Water Resources Management Plan

Arches National Park & Canyonlands National Park • Utah

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Arches National Park and Canyonlands National Park

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Yet the poets are needed, too.....The moral I am laboring toward is that a landscape as splendid as that of the canyonlands can best be understood by poets with their feet planted firmly in concrete data; and by geologists whose heads and hearts have not lost the capacity for wonder. Any good poet, in our age at least, must begin with the scientific view of the world; while the scientist must be something of a poet, that is capable of wonder, with the ability to communicate to others his sense of love and wonder.

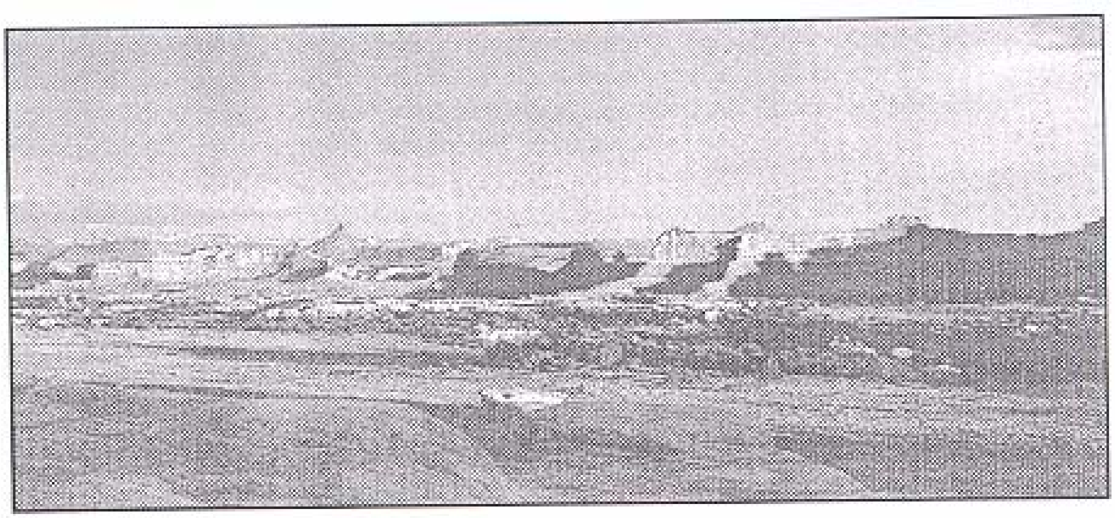
Edward Abbey
"Welcome to Canyonlands"
Four Corners Geological Society Guidebook
8th Field Conference, Canyonlands, 1975

PREFACE

The National Park Service recognizes the importance of preserving, conserving and protecting water resources within its boundaries. Water resources, whether as large as the Colorado River or as small as a seep in Ernie's Country of Canyonlands National Park, play a distinctive role in linking ecosystems and, in general, providing habitat for a number of organisms. To protect park water resources, the Park Service initiated a Water Resources Planning Program in 1991. The planning program provides an essential step in developing a comprehensive understanding of a park's hydrological system and the complex resource issues which surround it. The planning program includes several products including Water Resource Issues Overviews, Water Resources Scoping Reports, and Water Resources Management Plans.

This Water Resources Management Plan describes the water resources of Arches and Canyonlands National Parks and the issues affecting them. This plan provides detailed descriptions of the hydrologic environment in both parks, discussion of management issues developed in two scoping sessions, and management directives in the form of project statements. Typically, a Water Resource Management Plan is preceded by a scoping meeting held at the park. In this case, the Southeast Utah Group of parks, which includes Arches National Park, Canyonlands National Park, and Natural Bridges National Monument held two scoping meetings. The first scoping session resulted in the Canyonlands National Park, Arches National Park, and Natural Bridges National Monument Water Resources Scoping Report (Berghoff and Vana-Miller, 1997), and the second scoping meeting which took place in September 1997 involved federal, state, and local agencies which helped to refine further the issues developed in the scoping report.

The scoping report identified a number of issues including maintenance of water quality and quantity in light of increased visitation, development of culinary water sources, protection of threatened and endangered species, and definition of impacts from mining among others. The scoping report provided a broad overview of the parks' landscapes and water resources. More importantly, the scoping report laid the ground work for development of a Water Resources Management Plan. The scoping report recognized that the Southeast Group of parks face many challenges as result of an ever increasing visitor population and impacts to water resources originating outside the park boundaries. The complexity of the issues, the multitude of players outside the parks themselves, and a policy based and genuine interest in preserving the water resources of the parks are the basis for developing the Arches National Park and Canyonlands National Park Water Resource Management Plan was a necessity.



INTRODUCTION

Park Purposes

Both Arches National Park and Canyonlands National Park (Canyonlands) are located in southeastern Utah on the Colorado Plateau, a physiographic province, which spans parts of Colorado, Utah, Arizona, and New Mexico. Both parks have semi-desert environments encompassing grassland, shrubland, and woodland vegetative communities. Elevations of the parks range from less than 4,000 feet mean sea level (msl) (1220 meters) up to 8,000 feet msl (2440 meters). Canyonlands encompasses the confluence of the Green and the Colorado rivers. Arches is located 5 miles (8.1 kilometers) north of Moab, and Canyonlands approximately 20 miles (32.4 kilometers) downstream from Moab, Utah on the Colorado River (See Figures 1, 2, and 3).

Arches contains the largest concentration of natural stone arches in the world - approximately 2,000 natural stone openings within the 114 square miles of the park. On April 12, 1929, Proclamation No. 1875 established Arches National Monument, which states that the purpose of the monument is to "protect extraordinary examples of wind erosion in the form of gigantic arches, natural bridges, windows, spires, balanced rocks, and other unique wind worn sandstone formations, the preservation of which is desirable because of their educational and scenic value." (National Park Service, 1990a)

Public Law 92-155, November 12, 1971 established the monument as a park, and with boundary changes occurring throughout its history, the park now encompasses 76,536 acres (31,890 hectars). A major theme is the "sculpture of the land". The prominent landforms including arches, bridges, and spires have been produced by the erosive action of land and water.

Public Law 88-590, September 12, 1964, established Canyonlands " to preserve an area in the State of Utah possessing superlative scenic, scientific, and archeological features for the inspiration, benefit, and use of the public." (National Park Service, 1990b). The outstanding feature of Canyonlands is the sculpted nature of the land. Both the Green and Colorado rivers help shape and interact with the attendant riparian areas. Deep canyons, mesas, buttes, and land spires are created by intermittent rainfall and wind in this arid climate. Canyonlands encompasses approximately 337,570 acres (136,668 hectares).

Although not specifically mentioned in their Statements for Management, the two parks are defined by the presence of water, or perhaps more prominent, the lack thereof. Both parks encompass streams, springs, seeps, potholes, or major river systems which serve a host of ecological functions. From a natural resource perspective, water, and its erosive capabilities, synthesize land features in a chaotic manner over geologic time.

In addition to playing a key role in shaping the desert landscape, the parks' streams, seeps, springs, potholes and rivers provide habitat resources for wildlife. For example, the desert bighorn, a native inhabitant of the Colorado Plateau, extirpated, then reintroduced to Arches and Capitol Reef National Park from the Canyonlands herd, require consistent water resources. Wilson (1968) referred to the establishment of bighorn ranges as being adjacent to water; the animals move only when the available waterholes dry. During a 39-day observation period, the ewes and lambs, moved to water on a daily basis, unlike the rams (Wilson, 1968). Wildlife tends to concentrate in and around wet habitats. Wet sites consistently have the highest biodiversity in arid regions.

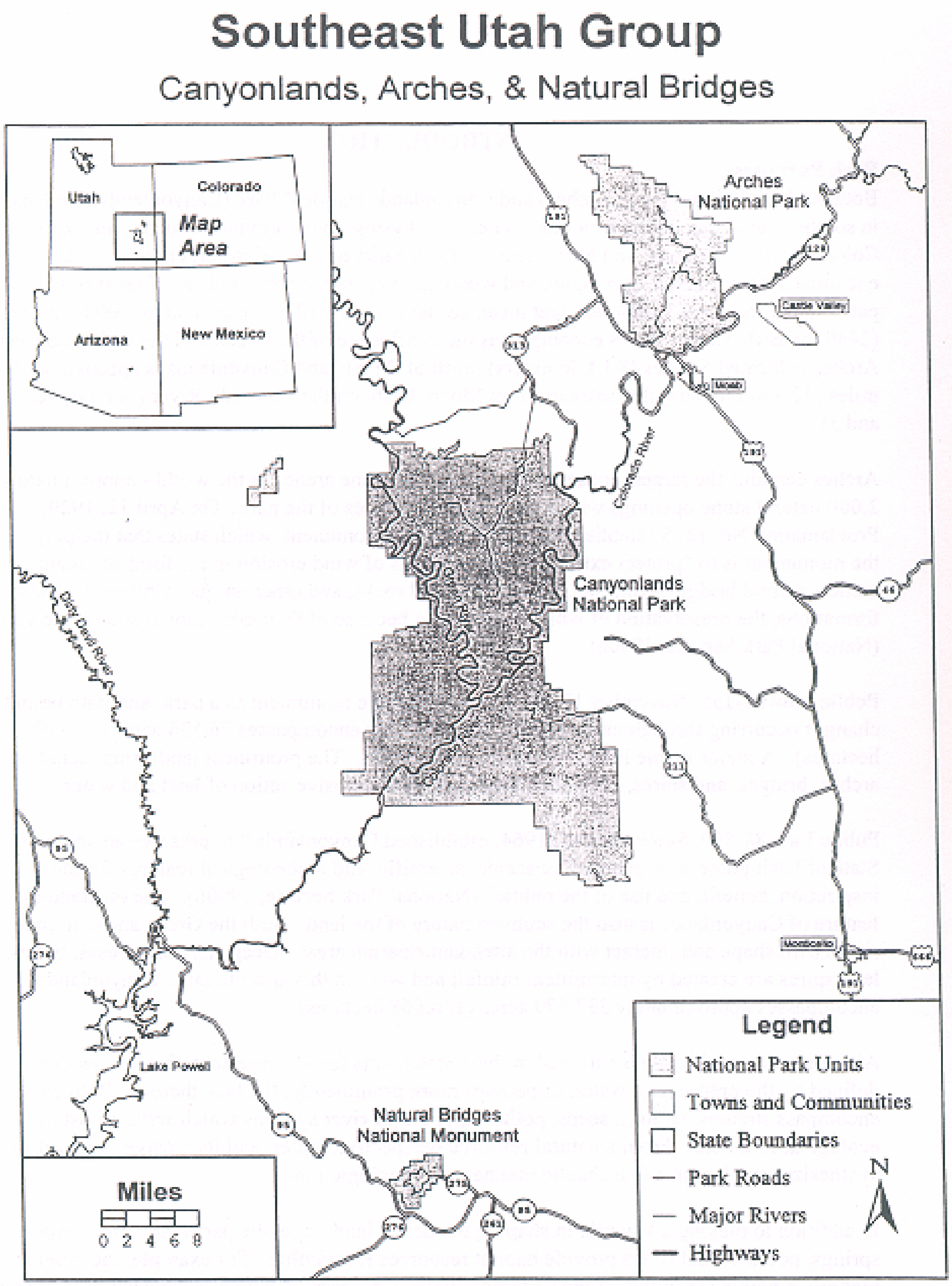


Figure 1. Geographical location of Canyonlands and Arches National Parks and major hydrography (modified from Long and Smith, 1996).

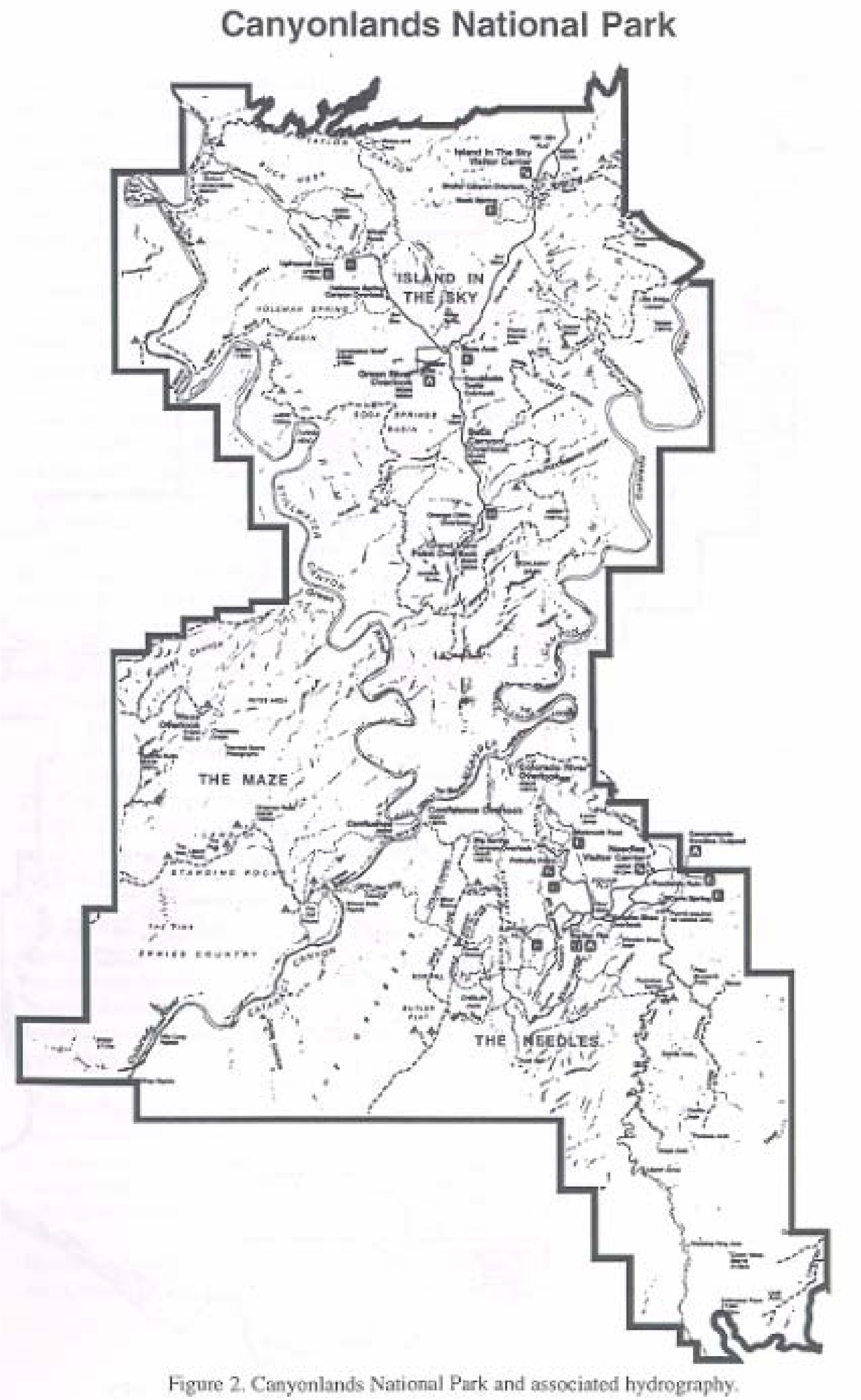


Figure 2. Canyonlands National Park and associated hydrography.

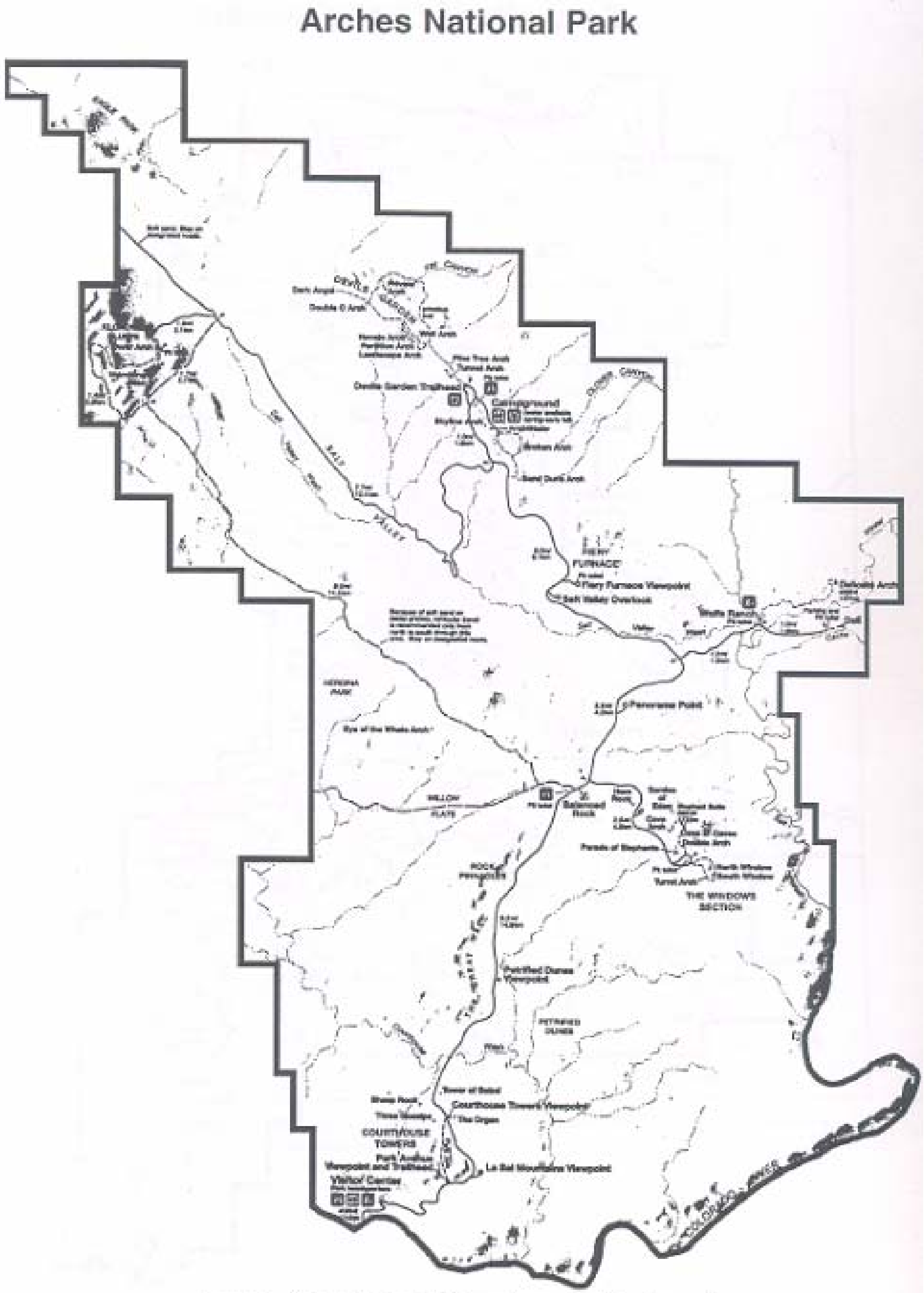


Figure 3. Arches National Park and associated hydrography.

The water resources of Arches and Canyonlands are important for other functions. For example, ground water recharge occurs via fractures and joints in formations such as the Kayenta, and this same water may discharge at seeps characteristically wetland in nature. Water quality improvement occurs at these same seep sites. Some plant species surrounding the seep may selectively enhance water quality by taking up various minerals and metals. Flood attenuation is a natural function of riparian wetlands; vegetation that remains intact along a stream can slow discharge and help increase settling of sediments from the water column.

Consumptive use by humans now diverts water away from wildlife, aquatic fauna and from receiving systems. Organisms in the desert have adapted to arid conditions, and are in a fragile balance that can be easily disrupted. With European colonization of the Colorado Plateau, humans and their domesticated animals use an abundance of water that once was present, albeit not plentiful, for wildlife in this desert environment. With construction of dams, increases in visitor use to the Colorado Plateau, and agricultural requirements, the critical balance of water availability for organisms and physical processes, such as river dynamics, has tipped towards insuring more water for human needs. Visitation to Canyonlands grew from 60,000 in 1980 to 434,834 in 1993. Likewise, visitation to Arches increased from 150,000 in 1965 to 700,000 in 1991 (Hecox and Ack, 1996). Visitation to Canyonlands in 1997 totaled 432,697, and at Arches visitation totaled 858,525. Changes have occurred within the Southeast Utah Group. This document addresses the presence of water resources, and the future strategic management of which may provide a balance for the use of water by humans and other organisms.

The Colorado and Green rivers dominate the Plateau country; their convergence in Canyonlands National Park dictate that the Park should obtain as much political, biological, and geophysical understanding of this system as possible. Pontius (1997) writes that:

> "growing constituencies for recreation, tourism, and conservation values conflict on occasion with the traditional view that the first priority must be to store and deliver water for people, to grow food, produce electricity and for other commercial uses."

The Park Service represents both sides of this conflict in that they support recreation and tourism, yet also retain federal reserve water rights. This document addresses ways in which water rights issues and management of large river systems may be addressed by Arches and Canyonlands National Parks.

National Park Service policy and law requires that a unit of the National Park System develop and implement a land and water use plan called a General Management Plan. The most recent General Management Plan for Arches is dated 1989, and the Canyonlands plan is dated 1978. Together these plans are the basis for park operations, and guide the level and location of resource development and resource protection within the framework of the two parks' enabling legislations.

National Park Service policy also requires that a unit of the National Park System develop and implement a Natural and Cultural Resources Management Plan (RMP). These plans have been developed and accepted by each park, and serve as strategic planning documents in effective management and preservation of park resources including plants, wildlife, water, paleontological and cultural resources.

This Water Resources Management Plan is being developed to complement the General Management Plan and the Natural and Cultural Resources Management Plan. It is very similar to the RMP, but focuses on water resources and issues related to water resources. Project statements developed in this plan are integrated into the RMP.

Significant Water Resource Values

Both parks encompass streams, springs, seeps, and major river systems which serve a host of ecological functions. Specific types of water sources include potholes, pools fed from seeplines in canyon alcoves, as well as from below ground percolation, plunge pools, springs that spout from rock walls and streams that flow continuously. Water in a desert environment is vital to its inhabitants. Wildlife such as bighorn sheep establish a range around water holes. Small mammals and birds also require water. The unique system of plunge pools, potholes, hanging gardens, ephemeral and intermittent streams and major river systems (the Colorado and Green rivers) provide habitat for unique fauna and flora such as the four endangered fish species, Colorado Squawfish (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), razorback suckers (*Xyrauchen texamus*), and the bonytail chub (*Gila robusta*)the southwestern willow flycatcher (*Empidomax traillii extimus*), the tiger salamander (*Ambystoma tigrinum*), the red-spotted toad (*Bufo punctatus*), the Woodhouse's toad (*Bufo woodhousii*), the great basin spadefoot toad, the canyon treefrog (*Hyla arenicolor*), the northern leopard frog (*Rana pipiens*), and numerous macroinvertebrates and plants.

WATER RESOURCES REGULATIONS AND LEGISLATION

Federal Legislation Influencing Water Resources Management

Legislation and memoranda of agreements or understandings which influence the management of water resources include:

The **National Park Service Organic Act (16 U.S.C. Sec. 1 et seq.) (1916)** directs the Service to preserve park resources for future generations while allowing for public enjoyment. In 1916 Congress created the National Park Service:

> "to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations... by such means and measures as to conform to the fundamental purpose of said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations."

The **Administration of the National Park Service Act (16 U.S.C. Sec. 1a-1 - 1c)** amended the NPS Organic Act to recognize the growing diversity among the various park units. This legislation declared:

> "...that these areas, though distinct in character, are united through their inter-related purposes and resources into one national park system as cumulative expressions of a single national heritage; that, individually and collectively, these areas derive increased national dignity and recognition of their superb environmental national quality through their inclusion jointly with each other in one national park system preserved and managed for the benefit and inspiration of all the people of the United States..."

Congress reaffirmed and amended the NPS Organic Act in the **Redwoods National Park Act (16 U.S.C. Sec. 1a-1 - 1c) (1970)** directing that the management of the National Parks:

> "... shall not be exercised in the derogation of the values and purposed for which these various areas have established, except as may have been or shall be directly and specifically provided by Congress."

The **Land and Water Conservation Fund Act of 1965 (16 U.S.C. 4601-4 et seq. (1988), Stat. 897, Pub. L. 88-578** makes available funds "to assist the States and federal agencies in meeting present and future outdoor recreation demands and needs of the American people." These funds are available to purchase land and have been used to buy land administered by the National Park Service.

The National Historic Preservation Act (16 USC 470 et seq) (1966) acknowledges the importance of the nation's cultural resources. The Park Service "will preserve and foster appreciation of the cultural resources in its custody" (National Park Service, 1988). To that end, all actions proposed in this water resources plan will be evaluated for compliance with this and other cultural resource protection mandates prior to initiation of the project.

The **National Environmental Policy Act (42 USC 4371 et seq) (NEPA) (1969)** requires that any major federal action which may significantly affect the environment including the human environment, be reviewed via the NEPA process. Any actions proposed within this document will be evaluated with regards to the NEPA process. Major federal actions could include activities under the Endangered Fish Recovery Program of the Upper Colorado River, remediation of abandoned mine sites or oil and gas sites, management of the flood plains where facilities or campsites are located, and alteration to wetlands.

The **Federal Water Pollution Control Act (the Clean Water Act 33 U.S.C. 1251, et.seq.)** was passed in 1972. Having undergone two major revisions in 1977 and 1987, the Act is up for renewal. The Act had set goals for fishable and swimmable waters by 1983 and no further discharge of pollutants into the nation's waterways by 1985. To an extent, these goals have been attained via two main programs. A major grant program offered funds to construct municipal sewage treatment facilities. A second program limited the amounts of pollutants that could be discharged. The National Pollutant Discharge Elimination System (NPDES), a permit system for point-source dischargers, reflects the programs "effluent limitation" approach. The Environmental Protection Agency has set limits for pollutants that may be released based on available technology and cost of treatment for various industrial categories.

The Act also recognizes state primacy in managing and regulating the nation's water quality. The states implement water quality protection, as promulgated by the Act, through water quality standards. Standards are set for designated uses for individual stream segments. Uses recognized by the State of Utah include the following general categories: domestic supply, recreation, aquatic organisms and other wildlife, and agriculture. Identified standards include physical, chemical, and biological characteristics that when applied to a segment will insure protection of the designated uses on that segment.

One of three levels of protection are afforded any particular stream segment. As the absolute foundation, designated uses are protected. Degradation of water quality cannot extend beyond a level detrimental to the designated use or uses. A second tier of protection is afforded those segments where water quality exceeds that which is needed to support swimming and fishing. Only limited degradation can occur in these waters, and only after an antidegradation review that prohibits substantial impacts to water quality. Social and economic aspects of the impacts are considered in evaluating the activity which may impact the stream segments. The High Quality - Category 1 or Outstanding Waters designation in the State of Utah safeguards the state's highest quality waters. The last tier of protection calls for no degradation of the stream segment once it has been designated as such.

The Clean Water Act with the 1987 amendments introduced new initiatives with emphasis on nonpoint source pollution control programs, toxics controls, and management of coastal and near-coastal waters. In addition, the Act, in Section 404, protects wetlands as these have been interpreted to be waters of the United States. With regards to this plan, the Act induces the Park to take part in triennial reviews, to continue with monitoring programs, to analyze available data, and to interact with the State of Utah Water Quality Division. Most recently, the State of Utah recognizes that some stretches of water do not meet state standards (Division of Water Quality, 1998). These segments must undergo a total maximum daily load review to seek remedies. Technical advisory committees have been developed to deal with problems which are typically related to non-point source pollution. No segments have been identified in the two parks.

The **Safe Drinking Water Act (40 CFR parts 141-144) (1974 and Amendments 1986)** applies to developed public drinking water supplies. It sets minimum national standards and requires regular testing of drinking water for bacterial contamination, metals, volatile organics, and nitrates. At the bequest of the supplier, some testing can be waived. Individual park units as deemed by the Public Health Management Guideline (NPS, 1993a) must assure "that water supply systems are properly operated and maintained...".

At Arches and Canyonlands , tests for total coliform and residual chlorine where applicable, occur on a schedule developed and required by the State of Utah for systems serving the public. Bacteriological testing occurs bi-weekly. The park has not been required to test its drinking water supply for organics.

The **Endangered Species Act (1973)** requires that all entities using federal funding must consult the Secretary of Interior on activities that potentially impact endangered flora and fauna (Section 6). It requires agencies to protect endangered and threatened species as well as designated critical habitats.

At Arches and Canyonlands National Parks, only a few species associated with water or riparian areas are listed. Four endangered fish species which inhabit the Green and Colorado rivers in Canyonlands fall under the auspices of the Endangered Species Act. The Colorado squawfish *(Ptychocheilus lucius)*, humpback chub *(Gila cypha)*, razorback sucker *(Xyrauchen texanus)*, and the bonytail chub *(Gila robusta)* are the species included in the Recovery Program for the Endangered Fishes of the Upper Colorado River. The Green and Colorado rivers as they flow through Canyonlands offer the least altered riverine habitat in the Colorado Basin. Research with the Endangered Fish Recovery Implementation Program has found that the width of the Colorado River has decreased approximately 30 % since the mid-1960’s (Ed Wick, NPS Fishery Biologist, Scoping Meeting Notes, Sept., 18, 1997).

The southwestern willow flycatcher may be included in the federally listed species found in Arches and Canyonlans. its habitat includes a variety of dense understory and/or midstory shrubs in broad riparian flood plains (Sferra et al., 1995). These communities can include dense monotypic or mixed stands of willows, and in some cases dense stands of tamarisk (*Tamarix ramosissima*). Though the bird has not yet been documented in either park, its habitate is present in both parks.

Executive Orders Influencing Water Resources

Flood Plain Management (E.O. 11988)([3CFR 121(Supp 177)] addresses protection and management of flood plains. The objective of this executive order is to "...avoid, to the extent possible long- and short-term adverse impacts associated with the occupancy and modifications of flood plains, and to avoid direct and indirect support of flood plain development whenever there is a practical alternative." In effect, this order directs the parks to avoid development in flood plains and to adhere to the Flood Plain Management Guidelines (National Park Service, 1993b). Arches conducted a flood plain study of their fee station at the park entry (National Park Service, 1990c). The study determined that the unnamed wash in Moab Canyon is subject to hazardous flood flows, and suggested preparation of plans to remove or protect facilities.

