be presented.

Stream Reaches

The study reach extends from the confluence of the Black River and the White River near Fort Apache to Granite Reef Dam near Phoenix (Figure 1), a distance of approximately 153 miles. For the purposes of the hydrologic investigation, the Upper Salt River hydrology may be considered in three stream reaches:

- Reach 1 - White River/ Black River confluence to Roosevelt Reservoir
- Reach 2 - Roosevelt Reservoir toStewart Mountain Dam
- Reach 3 - Stewart Mountain Dam to Granite Reef Dam

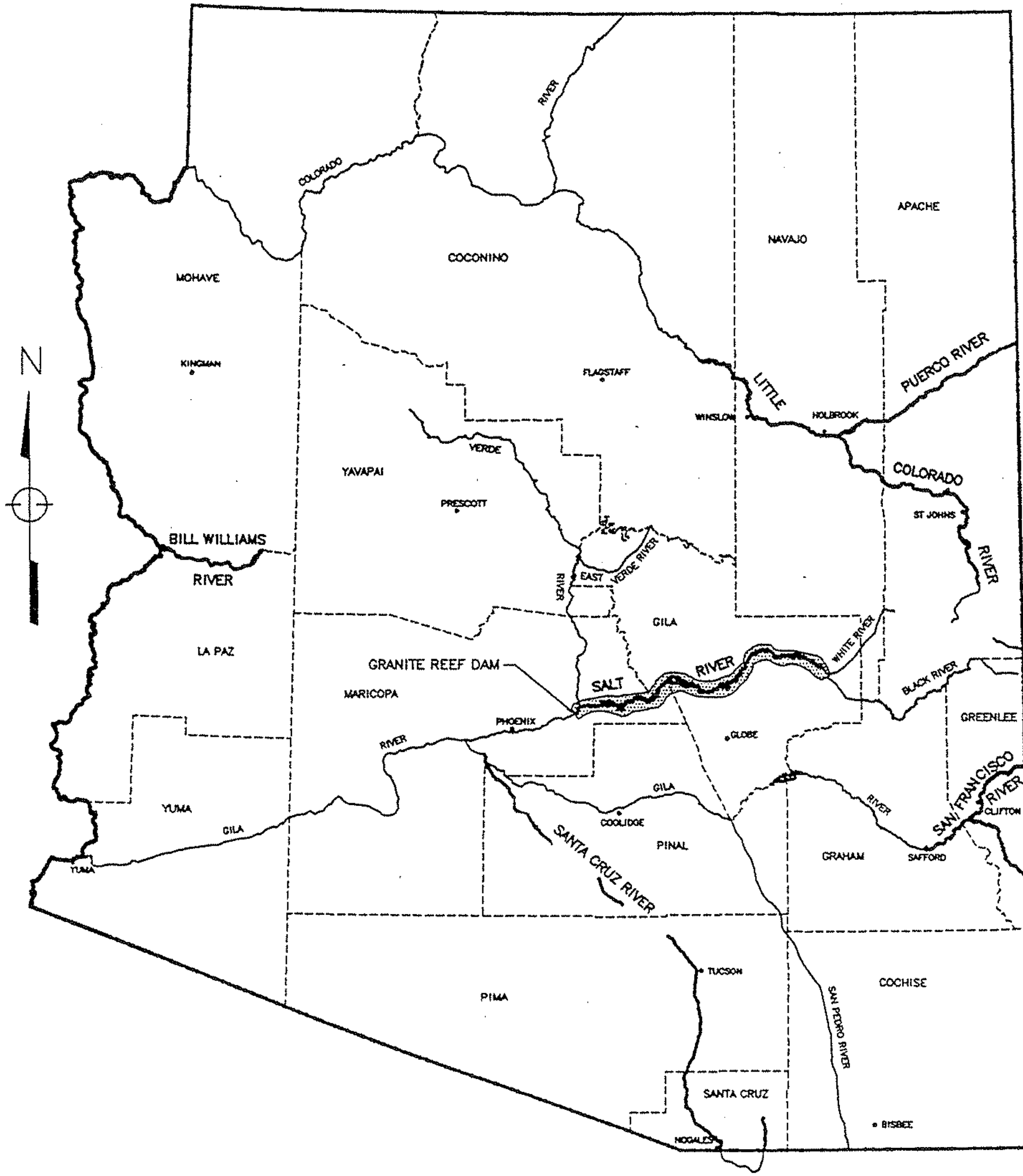

FIGURE 1

Study Reach Location Map

Reach 1. The hydrologic condition of Reach 1 is the closest to its pre-statehood condition of the three Upper Salt River reaches, and has been least impacted by human modifications of the channel and watershed. Reach 1 is located within the San Carlos Indian Reservation, the Tonto National Forest, and the Salt River Canyon Wilderness Area (Figures 1 and 2). The Salt River in Reach 1 is generally bounded by steep-walled bedrock canyons that lack a geologic floodplain. The bedrock canyon portions of Reach 1 probably have not experienced significant changes in their geomorphic channel conditions during the past 1,000 years (O'Connor et. al, 1985). Perennial tributaries that join the Salt River in Reach 1 includeCarrizo Creek, Cibeque Creek, Canyon Creek, Cherry Creek, Pinal Creek, and Tonto Creek.

Reach 2. The hydrology of Reach 2 has been substantially altered by construction of four major water supply dams: Roosevelt Dam (Roosevelt Lake), Horse Mesa Dam (Apache Lake), Morman Flat Dam (Canyon Lake), and Stewart Mountain Dam (Saguaro Lake). The natural condition of the Salt River has been altered by these reservoirs to the extent that the entire length of Reach 2 consists of reservoir ponding area, or is affected by reservoir backwater. Reach 2 is located entirely within the Tonto National Forest. The river and reservoirs in Reach 2 are bounded by bedrock canyons. In addition to Tonto Creek, a number of relatively small perennial and intermittent tributaries join the Salt River in Reach 2 (Figures 1 and 2).

Reach 3. Reach 3 extends from Stewart Mountain Dam to Granite Reef Dam. Flow in Reach 3 is significantly affected by Salt River Project water management and power generation practices, water rights requirements, and flood control practices on the six upstream reservoirs on both the Salt and Verde River systems. Unlike Reaches 1 and 2, Reach 3 is primarily bounded by stable, Pleistocene-aged alluvial terraces, rather than bedrock. Except for the Verde River, no significant perennial or intermittent tributaries join the Salt River in Reach 3. Reach 3 is located within the Tonto National Forest, the Salt River-Pima Maricopa Indian Community (SRPMIC), and includes a minor amount of private land.

Data Sources

Stream discharge information for the Upper Salt River study reach was obtained from long-term USGS stream gage records (cf. USGS, 1902ff; 1991), miscellaneous engineering reports (cf. Hancock, 1912), Flood Insurance Studies (FEMA, 1991), and other reports describing the hydrology of the Salt River. Key data sources are referenced in the bibliography. A list of some of the key existing and historical USGS stream gages and watershed characteristics for the study reach is provided in Table 1.

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[1] North half of the Salt River only, downstream of the Verde River Confluence

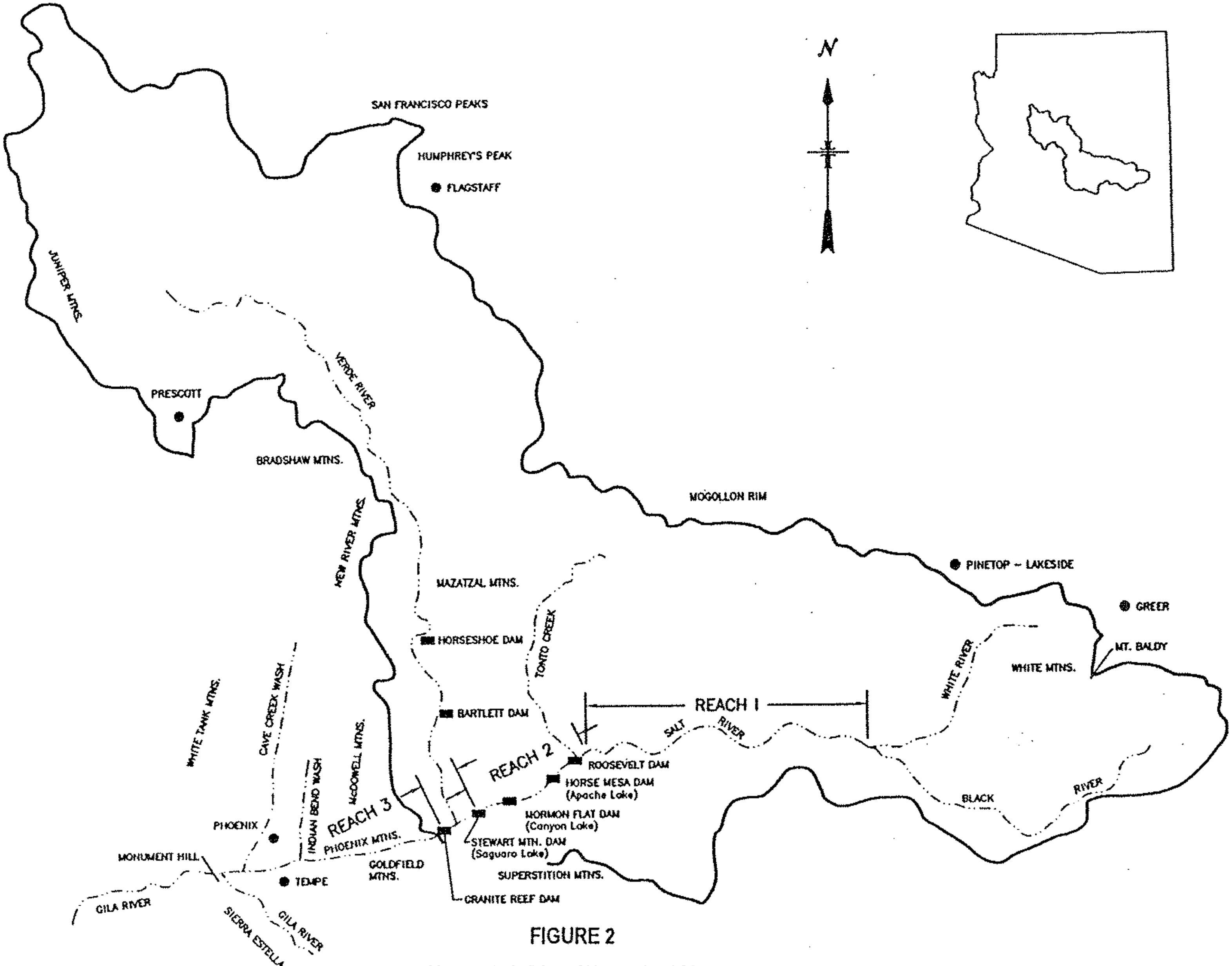

FIGURE 2

Upper Salt River Watershed Map

Data Sources

Stream discharge information for the Upper Salt River study reach was obtained from long-term USGS stream gage records (cf. USGS, 1902ff; 1991), miscellaneous engineering reports (cf. Hancock, 1912), Flood Insurance Studies (FEMA, 1991), and other reports describing the hydrology of the Salt River. Key data sources are referenced in the bibliography. A list of some of the key existing and historical USGS stream gages and watershed characteristics for the study reach is provided in Table 1.

Table 1. Upper Salt River Navigability Study
USGS Stream Gages in the Upper Salt River Watershed

Gage	USGS ID #	Drainage Area	Elevation of Station	Earliest Record
Salt River & Tributaries				
Black River near Fort Apache	09490500	1,232	4,310	1958
White River near Fort Apache	09494000	632	4,360	1958
Salt River nearChysotile	09497500	2,849	3,350	1925
Salt River below Cherry Creek	-		2,460	1906
Salt River near Roosevelt	09498500	4,306	2,200	1914
Salt River nearLivingstone	-			1901
Salt River at Roosevelt (Dam Site)	09498500	5,824	1,920	1904
Salt River below StewardMtn Dam	09502000	6,240	1,400	1934
Salt River atMcDowell	09502500	6,268	1,330	1897
Arizona Dam/Granite Reef Dam	-	12,000+	1,310	1890
Verde River & Tributaries				
Verde River @McDowell	-	6,160	1,330	1899
Verde River near McDowell	-	6,160	1,330	1888
Verde River below Bartlett	09510000	6,160	1,572	1937
Verde River below Tangle Creek	09508500	5,859	2,045	1925
Verde River near Camp Verde	09506000	5,010	2,880	1911
Verde River at Camp Verde	-	5,000	3,070	1912

Notes: Flow records at stations may be discontinuous. Elevations and drainage areas are approximate.

Hydrologic Setting

The Upper Salt River study reach is located in Gila and Maricopa Counties, although its 12,000 square mile watershed drains much of central and eastern Arizona (Figure 2), and includes portions of nine of the fourteen Arizona counties. The watershed ranges in elevation from 12,643 feet at Humphrey's Peak north of Flagstaff (11,590 ft. at Mt. Baldy near Greer) to about 1,300 feet at Granite Reef dam. The Salt River watershed is bounded by the Mogollon Rim to the north, the Mazatzal Mountains to the west, the Superstition Mountains and the Gila River watershed to the south, and the White Mountains to the east. The Verde River portion of the watershed is bounded by the Mogollon Rim and San Francisco Peaks to the north, the Juniper, Bradshaw, and New River Mountains to the west, and the Mazatzal Mountains to the east. The major perennial tributaries to the study reach include the White, Black, and Verde Rivers, and Tonto Creek.

Within the Upper Salt River study reach, the river is located almost entirely within steep bedrock canyons. The river channel itself consists of a relatively steep, bouldery channel with a pool and riffle channel pattern. The average channel slope is about 20 feet per mile (0.4 percent), and includes several small waterfalls. In many places the active channel completely fills the canyon bottom, although small flood deposits and alluvial surfaces that form isolated terraces above theordinary high watermark are found throughout the study reach. Near the downstream limit of the study reach in Reach 3, the active channel area becomes broader with a more extensive floodplain, and is bounded by stable late Quaternary-aged alluvial surfaces as well as by bedrock.

The climate within the Upper Salt River watershed varies significantly with elevation. The lower elevations are characterized by very hot, semi-arid desert conditions. The climate in the higher elevations ranges to alpine conditions (Table 2). Precipitation primarily occurs during two periods (Table 3): in late summer as intense localized orographic thunderstorms; and in winter as large-scale cyclonic storms which originate over the Pacific Ocean (Sellers and Hill, 1974). Winter storms, in conjunction with snow melt runoff, tend to produce the largest peaks and flow volumes on the Salt River, with over 90 percent of the largest storms occurring in winter months. About 60 percent of the annual rainfall and 82 percent of the runoff volume occurs during winter (Cooperrider and Sykes, 1938). Furthermore, all years with annual peak flows during summer months have had below average annual discharge volumes (Fuller, 1987). Runoff from spring snowmelt also comprises a significant component of the annual flow volume.

Table 2 Climatic Data for the Upper Salt River Watershed.			
Average Annual Statistic	**Granite Reef 1938-1967 elev.=1,325 ft.**	**St. Johns 1902-1957 elev.=5,725 ft.**	**Show Low 1933-1955 elev.=6,382 ft**
Precipitation (in)	8.9	11.4	18.4
Max. Temperature	86	70	65
Min. Temperature	54	35	36

Table 3 Seasonal Variation in Precipitation (Inches) and Temperature (°F) for the Salt River Watershed			
Month	**Granite Reef elev.=1,325 ft.**	**St. Johns elev.=5,725 ft.**	**Show Low elev.=6,382 ft.**
January	1.0	0.7*	1.3
February	0.8	0.7*	1.4
March	0.9	0.8*	1.6
April	0.4	0.5*	0.6
May	0.1	0.5*	0.7
June	0.1	0.6	0.4
July	0.8	2.1	2.5
August	1.5	2.1	2.5
September	0.8	1.3*	1.6
October	0.5	1.0*	1.7
November	.7	0.4*	1.4
December	1.3	0.7*	2.3
Annual	8.9	11.4	18.1
Aver. Max & Min. Temperature	86 / 54	70 / 35	65 / 35
* indicates precipitation may occur as snow			

Vegetation within the Salt River watershed also varies with elevation. The lower elevations in the watershed and the channel margins are dominated by Sonoran Desert Scrub-Lower Colorado River Plant communities, which include grasses, low shrubs, and saguaro cacti (Graf, 1981). Although tamarisk has replaced much of the native riparian vegetation, portions of the Upper Salt River were once lined by cottonwood, seepwillow, and mesquite trees (Davis, 1982). The upper watershed extends through several climatic-vegetation zones, including several areas above the tree line on the highest peaks.

Historically, sources of runoff included discharge from springs, snowmelt in the higher elevations, precipitation, and ground water discharge. While Reach 1 is effectively free-flowing, reservoir impoundments have substantially altered the natural flow regime in Reaches 2 and 3. The entire Upper Salt River study reach experiences perennial runoff in spite of reservoir impoundment.

Pre-Statehood Hydrology

There are four primary sources of information on the hydrology of the Salt River prior to its alteration during the 20th century. These include direct streamflow measurements, reconstruction of flow rates from modern gage records, reconstruction of flow rates by indirect methods such as tree-ring data, and historical and anecdotal accounts of flow conditions. Pre-statehood hydrologic records are indicative of the ordinary and natural flow conditions of the Salt River, without any human impacts.

Direct measurement. Direct measurement includes gaging of river flow at controlled or measured stream sections. The Salt River was gaged at a few stations between 1888 and 1912 within the study reach prior to statehood in 1912 (Tables 1 and 4). The Salt River at McDowell and Verde River at McDowell gages were located just upstream of the Salt River-Verde River confluence (respectively) in Reach 3. An additional gaging station was located downstream of the confluence at Arizona Dam until the dam failed in 1905, after which the gage was moved to the new dam location at Granite Reef. The gage records indicate that flow was perennial in the study area, with the minimum average annual recorded flow from 1888 to 1912 at about 240 cfs in 1903 on the Salt River at McDowell, and 311 cfs in 1899 at the Verde River at McDowell. The minimum combined average annual flow during this period was 625 cfs in 1903.

The average annual flow rates recorded at USGS gaging stations during the pre-statehood period are summarized in Table 5. Average flow rates for the month of February during the pre-statehood period are shown in Table 6. The month of February typically experienced flows well in excess of the average annual flow rate. Flow rates for the month of February are shown because Arizona statehood occurred in February, 1912.

Table 4 Salt River Pre-Statehood Gages - Direct Flow Measurements			
Gage Name	**Period of Record**	**Minimum Average Monthly Flow (cfs)**	**Minimum Average Annual Flow (cfs)**
Salt River @ Roosevelt Dam Site	1888-1907, 1910-1913	45 (July, 1902)	118 (1902)
Salt River @.McDowell	1895 - 1911	64 (June, 1904)	342 (1904)
Verde River @ McDowell[1]	1888 - 1932	52 (June, 1892)	175 (1900)
Salt River @ Arizona Dam	1888 - 1896	331 (October, 1889)	2,656 (1889)

Notes: gages were not operated continuously for entire period listed; Sites were moved.

[1] Gaging station equivalent to Verde River below Bartlett Dam 1932-1996

Table 5 Salt River Pre-Statehood Gages - Average Annual Flow		
Gage Name	**Period of Record**	**Average Annual Flow (cfs)**
Salt River @ Roosevelt Dam Site	1888-1907, 1910-1913	1,045 cfs
Salt River @.McDowell	1895 - 1911	1,560 cfs
Verde River @McDowell	1888 - 1932	783 cfs

Note: Average annual flow estimate based on reported average monthly flow data.

Table 6 Comparison of Average February Streamflow Records on Salt River, 1895-1905	
Salt River @McDowell	**Salt River @ Roosevelt**
1,801 cfs	1,390 cfs

Other less systematic streamflow measurements were also made during the period prior to statehood. Powell (1892) estimated the annual low flow of Salt River at 800-900 cfs below the Verde River confluence, though he revised his low flow estimate (1893) to an average minimum flow of 500 cfs. He reports an instantaneous low discharge of 417 cfs in August, 1889, and a high variable mean monthly discharge ranging from 940 cfs to 9400 cfs. Davis (1897), however, reports that the minimum instantaneous discharge between August 1888 and February 1891 was 300 cfs, and that the average monthly flow was 3,074 cfs. Davis and Powell were likely reporting flow conditions downstream of the Salt-Verde confluence, near Arizona Dam.

Flow Reconstruction From Stream Gage Records. Several investigators have attempted to reconstruct average flow conditions at Granite Reef Dam or in parts of the Upper Salt River study reach using stream gage records from stations located upstream of the Salt-Verde confluence (Table 7). Thomsen and Porcello (1991) determined an average annual (pre-development) flow rate of 1690 cfs at the Salt River Pima Maricopa Indian Community, with a median discharge (50% rate on the flow duration curve) of 1,230 cfs [2]. The Salt River Valley Water Users Association (SRP, 1954) used gage records from 1889 to 1953 to estimate a mean annual discharge of 1,773 cfs. Consideration of only the period from 1889 to 1912 would yield a mean annual discharge of about 1,880 cfs, with a range of average annual discharges of 400 cfs to 7,180 cfs. Daily flow measurements taken at the Verde River near McDowell gage between 1904 and 1924 indicate that the "expected daily flow" for that period was 968 cfs (Atshul, 1987).

Table 7
Pre-Statehood Runoff Estimates Derived from Upstream Gage Records - Salt River at Granite Reef Dam:

Reference	Average Annual Flow	Median Flow
Thomsen and Porcello (1991)	1,690	1,230
Salt River Water Users (1954)	1,880	n.a.
Stockton and Smith (1981)[1]	1,265	n.a.
Garrett and Gellenbeck (1991)[2]	1,455	581

Notes:
[1] 1,265 cfs is sum of Stockton and Smith's estimates for Salt (796 cfs) River and Verde River (469 cfs) for the Verde River above Tangle Creek and Salt River above Roosevelt stations.
[2] Arithematic sum of estimates from two USGS gages. (1) Salt River above Roosevelt (896 cfs) and (2) Verde River below Tangle Creek (559 cfs) modern gage record. Excludes drainage area downstream of gages. Provided for comparison with pre-statehood estimates.

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[2] The 50% flow rate is the flow rate that is equaled or exceeded 50% of the time. Thomsen and Porcello (1991) estimated average annual flow rate of 1,730 cfs if tree-ring data are included with stream gage records.

Indirect Estimates. Indirect estimates of average flow conditions in the study reach have been made from long-term tree-ring[3] chronologies from the Upper Salt and Verde River watersheds (Smith and Stockton, 1981; Fritts, 1980), from measurements of pre-statehood channel widths, and from canal diversion records. Tree-ring records dating to 780 A.D. (Graybill, 1989) indicate that the average annual flow rate for the modern gage record is slightly above the long-term mean. Tree-ring records from 1580 to 1989 were used to estimate average annual flows of 796 and 469 cfs for the Salt and Verde Rivers, respectively (Table 7). Modern stream gage records indicate average annual flow rates of 896 and 559 cfs (Garrett andGellenbeck, 1991; Table 7) for these Salt and Verde River stations. Comparison of gage data from 1895 to 1905 (prior to work on Roosevelt Dam) at the Salt River Roosevelt gage (site of long-term records) with Salt River McDowell gage data indicates that mean flow rates are similar at both stations (Tables 6 and 7). Use of flow data from the Salt River at Roosevelt Dam Site station (Reach 2) and Salt River above Roosevelt (Reach 1) for the period after 1905 would tend to under estimate flow rates in Reach 3 of the study area (Tables 6 and 7), since flow rates increase in the downstream direction along the Upper Salt River. Therefore, these indirect data studies support the conclusion that the USGS stream gage records for upstream stations are an acceptable source of reliable minimum streamflow data for the Upper Salt River study reach for estimating pre-statehood conditions.

Historical Accounts. The historical record of the Upper Salt River extends back to the first beaver trapping expeditions of the 1820's. Some of these historical records, as well as archaeological records, are summarized in more detail in Sections 2 and 3 of this report. For the purposes of hydrology, it is noted that of the numerous early expeditions along the Salt River study reach, all traveled by foot, horse, or wagon. However, early accounts of the river describe abundant waterfowl, fish, water, riparian vegetation, and grassy bottomland in the flats and in the Salt River Valley downstream (Davis, 1982). Bartlett (1854, cited in Davis, 1982) describes the lower Salt River as clear and sweet, averaging 80 to 120 feet wide, and two to three feet deep. Not one of the early explorers describes a dry riverbed in the Upper Salt River study area, at any time of year. Finally, several pre-statehood Arizona residents used boats to travel portions of the Upper Salt River study reach, as described in Section 3.

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[3] Tree-ring studies assume the thickness of the individual annual rings are related to discharge. Wet year (high average annual flow) give rise to thicker rings. Individual tree rings can be readily matched to specific years. Smith and Stockton's data was calibrated using recent gage data and recent tree-ring records.

Summary. Prior to statehood, the Upper Salt River was a perennial stream, with an average annual discharge ranging from about 1,400 cfs to 1,800 cfs. Monthly and annual fluctuations no doubt occurred in response to seasonal precipitation and snowmelt runoff, or slight climatic variations, similar to those which presently occur in the watershed above Roosevelt Dam. However, early records and reconstructed flow rates for the pre-statehood period indicate that flow rates exceeded 1,200 cfs more than half the time. Minimum flow rates generally exceeded 200 cfs, even during extended dry periods prior to 1912. Streamflow rates were sufficient to support rich riparian vegetation, fish and beaver populations, and a large irrigation based agricultural economy downstream of the Upper Salt River.

Statehood Hydrology

The hydrology of the Upper Salt River for 1912, the year of Arizona statehood, is not significantly different than for the 10 to 20 years of record immediately preceding statehood, except for the portions of Reaches 2 and 3 impacted by closure of Roosevelt Dam and the filling of Roosevelt Reservoir. However, only limited data are available from which to estimate flow conditions both for the entire year and for the month of February, 1912. Unfortunately, the record is not sufficiently detailed to be able to precisely define the flow rates and stream hydraulics for the entire study reach on the day of statehood.

Streamflow Data: 1912. Climatic data summarized in Section 2 of this report indicate that the year of statehood occurred during one of the wettest periods in the past 1,000 years (Smith and Stockton, 1981). However, the year of 1912 itself had a below-average annual runoff rate estimated at 1,176 cfs (Arizona State Planning Board, 1936; See Table 8), despite occurring during this wet period. The U.S. Reclamation Service/Salt River Project (1914) computed the average annual diversion from the Salt River in 1912 (calendar year), excluding the Tempe and Utah canals, at 1,040 cfs.[4] Therefore, the average natural streamflow input from the Upper Salt River study reach must have been at least 1,040 cfs.

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[4] The BUREC (1924) estimated the average annual flow rate for 1912 at 1,378 cfs. The BUREC rate may have included release of 460 cfs from water stored in Roosevelt Reservoir required to meet downstream requirements.

Table 8 Salt River Average Annual Flow Estimates for 1912		
Source	**Flow Rate**	**Upstream Stations**
US Reclamation/SRP (1914)	1,040 cfs	Salt River Valley diversions
BUREC (1924)	1,378 cfs	Granite Reef Dam
Ariz. State Board (1936)	1,176 cfs	Granite Reef Dam
USGS (1954)	757 cfs	Salt River @ Roosevelt
USGS (1954)	621 cfs	Verde River @McDowell
Combined USGS flow rates = 1,378 cfs, but does not include runoff from Tonto Creek and some Verde River tributaries.		

Streamflow Data: February, 1912. The month of February 1912 was unusually dry. Statistics developed by the Arizona State Planning Board (1936) estimate a monthly combined (natural) average flow rate of 398 cfs [5] for the Salt and Verde Rivers, a rate well below the mean flow for the year (1,176 cfs), and the long-term average for the month of February of about 3,300 cfs [6]. By comparison, mean flow rates for the months of February immediately preceding (1911) and following (1913) the year of statehood were 4,155 and 1,237 cfs, respectively. The Arizona State Planning Board estimates were made in part from the Salt River above Roosevelt station, and did not account for release of water stored in Roosevelt Reservoir required to meet downstream irrigation needs. Lippencott (1919) reports that average monthly discharge for February 1912 was 532 cfs on the Salt River, with the annual discharge only 62 percent of normal. In other documentation, the U.S. Reclamation Service/Salt River Project (1914) reports the average "natural" monthly flow of the Salt and Verde Rivers for February 1912 as 532 cfs, with a six year average of 3,396 cfs for the month of February. The U.S. Reclamation Service/Salt River Project (1913; 1914) reported that 963 cfs [7] was diverted from the Salt River downstream of the Upper Salt River study reach in February 1912, excluding diversions to the Tempe and Utah Canals. A summary of February 1912 flow rate estimates is shown in Table 9.

[5] Salt River above Roosevelt = 233 cfs; Verde aMcDowell = 165 cfs.

[6] February Average Monthly flow rates: Salt River above Roosevelt (1914-1989) = 1,360cfs;
Verde McDowell (1899-1932) = 1,990 cfs. Minimum average February flow rates are 168 cfs and 417 cfs for the Salt and Verde Rivers, respectively, for the same period of record.

[7] 616 cfs is listed in the 1913 report, but apparently is a typographic error. The value was reported as 35,420 acre-feet in the same 1913 report, and as 55,420 acre-feet in 1914 report. However, the annual value reported in 1913 is 20,000 acre-feet greater than the sum of monthly values. Therefore, it is assumed that 55,420 (963 cfs) is the correct value for February 1912. The 963 cfs must include releases from Roosevelt Dam given the February 1912 flow rates reported for stations upstream of Roosevelt Dam and for the Verde River.

Table 9 February 1912, Average Monthly Flow Rate (cfs)			
Station	**Flow Rate**	**Notes**	**Source**
Granite Reef Dam	532 cfs	February, 1912; 62% of normal	Lippincott, 1919
Salt River @ RooseveltDamsite	233 cfs	February, 1912	SRVWUA, 1934
Verde River @ McDowell	165 cfs	February, 1912	SRVWUA, 1934
Combined Salt & Verde	398 cfs	February, 1912	SRVWUA, 1934
Salt River at Roosevelt	233 cfs	February, 1912	USGS, 1915
Salt River Diversion	963 cfs	February, 1912	USRS/SRP, 1913

Streamflow Data: February 14, 1912. No streamflow measurements in the Upper Salt River study reach were reported for the day of Arizona statehood, February 14, 1912. The USGS (1914) reported a measurement for the Verde River at McDowell gage, located just upstream of the Salt-Verde confluence, of 269 cfs on February 16, 1912. No daily measurements for the year of 1912 for the Salt River are available from published USGS records. The Arizona Republican for February 1, 1912 reported a "normal discharge" of 99 cfs at Jointhead Dam and 520 cfs at Granite Reef Dam (Lacy et al, 1987). This discharge estimate was taken below the diversions at Granite Reef Dam, Utah Canal, and the Tempe Canal. It is also noted that because Roosevelt Reservoir was filling between 1911 and 1915 the normal flow of water downstream of Roosevelt Dam was significantly altered (reduced) during this period.

Summary. Although 1912 had below average flow on the Upper Salt River, the minimum flow rate was at least 200 cfs upstream of the Verde River confluence during the month of February 1912, and averaged over 1,000 cfs for the year of 1912.

Post-Statehood Hydrology

Since statehood, runoff in the study reach has been affected by the addition of five major reservoirs, with additional potential affects from regional ground water withdrawal and increased water use. The sum of these changes has had some affect on stream hydraulics, riparian conditions, biotic habitat, recreation along Reaches 2 and 3, and has changed the natural flow frequency and volume.

Reservoirs. Between 1900 and 1945, seven dams were constructed on the main streams of the Salt River system (Table 10). These dams have the capacity to store over 2 million acre feet of water. In addition, an uncounted number of stock ponds, mining ponds, and other impoundments have been built within the watershed. These reservoirs, while maintaining water supply at constant rates, have helped reduce flood peaks (Aldridge, 1980) and eliminate low flow discharges downstream of Granite Reef Dam. Evaporation losses alone on the six main reservoirs decrease the pre-development flow rates by an estimated 180 cfs (Thomsen and Porcello, 1991).

Table 10
Reservoirs on the Salt River System

Name	Date	Storage Capacity	Function
SALT RIVER			
Granite Reef Dam	1906	0	Irrigation Diversion
Roosevelt- Roosevelt Lake	1911 - Closure 1923 - Increase Storage 1995 - Increase Storage	1,284,000 AF 1,336,000 AF 1,650,000 AF	Water Supply Water Supply Add Flood Control
Morman Flat Dam - Canyon Lake	1923	57,800 AF	Water Supply
Horse Mesa Dam - Apache Lake	1927	245,000 AF	Water Supply
Stewart Mountain Dam - Saguaro Lake	1930	70,000 AF	Water Supply
VERDE RIVER			
Bartlett Dam - Bartlett Lake	1939	182,600 AF	Water Supply
Horseshoe Dam -Horseshoe Lake	1946	131,427 AF	Water Supply

Diversions. A list of some of the main irrigation and water supply diversions is shown in Table 11. The magnitude of the diversions in the Upper Salt River is significantly smaller than the irrigation diversions downstream in the Lower Salt River, below Granite Reef Dam.

Table 11 Water Diversions on the Salt River System			
Name	Date Constructed	Acres Irrigated	Notes
SALT RIVER			
Arizona Dam	1883	-	
Granite Reef Dam	1891	186,000*	Agricultural/Municipal
above Roosevelt	-	4,000	
above Chrysotile	-	3,100	
above Fort Apache	-	1,460	White River
above Fort Apache	-	-	Black River, I&M use
SALT RIVER TRIBUTARIES			
Tonto Creek	-	-	Small diversions
Cibecue Creek	-	-	Small diversions
Carrizo Creek	-	< 300	
Verde River	ca. 1870	n.a.	Verde Valley, Fort McDowell
* Note: Approximate acres irrigated in 1913.			

Hydraulic Characteristics. Due to geologic control of the channel geometry in most of the Upper Salt River, it is likely that the overall hydraulic characteristics of Reaches 1 and 3 were not significantly altered during the post-statehood period. Submergence by reservoir ponding completely changed the natural hydraulic characteristics of Reach 2. While channel width-depth-discharge relationships at any specific location in Reaches 2 and 3 may tend to fluctuate in response to flooding and movement of bed sediments, the overall channel geometry and stream conditions probably remained constant. USGS gage station summaries note these shifting local channel conditions at some stations, which required occasional modifications of the gage station rating curve. The nature of these geomorphic channel changes are summarized in Section 4 of this report. Rating curves for typical sections are discussed in more detail later in this section.

Hydrology. Long-duration stream gage records are available for stations located upstream of the Salt and Verde River Reservoirs. Flow duration statistics for these stations are summarized in Table 12. Tree-ring data suggest that the period of modern gaging may be slightly "drier" than the period around statehood (cf. Stockton and Smith, 1981; Graybill, 1989), but that the modern, long-term gage data is broadly representative of river conditions at the time of statehood. Average annual flow rates at selected Upper Salt River stream gaging stations are summarized in Table 13.

Table 12
Salt River Flow Duration Statistics (cfs)

Station	Aver. Annual	10% Flow	50% Flow	90% Flow
Salt River-Roosevelt	896	157	343	2,040
Verde River-Tangle Creek	559	120	238	917
Combined Flow	1,455	277	581	2,957
Reconstructed Flow (Table 7)	1,690	n.a.	1,230	n.a.

Note: Combined flow by addition of tributary stations. Reconstructed flow from Thomsen and Porcello (1991) for location downstream of Granite Reef

Table 13 Long-Term Average Annual Flow Estimates - Salt River		
Average Annual Flow Rate (cfs)	Notes	Source
658	@ Confluence of White River/Black River	Garrett & Gellenbeck, 1991
658	nr. Chrysotile	Garrett & Gellenbeck, 1991
896	nr. Roosevelt	Garrett & Gellenbeck, 1991
732	Roosevelt inflow, includes Tonto Creek	Aldridge, 1981
1,690	Granite Reef Dam	Thomsen & Porcello, 1991
1,773	Granite Reef Dam	Salt River Valley Water Users, 1957
2,051	Combined flow of Salt and Verde Rivers	Lippincott, 1919
1,265	Summed flow estimate for Salt and Verde Rivers	Stockton & Smith, 1981
1,445	Summed flow estimate for Salt and Verde Rivers	Garrett & Gellenbeck, 1991

The monthly flow statistics for the long-term stations located upstream of the reservoirs (Tables 3, 14 and 15) show that runoff directly follows precipitation patterns. Peak flow rates typically occur in February and March following snowmelt. Annual low flows typically occur during June and July, prior to monsoon rainfall. There are no data indicating that the monthly distribution of runoff at or prior to statehood differs from that measured by modern stream gage records.

Table 14

Salt River Monthly Minimum and Maximum Flow Rates (cfs)

Month	Salt River-Roosevelt			Verde River-Tangle Creek			Combined Flow
	Min.	Max.	Mean	Min.	Max.	Mean	(Mean, cfs)
January	161	16,000	982	224	2,710	655	1,637
February	168	9,070	1,360	220	11,000	1,060	2,420
March	220	10,400	1,960	194	10,400	1,460	3,420
April	212	6,280	2,040	155	5,640	878	2,918
May	127	5,930	1,050	113	1,320	219	1,269
June	79	1,370	367	83	316	134	501
July	78	3,280	341	76	430	181	522
August	151	3,610	599	127	1,180	334	933
September	78	1,850	460	99	1,460	271	731
October	86	4,830	461	155	4,190	353	814
November	122	2,150	380	192	1,380	383	763
December	127	6,330	786	227	4,640	803	1,589
Annual	236	3,250	896	189	1,710	559	1,445

Table 15

Monthly Mean Flow Variation at USGS gages (cfs) [1]

Gage [2]	Jn	Fb	Mr	Ap	My	Jn	Jl	Au	Sp	Oc	No	Dc
Black River nr Fort Apache #09490500 (1958-1989)	338	592	1040	1250	546	114	91	195	149	260	155	413
White River nr Fort Apache #09494000 (1958-1989)	113	166	354	610	467	164	76	125	105	123	90	128
Carrizo Creek nr Show Low #09496500 (1952-1989) [3]	81	120	157	55	22	13	14	18	11	35	25	84
Salt River near Chysotile #09497500 (1925-1989)	707	1010	1200	1280	936	257	103	237	255	586	209	786
Cibecue Creek nr Chysotile #09497800 (1960-1989)	48	74	102	60	26	15	25	36	32	39	30	62
Cherry Creek near Globe #09497980 (1966-1989)	43	98	96	30	13	7.7	9.9	17	18	30	19	67
Salt River near Roosevelt #09498500 (1914-1989)	982	1360	1960	2040	1050	367	341	599	460	461	380	786
Tonto Creek abv Gun Creek #09499000 (1942-1989)	285	338	444	148	41	13	23	100	47	68	75	266
Verde River blw Tangle Crk #09508500 (1946-1989)	655	1060	1460	878	219	134	181	334	271	353	383	803

Notes: 1. Source: (Garrett & Gellenbeck, 1991) 2. All gages listed are located upstream of major reservoirs. 3. Discontinuous record

Table 16 Flow Duration Estimates at USGS gages (cfs)							
Gage	1%	10%	20%	50%	80%	90%	99%
Black River near Fort Apache[3]	4,050	1,180	508	113	52	39	21
White River near Fort Apache[3]	1,508	539	289	95	46	34	10
Carrizo Creek near Show Low[3]	689	83	36	12	4.8	2.6	0.74
Salt River near Chysotile[3]	5,130	1,550	788	265	159	129	78
Cibecue Creek near Chysotile[3]	409	89	46	20	13	9.9	5.6
Cherry Creek near Globe	546	62	25	9.3	6.3	5.4	4.1
Salt River near Roosevelt[3]	7,100	2,040	1,010	343	198	157	90
Tonto Creek above Gun Creek[3]	2,450	252	97	24	9.0	4.5	0
Verde River blw Tangle Creek[3]	5,960	917	408	238	151	120	79

Notes:

1. Source: (Garrett & Gellenbeck, 1991).
2. Flow duration reported is percent of time given flow ratewas equalled or exceeded.
3. Irrigation diversion upstream of gage station diverts low flows. 4. All gages listed are located upstream of major reservoirs.

Summary. Hydrologic data for the study reach indicate that the Salt River upstream of Granite Reef Dam is perennial, with a natural average annual flow rate that ranges from 600 to 1,400 cfs within the study reach. The annual minimum flow occurs during summer months, but exceeds 100 to 400 cfs, on average. Flow duration statistics indicate that the natural flow rate in the study reach is above 150 to 250 cfs 90 percent of the time, and exceeds 300 cfs more than 50 percent of the time. For the purposes of estimating flow depth, velocity, and width, the flow rates representative of long-term average conditions on the Upper Salt River are shown in Table 17.

Table 17. Long-Term Flow Estimates for the Upper Salt River			
Reach	Median (50%) Flow Rate (cfs)	Average Annual Flow Rate (cfs)	Average Annual Minimum Flow Rate (cfs)
1	210-340	660	130-230
2	340	900	240
3	360-580	1,450	420

Climatic Variation

Analysis of climatic variation in Arizona in the past 100 year can provide information as to the relevance of post-statehood streamflow records for estimating streamflow conditions as of the time of statehood. Climate change is measured by monitoring weather characteristics such as daily, monthly, seasonal, or annual temperature, precipitation, or relative humidity. Although weather records for the period prior to Arizona statehood in 1912 are not as extensive as for the period since statehood, sufficient data exist to give indications of pre-statehood climatic and streamflow conditions. Stream gage data are available for the Salt River dating to 1888. Archaeological and historical records of flow in the Salt River extend the database back several centuries.

The BUREC began direct measurement of streamflow on the Salt-Verde River systems in late 1888 at the Arizona Dam irrigation diversion. Direct measurements have been continued to the present time by the USGS at several upstream locations. Smith and Stockton (1981) and Graybill (1989) used tree-ring records to extend gage records to 740 A.D.; Dean et al (1985), and Euler et al (1979) used tree-rings, pollen data, and alluvial sedimentation patterns to estimate periods of increased/decreased moisture to 600 A.D. Tree-ring records may be used to estimate annual flow volume. Smith and Stockton's interpretation of the tree-ring record indicates the following:

- The period from 1905-1920 (Arizona statehood) was the wettest period since 1580 in both the Salt and Verde River watersheds. If the Upper Salt River was navigable, it was more likely to have been navigable around the time of statehood than at other periods in the past 400 to 500 years.

- The period from 1900 to 1979 (Salt River gage record) had an average annual flow volume only slightly greater than the 400 year mean annual volume. Therefore, the gage records for the Upper Salt River are probably representative of long-term average conditions.

- The period from 1940-1977 on the Salt River, and from 1932-1977 on the Verde River had below average annual runoff. These time periods correspond to the majority of the period of record of most Arizona stream gages. Therefore, the gage records from this period tend to underestimate flow conditions for 1912.

- Base flow in the Verde River portion of the watershed is controlled by springs, rather than climatic factors. Below-average precipitation does not generally affect discharge from springs. Therefore, Reach 3 is not impacted as strongly by climatic change.

Graybill's tree-ring data also indicate that average flow from 740 -1370 A.D. was somewhat less than twentieth century average flows on the Salt River. However, summer low flows were found to have more predictable average flows during that period. Dean's and Euler's paleoenvironmental studies determined that there were no radical differences in the prehistoric Arizona climate (1,000 years before present (b.p.)) compared to the modern climate. Other tree-ring studies by Stockton (1975) elsewhere on the Colorado Plateau also found that the early 1900's was an unusually "wet" period.

In regional climatic studies, Sellers (1960) recorded a decreasing, but not statistically significant, trend in total annual precipitation averaging about 0.03 inch/year. Thomsen and Eychaner's (1991) statistical analysis of 109 years of rainfall records from the Tucson Basin indicated no trend in precipitation. Peterson (1950) demonstrated that total annual precipitation was above average between 1881 and 1884, a period of extensive channel change in southeastern Arizona. In northern Arizona, Hereford (1984) notes a period of lower than average runoff and precipitation and above average temperature in the 1940's and 1950's when compared to records for the rest of the twentieth century. This drought period affected most of the Rocky Mountain states. Hereford also concludes that beginning in 1900, precipitation abruptly increased until about 1910, at which time a progressive decline began that lasted until 1956. Since 1956, average temperatures have cooled somewhat, and discharges increased somewhat. Regional analyses of archaeological data have concluded that there were no radical differences in climate that would have affected streamflow (Graybill and Gregory, 1989). Analysis of national climatic data by Diaz and Quayle (1980) indicates that in the southwest, the period between 1920 and 1954 had warmer winters, cooler summers and less precipitation than the period from 1895 to 1920. These data generally support the observations of Hereford (1984) and Stockton (1975) cited above, and suggest that climatic conditions may have favored higher runoff rates around the period of Arizona statehood.

The effects of climatic variations on potential stream navigability and channel conditions are complex, and cannot always be clearly distinguished from stream changes initiated by man. However, some basic conclusions can be drawn from the studies cited above.

First, Arizona's climate at the time of statehood was not drastically different from existing or pre-statehood conditions. The same basic climatic patterns applied: summers were warm and relatively dry with intense, late summer monsoonal rainfall; and winters were cool, with less intense Pacific frontal storms bringing snow to higher elevations and rain to lower elevations. However, subtle differences in rainfall and temperature patterns around the time of statehood may have resulted in higher average streamflow. These differences included the following:

- Generally higher precipitation and streamflow volumes
- More frequent intense monsoonal rainfall
- Cooler average temperatures, with warmer summers and cooler winters

Therefore, the period surrounding statehood was probably subject to higher than average streamflow, indicating that streams may have been more likely to have carried additional flow at statehood than during other, less "wet" periods of Arizona history.[8] It is noted that some of Arizona's largest floods, in terms of both volume and peak flow rate, occurred in the twenty years prior to statehood.

Second, USGS stream gage records may be used to predict the natural, long-term average discharge rates. Tree-ring records indicate that the average annual flow rates on the Salt and Verde Rivers between 1900 and 1980 are just slightly above the average annual flow rates for the past 400 years. Gage records from 1905 to 1920 may predict average flow conditions well above long-term average rates, but may accurately reflect conditions at statehood. Gage records with the majority of years of record in the 1940's and 1950's may predict average flow conditions below the long-term average, and well below the wetter conditions at statehood. Of course, stream gage data must also be filtered to account for human impacts on streamflow, such as reservoirs, irrigation diversions, and groundwater withdrawal. *In general, use of the existing stream gage database will probably result in prediction of flow rates slightly less than those that existed at statehood.*

For the Upper Salt River, any potential effects on runoff rates from climatic changes are almost completely obscured by human impacts on the stream system. These human impacts include, but are not limited to, the changes induced by construction of the reservoirs.

