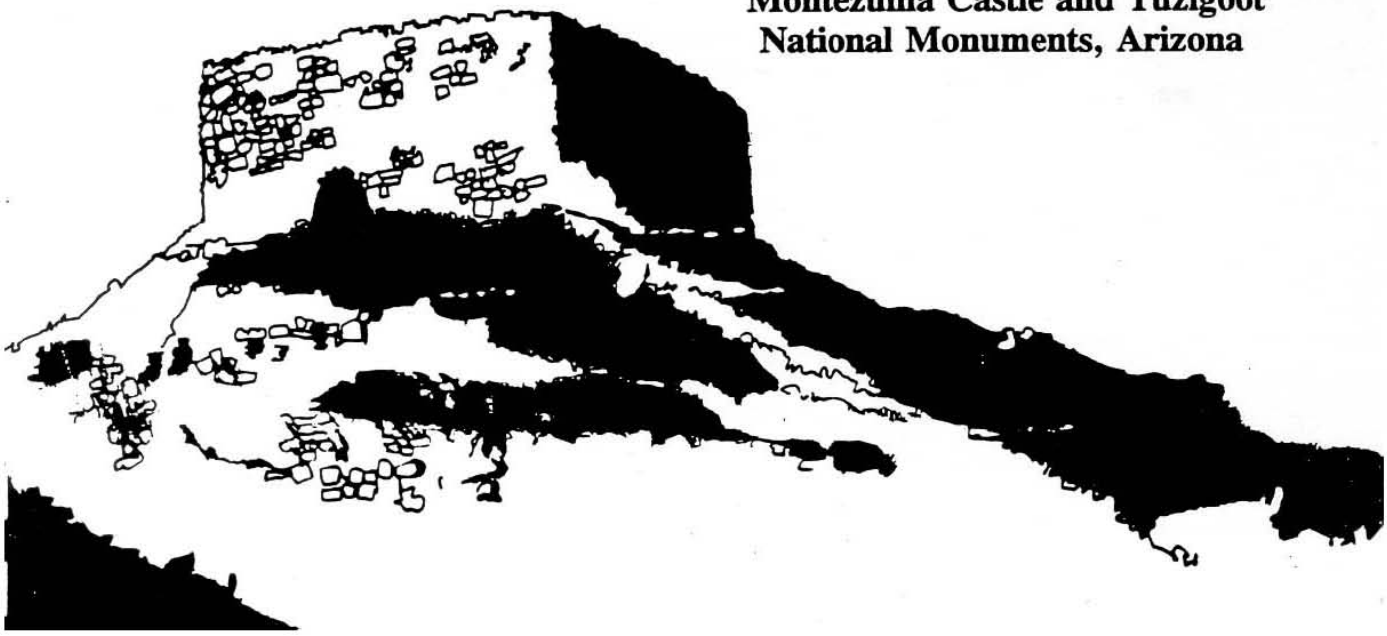
Fig I. Flora Sharron

WATER RESOURCES MANAGEMENT PLAN

Montezuma Castle and Tuzigoot National Monuments, Arizona



MONTEZUMA CASTLE AND TUZIGOOT
NATIONAL MONUMENTS
ARIZONA

Water Resource Management Plan

SEPTEMBER 1992

United States Department of the Interior
National Park Service

WATER RESOURCES MANAGEMENT PLAN

MONTEZUMA CASTLE AND TUZIGOOT NATIONAL MONUMENTS

Recommended by: Concurred by: Approved by:

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1 INTRODUCTION

Montezuma Castle National Monument, including the Montezuma Well Unit, and Tuzigoot National Monument were established to preserve and protect examples of prehistoric Hohokam and Sinagua cultures in the Verde Valley of central Arizona (Figure 1). These sites were occupied as early as 800 A.D., with floodplain farming providing primary subsistence.

Montezuma Castle was established as a monument in 1906 and preserves a 19-room, 4-story Sinagua cliff dwelling. Currently, it encompasses 580 acres along Beaver Creek in central Yavapai County, Arizona (Figure 2).

Montezuma Well is a limnocrene (a pooled spring) fed by artesian waters arising from two or three deep fissures near its center (Cole 1982). The Well was established in 1943 to protect prehistoric Hohokam and Sinagua sites and historic Apache sites surrounding the Well. It occupies 278 acres along Wet Beaver Creek upstream of the Castle (Figure 3). Administratively, the Well is a unit of Montezuma Castle. It is be collectively referred to as Montezuma Castle National Monument within this plan.

Tuzigoot National Monument, established in 1939, contains the ruins of a 110-room Sinagua pueblo on almost 59 acres. Most of the area is on a hilltop, above the floodplain of the Verde River. It is located between the towns of Clarkdale and Cottonwood in Yavapai County, Arizona (Figure 4). Existing legislated boundaries contain 732 acres of privately owned lands. A 1988 amendment to the Master Plan (1975) would reduce the boundaries to include approximately 320 acres of private land. Potential lands for acquisition include Tavasci Marsh, a spring fed wetland.

Management of water resources has been a primary concern since the establishment of each monument. Comprehensive information relating to water matters are on file at the headquarters for Montezuma Castle. These files reflect water issues concerning National Park Service (NPS) personnel in the Verde Valley since the early 1900s. Prehistoric, historic, and recent stewards of these sites have been concerned with the conveyance of irrigation water. Monument staff coordinates irrigation schedules for NPS properties and users downstream from Montezuma Well. Monument staff has been active in filing for and acquiring water rights. The US Geological Survey (USGS), under a cooperative agreement with NPS, has monitored discharge of Montezuma Well since 1977. This database establishes an historical record of discharge from the spring. It facilitates protection of this resource against future human-induced reductions in flow. Monument facilities use drilled wells within the regional aquifer to provide potable water to visitors and staff. Increasing visitation, regional growth, and changes in adjacent land use suggest that the NPS role in water resource management, basin-wide, will continually evolve.

Water Resources Planning and Legislation Requirements

Water is a significant resource at Montezuma Castle and Tuzigoot National Monuments. A course of action needs to be determined with respect to protection, conservation, use, and management of water resources that will comply with all legal requirements. The Environmental Protection Agency (EPA) and NPS have developed a memorandum of understanding on water

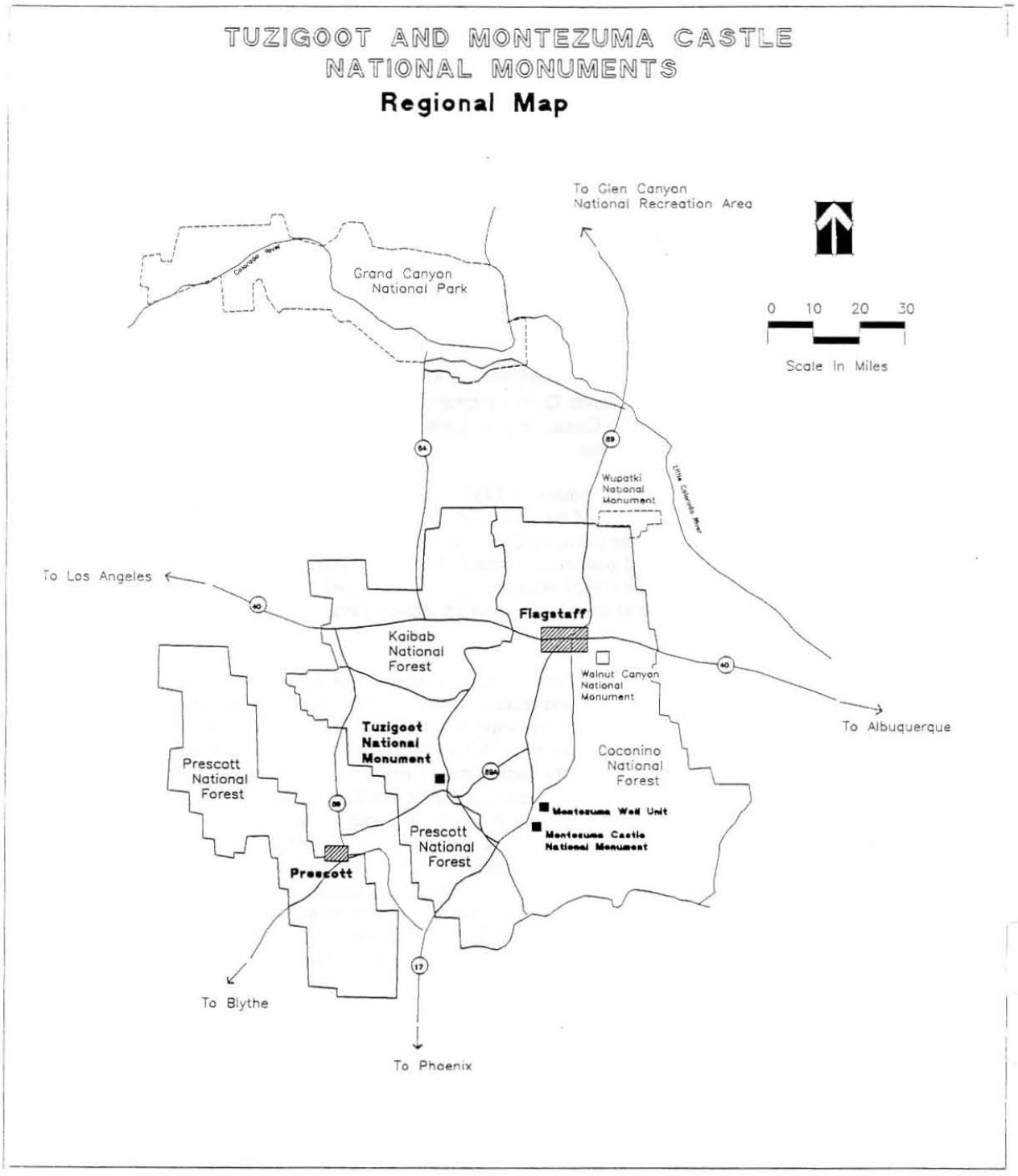


Figure 1. Verde Valley and environs in central Arizona.

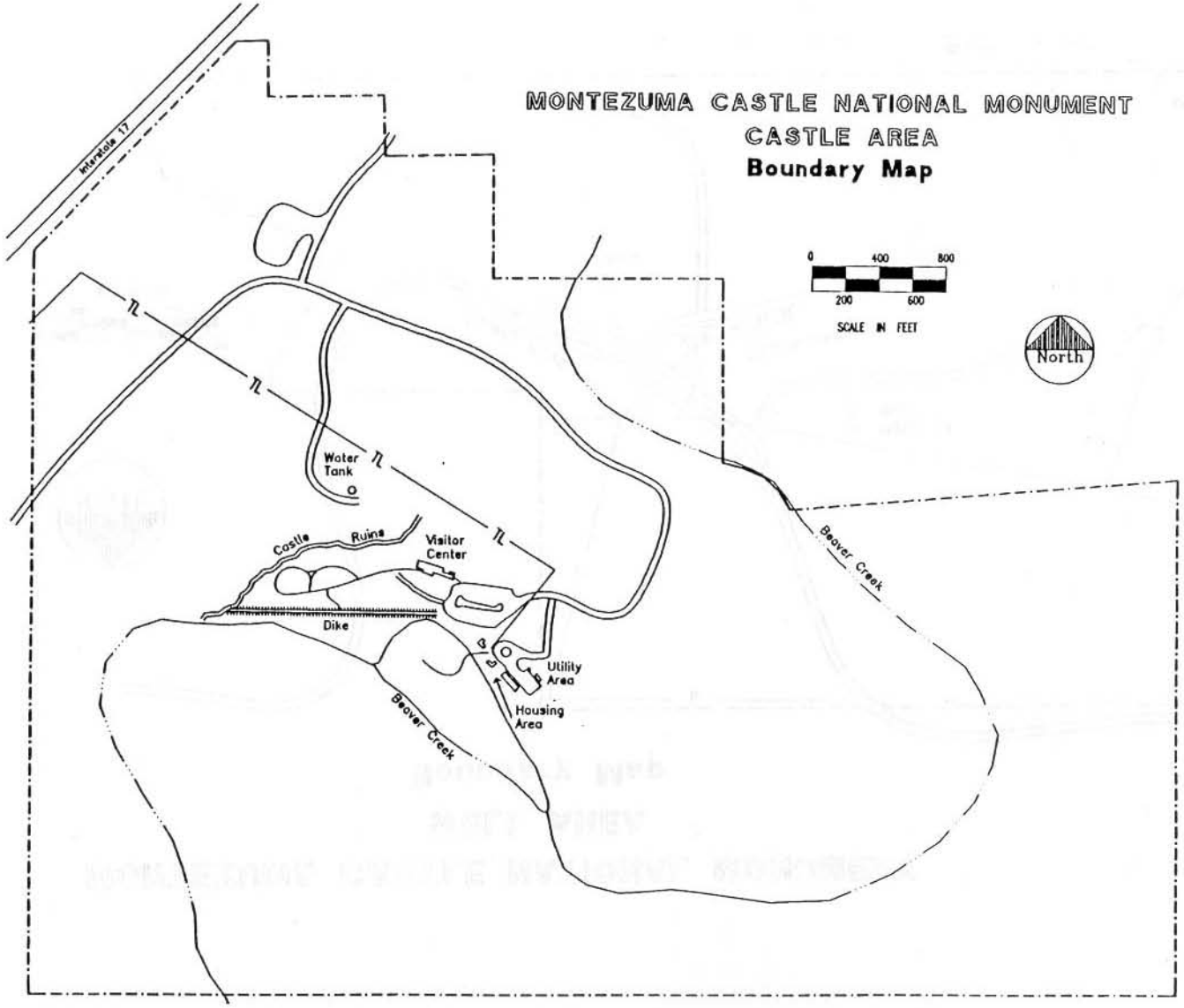


Figure 2. Montezuma Castle National Monument.

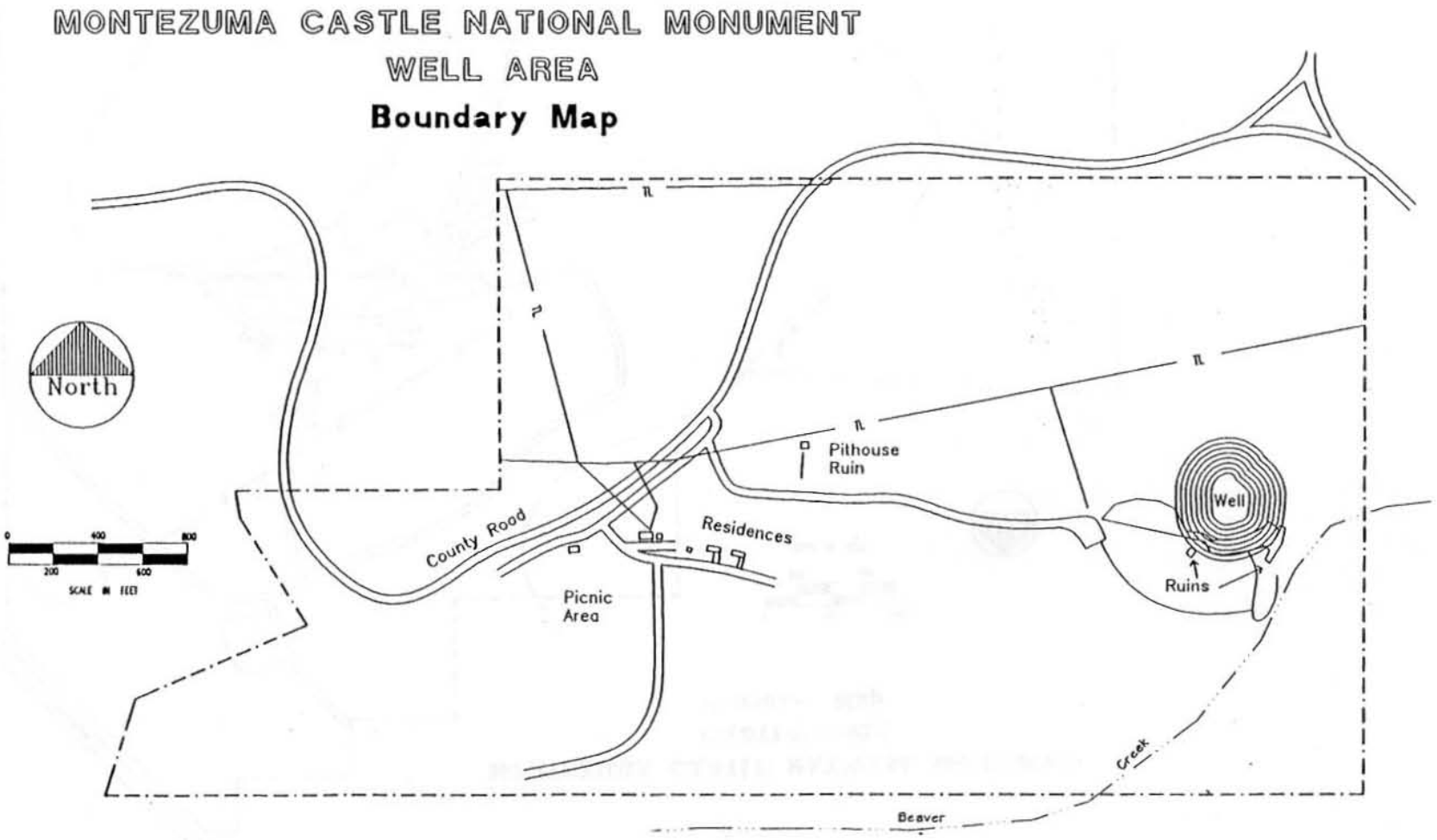


Figure 3. Montezuma Well Unit of Montezuma Castle National Monument.

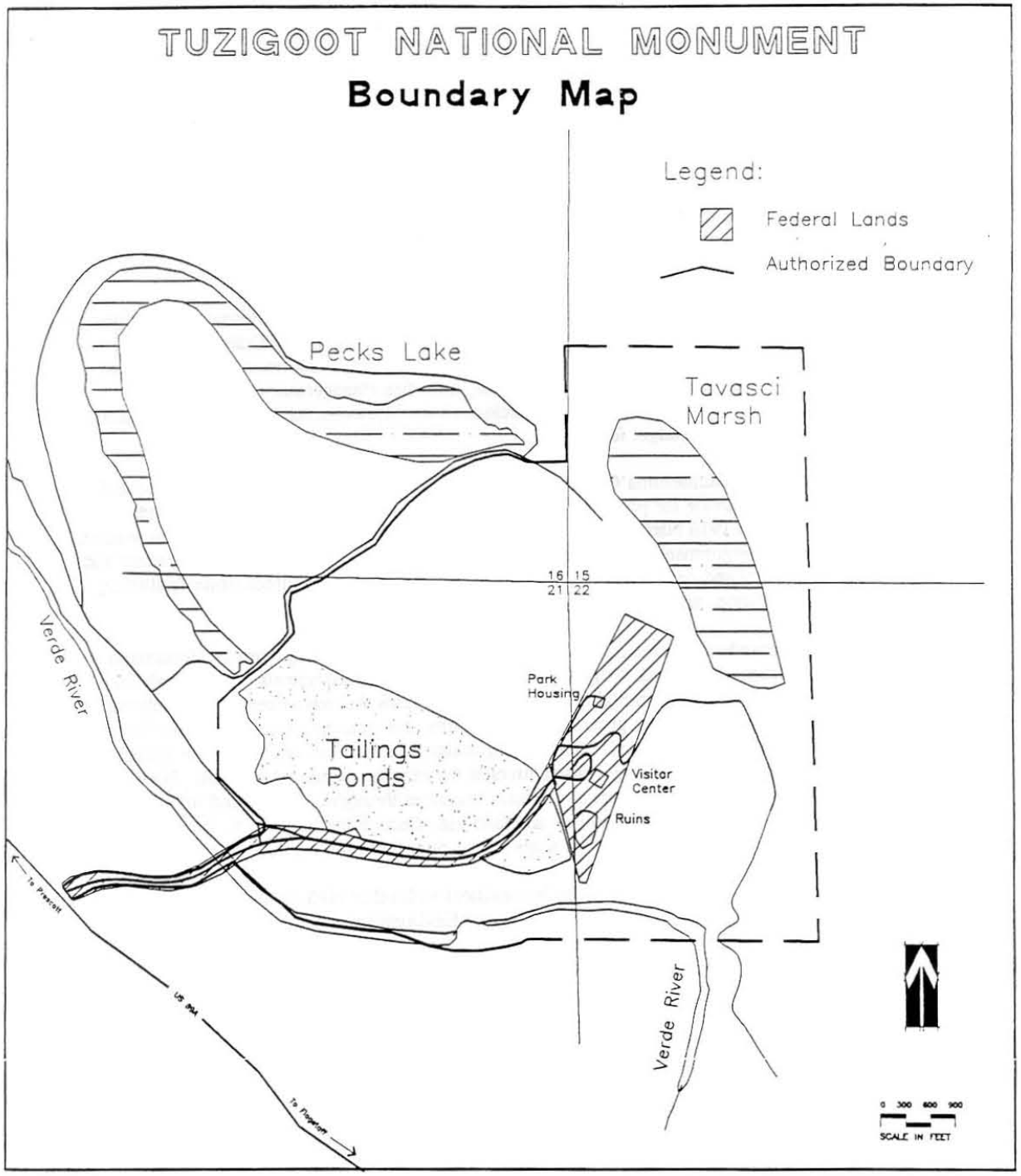


Figure 4. Tuzigoot National Monument.

quality management. This agreement has prompted the Director of the National Park Service to designate the Water Resources Management Plan as the working document for each park to attain compliance and ensure cooperation with others in water planning. Although water quality provides the impetus for preparing a Water Resources Management Plan, the plan addresses all aspects of water resources.

Water management on lands under NPS jurisdiction is mandated by PL 92-217 (Clean Water Act of 1977), amending the Federal Water Pollution Control Act Amendment of 1972. Public land management agencies are subject to, and must comply with, all federal, interstate, state, and local requirements pertaining to water.

The Superintendent directs preparation and implementation of the Water Resources Management Plan. In this case, one plan is being written for Montezuma Castle and Tuzigoot National Monuments, which are jointly administered. It is an active, evolving management tool that provides an information base on water resources, identifies management objectives, and prescribes management actions. The plan includes a list of continuing and proposed projects, project statements, and budget forms.

Water resources at Montezuma Castle and Tuzigoot must be managed to protect aquatic and riparian habitat, provide for public health and safety, and interpret resources values and preservation. The 1916 National Park Service Organic Act directs NPS to regulate monument use and promote enjoyment of those lands in a manner consistent with conserving scenery and protecting cultural and natural resources. Managers must protect resources while facilitating public use, education, and enjoyment.

Surface and groundwaters create and sustain aquatic and riparian ecosystems at Montezuma Castle, Montezuma Well, and Tuzigoot. Riparian and aquatic ecosystems are relatively rare in the arid Southwest. They are highly productive ecosystems that have been greatly reduced in a areal extent and complexity by groundwater overdrafts, overgrazing, streambed channelization, impoundments, and climatological changes. Agricultural, industrial, and municipal interests over the past 125 years have been major water users at the expense of natural systems. Potential conflicts occur between water users and natural resources through diversion and impoundment of stream waters, groundwater withdrawal, and land use affecting the watershed. State administration of water rights can facilitate or, in some cases, complicate the resolution of these conflicts.

The Water Resources Management Plan is consistent with other NPS plans related to Montezuma Castle and Tuzigoot including the Master Plan and Environmental Assessment (1975), Natural and Cultural Resources Management Plans and Environmental Assessment (first written in 1975, updated in 1981 and 1987, and completely revised in 1989 and 1990, respectively, for both monuments), Land Protection Plans (1984), and Statements for Management (1990-Tuzigoot; 1991-Montezuma Castle). The Water Resources Management Plan is subordinate to the Natural and Cultural Resources Management Plans, and the project statements appearing here were first identified in the major revision process for those plans in 1989. Actions described in the Water Resources Management Plan will comply with regulations of the National Environmental Policy Act and National Historical Preservation Act. Direction for compliance is provided by individual project statements.

In addition to the enabling legislations for the monuments, there are other executive orders, federal and state legislation, and state statues influencing water resources management. They include:

Federal

- National Environmental Policy Act (1969) - Any major federal action that affects the human environment must include public review with the NEPA process. Concerning water resources this pertains to changes or increases in water use and treatment (i.e. constructing sewage treatment plants, pipelines, residences, and visitor facilities).

- National Historic Preservation Act (1966) - This act sets forth the basic concern of the nation for the preservation of its heritage. Section 106 of the act requires comments on any project that involves any ground disturbance.

- Safe Drinking Water Act (1974) and amendments (1986) - This legislation applies to domestic drinking water supplies. Provisions of the recent amendments include more stringent regulation of contamination with which utility managers should be familiar.

- Clean Water Act (1977) and amendments (1987) - This act provides for pollution control activities and funding at the federal level including grant programs research and related programs. It also includes provisions for setting standards and enforcement actions. The act recognizes the primary role of state agencies in managing and regulating the nation's water quality within the framework developed by Congress. Part of that framework requires that all federal agencies comply with the requirements of state law for water quality management regardless of jurisdiction status or land ownership.

- Endangered Species Act (1973) - This act requires all entities using federal funding to consult with the Secretary of Interior on activities that potentially impact endangered flora and fauna. It requires agencies to protect endangered species and designated critical habitats.

- Executive Order 11987 (Exotic Species) (1977) - This states that "executive agencies shall, to the extent permitted by law, restrict the introduction of exotic species into the natural ecosystem on lands and waters which they own, lease or hold for purposes of administration; and, shall encourage the states, local governments, and private citizens to prevent the introduction of exotic species into natural ecosystems of the United States."

- Executive Order 11988 (Floodplain Management) (1977) - This order seeks to minimize impacts on human life and reduce property loss by planning that avoids building in floodplain or, when possible, to remove people and structures. It recognizes restoring and preserving the natural and beneficial values of floodplain and provides for public review of federally funded projects affecting floodplain. In compliance with this Order, NPS developed *Floodplain Management and Wetland Protection Guidelines (45* FR 35916).

- Executive Order 11990 (Protection of Wetlands) (1977) - This orders federal agencies to avoid impact from destroying or modifying wetlands. It supports building developments outside of wetlands and recognizes the beneficial value of wetlands. In compliance with this Order, NPS developed *Floodplain Management and Wetland Protection Guidelines* (45 FR 35916).

- Executive Order 12088 (Environmental Pollution) (1978) - This order requires that federal agencies, including NPS, cooperate with state, intrastate, and local agencies in the prevention, control, and abatement of environmental pollution.

State

- Arizona State Water Ouality Regulations (1978) - These are state regulations promulgated to aid in enforcement of federal requirements of the Safe Drinking Water Act and Clean Water Act. They include standards for water quality and designated uses. Two state statues apply, which are the Arizona Water Quality Control Law and Arizona Surface Water Quality Standards. These statues set surface and groundwater quality goals.

- Arizona Groundwater Management Act (1980) - This act provides for the management and use of groundwater in Arizona. It established a Department of Water Resources. Included in this legislation are the determination of rights to withdraw and use groundwater within the State.

- Arizona Environmental Ouality Act (1986) - This act established the Department of Environmental Quality. It prescribes definitions, powers, duties, procedures, rights conditions, and enforcement actions relating to water quality statewide.