The Protection of Wetlands Executive Order (E.O. 11990)[3CFR 121 (Supp 177)] directs federal agencies to "...avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands whenever there is a practical alternative...". This order stipulates that the park avoid impacts to wetlands, and since the issue of this order, Arches and Canyonlands have avoided impacts in natural wetlands, and have complied with the Section 404 permitting process outlined in the Clean Water Act.

State Water Resources Legislation

State of Utah Water Quality Standards (R317-2, Utah Dept. of Environmental Quality, 1997) Utah's Water Quality Standards recognizes that:

> ... the pollution of the waters of this state constitute a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life .... it is hereby declared to be the public policy of this state to conserve the waters of the state and to protect, maintain and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life, and for domestic, agricultural, industrial, recreational, and other legitimate beneficial uses...

The standards developed by the State of Utah as they pertain to waters within Arches and Canyonlands are presented in Table 1 which provide classifications, uses and designations for stream segments.

The degree to which actual water quality meets these standards is discussed in Long and Smith (1996) and in the water quality section of this document. In Arches National Park and Canyonlands National Park, waters are protected for domestic purposes with prior treatment, for secondary contact such as wading and boating, for warm water species of game fish and other warm water aquatic life, and for agricultural uses. A 1C designation for a drinking water source denotes a maximum total coliform count per 100 ml (30-day geometric mean) of 5000, and a maximum fecal coliform count per 100 ml (30-day geometric mean) of 2000. A 2B designation for recreational use restricts maximum total coliform count per 100 ml (30-day geometric mean) to 5000, and a maximum fecal coliform count per 100 ml (30-day geometric mean) to 200. The 4 designation for agricultural use restricts total dissolved solids to 1200 mg/L, and the 3B designation requires that the maximum temperature can exceed $27^{o}C$.

State of Utah Stream Channel Alteration Act (73-3-29 of the Utah Code) which is administered by the Utah Division of Water Rights requires a permit to change the course, current, or cross section of a stream channel. Any disturbance which alters the bed or banks of a stream requires such a permit.

Table 1. Designated Use Classification for stream segments in Arches National Park and Canyonlands National Park.

Designated Use Classifications for Arches and Canyonlands National Park			
Park Unit	**Stream Segments**	**Designation**	**Classification** [a]
Arches NP	Colorado River and tributaries, from Lake Powell to state line	N/A	1C,2B,3B,4
Canyonlands NP	Colorado River and tributaries, from Lake Powell to state line	N/A	1C,2B,3B,4
Canyonlands NP	Indian Creek and tributaries, from confluence with Colorado River to Newspaper Rock State Park	N/A	2B,3B,4
Canyonlands NP	Green River and tributaries, from confluence with Colorado River to state line	N/A	1C,2B,3B,4

[a]1C- Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Department of Health ; 2B- Protected for secondary contact recreation such as boating, wading, or similar uses; 3B- Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain; 4- Protected for agricultural use including irrigation of crops and live stock watering.

State of Utah Safe Drinking Water Act (Title 19, Chapter 4)

The Utah Safe Drinking Water Act of the Utah Code enables the Utah Drinking Water Board to enact rules pertaining to public water systems. Utah, by agreement with the Environmental Protection Agency, administers the Federal Safe Drinking Water Act. The Utah Safe Drinking Water regulations apply to the parks. The act states that the owner or operator is responsible for providing a safe and reliable supply of water to its customers. The delivered water must meet all applicable maximum contaminant levels. The parks have maintenance personnel who are trained and qualified to operate the drinking water systems and conduct the appropriate monitoring according to Utah regulations.

State of Utah Administrative Rules for Large Underground Wastewater Disposal Systems and Individual Wastewater Disposal Systems (R 317-501 and 317-513 of the Utah Administrative Code) governs the wastewater disposal in the State of Utah. The state delegated administration of these regulations to local health departments. Parks must adhere to these regulations.

Local Planning Regulations

Regulations at the county level for San Juan, Grand, Emery, Wayne, and Garfield are not far reaching. Since the regulations are not comprehensive, those that pertain to septic system placement, stormwater management, and construction on private lands near park boundaries could negatively impact water resources in the park.

DESCRIPTION OF THE HYDROLOGICAL ENVIRONMENT AND WATER RELATED RESOURCES

Climate

Arches and Canyonlands National Parks are typified by a semi-arid to arid climate. Annual precipitation is typically less than 8 inches (20 cm) in lower elevations and up to 10 inches (25 cm) in higher elevations (Richter, 1980). Figures 4 and 5 reveal the mean monthly precipitation and snowfall. The two parks are part of the Colorado Plateau, which have a bi-seasonal weather regime with distinct winter and summer precipitation maxima. The influx of monsoon air from the south results typically result in a summer rainy season during July and August. During the winter, the area receives infrequent intrusions of Pacific air also resulting in moisture. For Arches potential evaporation can equal 40 inches/yr (101 cm/yr) (Sumsion, 1971), and Canyonlands potential evaporation is approximately 41 inches/yr (104 cm/yr) (Richter, 1980). Temperatures range from below -16^{o}F (-27^{o}C) to frequently above 100^{o}F (37.5^{o} C). Mean annual temperature varies from 56^{o}F (13^{o}C) in Arches and 53^{o}F (12^{o}C) in Canyonlands. Figure 6 reveals mean temperature for Moab, Utah located between Arches and Canyonlands National Parks.

Soils and Geology

Southeast Utah consists of numerous red rock canyons carved into layers of sedimentary rock formations that have been molded and eroded by a variety of uplifting and erosional processes. The geologic strata exposed in Arches and Canyonlands range from the Paradox Formation (Pennsylvanian Period) to the Mancos Shale Formation (Cretaceous Period). These formations consist of many intermixed layers of marine, freshwater and eolian deposition that are collectively several thousand feet thick. Regionally, these depositional layers are nearly horizontal with a slight dip to the north (Berghoff and Vana-Miller, 1997).

The area is an erosional landscape with over a quarter of the area being exposed bedrock. Erosional processes can impact water resources, and do so in these two parks. For example, sediments and evaporites from the Paradox Formation cause dissolved solids levels to increase significantly (thousands of milligrams per liter) in local waters. Ground water encountered in formations below the Carmel Formation can typically be high in sulfates (Hand, 1979).

The soils vary widely on the Colorado Plateau and typically reflect the parent material from which they are derived. Vegetation boundaries are usually abrupt, corresponding to sharp changes in substrate or available soil moisture. Soils located in the lower elevations and canyon floors are typically hot and dry, and are poorly developed, while those at higher elevations are cool and moist. Soils found in recent eolian deposits, derived from sandstone, range from sandy loam to sand . Those derived from shale parent material range from clay loam to clay. Deeper soils are found in the valley alluvial fills, whereas shallow soils and exposed sandstone are found on rims, benches, and slopes associated with anticlines and synclines (Lammars, 1991).

Overgrazing by livestock has led to an increase in precipitation, runoff and erosion of soils. Vast changes in plant cover and composition have been the result, as have the downcutting of streams and loss of the A-horizon from the soil profile (Barth and McCullough, 1988). These changes have made it easier for exotic species to be introduced and flourish. Knopf and Cannon (1981) found that willow is often slow to recover following overgrazing and, Kennedy (1977) reported

Figure 4. Mean monthly precipitation (inches) for the Moab, Utah area. Data are from National Weather Service for Canyonlands National Park (1997).

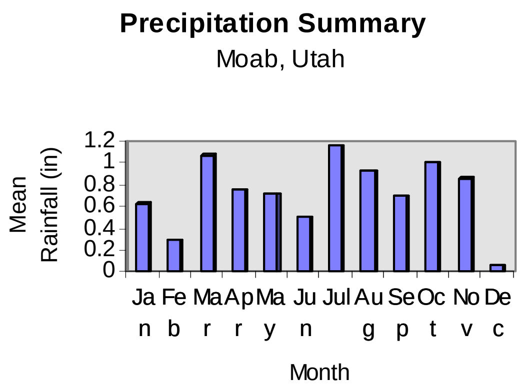


Figure 5. Mean monthly snowfall (inches) for the Moab, Utah area. Data are from National Weather Service for Canyonlands National Park (1997).

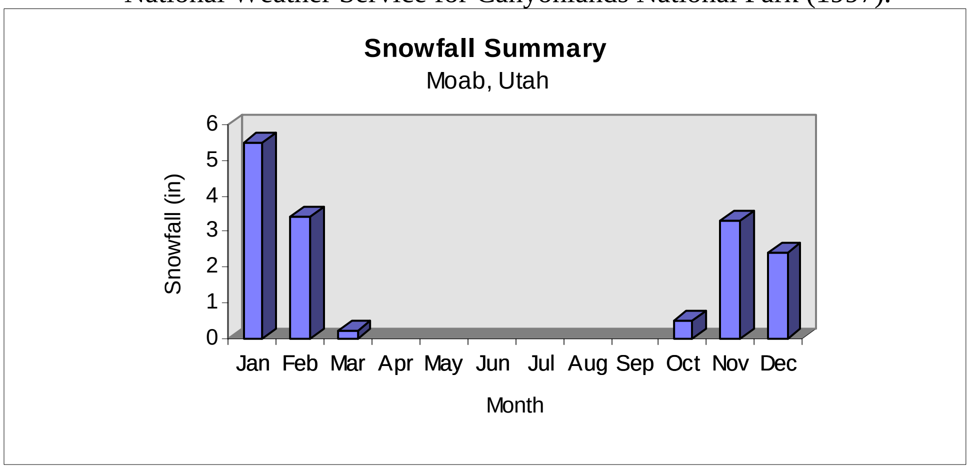
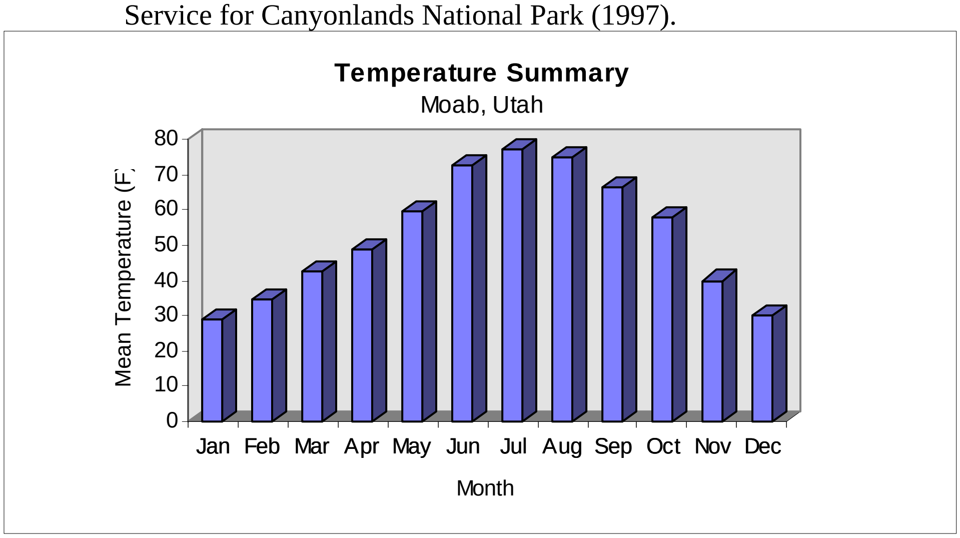


Figure 6. Mean Temperature (^{o} F) for the Moab, Utah area. Data are from National Weather Service for Canyonlands National Park (1997).



that complete conversion of the vegetative is the result of grazing in some western areas of the United States. Since these systems alterations are often slow to recover in an arid environment, and the changes can be so drastic, management techniques in many cases do not work, except for the sometimes costly and difficult task of removing the problem that caused the initial impact.

Vegetation

Arches and Canyonlands National Parks encompass several plant communities including grasslands, shrublands, forblands, and woodlands; these each harbor a wide variety of vegetation types including pinyon-juniper; mixed shrublands of sagebrush, saltbush, and Mormon tea: monotypic stands of blackbrush; greasewood; riparian areas supporting willows, cottonwood, and tamarisk; and perennial grasslands of dropseed, Indian ricegrass, and needle and thread grass (Thomas et al., 1987). Vegetation association and habitat maps have been developed, but they do need to be improved.

The native riparian vegetation consists of Fremont cottonwood, willows, box elder, phragmites, sedges and rushes, and horsetail. The hanging garden areas contain maidenhair fern, monkey flower, death camus, and alcove bog-orchid. These plant communities are localized and unique to the canyon country; they are water dependent, and changes to quantity or quality of the waters in these areas would most likely result in changes to the species composition.

Invasion and introduction of exotic species readily reduces the viability of native plant communities. Tamarisk, Russian olive, cheatgrass, Russian- thistle, halogeton, and Russian knapweed are all present in the parks and have significantly altered the natural vegetation therein. The impacts of introduced exotic plants have placed large portions of these ecosystems at risk (National Park Service, 1993c).

Ground Water

The physiographic province of the Colorado Plateau is extensively comprised of sedimentary rocks of the Paleozoic era (250-500 million years ago) through the Recent (<10,000 years) epoch. These rocks are typically flat-lying and are dissected by the Colorado River drainage. The Navajo, Wingate, White Rim, and Cedar Mesa sandstones, which serve as aquifers, are a few of the transmissive formations underlain by relatively impermeable strata (Taylor and Hood, 1988). May et al. (1995) postulate that ground water within the Colorado Plateau is Pleistocene in age and that the more recent arid climate insures low recharge rates. This ground water system is vulnerable to permanent draw-down, and thus ground water mining for park operations must be considered carefully.

The following discussion summarizes studies conducted form the late 1950s to the early 1980s, which provide results of some of the earliest water quality assessments in Arches and Canyonlands. This synthesized information can be used by park management and engineers to facilitate economic and feasibility studies of culinary water development. The discussion is not meant as a comprehensive synopsis of water quality in the parks from their initiation to the present, but instead provides information from old studies to specific water resource development.

Arches National Park Ground Water

Arches is in the southeastern part of the Salt Valley anticline. The Salt Valley now occupies the crest of the Salt Valley anticline as a result of breaching and erosion (Sumsion, 1971). Specifically, in recent geologic history, ground waters that moved through the near-surface rocks, encountered the salt masses left as a result of resistance to the pressure of overburden and concomitant salt flow during the Middle Pennsylvanian through the Jurassic period. The ground water dissolved the salt from the upper structures, leaving less soluble gypsum behind. The volume of salt near the surface has thus been reduced. The elongate valleys (23 miles long, 37 kilometers) such as Salt Wash in Arches resulted from overlying strata collapsing into the elongate crests of these salt features (Baars, 1972).

Exposed on the limbs of the anticline are the Wingate Sandstone of the Triassic period (210 million years ago), the Navajo Sandstone of the Triassic and Jurassic (145 million years ago) periods, and the Entrada Sandstone of the Jurassic period. Other formations in the park range in geologic age from the Pennsylvanian (285 million years ago) to Cretaceous (65 million years ago); these formations are dry due to very low transmissivity which retards recharge or they contain unpotable water unlike many other formations which can support aquifers if the right hydrologic conditions exist. Typically, wells associated with the Navajo, Entrada, or Wingate formations provide water through fractures or joints. The initial supply of water to these formations is through percolation down through permeable layers of rock and through these joints and fractures.

In the late 1950's and early 60's, Arches' staff sought information on a replacement drinking water source at Arches Headquarters and a potable water source at the Devil's Garden campsite At that time park staff hauled water into the campsite from the park headquarters, 12 miles to the south. Price (1959) , Arnow (1963) and Sumsion (1971) summarized attempts to locate potable water sources at three different areas within Arches. Water quality data from these studies are presented in Tables 2a and 2b. Engineers located water at approximately 86 feet (26 meters) at the park headquarters according to price (1959). The final well depth was 123.4 feet (37.6 meters), and the entire length of the well remained in the Navajo Sandstone. The water quality data for the replacement headquarters well revealed hard water (224 ppm as $CaCO_3$) and high specific conductance (762 µmhos).

Table 2a. Historical water quality data for various wells in Arches National Park.

	Site	
Parameters	Replacement Headquarters Well	Test Well: Devil's Garden
Date	Dec. 11, 1958	July 1962
Temperature ^{o}F	67	61
Specific Conductance (µmhos)	762	530
Silica (ppm)	12	5
Calcium (ppm)	55	28
Magnesium (ppm)	21	18
Sodium and Potassium (ppm)	75	54
Bicarbonate (ppm)	218	163
Sulfate (ppm)	133	36
Chloride (ppm)	49	62
Nitrate (ppm)	1.6	0.3
Dissolved Solids (ppm)	454	289
Hardness as $CaCO_{3\ (ppm)}$	224	142
Non-carbonate	45	8
pH	7.4	7.3

Source: Information for Test Well at Devil's Garden - Arnow, 1963.
Information for Replacement Headquarters Well - Price, 1959

Arnow (1963) described a weel drilled into the Navajo Sandstone in the Devil's garden area of Arches. The well depth totaled 900 feet, and engineers encountered water at 745 feet (227 meters) in the Wingate formation. The maximum yield for this well was 4 gallons per minute (gpm). Arnow (1963) noted that additional water could be sought by developing one or more of the springs, or by drilling in the Navajo Sandstone one mile northeast of Devil's Garden. Numerous springs and seeps emanate from the contact between the Dewey Bridge member, a less permeable rock, and the Slick Rock Member of the Entrada Sandstone. An operable well now exists at Devil's Garden Campground.

Sumsion (1971) reports on the hydrologic investigations of the Willow Flats area for a potential water source in the Navajo Sandstone. He estimated that this formation would provide 50 to 56 gallons per minute (gpm)of water, and that the water would move through fractures. This information is based on a soil boring hole drilled in 1969 approximately 1.5 miles to the west of the proposed test area. The driller reported a yield of 56 gpm of water at a depth of 1,570 feet (479 meters) at the base of the Navajo Sandstone. Eight springs in the western portion of the park near Herdina Park were tested for quality, all of which were potable. A ninth spring, called Winter Camp Spring near the Turnbow Cabin, and emanating from the Summerville Formation, was unpotable as a result of total dissolved solids equaling 5,560 mg/L. Further the Winter Camp Spring water contains high sulfate levels at 306 ppm (Table 2b). These springs are actually seepage sites in the Entrada Sandstone for the most part, because the channel is eroded below the water table.

Canyonlands National Park Ground Water

The Island in the Sky, Needles, and Maze districts comprise Canyonlands. For the most part, in depth studies concerning ground water hydrology have been completed for the purpose of locating potential drinking water supplies. Sumsion and Bolke (1972) describe results of water quality tests conducted for developed wells and springs for two districts in Canyonlands. Huntoon (1977) describes the occurrence of ground water in the northern part of Canyonlands between the Green and Colorado rivers (Island in the Sky District). Richter (1980) did the same for ground water east of the Colorado River in essentially the Needles District, and Hand (1979) provides information on ground water occurrence west of the Green and Colorado rivers, in the Maze district. Each district is decribed below separatly

The Needles District: Elevations of springs and seeps, static water levels in water wells, and elevations of water bearing intervals in petroleum test wells indicate that the general flow of ground water in the Permian rocks of the Needles District is generally northward and the flow converges on the Colorado River and tributary canyons (Richter, 1980); Figure 7 from Richter (1980) depicts this flow. Furthermore, the report notes the hydraulic importance of geologic structures such as joints, folds, faults, and basins. Joints are present in the Kayenta, Navajo, Moenkopi, undivided Culter and Cedar Mesa formations, because these units are brittle and have extensive surface exposures. These formations have to be saturated in order to serve as a supply of water (See Figure 8 for general lithology in the Needles District).

Sumsion and Bolke (1972) provide water quality data on seeps, springs and wells, in this district. They observed that the water quality of the springs in this district provided potable water (dissolved solids ranging from 54 to 583 mg/L) with the exception of Lower Jump Spring. The pH for these spring sites ranged from 7.2 to 8.1. Carbonate hardness ranged from soft to very hard water (70-926 ppm as $CaCO_3$). Sumsion and Bolke (1972) further noted that water supplies near

Table 2b. Historical water quality for seeps and springs in Arches National Park. Analysis by U.S. Geological Survey. Chemical constituents in mg/L.

Site	Sevenmile Spring	Willow Spring	Lower Willow Spring	Corner Spring	Hanging Garden Spring	Alcove Spring	Antler Pool Spring	Massy Pool Spring	Do.[a]	Winter Camp Spring
Date	9-15-70	9-15-70	9-15-70	9-15-70	9-15-70	9-15-70	9-15-70	3-18-63	9-15-70	9-16-70
Discharge (gpm)	3	0.1	5.1	3	5	8.2	6.3	5	11.1	0.1
Temp. °C	13.0	13.0	13.0	13.0	13.0	13.0	12.5		13.0	14.5
Cond. (µmhos)		639				226	271	167	250	9,190
Silica		20				10	11	4.3	9.5	13
Iron		0.02				.00	.00	.12	.00	.00
Calcium		65				43	49	33	49	194
Magnesium		2.5				3.2	4.1	1.7	3.3	80
Sodium		36				2.3	3.8	1.5	2.6	1,820
Potassium		7.5				1.6	1.7	1.0	1.1	9.6
Bicarbonate		255				133	156	96	148	449
Sulfate		84				6.5	12	6.4	10	306
Chloride		32				3.5	5.0	4.0	5.0	2,880
Fluoride		0.7				0.4	0.5	0.3	0.5	0.8
Nitrate		0.5				0.4	0.3	0.4	0.1	0.5
Dissolved Solids		396				143	157	102	145	5,560
Carbonate		265				120	140	90	136	813
Non Carbonate								11		
pH		7.6				7.7	8.0	7.3	7.4	7.8

Source: Sumsion, 1971.

[a] Unknown name

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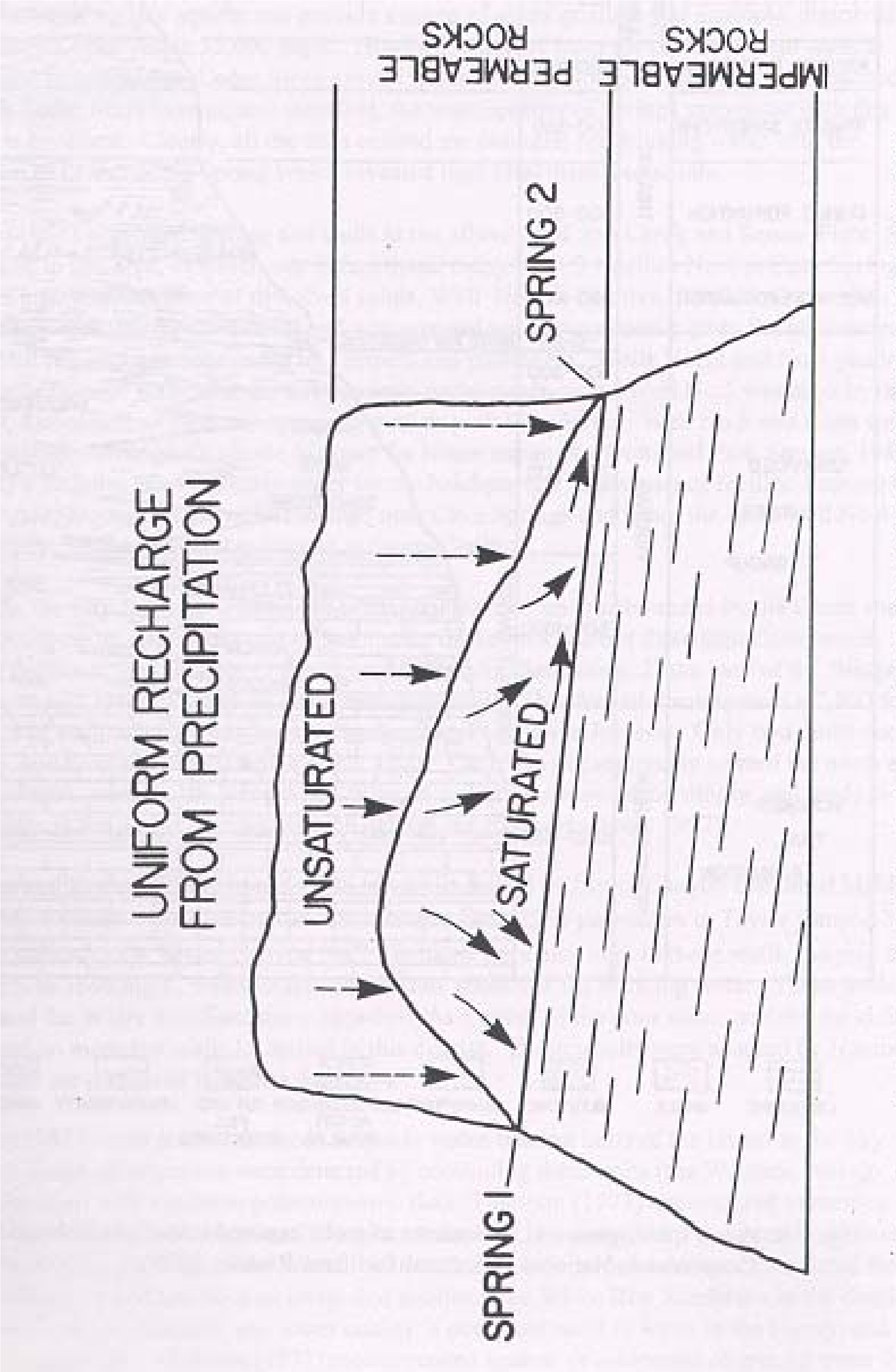

Figure 7. Schematic profile through a tilted butte showing ground water flow directions (adapted from Huntoon, 1977).

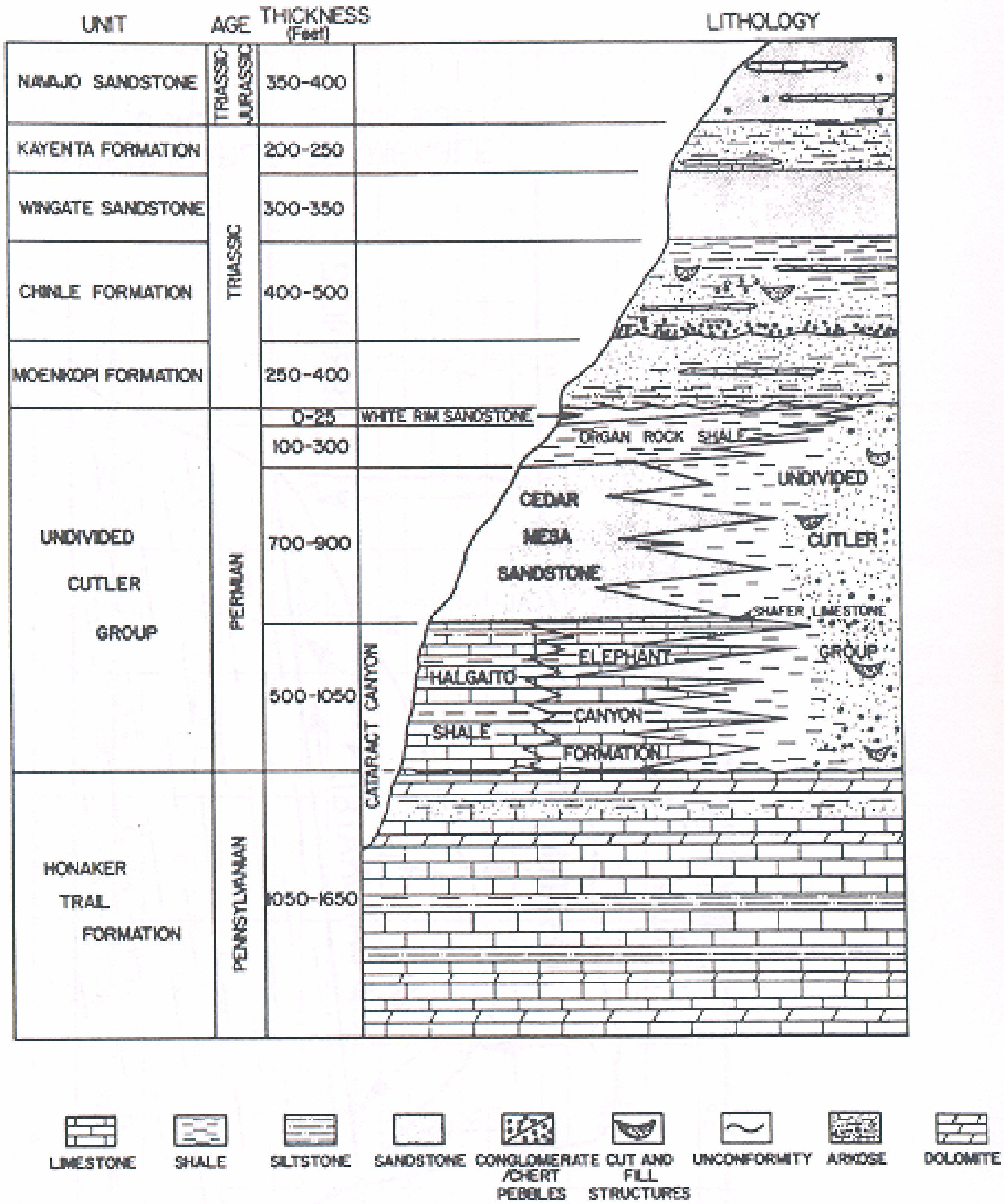

Figure 8. Ages, lithologies, and thicknesses of rocks exposed east of the Colorado River in Canyonlands National Park (modified from Richter, 1980).

the confluence of Salt and Squaw Creek are good. The Cedar Mesa Member appears to provide the greatest potential for ground water development.

Tables 3a and 3b exhibit well, spring, seep, and rise data from Sumsion and Bolke (1972) and adopted by Richter (1980) for sites in the Needles District. These springs and wells are located in the Cutler Aquifer; this aquifer can provide a range of water quality. For example, dissolved solids ranged from 100 to 35,000 mg./L. However, samples from the park represent waters discharged from the local Cedar Mesa ground water system. Soluble salts have been leached from the Cedar Mesa system, and therefore, the water quality of springs associated with this system is excellent. Clearly, all the sites offer the potential for drinking water with the exception of Lower Jump Spring which reveals high total dissolved solids.