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[8] Human impacts such as reservoir construction, ground water withdrawal, etc., have tended to lessen average stream discharge rates obscuring climatic affects on some Arizona streams.

Floods

Construction and operation of the Salt-Verde reservoir system has significant impacts on flood peaks in the study area.[9] Aldridge (1989) estimated, for instance, that the 123,000 cfs peak of the March 2, 1978 flood would have been about 260,000 cfs without storage of flood waters in reservoirs and canals. No flood recurrence interval data are available for the period prior to statehood, and gage records are not detailed enough to develop statistically significant estimates for this period. However, evidence of floods in the study reach was recorded in newspapers and by early residents and explorers. Bartlett (1854) describes seeing flood debris 15 to 20 feet above the channel bottom. Powell (1893) reports that floods of 10,000 to 20,000 cfs occurred annually (compare to data summarized in Table 18).

[9] It is noted that until the 1996 improvements to Roosevelt Dam, none of the reservoirs on the Salt Verde River system were designed or operated for flood control purposes.

Table 18

Floods Greater Than 20,000 cfs, 1888-1939 (mean daily cfs)

Date	Discharge	Date	Discharge
1888	41,315	Jan. 20, 1916	83,475
Mar. 17, 1889	33,794	Apr. 18, 1917	27,668
Feb. 22, 1890	143,288	Mar. 9, 1918	45,375
Feb., 1891	285,000	Nov. 28, 1919	101,867
March, 1893	351,514	Feb. 23, 1920	108,600
Jan. 18, 1895	82,994	Sept. 17, 1925	20,000
Jan., 1897	35,109	Apr. 6, 1926	32,000
Apr. 2, 1903	21,500	Feb. 17, 1927	70,000
Nov. 27, 1905	199,500	Apr. 5, 1929	26,000
Mar. 14, 1906	67,000	Feb. 14, 1931	34,000
Mar. 6, 1907	50,770	Feb. 9, 1932	53,000
Dec. 16, 1908	63,000	Feb. 7, 1937	63,000
Jan. 2, 1910	294,000	Mar. 4, 1938	95,000

Note: After 1939, Bartlett Dam was closed, creating a measure of flow regulation on both branches of the Salt River system.

Flood Frequency Estimates. Flood discharge rates at various key concentration points are listed in Tables 19 and 20. Flow rates obtained from Flood Insurance Studies (FIS, 1991; 1992) are based on rainfall runoff modeling (Table 19) and are significantly larger than flow rates determined by the USGS (Garrett &Gellenbeck, 1991) using streamflow records (Table 20). The flood frequency data summarized in Table19 were determined considering the impacts of reservoirs and diversions on flood peaks. For comparison, a discharge-area regression equation developed by the USGS (Roeske, 1978) was applied for the basin characteristics at Granite Reef Dam. This equation, developed from regional stream gage records, predicts flood peaks for various recurrence intervals using the drainage area, mean basin elevation, and annual precipitation. The flood frequency data shown in Table 19 generally support early claims that floods of about 20,000 cfs occurred annually at the time of statehood.

Table 19
Summary of Salt River Discharges, Existing Conditions (cfs)

Location	Area (mi^2)	Flood Recurrence Interval					
		2-Year	5-Year	10-Year	50-Year	100-Year	500-Year
Verde-Tangle Creek[a]	5,589	16,000	39,400	61,300	128,000	164,000	-
Salt-Roosevelt[a]	4,306	13,800	36,000	60,000	150,000	208,000	-
Granite Reef Dam[b]	12,250	-	-	68,000[c]	175,000[c]	245,000	-
Granite Reef Dam[d]	12,250	-	22,000	60,000	150,000	175,000	250,000
USGS Eq'n[e]-Granite Reef	12,250	21,300	54,000	87,900	197,000	257,000	442,000

[a] Source: USGS, 1991; upstream of reservoirs

[b] Source: FEMA, 1991; accounts for reservoir attenuation prior to 1995 improvements to Roosevelt Dam

[c] Source: Newton, 1957 cited in Halpenny, 1966

d Flood frequency after 1996 improvements to Roosevelt Dam.

[d] Source: Roeske, 1978, does not account for reservoir attention or diversions

Table 20 Peak Discharge Estimates at USGS gages (cfs)						
Gage	Q2	Q5	Q10	Q25	Q50	Q100
Black River near Fort Apache	6,360	18,100	30,500	52,100	72,900	97,900
White River near Fort Apache	3,140	5,800	8,020	11,400	14,300	17,600
Carrizo Creek near Show Low	2,980	7,070	11,300	19,000	26,600	36,400
Salt River near Chysotile	9,750	23,600	37,800	62,800	87,500	118,000
Cibecue Creek near Chysotile	4,020	7,470	10,300	14,400	18,000	21,800
Cherry Creek near Globe	2,150	5,480	8,850	14,700	20,200	27,000
Salt River near Roosevelt	13,800	36,000	60,000	104,000	150,000	208,000
Tonto Creek above Gun Creek	11,200	25,700	39,000	60,100	79,100	101,000
Verde River below Tangle Creek	16,000	39,400	61,300	96,500	128,000	164,000
Notes: 1. Source: (Garrett & Gellenbeck, 1991) 2 All gages listed are located upstream of major reservoirs.						

Summary. Large flow rates occur frequently within the study reach, although peak discharges are somewhat attenuated by the Salt-Verde system of reservoirs. Annual peak discharges exceeded 20,000 cfs almost every year prior to construction of the dams (Table 17). Flows exceeding about 13,000 cfs continue to occur periodically upstream of Roosevelt Dam in Reach 1. Floods are part of the natural flow regime of the Upper Salt River study reach.

Hydraulic Rating Curves

Rating curves relate stream discharge to flow width, velocity, and/or depth. Rating curves for the Upper Salt River were developed from existing information obtained during the literature search and agency contact tasks for representative locations in each of the three Upper Salt River reaches. The objective for preparing rating curves was to estimate approximate flow conditions as of the time of statehood. Because the cross section geometry, slope, hydraulic roughness, and geology of natural rivers usually varies with distance and time, the estimated flow depths, widths and velocities should be considered average values, broadly representative of river conditions within a reach, rather than exact specifications of permanent river conditions.

A variety of information was used to obtain the estimates of hydraulic characteristics for each reach, for existing conditions and statehood conditions, as summarized in Table 21. As summarized in Section 4 of this report, the geomorphology of Reach 2 has been altered since the time of statehood. For existing conditions in Reach 2, reservoir impoundments have created a nearly continuous ponding area between State Route 288 upstream of Roosevelt Reservoir and Stewart Mountain Dam. These ponding areas may be assumed to have no effective velocity, and to have depths well in excess of 10 feet. The reservoirs are suitable for year-round operation of a wide variety of boats, including at least one commercially operated riverboat. Given the similar geology and geomorphology of Reaches 1 and 2, it was assumed that the rating curves for Reach 1 would be broadly applicable to the pre-statehood (pre-reservoir) conditions for Reach 2. For Reach 3, reservoir releases and impoundments have significantly altered the natural flow rates, and probably has made the river less subject to weather-, seasonal-, and climate-related flow variations, although no impact on the average channel cross section for Reach 3 was identified. Since no evidence of substantial geomorphic change since statehood was identified for Reach 3, the existing conditions rating curve was used. Reach 1 is substantially unchanged from pre-statehood conditions, and the existing condition rating curve was used to estimate statehood conditions.

Table 21
Upper Salt River Rating Curve - List of Source Data & Assumptions

Reach #	1912 Conditions	Existing Conditions
1	Assume Equivalent to Existing	USGS Rating Curve & Surveyed Cross Section
2	Assume Equal to Reach 1	Reservoir Ponding Areas
3	Historical USGS Discharge Measurements	Topographic Map Geometry

The geometry of the typical cross sections used in developing the rating curves is shown in Figure 3, and the rating curves for existing conditions are shown in Figure 4. Estimates of average channel depth, velocity and top width for each of the three reaches are shown in Table 22. Not surprisingly, the rating curves predict similar results for the entire Upper Salt River study reach.

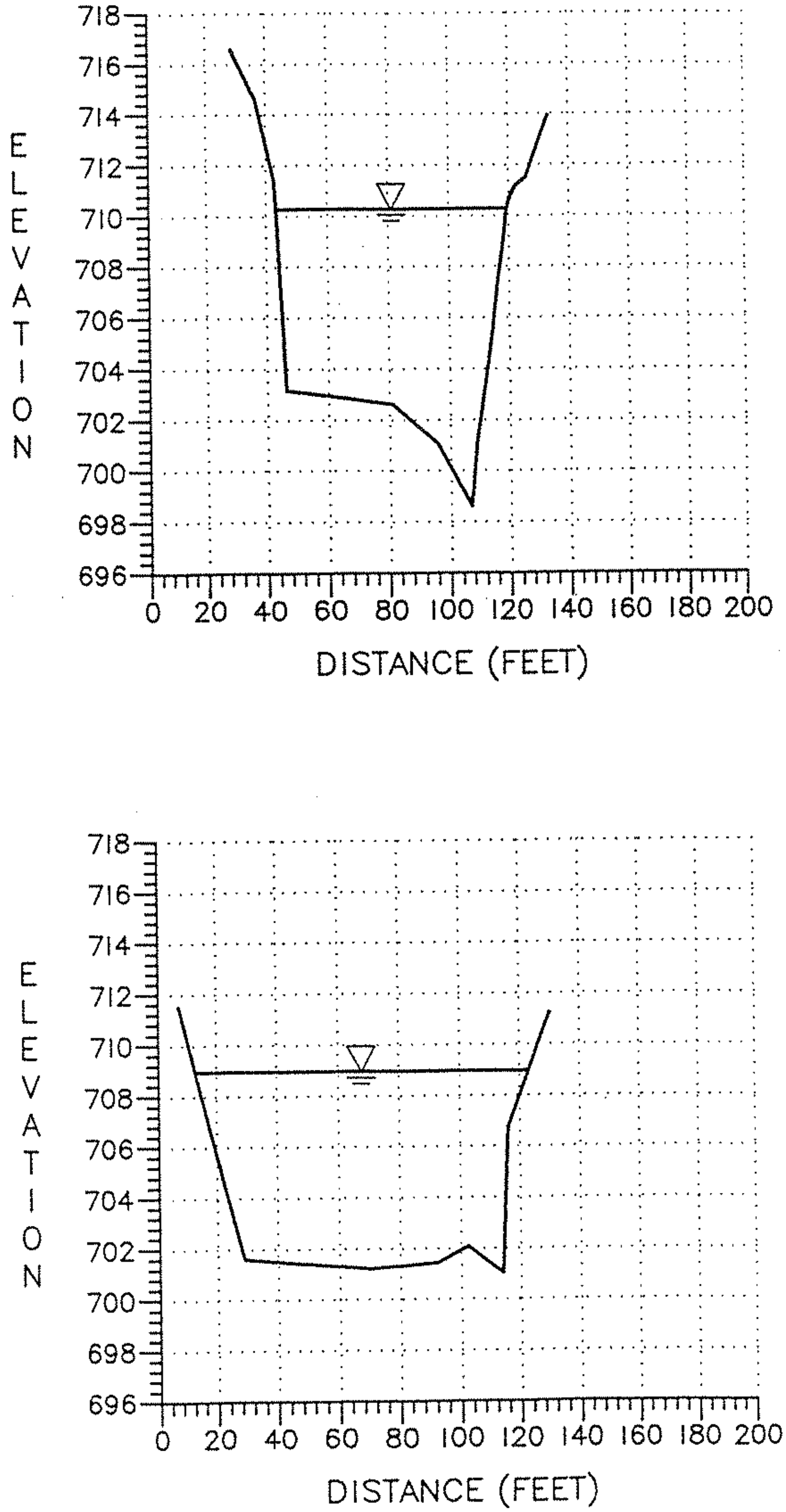
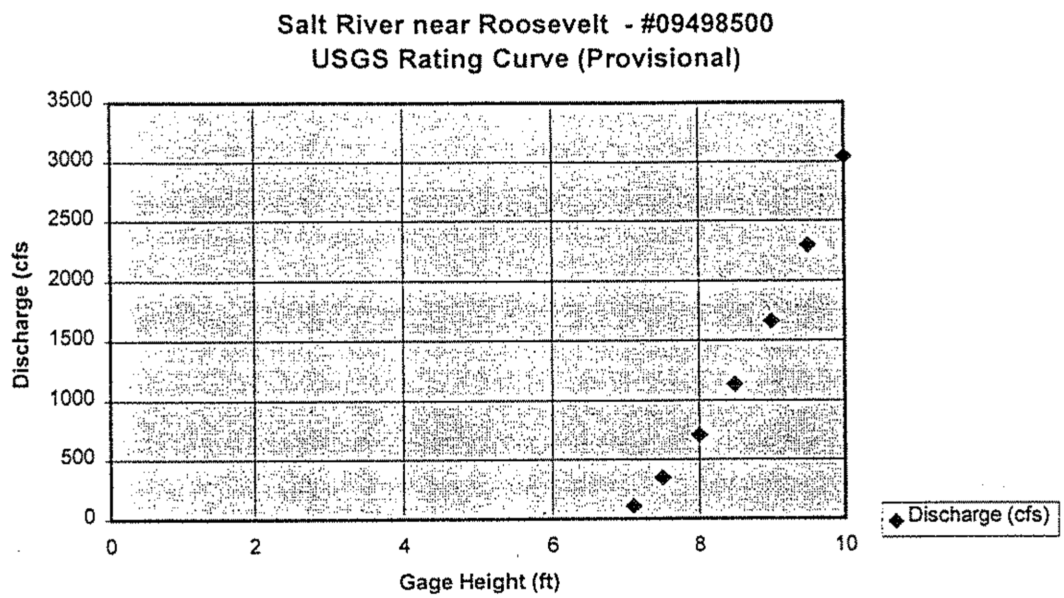


FIGURE 3

Rating Curve Cross Sections for Reach 1



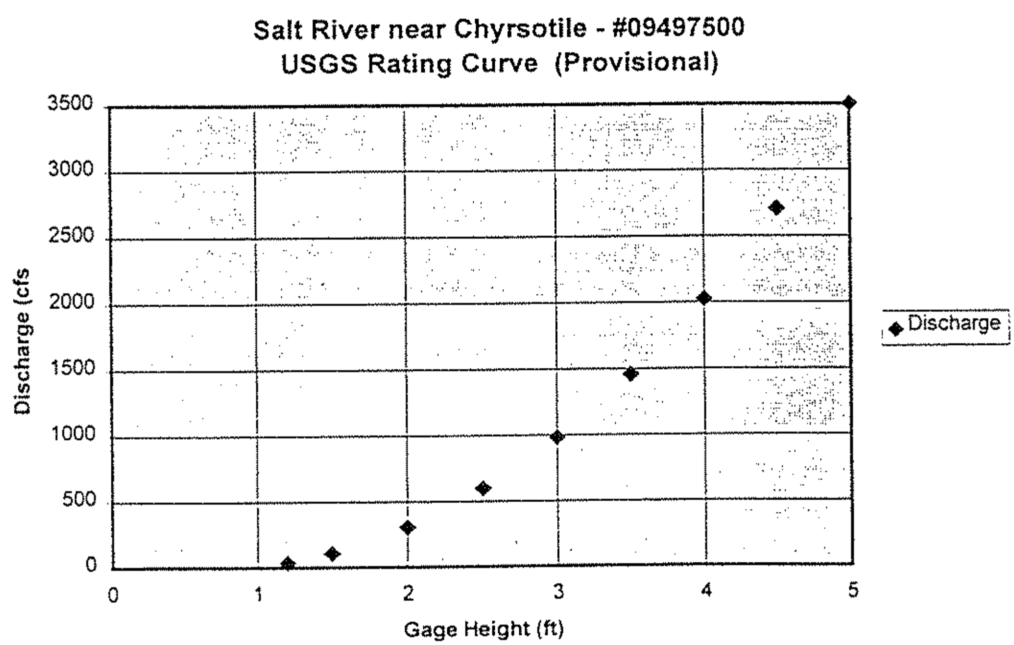


FIGURE 4

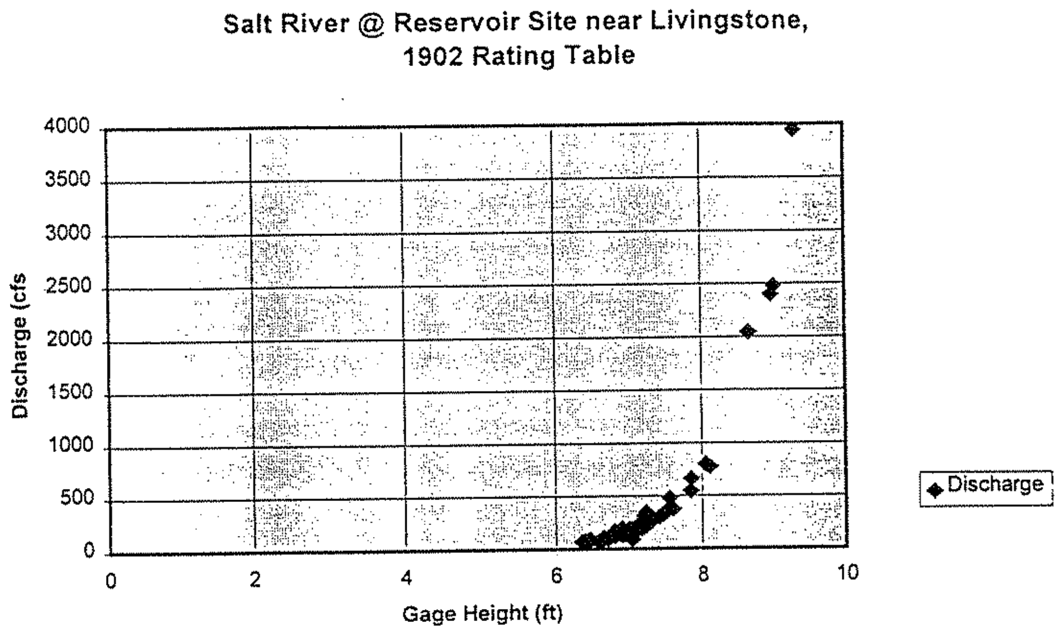
Existing Condition Rating Curves for the Upper Salt RiverGaging Stations

Table 22. Upper Salt River Flow Characteristics				
Recurrence Interval	Discharge (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Reach 1: Salt River Above Roosevelt - Shear Canyon Section				
Mean Annual Flow	896	1.4	2.4	266
2-Year Flood	13,800	7.1	6.9	295
5-Year Flood	36,000	12.2	9.8	308
Reach 1: Salt River Above Roosevelt - Canyon Section With Gravel/Boulder Bar				
Mean Annual Flow	896	3.6	4.5	55
2-Year Flood	13,800	8.1	7.8	221
5-Year Flood	36,000	14.1	11	230
Reach 2: Salt River Reservoirs - Existing Conditions				
Mean Annual Flow	896	> 10	0	> 1,000
2-Year Flood	13,800	> 10	0	> 1,000
5-Year Flood	36,000	> 10	0	> 1,000
Reach 3: Salt River Near Verde River Confluence - Alluvial Channel Section				
Mean Annual Flow	1,455	2.9	3.0	1,455
2-Year Flood	21,300	4.8	4.2	1,065
5-Year Flood	54,000	6.6	5.2	1,595

Some historical flow measurements were published by the US Geological Survey and US Reclamation Department around the time of statehood for the Upper Salt River. Sample gage height vs. discharge curves are shown in Figure 5. Gage height is equivalent to flow depth relative to some established (semi-)permanent datum. The historical gage sites reported in Figure 5 include:

- Salt River at Roosevelt Dam Site - located in Salt River Canyon near proposed Roosevelt Dam, downstream of confluence with Tonto Creek.

- Salt River at McDowell - located about 4000 feet upstream of the confluence of the Verde River downstream of the Salt River Canyon. The low flow channel width was about 150 feet, high flow width equals about 700 feet. The low flow channel reported to be shifting resulting in damage to thegaging station.



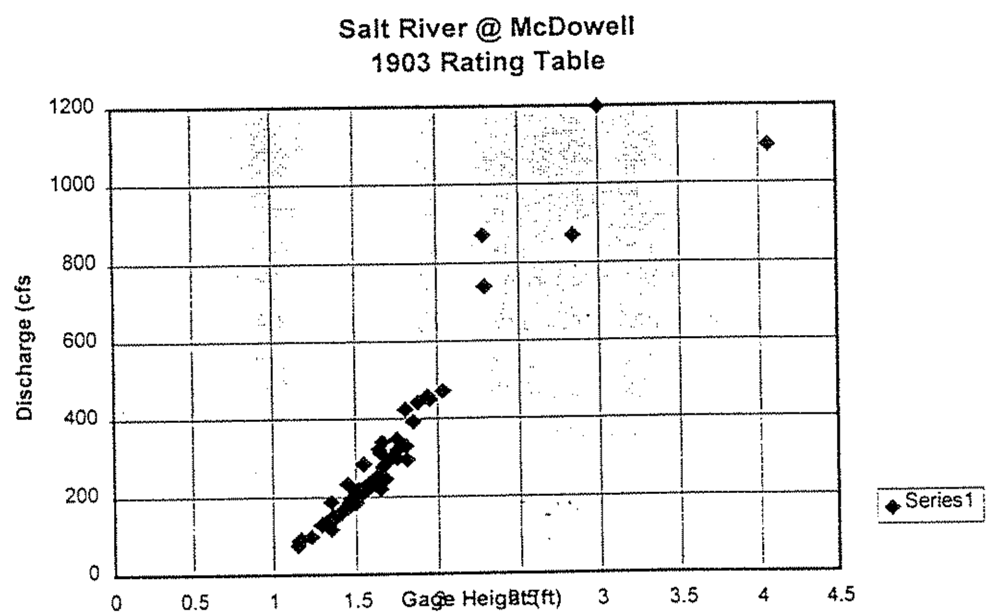


FIGURE 5

Historical Rating Curves for Upper Salt RiverGaging Stations

Summary

The Salt River Valley has a long history of reliance on the perennial flows from the Upper Salt River watershed. What flow rate is considered typical or average depends in part on what river conditions are considered "ordinary and natural." Prior to Anglo settlement, without any disturbance of natural conditions in the reach or upper watershed, the mean annual flow was about 1,300 to 1,700 cfs. The median flow rate exceeded 1,200 cfs during the pre-statehood period. That is, more than half of the time, flow rates greater than 1,200 cfs could be expected. Flow rates upstream of the Verde River confluence would have been slightly less, as shown in Table 17. In 1912, the year of statehood, the typical hydrologic condition of the river in Reaches 2 and 3 was in part a function of upstream water storage and downstream irrigation demands.

For Reach 1, and for Reaches 2 and 3 prior to construction of Roosevelt Dam, periods of low flow usually occurred during the early summer months of June and July, and may have been as low as 130 to 300 cfs upstream of the Verde River confluence, during a few dry periods. Average flow rates during the winter months and February typically exceeded 1,000 cfs, prior to the closure of Roosevelt Dam, with annual flood discharges approaching 20,000 cfs in Reach 3. After closure of Roosevelt Dam, winter flow rates were significantly reduced from the natural flow condition. Typical flow depths during the lowest seasonal flows were probably one to three feet deep, with average flow widths ranging from about 40 to 80 feet depending on the channel geometry of the canyon bottom (See Table 22). Typical flow depths for the average annual flow were probably about three to five feet deep. At higher flow rates, such as for the 2- and 5-year flood peaks (10,000 to 50,000 cfs), velocities typically would not exceed 10 feet per second.

According to boating criteria established by some federal agencies, as described in Section 6 of this report, and the hydraulic characteristics summarized in Table 22, the Upper Salt River was susceptible to use by canoes, kayaks, and rafts at flow rates ranging from the annual minimum flow to the 5-year flood peak. Use of keelboats, steamboats, and powered barges probably could not have safely occurred on the Upper Salt River in the conditions summarized in Table 22 due to shallow water, rapid velocities, narrow canyons, and natural obstructions such as riffles and waterfalls.

Given the criteria for navigability established by HB 2589, the hydrologic record for the Upper Salt River indicates the following:

- The Upper Salt River is perennial, with an average annual flow rate ranging from about 700 cfs upstream of Roosevelt Reservoir to about 1,500 cfs downstream of the Verde River confluence. At these discharge rates, flow depths, widths, and velocities of about 3 feet, 100 feet, and 4 feet per second may be expected. These river conditions are susceptible to boating using canoes, rafts, kayaks and other low-draft boats. Larger high-draft boats could not be used in these conditions.

- For the year of statehood, 1912, the average annual flow rate was about 1,200 cfs, making it a below average year of flow. The average flow rate for the month of February 1912 was about 400 cfs downstream of the Verde River and about 230 cfs upstream of Roosevelt Dam. Flow rates of about 400 cfs, approximately the average annual minimum flow rate, would result in average channel depths of about 1 foot or less in many reaches of the Upper Salt River. These flow rates and depths would make the boulder riffles in the canyon reaches less passable by most types of boats, except for canoes and kayaks. Use of keelboats, steamboats, and powered barges would not have been possible, particularly at low flow conditions, on the Upper Salt River.

- At the time of statehood, Roosevelt Dam was filling. Filling continued until 1915, during which period flow in the reaches downstream of the dam were severely restricted. However, the portion of Reach 3 downstream of the Verde River confluence remained free flowing.

- Diversions were made from the lower Salt River to irrigate and reclaim land, including diversion to Federal reclamation projects and Indian lands. Many of these diversions were appropriated prior to the time of statehood. These diversions, although they were located downstream of the Upper Salt River study reach, appropriated river flow from the Upper Salt River.

- There was at least one dam in the Upper Salt River at the time of statehood (Roosevelt) that could have created an impediment to certain types of navigation. However, while the dam may have been an impediment to downstream travel, navigability was improved within the reservoir created by the dam. Since statehood, a number of other dams and hydraulic structures have been constructed in the study reach.

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Arizona State Land Department

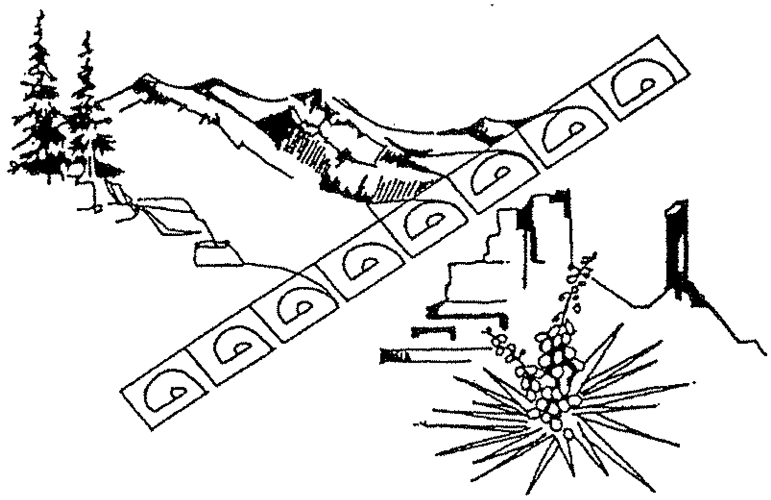
ARIZONA STREAM NAVIGABILITY STUDY

for the

UPPER SALT RIVER

Granite Reef Dam to the Confluence of the White and Black Rivers

Final Report



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Section 6

Boating on the Upper Salt River

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Boating on the Upper Salt River

Introduction

The exact boat types, stream depths, widths, velocities, and flow durations which define what "navigability" means for Arizona rivers have not yet been definitively established by ANSAC, although H.B. 2589 lists several boat types[1] to be used to establish a presumption of non-navigability. The objective of this section of the report is to provide information on federal boating criteria and the types of boating which have occurred historically on the Upper Salt River. Several types of information are presented including:

- Federal navigability criteria
- Historical accounts of boating
- Modern boating records

Historical and modern accounts of boating on the Upper Salt River are presented in this section. Historical boating on the river includes use of low-draft flatboats, skiffs, rowboats, canoes, and rafts. Modern boating on the river includes use of canoes, rafts, and kayaks. Boating on the Upper Salt River reservoirs includes historical use of boats during the construction of Roosevelt Dam and modern recreational boating using a wide variety of large and small boats. Other information on Salt River boating was presented in Section 3.

Federal Criteria for Navigability

Some federal agencies have formally described stream conditions which favor various types of boating. One such description was developed by an intergovernmental task force, the Instream Flow Group, to quantify instream flow needs for certain recreational activities, including boating (US Fish and Wildlife, 1978). The US Department of the Interior independently developed their own boating standards (Cortell and Associates, 1977). These federal criteria, summarized in Tables 1 and 2, were developed primarily for recreational boating, not necessarily for commercial boating. Minimum stream conditions required are summarized in Table 1. Minimum and maximum conditions are summarized in Table 2.

1 Keelboats, steamboats, and powered barges

Table 1 Minimum Required Stream Width and Depth for Recreation Craft		
Type of Craft	**Depth (ft.)**	**Width (ft.)**
Canoe, Kayak	0.5	4
Raft, Drift Boat, Row Boat	1.0	6
Tube	1.0	4
Power Boat	3.0	6
Source: US Fish and Wildlife, 1978		

Table 2 Minimum and Maximum Conditions for Recreational Water Boating						
Type of Boat	**Minimum Condition**			**Maximum Condition**		
	Width	**Depth**	**Velocity**	**Width**	**Depth**	**Velocity**
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-	-	10 fps
Source: Cortell and Associates, 1977						

Some Arizona boaters surveyed for previous navigability studies did not agree with the minimum velocity criteria given in Table 2. They argue that since boats can be used on lakes and ponds which have no measurable (zero) velocity, no real minimum velocity exists, except perhaps for tubing. Therefore, it is assumed that the minimum velocities in Table 2 are probably intended to indicate what stream conditions are most typically considered "fun."

The Bureau of Land Management (BLM) apparently has adopted a "narrow" definition of navigability (Rosenkrance, 1992). BLM criteria to determine title navigability include:

- The original condition of waterway at date of statehood is used.
- Use by small, flat bottom sport boats or canoes is not navigation.
- Navigation must occur at times other than seasonal floods.
- Inaccessible streams are not navigable.
- Long obstructions such as bars makes upstream segments non-navigable.

No documentation of application of these guidelines by the BLM in Arizona was uncovered, although the BLM did not consider the Salt River (Lower Salt River, and Reaches 2 and 3 of the Upper Salt River) navigable at statehood due to the closure of Roosevelt Dam (BLM, 1964). Also, the BLM navigability criteria do not necessarily conform to the federal or Arizona definition of navigability.. Other federal agencies have stated that the Salt and Verde are non-navigable streams, as discussed below, although specific criteria which formed the technical bases of these decisions are lacking.

Historical Accounts of Boating

Boats were in use during the period around statehood. Newspaper stories, contemporary reports, anecdotal information, and oral histories all provide evidence of boating on Arizona rivers. Documented uses of boats included:

- Travel
- Recreation
- Transport of Goods

Several accounts of floating logs down Arizona rivers are also documented. Review of historical records of boating gives the general impression that there was no shortage of boats in Arizona. Whenever a boat was needed to cross a flooded river, even during the period of early exploration, boats were borrowed from local residents, used and returned. The presence of boats in arid regions like Arizona, despite there being no sizable lakes within several days travel, argues for occasional, or necessary, use of boats on the river.

The most extensive documentation of historical river boating in Arizona is for the Salt River. Prior to statehood, before irrigation diversions and closure of dams upstream depleted river flows, at least five ferries were in operation at various locations between Granite Reef Dam and the Gila River. Sixteen episodes of boating, involving portions or the entire study reach, were recorded. A few, but not most of these boating episodes were unsuccessful, though not for lack of streamflow within the study area. Typical problems encountered included snags and sandbars in the lower Salt River, or the rapids and falls in the narrow canyons of the Upper Salt River.

It is noted that for all of the instances of boat use on the Salt River, the boaters traveled downstream or across the river. No evidence of boating in the upstream direction was found. Boating on the Salt River apparently was not limited to the wetter months or seasonal floods. Several accounts of boating the Salt River during May and June, two months which typically have annual minimum flows. Both attempts to float logs were conceived and attempted by Salt River Valley residents during summer months, not winter high flow periods.

The type of boats typically used were flat-bottomed boats, skiffs, or canvas and wooden canoes. Information presented in Table 3 summarizes probable stream characteristics required to support use of the types of boats available at statehood. The criteria for canoes are not substantially different from criteria for canoes available today.

Table 3
Flow Requirements for Pre-1940 Canoeing

Boat Type	Depth
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.

Source: Slingluff, J., 1987

Historical Accounts of Fish

Although the presence of fish in a river does not necessarily indicate that boatable conditions exist, existence of certain species do provide some information about flow conditions. Archaeological evidence indicates that the same species found in Arizona rivers in prehistoric times were also present around the time of statehood (James, 1992). Change in fish species distributions did not occur in most rivers until the 1940's (Minkley, 1993). Some of the species found in the Salt River included very large fish such as squawfish (aka Salt River Salmon, Colorado River Salmon, some of which grow to over three feet long), razorback sucker, andflannelmouth sucker. The latter fish tend to indicate "big river" conditions (Minkley, 1993), by Arizona standards, at the river localities where these fish are found. Historical accounts of fishing are centered on early explorer routes and settlements. There are numerous accounts of "salmon" runs (actually squawfish) on the Lower Salt River, and of catching hundreds of fish from the Salt River near Phoenix, and of fish left to die after canals diverted streamflow.

Modern Accounts of Boating

Some Arizona rivers are still boated in modern times. While modern boat use of a river may not provide definitive proof of susceptibility of a stream to navigation at statehood, it is evidence that is readily available for consideration. Given that no evidence of substantive change in stream geomorphology and hydrology was identified for Reach 1 of the Upper Salt River, modern boating records are directly applicable to historical conditions. Boat-making technology has improved since the time of statehood, with the use of inflatable rafts, inflatable and hard-shell kayaks becoming some of the preferred modes of recreational travel (and commercial operations offering recreational trips). However, while canoe technology has changed to make these boats more durable, the depth of water required for canoeing has not substantially changed. In addition, flow rates on Arizona rivers have generally declined since the time of statehood. Therefore, modern use of a river reach by canoes probably indicates that canoes could have been used as of the time of statehood.

The Central Arizona Paddlers Club (CAPD), an organization of boaters, recently conducted a survey of their members to determine what rivers had been boated (see Table4). With 20 percent of members responding, the survey indicated that all of the Upper Salt River study reach has been boated in recent years (Central Arizona Paddlers Club, 1992). Informally polled CAPD members willing to be interviewed also estimated flow conditions at the time the various rivers were boated.

The entire Upper Salt River study reach is regularly boated, primarily during winter and spring flow. Arizona State Parks (1978) lists the Upper Salt River in its outdoor recreation and boating guide. A boating guide to the southwest lists the Upper Salt River (Anderson, 1982) as a rafting stream. Several commercial recreational rafting trip outfitters currently hold U.S. Forest Service leases for commercial operations on the Upper Salt River. Numerous boating activities occur on the Salt River reservoirs, including some relatively large passenger-oriented paddleboats. Modern boating using canoes, rafts, and kayaks on the Upper Salt River Reach 1 occurs throughout the entire year, although most boating is done during the late winter and spring during the annual high flow period. Modern boating on Reach 2 of the Upper Salt River occurs year round due to improved boating conditions on the reservoirs. Modern boating on Reach 3 of the Upper Salt River occurs during most of the year, except when the river flow is stopped during periods when the canals downstream of Granite Reef dam are maintained.

Table 4
Central Arizona Boaters Club Survey Results: Selected Reaches Boated & Estimated Flow Conditions

River	Reach	Date mo-yr	Flow (cfs)	Depth (ft)	Width (ft)	Craft	Portage (%)
Upper Salt	Above Roosevelt	Many	200+			canoe, raft, kayak	0
	Below Roosevelt, on reservoirs	All year	n/a	> 10	> 1,000	power, all others	0
	Below Stewart Mountain Dam	All year	200+			canoe, raft, kayak	0

Summary

The Upper Salt River was used for boating and transport of materials as of the time of statehood (Section 3). Historical hydrologic conditions in the Upper Salt River (Compare Tables 4 and 2) probably would have met current federal critieria for some types of recreational boating, for most of the year. No evidence of boating in the upstream direction along the Upper Salt River, or use of large machine-powered boats was found. No evidence of significant commercial boating industries developed on the Upper Salt River as of 1912 was uncovered. Reach 1 is currently boated for recreational purposes, primarily during the winter and spring months. Reach 2 is currently boated throughout the year, due to improved boating conditions on the reservoirs. Reach 3 of the Upper Salt River is currently boated for recreational purposes during most of the year.

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Arizona State Land Department

ARIZONA STREAM NAVIGABILITY STUDY

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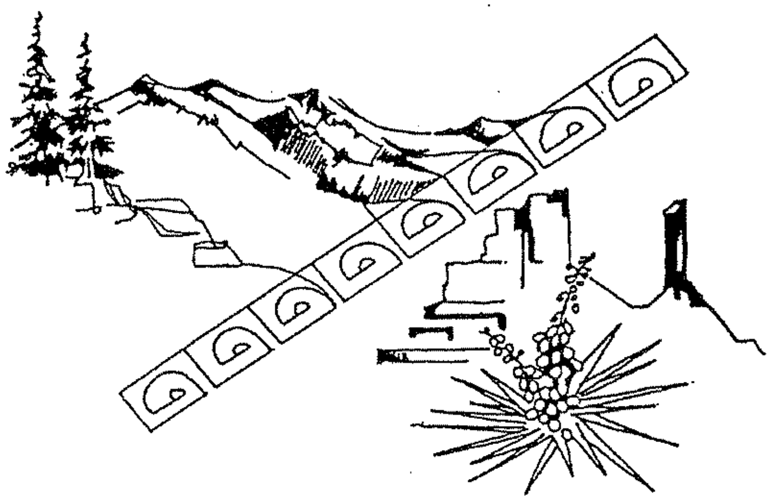

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Section 7

Navigable Rivers Land Use GIS

I. Methodology

A Geographic Information System (GIS) was developed depicting the 100-year floodplain and land ownership/use within the floodplain (see Appendix A for data organization). The GIS was designed not to aid in the determination of navigability but to help study the impacts should the river be found navigable. Information regarding the ownership and use of land in the vicinity of the river may be depicted as maps or as statistics.

The general land ownership categories depicted by the GIS are as follows:

Ownership Categories
Private
State of Arizona
Bureau of Land Management (BLM)
U.S. Forest Service
National Wildlife Refuge
National Park Service
Indian Reservation
Other / No Data

The general land use categories depicted by the GIS are as follows:

Land Use Categories
Vacant Land
Residential - Single Family
Residential - Multiple Family
Hotel - Motel - Resorts
Condominiums
Commercial Property
Industrial Property
Farm/Ranch Property
Public Utilities
Natural Resources
Special Use Property
General Service Use

Additional data are also contained in the GIS, such as county, township, range, section, book, map, parcel, source, legal parcel area, state land use code, and owner descriptions.

A. Base Data

The base layers for the GIS, including rivers, counties, and public land survey system, were obtained from the Arizona Land Resources Information System (ALRIS) maintained by the Arizona State Land Department (ASLD). Additional river data were obtained from 1:100,000 scale Digital Line Graph (DLG) files maintained by the United States Geological Survey (USGS).

B. Floodplain

The 100-year floodplain was digitized from Federal Emergency Management Agency (FEMA) maps of varying scales. Georeferencing (i.e. registration of map data to real world coordinates) was accomplished via section corners and, in a few circumstances, street intersections. Arbitrary lines were digitized at junctions with tributary floodplains. Adjacent maps were edgematched; significant mismatches were not adjusted but were closed using straight line segments.

C. Land Ownership/Use

Parcels were digitized from paper County Assessor maps. Georeferencing was accomplished using the following:

1) Section corners or subdivisions (e.g. quarter-quarter-section corners),

2) Legal descriptions using a section corner or subdivision as a reference point,

3) Distances, based on map scale, from a section corner or subdivision,

4) Corresponding features in a smaller scale map (e.g. a map of a housing development might be registered via its corresponding outline depicted in a section map), and/or

5) Adjacent features.

Digitizing was accomplished as follows:

1) Clearly delineated parcel boundaries were digitized as depicted. Lines in large scale maps generally took precedence over corresponding lines in small scale maps.

2) Areas of parcel overlap were assigned to one parcel or the other as deemed best. Unclear boundaries between two parcels were digitized according to best judgement.

3) Parcels of vague or undepicted location were not digitized unless an outline could be obtained from an alternate source (e.g. ALRIS data or USGS 1:100,000 DLG files).

4) Linear (non-polygonal) parcels, depicting railroad right-of-way (ROW), were not digitized. An exception was made if adjacent parcels clearly depended on a ROW edge, in which case a 200' wide corridor was applied.

When necessary, adjacent maps were edgematched. Small scale features were adjusted to large scale features. Attributes were assigned in a fashion consistent with ASLD's Gila River coverage:

1) Parcel numbers were assigned where clearly designated, unless the parcel clearly was non-private (State, BLM, etc.), in which case a "non-private" parcel code (AZ, BLM, etc.) was assigned.

2) Parcels which were not numbered, but were clearly labeled (Arizona, U.S.A., etc.) were assigned non-private codes as appropriate. Where a conflict existed between assessor maps and ALRIS data over USA versus State ownership, the ownership reflected in the ALRIS data was assigned.

3) Unlabeled or questionable parcels, uncoded road and rail ROW parcels, parcels outside the floodplain, and undigitized regions were assigned a zero parcel number.

4) Sections outside the study area were assigned "background" (BACK) parcel codes.

Relate files, containing land ownership and use data, were generated from State Revenue data. A list of parcel values was generated from the digitized parcels and submitted to the State Revenue office. Data received from the State Revenue office were converted to a table and reprocessed. If, after a quality check, the ID of a digitized parcel was not listed in the State Revenue data (e.g., if a parcel split or merge had not yet been depicted on the County Assessor map), it was assigned "Other / No Data" ownership.

D. Plots

Once all datasets were assembled, checked, and finalized, they were transported to the State Land Department building in Phoenix. Annotation coverages were be created for the final plots, and existing scripts and tables adapted to production of the final plots. One complete series was created for each river reach.

II. Results and Discussion

The study area was divided into six map sheets for plotting purposes. Floodplain maps were only available for two portions of the study area: sections 3-5 of T2N R7E and sections 32-34 of T3N R7E, and Theodore Roosevelt Lake.

All private parcels were digitized from paper maps with two exceptions in Gila County: the position of Parcel 3 in Book 203 Map 2 was incorrectly depicted, and no outline was depicted for Parcel 1 of Book 203 Map 25. In both cases, outlines were obtained from the ALRIS LAND coverage. The boundaries of the Salt River Indian Reservation, White Mountain Apache Reservation, and San Carlos Apache Reservation were obtained from USGS 1:100,000 DLG files.

Ownership Category	Percent
Private	0.4
U.S. Forest Service	76.5
National Wildlife Refuge	11.6
National Park Service	0.3
Indian Reservation	11.2

Land Use Category	Percent
Vacant Land	< 0.1
Residential - Multiple Family	< 0.1
Commercial Property	< 0.1
Industrial Property	0.1
Farm/Ranch Property	0.2
Natural Resources	< 0.1
General Service Use	99.6

Appendix A: GIS Data Organization

A. Base and Reference Layers from ALRIS

Name	Contents
AZTRS	Public Land Survey System of Arizona
COUNTIES	County Boundaries
HYDRO	Hydrology
LAND	Surface Management
RAILS	Railroads
TRANS123	Major Roads

B. Data Organization

A separate workspace is created for each river reach. The principal ARC/INFO coverages contained in each workspace are FLOOD, depicting the 100 year floodplain, PARCELS, containing digitized parcels, RIVER, depicting the river itself, and SHEETS, depicting the mapsheets.

1. FLOOD

The FLOOD coverage has polygon topology wherever possible. The PAT contains the following item:

ITEM NAME	WIDTH	TYPE	N.DEC
IN_OUT	3	C	0

IN_OUT Values:
in = Part of floodplain
out = Not part of floodplain

2. PARCELS

The PARCELS coverage has polygon topology. The PAT contains the following items:

ITEM NAME	WIDTH	TYPE	N.DEC
TOWNSHIP	4	C	0
RANGE	4	C	0
SECTION	2	C	0
COUNTY	2	N	0
BOOK	3	C	0
MAP	3	C	0
PARCEL	4	C	0
CODEDATE	8	D	0
OWN_CODE	12	C	0
SOURCE	20	C	0
CATEGORY	10	C	0

Items TOWNSHIP, RANGE, SECTION, and COUNTY conform to the data dictionary of the ALRIS LAND layer.

Parcels which have a book, map, and parcel number, are coded as follows:

ITEM	Example
COUNTY	9
BOOK	103
MAP	043
PARCEL	1A
OWN_CODE	091030431A

Other parcels are coded as follows:

STANDARD CODES FOR NON-PRIVATE PARCELS

ITEM	Example
BOOK	101
MAP	040
PARCEL	0
OWN_CODE	0

PARCEL Values:

0	=	No data or "other" (e.g. Right-of-Way)
AKCH	=	Ak-Chin (Maricopa) I.R.
ASNF	=	Apache-Sitgreaves NF
AZ	=	State of AZ
BLM	=	BLM
BWR	=	Bill Williams N.W.R.
CONF	=	Coronado National Forest
GILA	=	Gila River I.R.
NAV	=	Navajo I.R.
PFNP	=	Petrified Forest NP
SANC	=	San Carlos I.R.
SANX	=	San Xavier I.R.
SALT	=	Salt River I.R.
SRWR	=	Salt River N.W.R.
TOHO	=	Tohono O' Odham (Papago) I.R.
TONF	=	Tonto National Forest
TONM	=	Tonto National Monument
WMA	=	White Mountain Apache I.R.