- Arizona State Water Law - Regarding the use of surface waters, NPS and other federal land management agencies will abide by all water laws as interpreted by Arizona. The State is recognized as the administering agency for water rights.

- Arizona Wastewater Treatment Law - This applies to wastewater collection and treatment facilities. It requires the Department of Environmental Quality to adopt and enforce rules relating to the design, construction, operation, and maintenance of all existing and proposed on-site wastewater treatment facilities.

- Arizona Wastewater Disposal Regulations - This law establishes regulations for the reuse of wastewater and includes specific standards and permit monitoring requirements for the reuse. It also establishes rules for the construction and operation of sewage systems within the State.

- Arizona Hazardous Substances Spill Response Law - This law designates the Department of Environmental Quality as the administering agency for spill response. The law establishes a Water Quality Assurance Fund, defines its uses, and details responsible party, remedial action, and liability for remedial action costs criteria.

- Arizona Remedial Action Regulations for Hazardous Substances Spills - This law details the regulations necessary to administer the Water Quality Assurance Fund established in the Arizona Hazardous Substances Spill Response Law.

2 MANAGEMENT OBJECTIVES

Goals

The goals of this program are twofold:

1. To restore or maintain natural aquatic and riparian environments in which physical, chemical, and biological processes function with minimal interference

2. To inform all visitors and employees of riparian and aquatic resources, hazards, and restrictions

Objectives

To fulfill the purposes of the monuments, the following management objectives are identified to protect the significant resources values:

1. To assure water rights claims are recognized by the State of Arizona and are sufficient to protect the purpose of the monuments

2. To monitor the discharge of monument waters and establish a baseline of historic flows

3. To provide background information and monitor the relationship between surface and groundwaters in the Verde Valley affecting the monuments

4. To assure that Montezuma Well maintains its physical, chemical, and biological integrity

5. To locate and document the magnitude and direction of changes in aquatic environments that are caused by upstream and downstream land use activities and to develop and implement management programs to mitigate those activities

6. To monitor the quality of water entering and leaving the monuments with regard to compliance with local, state, and federal standards

7. To comply with state and local water quality requirements for the monuments' public water and wastewater systems

8. To acquire sufficient knowledge about water quality to effectively participate in state and local water management planning

9. To detect and evaluate external influences (e.g. growth, land use, and groundwater development) that may impact NPS water resources and water-related attributes

10. To understand stream influences on riparian and wetlands ecosystems

11. To acquire and maintain an adequate information base to define natural features and processes and to identify impacts on them

12. To manage floodplain in accordance with state and federal requirements

3 HYDROLOGIC ENVIRONMENT

Description of the Area

Climate

The climate is semiarid with mild winters and hot summers. July and August are hot with temperatures often over 100 degrees F. Cool weather occurs between October and April. Snow may fall but does not linger.

Average annual precipitation for the monuments is approximately 12 inches (Sellers and Hill 1974) (Table 1). The Cottonwood weather station reading would be representative for Tuzigoot. There is a weather station at Montezuma Castle, and the stations at Rimrock and Beaver Creek represent Montezuma Well. Precipitation varies considerably between years in the Verde Valley. Extreme values of average annual precipitation have been recorded from less than 4 inches to more than 22 inches.

Table 1 shows that between 29 and 36 percent of mean annual precipitation falls from December through March, usually as rain in the Verde Valley. Winter precipitation is related to the eastward movement of middle latitude storms that form in the northern Pacific Ocean. They may produce major floods in the Verde Valley, particularly when rains fall on snowpack at higher elevations along the Mogollon Rim. During this period, 37 to 46 percent of the average annual precipitation occurs from July through September. Summer storms are typically of short duration and locally intense. These storms may produce local flash flooding.

Geology and Hydrology

The location of Montezuma Castle, Montezuma Well, and Tuzigoot in the Verde Valley of central Arizona is transitional between the Basin and Range Physiographic Province to the south and west and the Colorado Plateau Physiographic Province to the north and east. The Verde Valley is within the Central Highlands Water Province (Cross et al. 1960) (Figure 5). The Mogollon Rim, which is the most distinctive feature of the Central Highlands, extends more than 200 miles from the White Mountains to the headwaters of the Verde River. Elevations range from about 3200 feet in the bottom of Verde Valley to 7000 feet at the lip of Mogollon Rim, only 20 miles north.

The Verde Valley is a downfaulted trough bounded on the northeast by the Mogollon Rim and on the southwest by the Black Hills. The two major geologic features defining the watershed are the Mormon Mountain anticline and the Verde Fault. The Mormon Mountain anticline, 15 to 30 miles east of the Verde Valley, is a northwest-trending, asymmetrical anticline that forms the groundwater divide on the northeastern margin of the Valley. On the southwestern margin the Verde Fault, whose scarp is conspicuously defined by Mingus Mountain, the Black Hills, and

Table 1. Average monthly and annual precipitation in inches at Beaver Creek Ranger Station, Cottonwood, Montezuma Castle, and Rimrock in the Verde Valley (Sellers and Hill 1974).

Station	*Cottonwood*	*Montezuma Castle*	*Rimrock*	*Beaver Creek*
Years of Record	*22*	*30*	*21*	*14*
	* _____inches----------*			
January	0.85	0.95	1.25	1.00
February	0.77	0.88	1.02	1.12
March	0.87	1.04	1.08	1.47
April	0.57	0.78	0.74	0.89
May	0.35	0.27	0.30	0.40
June	0.58	0.30	0.32	0.30
July	2.02	1.47	1.50	1.34
August	2.43	1.99	1.88	2.00
September	1.12	1.34	1.29	[illegible]
October	0.80	0.80	0.94	1.08
November	0.74	0.72	0.83	
December	1.11	1.16	1.22	1.28
ANNUAL	12.21	11.70	12.37	13.66

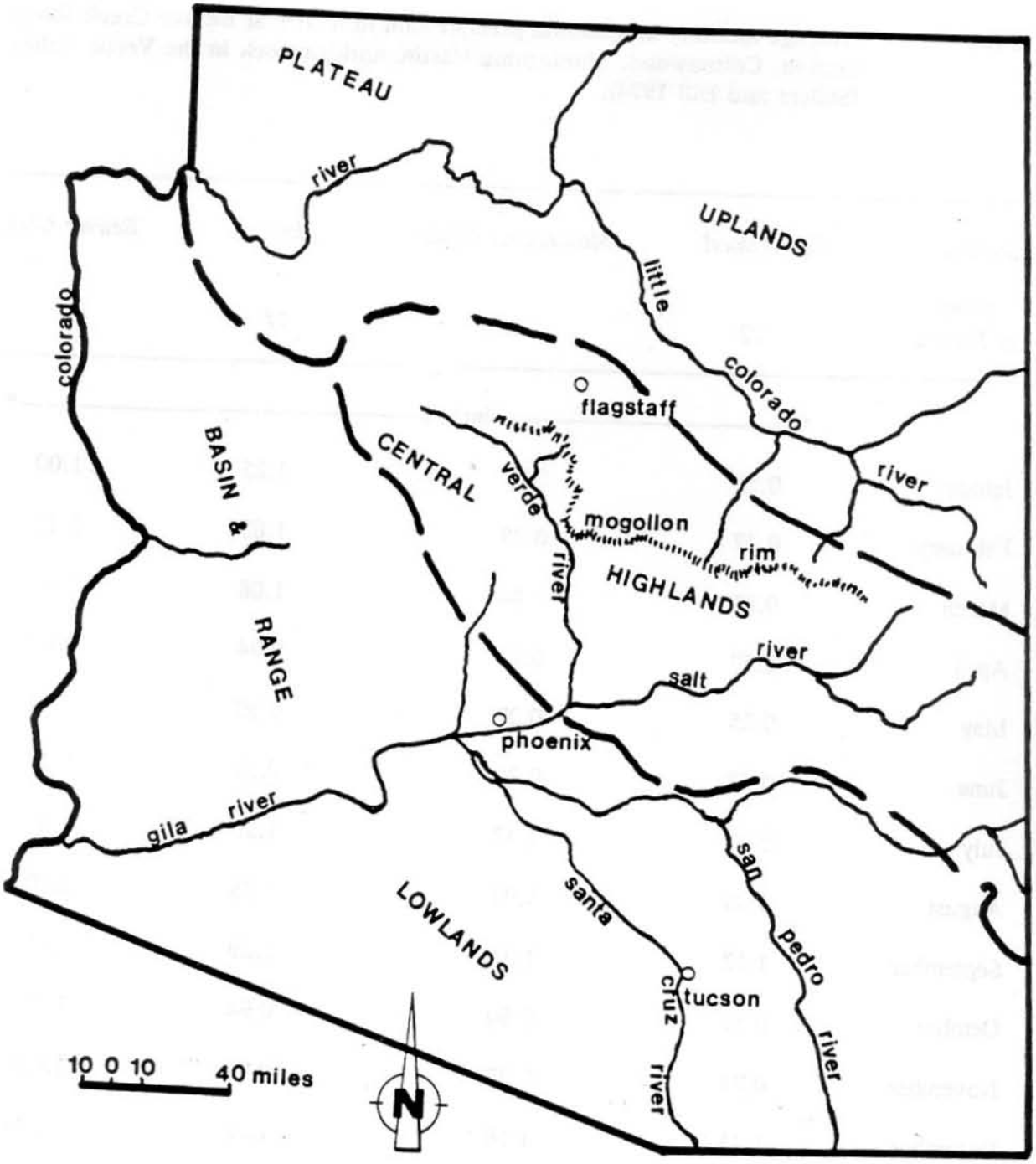


Figure 5. Water provinces of Arizona (Cross et al. 1960).

Squaw Peak, forms the groundwater divide (Twenter and Metzger 1963). Valley margins are composed of Precambrian igneous and metamorphic rocks and Paleozoic sedimentary rocks capped by Cenozoic basalts. Mesozoic strata are not present in the Verde Valley (Twenter and Metzger 1963, Nations et al. 1981).

The valley is drained by the Verde River (Figure 6). Major perennial tributaries within the study area are Oak, Wet Beaver, and Dry Beaver Creeks, all with headwaters on the Mogollon Rim to the north and east. Two tributaries, West Clear Creek and Fossil Creek, discharge water from the Mogollon Rim into the Verde downstream of the river's confluence with Beaver Creek. Most drainages entering the Verde from the south and west are ephemeral, flowing only in response to snowmelt or rainfall (Owen-Joyce and Bell 1983).

Although Montezuma Castle, Montezuma Well, and Tuzigoot are separated by up to 20 miles, they share a common watershed. Regional constraints imposed by the area's geology, history, and development link the ground and surface waters of the Verde Valley. Water resources were (and are) the primary attraction for the people occupying and utilizing these areas for centuries.

The sequence of events that formed the Verde Valley during the Tertiary and Quaternary is presented below from by Nations et al. (1981). These authors provide a clear understanding of the relationship between regional geology and the hydrology of surface flows and groundwaters. This relationship is critical as base flow is maintained by discharge from the regional aquifer in the Verde River and its perennial tributaries (Twenter and Metzger 1963, Owen-Joyce and Bell 1983). Additional references pertinent to the following geologic sequence include Elston et al. (1974), Peirce et al. (1979), and McKee and Elston (1980). The sequence is described below:

- Laramide (55 to 66 million years before present or mybp) - uplift of central and northern Arizona and erosion of Mesozoic and Paleozoic rocks

- Early Tertiary (35 to 55 mybp) - transport of gravel from central Arizona northward across present location of the Verde basin

- Hypothesized Oligocene (24 to 35 mybp) - formation of ancestral Mogollon Rim and establishment of through-flowing Verde River drainage to the southeast

- Miocene (5 to 24 mybp) - interruption of Verde River drainage by tectonic and volcanic events in the Hackberry Mountain and Thirteen Mile Rock volcanic center; Miocene volcaniclastic, clastic, and evaporite sedimentation within a closed Verde basin; Re-establishment of external drainage to the south by periodic overflow and partial breaching of the volcanic-tectonic darn; Periodic flooding of basin by fresh water, accumulation of lacustrine limestones, and fluvial clastic sediments

- Late Miocene (ca. 5 mybp) eruption of interbedded basaltic lava flows in the House Mountain and Beaver Creek areas

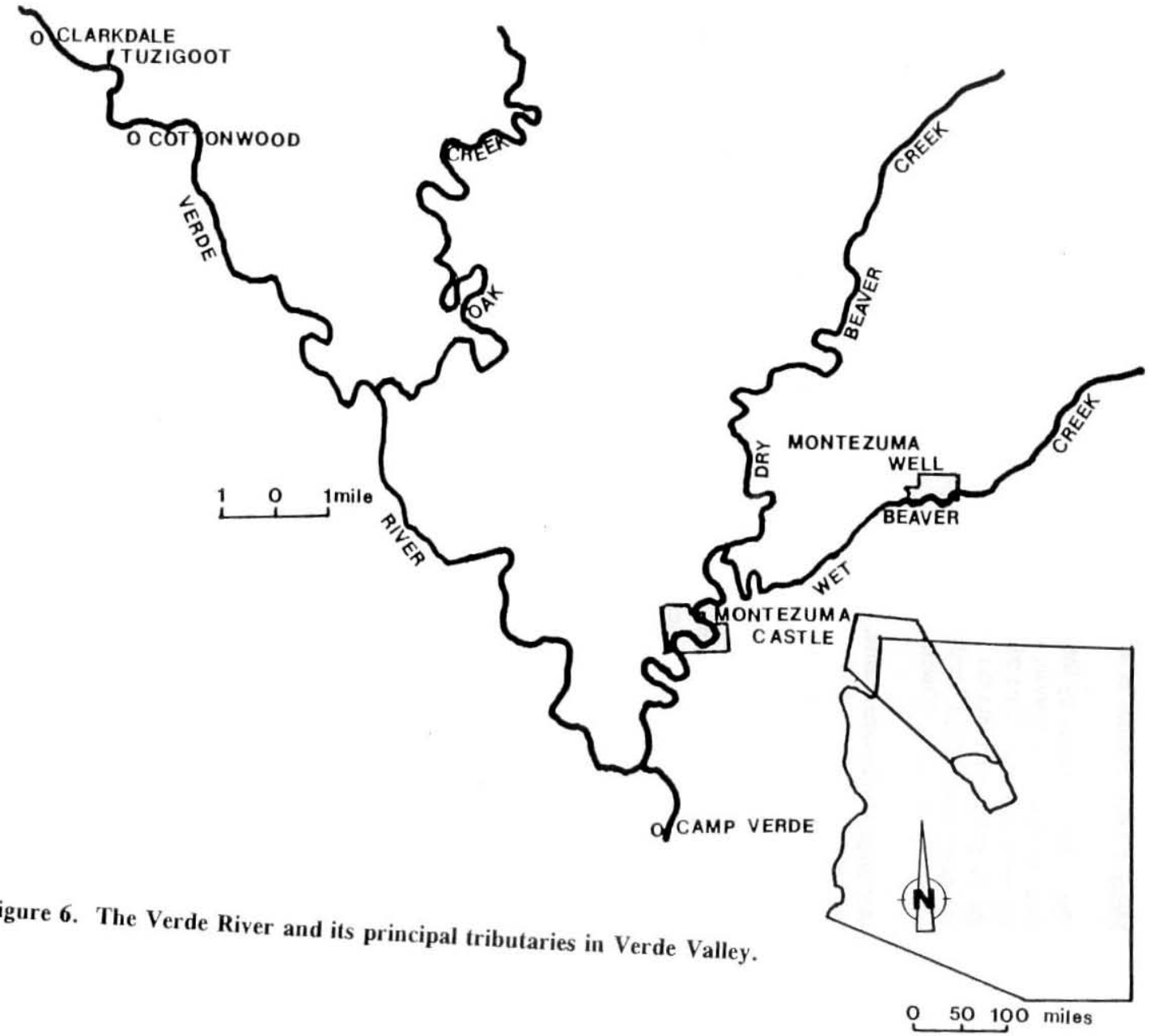


Figure 6. The Verde River and its principal tributaries in Verde Valley.

Pliocene (2 to 5 mybp) cessation of volcanism and continuation of lacustrine-fluvial sedimentation with absence of evaporites and abundance of aquatic plants and invertebrates; Verde Formation occurred during this sequence

- Quaternary (0 to 2 mybp) - complete breaching of the volcanic-tectonic dam and erosional excavation of much of the Verde Formation

Figure 7 shows a geologic cross section of the Verde Valley region (Zion Natural History Association 1975).

Soils

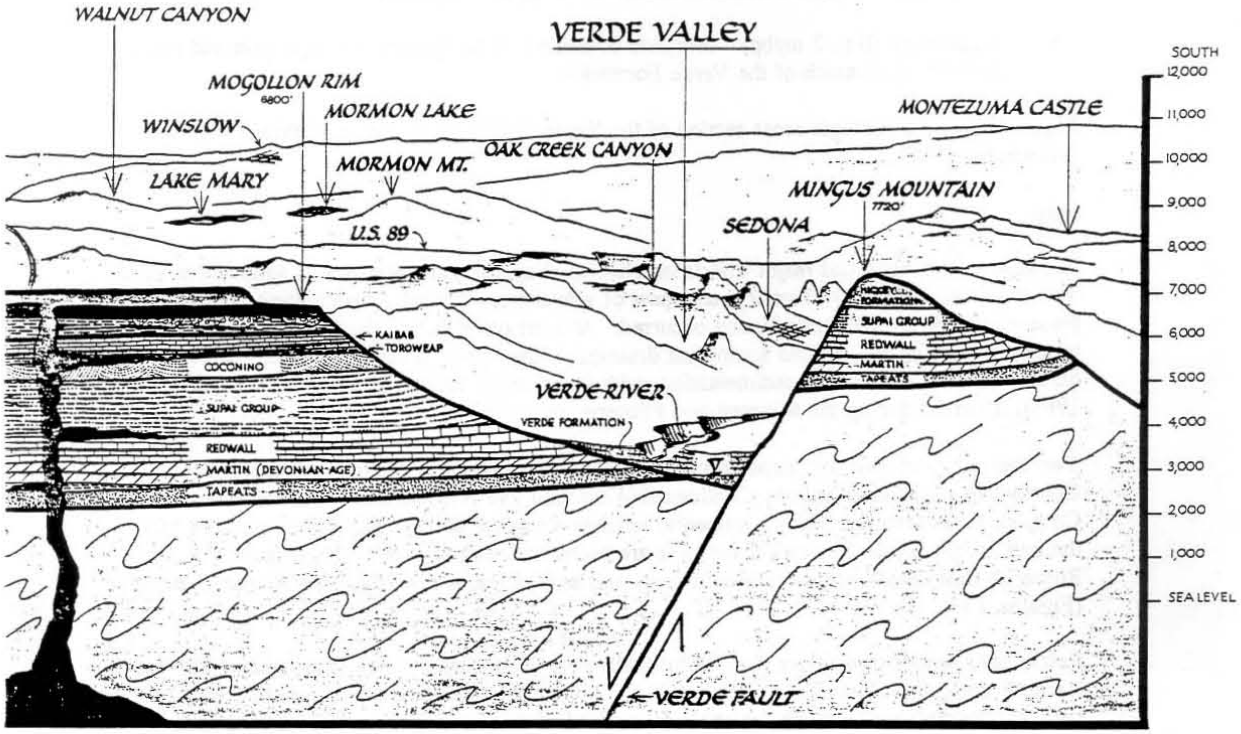
Geologic events have had major effects on physico-chemical characteristics of soils in the Verde Valley. During the early Tertiary, transport of gravel from central Arizona northward across the present location of the Verde Valley occurred. At least twice during the Miocene, volcanic and tectonic events interrupted the southward drainage of the Verde River. Subsequently, two periods of lacustrine-fluvial sedimentation, with and without evaporites (Twenter and Metzger 1963), occurred during the Miocene and Pliocene, respectively.

Two thermic, semiarid soil associations are present at Montezuma Castle, the Retriever-Courthouse Association and the Continental-Whitlock-Cave Association. Here the Retriever-Courthouse soils are generally confined to uplands along the eastern quarter and western half of the unit. Continental-Whitlock-Cave soils are prevalent along Beaver Creek (Figure 8). The Retriever-Courthouse Association is the only soil association at Montezuma Well and Tuzigoot (Figures 9 and 10).

Retriever-Courthouse soils are shallow to moderately deep calcareous soils associated with the Verde Formation. These soils occur in upland and riparian habitats with slopes of 2 to 40 percent. Retriever soils comprise about 50 percent of the association, and Courtland soils comprise another 15 percent. Rock outcrop and shallow stony soils, small areas of shallow to moderately deep limestone-derived soils, and narrow bands of recent alluvial soils in drainages make up the remaining 35 percent (Soil Conservation Service 1972).

Retriever soils are typically pale brown calcareous, gravelly foams to a maximum depth of 20 inches, which are underlain by limestone bedrock (Verde Formation). Ledges of limestone outcrop are frequently encountered (Soil Conservation Service 1972). Characteristic Courthouse soils have reddish, gravelly to stony fine sandy loam. Calcareous sandstone bedrock (Verde Formation) occurs at a depth of 9 to 20 inches. Sandstone outcrops and some deeper soils may occur locally.

Continental-Whitlock-Cave soils include a variety of materials from sandy foams to clays. Parent material is predominantly of granitic origins. Typically, slopes range from 0 to 30 percent. Continental soils comprise approximately 30 percent of the association. Whitlock and Cave soils



Geology and Cross Section by William J. Breed Revised; 1985
Artwork by Dick Beasley

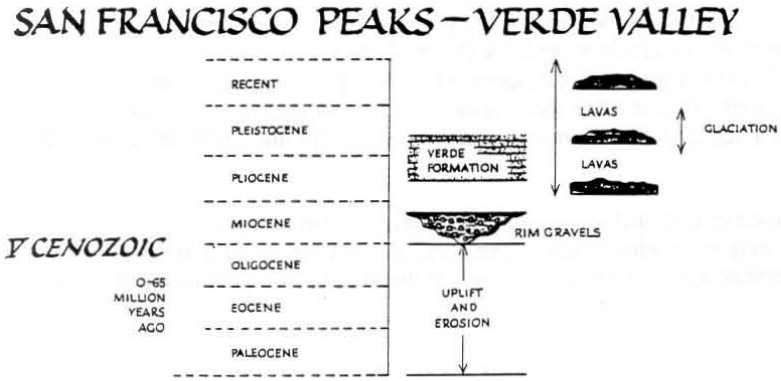


Figure 7. Geologic cross section of the Verde Valley Region.

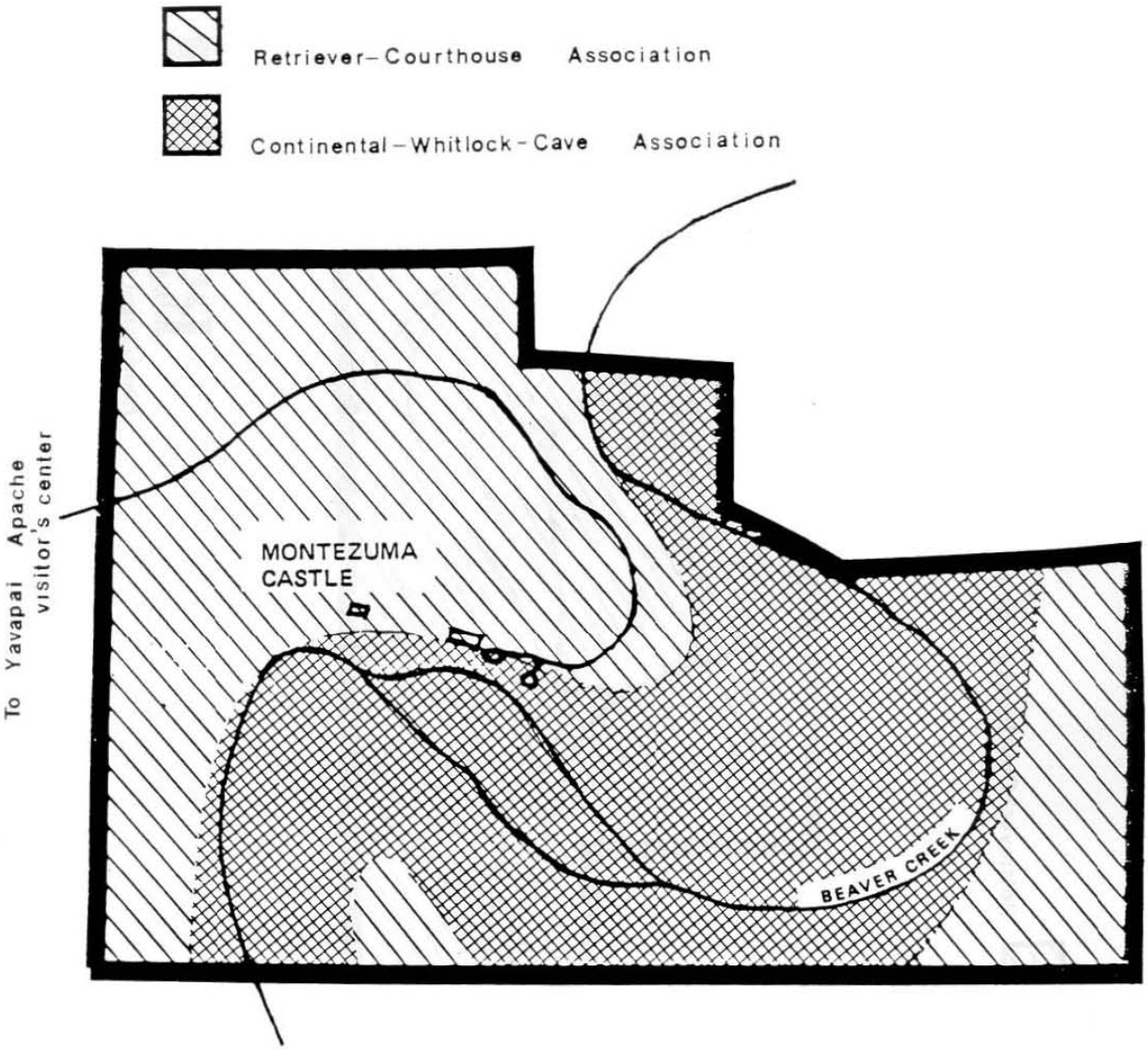


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Figure 8. Soils map for Montezuma Castle National Monument.