Richter (1980) suggested drilling test wells in the alluvium of Salt Creek and Squaw Flats. Six wells already exist in this area, of which one is functional today (NPS Needles #4 at Cave Springs). Due to a high concentration of dissolved solids, Well No. 1 was abandoned. Well No. 2 served as the main source of water for the district and was pumped via underground pipe to the maintenance area. Well No. 3b was used mostly by campers and picnickers. Wells No. 3a and 4 yielded usable quantities of water, but are not currently under production. Well No. 5 was used by the Outpost, a commercial business operating outside park boundaries. Well No. 6 was a test well that appears promising as a source of water for future expansion (NPS, 1989a). Now, NPS Needles #4 provides water for the headquarters, maintenance facility, housing units, and the campgrounds. This well is located near Cave Springs and is not the same Well # 4 as noted above. This older well is located at Squaw Spring.

Island in the Sky District: The Island in the Sky District, an area bounded by the Green and Colorado rivers on the eastern and western sides of the park, harbor three significant water-bearing horizons; they include 1) the base of the Navajo Sandstone, 2) the base of the Wingate Sandstone, and 3) the White Rim Sandstone (Figure 9). This district encompasses a 2,800 ft sequence of sedimentary rocks ranging in age from Permian to Jurassic. Only two faults occur in the area and they are located near Potash, UT. The rocks dip regionally toward the north and west, and thus, water in the Navajo and Wingate formations move accordingly, and tends to accumulate in the gentle synclines which deform the rocks (Huntoon, 1977).

Sumsion and Bolke (1972) observed that test wells drilled in Taylor Canyon contained highly mineralized waters - specific conductance ranging from 2560 μmhos/cm at Taylor Canyon #2 to 2970 μmhos/cm at Taylor Canyon #3. Sulfates were also high in these wells, ranging from 480 mg/L to 1640 mg/L, considerably above state standards for drinking water. These wells penetrated the White Rim Sandstone Member. The authors suggested not to drill any more test wells in this district as a result of the poor water quality. These results are adopted by Huntoon (1977) and represented in Tables 4a and 4b.

Huntoon (1977) used several methods to assess water-bearing units of the Island in the Sky District. Zones of saturation were detected by combining these units (the Wingate, Navajo, and the White Rim) with available potentiometric data. Huntoon (1977) encountered numerous springs and seeps in the Navajo and Wingate sandstones; however, they are small. Numerous seeps occur along the base of the White Rim Sandstone and represent water accumulated from direct infiltration and not from an integrated aquifer. The White Rim Sandstone in the district below 4000 ft is saturated, and water quality is poor compared to water in the Navajo and Wingate sandstones. Huntoon (1977) recommended that development of ground water from

Table 3a. Historical water quality from selected springs, seeps, rises and wells in Canyonlands National Park east of the Colorado River, Utah. All chemical analyses are in mg/L.

Parameter	Loop Trail Spring	Lower Big Spring	Lower Little Spring	Lower Jump Spring	Little Spring	Cave Spring	Needles Well No.2	Soda Spring
Location[a]	29.5-19-36 bbb	30-19-10 dbd	30-19-14 adb	30-19-12 acc	30-19-23 dad	30-20-20 cdd	30-20-20 dad	30-19-34 baa
Site names[b]		B56	LS2	S21	LS1	SQ3		B53
Date	4/7/70	4/8/70	4/7/70	5/20/69	3/5/68	7/21/78	5/2/68	9/4/69
Temp. °C	10	10.5	10.5	13	9	18.5	15	22
Ca	30	46	59	43	58	69	71	90
Mg	18	17	21	156	11	48	22	20
Na	162	19	39	504	12	42	19	6.6
K	5.4	2.8	3.6	10	3.4	4.0	1.6	3.5
HCO_3	251	253	338	662	203	400	322	362
SO_4	57	13	25	639	38	68	17	18
Cl	170	5.8	16	474	10	23	9.3	6.2
NO_3	1.3	1.0	0.2	2.0	0.0	0.0	0.2	0.1
F	0.5	0.1	0.3	1.2	0.3	0.4	0.3	0.0
B						0.1		
SiO_2	8.3	7.7	9.2	8.3	5.6	9.0	8.4	9.5
Diss. Solids	583	236	337	2180	237	480	305	334
Hardness as $CaCO_3$	148	182	234	750	188	370	268	571
pH	7.8	7.7	7.6	8.1	7.4	8.3	7.9	7.7
Specific Conductance µmhos	1020	405	571	3250	404	839	524	571
Discharge gal/min	0.1	5.2	13E	0.1E	1.3	0.E		0.1

Source: Richter, 1980

a Location of wells based on well and spring numbering system used in Utah. Numbers refer to township, range, and section, respectively. Letters refer to quarter-quarter-quarter section, where "a" refers to the upper right quarter, and lettering proceeds counter clockwise.

b Site names refer to those provided in Long and Smith (1996). If no name is provided then Long and Smith (1996) do not document that site.

E Estimated, discharge measured on same day sample collected.

Table 3b. Historical water quality from selected springs, seeps, rises and wells in Canyonlands National Park east of the Colorado River, Utah. All chemical analyses are in mg/L.

Parameter	Big Springs	Squaw Spring	Needles Well No.4	Needles Well No.3	Hangover Spring	Dorius Spring	Echo Spring	Peekaboo Spring	Paul Bunyan Spring
Location[a]	30-19-26 cbc	30-19-25 cdc	30-19-25aca	30-20-30 cba	30.5-19-34 cac	31-19-4 adc	30-19-3 bad	31-20-5 bcb	31-20-4 abb
Site names[b]	BS4	SQ2							
Date	7/2/78	5/2/68	10/9/68	5/2/68	10/9/68	5/20/69	8/5/78	5/2/68	6/15/78
Temp. °C	15.0	14.0	15.0	14.0	13.0	13.0	12.5	13.0	18.0
Ca	70	68	88	36	18	69	75	48	27
Mg	15.0	18.0	73.0	92.0	2.9	12.0	8.8	43.0	12.0
Na	8.0	12.0	162.0	150.0	0.7	3.0	5.1	29.0	12.0
K	2.0	1.5	1.6	3.4	1.0	1.1	1.8	3.9	1.6
HCO_3	287	294	536	496	60	279	290	336	130
SO_4	11.0	18.0	223.0	214.0	3.8	1.8	11.0	52.0	24.0
Cl	4.1	6.2	128.0	122.0	1.6	3.8	3.3	21.0	9.4
NO_3	1.2	0.3	0.3	0.5	1.3	0.7	0.2	0.3	1.9
F	0.2	0.2	0.9	1.1	0.1	0.2	0.2	0.4	0.3
B	0.1								
SiO_2	4.6	8.0	16.0	17.0	1.6	6.2	6.3	6.8	7.9
Diss. Solids	271	279	926	867	54	228	248	380	164
Hardness as $CaCO_3$	240	244	520	468	56	221	145	296	110
pH	7.8	7.8	8.0	7.9	7.4	8.1	8.1	7.8	8.3
Specific Conductance µmhos	452	475	1490	1380	101	405	440	640	297
Discharge gal/min	4.3	10.5			0.1E	0.1E	2E	3.1	0.7

Source: Richter, 1980.

[a] Location of wells based on well and spring numbering system used in Utah. Numbers refer to Township, Range, and Section, respectively. Letters refer to quarter-quarter-quarter section, where "a" refers to the upper right quarter, and lettering proceeds counter clockwise.

[b] Site names refer to those provided in Long and Smith (1996). If no name is provided then Long and Smith (1996) do not document that site.

E Estimated, discharge measured same day sample collected.

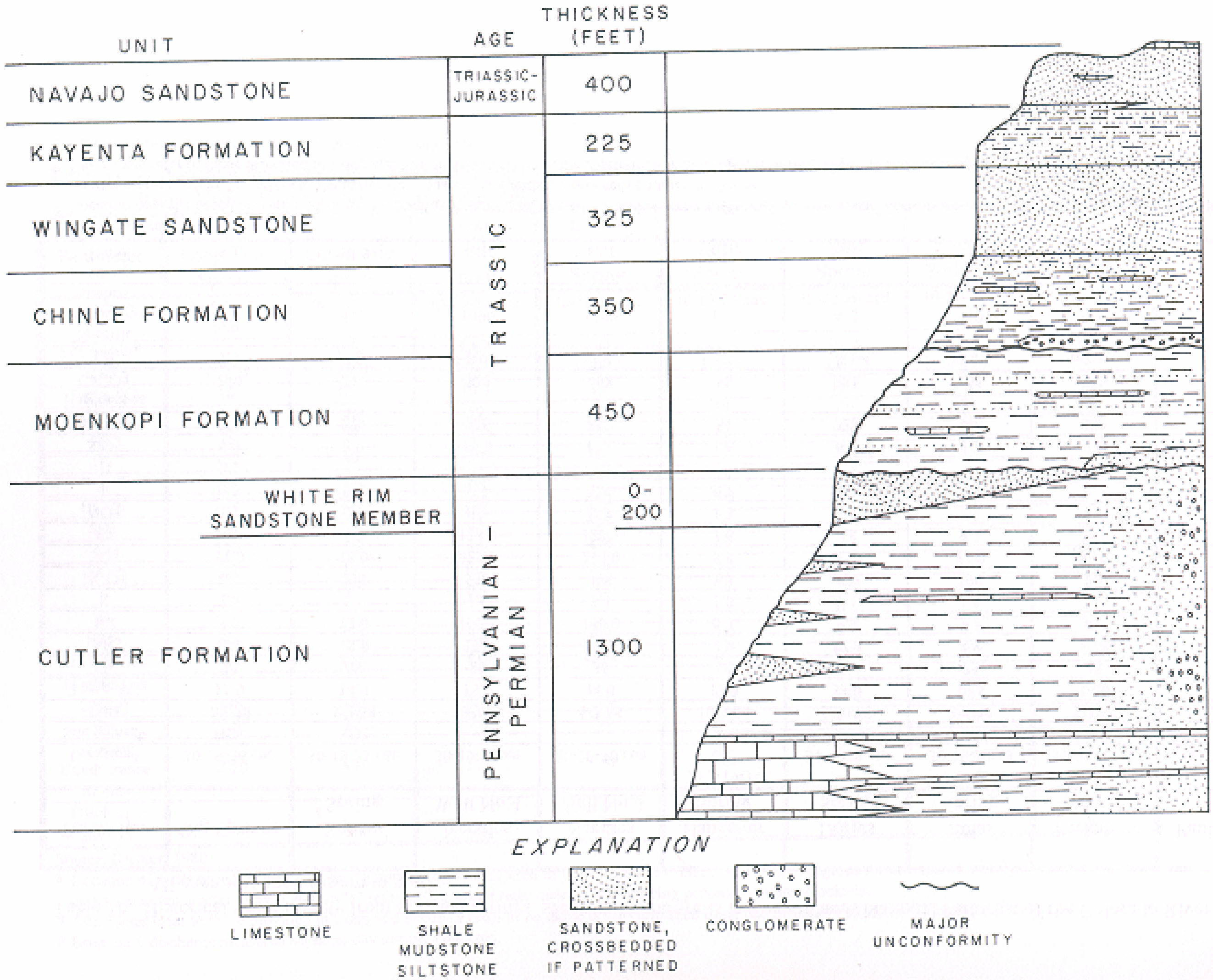

Figure 9. Ages, lithologies, and thicknesses of rocks exposed in northern Canyonlands National Park (modified from Huntoon, 1977).

Table 4a. Historical water quality from selected springs and wells in northern Canyonlands National Park, Utah. All chemical analyses are in mg/L.

	Sites						
Parameter	Cabin Spring	Willow Seep	Syncline Spring	Holeman Spring	Sheep Spring	White Rim No.1 Spring	White Rim No.2 Spring
Location	27-19-21 bcd	28-18-1 abc	27-18-15 bcc	27-18-27 ccb	27-18-32 dcb	28-19-11 aac	28-19-15 bbb
Date of collection	10/24/67	11/13/69	7/77	5/14/68	3/04/70	8/21/77	8/21/77
Sampling Agency	U.S. Geological Survey	U.S. Geological Survey	WWRRI	U.S. Geological Survey	U.S. Geological Survey	WWRRI	WWRRI
Temp. °F	48	58	62	59	48	63	67
Ca	24	80	26	43	160	42	39
Mg	8.5	49	14	30	105	13	13
Na	1.9	13	3.8	15	94	13	21
K	1.4	3.4	1.6	3.5	15	1.8	2.8
HCO_3	106	447	130	272	219	220	160
SO_4	6.8	19	8.0	24	765	12	35
Cl	4.9	20	5.9	8.3	28	7.9	16
NO_3	5.0	0.4	1.7	0.3	0.0	3.0	2.8
F	0.1	0.2	0.2	0.4	0.5	0.3	0.4
B			0.04			0.06	0.05
SiO_2	8.1	12	16	10	9.4	19	16
Fe	0.0	0.05		0.0	0.09		
Cu							
As							
Se							
Diss. Solids	108	500	234	261	1410	270	308
Hardness as $CaCO_3$	95	400	120	232	830	160	150
pH[a]	7.5	7.9	8.3	7.9	7.7	7.9	7.8
Specific Conductance[b]	197	812	252	440	1680	395	386

Source: Huntoon, 1979

[a] pH determined in the laboratory.

[b] µmhos per centimeter at 25° C.

Table 4b. Historical water quality from selected springs and wells in northern Canyonlands National Park, Utah. All chemical analyses are in mg/L.

	Sites					
Parameter	Taylor Canyon Well No.1	Taylor Canyon Well No.1	Taylor Canyon Well No.3	Taylor Canyon Well No.2	Hardscrabble Spring (Leaky Well)	Lathrop Spring
Location	27-17.5-1 ddc	27-17.5-1 ddc	27-18-9 baa	27-18-10 aaa	27-17.5-13 cba	28-19-1 ccd
Date of collection	10/08/68	8/22/77	3/03/69	2/20/69	3/04/70	8/21/77
Sampling Agency	U.S. Geological Survey	WWRRI	U.S. Geological Survey	U.S. Geological Survey	U.S. Geological Survey	WWRRI
Temp. °F	55	64	67	68	50	75
Ca	505	300	393	144	513	70
Mg	102	71	78	19	78	72.5
Na	137	160	233	400	125	760
K	30	29	43	43	30	25
HCO_3	328	12	382	591	300	380
SO_4	1640	1300	1160	480	1430	300
Cl	80	83	140	280	74	1000
NO_3	0.6	0.6	3.7	2.8	0.0	0.9
F	3.0	1.1	0.2	0.3	2.2	0.8
B	0.62	0.40	0.86	0.98		0.27
SiO_2	8.5	0.36	7.7	7.4	9.5	25
Fe	0.18		0.30	0.20	0.09	
Cu	0.0		.04	0.04		
As	0.0		0.0	0.0		
Se	0.0		0.0	0.0		
Dissolved Solids	2730	1990	2570	1720	2730	2410
Hardness as $CaCO_3$	1680	1000	1300	440	1600	470
pH[a]	7.7	6.7	7.7	8.0	7.8	8.1
Specific Conductance[b]	2870	2220	2970	2560	2810	3970

Source: Huntoon, 1979

[a] pH determined in the laboratory.

[b] μmhos per centimeter at 25° C.

the Navajo and Wingate sandstones not be considered because the rocks are well drained, receive little recharge, and lack structural traps. However, the White Rim sandstone at elevations of less than 4000 ft msl under the western parts of Horsethief and Mineral points is saturated and will generate 25 to 100 gallons per minute. The drawback in developing this source is the water quality: dissolved solids total as much as 2730 mg/L .

Huntoon (1977) noted that ground water needs in the district were modest at the time. Times have changed and the need for ground water development has increased, as a result of increased visitor use. Development of the White Rim ground water source would require extensive treatment. Presently, water is trucked from Arches to the area (John Jones, Maintenance, Canyonlands , Jan 1, 1998). Anticipation of increased visitor use may require a ground water engineering and feasibility study of this particular district. Huntoon (1977) notes test drilling sites, selected wells (oil wells), springs, and seeps. This information may serve as a basis for a more thorough investigation of the White Rim Sandstone.

Maze District: Hand (1979) discusses the ground water resources in the area of the Maze District and the Horseshoe Canyon Detached Unit of Canyonlands. Hand (1979) identified aquifers based on production zones in wells and the location of springs and seeps. In the Maze District and the detached unit, Hand (1979) identified two geologic units, the Cedar Mesa Sandstone, and the Navajo Sandstone-Upper Kayenta Formation, which could serve as potential ground water sources (Figure 10). In addition, the Wingate Sandstone near Hans Flat and the detached unit also serve as potential sources. The inclusion of the latter is important, because Hans Flat within Glen Canyon Recreational Area is a developed site requiring a source of water, and Spring #2 outside of the detached unit provides the largest amount of water (30 gallons per minute) of identified springs in the study area.

The Cedar Mesa Sandstone in the Maze District consists of white, gray and tan rock with medium to coarse-grained eolian crossbeds of quartz sandstone. It has low permeability and most of the water in the Maze District emanates from joints in this sandstone. Discharge is low - 0.1 gallons per minute at Spring No. 21 in Horse Canyon (Hand, 1979). The Hans Flat well, which the National Park Service has considers capping, was drilled in 1973. The total well depth is 2750 ft, and water was encountered at 2510 feet within the Cedar Mesa unit. Hand (1979) calculated the transmissivity at 40 gallons/day-foot, indicating that permeabilities in this unit are very low. Generally water quality is good in the Maze District, but poor at Hans Flat, because the water has had a long residence time and has been contaminated by poor quality waters of nearby strata. Table 5 reveals that two sites, the Hans Flat Well and Horse Spring Canyon, are dominated by calcium, sodium, potassium and sulfate ions, whereas other sites that discharge from the Cedar Mesa Sandstone do not contain sulfate ions at high levels. These include South Fork Spring, Pictograph Spring, Jasper Canyon Spring, Water Canyon Spring, Sheeper's Spring.

The Kayenta Formation and the Navajo Sandstone respond as a single aquifer in which the Navajo overlies the Kayenta The Kayenta Formation is tightly cemented with calcium carbonate and is permeable only where jointed. The Navajo Sandstone is highly jointed and together these two units yield water to springs or seeps. Springs within the Navajo Sandstone- Upper Kayenta Formation aquifer occur within the detached unit and to the west of Hans Flat. Recharge to this aquifer increases to the north as evidenced by the large yield at the spring #2 near the detached

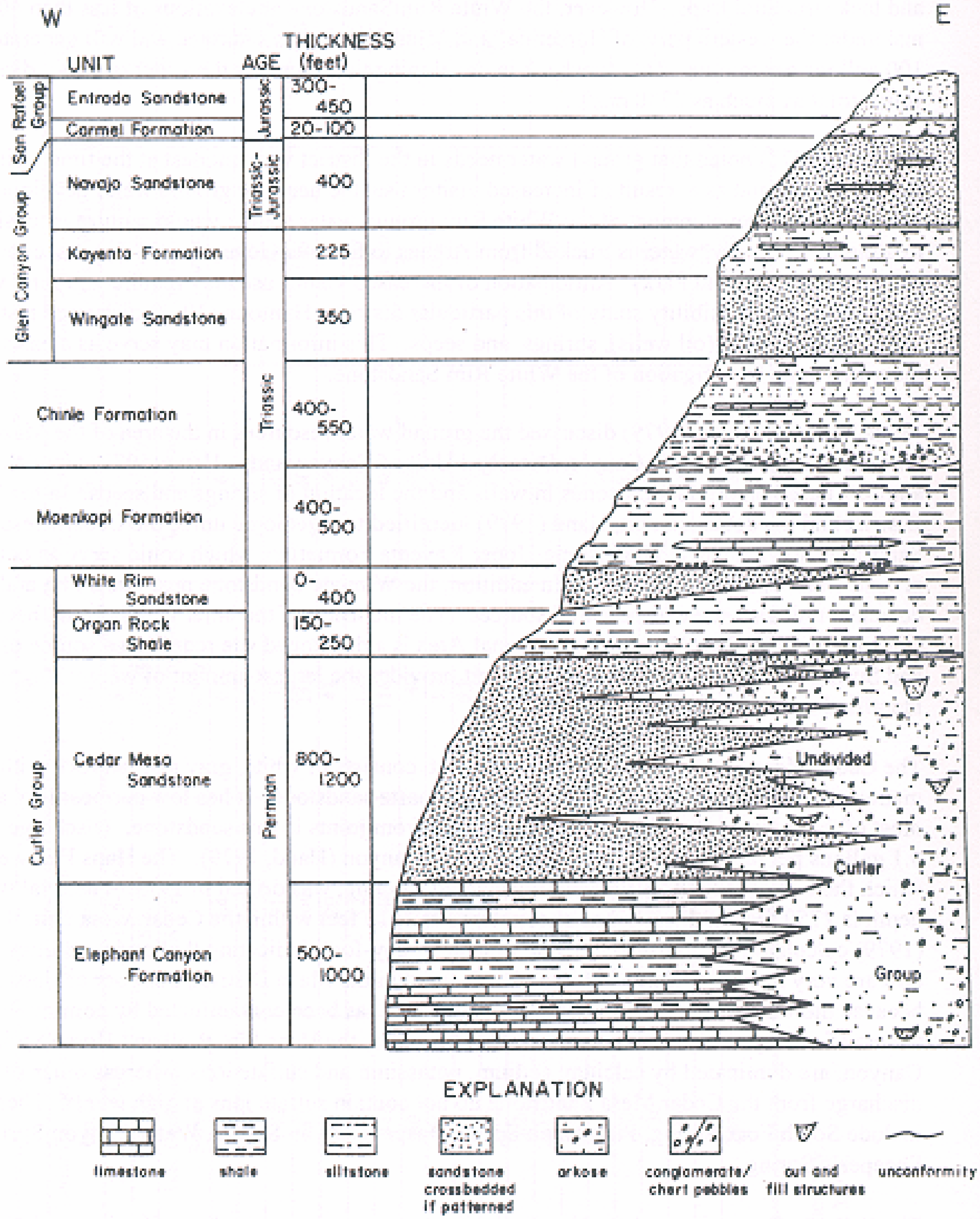

Figure 10. Ages, lithologies, and thicknesses of rocks exposed east of the Colorado River in Canyonlands National Park (modified from Richter, 1980).

unit.   Water quality is generally excellent from this source, because waters drain local outcrops where soluble salts have been leached from the rocks. Table 5 reveals that water from this strata is a calcium, magnesium, bicarbonate type with low dissolved solids ranging from 152 to 256 μmhos.

The Wingate Sandstone does not support a particularly good aquifer, because it is well drained and receives very little recharge (Hand, 1979). However, the springs and seeps associated with the Wingate are localized at the base of the unit and can serve as sources of water for wildlife. The amount of water storage in the Wingate increases to the north and west. The springs near Hans Flat receive water from nearby outcrops and storage waters down-gradient of recharge areas to the south and west.   Circulation data within the Wingate is unknown, but Hand (1979) notes that developing ground water in the Wingate is marginal because expected yields are low. Water quality of this aquifer is good.

Hand (1979) recommended either 1) developing springs that provide substantial discharge, or 2) drilling in areas north and west of the study area where the Glen Canyon Group (Wingate Sandstone, Kayenta Formation, and Navajo Sandstone) is buried. Hand (1979) in terms of priority for Canyonlands , recommends developing Spring No. 2 one mile northeast of the Horseshoe Canyon Detached Unit, and developing Springs No. 9 and No. 11 west of Hans Flat. Both recommendations would provide sources of water for visitors and park personnel near Canyonlands . Presently water is hauled to the Maze District from Moab. Two tanks totaling 25,000 gallons are hauled four times per year and stored at the Maze District headquarters. This water is chlorinated (Pat Flanigan, Maintenance, Canyonlands , October 6, 1997).   An engineering and economic feasibility study would determine whether water developed water supplies from these springs would serve the two parks appropriately.

Springs and Seeps

With the exception of the Green and Colorado rivers, springs and seeps within the two parks cover a small land area, but provide a vital source of water for wildlife, aquatic organisms, vegetation, and visitors. Long and Smith (1996) analyzed nine years (1983-1992) of data collected at over 50 seep and spring sites in or near the two parks. Some 34 sites in Canyonlands , 11 sites in Arches , 2 sites within Glen Canyon National Recreation Area, and one BLM site are included in the analysis. Maps of the location of the present day sampling sites are shown in Figures 2 and 3. The reader is referred to Long and Smith (1996) for complete data analysis of water quality for seeps, springs, and streams.

According to Richter (1980), Huntoon (1979), and Hand (1977) the Navajo Sandstone, the Wingate Sandstone, and the White Rim Sandstone provide spring and seep surface water as a result of contact between the more porous formation coming into contact with an impermeable layer. The Navajo, Wingate, and White Rim are jointed such that water infiltrating from a local region surfaces at the interfaces mentioned above. In the Maze District of Canyonlands, the Cedar Mesa Sandstone, and the Navajo-Kayenta aquifer also serve as a water source for springs and seeps. Water quality ranges from unpalatable (poor) to excellent depending on the source and overlying geology. Quantity is low as there are no regional aquifers, only local ones supported by infiltration through the rock layers.

Discharge of water from seeps and springs is variable, but typically low. In Canyonlands, the spring with the highest flow is Plug Spring in the Maze District with a mean discharge of

Table 5. Historical water quality from selected springs, seeps and wells in western Canyonlands National Park and Glen Canyon National Recreation Area, Utah. All chemical analyses are in mg/L.

	Site										
Parameter	Horseshoe Canyon	Wildcat Spring	Spring No. 9	Burro Seep	Hans Flat Well	Horse Canyon Spring	South Fork Spring	Pictograph Spring	Jasper Canyon Spring	Water Canyon Spring	Sheeper's Spring
Location	27-16-4 bdc	29-15-13 ccd	29-15-24 aba	29-16-20 add	29-16-28 cbc	29-18-20 ccd	30-17-23 ccc	30-18-6 dbc	30-18-9 bbd	30-18-15 cca	30.5-17-28 cdb
Date of collection	8/01/78	6/13/78	6/14/78	6/18/78	11/25/78	7/25/78	7/29/78	7/26/78	7/27/78	8/02/78	7/24/78
Ca	27	53	33	43	230	110	58	51	82	74	33
Mg	36	31	22	22	51	58	28	50	29	16	17
Na	17	7.3	4.9	6.9	180	46	13	30	12	26	7.1
K	7.6	2.5	1.9	2.2	47	10	3.8	4.6	2.6	2.1	2.7
HCO_3	240	300	200	200	230	280	300	340	360	300	180
SO_4	67	24	17	13	960	380	51	89	8.0	49	25
Cl	14	8.5	8.1	8.5	52	20	14	8.5	10	15	2.2
NO_3	3.1	0.4	2.2	4.0	0.0	3.1	0.4	1.3	0.7	1.3	3.5
F	0.5	0.2	0.2	0.2	0.6	0.5	0.3	0.4	0.3	0.3	0.2
B	0.1	0.0	0.0	0.0	0.9	0.1	0.0	0.1	0.0	0.1	0.0
SiO_2	8.5	12	6.3	6.9	6.5	12	8.1	12	14.6	7.7	7.8
Diss. Solids	246	256	164	152	1600	814	282	406	360	322	120
Hardness as $CaCO_3$	220	260	170	200	780	510	260	330	320	250	150
pH	8.0	7.9	7.9	7.5	7.5	8.0	8.0	8.1	8.0	7.9	7.7
Specific Conductance (μmhos)	521	532	377	430	2080	1160	575	773	339	595	343

Source: Hand, 1979.

[a] Location of wells based on well and spring numbering system used in Utah. Numbers refer to township, range, and section, respectively. Letters refer to quarter-quarter-quarter section, where "a" refers to the upper right quarter, and lettering proceeds counter clockwise.

49.75 gpm (n=3). In Arches , Freshwater Canyon supports the greatest discharge with a mean of 295.87 gpm. Development of springs is difficult due either to low flow, poor water quality, or the lack of access in a remote location. All of these springs provide an important source of water critical to the survival of wildlife, vegetation, and other aquatic organisms.

Additionally, ground water seepage from aquifer-bearing geologic formations provide a distribution of plant communities called hanging gardens. Ground water sapping produces a geomorphology found commonly on the up-side of broad dip planes in the plateau sandstones (Laity and Malin, 1985). Sapping occurs where flow concentrates and exits as a seep, eroding rock in that zone and removing the basal support of overlying rock (Dunne, 1990). Hanging gardens require two geomorphologic parameters: these are the protective concave geometry of the canyon wall, and a perennial seep water source. In Canyonlands , the Navajo Sandstone supports the greatest number of hanging gardens, but the top of the Chinle Formation also provides both geomorphic parameters for the development of hanging gardens (May et al., 1995). Arches also supports hanging gardens, and they are evident along the seep line that connects the Moab Tongue and Slickrock Members of the Entrada Formation.   These hanging gardens support a myriad of endemic plants and invertebrates. Disturbance to these communities may occur from down-drawing of the slowly recharged sandstone aquifers.

Surface Water

Perennial and Ephemeral Streams

A large number of canyons on the Colorado Plateau do not carry perennial waters, but instead are ephemeral in nature. These channels lead to the Green and Colorado rivers and were formed by fluvial processes. During storm events, these channels can carry large amounts of water and debris. Remembering the destructive power of these flash floods is important when considering development is proposed in associated flood plains (Berghoff and Vana-Miller, 1997). In addition, these floods can carry a tremendous amount of sediment contributing to a water quality problem albeit a naturally induced one. Certain activities within the parks may exacerbate sedimentation problems; these include trampling and removal of vegetation, use of four 4-wheel drive vehicles and trespass cattle.