"Background" parcels, i.e., sections outside the study area, are coded as follows:

ITEM	Example
BOOK	999
MAP	999
PARCEL	BACK
OWN_CODE	BACK

The CODEDATE item contains the date of completion of the coverage. The principal source used to determine the geometry of a particular parcel is documented via the SOURCE item.

SOURCE Values:

ASLD Base	=	Base data from AZ State Land Dept. (AZTRS)
County/Paper	=	County Assessor paper maps
County/Digital	=	County Assessor digital maps
County/GIS	=	County GIS
USGS 100K DLG	=	USGS 1:100,000 DLG files
ALRIS LAND	=	ALRIS LAND coverage
Various	=	Various Sources

The CATEGORY item is a temporary item used in the generation of status maps.

Each PARCEL coverage has a relate file, OWNDATA, with the following structure:

ITEM NAME	WIDTH	TYPE	N.DEC
OWN_CODE	12	C	0
OWNER	2	N	0
LC	2	C	0
DEL_FLAG	1	C	0
STATUS_DAT	8	D	0
LAND_USE	4	C	0
AREA	8	C	0
UNITS	1	C	0
OWNER1	40	C	0
OWNER2	40	C	0
OWNER3	40	C	0

OWN_CODE is the relate item to the PARCELS coverage. OWNER is the ownership lookup code and LC the use lookup code, used for querying and plotting. DEL_FLAG is a State Revenue record code, probably indicating a record slated for future deletion. STATUS_DAT is the date of the record. LAND_USE is the four-digit State land use code. AREA is the legal area of the entire parcel. UNITS is the units of the legal area (acres or square feet). OWNER1 through OWNER3 are the first three fields of the taxpayer name and address section.

3. RIVER

The RIVER coverage has line topology. There are no additional attribute items.

4. SHEETS

The SHEETS coverage has line topology. The AAT contains the following item:

ITEM NAME	WIDTH	TYPE	N.DEC
SHEET	2	N	0

Values correspond to the mapsheet number.

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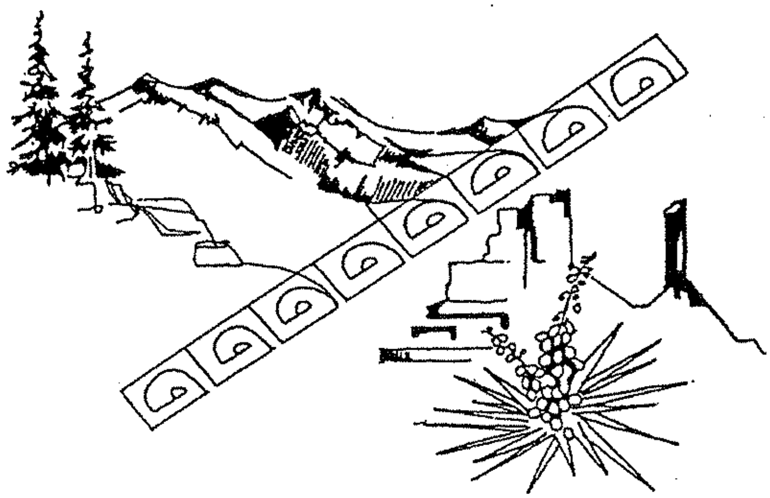

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Section 8

Summary for the Upper Salt River

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Section 8
Summary

The Upper Salt River has been a reliable source of water for the Salt River Valley for more than a millennium. River flow passing through the Upper Salt River has supplied water for irrigation and municipal purposes, hydropower, recreational and commercial boating opportunities, fishing, swimming and other recreational uses. This report has documented the continuous use and changing conditions of the Upper Salt River from the time of the Hohokam, through the period around statehood, and up to the modern era.

The Native American Hohokam civilization in central Arizona was dependent on water diverted from the Salt River to support their agricultural economy. TheHohokam built an extensive irrigation system that included approximately 315 miles of canals that provided water to about 140,000 acres of farmland, and supported a population of about 200,000. The water that supplied this extensive canal system was ultimately derived from the Upper Salt River. Archaeological records indicate that numerous fish species, similar to those described by early Anglo residents and explorers, populated the Salt River and supplemented the diet of the Hohokam. Archaeological records also indicate that climatic conditions and streamflow rates were not significantly different from conditions around the time of statehood.

The first Anglo explorers of the Upper Salt River found it in much the same condition that existed when the Hohokam and Apache settled in the area. The river had reliable streamflow, healthy beaver populations, a variety of large fish species, and dense riparian vegetation. EarlyAnglo residents floated canoes, flatboats, and logs down the river, although the primary mode of transportation was on foot, horseback or wagon. At least eight documented accounts of commercial and recreational boating on the Upper Salt River between 1870 and 1910 were identified as part of this study. Some types of boating occurred during all months of the year during the period leading up to statehood. One successful attempt to float logs to Tempe from the upper watershed above Roosevelt took place during the month of June (1885), typically a month of seasonal low flows.

Use of boats on the riverine portions of the Upper Salt River was limited to shallow water, low-draft, floating boats used only in the downstream direction. Steamboats and commercial shipping operations like those found on the Colorado and lower Gila Rivers apparently were not developed on the Upper Salt River. The boats used on the Salt River sometimes encountered difficulties in transit due to snags, boulder riffles, narrow canyons, waterfalls, or other natural hazards, and experienced difficulties at man-made obstructions such as irrigation diversions. A variety of boats were used to construct Roosevelt and Granite Reef dams, including a gas launch and boats used to haul construction materials to the dam site. Since the closure of Roosevelt Dam in 1911, recreational boating has been popular on Roosevelt Reservoir. Recreational and commercial rafting has been conducted on the Upper Salt River upstream of Roosevelt Reservoir since the 1950's.

By 1912, reservoir impoundments had lessened flow rates in the river channel itself, though the natural water supply upstream of Roosevelt Dam was no less reliable than in previous years. Documented accounts of boat use after 1911 on the Salt River downstream of Roosevelt Dam were limited to periods of high flow and floods. During the period after Roosevelt Dam was closed, and Roosevelt Reservoir was filling, streamflow in Reaches 2 and 3 of the Upper Salt River was limited to flood discharges and flow releases to supply downstream irrigation diversions. However, even during this period of reduced low flow in the Salt River, winter discharges could occupy the channel for months at a time, making the river susceptible to recreational boating using canoes, kayaks, rafts and other low-draft boats.

Review of geologic conditions in the Upper Salt River indicates that the channel geomorphology is substantially unchanged from the conditions at or before statehood, except where the river has been inundated by the reservoirs. The Upper Salt River is formed within deep canyons. Bedrock in these canyons has prevented significant channel changes from occurring. In addition, the bedrock geology of the Upper Salt River area made access to the river difficult during the period around statehood, prevented development of extensive irrigation systems, and created natural impediments to types of boats that could not be portaged. However, the bedrock geology of the Upper Salt River was conducive to construction of large dams and water supply reservoirs. Construction of the four reservoirs induced the only significant changes in the natural geomorphology of the study Reach. In addition to the obvious changes in downstream runoff rates caused by the reservoirs, the ordinary high watermarks and ordinary low watermarks located were changed by impounding water along the Upper Salt River system.

The Salt River Valley has a long history of reliance on the perennial flows from the Upper Salt River watershed. Without considering any disturbance by humans, the mean annual flow rate ranges from about 700 to 1,500 cfs, with relatively minor flow attenuation within the Reach due to shallow groundwater levels, narrow bedrock canyons, and perennial flow. In the year of statehood, 1912, the typical hydrologic condition of the river in Reaches 2 and 3 was in part a function of upstream water storage and downstream irrigation demands. For Reach 1, and for Reaches 2 and 3 prior to construction of Roosevelt Dam, periods of low flow usually occurred during the early summer months of June and July, and may have been as low as 100 to 300 cfs upstream of the Verde River confluence during the driest months of the year. Average winter flow rates typically exceeded 1,000 cfs prior to the closure of Roosevelt Dam, with annual flood discharges approaching 20,000 cfs in Reach 3. After closure of Roosevelt Dam, until it filled in 1915, winter flow rates were significantly reduced from the natural flow condition.

Typical flow depths during the lowest seasonal flows were probably one to three feet deep, with average flow widths ranging from about 50 to 100 feet depending on the channel geometry of the canyon bottom. Typical flow depths for the average annual flow were probably about three to five feet deep. At higher flow rates, such as for the 2- and 5-year flood peaks, velocities typically did not exceed 10 feet per second, which is within the range of boatable conditions for canoes, kayaks and rafts.

Under HB 2589, the Arizona Legislature defined navigability criteria that establish a presumption of non-navigability to be used by ANSAC when considering evidence for specific streams. For the Upper Salt River, the following data described in this report relate to the State's navigability criteria:

- **Commercial Trade and Travel** As of the time of statehood, the Upper Salt River was susceptible to limited forms of commercial trade and travel. The hydrologic and historical record shows that there was sufficient water in the river that would allow use of shallow water boats during regularly occurring portions of the year. Shallow water boating in the downstream direction was most feasible, given the normal conditions of the Upper Salt River.

- **Flow Regime.** As of the time of statehood, the hydrologic record shows that the Upper Salt River was and is a perennial stream. That is, it flows at times other than in direct response to precipitation. Like all rivers, the Upper Salt River responds to excess precipitation with increased flow rates. However, even during the driest portions of the year, the entire Upper Salt River remains perennial despite impoundment of flow in four major reservoirs.

- **Sustained Trade and Travel Upstream and Downstream** There was no evidence identified for this study that sustained trade and travel ever occurred on the Upper Salt River, nor is there evidence that trade or travel in the upstream direction ever occurred. However, the hydraulic rating curves indicate that some types of boat traffic could have occurred both upstream and downstream during regularly occurring portions of the year, although upstream travel would have been more difficult than downstream travel.

- **Profitable Commercial Enterprise** There was no historical evidence identified for this study that profitable commercial enterprises were conducted using the Upper Salt River for trade and travel as of the time of statehood.

- **Types of Vessels.** The historical record indicates that canoes, flat boats, rafts, rowboats, skiffs, and floating logs were the only vessels to be used on the Upper Salt River. Historical records indicate that use of any type of boats on the river diminished by the time of statehood. Keelboats and other powered barges were used on the Upper Salt River during the construction of Roosevelt Dam from 1906 to 1911, and have been used on the Salt River reservoirs since statehood. The hydraulic rating curves prepared for the Upper Salt River study reach indicate that large keelboats, steamboats or powered barges could not have been used during the low flow conditions on the river itself as it existed in 1912. During high flows, high velocities and river conditions may have made use of these types of high-draft boats hazardous or impractical.

- **Diversions.** Irrigation diversions at Granite Reef Dam, the downstream end of the Upper Salt River study reach, removed the entire flow from the Salt River as of 1912. Some lands irrigated with water from the Upper Salt River were covered under the Desert Land Act of 1877, or were within an Indian Reservation. It is uncertain whether any of the local irrigation diversions along the Upper Salt River upstream of Granite Reef Dam were for lands covered under the Desert Land Act of 1877.

- **Recreational Boating.** Most, but not all, of the historical accounts of boating on the Upper Salt River were for recreational purposes.

- **Regular Flotation of Logs.** Logs or other material probably could have been floated through the entire Upper Salt River as of the time of statehood throughout the entire year, although some type of portage would have been required in some reaches and at Roosevelt Dam.

- **Impediments to Navigation.** Roosevelt Dam was the only known non-natural impediment to navigation in the Upper Salt River that existed in 1912.

- **Customary Modes of Transportation.** The customary mode of transportation in the region near the Upper Salt River was not by boat. By 1912, alternatives to boat travel included foot, horse, mule train, wagon, and train.

- **Rivers and Harbors Act of 1899.** The Salt River is not one of the streams listed under the Rivers and Harbors Act of 1899.

The Salt River could have and did support some types of boating during the period prior to statehood. By 1912, use of boats on the river had declined, but was still possible during most years, a condition which persists today.

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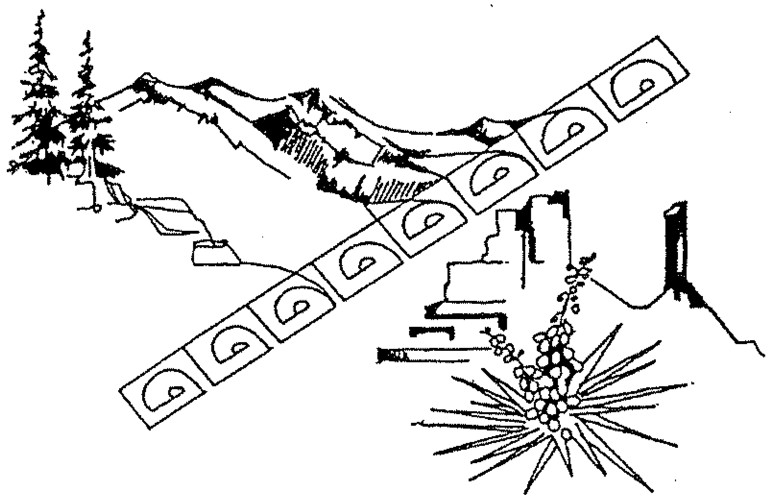

Prepared by

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March 1997

Glossary

GLOSSARY

Acequia - An irrigation ditch or canal.

Aggradation - Progressive deposition of sediment, raising the elevation of thestreambed. See Degradation.

Alluvial - See Alluvium.

Alluvial Fan - A large fan-shaped accumulation of sediment; usually formed where a stream's velocity decreases as it emerges from a narrow canyon onto a flatter plain at the foot of a mountain range.

Alluvial Stream - A stream whose bed and banks are formed in sediment transported by the stream itself; a stream with a non-bedrock channel.

Alluvium - A general term for eroded rock material, including soil, deposited by rivers; loose sediment, often from the recent geologic past.

Anecdotal - Undocumented evidence or accounting of an event.

Aquifer - A water-bearing bedrock or alluvium layer.

Archaeology - The systematic recovery, and scientific study, of material evidence of human life and culture from past ages. The study of antiquity.

Arroyo - A term used in the southwest to describe an entrenched, dry wash.

Average Flow - See Mean Flow.

Avulsion - In geomorphology, an avulsion is the sudden relocation of a stream away from its original flow path, usually due to catastrophic sediment deposition in the original flow path.

Bajada - A piedmont comprised of coalescing alluvial fans.

Base Flow - Stream discharge which does not fluctuate in response to precipitation. The minimum discharge in a stream.

Base Level - The minimum elevation to which a stream can erode.

Basin and Range - One of three physiographic provinces in Arizona. The Basin and Range is characterized by elongated, parallel mountain ranges trending northwest to southeast, with intervening basins filled by alluvium eroded from the mountains.

Braided - A braided stream is one flowing with branching and reuniting channels. May be ephemeral or perennial.

Cadastral Survey - A land (legal) survey.

Central Mountain Province (Transition Zone) - One of three physiographic provinces in Arizona, characterized by deeply eroded mountains composed ofgranitic bedrock.

CFS - Abbreviation for cubic feet per second, a measure of the rate of stream flow.

Channelization - The process of a stream changing from a broad unconcentrated flow path to a more confined, or single flow path.

Confluence - The point where two streams join.

Continuous Gage - A type of stream measuring equipment that records water surface elevations continuously throughout a flood, or over a long period of time regardless of flow conditions. Water surface elevations in the stream can be related to discharge rate.

Control - The river reach or structure which governs stream flow characteristics at a stream gage is called the control. A gage with reliable, consistent stream flow characteristics has "good control."

Crest Stage Gage - A type of stream measuring equipment that records only the highest water surface elevation during a flood or flow event. Water surface elevation can be related to stream discharge rate through use of a rating curve. See Continuous Gage.

Degradation - Channel bed erosion resulting in a topographically lowerstreambed.

Dominant Discharge - The dominant discharge is the stream flow rate responsible for forming a stream=s geometry. This theory is tenuous when applied to streams in Arizona or bedrock streams.

Empirical - Empirical methods are based on experimentally derived equations, rather than theoretically derived equations.

Entrenchment (Entrench) - Progressive degradation of a streambed or channel resulting in a topographically lower channel bottom usually with steep or vertical banks; a process associated with arroyo formation.

Ephemeral Stream - A stream which flows only in direct response to rainfall. It receives little or no water from springs and no long continued supply from snow or other sources. Its channel is at all times above the water table.

Equilibrium - Balance. When applied to streams, equilibrium means lack of change.

Erosion - Removal of bedrock or alluvium by water or wind.

Flash Floods - Floods which reach their peak discharge rate very quickly are flash floods. In Arizona, the term is often used to describe a flood or flow event moving down a previously dry river channel.

Flow Duration Curve - A cumulative frequency curve depicting the percent of time a given discharge on a stream is equaled or exceeded in a specific period. For instance, a 10 percent flow of 20 cfs means that the stream discharge only exceeds 20 cfs 10 percent of the time; a 90 percent flow of 1 cfs means that the stream flows at discharges greater than 1 cfs 90 percent of the time; the 50 percent flow is the median (not average) flow rate.

Fluvial - Relating to stream flow.

Fluvial Geomorphology - The branch of geomorphology relating to streams. See Geomorphology.

Ford - A river crossing; usually, but not necessarily, with shallow flowing water.

Frequency Distribution - A table which presents data in a number of small classes for use in statistical treatments of the data.

Geomorphic - Parameters or variables relating to geomorphology.

Geomorphology - A branch of geology concerned with the formation, characteristics, and processes of landforms, including rivers.

GIS - Geographic Information System. A database which relates information to spatial characteristics of some land area.

Ground Water - Water stored or moving beneath the ground surface, usually in pore spaces in alluvium, or voids in bedrock.

Ground Water Decline - Lowering of the elevation or volume of ground water relative to the ground surface.

Ground Water Discharge - Transfer or flow of water from underground sources into surface water; a spring.

Headcutting - A process of channel bed erosion whereby a sharp break in the average channel bed slope moves upstream, rapidly lowering the channel bed elevation.

Headwaters - The point, or area, where a stream originates; or the most upstream point of a stream.

Holocene - The most recent epoch of geologic history, usually the past 10,000 years before present; part of the Pleistocene geologic period.

Hydraulics - The science or technology of the behavior of fluids. Characteristics of stream flow such as depth, velocity, and width.

Hydrology - A branch of engineering concerned with water. In the context of this report, hydrology means the characteristics of water flow.

Incised Channel - A stream or waterway which has eroded its bed, creating steep or vertical stream banks. An arroyo, or degraded stream channel.

Infiltration - The process whereby water passes through an interface, such as from air into soil.

Instantaneous Flow Rate - Stream discharge at an instant in time, as opposed to a discharge averaged over a period of time. See Mean Flow.

Intermittant Stream - A stream which flows only for portions of the year, but has sustained flow for a period after rainfall. See Perennial Stream and Ephemeral Stream.

Mean Flow - The mean flow of a river is determined by dividing the total runoff volume by the time in which that volume was discharged, i.e., mean annual flow is the average rate at which the average yearly flow volume would be discharged.

Median Flow - The flow rate which is exceeded 50 percent of the time (conversely, the rate is not exceeded 50 percent of the time).

Morphology - The shape or geometric characteristics, especially of a stream or stream reach.

Navigable (Navigable Watercourse) - A watercourse, or portion of a reach of a watercourse, that was in existence on February 14, 1912, and that was used or was susceptible to being used, in its ordinary and natural condition, as a highway for commerce, over which trade and travel were or could have been conducted in the customary modes of trade and travel on water.

Perennial Stream - A stream which flows year round; non-zero base flow.

Permanent Water - Perennial stream flow.

Permeable - A rock or soil unit which is permeable will allow water to pass through it.

Phreatophytes - Deep-rooted plants that obtain water from the water table or the layer of soil just above it.

Physiographic Province - A region of similar geology. In Arizona, three physiographic provinces are recognized: the Basin and Range, the Central Highland (Transition Zone), and the Colorado Plateau.

Pleistocene - The most recent geologic period, usually the past 1,000,000 years before present.

Point of Zero Flow - The stage on a rating curve or gage record where no discharge occurs.

Quit claim - A transfer of one=s interest in a property, especially without a warranty of title to give up claim to property by means of a quit claim deed.

Quit claim deed - A deed that conveys to the grantee only such interests in property as the grantor may have, the grantee assuming responsibility for any claims brought against the property.

Rating Curve - A graph which relates stream discharge to some other measurable stream characteristic such as stage, width, depth, or velocity.

Reach - A segment of a stream, usually with uniform characteristics.

Riparian - Refers to that which is related to, or located near, or living along a watercourse whether natural, man-made, ephemeral, intermittent, or perennial.

Salt Cedar - A non-native, undomesticated tamarisk tree.

Scour - Removal of streambed material by flowing water.

Seep - A small, diffuse spring generally of low discharge rate.

Sinuosity - A measure of how sinuous a stream is: the ratio of the length along the thalweg to the length along the stream valley. Always greater than one.

Sinuous - The Acurviness@ of the channel planform; the degree of meandering.

Spring - The point where underground sources of water discharge at the surface.

Stage - A term used in stream gaging to describe the elevation of the water surface of a stream relative to some datum (fixed elevation). Stream stage is analogous to stream depth.

Stream Gage - A site operated for the purpose of measuring the rate or volume of water discharge in a stream. Accumulated data from a stream gage are called stream gage records.

Subflow - See Underflow.

Tamarisk (salt cedar) - Non-native riparian plants. Presently the dominant vegetation on the floodplain of many streams due to opportunistic growth in channel systems in the southwestern United States.

Terrace (Bench) - A relatively flat geologic or geomorphic surface which parallels a stream and is elevated above the floodplain, and was formed when the river flowed at a higher elevation.

Thalweg - The centerpoint, or low flow channel, of a stream.

Topwidth - The distance across the water surface, perpendicular to the channel, of a flowing stream.

Transition Zone - See Central Mountain Province.

Transmission Losses - Reductions in stream flow due to infiltration of water into thestreambed and subsurface.

Underflow - A term used interchangeably with subflow to describe the ground water underlying the surface of a stream's channel.

Unentrenched - See Entrenchment.

Wash - A river or stream with low banks and numerous channels.

Water Table - The upper surface of the underground zone of saturation; the plane which represents the elevation of ground water.

Watershed - The land area draining into a stream, or other body of water.

Xerophytes - Plants that are structurally adapted for life and growth with a limited water supply.

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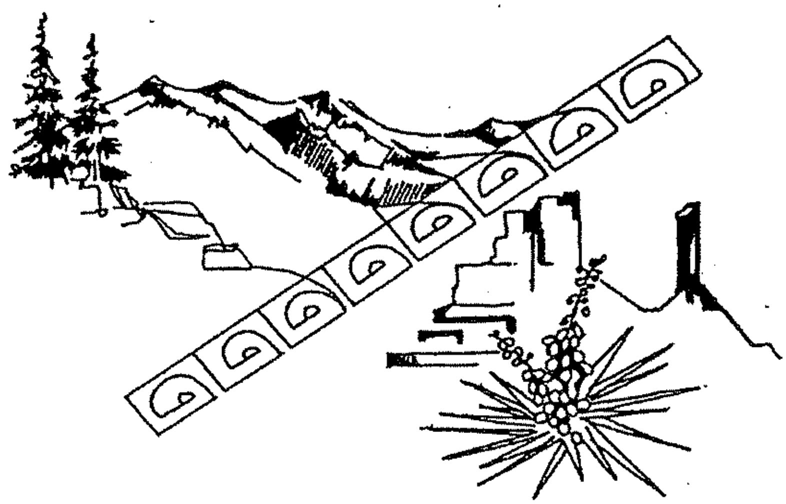

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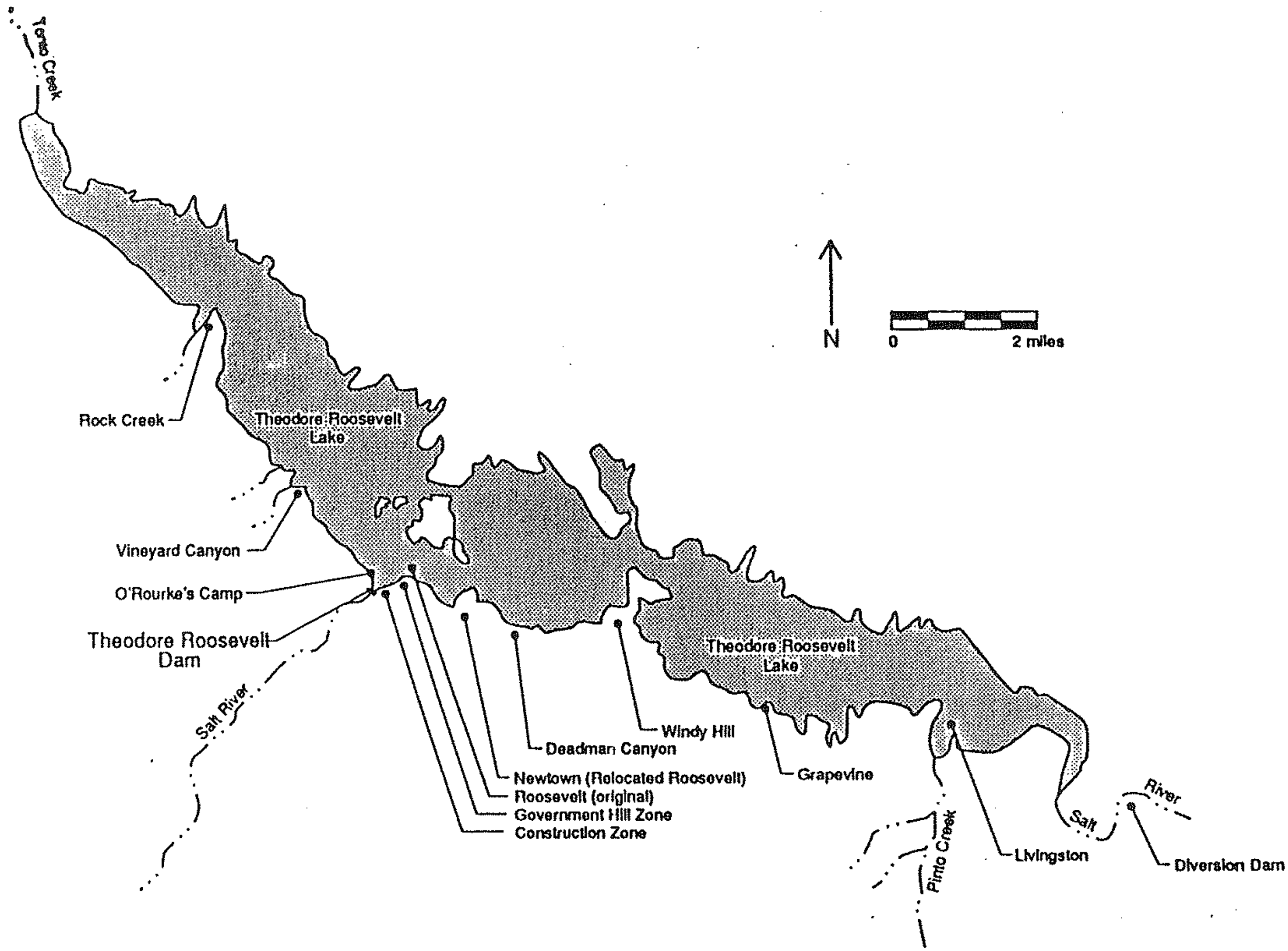
March 1997

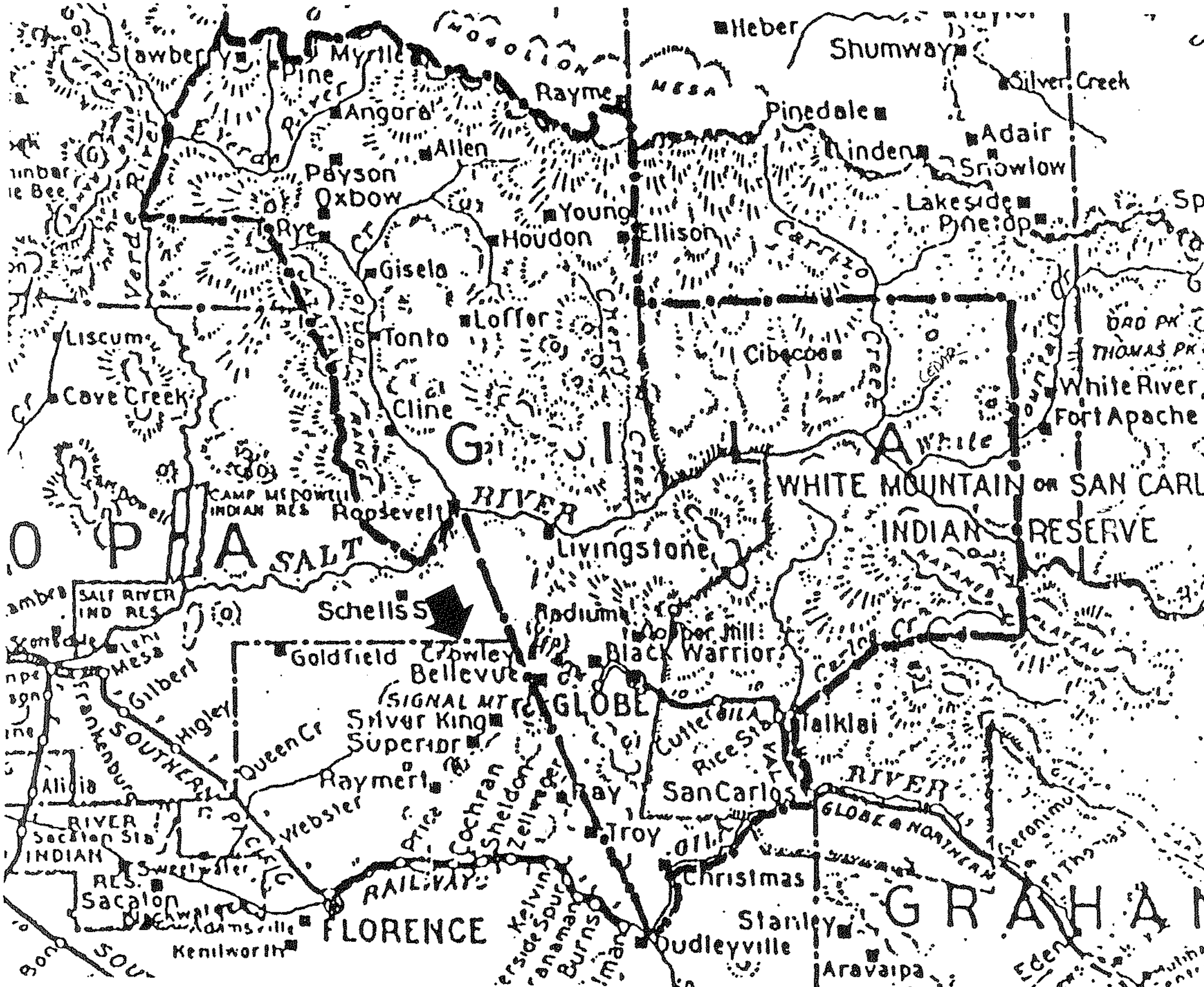
Acronyms

LIST OF ACRONYMS

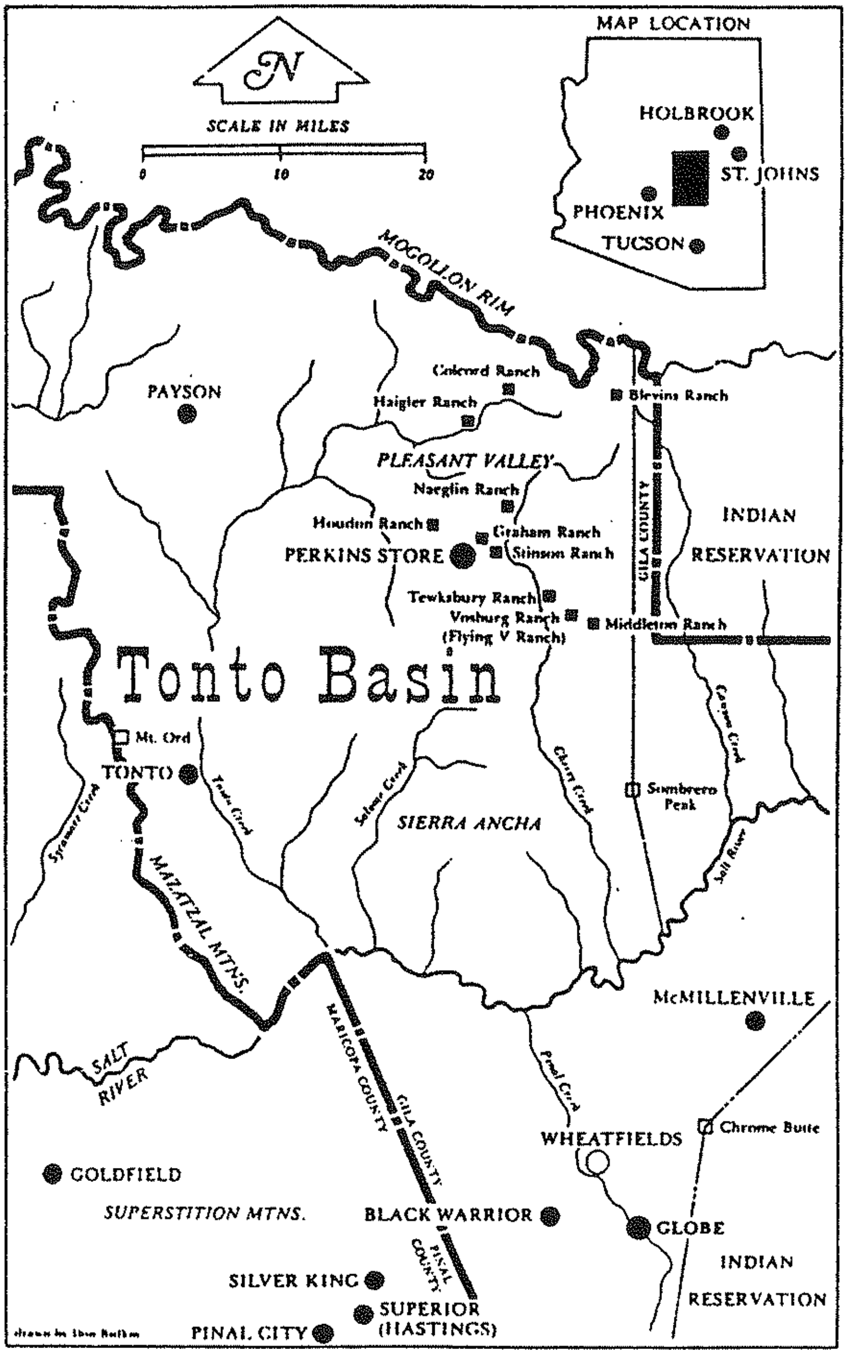
Arizona Geological Survey	AZGS
Arizona Land Resource Information System	ALRIS
Arizona Navigable Stream Adjudication Commission	ANSAC
Arizona Revised Statutes	A.R.S.
Arizona State Land Department	ASLD
Arizona Upland	AU
Bureau of Land Management	BLM
Cubic feet per second	cfs
Federal Emergency Management Agency	FEMA
Flood Insurance Rate Map	FIRM
General Land Office	GLO
Geographic Information System	GIS
House Bill	HB
Lower Colorado River Valley	LCRV
Right of Way	ROW
Santa Cruz River	SCR
US Geological Survey	USGS



Historic site locations in Roosevelt Dam locale (Ayres et al. 1994:Figure 1-2).

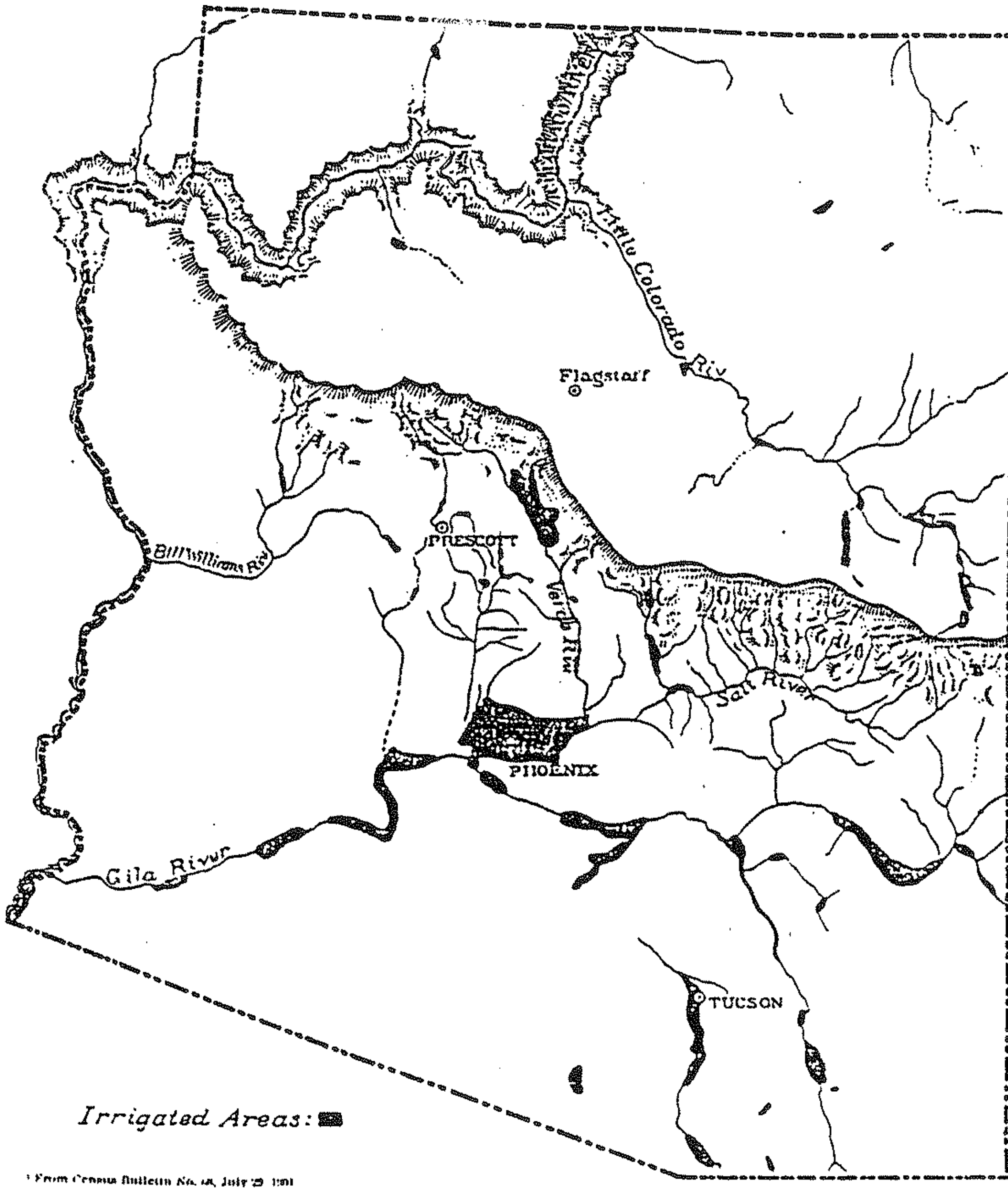


Gila County map, circa 1910 (from Haak 1991).



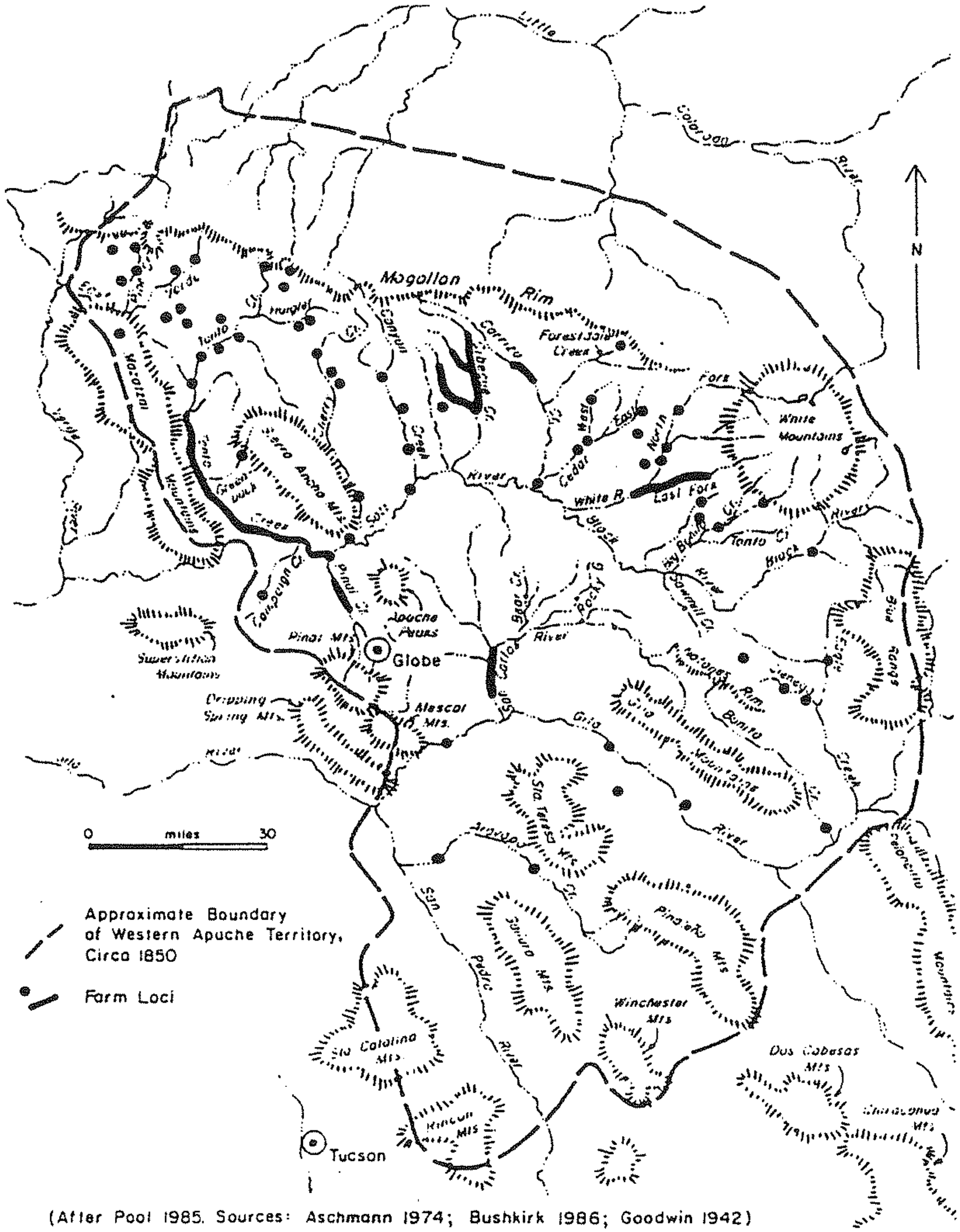
Map of the Tonto Basin (Woody and Schwartz 1977:100).

Map of Globe Mining District (Bigando 1990:10).

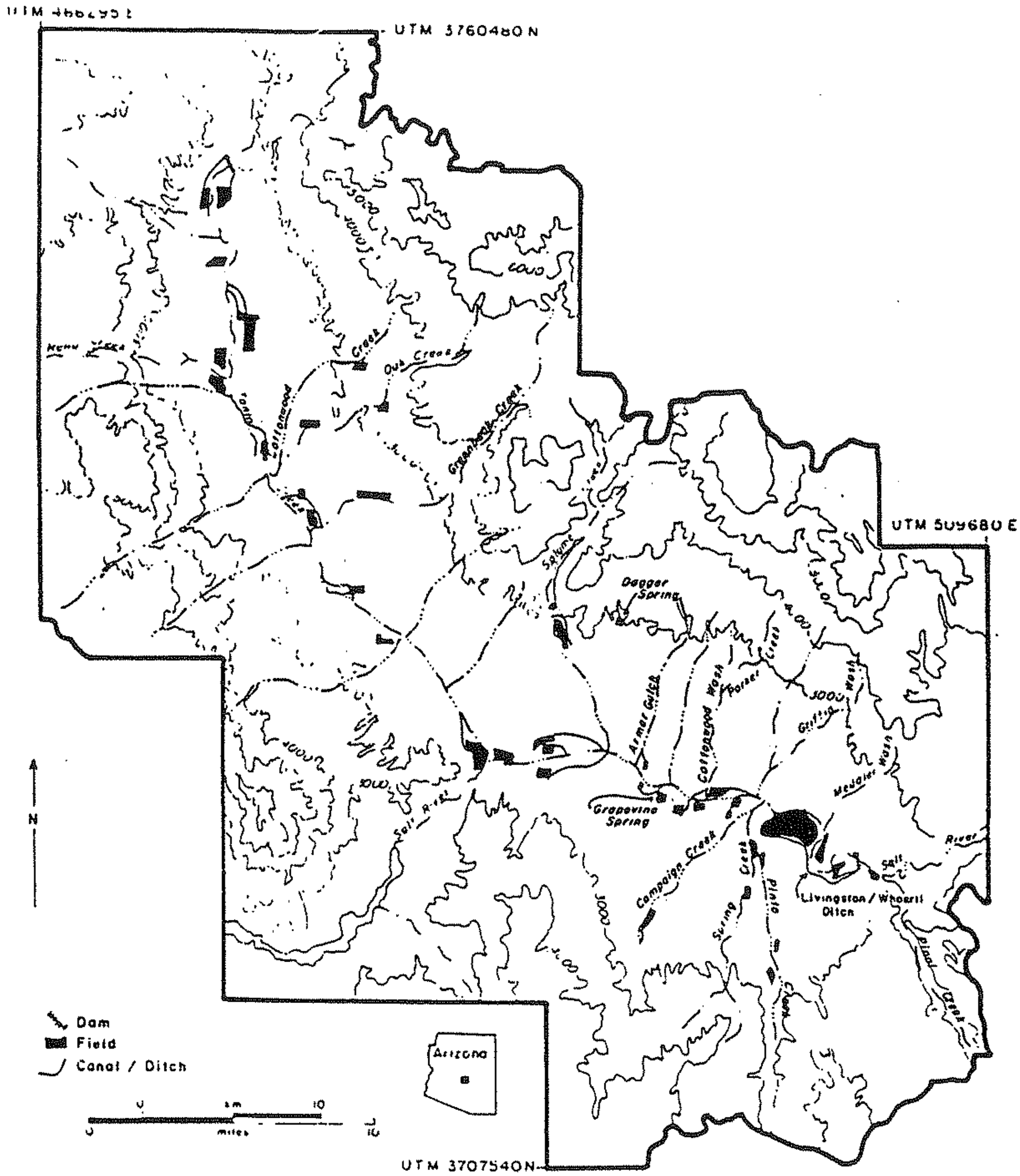


¹ From Census Bulletin No. 68, July 29, 1901

Map of irrigated areas in Arizona from Census Bulletin No. 68, July 29, 1901.