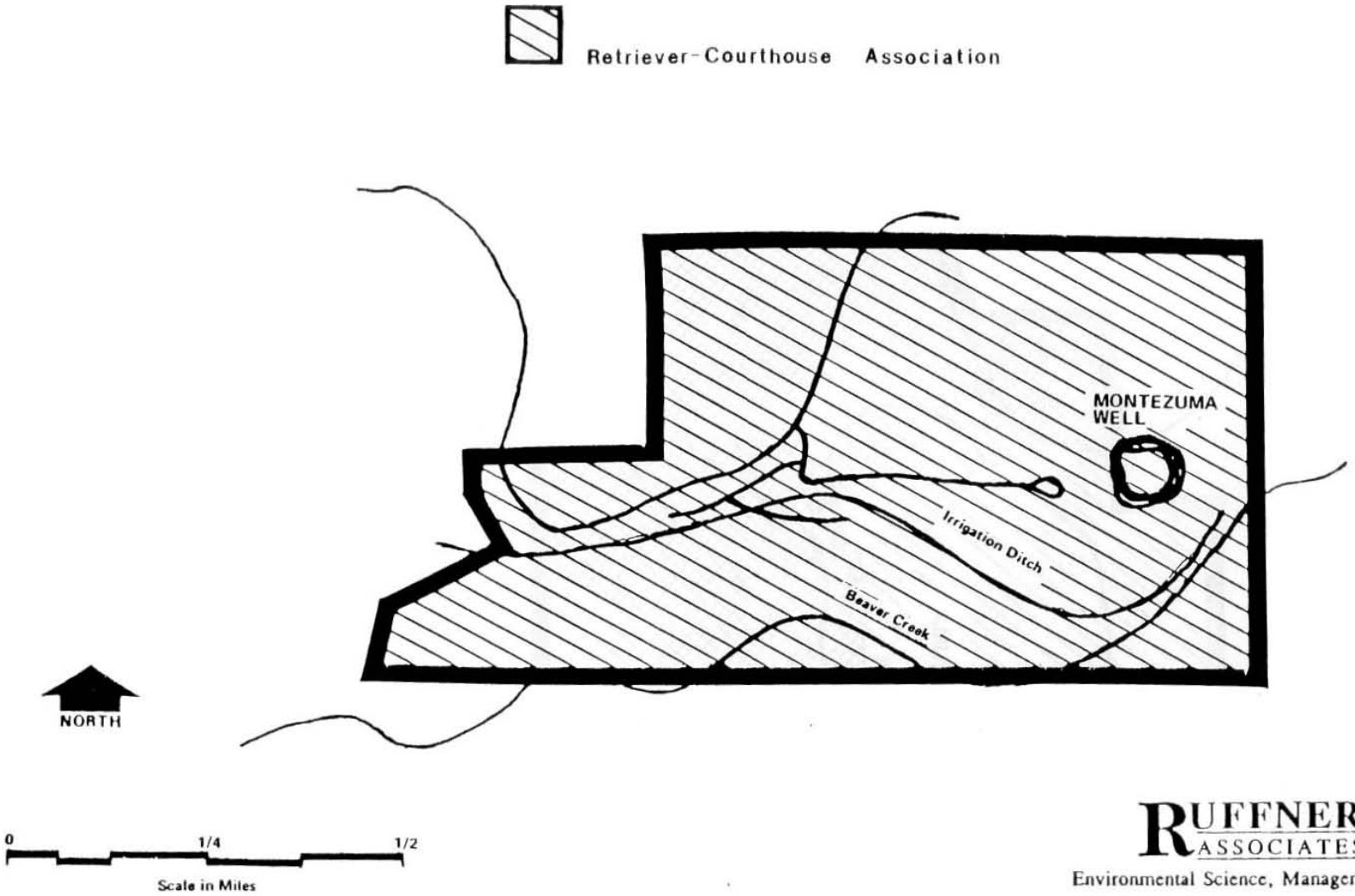

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Figure 9. Soils map for Montezuma Well Unit.

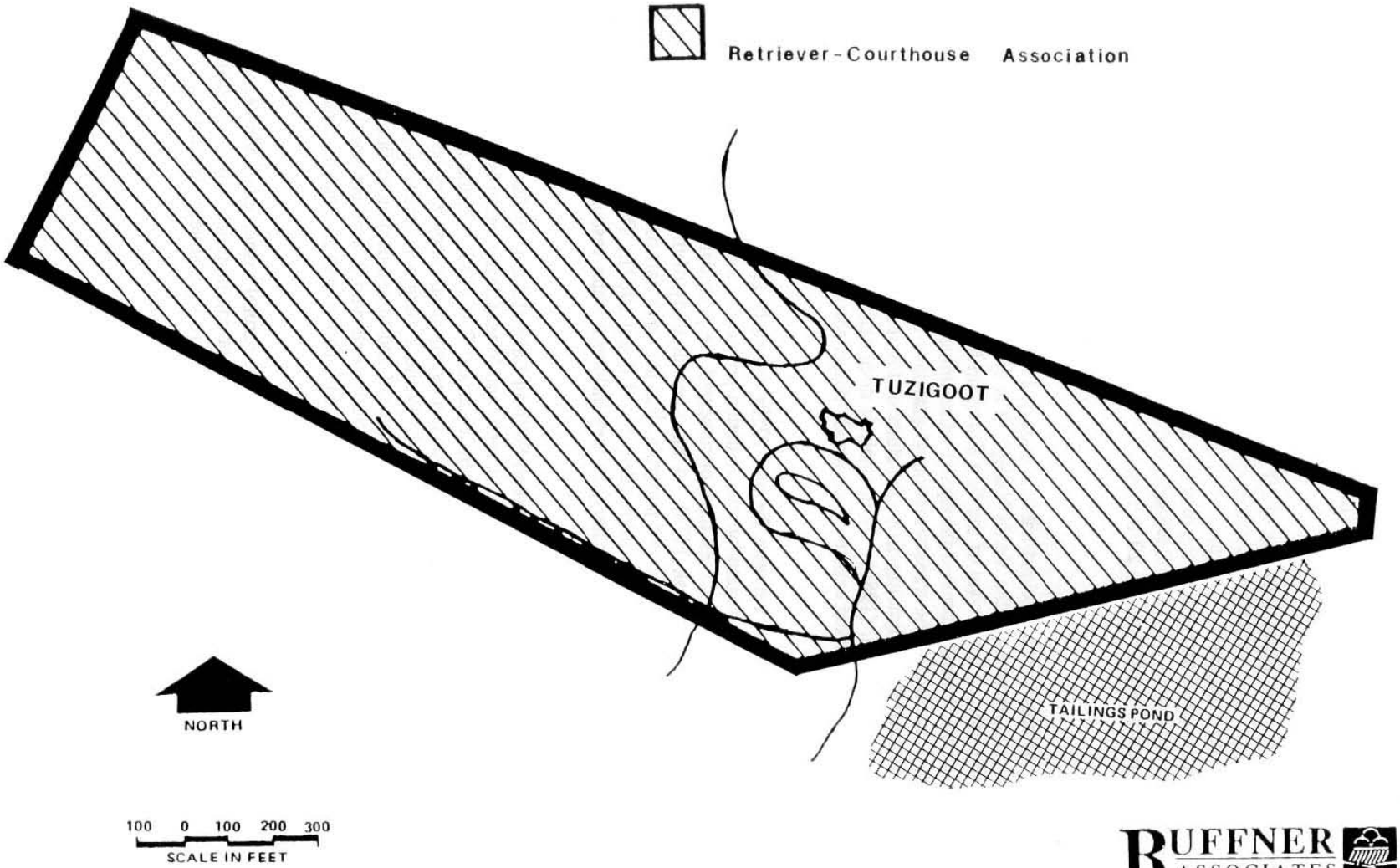

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Figure 10. Soils map for Tuzigoot National Monument.

are 35 to 20 percent, respectively. The remaining 15 percent is comprised of local patches of Mojave, Anthony, Palos Verdes, Laveen, Tres Alamos, and Gila soils (Soil Conservation Service 1972).

Continental soils are deep, often in excess of 30 inches. A thin surface layer of fine sandy loam is underlain by reddish clay subsoils and calcareous gravelly clay barns to gravelly sandy loams. Loams may be weakly cemented. Whitlock soils are also relatively deep soils. They are moderately coarse textured throughout the profile. Lime may accumulate at shallow depths resulting in weak cementing. Typical Cave soils have a shallow, gravelly sandy loam profile with a hard lime pan at depths of 4 to 20 inches.

Biota

The juxtaposition of upland and lowland habitats dissected by floodplain produce unique and diverse biological communities in the Verde Valley. It is one of the most significant bio-regions of Arizona. At the time of the arrival of the first European inhabitants, the Verde Valley was characterized by dense, heavily forested floodplain communities and grasslands in upland communities (Hawkins n.d.). The transformation of grassland and riparian habitats in the Verde Valley has been documented palynologically (the study of fossil spores and pollen) and photographically by Davis et al. (1986). Their analysis documents the regional expansion of pinyon juniper woodland and local expansion of woody desert shrubs, particularly creosote bush and mesquite.

Watershed management practices between the mid-1950s and early 1970s affected Verde Valley biotic communities. Large scale vegetation manipulation projects in coniferous forest and woodland habitats on upper Beaver Creek have documented the potential for increased water yield from the watershed (Brown et al. 1974). A more recent study of these efforts indicated that in the absence of downstream recharge and pumping, less than one half of streamflow increases in the Verde River reaches consumptive users (Brown and Fogel 1987). The downstream affects of these experiments are unknown, particularly as they influence water resources of Montezuma Well and Montezuma Castle.

Evapotranspiration from the Verde River between Sullivan Lake and the confluence with the East Verde River (including Oak Creek, Wet Beaver Creek, and West Clear Creek) is approximately 35,000 acre-feet per year (Anderson 1976 in Owen-Joyce and Bell 1983). In the late 1960s an experiment was initiated to determine what reductions in evapotranspiration may be anticipated as a result of phreatophyte (water-loving plants) control. While a marginal increase in water yield may be realized, the negative effect of clearing cottonwood and mixed deciduous floodplain forests on breeding bird communities has been dramatically indicated (Carothers and Johnson 1970, Carothers et al. 1974, Carothers and Johnson 1975). The effects of these manipulations on other wildlife groups is unknown.

The following discussions describe the terrestrial and aquatic natural resources of Montezuma Castle, Montezuma Well, and Tuzigoot with emphasis on plant communities, wildlife, sensitive species, and Montezuma Well. Although these monuments were legislatively established

primarily to protect prehistoric and historic cultural resources, they also protect significant natural elements.

Plant Communities. Terrestrial plant communities have been mapped at all three monuments (Ruffner and Johnson 1990). Seven distinct plant associations were found (Table 2).

Upland plant associations, the Snakeweed-Mesquite Association and the Creosote-Crucifixion Thorn Association, are not strongly influenced by surface waters since they are often located away from water. The Mesquite Association is affiliated with available groundwater since it is located on floodplain between the upland and riparian habitats. The associations for riparian forests and woodlands and for wetlands are strongly dependent on the water resources. These are the Sycamore-Ash-Cottonwood-Mixed Deciduous Association, the Cattail Association, the Cottonwood Association, and the Pondweed Association.

Hydrologic regimes are known to affect riparian plant species and communities (Johnson et al. 1976, Reily and Johnson 1982, Turner and Karpiscak 1980). The mixed deciduous association is best developed at Montezuma Castle along Beaver Creek and at Montezuma Well along Wet Beaver Creek. The Mesquite Association occurs on the edge of floodplain at the Castle and Well. The Pondweed Association is found only within the pond of Montezuma Well. Near Tuzigoot the Cottonwood Association occurs along the Verde River and the Cattail Association occurs in Tavasci Marsh. Lists of typical plants of major habitat types are given in Brown (1982).

Wildlife. A diversity of aquatic and terrestrial wildlife species are present in the Verde Valley. Birds, however, are probably the most commonly observed wildlife. Breeding bird density in undisturbed riparian habitats, particularly the Cottonwood Association, is among the highest reported from North America. Breeding bird density is generally lower in habitats characterized by the Sycamore-Ash-Cottonwood-Mixed Deciduous Association (Carothers et al. 1974). Lists of typically found fishes, amphibians, reptiles, birds, and mammals by major habitats are provided in Brown (1982).

A fishery dominated by introduced species exists in Wet Beaver Creek, Beaver Creek, and Verde River. Introduced species, primarily gamefish, include smallmouth bass, largemouth bass, carp, green sunfish, yellow bullhead, channel catfish, flathead catfish, mosquito fish, and flathead minnow. Rainbow trout, which is stocked by Arizona Game and Fish Department, and brown trout occur in the upper reaches of Wet Beaver Creek (Arizona Game and Fish Department 1985). Native fishes include Sonora sucker, desert mountain sucker, spikedace, Colorado squawfish, and razorback sucker.

Rare. Threatened, and Endangered Species. Several sensitive species, those protected or of special concern to the US Fish and Wildlife Service (USFWS) and Arizona Game and Fish Department (AGFD), are known from the Verde Valley. Arizona cliffrose is found on calcerous upland soils derived from the Verde Formation (Schaack and Morefield 1985). It is classified as endangered by USFWS. Suitable habitat for this plant exists at Montezuma Castle, Montezuma Well, and Tuzigoot; however, it has not been documented from any of these areas. It is probable that most activities associated with water resources management will have no adverse effect on

Table 2. Biotic associations occurring in Montezuma Castle and Tuzigoot National Monuments. Classification based on Brown et al. (1974).

Biotic Association	*Acres/Percent by Monument*		
	Montezuma Castle	*Montezuma Well*	*Tuzigoot*
Snakeweed-Mesquite 143.165	0	0	212/32
Creosote-Crucifixion Thorn 154.124			
Cottonwood 223.212	0	0	47/7
Sycamore-Ash-Cottonwood Mixed Deciduous 223.221	125/22	75/27	0
Mesquite 224.522	146/25	36/13	
			173/26
Cattail 244.712	0	0	
	0	2/1	104/15
Pondweed 264.712			
TOTAL	580/100	278[1]/100	673[2]/100

'Includes a 16.83-acre private inholding

'Excludes 188-acre tailings pond and dam

this species. The southern bald eagle, another USFWS endangered species, is known to nest in the area. Wet Beaver Creek, Beaver Creek, and the upper Verde River may be used by foraging eagles. Two sensitive species, the yellow-billed cuckoo and common black hawk, which are riparian obligates, breed on the riparian community of Montezuma Castle. Experimental populations of razorback sucker and Colorado squawfish have been re-introduced into the Verde River upstream of Clarkdale by AGFD. Spikedace are known from the Verde River upstream of Clarkdale. This species is classified as threatened by USFWS.

Montezuma Well. Montezuma Well is among the premier natural resources managed by NPS. It supports taxa that are found no where else in the world. Many are presently undescribed. The Well's unique characteristic was recognized when it was brought into the NPS system; however, its diversity and the complexity of interactions between organisms occupying this ecosystem have only recently been studied. Two long time workers, Dr. Gerald A. Cole from Arizona State University and Dr. Dean W. Blinn from Northern Arizona University, believe that the Montezuma Well ecosystem may be globally unique. Cole's work (1982) and a composite list of publications by Blinn and his students are on file at monument headquarters.

Water Resources

Water resources addressed by this plan include perennial and ephemeral streams, springs, and wells in the regional aquifer. The water resources of Montezuma Castle include Beaver Creek and a well (A-14-5 17 aac) providing water to resident NPS staff and visitors. The well numbering system used by the USGS in Arizona is in accordance with the Bureau of Land Management's system of land subdivision. The well numbering system is described in Appendix B. Beaver Creek is fed by ephemeral discharge in Dry Beaver Creek and a perennial spring in Section 14, T 15 N, R 7 E, which discharges into Wet Beaver Creek. Beaver Creek is perennial from the confluence of Wet and Dry Beaver Creeks to Montezuma Castle. A sewage lagoon is the only artificial impoundment at the Castle Unit.

Water resources at Montezuma Well unit consist of the natural well, Wet Beaver Creek, and two wells (A-15-06 31 cba 1 and A-15-06 31 cba 2) in the Verde Formation providing public water supplies to resident NPS staff and visitors. Montezuma Well occurs in a circular limestone depression in the Verde Formation. Water enters the Well from at least three fissures at the bottom (Cole and Barry 1973). An outlet along the southeast margin discharges into an irrigation ditch of prehistoric origins which is still used today.

Water resources within Tuzigoot consist of a single well (A-16-03 22 bcc) providing a public water supply to resident NPS staff and visitors. However, Shea Spring (A-16-3 15 cdb) discharging into and maintaining Tavasci Marsh, which is north and east of the visitor center, and the Verde River, which is immediately south, are significant resources within the legislated boundary of the monument. Much of the legislated 732 acres are privately owned by the Phelps Dodge Corporation. Through an agreement with this Corporation, the Arizona Game and Fish Department exercises management control of Tavasci Marsh. Discharge from the public water supply well and Shea Spring issues from the Verde Formation (Owen-Joyce and Bell 1983).

The regional aquifer includes the alluvium of the Verde River, Verde Formation, Coconino Sandstone, Supai Formation, Naco Formation, Redwall Limestone, Martin Formation, and Tapeats Sandstone. They are hydraulically connected. Groundwater movement within the Verde Valley is controlled by the Mormon Mountain anticline located 15 to 30 miles northeast of the Mogollon Rim and by the crest of the Black Hills. Groundwater movement in this area is basinward (Twenter and Metzger 1963, Glotfelty 1985). The highest yields from wells (greater than 500 gallons/minute) occur in the Verde Formation, Coconino Sandstone, and Redwall Limestone. Transmissivity within the regional aquifer ranges from a low of 20 to a high of 16,000 square feet per day (Owen-Joyce and Bell 1983).

Water resources within the Verde Valley have been used since prehistoric times. Irrigation ditches used by Native cultures are evident on or near all three monuments, but they are usually difficult to locate and document. Europeans entered the Verde Valley on a number of occasions from the early 1500s through the mid-1800s. Within the past 125 years changes in land use and water resources have been better documented. Anglo-American soldiers, miners, farmers, and stockmen established permanent settlements by the 1860s. Riparian forests, woodlands, shrublands, and grasslands were altered by agricultural practices, timber harvesting, and mining. For decades these activities dominated land and water uses in the Verde Valley. However, declining ore bodies and highly mobile retirees seeking "sunbelt" communities are prompting another shift in land and water use patterns. Rapid urbanization is presently occurring throughout the Verde Valley. The estimated 1988 population of the Verde Valley is approximately 23,000. This is expected to increase to almost 36,000 by the year 2005 (Northern Arizona Council of Governments 1984).

The hydraulic connection between groundwater and surface water resources and the probability that additional growth in the Verde Valley will rely on groundwater (Owen-Joyce and Bell 1983) suggest that well drilling activity will increase with population growth. Records for lands occupied by an NPS facility and the four adjoining sections (a radius of approximately 1.5 miles) indicate that the number of wells drilled and the rate of well drilling (number per year) has apparently increased since the early 1970s (Table 3), particularly in the vicinity of the Castle and Tuzigoot (Arizona Department of Water Resources 1988). Data are incomplete for Tuzigoot because landowners are not required to report the year a particular well was drilled. Consequently, dates are lacking for 43 wells on lands adjacent to that monument. Drilling activity has, fortunately, been less in the area surrounding Montezuma Well, and no new wells were registered with Arizona Department of Water Resources between 1970 and 1990. The surrounding private lands remained undeveloped for several years, but recently they have begun to be developed. Discharge from Montezuma Well could be influenced by groundwater extraction from the regional aquifer.

Land and water use patterns in the Verde Valley indicate that water rights, water quality, aquifer protection, floodplain regulation, instream mining, instream flow, riparian habitats, wildlife, and endangered species are among the concerns that are likely to surface in the future. This Water Resource Management Plan presents proposed actions and alternatives addressing these issues for the monuments.

Table 3. Well drilling activity in the vicinity of Montezuma Castle and Tuzigoot National Monuments from pre-1900 to 1986. Data summarized by the Arizona Department of Water Resources (1988).

	* Time Interval						
	<1900	*1901/ 1950*	*1951/ 1970*	*1971/ 1980*	*1980/ 1986*	*Drilling Date Unknown*	*Total*
Montezuma Castle	0' (0)[2]	1 (<0.1)	4 (0.2)	16 (2.3)	5 (0.8)	7	33
Montezuma Well	2 (<0.1)	2 (<0.1)	2 (0.1)	0 (0)	0 (0)	0 (0)	6
Tuzigoot	0 (0)	3 (<0.1)	8 (0.2)	22 (1.6)	13 (1.8)	43	89

'Wells drilled during time interval 'Average number of wells drilled per year

Surface Waters

Beaver Creek extends about 9 miles from the confluence of Wet Beaver Creek and Dry Beaver Creek to the Verde River. About 1.5 miles of this stream flows through the Montezuma Castle Unit, which is located about 4 miles above the confluence with the Verde River. Beaver Creek is perennial from it's origin to the Castle; however, part or all of the flow is diverted for irrigation during the summer (Owen-Joyce and Bell 1983, Glotfelty 1985).

A lined, 4-celled, 1.6-acre sewage lagoon is located approximately 1300 feet northeast of the visitor center at Montezuma Castle. It is above the 500-year floodplain of Beaver Creek and has a capacity of 2,081,000 gallons (pers. comm. Tom Lew, Denver Service Center, NPS 1988).

Montezuma Well and a perennially flowing reach of Wet Beaver Creek are the surface waters found within the Well Unit. Wet Beaver Creek originates from springs in the Coconino Sandstone in Section 33, T 15 N, R 7 E. It flows west southwest for about 14 miles towards the Well, which is 6 miles above the confluence with Dry Beaver Creek.

Following is a description of Montezuma Well from Cole (1982):

> "The Well is a limnocrene fed by artesian waters arising from two or three deep fissures near the center. Cole and Barry (1973) presented a bathymetric map and a table of morphometric data applying to the Well basin. Other details that may facilitate further research are presented here. The water pours out of this spring lake from a point at the southeast border. Many years ago this outlet was dubbed the swallet by Monument personnel. It is also called the inner outlet. The water disappears into a limestone cave for about seven minutes' flow before emerging at the outer outlet (ca. 5 m lower altitude). This heads an effluent stream simply called the ditch. Under natural conditions the outer outlet would pour into Wet Beaver Creek. The ditch is man made and served originally as an Indian irrigation canal. A calibrated Parshall flume or "weir" present a few meters downstream served for making rough estimates of water entering the Well daily, without taking into account evaporation and unknown losses from the Well elsewhere." (Note: The wier installation, maintenance, and discharge monitoring are carried out under a cooperative agreement between NPS and USGS.)

There are no surface waters on the federally owned lands in Tuzigoot National Monument. The Verde River, Tavasci Marsh, and its source, Shea Springs, are within the legislative boundary. Shea Springs has also been identified as Tuzigoot Spring. It is recorded as well A-16-3 15 cdb based on the numbering system used in Arizona.

The NPS has proposed eliminating a tailings pond from the proposed legislative boundaries of Tuzigoot. An evaluation of the tailings pond was requested by NPS (Peterson et al. 1978), which is located immediately west of the monument and lies in an abandoned river channel, an ancient cutoff meander that forms Pecks Lake. The tailings pond lies in a northwest-southeast direction and is 4200 feet long and 1700 feet wide at its widest point. The northwest crest is about 65 feet higher than the old channel, and the face slopes at 40 degrees. No water is purposely impounded, but the entire surface is diked and irrigated to reduce blowing dust.

The tailings deposit was started in 1927 by the United Verde Copper Company to dispose of copper tailings from its Clarkdale, Arizona, milling operations (Peterson et al. 1978). The deposit started with construction of an earth dike across an abandoned channel of the Verde River. The dike was built at the northwest end of the present tailings deposit. Tailings were deposited into the abandoned channel southeast of the dike. Disposal continued until 1929 until the mine and mill shut down. Phelps Dodge Corporation acquired the mining operations in 1935 and resumed disposal until 1950 when the Clarkdale smelter was permanently closed.

Local residents complained to Phelps Dodge Corporation about the dust problems from fine tailings material. The corporation initiated an irrigation program to lessen the nuisance of blowing dust. The deposit's surface was graded and diked so water from Pecks Lake could be pumped to the site and distributed over the entire surface by gravity flow. The program has continued since 1956.

Visual examination of the tailings deposits by Peterson et al. (1978) indicated:

1. The northwest end was comprised of the coarser fraction of the deposited tailings. This material would expectedly have the highest permeability of any of the deposited material and tend to depress the phreatic surface in the area of the sloped embankment.

2. The continual application of water for dust control would tend to keep the deposited material in a state of high saturation. However, the high evaporation rate for the area (about 60 inches per year) would limit the amount of moisture actually penetrating and remaining within the embankment.

3. The ponding of water in the irrigation channels and the fine clay-like material lining the channels have created a "skin effect," which also reduced the penetration of the irrigation water into the tailings deposit. This "skin" material was probably a mixture of the clay portion of the material used for dike building and the extremely fine fraction of the deposited tailings.

   No seepage was apparent along the northwest face during this examination even though irrigation was being conducted immediately behind the face. Irrigation had occurred 5 days per week for about a month prior to the site visit.

5. The irrigation ditches are normally dry within a few days after irrigation water is turned off. A strong, pungent acid smell was prevalent along the partially dried ditches.

6. Severe erosion occurred along the entire northwest face of the deposit. Multiple motorbike trails contributed to the erosion.

7. Cracks or surface depressions were not evident along or across the paved access road that crossed the deposit near the southeast corner.

The conclusions by Peterson et al. (1978) were that major slope failure of the tailing deposit was unlikely under conditions at the time. The absence of seepage along the northwest face, where

the most highly permeable sand was deposited, indicated that either the saturated material within the embankment laid well back from the existing face, or that the evaporation rate was greater than the seepage rate. If water quantities placed on the surface of the deposit were consistent with the application at that time, no slope failures were anticipated. The report recommended a regrading operation of the deposit to reduce erosion and drilling a series of monitoring well to detect buildup of phreatic conditions.

These recommendations were not enacted by NPS since it is not federal land. However, Phelps Dodge Corporation has done some repair work on the berms and drilled some monitoring wells. The corporation has undertaken plans to build Verde Valley Ranch, a residential community adjacent to the west boundary of the monument. The tailings pond will be developed into a golf course. Phelps Dodge Corporation is providing information to the Arizona Department of Environmental Quality as part of their application for an Aquifer Protection Permit. The data is not yet public information.

Classification of Surface Water by Existing Uses

The State of Arizona, through the Department of Environmental Quality, has promulgated water quality standards for surface waters of the state (Arizona State Water Quality Regulations, Arizona Administrative Code Title 9 Chapter 21 1987). They include standards for water quality and designated uses. Two statues apply, i.e. Arizona Water Quality Control Law and Arizona Surface Water Quality Standards, which set the following surface and groundwater quality goals:

> Wherever attainable, surface water quality which provides for the protection of aquatic life and wildlife, for the protection of recreation in and on the water and for the protection of domestic water supply shall be achieved and maintained. For a particular surface water segment, the feasibility of attaining the above stated goals shall be based on a balanced consideration of technological, economic, social, legal, and environmental quality factors.

Waters are classified according to their primary (P) use and, where appropriate, the secondary (S) use. The Arizona State Water Quality Standards identify six protected uses; domestic water source, full body contact, incidental human contact, aquatic and wildlife, agricultural irrigation, and agricultural livestock watering. Four protected uses pertain to the monuments since they were applied to surface waters of the Verde River upstream from Bartlett Dam, Dry Beaver Creek, Wet Beaver Creek, and unlisted tributaries or segments under the tributary rule. The tributary rule applies protected uses given for the nearest downstream listed surface water segment that is not effluent dominated to an unlisted water segment or tributary. Those four protected uses are defined below:

> Full body contact (FBC) is the use of a surface water for an activity which normally causes the human body to come into direct contact with the water to the point of complete body submergence. It includes swimming, water skiing, skin diving, and other similar activities during which water may be ingested accidentally and certain sensitive body organs, such as eyes, ears, nose, etc., may be exposed to the water.

Aquatic and wildlife (A&W) is the use of a surface water for the growth and propagation of fish, waterfowl, fur-bearers, other aquatic life, semiaquatic life, or other wildlife. This water may be used for a cold water fishery (e.g., Wet Beaver Creek), warm water fishery (e.g., Dry Beaver Creek), wildlife habitat, or other similar uses.