There are only three perennial streams within Canyonlands – the Colorado and Green rivers and Salt Creek. Documented flows in Salt Creek range from 0.448 to 0.896 cubic feet/second (cfs) (Long and Smith, 1996). The creek commences on Bureau of land Managment land and flows north to the park. Several issues regarding this water resource and the surrounding area are discussed thoroughly in the issues section of this report. Other perennial streams located in Arches are Salt Wash and Courthouse Wash. Flows for Salt Wash range from 0.25 to 1.4 cfs, and a one time measurement for Courthouse Wash was 0.1 cfs (Long and Smith, 1996).   All of these systems depend on spring source water as well as precipitation to drive fluvial processes.

The Colorado and Green Rivers

Arches and Canyonlands National Parks are centrally located on the Colorado Plateau in the Upper Colorado River Basin. The Colorado and Green Rivers comprise the major drainages of the Colorado Plateau physiographic province, and both flow through Canyonlands National Park. Seasonal hydrographs for the Colorado and Green rivers display a typical snowmelt runoff peak, with a majority of the discharge occurring in May and June. Flow records show a great deal of monthly and annual variability. Localized storms contribute to the flashy nature of discharge from the smaller tributaries to the Green and Colorado rivers (Berghoff and Vana-Miller, 1997).

The US Geological Survey (USGS) collects daily streamflow and water quality data at long-term monitoring stations on both the Green and Colorado rivers. Both of these stations are located upstream from Canyonlands (Table 6). The Colorado River has one major tributary, the Dolores River between the Cisco station and Canyonlands , and the San Rafael River joins the Green River between the Green River station and the park.

The Colorado River: The headwaters of the Colorado River begin at 14,000 feet msl in the high peaks of Rocky Mountain National Park in Colorado. The Colorado River flows 420 miles through the Upper Basin to its confluence with the Green River in the heart of Canyonlands . The average river gradient above the confluence is 24 feet per mile. Mean discharge from 1914-1995, computed from records at the USGS gaging station near Cisco, Utah, is 7393 cfs. Extreme flows for the period of record area maximum of 76,800 cfs on June 19, 1917 and a minimum of 558 cfs on July 21, 1934 (USGS, 1995).

Table 6. USGS long term monitoring stations upstream from Canyonlands National Park. Parameters collected include: Discharge, water chemistry, and suspended sediment. [a]

USGS #	Station Name	Distance Upstream from Confluence	Period of Record
09180500	Colorado River near Cisco, Utah	97 miles	1895- present (discharge) 1928- present (water quality)
09315000	Green River at Green River, Utah	118 miles	1894- 1899, 1904- present (discharge) 1928 - present (water quality)

[a] Water chemistry includes temperature, pH, dissolved oxygen, nutrients, and metals. Over 300 chemical, physical, and biological parameters have been collected on a variable basis at these sites.

Water resource development projects in the Upper Colorado River Basin have significantly affected the flow regime of the river in Canyonlands. Although there is only one reservoir on the Colorado River upstream from the Park (i.e., Lake Granby near Rocky Mountain National Park), flow is regulated by numerous reservoirs on most of the upstream tributaries. Blue Mesa Reservoir on the Gunnison River was completed in 1966 and is the largest impoundment in the Colorado River upstream from Canyonlands drainage. Beginning in the early to mid-1900's, reservoirs were constructed primarily for water storage, irrigation, and flood control. Availability of water in this region characterized by an arid environment and seasonal streamflow was important component for agricultural development. Water demand and flood control drove construction in the upper Colorado River Basin of over 80 reservoirs having a storage capacity greater than 5000 acre-feet (Liebermann et al., 1989). Major effects of reservoirs on the Colorado River system include the evaporative losses associated with water impoundment and the disruption of the normal temperature and flow regimes of the river. Flow regulation from reservoirs tends to decrease the seasonal variability of streamflow, resulting in decreased peak flow and flood frequency, and increased base flow discharge. The overall effect of impoundments has been stabilization of river flows from month to month with daily fluctuations resulting from power generation.

A plot of annual maximum discharge at the Cisco gaging station for 1914 to 1993, shows a substantial decrease in the mean annual peak discharge when comparing the pre- and post- 1966 record (year of Blue Mesa dam closure) (Figure 11). Alterations in the flow regime have shown a significant affect on channel morphology and width leading to encroachment of exotic vegetation and reduction of fish habitat (Pemberton, 1976; Williams and Wolman, 1984; Andrews, 1986; Gellis et al., 1991; Lyons and Pucherelli, 1992).

From 1930 to1982, the US Geologic Survey collected suspended sediment data at the Cisco gaging station. Analysis of these data show two significant changes in the relationship between suspended sediment and river discharge (Thompson, 1984a). The first change occurred in the early 1940’s and coincides with a change in sampling equipment, and the second change occurred in 1966 and coincides with the closure of Blue Mesa Reservoir. The 1930-1982 suspended sediment data were divided into three data sets based on the changes observed. Table 7 lists the descriptive statistics before (1930-1945), and after the equipment change (1946-1967), and before (1946-1967) and after (1968-1982) the construction of Blue Mesa Reservoir.

Although the shift observed after the change in sampling equipment appears substantial, it may not reflect a true alteration in suspended sediment load. Thompson (1984a) determined the 1946-1967 record more accurately represents the pre-reservoir suspended sediment load conditions. Comparison between these data and the 1968-1982 record likely represents the actual change that did occur (Table 7).

Table 7. Suspended sediment load in millions of tons at the Colorado River Cisco, Utah gaging station.

	Pre-Equipment	Post-Equipment Change	
		Pre-Dam	Post-Dam
	1930-1945	1946-1967	1968-1982
Mean	17.64	9.44	7.59
Minimum	2.72	3.46	2.04
Maximum	35.7	21.54	14.55
Standard Deviation	10.17	5.07	4.01
% Change		46%	20%

In addition to the effects of water impoundments, large volumes of water are exported out of the Upper Colorado River Basin to the Arkansas, Missouri, South Platte, and Rio Grande basins (USDI, 1995). These transmountain diversions have been substantial, exporting over 700,000 ac-ft annually (Liebermann et al., 1989). One transmountain diversion is presently being litigated; the proposed diversion involves the Gunnison River Basin, tributary to the Colorado. Arapahoe County wishes to impound waters in a reservoir larger than Blue Mesa Reservoir which stores 940,000 ac-ft. Transbasin exports from the Colorado River Basin are primarily from the headwater areas, removing relatively pure water with low dissolved solid concentrations. This removes the dilution effect of the pure headwaters flow and results in increased dissolved solids concentration downstream.

The Green River: The Green River starts in the Wind River Mountains of Wyoming and flows south 730 miles to its confluence with the Colorado River. The Green River drains approximately 70 percent more area than the Colorado River, but produces approximately 25 percent less discharge (Bureau of Reclimation, 1995). Mean discharge from 1906-1995 at the U.S. Geological Survey gaging station at Green River, Utah, was 6191 cfs. Flow extremes for

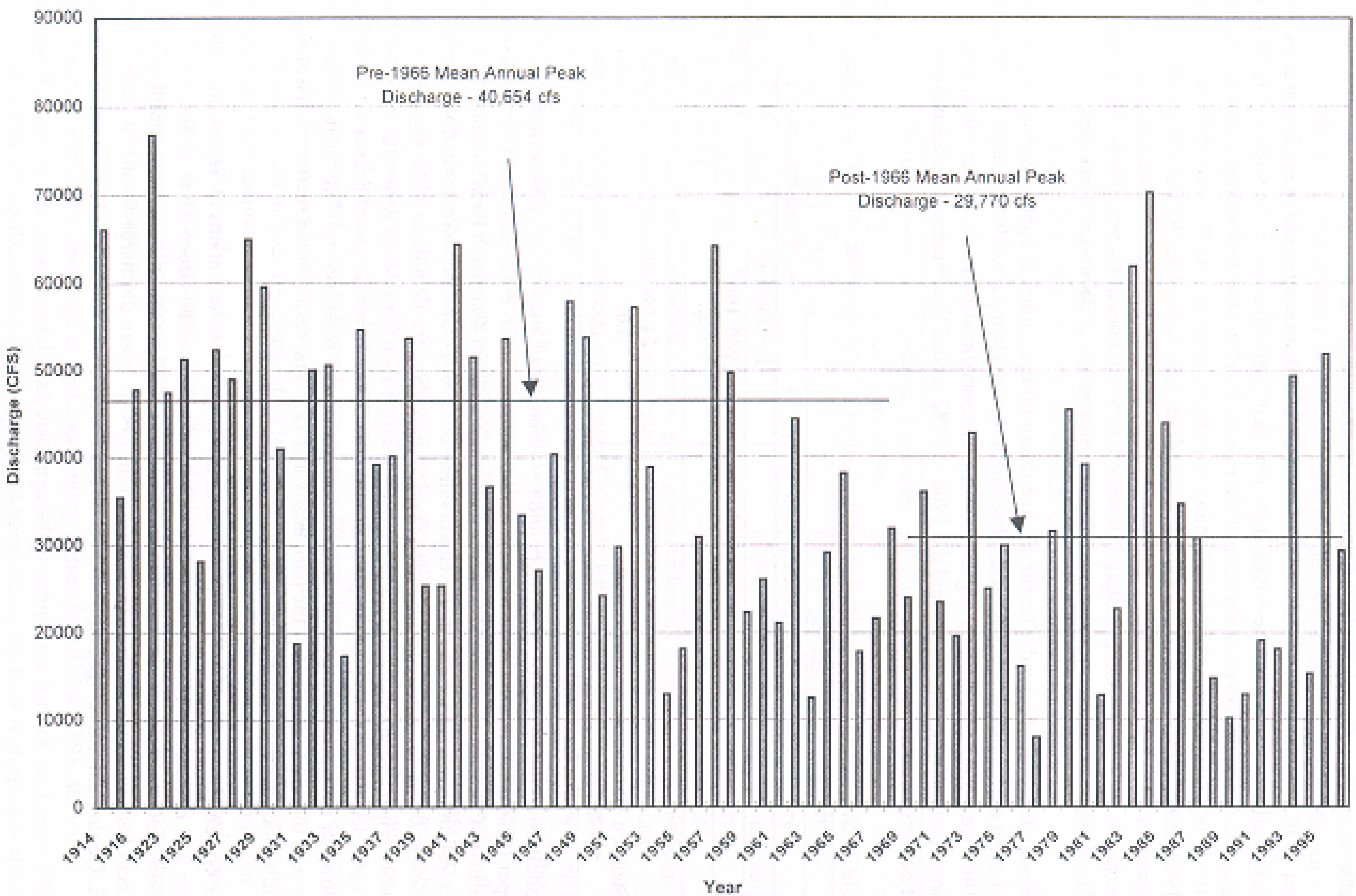

Figure 11. Annual peak discharge of the Colorado River at Cisco, Utah, station.

the period of record were a maximum of 68,100 cfs on June 27, 1917 and a minimum of 255 cfs on November 26, 1931. Flow is regulated mainly by the Flaming Gorge Reservoir located 412 miles upstream from the Colorado River confluence and also by numerous other reservoirs on most of the tributaries. Inspection of the flow record at the Green River, Utah, gaging station reveal similar flow alterations as those observed on the Colorado River. Flow regulation for hydropower generation has resulted in an increase in the mean base flow discharge (FLO Engineering, 1995). The mean annual peak discharge showed a decrease (Figure 12) when comparing the pre- and post- 1962 record (date of Flaming Gorge dam completion).

The 1930-1982 suspended sediment record also shows trends similar to the Colorado River. A double mass curve of the data shows the same change in the early 1940's corresponding to the change in sampling equipment. In addition, a second change occurred in 1963 and corresponded with the closure of Flaming Gorge Reservoir. Thompson (1984b) shows mean annual suspended sediment load decreasing by 35% after completion of Flaming Gorge Dam. The actual decrease would most likely be less if the change in sampling equipment was considered.

Andrews (1986) suggests that the Green River is an aggrading system below the gaging station at Green River, Utah. The assumption is based on calculations showing that the inflow of suspended sediment is greater than the outflow on a reach above the Green River, gage. This reach is accumulating almost 2.0×10^6 tons/yr. The Hydraulic characteristics of a channel will adjust over a period of years to transport the quantity of sediment supplied with the available discharge (Dunne and Leopold, 1978). Andrews (1986) revealed that the decrease in mean annual sediment transport at the Green River gage since 1962 is due entirely to a decrease in magnitude of river flows that are equaled or exceeded less than 30 percent of the time. This has resulted in a change in channel morphometry. Specifically, the bank-full channel downstream from the Green River gage has decreased from 515 to 465 ft, and this bank-full channel width is consistent with the prevailing effective discharge - the increment of discharge that transports the largest quantity of sediment over a period of years. Andrews (1986) offers that aggradation of the Green River channel occurs downstream from the Green River gaging station. Wick (1997, pers. Comm.., National Park Service) noted a 30percent decrease in channel width on the Colorado River in Canyonlands.

To the contrary, Lyons and Pucherelli (1992) relate that the Green River below Flaming Gorge Reservoir has reached quasi-equilibrium where the river transports the load supplied to it. The system apparently is responsive to increases in flows as evidenced by channel widening during 1983, 1984, and 1986 (years of notably high flows). The authors recommend that adjustments to channel characteristics, such as profile and dimension, be limited to changes in discharge, and sediment supply and transport in the basin. Lyons and Pucherelli (1992) based their work on comparative analysis of aerial photographs, published sediment data and discharge, and data collected on the Green River during 1986 through 1988. More importantly, they note that channel margin changes (narrowing of the channel) in response to change in sediment load following closure of the Flaming Gorge Dam could be very slow and difficult to detect amidst the fluctuating response of channel width to discharge.

Water Quality

General Influences on Water Quality by Local Geology and Land Use Practices

Water quality in the Upper Colorado River Basin is affected by local geology and upstream human impacts. Salinity is one of the major and most pervasive water quality problems in the entire Colorado River Basin. Nearly half (47percent) of the salinity load in the Colorado River

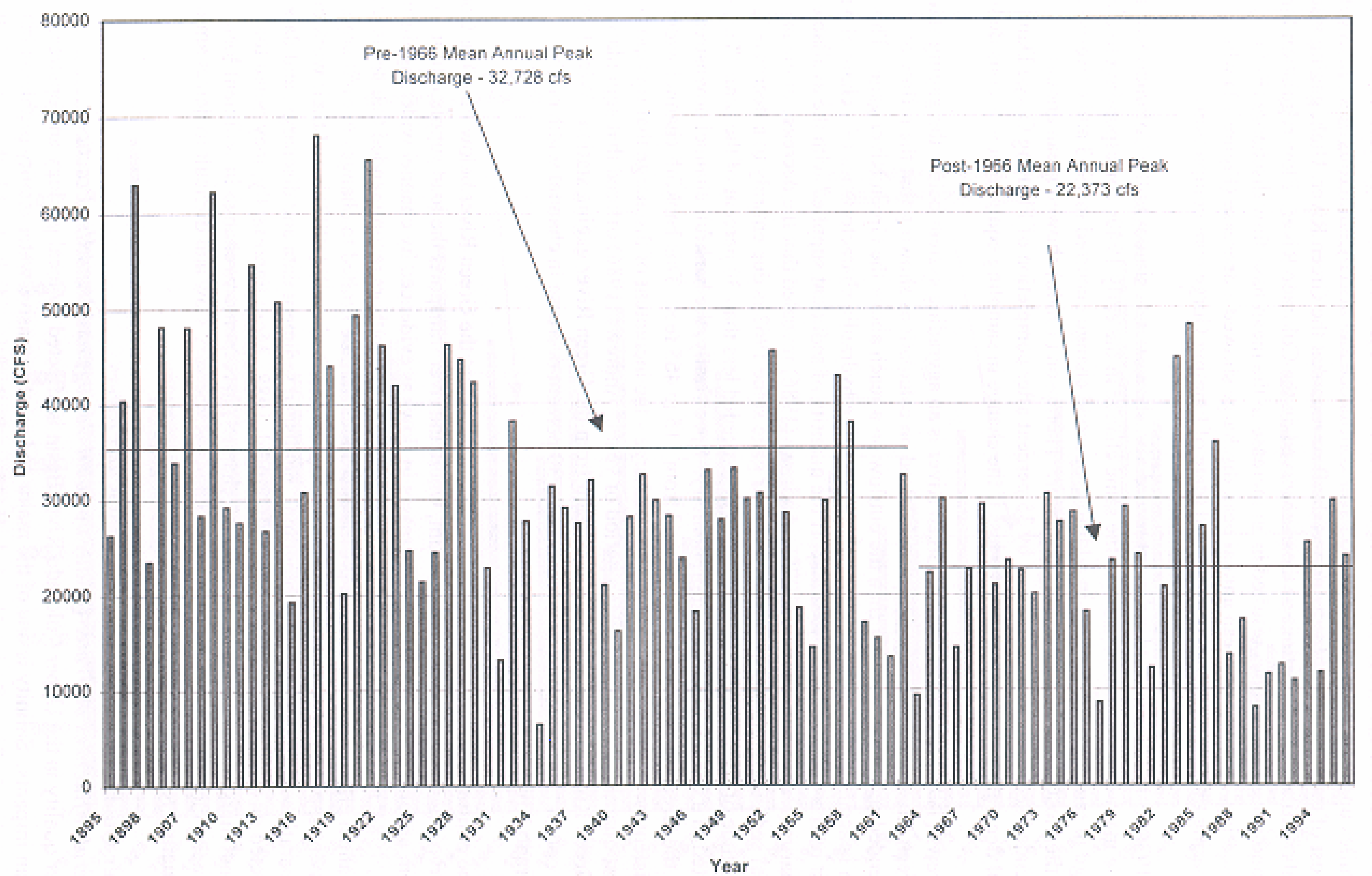

Figure 12. Annual peak discharge of the Green River at Green River, Utah, station.

is from natural sources such as saline springs, erosion of geologic formations, and soils with a high degree of soluble minerals, and surface runoff. However, the naturally high salt levels of the Green and Colorado rivers have been increased by water developments in a number of ways. Net evaporative losses from reservoirs tend to increase the dissolved solids concentration of the released water. In addition, when the reservoir is drawn down, water in bank storage may have a high concentration of dissolved solids if it has been in contact with soluble minerals typical of soils in the Upper Basin. Transbasin exports of water from the headwaters area result in increased dissolved solids downstream, since the dilutive effect of snowmelt water, which is typically low in dissolved solids has been removed Irrigated agriculture is the second largest contributor of salinity to the system (37percent), approximately 3.4 million tons of salt per year. Irrigation increases salinity by dissolving salts found in underlying saline soils and geologic formations, and by water consumption (Bureau of Reclimation, 1997). Consumptive use by crops averaged 1.8 million acre-ft/yr during the 1973to 1982 water years, which is approximately 13 percent of the annual virgin streamflow of the Colorado River at Lees Ferry, AZ (Liebermann et al., 1989). Salinity control practices can limit the contribution of salts to rivers.

Many of the geologic formations in the region were deposited in marine environments and therefore have a naturally high concentration of dissolved solids. Energy resource development for coal, oil and gas, and oil shale can contribute to the salt loading problem. Fossil fuels are generally located in association with marine shales and extraction of these resources results in increased levels of dissolved minerals in the water. Increased salinity can be caused by leaching of spoils material, discharge of saline ground water, and increased erosion from surface disturbances. Total dissolved solids from mining spoils leachate have been recorded as high as 3900 mg/L in northwestern Colorado (Parker and Norris, 1983). In addition to fossil fuel extraction, there has been a substantial amount of uranium mining in areas surrounding the National Park Service lands on the Colorado Plateau. Surface runoff and pollution from uranium mines can result in elevated levels of heavy metals, radionuclides and other toxic elements.

The concentration of dissolved solids typically increases downstream. The mean annual dissolved solids concentrations increase from less than 100 mg/L in the headwaters area to greater than 500 mg/L at the bottom of the Upper Colorado River Basin (Liebermann et al., 1989).

There are a number of potential sources of selenium in the Upper Colorado River Basin. Mancos shale and soils derived from this parent material are naturally high in selenium, containing levels as high as 1100 μg/L (Stephens et al., 1992). Surface irrigation flow and shallow ground water flow through the Mancos shale mobilize the soluble selenium and transport it to the rivers and adjacent riparian areas. Median concentrations of selenium in drainwater discharged to Stewart Lake in the middle Green River Basin have been detected as high as 140 mg/L, greatly exceeding the Utah state standard of 5 μg/L (0.005 mg/L). Studies have shown that selenium bioaccumulates through the food chain, with elevated levels found in fish (Hamilton and Waddell, 1994) and waterfowl (Stephens, 1994). Currently, several agencies, including the US Fish and Wildlife Service (USFWS), Bureau of Reclamation (BurRec), and the USGS are conducting studies on selenium levels that impair reproduction and larval survival of razorback suckers.

Results of Water Quality Studies

The southeast Utah Group initiated a water quality monitoring program in 1983 of seep and spring sites. This program responded to a proposed siting of a nuclear waste repository near

Canyonlands, and also to issues raised by Sumsion and Bolke (1972), Richter (1980), and Conner and Kepner (1983). In 1992 the National Park Service Water Resource Division assisted the Group parks by analyzing the existing data and by providing recommendations regarding the revision of the water quality monitoring plan (Long and Smith 1996). These recommendations served as a basis for the development of the Southeast Utah Group water quality monitoring plan (National Park Service 1994). The purpose of the plan included baseline assessment of springs and seeps in Arches and Canyonlands, and examinations of changes in waster quality resulting form internal and external threats. The plan identified such threats as internal development, visitor use, livestock use, and oil and gas development. The monitoring plan reduced the number of sites sampled from approximately 50 sites annually to 20 sites four times per year.

In the early 1980's, the Department of Energy identified a possible site for a nuclear waste repository within a mile of the Canyonlands boundary. Park management expressed concerns over the potential impacts to water quality at springs near the proposed site. As a result, the National Park Service funded a study of the water resources in the Needles District of Canyonlands and adjacent Bureau of Land Management lands (Ecosystems Research Institute, 1984). The study highlighted the contribution of geology to the quality of water, reviewed studies by Sumsion and Bolke (1972), Richter (1980), and Conner and Kepner (1983), presents water quality data, and formulates a future monitoring program. The study also provides an exceptional table noting all wells, springs, seeps, and rivers sampled, land ownership, geology, and who completed the work.

Earilier studies completed in the 1970s and 1980 provided a basic assessment of ground water, seeps and springs. These results have been depicted in Tables 2-5. Results from Sumsion and Bolke (1972) revealed some springs and test well water that were highly mineralized; Lower Jump Spring, Hardscrabble Spring and Taylor Canyon wells had high levels of sulfates, and specific conductance exceeded 2000 mg/L of dissolved solids at Kane Creek Seep, Lockhart Canyon, and Lower Jump Spring. Results from Richter (1980) which describe ground water in the Needles District of Canyonlands revealed that alluvial aquifers generally contained water of potable quality with low total dissolved solids (<400 mg/L). The Cutler Aquifer contained waters of highly variable quality ranging from fresh to saline, and springs discharging from the local Cedar Mesa systems contained water of excellent quality (<350 mg/L) due to prior leaching of salts (Ecosystems Research Institute,1984). Huntoon (1977) found that the White Rim Sandstone in the district below 4000 feet msl was saturated, and water quality was poor compared to water in the Navajo and Wingate sandstones. Hand (1979) observed that water quality was generally good in the Maze District, but poor at Hans Flat, because the water has had a long residence time and has been contaminated by poor quality waters of nearby strata.

Conner and Kepner (1983) noted that water quality of samples taken from Arches generally met state standards. Specific conductance and sulfate content were high in most Arches samples (Salt Wash #3 - 8830 μmhos/cm, 1170 mg/L for sulfates). In Canyonlands, the authors found that the water quality at springs was within state standards with sulfates being high at Little Spring in the Needles District. The results of Conner and Kepner (1983) differ from Richter (1980); the difference may be due to temporal and spatial influences (Ecosystems Research Institute,1984).

Ecosystems Research Institute (1984) developed a means of clustering like water qualities of various drainages in the Needles District. This clustering technique allowed researchers to capture impacts to a water source by pairing like water quality sites up and downstream of the potential pollutant source. It also compared water quality to public drinking water standards. Of all the parameters measured, the recommended coliform bacteria criterion was most often exceeded. A total of 29 sites were sampled of which 18 percent were in exceedance. Only 7 sites of a 20 sampled for gross alpha and gross beta (pCi/L) did not exceed State of Utah primary and secondary drinking water standards. Sulfate was the most often sampled standard, and if all sites were sampled equally, sulfates exceeded state standards most often. The Colorado River, Green River, Indian Creek, and Davis and Lavender Canyon sites exceeded drinking water standards for coliform bacteria. Radiological exceedances were concentrated within the Colorado River and sites impacted by the waters of the Colorado River

Through their clustering technique, Ecosystems Research Institute (1984) found that several drainage basins contained similar water chemistries. Two distinguishable clusters grouped by watershed are shown in Table 8. Ecosystems Research Institute (1984) revealed that the Cluster 1 drainages have lower salinity levels than the Cluster 2 drainages. Also sulfates levels are higher in Cluster 2 than Cluster 1 drainages. Ecosystems Research Institute (1984) tried to determine the basis for the water quality differences, and geology appeared to play an imprecise role. Cluster 1 was dominated by sources in the Cedar Mesa Formation or its alluvial positions, and Cluster 2 contained more sources within the Elephant Canyon formation.

Table 8. Means of dominant chemical parameters for clusters using drainage basin data in the Needles District. [a]

	Cluster No. 1	Cluster No. 2
Hardness (mg/L)	325.1	436.8
pH	8.17	7.89
Chloride (mg/L)	23.5	273.3
Sulfate (mg/L)	39.1	416.8
Conductivity (μmhos/cm)	636.6	1876.0
Calcium (mg/L)	56.2	91.6
Magnesium (mg/L)	29.9	54.3
Sodium (mg/L)	28.5	330.1

[a] adapted from Ecosystems Research Institute (1984)

Cluster 1 contained the following drainages Beef Basin Wash, Davis Canyon, Elephant Canyon, Horse Canyon, Indian Canyon, Lost Canyon, and Squaw Canyon. Cluster 2 included Big Spring Canyon, Hart's Draw, Lavender Canyon, Little Spring Canyon, Lockhart Basin, Wells No.2-5 in the Needles District, Kane Springs Canyon, Salt Creek.

The Southeast Utah Group monitoring program from 1983 to 1992 showed median values for most water quality parameters to be within normal levels for typical small springs on the Colorado Plateau. The data displayed a wide range and large degree of variability, possibly due to ambient conditions and sampling errors. Analyses were performed for several trace elements with most of the results reported as values below the laboratory detection limit. Several different spring types were identified based on location and physical characteristics. Many parameters such as pH, dissolved oxygen, and phosphorus remain relatively consistent among the different spring types (Long and Smith, 1996).

Currently, park personnel collect samples from 14 spring and seep sites. Theses are listed in Appendix F. Table 9 reveals 1983 to 1992 median levels for selected parameters at sites that are part of the present water quality sampling program. Median pH range from 7.2 to 8.4 standard

Table 9. Median values for water quality at springs and seeps in Arches and Canyonlands National Parks, 1983-1992[a]. Number of samples are in parentheses. Blank spaces represent no data available.

Parameter	Arches National Park					Canyonlands National Park				
	Courthouse Wash	Freshwater Spring	Sleepy Hollow	Willow Spring	Salt Wash	Cave Spring	Little Spring Canyon	2.4 Mile Loop	Maze Overlook	Chocolate Drops
Temperature °C	18.7(19)	18.6(18)	15.1(16)	19(14)	18.1(18)	16.3(17)	13.9(1)	15.3(13)	17.4(16)	19(15)
pH	8.1(17)	7.85(18)	7.5(15)	7.45(13)	7.55(18)	7.2(17)	8.4(1)	7.4(13)	7.65(16)	8.4(15)
Conductance µmhos/cm	832(19)	369 (18)	265.5(16)	566.5(14)	396.5(18)	299(17)	803(1)	303(13)	574(16)	596(15)
Oxygen, diss. mg/L	8.05(18)	8.9(17)	8.82(16)	6.5(13)	9.8(17)	6.9(14)	8.4(1)	5.5(11)	8(15)	6.25(14)
Hardness as $CaCO_3$ mg/L	359.1 (20)	190 (19)	136.8 (16)	273.6 (17)	359.1 (19)	185.3 (15)	307.3 (1)	128.75 (12)	300 (15)	300 (15)
Total Suspended Solids mg/L	27.5(6)	1.5(6)	3.2(6)	1.5(4)	17.5(4)	78(3)	1.5(1)	4.75(4)	1.5(5)	2.75(6)
NO_2+NO_3, diss. mg/L	0.03(6)	0.07(5)	0.16(6)	0.005(1)	0.02(1)	0.41(4)	0.65(1)	0.01(1)	0.03(3)	0.036(2)
Phosphorus, diss. mg/L	0.02(5)	0.005(5)	0.005(6)	0.005(3)	0.005(2)	0.018(4)	0.005(1)	0.02(4)	0.005(4)	0.005(6)
Calcium, diss. mg/L	83.5(6)	40(6)	47.5(6)	72(4)	61(4)	29.5(4)	77(1)	46(5)	47(5)	52(6)
Magnesium, diss. mg/L	38(6)	13(6)	3.8(6)	13(4)	33.5(4)	21(4)	28(1)	17(5)	36(5)	34(6)
Potassium, diss. mg/L	5(6)	2.3(6)	1.95(6)	2.25(4)	8.75(4)	1.55(4)	3.7(1)	2.9(5)	5.8(5)	18(6)
Sodium, diss. mg/L	47(6)	9.45(6)	3.6(6)	25(4)	660(4)	4(4)	63(1)	25(5)	20(5)	18(6)
Chloride, total mg/L	70.5 (15)	22.7 (14)	7.6 (13)	45.5 (9)	1232.7 (12)	30.3 (12)	44.5 (1)	30.3 (11)	37.9 (12)	30.3 (13)
Sulfate, total mg/L	196(19)	17.5(18)	13(15)	37.4(16)	80(17)	17.26(16)	92.27(1)	8(13)	62.5(16)	65(15)
Cadmium, diss. µg/L	0.5(1)	0.5(1)	0.5(1)				0.5(1)			0.5(1)
Copper, diss. µg/L	10(1)	10(1)	10(1)				10(1)			10(1)
Lead, diss., µg/L	1.5(1)	1.5(1)	1.5(1)				1.5(1)			1.5(1)
Zinc, diss., µg/L	15(1)	15(1)	15(1)				15(1)			15(1)

[a] Adapted from Long and Smith (1996). Diss. refers to the dissolved form.

units. Median conductivity levels ranged from 229 to 832 µmhos/cm. Nutrient levels as measured by nitrite plus nitrate and dissolved phosphorus remained low at most sites. Salt Wash, compared to other sites, revealed the highest median chloride and sodium levels at 1232.7 and 660 mg/L, respectively. Courthouse Wash revealed both the highest median conductivity level (832 µmhos/cm) and sulfate level (196 mg/L). Apparently, the limit of detection was reached for dissolved metals as shown in table 9; there was no difference between sites for a specific dissolved metal.