Locations of Western Apache farms in the Tonto Basin and adjacent areas (Welch and Ciolek-Torrello 1994:Figure 4.1).



Locations of historic irrigation ditches and irrigated fields in the Tonto Basin (Welch and Ciolek-Torrello 1994:Figure 4.2).

APPENDIX B

INVENTORY OF HISTORICAL PHOTOGRAPHS OF THE UPPER SALT RIVER

INVENTORY OF HISTORICAL PHOTOGRAPHS OF THE UPPER SALT RIVER

BOATING

Title: At the Junction of the Verde and the Salt
Location: Published photograph
Number: none
Description/Comments: In Al Beasley (editor), 1908, *Twentieth-Century Phoenix, Illustrated*, Phoenix, Arizona, p. 4. Another copy of this photograph is in the collections of the Arizona Historical Foundation, Hayden Library, Arizona State University, under call number G-554.

Title: Boating on Salt River
Location: Arizona Historical Foundation, Hayden Library, Arizona State University
Number: G-554
Description/Comments: Published as "At the Junction of the Verde and the Salt" in Al Beasley, editor, 1908, *Twentieth-Century Phoenix, Illustrated* Phoenix, Arizona, p. 4.

Title: Three People in a Row Boat on the Salt River, Arizona, Circa 1918.
Location: Arizona State University, Hayden Library, Special Collections
Number: CP CTH 2064
Description/Comments: Carl Hayden Photograph Collection, 1918. This postcard is postmarked Dec. 17, 1918. The same photograph was published in the early 1900s magazine *Arizona*, Vol. 1, No. 1 (February 1910), p. 16. It is also reproduced in Barbara Behan, 1988, *An Historical Analysis of the Salt River*, 1830-1912, Figure 2. The general terrain pictured suggests that it was taken above Granite Reef Dam, perhaps in the Roosevelt area.

Title: Arizona Canal Under Construction, Phoenix, Arizona, Circa 1885
Location: Arizona State University, Hayden Library, Special Collections
Number: CP MCL 97342.A3
Description/Comments: Herb and Dorothy McLaughlin Photographs, 1885. Original in Arizona Department of Library and Archives Collection, Archives 3 (Rothrock and Barnett). Shows flatboat being used in river for dam construction.

Title: Arizona Canal Under Construction, Phoenix, Arizona, Circa 1885
Location: Arizona State University, Hayden Library, Special Collections
Number: CP MCL 97343.A3
Description/Comments: Herb and Dorothy McLaughlin Photographs, 1885. Original in Arizona Department of Library and Archives Collection, Archives 3 (Rothrock and Barnett). Shows flatboat being used in river for dam construction.

Title: The Dredge Used by the U.S. Reclamation Service to Enlarge the Arizona Canal
Location: Published photograph in Brown, Patricia E., 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 79.
Number: Published
Description/Comments: Shows steam dredge floating down the canal with the Salt River in the background.

Title: Barge Crossing Roosevelt Lake on the Upper End, Prior to Construction of the Salt River Bridge
Location: Published photograph in Guy Anderson and Donna Anderson, editors, 1976, *Honor the Past, Mold the Future: Gila Centennials, Inc. Historical Celebration and Pageant, September 10-19, 1976*, Gila Centennials, Inc., Globe, Arizona, p. 30.
Number: Published
Description/Comments: Shows barge on the lake.

Title: Photograph of Clamshell Derrick, Horse Mesa Dam, ca. 1926
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Turnmire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-8.
Number: Published
Description/Comments: Photograph of clamshell derrick operating in the impounded river.

GRANITE REEF DAM

Title: Panoramic View of the Granite Reef Construction Camp Circa 1907
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, Plate 1.
Number: Published
Description/Comments: Caption reads, "Panoramic view of the Granite Reef work camp circa 1907. Looking north toward Mt. McDowell. Photograph obtained from Salt River Project." Shows work camp in foreground, wooden tower on left, river flowing as a braided stream in middle ground, Mt.McDowell in background.

Title: General View of Granite Reef Diversion Dam Construction, October 31, 1907
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 72.
Number: Published
Description/Comments: Shows wooden tower with river in background.

Title: Construction of Granite Reef Diversion Dam from North Shore; Arizona Canal, Foreground
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 79.
Number: Published
Description/Comments: Shows dam and river flowing bank to bank.

Title: Snapshot of Building at Granite Reef Dam, Maricopa County, Arizona, 1917
Location: Arizona State University, Hayden Library, Special Collections
Number: CP GM 56
Description/Comments: Gertrude Muir Photographs. View of spillway and office, lake full, water going over dam.

Title: Old Boat Landing on Salt River at Headgate Tender's Residence, Maricopa County, Arizona, 1913
Location: Arizona State University, Hayden Library, Special Collections
Number: CP GM 58
Description/Comments: Gertrude Muir Photographs. Old boat landing on Salt River in front of headgate tender's house, Granite Reef, Arizona, April 1913.

Title: Granite Reef Dam, Arizona, 1917-1932
Location: Arizona State University, Hayden Library, Special Collections
Number: CP GM 59
Description/Comments: Gertrude Muir Photographs. Granite Reef Dam in floodtime.

Title: Snapshot of Building at Granite Reef Dam, Maricopa County, Arizona, 1917.
Location: Arizona State University, Hayden Library, Special Collections
Number: CP GM 62
Description/Comments: Muir Photographs. Same as GM 56 but slightly to the left.

Title: SS Gates, Granite Reef Dam
Location: Arizona State University, Hayden Library, Special Collections
Number: CP SPC 53:17
Description/Comments: Crowd on hand, office on right of dam, slack water in foreground.

OTHER

Title: Salt River-Maricopa County
Location: Arizona Pioneers Historical Society, Tucson
Number: 91796; File: Places, Pictures-Salt River, Maricopa County
Description/Comments: Rothrock Collection. Shows canal dam.

Title: Salt River by Moonlight, Near Phoenix Arizona
Location: Arizona Pioneers Historical Society, Tucson
Number: 10191; File: Pictures-Places-Salt River Valley
Description/Comments: Original from the Arizona Governor's Report, 1896. Duplicate print #24381 from Sylvia Kennedy Hawkins. Holliday Collection #160. Same as CP MCL 98056.A3. Published as CP MCL 98056.PHX39 in Herb McLaughlin and Dorothy McLaughlin, 1970, *Phoenix 1870-1970 in Photographs*, Arizona Photographic Consultants, Phoenix, p. 39. This was a popular photograph at the turn of the century. It was reproduced as a tinted postcard (University of Arizona Library, Special Collections Salt River [Ariz.] Photographs, Postcards, Folder 1) and can also be found in the Pickrell Collection, University of Arizona Library, Special Collections (Salt River [Ariz.] Photographs, Postcards, Folder 1).

Title: Moonlight on Salt River, Near Phoenix
Location: University of Arizona, Special Collections
Number: None; File: Salt River (Ariz.): Photographs, Postcards, Folder 1
Description/Comments: From Charles U. Pickrell Collection. Same as CP MCL 98056.A3. Published as CP MCL 98056.PHX39 in McLaughlin, Herb, and Dorothy McLaughlin, 1970, *Phoenix 1870-1970 In Photographs*, Arizona Photographic Consultants, Phoenix, p.39. This was a popular photograph at the turn of the century. It was used in the Governor's Report of 1896 (Arizona Pioneers Historical Society, Tucson, Photograph 10191), and reproduced as a tinted postcard (University of Arizona Library, Special Collections Salt River [Ariz.] Photographs, Postcards, Folder 1).

Title: Salt River, Arizona, On the Line of the S.P.R.R.
Location: University of Arizona, Special Collections
Number: None; File: Salt River (Ariz.): Photographs, Postcards, Folder 1
Description/Comments: Tinted postcard, Published by Newman Postcard Co., Los Angeles and San Francisco, No. AR27. Same as CP MCL 98056.A3. Published as CP MCL 98056.PHX39 in Herb McLaughlin and Dorothy McLaughlin, 1970, *Phoenix 1870-1970 in Photographs*, Arizona Photographic Consultants, Phoenix, p.39. This was a popular photograph at the turn of the century. It was used in the Governor's Report of 1896 (Arizona Pioneers Historical Society, Tucson, Photograph 10191). It can also be found in the Pickrell Collection, University of Arizona Library, Special Collections (Salt River [Ariz.] Photographs, Postcards, Folder 1).

Title: Sunset on the Salt
Location: Arizona Pioneers Historical Society, Tucson
Number: 19206; File: Pictures-Places-Salt River Project
Description/Comments: On back of photograph: "As we looked forward just before crossing the river we could see a most remarkable sunset just ready to drop behind the low hills that were gradually tapering down towards the desert in the direction of Granite Reef, where the construction of a great irrigation enterprise was being undertaken by the Reclamation Service to reclaim part of this vast desert that lies in the direction of the setting sun."

Title: Sheep Crossing Salt River with McDowell Butte Beyond, Circa 1918
Location: Arizona Historical Foundation, Hayden Library, Arizona State University
Number: DC COO:14
Description/Comments: Dane Coolidge Collection, 1918

Title: Beaver Dams, Salt River, Circa 1915
Location: Arizona Historical Foundation, Hayden Library, Arizona State University
Number: DC COO 1191-1192
Description/Comments: Dane Coolidge Collection, 1915. There is no way to determine where these dams were located, although other photographs in the Dane Coolidge Collection were taken around Granite Reef Dam.

Title: Mormon Flat, Salt River, 1920
Location: Arizona Pioneers Historical Society, Tucson
Number: 77057; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer. This is a good view of Mormon Flat, but the river is barely visible.

Title: Salt River, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77087; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77088; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77089; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, ca. 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77090; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River near Diversion Dam &Pinal Creek, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77107; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77108; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77111; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77112; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77113; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77114; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77115; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, Feb 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77116; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River Canyon, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77097; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River Canyon, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77098; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Apache Trail and Salt River, Jan 1921
Location: Arizona Pioneers Historical Society, Tucson
Number: 77099; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Salt River, August 20-Oct 20, 1920
Location: Arizona Pioneers Historical Society, Tucson
Number: 77049; File: J. B. Richardson Collection (Album), 1911-1922
Description/Comments: J. B. Richardson was a miner, fur trapper, electrical engineer, and amateur photographer.

Title: Sections of Canal Built to Develop Electricity with Falling Water, March 6, 1906
Location: Published photograph in Earl Zarbin, 1984, *Roosevelt Dam: A History to 1911*, Salt River Project, Phoenix, p. 128.
Number: Published
Description/Comments: Shows canal in foreground with Salt River (through Tonto Basin) as braided stream in background.

Title: Looking Upstream at Site of Roosevelt Dam on the Salt River, April 16, 1906
Location: Published photograph in Earl Zarbin, 1984, *Roosevelt Dam: A History to 1911*, Salt River Project, Phoenix, p. 134.
Number: Published
Description/Comments: Shows Salt River flowing canyon wall to canyon wall with a few beaches on either side.

Title: Main Street at Roosevelt, February 1907
Location: Published photograph in Earl Zarbin, 1984, *Roosevelt Dam: A History to 1911*, Salt River Project, Phoenix, p. 147.
Number: Published
Description/Comments: Shows town of Roosevelt from above with Salt River as a braided stream on a sandy bed in background.

Title: The West End of the Town of Roosevelt, Arizona, March 1906
Location: Published photograph in Karen L. Smith, 1986 *The Magnificent Experiment: Building the Salt River Reclamation Project, 1890-1917*, University of Arizona Press, Tucson, p. 71.
Number: Published
Description/Comments: Caption reads, "The west end of the town of Roosevelt, Arizona, as it was in March, 1906, during construction of the dam. Located on the south side of Salt River approximately one-half mile upstream from the damsite, the town had a population of about 500 during the peak of construction. After the dam was completed and the reservoir began to fill, the town was abandoned and eventually inundated." The Salt River, covering about half of its broad, sandy bed is shown in the foreground; the town of Roosevelt is on the opposite bank in the background.

Title: Downstream View of Salt River Prior to Roosevelt Dam's Construction.
Location: Published photograph in Palmer, Ralph F., 1979, *Doctor on Horseback: A Collection of Anecdotes Largely but Not Exclusively Medically Oriented* Mesa Historical and Archaeological Society, Mesa, Arizona.
Number: Published
Description/Comments: Salt River flowing canyon wall to canyon wall.

Title: Tonto Basin, Prior to Construction of Roosevelt Dam
Location: Published photograph in Guy Anderson and Donna Anderson, editors, 1976, *Honor the Past, Mold the Future: Gila Centennials, Inc., Historical Celebration and Pageant, September 10-19, 1976*, Gila Centennials, Inc., Globe, Arizona, p. 65.
Number: Published
Description/Comments: Caption reads, "Tonto Basin, prior to construction of Roosevelt Dam. Catwalk across the point is about where the dam was later built." Shows the Salt River as a braided stream running across a broad, sandy river bed and entering the canyon.

Title: Arizona Dam Destroyed by Flood, April 13-16, 1905
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 8.
Number: Published
Description/Comments: Caption reads, "Most of the Arizona Dam was carried away by floods April 13-16, 1905." Upper photograph is closeup of the top of the dam.

Title: Arizona Dam Destroyed by Flood, April 13-16, 1905
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 8.
Number: Published
Description/Comments: Caption reads, "Most of the Arizona Dam was carried away by floods April 13-16, 1905." Lower photograph shows the area behind the dam after the dam was breached.

Title: Flood Damage to Arizona Dam, 1905
Location: Published photograph in Patricia E. Brown, 1978, *Archaeological Investigations at AZ:6:2 (ASU), an Historic Camp on the Banks of the Salt River, Maricopa County, Arizona (Granite Reef Dam)*, Office of Cultural Resource Management Report No. 32, Arizona State University, Tempe, p. 9.
Number: Published
Description/Comments: Caption reads, "Photographs show washed out sections of the Arizona Dam and the Arizona Canal head." Two similar views.

Title: Photograph of Mormon Flat Construction Camp, 1923
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Tummire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 1-4.
Number: Published
Description/Comments: Shows Mormon Flat in foreground with a glimpse of the Salt River in the middle ground.

Title: Photograph of Surveyors' Rock Shelter at Horse Mesa, October 1924
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Tummire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-2.
Number: Published
Description/Comments: Shows Salt River in foreground with rocky beach and rock shelter on opposite bank in background.

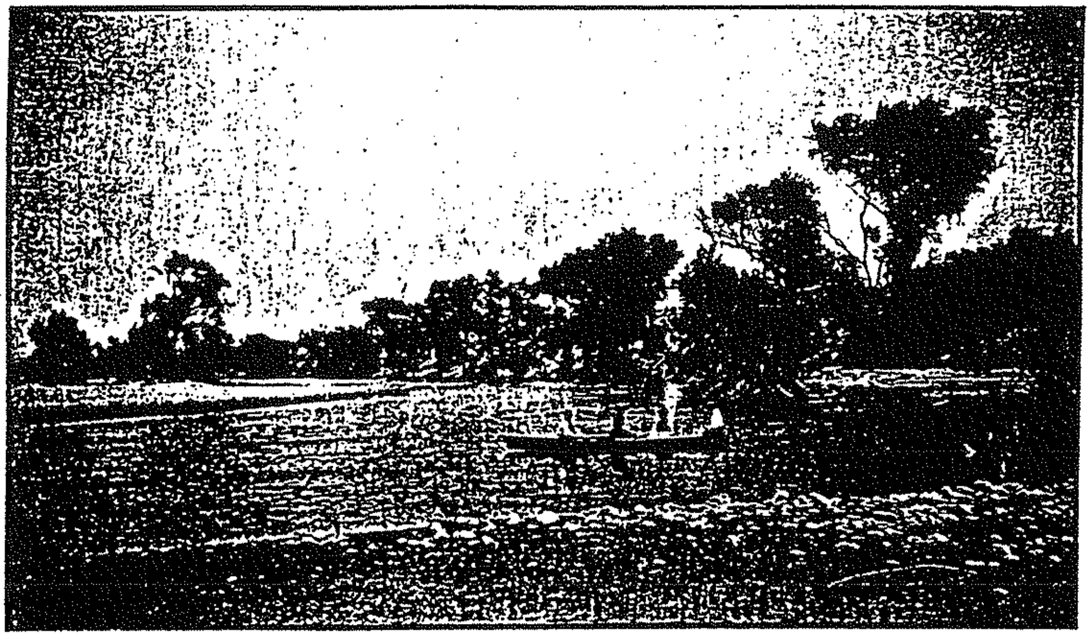
Title: Photograph of Horse Mesa Dam Construction Camp, ca. 1926
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Tummire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-5.
Number: Published
Description/Comments: Caption reads, "Photograph of Horse Mesa Dam Construction Camp, ca. 1926 (view of northern portion of the northern section of camp." View from above shows Salt River flowing through canyon on lower right.

Title: Photograph of Horse Mesa Dam Construction Camp, ca. 1926
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Turnmire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-6.
Number: Published
Description/Comments: Caption reads, "Photograph of Horse Mesa Dam Construction Camp, ca. 1926 (view of central portion of the northern section of camp." View from river shows Salt River flowing through canyon on lower right.

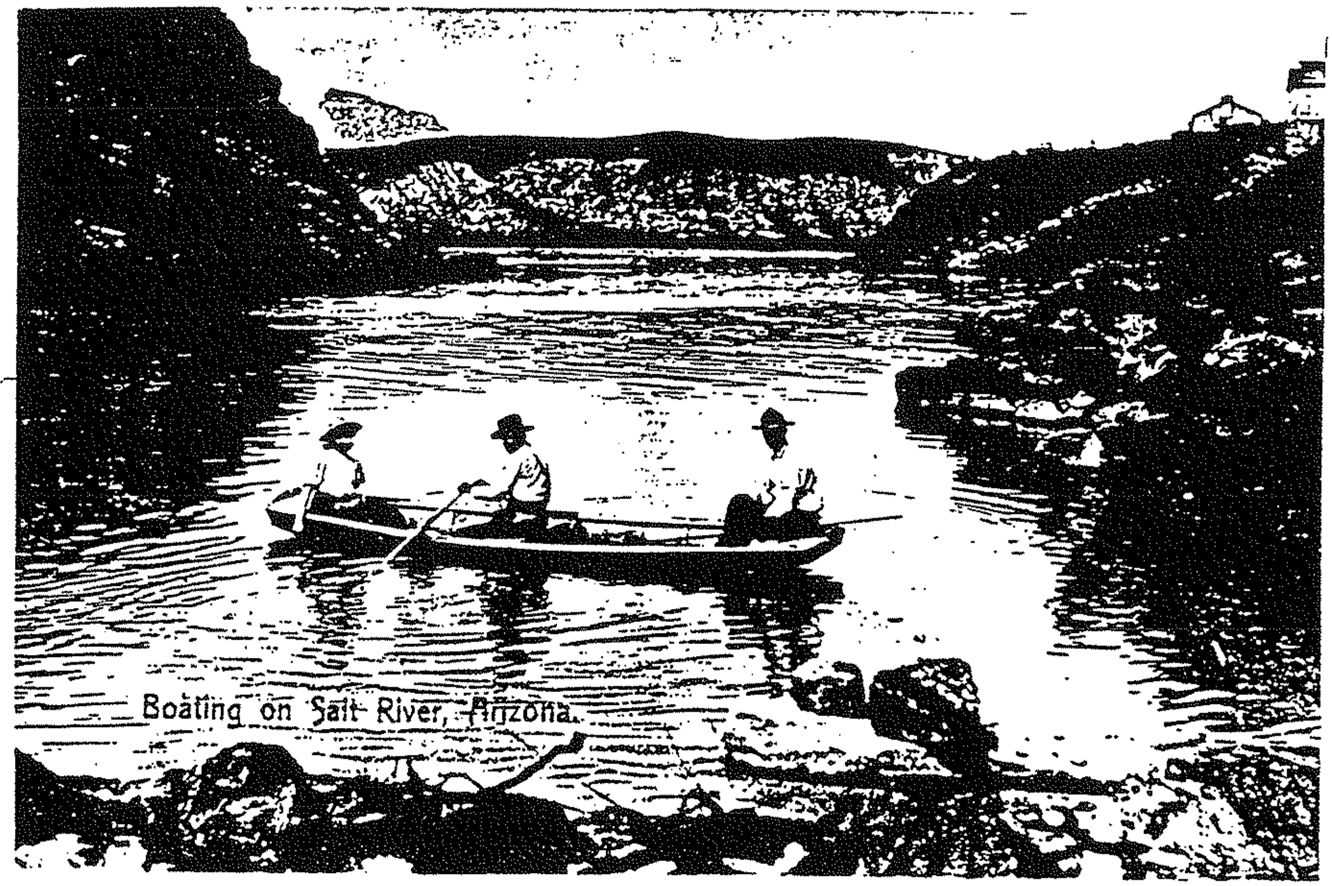
Title: Photograph of Horse Mesa Dam Construction Camp, ca. 1926
Location: Published photograph in Diane L. Douglas, A. E. Rogge, Karen Turnmire, Melissa Keane, James E. Ayres, Everett J. Bassett, and Cindy L. Myers, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2C: Sites at Other Dams along the Salt and Verde Rivers*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 13, Phoenix, Figure 2-7.
Number: Published
Description/Comments: Caption reads, "Photograph of Horse Mesa Dam Construction Camp, ca. 1926 (view of southern portion of the northern section of camp." View from above shows Salt River flowing through canyon from upper left to lower right.

Title: Photograph of Lake Roosevelt During Flood, February 4, 1908
Location: Published photograph in James E. Ayres, A. E. Rogge, Melissa Keane, Diane L. Douglas, Everett J. Bassett, Diane L. Fenicle, Cindy L. Myers, Bonnie J. Clark, and Karen Turnmire, 1994, *The Historical Archaeology of Dam Construction Sites in Central Arizona, Volume 2A: Sites in the Roosevelt Dam Area*, Dames & Moore Intermountain Cultural Resource Services Research Paper No. 11, Phoenix, Figure 3-41.
Number: Published
Description/Comments: Shows impounded waters with town of Roosevelt in middle ground.

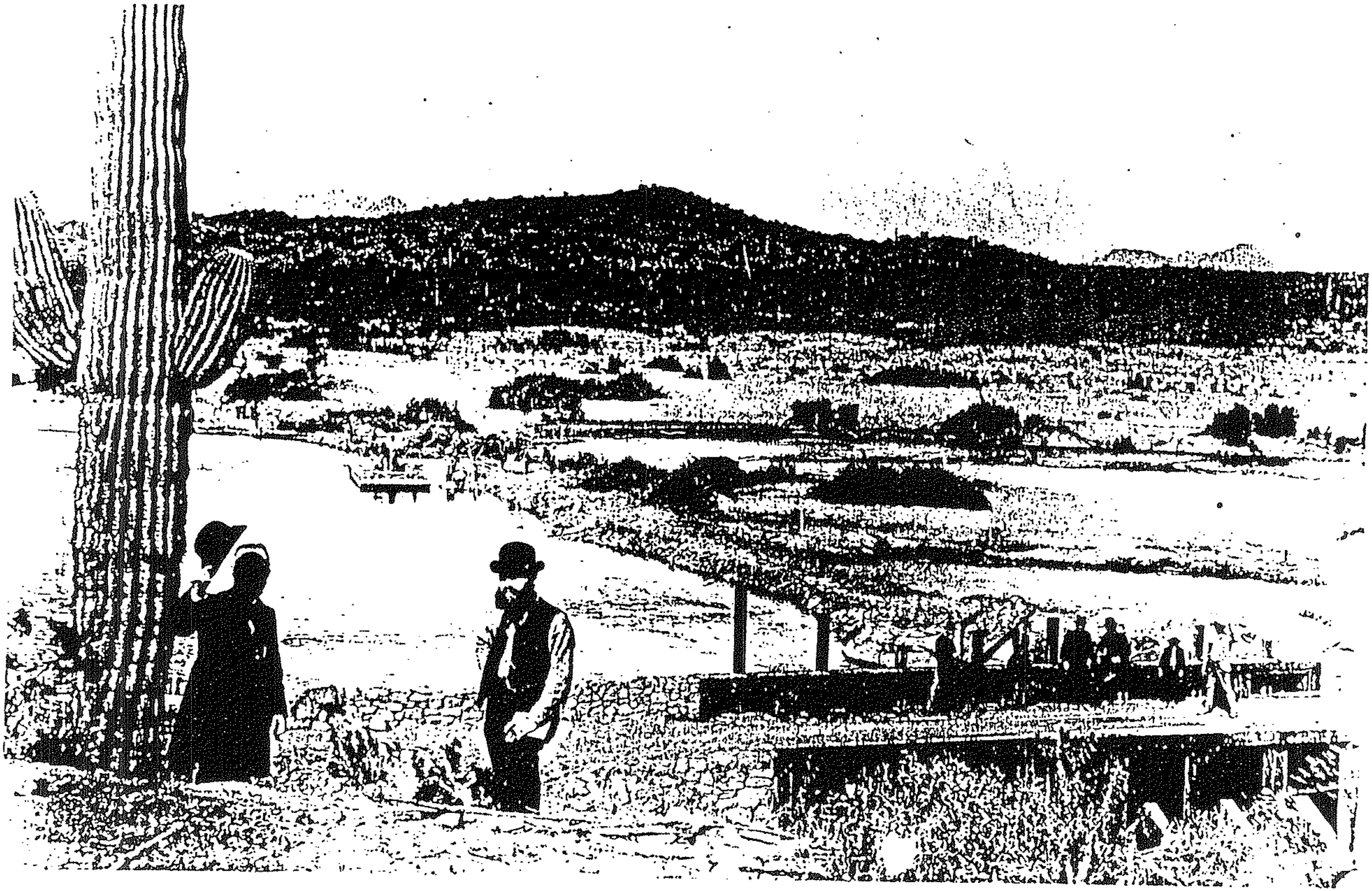
Boating on the Salt River (G-554, Arizona Historical Foundation, Hayden Library, Arizona State University).



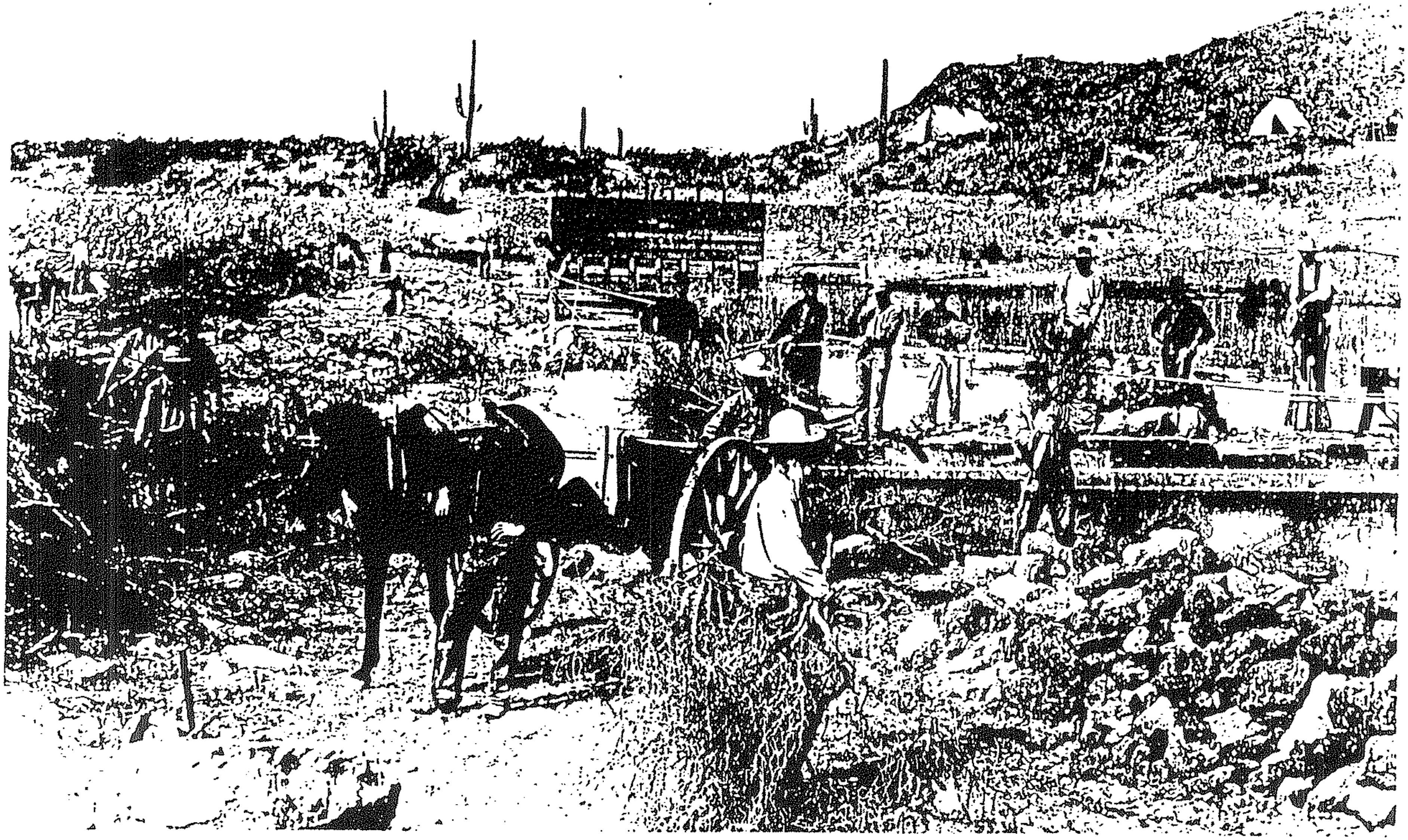
At the Junction of the Verde and the Salt (from Beasley 1908:4).



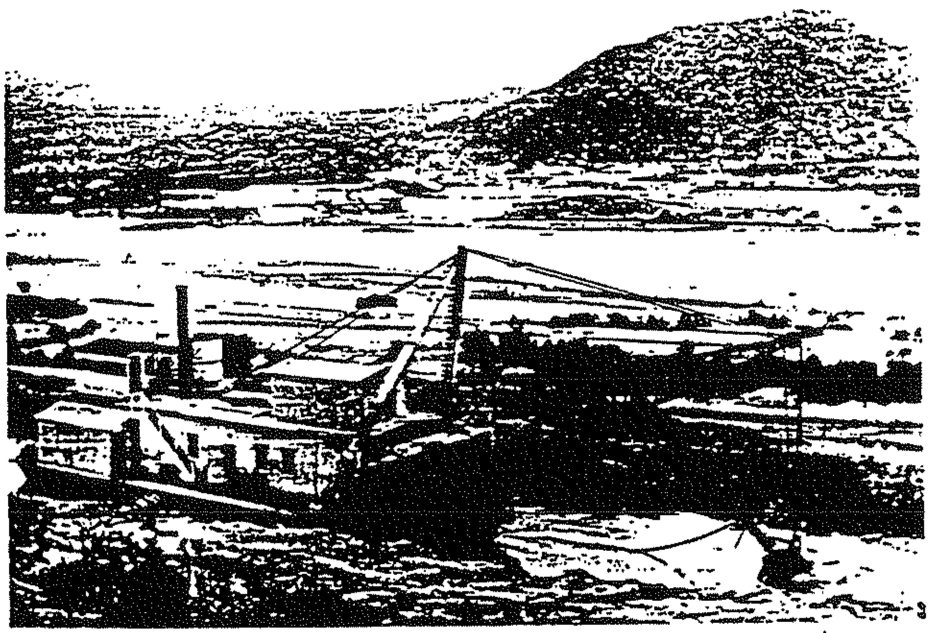
Boating on the Salt River (CP CTH 2064, Arizona State University, Hayden Library, Special Collections).



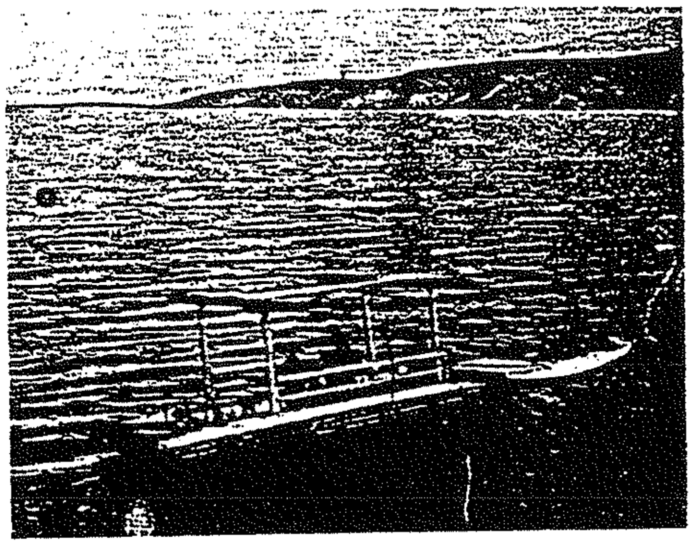
Arizona Canal under construction, Phoenix, Arizona, circa 1885 (CP MCL 9742.A3, Arizona State University, Hayden Library, Special Collections



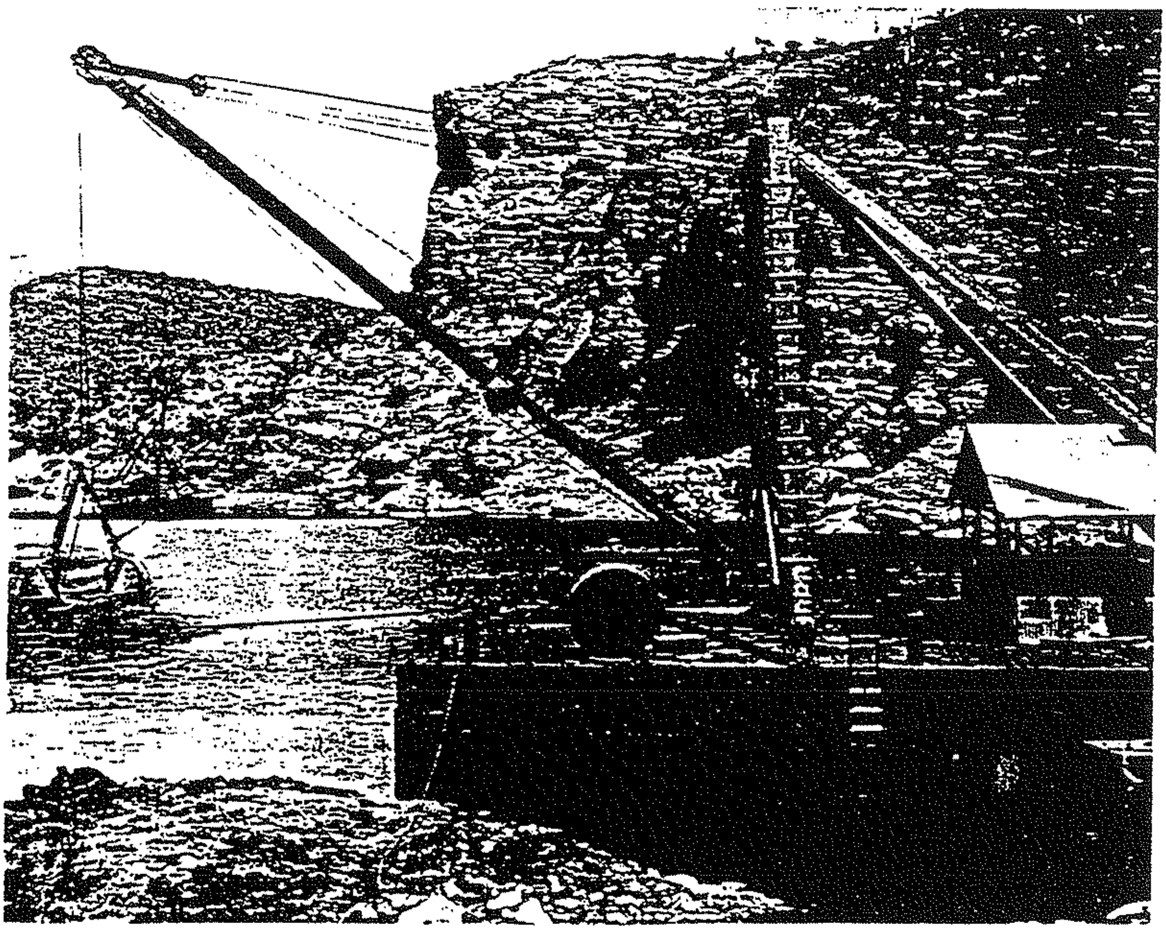
Arizona Canal under construction, Phoenix, Arizona, circa 1885 (CP MCL 9743.A3, Arizona State University, Hayden Library, Special Collections



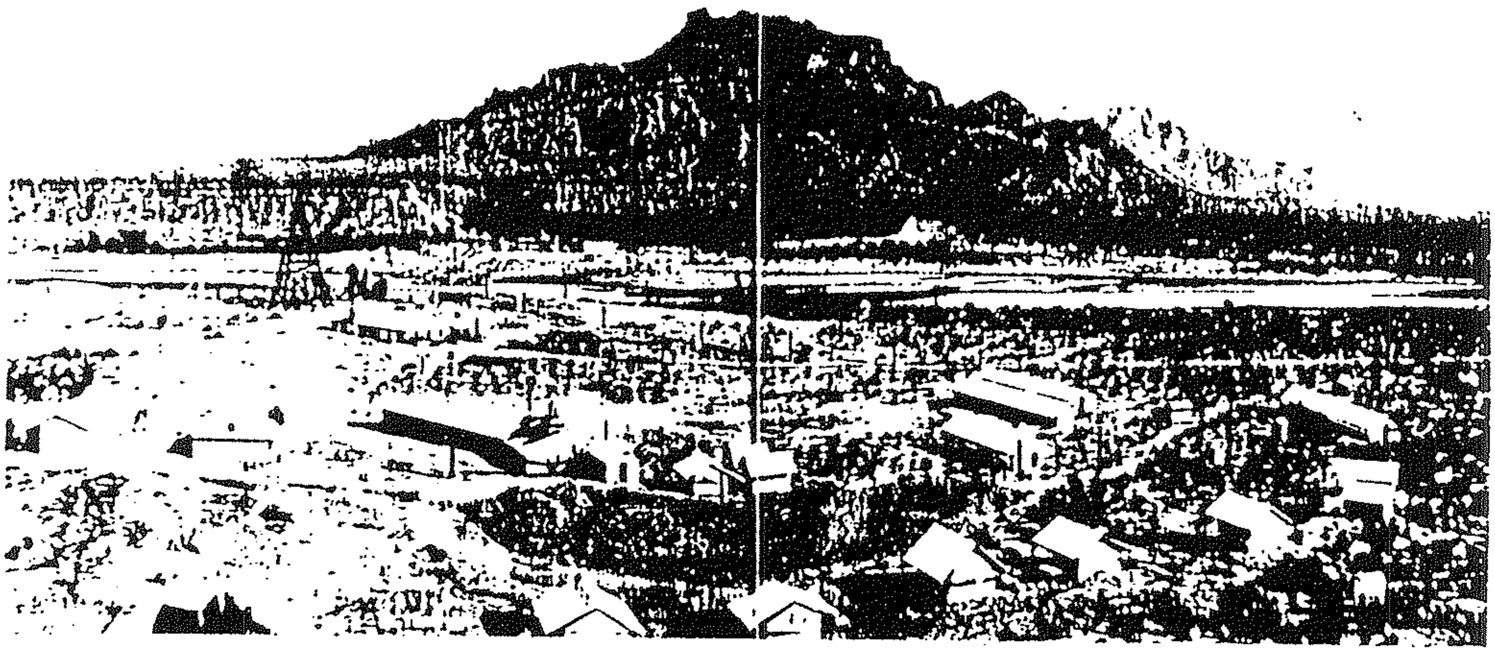
The dredge used by the U.S. Reclamation Service to enlarge the Arizona Canal (Brown 1978:79).



Barge crossing Roosevelt Lake on the upper end, prior to construction of the Salt River Bridge (Anderson and Anderson 1976:30).

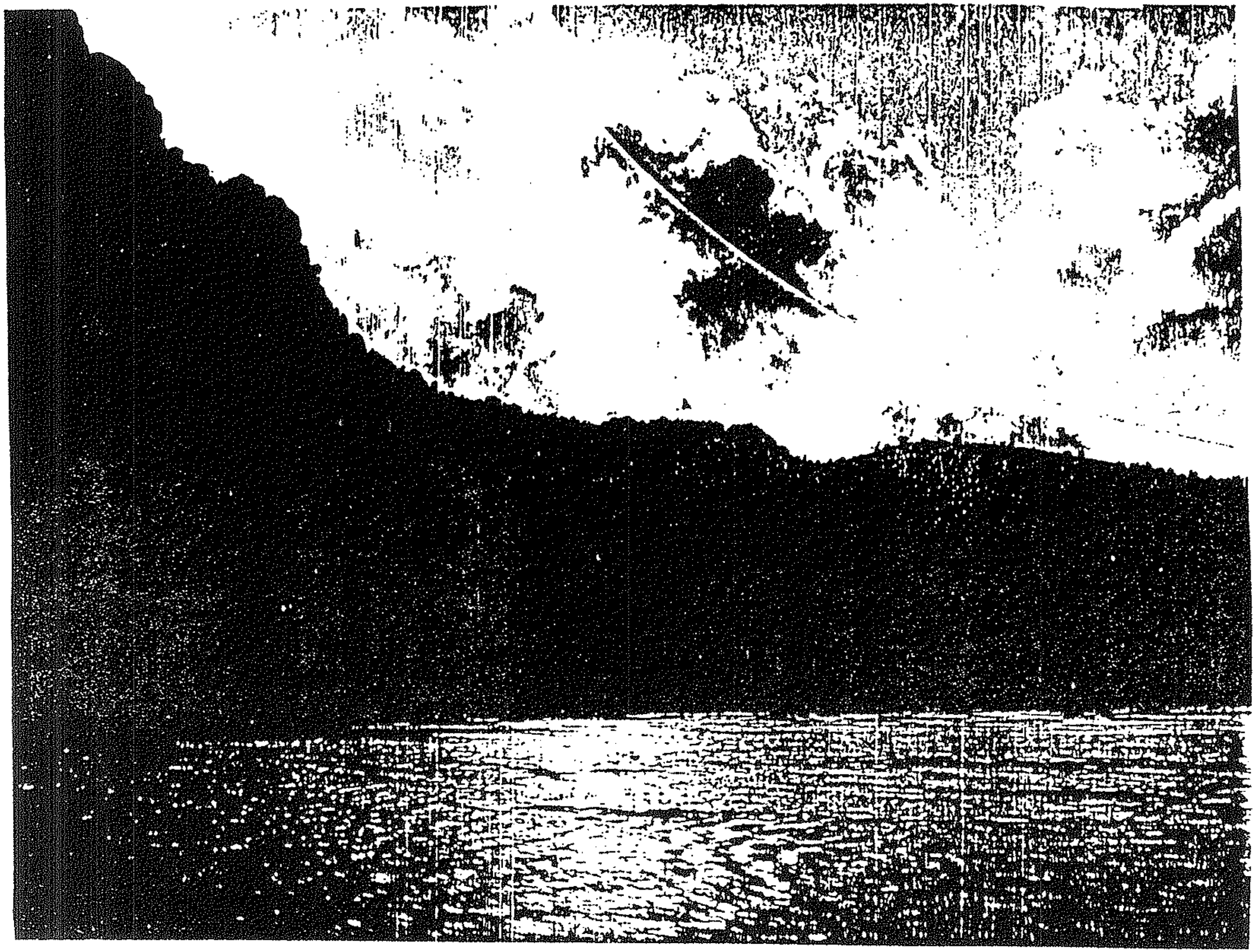


Photograph of clamshell derrick, Horse Mesa Dam, circa 1926 (Douglas et al. 1994:Figure 2-8).



Panoramic view of the Granite Reef work camp circa 1907. Looking north toward Mt. McDowell.
Photograph obtained from Salt River Project (Brown 1978:Plate 1).

General view of Granite Reef Diversion Dam construction October 31, 1907 (Brown 1978:72).



Sunset on the Salt (#19, 206, Arizona Pioneers Historical Society, Tucson).

"Sunset on the Salt." As we looked forward just before crossing the river we could see a most remarkable sunset just ready to drop behind the low hills that were gradually tapering down towards the desert in the direction of Granite Reef, where the construction of a great irrigation enterprise was being undertaken by the Reclamation Service to reclaim part of this vast desert that lies in the direction of the setting sun.