- Agricultural irrigation (AgI) is the use of surface water for irrigated farming. It does not include the use of a surface water for washing and cooling raw farm products and washing milk handling equipment and cooling dairy products.

- Agricultural livestock watering (AgL) is the use of a surface water supply for livestock, including but not limited to beef cattle, dairy cattle, sheep, swine, horses, and poultry.

Table 4 shows the types of water in the monuments with notation of primary (P) or secondary (S) use and of protected use, i.e. FBC, A&W, AgI, and AgL.

Water Quantity

Waters of the Verde Valley ultimately discharge into the Verde River, which drains an area in excess of 3,800 square miles above Clarkdale (Table 5). The river headwaters are in central Yavapai County and receive runoff from the Sierra Prieta, Mogollon Rim, and Chino Valley. Direct runoff and base flow are the two major components of streamflow (Owen-Joyce and Bell 1983). The contribution of direct runoff is greatest during the late winter and spring when snowpack on upper reaches of the drainage, particularly the Mogollon Rim, are melting. Base flows in the Verde River and its perennial tributaries are maintained by discharge from the regional aquifer. Average discharge at Clarkdale is 202 cubic feet per second (cfs), and the median of mean discharge is 170 cfs for the 24-year period of record (US Geological Survey 1988). Extremes for the period of record are 50,600 cfs and 55 cfs (Table 6). The gaging station records are on file in the US Geological Survey offices in Flagstaff.

Beaver Creek is perennial from its confluence origin through the Montezuma Castle Unit; however, part or all of the flow is diverted for irrigation during the summer (Owen-Joyce and Bell 1983, Glotfelty 1985). During the peak irrigation season (June), half of the 15 cfs streamflow gain in the Verde River at the mouth of Beaver Creek is attributable to subsurface irrigation return flows through the alluvium (Owen-Joyce and Bell 1984).

The mean discharge of Wet Beaver Creek measured at the gaging station (Wet Beaver Creek near Rimrock) is 30 cfs over a 16-year period of record. This gage, with a drainage area in excess of 100 square miles (Table 5), is two miles upstream from Montezuma Well and above Red Tank Draw, which is an intermittent stream that occasionally contributes substantial discharge to Wet Beaver Creek. The median of yearly mean discharge is 24 cfs (US Geological Survey 1988), and base flow ranges from 6 to 8 cfs (Owen-Joyce and Bell 1983). Maximum discharge for the 16-year record period is 3,960 cfs (Table 6).

Montezuma Well is fed by artesian waters that enter from the fissures at rates varying from less than 2 to almost 3 cfs (Cole and Barry 1973). The source of this discharge is currently

Table 4. Use classifications of surface waters in Montezuma Castle and Tuzigoot National Monuments.

Water Type	*Uses*
Public Water Supply Non-Public	Domestic water wells at each monument - P
Water System Maintenance of	None
Ecosystem; General	All natural surface waters within the present boundaries of each monument - P, A&W
Maintenance of Ecosystem; Species of Special Interest Other than Threatened and Endangered Species	Wet Beaver Creek - P Beaver Creek - P, A&W Montezuma Well - P, A&W
Maintenance of Ecosystem; Threatened, Endangered, and Indigenous Species	Wet Beaver Creek - P, A&W Beaver Creek - P, A&W Montezuma Well - P, A&W
Recreational Purposes; Contact	Wet Beaver Creek - S, FBC Beaver Creek - S, FBC
Recreational Purposes; Non-Contact	Wet Beaver Creek - P, A&W Beaver Creek - P, A&W Montezuma Well - P, A&W
Agricultural Irrigation and Livestock Watering	Wet Beaver Creek - S, AgI, AgL Beaver Creek - S, AgI, AgL Montezuma Well - P, AgI, AgL
Disposal of Sewage Effluent	None

P - Primary
S - Secondary
FBC - Full body contact
A&W - Aquatic and wildlife
AgL - Agricultural irrigation
AgL - Agricultural livestock watering

unknown; however, some evidence indicates that it may originate in the Supai Formation (Cole and Barry 1973, Glotfelty 1985).

Montezuma Well discharges at an average annual rate in excess of 2 cfs. The water pours out of this spring lake from a point at the southeast border referred to as "the swallet" (inner outlet). The discharged water disappears into a limestone cave for about a 7-minute flow before emerging at the outer outlet. This heads an effluent stream referred to as "the ditch". Under natural conditions the outer outlet would pour into Wet Beaver Creek (Cole and Batchelder 1969, Cole and Berry 1973, Cole 1982). Extremes for the 8-year period of record are from slightly greater than 2 cfs to approximately 1 cfs (Table 6).

Discharge of Shea Springs at Tuzigoot has not been measured. It is estimated to be approximately 2 cfs (Reed 1980). Periodically, USGS and NPS staff measure well levels, conduct drawdown tests, and conduct other pertinent evaluations of wells at Montezuma Castle, Montezuma Well, and Tuzigoot. Data for all three areas and associated correspondence are on file at monument headquarters.

Water Ouality

Water quality data are available from a number of groundwater and surface water sources in the Verde Valley. The largest database is STORET, maintained by Environmental Protection Agency (EPA) and Arizona Department of Environmental Quality (ADEQ). Not all available data are in this database, and there is a backlog of information awaiting entry. Water quality information is available from 30 stations in the vicinity of Montezuma Castle, Montezuma Well, and Tuzigoot (Table 7).

The Northern Arizona Council of Governments (1979) conducted an analysis of water pollution sources in the Verde Valley. The council analyzed pollution sources in terms of three major land use activities: urban, agricultural, and mining/industrial. Based on available geologic, hydrologic, soils, land use, water quality, and other pertinent information, several suspected water pollution problem areas were identified.

The analysis indicated that urban land use practices generally had the greatest pollution potential of the three major land use activities. Mining operations in Bitter Creek and on the Verde River were probably significant pollution sources; however, mining land use was much less widespread than was urban land use in the Verde Valley. The agricultural activities occurring in the study area did not appear to be a significant source of water pollution.

At the time of the study, water quality data was scarce. Consequently, firm conclusions with regard to pollution source assessment could not be made. The report recommended a tentative water sampling program designed to provide more definitive information on the nature and extent of suspected water quality problem areas. It listed several problem areas recommended for future sampling throughout the Verde Valley. The pollution problems included septic system leachate, wastewater leachate and overland flow, acid mine drainage, suspended sediments and turbidity from sand and gravel mining operations, solid waste leachate, urban runoff, and pesticides and dissolved solids in irrigation waters.

Table 5. Measurements from gaging stations on principal drainages influencing Montezuma Castle and Tuzigoot National Monuments (US Geological Survey 1988).

Station	*Number*	*Period of record*	*Watershed area (sq. mi.)*	*Average discharge (ac.ft. /yr.)*
Dry Beaver Creek near Rimrock	09505350	1960/85	142	35,570
Montezuma Well Outlet	09505260	1978/85	NA	1,640
Verde River near Clarkdale	09504000	1965/85	3,520	146,300
Wet Beaver Creek near Rimrock	09505200	1961/85	11	

Table 6. Discharge at gaging stations on principal drainages influencing Montezuma Castle and Tuzigoot National Monument (US Geological Survey 1988).

Station	*Maximum discharge fcfs)2*	*Minimum daily* (cis)	*Extremes 1985'* Al's)	*Total discharge 1985* (cis)
Dry Beaver Creek near Rimrock	26,600	0	0/4,250	19,481
Montezuma Well Outlet	3	1	1/2	627
Verde River near Clarkdale	50,600	55	81/4,760	64,958
Wet Beaver Creek near Clarkdale			nd[3]/3,960	

'Low and high extreme values for 1985

'Cubic feet per second

[3]No Data

Table 7. Stations on principal drainages influencing Montezuma Castle and Tuzigoot National Monuments with water quality data in STORET.

Station name	*Station number*
Verde River below confluence with Beaver Creek	700000000017870
Verde River bridge above Camp Verde	700000000017980
Verde River above Beaver Creek near Camp Verde	43424111513300
Beaver Creek above confluence with Verde River at Camp Verde	343428111511600
Verde River at I-17 Bridge	VR 7
Beaver Creek above confluence with Verde River	704600000000030
Verde River at I-17 Bridge near Camp Verde	343513111524600
Wet Beaver Creek below Top-of-Morning Ford	704600100002180 VV12
Wet Beaver Creek at Rusty Spur Ford	343752111473500
Dry Beaver Creek above mouth Wet Beaver Creek at Montezuma Avenue Bridge	704600100002390 VV11
Wet Beaver Creek above Lake Montezuma	704600100002460 VV10
Wet Beaver Creek near Rimrock	09505200
Red Tank Draw near Rimrock	09505250
Rattlesnake Canyon near Rimrock	09505300
Red Tank Draw above mouth Dry	704600130000450
Beaver Creek near Rimrock	9505350
Verde River below Rio Verde Circle Ford	700000000022250 VV09
Verde River below Dead Horse Ranch Ford	700000000022425 VV08
Verde River above Cottonwood	700000000022450 VV07
Verde River near Tuzigoot	700000000022022
Tavasci Marsh Wash at mouth near Clarkdale	344557112011600
Verde River at Tuzigoot Bridge Verde River	344557112014600
below Tuzigoot Bridge Bitter Creek near	700000000022000 VV06
Cement Plant Bridge Verde River below Bitter	702600100000363 VVO4
Creek Bitter Creek near Verde River Verde	700000000023025 VV02
River above Bitter Creek Pecks Lake	702600100000001 VV03
Verde River near Clarkdale	700000000022100 VV01
	000240 AZTOX240
	09504000

No money followed this report by the Northern Arizona Council of Governments to conduct the recommended sampling or to correct problems. However, a few problems affecting the monuments have been addressed.

One problem area specifically named was the wastewater treatment facility for Montezuma Castle National Monument (Northern Arizona Council of Governments 1979). Sanitary waste effluent from the septic tank was fed into earth lagoons for ultimate disposal. It was located in a sharp bend of Wet Beaver Creek in the floodplain, and there was occasional flooding of the lagoons due to seasonal high water levels. In addition, there was the possibility of groundwater pollution due to the lagoons. Sandy soils in the vicinity of the ponds, together with a shallow depth to groundwater (estimated to be 35 feet) made that a strong possibility. The NPS built a new wastewater treatment facility with lined sewage lagoons on another site above the base and critical action floodplain boundaries to solve this problem.

The Council's report discussed two major land uses that affect Tuzigoot National Monument. The one specifically named was the Phelps Dodge tailings pond, which is waste rock materials left after treatment to extract copper. A chemical analysis of elements of the tailings was included in the report. The tailings pond is discussed in this water resources management plan in the previous subsection about surface waters. Phelps Dodge Corporation grooms and irrigates if for dust control and has repaired the southeast berm after being notified that erosion was occurring. The report recommended reclamation for the site. While at the time it was written, there were a few potential reclamation projects, nothing has been implemented. The proposed Verde Valley Ranch development by Phelps Dodge Corporation would include converting the pond to a golf course.

While the Northern Arizona Council of Governments' report (1979) did not specifically discuss this site, it did describe the polluting effects of grazing on the Verde River. They include inorganic nitrogen, fertilizer phosphorous, sediment, and pesticides. Sufficient concentrations of such substances can have damaging effects on animal, plant, and human life. The primary pathways through which agricultural chemicals are transported to surface waters are seepage from irrigation canals, leachate from irrigated fields, and overland flow from irrigated fields.

Tavasci Marsh has been leased for several years from Phelps Dodge Corporation for cattle grazing. The lease recently was eliminated, and Arizona Game and Fish Department has initiated a project with Phelps Dodge Corporation to restore Tavasci Marsh. The project objective is to restore wildlife habitat. In addition to no more agricultural chemical application, the ditches made to drain the Marsh will be filled in.

An overview of regional water quality was completed by Owen-Joyce and Bell (1983). Concentrations of major cations, anions and dissolved solids are related to contribution groundwater aquifers (particularly the Verde Formation) to surface water flows. During periods of base flows, groundwater and surface water qualities are similar. However, during periods of medium and high flows (spring and late summer) when the watershed receives runoff from snowmelt and rainfall, the high concentration of dissolved solids and ions associated with the Verde Formation are diluted.

Dissolved solids in 211 samples throughout the Verde Valley (including Oak Creek) during a variety of flows were analyzed by Owen-Joyce and Bell (1983). Extreme values for the watershed were 32

and 1570 mg/1. The positive relationship between concentration of dissolved solids and specific conductance during periods of low flow (June) is stronger at downstream stations near Camp Verde than upstream at Clarkdale. Coincident with increasing concentration of dissolved solids are changes in concentrations of major ions, particularly sodium and sulfate ions. The increase in concentrations of these ions is probably related to their solution by ground water moving through salt and gypsum deposits in the Verde Formation. Annually, the dominant ions are calcium, magnesium, and bicarbonate.

Fecal coliform increases in the Verde River between Clarkdale and Cottonwood. This increase is probably related to a cattle grazing operation in Tavasci Marsh. During January 1981, waters draining the marsh area had a fecal coliform count of 2,100 cfu/100 ml. Above the point where this drainage discharges into the Verde, fecal coliform concentration was less than 1 cfu/100 ml. Fecal coliform concentration in the Verde River below Tavasci Marsh increased to 203 cfu/100 ml (Northern Arizona Council of Governments 1982).

The limnology of Montezuma Well has been studied extensively by Dr Gerald A. Cole, Dr. Dean W. Blinn, and their students. Cole (1982) has summarized most of the research featuring the Well. The evolution and chemistry of CO_2 entering the Well have been described in detail by Cole and Batchelder (1969) and Cole and Barry (1973). "The water is a concentrated bicarbonate type with considerable amounts of NaCl" (Cole and Barry 1983).

The NPS has water quality data for wells at each monument on file at headquarters. Most analyses are periodic tests of well water to assure compliance with public health standards for drinking water supplies. Some information, however, pertains to quality of surface waters, particularly Montezuma Well. The staff recognizes the need to develop a more comprehensive water quality program.

Water Rights

The United States National Park Service holds both state appropriate and federal reserved water rights in Montezuma Castle, Montezuma Well, and Tuzigoot National Monuments. State water rights in Arizona are based on the Doctrine of Prior Appropriation. Under this Doctrine, the party who first uses water for a beneficial use has a prior right to use, against all other appropriators, e.g., "first in time, first in right." The water must be put to beneficial use as defined by the state. In Arizona, beneficial uses include irrigation, domestic, stock watering, municipal, commercial, industrial, mining, recreation, fish and wildlife, and other uses. An appropriative water right is a property right. Under state law it can be bought or sold and its place of use, purpose, and point of diversion may be changed without loss of priority provided there is no injury to the water rights of others.

Federal reserve water rights arise from the purpose for the reservation of land by the federal government. When the federal government reserves land for a particular purpose, it also reserves, by implication, enough water unappropriated at the time of the reservation as is necessary to accomplish the purposes for which Congress or the President authorized the land to be reserved, without regard to the limitations of state law. The rights vest of the date of the reservation, whether or not the water is actually put to use, and are superior to the rights of those who commence the use of water after the reservation date. General basinwide adjudications are the means by which the

federal government claims its reserved water rights. The McCarran Amendment (66 Stat. 560, 43 USC 666, June 10, 1952) provides the mechanism by which the United States, when properly joined, consents to be a defendant in an adjudication.

Once adjudicated by the state, the water rights of the United States, reserved and appropriated, fit into the state priority system along with those of all other appropriators. In general, when it is brought into a general adjudication, the United States is given its only opportunity to assert its claim to water rights. Unless legally absent from the proceedings, it is generally understood that failure to assert a claim in such a proceeding may result in forfeiture of these water rights.

In 1985, in a general water rights adjudication of the Verde River, the United States Department of Justice, on behalf of the National Park Service, submitted both federal reserved and state appropriative water right claims for Montezuma Castle, Montezuma Well, and Tuzigoot National Monuments. State appropriative water rights were claimed for domestic, municipal, and fire protection uses and historic integrity. Federal reserved water rights were claimed for water necessary to fulfill reservation purposes. The federal reserved water rights have not yet been quantified.

In addition to these claims, non-NPS (alien) claims for rights to water from sources within and near Montezuma Castle and Tuzigoot occur. The status and validity of these claims, as well as their potential impacts on management of the park resources, are unknown.

Legal Authority for Water Resources

Although the NPS is in the process of resolving water rights claims at these monuments, the rights were acquired when lands were withdrawn from the public domain, purchased by, or donated to NPS. The Superintendent *exercises proprietary jurisdiction over waters of these* facilities.

The State of Arizona is recognized by NPS as the administering agency for water rights. The state also regulates water quality matters through ADEQ and the Water Quality Control Council. Finally, the Northern Area Council of Governments is the regional entity charged with developing and implementing the Verde River Water Quality Management Plan (1982).

Diversions

In the summer, all or part of the flow of Beaver Creek above Montezuma Castle is diverted for irrigation (Owen-Joyce and Bell 1983). A number of current, historic, and prehistoric irrigation ditches are also found in Montezuma Castle. Currently they are not mapped.

The ditch into which Montezuma Well discharges is one of several historic and prehistoric irrigation ditches present on the area. Currently, they are not mapped.

Floodplain Management

Compliance with Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands) is mandatory for NPS. Executive Order 11988 ties "together the need to protect lives and property with the need to restore and preserve natural and beneficial floodplain values." On February 10, 1978, the US Water Resources Council published *Floodplain Management Guidelines* in 45 FR 6030 as assistance to government agencies in implementing the Executive Order and assist each agency to develop its own procedures for compliance. The National Park Service responded by publishing its *Floodplain Management and Wetlands Protection Guidelines* for implementation in 45 FR 35916. Minor revisions were published in 47 FR 36718. Executive Order 11988 only addresses floodplain within the 100- and 500-year floodplain. The NPS guidelines direct that in areas where "flash floods" occur, protection from the Probable Maximum Flood will be provided by not constructing developments that tend to congregate people within the floodplain, i.e. campgrounds, picnic areas, etc. The Probable Maximum Flood is the largest flood believed reasonably possible as calculated by engineers and scientists.

Federal Emergency Management Agency flood boundary and floodway maps are available for areas adjacent to Montezuma Castle, Montezuma Well, and Tuzigoot. Only portions of the three monuments that are adjacent to principal drainages have been mapped by the Agency.

The 100-year floodplain is the base floodplain, and the 500-year floodplain is the critical action floodplain. Certain activities or types of developments may only occur above the critical action floodplain. The Montezuma Castle sewage lagoon evaporation ponds are an example of a development action that should be well removed from the potential for flooding. Other activities, for example picnic grounds and flood control structures, may occur above or at the base floodplain unless the area is subject to flood hazards, such as flash flooding. A gabion was constructed to keep flood water from the visitor center area of Montezuma Castle.

The NPS has conducted a floodplain study defining the base and critical action floodplain boundaries of Beaver Creek for the sewage treatment and disposal system at the Castle (National Park Service 1981). Elevations of the base and critical action floodplain boundaries are 3102.5 feet and 3106.5 feet, respectively. As a consequence of the study, NPS constructed new sewage lagoons on a site above 3100 feet and removed the older ones, which were occasionally flooded when located at a bend in the creek below 3000 feet.

Flood hazard of an unknown degree exists at Montezuma Castle and Montezuma Well. There are no significant flood hazards within the existing boundary at Tuzigoot; however, an unknown degree of hazard is associated with lands within the legislative boundary.

Gravel Mining

A hydrologic study of gravel mining impacts along a 2 mile reach of the Verde River was prepared for Yavapai County by Simons, Li, and Associates (1985). The study reach began less than one mile downstream from Tuzigoot. It suggested that gravel mining within the Verde River floodplain influences channel alignment, headcut propagation, downstream degradation,

bank erosion, and streamside vegetation. The effects, if any, on adjacent floodplain lands have not been evaluated.

Wetlands and Riparian Ecosystems

Wetlands occur within the present boundaries of Montezuma Castle, Montezuma Well, and Tuzigoot. A small area of Pondweed Association vegetation type is present at Montezuma Well and significant stands of riparian deciduous forest and woodland associations are present at all three areas (Ruffner and Johnson 1990). The latter are the Sycamore-Ash-Cottonwood-Mixed Deciduous Association, the Cattail Association, and the Cottonwood Association. Cole's (1982) review of fossil pollen evidence suggested that Montezuma Well was a wet meadow prior to its formation. Tavasci Marsh comprises approximately 35 acres of marshlands north of Tuzigoot and within the legislated boundary.

Potable Water Supply Systems

Each monument provides potable water supplies for residents, employees, and visitors. Water is tested monthly for public health standards. A summary of these supply systems is presented in Table 8. These appear to be reliable sources and of good quality. There is no indication the Montezuma Well supply system impacts the spring feeding the Well or other natural values.

Wastewater Disposal Systems

Each monument has a wastewater disposal system. The US Public Health Service and the Arizona Department of Environmental Quality have inspected all systems and have not indicated any problems or concerns. They are summarized by monument in Table 9. The new sewage lagoon system was installed at Montezuma Castle to resolve the problem of the previous one's being an earth lagoon system located in the floodplain. At Tuzigoot and Montezuma Well, septic tanks are the primary systems with a chemical toilet in use at the Well. These systems are adequate at this time. Water saving devices were put on toilets and faucets to reduce water flow into the system. A fourth lagoon pond was built in 1989 for Montezuma Castle.

Verde River Valley Planning

Two significant planning processes conducted by local, state, and federal agencies affect the Verde River region. The National Park Service is an active participant in both efforts.

Verde River Corridor Project

The Verde River Corridor Project began in fall of 1989 as **a** locally directed effort to examine all uses and values of the river corridor and develop a plan of action with a common vision that could be supported by the public and managing agencies. A Final Report and Plan of Action (Arizona State Parks 1991) was issued that the ultimate goal is to conserve the river and its related resources in a way that was balanced with growth and economics. The mission is to identify and recognize all uses of the corridor, encourage protection of the river and its natural and cultural resources, and promote coordinated decision-making.

Table 8. Potable water supply systems at Montezuma Castle and Tuzigoot National Monuments.

Monument and facilities	*Raw water source*	*Treatment*
MONTEZUMA CASTLE		
Visitor center Picnic grounds Employee housing Maintenance	Well in Verde Formation	Chlorinator
MONTEZUMA WELL		
Visitor contact station Picnic grounds Employee housing Maintenance	Well in Verde Formation	Chlorinator
TUZIGOOT		
Museum/administration Employee housing Maintenance	Well in Verde Formation	Chlorinator

Table 9. Wastewater treatment systems at Montezuma Castle and Tuzigoot National Monuments.

Monument and facilities	*Treatment*	*Comments*
MONTEZUMA CASTLE		
Visitor center Picnic grounds Employee housing Maintenance	Lined sewage lagoon; total evaporation	Current capacity is 2,081,000 gallons; 7,500-gallon septic tank is an emergency holding tank
MONTEZUMA WELL		
Visitor contact station	Chemical toilet	
Picnic grounds	Septic tank	
Employee housing	Septic tank	
Maintenance	Septic tank	
TUZIGOOT		
Museum/administration	Septic tank	
Employee housing	Septic tank	
Maintenance	Septic tank	

Arizona Rivers Assessment

The Arizona Rivers Assessment is a statewide effort to inventory and evaluate the significant river, stream, and riparian resources of Arizona. It is a cooperative project being undertaken by state and federal agencies and in conjunction with the Governor's Task Force on Streams and Riparian Resources. The goal of the assessment is to provide a planning tool that can be used by resources management agencies, organizations, and decision makers to plan for the future of Arizona's priceless river and riparian heritage and to balance the needs for resource conservation and economic development (Arizona State Parks Board and National Park Service 1990).

Tavasci Marsh Wildlife Habitat Restoration

Phelps Dodge Development Corporation has given Arizona Game and Fish Department authority to restore and manage wildlife habitat in Tavasci Marsh. An interdisciplinary team, which includes NPS representatives, has been convened to design the project with the goal "to protect, enhance, restore, and monitor native biological diversity of Tavasci Marsh." Using Heritage funds derived from the state lottery, the project is aimed to develop wildlife habitat and to provide educational and recreational uses. As an initial step, ranching and draining of the marsh has stopped. A crucial factor will be to maintain water quality since upslope of the marsh there will be intense residential and recreational development, i.e., housing, golf course, boating, fishing, etc.

4 MANAGEMENT PROGRAM

Management Issues

The following issues have been identified for water resources of the monuments.

- Water rights and the Verde River adjudication

  Presently, water rights on the upper Verde River are being adjudicated in Maricopa County Superior Court. This process has been underway since 1985 and will possibly require several more years. It is necessary to keep informed on the adjudication process and aware of additional documentation that may be required by the court.

- Land acquisition

  Some lands within or adjacent to existing NPS boundaries are being considered for acquisition. Some properties should be brought under NPS jurisdiction to protect resources and to enhance management and interpretive opportunities. An example is Tavasci Marsh. The National Park Service is conducting an inventory of adjacent land uses to develop an atlas of current land ownership and uses. With this, NPS can better become a proactive cooperator and protector for resources.

- Instream mining

  Extraction of sand, gravel, and other minerals from the floodplain may result in sediment transport, changes in channel configuration, and altered stream courses. Though no gravel mining occurs upstream of any of these units, there was an active operation a half mile downstream of Tuzigoot. The Environmental Protection Agency has shut down instream gravel operations, and park management is unaware of any companies trying to obtain the permits necessary to operate. Impacts have not been documented inside any of the park units, but the situation will continue to be monitored as well as any proposals for operations. This will be accomplished through participating in permitting procedures of the Yavapai County Flood Control Board and the Army Corps of Engineers.

- Research at Montezuma Well

  Currently, all potential researchers must submit a proposal detailing the study's design, methods, and expected significance. Potentially adverse effects of research efforts should be carefully evaluated prior to issuing permission to conduct research at the Well. Destructive sampling should be well justified.

- Montezuma Well discharge

  In 1977, NPS 'contracted with USGS to initiate monitoring of the discharge in the ditch leading from the Well. This work provides NPS with a long term record of continuous discharge measurements. Due to leakage and evapotranspiration losses along the ditch,

the need to monitor the flow at the Well is now recognized. A clearer understanding of the local aquifer and the aquifer(s) discharging into the Well is necessary to provide management with guidance in evaluating future modifications within the groundwater source area. This information could provide additional protection to the Well, particularly if additional groundwater development to the north and west is proposed.

- Maintenance of adequate discharge to support wetlands and riparian ecosystem

  The large sycamore trees at Montezuma Castle are an integral ecological component and contribute to an enjoyable visitor experience. Successional characteristics in riparian deciduous forests suggest that sycamore have not replaced themselves over the long term. Efforts need to be undertaken to determine if adequate discharge is available from Beaver Creek to support these trees and other plant components. Montezuma Well and Tavasci Marsh are vital wetlands habitat. Protection of groundwater and surface water quantity and quality are essential to their existence.

- Adjacent development influences on water quantity and quality

  The Verde Valley is rapidly growing. Private lands adjacent to NPS areas may be developed in the future. The effect of proposed development on water quantity, water quality, and riparian resources should be evaluated.

Program Implementation

Specific actions regarding water resources are monitoring, administration, research or mitigation. Some complex issues (e.g., non-point pollution) may warrant simultaneous actions in all of these areas. This plan with the project statements are reviewed annually by the superintendent to ensure that the proposals and actions taken result in prudent management of water resources.