Over 300 chemical and physical parameters have been used by the U.S. Geologic Survey to describe the water quality of the Green and Colorado rivers. Ecosystems Research Institute (1984) reviewed discharge, suspended soils, conductivity, and temperatures for these two rivers. Their review of discharge and suspended sediment is comparable to the discussion of Berghoff and Vana-Miller (1997) and the summary already provided in the section titled "The Green and Colorado rivers". They found that conductivity followed a consistent pattern every year. As runoff occurred (June through July), dilution took place, lowering the concentration of dissolved constituents. As flows decreased, dissolved constituents concentrate resulting in higher conductivity. The Colorado river conductivity levels were generally higher than the green river levels.

Park personnel collect water quality data from two sites on the Green river, one at Mineral Bottoms and another above the confluence with the Colorado River. They also collect water quality samples three to four times a year at six Colorado River sites. These include Colorado River below Big Drop no. 3 rapids, above the confluence with the Green River, at Lathrop Canyon, at Indian Creek, at the Potash boat ramp, and ¼ mile below Moab Salt Canyon 3. Samples and field data have been collected from these sites for approximately the last ten years. Since the river database is large, no detailed analysis is provided here. However, a brief review of that data reveled that the pH was circumneutral or greater. Dissolved Oxygen was typically greater than 7 mg/L, but dissolved oxygen levels of 5 mg/L have been recorded. These rivers reveled their high salt content with conductivity level ranging beyond 1000 µmhos/cm in some cases. Nutrient level in a biologically available form were relatively low in tenths of milligrams per liter. Dissolved metals were not detectable, except for some elevated zinc and selenium levels.

Lastly, the National Park Service Water Resources Division will prepare water quality summaries through their Baseline Water Quality Data Inventory and Analysis studies for Arches for Canyonlands in 1999 (Dean Tucker, WRD-NPS, pers. comm., 3/23/98). These efforts provide a thorough review of the water quality in the parks. Specifically, the report will include a 1) complete inventory of all retrieved water quality parameter data, 2) descriptive statistics and appropriate graphical plots of water quality data characterizing annual and seasonal central tendencies and trends, 3) comparison of the parks' water quality data to relevant EPA and WRD water quality screening criteria, and 4) an Inventory Data Evaluation and Analysis to determine what Servicewide Inventory and Monitoring Program "Level I" water quality parameters have been measured.   Disks which contain digital copies of the all data accompany the report.

Data collection and management

Presently water samples are collected by park personnel. Some data including pH, temperature, dissolved oxygen, and specific conductance are collected in the field. These data along with the water quality samples are sent to Utah Department of Environmental Quality, Division of Water

Quality, where the samples are analyzed. The field and laboratory data are entered into the state's water quality database. These data also become part of the U.S. Environmental Protection Agency STORET database. At year's end state personnel send a summary report to the Southeast Utah Group and to Barry Long with the National Park Service Water Resource Division. Long and Smith (1996) developed two databases; the spring archive data (SARCHIV$>DBF) and the river archive data (RARCHIV4.DBF). Both of these are part of the Southeast Utah Group water quality database. Data collected prior to the initiation of the parks' program in 1983 are in report form and available at the Southeast Utah Group headquarters in Moab, Utah. Also reports by Ecosystem Research Institute (1984) and Conner and Kepner (1983) are available at the park headquarters.

Aquatic Invertebrates

Some information exists on the aquatic invertebrate and plant/algae populations located in the water resources of Arches and Canyonlands. The various types of water sources including potholes, pools fed from seeplines in canyon alcoves, pools fed by below ground percolation, plunge pools, and springs that spout from rock walls provide temporary, but often stable, habitat for aquatic invertebrates. For example, water found in springs tends to be a uniform temperature, usually the mean annual air temperature of the region (Hynes, 1970). Therefore, springs provide uniform conditions in areas that are subject to seasonal changes. In these spring environments, relictual species may have survived and many crenobionts (species confined to springs) can occur outside their normal geographical range (Hynes, 1970).

The malicolous habitat consists of thin sheets of water flowing over rock faces (Hynes, 1970). In these parks, this habitat is referred to as "hanging gardens". May et al. (1995) and Fowler et al. (1995) describe the geomorphology and level of endemism in hanging gardens on the Colorado Plateau. This unique habitat can provide for some unusual species and associated biological adaptations. For example, the Diptera are usually the most numerous madicoles, and in contrast to the truly stream-dwelling families of insects, they are all air-breathing (Hynes, 1970).

Some attempts have been made to rectify this paucity of information on aquatic invertebrates. Conner and Kepner (1983) found few aquatic invertebrates in their search at several springs in Arches and Canyonlands. The lack of organisms prohibited a quantitative analysis, but they found various aquatic beetles, mayflies, dipteran larvae, and damselflies. Wolz and Shiozawa (1995) conducted their study within the Needles District of Canyonlands. They found a total of 521 individuals representing 37 taxa with Diptera (fly larvae) being the most prevalent in Lost Canyon, Salt Creek, Big Spring Canyon, and Squaw Creek. Jordan et al. (1997) quantified aquatic invertebrates in selected habitats of the Colorado and Green rivers in Canyonlands . Preliminary results indicate significant differences in densities of nematodes, copepods, and rotifers for both sites and habitats. The researchers used artificial substrates and found that if placed appropriately, the artificial substrates could be monitored every few months over the year to generate information on the water quality. The group of species sampled appeared representative of large, low-gradient Colorado Plateau streams. Quantification of density and standing crop will reveal how comparable these assemblages are with regulated reaches of the Colorado River downstream. Finer taxonomic treatments are needed to determine the functional differences among sites within Canyonlands and Arches and between the Colorado and Green rivers and other sites in the Colorado River watershed.

Lastly, both Arches and Canyonlands support stagnant aquatic systems in the form of potholes and pools in drainages where water is no longer flowing. These stagnant waters may serve as an adequate environment for the protozoan, *Naegleria fowleri*. This organism is the causative agent of fatal human amoebic meningoencephalitis. The organism is ubiquitous in nature could be found in the stagnant pools at both parks especially when temperatures increase. The organism decomposes organic material and consumes other microorganisms. Infection occurs through orifices, open wounds, and infections of the eye and ear. Of those infected with the protozoan, only three of more than 100 cases has survived. To date, this organism has not been documented in the park, nor has research been conducted to determine the presence of this deadly organism. The Backcountry Management Plan (National Park Service, 1995) restricts swimming in Canyonlands potholes.

Fish

The present Colorado River drainage was established when two ancestral river systems forged a connection by cutting through the present Grand Canyon several million years ago in the Pliocene (McKee et al., 1967). Except for mainstream species, there has always been a sharp faunistic separation between Upper and Lower Basin fishes (above and below the Grand Canyon). The Upper Colorado River Basin probably lacked direct connections with any other major drainage for millions of years. This resulted in long isolation of the fish fauna. Except for species inhabiting head water streams such as trout, sculpins, speckled dace, and mountain suckers, which can be transferred between drainage basins by stream capture, the majority of the native species of the Colorado River Basin are endemic, that is, they have been so long isolated they have evolved into species now restricted to the Colorado Basin. The Colorado Basin fish fauna exhibit the highest degree of endemism of any major drainage in North America (Behnke and Benson, 1980). The minnows (Cyprinidae) and suckers (Catostomidae) comprise about 70 percent of the freshwater fish species native to the Colorado River Basin. Miller (1958) claimed 87 percent of the 23 species of minnows and suckers known to be native to the basin at that time were endemic to the basin. Of the over 35 species of freshwater fishes native to the Colorado River Basin, 14 are native to the Upper Basin (Table 9). Almost 42 introduced fishes are presently reported in the upper Colorado River.

Table 10. Common and scientific names of the native fishes of the Upper Colorado River Basin (modified from Behnke and Benson, 1980).

Family		**Family**	
Common	Scientific	Common	Scientific
Salmonidae (trout)		**Catostomidae** (suckers)	
Colorado River cutthroat trout	*Onchorynchus clarki pleuriticus*	Razorback sucker	*Xyrauchen texanus*
Rocky Mountain whitefish	*Prosopium williamsoni*	Flannelmouth sucker	*Catostomus latipinnis*
		Bluehead mountain sucker	*Catostomus discobolus*
		Mountain sucker	*Catostomus platyrhynchus*
Cyprinidae (minnows)		**Cottidae** (sculpins)	
Colorado River squawfish	*Ptychocheilus lucius*	Mottled sculpin	*Cottus bairdi*
Humpback chub	*Gila cypha*	Paiute sculpin	*Cottus beldingi*
Bonytail chub	*Gila elegans*		
Roundtail chub	*Gila robusta*		
Speckled dace	*Rhinichthys osculus yarrowi*		
Kendall Warm Springs dace	*Rhinichthys osculus thermalis*		

Prior to human induced alterations, the Colorado River system was characterized by tremendous fluctuation in flow and turbidity. Miller (1961) cites flows recorded in the Colorado River at Yuma, Ariz., ranging from 18 cfs in 1934 to 250,000 cfs in 1916. In recent geologic time, the drainage basin lacked large natural lakes, so the native fishes never adapted specializations for specialization for lacustrine environments. The unique environment of the Colorado River with its great diversity and torrential flows through canyon areas, directed the evolutionary pathways followed by the native fishes. This environment molded the bizarre morphologies of the razorback sucker, the humpback and bonytail chubs, and produced the largest of all North American minnows, the squawfish. Behnke and Benson (1980) provide a good overview of distribution, life history, causes of decline for these unique species.

The construction of mainstream dams, forming large lakes, regulating flow regimes, precipitating out the silt load and releasing cold, clear water, created new environments for which the native mainstream fishes were ill adapted (Vanicek, 1967; Seethaler, 1978; Holden and Wick 1982; Minckley et al., 1991; Tyus, 1991; Modde et al., 1995). In addition, predation and competition from nonnative fishes (Behnke and Benson, 1980) and toxic metal contamination (Stephens et al., 1992) have contributed to the decline of these species. These factors have impaired the ability of these species to recruit throughout their ranges (McAda and Wydoski, 1980; Tyus, 1992). Consequently, it is not surprising that the Colorado River squawfish, humpback chub, bonytail chub, and razorback sucker are federally listed endangered species. In addition, two other native species, the flannelmouth sucker and roundtail chub, are candidate species for potential future inclusion on the Federal Threatened and Endangered Species List.

Research on the status of the four endangered fish species in the Upper Colorado River Basin has been conducted by the US Fish and Wildlife Service, Utah Division of Wildlife Resources, Bureau of Reclamation, and National Park Service. The Colorado and Green rivers through Canyonlands contain significant habitat for these endangered species (Valdez, 1990; Valdez and Williams, 1993). Given the limited information available, species recruitment appears to be associated with high-flow events, most notably with the availability of flooded bottomlands (Modde et al., 1995). Riverside wetlands provide important and perhaps critical habitat for young fish. Water development projects (dams, levees, and other flood-control structures) often prevent the rivers from overflowing their banks and flooding the bottomlands. These wetlands can be provided by removing barriers to historic bottomlands and by providing sufficient flow to inundate bottomlands in a manner that approximates the natural hydrograph.

The U.S. Fish and Wildlife Service has consulted with other federal agencies in the Upper Colorado River Basin under provisions of the Endangered Species Act of 1973 as amended, and has issued over 100 Biological Opinions pursuant to Section 7 of the Act (Tyus, 1991). In general, the U.S. Fish and Wildlife Service has determined that water depletion and dam operation would likely jeopardize the continued existence of some listed fishes. An interagency program has been established in the Upper Colorado River Basin in an effort to recover listed fishes without violating existing state and federal water agreements. This program oversees recovery activities in the upper Colorado River, provides funds for evaluating habitat requirements of the fishes, and seeks ways to obtain water needed by the fishes (Tyus, 1991).

ARCHES NATIONAL PARK AND CANYONLANDS NATIONAL PARK OBJECTIVES FOR WATER RESOURCES

Representatives for the National Park Service (Arches, Canyonlands, Glen Canyon National Recreation Area, Water Resources Division), Bureau of Land Management and the Utah Water Rights and Environmental Quality Divisions attended a water resources scoping meeting held on September 18, 1997 (Appendix A). These attendees developed a list of objectives for management of water resources at Canyonlands and Arches. The list focuses not only on impacts to water resources from outside the park, but also on the impacts from day-to-day park operations.

Water Quality and Quantity

- Insure that water resources, especially at seeps and springs, are available to wildlife, aquatic organisms, and plants in quantities and of a quality that promote the existence and well being of these organisms.
- Promote the continued study of the four endangered fish species and the implementation of management techniques which not only insure their continued existence, but also their perspective population increases in the Green and Colorado Rivers within Canyonlands National Park.
- Recognize opportunities to develop plans and studies, and implement techniques in the management of the Green and Colorado Rivers through the annual operating planning meetings and other avenues. Participation in river management along the Green and Colorado Rivers promotes an ecosystem approach to coordination of recovery efforts on the Green and Colorado Rivers.
- Recognize importance of healthy watersheds, and in doing so promote efforts to reduce erosion and sediment production inside and outside park boundaries.
- Recognize importance of wetlands, and initiate wetland delineation studies as required by Section 404 of the Clean Water Act.
- Recognize the concerns and regulations relating to flood plain management and development of any kind within those zones.
- Investigate, acquire, quantify, and/or maintain water rights for Arches and Canyonlands National Parks.

Inventory and Monitoring

- Continue to gather, compile and analyze water quality and quantity data in both Arches NP and Canyonlands NP in order to detect trends in either quality or quantity.
- Encourage partnerships between state and federal agencies in monitoring water quality and biota.
- Gather and analyze information on the structure and function of organisms which inhabit springs and seeps, and implement studies which determine the effects of increased visitor use of springs and seeps.
- Participate in the active development of reclamation plans, or studies which assess impacts of past or present mining or oil and gas exploration, and actively continue remediation of extraction sites within park boundaries as deemed necessary.

Park Operations

- Through educational programs promote and maintain riparian or aquatic habitats for wildlife, fish, plants, and other aquatic organisms.
- In light of the significant increase in park visitation, continue to provide safe and adequate quantities of culinary water for visitors and park personnel.
- Insure that park operations do not adversely impact park water resources and water dependent environments.

- Insure that special uses of park water resources adhere and correspond to enabling legislation and management statements and plans of the parks.
- Promote water conservation through both the National Park Service actions, and cooperation with local businesses and communities, and state and federal agencies.

WATER RESOURCES MANAGEMENT ISSUES

Berghoff and Vana-Miller (1997) recommend a Water Resource Management Plan for Arches and Canyonlands as a result of complex issues facing the Southeast Utah Group parks. An array of water related issues stem from explosive growth in visitation to Colorado Plateau parks, the major activities of federal and private entities upstream of the Canyonlands and Arches, and legal challenges of management plans in backcountry areas of Canyonlands.

The scoping report (Berghoff and Vana-Miller 1997) coupled with a scoping meeting on September 18, 1997 involving federal area managers and state officials culminated in a set of broadly defined issues. This management plan while fully describing the hydrological setting of the two parks, more importantly presents a series of management actions or project statements intended to deal with some of the aspects of the identified water resource issues.

1. Aquatic Resources and Water Quality of Seeps and Springs: Use and Abuse
2. Culinary Water Development: Where, When, and How
3. Threatened and Endangered Fish Species, and Other Fish Species
4. Salt Creek, Horse, Lavender, and Davis Canyons in Canyonlands : Visitor Use Issues
5. Water Rights: Now or Never
6. Mining: From Atlas to Potash
7. National Park Service Wastewater Management
8. Wetlands and Flood Plains
9. Salinity: Natural and Human Induced
10. Cooperation and Coordination: Between Agencies and Among River parks
11. Staffing Needs: A Park Fisheries Biologist Hydrological Technician

The number and types of issues listed above confirm the elaborate nature of water resource management at Arches and Canyonlands . The National Park Service's dual mandate of "provid(ing) for their (visitors') enjoyment" ... while leaving the natural resources "... unimpaired for future generations" has never been more difficult due to the multitude of new and returning visitors who demand more amenities and greater penetration of the backcountry of the parks. Some time ago, the US Department of Interior (1946) prepared a document entitled the "The Colorado River" . The foreword begins:

> Yesterday the Colorado River was a natural menace. Unharnessed it tore through deserts, flooded fields, and ravaged villages. It drained the water from the mountains and plains, rushed it through sun-baked thirsty lands, and dumped it into the Pacific Ocean - a treasure lost forever...
>
> Today this mighty river is recognized as a national resource. It is a lifegiver, a power producer, a great constructive force...
>
> Tomorrow the Colorado River will be utilized to the very last drop. Its water will convert thousands of additional acres of sagebrush desert to flourishing farms and beautiful

> homes for serviceman, industrial workers, and native farmers .... Its terrifying energy will be harnessed completely to an even bigger job in building bulwarks of peace.

The dichotomy is not lost, the Colorado River still runs unharnessed in certain sections, an important fact especially for Canyonlands. Unfortunately, harnessing tributaries such as the Price and Duchesne rivers, and diverting the Colorado River and its tributaries to other basins, have harmed the park's riparian ecosystem . Fortunately the National Park Service's dual mandate provides a stopgap to the uneducated control of the river, and allows this management plan and perhaps an Integrated Colorado River parks Management Plan the chance to insure a relatively unimpaired natural environment as well as the opportunity for future generations to see and enjoy Arches and Canyonlands.

ISSUE 1: **Aquatic Resources and Water Quality of Seeps and Springs: Use and Abuse**

The parks are primarily concerned with three areas of impact to springs and seeps: visitors use, herbicides, and livestock watering. Since springs and seeps in both parks provide a respite from desert heat for visitors, use is high. Human use of these areas causes reduced riparian vegetation, infestation by exotic plant species, possible reduction in spring discharge, increased sedimentation, and loss of aquatic habitat. Secondly, use of herbicides to decrease the number of tamarisk stands may cause water quality problems in associated springs and streams. Lastly, trespass cattle can damage spring habitat and reduce the amount of water available for wildlife.

Human use of the park springs and seeps and its effects are undocumented except for work completed by Mitchell and Woodward (1993) and Wolz and Shiozawa (1995). Regardless, the Backcountry Management Plan (National Park Service, 1995) prohibits swimming and bathing in Canyonlands water sources, except for the Green and Colorado Rivers, and prohibits camping within 300 ft of water sources. The basis for the regulation is obvious; the level of disturbance to aquatic organisms, and trampling of the surrounding vegetation is reduced. Yet, the level of potential impacts to water resources from visitor use is still unknown. A complete literature search revealed that no other studies of impacts to springs and seeps from visitor use are documented (Muckleroy, P., 1997 pers. Comm.., Western State College,). The Backcountry Management Plan (National Park Service, 1995) is a proactive document, and implements a means of protecting natural resources instead of demanding further study of impacts that park personnel already recognize. However, the parks are also obligated to understand how and to what level seeps and springs are changed as a result of public use.

Projects by Conner and Kepner (1983), Woodward and Mitchell (1993), and Wolz and Shiozawa (1995) revealed information on aquatic organisms and plants near or in streams, springs, and seeps in both parks. Mitchell and Woodward (1993) addressed concerns regarding impacts to aquatic systems and their diversity due to visitor use in Canyonlands. Indeed, they found numbers and types of organisms and amount of sand accumulation varied greatly upstream and downstream of road crossings in salt creek. A large portion of this road was closed to vehicular traffic in July 1998. Aloz and Shiozawa (1995) suggested that the road influences the site's ability to support aquatic invertebrates.

In 1998, John Spence and Kevin Berghoff of Glen Canyon National Recreation Area with assistance of Charlie Schelz, biologist for the Southeast Utah Group, sampled five springs in Arches and three in Canyonlands . They sampled water quality, invertebrate, and plant cover. That effort is a part of a larger study of springs near the Colorado River (K. Berghoff, 1998, pers. Comm., National Park Service). In addition to the work begun by Spence and Berghoff, a study is needed to assess the flora and fauna and to determine if rare or threatened and endangered vegitaion and aquatic organisms exist at spring and seep sites (see ARCH-N-026.000, CAN-N-030.000, ARCH-N-029.000, and CANY-N- 036.000). Determination of the level of impacts on to several drainages resulting from various types of visitor use is described in a project statement (CANY-N-034.000)

In an effort to insure adequate water quality, park personnel are responsible for knowing and understanding the effects of management activities in and around seeps and springs. Salt Valley Wash is a tributary of Salt Wash in Arches . Concerns regarding the spraying of Garlon 4 to eradicate tamarisk have been voiced by park personnel. The use of this herbicide is somewhat effective, but this plant requires repeated treatments, mechanical or chemical. The last survey for the extent of tamarisk cover in the two parks took place in 1983. Thomas et al. (1987) noted that these surveys should be conducted every 5 to 10 years. The concern is that spring water is not contaminated as a result of eradication of exotic species. A project statement summarizing a study of the effects of Garlon 4 on water quality is offered (ARCH-N-027.000)>

Trespass cattle at a number of springs in Arches and Canyonlands also raises a concern regarding maintenance of good water quality. Although fecal contamination tends to be the greatest concern, trampling of the surrounding vegetation degrades the overall system and thus water quality. Willow Spring and Courthouse Wash are such examples. Table 10 presents data regarding fecal contamination of several springs in Arches National Park affected by cattle use. Mean levels of fecal coliform bacteria exceeded recommended state criteria (200 colony forming units/100 ml); however, note that the standard deviation and range establish high variability regarding this parameter. A geometric mean was not calculated and the sampling technique used may contribute to this high mean. The western boundary of the park where these springs exist has been fenced off . Monitoring will continue at these spring sites (Schelz, C., 1997 pers. Comm., National Park Service) to capture any changes in water quality as a result of fencing the western boundary. Canyonlands continues to experience trespass cattle.

Table 11. Mean and ranges for total and fecal coliform bacteria (cfu/100ml) at spring sites in Arches National Park. Standard deviations are in parentheses.

Site	Total Coliform			Fecal Coliform		
	Sample Size	Mean	Range	Sample Size	Mean	Range
Willow Spring (WS1)	12	793.3(2095.2)	0-7210	9	1121.1(3329.6)	0-10000
Sleepy Hollow (SH1)	10	63.5(137.7)	0-450	8	6.5(9.3)	0-20
Seven Mile (SM1)	8	7.5(17.5)	0-50	6	0.3(0.8)	0-2
Courthouse Wash (CW1)	10	271.6(547.6)	0-1800	8	205.5(317.6)	0-800

Source: Long and Smith (1996)

The parks promote careful management of cattle around springs and recognize the need to reduce contamination or degradation of major springs in the parks. The issue is complicated by seepage and contamination flowing into the park from springs located outside the parks' boundaries.

ISSUE 2: **Culinary Water Development: When, Where, and How**
Culinary water sources are limited in Arches and Canyonlands. Water is trucked from Moab, Utah to the Maze District, and water from Arches is trucked to the Island in the Sky District. Visitation to the parks has increased tremendously. For example, Canyonlands visitation grew from 60,000 in 1980 to 434,834 in 1993 and decreased slightly in 1997 to 432,697. Visitation to Arches increased from 150,000 in 1965 to 700,000 in 1991, and to 858525 in 1997 (Hecox and Ack, 1996). The previos studies for devloupment of culinary water sources occurred in the late 1970s and early 1980s, well before the vast increase in visitor numbers. Arches and Canyonlands are faced with a dilemma to provide water for visitors, but also to insure that degradation of natural resources does not occur.

Arches NP
Headquarters
One of two wells located at Arches Headquarters serves park personnel and visitors. An old well, drilled sometime in the 1930s has been used once in the last ten years. Due to the age of this well, no data are available regarding depth or capacity.

The primary well is 172 feet deep in the Navajo Sandstone. The well was completed in 1978 with water right application A-57272. The yield totals 30-50 gallons per minute (gpm) and is typically pumped at 32-35 gpm. The well water was tested for radiological chemistry and volatile organic compounds, the latter of which did not exceed state standards.

The proximity of the Atlas Corporation tailings pile caused the state to continue sampling for radioactivity in the form of alpha levels at the primary well. Results show that levels increased during 1996. The state standard is 15 pC/L. A February sample contained 9.2 pC/L, a March sample contained 6.0 pC/L, and the July sample contained 24.0 pC/L. Sampling will continue at the primary well, and it must be noted that the bottom of the tailings pile at 3970 feet msl is higher than the depth to water in the Arches headquarters well. Park personnel are concerned with this situation even though the alluvial ground water movement is typically from the northwest to the southeast towards the Colorado River and away from the park's well. However, within the tailings pile itself, the measured water level is 40-60 ft (12 to 18 m) above the alluvial ground water (US Nuclear Regulatory Commission, 1997). The potential for movement of contaminated ground water under the mill and tailing site is possible due to hydraulic pressure caused by hydraulic head which exists in the tailings pile above the base of the tailings pile.

Water from the primary well is stored in a 50,000 gallon steel tank; the water is chlorinated prior to storage. The water is sampled at various outlets twice per month for bacteriological testing. Results showed no contamination problems. The water is tested yearly for nitrates and nitrites, and future volatile organic compound testing has been waived (Darcey III, F., 1997 pers. comm., National Park Service). Park personnel typically do not drink the water from the headquarters well due to taste. Instead many get their water from Matrimony Spring located on Bureau of Land Management property at Utah State Hwy 128. This water is not treated, but is tested on a quarterly basis for total coliform bacteria by Grand County. No total coliform bacteria have been detected during the last three sampling efforts on 12/9/97, 1/6/98, and 4/6/98 (data from Southeastern Utah District Health Dept.). The National Park Service collected a water quality sample from the spring on 1/10/91, and the result showed no exceedance of primary or secondary inorganic parameters. No organic parameters were analyzed (Long and Smith, 1996).

Canyonlands NP

Maze District

Water is hauled from the City of Moab, Utah four times per year to two tanks totaling 25,000 gallons. This water is chlorinated and tested for total coliform bacteria twice per month. Residual chlorine tests are conducted on a daily basis. Testing for nitrates, nitrites, and sulfates is not required. The number of park personnel served by water sources differs according to season. Three to four people are served during the winter, and up to fifteen individuals during the summer months. Visitors are also served by this source of water.

A Resource Management Plan project statement calls for capping the Hans Flat well located outside of Canyonlands , in Glen Canyon National Recreation Area. This well was drilled in 1973; the total well depth is 2750 ft, and water was encountered at 2510 ft within the Cedar Mesa unit. Water quality at the Hans Flat well is poor with a sulfate content of 960 mg/L, specific conductance of 2080 μmhos/cm, and total dissolved solids of 1600 mg/L.

The previous discussion of ground water sources at the parks reveals that in order to provide potable water for an ever increasing level of visitation, engineering and economic feasibility studies must be conducted within Canyonlands.

Needles District

At least six wells are located near the Needles District Headquarters. Of these six wells only one well is used for drinking water, and is referred to as NPS Needles #4. This well is 253 feet deep and was drilled in 1991 into the Cedar Mesa Sandstone. The yield is 40 gpm but is typically drawn at 27 gpm due to limitations of the treatment system. The water is treated by sand filtration with addition of potassium permanganate, and later aeration to remove iron. The iron content is reduced from approximately 0.5 mg/L to 0.03 mg/L. This treated water is chlorinated and stored in three 20,000 gallon tanks. The water is distributed to the visitor center, the maintenance facility, a housing unit consisting of 19 units and a campground area. Actual water usage totals more than one million gallons per year (e.g., 1,136,440 gallons were used in 1996). The summer months typically have the highest use beginning with May (greater than 100,000 gallons per month). Low usage months include December, January, and February where levels approximate 50,000 gallons per month.

Park personnel sample for total coliform bacteria twice per month at the visitor center, maintenance facility, housing area, and campground; they rotate the sampling sites per a schedule. Residual chlorine levels are tested at least once per day at scheduled site, and randomly at non-scheduled sites on a daily basis. Turbidity levels do not exceed 0.5 NTU and bacteriological testing reveal no contamination. The last record of volatile organic compound sampling is from 1994 and revealed no levels exceeding state standards. Nitrates and nitrites are measured on a yearly basis (Johnson, J., 1998 pers. comm., National Park Service).

The history of well development in the Needles District is complicated. The present drinking water well, drilled in 1991, located near Cave Spring, but should not be confused with Well No.4 located near Squaw Spring. Collins (1991) noted that Wells Nos. 3a, 3b, 4 and 5 were inactive. Wells 2 and 4 were used up until 1990, and replaced by the Cave Springs NPS Needles No.4 in 1991. A Resource Management Plan project statement requests funding to cap four wells in the Needles District and these include Well No.2 - Salt Creek Well, Well No.3a - Headquarters Well, Well No.3b - Headquarters Well, and Well No.4 - Squaw Spring Well. As of yet no funding is available to cap these wells.

Park personnel raised a concern regarding the ability of the existing pump to deliver water to the campgrounds. At 120 pounds of pressure, the staff recognizes that the pump could overheat. The park has no spare pump or storage tanks in place. If the pump were to breakdown, the campground would go without water until a new pumped arrived and was installed.

Abandoned Landfill - Needles District: An abandoned landfill, located approximately one mile south of the Needles District visitor center, poses a potential problem to ground water and stream water quality in the vicinity. The landfill was operated from 1966 to 1987. The closest domestic well is approximately 3000 feet to the north of the landfill, and has been designated for capping. A Comprehensive Environmental Response, Compensation, Liability Act Preliminary Assessment (Mesa State College, 1996) determined that potential contaminants at the site may include: paints and thinners, batteries, pesticides, aerosol cans, human waste, oils, construction debris and household waste.