U. S. G. S.

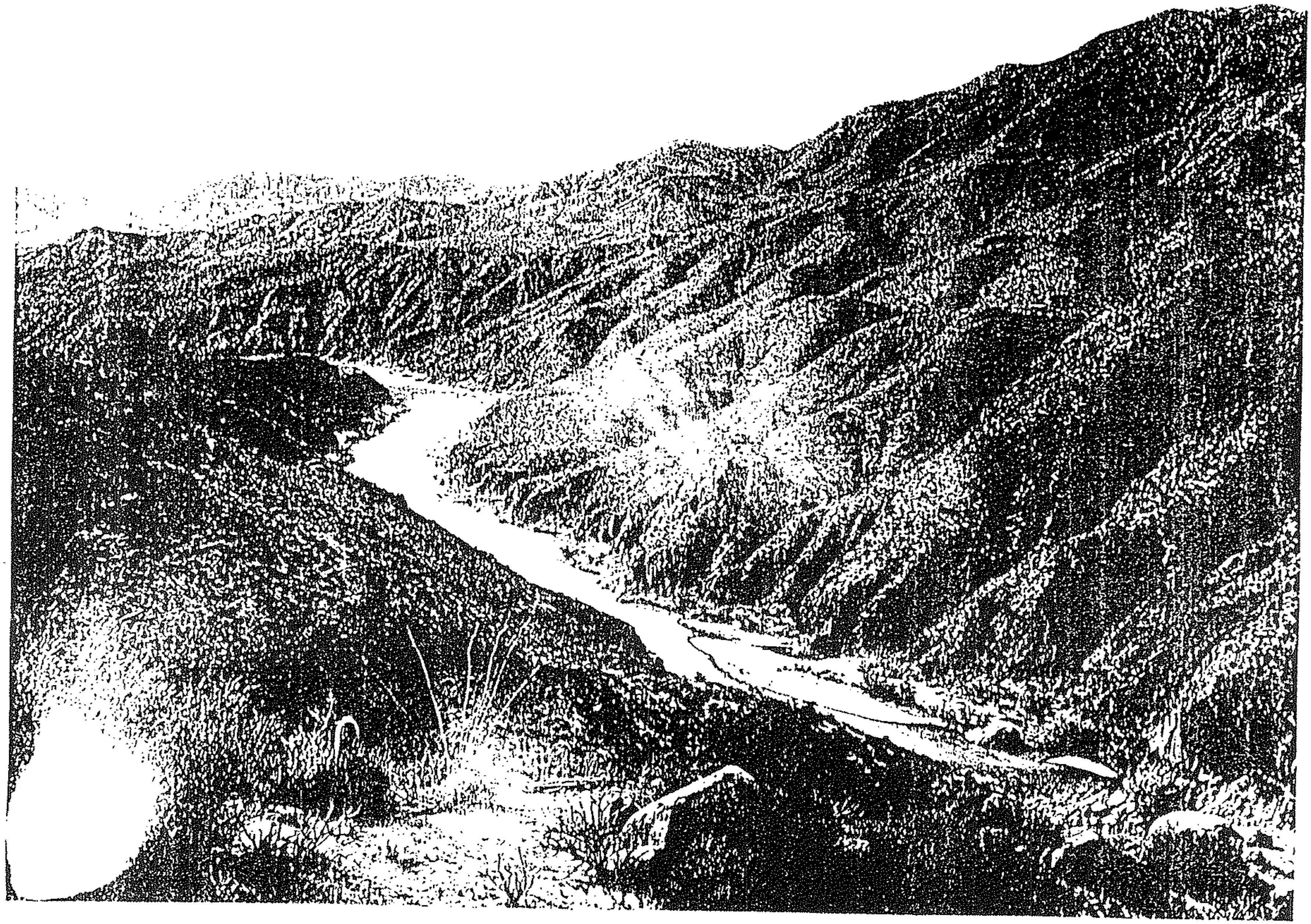
2710 Salt River Project, Arizona

19,206

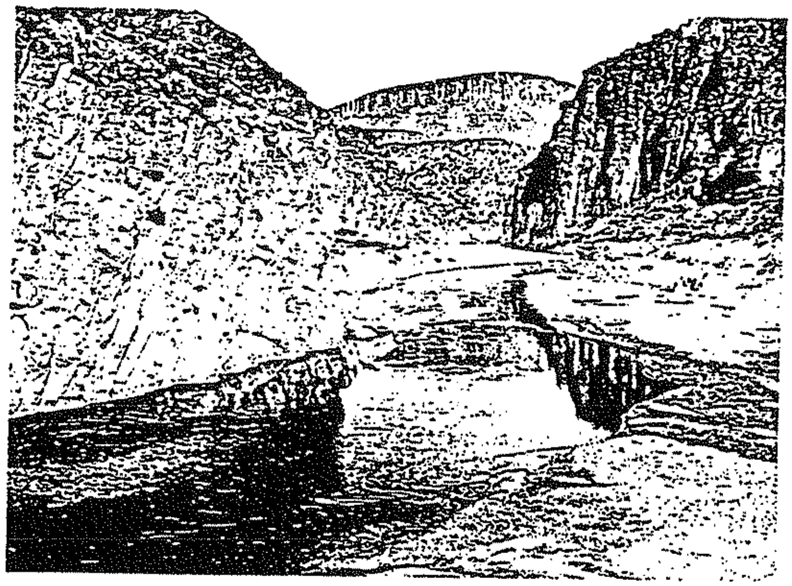
Pictures - Places - Salt River Project

Writing on back of Photograph #19, 206, Arizona Pioneers Historical Society, Tucson.

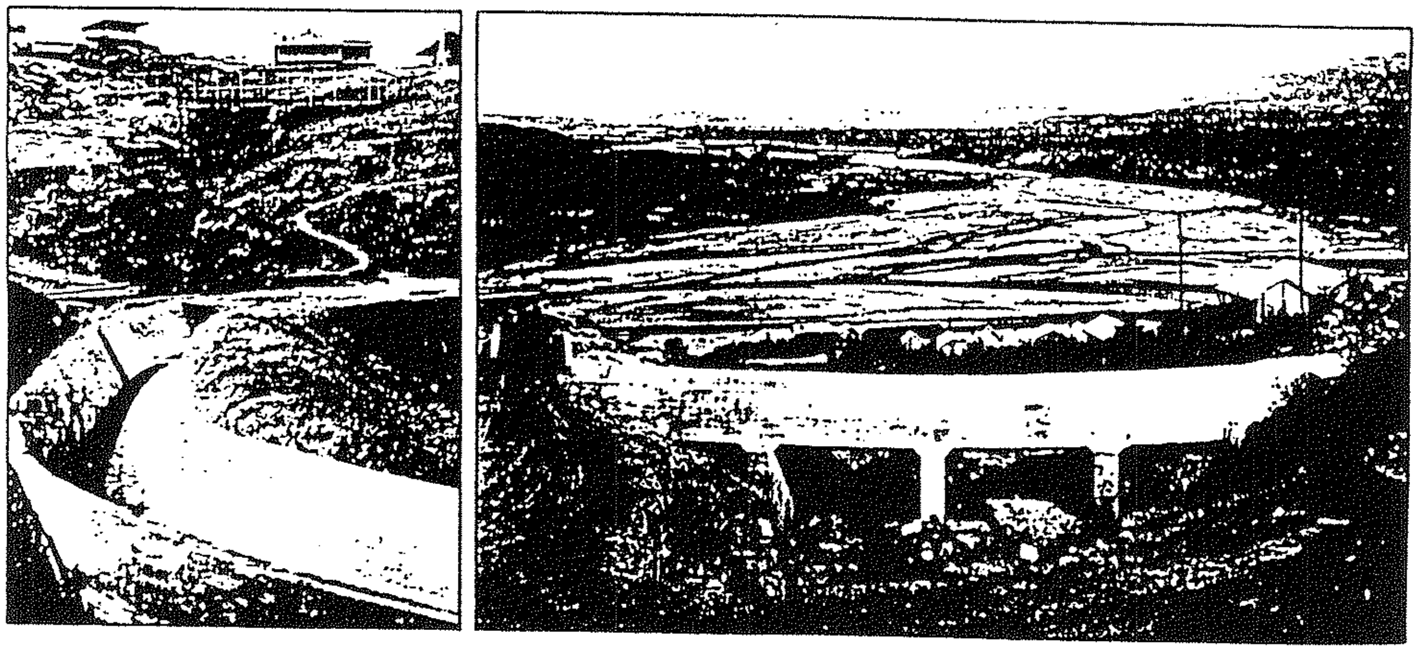
Sheep crossing Salt River with McDowell Butte beyond, circa 1918 (DC C00:14, Arizona Historical Foundation, Hayden Library, Arizona State University).



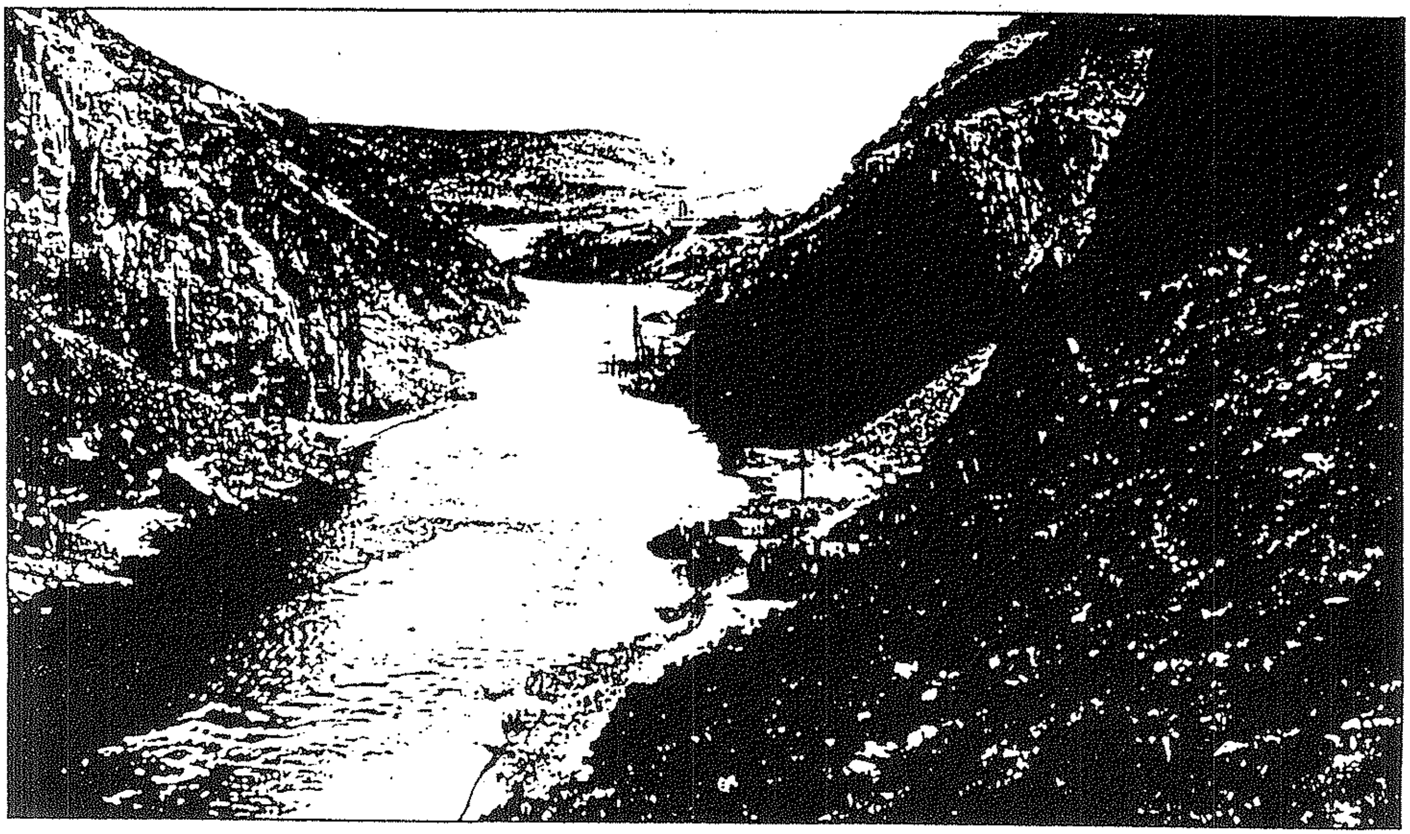
Salt River, circa 1921 (#77090, Arizona Pioneers Historical Society, Tucson).



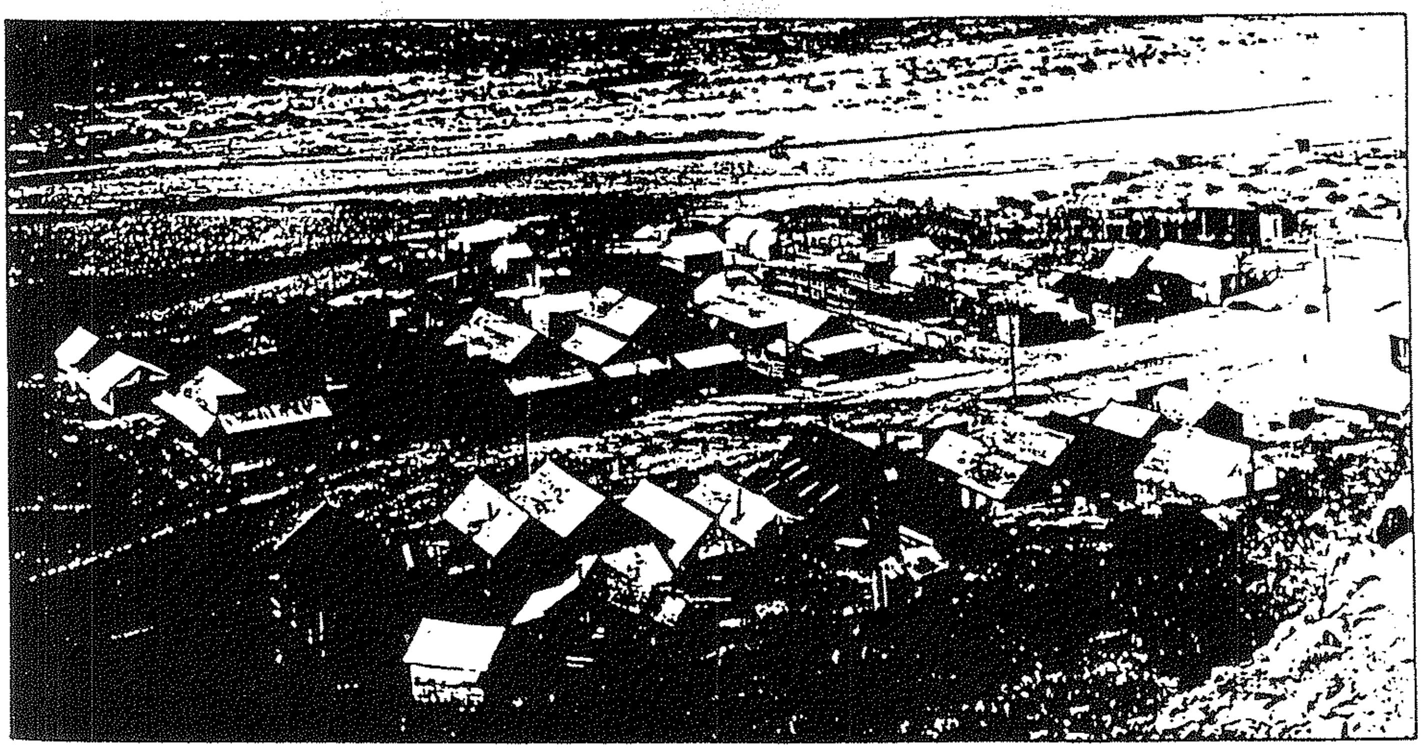
Salt River near diversion dam and Pinal Creek, February 1921 (#77107, Arizona Pioneers Historical Society, Tucson).



Sections of canal built to develop electricity with falling water, March 6, 1906 (Zarbin 1984:128).



Looking upstream at site of Roosevelt Dam on the Salt River, April 16, 1906 (Zarbin 1984:134).

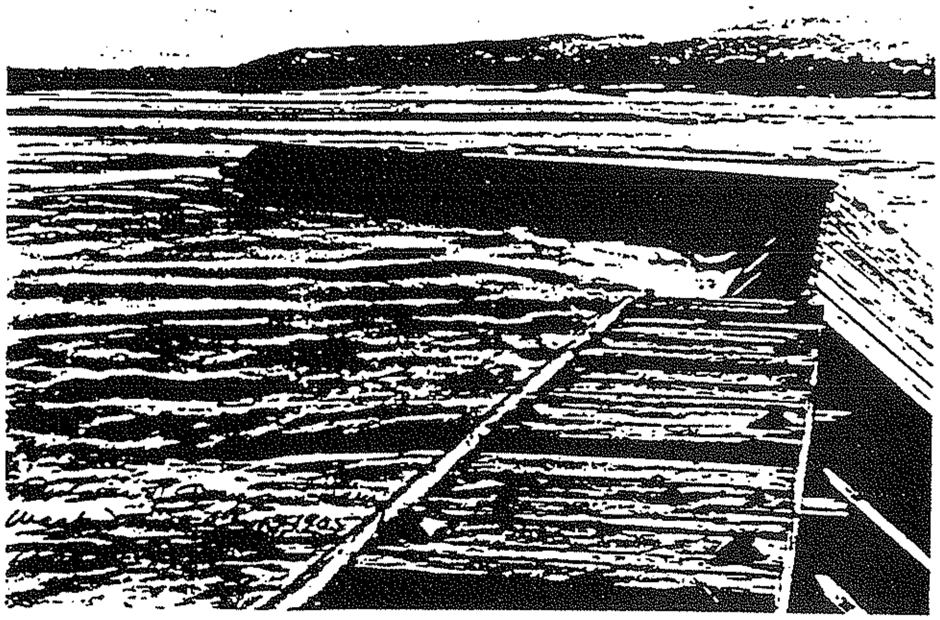


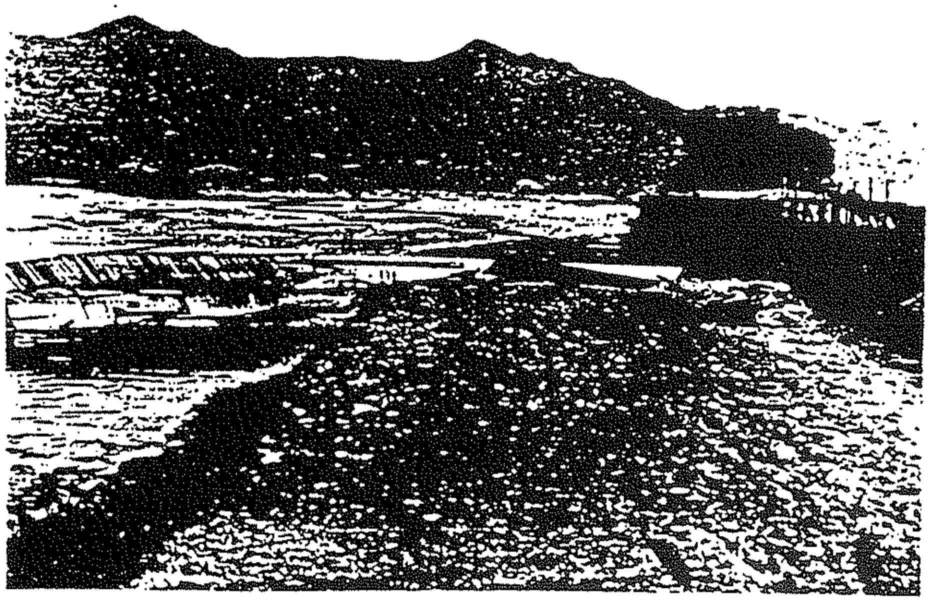
Main street at Roosevelt, February 1907 (Zarbin 1984:147).

The west end of the town of Roosevelt, Arizona, as it was in March 1906, during construction of the dam. Located on the south side of Salt River approximately one-half mile upstream from the dam site, the town had a population of about 500 during the peak of construction. After the dam was completed and the reservoir began to fill, the town was abandoned and eventually inundated (K. Smith 1986:71).

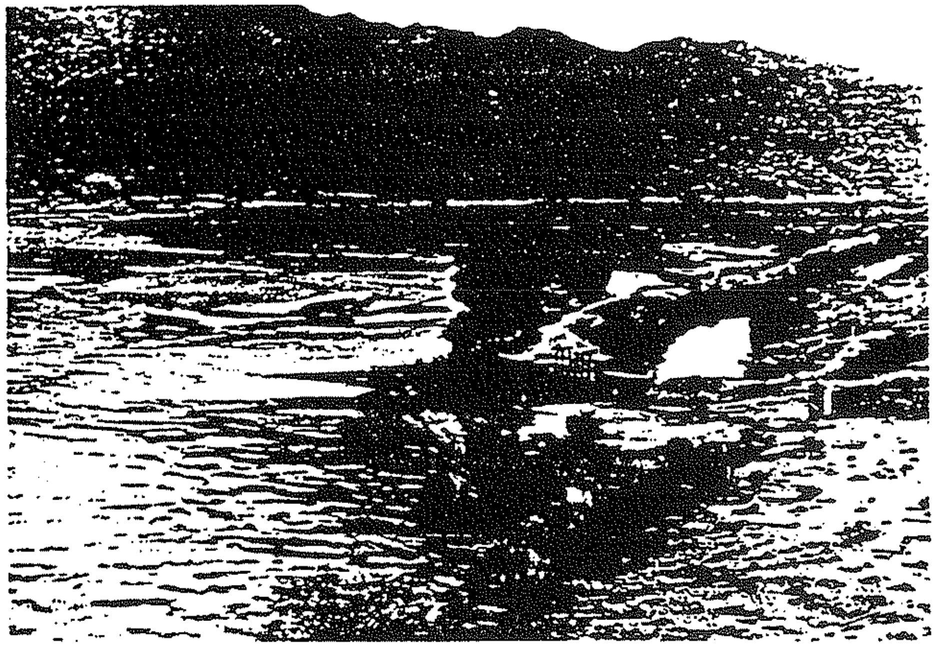
Downstream view of Salt River prior to dam's construction (Palmer 1979).

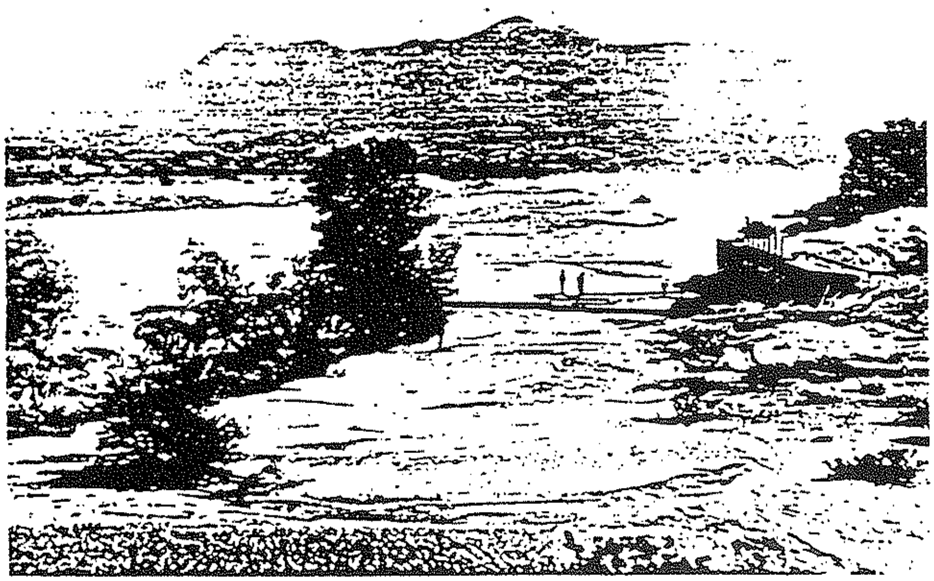
Tonto Basin, prior to construction to Roosevelt Dam. Catwalk across the point is about where the dam was later built (Anderson and Anderson 1976:65).





Most of the Arizona Dam was carried away by floods April 13-16, 1905 (Brown 1978:8).



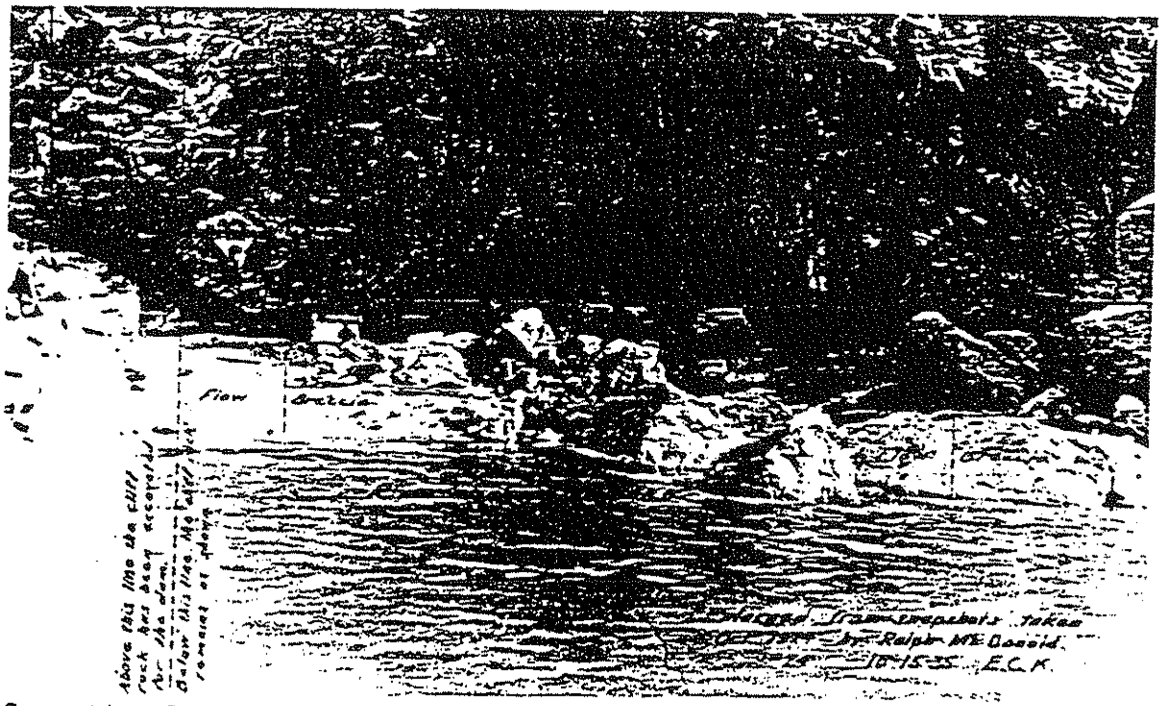


Photographs show washed out sections of the Arizona Dam and the Arizona Canal head (Brown 1978:9).

Source: Salt River Project

Photograph of Mormon Flat Construction Camp, 1923
Figure 1-4

(Douglas et al. 1994:17).



Source: Arizona Department of Library, Archives and Public Records

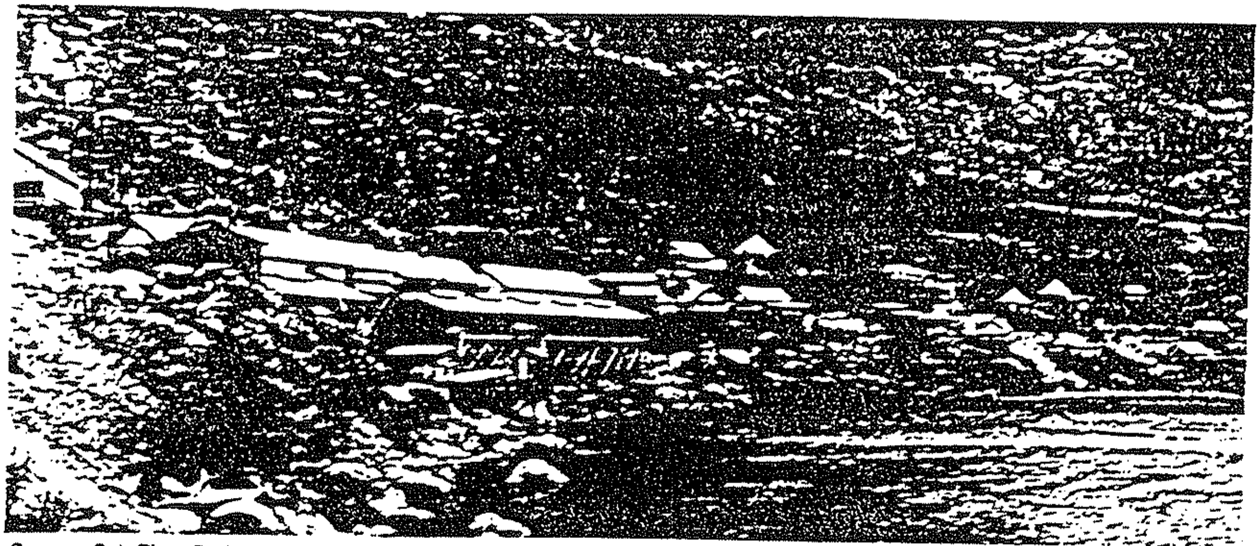
Photograph of Surveyors' Rock Shelter at Horse Mesa, October 1924
Figure 2-2

(Douglas et al. 1994:51).

Source: Salt River Project

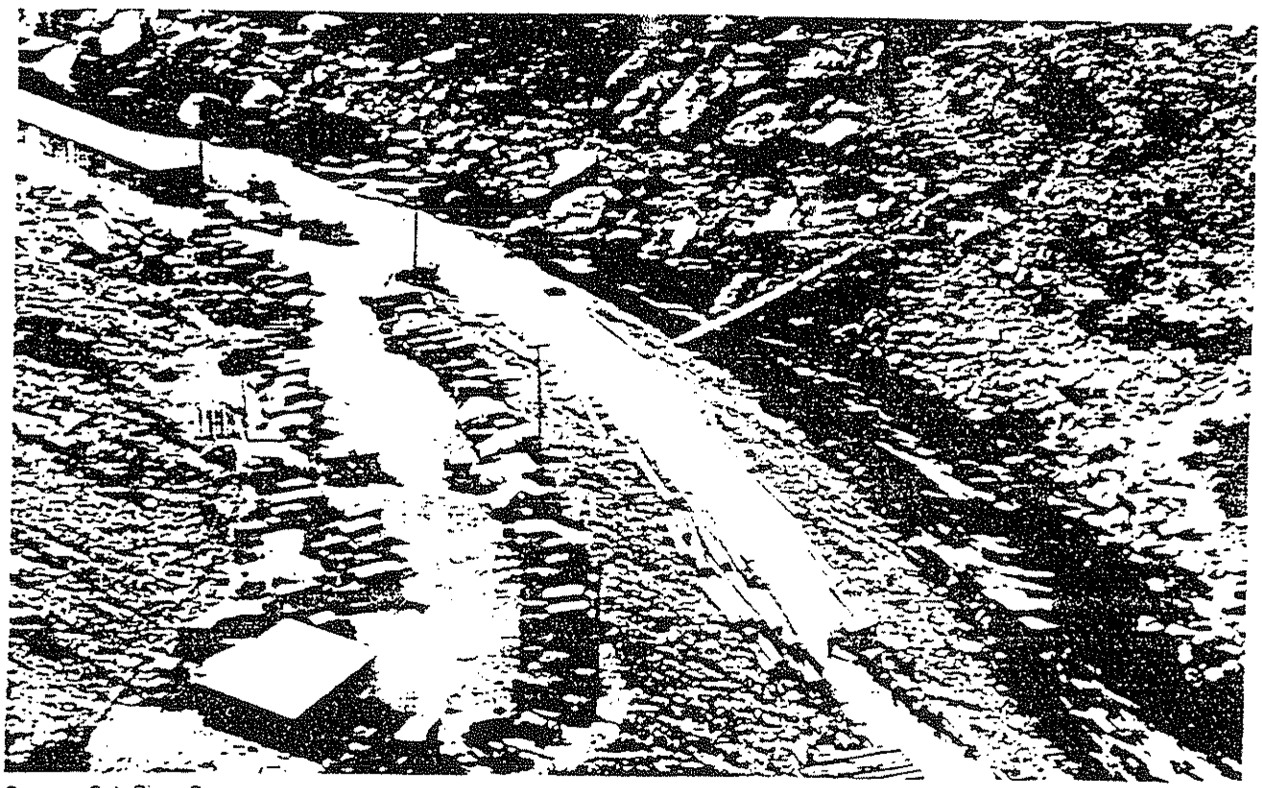
Photograph of Horse Mesa Dam Construction Camp, ca. 1926
(view of northern portion of the northern section of camp)
Figure 2-5

(Douglas et al. 1994:53).



Source: Salt River Project

Photograph of Horse Mesa Dam Construction Camp, ca. 1926
(view of central portion of northern section of camp)
Figure 2-6



Source: Salt River Project

Photograph of Horse Mesa Dam Construction Camp, ca. 1926
(view of southern portion of northern section of camp)
Figure 2-7

(Douglas et al. 1994:54).

Arizona State Land Department

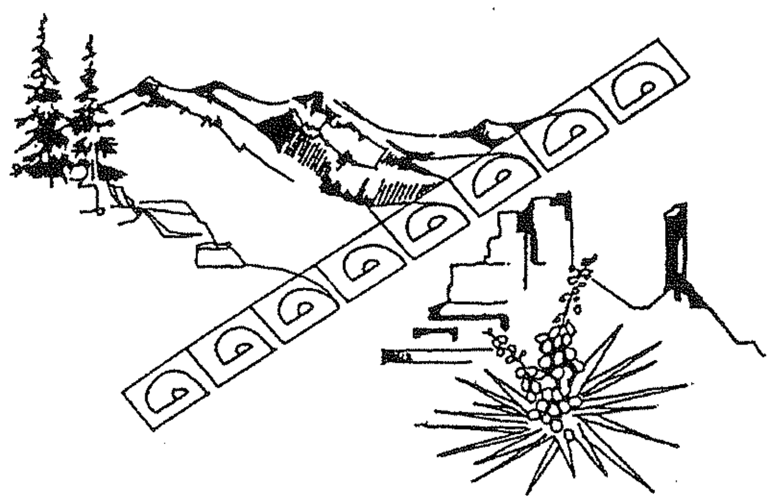
ARIZONA STREAM NAVIGABILITY STUDY

for the

UPPER SALT RIVER

Granite Reef Dam to the Confluence of the White and Black Rivers

Final Report



Prepared by

SFC Engineering Company

In Association With

George V. Sabol Consulting Engineers, Inc.,

JE Fuller/Hydrology & Geomorphology, Inc.,

and

SWCA, Inc. Environmental Consultants

March 1997

Section 4

Geomorphology of the Upper Salt River

Prepared for

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&

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February 14, 1997

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Section 4:

Geomorphology of the Upper Salt River

Introduction

This section describes the regional geology and fluvial geomorphology of the Upper Salt River. The objectives of this section are to:

- Describe potential geologic impacts on streamflow
- Describe channel changes, if any, that occurred since statehood
- Provide a geologic context for discussion of historical stream conditions
- Describe the location of the ordinary high watermark and ordinary low watermark

Resources used to support this overview of the Upper Salt River geology included summaries of regional geologic history, aerial photographs, detailed geomorphic mapping published for limited portions of the study area, field observations, and topographic maps.

Stream Reaches

The study reach extends from the confluence of the Black River and the White River near Fort Apache to Granite Reef Dam near Phoenix (Figure 1), a distance of approximately 153 miles. For the purposes of the geomorphic investigation, the Upper Salt River may be considered in three stream reaches (Figure 2):

- Reach 1 - White River/ Black River confluence to Roosevelt Reservoir
- Reach 2 - Roosevelt Reservoir toStewart Mountain Dam
- Reach 3 - Stewart Mountain Dam to Granite Reef Dam

The geomorphology of these three reaches is described in the following sections.

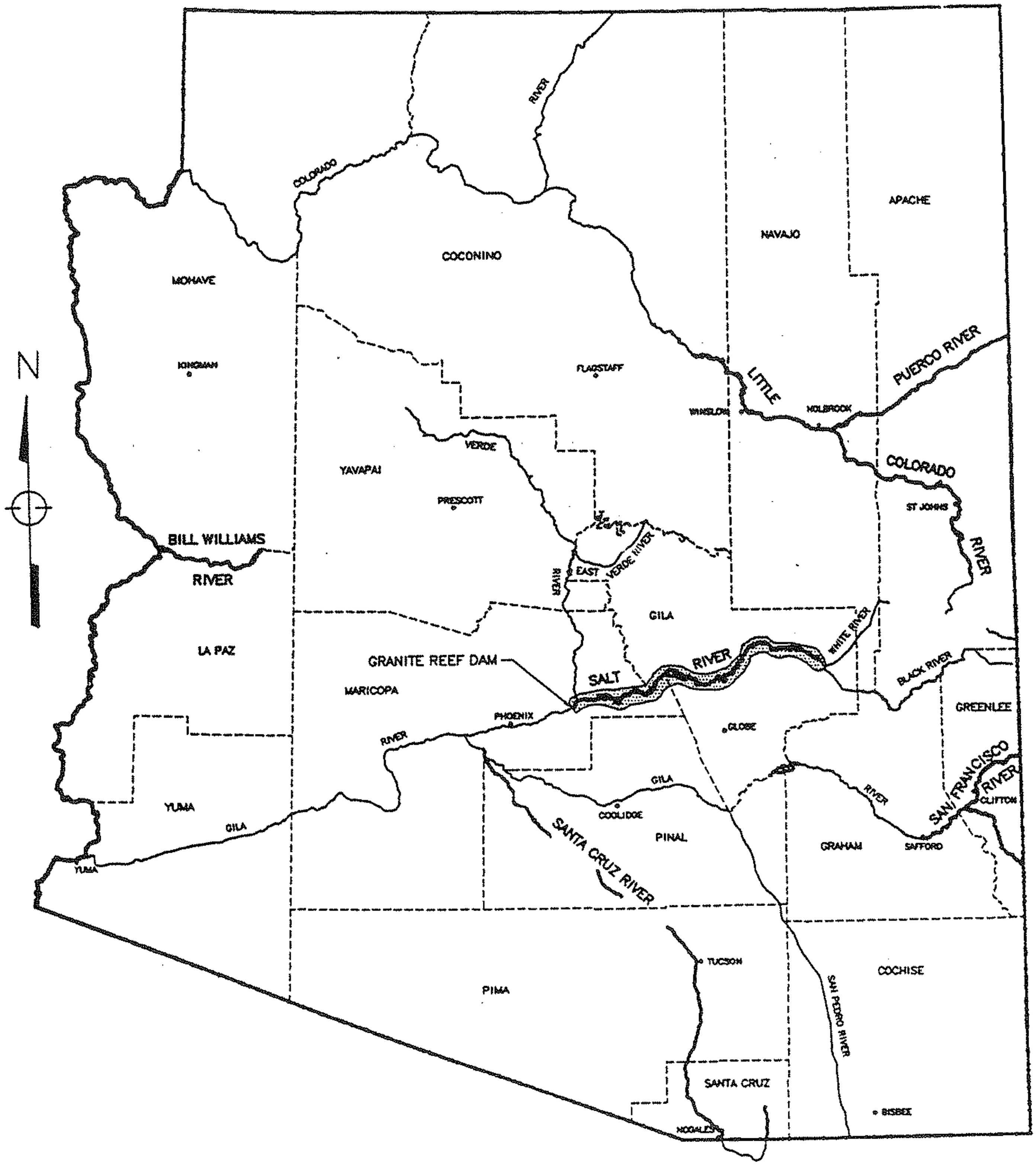

FIGURE 1

Study Reach Location Map

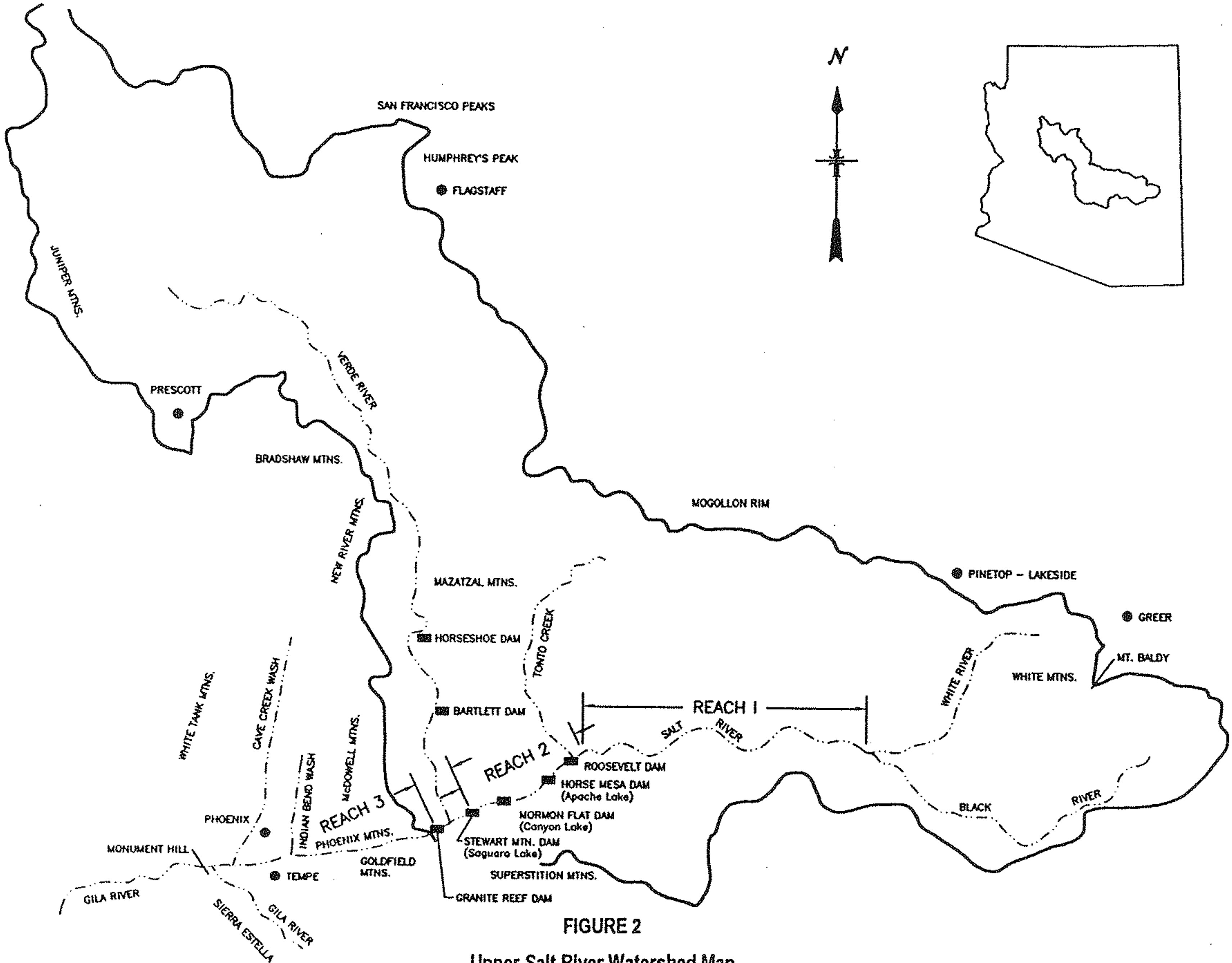

FIGURE 2

Upper Salt River Watershed Map

Physiography

The 153-mile Upper Salt River study reach is located entirely within Maricopa and Gila Counties, although the Salt River watershed extends through about 12,000 square miles of central and eastern Arizona (Figure 2). The watershed ranges in elevation from 12,643 feet at Humphrey's Peak north of Flagstaff (11,590 ft. at Mt. Baldy near Greer) to 1,300 feet at the base of Granite Reef Dam. The Upper Salt River watershed is bounded by the Mogollon Rim to the north, the Mazatzal Mountains to the west, the Superstition Mountains and the Gila River watershed to the south, and the White Mountains to the east. The Verde River portion of the upper watershed is bounded by the Mogollon Rim and San Francisco Peaks to the north, the Juniper, Bradshaw, and New River Mountains to the west, and the Mazatzal Mountains to the east. Major perennial tributaries to the upper watershed include the White, Black, and Verde Rivers, and Tonto Creek.

The study reach experiences a hot, dry climate typical of the upper Sonoran Desert. Mean precipitation and temperature does not vary significantly within the study limits, although climate varies significantly with elevation within the watershed of the study reach (Table 1). Precipitation occurs during two major seasons: in late summer as intense, localized orographic thunderstorms; and in winter as large-scale cyclonic storms which originate over the Pacific Ocean (Sellers and Hill, 1974). Winter storms tend to produce the largest (peak and volume) flows on the Salt River, with over 90 percent of the largest storms occurring in winter months.

Table 1
Climatic Data for the Upper Salt River Watershed.

Average Annual Statistic	Granite Reef 1938-1967 elev.=1,325 ft.	St. Johns 1902-1957 elev.=5,725 ft.	Show Low 1933-1955 elev.=6,382 ft
Precipitation (in)	8.9	11.4	18.4
Max. Temperature	86	70	65
Min. Temperature	54	35	36

Vegetation in the study area is dominated by Sonoran Desert Scrub-Lower Colorado River Subdivision communities which include grasses, low shrubs, and saguaro cacti (Randall, 1993). Since the 1940's, the dominant riparian vegetation species is tamarisk, although previously some reaches were lined by cottonwood, seepwillow, and mesquite trees (Randall, 1993), particularly in Reach 3 and within the flats in Reaches 1 and 2. The upper watershed extends through several climatic-vegetation zones, including areas above the tree line on the highest peaks in the drainage area.

Historically, sources of runoff in the study reach included discharge from springs, snowmelt from higher elevation areas in the upper watershed, and direct runoff from precipitation. Long-term and/or historical streamflow records are available for the entire study reach upstream of Granite Reef Dam. Additional estimates of long-term flow rates for the study reach have been developed based on indirect data such as climatic reconstruction using tree-ring records (cf. Smith and Stockton, 1981), short-term stream gage records made prior to statehood (cf. Davis, 1897), reconstruction of pre-development flows derived from modern stream gage records (cf. Thomsen and Porcello, 1991), accounts of early explorers (cf. Bartlett, 1854), or extrapolations based on irrigation capacity (cf. Kent, 1910). Some of these flow data are summarized in Tables 2 and 3. Hydrologic data for the study reach are discussed in more detail in Section 5 of this report. Historical and hydrologic data indicate that the Salt River was perennial throughout the study area as of the time of statehood, as it is today.

Table 2

Flow Statistics, Salt River Sites Upstream of Reservoirs [a] (cfs).

Month	Salt River above Roosevelt 1914-1989	Verde nr. Tangle Creek 1946-1989
Average Annual Flow	896	559
10% Flow Rate	157	120
50% Flow Rate	343	238
90% Flow Rate	2,040	917

[a] Roosevelt and Tangle Ck. gages located upstream of Salt-Verde confluence.

Table 3
Some Estimates of Average Annual Flow, Salt River at Granite Reef Dam(cfs)

Average Annual Flow	50% Flow Rate	Source/Methodology
1,045	n.a.	Smith and Stockton, 1981; Tree-ring records
1,689	1,230	Thomsen and Porcello, 1991; Modem Gage Records
2,844	n.a .	Powell, 1893; Short-Term Records

Note: Includes runoff from Verde River.