Below is a discussion of the management actions as they relate to current and proposed work. Table 10 shows the project statements with code names and the related servicewide issues. The full project statements are presented in a later section.

<u>Monitoring</u>

The monitoring program includes continual measurement of the discharge at Montezuma Well (MOCA-N-03) and evaluation of the water delivery systems for the Well Unit (MOCA-N-05). Discharge measurements and water quality analyses from domestic water wells and waste water treatment are on-going monitoring activities being conducted by the staff. In the future it may be necessary to monitor the effects of instream gravel mining near the units and other adjacent development activities.

Measurement of discharge from waters in and around the monuments is being conducted by USGS. Montezuma Well is maintained under cooperative agreement with NPS. Other gaging stations in the Verde Valley are maintained by USGS and other cooperators, who make the data available to NPS. Water quality analyses will be conducted at selected USGS gaging stations

Table 10. Water resources management projects and related servicewide issues.

Project name and number	*Servicewide issue*
Funded	
MOCA-N-03 Outflow Measurements for Montezuma Well	Alteration of natural flow regimes
MOCA-N-04 Identify and Inventory Water-Related Resource Attributes	Lack of basic data and understanding; Degradation of park water quality
MOCA-N-06 Analysis of Adjacent Land Use and Status	Alteration of natural flow regimes; Degradation of park water quality
MOCA-N-12 Protect the Hydrologic Characteristics of the Archeological and Historical Setting at Montezuma Well	Alteration of natural flow regimes
MOCA-I-02 Prepare a Management Plan for Prehistoric Sinagua Fields	Loss of resources due to consumptive uses; Restoration of prehistoric landscape
TUZI-N-04 Analyze Adjacent Land Use and Status	Alteration of natural flow regimes; Degradation of park water quality
MOCA-N-27 Determine Vulnerability of Unique Biota to Changes in Hydrologic Regimes	Alteration of natural flow regimes; Impacts on threatened, endangered and other sensitive animals
Unfunded	
MOCA-N-05 Evaluate Water Delivery Monitoring System	Lack of secure water rights
MOCA-N-07 Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat	Lack of basic data and understanding; Degradation of park water quality
MOCA-N-08 Assess Habitat Requirements of Aquatic Organisms at Montezuma Well	Lack of basic data and understanding; Degradation of park water quality

Table 10. (Continued) Water resources management projects and related servicewide issue.

Project name and number	*Servicewide issue*
MOCA-N-09 Conduct Riparian Ecosystem Research	Lack of basic data and understanding; Alteration of natural flow regimes
MOCA-N-11 Delineate and Evaluate Strategies for Wetlands Protection	Degradation of park water quality; Alteration of natural flow regimes
MOCA-N-13 Identify Flood-Prone Areas for Protection of Lives and Property	Lack of basic data and understanding
MOCA-N-23 Evaluate Effects of Hydrologic Characteristics on Morphological Properties of Flowing Streams	Alteration of natural flow regimes
MOCA-N-24 Evaluate Effects of Hydrologic Characteristics on Regeneration of Vegetation in Riparian Areas	Lack of basic data and understanding; Alteration of natural flow regimes
MOCA-N-26 Conduct Inventory and Assessment: Fishes	Lack of basic data and understanding
MOCA-C-08 Study of Montezuma Castle Irrigation System	Inadequate archeological survey and inventory
TUZI-N-02 Identify and Inventory Water-Related Resource Attributes	Lack of basic data and understanding; Degradation of park water quality
TUZI-N-03 Restore Tavasci Marsh	Alteration of natural flow regimes; Loss of cultural landscapes
TUZI-N-06 Delineate and Evaluate Strategies for Wetlands Protection	Degradation of park water quality; Alteration of natural of natural flow regimes
TUZI-N-05 Conduct Riparian and Wetlands Ecosystem Research	Lack of basic data and understanding

Table 10. (Continued) Water resources management projects and related servicewide issue.

Project name and number	*Servicewide issue*
TUZI-C-04 Preserve and Restore the Prehistoric Scene	Alteration of natural flow regimes; Restoration of prehistoric landscape

within the Verde Valley and at a network of fixed stations established by ADEQ. Groundwater quality is monitored only insofar as it pertains to maintaining potable domestic water supplies.

Administration

One administrative project statement addresses preparation of a management plan for the current pasture at the Well Unit (MOCA-I-02). Regulatory compliance with relevant state statues addressing potable water and waste water systems is an on-going administrative action of the Superintendent and staff. Additional project statements addressing water rights, the Verde River adjudication, and a formal protocol to administer research at Montezuma Well could be developed.

Research

Thirteen project statements for Montezuma Castle and four for Tuzigoot address research activities. Activities are focused on identity and inventory of water-related resource attributes (MOCA-N-04, TUZI-N-02), adjacent land use (MOCA-N-06, TUZI-N-04), inventory of Montezuma Well and environs (MOCA-N-07), riparian ecosystem research (MOCA-N-08, MOCA-N-09, MOCA-N-26, MOCA-N-27, TUZI-N-05), wetlands delineation and protection (MOCA-N-11, TUZI-N-06), hydrologic characteristics of the archeologic and historic setting (MOCA-N-12), identity of flood prone areas (MOCA-N-13), effects of hydrologic characteristics on stream morphology (MOCA-N-23), evaluation of hydrologic characteristics on regeneration of riparian vegetation (MOCA-N-24), and mapping of historic and prehistoric irrigation system (MOCA-C-08).

The NPS has supported research and continues to do so for all monuments. Past projects include detailed studies of aquatic invertebrates and plants and geology of Montezuma Well, riparian trees at the Castle, autoecology of sycamore trees, bird surveys, plant inventories, vegetation community classification and mapping, low level air photographs, and archeological surveys.

Mitigation

To date no project statements have been developed that address mitigation of water-related attributes at Montezuma Castle. These could be developed in the future if dictated by external land uses, changes in internal land uses, or in the event that current monitoring and research projects identify a need for mitigation. Two mitigation projects have been written for Tuzigoot to restore Tavasci Marsh (TUZI-N-03) and preserve and restore the prehistoric scene (TUZI-C-04).

Overview of Water Resources Project Statements

Following is a summary of each water resources project statement in this plan. The entire project statements are provided in a later section. The funded ones are presented first.

These are seven funded projects, of which most will be completed by 1993. However, each will require further monitoring or mitigation as a result of the initial work.

- Outflow Measurements for Montezuma Well (MOCA-N-03)

  In cooperation with the USGS, the monument has monitored outflow from Montezuma Well since the late 1970s. The monitoring will continue to provide consistent data gathering to analyze trends against the baseline established.

- Identify and Inventory Water-Related Resource Attributes (MOCA-N-04)

  Existing data regarding the relationship of water to the resources of the monument is incomplete and perhaps inadequate. The first step to correct this is identifying and inventorying the nature and magnitude of resource attributes that are affected by, or dependent upon, surface and subsurface waters. The possibility of future impact to water-related resource attributes exists because of potential development adjacent to the Castle and Well units. Water removal from aquifers underlying the monument or alterations in surface flow regimes of tributaries are likely to affect water-related resource attributes.

- Analysis of Adjacent Land Use and Status (MOCA-N-06)

  The population of the Verde Valley is rapidly growing, which influences the rate and complexity of resources management issues to be addressed by monument staff. These concerns are magnified by the needs of three disjunct management units. A land use study of monument and adjacent lands will be conducted. The objectives are to compare past and present land use patterns, evaluate present utilization conflicts, and identify resource concerns currently impacting the monument. This project will also attempt to develop a system for quantifying the potential risks associated with each resource concern.

- Protect the Hydrologic Characteristics of the Archeological and Historical Setting at Montezuma Well (MOCA-N-12)

  While discharge from the Well is being monitored, no information has been collected that addresses water surface elevation or inflow. A comprehensive hydrologic characterization of the groundwater system supporting and maintaining the Well will be conducted. This information is essential for evaluating impacts of existing and potential off-site development on the Well through the use of mathematical modeling.

- Prepare a Management Plan for Prehistoric Sinagua Fields (MOCA-I-02)

  A 27-acre pasture has been leased for grazing for several years. Agricultural use was a practice continued since the purchase of the farm land that is now in the Well Unit. An environmental assessment was prepared describing several possible land uses. Public response dictated a strong desire for the parcel to be restored to native vegetation and habitat. The next stage is to develop the plan for that use.

- Analyze Adjacent Land Use and Status (TUZI-N-04)

  The population of the Verde Valley is rapidly growing, which influences the rate and complexity of resources management issues to be addressed by the monument staff. These concerns are magnified by the needs of three disjunct management units. A land use study of monument and adjacent lands will be conducted. The objectives are to compare past and present land use patterns, evaluate present utilization conflicts, and identify resource concerns currently impacting the monument. This project will also attempt to develop **a** system for quantifying the potential risks associated with each resource concern.

- Determine Vulnerability of Unique Biota to Changes in Hydrologic Regimes (MOCA-N-27)

  The growing population in the Verde Valley necessarily increases demand for and consumption of groundwater. This will alter the hydrologic regimes in the region and may have significant impacts on the monument and the organisms that live in it. A survey of all biotic resources and an assessment of their habitat requirements are essential to the proper management of the monument and the protection of these sensitive resources. This project will provide information about biological resources and their habitat needs.

The following are 15 unfunded projects. When these are addressed, most will require further monitoring or mitigation as a result of the initial work.

- Evaluate Water Delivery Monitoring System (MOCA-N-05)

  Rights to the use of water from Montezuma Well are held by NPS and other users downstream. The present system to monitor deliveries to NPS and other downstream users should be evaluated to assure that partitioned water rights are being fairly and correctly metered.

- Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat (MOCA-N-07)

  Montezuma Well is a spring fed limnocrene nearly circular in shape with a diameter of approximately 360 feet. It supports a unique assemblage of endemic organisms and has no known ecological equivalents. Increasing visitation and changing land use patterns present potential threats to the long term protection of this resource. A resources basic inventory will provide information about occurrence and status of endemic species in the Well and some aspects of their life history. This study will also indicate what species of native and non-native organisms are present and provide an understanding of relationships among the aquatic, riparian, and terrestrial components of the ecosystem.

- Assess Habitat Requirements of Aquatic Organisms at Montezuma Well (MOCA-N-08)

  The aquatic organisms endemic to Montezuma Well are water-related resource attributes of major significance. It is not unreasonable to anticipate that changes in water quantity and quality could occur due to development in locations peripheral to the site. An inventory of aquatic organisms and their habitat requirements at Montezuma Well will be studied. This effort could require assessment of residence time of water in the Well, water surface elevation, water quality, organism habitat requirements, changes in water quantity, and off-site activities that could impact water quantity or quality. The project requires an interdisciplinary perspective.

- Conduct Riparian Ecosystem Research (MOCA-N-09)

  Riparian resources are of major management concern at Montezuma Castle and Montezuma Well. This research will focus on an inventory and assessment of natural riparian resources and assessment of past, current, and proposed management activities impacting riparian resources. Emphasis will be placed on ecological components, e.g. indicator species, that are of particular concern to interpreters and managers. Hydrologic and soil parameters important to riparian vegetation will be evaluated. Demography, distribution, and health of riparian plant populations will be analyzed. The relationship between riparian habitats and major vertebrate groups will be assessed.

- Delineate and Evaluate Strategies for Wetlands Protection (MOCA-N-11)

  Wetlands have not been evaluated or delineated within both units of Montezuma Castle. External factors such as grazing, mining, and non-native species are impacting the quality and quantity of the valuable water-related resources. A series of maps will be produced delineating all wetlands in the monument including wetlands regulated under the Clean Water Act as administered by the Army Corps of Engineers. Subsurface water movement, stability, stream dynamics, erosion potential, and other hydrologic parameters will also be evaluated. Possible threats to wetlands resources will be assessed to develop action oriented strategies.

- Identify Flood-Prone Areas for Protection of Lives and Property (MOCA-N-13)

  Important visitor attractions are found in close proximity to active floodplain. The flood hazard assessment will identify areas within both units of Montezuma Castle that lie within the limits of selected design floods including the probable maximum flood. This information will ensure that public health and safety are protected from unreasonable exposure to flood hazards. This project will also include evaluation of potential mitigation measures.

- Evaluate Effects of Hydrologic Characteristics on Morphological Properties of Flowing Streams (MOCA-N-23)

  Stream channel features of Beaver Creek and Wet Beaver Creek, which are within Montezuma Castle, are associated with water-related resource attributes such as the historic and prehistoric habitations. These quantifiable features can be dramatically modified through human-induced changes in the hydrologic regime. Characterization of existing channel features, sediment transport, and modeling of existing and potential flow regimes will be undertaken.

- Evaluate Effects of Hydrologic Characteristics on Regeneration of Vegetation in Riparian Areas (MOCA-N-24)

  Hydrologic characteristics of streams, e.g. the periodicity of over-bank discharge, can strongly effect regeneration of riparian vegetation. This study will characterize existing hydrology, channel features, depth to subsurface water in the floodplain, sediment transport, existing flow regimes, and potential flow regimes. The potential for change in any one, or several, of these characteristics may already exist or could arise due to off-site water development or on-site human impacts.

- Conduct Inventory and Assessment: Fishes (MOCA-N-26)

  The native fish species of Wet Beaver Creek and Beaver Creek have been modified by water development and introduction of non-native fishes. Native fishes of these streams will be inventoried using non-destructive sampling. Seasonal sampling will allow inferences regarding relative abundance, habitat preferences, natural history, and potential threats. These stream segments will be evaluated to determine if there are opportunities to re-introduce native species that have been extirpated.

- Study of Montezuma Castle Irrigation System (MOCA-C-08)

  Prehistoric and historic inhabitants of the Verde Valley relied on a network of irrigation ditches to deliver water to fields. However, the canals have not been systematically studied. Past records of canal systems will be gathered, existing aerial photography will be reviewed, and new photography taken as needed. Visible canal systems will be mapped. Exposed canals will be examined and additional segments will be exposed and sectioned to examine mineral deposits and estimate discharge.

- Identify and Inventory Water-Related Resource Attributes (TUZI-N-02)

  Existing data regarding the relationship of water to the resources of the monument is incomplete and perhaps inadequate. The first step to correct this is identifying and inventorying the nature and magnitude of resource attributes that are affected by, or dependent upon, surface and subsurface waters. The possibility of future impact to water-related resource attributes exists because of potential development adjacent to

Tuzigoot. Water removal from aquifers underlying the monument or alterations in surface flow regimes of tributaries is likely to affect water-related resource attributes.

- Restore Tavasci Marsh (TUZI-N-03)

The marsh has been privately owned for a number of years; however, the NPS and Phelps Dodge Corporation have discussed the possibility of adding this feature to Tuzigoot. A feasibility study will address potential concerns including the ecological viability of the marsh, affects of previous land uses, water quality issues, and jurisdictional liabilities. This effort will be completed by an interdisciplinary team.

- Delineate and Evaluate Strategies for Wetlands Protection (TUZI-N-06)

Wetlands have not been evaluated or delineated within the legislated boundaries of Tuzigoot. External factors such as grazing (past), mining, and non-native species are impacting the quality and quantity of the valuable water-related resources. A series of maps will be produced delineating all wetlands in the monument including wetlands regulated under The Clean Water Act as administered by the Army Corps of Engineers. Subsurface water movement, stability, stream dynamics, erosion potential, and other hydrologic parameters will also be evaluated. Possible threats to wetlands resources will be assessed to develop action oriented strategies. This effort is interdisciplinary in scope.

- Conduct Riparian and Wetlands Ecosystem Research (TUZI-N-05)

Riparian and wetlands resources are of major management concern. This effort will focus on an inventory and assessment of natural riparian resources and assessment of past, current, and proposed management activities impacting riparian resources. Emphasis will be placed on ecological components, e.g. indicator species, that are of particular concern to interpreters and managers. Hydrologic and soil parameters important to riparian vegetation will be evaluated. Demography, distribution, and health of significant perennial plant populations will be analyzed. The relationship between riparian habitats and major vertebrate groups will be assessed.

- Preserve and Restore the Prehistoric Scene (TUZI-C-04)

The acquisition of lands for addition to Tuzigoot National Monument is the objective of this project. It would preserve and restore the prehistoric scene and setting immediately to the east of the existing monument. This area includes riparian habitats, prehistoric croplands, desert uplands, and Tavasci Marsh.

Programming Sheets

The programming sheets for water resources management projects are on the following pages. These sheets summarize funded and unfunded projects. The individual project statements follow these sheets.

PROGRAMMING SHEET 1
CURRENT YEAR FUNDED WATER RESOURCES ACTIVITIES
(S in thousands)

FY: 93
Park: MOCA 8 TUZI
Region: WESTERN

PROJ NUM	PROJECT OR ACTIVITY STMT TITLE	PKG NUM	CULT RES	SERVICE-WIDE TYPE	FUNDING SOURCE	ACT TYPE	CURRENT YEAR		OUTYEAR 1 SS	OUTYEAR 1 FTE	OUTYEAR 2 SS	OUTYEAR 2 FTE	OUTYEAR 3 SS	OUTYEAR 3 FTE	TOTAL SS	TOTAL FTE
MOCA-N-03																
	Outflow Measurements for Montezuma Well	N/A	N/A	N12	NF2	MON	1.0	.05	1.0	.05	1.0	.05	1.0	.05	4.0	.2
					NF8	MON	2.0	0	2.0	0	2.0	0	2.0		8.0	0
MOCA-N-04																
	Identify and Inven-Related Resources	N/A	N/A	N20	NF8	RES	20.0	0	0	0	0	0	0	0	20.0	0
MOCA-N-06																
	Analysis of Adjacent Land Use and Status	N/A	N/A	N16	NF3	RES	30.0	0	0	0	0	0	0	0	30.0	0
MOCA-N-12																
	Protect Hydrologic Characteristics of the Archeological and Historical Setting at Montezuma Well	N/A	N/A	N12	NF8	RES	50.0	0	40.0	0	40.0	0	0	0	130.0	0
MOCA-1-02																
	Prepare a Management Plan for Prehistoric Sinagua Fields	N/A	CULL	N08 C13	CF2 NF2	ADM MIT	2.0	.05	0	0	0	0	0	0	2.0	.05
TUZI-N-O4																
	Analysis of Adjacent Land Use and Status	N/A	N/A	N16	NF3	RES	0	0	6.2	0	0	0	0	0	6.2	0
MOCA-N-27																
	Determine Vulnerability of Unique Biota to Changes in Hydrologic Regimes	N/A	N/A	N-12 N-02	NF3	RES MON	79.0	1.5	79.0	1.5	89.0	1.5	0	0	242.0	4.5

PROGRAMMING SHEET 2 UNFUNDED WATER RESOURCES ACTIVITIES (E in thousands)

FY: 93
Park: MOCA 8 TUZI
Region: WESTERN

PK PRI NUM	PROJ STATM NUM	PROJECT OR ACTIVITY TITLE	PKG NUM	CULT RES TYPE	SERVICE-WIDE ISSUE(S)	FUNDING SOURCE	ACT TYPE	STARTING YEAR	OUTYEAR 1 ES	OUTYEAR 1 FTE	OUTYEAR 1 EE	OUTYEAR 2 FTE	OUTYEAR 2 EE	OUTYEAR 3 ES	OUTYEAR 3 FTE	OUTYEAR 3 EE	TOTAL FTE	TOTAL EE
1	MOCA-N-05	Evaluate Water Monitoring System	N/A	N/A	N13	NF8	RES		10.0	0	0	0	0	0	0	0	10.0	0 Delivery
2	MOCA-N-07	Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat	N/A	N/A	N20	NF3	RES		22.0	0.7	12.3	0.4	0	0	0	0	34.4	1.1
7	MOCA-N-08	Assess Habitat Requirements of Aquatic Organisms at Montezuma Well	N/A	N/A	N20	NF3	RES		25.0	0	22.0	0	18.0	0	0	0	65.0	0
8	MOCA-N-09	Conduct Riparian Ecosystem Research	N/A	N/A	N12	NF3	RES		10.0	0.2	10.0	0.2	15.0	0.4	15.0	0.4	50.0	1.2
11	MOCA-N-11	Delineate and Evaluate Strategies for Wetlands Protection	N/A	N/A	N12	NF8	RES		15.0	0	0	0	0	0	0	0	15.0	0
13	MOCA-N-13	Identify Flood for Protection of Lives and Property	N/A	N/A	N20	NF8	RES		35.0	0	0	0	0	0	0	0	35.0	0 Prone Areas

PROGRAMMING SHEET 2 UNFUNDED WATER RESOURCES ACTIVITIES (S in thousands)

FY: 90
Park: MOCA 8 TUZI
Region: WESTERN

PK PRI NUM	PROJ NUM	PROJECT OR ACTIVITY: PKG STATMI TITLE	NUM	CULT RES TYPE	SERVICE-WIDE ISSUE(S)	FUNDING SOURCE	ACT TYPE	STARTING YEAR	OUTYEAR 1	FTE	OUTYEAR 2	FTE	OUTYEAR 3	FTE	TOTAL	FTE
23	MOCA-N-23	Evaluate Effects of Hydrologic Characteristics on Morphological Properties of Flowing Streams	N/A	N/A	N12	NF8	RES	30.0	10.0	0	0	0	0	0	40.0	0
24	MOCA-N-24	Evaluate Effects of Hydrologic Characteristics on Regeneration of Vegetation in Riparian Areas	N/A		N12	NF8	RES	35.0	20.0	0	20.0	0	0	0	75.0	0
26	MOCA-N-26	Conduct Inventory and Assessment: Fishes	N/A	N/A	N20	NF3	RES	8.3	8.2	0.1	0	0	0	0	16.5	0.2
8	MOCA-C-08	Study of Montezuma Irrigation System	N/A	SITE	CO2	CF5	RES	14.4	0	0	0	0	0	0	14.4	0.3 Castle
2	TUZI-N-02	Identify and Inven- Water related Resource Attributes	N/A	N/A	N20	NF8	RES	25.0	25.0	0	25.0	0	0	0	75.0	0 tory
3	TUZI-N-03	Restore Tavasci Marsh	N/A	N/A	N12	NF3	RES	59.0	48.0	0.6	33.0	0.6	0	0	140.0	2.0

PROGRAMMING SHEET 2
UNFUNDED WATER RESOURCES ACTIVITIES
(S in thousands)

FY: 90
Park: MOCA & TUZI
Region: WESTERN

PK PRI NUM	PROJ : PROJECT OR ACTIVITY: PKG : CULT : SERVICE- STATM: TITLE	: NUM : RES : WIDE			FUNDING SOURCE	ACT : STARTING TYPE : YEAR			OUTYEAR 1 : OUTYEAR 2				OUTYEAR 3		TOTAL	
	NUM ;	I	I TYPE	I ISSUE(S)			; $$	FTE	$$	FTE	$$	FTE	$$	FTE	$$	FTE
5	TUZI-H-05 Conduct Riparian and Wetlands Ecosystem Research	N/A	N/A	N20	NF3	RES	15.5	0.6	15.5	0.6	17.0	0.6	18.0	0.6	66.0	2.4
6	TUZI-H-06 Delineate and Evaluate Strategies for Wetlands Protection	N/A	N/A	N16	NF6	RES	20.0	0	30.0	0	33.0	0	0	0	83.0	0
1	TUZI-C-04 Preserve and Restore the Prehistoric Scene	N/A	SITE	C13	CF12	MIT	Land acquisition funding needs are uncertain. Legislative ceiling is $1,350,000									

Project Statements

On the following pages are the water resources management project statements. They are labeled as either funded or unfunded. These are also found and discussed in the Natural and Cultural Resources Management Plan for each monument in the content of the entire resources program.

PROJECT STATEMENT

Funded

1. Project Number: MOCA-N-03

2. Project Title: Outflow Measurements for Montezuma Well

3. Servicewide Issue(s):

N12 - Alteration of Natural Flow Regimes/Groundwater Levels

4. Problem Statement: Natural spring flows from Montezuma Well are monitored through an agreement with the USGS. This agreement has been in force since the late 1970s. The USGS maintains the flow records and reports the results to the NPS on an annual basis. The NPS takes daily readings according to a protocol developed by the USGS and sends these data to them for compilation and summary. This is the only long term monitoring currently being performed on the water resources of the Well.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. This alternative would entail the cessation of the monitoring program. This is an unacceptable alternative.

b. Continue Current Monitoring Agreement with USGS. This alternative would keep the current agreement in force and continue the interagency cooperation that is so important to this effort.

6. Description of the Recommended Project or Activity: Option b. is the recommended solution for this issue.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of the Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least three other projects listed in this plan. These are as follows:

MOCA-N-04 Identify and Inventory Water-Related Resources
MOCA-N-05 Evaluate Water Delivery Monitoring System
MOCA-N-12 Protect the Hydrologic Characteristics of the Archeological and Historical Setting at Montezuma Well

9. Funding Requirements:

	Year 1	Year 2	Year 3	Year 4
Personal Services				
Park Base Funds	$1,000	$1,000	$1,000	$1,000
WASO Water Resources	$2,000	$2,000	2,000	2,000
Travel and Per Diem	0	0	0	0
Supplies & Materials	0	0	0	0
Total	$3,000	$3,000	$3,000	$3,000

10. Annual Project Status and Accomplishments: This report will be initiated once final determination is made by WASO on the proper Servicewide format.

PROJECT STATEMENT

Funded

1. Project Number: MOCA-N-04

2. Project Title: Identify and Inventory Water-Related Resources

3. Servicewide Issue(s):

N20 - Lack of Basic Data: Insufficient Understanding of Park Ecosystems and Threats to Them N11 - Degradation of Park Water Quality due to External Activities

4. Problem Statement: The water-related resources of the monument have not been fully identified. An inventory is needed to both identify the possibility of impact and to measure its magnitude, in the event impact does occur. This information will be required in water rights litigation or in any other similar arena in which the NPS seeks relief from such impact to protect the monument for the purposes for which it was created.

At present there exists an incomplete, and perhaps inadequate, understanding of the relationship of water to the resources of the monument. The first step in developing this understanding is identifying and inventorying the resources that are affected by or dependent upon water, both surface and subsurface.

The possibility of future impact to water-related resources exists because of residential and commercial development which is increasing in locations peripheral to the site. Water withdrawals from aquifers underlying the monument or alterations in surface water flow regimes are likely to affect water-related resources. Without an identification and inventory, assessments to arrest and reverse effects will be delayed resulting in additional or longer-lasting effects.

5. Alternative Actions/Solutions and their Probable Impacts:

a. No Action. This action would leave the monument without an adequate data base to protect its water rights or to understand the relationships between water resources of the monument and early man's activities at the site. Water-related resources might be lost under such stewardship.

b. Conduct a Thorough Inventory of All Water-Related Resources in Montezuma Castle National Monument. Such a broad survey will give the superintendent an adequate data base from which to make informed management decisions and to protect water rights. Such results will also be of use to all other resource related inventories conducted at the monument.