The report also concludes that release of hazardous substances to the ground water associated with Salt Creek, Lost and Squaw canyons may have occurred. The soils in the area consist of sandy loose materials, 10 to 20 feet deep, and were formed in alluvial and eolian deposits. High permeability and infiltration associated with these soils lend to a high potential for ground water contamination. A total of eight National Park Service drinking water wells are located in this area , and all but 4 are destined for capping.

Surface water contamination may result from contact between ground water and surface water, and in drainages where alluvial deposits comprise the substrate, surface water and ground water act in concert. Lost Creek and Squaw Creek carry ephemeral flows; these flows may be contaminated if ground water mingles with any surface runoff.

The National Park Service Water Resources Division has already initiated and completed flood plain modeling of Salt Creek. Monitoring wells were installed on October 8, 1997 at the landfill site for an ambient water quality study. A Comprehensive Environmental Response, Compensation, Liability Act site investigation has been conducted within the past year; thus the park is pursuing the risk assessment and remediation of this site already.

Island in the Sky District
This district obtains its culinary water from the primary well at Arches. A truck hauls an 8000 gallon tank of water to the district. The water is transferred and stored in a 30,000 gallon storage tank. Approximately three truck loads per month are hauled during the high visitor use season, and perhaps one to two loads during the winter season.

The water is initially treated with chlorine at Arches. Arches tests for nitrates and nitrites annually, but no testing for volatile organic compounds is required. After storage in the Island of the Sky District tank no further chlorination takes place. However, the park is installing a chlorinator.

This water source services nine housing units, the maintenance shop, and the visitor center. Other than a drinking fountain, there is no dedicated source of water for visitors to this area. During the summer season typically 10 to 20 park staff obtain water from this source, while during the winter season the number is halved.

Aquifers in the Colorado Plateau may be recharged slowly and susceptible to drawdown (May et al., 1995). As a result, consumptive use of this water through large development efforts may reduce important water resources for wildlife as well as vegetative communities like hanging gardens. In addition, poor water quality associated with certain rock strata limit water development. For example, the Island in the Sky District encompasses parts of the White Rim formation. Water sources have been found here, but total dissolved solid levels exceed 1990 mg/L (Huntoon, 1977). A project statement calls for an economic and feasibility study of water development in the Maze and Island in the Sky District. Emphasis is placed on feasibility of water development versus insuring the needs of wildlife.

ISSUE 3: **Threatened and Endangered Fish Species, and Other Fish Species**
The Colorado River near Arches and in Canyonlands , and the Green River in Canyonlands were designated by the US Fish and Wildlife Service as critical habitat for four federally endangered fish species - the Colorado squawfish (*Ptychocheilus lucious*), humpback chub (*Gila cypha*), bonytail chub (*Gila elegans*), and the razorback sucker (*Xyrauchen texanus*). The lower 50 miles of the Green River constitutes one of the most important nursery areas for Colorado squawfish in the basin, due to relatively high densities in backwater habitats. Similarly, the Colorado River in Cataract Canyon contains the most recently discovered reproducing population of humpback chub. It is also one of only three locations in the Upper Colorado River Basin where bonytail chub have recently been reported (Valdez and Williams, 1993). In 1996, more than 170 razorback sucker larvae were documented from the lower Green River near Canyonlands (US Fish and Wildlife Service, 1996).

Flow regime and channel geomorphology have changed dramatically over time. Flow in the Green River has been regulated by various water development projects and the Flaming Gorge Dam since 1963. The mean annual peak discharge at the Green River gaging station at Green River, UT has decreased 33% from 32,728 cfs to 22,091 cfs between pre-and post- 1963 streamflow data. While the pre- and post- 1963mean annual flow levels remained relatively unchanged at 5800 cfs and 5600 cfs, the mean base flow (represented by flow data from September 1 through March 1) for the same period of record increased 64 percent from 2150 cfs to 3380 cfs (FLO Engineering, 1996).

Extreme flows on the Colorado River, measured at the Cisco, Utah gaging station from 1914 to 1995, reached a maximum of 76,800 cfs on June 19, 1917 and a minimum of 558 cfs on July 21, 1934 (U.S. Geologic Survey, 1995). Flow in the Colorado River has been indirectly regulated by Blue Mesa Reservoir on the Gunnison River, which was completed in 1966 and is the largest impoundment upstream from Canyonlands in the Colorado River Drainage. This reservoir is one of three reservoirs on the Gunnison River comprising the Aspinall Unit . the mean annual peak discharge at the Cisco, Utah, gaging station has decreased 27 percent from 40,653 cfs to 29,770 cfs between pre- and post- 1966 stream flow data.

Reservoirs act as sediment traps, blocking sediment transport downstream. However, Andrews (1986) indicated that a decrease in sediment transport at the lower end of the Green River Basin was primarily due to a decrease in the magnitude of the river flows and not necessarily a decrease in available sediment. The reduction in magnitude and frequency of peak discharges and the decrease in sediment transport have resulted in significant changes to channel morphology. The result of these changes has been extensive vegetation encroachment, stabilization and bank attachment of sand bars within the active river channel, as well as narrowing of the river channel. Comparison of historic photographs in specific reaches on the Green River in Canyonlands clearly show some large sandbars becoming so densly vegetated that inundation results in sediment deposition and development of the bars (FLO Engineering, 1996). Eventually, this process resulting in the loss of persistent deep backwater channels which are considered the key spawning habitat for some of the native fish. Further, Cluer (1997) observed erosional processes on unregulated rivers that did not occur on regulated rivers. One major annual cycle of erosion and deposition occurred in the naturally flowing river setting, in contrast to several cycles witnessed in the regulated river environment (Cluer and Dexter,1994)

Studies, which examine the effect of flow on the various aspects of the endangered fish species' biology, have occurred since 1992 on the Colorado River and 1990 on the Green River as a part of the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. In a draft report, McAda and Ryel (1998) determined that young-of-year Colorado squawfish were most abundant in moderate runoff years that had been proceeded by year with high runoff in the Colorado River. They recommended modifying reservoir releases to enhance spring flows for more frequent scouring of cobble to assure Colorado squawfish hatching success. In a draft report, Trammel and Chart (1998a) found that the moderate flow year of 1996 resulted in the highest larval and juvenile abundance despite high numbers of non-native cyprinids. In another draft report the, Trammel and Chart (1998b) found that increasing the relative quantity of deep backwater persistent habitat may have increased survival of young - of - year Colorado squawfish. They concluded that formation and maintenance of nursery habitat for the Colorado squawfish was still not clearly understood. Day and Crosby (1998) started that flow recommendation for the Green River were difficult, due to differential effects of high flows on backwater habitat formation and Colorado squawfish abundance. However, they emphasized the importance of large, deep backwaters as a nursery habitat. They suggested that one periodic high flow event followed by several years of lower and varied flows may be preferred.

Flaming Gorge Reservoir, the Aspinall Unit, and other reservoirs in the Upper and Lower Colorado River basins, are operated in accordance with the "Law of the River". The 1997 Annual Operating Plan for the Colorado River Reservoir states, "All operations will be undertaken subject to the primary water storage and delivery requirements established by the 'Law of the River' including enhancement of fish and wildlife, and other environmental factors." Flaming Gorge has been operated under criteria specified in the Biological Opinion since 1992. The Aspinall Unit has been operated under agreed upon flows until a Biological Opinion from the U.S. Fish and Wildlife is Formulated.

The 1996 water year was the final year of a five year study called for in the Biological Opinion initiated to determine river flows necessary to maintain native endangered fish populations. The U.S. Fish and Wildlife will release in fall 1999 a revised Biological Opinion which modifies specific constraints regarding decisions made on operating criteria for Flaming Gorge Reservoir on the green river. A draft Biological Opinion will be released in 1999 for the Aspinall Unit on the Gunnison River, a tributary to the Colorado River. This Biological Opinion will direct flow releases necessary to maintain native endangered fish populations in the Gunnison River. Releases from Flaming Gorge and the Aspinall Unit will determine future changes in channel geomorphology as far downstream as Canyonlands.

The endangered fish species have not been recovered, and their recovery rests with continued cooperation between a coalition of federal, state, and private agencies, water conservation districts, and other interested parties who wish to see the fish populations recover while allowing for continued water development. The cooperation of various agencies charged with the protection of the fisheries and management of the water will permit the development and testing of management procedures and practices for recovery of listed fishes; presumably to the benefit of the entire native fish fauna.

A project statement (CANY-N-033.000), presented in this document, requires re-evaluates of cross-sections of the Green River and modeling of the flood plain. Such a statement can contribute to increased knowledge regarding endangered fish requirements and habitat and flow management, and manipulation for those fish. This project and information would be coordinated and used by the Recovery Implementation Program for the endangered fish species.

ISSUE 4: **Salt Creek, Horse, Lavender, and Davis Canyons in Canyonlands NP: Visitor Use Issues**

Salt Creek, Horse Canyon and Lavender Canyon in the Needles District of Canyonlands are popular destinations for four-wheelers. Davis Canyon within the park provides an opportunity for hiking. Of these four drainages, only Salt Creek is a perennial stream, and as a result, the riparian resource provides substantial habitat for aquatic organisms and wildlife. The other drainages support riparian habitat in places and do have water sources present. The Canyonlands Backcountry Management Plan (National Park Service, 1995) previously restricted vehicular use in Salt Creek by requiring a permit to access the area. However, a federal court order issued on July 6, 1998 now prohibits vehicles above Peekaboo Spring in Salt Creek. Day use permits are still issued for lower Salt Creek and Horse Canyon. These permits are limited to ten private motor vehicles and two commercial motor vehicles, one to seven permits for private or commercial bicyclists, and one to seven permits for pack or saddle stock per day for each type of use. Overnight use in vehicle campsites occur at the Peekaboo campsites located on a bench outside of the floodplain. Horse Canyon, tributary to Salt Creek, receives continued vehicular use. Lavender Canyon receives vehicular use under a permitted system. Davis Canyon within the park boundary is closed to vehicular traffic, and instead the park allows foot traffic.

Only limited types of recreational use are allowed because the typical alignment of roads is directly in the drainages. As a result impacts to the water resource may occur. Ecosystems Research Institute (1984) detailed the lack of biota present in Salt Creek. They described the creek as having high turbidity, a constantly shifting sand/silt substrate, warm temperatures, high salinity levels and dramatic flow fluctuations. As a result, no fish have been recorded in Salt Creek except for the lower most 0.6 miles (1 kilometer) of the creek. These adverse conditions may prove suitable to only specialized euryhaline organisms (Ecosystems Research Institute, 1984). Conductivity levels in seeps and rises of Horse Canyon range from 200 to greater than 1000 μmhos/cm (Richter, 1980; Ecosystems Research Institute, 1984). Water sources of springs and rises in Lavender Canyon revealed high conductivity levels (1035 - 5070 μmhos/cm) (Richter, 1980; Ecosystems Research Institute, 1984). Water sources of springs and rises in Davis Canyon reveal conductivity levels ranging from 700 to 900 μmhos/cm (Richter, 1980; Conner and Kepner, 1983). Conner and Kepner (1983) found no aquatic invertebrates in a pool from which they collected water. Because so little assessment work has been completed in Horse, Lavender, and Davis canyons, and because Salt Creek, Horse and Lavender canyons receive continued vehicular use in certain reaches, National Park Service representatives at the first scoping meeting (Berghoff and Vana-Miller, 1997), and at the second meeting, identified Salt Creek as a primary area of focus.

Later, park management identified Horse, Lavender, and Davis canyons as areas in which recreational use is significant and the aquatic and associated terrestrial organisms may be disturbed. Since pressure and type of use varies within these drainages, an assessment of their biota can provide information on levels of impacts and may serve as a predictor for similar impacts to other drainages undergoing increased recreational use.

Project statements presented in this document address bioassessment and assessment of recreational impacts to these drainages. (ARCH-N-029.000 and CANY-N-036.000, CANY-N-034.000).

ISSUE 5: **Water Rights: Now or Never**

A system of allocating water for beneficial use was developed because of the arid climate and limited availability of water in the western United States. This system is known as the prior appropriation doctrine and is the primary philosophy regarding allocation of water resources in the West. The concept "first in time, first in right" applies in western water rights, meaning the date of appropriation determines the users priority to use water. If there is insufficient water to meet all needs, the senior appropriators will obtain all of their allocated water before junior appropriators obtain any of theirs. The prior appropriation system is under the jurisdiction of the individual states in the western United States (Getches, 1984).

In addition to the prior appropriation doctrine, water allocation and use in the western United States is governed by the Federal reserve water rights doctrine (also known as the Winters Doctrine). This doctrine asserts that the US reserves, by implication, the right to enough of the unappropriated water on or adjacent to the reserved lands to fulfill the purpose of the reservation (Newberry, 1995). Reserve water rights institute a priority date to when the reservation was established and are not subject to state water law except when properly joined in a general adjudication. This concept of federal primacy over state control of water is of great concern to states' water rights holders.

Water allocation in the Upper Colorado River Basin is dictated by states' rights, federal reserve rights, and the "Law of the River". The McCarran Amendment (1952, 66 stat. 560) grants a limited waiver of Sovereign Immunity to allow the United States to be joined as a defendant in suits involving the adjudication of water rights. This amendment requires the United States to assert its claim to water rights when general adjudication is occurring in the pertinent river system. Failure to assert a claim to water rights in such a proceedings may result in forfeiture of these rights. Portions of the Colorado River drainage system through Utah are currently undergoing water rights adjudication, and the federal government is expected to be a part of this adjudication procedure sometime in the future. The National Park Service will need information to support water rights claims for Arches and Caynonlands on these adjudications. The Southeast Utah Group is part of this system by the nature of their location in the heart of the Upper Basin.

Areas of concern for both parks are the water rights associated with springs and with wells drilled using park funds. Presently, two situations exist where water rights on springs are questionable They include a spring located in Lost Spring Canyon northeast of Arches National Park and one located in Courthouse Wash in Arches. The spring in Lost Spring Canyon is adjacent to a parcel which Congress added to Arches in 1998. The Courthouse Wash spring is just inside the park boundary and has been used to water livestock. Concerns include the impacts to these springs from cattle grazing, and the need for water to support park purposes such as recreational use and resource preservation. Should the boundaries of Arches or Canyonlands ever be extended, water rights questions would arise for water sources within the additions.

Water rights issues will be presented as a technical assistance request to the National Park Service, Water Rights Branch.

ISSUE 6: **Mining: From Atlas to Potash**

Atlas Corporation Moab Mill Site

An overwhelming concern of both parks is the remediation efforts of Atlas Corporation Moab Mill, a now decommissioned uranium mill site. The mill site and associated tailings are located on the northwest bank of the Colorado River southeast of Arches headquarters, and 1.9 miles (5 kilometers) northwest of Moab. The site totals 400 acres (162 hectares) comprised of a processing facility, tailings pond and pile. The 10.5 million ton (9.5 million metric ton) pile covers some 130 acres (52.6 hectares). Atlas Corporation submitted an amendment to its existing Nuclear Regulatory Commission License No. SUA-917 requesting that Atlas be allowed to 1) reclaim and stabilize the tailings pile for permanent disposal at its present location near Moab, 2) discontinue its responsibility for the tailings, and 3) prepare the 400 acre site for closure (US Nuclear Regulatory Commission, 1996a). A draft and technical evaluation of Atlas' remediation plan raise additional questions about ground water contamination (US Nuclear Regulatory Commission, 1996b, 1997).

The National Park Service's major concern is an elevated ammonia level in the Colorado River downstream of the pile. The U.S. Fish and Wildlife Service issued a jeopardy opinion in reference to the remediation plan as a result of the elevated ammonia level (Irwin, R., 1997 pers. Comm., National Park Service). Ammonium levels of 2400 mg/L were measured in the tailings fluid in 1987 (U.S. Nuclear Regulatory Commission, 1997). At a pH of 8.0 and a water temperature of 10°C, a total ammonia level of 5.86 mg/L can be toxic to fish. Ground water at the background monitoring site AMM-1 established in 1988 was generally a sodium/chloride type, whereas the tailing fluids are a sodium-magnesium/sulfate type water. Sulfate is the dominant anion of the tailing fluid and apparently does influence the ground water at a well to the south. The Nuclear Regulatory Commission questions whether the AMM-1 site was a suitable background monitoring well, because of its close proximity to an old ore storage pad (U.S. Nuclear Regulatory Commission, 1997).

Generally, the shallow alluvial ground water flow is from northwest to southeast towards the Colorado River; however, flow directions and gradients are likely to be variable throughout the year due to stage influences of the Colorado River. During much of the year, shallow and deep monitoring wells in the alluvium show that ground water elevations are above the river stage, demonstrating that the river is gaining flow from the ground water, however, during spring runoff, the river stage exceeds the ground water elevation in the wells, thus the river contributes flow to the alluvial ground water during this period (U.S. Nuclear Regulatory Commission, 1997).

Arches, Canyonlands, and the Water Resources Division of the National Park Service continue to work closely with Atlas Corporation and the Nuclear Regulatory Commission on an acceptable remediation plan for the Atlas Corporation Mill Site.

Dolores Mining District

Upstream approximately, 20 miles from Moab, the Dolores River joins the Colorado River This confluence is significant because uranium tailings remediation of the Uravan mill site is located approximately 50 river miles away from the Colorado River near Moab. Umetco Minerals

Corporation, a division of Union Carbide, has supervised the reclamation of the Uravan Mill Site since 1988 when the mill was decommissioned. Since the early 1900's, much of the country's uranium ore was milled at this site. Radiological contamination of the ground water, soils, and facilities caused the US Environmental Protection Agency to consider this site a Superfund site regulated under the Comprehensive Environmental Response Compensation, Liability Act and the Resource Conservation and Recovery Act. Since 1988, the site facilities have been razed, contaminated soils removed, and contaminated ground water pumped to evaporation ponds. All contaminated materials have been placed on a mesa top at the Uravan site where liquid waste materials were sprayed. These materials will be capped in place. It is estimated that the remeditation process will take 17 years. Monitoring of contamination is an ongoing process.

The Uravan Mill Site is located on the San Miguel River, tributary to the Dolores River. Old tailings ponds designed to leach extraction solutions to the ground water and river were replaced in the early 1990's with lined evaporation ponds. These old ponds leached highly toxic and radioactive materials to the ground water and the San Miguel River. Also, prior to reclamation, a pipeline carrying a brine solution followed the San Miguel and the Dolores river. Breaks in this pipe occurred often, resulting in a plume of highly saline solution released on nearby vegetation and into the river. This pipeline no longer exists. (Cudlip, L 1987 to 1997, pers. Obser., Bio-Environs).

Since remediation began, water quality samples and bioassays of aquatic organisms reveal low levels of radionuclides and metals. More interesting is the immediate increase of Simuliidae larvae (black fly larvae), a pollution tolerant organism, after increased sedimentation. Increased sedimentation in the past 10 years has been typically related to intensive work in the San Miguel River streambed to remove contaminated soils, to reconstruct the river channel, or to create wetlands (Cudlip, L 1987 to 1997, pers. Obser., Bio-Environs).

Contamination of the Colorado River prior to remediation of this mill site may have been possible, but is undocumented. More likely, contaminants associated with sediments flowing downstream from the site, settle along the San Miguel or Dolores River before reaching the Colorado River, and before reaching the parks. Regardless, remediation of the site was clearly mandated, and the project is nearing compleation.

Lisbon Valley

Copper mining may return to the Lisbon Valley near Canyonlands. On August 8, 1995 Summo USA Corporation submitted a proposed Plan of Operations to the Bureau of Land Management, Moab District to develop a copper mine in Lisbon Valley, east of the Canyonlands Needles District. A heap leach sulfuric acid process would be introduced to extract copper from formally milled tailings and from ore. In this process, ore is crushed, piled in a heap and then sprinkled with sulfuric acid. As the sulfuric acid filters through the pile it dissolves the copper. The solution is then pumped out, and the copper recovered. The proposal includes the development of 4 open pits to access copper ore; four waste dumps, crushing facilities; a 266 acre leaching pad; a processing plant and ponds to recover the ore; construction of a 10.8 mile powerline to the project site; and associated support facilities. The total disturbance would include 1,103 acres and be located on a combination of federal, state, and private lands. Mining and processing would occur for a ten year period, with reclamation taking an additional five years to complete (Bureau of Land Management, 1997).

Geologically, the area is a collapsed salt valley which drains into the Dolores River. The record of decision in the Environmental Impact Statement confirmed the project, but this record of decision was protested as a result of inadequate ground water data. Recently, data and models assessing the development of pit lakes and the leaching characteristics of the rock substrate confirmed earlier conclusions that the copper operations would not cause impacts to the surrounding aquifers (Adrian Brown, Inc., 1998) . The Annual Hydrogeologic Update (Adrian Brown, Inc., 1998) demonstrates through modeling that water collected in the pits would be significantly better than the intact Burro Canyon aquifer at the end of mining and for 45 to 69 years later. However, the combined effects of evaporation and shallow ground water flowing to the pits contribute to an increase in total dissolved solids (TDS) above those in the Burro Canyon Aquifer (2,039 mg/L total dissolved solids). The shallow ground water will not be affected by these pits because ground water will flow from the aquifer to the pits in the long term according to Adrian Brown (1998), the consulting firm which conducted the modeling.

A deeper aquifer, the N-aquifer, has total dissolved solids level of 273,177 mg/L. Contamination of this aquifer would not occur, but water quality will tend to improve for 90 to 110 years after mining due to delivery of relatively clean water from the pits to the deep aquifer. Eventually concentrated pit water could reach the deep aquifer and increase total dissolved solids in the aquifer from 3 percent to 7 percent, well below the 25 percent total dissolved solids limit increase allowed by the ground water quality protection regulations (Adrian Brown, 1998).

Trace metals are not expected to concentrate in the pit ponds. Adrian Brown, Inc. (1998), through field tests, suggests that trace metals would be attenuated through natural processes and would not appear to concentrate in solution. Sorption and other chemical processes may control the fate of trace metals in the system. All told, ground water in the Lisbon Valley area appears to move northeast towards the Dolores River, and a fault system literally blocks movement of ground water to the west where the Needles District is located.

Potash

The Texaco Gulf Potash Mine (also known as Texasgulf, Inc. and Texas Gulf Sulfur Inc.) located on the Colorado River at the town of Potash was operated to collect potash originally through a pillar and post technique. This technique involves cutting rooms into the underground area leaving a series of pillars. These pillars support the mine roof and control the flow of air. In a tragic accident part of the mine collapsed killing several humans. Following this disaster, deposits were mined via an evaporative process. In 1970, Texas Gulf Sulfur Inc. began filling the underground mine with ground water from drilled wells. While drilling one of the wells for ground water, several artesian aquifers were encountered. These artesians broke into the mine and flooded it by January, 1971 months before complete fill of the mine was anticipated. Since they could not control water from the artesians, all the wells had to be capped. Instead, Colorado River water was pumped into the mine, and the solution containing potash was brought to the surface, transferred into ponds and allowed to evaporate (Phillips, 1975). The evaporite consisted of potash (KCl) as well as large amounts of salt ($NaCl$). The salt was stockpiled, and its proximity next to the Colorado River raised the concern that leachates may reach the river.

In the last 3 or 4 years, through a process of solution with Colorado River water and evaporation, the salt is developed into a marketable product. The pile size has been reduced considerably by this technique (Barnett, J., 1998, pers. comm., Colorado Salinity Control Forum). Presently, there are seven existing leases in the area and thirteen prospecting applications that have not been processed. If an entity were interested in mining the area, the Bureau of Land Management would guide the development of an Environmental Impact Statement (Jackson, L., pers. comm.., Bureau of Land Management). The Bureau of Land Management periodically sees increased interest in this area, but no serious mining plans have come to fruition.

Abandoned Mines

The number of prospecting hatches on topographic maps and actual mine adits found on the ground attest to the rich mining history within Arches and Canyonlands National Parks and outside their boundaries. Concerns associated with abandoned mines relate to elevated radiation levels emitted from the mines and contaminated mine drainage. The development of mines on the Colorado Plateau stems from the exploration for and mining of the nation's radioactive ores since 1900. Radium was used for medicinal purposes and in the production of luminescent dials. Vanadium was used in steel production, and beginning in 1943, uranium was mined for nuclear weapons and later during the mid-1960's, uranium was used for nuclear generation of electric power. Since the 1960's production of uranium has declined, but continues on a small scale (Burghardt, 1996).

Burghardt (1996) notes that there are no active mines on National Park Service lands in the Colorado Plateau, but the National Park Service inventory shows 44 abandoned radium or uranium sites in or immediately adjacent to National Park Service units. Reclamation of these mines was not required when many mines were opened; the responsible parties are long gone. Clean up or remediation of the sites comes under the auspices of the current land manager - typically the National Park Service, Bureau of Land Management or U.S. Forest Service.

In Canyonlands, Burghardt (1988) was instrumental in recommending the type of closure for ten mines in Lathrop Canyon. The mines were closed using cable nets in February 1989 (Burghardt, 1990). Six more mine openings were closed in 1996, and another five were closed in 1998. Inventories by park personnel and by Burghardt document several other mine opening sites. These include one site with two openings in Arches; these have been backfilled. In Canyonlands, there are 13 sites with 33 openings of which 16 portals have been closed. More importantly, there are numerous abandoned mine sites adjacent to both parks' boundaries, particularly in the Yellowcat Mining District north and east of Arches National Park.

Water contamination in these abandoned mines is evidenced by samples taken from the Lathrop Canyon Mines that were closed. Gross alpha, gross beta, and radium 226 exceeded state standards. Burghardt (1988) also expressed concern with trace elements in the mine waters and increases in contamination downstream of the mine openings. The data were insufficient to determine if the increases were due to the abandoned uranium mines.

The National Park Service, Geologic Resource Division, spearhead the effort to inventory abandoned mines, eliminate public hazards in and near mines, and rehabilitate natural resources as they relate to abandoned mine sites on park lands. However, more work could be accomplished on lands adjacent to the park where the proximity of the abandoned mine or drainage from the mine may impact park lands and water. A project statement is presented to this effect (ARCH-N-030.000, CANY-N-037.000)

Abandoned Oil and Gas Wells

A number of abandoned oil and gas wells exist within and close to park boundaries; they were used in the late 1970's and early 1980's to assess ground water quality for possible culinary water supply development (Sumsion and Bolke,1972; Richter, 1980; Hand, 1979) and to examine hydrology of the Needles District specific to a proposed nuclear waste facility east of Canyonlands (Ecosystems Research Institute, 1984). Sumsion and Bolke (1972) list three oil and gas wells in the northern part of Canyonlands. Developed by Husky Oil Co., Rosen Oil Co., and Pure Oil, there is information on the location, well depth, and geological formation associated with these wells. Ecosystems Research Institute (1984) also notes the Pure Oil well. Richter (1980) lists 29 petroleum test wells in the Needles District area and contiguous lands. Richer (1980) provided information on each well's location, depth to source, depth to production zone, reported rate of production, and reported water quality. Of these 29, 13 produced saline waters. Hand (1979) listed five petroleum test wells in the Maze District one of which produced saline waters, and two where water quality was unknown. Those parameters noted in Richter (1980) were also listed in Hand (1979). It is not known whether these wells were developed or were capped. Also there is no information regarding petroleum test wells in Arches.

Some of the geologic formations in the region were crated in marine environments and therefore have a naturally high concentration of dissolved solids. Fossil fuels are generally associated with marine shales and extraction of these resources results in increased dissolution of soluble minerals. Development of petroleum test wells can result in the discharge of saline ground water. Old well casings may corrode resulting in a release of saline water into the well. These wells were drilled in many cases over thirty years ago. No recent information regarding these wells has been found that may indicate disturbance, and the Bureau of Land Management requires that abandoned wells be plugged. However, the park needs to assess the status of the wells and any other petroleum test wells that may be present. A project statement addresses the need to inventory abandoned gas and oil wells. (ARCH-N-030.000, CANY-N-037.000)

Existing Mines and Oil and Gas Operations

There are approximately 31 active mines, mostly uranium mines within Grand, San Juan, Garfield, and Wayne counties that the Utah Division of Oil, Gas and Mining have recorded. This number does not include a State Institutional and Trust Lands inventory nor leases on private lands. Mining in the vicinity of Canyonlands and Arches may present potential impacts to water resources within the parks. A substantial amount of uranium mining in areas surrounding the National Park Servicelands on the Colorado Plateau has occurred in the past. Ground surface disturbance leading to erosion can impact water resources. Surface runoff and pollution from uranium mines can result in elevated levels of heavy metals, radionuclides and other toxic elements. Explortaion of oil and gas can result in the release of highly saline waters, because many of the wells reach geologic formations created in marine environments. In cases where drilling techniques do not meet approved protocols, drilling into or through these formations may cause contamination of less saline water in other formations (Aubry, A., 1998 pers. comm., Bureau of Land Management).

Several people at the September 18, 1997 scoping meeting expressed interest in an inventory of active mineral mines and oil and gas leases. To that end, a project statement is presented. (ARCH-N-030.000, CANY-N-037.000).

ISSUE 7: **NPS Wastewater Management**

Canyonlands NP

The Needles District has six functioning individual sewage disposal systems. One individual system services the visitor center, the maintenance facility, and a campground loop. Two systems service the 19 housing units. These systems are pumped out periodically and appear to function properly (Johnson, J.,1998 pers. comm.., National Park Service). The Maze District houses one individual sewage disposal system, and according to Pat Flannigan (1997 , pers, comm.., National Park Service), the system works properly, and are pumped frequently. There are currently no plans to increase the number of systems. There are three individual sewage disposal systems in the Island in the Sky District; two are dedicated to the nine housing units, and one is used by the maintenance shop. The visitor center utilizes vault toilets which are pumped three times per year. The systems and vault toilets are functioning properly according to John Jones (1998, pers, comm., National Park Service).

Arches NP

Arches utilizes two individual sewage disposal systems. They are located at the headquarters and at the Devil's Garden Campground. The latter system supports a 2,500 gallon septic tank and leach field. The tank is pumped as needed, and will be placed on a regular pumping schedule in the future (Frank Darcey, Facilities Manager, Maintenance Worker, pers. comm., Oct. 6, 1997).