Geologic Setting

Arizona is comprised of two great geologic regions: the Colorado Plateau Province, and the Basin and Range Province; with a transition zone, or Central Mountain Province, dividing them (Figure 3). The Upper Salt River drains the Central Mountain Region, and drains into the northern portion of the Basin and Range Province. The Central Mountain Region is characterized by mountains of Precambrian igneous, metamorphic rocks, capped by remnants of Quaternary and Late Tertiary volcanics. Regional uplift of the entire state, including the Central Mountains, is thought to have occurred during the Laramide Orogeny in late Cretaceous/early Tertiary time (65 Ma[1]). Volcanic activity in the study area generally occurred about 29 million years before present (b.p.) during the Tertiary Period. The mountains of the transition zone generally experienced longer periods of erosion, resulting in generally lower elevations than the mountains of the two other provinces (Nations and Stump, 1981). Central Mountain Region ranges within the Upper Salt River basin include the White, Bradshaw, Superstition, and Mazatzal Mountains. These ranges consist primarily of Precambrian metamorphic and igneous rock with some more recent volcanics.

[1] My = 1,000,000 years; 1 Ma = 1 My before present; 1 ky = 1,000 years; 1 ka = 1 ky before present (North American Commission on Stratigraphic Nomenclature, 1983).

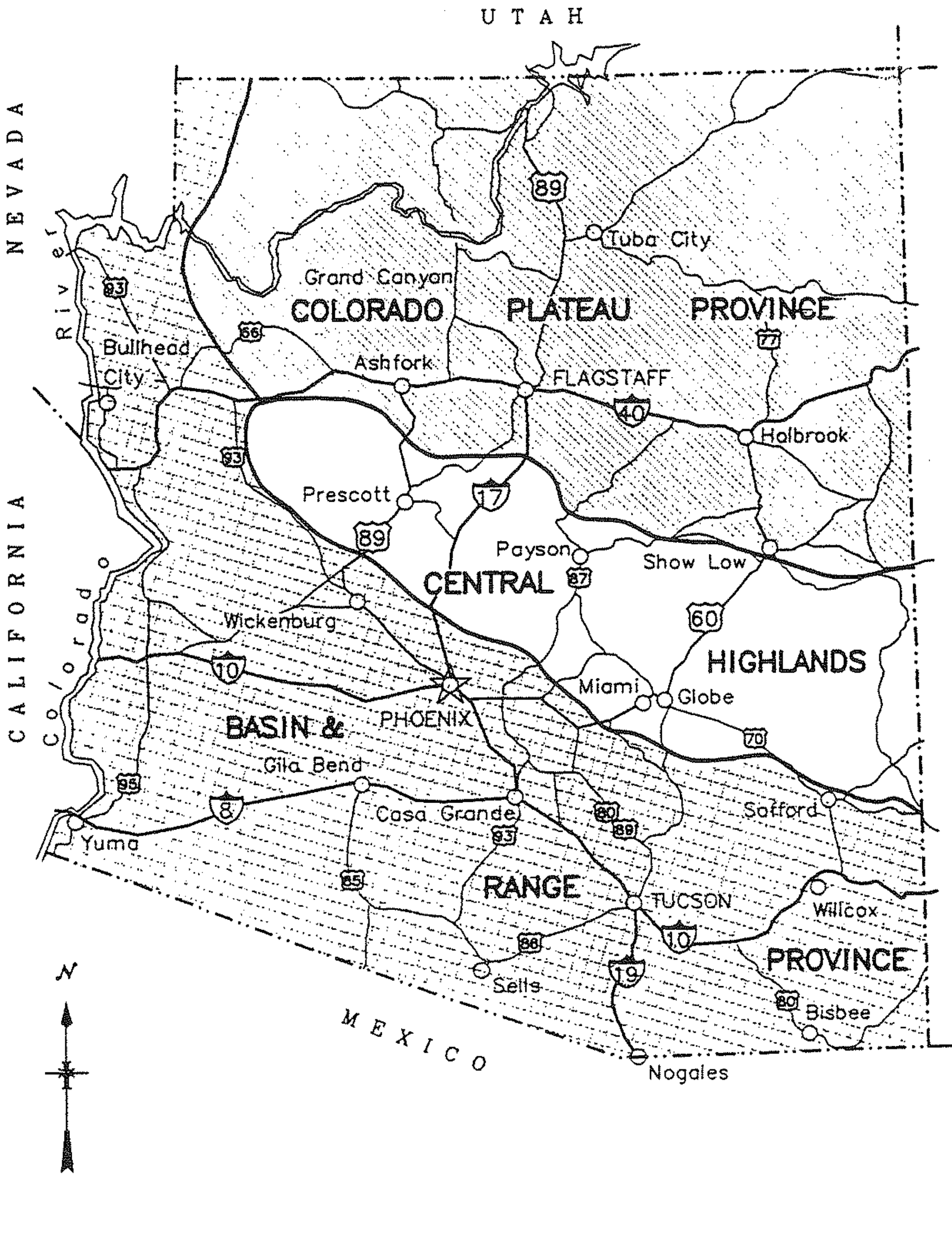

FIGURE 3

Physiographic Province Map

The Upper Salt River study area is located mostly within the narrow confined bedrock canyons of the Central Mountain Province. The geomorphology of most of the Upper Salt River is dictated by the bedrock cropping out in these narrow canyons. Several broader valleys, or "flats," existed along portions of the Upper Salt River in the Central Mountain Province prior to construction of the reservoir system, but have since been inundated by the reservoir storage pools. A few small flats are still found upstream of Roosevelt Reservoir within the Tonto National Forest and Fort Apache Indian Community, including locations such as Redmon Flat and Gleason Flat. No evidence of river instability or significant channel changes during (or since) the historical period was identified in any of the remaining flats.

West of the Central Mountain Region, at the downstream end of the study reach, near Granite Reef Dam and the Verde River confluence, the river enters the Basin and Range Province. The Basin and Range Disturbance (8-15 Ma) was the most recent tectonic event to affect Arizona (Nations and Stump, 1981). This event consisted of tensional stress resulting in steep, normal block faulting which formed a series of northwest-southeast trending mountain blocks. Uplift of mountain blocks was accompanied by downdropping of basin areas and subsequent filling of the intermountain basins by alluvium eroded from the mountains. Most of Reach 3 is formed within a deep alluvial basin at the margin of the Basin and Range Province.

Four sets of distinct geomorphic terraces have been described along the Salt River, within the Basin and Range Province portion of Reach 3. These terraces extend as far upstream as the Blue Point Ranger Station near Saguaro Lake, where the highest (and oldest) terrace is located more than 200 feet above the existing streambed. The elevations of the four terraces converge in the downstream direction until disappearing in the alluvial fill of the Salt River Valley near Tempe. The two highest (and oldest) terraces do not impact the geomorphology of the Upper Salt River study reach. The second youngest of these terraces, the so-called Blue Point terrace, forms the boundaries of the alluvial (geologic) floodplain in Reach 3 near Granite Reef Dam (Kokalis, 1971; Pewe, 1978; 1987). The margins of the Blue Point Terrace constrain the maximum extent of prehistoric river movement during recent geologic time (+/-10,000 years b.p.) in Reach 3. Channel movement during the historic period since the time of statehood was confined well within the Blue Point Terrace margins, near or at the existing channel boundaries. The lowest (and youngest) terrace is the geologic floodplain of Reach 3, an infrequently flooded surface located topographically above the existing stream channel. The active channel and ordinary high (and low) watermark is confined by this lowest terrace.

Geologic Impacts on Streamflow

Bedrock crops out in the bed and banks of most of the Upper Salt River study reach. The bedrock geology of the study reach exerts strong control on river conditions in the Upper Salt River study reach in several ways:

- First, bedrock limits the potential for lateral movement of the stream channel and prevents significant modifications of the channel cross sections with time (OConnor et. al., 1985). The natural erosion rate of bedrock is slow enough to be considered insignificant within the historical period. Within the bedrock-confined canyons of Reaches 1 and 2, no significant changes in channel geomorphology were identified during the period since statehood. In these canyon reaches, the exact locations or geometry of specific pools and riffles may fluctuate in response to large floods, but the overall channel pattern and reach-averaged width-depth-velocity relationships remain essentially unchanged.

- Second, bedrock cropping out in the bed of the river forms small waterfalls and rapids that would have created obstacles for some types of boating at the time of statehood, such as large-draft keel boats, steamboats, or powered barges. Large rapids and low flow riffles are also formed by large cobble and boulder deposits. These riffles could have been local impediments to navigation during some annual low flow periods, for even the most shallow-draft boats available as of the time of statehood.

- Third, bedrock canyons provided a favorable environment for construction of dams and impoundment of water upstream of the dams. Construction of these reservoirs has altered the natural river conditions downstream. Nearly all of the Upper Salt River between State Route 288 and Stewart Mountain Dam (Reach 2) is within a reservoir ponding area, or is affected by backwater from a reservoir. Runoff in Reach 3 is controlled entirely by releases from reservoirs constructed in these bedrock canyons.

- Fourth, narrow bedrock canyons do not provide favorable environments for extensive agricultural operations. Therefore, irrigation diversions as of the time of statehood were limited to very small ditches used for small ranches on the flats and for local water supply. The largest flat and agricultural area along the Upper Salt River located near Roosevelt was submerged by the reservoir prior to statehood.

- Fifth, discharges from springs in bedrock aquifers provide a significant source of streamflow, in addition to the dissolved solids that give the Salt River its name. Discharge from springs provides a constant base flow, making the Upper Salt River a perennial stream, with an average discharge greater than 350 cfs [2] during the driest months of the year (in Reach 3).

- Sixth, given that changes in channel geometry since the time of statehood are generally insignificant, rating curves for existing streamflow gaging stations and rating curves prepared from recent channel surveys may be used to estimate channel characteristics as of the time of statehood.

- Finally, the rugged terrain and remoteness of the bedrock canyons of the Upper Salt River minimized the potential for human impacts on the watershed and channel as of the time of statehood. Few towns and no significant cities were located on the Upper Salt River. Therefore, transportation routes, including ferries, roads and railroads, almost completely avoided the Upper Salt River. The few transportation routes in the study area are described in Section 3 of this report.

Channel Geomorphology

Descriptions of Historical River Conditions. The early explorers and residents of Arizona record river conditions in the Upper Salt River that are similar to the conditions that may be observed today. These historical accounts, provided elsewhere in this report, describe steep, inaccessible bedrock canyons (except in the flats now inundated by the reservoirs), perennial flow, and narrow canyon bottoms that generally prevented travel by foot or wagon, except during periods of low water. Historical accounts of boating the Upper Salt River describe waterfalls and rapids, and sheer canyon reaches that lacked beaches or bars on which to land. No physical or anecdotal evidence was identified that suggests that the geomorphology of the Upper Salt River has significantly changed during the period since statehood, except for the reaches altered by reservoir construction and by reservoir operation practices.

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[2] Salt River above Roosevelt - USGS Station #09498500 (1914-1989). See Section 5 of this report.

Existing Conditions. In its current condition, the Upper Salt River is a slightly sinuous, moderately steep, entrenched bedrock stream. The channel consists of cobble and boulder riffle sequences, interspersed with shallow, sand- and gravel-bed pools. The channel slope averages about 0.4 ft./ft. (0.4 percent). The average sinuosity is less than 1.5. The channel margins are composed of bedrock and geologically older[3] alluvial terraces, with inset silty sand terraces formed in low energy slackwater zones. Descriptions of some geomorphic characteristics of the three reaches of the Upper Salt River are provided in Table 4.

Table 4.
Reach Geomorphology Description for the Upper Salt River - Existing Conditions

Characteristic	Reach 1	Reach 2	Reach 3
Slope	0.2 ft/ft	0.4 ft/ft*	0.2 ft/ft
Sinuosity	1.6	1.5*	1.3
Channel Pattern	Pool & Riffle	Pool & Riffle*	Riffles, Minor Braiding
Bed Material	Bedrock; Boulders	Bedrock; Boulders*	Gravel-Boulders
Bank Material	Bedrock	Bedrock*	Alluvium
Flow Condition	Perennial	Perennial	Perennial
Human Impacts	Minimal	Reservoir Ponding	Reservoir Releases Flow Regulation
Lateral Stability	Stable	Stable	Stable, Local Erosion

* Note: Characteristic assumed due to reservoir impoundment obscuring data

In general, the geomorphology of the Upper Salt River reflects the bedrock geology of the reach. Minor changes in channel geomorphology can occur, typically occur during the extreme floods. During extreme floods, there is sufficient energy to transport the large diameter bed sediments (boulders) that form the riffles and bars in the canyons. The high-energy floodwater also transports large amounts of finer sediments which are left as thin deposits along the margins of the bedrock canyons (O'Connor et. al., 1986). Streambank riparian vegetation, if it occurs along the channel, grows predominantly on these deposits of finer material. While these finer deposits and

[3] Late Pleistocene to Early Holocene age.

the boulder bars and riffles are subject to erosion during large floods, the net changes in overall channel characteristics typically are minor for an extended river reach. That is, erosion of a bar or riffle in one location generally is balanced by deposition elsewhere in the reach. The overall stream characteristics are preserved, although the exact channel dimensions at any given location may change with time.

In the alluvial portions of Reach 3, large floods flow across the broader geologic floodplain and have the potential to cut new channels within the active channel area. The active channel area is inset within the geologic floodplain. However, like the erosion and deposition in the canyon reaches, any local changes in low flow channel geometry are generally balanced when considered from a reach-wide perspective. No evidence of any significant changes in overall channel geomorphology since the time of statehood was identified for Reach 3.

Ordinary High Watermark

Methodologies for defining the ordinary high watermark are not rigorously defined. In practice, the ordinary high watermark is identified by a marked change in vegetation or soil characteristics between the channel bottom and the overbank area. Occasionally, this change is accompanied by a break in slope between the flat bottom of the active channel and a steep or vertical bank. At one time, several review agencies recommended using the floodplain limits of the 20-year flood to map the ordinary high watermark. The 20-year floodplain limit is generally not used in Arizona at the present time, and was not used for this study.

For the stream navigability studies, House Bill 2594 (1991) defined the ordinary high watermark as:

> ...the line on the shore of a watercourse established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of the soil, destruction of terrestrial vegetation or the presence of litter or debris, or by other appropriate means that consider the characteristics of the surrounding areas. Ordinary high watermark does not mean the line reached by unusual floods.

In Reach 1, lacking evidence to the contrary, it is assumed that the existing river conditions are substantially unchanged from river conditions as of the time of statehood. Therefore, ordinary high watermarks observed in the field probably are very similar to the ordinary high watermarks at statehood. In the narrow bedrock canyons of Reach 1, the canyon walls form the limits of the ordinary high watermark. In the flats, and in areas of larger bars or other alluvial deposits, there are generally readily-identified vertical cut banks that form the ordinary high watermark.

In Reach 2, historical changes to the river preclude use of the normal identifying characteristics of the ordinary high- or low-water marks along the river today. Specifically, inundation of the natural channels by the reservoir impoundment areas have transformed the Salt River into a series of adjacent reservoir pools. The ordinary and natural condition of the river as of the time of statehood is no longer visible. It is interesting to note that as of the time of statehood, in its ordinary and natural condition, the shoreline of Roosevelt Reservoir was the ordinary high watermark. The shoreline of Roosevelt Reservoir, if used as the ordinary high watermark, would greatly widen the limits of the (riverine; pre-statehood) ordinary high watermark along the Salt River upstream of Roosevelt Dam.

In Reach 3, it is possible that alteration of the natural flow regime due to water and power supply concerns, has led to some change in the ordinary and natural condition of the river as of the time of statehood. However, Reach 3, which is located within the Tonto National Forest, has not been extensively developed or channelized, or been subject to other major human modifications. Therefore, it is assumed that the physical characteristics of Reach 3 below the ordinary high watermark have not significantly changed since 1912. Like Reach 1, the ordinary high watermark can be identified in the field by the location of vertical cut banks, the onset of riparian vegetation such as mesquite bosques, and presence of fine-grained soil materials in direct contrast to the very coarse active channel sediments.

Ordinary high watermarks were estimated from the most recent 7.5 minute USGS topographic maps using the break in slope at the main channel indicated by the contour lines. If the State makes any future claim to the bed of the Upper Salt River, it will be necessary to refine the delineation of the ordinary high watermark using more detailed topographic mapping and/or field survey techniques. Ordinary high water flow rates, according to information presented elsewhere, probably exceeded 20,000 cfs (cf. Powell, 1893), a rate which occurred nearly every year prior to completion of the Salt-Verde Reservoir system, and which would fill the channel of the Upper Salt River. In general, the ordinary high water area follows the blue and stippled zone along the main channel on the topographic maps.

Ordinary Low Watermark

HB 2589 limited the State's claim to navigable watercourses to the land within the ordinary low watermark. The ordinary low watermark is defined in HB 2589 as:

> ...the line on the banks of a watercourse created when the water recedes at its regularly recurring lowest stage in normal years without reference to unusual droughts.

In practice, the ordinary low watermark may be difficult to identify on Arizona rivers, but is generally identified in conjunction with delineation of the high watermark, or is defined on the basis of site-specific or hydrologic characteristics. Unlike high watermarks, low watermarks are more ephemeral and may be erased by subsequent high flows. Case histories for application of a low watermark standard in Arizona are lacking.

The following general statements can be made in regard to delineation of the ordinary low watermark for the Upper Salt River:

- The Upper Salt River is a perennial stream. Therefore, an ordinary low watermark exists for the study reach. It was assumed for purposes of delineating the ordinary low watermark that no unusual drought conditions currently exist, or existed at the time the USGS topographic maps were prepared.

- Portions of Reach 2 are within the impoundment areas of the Salt River reservoir system. Any physical evidence of the riverine ordinary low watermark as of the time of statehood in these reservoir areas is now buried under the surface of the reservoir. The existing ordinary low watermark for Reach 2 reflects the normal storage pool elevation of each reservoir, which represents a much larger land area than the pre-reservoir riverine ordinary low watermark. One of these reservoirs, Roosevelt, was in existence at the time of statehood.

- Within the narrow bedrock canyon portions of the Upper Salt River, there is very little difference in land area between the ordinary high watermark and the ordinary low watermark, especially at the scale of mapping used for this study. This land area between the two marks generally consists of narrow bouldery channel bars and sandy deposits devoid of vegetation.

- For the purposes of this study, the limits of the blue river symbol on the USGS topographic map may be taken as the limits of the ordinary low watermark. Should a claim of ownership based on the ordinary low watermark be made by the state, a more detailed delineation is recommended using detailed topographic mapping and/or field survey.

Regardless of whether the ordinary low watermark is delineated for existing (1996) conditions or for conditions as of the time of statehood (1912), the entire Upper Salt River was perennial in its ordinary and natural condition, as defined by HB 2589.

Summary

Review of the geology of the Upper Salt River indicates that the channel geomorphology is substantially unchanged from its condition at or before statehood, except where the river has been inundated by reservoir impoundments. Most of the Upper Salt River is formed within deep bedrock canyons. Bedrock along the channel margins in these canyons precludes significant movement of the river channel or other channel changes. In addition, the bedrock geology of the Upper Salt River area made access to the river difficult during the period around statehood, prevented development of extensive irrigation systems, and prevented the development of large population centers near the river. Bedrock outcrops in the channel created waterfalls, rapids, and narrow canyons which may have been potential impediments to navigation for some types of boats such as keel boats, steamboats, and powered barges.

However, the bedrock geology of the Upper Salt River was also conducive to construction of large dams and water supply reservoirs. Construction of the four reservoirs induced the only significant changes in the natural geomorphology of the study reach. In addition to the obvious changes in runoff rates caused by the reservoirs, the location of the ordinary high water and ordinary low watermarks were changed by impounding water along the Upper Salt River system. The bedrock geology is also responsible for the large number of springs which discharge into the river, giving it a reliable source of perennial base flow runoff.

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Arizona State Land Department

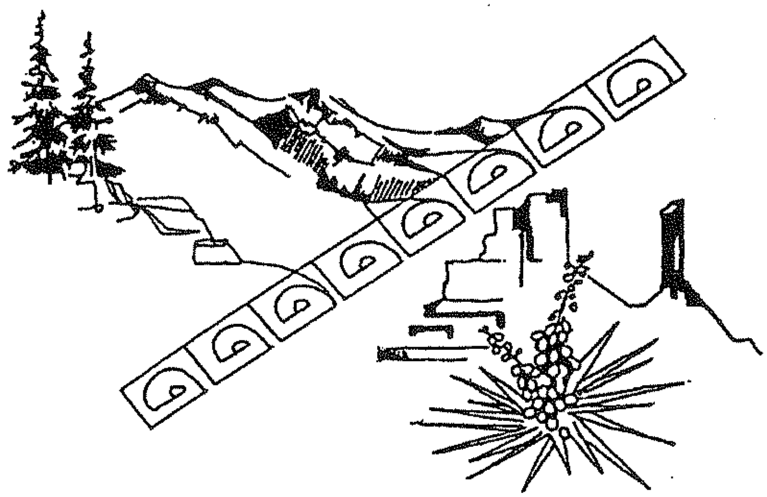
ARIZONA STREAM NAVIGABILITY STUDY

for the

UPPER SALT RIVER

Granite Reef Dam to the Confluence of the White and Black Rivers

Final Report



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Section 5

Hydrology of the Upper Salt River

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Section 5:
Hydrology of the Upper Salt River

Introduction

The objective of this section is to evaluate the ordinary and natural discharge of the Upper Salt River. The hydrology of the Salt River upstream of Granite Reef Dam was significantly altered by human activities beginning with the construction of Roosevelt Dam in the early 1900's. Therefore, the ordinary and natural hydrologic condition of the Salt River depends on which changes are considered non-natural. So that the range in potentially "natural" conditions is presented, this section summarizes information that describes the hydrology of the Upper Salt River for the following time periods:

- Pre-Settlement - Flow conditions for the period leading up to statehood
- Statehood - Flow conditions in 1912, the year of Arizona statehood
- Post-Statehood - Long-term flow conditions, including the period after 1912

For stream conditions during each of these time periods, estimates of monthly and annual flow rates, anecdotal information regarding the appearance and character of the stream, and flood data will be summarized. Hydraulic rating curves relating discharge to stream depth, width, and velocity for existing and historical river conditions will also be presented.

Stream Reaches

The study reach extends from the confluence of the Black River and the White River near Fort Apache to Granite Reef Dam near Phoenix (Figure 1), a distance of approximately 153 miles. For the purposes of the hydrologic investigation, the Upper Salt River hydrology may be considered in three stream reaches:

- Reach 1 - White River/ Black River confluence to Roosevelt Reservoir
- Reach 2 - Roosevelt Reservoir toStewart Mountain Dam
- Reach 3 - Stewart Mountain Dam to Granite Reef Dam

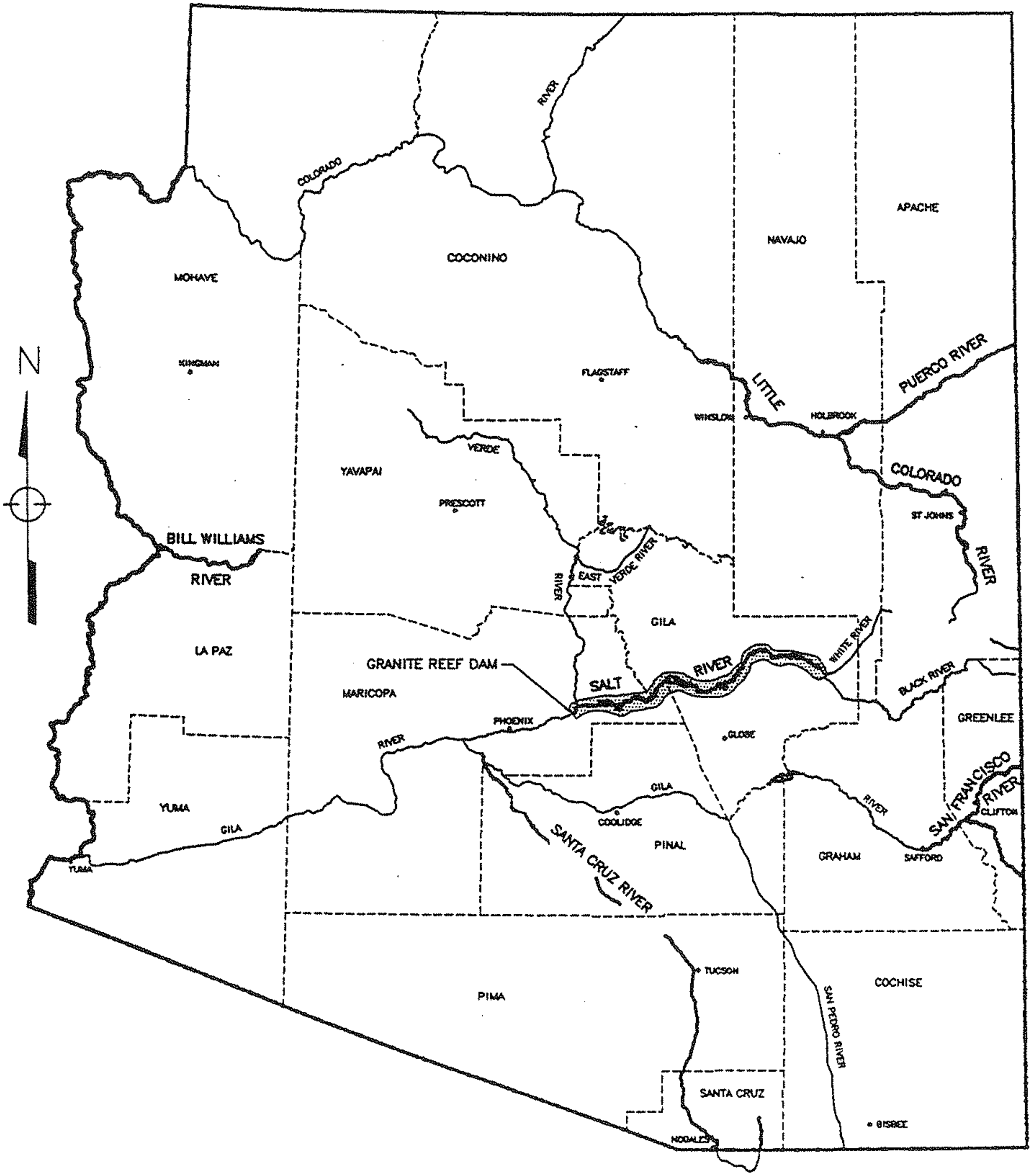

FIGURE 1

Study Reach Location Map

Reach 1. The hydrologic condition of Reach 1 is the closest to its pre-statehood condition of the three Upper Salt River reaches, and has been least impacted by human modifications of the channel and watershed. Reach 1 is located within the San Carlos Indian Reservation, the Tonto National Forest, and the Salt River Canyon Wilderness Area (Figures 1 and 2). The Salt River in Reach 1 is generally bounded by steep-walled bedrock canyons that lack a geologic floodplain. The bedrock canyon portions of Reach 1 probably have not experienced significant changes in their geomorphic channel conditions during the past 1,000 years (O'Connor et. al, 1985). Perennial tributaries that join the Salt River in Reach 1 includeCarrizo Creek, Cibeque Creek, Canyon Creek, Cherry Creek, Pinal Creek, and Tonto Creek.

Reach 2. The hydrology of Reach 2 has been substantially altered by construction of four major water supply dams: Roosevelt Dam (Roosevelt Lake), Horse Mesa Dam (Apache Lake), Morman Flat Dam (Canyon Lake), and Stewart Mountain Dam (Saguaro Lake). The natural condition of the Salt River has been altered by these reservoirs to the extent that the entire length of Reach 2 consists of reservoir ponding area, or is affected by reservoir backwater. Reach 2 is located entirely within the Tonto National Forest. The river and reservoirs in Reach 2 are bounded by bedrock canyons. In addition to Tonto Creek, a number of relatively small perennial and intermittent tributaries join the Salt River in Reach 2 (Figures 1 and 2).

Reach 3. Reach 3 extends from Stewart Mountain Dam to Granite Reef Dam. Flow in Reach 3 is significantly affected by Salt River Project water management and power generation practices, water rights requirements, and flood control practices on the six upstream reservoirs on both the Salt and Verde River systems. Unlike Reaches 1 and 2, Reach 3 is primarily bounded by stable, Pleistocene-aged alluvial terraces, rather than bedrock. Except for the Verde River, no significant perennial or intermittent tributaries join the Salt River in Reach 3. Reach 3 is located within the Tonto National Forest, the Salt River-Pima Maricopa Indian Community (SRPMIC), and includes a minor amount of private land.

Data Sources

Stream discharge information for the Upper Salt River study reach was obtained from long-term USGS stream gage records (cf. USGS, 1902ff; 1991), miscellaneous engineering reports (cf. Hancock, 1912), Flood Insurance Studies (FEMA, 1991), and other reports describing the hydrology of the Salt River. Key data sources are referenced in the bibliography. A list of some of the key existing and historical USGS stream gages and watershed characteristics for the study reach is provided in Table 1.

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[1] North half of the Salt River only, downstream of the Verde River Confluence

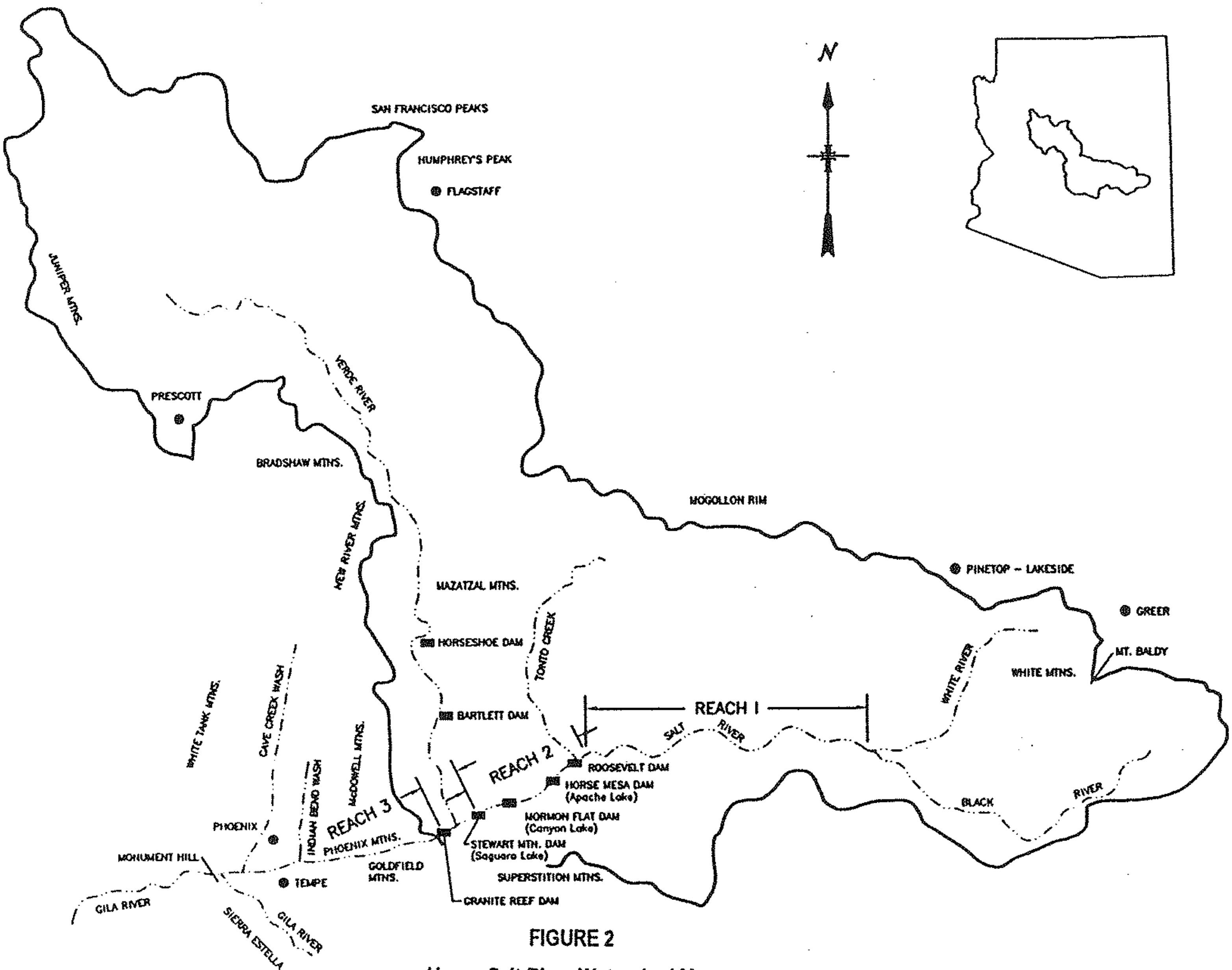

FIGURE 2

Upper Salt River Watershed Map

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Data Sources

Stream discharge information for the Upper Salt River study reach was obtained from long-term USGS stream gage records (cf. USGS, 1902ff; 1991), miscellaneous engineering reports (cf. Hancock, 1912), Flood Insurance Studies (FEMA, 1991), and other reports describing the hydrology of the Salt River. Key data sources are referenced in the bibliography. A list of some of the key existing and historical USGS stream gages and watershed characteristics for the study reach is provided in Table 1.

Table 1. Upper Salt River Navigability Study
USGS Stream Gages in the Upper Salt River Watershed

Gage	USGS ID #	Drainage Area	Elevation of Station	Earliest Record
Salt River & Tributaries				
Black River near Fort Apache	09490500	1,232	4,310	1958
White River near Fort Apache	09494000	632	4,360	1958
Salt River nearChysotile	09497500	2,849	3,350	1925
Salt River below Cherry Creek	-		2,460	1906
Salt River near Roosevelt	09498500	4,306	2,200	1914
Salt River nearLivingstone	-			1901
Salt River at Roosevelt (Dam Site)	09498500	5,824	1,920	1904
Salt River below StewardMtn Dam	09502000	6,240	1,400	1934
Salt River atMcDowell	09502500	6,268	1,330	1897
Arizona Dam/Granite Reef Dam	-	12,000+	1,310	1890
Verde River & Tributaries				
Verde River @McDowell	-	6,160	1,330	1899
Verde River near McDowell	-	6,160	1,330	1888
Verde River below Bartlett	09510000	6,160	1,572	1937
Verde River below Tangle Creek	09508500	5,859	2,045	1925
Verde River near Camp Verde	09506000	5,010	2,880	1911
Verde River at Camp Verde	-	5,000	3,070	1912

Notes: Flow records at stations may be discontinuous. Elevations and drainage areas are approximate.

Hydrologic Setting

The Upper Salt River study reach is located in Gila and Maricopa Counties, although its 12,000 square mile watershed drains much of central and eastern Arizona (Figure 2), and includes portions of nine of the fourteen Arizona counties. The watershed ranges in elevation from 12,643 feet at Humphrey's Peak north of Flagstaff (11,590 ft. at Mt. Baldy near Greer) to about 1,300 feet at Granite Reef dam. The Salt River watershed is bounded by the Mogollon Rim to the north, the Mazatzal Mountains to the west, the Superstition Mountains and the Gila River watershed to the south, and the White Mountains to the east. The Verde River portion of the watershed is bounded by the Mogollon Rim and San Francisco Peaks to the north, the Juniper, Bradshaw, and New River Mountains to the west, and the Mazatzal Mountains to the east. The major perennial tributaries to the study reach include the White, Black, and Verde Rivers, and Tonto Creek.

Within the Upper Salt River study reach, the river is located almost entirely within steep bedrock canyons. The river channel itself consists of a relatively steep, bouldery channel with a pool and riffle channel pattern. The average channel slope is about 20 feet per mile (0.4 percent), and includes several small waterfalls. In many places the active channel completely fills the canyon bottom, although small flood deposits and alluvial surfaces that form isolated terraces above theordinary high watermark are found throughout the study reach. Near the downstream limit of the study reach in Reach 3, the active channel area becomes broader with a more extensive floodplain, and is bounded by stable late Quaternary-aged alluvial surfaces as well as by bedrock.

The climate within the Upper Salt River watershed varies significantly with elevation. The lower elevations are characterized by very hot, semi-arid desert conditions. The climate in the higher elevations ranges to alpine conditions (Table 2). Precipitation primarily occurs during two periods (Table 3): in late summer as intense localized orographic thunderstorms; and in winter as large-scale cyclonic storms which originate over the Pacific Ocean (Sellers and Hill, 1974). Winter storms, in conjunction with snow melt runoff, tend to produce the largest peaks and flow volumes on the Salt River, with over 90 percent of the largest storms occurring in winter months. About 60 percent of the annual rainfall and 82 percent of the runoff volume occurs during winter (Cooperrider and Sykes, 1938). Furthermore, all years with annual peak flows during summer months have had below average annual discharge volumes (Fuller, 1987). Runoff from spring snowmelt also comprises a significant component of the annual flow volume.

Table 2 Climatic Data for the Upper Salt River Watershed.			
Average Annual Statistic	Granite Reef 1938-1967 elev.=1,325 ft.	St. Johns 1902-1957 elev.=5,725 ft.	Show Low 1933-1955 elev.=6,382 ft
Precipitation (in)	8.9	11.4	18.4
Max. Temperature	86	70	65
Min. Temperature	54	35	36

Table 3 Seasonal Variation in Precipitation (Inches) and Temperature (°F) for the Salt River Watershed			
Month	Granite Reef elev.=1,325 ft.	St. Johns elev.=5,725 ft.	Show Low elev.=6,382 ft.
January	1.0	0.7*	1.3
February	0.8	0.7*	1.4
March	0.9	0.8*	1.6
April	0.4	0.5*	0.6
May	0.1	0.5*	0.7
June	0.1	0.6	0.4
July	0.8	2.1	2.5
August	1.5	2.1	2.5
September	0.8	1.3*	1.6
October	0.5	1.0*	1.7
November	.7	0.4*	1.4
December	1.3	0.7*	2.3
Annual	8.9	11.4	18.1
Aver. Max & Min. Temperature	86 / 54	70 / 35	65 / 35
* indicates precipitation may occur as snow			

Vegetation within the Salt River watershed also varies with elevation. The lower elevations in the watershed and the channel margins are dominated by Sonoran Desert Scrub-Lower Colorado River Plant communities, which include grasses, low shrubs, and saguaro cacti (Graf, 1981). Although tamarisk has replaced much of the native riparian vegetation, portions of the Upper Salt River were once lined by cottonwood, seepwillow, and mesquite trees (Davis, 1982). The upper watershed extends through several climatic-vegetation zones, including several areas above the tree line on the highest peaks.

Historically, sources of runoff included discharge from springs, snowmelt in the higher elevations, precipitation, and ground water discharge. While Reach 1 is effectively free-flowing, reservoir impoundments have substantially altered the natural flow regime in Reaches 2 and 3. The entire Upper Salt River study reach experiences perennial runoff in spite of reservoir impoundment.

Pre-Statehood Hydrology

There are four primary sources of information on the hydrology of the Salt River prior to its alteration during the 20th century. These include direct streamflow measurements, reconstruction of flow rates from modern gage records, reconstruction of flow rates by indirect methods such as tree-ring data, and historical and anecdotal accounts of flow conditions. Pre-statehood hydrologic records are indicative of the ordinary and natural flow conditions of the Salt River, without any human impacts.

Direct measurement. Direct measurement includes gaging of river flow at controlled or measured stream sections. The Salt River was gaged at a few stations between 1888 and 1912 within the study reach prior to statehood in 1912 (Tables 1 and 4). The Salt River at McDowell and Verde River at McDowell gages were located just upstream of the Salt River-Verde River confluence (respectively) in Reach 3. An additional gaging station was located downstream of the confluence at Arizona Dam until the dam failed in 1905, after which the gage was moved to the new dam location at Granite Reef. The gage records indicate that flow was perennial in the study area, with the minimum average annual recorded flow from 1888 to 1912 at about 240 cfs in 1903 on the Salt River at McDowell, and 311 cfs in 1899 at the Verde River at McDowell. The minimum combined average annual flow during this period was 625 cfs in 1903.

The average annual flow rates recorded at USGS gaging stations during the pre-statehood period are summarized in Table 5. Average flow rates for the month of February during the pre-statehood period are shown in Table 6. The month of February typically experienced flows well in excess of the average annual flow rate. Flow rates for the month of February are shown because Arizona statehood occurred in February, 1912.

Table 4 Salt River Pre-Statehood Gages - Direct Flow Measurements			
Gage Name	Period of Record	Minimum Average Monthly Flow (cfs)	Minimum Average Annual Flow (cfs)
Salt River @ Roosevelt Dam Site	1888-1907, 1910-1913	45 (July, 1902)	118 (1902)
Salt River @.McDowell	1895 - 1911	64 (June, 1904)	342 (1904)
Verde River @ McDowell	1888 - 1932	52 (June, 1892)	175 (1900)
Salt River @ Arizona Dam	1888 - 1896	331 (October, 1889)	2,656 (1889)
Notes: gages were not operated continuously for entire period listed; Sites were moved. † Gaging station equivalent to Verde River below Bartlett Dam 1932-1996			

Table 5 Salt River Pre-Statehood Gages - Average Annual Flow		
Gage Name	Period of Record	Average Annual Flow (cfs)
Salt River @ Roosevelt Dam Site	1888-1907, 1910-1913	1,045 cfs
Salt River @.McDowell	1895 - 1911	1,560 cfs
Verde River @McDowell	1888 - 1932	783 cfs
Note: Average annual flow estimate based on reported average monthly flow data.		

Table 6 Comparison of Average February Streamflow Records on Salt River, 1895-1905	
Salt River @McDowell	Salt River @ Roosevelt
1,801 cfs	1,390 cfs

Other less systematic streamflow measurements were also made during the period prior to statehood. Powell (1892) estimated the annual low flow of Salt River at 800-900 cfs below the Verde River confluence, though he revised his low flow estimate (1893) to an average minimum flow of 500 cfs. He reports an instantaneous low discharge of 417 cfs in August, 1889, and a high variable mean monthly discharge ranging from 940 cfs to 9400 cfs. Davis (1897), however, reports that the minimum instantaneous discharge between August 1888 and February 1891 was 300 cfs, and that the average monthly flow was 3,074 cfs. Davis and Powell were likely reporting flow conditions downstream of the Salt-Verde confluence, near Arizona Dam.

Flow Reconstruction From Stream Gage Records. Several investigators have attempted to reconstruct average flow conditions at Granite Reef Dam or in parts of the Upper Salt River study reach using stream gage records from stations located upstream of the Salt-Verde confluence (Table 7). Thomsen and Porcello (1991) determined an average annual (pre-development) flow rate of 1690 cfs at the Salt River Pima Maricopa Indian Community, with a median discharge (50% rate on the flow duration curve) of 1,230 cfs [2]. The Salt River Valley Water Users Association (SRP, 1954) used gage records from 1889 to 1953 to estimate a mean annual discharge of 1,773 cfs. Consideration of only the period from 1889 to 1912 would yield a mean annual discharge of about 1,880 cfs, with a range of average annual discharges of 400 cfs to 7,180 cfs. Daily flow measurements taken at the Verde River near McDowell gage between 1904 and 1924 indicate that the "expected daily flow" for that period was 968 cfs (Atshul, 1987).

Table 7

Pre-Statehood Runoff Estimates Derived from Upstream Gage Records - Salt River at Granite Reef Dam:

Reference	Average Annual Flow	Median Flow
Thomsen and Porcello (1991)	1,690	1,230
Salt River Water Users (1954)	1,880	n.a.
Stockton and Smith (1981)[1]	1,265	n.a.
Garrett and Gellenbeck (1991)[2]	1,455	581

Notes.

[1] 1,265 cfs is sum of Stockton and Smith's estimates for Salt (796 cfs) River and Verde River (469 cfs) for the Verde River above Tangle Creek and Salt River above Roosevelt stations.

[2] Arithematic sum of estimates from two USGS gages. (1) Salt River above Roosevelt (896 cfs) and (2) Verde River below Tangle Creek (559 cfs) modern gage record. Excludes drainage area downstream of gages. Provided for comparison with pre-statehood estimates.

[2] The 50% flow rate is the flow rate that is equaled or exceeded 50% of the time. Thomsen and Porcello (1991) estimated average annual flow rate of 1,730 cfs if tree-ring data are included with stream gage records.

Indirect Estimates. Indirect estimates of average flow conditions in the study reach have been made from long-term tree-ring[3] chronologies from the Upper Salt and Verde River watersheds (Smith and Stockton, 1981; Fritts, 1980), from measurements of pre-statehood channel widths, and from canal diversion records. Tree-ring records dating to 780 A.D. (Graybill, 1989) indicate that the average annual flow rate for the modern gage record is slightly above the long-term mean. Tree-ring records from 1580 to 1989 were used to estimate average annual flows of 796 and 469 cfs for the Salt and Verde Rivers, respectively (Table 7). Modern stream gage records indicate average annual flow rates of 896 and 559 cfs (Garrett andGellenbeck, 1991; Table 7) for these Salt and Verde River stations. Comparison of gage data from 1895 to 1905 (prior to work on Roosevelt Dam) at the Salt River Roosevelt gage (site of long-term records) with Salt River McDowell gage data indicates that mean flow rates are similar at both stations (Tables 6 and 7). Use of flow data from the Salt River at Roosevelt Dam Site station (Reach 2) and Salt River above Roosevelt (Reach 1) for the period after 1905 would tend to under estimate flow rates in Reach 3 of the study area (Tables 6 and 7), since flow rates increase in the downstream direction along the Upper Salt River. Therefore, these indirect data studies support the conclusion that the USGS stream gage records for upstream stations are an acceptable source of reliable minimum streamflow data for the Upper Salt River study reach for estimating pre-statehood conditions.

Historical Accounts. The historical record of the Upper Salt River extends back to the first beaver trapping expeditions of the 1820's. Some of these historical records, as well as archaeological records, are summarized in more detail in Sections 2 and 3 of this report. For the purposes of hydrology, it is noted that of the numerous early expeditions along the Salt River study reach, all traveled by foot, horse, or wagon. However, early accounts of the river describe abundant waterfowl, fish, water, riparian vegetation, and grassy bottomland in the flats and in the Salt River Valley downstream (Davis, 1982). Bartlett (1854, cited in Davis, 1982) describes the lower Salt River as clear and sweet, averaging 80 to 120 feet wide, and two to three feet deep. Not one of the early explorers describes a dry riverbed in the Upper Salt River study area, at any time of year. Finally, several pre-statehood Arizona residents used boats to travel portions of the Upper Salt River study reach, as described in Section 3.