6. Description of the Recommended Project or Activity: Option b. is the recommended solution for this issue. This basic inventory of water-related resources will require a technical assessment of natural resources and scientific literature. This project will be best undertaken by an interdisciplinary team working as a unit. Field and office assessments will result in summary reports, maps and atlases. When completed, additional projects and/or studies will be required to evaluate the nature and magnitude of the relationship between water and water-related resources. Some of these studies are identified below.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least nine other projects listed in this plan. These are as follows:

MOCA-N-05 Evaluate Water Delivery Monitoring System
MOCA-N-06 Analysis of Adjacent Land Use and Status
MOCA-N-07 Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat
MOCA-N-08 Assess Habitat Requirements of Aquatic Organisms at Montezuma Well
MOCA-N-09 Conduct Riparian Ecosystem Research
MOCA-N-11 Delineate and Evaluate Strategies for Wetlands Protection
MOCA-N-12 Protect the Hydrologic Characteristics of the Archeological and Historical Setting at Montezuma Well
MOCA-N-23 Evaluate Effects of Hydrologic Characteristics on Morphological Properties of Flowing Streams
MOCA-N-24 Evaluate Effects of Hydrologic Characteristics on Regeneration of Vegetation in Riparian Areas

9. Funding Requirements:

	Year 1
Project Contract	$20,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Funded

1. Project Number: MOCA-N-06

2. Project Title: Analysis of Adjacent Land Use and Status

3. Servicewide Issue(s):

N11 - Degradation of Park Water Quality due to External Activities
N12 - Alteration of Natural Flow Regimes/Groundwater Levels
N16 - Visual and Biological Impacts of Urbanization and Other Near-Park Development on Park Resources

4. Problem Statement: The Verde Valley of Arizona has an enormous array of recreational opportunities. According to Marshall A. Worden in the publication *Papers in Community and Rural Development, 1981,* "the Verde valley may well contain the greatest density of different types of vacation or recreational experiences of any similarly sized area in Arizona." Tourism at the Castle alone last year exceeded 657,000 people. Concomitant local population growth has also increased dramatically as economic employment opportunities increased. Consequently, the diversification of land use practices are changing at an alarming rate. Accelerated growth increases the frequency and complexity of resource issues while simultaneously reducing the amount of time that management has to react to resource concerns. In addition, having three discontinuous management units of less than 870 acres magnifies the degree of danger associated with each potential threat. The ingredients and characteristics that have created such an unusually rich and diverse environment for resource concerns are many.

A few examples of nearby land uses are urbanization, aggregate mining, surface water diversions, agriculture, grazing, ranching, and recreational opportunities such as camping, golf, fishing, horseback riding, and swimming. These activities are impacting cultural, water, and other natural resources at Montezuma Castle, Montezuma Well, and along Beaver Creek and its tributaries.

Beaver creek, a significant part of the historic scene and a major tributary of the Verde River, meanders southward approximately 10 miles from the Well before joining the Verde River from the North. Six river miles upstream from its mouth, Beaver Creek passes Montezuma Castle. The Castle is the best preserved example of cliff dwellings remaining from an extinct Sinaguan culture.

Dry Beaver Creek flows adjacent to Montezuma Well and is located about six miles upstream of the confluence of Wet Beaver Creek and Beaver Creek. Continued expansion of nearby population centers prompts concern for protection of this valuable resource.

Without the basic baseline information necessary for assessing future changes in the area's hydrological regime and proximate land utilization factors the historic and cultural scenes cannot be maintained adequately. An analysis of adjacent land use is a prerequisite step in determining the degree and magnitude of factors that may influence management's ability to resolve or

anticipate potential resource utilization conflicts. Preliminary *indications* suggest that recent habitat *conversions* have already resulted in a loss of biological diversity and are impacting the adjacent riparian corridor.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. Analysis of Adjacent Land Use and Status. Contract a land use research study that compares past and present land use patterns, evaluates present utilization conflicts, and assess resource *concerns* that are currently impacting the monument. This project should also attempt to develop a system that quantifies the potential risks associated with each resource threat or concern.

b. No Action. With this action the *monument* will have to continue to operate without being able to estimate or predict *significant* external threats resulting from changing land use patterns. This places management in a difficult position of trying preserve and protect a cultural landmark without knowledge of existing external threats.

6. Description of the Recommended Project or Activity: Option a. is the recommended solution for this issue. Let a research contract to document and map existing land uses, evaluate historical patterns of land use, and identify external threats resulting from adjacent land use practices. This would entail a three part research study as follows:

a. Identify issues, *concerns,* and opportunities by: 1) developing land utilization maps that illustrate present uses, historical changes, and legal land status; and 2) developing a research program to quantify and evaluate potential threats resulting from land use conflicts.

b. Analyze the management situation and assess the risk level stemming from each external threat attributed to a land use pattern or concern.

c. Develop a cost effective monitoring protocol system for monument staff to reevaluate external threats on a periodic basis. Recommend management actions to mitigate, or if possible eliminate, external threats stemming from external land uses. Make recommendations on how to develop community awareness programs through interpretive and outreach programs.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least 12 projects listed in this plan. These are as follows:

MOCA-N-07 Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat
MOCA-N-09 Conduct Riparian Ecosystem Research
MOCA-N-15 Conduct *inventory* and Assessment: Vegetation and Flora

MOCA-N-16 Conduct Inventory and Assessment: Invertebrates
MOCA-N-17 Conduct Inventory and Assessment: Amphibians and Reptiles
MOCA-N-18 Conduct inventory and Assessment: Birds
MOCA-N-19 Conduct inventory and Assessment: Soils
MOCA-N-20 Conduct inventory and Assessment: Mammals
MOCA-N-24 Evaluate Effects of Hydrologic Characteristics on Regeneration of Vegetation in Riparian Areas
MOCA-N-26 Conduct inventory and Assessment: Fishes
MOCA-I-04 Develop Bibliographic Assessment and Computerized Bibliographic Information Retrieval System
MOCA-I-05 Integrate Program for Long-Term Monitoring of Cultural and Natural Resources

9. Funding Requirements:

	Year 1
Research Contract	$30,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Funded

1. Project Number: MOCA-N-12

2. Project Title: Protect the Hydrologic Characteristics of the Archeological and Historical Setting at Montezuma Well

3. Servicewide Issue(s): N12 - Alteration of Natural Flow

Regimes/Groundwater Levels

4. Problem Statement: The water surface level at Montezuma Well is, itself, a water-related resource of this site. The height to which water rises in the Well is important to the archaeological and historical story of this NPS unit. Specifically, the visitor is presented with a unique, for this desert location, natural structure which had an obviously important relationship to the habitation of this area by ancient people. Subject to natural variation, the water surface elevation in the Well should be maintained as close to its prehistoric level as possible to convey to the visitor an appreciation of: a) the locations of water and dwellings, relative to one another; and b) the delivery of water to the ancient irrigation systems.

Population increases have occurred in this area as in many others in the southwest. Consequently, residential and commercial development has been steadily increasing in locations peripheral to the Well Unit. The nature and effect of increased water use and consumption associated with this development is presently unknown. However, it may be that water is being removed from the natural avenues of surface and subsurface water delivery that supply the Well. If a significant diminution in water delivery occurs, this water-related resource attributes may be adversely affected, and, as **a** consequence, the purposes for which this unit was established may be jeopardized.

While outflow from the Well has been monitored in the past, no information has been collected which assesses either water surface elevation or inflow to the system. Furthermore, questions have been raised as to the efficacy of current outflow measurement efforts due to shortcomings in the measurement installation. More importantly, there currently exists no means for alerting management to imminent adverse, and possibly irreversible, effects to this resource attribute from external water use.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. This option will dictate that the Service continue to manage Montezuma Well without a scientifically designed and tested monitoring system. Management without factual data is a dangerous proposition.

b. Study Hydrologic Characteristics. Conduct a thorough hydrologic characterization of the groundwater system supporting and maintaining Montezuma Well. This information will make it possible to evaluate potential effects of off-site land development on water flows in the Well through the use of mathematical models of existing and potential water withdrawals.

6. Description of the Recommended Project or Activity: Option b. is the recommended solution for this issue. The protection of the hydrologic characteristics of the archaeologic and historic setting at the Well requires monitoring the standing water surface elevation and identifying geographical areas where existing and future water withdrawals may be of concern. To explain, the areas around the Well which recharge the aquifer supplying the springs within its perimeter, should be identified so that special attention may be directed toward monitoring off-site water development. If water development is found to affect this water-related resource attribute, then appropriate action may be taken, through state administration of water rights or through other means, to prevent both irreversible damage to the site and financial hardship to private development interests outside the unit.

However, to support allegations of impact from outside water development and use, the characteristics of the aquifer must be scientifically identified and potential impacts must be evaluated. This will require a thorough hydrologic characterization of the water system supporting the Well. This characterization will include assessments of piezometric water surface in the recharge area, aquifer characteristics and, possibly, ground water quality or age determination followed by mathematical modelling of existing and potential water withdrawal. Ancillary to these efforts would be an assessment of historical water levels using both computer simulation and historical research.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least four other projects listed in this plan. These are as follows:

MOCA-N-07 Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat
MOCA-N-08 Identify and Inventory Aquatic Organisms and Their Habitat Requirements at Montezuma Well
MOCA-N-11 Delineate and Evaluate Strategies for Wetlands Protection
MOCA-I-05 Integrate Program for Long-Term Monitoring of Cultural and Natural Resources

9. Funding Requirements:

	Year 1	Year 2	Year 3
Research Contract	$50,000	$40,000	$40,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Funded

1. Project Number: MOCA-I-02

2. Project Title: Prepare a Management Plan for Prehistoric Sinagua Fields

3. Servicewide Issue(s):

N08 - Loss of Cultural Landscapes
C13 - Need for Rehabilitation or Restoration of Historic and Prehistoric Structures and of Cultural Landscapes

4. Problem Statement: In prehistoric times, Sinagua people farmed the bench adjacent to the now Wet Beaver Creek in the Montezuma Well unit of Montezuma Castle National Monument. This bench supports a natural mesquite bosque community and is the upland area of the riparian zone, which is characterized by sycamore, velvet ash, walnut, and hackberry trees. During prehistoric times, the bench was extensively farmed with agricultural crops essential to the existence of the Sinaguas. A sophisticated system of irrigation ditches provided water; some portions of which are above ground and traceable. Project MOCA-C-08 pertains to studying this integrate irrigation system.

In historic times during the 1870s, this prehistoric field was the site of farm houses, barn, and outbuildings and of cultivated crops and occasional pasturing. Noted crops were hay, alfalfa, watermelon, cantaloupes, and personal gardens. In the 1939 National Park Service appraisal for Montezuma Well, the total land was listed as 179.43 acres with 41.22 acres irrigated (agricultural), 92.21 acres as grazing, and 46.00 as other uses. A ditch irrigation system distributed water, and some of it followed the prehistoric alignment.

When Montezuma Well was established, haying and pasturing on part of the land was continued. In the late 1940s it was noted that hay from Montezuma Well was baled and transported to Saguaro National Monument for use by government livestock.

The monument has rights to half the flow from the Well, which is expressed as using the water for alternate 8-day periods. Generally, rights were obtained for the State of Arizona on the basis of "beneficial uses", usually interpreted as agricultural, commercial or other economic uses. The monument diverts water for eight days then it flows through to downstream users for the following eight days. This pattern repeats. During winter the water primarily is diverted into Wet Beaver Creek. During summer, it irrigates the pasture and picnic area. The Water Resources Division (Washington Office) is involved in the adjudication process for these water rights. They have been claimed for "ethnological interests" and "historical integrity."

Currently, there is a 27-acre parcel leased for cattle pasturing, a use that has supported the appropriated water rights of the Well for several decades. Sections of the historic irrigation system are still used. The current lessee operates with a special use permit and has used the pasture for several years. He is permitted to run 22 head of cattle from April 1 through November 30 and five cattle from December 1 through March 31. Pasture species are exotic

grasses and forbs. The lessee also maintains the fences and the ditch (with a minimum of two hand clearings yearly). Upon termination of the lease, any improvements become property of the National Park Service. To date, there has been no assessment of cattle use levels, carrying capacity, or production of the pasture. The monument has not been monitored to evaluate impacts of grazing or use levels of the pasture.

The authority to use the irrigated pasture for cattle is not provided for in any of the monument's legislation. The practice apparently comes from an assumption of nexus between farming and maintaining an irrigated pasture grazed by cattle. The earliest record is an August 17, 1954, memorandum from the Acting Assistant Director. It indicated that for a number of years prior to that date, special use permits were issued that allowed pasturing of cattle and horses. The assumption can be made that the practice has been followed from the time the National Park Service bought Montezuma Well property in 1947. The practice has continued to the present.

The problem is determining the appropriate use of the pasture considering prehistoric and historic uses as well as water rights, grazing impacts, protection of cultural and natural resources, and visitor and employee safety.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. This alternative entails maintaining the existing use levels of the pasture and current arrangements with the lessee. There would be no assessment of pasture value or grazing impacts. However, this alternative is precluded by Federal requirements for competitive leasing for special park uses, including agriculture and grazing. An environmental assessment is also needed for this consumptive use.

b. Assess Alternative Land Uses. This alternative involves considering other land uses and preparing an environmental assessment to evaluate those alternatives and select one. The alternatives will include, but not be limited to: 1) irrigated pasture with grazing; 2) irrigated meadow for hay without grazing; 3) irrigated hay meadow with some grazing; 4) cultivated alfalfa, corn, or other crop; and 5) restore native mesquite bosque community. For the alternative selected, a management plan will be written to direct actions.

6. Description of the Recommended Project or Activity. Option b. is the recommended solution for this issue. Monument and group office staff have already begun the process of gathering information for an environmental assessment. To date, old records have been gathered, review assistance has been obtained from an NPS range conservationist, and Soil Conservation Service range conservationists been on site twice to discuss agricultural land uses and professional practices with monument and group office staff. An assessment will be written and distributed for public and agency review and comment. After evaluating public and agency input, the Superintendent will select a land use. Following that, a management plan will be written as appropriate.

7. Compliance: This project will require an environmental assessment. The NHPA compliance under Section 106 will also be required so contact will be made with staff from the Western Archeological and Conservation Center.

8. Relationships: This project is related to at least five other projects listed in this plan. These are as follows:

MOCA-N-15 Conduct Inventory, Assessment, and Monitoring: Vegetation and Flora
MOCA-N-22 Examination of Old Fields
MOCA-C-08 Study Montezuma Castle Irrigation System
MOCA-C-20 Obtain Historic Photographs of Montezuma Castle
MOCA-I-05 Integrate Program for Long-Term Monitoring of Cultural and Natural Resources

9. Funding Requirements: Costs for preparing an environmental assessment will be supplied by monument and Southern Arizona Group Office staff. Depending on the results of this assessment and review process, funds may be requested to write and carry out the management plan. The estimated cost for the monument is a total of $1,000 in salaries and support for preparing the assessment. The estimated cost of involvement of the Southern Arizona Group Office staff is a total of $2,000 in salaries and support for preparing the assessment.

	Year 1
Personal Services	
MOCA base	$2,000
SOAR base	2,000
Travel and Per Diem	1,000
Supplies & Materials	0
Total	$5,000

10. Annual Project Status and Accomplishments: This report will be initiated once final determination is made by WASO on the proper Servicewide format.

PROJECT STATEMENT

Funded

1. Project Number: TUZI-N-04

2. Project Title: Analyze Adjacent Land Use and Status

3. Servicewide Issue(s):

N11 - Degradation of Park Water Quality due to External Activities
N12 - Alteration of Natural Flow Regimes/Groundwater Levels
N16 - Visual and Biological Impacts of Urbanization and Other Near-Park Development on Park Resources

4. Problem Statement: The Verde Valley of Arizona has an enormous array of recreational opportunities. According to Marshall A. Worden in the publication Papers in Community and Rural Development, 1981, "the Verde valley may well contain the greatest density of different types of vacation or recreational experiences of any similarly sized area in Arizona."

Concomitant local population growth has also increased dramatically as economic employment opportunities increased. Consequently, the diversification of land use practices are changing at an alarming rate. For example, one adjacent landowner is considering a development project that would build a large apartment complex adjacent to the Monuments boundary approximately 700 yards from the Tuzigoot ruins. Accelerated growth increases the frequency and complexity of resource issues while simultaneously reducing the amount of time that management has to react to resource *concerns*. The ingredients and characteristics that have created such an unusually rich and diverse environment for resource concerns are many.

A few examples of nearby land uses are urbanization, **aggregate** stream mining, mine tailing deposition and storage, surface water diversions, agriculture, grazing, ranching, and recreational opportunities such as camping, golf, fishing, horseback riding, and boating. These activities are impacting the Monument's cultural and natural resources.

Without the basic baseline *information* necessary for assessing future changes in the area's hydrological regime and associated proximate land utilization factors coupled with development the historic and cultural scenes cannot be maintained adequately. An analysis of adjacent land use is a prerequisite step in determining the degree and magnitude of proximate factors that may influence management's ability to resolve or anticipate potential resource utilization conflicts. Preliminary investigations suggest that recent habitat conversions have already resulted in a loss of biological diversity and are impacting the adjacent riparian corridor and the potential Tavasci Marsh natural area.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. With this action the monument will have to continue to operate without being able to estimate or predict significant external threats resulting from changing land use patterns.

This places management in a difficult position of trying to preserve and protect a cultural landmark without adequate knowledge of existing external threats.

b. Analysis of Adjacent Land Use and Status. Contract a land use research study that compares past and present land use patterns, evaluates present utilization conflicts and resource concerns that are currently impacting the Monument. The project should also attempt to develop a system that quantifies the potential risks associated with each resource threat or concern.

6. Description of the Recommended Project or Activity: Option b. is the recommended solution for this issue. The NPS will issue a research contract to document and map existing land uses, evaluate historical patterns of land use, and identify external threats resulting from adjacent land use practices. This would entail **a** three phase research study as follows:

a. Identify issues, concerns, and opportunities through the creation of land utilization maps that illustrate present uses, historical changes, and legal land status. Develop a research program to quantify and evaluate potential threats resulting from land use conflicts.

b. Analyze the management situation and assess the risks stemming from each external threat attributed to a land use pattern or concern.

c. Develop a cost effective monitoring protocol system to monitor external threats on a periodic basis, recommend management actions to mitigate or if possible eliminate external threats stemming from external land use patterns, and make recommendations on how to develop community awareness programs through interpretive and outreach programs.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of the Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project will support numerous other management activities or programs to evaluate or monitor the condition of the cultural and natural resources of the monument.

9. Funding Requirements:

	Year 1	Year 2
Research Contract	$18,000	$18,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on this project.

PROJECT STATEMENT

Funded

1. Project Number: MOCA-N-27

2. Project Title: Determine Vulnerability of Unique Biota to Changes in Hydrologic Regimes

3. Servicewide Issue(s):

N12 - Alteration of Natural Flow Regimes
NO2 - Impacts on Threatened, Endangered and Other Sensitive Animals

4. Problem Statement: The Verde Valley is one of the fastest growing areas in the Southwest. Its running streams and associated riparian and aquatic resources make this valley one of the choice natural and cultural landmarks of the Sonoran Desert. Montezuma Castle National Monument possesses unique aquatic resources that are severely threatened by the Valley's exploding growth.

Montezuma Well, a unit of Montezuma Castle, is a unique, spring-fed lake nearly circular in shape with a diameter of about 360 ft. It is a collapsed travertine mound formed approximately 10,000 years ago. No other ecological equivalent has yet been found worldwide. Seven taxa have been identified to date in Montezuma Well, which are found nowhere else on earth. This includes a crustacean (Hyalella montezuma), a water scorpion (Ranatra montezuma), a leach (ErpobdelIq montezuma), three diatoms (Caloneis latiuscula var. reimeri), (Cyclotella pseudostelligera from parva), (Gomphonema montezumense) and another endemic diatom currently being named. Two additional taxa, a mud turtle (Kinosternon) and a pondweed (Potamogeton) have been tentatively identified, and are also as yet unnamed. The breadth of species diversity and the complexity of interactions among organisms in this one-of-a-kind ecosystem are only now beginning to be recognized. Ecological knowledge of the Well is very limited. It is anticipated that this proposed research may well disclose additional taxa that are new to science.

The growing population nearby necessarily increases demand for and consumption of groundwater. This will alter the hydrologic regimes in the region and may have significant impacts on the Well and the organisms that live in it. A survey of all biotic resources associated with the Well, and an assessment of their habitat requirements are essential to the proper management of the monument and the protection of these sensitive resources.

The riparian zone along Beaver Creek is also threatened by the growth in the surrounding areas and associated water withdrawals. This riparian zone is immediately adjacent to the historic and prehistoric structures of the monument, and is integral to the historic scene. Yet, little is known of the biological resources in this zone, their water requirements, and possible impacts of additional water withdrawal. Endangered species in the Montezuma Castle region include nesting Bald Eagles (Haliaeetus leucocephalus), the spikedace (Meda fulgida) and two other reintroduced fishes, the razorback sucker (Xyrauchen texanus) and Colorado River squawfish (Ptychocheilus lucius). In addition there are several state-listed species of fish found in the region. The

importance of retaining historic flows in Beaver Creek on these sensitive species is currently unknown.

Alteration of natural flow regimes through activities such as water diversion, gravel mining, and other human perturbations in Beaver Creek could cause down-cutting or deposition_ in the channel, flooding or change of flow levels. Most or all of perennial Beaver. Creek is diverted for irrigation during the summer months: Such activities pose a serious threat to the integrity of native ecosystems. Human activities have already drastically reduced populations of beavers (Castor canadensis), and have extirpated river otters (Lutra canadensis) locally.

To work effectively with other agencies, groups, and individuals to protect the park's important biotic resources and its water rights, the park needs to: a) systematically track proposed new nearby development; b) determine the hydrologic consequences of additional groundwater withdrawal in the area on Montezuma Well, Beaver Creek, and the aquifers of the region; and c) better understand and document the water related biotic resources in the park and their habitat requirements.

The first two objectives are currently being met. First, the Western Region has funded a $60,000 University of Arizona study now underway to assess the risks associated with proposed land use changes, and to develop a system for tracking land use proposals of concern. Secondly, the NPS Water Resources Division has funded a three year $150,000 USGS study also underway to determine the physical hydrology of the Montezuma Castle region, to measure the outflow from Montezuma Well and evaluate the current water delivery monitoring system below the Well, and to conduct a broad survey of water related resources in Montezuma Castle.

This project will provide the final critical piece. It will include an intensive inventory of the park's water related biota, an assessment of the habitat requirements of these organisms, and the development of strategies for effectively protecting them. This project, combined with the hydrologic data now being compiled, will provide a database that will enable the park to make informed management decisions, and to successfully protect its water rights. Without solid, scientifically based information derived from the proposed studies, management has only weak, subjective means of attempting to protect these unique values.

Description of the Recommended Project or Activity: This project will have three overlapping phases. In the first phase, a bibliographic search and intensive resource inventories and assessments of Montezuma Well and the Beaver Creek riparian zone will be conducted. In the second phase, a complete taxonomic listing of aquatic and riparian plants and animals will be developed and their habitat requirements will be identified. And in the final phase, a multidisciplinary group will be convened to develop management options, and the results of this research will be prepared for use in park interpretive programs.

Phase I

1. Year 1: Conduct a thorough bibliographic search, review, and summary of information from literature. Over 50 scientific reports and papers have been published on a variety of scientific subjects regarding water resources of the monument, mostly related to the Well.

This search will include historic photos and aerial photographs of the aquatic and riparian portions of the monument.

2. Year 1 and 2: Conduct inventories and assessments of the monument's biota in and adjacent to Montezuma Well and within the Beaver Creek riparian zone including invertebrates, amphibians and reptiles, birds, mammals, flora, and vegetation. Develop monitoring protocols and train park staff in their use. This will provide the park with an early warning system for detecting changes, and will increase management's ability to respond effectively to these changes in a timely manner.

Phase II

3. Years 2 and 3: Production of a complete taxonomic listing of aquatic and riparian plants and animals that occur in the monument including annotations on relative abundance, distribution, life history, phenology, etc. based on observations during this study, as well as information from the literature. The species inventory within the Well and its associated outflow ditch will include phytoplankton and zooplankton.

4. Years 2 and 3: Determine habitat requirements of aquatic and riparian organisms and other ecological relationships within the aquatic and riparian zones. The unique environment and the evolution of these organisms in isolation suggest that these organisms may well have very narrow habitat requirements. Each identified organism will be studied to determine what those requirements might be. Some of the Well's unique characteristics include its constant temperature and its high calcium carbonate content, which precludes many species including all fish.

Phase III

5. Year 3: A multidisciplinary group will be convened to develop management options for reducing the external pressures exerted upon the monument's resources.

6. Year 3: Provide information from the scientific studies for interpretive programs. This will provide valuable information to the visiting public about the importance of wetlands ecosystems at the same time that it upgrades park interpretive programs.

DELIVERABLES

1. Biannual Progress Reports will contain brief statements of objectives, major accomplishments, problems encountered, fiscal status, and future plans.

2. Annual Reports will meet the content and format requirements of the Service's Investigators Annual Report.
3. Interim Reports

    a. Annotated bibliography of Montezuma Castle's aquatic and riparian resources. 77

b. Biotic lists including annotation on relative abundance, distribution, life history, phenology, etc.

Vegetation
Flora
Vertebrates: Fish; Amphibians and Reptiles; Birds; and Mammals
Invertebrates

c. Habitat requirement analyses; one for each identified taxon.

d. Recommendations of management strategies for protecting Montezuma Castle's aquatic and riparian resources.

4. Final Report compiling, integrating and synthesizing the information contained in the interim reports prepared by individual subject area principal investigators.

5. Collection of critical voucher specimens collecting and cataloging will be according to NPS standards.

6. Summary of research suitable for incorporation into interpretive programs.

7. Professional, peer-reviewed papers anticipated they will be ultimately prepared following conclusion of the project.

STAFFING REQUIREMENTS

Four major components, birds, flora and vegetation, mammals, and synthesis of this multi-disciplinary study will be accomplished under the direction of NPS scientists, thereby requiring a total of 1.5 FTE's each year for half-time biological technicians. Three other major components, herpetology, invertebrates, and aquatics will be accomplished under contracts or cooperative agreements, thereby requiring no additional FTE's.

COMPLIANCE

This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U. S. Department of Interior. NHPA compliance under Section 106 is likewise not required for this project.

FUNDING REQUIREMENTS

	Year 1	Year 2	Year 3
Personal Services 3 half-time GS-7 Bio. Techs/yr 3 graduate students/yr	$60,000	$60,000	$55,000
Travel and Per Diem	$15,000	$15,000	$15,000
Supplies and Materials	$ 4,000	$ 2,000	$ 2,000
Publication Costs	$0	$ 2.000	$12.000
TOTAL	$79,000	$79,000	$84,000

GRAND TOTAL - $242,000

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-N-05

2. Project Title: Evaluate Water Delivery Monitoring System

3. Servicewide Issue(s1:

N13 - Lack of Secure Water Rights

4. Problem Statement: Rights to the use of the water yield from Montezuma Well are held by the NPS and others. The rights held by the NPS are used for administrative purposes and historic irrigation. The existing system for monitoring the delivery of water to parties having rights thereto is inadequately installed. The result of this installation inadequacy is a poor data set and possibly inappropriate apportionment of available water. Further, this data inadequacy may place the NPS in an undesirable position if it were to be involved in water rights-related litigation.

Population increases have occurred in this area as in many others places in the southwest. Consequently, residential and commercial development have been steadily increasing in locations peripheral to the site. The nature and effect of increased water use and consumption associated with this development are presently unknown. However, it may be that water is being removed from the natural avenues of surface and subsurface water delivery that supply the Well. If a significant diminution in water delivery occurs, the water rights of the United States may be impaired.