The headquarters system has been upgraded in the past; the most recent upgrade from 2,500 to 5,000 gallons in 1992. The system remains undersized, and the US Public Health Service has developed recommendations for its remediation (Darcey III, F., 1997, pers. comm., National Park Service). Undersized systems can result in odor problems, ground surface contamination, water pollution, and an overall health problem. The park recently received $50,000 for FY 1999 to upgrade the existing system. Arches will either have two functioning 5,000 gallon septic tanks or one 10,000 gallon septic tank with appropriately sized leach field depending upon the final plans developed by the engineer. Arches continues to consider hooking into the Town of Moab sewer and water system some time in the future.

The greatest need regarding waste treatment systems in the parks is at Arches headquarters, and the engineering to remediate the problem has begun.

ISSUE 8: **Wetlands and Flood Plains**

Section 404 of the Clean Water Act notes that any discharge to waters of the United States requires a permit; wetlands are considered waters of the United States. In addition, Executive Order No. E.O. 11990 states there shall be no net loss of wetlands. To that end, National Park Service is responsible for insuring that no discharge to wetlands occurs without the proper permit.

A full delineation of all wetlands in both parks is not justifiable nor necessary, but instead, where potential development or an abundance of recreational activity has the potential to damage wetland resources, the parks should initiate wetland assessments. More importantly, assessment of riparian areas, i.e., documentation of flora and fauna within the riparian zone and wetlands is presented in a project statement. The parks need to recognize the significance of the riparian and wetland resources including those in Courthouse Wash, Salt Wash Valley, Salt Creek, and Indian Creek.

Impacts to flood plains result from depletion of water in the Green River, from recreational overuse, and from roads that follow stream systems. In addition, backcountry waste disposal poses a problem due to the continued increase of visitors to the backcountry. The Backcountry Management Plan (National Park Service, 1995) suggests that if the problem continues to increases, campers may be required to carry out their wastes; boaters are already required to do so. The arid climate and shallow or nonexistent soils preclude the timely decomposition of the human wastes - the only real value of these wastes being relegated to future archeologists, some invertebrates, and microorganisms.

To reduce impacts to flood plains and to adhere to National Park Service Flood Plain Management Guidelines (National Park Service, 1993b), the parks should ensure that backpack campsites are not located in high hazard flood plains. Several backcountry vehicle campsites were previously moved out of high hazard flood plains.

A flood plain assessment (National Park Service, 1990c) of the unnamed wash in Moab Canyon located by Arches Headquarters determined that the drainage was subject to hazardous flood flows that would present immediate danger to park visitors and employees in the vicinity of the park's main entrance. The assessment calls for more detailed assessment of bridge strength, a more detailed analysis of tributary flow, and the potential for debris flow. Lastly the assessment calls for a structural mitigation study that evaluates alternatives to the removal or relocation of vulnerable facilities. This study has not been completed and no relocation of buildings has occurred.

A project statement (CANY-N-030.000) is presented that details the problems of water depletion of the Green River and concomitant disconnection of the river from its flood plain. This situation is cast in a much larger problem regarding the regulation of the Colorado and Green rivers and how the National Park Service units along the Colorado River and its tributary may confront the challenges to their natural resources in the future.

ISSUE 9: **Salinity**

Jack Barnett (1998, pers. comm.., Colorado River Salinity Forum) noted that approximately $750 million of damage resulting from high salinity levels in the Colorado River occurs in the Lower Basin States. Increases in salinity (also referred to as total dissolved solids) are a concern, because high levels affect crop productivity, municipal and industrial users and the Republic of Mexico. Under Title I of the Colorado River Salinity Control Act (PL 93-320, 98-569, and 104-20), the United States is required to deliver water to Mexico having an average salinity no greater than 115 ppm +/- 30 ppm above the average annual salinity of the Colorado River at Imperial Dam (US Dept. of Interior, 1997).

The Upper Basin serves as an unlimited source of total dissolved solids to the Lower Basin states. Half of this source is from salt domes and the other half is from irrigation practices. The salt domes, a type of geologic formation containing high amounts of soluble minerals like NaCl, contribute to salinity in the Colorado River Basin through natural erosion processes. Several salt domes occur on the border of Colorado and Utah near Grand Junction, CO. Another salt dome, although collapsed, is a prominent feature of Arches.

The Colorado River Salinity Forum, the agency which seeks and is funded to reduce human induced increases in salinity to the Colorado River, has actively encouraged the Bureau of Land Management to target salinity problems on their lands. Target areas include cost effective management tools such as increasing vegetative cover, reducing use by all terrain vehicles, and reviewing and limiting discharges from oil and gas drilling operations. Barnett (1998, pers. comm.., Colorado river Salinity Forum) suggested that the National Park Service could implement management tools in Arches and Canyonlands similar to techniques outlined for the Bureau of Land Management BLM.

The Forum is exploring ways to close highly saline springs on public lands such as Onion Spring and Stinking Spring. Though they have not concentrated on determining what constitutes the total dissolved solids in the Colorado River; the Forum has interest in specific contaminants from the Atlas Corporation Moab Mill tailings site and at Potash. Also they have utilized federal funding to evaluate potential salinity production using a watershed modeling approach. To date, the Forum has analyzed watersheds in Utah and located the most cost effective watersheds in which to reduce salinity – approximately 15 watersheds out of some 300 possible. Additionally, another map depicting the Upper Basin states reveals those watersheds which contribute the greatest amount of salinity to the Colorado River (Figure 13). The following areas and formations apparently contribute the greatest amount of total dissolved solids to the river: 1) the Mancos Formation in the Grand Junction Valley, 2) the Paradox Salt Dome in and near Arches, and 3) the Paradox Valley in southwestern Colorado. In the latter area, alluvium saturated with brine is extracted and pumped to wells over 16,000 feet deep.

Park management may help reduce salinity in the Colorado River by utilizing techniques outlined in a project statement (ARCH-N-032.000, CANY-N-0403000).

ISSUE 10: **Coordination and Cooperation: Between Agencies and Among River Parks**
From a natural resource perspective, linkages among local, state, federal agencies, grass-roots organizations, and the scientific community are forged by geological location, jurisdiction, common interests, and most importantly, by the past and present political climate. Arches and Canyonlands cannot manage their resources without coordination between other agencies. Since park waters are not confined within park boundaries, how other agencies or private landowners manage their property affects these resources. A Water Resources Management Plan such as this can identify the stakeholders which are vital to a management effort across the landscape regardless of political boundaries.

The following provides a list of players, issues, and meetings with which the parks can work and engage. The Bureau of Land Management manages a tremendous amount of land surrounding the parks. Mining, recreation, and grazing are some of the main extractive activities occurring on these lands. The State of Utah maintains a checkerboard of land, which it can lease for extractive purposes. State-owned land within Arches totals 6902 acres. Congress is considering land passing legislation which would allow for the exchange of these lands. Portions of these lands are under State oil and gas leases and grazing permits. However, no development or grazing is occurring. The park land protection program recommends acquisition by exchange and eventual elimination of leases and permits (National Park Service, 1990a). There are no State sections within Canyonlands, however, some State sections within Bureau of Land Management lands abut the park (National Park Service, 1990b).

National Forest Lands managed by the US Forest Service do not abut the parks boundaries, but activities occurring on these lands do affect water resources in the parks if road building, grazing, mining, and recreation occur in specific watersheds. Management decisions by all three agencies can affect what happens to water resources within the parks. Two project statements addressing external land use activities provide tools for park management decisions.

The Bureau of Reclamation manages the operation of Flaming Gorge Reservoir from which the Green River flows. Operation of this dam has changed the flow dynamics and the channel configuration of the Green River through Canyonlands. A Biological Opinion to be issued in 1999 will direct how the Bureau of Reclamation will control flow releases from the

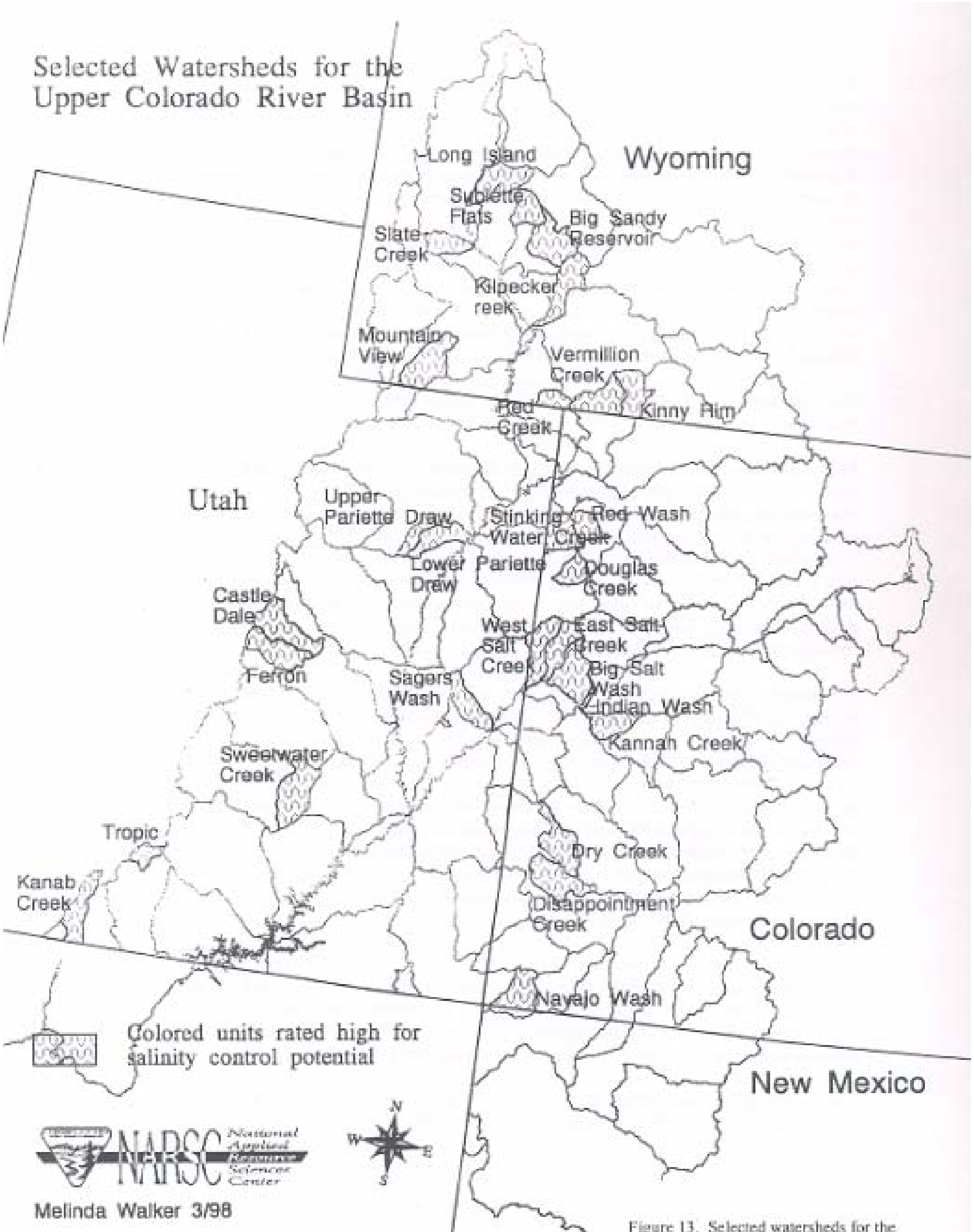

Figure 13. Selected watersheds for the Upper Colorado River Basin: High salinity control potential.

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reservoir.The Opinion is directed towards managing flows for the recovery of four endangered fish species in the Colorado and Green rivers. One park unit, Dinosaur National Monument, has been vocal regarding flow management in light of the recovery program as well as the efforts of the US Department of Energy, Western Area Power Administration (WAPA) to evaluate power marketing. Canyonlands personnel can play a significant role in the management of flows through the park by attending the Annual Operating Plan meeting held by the Bureau of Reclamation on a quarterly basis. At these meetings all parties discuss monthly and annual flow releases from Flaming Gorge Reservoir.

Two agencies interact with the parks regarding water quality assessment. The Utah Water Quality Division and the U.S. Geological Survey are involved in collecting water quality and flow data near the parks, and the state analyzes water samples collected by park personnel. These complimentary efforts continue to benefit all agencies. Key to this coordination is sharing of data, assistance from the state in improving or maintaining good water quality, and consideration of designation changes to stream segment classifications.

Lastly, the Bureau of Land Management manages much of the land which surrounds the two parks. Proper management of Bureau of Land Management as directed by their mission statement can insure that park lands and water sources are protected. However, because uses of Bureau of Land Management lands extend not only to mining and grazing, but recreation as well, severe impacts may occur to water resources entering the park. A lack of preventative management of land erosion and sedimentation in streams within Bureau of Land Management boundaries is a real problem, and can contribute to high total dissolved solids in the Colorado River (Barnett, J., 1998, pers. comm.., Colorado Salinity Control Forum).

At the least, park management staff should apprise themselves of all issues regarding the Green and Colorado rivers. It is of benefit to have representatives participate in and initiate informational and decision-making meetings. Advancing a National Park Service Colorado River parks stance through an expert, i.e., a fisheries biologist, could contribute greatly to confronting river issues such as channel narrowing and recovery of the fish species.

ISSUE 11: **Staffing Needs: A Park Hydrological Technician**
The value of water resources at Arches and Canyonlands National Parks is immense; due to the general scarcity of water and increased demand because of increased visitor use . In order to meet the water resource objectives of the parks, and to maintain viable water resources for wildlife, aquatic organisms and humans, an expert with a strong hydrological or fisheries background should be incorporated into the parks' efforts. The Southeast Utah Group has initiated efforts to hire a fisheries biologist. This person, with oversight from the Chief Resources Management could 1) initiate some of the following suggested water resource projects, 2) insure that water rights applications are being pursued, 3) participate in discussions of Colorado River and Green River issues ranging from Endangered Fish Recovery Implementation Plans to the Annual Operating Planning Meetings, and 4) insure that monitoring of seeps, springs, streams, and rivers is continued and adheres to standard protocols.

Since many of the projects outlined in this report (see Table 12) require greater technical assistance apart from what a fishery biologist could provide, the parks can pursue other funding sources that are well established. The project statements at the end of this document are developed specifically to seek funding from other sources including the unified calls that come from National Park Service in Washington, DC. In the event that park management wants to complete a project which is unfunded, a seasonal Hydrological or biological Technician could be hired This seasonal position is presented in Figure 14.

Current staffing related to water resources requires three permanent positions. The Chief, Resources Management, oversees five GS-11 positions, a Biologist, a Resource Management Specialist, a Planner, a GIS Specialist, and an Archeologist. The Biologist is involved with inventorying and monitoring, research management, the water quality sampling program, and visitor impact monitoring. The Resource Management Specialist works on river issues, wildlife biology, and some water quality assessment. The third permanent position, a planning position, is directly involved with management plans that affect water resources, for example the Canyonlands National Park and Orange Cliffs Unit of Glen Canyon National Recreation Area Backcountry Management Plan (National Park Service, 1995) and the Canyonlands National Park River Management Plan. The GIS Specialist is responsible for developing natural resource data layers. The Archeologist oversees archeological sites within the parks, which are often near water. A proposed Fisheries Biologist position would concentrate on threatened and endangered species issues and river issues. The Southeast Utah Group officially requested base funding for a Fishery Biologist position.

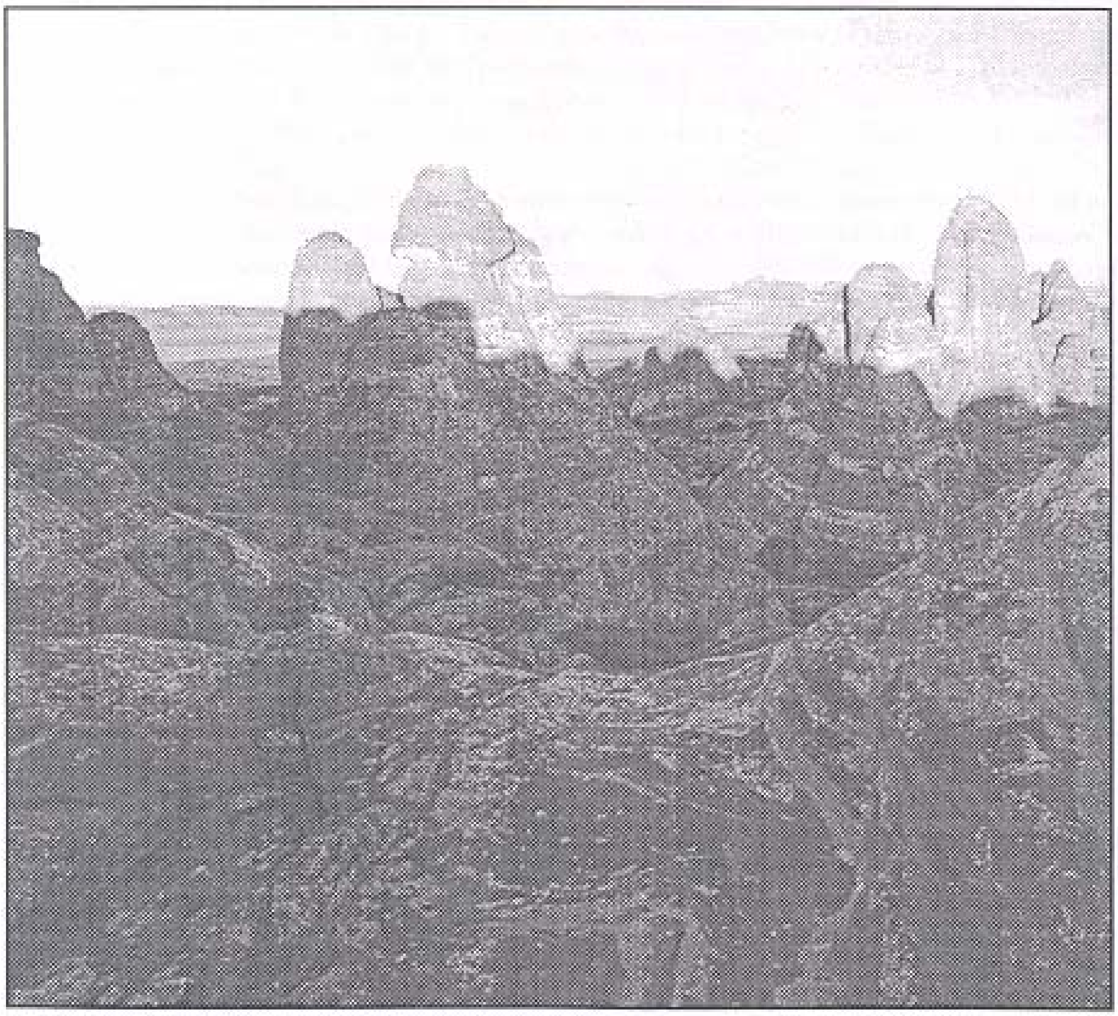
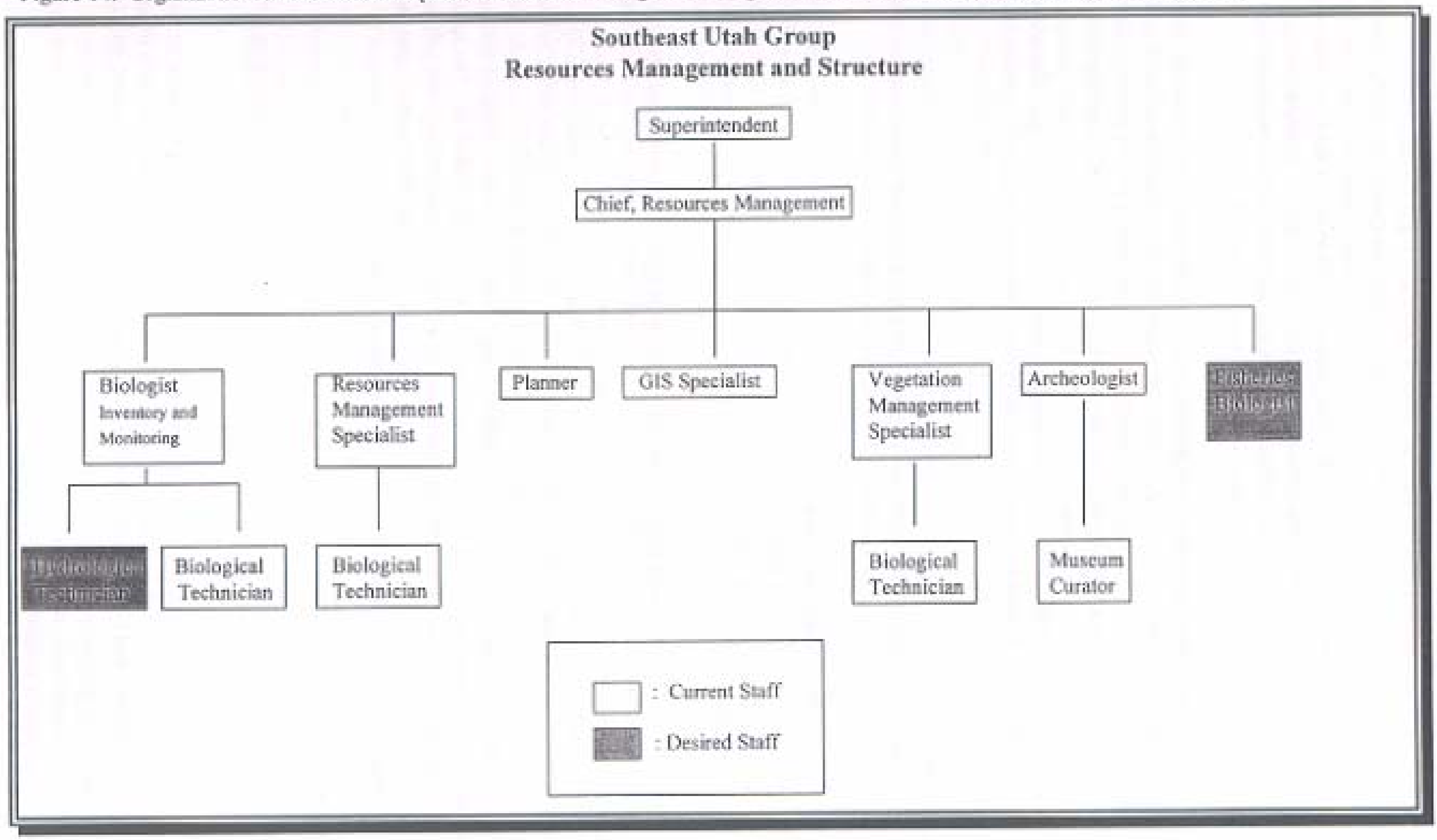


Figure 14. Organization Structure for Proposed Resources Management Program involved with Water at Southeast Utah Group .



WATER RESOURCES MANAGEMENT PROGRAM

The increased level of visitation to both Arches National Park and Canyonlands National Park dictates the need for a comprehensive water resources management plan in this arid environment. External threats from mining and recreation, and internal threats from visitor use of the resource encourage management to view water resources carefully, and to outline a program which consistently monitors water resources, addresses concerns, and alleviates water quality and quantity problems, or impacts to biota associated with water resources.

The current program consists of monitoring water quality at sites within the two parks and encouraging and supporting scientific research. The water quality monitoring effort is focused and adequate if the data are analyzed on a yearly basis. The research efforts are also highly informational, but their acknowledgment by the scientific community and more importantly by the parks is inconsistent or slow. Presently, the most overwhelming threat to water resources appears to be the parks ablity to meet water needs of an increasing visitor population while insuring that these water resources and associated habitats and their attendant organisms are not diminished.

The Program

The water resources management plan provides for a program with four components relating to the parks' water resource goals mentioned earlier in this document. They are:

- Inventory and Monitoring
- Cooperation and Coordination
- Specific Water Resource Issues
- Staffing Needs

Thirteen proposed projects have been developed within these four components and are not exclusive to any one project. The inventory and monitoring aspect of the program provides a basic understanding of the parks' water resources and a continuous assessment of these resources. The cooperation and coordination aspect is fundamental to the parks' roles as Colorado River parks share similar concerns, but, in some cases, have very dissimilar needs. Each park has issues that are site specific. For example, the effort to eradicate tamarisk, although pertinent to all Colorado River parks, is of particular significance to Arches, because this park is concerned about contamination of its spring resources which are vital to wildlife. The specific issues component addresses problems that have been consistently raised through this process as well as other resource initiative efforts. Lastly, staff needs are identified as they apply to implementation of projects outlined in this water resource plan.

Inventory and Monitoring

The purpose of the monitoring program at Arches and Canyonlands combines several specific objectives:

- Continue to collect and analyze water quality and quantity data on springs, seeps, streams, and rivers, to develop a meaningful information base on the structure and function of seeps, springs, streams and rivers, and to provide a database for informed management decisions.

- Continue and initiate monitoring of aquatic flora and fauna, atmospheric deposition, wetlands, abandoned mines, and land use activities to develop a scientifically sound database useful to park management.

The water quality monitoring program for Arches and Canyonlands underwent a major renovation in 1995; frequency of sampling increased and the number of sites sampled decreased. The present program includes sampling a cross-section of springs, creeks, and rivers. This streamlined program is structured for rigorous quality control and assurance and for yearly analysis. Support for this long-term effort is paramount to retrieving and understanding how these systems function and to determine and reacting to impacts from visitors and other external threats.

Support for assessment of the structure of the seeps and springs and certain creeks is less apparent. Substantial improvement in the collection and monitoring of the flora and fauna associated with these areas is needed. Again support of this aspect of the monitoring program will provide management with a basis for competent decision-making.

The confluence of the Colorado and Green rivers join in Canyonlands, and the Colorado River borders Arches. Although water quality assessment continues today, the parks have not remained sentient to the changing quality and quantity issues on the rivers. The parks have little information on land use activities external to their units. Not only do the parks' water resources need to be monitored, but the activities external to the parks need to be assessed. Trends in pH and ammonia, recovery of endangered fish species, and flow releases from Flaming Gorge Reservoir warrant greater attention.

The parks planners remain less knowledgeable than good management dictates regarding external mine and oil and gas lease locations, and land use outside park boundaries. Two project statements outline a means of developing a digital database which would include types of land use and location of abandoned mine lands, active oil and gas leases, existing mining claims, and coal mines within or near park boundaries.

- *Assess Springs and Seeps for Aquatic Flora and Fauna*
- *Evaluate Impacts to Salt Creek, and Horse, Lavender, and Davis Canyons in Canyonlands National Park*
- *Assess Salt Creek, Courthouse Wash and Salt Wash for Rare, Threatened, and Endangered Species*
- *Wetland Delineation of Salt Creek in Canyonlands National Park and Courthouse Wash in Arches National Park*
- *Location of Abandoned Mine Lands, Active Oil and Gas Leases, Existing Mining Claims, and Coal Mines within or near Park Boundaries*
- *Inventory of Land Use Activities External to parks*
- *Phased Study of pH and Ammonia on the Green and Colorado Rivers*
- *Evaluate the Structure and Function of the Colorado and Green River Corridors Ecosystem*

Coordination and Cooperation

This aspect of the program incorporates the following objectives:

- Recognize opportunities to develop plans and studies, and implement techniques in watershed management, and the management of the Green and Colorado rivers through the annual operating planning meetings and other avenues.
- Participation in watershed management invites coordination on issues such as salinity and external development.
- Participation in river management along the Green and Colorado rivers promotes an ecosystem approach to coordination of recovery efforts on the Green and Colorado rivers.

Development external to the parks and visitor use within the parks can lead to the degradation of whole watersheds. By focusing on watersheds instead of parsing by land agency boundaries, problems such as salinity may solved. Coordination is the key. The issues of the Colorado and Green rivers are not isolated to Arches and Canyonlands National Parks, but instead emanate from dams upstream on both rivers and tributaries to these rivers. Reduced flows and timing of flows, increased urbanization, the mining industry, and increased visitor use are common issues for the Colorado River parks. Arches and Canyonlands need to participate in and coordinate scientific and management efforts on these two rivers. Management also needs to insure that protocols for scientific research and monitoring in the two parks are clearly matched to and accepted by the scientific community and the National Park Service Water Resources Division. The following projects address the coordination component of the parks' program.

- *Hydrological Effects of Upstream Dams on Endangered Fish in the Colorado and Green Rivers*
- *Phased Study of pH and Ammonia on the Green and Colorado Rivers*
- *Evaluate and Reduce Contribution of Total Dissolved Solids to Major River Systems*
- *Evaluate the Structure and Function of the Colorado and Green River Corridors Ecosystem*

In addition, the parks need to
1. Participate in the Annual Operating Plan meetings for the Colorado and Green rivers.
2. Assign a park position to Colorado River parks coordination and research.
3. Establish a water resources initiative group for Southeast Utah.

Specific Water Resource Issues

This component of the program addresses issues identified as critical to proper park operations. The purpose of this aspect of the plan again combines several of the parks' objectives, and Recognize and address park water resource issues as directed by visitation levels, internal resource management, and activities external to the parks.

Parks operations sometimes impact natural resources. These impacts must be identified and understood before they become serious enough to diminish park natural resources. Arches uses Garlon 4 to eradicate tamarisk, and its use is effective; however, the park does not know to what extent the herbicide affects the aquatic environment. Also, an abandoned landfill consisting of park materials exists in the Needles District of Canyonlands. The park has already taken steps to evaluate and remediate the site. The parks to reconsider their ability to provide enough water to fill the demands inherent in increased visitor use and the related increase in park staff.. The parks again need locate water sources within their boundaries or continue to haul it.

Mining, poor grazing management, and urbanization negatively affect Arches and Canyonlands National Parks. Degradation of seeps and springs has always been a concern, but if the parks pursue water rights on springs used by trespass cattle, degradation of these sites may diminish. Mining efforts, such as the Moab Mill site, and the growth around Moab, Utah continue to pose serious external threats. Determining the location, and extent of external threats is a proactive means of protecting the resource. Park management may coordinate with other land management agencies to reduce impacts to park land. The following projects address specific issues at Arches and Canyonlands.