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[3] Tree-ring studies assume the thickness of the individual annual rings are related to discharge. Wet year (high average annual flow) give rise to thicker rings. Individual tree rings can be readily matched to specific years. Smith and Stockton's data was calibrated using recent gage data and recent tree-ring records.

Summary. Prior to statehood, the Upper Salt River was a perennial stream, with an average annual discharge ranging from about 1,400 cfs to 1,800 cfs. Monthly and annual fluctuations no doubt occurred in response to seasonal precipitation and snowmelt runoff, or slight climatic variations, similar to those which presently occur in the watershed above Roosevelt Dam. However, early records and reconstructed flow rates for the pre-statehood period indicate that flow rates exceeded 1,200 cfs more than half the time. Minimum flow rates generally exceeded 200 cfs, even during extended dry periods prior to 1912. Streamflow rates were sufficient to support rich riparian vegetation, fish and beaver populations, and a large irrigation based agricultural economy downstream of the Upper Salt River.

Statehood Hydrology

The hydrology of the Upper Salt River for 1912, the year of Arizona statehood, is not significantly different than for the 10 to 20 years of record immediately preceding statehood, except for the portions of Reaches 2 and 3 impacted by closure of Roosevelt Dam and the filling of Roosevelt Reservoir. However, only limited data are available from which to estimate flow conditions both for the entire year and for the month of February, 1912. Unfortunately, the record is not sufficiently detailed to be able to precisely define the flow rates and stream hydraulics for the entire study reach on the day of statehood.

Streamflow Data: 1912. Climatic data summarized in Section 2 of this report indicate that the year of statehood occurred during one of the wettest periods in the past 1,000 years (Smith and Stockton, 1981). However, the year of 1912 itself had a below-average annual runoff rate estimated at 1,176 cfs (Arizona State Planning Board, 1936; See Table 8), despite occurring during this wet period. The U.S. Reclamation Service/Salt River Project (1914) computed the average annual diversion from the Salt River in 1912 (calendar year), excluding the Tempe and Utah canals, at 1,040 cfs.[4] Therefore, the average natural streamflow input from the Upper Salt River study reach must have been at least 1,040 cfs.

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[4] The BUREC (1924) estimated the average annual flow rate for 1912 at 1,378 cfs. The BUREC rate may have included release of 460 cfs from water stored in Roosevelt Reservoir required to meet downstream requirements.

Table 8 Salt River Average Annual Flow Estimates for 1912		
Source	**Flow Rate**	**Upstream Stations**
US Reclamation/SRP (1914)	1,040 cfs	Salt River Valley diversions
BUREC (1924)	1,378 cfs	Granite Reef Dam
Ariz. State Board (1936)	1,176 cfs	Granite Reef Dam
USGS (1954)	757 cfs	Salt River @ Roosevelt
USGS (1954)	621 cfs	Verde River @McDowell
Combined USGS flow rates = 1,378 cfs, but does not include runoff from Tonto Creek and some Verde River tributaries.		

Streamflow Data: February, 1912. The month of February 1912 was unusually dry. Statistics developed by the Arizona State Planning Board (1936) estimate a monthly combined (natural) average flow rate of 398 cfs [5] for the Salt and Verde Rivers, a rate well below the mean flow for the year (1,176 cfs), and the long-term average for the month of February of about 3,300 cfs [6]. By comparison, mean flow rates for the months of February immediately preceding (1911) and following (1913) the year of statehood were 4,155 and 1,237 cfs, respectively. The Arizona State Planning Board estimates were made in part from the Salt River above Roosevelt station, and did not account for release of water stored in Roosevelt Reservoir required to meet downstream irrigation needs. Lippencott (1919) reports that average monthly discharge for February 1912 was 532 cfs on the Salt River, with the annual discharge only 62 percent of normal. In other documentation, the U.S. Reclamation Service/Salt River Project (1914) reports the average "natural" monthly flow of the Salt and Verde Rivers for February 1912 as 532 cfs, with a six year average of 3,396 cfs for the month of February. The U.S. Reclamation Service/Salt River Project (1913; 1914) reported that 963cfs [7] was diverted from the Salt River downstream of the Upper Salt River study reach in February 1912, excluding diversions to the Tempe and Utah Canals. A summary of February 1912 flow rate estimates is shown in Table 9.

[5] Salt River above Roosevelt = 233 cfs; Verde aMcDowell = 165 cfs.

[6] February Average Monthly flow rates: Salt River above Roosevelt (1914-1989) = 1,360cfs;
Verde McDowell (1899-1932) = 1,990 cfs. Minimum average February flow rates are 168 cfs and 417 cfs for the Salt and Verde Rivers, respectively, for the same period of record.

[7] 616 cfs is listed in the 1913 report, but apparently is a typographic error. The value was reported as 35,420 acre-feet in the same 1913 report, and as 55,420 acre-feet in 1914 report. However, the annual value reported in 1913 is 20,000 acre-feet greater than the sum of monthly values. Therefore, it is assumed that 55,420 (963 cfs) is the correct value for February 1912. The 963 cfs must include releases from Roosevelt Dam given the February 1912 flow rates reported for stations upstream of Roosevelt Dam and for the Verde River.

Table 9 February 1912, Average Monthly Flow Rate (cfs)			
Station	**Flow Rate**	**Notes**	**Source**
Granite Reef Dam	532 cfs	February, 1912; 62% of normal	Lippincott, 1919
Salt River @ Roosevelt Damsite	233 cfs	February, 1912	SRVWUA, 1934
Verde River @ McDowell	165 cfs	February, 1912	SRVWUA, 1934
Combined Salt & Verde	398 cfs	February, 1912	SRVWUA, 1934
Salt River at Roosevelt	233 cfs	February, 1912	USGS, 1915
Salt River Diversion	963 cfs	February, 1912	USRS/SRP, 1913

Streamflow Data: February 14, 1912. No streamflow measurements in the Upper Salt River study reach were reported for the day of Arizona statehood, February 14, 1912. The USGS (1914) reported a measurement for the Verde River at McDowell gage, located just upstream of the Salt-Verde confluence, of 269 cfs on February 16, 1912. No daily measurements for the year of 1912 for the Salt River are available from published USGS records. The Arizona Republican for February 1, 1912 reported a "normal discharge" of 99 cfs at Jointhead Dam and 520 cfs at Granite Reef Dam (Lacy et al, 1987). This discharge estimate was taken below the diversions at Granite Reef Dam, Utah Canal, and the Tempe Canal. It is also noted that because Roosevelt Reservoir was filling between 1911 and 1915 the normal flow of water downstream of Roosevelt Dam was significantly altered (reduced) during this period.

Summary. Although 1912 had below average flow on the Upper Salt River, the minimum flow rate was at least 200 cfs upstream of the Verde River confluence during the month of February 1912, and averaged over 1,000 cfs for the year of 1912.

Post-Statehood Hydrology

Since statehood, runoff in the study reach has been affected by the addition of five major reservoirs, with additional potential affects from regional ground water withdrawal and increased water use. The sum of these changes has had some affect on stream hydraulics, riparian conditions, biotic habitat, recreation along Reaches 2 and 3, and has changed the natural flow frequency and volume.

Reservoirs. Between 1900 and 1945, seven dams were constructed on the main streams of the Salt River system (Table 10). These dams have the capacity to store over 2 million acre feet of water. In addition, an uncounted number of stock ponds, mining ponds, and other impoundments have been built within the watershed. These reservoirs, while maintaining water supply at constant rates, have helped reduce flood peaks (Aldridge, 1980) and eliminate low flow discharges downstream of Granite Reef Dam. Evaporation losses alone on the six main reservoirs decrease the pre-development flow rates by an estimated 180 cfs (Thomsen and Porcello, 1991).

Table 10

Reservoirs on the Salt River System

Name	Date	Storage Capacity	Function
SALT RIVER			
Granite Reef Dam	1906	0	Irrigation Diversion
Roosevelt- Roosevelt Lake	1911 - Closure 1923 - Increase Storage 1995 - Increase Storage	1,284,000 AF 1,336,000 AF 1,650,000 AF	Water Supply Water Supply Add Flood Control
Morman Flat Dam - Canyon Lake	1923	57,800 AF	Water Supply
Horse Mesa Dam - Apache Lake	1927	245,000 AF	Water Supply
Stewart Mountain Dam - Saguaro Lake	1930	70,000 AF	Water Supply
VERDE RIVER			
Bartlett Dam - Bartlett Lake	1939	182,600 AF	Water Supply
Horseshoe Dam -Horseshoe Lake	1946	131,427 AF	Water Supply

Diversions. A list of some of the main irrigation and water supply diversions is shown in Table 11. The magnitude of the diversions in the Upper Salt River is significantly smaller than the irrigation diversions downstream in the Lower Salt River, below Granite Reef Dam.

Table 11

Water Diversions on the Salt River System

Name	Date Constructed	Acres Irrigated	Notes
SALT RIVER			
Arizona Dam	1883	-	
Granite Reef Dam	1891	186,000*	Agricultural/Municipal
above Roosevelt	-	4,000	
above Chrysotile	-	3,100	
above Fort Apache	-	1,460	White River
above Fort Apache	-	-	Black River, I&M use
SALT RIVER TRIBUTARIES			
Tonto Creek	-	-	Small diversions
Cibecue Creek	-	-	Small diversions
Carrizo Creek	-	< 300	
Verde River	ca. 1870	n.a.	Verde Valley, Fort McDowell

* Note: Approximate acres irrigated in 1913.

Hydraulic Characteristics. Due to geologic control of the channel geometry in most of the Upper Salt River, it is likely that the overall hydraulic characteristics of Reaches 1 and 3 were not significantly altered during the post-statehood period. Submergence by reservoir ponding completely changed the natural hydraulic characteristics of Reach 2. While channel width-depth-discharge relationships at any specific location in Reaches 2 and 3 may tend to fluctuate in response to flooding and movement of bed sediments, the overall channel geometry and stream conditions probably remained constant. USGS gage station summaries note these shifting local channel conditions at some stations, which required occasional modifications of the gage station rating curve. The nature of these geomorphic channel changes are summarized in Section 4 of this report. Rating curves for typical sections are discussed in more detail later in this section.

Hydrology. Long-duration stream gage records are available for stations located upstream of the Salt and Verde River Reservoirs. Flow duration statistics for these stations are summarized in Table 12. Tree-ring data suggest that the period of modern gaging may be slightly "drier" than the period around statehood (cf. Stockton and Smith, 1981; Graybill, 1989), but that the modern, long-term gage data is broadly representative of river conditions at the time of statehood. Average annual flow rates at selected Upper Salt River stream gaging stations are summarized in Table 13.

Table 12
Salt River Flow Duration Statistics (cfs)

Station	Aver. Annual	10% Flow	50% Flow	90% Flow
Salt River-Roosevelt	896	157	343	2,040
Verde River-Tangle Creek	559	120	238	917
Combined Flow	1,455	277	581	2,957
Reconstructed Flow (Table 7)	1,690	n.a.	1,230	n.a.

Note: Combined flow by addition of tributary stations. Reconstructed flow from Thomsen and Porcello (1991) for location downstream of Granite Reef

Table 13 Long-Term Average Annual Flow Estimates - Salt River		
Average Annual Flow Rate (cfs)	Notes	Source
658	@ Confluence of White River/Black River	Garrett & Gellenbeck, 1991
658	nr. Chrysotile	Garrett & Gellenbeck, 1991
896	nr. Roosevelt	Garrett & Gellenbeck, 1991
732	Roosevelt inflow, includes Tonto Creek	Aldridge, 1981
1,690	Granite Reef Dam	Thomsen & Porcello, 1991
1,773	Granite Reef Dam	Salt River Valley Water Users, 1957
2,051	Combined flow of Salt and Verde Rivers	Lippincott, 1919
1,265	Summed flow estimate for Salt and Verde Rivers	Stockton & Smith, 1981
1,445	Summed flow estimate for Salt and Verde Rivers	Garrett & Gellenbeck, 1991

The monthly flow statistics for the long-term stations located upstream of the reservoirs (Tables 3, 14 and 15) show that runoff directly follows precipitation patterns. Peak flow rates typically occur in February and March following snowmelt. Annual low flows typically occur during June and July, prior to monsoon rainfall. There are no data indicating that the monthly distribution of runoff at or prior to statehood differs from that measured by modern stream gage records.

Table 14

Salt River Monthly Minimum and Maximum Flow Rates (cfs)

Month	Salt River-Roosevelt			Verde River-Tangle Creek			Combined Flow
	Min.	Max.	Mean	Min.	Max.	Mean	(Mean, cfs)
January	161	16,000	982	224	2,710	655	1,637
February	168	9,070	1,360	220	11,000	1,060	2,420
March	220	10,400	1,960	194	10,400	1,460	3,420
April	212	6,280	2,040	155	5,640	878	2,918
May	127	5,930	1,050	113	1,320	219	1,269
June	79	1,370	367	83	316	134	501
July	78	3,280	341	76	430	181	522
August	151	3,610	599	127	1,180	334	933
September	78	1,850	460	99	1,460	271	731
October	86	4,830	461	155	4,190	353	814
November	122	2,150	380	192	1,380	383	763
December	127	6,330	786	227	4,640	803	1,589
Annual	236	3,250	896	189	1,710	559	1,445

Table 15

Monthly Mean Flow Variation at USGS gages (cfs) [1]

Gage [2]	Jn	Fb	Mr	Ap	My	Jn	Jl	Au	Sp	Oc	No	Dc
Black River nr Fort Apache #09490500 (1958-1989)	338	592	1040	1250	546	114	91	195	149	260	155	413
White River nr Fort Apache #09494000 (1958-1989)	113	166	354	610	467	164	76	125	105	123	90	128
Carrizo Creek nr Show Low #09496500 (1952-1989) [3]	81	120	157	55	22	13	14	18	11	35	25	84
Salt River near Chysotile #09497500 (1925-1989)	707	1010	1200	1280	936	257	103	237	255	586	209	786
Cibecue Creek nr Chysotile #09497800 (1960-1989)	48	74	102	60	26	15	25	36	32	39	30	62
Cherry Creek near Globe #09497980 (1966-1989)	43	98	96	30	13	7.7	9.9	17	18	30	19	67
Salt River near Roosevelt #09498500 (1914-1989)	982	1360	1960	2040	1050	367	341	599	460	461	380	786
Tonto Creek abv Gun Creek #09499000 (1942-1989)	285	338	444	148	41	13	23	100	47	68	75	266
Verde River blw Tangle Crk #09508500 (1946-1989)	655	1060	1460	878	219	134	181	334	271	353	383	803

Notes: 1. Source: (Garrett & Gellenbeck, 1991) 2. All gages listed are located upstream of major reservoirs. 3. Discontinuous record

Table 16 Flow Duration Estimates at USGS gages (cfs)							
Gage	1%	10%	20%	50%	80%	90%	99%
Black River near Fort Apache[3]	4,050	1,180	508	113	52	39	21
White River near Fort Apache[3]	1,508	539	289	95	46	34	10
Carrizo Creek near Show Low[3]	689	83	36	12	4.8	2.6	0.74
Salt River near Chysotile[3]	5,130	1,550	788	265	159	129	78
Cibecue Creek near Chysotile[3]	409	89	46	20	13	9.9	5.6
Cherry Creek near Globe	546	62	25	9.3	6.3	5.4	4.1
Salt River near Roosevelt[3]	7,100	2,040	1,010	343	198	157	90
Tonto Creek above Gun Creek[3]	2,450	252	97	24	9.0	4.5	0
Verde River blw Tangle Creek[3]	5,960	917	408	238	151	120	79

Notes:

1. Source: (Garrett & Gellenbeck, 1991).
2. Flow duration reported is percent of time given flow ratewas equalled or exceeded.
3. Irrigation diversion upstream of gage station diverts low flows. 4. All gages listed are located upstream of major reservoirs.

Summary. Hydrologic data for the study reach indicate that the Salt River upstream of Granite Reef Dam is perennial, with a natural average annual flow rate that ranges from 600 to 1,400 cfs within the study reach. The annual minimum flow occurs during summer months, but exceeds 100 to 400 cfs, on average. Flow duration statistics indicate that the natural flow rate in the study reach is above 150 to 250 cfs 90 percent of the time, and exceeds 300 cfs more than 50 percent of the time. For the purposes of estimating flow depth, velocity, and width, the flow rates representative of long-term average conditions on the Upper Salt River are shown in Table 17.

Table 17. Long-Term Flow Estimates for the Upper Salt River			
Reach	Median (50%) Flow Rate (cfs)	Average Annual Flow Rate (cfs)	Average Annual Minimum Flow Rate (cfs)
1	210-340	660	130-230
2	340	900	240
3	360-580	1,450	420

Climatic Variation

Analysis of climatic variation in Arizona in the past 100 year can provide information as to the relevance of post-statehood streamflow records for estimating streamflow conditions as of the time of statehood. Climate change is measured by monitoring weather characteristics such as daily, monthly, seasonal, or annual temperature, precipitation, or relative humidity. Although weather records for the period prior to Arizona statehood in 1912 are not as extensive as for the period since statehood, sufficient data exist to give indications of pre-statehood climatic and streamflow conditions. Stream gage data are available for the Salt River dating to 1888. Archaeological and historical records of flow in the Salt River extend the database back several centuries.

The BUREC began direct measurement of streamflow on the Salt-Verde River systems in late 1888 at the Arizona Dam irrigation diversion. Direct measurements have been continued to the present time by the USGS at several upstream locations. Smith and Stockton (1981) and Graybill (1989) used tree-ring records to extend gage records to 740 A.D.; Dean et al (1985), and Euler et al (1979) used tree-rings, pollen data, and alluvial sedimentation patterns to estimate periods of increased/decreased moisture to 600 A.D. Tree-ring records may be used to estimate annual flow volume. Smith and Stockton's interpretation of the tree-ring record indicates the following:

- The period from 1905-1920 (Arizona statehood) was the wettest period since 1580 in both the Salt and Verde River watersheds. If the Upper Salt River was navigable, it was more likely to have been navigable around the time of statehood than at other periods in the past 400 to 500 years.

- The period from 1900 to 1979 (Salt River gage record) had an average annual flow volume only slightly greater than the 400 year mean annual volume. Therefore, the gage records for the Upper Salt River are probably representative of long-term average conditions.

- The period from 1940-1977 on the Salt River, and from 1932-1977 on the Verde River had below average annual runoff. These time periods correspond to the majority of the period of record of most Arizona stream gages. Therefore, the gage records from this period tend to underestimate flow conditions for 1912.

- Base flow in the Verde River portion of the watershed is controlled by springs, rather than climatic factors. Below-average precipitation does not generally affect discharge from springs. Therefore, Reach 3 is not impacted as strongly by climatic change.

Graybill's tree-ring data also indicate that average flow from 740 -1370 A.D. was somewhat less than twentieth century average flows on the Salt River. However, summer low flows were found to have more predictable average flows during that period. Dean's and Euler's paleoenvironmental studies determined that there were no radical differences in the prehistoric Arizona climate (1,000 years before present (b.p.)) compared to the modern climate. Other tree-ring studies by Stockton (1975) elsewhere on the Colorado Plateau also found that the early 1900's was an unusually "wet" period.

In regional climatic studies, Sellers (1960) recorded a decreasing, but not statistically significant, trend in total annual precipitation averaging about 0.03 inch/year. Thomsen and Eychaner's (1991) statistical analysis of 109 years of rainfall records from the Tucson Basin indicated no trend in precipitation. Peterson (1950) demonstrated that total annual precipitation was above average between 1881 and 1884, a period of extensive channel change in southeastern Arizona. In northern Arizona, Hereford (1984) notes a period of lower than average runoff and precipitation and above average temperature in the 1940's and 1950's when compared to records for the rest of the twentieth century. This drought period affected most of the Rocky Mountain states. Hereford also concludes that beginning in 1900, precipitation abruptly increased until about 1910, at which time a progressive decline began that lasted until 1956. Since 1956, average temperatures have cooled somewhat, and discharges increased somewhat. Regional analyses of archaeological data have concluded that there were no radical differences in climate that would have affected streamflow (Graybill and Gregory, 1989). Analysis of national climatic data by Diaz and Quayle (1980) indicates that in the southwest, the period between 1920 and 1954 had warmer winters, cooler summers and less precipitation than the period from 1895 to 1920. These data generally support the observations of Hereford (1984) and Stockton (1975) cited above, and suggest that climatic conditions may have favored higher runoff rates around the period of Arizona statehood.

The effects of climatic variations on potential stream navigability and channel conditions are complex, and cannot always be clearly distinguished from stream changes initiated by man. However, some basic conclusions can be drawn from the studies cited above.

First, Arizona's climate at the time of statehood was not drastically different from existing or pre-statehood conditions. The same basic climatic patterns applied: summers were warm and relatively dry with intense, late summer monsoonal rainfall; and winters were cool, with less intense Pacific frontal storms bringing snow to higher elevations and rain to lower elevations. However, subtle differences in rainfall and temperature patterns around the time of statehood may have resulted in higher average streamflow. These differences included the following:

- Generally higher precipitation and streamflow volumes
- More frequent intense monsoonal rainfall
- Cooler average temperatures, with warmer summers and cooler winters

Therefore, the period surrounding statehood was probably subject to higher than average streamflow, indicating that streams may have been more likely to have carried additional flow at statehood than during other, less "wet" periods of Arizona history.[8] It is noted that some of Arizona's largest floods, in terms of both volume and peak flow rate, occurred in the twenty years prior to statehood.

Second, USGS stream gage records may be used to predict the natural, long-term average discharge rates. Tree-ring records indicate that the average annual flow rates on the Salt and Verde Rivers between 1900 and 1980 are just slightly above the average annual flow rates for the past 400 years. Gage records from 1905 to 1920 may predict average flow conditions well above long-term average rates, but may accurately reflect conditions at statehood. Gage records with the majority of years of record in the 1940's and 1950's may predict average flow conditions below the long-term average, and well below the wetter conditions at statehood. Of course, stream gage data must also be filtered to account for human impacts on streamflow, such as reservoirs, irrigation diversions, and groundwater withdrawal. *In general, use of the existing stream gage database will probably result in prediction of flow rates slightly less than those that existed at statehood.*

For the Upper Salt River, any potential effects on runoff rates from climatic changes are almost completely obscured by human impacts on the stream system. These human impacts include, but are not limited to, the changes induced by construction of the reservoirs.

[8] Human impacts such as reservoir construction, ground water withdrawal, etc., have tended to lessen average stream discharge rates obscuring climatic affects on some Arizona streams.

Floods

Construction and operation of the Salt-Verde reservoir system has significant impacts on flood peaks in the study area.[9] Aldridge (1989) estimated, for instance, that the 123,000 cfs peak of the March 2, 1978 flood would have been about 260,000 cfs without storage of flood waters in reservoirs and canals. No flood recurrence interval data are available for the period prior to statehood, and gage records are not detailed enough to develop statistically significant estimates for this period. However, evidence of floods in the study reach was recorded in newspapers and by early residents and explorers. Bartlett (1854) describes seeing flood debris 15 to 20 feet above the channel bottom. Powell (1893) reports that floods of 10,000 to 20,000 cfs occurred annually (compare to data summarized in Table 18).

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[9] It is noted that until the 1996 improvements to Roosevelt Dam, none of the reservoirs on the Salt Verde River system were designed or operated for flood control purposes.

Table 18

Floods Greater Than 20,000 cfs, 1888-1939 (mean daily cfs)

Date	Discharge	Date	Discharge
1888	41,315	Jan. 20, 1916	83,475
Mar. 17, 1889	33,794	Apr. 18, 1917	27,668
Feb. 22, 1890	143,288	Mar. 9, 1918	45,375
Feb., 1891	285,000	Nov. 28, 1919	101,867
March, 1893	351,514	Feb. 23, 1920	108,600
Jan. 18, 1895	82,994	Sept. 17, 1925	20,000
Jan., 1897	35,109	Apr. 6, 1926	32,000
Apr. 2, 1903	21,500	Feb. 17, 1927	70,000
Nov. 27, 1905	199,500	Apr. 5, 1929	26,000
Mar. 14, 1906	67,000	Feb. 14, 1931	34,000
Mar. 6, 1907	50,770	Feb. 9, 1932	53,000
Dec. 16, 1908	63,000	Feb. 7, 1937	63,000
Jan. 2, 1910	294,000	Mar. 4, 1938	95,000

Note: After 1939, Bartlett Dam was closed, creating a measure of flow regulation on both branches of the Salt River system.

Flood Frequency Estimates. Flood discharge rates at various key concentration points are listed in Tables 19 and 20. Flow rates obtained from Flood Insurance Studies (FIS, 1991; 1992) are based on rainfall runoff modeling (Table 19) and are significantly larger than flow rates determined by the USGS (Garrett &Gellenbeck, 1991) using streamflow records (Table 20). The flood frequency data summarized in Table19 were determined considering the impacts of reservoirs and diversions on flood peaks. For comparison, a discharge-area regression equation developed by the USGS (Roeske, 1978) was applied for the basin characteristics at Granite Reef Dam. This equation, developed from regional stream gage records, predicts flood peaks for various recurrence intervals using the drainage area, mean basin elevation, and annual precipitation. The flood frequency data shown in Table 19 generally support early claims that floods of about 20,000 cfs occurred annually at the time of statehood.

Table 19
Summary of Salt River Discharges, Existing Conditions (cfs)

Location	Area (mi^2)	Flood Recurrence Interval					
		2-Year	5-Year	10-Year	50-Year	100-Year	500-Year
Verde-Tangle Creek[a]	5,589	16,000	39,400	61,300	128,000	164,000	-
Salt-Roosevelt[a]	4,306	13,800	36,000	60,000	150,000	208,000	-
Granite Reef Dam[b]	12,250	-	-	68,000[c]	175,000[c]	245,000	-
Granite Reef Dam[d]	12,250	-	22,000	60,000	150,000	175,000	250,000
USGS Eq'n[e]-Granite Reef	12,250	21,300	54,000	87,900	197,000	257,000	442,000

[a] Source: USGS, 1991; upstream of reservoirs
[b] Source: FEMA, 1991; accounts for reservoir attenuation prior to 1995 improvements to Roosevelt Dam
[c] Source: Newton, 1957 cited in Halpenny, 1966
d Flood frequency after 1996 improvements to Roosevelt Dam.
[e] Source: Roeske, 1978, does not account for reservoir attention or diversions

Table 20 Peak Discharge Estimates at USGS gages (cfs)						
Gage	Q2	Q5	Q10	Q25	Q50	Q100
Black River near Fort Apache	6,360	18,100	30,500	52,100	72,900	97,900
White River near Fort Apache	3,140	5,800	8,020	11,400	14,300	17,600
Carrizo Creek near Show Low	2,980	7,070	11,300	19,000	26,600	36,400
Salt River near Chysotile	9,750	23,600	37,800	62,800	87,500	118,000
Cibecue Creek near Chysotile	4,020	7,470	10,300	14,400	18,000	21,800
Cherry Creek near Globe	2,150	5,480	8,850	14,700	20,200	27,000
Salt River near Roosevelt	13,800	36,000	60,000	104,000	150,000	208,000
Tonto Creek above Gun Creek	11,200	25,700	39,000	60,100	79,100	101,000
Verde River below Tangle Creek	16,000	39,400	61,300	96,500	128,000	164,000
Notes: 1. Source: (Garrett & Gellenbeck, 1991) 2 All gages listed are located upstream of major reservoirs.						

Summary. Large flow rates occur frequently within the study reach, although peak discharges are somewhat attenuated by the Salt-Verde system of reservoirs. Annual peak discharges exceeded 20,000 cfs almost every year prior to construction of the dams (Table 17). Flows exceeding about 13,000 cfs continue to occur periodically upstream of Roosevelt Dam in Reach 1. Floods are part of the natural flow regime of the Upper Salt River study reach.

Hydraulic Rating Curves

Rating curves relate stream discharge to flow width, velocity, and/or depth. Rating curves for the Upper Salt River were developed from existing information obtained during the literature search and agency contact tasks for representative locations in each of the three Upper Salt River reaches. The objective for preparing rating curves was to estimate approximate flow conditions as of the time of statehood. Because the cross section geometry, slope, hydraulic roughness, and geology of natural rivers usually varies with distance and time, the estimated flow depths, widths and velocities should be considered average values, broadly representative of river conditions within a reach, rather than exact specifications of permanent river conditions.

A variety of information was used to obtain the estimates of hydraulic characteristics for each reach, for existing conditions and statehood conditions, as summarized in Table 21. As summarized in Section 4 of this report, the geomorphology of Reach 2 has been altered since the time of statehood. For existing conditions in Reach 2, reservoir impoundments have created a nearly continuous ponding area between State Route 288 upstream of Roosevelt Reservoir and Stewart Mountain Dam. These ponding areas may be assumed to have no effective velocity, and to have depths well in excess of 10 feet. The reservoirs are suitable for year-round operation of a wide variety of boats, including at least one commercially operated riverboat. Given the similar geology and geomorphology of Reaches 1 and 2, it was assumed that the rating curves for Reach 1 would be broadly applicable to the pre-statehood (pre-reservoir) conditions for Reach 2. For Reach 3, reservoir releases and impoundments have significantly altered the natural flow rates, and probably has made the river less subject to weather-, seasonal-, and climate-related flow variations, although no impact on the average channel cross section for Reach 3 was identified. Since no evidence of substantial geomorphic change since statehood was identified for Reach 3, the existing conditions rating curve was used. Reach 1 is substantially unchanged from pre-statehood conditions, and the existing condition rating curve was used to estimate statehood conditions.

Table 21
Upper Salt River Rating Curve - List of Source Data & Assumptions

Reach #	1912 Conditions	Existing Conditions
1	Assume Equivalent to Existing	USGS Rating Curve & Surveyed Cross Section
2	Assume Equal to Reach 1	Reservoir Ponding Areas
3	Historical USGS Discharge Measurements	Topographic Map Geometry

The geometry of the typical cross sections used in developing the rating curves is shown in Figure 3, and the rating curves for existing conditions are shown in Figure 4. Estimates of average channel depth, velocity and top width for each of the three reaches are shown in Table 22. Not surprisingly, the rating curves predict similar results for the entire Upper Salt River study reach.

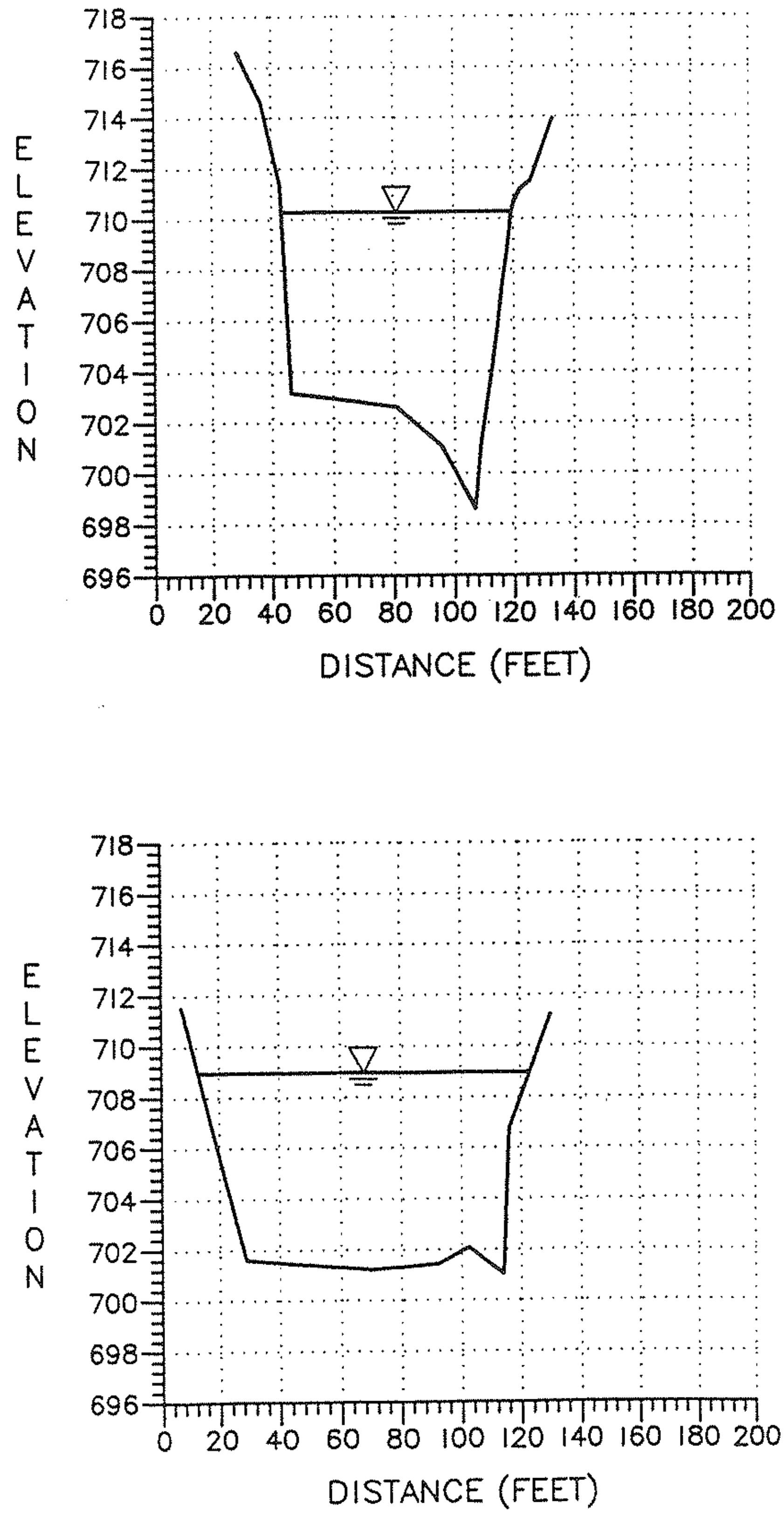
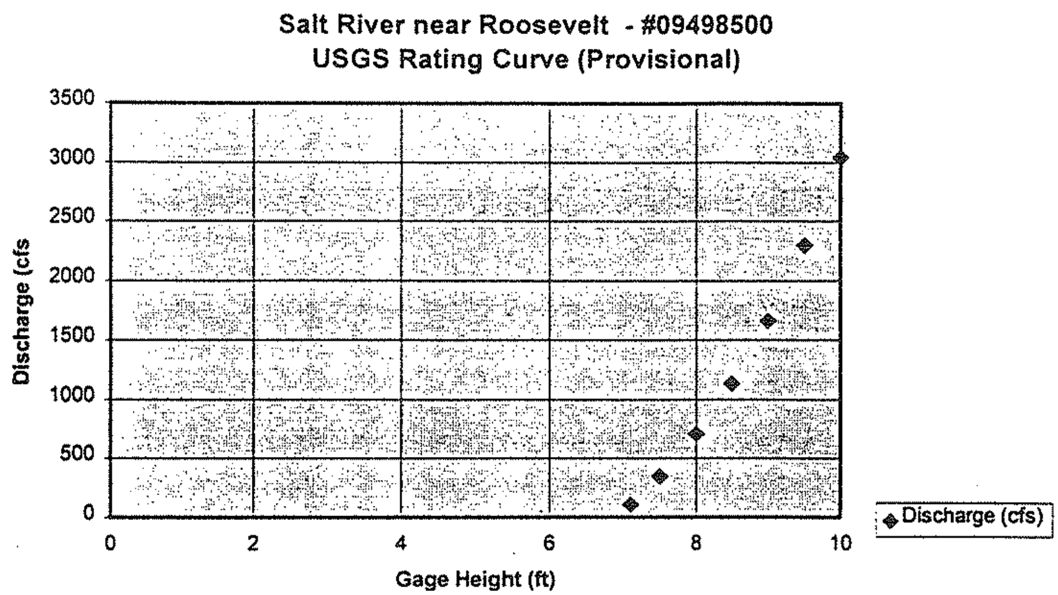


FIGURE 3

Rating Curve Cross Sections for Reach 1



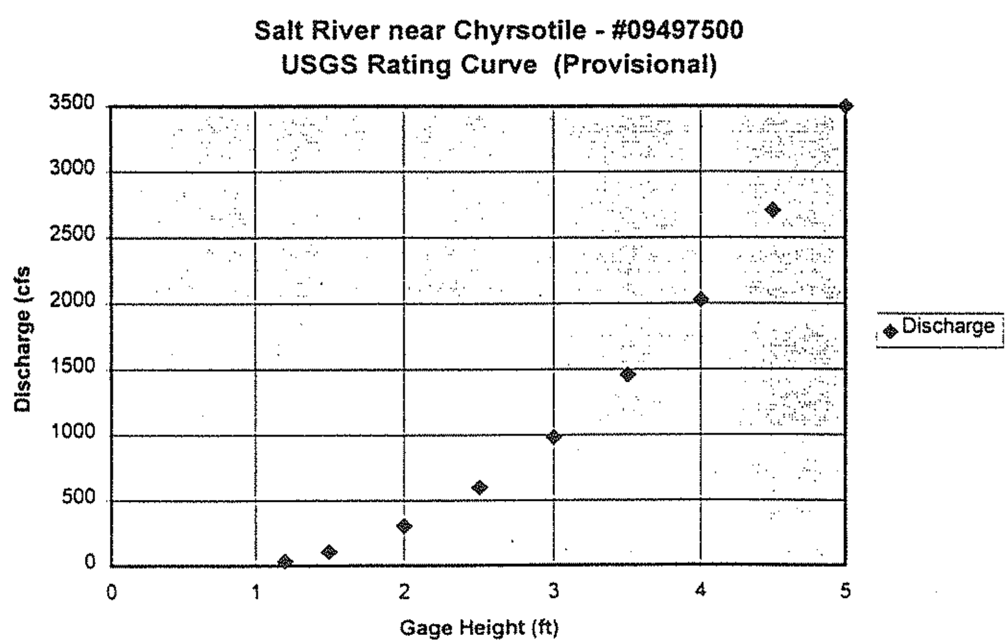


FIGURE 4

Existing Condition Rating Curves for the Upper Salt RiverGaging Stations

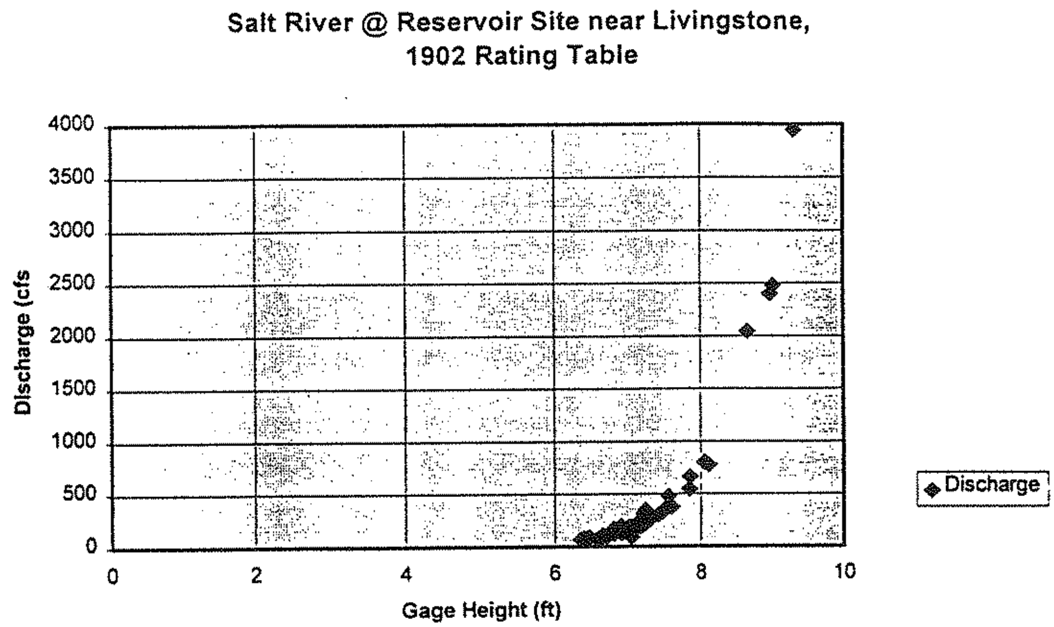
Table 22.
Upper Salt River Flow Characteristics

Recurrence Interval	Discharge (cfs)	Average Depth (ft)	Velocity (ft/sec)	Topwidth (ft)
Reach 1: Salt River Above Roosevelt - Shear Canyon Section				
Mean Annual Flow	896	1.4	2.4	266
2-Year Flood	13,800	7.1	6.9	295
5-Year Flood	36,000	12.2	9.8	308
Reach 1: Salt River Above Roosevelt - Canyon Section With Gravel/Boulder Bar				
Mean Annual Flow	896	3.6	4.5	55
2-Year Flood	13,800	8.1	7.8	221
5-Year Flood	36,000	14.1	11	230
Reach 2: Salt River Reservoirs - Existing Conditions				
Mean Annual Flow	896	> 10	0	> 1,000
2-Year Flood	13,800	> 10	0	> 1,000
5-Year Flood	36,000	> 10	0	> 1,000
Reach 3: Salt River Near Verde River Confluence - Alluvial Channel Section				
Mean Annual Flow	1,455	2.9	3.0	1,455
2-Year Flood	21,300	4.8	4.2	1,065
5-Year Flood	54,000	6.6	5.2	1,595

Some historical flow measurements were published by the US Geological Survey and US Reclamation Department around the time of statehood for the Upper Salt River. Sample gage height vs. discharge curves are shown in Figure 5. Gage height is equivalent to flow depth relative to some established (semi-)permanent datum. The historical gage sites reported in Figure 5 include:

- Salt River at Roosevelt Dam Site - located in Salt River Canyon near proposed Roosevelt Dam, downstream of confluence with Tonto Creek.

- Salt River at McDowell - located about 4000 feet upstream of the confluence of the Verde River downstream of the Salt River Canyon. The low flow channel width was about 150 feet, high flow width equals about 700 feet. The low flow channel reported to be shifting resulting in damage to thegaging station.



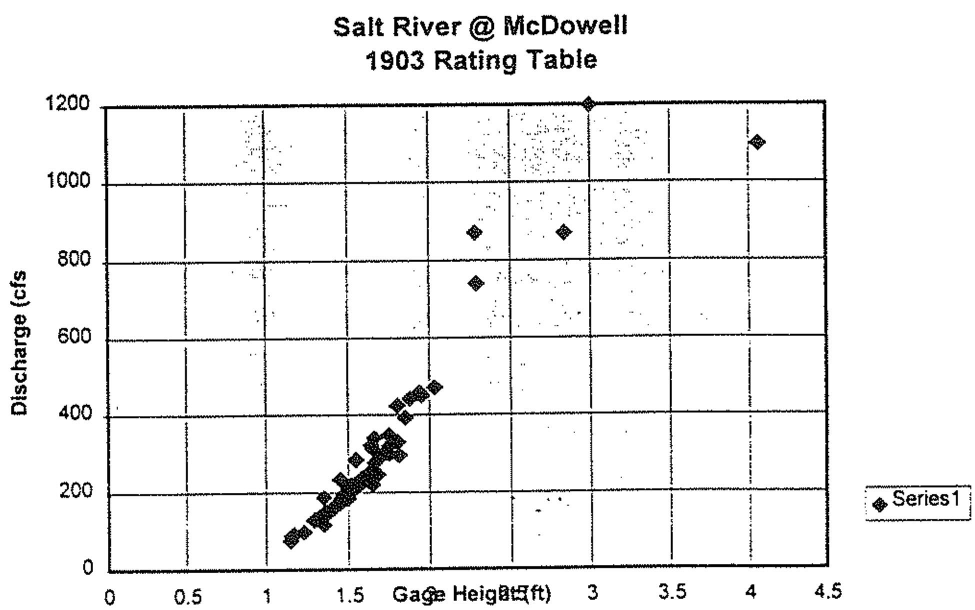


FIGURE 5

Historical Rating Curves for Upper Salt RiverGaging Stations

Summary

The Salt River Valley has a long history of reliance on the perennial flows from the Upper Salt River watershed. What flow rate is considered typical or average depends in part on what river conditions are considered "ordinary and natural." Prior to Anglo settlement, without any disturbance of natural conditions in the reach or upper watershed, the mean annual flow was about 1,300 to 1,700 cfs. The median flow rate exceeded 1,200 cfs during the pre-statehood period. That is, more than half of the time, flow rates greater than 1,200 cfs could be expected. Flow rates upstream of the Verde River confluence would have been slightly less, as shown in Table 17. In 1912, the year of statehood, the typical hydrologic condition of the river in Reaches 2 and 3 was in part a function of upstream water storage and downstream irrigation demands.

For Reach 1, and for Reaches 2 and 3 prior to construction of Roosevelt Dam, periods of low flow usually occurred during the early summer months of June and July, and may have been as low as 130 to 300 cfs upstream of the Verde River confluence, during a few dry periods. Average flow rates during the winter months and February typically exceeded 1,000 cfs, prior to the closure of Roosevelt Dam, with annual flood discharges approaching 20,000 cfs in Reach 3. After closure of Roosevelt Dam, winter flow rates were significantly reduced from the natural flow condition. Typical flow depths during the lowest seasonal flows were probably one to three feet deep, with average flow widths ranging from about 40 to 80 feet depending on the channel geometry of the canyon bottom (See Table 22). Typical flow depths for the average annual flow were probably about three to five feet deep. At higher flow rates, such as for the 2- and 5-year flood peaks (10,000 to 50,000 cfs), velocities typically would not exceed 10 feet per second.

According to boating criteria established by some federal agencies, as described in Section 6 of this report, and the hydraulic characteristics summarized in Table 22, the Upper Salt River was susceptible to use by canoes, kayaks, and rafts at flow rates ranging from the annual minimum flow to the 5-year flood peak. Use of keelboats, steamboats, and powered barges probably could not have safely occurred on the Upper Salt River in the conditions summarized in Table 22 due to shallow water, rapid velocities, narrow canyons, and natural obstructions such as riffles and waterfalls.

Given the criteria for navigability established by HB 2589, the hydrologic record for the Upper Salt River indicates the following:

- The Upper Salt River is perennial, with an average annual flow rate ranging from about 700 cfs upstream of Roosevelt Reservoir to about 1,500 cfs downstream of the Verde River confluence. At these discharge rates, flow depths, widths, and velocities of about 3 feet, 100 feet, and 4 feet per second may be expected. These river conditions are susceptible to boating using canoes, rafts, kayaks and other low-draft boats. Larger high-draft boats could not be used in these conditions.