5. Alternative Actions/Solutions and their Probable Impacts:

a. No Action. This option would require that the monument continue to operate its water rights partitioning program under a antiquated delivery system that has not been monitored or evaluated for accuracy for many years.

b. Evaluate Water Monitoring System. Conduct an evaluation of the water monitoring system to ensure that the partitioned water rights are being fairly and correctly metered. The effects of population growth in the Verde Valley on spring flow also need to be evaluated.

6. Description of the Recommended Proiect or Activity: Option b. is the recommended solution for this issue. Improving the water delivery monitoring system requires a careful analysis of all existing data, construction of a new monitoring system, and the correlation of old with new discharge data. This project will require some facility construction and the development of rating curves.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least four other projects listed in this plan. These are as follows:

MOCA-N-12 Protect the Hydrologic Characteristics of the Archeological and Historical Setting at Montezuma Well
MOCA-N-22 Examine Old Fields
MOCA-C-08 Study Montezuma Castle Irrigation System
MOCA-C-16 Prepare Historic Structures Preservation Guide: Prehistoric Structures

9. Funding Requirements:

	Year 1
Research Contract	$10,000

10. Annual Proiect Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-N-07

2. Project Title: Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat

3. Servicewide Issue(s):

N11 - Degradation of Park Water Quality due to External Activities
N20 - Lack of Basic Data: Insufficient Understanding of Park Ecosystems and Threats to Them

4. Problem Statement: Montezuma Well is a unique, spring fed lake nearly circular in shape, with a diameter of about 360 ft. It was formed in a limestone sink approximately 10,000 years ago. No other ecological equivalent to Montezuma Well has yet been found worldwide. A sizeable human community has developed just south of the monument in the past 20 years, and it is still growing. A growing population necessarily increases demand for and consumption of groundwater, which consumption may have a negative impact on the Well. A survey of all resources associated with the Well is badly needed. A few taxa in Montezuma Well are found nowhere else on earth. The breadth of species diversity and the complexity of interactions among organisms in this one-of-a-kind ecosystem are only now beginning to be recognized. Ecological knowledge of the Well is very limited. Increasing visitation, human population growth, and changes in land use patterns present a real threat to the long-term protection of this unique resource.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. This option will result in continued management of the Well without knowing what unique species and communities exist there. It is likely that any degradation of the Well may occur without NPS knowledge or management action to prevent it. Species, or entire ecological communities, could be lost without anyone being aware.

b. Continue Present Program. The National Park Service has funded very little biological research in the Well. A vegetation study around the rim of the Well was funded in 1987 and one within the sink was funded in 1988. Outside researchers, however, are encouraged to use their own funding sources to conduct studies in the Well, provided their research proposal demonstrates that they will do no harm to the resources. This option may result in many of the same problems as the no action alternative due to the slow pace of research.

c. Fund and Conduct a Thorough Resources Basic Inventory of the Well and Adjacent Riparian and Terrestrial Areas. This option will provide the Superintendent with in-depth information on occurrence and status of rare species in the Well and some aspects of their life history. This study will also indicate what species of native and non-native plants and animals are present in the Well and its adjacent areas. The study will also provide an understanding of the interrelationships among the aquatic, riparian, and terrestrial components of the ecosystem. This

information about the Well and its biota will allow the manager to make appropriate decisions in protecting the resources associated with the well on both a short term and a long term basis.

6. Description of the Recommended Project or Activity: Option c. is the recommended solution for this issue. Fund and conduct a thorough resources basic inventory of the Well and adjacent riparian and terrestrial areas. This study will be conducted through a combination of research contracts and NPS scientists. It will consist of the following components:

a. A thorough bibliographic search, review, and summary of information from literature. Over 50 scientific reports and papers have been published on a variety of scientific subjects regarding the Well. They describe its geology, provide some data on water quality and quantity, water turnover rate, sediments, etc. This search should include historic photos and aerial photographs of the area.

b. A complete taxonomic listing of plants (including cryptogams) and animals that occur in the study site, including annotations on relative abundance, distribution, life history, phenology, etc., based on observations during this study as well as information from the literature. The species inventory within the Well and its associated outflow irrigation ditch will include phytoplankton and zooplankton.

c. An evaluation of interrelationships among the aquatic, riparian, and terrestrial species and ecological communities. The study will evaluate, for example, the ecological role of water fowl and other birds along the Well and outflow ditch.

d. A written evaluation of key species and critical food chains, also discussing observations of, or potential for, any native species being threatened by alien species or human activities. A discussion of known or potential threats to ecosystem components, along with considerations of manipulative management, habitat, or species protection or restoration, etc. will also be included here.

e. The preparation of interpretive and educational programs for use in presenting a more complete and accurate story of this unique resource.

f. Products from this study will be scientific reports, species listings and annotations, taxonomically identified specimens to be curated in appropriate museums and herbaria, and reference specimens of selected species for use in the monument by scientists, interpreters, etc. Specific suggestions will be made in writing and in an oral presentation to the monument staff on the implications of study findings to both management and interpretation. The researchers will also recommend any further studies that may be necessary to manage the resources of the Well, the outflow ditch, and adjacent riparian and terrestrial habitats.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least eight other projects listed in this plan. These are as follows:

MOCA-N-04 Identify and Inventory Water-Related Resources
MOCA-N-09 Conduct Riparian Ecosystem Research
MOCA-N-11 Delineate and Evaluate Strategies for Wetlands Protection
MOCA-N-16 Conduct Inventory and Assessment: Invertebrates MOCA-N-17
Conduct Inventory and Assessment: Amphibians and Reptiles MOCA-N-18
Conduct Inventory and Assessment: Birds
MOCA-N-20 Conduct Inventory and Assessment: Mammals
MOCA-N-21 Conduct inventory and Assessment: Non-native Species

9. Funding Requirements:

	Year 1	Year 2
Personal Services	$18,000	$10,000
Travel and Per Diem	3,000	1,500
Limnological Supplies	1,000	0
Publication Costs		800
Total	$22,000	$12,300

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-N-08

2. Project Title: Assess Habitat Requirements of Aquatic Organisms at Montezuma Well

3. Servicewide Issue(s):

N11 - Degradation of Park Water Quality due to External Activities
N20 - Lack of Basic Data: Insufficient Understanding of Park Ecosystems and Threats to Them

4. Problem Statement: The aquatic organisms indigenous to Montezuma Well are water-related resource attributes of importance to this site. Their importance to the archeological and historical story of this NPS unit is unknown but the organisms have importance in their own right due to their uniqueness. Their habitat requirements have been met historically through the particular combination of water quality and quantity in the Well. However, it is not known whether these characteristics have been stable over time or have been changing progressively. If changes have occurred, the present state-of-knowledge does not allow for an assessment of the nature, magnitude, or cause for such change or of the possible consequences.

It is not unreasonable to anticipate that changes in water quantity and quality will be manifest at the Well due to increasing residential and commercial development in locations peripheral to the site. If a significant diminution in water delivery occurs, or if water quality substantially changes, then this water-related resource attribute may be adversely affected. Once affected, there is presently no means whereby the consequences may be assessed.

5. Alternative Actions/Solutions and their Probable Impacts:

a. No Action. This option would mandate the monument continue to manage the Well without any empirical knowledge of the resources of the Well. The Well is a unique natural wonder that contains many rare and endemic species. It is only through the acquisition of scientific data that this habitat can be properly protected and interpreted.

b. Study Aquatic Organisms. Conduct a scientific study of aquatic organisms and their habitat requirements at Montezuma Well. The few studies that have been conducted thus far have found many unique endemic life forms in the Well. This resource is obviously unusual and has led to the development of life forms found nowhere else on earth. It is imperative that the Well be systematically studied before unforeseen events degrade the Well and destroy unknown organisms.

6. Description of the Recommended Proiect or Activity: Option b. is the recommended solution for this issue. The assessment of aquatic organisms and their habitat requirements requires monitoring water replacement rate and standing water surface elevation, characterizing existing water quality, characterizing organism habitat requirements, modelling and/or estimating potential changes in water quantity and quality, and identifying activities or geographical areas that could

impact water quantity or quality. This information would be necessary to ensure protection of this water-related resource attribute from off-site water development and use.

Accomplishing the above requires an interdisciplinary approach to characterize the existing hydrologic and water quality regimes as well as the biotic needs of the indigenous organisms. The analysis of data collected will require the use of both computer models and expert opinion to assess current conditions and to predict probable conditions.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least two other projects listed in this plan. These are as follows:

MOCA-N-04 Identify and Inventory Water-Related Resources
MOCA-N-07 Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat

9. Funding Requirements:

	Year 1	Year 2	Year 3
Research Contract	$25,000	$22,000	$18,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-N-09

2. Project Title: Conduct Riparian Ecosystem Research

3. Servicewide Issue(s):

N12 - Alteration of Natural Flow Regimes/Groundwater Levels
N20 - Lack of Basic Data: Insufficient Understanding of Park Ecosystems and Threats to Them

4. Problem Statement: Two levels of concern are: a) completion of an inventory and assessment of natural riparian resources; and b) an assessment of past, current, and proposed management actions and visitor activities on natural riparian resources. Montezuma Castle National Monument was set aside because of its "...ethnological value and scientific interest..." The historic and prehistoric structures around which the major interest for visitors is focused are located on cliffs immediately adjacent to the floodplain and riparian lands along Beaver Creek. The surface and groundwater sources that currently support riparian ecosystems also served as water supplies for domestic and agricultural use for prehistoric humans. More, riparian vegetation produces the cooler, more mesic landscape that is so attractive to visitors in this arid region. Additional information is also needed for increasing the interpretive values and general understanding of these riparian lands.

Structures currently located in the riparian zone include surfaced walks, drinking fountains, interpretive displays, a picnic area, and a several hundred-foot-long gabion structure of rock and reinforcing metal mesh constructed by the CCC in the 1930s to deflect flood waters from areas of high visitor-use.

Visual examination of the riparian zone indicates that reestablishment rates of riparian trees (Arizona sycamore, net-leafed hackberry, chinaberry, velvet ash, etc.) seem low. Recruitment rates of young trees may be insufficient to replace the desirable riparian groves which are an important part of both the natural and cultural landscape. Examination of similar (control) areas nearby is needed to determine the relative condition of our groves and, if they are in poor condition, whether current and/or past management practices and/or visitor activities may be implicated and what changes would be needed to modify current impacts.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. Conduct Riparian Ecosystem Research. This option, discussed in detail in the following section of this project statement, would provide management with alternatives, including proposed actions and probable results, based on solid research findings. In addition to vegetation and faunistic implications of proposed management actions, attempts will be made to integrate information on soils, hydrology, and flood regimes with supporting information from current and past research programs in the area. The principal investigator will also design long term monitoring protocols for these components of the ecosystem.

b. No Action. This option would cause the continued management of the monument with insufficient knowledge of existing ecosystem components and processes with possible losses to both the natural and cultural landscapes and reduction in visitor satisfaction.

6. Description of the Recommended Project or Activity: Option a. is the recommended solution for this issue. An inventory of the riparian zone adjacent to both Montezuma Castle and Montezuma Well will examine biotic and abiotic ecosystem components with emphasis on vertebrates and flowering plants. An assessment of major components will be conducted for riparian plants, birds, and other groups that are determined to be of particular significance during the study. In addition, close monitoring of other studies is needed to interrelate and synthesis information of value to this project. Emphasis will be placed on ecological components, e.g. indicator species, that are of particular concern to interpreters and resource managers. Major project components, or sub-projects, identified at the time of writing this project statement are listed below. However, additional components may be identified from information gathered during the course of the projects.

a. Conduct an inventory and assessment of plants populations, their demographic structure, distribution, and health.

b. Examine hydrologic and soil parameters associated with riparian groves.

c. Conduct an assessment of riparian plants and their interrelationships with hydrology, soil, and animals species.

d. Use information from the avian inventory and assessment to examine avian populations in relation to vegetational parameters and interpretive value.

e. Use information from the mammalian inventory and assessment to examine mammalian populations in relation to vegetational parameters with special emphasis on pest species, e.g. rock squirrels and ring-tailed cats.

f. Use information from the herpetological inventory and assessment to examine amphibians and reptiles with emphasis on their interrelationships with vegetational communities and interpretive values.

g. Use information from the invertebrate inventory and assessment to examine interrelationships with plants and other animals and interpretive value of such information.

h. A long term monitoring program will be designed for these components of the ecosystem. The monument staff will be trained in the implementation of these protocols.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least five other projects listed in this plan. These are as follows:

MOCA-N-04 Identify and Inventory Water-Related Resources
MOCA-N-06 Analysis of Adjacent Land Use and Status
MOCA-N-07 Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat
MOCA-N-08 Identify and Inventory Aquatic Organisms and Their Habitat Requirements at Montezuma Well
MOCA-I-05 Integrate Program for Long-Term Monitoring of Cultural and Natural Resources

9. Funding Requirements:

	Year 1	Year 2	Year 3	Year 4
Personal Services	$8,000	#8,000	$12,500	$12,500
Travel and Per Diem	1,500	1,500	2,000	500
Equipment and Supplies	500	500	500	2.000
Total	$10,000	$10,000	$15,000	$15,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-N-11

2. Project Title: Delineate and Evaluate Strategies for Wetlands Protection

3. Servicewide Issue(s):

N11 - Degradation of Park Water Quality due to External Activities
N12 - Alteration of Natural Flow Regimes/Groundwater Levels

4. Problem Statement: Corps of Engineers and EPA regulations (33 CFR Section 238.3 and 40 CFR Section 230.3 respectively) define wetlands as "...areas that are inundated or saturated with surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." This definition has been in effect since 1977. Both Montezuma Castle management districts have wetlands that have not been evaluated or clearly delineated. External factors are impacting the quality and quantity of these water related resources, which directly affects management's ability to preserve and protect the resources.

The best known of these water resources is Montezuma Well, which is an unstratified, thermal limnocrene, with an area of 1.9 acres and a maximum depth of 55.8 feet with average subterranean flows of 1.5 million gallons a day. It is internationally recognized for its scientific and cultural uniqueness.

Beaver Creek, Wet Beaver Creek, and adjacent wetlands are integrated components of the cultural setting and are the primary resources responsible for maintaining the existing biological diversity. The Master Plan (1975) calls for staff to preserve the integrity of the cultural and natural settings. This cannot be accomplished without evaluating the permanence of the existing wetlands using a multidisciplinary approach. A multidisciplinary strategy must be developed to generate management options to reduce the external pressures exerted upon the Monument's resources. Furthermore, an examination of regulatory issues is mandatory to provide management with the appropriate context for decision making.

In addition to developing a multidisciplinary approach to collect the necessary field data and information, many technical judgments and inferences will have to be made to delineate and evaluate the wetlands in the appropriate jurisdictional setting. Operational methodologies will have to be developed for monitoring the health and stability of the water resources. Administrative policies, guidelines, and constraints will have to be reviewed extensively in the delineation process to secure and protect these wetlands.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. With this alternative the monument will not be able to assess the degree of external threats and pressures exerted upon the monument's cultural, natural and water resources. Management will have to make decisions in the absence of knowledge and without quantification

of hydrological factors that are used in evaluating, delineating, and protecting water resources and wetlands.

b. Delineate and Evaluate Strategies for Wetlands Protection. Based upon the results of MOCAN-04 and MOCA-N-09, a multi-disciplinary research team will quantify the current status of existing and potential threats to Montezuma Castle's wetland resources. Subterranean water flow, stability, and other hydrological factors will be examined along with stream dynamics and erosion potentials. Administrative guidance for these actions may be found in Executive Order 11990, the 1975 Master Plan, the current Resource Management Plan, and numerous NPS regulatory requirements and guidelines. In addition to quantifying water resource threats, the research team will develop strategies to protect these resources. Management alternatives and options will be identified to mitigate each threat. All recommendations would be subsequently prioritized and evaluated on evidence.

6. Description of the Recommended Proiect or Activity: Option b. is the recommended solution for this issue. A multi-disciplinary team would be contracted or assembled to address the concerns outlined in the above problem statement. NPS specialists, along with other experts, would participate actively to develop the necessary management strategies involved in protecting these resources. Some technological analysis may have to be contracted to obtain the necessary field data and hydrological information.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least eight other projects listed in this plan. These are as follows:

MOCA-N-04 Identify and Inventory Water-Related Resources
MOCA-N-07 Inventory the Basic Natural Resources of Montezuma Well and Adjacent Riparian and Terrestrial Habitat
MOCA-N-08 Identify and Inventory Aquatic Organisms and Their Habitat Requirements at Montezuma Well
MOCA-N-09 Conduct Riparian Ecosystem Research
MOCA-N-12 Protect the Hydrologic Characteristics of the Archeological and Historical Setting at Montezuma Well
MOCA-N-25 Develop GIS System
MOCA-I-04 Develop Bibliographic Assessment and Computerized Bibliographic Information Retrieval System
MOCA-I-05 Integrate Program for Long-Term Monitoring of Cultural and Natural Resources

9. Funding Requirements:

	Year 1
Research Contract	$15,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-N-13

2. Project Title: Identify Flood-Prone Areas for Protection of lives and Property

3. Servicewide Issue(s):

N20 - Lack of Basic Data: Insufficient Understanding of Park Ecosystems and Threats to Them

4. Problem Statement: Important visitor attractions are found in close proximity to active floodplain. With this the case, park management is concerned that visitors and property may be at risk from flash flood hazards. There is not presently available for management's use, a flood hazard assessment which identifies the areas that lie within the limits of selected design floods including the "Probable Maximum Flood." In addition, there are no mitigation recommendations specifically applicable to the *monument* that management may employ where hazards might exist.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. This option leaves the monument operating without good data on the potential flood hazard of various locations and developments in the monument. It is an unacceptable option for this reason.

b. Examine Flood Prone Areas. Conduct a thorough hydrologic evaluation to delineate and evaluate flood hazards for all areas of the monument. This prudent study would give the Superintendent the information necessary to ensure that public and employee safety is being protected from unreasonable exposure to flood hazards.

6. Description of the Recommended Project or Activity: Option b. is the recommended solution for this issue. A hydrologic investigation, designed to assess flood hazards in the monument, will include stochastic analyses of available data and on-site measurements of the channel. Flood hazard maps will be constructed which define the probable limits of flooded areas for selected design floods including the "Probable Maximum Flood." In companion to this assessment will be an assessment of potential means of mitigation including an evaluation of opportunities and constraints associated with each.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least two other projects listed in this plan. These are as follows:

MOCA-N-09 Conduct Riparian Ecosystem Research
MOCA-N-11 Delineate and Evaluate Strategies for Wetlands Protection

9. Funding Requirements:

	Year 1
Research Contract	$35,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-N-23

2. Project Title: Evaluate Effects of Hydrologic Characteristics on Morphological Properties of Flowing Streams

3. Servicewide Issue(s):

N12 - Alteration of Natural Flow Regimes/Groundwater Levels

4. Problem Statement: The channel features found in Beaver Creek and Wet Beaver Creek are associated with water-related resource attributes such as the historic setting and the rationale for early habitation at the site. These measurable features can be dramatically altered through human-induced changes in the hydrologic regime (amount, duration, and timing of discharges). Alterations of this kind may affect existing channel form in such a way as to severely compromise site integrity and thereby diminish scientific values for scholars and the recreational and interpretive values for visitors.

The potential for changes in sediment and hydrologic regimes arise from mining, upstream diversions, and/or storage. Changes in existing diversion and storage arrangements are likely to occur as population pressure increases in this geographic area. Therefore, the alterations in channel form could arise in the near future if they have not already. In either case, the NPS presently lacks the data describing existing or potential impacts which could be used in litigation aimed at preventing or providing remedy for adverse effects of this kind.

5. Alternative Actions/Solutions and their Probable Impacts:

a. No Action. Continue to operate the monument without any type of hydrologic evaluation. This deprives the interpretive program of information relative to the relationship between the presence of the flowing streams and implications for life during the prehistoric occupation period. The effects of external activities on water quantity, quality, sediment load, and flood hazard will remain unknown.

b. Study Effects of Hydrologic Characteristics. Thoroughly evaluate hydrologic effects on morphological characteristics of flowing streams in Montezuma Castle National Monument. Develop a mathematical model for such characteristics to assist the Superintendent in protecting water rights, evaluating the potential effects of proposed upstream land developments, etc.

6. Description of the Recommended Proiect or Activity: Option b. is the recommended solution for this issue. An evaluation of hydrologic effects upon morphological characteristics of flowing streams from changes in hydrologic regimes will require the characterization of existing hydrology, channel features, sediment transport, as well as the modelling of existing and potential flow regimes. The collection of discharge and sediment data will be accompanied by the characterization of channel geometry, bed material, and depositional forms. Standard approaches for modelling sediment transport will be applied to existing and collected data to describe the

likely future form of the channel under a set of hypothetical hydrologic regimes. Evaluation of the effects upon the historic scene, and other water-related resource attributes will be made using analytical methods as well as expert opinion.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least four other projects listed in this plan. These are as follows:

MOCA-N-04 Identify and Inventory Water-Related Resources
MOCA-N-05 Evaluate Water Delivery Monitoring System
MOCA-N-13 Identify Flood-Prone Areas for the Protection of Lives and Property MOCA-I-04 Develop Bibliographic Assessment and Computerized Bibliographic Information Retrieval System

9. Funding Requirements:

	Year 1	Year 2
Research Contract	$30,000	$10,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-N-24

2. Project Title: Evaluate Effects of Hydrologic Characteristics on Regeneration of Vegetation in Riparian Areas

3. Servicewide Issue(s):

N12 - Alteration of Natural Flow Regimes/Groundwater Levels
N20 - Lack of Basic Data: Insufficient Understanding of Park Ecosystems and Threats to Them

4. Problem Statement: Riparian vegetation at Montezuma Castle is a water-related resource attribute of specific concern to management. Many riparian plants have regeneration requirements which are related to the normal periodicity of over-bank discharges. Elimination of these discharges or a change in their periodicity may adversely affect vegetation replacement and the organisms dependent upon riparian vegetation. The potential for a change in over-bank flows can arise from upstream water development such as diversion and storage, or from on-site channel modifications. These effects may already exist or could arise in the future due to off-site water development or on-site human impacts.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. This option will leave the monument operating without any empirical data as to the current status of vegetative reproduction in the riparian zone or the hydrologic factors influencing the health of this ecosystem.

b. Study Effects of Hydrologic Characteristics. Conduct an evaluation of the effects of current hydrologic characteristics on vegetation in the riparian zone at the monument. This information will be valuable to the Superintendent when responding to proposed developments upstream of the monument. It will also be very helpful in evaluating the long-term prospects for riparian ecosystems in the monument.

6. Description of the Recommended Project or Activity: Option b. is the recommended solution for this issue. An evaluation of hydrologic effects on regeneration of vegetation in riparian areas will require the characterization of existing hydrology, channel features, sediment transport, and riparian vegetation, as well as mathematical modelling of existing and potential flow regimes. The collection of discharge and sediment data will be accompanied by the mapping of floodplain areas and their associated vegetation. Standard approaches for frequency analysis will be applied to existing and collected discharge data in a modelling effort which will describe areas and frequency of inundation under existing and possible conditions of off-site water development and on-site channel modification. Evaluation of the effects on riparian vegetation and organisms dependent thereon will be made by experts using results of the above described assessment.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least six other projects listed in this plan. These are as follows:

MOCA-N-04 Identify and Inventory Water-Related Resources
MOCA-N-09 Conduct Riparian Ecosystem Research
MOCA-N-11 Delineate and Evaluate Strategies for Wetlands Protection
MOCA-N-23 Evaluate Effects of Hydrologic Characteristics on Morphological Properties of Flowing Streams
MOCA-I-04 Develop Bibliographic Assessment and Computerized Bibliographic Information Retrieval System
MOCA-I-05 Integrate Program for Long-Term Monitoring of Cultural and Natural Resources

9. Funding Requirements:

	Year 1	Year 2	Year 3
Research Contract	$35,000	$20,000	$20,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-N-26

2. Project Title: Conduct Inventory and Assessment: Fishes

3. Servicewide Issue(s):

N20 - Lack of Basic Data: Insufficient Understanding of Park Ecosystems and Threats to Them

4. Problem Statement: The native fish fauna of Wet Beaver Creek and Beaver Creek has been modified by water management practices and introductions of non-native fishes. Five species of native fishes (gila mountain sucker, gila sucker, roundtail chub, speckled dace, and longfin dace) are known from these waters. Several species have been extirpated from Wet Beaver Creek and Beaver Creek.

Native fishes have been a significant resource consideration for monument staff because of the relatively low diversity of natives, threats posed by non-native fishes, and water management practices. Arizona Game and Fish Department and U.S. Fish and Wildlife Service have conducted periodic inventories of the Wet Beaver Creek and Beaver Creek drainages. However, these efforts are generally targeting alien gamefishes. There are no known impacts on current park activities or health and safety of park employees and visitors resulting from the existing native fishery.

This study is also designed to provide a long-term monitoring program for these components of the ecosystem.

5. Alternative Actions/Solutions and Their Probable Impacts,:

a. No Action. This alternative entails maintenance of the status quo. No research on the native fishery would be undertaken. There would be no efforts to evaluate opportunities for potential re-introduction of experimental native fish populations.

b. Inventory the Existing Native Fishery. This alternative requires completion of an inventory of native fishes in Wet Beaver Creek and Beaver Creek. The inventory would be conducted using electrofishing, seining and other non-destructive sampling techniques to characterize the composition of the fishery. Seasonal sampling would allow some insights into the relative abundance, natural history of native fishes and potential threats. Contract researchers would be retained to conduct the inventory. The contractor would be required to obtain necessary permits from the State of Arizona, US Fish and Wildlife Service, and NPS. The principal investigator will also design long term monitoring protocols for these components of the ecosystem.

6. Description of the Recommended Project or Activity: Option b. is the recommended solution for this issue. Conduct an inventory of native fishes in Wet Beaver Creek and Beaver Creek. This research project will document the occurrence of native fish species at Montezuma Castle. A variety of collecting techniques should be used to effectively sample the diversity of aquatic

habitats found (i.e. pools, runs, riffles, and backwaters). A seasonal sampling regime will allow the research to make initial determinations of relative abundance, reproductive activity, length-frequency relationships within species, habitat preferences, and other natural history attributes. The study effort should be initiated with a comprehensive review of the native fishery literature regarding the Beaver Creek drainage and introduction of non-native fishes. These data should be analyzed using descriptive statistics (e.g., mean, standard deviation, etc.). The researcher should also develop recommendations for subsequent studies which may provide assessment level information on individual fish species having management significance. The drainages should be evaluated for opportunities to re-introduce extirpated species.