- For the year of statehood, 1912, the average annual flow rate was about 1,200 cfs, making it a below average year of flow. The average flow rate for the month of February 1912 was about 400 cfs downstream of the Verde River and about 230 cfs upstream of Roosevelt Dam. Flow rates of about 400 cfs, approximately the average annual minimum flow rate, would result in average channel depths of about 1 foot or less in many reaches of the Upper Salt River. These flow rates and depths would make the boulder riffles in the canyon reaches less passable by most types of boats, except for canoes and kayaks. Use of keelboats, steamboats, and powered barges would not have been possible, particularly at low flow conditions, on the Upper Salt River.

- At the time of statehood, Roosevelt Dam was filling. Filling continued until 1915, during which period flow in the reaches downstream of the dam were severely restricted. However, the portion of Reach 3 downstream of the Verde River confluence remained free flowing.

- Diversions were made from the lower Salt River to irrigate and reclaim land, including diversion to Federal reclamation projects and Indian lands. Many of these diversions were appropriated prior to the time of statehood. These diversions, although they were located downstream of the Upper Salt River study reach, appropriated river flow from the Upper Salt River.

- There was at least one dam in the Upper Salt River at the time of statehood (Roosevelt) that could have created an impediment to certain types of navigation. However, while the dam may have been an impediment to downstream travel, navigability was improved within the reservoir created by the dam. Since statehood, a number of other dams and hydraulic structures have been constructed in the study reach.

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Arizona State Land Department

ARIZONA STREAM NAVIGABILITY STUDY

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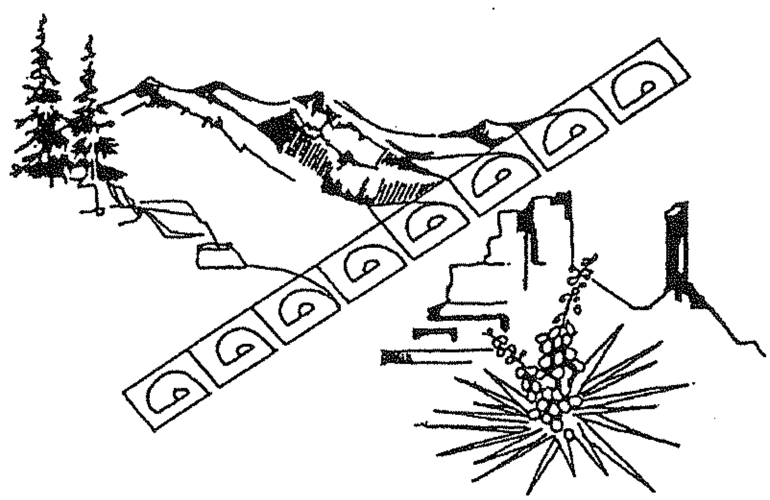
UPPER SALT RIVER

Granite Reef Dam to the Confluence of the White and Black Rivers

Final Report



Prepared by

SFC Engineering Company

In Association With

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SWCA, Inc. Environmental Consultants

March 1997

Section 6

Boating on the Upper Salt River

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&

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Boating on the Upper Salt River

Introduction

The exact boat types, stream depths, widths, velocities, and flow durations which define what "navigability" means for Arizona rivers have not yet been definitively established by ANSAC, although H.B. 2589 lists several boat types[1] to be used to establish a presumption of non-navigability. The objective of this section of the report is to provide information on federal boating criteria and the types of boating which have occurred historically on the Upper Salt River. Several types of information are presented including:

- Federal navigability criteria
- Historical accounts of boating
- Modern boating records

Historical and modern accounts of boating on the Upper Salt River are presented in this section. Historical boating on the river includes use of low-draft flatboats, skiffs, rowboats, canoes, and rafts. Modern boating on the river includes use of canoes, rafts, and kayaks. Boating on the Upper Salt River reservoirs includes historical use of boats during the construction of Roosevelt Dam and modern recreational boating using a wide variety of large and small boats. Other information on Salt River boating was presented in Section 3.

Federal Criteria for Navigability

Some federal agencies have formally described stream conditions which favor various types of boating. One such description was developed by an intergovernmental task force, the Instream Flow Group, to quantify instream flow needs for certain recreational activities, including boating (US Fish and Wildlife, 1978). The US Department of the Interior independently developed their own boating standards (Cortell and Associates, 1977). These federal criteria, summarized in Tables 1 and 2, were developed primarily for recreational boating, not necessarily for commercial boating. Minimum stream conditions required are summarized in Table 1. Minimum and maximum conditions are summarized in Table 2.

---

1 Keelboats, steamboats, and powered barges

Table 1 Minimum Required Stream Width and Depth for Recreation Craft		
Type of Craft	**Depth (ft.)**	**Width (ft.)**
Canoe, Kayak	0.5	4
Raft, Drift Boat, Row Boat	1.0	6
Tube	1.0	4
Power Boat	3.0	6
Source: US Fish and Wildlife, 1978		

Table 2 Minimum and Maximum Conditions for Recreational Water Boating						
Type of Boat	**Minimum Condition**			**Maximum Condition**		
	Width	**Depth**	**Velocity**	**Width**	**Depth**	**Velocity**
Canoe, Kayak	25 ft.	3-6 in.	5 fps	-	-	15 fps
Raft, Drift Boat	50 ft.	1 ft.	5 fps	-	-	15 fps
Low Power Boating	25 ft.	1 ft.	-	-	-	10 fps
Tube	25 ft.	1 ft.	1 fps	-	-	10 fps
Source: Cortell and Associates, 1977						

Some Arizona boaters surveyed for previous navigability studies did not agree with the minimum velocity criteria given in Table 2. They argue that since boats can be used on lakes and ponds which have no measurable (zero) velocity, no real minimum velocity exists, except perhaps for tubing. Therefore, it is assumed that the minimum velocities in Table 2 are probably intended to indicate what stream conditions are most typically considered "fun."

The Bureau of Land Management (BLM) apparently has adopted a "narrow" definition of navigability (Rosenkrance, 1992). BLM criteria to determine title navigability include:

- The original condition of waterway at date of statehood is used.
- Use by small, flat bottom sport boats or canoes is not navigation.
- Navigation must occur at times other than seasonal floods.
- Inaccessible streams are not navigable.
- Long obstructions such as bars makes upstream segments non-navigable.

No documentation of application of these guidelines by the BLM in Arizona was uncovered, although the BLM did not consider the Salt River (Lower Salt River, and Reaches 2 and 3 of the Upper Salt River) navigable at statehood due to the closure of Roosevelt Dam (BLM, 1964). Also, the BLM navigability criteria do not necessarily conform to the federal or Arizona definition of navigability. Other federal agencies have stated that the Salt and Verde are non-navigable streams, as discussed below, although specific criteria which formed the technical bases of these decisions are lacking.

Historical Accounts of Boating

Boats were in use during the period around statehood. Newspaper stories, contemporary reports, anecdotal information, and oral histories all provide evidence of boating on Arizona rivers. Documented uses of boats included:

- Travel
- Recreation
- Transport of Goods

Several accounts of floating logs down Arizona rivers are also documented. Review of historical records of boating gives the general impression that there was no shortage of boats in Arizona. Whenever a boat was needed to cross a flooded river, even during the period of early exploration, boats were borrowed from local residents, used and returned. The presence of boats in arid regions like Arizona, despite there being no sizable lakes within several days travel, argues for occasional, or necessary, use of boats on the river.

The most extensive documentation of historical river boating in Arizona is for the Salt River. Prior to statehood, before irrigation diversions and closure of dams upstream depleted river flows, at least five ferries were in operation at various locations between Granite Reef Dam and the Gila River. Sixteen episodes of boating, involving portions or the entire study reach, were recorded. A few, but not most of these boating episodes were unsuccessful, though not for lack of streamflow within the study area. Typical problems encountered included snags and sandbars in the lower Salt River, or the rapids and falls in the narrow canyons of the Upper Salt River.

It is noted that for all of the instances of boat use on the Salt River, the boaters traveled downstream or across the river. No evidence of boating in the upstream direction was found. Boating on the Salt River apparently was not limited to the wetter months or seasonal floods. Several accounts of boating the Salt River during May and June, two months which typically have annual minimum flows. Both attempts to float logs were conceived and attempted by Salt River Valley residents during summer months, not winter high flow periods.

The type of boats typically used were flat-bottomed boats, skiffs, or canvas and wooden canoes. Information presented in Table 3 summarizes probable stream characteristics required to support use of the types of boats available at statehood. The criteria for canoes are not substantially different from criteria for canoes available today.

Table 3
Flow Requirements for Pre-1940 Canoeing

Boat Type	Depth
Flat Bottomed (Wood or Canvas)	4 in.
Round Bottomed (Wood or Canvas)	6 in.

Source: Slingluff, J., 1987

Historical Accounts of Fish

Although the presence of fish in a river does not necessarily indicate that boatable conditions exist, existence of certain species do provide some information about flow conditions. Archaeological evidence indicates that the same species found in Arizona rivers in prehistoric times were also present around the time of statehood (James, 1992). Change in fish species distributions did not occur in most rivers until the 1940's (Minkley, 1993). Some of the species found in the Salt River included very large fish such as squawfish (aka Salt River Salmon, Colorado River Salmon, some of which grow to over three feet long), razorback sucker, and flannelmouth sucker. The latter fish tend to indicate "big river" conditions (Minkley, 1993), by Arizona standards, at the river localities where these fish are found. Historical accounts of fishing are centered on early explorer routes and settlements. There are numerous accounts of "salmon" runs (actually squawfish) on the Lower Salt River, and of catching hundreds of fish from the Salt River near Phoenix, and of fish left to die after canals diverted streamflow.

Modern Accounts of Boating

Some Arizona rivers are still boated in modern times. While modern boat use of a river may not provide definitive proof of susceptibility of a stream to navigation at statehood, it is evidence that is readily available for consideration. Given that no evidence of substantive change in stream geomorphology and hydrology was identified for Reach 1 of the Upper Salt River, modern boating records are directly applicable to historical conditions. Boat-making technology has improved since the time of statehood, with the use of inflatable rafts, inflatable and hard-shell kayaks becoming some of the preferred modes of recreational travel (and commercial operations offering recreational trips). However, while canoe technology has changed to make these boats more durable, the depth of water required for canoeing has not substantially changed. In addition, flow rates on Arizona rivers have generally declined since the time of statehood. Therefore, modern use of a river reach by canoes probably indicates that canoes could have been used as of the time of statehood.

The Central Arizona Paddlers Club (CAPD), an organization of boaters, recently conducted a survey of their members to determine what rivers had been boated (see Table 4). With 20 percent of members responding, the survey indicated that all of the Upper Salt River study reach has been boated in recent years (Central Arizona Paddlers Club, 1992). Informally polled CAPD members willing to be interviewed also estimated flow conditions at the time the various rivers were boated.

The entire Upper Salt River study reach is regularly boated, primarily during winter and spring flow. Arizona State Parks (1978) lists the Upper Salt River in its outdoor recreation and boating guide. A boating guide to the southwest lists the Upper Salt River (Anderson, 1982) as a rafting stream. Several commercial recreational rafting trip outfitters currently hold U.S. Forest Service leases for commercial operations on the Upper Salt River. Numerous boating activities occur on the Salt River reservoirs, including some relatively large passenger-oriented paddleboats. Modern boating using canoes, rafts, and kayaks on the Upper Salt River Reach 1 occurs throughout the entire year, although most boating is done during the late winter and spring during the annual high flow period. Modern boating on Reach 2 of the Upper Salt River occurs year round due to improved boating conditions on the reservoirs. Modern boating on Reach 3 of the Upper Salt River occurs during most of the year, except when the river flow is stopped during periods when the canals downstream of Granite Reef dam are maintained.

Table 4
Central Arizona Boaters Club Survey Results: Selected Reaches Boated & Estimated Flow Conditions

River	Reach	Date mo-yr	Flow (cfs)	Depth (ft)	Width (ft)	Craft	Portage (%)
Upper Salt	Above Roosevelt	Many	200+			canoe, raft, kayak	0
	Below Roosevelt, on reservoirs	All year	n/a	> 10	> 1,000	power, all others	0
	Below Stewart Mountain Dam	All year	200+			canoe, raft, kayak	0

Summary

The Upper Salt River was used for boating and transport of materials as of the time of statehood (Section 3). Historical hydrologic conditions in the Upper Salt River (Compare Tables 4 and 2) probably would have met current federal critieria for some types of recreational boating, for most of the year. No evidence of boating in the upstream direction along the Upper Salt River, or use of large machine-powered boats was found. No evidence of significant commercial boating industries developed on the Upper Salt River as of 1912 was uncovered. Reach 1 is currently boated for recreational purposes, primarily during the winter and spring months. Reach 2 is currently boated throughout the year, due to improved boating conditions on the reservoirs. Reach 3 of the Upper Salt River is currently boated for recreational purposes during most of the year.

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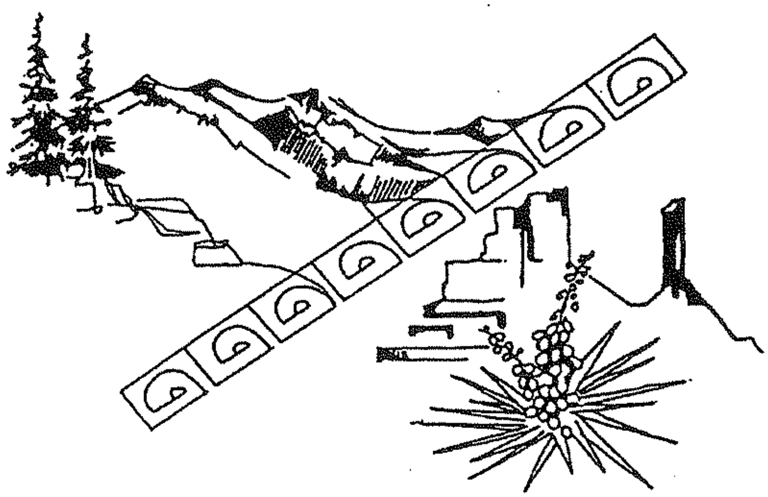

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Section 7

Navigable Rivers Land Use GIS

I. Methodology

A Geographic Information System (GIS) was developed depicting the 100-year floodplain and land ownership/use within the floodplain (see Appendix A for data organization). The GIS was designed not to aid in the determination of navigability but to help study the impacts should the river be found navigable. Information regarding the ownership and use of land in the vicinity of the river may be depicted as maps or as statistics.

The general land ownership categories depicted by the GIS are as follows:

Ownership Categories

Private
State of Arizona
Bureau of Land Management (BLM)
U.S. Forest Service
National Wildlife Refuge
National Park Service
Indian Reservation
Other / No Data

The general land use categories depicted by the GIS are as follows:

Land Use Categories

Vacant Land
Residential - Single Family
Residential - Multiple Family
Hotel - Motel - Resorts
Condominiums
Commercial Property
Industrial Property
Farm/Ranch Property
Public Utilities
Natural Resources
Special Use Property
General Service Use

Additional data are also contained in the GIS, such as county, township, range, section, book, map, parcel, source, legal parcel area, state land use code, and owner descriptions.

A. Base Data

The base layers for the GIS, including rivers, counties, and public land survey system, were obtained from the Arizona Land Resources Information System (ALRIS) maintained by the Arizona State Land Department (ASLD). Additional river data were obtained from 1:100,000 scale Digital Line Graph (DLG) files maintained by the United States Geological Survey (USGS).

B. Floodplain

The 100-year floodplain was digitized from Federal Emergency Management Agency (FEMA) maps of varying scales. Georeferencing (i.e. registration of map data to real world coordinates) was accomplished via section corners and, in a few circumstances, street intersections. Arbitrary lines were digitized at junctions with tributary floodplains. Adjacent maps were edgematched; significant mismatches were not adjusted but were closed using straight line segments.

C. Land Ownership/Use

Parcels were digitized from paper County Assessor maps. Georeferencing was accomplished using the following:

1) Section corners or subdivisions (e.g. quarter-quarter-section corners),

2) Legal descriptions using a section corner or subdivision as a reference point,

3) Distances, based on map scale, from a section corner or subdivision,

4) Corresponding features in a smaller scale map (e.g. a map of a housing development might be registered via its corresponding outline depicted in a section map), and/or

5) Adjacent features.

Digitizing was accomplished as follows:

1) Clearly delineated parcel boundaries were digitized as depicted. Lines in large scale maps generally took precedence over corresponding lines in small scale maps.

2) Areas of parcel overlap were assigned to one parcel or the other as deemed best. Unclear boundaries between two parcels were digitized according to best judgement.

3) Parcels of vague or undepicted location were not digitized unless an outline could be obtained from an alternate source (e.g. ALRIS data or USGS 1:100,000 DLG files).

4) Linear (non-polygonal) parcels, depicting railroad right-of-way (ROW), were not digitized. An exception was made if adjacent parcels clearly depended on a ROW edge, in which case a 200' wide corridor was applied.

When necessary, adjacent maps were edgematched. Small scale features were adjusted to large scale features. Attributes were assigned in a fashion consistent with ASLD's Gila River coverage:

1) Parcel numbers were assigned where clearly designated, unless the parcel clearly was non-private (State, BLM, etc.), in which case a "non-private" parcel code (AZ, BLM, etc.) was assigned.

2) Parcels which were not numbered, but were clearly labeled (Arizona, U.S.A., etc.) were assigned non-private codes as appropriate. Where a conflict existed between assessor maps and ALRIS data over USA versus State ownership, the ownership reflected in the ALRIS data was assigned.

3) Unlabeled or questionable parcels, uncoded road and rail ROW parcels, parcels outside the floodplain, and undigitized regions were assigned a zero parcel number.

4) Sections outside the study area were assigned "background" (BACK) parcel codes.

Relate files, containing land ownership and use data, were generated from State Revenue data. A list of parcel values was generated from the digitized parcels and submitted to the State Revenue office. Data received from the State Revenue office were converted to a table and reprocessed. If, after a quality check, the ID of a digitized parcel was not listed in the State Revenue data (e.g., if a parcel split or merge had not yet been depicted on the County Assessor map), it was assigned "Other / No Data" ownership.

D. Plots

Once all datasets were assembled, checked, and finalized, they were transported to the State Land Department building in Phoenix. Annotation coverages were be created for the final plots, and existing scripts and tables adapted to production of the final plots. One complete series was created for each river reach.

II. Results and Discussion

The study area was divided into six map sheets for plotting purposes. Floodplain maps were only available for two portions of the study area: sections 3-5 of T2N R7E and sections 32-34 of T3N R7E, and Theodore Roosevelt Lake.

All private parcels were digitized from paper maps with two exceptions in Gila County: the position of Parcel 3 in Book 203 Map 2 was incorrectly depicted, and no outline was depicted for Parcel 1 of Book 203 Map 25. In both cases, outlines were obtained from the ALRIS LAND coverage. The boundaries of the Salt River Indian Reservation, White Mountain Apache Reservation, and San Carlos Apache Reservation were obtained from USGS 1:100,000 DLG files.

Ownership Category	Percent
Private	0.4
U.S. Forest Service	76.5
National Wildlife Refuge	11.6
National Park Service	0.3
Indian Reservation	11.2

Land Use Category	Percent
Vacant Land	< 0.1
Residential - Multiple Family	< 0.1
Commercial Property	< 0.1
Industrial Property	0.1
Farm/Ranch Property	0.2
Natural Resources	< 0.1
General Service Use	99.6

Appendix A: GIS Data Organization

A. Base and Reference Layers from ALRIS

Name	Contents
AZTRS	Public Land Survey System of Arizona
COUNTIES	County Boundaries
HYDRO	Hydrology
LAND	Surface Management
RAILS	Railroads
TRANS123	Major Roads

B. Data Organization

A separate workspace is created for each river reach. The principal ARC/INFO coverages contained in each workspace are FLOOD, depicting the 100 year floodplain, PARCELS, containing digitized parcels, RIVER, depicting the river itself, and SHEETS, depicting the mapsheets.

1. FLOOD

The FLOOD coverage has polygon topology wherever possible. The PAT contains the following item:

ITEM NAME	WIDTH	TYPE	N.DEC
IN_OUT	3	C	0

IN_OUT Values:
in = Part of floodplain
out = Not part of floodplain

2. PARCELS

The PARCELS coverage has polygon topology. The PAT contains the following items:

ITEM NAME	WIDTH	TYPE	N.DEC
TOWNSHIP	4	C	0
RANGE	4	C	0
SECTION	2	C	0
COUNTY	2	N	0
BOOK	3	C	0
MAP	3	C	0
PARCEL	4	C	0
CODEDATE	8	D	0
OWN_CODE	12	C	0
SOURCE	20	C	0
CATEGORY	10	C	0

Items TOWNSHIP, RANGE, SECTION, and COUNTY conform to the data dictionary of the ALRIS LAND layer.

Parcels which have a book, map, and parcel number, are coded as follows:

ITEM	Example
COUNTY	9
BOOK	103
MAP	043
PARCEL	1A
OWN_CODE	091030431A

Other parcels are coded as follows:

STANDARD CODES FOR NON-PRIVATE PARCELS

ITEM	Example
BOOK	101
MAP	040
PARCEL	0
OWN_CODE	0

PARCEL Values:

0	=	No data or "other" (e.g. Right-of-Way)
AKCH	=	Ak-Chin (Maricopa) I.R.
ASNF	=	Apache-Sitgreaves NF
AZ	=	State of AZ
BLM	=	BLM
BWR	=	Bill Williams N.W.R.
CONF	=	Coronado National Forest
GILA	=	Gila River I.R.
NAV	=	Navajo I.R.
PFNP	=	Petrified Forest NP
SANC	=	San Carlos I.R.
SANX	=	San Xavier I.R.
SALT	=	Salt River I.R.
SRWR	=	Salt River N.W.R.
TOHO	=	Tohono O' Odham (Papago) I.R.
TONF	=	Tonto National Forest
TONM	=	Tonto National Monument
WMA	=	White Mountain Apache I.R.

"Background" parcels, i.e., sections outside the study area, are coded as follows:

ITEM	Example
BOOK	999
MAP	999
PARCEL	BACK
OWN_CODE	BACK

The CODEDATE item contains the date of completion of the coverage. The principal source used to determine the geometry of a particular parcel is documented via the SOURCE item.

SOURCE Values:

ASLD Base	=	Base data from AZ State Land Dept. (AZTRS)
County/Paper	=	County Assessor paper maps
County/Digital	=	County Assessor digital maps
County/GIS	=	County GIS
USGS 100K DLG	=	USGS 1:100,000 DLG files
ALRIS LAND	=	ALRIS LAND coverage
Various	=	Various Sources

The CATEGORY item is a temporary item used in the generation of status maps.

Each PARCEL coverage has a relate file, OWNDATA, with the following structure:

ITEM NAME	WIDTH	TYPE	N.DEC
OWN_CODE	12	C	0
OWNER	2	N	0
LC	2	C	0
DEL_FLAG	1	C	0
STATUS_DAT	8	D	0
LAND_USE	4	C	0
AREA	8	C	0
UNITS	1	C	0
OWNER1	40	C	0
OWNER2	40	C	0
OWNER3	40	C	0

OWN_CODE is the relate item to the PARCELS coverage. OWNER is the ownership lookup code and LC the use lookup code, used for querying and plotting. DEL_FLAG is a State Revenue record code, probably indicating a record slated for future deletion. STATUS_DAT is the date of the record. LAND_USE is the four-digit State land use code. AREA is the legal area of the entire parcel. UNITS is the units of the legal area (acres or square feet). OWNER1 through OWNER3 are the first three fields of the taxpayer name and address section.

3. RIVER

The RIVER coverage has line topology. There are no additional attribute items.

4. SHEETS

The SHEETS coverage has line topology. The AAT contains the following item:

ITEM NAME	WIDTH	TYPE	N.DEC
SHEET	2	N	0

Values correspond to the mapsheet number.

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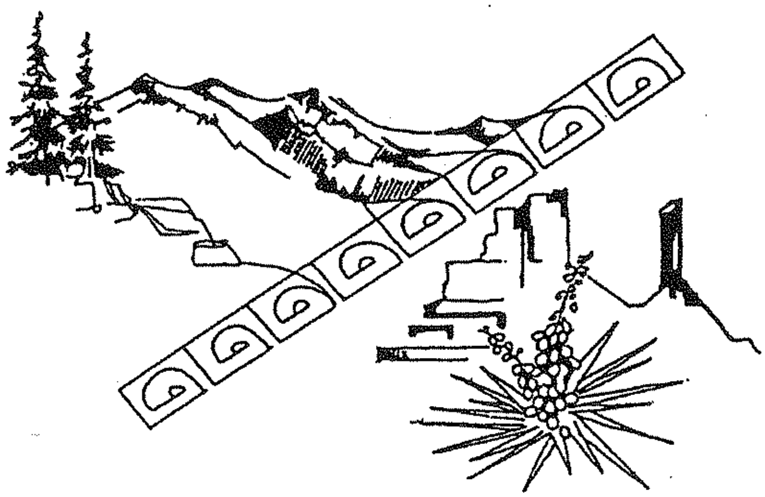
Final Report



Prepared by

SFC Engineering Company

In Association With

George V. Sabol Consulting Engineers, Inc.,

JE Fuller/Hydrology & Geomorphology, Inc.,

and

SWCA, Inc. Environmental Consultants

March 1997

Section 8

Summary for the Upper Salt River

Prepared for

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Section 8
Summary

The Upper Salt River has been a reliable source of water for the Salt River Valley for more than a millennium. River flow passing through the Upper Salt River has supplied water for irrigation and municipal purposes, hydropower, recreational and commercial boating opportunities, fishing, swimming and other recreational uses. This report has documented the continuous use and changing conditions of the Upper Salt River from the time of the Hohokam, through the period around statehood, and up to the modern era.

The Native American Hohokam civilization in central Arizona was dependent on water diverted from the Salt River to support their agricultural economy. TheHohokam built an extensive irrigation system that included approximately 315 miles of canals that provided water to about 140,000 acres of farmland, and supported a population of about 200,000. The water that supplied this extensive canal system was ultimately derived from the Upper Salt River. Archaeological records indicate that numerous fish species, similar to those described by early Anglo residents and explorers, populated the Salt River and supplemented the diet of the Hohokam. Archaeological records also indicate that climatic conditions and streamflow rates were not significantly different from conditions around the time of statehood.

The first Anglo explorers of the Upper Salt River found it in much the same condition that existed when the Hohokam and Apache settled in the area. The river had reliable streamflow, healthy beaver populations, a variety of large fish species, and dense riparian vegetation. EarlyAnglo residents floated canoes, flatboats, and logs down the river, although the primary mode of transportation was on foot, horseback or wagon. At least eight documented accounts of commercial and recreational boating on the Upper Salt River between 1870 and 1910 were identified as part of this study. Some types of boating occurred during all months of the year during the period leading up to statehood. One successful attempt to float logs to Tempe from the upper watershed above Roosevelt took place during the month of June (1885), typically a month of seasonal low flows.

Use of boats on the riverine portions of the Upper Salt River was limited to shallow water, low-draft, floating boats used only in the downstream direction. Steamboats and commercial shipping operations like those found on the Colorado and lower Gila Rivers apparently were not developed on the Upper Salt River. The boats used on the Salt River sometimes encountered difficulties in transit due to snags, boulder riffles, narrow canyons, waterfalls, or other natural hazards, and experienced difficulties at man-made obstructions such as irrigation diversions. A variety of boats were used to construct Roosevelt and Granite Reef dams, including a gas launch and boats used to haul construction materials to the dam site. Since the closure of Roosevelt Dam in 1911, recreational boating has been popular on Roosevelt Reservoir. Recreational and commercial rafting has been conducted on the Upper Salt River upstream of Roosevelt Reservoir since the 1950's.

By 1912, reservoir impoundments had lessened flow rates in the river channel itself, though the natural water supply upstream of Roosevelt Dam was no less reliable than in previous years. Documented accounts of boat use after 1911 on the Salt River downstream of Roosevelt Dam were limited to periods of high flow and floods. During the period after Roosevelt Dam was closed, and Roosevelt Reservoir was filling, streamflow in Reaches 2 and 3 of the Upper Salt River was limited to flood discharges and flow releases to supply downstream irrigation diversions. However, even during this period of reduced low flow in the Salt River, winter discharges could occupy the channel for months at a time, making the river susceptible to recreational boating using canoes, kayaks, rafts and other low-draft boats.

Review of geologic conditions in the Upper Salt River indicates that the channel geomorphology is substantially unchanged from the conditions at or before statehood, except where the river has been inundated by the reservoirs. The Upper Salt River is formed within deep canyons. Bedrock in these canyons has prevented significant channel changes from occurring. In addition, the bedrock geology of the Upper Salt River area made access to the river difficult during the period around statehood, prevented development of extensive irrigation systems, and created natural impediments to types of boats that could not be portaged. However, the bedrock geology of the Upper Salt River was conducive to construction of large dams and water supply reservoirs. Construction of the four reservoirs induced the only significant changes in the natural geomorphology of the study Reach. In addition to the obvious changes in downstream runoff rates caused by the reservoirs, the ordinary high watermarks and ordinary low watermarks located were changed by impounding water along the Upper Salt River system.

The Salt River Valley has a long history of reliance on the perennial flows from the Upper Salt River watershed. Without considering any disturbance by humans, the mean annual flow rate ranges from about 700 to 1,500 cfs, with relatively minor flow attenuation within the Reach due to shallow groundwater levels, narrow bedrock canyons, and perennial flow. In the year of statehood, 1912, the typical hydrologic condition of the river in Reaches 2 and 3 was in part a function of upstream water storage and downstream irrigation demands. For Reach 1, and for Reaches 2 and 3 prior to construction of Roosevelt Dam, periods of low flow usually occurred during the early summer months of June and July, and may have been as low as 100 to 300 cfs upstream of the Verde River confluence during the driest months of the year. Average winter flow rates typically exceeded 1,000 cfs prior to the closure of Roosevelt Dam, with annual flood discharges approaching 20,000 cfs in Reach 3. After closure of Roosevelt Dam, until it filled in 1915, winter flow rates were significantly reduced from the natural flow condition.

Typical flow depths during the lowest seasonal flows were probably one to three feet deep, with average flow widths ranging from about 50 to 100 feet depending on the channel geometry of the canyon bottom. Typical flow depths for the average annual flow were probably about three to five feet deep. At higher flow rates, such as for the 2- and 5-year flood peaks, velocities typically did not exceed 10 feet per second, which is within the range of boatable conditions for canoes, kayaks and rafts.

Under HB 2589, the Arizona Legislature defined navigability criteria that establish a presumption of non-navigability to be used by ANSAC when considering evidence for specific streams. For the Upper Salt River, the following data described in this report relate to the State's navigability criteria:

- **Commercial Trade and Travel** As of the time of statehood, the Upper Salt River was susceptible to limited forms of commercial trade and travel. The hydrologic and historical record shows that there was sufficient water in the river that would allow use of shallow water boats during regularly occurring portions of the year. Shallow water boating in the downstream direction was most feasible, given the normal conditions of the Upper Salt River.

- **Flow Regime.** As of the time of statehood, the hydrologic record shows that the Upper Salt River was and is a perennial stream. That is, it flows at times other than in direct response to precipitation. Like all rivers, the Upper Salt River responds to excess precipitation with increased flow rates. However, even during the driest portions of the year, the entire Upper Salt River remains perennial despite impoundment of flow in four major reservoirs.

- **Sustained Trade and Travel Upstream and Downstream** There was no evidence identified for this study that sustained trade and travel ever occurred on the Upper Salt River, nor is there evidence that trade or travel in the upstream direction ever occurred. However, the hydraulic rating curves indicate that some types of boat traffic could have occurred both upstream and downstream during regularly occurring portions of the year, although upstream travel would have been more difficult than downstream travel.

- **Profitable Commercial Enterprise** There was no historical evidence identified for this study that profitable commercial enterprises were conducted using the Upper Salt River for trade and travel as of the time of statehood.

- **Types of Vessels.** The historical record indicates that canoes, flat boats, rafts, rowboats, skiffs, and floating logs were the only vessels to be used on the Upper Salt River. Historical records indicate that use of any type of boats on the river diminished by the time of statehood. Keelboats and other powered barges were used on the Upper Salt River during the construction of Roosevelt Dam from 1906 to 1911, and have been used on the Salt River reservoirs since statehood. The hydraulic rating curves prepared for the Upper Salt River study reach indicate that large keelboats, steamboats or powered barges could not have been used during the low flow conditions on the river itself as it existed in 1912. During high flows, high velocities and river conditions may have made use of these types of high-draft boats hazardous or impractical.

- **Diversions.** Irrigation diversions at Granite Reef Dam, the downstream end of the Upper Salt River study reach, removed the entire flow from the Salt River as of 1912. Some lands irrigated with water from the Upper Salt River were covered under the Desert Land Act of 1877, or were within an Indian Reservation. It is uncertain whether any of the local irrigation diversions along the Upper Salt River upstream of Granite Reef Dam were for lands covered under the Desert Land Act of 1877.

- **Recreational Boating.** Most, but not all, of the historical accounts of boating on the Upper Salt River were for recreational purposes.

- **Regular Flotation of Logs.** Logs or other material probably could have been floated through the entire Upper Salt River as of the time of statehood throughout the entire year, although some type of portage would have been required in some reaches and at Roosevelt Dam.

- **Impediments to Navigation.** Roosevelt Dam was the only known non-natural impediment to navigation in the Upper Salt River that existed in 1912.

- **Customary Modes of Transportation** The customary mode of transportation in the region near the Upper Salt River was not by boat. By 1912, alternatives to boat travel included foot, horse, mule train, wagon, and train.

- **Rivers and Harbors Act of 1899.** The Salt River is not one of the streams listed under the Rivers and Harbors Act of 1899.

The Salt River could have and did support some types of boating during the period prior to statehood. By 1912, use of boats on the river had declined, but was still possible during most years, a condition which persists today.

Arizona State Land Department

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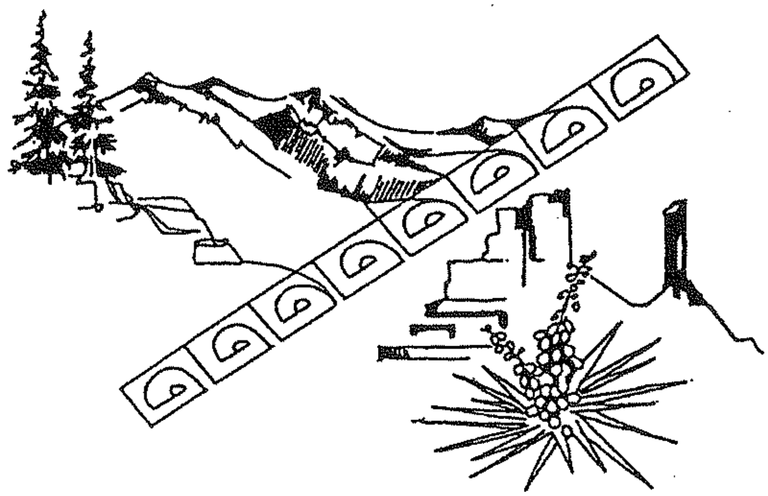

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Glossary

GLOSSARY

Acequia - An irrigation ditch or canal.

Aggradation - Progressive deposition of sediment, raising the elevation of thestreambed. See Degradation.

Alluvial - See Alluvium.

Alluvial Fan - A large fan-shaped accumulation of sediment; usually formed where a stream's velocity decreases as it emerges from a narrow canyon onto a flatter plain at the foot of a mountain range.

Alluvial Stream - A stream whose bed and banks are formed in sediment transported by the stream itself; a stream with a non-bedrock channel.

Alluvium - A general term for eroded rock material, including soil, deposited by rivers; loose sediment, often from the recent geologic past.

Anecdotal - Undocumented evidence or accounting of an event.

Aquifer - A water-bearing bedrock or alluvium layer.

Archaeology - The systematic recovery, and scientific study, of material evidence of human life and culture from past ages. The study of antiquity.

Arroyo - A term used in the southwest to describe an entrenched, dry wash.

Average Flow - See Mean Flow.

Avulsion - In geomorphology, an avulsion is the sudden relocation of a stream away from its original flow path, usually due to catastrophic sediment deposition in the original flow path.

Bajada - A piedmont comprised of coalescing alluvial fans.

Base Flow - Stream discharge which does not fluctuate in response to precipitation. The minimum discharge in a stream.

Base Level - The minimum elevation to which a stream can erode.

Basin and Range - One of three physiographic provinces in Arizona. The Basin and Range is characterized by elongated, parallel mountain ranges trending northwest to southeast, with intervening basins filled by alluvium eroded from the mountains.

Braided - A braided stream is one flowing with branching and reuniting channels. May be ephemeral or perennial.

Cadastral Survey - A land (legal) survey.

Central Mountain Province (Transition Zone) - One of three physiographic provinces in Arizona, characterized by deeply eroded mountains composed ofgranitic bedrock.

CFS - Abbreviation for cubic feet per second, a measure of the rate of stream flow.

Channelization - The process of a stream changing from a broad unconcentrated flow path to a more confined, or single flow path.

Confluence - The point where two streams join.

Continuous Gage - A type of stream measuring equipment that records water surface elevations continuously throughout a flood, or over a long period of time regardless of flow conditions. Water surface elevations in the stream can be related to discharge rate.

Control - The river reach or structure which governs stream flow characteristics at a stream gage is called the control. A gage with reliable, consistent stream flow characteristics has "good control."

Crest Stage Gage - A type of stream measuring equipment that records only the highest water surface elevation during a flood or flow event. Water surface elevation can be related to stream discharge rate through use of a rating curve. See Continuous Gage.

Degradation - Channel bed erosion resulting in a topographically lowerstreambed.

Dominant Discharge - The dominant discharge is the stream flow rate responsible for forming a stream=s geometry. This theory is tenuous when applied to streams in Arizona or bedrock streams.

Empirical - Empirical methods are based on experimentally derived equations, rather than theoretically derived equations.

Entrenchment (Entrench) - Progressive degradation of a streambed or channel resulting in a topographically lower channel bottom usually with steep or vertical banks; a process associated with arroyo formation.

Ephemeral Stream - A stream which flows only in direct response to rainfall. It receives little or no water from springs and no long continued supply from snow or other sources. Its channel is at all times above the water table.

Equilibrium - Balance. When applied to streams, equilibrium means lack of change.

Erosion - Removal of bedrock or alluvium by water or wind.

Flash Floods - Floods which reach their peak discharge rate very quickly are flash floods. In Arizona, the term is often used to describe a flood or flow event moving down a previously dry river channel.

Flow Duration Curve - A cumulative frequency curve depicting the percent of time a given discharge on a stream is equaled or exceeded in a specific period. For instance, a 10 percent flow of 20 cfs means that the stream discharge only exceeds 20 cfs 10 percent of the time; a 90 percent flow of 1 cfs means that the stream flows at discharges greater than 1 cfs 90 percent of the time; the 50 percent flow is the median (not average) flow rate.

Fluvial - Relating to stream flow.

Fluvial Geomorphology - The branch of geomorphology relating to streams. See Geomorphology.

Ford - A river crossing; usually, but not necessarily, with shallow flowing water.

Frequency Distribution - A table which presents data in a number of small classes for use in statistical treatments of the data.

Geomorphic - Parameters or variables relating to geomorphology.

Geomorphology - A branch of geology concerned with the formation, characteristics, and processes of landforms, including rivers.

GIS - Geographic Information System. A database which relates information to spatial characteristics of some land area.

Ground Water - Water stored or moving beneath the ground surface, usually in pore spaces in alluvium, or voids in bedrock.

Ground Water Decline - Lowering of the elevation or volume of ground water relative to the ground surface.

Ground Water Discharge - Transfer or flow of water from underground sources into surface water; a spring.

Headcutting - A process of channel bed erosion whereby a sharp break in the average channel bed slope moves upstream, rapidly lowering the channel bed elevation.

Headwaters - The point, or area, where a stream originates; or the most upstream point of a stream.

Holocene - The most recent epoch of geologic history, usually the past 10,000 years before present; part of the Pleistocene geologic period.

Hydraulics - The science or technology of the behavior of fluids. Characteristics of stream flow such as depth, velocity, and width.

Hydrology - A branch of engineering concerned with water. In the context of this report, hydrology means the characteristics of water flow.

Incised Channel - A stream or waterway which has eroded its bed, creating steep or vertical stream banks. An arroyo, or degraded stream channel.

Infiltration - The process whereby water passes through an interface, such as from air into soil.

Instantaneous Flow Rate - Stream discharge at an instant in time, as opposed to a discharge averaged over a period of time. See Mean Flow.

Intermittant Stream - A stream which flows only for portions of the year, but has sustained flow for a period after rainfall. See Perennial Stream and Ephemeral Stream.

Mean Flow - The mean flow of a river is determined by dividing the total runoff volume by the time in which that volume was discharged, i.e., mean annual flow is the average rate at which the average yearly flow volume would be discharged.

Median Flow - The flow rate which is exceeded 50 percent of the time (conversely, the rate is not exceeded 50 percent of the time).

Morphology - The shape or geometric characteristics, especially of a stream or stream reach.

Navigable (Navigable Watercourse) - A watercourse, or portion of a reach of a watercourse, that was in existence on February 14, 1912, and that was used or was susceptible to being used, in its ordinary and natural condition, as a highway for commerce, over which trade and travel were or could have been conducted in the customary modes of trade and travel on water.

Perennial Stream - A stream which flows year round; non-zero base flow.

Permanent Water - Perennial stream flow.

Permeable - A rock or soil unit which is permeable will allow water to pass through it.

Phreatophytes - Deep-rooted plants that obtain water from the water table or the layer of soil just above it.

Physiographic Province - A region of similar geology. In Arizona, three physiographic provinces are recognized: the Basin and Range, the Central Highland (Transition Zone), and the Colorado Plateau.

Pleistocene - The most recent geologic period, usually the past 1,000,000 years before present.

Point of Zero Flow - The stage on a rating curve or gage record where no discharge occurs.

Quit claim - A transfer of one=s interest in a property, especially without a warranty of title to give up claim to property by means of a quit claim deed.

Quit claim deed - A deed that conveys to the grantee only such interests in property as the grantor may have, the grantee assuming responsibility for any claims brought against the property.

Rating Curve - A graph which relates stream discharge to some other measurable stream characteristic such as stage, width, depth, or velocity.

Reach - A segment of a stream, usually with uniform characteristics.

Riparian - Refers to that which is related to, or located near, or living along a watercourse whether natural, man-made, ephemeral, intermittent, or perennial.

Salt Cedar - A non-native, undomesticated tamarisk tree.

Scour - Removal of streambed material by flowing water.

Seep - A small, diffuse spring generally of low discharge rate.

Sinuosity - A measure of how sinuous a stream is: the ratio of the length along the thalweg to the length along the stream valley. Always greater than one.

Sinuous - The Acurviness@ of the channel planform; the degree of meandering.

Spring - The point where underground sources of water discharge at the surface.

Stage - A term used in stream gaging to describe the elevation of the water surface of a stream relative to some datum (fixed elevation). Stream stage is analogous to stream depth.

Stream Gage - A site operated for the purpose of measuring the rate or volume of water discharge in a stream. Accumulated data from a stream gage are called stream gage records.

Subflow - See Underflow.

Tamarisk (salt cedar) - Non-native riparian plants. Presently the dominant vegetation on the floodplain of many streams due to opportunistic growth in channel systems in the southwestern United States.

Terrace (Bench) - A relatively flat geologic or geomorphic surface which parallels a stream and is elevated above the floodplain, and was formed when the river flowed at a higher elevation.

Thalweg - The centerpoint, or low flow channel, of a stream.

Topwidth - The distance across the water surface, perpendicular to the channel, of a flowing stream.

Transition Zone - See Central Mountain Province.

Transmission Losses - Reductions in stream flow due to infiltration of water into thestreambed and subsurface.

Underflow - A term used interchangeably with subflow to describe the ground water underlying the surface of a stream's channel.

Unentrenched - See Entrenchment.

Wash - A river or stream with low banks and numerous channels.

Water Table - The upper surface of the underground zone of saturation; the plane which represents the elevation of ground water.

Watershed - The land area draining into a stream, or other body of water.

Xerophytes - Plants that are structurally adapted for life and growth with a limited water supply.

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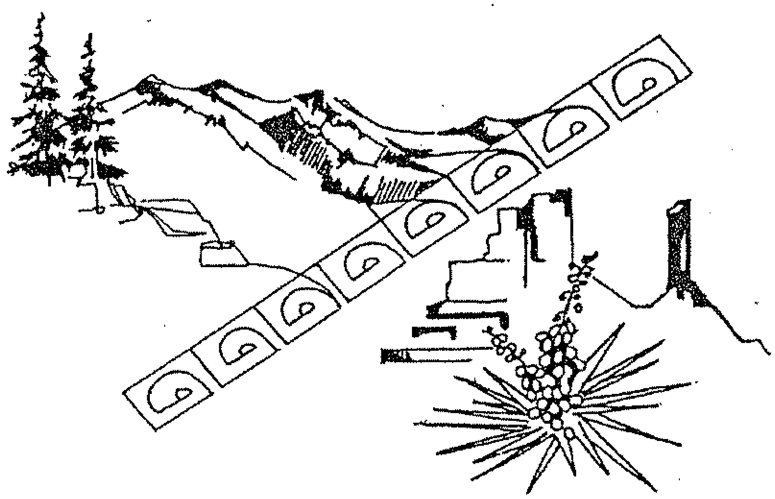

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Acronyms

LIST OF ACRONYMS

Arizona Geological Survey	AZGS
Arizona Land Resource Information System	ALRIS
Arizona Navigable Stream Adjudication Commission	ANSAC
Arizona Revised Statutes	A.R.S.
Arizona State Land Department	ASLD
Arizona Upland	AU
Bureau of Land Management	BLM
Cubic feet per second	cfs
Federal Emergency Management Agency	FEMA
Flood Insurance Rate Map	FIRM
General Land Office	GLO
Geographic Information System	GIS
House Bill	HB
Lower Colorado River Valley	LCRV
Right of Way	ROW
Santa Cruz River	SCR
US Geological Survey	USGS