A long term monitoring program will be designed for these components of the ecosystem. The monument staff will be trained in the implementation of these protocols.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least 12 other projects listed in this plan. These are as follows:

MOCA-N-06 Analysis of Adjacent Land Use and Status
MOCA-N-09 Conduct Riparian Ecosystem Research
MOCA-N-15 Conduct inventory and Assessment: Vegetation and Flora
MOCA-N-16 Conduct Inventory and Assessment: Invertebrates
MOCA-N-17 Conduct inventory and Assessment: Amphibians and Reptiles
MOCA-N-18 Conduct inventory and Assessment: Birds
MOCA-N-19 Conduct inventory and Assessment: Soils
MOCA-N-20 Conduct inventory and Assessment: Mammals
MOCA-N-21 Conduct inventory and Assessment: Non-native Species
MOCA-N-24 Evaluate Effects of Hydrologic Characteristics on Regeneration of Vegetation in Riparian Areas
MOCA-I-04 Develop Bibliographic Assessment and Computerized Bibliographic Information Retrieval System
MOCA-I-05 Integrate Program for Long-Term Monitoring of Cultural and Natural Resources

9. Funding Requirements:

	Year 1	Year 2
Personal Services	$6,500	$6,500
Travel and Per Diem	1,000	850
Supplies and Materials	800	350
Publication Costs		500
Total	$8,300	$8,200

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: MOCA-C-08

2. Project Title: Study of Montezuma Castle Irrigation System

3. Servicewide Issue:

CO2 - Inadequate Archeological Survey and Inventory, Including Archeological Identification and Evaluation Studies, Overviews, and Assessments

4. Problem Statement: It is assumed that the prehistoric sites near Montezuma Well were small farming settlements that relied on irrigation ditches coming from the Well. However, the ditch system has not been systematically studied to determine its age, extent, flow capacity, or the results of mineral deposits in the canal.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. The interpretive story at the Well will rely on traditional lore and analogy with modern irrigation systems.

b. Review Documentation of Prehistoric Systems in the Southwest. This will add some background for interpretation but will not increase knowledge of the system at Montezuma Well.

c. Study Irrigation System. This option would conduct a thorough study of the Montezuma Castle irrigation ditch system to gather as much information as possible on flow rates, length of use, aerial extent of the system, etc.

6. Description of the Recommended Project or Activity: Option c. is the recommended solution to this issue. Past records of canal systems will be gathered, existing aerial photographs will be examined and new low-altitude low angle aerial photographs will be taken. Visible canal systems will be mapped. Exposed canals will be examined, and additional segments will be exposed and sectioned to examine mineral deposits and estimate flow rates. Feasibility of dating canals will be assessed. Canal system's age, extent, and capacity will be compared to other prehistoric canal systems. Potential for further research will be assessed, and proposals for further work will be prepared.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of Interior. The NHPA compliance through Section 106 will require regional and SHPO review and approval.

8. Relationships: This project has no relationship to any other project in this plan. Findings, however, will be incorporated into the monument's interpretive program and prospectus.

9. Funding Requirements:

	Year 1
Personal Services	$10,000
Travel and Per Diem	2,000
Aerial Photography	1,000
Supplies and Materials	600
Publication Costs	800
Total	$14,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on a project.

PROJECT STATEMENT

Unfunded

1. Project Number: TUZI-N-02

2. Project Title: Identify and Inventory Water-Related Resource Attributes

3. Servicewide Issue(s):

N11 - Degradation of Park Water Quality due to External Activities
N20 - Lack of Basic Data: Insufficient Understanding of Park Ecosystems and Threats to Them

4. Problem Statement: The water-related resource attributes of the monument have not been fully identified. This identification is necessary in the event that water development and use by parties outside of the boundaries of the monument affects or is likely to affect the resources of this unit or the purposes for which it was created. The identification and inventory is needed to both identify the possibility of impact and to measure its magnitude in the event impact does occur. This information will be required in water rights litigation or in any other similar arena in which the NPS seeks relief from such impact.

At present there exists an incomplete, and perhaps inadequate understanding of the relationship of water to the resources of the monument. The first step in developing this understanding is identifying and inventorying the nature and magnitude of resource attributes that are affected by or dependent upon water, both surface and subsurface.

The possibility of future impact to water-related resource attributes exists because of residential and commercial development which is increasing in locations peripheral to the site. Water withdrawals from aquifers underlying the monument or alterations in surface water flow regimes are likely to affect water-related resource attributes. Without an identification and inventory, assessments to arrest and reverse effects will be delayed resulting in additional or longer-lasting effects.

5. Alternative Actions/Solutions and their Probable Impacts:

a. No Action. This action would leave the monument without an adequate data base to protect its water rights or to understand the relationships between water resources of the monument and early man's activities at the site. Water resource attributes might be lost under such stewardship.

b. Conduct a Thorough Inventory of All Water-Related Resource Attributes in Tuzigoot National Monument. Such a study will give the Superintendent an adequate data base from which to make informed management decisions and to protect water rights. Such results will also be of use to other resource related inventories conducted in the monument.

6. Description of the Recommended Proiect or Activity: Option b. is the recommended solution for this issue. Identification and inventory of water-related resource attributes require a technical assessment of physical resources and scientific literature. This project is best undertaken by an interdisciplinary team working as a unit. Field and office assessments will

result in summary reports, maps and atlases. When completed, additional 'projects and/or studies may be required to evaluate the nature and magnitude of the relationship between water and water-related resource attributes.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of the Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least three other projects listed in this plan. These are as follows:

TUZI-C-06 Survey and Inventory Collections for Tuzigoot Objects
TUZI-N-05 Conduct Riparian and Wetlands Ecosystem Research TUZI-N-06 Delineate and Evaluate Strategies for Wetlands Protection

9. Funding Requirements:

	Year 1	Year 2	Year 3
Research Contract	$25,000	$25,000	$25,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on this project.

PROJECT STATEMENT

. **Unfunded**

1. Project Number: TUZI-N-03

2. Project Title: Restore Tavasci Marsh

3. Servicewide Issue(s):

N08 - Loss of Cultural Landscapes
N12 - Alteration of Natural Flow Regimes/Groundwater Levels

4. Problem Statement: Tavasci Marsh is located 0.6 miles southeast of Pecks Lake and about 650 yards northeast of Tuzigoot National Monument Headquarters. It is fed by springs that emerge upstream from the marsh. Of the 35-acre Tavasci Marsh, approximately 10 acres are covered by cattails and 25 acres consist of open water and or intermittently submerged meadows populated by Ranunculus, Cyperus, and Eleocharis species.

The most unusual faunal elements of this area are two species of Cattail marsh inhabiting birds. It is likely that both sora and virginia rails breed at Tavasci Marsh. Both are uncommon Arizona species and are only two examples of the 73 species of birds that are known to occur in the marsh area. Other water orientated vertebrates known to occur at the marsh include the bullfrog, leopard frog, sonoran mud turtle, and muskrat. Numerous other species such as coyotes, deer, and rabbits undoubtedly occur in the area. The marsh is drained by the Verde River which extends north and south. Archeologically, Tavasci Marsh is situated adjacent to the Tuzigoot pueblo-type dwellings that were occupied until the 14th century.

The marsh, an oxbow remnant of the Verde River, is owned by the Phelps Dodge Corporation and is currently leased to the Tavasci family of Clarkdale, Arizona. Past negotiations have discussed the possibility of transferring Tavasci marsh to the National Park Service. Prior to re-establishing Tavasci Marsh as a natural area a feasibility study which would delineate all potential concerns including, an ecological viability assessment, potential hydrological effects from nearby mine tailings, water quality issues, and jurisdictional liabilities, should be conducted. The marsh and its associated riparian habitats are valuable and scarce natural resources that are significantly integrated with the surrounding cultural landscapes. There are few marshes of scientific interest available in Arizona.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. This alternative entails maintenance of the status quo. The Tavasci Marsh would remain under private ownership. Potential future development concerns of the marsh area would not be eliminated. Loss of cultural landscapes are expected along with visual and biological impacts resulting from the loss or conversion of this natural area to a more developed status.

b. Once Acquisition of the Marsh is Imminent. Conduct a Tavasci Marsh Restoration Study. This action would entail assembling a NPS multidisciplinary team to evaluate all potential liabilities and develop strategies to restore the marsh area. Special attention would be given to

marsh ecology, subterranean water flow and stability, adjacent stream dynamics, water quality and hydrological factors that influence the stability of Tavasci Marsh in the general vicinity. Water quality issues and soils evaluations would require some laboratory testing. Spring gauges and local well information would have to be gathered in addition to information on potential point pollution sources. The multidisciplinary NPS team would decided on how to prioritize the issues and allocate monetary resources.

c. Accept Tavasci Marsh Without Examining the Issues. This option would transfer stewardship of the marsh to the National Park Service without examining potential liabilities or other marsh restoration issues that may arise. The monument staff would have little information how to restore or manage the Tavasci Marsh as a natural area. Ecological and hydrological concerns may not be addressed adequately to satisfy local or national interests.

6. Description of the Recommended Proiect or Activity: Option b. is the recommended solution for this issue. A multidisciplinary team would be assembled to examine all restoration issues. The team would conduct ecological and hydrological inventories along with legal assessments prior to restoration. Water quality, hydrological dynamics, and ecological evaluations would require some analytical laboratory testing over the first and second years. The study would be conducted over three years to obtain the necessary seasonal data which may be highly variable. A final report would be issued in the third year identifying the resources, manpower, monitoring programs, and management strategies necessary for complete restoration.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of the Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least seven other projects listed in this plan. These are as follows:

TUZI-N-01 Manage Vegetation: Rehabilitation, Landscaping, and Hazard Tree Removal
TUZI-N-04 Analyze Adjacent Land Use and Status
TUZI-N-05 Conduct Riparian and Wetlands Ecosystem Research
TUZI-N-06 Delineate and Evaluate Strategies for Wetlands Protection
TUZI-N-08 Conduct Inventory and Assessment: Vegetation and Flora
TUZI-N-13 Inventory and Evaluate Control of Non-Native Species
TUZI-N-15 Resource Basic Inventory and Assessment: Mammals

9. Funding Requirements:

	Year 1	Year 2	Year 3	Year 4
Personal Services	$25,000	$20,000	$20,000	$ 0
Travel and Per Diem	5,000	4,500	3,500	0
Lab and Field Testing	10,000	20,000	5,000	0
Monitoring Equipment	15,000	0	0	0
Miscellaneous Supplies	4,000	2,500	2,500	0
Reproductions/Reports		1.000	2.000	_Q
Total	$59,000	$48,000	$33,000	$ 0

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on this project.

PROJECT STATEMENT

Unfunded

1. Project Number: TUZI-N-05

2. Project Title: Conduct Riparian and Wetlands Ecosystem Research

3. Servicewide Issue(s):

N20 - Lack of Basic Data: Insufficient Understanding of Park Ecosystems and Threats to Them

4. Problem Statement: Two levels of concern with this issue are: a) completion of an inventory and assessment of natural riparian and wetland resources; and b) an assessment of past, current, and proposed management actions and visitor activities on natural riparian and wetland resources. The prehistoric structures around which the major interest for visitors is focused are located on a hill immediately adjacent to the floodplain and riparian lands along the Verde River. Tavasci Marsh is located in an ancient oxbow of the Verde River just north of the visitor center. The surface and groundwater sources that currently support riparian ecosystems also served as water supplies for domestic and agricultural use for historic and prehistoric humans. Additionally, riparian vegetation produces the cooler, more mesic landscape that is so attractive to visitors in this arid region. Additional information is also needed for increasing the interpretive values and general understanding of these riparian lands. Tavasci Marsh has been partially drained and badly overgrazed. Methods for rehabilitating this area need to be developed.

5. Alternative Actions/Solutions and Their Probable Impacts,:

a. No Action: Manage with insufficient knowledge of existing ecosystem components and processes with possible losses to both the natural and cultural landscapes and reduction in visitor satisfaction.

b. Conduct Riparian Ecosystem Research and Provide Management Alternatives Based on Scientific Findings. This option will provide management alternatives *including* proposed actions and probable results based on solid research findings. In addition to vegetation and faunistic implications of proposed management actions, attempts will be made to integrate information on soils, hydrology, and flood regimes with supporting information from current and past research programs in the area.

6. Description of the Recommended Proiect or Activity: Option b. is the recommended solution for this issue. An inventory of the riparian zone and wetlands adjacent to the ruins will examine both biotic and abiotic ecosystem components with emphasis on vertebrates and flowering plants. An assessment of major components will be conducted, e.g. for riparian plants, birds, and other groups that are determined to be of outstanding significance during the study. In addition, close monitoring of other studies is needed to interrelate and synthesis information of value to this project. Emphasis will be placed on ecological components, e.g. indicator species, that are of particular concern to interpreters and resource managers.

While additional subprojects may be identified from information gathered during the course of this study, major components of this project, as currently identified, are as follows:

a. Conduct an inventory and assessment of tree and shrub populations, their demographic structure, distribution, and health.

b. Examine hydrologic and soil parameters associated with riparian lands and wetlands.

c. Conduct an assessment of riparian and wetland plants and their interrelationships with hydrology, soil, and animals species.

d. Use information from the avian inventory and assessment to examine avian populations in relation to vegetational parameters and interpretive values.

e. Use information from the mammalian inventory and assessment to examine mammalian populations in relation to vegetational parameters with special emphasis on pest species, e.g. rock squirrels and ringtail cats.

f. Use information from the herpetological inventory and assessment to examine amphibians and reptiles with emphasis on their interrelationships with vegetational communities and interpretive values.

g. Use information from the invertebrate inventory and assessment to examine interrelationships with plants and other animals and interpretive values of such information.

h. Evaluate the ecological health of Tavasci Marsh. The marsh is located along with Pecks Lake in an ancient abandoned meander (oxbow) of the Verde River encircling much of the hill on which the ruins and visitor center are located. The marsh has been largely drained and heavily overgrazed during the past several decades. Means of rehabilitating the marsh will be examined.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of the Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least three other projects listed in this plan. These are as follows:

TUZI-N-02 Identify and Inventory Water-related Resources Attributes
TUZI-N-03 Restore Tavasci Marsh TUZI-N-06 Delineate and Evaluate Strategies for Wetlands Protection

9. Funding Requirements:

	Year 1	Year 2	Year 3	Year 4
Personal Services	$12,000	$12,000	$12,500	$12,500
Travel and Per Diem	2,000	2,000	2,000	2,000
Supplies	1,500	1,500	1,500	1,500
Publication Costs	0	0	1.000	2.000
Total	$15,500	$15,500	$17,000	$18,000

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on this project.

PROJECT STATEMENT

Unfunded

1. Project Number: TUZI-N-06

2. Project Title: Delineate and Evaluate Strategies for Wetlands Protection

3. Servicewide Issue(s):

N11 - Degradation of Park Water Quality due to External Activities
N12 - Alteration of Natural Flow Regimes/Groundwater Levels
N16 - Visual and Biological Impacts of Urbanization and Other Near-Park Development on Park Resources

4. Problem Statement: Corp of Engineers and EPA regulations (33 CFR Section 238.3 and 40 CFR Section 230.3 respectively) define wetlands as "...areas that are inundated or saturated with surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions." This definition has been in effect since 1977. Tuzigoot National Monument and the potential Tavasci Marsh natural area have water resources that have not been evaluated or clearly delineated. External factors may be impacting the quality and quantity of the water at Tuzigoot National Monument that directly affects management's ability to preserve and protect the potential Tavasci Marsh natural area and monument's cultural resources. Groundwater withdrawal may affect the long stability of the 14th century archeological ruins.

The Verde River and adjacent wetlands are integrated components of the cultural setting and are the primary resources responsible for maintaining the existing biological diversity. The Master Plan (1975) calls for monument staff to preserve the integrity of the cultural and natural settings. This cannot be accomplished without evaluating the permanence of the existing riparian areas and wetlands using a multidisciplinary approach. A multidisciplinary strategy must be developed to generate management options to reduce the external pressures exerted upon the monument's resources. Furthermore, an examination of regulatory issues is mandatory to provide management with the appropriate context for decision making.

In addition to developing a multidisciplinary approach to collect the necessary field data and information, many technical judgments and inferences will have to be made to delineate and evaluate the wetlands in the appropriate jurisdictional setting. Operational methodologies need to be developed so that the monument can monitor the health and stability of the water resources. Administrative policies, guidelines, and constraints will have to be reviewed extensively in the delineation process to secure and protect the monument's resources.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. With this alternative the monument will not be able to assess the degree of external threats and pressures exerted upon its cultural, natural and water resources. Management will have to make decisions in the absence of knowledge and without quantification

of hydrological factors that are used in evaluating, delineating, and protecting cultural and natural resources and adjacent wetlands.

b. Delineate and Evaluate Monument Wetlands Strategies for Protection. This option would entail convening a multi-disciplinary research team to evaluate and delineate all wetlands and water resources issues and to quantify the current status of existing and potential water resource threats. Subterranean water flow, stability, and other hydrological factors should be examined along with stream dynamics and erosion potentials. Administrative guidance for these actions may be found in Executive Order 11990, the Master Plan, the current Natural and Cultural Resources Management Plan, and numerous DOI regulatory requirements and or guidelines. In addition to quantifying water resource threats, the research team would develop action orientated strategies to protect the Monument's water resources and the adjacent landscapes. Management alternatives and options would be identified to mitigate each threat after data collection and multiple factor analysis. All recommendations would be subsequently prioritized and evaluated on evidence.

6. Description of the Recommended Proiect or Activity: Option b. is the recommended solution for this issue. A multidisciplinary team would be contracted or assembled to address the above concerns as outlined in the above problem statement. The NPS specialists, along with other subject experts, would participate actively to develop the necessary management strategies involved in protecting the monument's resources. Some technological analysis may have to be contracted to obtain the necessary field data and hydrological information.

7. Compliance: This project is categorically excluded from NEPA compliance, Departmental Categorical Exclusions, 516 DM, Chapter 2, Appendices 1 and 7, U.S. Department of the Interior. The NHPA compliance under Section 106 is likewise not required for this project.

8. Relationships: This project is related to at least three other projects listed in this plan. These are as follows:

TUZI-N-02 Identify and Inventory Water-related Resources Attributes
TUZI-N-03 Restore Tavasci Marsh TUZI-N-05 Conduct Riparian and Wetlands Ecosystem Research

9. Funding Requirements:

	Year 1	Year 2	Year 3	Year 4
Research Contract	$20,000	$20,000	$33,000	$ 0

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on this project.

PROJECT STATEMENT

Unfunded

1. Project Number: TUZI-C-04

2. Project Title: Preserve and Restore the Prehistoric Scene

3. Servicewide Issue(s):

N12 - Alteration of Natural Flow Regimes/Groundwater Levels
C13 - Need for Rehabilitation or Restoration of Historic and Prehistoric Structures, and Cultural Landscapes

4. Problem Statement: Preserve and restore the prehistoric setting and scene immediately to the east and below the 100-room pueblo. This view area includes riparian areas, prehistoric croplands, desert uplands, and Tavasci Marsh.

Tavasci Marsh, first identified as a significantly rare habitat by the Arizona Academy of Science has also been identified in the National Natural Landmark Theme Study, Biotic Themes, Mojave-*Sonoran* Desert Region. The Marsh is of importance as a riparian habitat, with an extensive diversity of flora and fauna, and also represents geologic processes and lake formation.

The 60-acre marsh is a key aspect relating to the prehistoric occupation of the area. The marsh is being drained, heavy grazing is occurring, some development exists, a dirt road crosses the middle of the area, and the flora and fauna are being adversely altered. The potential exists for extensive modern farming and development of most of the small valley for housing. Extensive development of adjacent lands is occurring for housing.

The 1975 Master Plan addressed the critical area and called for acquisition. The 1984 Land Protection Plan also recognized the critical area and called for acquisition. Discussions have been held with the owner of the property concerning possible exchange for other lands in the Southwest. The 1979 Natural Landmark Theme Study also recommended that Tavasci Marsh should be added to Tuzigoot National Monument.

5. Alternative Actions/Solutions and Their Probable Impacts:

a. No Action. This option would fail to provide protection to Tavasci Marsh and adjacent lands. Changing land use patterns in the area will almost guarantee that these lands will be developed for housing and intense recreational pursuits in the near future if no protection is provided.

b. Purchase These Lands for Addition to the Monument. This option would guarantee that this important part of the prehistoric scene at Tuzigoot National Monument could be permanently protected from urban development. This area also has important ecological values as a wetland that should be protected.

6. Description of the Recommended Project or Activity: Option b. is the recommended solution for this issue. Acquisition of the culturally significant lands including riparian areas,

prehistoric croplands, desert uplands and Tavasci Marsh will provide protection for these lands and better preserve a more complete picture of the prehistoric scene in the Tuzigoot area.

7. Compliance: This project will require an environmental assessment or impact statement under NEPA regulations. Such compliance will be prepared on an individual basis at the time that the project is funded. The NHPA compliance under Section 106 may be required for this project.

8. Relationships: This project is related to at least two other projects listed in this plan. These are as follows:

TUZI-N-03 Restoration of Tavasci Marsh
TUZI-I-04 Examine Old Fields

9. Funding Requirements: The current legislatively mandated acquisition ceiling for Tuzigoot National Monument is $1,350,000. The cost of purchasing these additional lands has not yet been determined.

10. Annual Project Status and Accomplishments: This report will be initiated once action begins on this project.

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GLOSSARY

Terms used in this report are defined below. The definitions were adapted from the American Geological Institute (1976) and Owen-Joyce and Bell (1983).

Alluvium - Detrital deposits resulting from the operations of modern rivers, thus including the sediments laid down in river beds, floodplain, lakes, fans at the foot of mountain slopes, and estuaries.

Aquifer - A geologic formation, group of formations or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs.

Base flow - Groundwater that has been discharged into a stream channel as spring or seepage water.

Ephemeral stream - A stream or reach of a stream which flows only in direct response to precipitation.

Evaporites - Sediments that are deposited from an aqueous solution as a result of extensive or total evaporation of a solvent.

Evapotranspiration - Water withdrawn from a land area by evaporation from water surfaces and moist soil and by plant transpiration.

Fluvial - Of, or pertaining to, rivers; growing or living in streams or ponds; produced by river action as, a fluvial plain.

Groundwater divide - A ridge in the water table or other potentiometric surface from which ground water moves away in both directions.

Hydraulic conductivity - The volume of water that will move in unit time under a unit hydraulic gradient through a unit area measured at right angles to the direction of flow. Hydraulic conductivity describes the ability of the aquifer material to transmit water and may have substantially different values for horizontal and vertical flow through the same material.

Hydraulic connection - The process by which movement between surface waters and groundwater aquifers occurs.

Hydraulic gradient - The change in head per unit of distance in a given direction.

Lacustrine - Pertaining to, produced by, or forming in, a lake or lakes.

Limnocrene - A pooled spring, frequently occurring in limestone.

Perennial stream - One which flows continuously.

Regional aquifer - The surface and groundwaters of the study area. Large scale hydraulic connections facilitate movement of water regionally.

Transmissivity - The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. Transmissivity describes the ability of the entire thickness of an aquifer to transmit water and is the product of hydraulic conductivity and saturated thickness.

Water table - The surface in an unconfined aquifer below which the rocks are saturated with water. The water table is the level at which water stands in wells that penetrate the uppermost part of an unconfined aquifer.

CONSULTATION AND COORDINATION

National Park Service

Water Resources Division, Washington Office
Bill Werrell, Hydrologist, Water Services Branch
Bill Reed, Hydrologist, Water Services Branch
Gerald Witucki (retired), Hydrologist, Water Services Branch
Dan Kimball, Chief, Policy, Planning, and Evaluation Branch
Dave Sharrow, Hydrologist, Policy, Planning, and Evaluation Branch
Owen Williams, Chief, Water Rights Branch

Western Regional Office
Richard Hadley, Biological Technician, Division of Natural Resources and Research

Southern Arizona Group Jim
Rancier, Archeologist

Cooperative Park Studies Unit
Dennis Fenn, Unit Leader (former), University of Arizona
Mark Sogge, Ecologist, Northern Arizona University

Department of the Interior

US Fish and Wildlife Service

Department of Agriculture

Prescott National Forest

State of Arizona

Arizona Department of Water Resources Arizona
Department of Environmental Quality Arizona
Game and Fish Department
Arizona State Parks
State Historical Preservation Office

Verde Natural Resources Conservation District

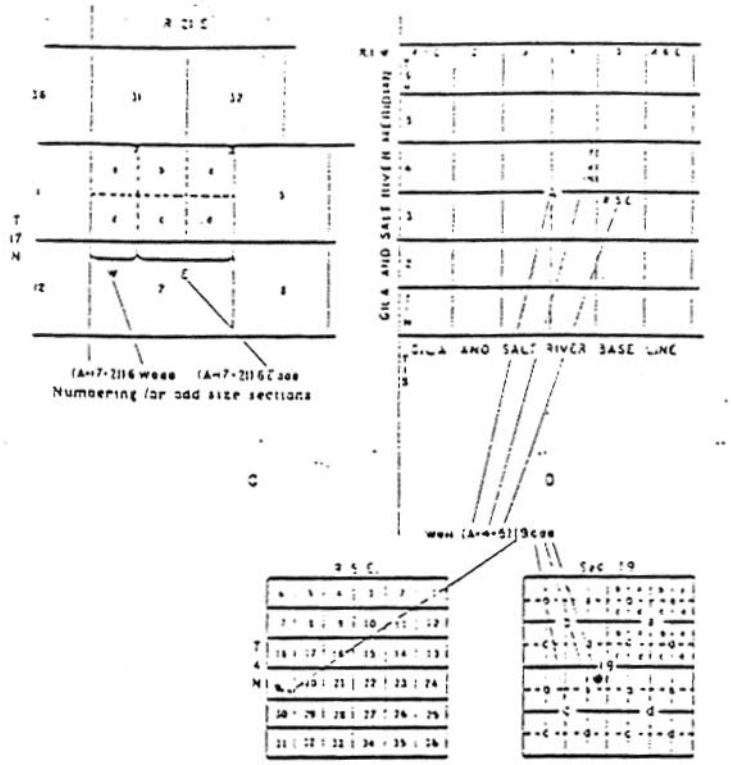
In addition to the above contacts for consultation and coordination, two drafts of the plan were available for public review and comment. Notice of availability was given via the local newspaper and on radio.

APPENDICES

APPENDIX A. List of Preparers

Below is a list of preparers:

George Ruffner, Consultant, Ruffner and Associates
Kathy Davis, Resources Manager, Southern Arizona Group
Glen Henderson, Superintendent, Montezuma Castle and Tuzigoot
Mary Glen, Secretary, Southern Arizona Group



The well numbers and letters used by the Geological Survey in Arizona are in accordance with the Bureau of Land Management's system of land subdivision. The land survey in Arizona is based on the Gila and Salt River meridian and base line, which divide the State into four capital letters, A, B, C, and D. All land north and east of the point of origin is in A quadrant, that north and west is in B quadrant, that south and west in C quadrant, and that south and east in D quadrant.

The first digit of a well number indicates the township, the second the range, and the third the section in which the well is situated. The lowercase letters, a, b, c, and d after the section number indicate the well location within the section. The first letter denotes a particular 160-acre tract, the second the 40-acre tract, and the third the 10-acre tract. These letters are also assigned in a counterclockwise direction, beginning in the northeast quarter. If the location is known within the 10-acre tract, three lowercase letters are shown in the well number. In the example shown in figure 2, well number (A-4-5)l9caa designates the well as being in the NE'ANE'4SW'4 sec. 19, T. 4 N., R. 5 E. Where there is more than one well within a 10-acre tract, consecutive numbers beginning with 1 are added as suffixes.

When a section is more than 1 mile in any dimension, the section number applies as usual. The oversized section is divided so that a full square-mile unit of the section is adjacent to a normal section within the same township; the remainder is considered as a separate unit of land. Appropriate N., S., E., or W. letters are assigned to the units, depending upon where they lie in relation to the full square-mile unit. A well would be designated as shown in figure 2 with the appropriate letter following the section number in which the well is located.