- *Assess Contamination of Springs from Tamarisk Control*
- *Water Rights Investigation for Canyonlands NP and Arches NP*
- *Culinary Water Development in Canyonlands NP*
- *Assess Locations of Backcountry Campsites Relative to Flood Plains*
- *Evaluate and Reduce Contribution of Total Dissolved Solids to Major River Systems*
- *Evaluate the Structure and Function of the Colorado and Green River Corridors Ecosystem*

Staffing Needs

It is necessary to identify the staff required to implement this management plan. Funding for operation of the Southeast Utah Group comes in two forms: base funding or project funding. Increases in base funding were realized in recent years, thus additional base funding is not likely to be forthcoming.

Many water resource activities are long-term, complex in nature and require a consistent and extensive knowledge base that can only be accomplished by a permanent staff member. The project statements are a means of funding a hydrological technician position. Current staffing is limited, and one person handles terrestrial and aquatic monitoring and specific projects. A Hydrological technician is necessary to implement or assist with many of these projects. This technician would be responsible for data collection and interpretation on seven projects. Four projects require the expertise of a Geographic Information Specialist. Eleven projects require park base funding for assistance from a Hydrological Technician. Nine projects require a Principal Investigator or Contractor for implementation, and one project requires the expertise of the Water Rights Branch of the Water Resource Division.

The parks should request the addition of a Hydrological Technician, who would be responsible for implementing several of the projects. The following section outlines the projects in a table format. The actual statements are presented (see Project Statement section) in a format compatible with the Resource Management Plan and can easily be incorporated into that document. The parks also request the addition of a Fishery Biologist to fulfill cooperation, coordination, and research obligations on the Green and Colorado rivers.

PROJECT STATEMENTS

Fourteen project statements are listed below in order of priority. This priority may change as tasks are completed, or as the political and natural resource environment changes. Where a project occurs in both Arches NP and Canyonlands NP, the project is assigned an Arches number and a Canyonlands number. Funding details are presented in the actual project statements. The estimated FTE requirements and grades are defined for each project statement. Table 11 summarizes the project statements.

ARCH-N-026.000 CANY-N-030.000	Assess Springs and Seeps for Aquatic Flora and Fauna
CANY-N-031.000	Phased Study of pH and Ammonia on the Green and Colorado Rivers
ARCH-N-027.000	Assess Contamination of Springs from Tamarisk Control in Arches NP
CANY-N-032.000	Culinary Water Development in Canyonlands NP
CANY-N-033.000	Hydrological Effects of Upstream Dams on Endangered Fish in the Colorado and Green Rivers
CANY-N-034.000	Evaluate Impacts in Salt Creek, Horse, Lavender and Davis Canyons in Canyonlands NP
ARCH-N-028.000 CANY-N-035.000	Wetland Delineation of Salt Creek in Canyonlands NP and Courthouse Wash in Arches NP
ARCH-N-029.000 CANY-N-036.000	Assess Salt Creek, Courthouse Wash and Salt Wash for Rare, Threatened, and Endangered Species
ARCH-N-030.000 CANY-N-037.000	Water Rights Investigation for Canyonlands NP and Arches NP
ARCH-N-031.000 CANY-N-038.000	Location of Abandoned Mine Lands, Active Oil and Gas Leases, Existing Mining Claims, and Coal Mines within or near Park Boundaries
ARCH-N-032.000 CANY-N-039.000	Inventory of Land Use Activities External to Parks
CANY-N-040.000	Assess Locations of Backcountry Campsites Relative to Flood Plains
ARCH-N-033.000 CANY-N-041.000	Evaluate and Reduce Contribution of Total Dissolved Solids to Major River Systems
ARCH-N-034.000 CANY-N-042.000	Evaluate the Structure and Function of the Colorado and Green River Corridors Ecosystem

Table 12
Summary of Project Statements

PROJECT #	PROJECT NAME	ISSUES ADDRESSED	PROBLEM SUMMARY	SUMMARY OF PROPOSED ACTIONS
ARCH-N-026.000 CANY-N-030.000	Assess Springs and Seeps for Aquatic Flora and Fauna	Inventory and Monitoring	Increased visitor use may impact aquatic resources. This project enables the parks to document their aquatic resources and to measure impacts.	Springs and seeps not assessed by Glen Canyon National Recreation Area will be assessed for amphibians and reptiles, vegetation, vegetation utilization by vertebrates, aquatic invertebrates, and human impacts.
CANY-N-031.000	Phased Study of pH and Ammonia on the Green and Colorado Rivers	Inventory and Monitoring Coordination and Cooperation	Trends in pH and ammonia in the Colorado and Green rivers bode poorly for the recovery of the endangered fish species.	The screening level includes permanent monitoring stations which measure pH, temperature and flow. Sampling also includes monitoring ammonia levels relative to storm events on the Colorado River below the Moab Mill Site. The multi-park level includes coordination of monitoring programs with other Colorado River parks.
ARCH-N-027.00	Assess Contamination of Springs from Tamarisk Control in Arches National Park	Specific Internal Water Resources Issue	Use of Garlon 4 in Arches may contaminate water resources used by wildlife, and impact ground water quality.	Sampling water for Garlon 4 after spraying, and whole effluent toxicity testing methods will be used to determine if there is a contamination problem.
CANY-N-032.000	Culinary Water Development in Canyonlands National Park	Specific Internal Water Resources Issue	Canyonlands continues to haul water to the Maze and Island in the Sky districts. Visitor use is increasing in the park. The park needs to determine if it feasible is to develop water sources.	An engineering and economic feasibility study is proposed to determine if development of water sources in or near the Maze District is possible. Water quality data relate that development of water in Island in the Sky is not desirable.
CANY-N-033.000	Hydrological Effects of Upstream Dams on Endangered Fish in the Colorado and Green Rivers	Coordination and Cooperation	Canyonlands harbors habitat vital to the survival and recovery of four endangered fish species. Vegetation encroachment restricts habitat availability. Flow releases from Flaming Gorge are related to this vegetation encroachment in the river.	Re-evaluation of cross-sections from Millard Canyon to the Sphinx in Canyonlands will help to calibrate models used to define the floodplain and to route flow releases from Flaming Gorge. Time lapsed photography will document changes in vegetation as a result of flow releases from the reservoir.
CANY-N-034.000	Evaluate Impacts to Salt Creek, Horse, Lavender and Davis Canyons in Canyonlands National Park	Inventory and Monitoring	Impacts from different types of recreational use and changes in management, particularly Salt Creek, require baseline inventory and comparison monitoring in Salt Creek, Horse, Lavender and Davis canyons.	The park will assess impacts to the aquatic invertebrate and riparian plant community based on a paired site comparison similar to Mitchell and Woodward (1993). Data collection and analysis will be used to assess the efficacy of the Backcountry Management Plan.
ARCH-N-028.000 CANY-N-035.000	Wetland Delineation of Salt Creek in Canyonlands and Courthouse Wash in Arches	Inventory and Monitoring	Discharges to jurisdictional wetlands require permits from the Corps of Engineers. Two areas within the parks which receive high use should be delineated for wetland resources.	A wetland delineation according to the 1987 Army Corps of Engineers Wetland Delineation Manual will be conducted on Courthouse Wash in Arches and on Salt Creek in Canyonlands.

Summary of Project Statements (continued)

PROJECT #	PROJECT NAME	ISSUES ADDRESSED	PROBLEM SUMMARY	SUMMARY OF PROPOSED ACTIONS
ARCH-N-029.000 CANY-N-036.000	Assess Salt Creek, Courthouse Wash, and Salt Wash for Rare, Threatened, and Endangered Species	Inventory and Monitoring	Inventories have not been conducted for threatened and endangered species in the Salt Creek drainage, nor in the Salt and Courthouse washes. Impacts from visitor use may encourage degradation of habitat for any species present.	The park would implement an inventory of rare, threatened, or endangered species in Salt Creek, Courthouse and Salt washes. Aquatic invertebrates, plants and the southwestern willow flycatcher will be surveyed.
ARCH-N-030.000 CANY-N-037.00	Location of Abandoned Mine Lands, Active Oil and Gas Leases, Existing Mining Claims, and Coal Mines within or near Park Boundaries	Inventory and Monitoring	Threats to the parks' water resources may include contamination of ground water and surface water resources as a result of mining and oil and gas leases.	The parks wish to develop a data layer or layers in a GIS to locate abandoned mine lands, active mines, and oil and gas leases. Preparatory work requires literature search and a review of the history of all the mining districts that may influence park water resources.
ARCH-N-031.000 CANY-N-038.000	Inventory of Land Use Activities External to Parks	Inventory and Monitoring	Threats to the parks' water resources from external land use activities may include urbanization, recreational uses, grazing and others. The parks need to map all the external land use activities.	The parks wish to develop a data layer for the GIS which documents land use activities around the parks. This will provide management with a basis for decision-making.
CANY-N-039.000	Assess Locations of Backcountry Campsites Relative to Floodplains	Specific Water Resources Issues	To insure the safety of visitors and to adhere to National Park Service Flood Plain Management Guidelines, the park needs to review the location of designated backcountry campsites.	The park is requesting technical assistance from WRD to assess the location of 21 designated backcountry campsites relative to the floodplain.
ARCH-N-032.000 CANY-N-040.000	Evaluate and Reduce Contribution of Total Dissolved Solids to Major River Systems	Specific Water Resources Issues Coordination and Cooperation	Salinity is one of the major and most pervasive water quality problems throughout Colorado River system. Contribution of dissolved solids to the system can be exacerbated by activities on public lands including park lands.	This project involves 1) reviewing the Colorado Salinity Control Forum's map which shows priority watersheds; 2) mapping saline springs and streams in a GIS; 3) collating the spring locations with roads, trails, and growth areas; and 4) summarizing a means of controlling salinity loading to the Green and Colorado rivers and to their tributaries.

Summary of Project Statements (continued)

PROJECT #	PROJECT NAME	ISSUES ADDRESSED	PROBLEM SUMMARY	SUMMARY OF PROPOSED ACTION
ARCH-N-033.000 CANY-N-041.000	Evaluate the Structure and Function of the Colorado and Green River Corridors Ecosystem	Specific Water Resources Issues Coordination and Cooperation Inventory and Monitoring	The Colorado and Green rivers are integral to both Canyonlands and Arches as well as to other National Parks. Several issues including visitor use, channel narrowing, loss of backwater habitat, tamarisk invasion, and lack of knowledge regarding structure and function of the riparian area, need study in order for Southeast Utah Group to make contributions to the management of the entire riverine system in these parks as well as in other river corridor parks.	This project involves 1) inventory and monitoring of all biota that use the riparian corridor; 2) installing permanent cross-sections and photo points from historic photos to document channel changes; 3) determining the capability of the riparian area for establishment of cottonwoods; 4) developing foods web interactions and an energy budget for the riparian ecosystem; 5) surveying for rare, threatened and endangered species along the river corridors; and 6) surveying river campsites for impacts.

Project Statement : ARCH-N-026.000
CANY-N-030.000
Last Update: 3/21/98
Initial Proposal: 3/21/98
Title: ASSESS SPRINGS AND SEEPS FOR AQUATIC FLORA AND FAUNA
Funding Status: Funded: 12.0 Unfunded: 33.0
Service Wide Issues: N17, N20, N22

Problem Statement: Water is the most important resorce in the semi-arid environment of the Southeast Utah Group, which includes Canyonlands and Arches National park. Without water, few of the attendant biological, geophysical, or chemical processes would occur. Exerting pressure on this critical resource is the increased visitations these parks are experiencing. The impacts to the parks' resources have increased as visitor numbers have grown. To be able to asses and address theses impacts, managers at the Southeast Utah Group must fist have comprehensive information on the water resources as they currently exist.

The Colorado River forms the lower southeast boundary of Arches, and both the Colorado and Green rivers bisect Canyonlands, which is also where the confluence of these two rivers is located. Other critical water resources in both parks are the seeps and springs, which can often be the only source of water in a large area. Seeps and springs serve a myriad of organisms, and park managers need to understand the structure these systems and how they function.

Spence (1996a) outlined a plan to characterize and identify water quality and biotic components in isolated springs along the Colorado River drainage system in three Colorado River parks including Canyonlands. The study plan (Spence, 1996a) directed that springs within 10 kilometers of the river corridor be surveyed. Only 15 percent of the 850 kilometer study reach of the Colorado River is contained within Canyonlands. This massive project failed to address springs and seeps of Arches and Canyonlands not within close proximity to the Colorado River. Additionally, National Park Service (1993c) outlined a research plan for the Southeast Utah Group. It presented one project statement for study of springs and seeps including those outside 10 kilometer distance from the Colorado River. The plan broadly compiled steps to address impacts to seeps and springs by humans; no specific techniques were provided

Water quality studies implemented since the 1970s continue today although on a much refined scale (National Park Service, 1994; Long and Smith 1996). A brief summary of water quality data by Long and Smith (1996) showed that median specific conductance for springs sampled in Arches and Canyonlands ranged from 190 μmhos/cm at Cabin Spring in the Island in the Sky District to 6000 μmhos/cm at Salt Creek Lower Jump in the Needles District. Their analysis revealed that a number of measured parameters exceeded state standards. For example, Salt Valley Wash in Arches revealed high metal levels (Cu > 20 μg/L, Pb =60 μg/L, and Zn = 190 μg/L) in a sample collected on 4/24/91. Further, the analysis indicated that most median water quality parameters appear to be within normal levels for small springs within the Colorado Plateau; however, 433 potential violations of state standards were identified in the water quality standards analysis. Quality control factors may have played a role in such a high number of parameters exceeding state standards.

The occurrence of vegetation and aquatic organisms associated with the springs and seeps has not been well documented. Conner and Kepner (1983) found few aquatic invertebrates in their search at several springs in Arches and Canyonlands . The lack of organisms prohibited a quantitative analysis, but they did find various aquatic beetles, mayflies, dipteran larvae, and damselflies. Wolz and Shiozawa (1995) conducted their study within the Needles District of Canyonlands. They found a total of 521 individuals representing 37 taxa with Diptera (fly larvae) being the most prevalent in Lost Canyon, Salt Creek, Big Spring Canyon, and Squaw Creek. Vegetative studies along springs and creeks are few, but include a rapid riparian assessment (Tolisano, 1996) which determined that adverse impacts to the proper functioning conditions in the riparian ecosystem in Salt Creek (Canyonlands) were more evident downstream of road crossings than upstream. The author focused on sediment as the element which caused degradation of the downstream sites.

The current Backcountry Management Plan (National Park Service, 1995) prohibits "swimming, bathing and immersing human bodies in water sources" little has been done to understand the effects of such actions on aquatic organisms and surrounding vegetation. Conducting water quality studies to assess levels of suntan oil, insect spray, and other cosmetic synthetic compounds in these water sources is achievable, but costly and the timing problematical because residence time of these chemicals may be short. Instead, monitoring specifically threatened seeps and springs for the survival, proliferation, and sustainability of associated aquatic organisms may be more suitable. In effect, Arches and Canyonlands can learn more about these specific resources by having at hand an ecological site characterization of various types of seeps and springs. If a particular system has been altered either naturally, by cattle or by humans, a continual monitoring program provides a means of cataloging existing conditions, changes, and provides guidance for remediation if the site becomes degraded.

Such a bioassessment of seeps and springs affords the parks the ability to document any threatened or endangered species, and to document the extent of invasion by exotics, and the extent of vegetation trampling by humans or cattle. Access to many of the springs and seeps is difficult, and thus gathering of information is optimized by collecting as much physical and site locale information as possible in addition to identifying and quantifying aquatic organisms and associated vegetation.

<u>Description of Recommended Project or Activity:</u>

Duration

This study will include 2 years of field work. The second year will also include data analysis and summary report preparation.

Site Selection

All springs, seeps, and pools regarded by the two parks as essential for the classification and assessment of these water resources must be included. Sites historically assessed for water quality should be included in the study. Additional sites may be included if they can provide a range of natural variation from pristine to degraded. Stream sites are not considered in this particular project statement. Site criteria for inclusion in this study are: presence of obligate wetland plant species, discharge of water for some period during the year, and location.

A preliminary list of sites by park is found in Table 1. Table 1 is a compilation of springs, seeps, pools selected from Huntoon (1977), Hand (1979), Richter (1980), National Park Service (1993), Long and Smith (1996), and Charlie Schelz (1997, pers. comm.., National Park Service). Review of this list may indicate elimination of some sites; however, sites without known threats must be included in this study as they serve as reference sites with proper functioning conditions and sound structure. Each site will be visited at least once over a two year period. Those Sites serving as reference or that have been highly threatened by trespass cattle or human use will be visited annually.

Methods

At each site, the following information should be collected:

- Presence/Absence and identification of amphibians and reptiles
- Vegetation cover and frequency of wetland obligate and facultative wetland species
- Physical attributes including soil type, texture, color within vegetation types
- Type of water resource: alcove seep, wash spring, plunge pool, plunge seep, wall spring, wall seep
- Indicators of human use
- Utilization of vegetation by cattle
- Identification and quantification of aquatic organisms
- Identification of threatened and endangered terrestrial and aquatic organisms

Amphibians and reptiles

Many amphibian populations have declined in recent years, and habitat destruction has been identified as an important contributing factor. To monitor the vigor of amphibian and reptile populations, this study proposes a presence/absence assessment of these organisms at selected seep, spring, and pool sites. The technician will identify species, determine number present at the site, and determine if they are threatened or endangered species. Vocalizations will also be recorded. Pit trapping will be used at selected reference sites and at threatened sites. This technique will require that a technician remain at the site for several nights in order to obtain amphibian and reptile abundance information. The pit trapping data will be combined with daily and nightly observations for a tabulation of the kinds and numbers of organisms at the springs or seeps.

Vegetation Cover and Frequency

Site selection criteria state that obligate wetland species must be present at the site. These species require water throughout the growing season, and almost always occur (estimated probability >99 percent) in wetlands under natural conditions (U.S. Army Corp of Engineers, 1987). The vegetation at each site will be described by assigning each species to a prominence level (Spence 1993, 1996b). Unidentified species will be collected, and a complete set of voucher specimens will also be collected. The presence of threatened or endangered species will be determined, and no collections made of these species. Life forms (annual forb, annual graminoid, perennial forb, perennial grass, shrub, tree, vine) will be noted for each species.

Invertebrates

Aquatic invertebrates will be identified, quantified, and collected at each microhabitat within a site. Dip nets and surber samplers will be used to collect invertebrates. A timed search approach allows comparison between sites, and within microhabitats. Diversity and abundance analyses will also be used to compare sites. Other information noted will be life form, dispersal mode, and geographic distribution. Invertebrates will be identified by specialists, and threatened and endangered species will be noted. Unless absolutely necessary, no threatened or endangered species will be collected.

Physical components

The geological attributes of the site will be recorded including the stratigraphy and the geomorphological landform. Soils type, color (if not sandy), and texture will be noted for each vegetation type encountered at the site. Elevation, aspect, and slope will be documented. Permanent photographic points will be established, georeferenced and mapped.

Impacts

Utilization of graminoids and shrubs will be documented and recorded as follows:

Severe:	81-100% utilization of present year's growth
Heavy:	61-80% utilization of present year's growth
Moderate:	41-60% utilization of present year's growth
Light:	21-40% utilization of present year's growth
Slight:	1-20% utilization of present year's growth

Human impacts will be noted as present, absent, and level of human activity determined using a scale of abundance of tracks.

Other organisms' use of the site will be documented by noting type and number of tracks.

Analyses

All data will be recorded in Microsoft ACCESS. Sites will be classified using an assortment of multivariate comparison techniques. Maps depicting areas of slight to severe stock use will be completed. Analysis of impacts from humans will be qualitative and referenced to the time period in which the site was visited. Maps will also be produced revealing level of use by humans.

Alternate Actions and their Probable Impacts: No action would result in a continued lack of understanding regarding the structure and function of these seeps and springs, and an inability to gage changes to these systems. Drought conditions occur periodically and have recently occurred. Less direct threats, include oil and gas development, and mining. Without cataloging and monitoring these systems over a period of time, a natural range of function and diversity will never be established. Attempts to distinguish impacts from outside sources will be limited.

Personnel: A Principal Investigator or GS-11 will oversee the project and implement the monitoring program. The Principal will select sites, confer with Glen Canyon National Recreation Area on the Colorado River sites, conduct monitoring, and perform analysis of data. Both years include assessment of springs and seeps, and Year 2 is devoted to completion of the data analysis. This project also requires the expertise of a Hydrological Technician and a Biological Science Technician (both at GS-7 levels) for 6 months per year for 2 years.

Compliance: CATEGORICAL EXCLUSION BASED on 516 DM2 App. 1.6

Relationship: This project directly related to a project at Glen Canyon National Recreation Area. At Glen Canyon, park personnel have collected water quality samples, assessed plant communities and aquatic vertebrate and invertebrate communities at springs within 10 kilometers of the Colorado River.

Funding:

BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:	PKBASE	Bio.Tech	6.0	0.25
2nd Year:	PKBASE	Bio.Tech.	6.0	0.25
3rd Year:				
		Total:	12.0	0.5

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	Prin. Invest.	10.0	0.2
	WRD	Hydro. Tech.	6.0	0.25
	WRD	Equip. and ID of Invertebrates	4.0	0.1
2nd Year:	WRD	Prin. Invest.	10.0	0.2
	WRD	Hydro. Tech.	6.0	0.25
	WRD	ID of Invertebrates	3.0	0.1
3rd Year:				
		Total:	39.0	1.1

Annual Project Status and Accomplishments: The annual reports will contain an assessment of the data through that year. The final report will detail findings, provide a statistical analysis of the types of communities found, and how these sites are impacted by humans as well as other organisms.

Literature Cited:

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Spence, J.R. 1993. A preliminary survey of hanging gardens and related vegetation along the Colorado River, Grand Canyon National Park. Report to Glen Canyon Environmental Studies and Grand Canyon National Park. Resource Management Division, Glen Canyon National Recreation Area.

Spence, J. R. 1996a. Research Study Plan: Characterization and identification of water quality and biotic components in isolated springs along the Colorado River Drainage system, Utah and Arizona: Canyonlands National Park, Grand Canyon National Park, and Glen Canyon National Recreation Area. National Park Service.

Spence, J.R. 1996b. Riparian vegetation in side canyons of Lake Powell: community structure, species diversity and site relationships. Final report, National Park Service, Resource Management Division, Glen Canyon National Recreation Area.

Tolisano, J. 1996. Analysis of ecological impacts from jeep trail use on riparian communities in the Salt Creek watershed. Investigators Annual Report. Canyonlands National Park.

Wolz, E.R. and D.K. Shiozawa. 1995. Aquatic macroinvertebrates of the Needles District, Canyonlands National Park, Utah (including Lost Canyon, Salt Creek, Big Spring Canyon, and Squaw Canyon). Brigham Young University, Provo, Utah.

Table 1. Location of historical springs and seeps that have water quality data associated with them.

Park Unit/District	Location	Code[a]	Threat and Level[b]
ARCH	Courthouse Wash	CW1	Swimming; H
ARCH	Freshwater Spring	FW1	Swimming; H
ARCH	Sleepy Hollow	SH1	Swimming; H
ARCH	Willow Spring	WS1	Livestock; H
CANY/Island	Holeman Spring	HSB1	Oil/Gas; L
CANY/Island	The Neck Spring	TC1	unknown
CANY/Island	Cabin Spring	TC2	unknown
CANY/Island	Willow Seep		unknown
CANY/Island	Syncline Spring		unknown
CANY/Island	Seven Mile Spring		unknown
CANY/Island	Sheep Spring		unknown
CANY/Island	White Rim #1 Spring		unknown
CANY/Island	White Rim #2 Spring		unknown
CANY/Island	Hardscrabble Spring		unknown
CANY/Island	Lathrop Spring	WR1	unknown
CANY/Island	Shafer Spring	SHS1	unknown
8CANY/Needles	2.4 Mile Loop Pool	BS2	Swimming; H
CANY/Needles	Cave Spring	SQ3	Leach Field: H
CANY/Needles	Big Spring Lower	BS6	unknown
CANY/Needles	Soda Spring	BS3	unknown
CANY/Needles	Big Spring Upper	BS4	unknown
CANY/Needles	Little Spring Canyon	LS1	unknown
CANY/Needles	Davis Canyon	DC8	unknown
CANY/Needles	Loop Trail Spring		unknown
CANY/Needles	Hangover Spring		unknown
CANY/Needles	Dorius Spring		unknown
CANY/Needles	Echo Spring		unknown
CANY/Needles	Peekaboo Spring		unknown
CANY/Maze	Maze Overlook	SF3	Swimming: H
CANY/Maze	Chocolate Drops	SF4	Swimming; H
CANY/Maze	Horseshoe Upper	HSC1	unknown
CANY/Maze	Horseshoe Lower	HSC2	unknown
CANY/Maze	Junction Spring	HC1	unknown
CANY/Maze	Plug Spring	SF1	unknown
CANY/Maze	Harvest Scene	SF2	unknown
CANY/Maze	Gap Downstream	SF5	unknown
CANY/Maze	Gap Upper Spring	SF6	unknown
CANY/Maze	Lower South Fork	SF7	unknown
CANY/Maze	Ernie's Country West	WA1	unknown
CANY/Maze	Ernie's Country East	WA2	unknown
CANY/Maze	Water Canyon	WC1	unknown
CANY/Maze	South Fork Spring		unknown
CANY/Maze	Jasper Canyon Spring		unknown
CANY/Maze	Sheeper's Spring		unknown

[a] Code as assigned in Long and Smith (1996). Blank codes reveal that these sites are from Huntoon (1977), Hand (1979), and Richter (1980).
[b] Level refers to level intensity of suspected use. H - high threat, L - low threat.

Project Statement CANY-N-031.00
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: PHASED STUDY OF pH AND AMMONIA ON THE GREEN AND COLORADO RIVERS
Funding Status: Funded: 12.0 Unfunded: 32.5
Service Wide Issues: N00, N02, N11

Problem Statement: Possible trends in the level of pH on the Colorado and Green rivers may bode poorly for the health of the native and non-native fishery. Measured pH levels in Desolation Canyon on the Green River have been as high as 9.3 and 10 standard units. This is the same area in which fish kills have been noted. Additionally, other pH levels on the Green River have been measured well above 8.8. Before and after a rain at mile 35.4, the pH was 8.8 and 9.7, respectively, possibly indicating low acidity (i.e., buffering capacity).

This increase in pH may be linked to several human activities. Increases in the number of acres of irrigated land since colonization of the West has contributed to increased salinity and alkalinity in the Green and Colorado rivers. Also, the mean annual dissolved solids concentrations has increased from less than 100 mg/L in the headwaters area to greater than 500 mg/L at the lower reaches of the Upper Colorado River Basin. Decreased water flows in tributaries to the Green River may be linked to increased pH levels (Wick, e., 1997, pers. comm., National Park Service).

Increased amounts of nutrients in the Colorado River system arise from various inputs of nutrients by human activities, including: sewage inputs from older treatment systems, non-point source runoff, side wash spates containing organic material driven by intense thunderstorms, increased urbanization (e.g., golf courses, fertilizers from yards), and irrigation. As a result nutrient enrichment of these large river systems can increase causing plankton blooms and concomitantly, a rise in pH levels. Such rises would be of particular concern during the hot summer months and fall low-flow months (Irwin, R., 1998, pers. comm., National Park Service).

Associated with rising pH levels and increased temperatures during summer months is the possibility of ammonia toxicity. The potential increase in ammonia levels in the Colorado River downstream of the Atlas Mill Site in Moab, UT continues to be discussed as the Nuclear Regulatory Commission provides oversight to the remediation of the Atlas Corporation Moab Mill. Ammonia serves as a chelating agent and can strip metals from other compounds; the result may be increased movement of metals from the uranium tailings pile into the Colorado River. Also, most fish do not produce urea. To rid their bodies of ammonia, the concentration of ammonia in the water must be lower than the concentration in their bodies. If the pH of the water is greater than 9.3 the fish may be unable to rid their systems of ammonia, which can lead to high stress, toxicity and death (Irwin, R., 1998, pers. comm., National Park Service).

The Southeast Utah Group has sampled the Green and Colorado rivers since 1983. Ammonia was not typically measured, but pH has been consistently measured in situ using a Hydrolab unit. These same data at a site near the Highway 191 crossing at Moab on the Colorado River reveal a slight visual upward trend, but may reflect higher variability in earlier samples (1970’s) as opposed to later data collected in the 1990’s (STORET data, 1975 to present, retrieved from the Utah Dept. of Environmental Quality). Also scatter plots of pH data along the Colorado River system from independent sources show a slight upward trend at Moab, in Glen Canyon

National Recreational Area, in Grand Canyon National Park, and in Lake Mead and its tributaries near Las Vegas.

The Southeast Utah Group monitor sites on the Colorado and Green rivers once per month only. At such a frequency little can be inferred about pH changes as a result of climatic events, local weather storms, or changes in flow as a result of upstream control. Further, samples for ammonia analysis are collected at eight sites on the Green and Colorado River at the same time pH levels are measured. Again, the frequency at which these data are collected does not lend itself to a comprehensive understanding of what happens to these water quality parameters on a weekly basis, not to mention on a diel basis. Presently, Canyonlands personnel are concerned with any further increases in pH levels and would like to obtain better data on the ammonia levels are in the Green and Colorado Rivers.

Description of Recommended Project or Activity:

The park recommends a phased program including a screening level project which could lead to a much larger multi-park project along the Green and Colorado rivers.

Phase I -Screening Level

pH and Temperature

Park managers propose installing three permanent monitoring stations which record stage of water, pH and temperature. The sites would be located on the Colorado River at Moab, Utah, below the Atlas Corporation Moab Mill, below a side wash on the Colorado River within Canyonlands, and on the Green River within Canyonlands. These stations will consist of a stilling well, which would house a unit with the capability of monitoring pH and temperature, and a pressure transducer which would record stage of the river.

The pH and temperature monitoring device would record data on an hourly basis and information can be downloaded from the unit according to the storage capability of the datalogger. The transducer will provide river stage and will be calibrated to an actual instream flow measurement each time the transducer was instantaneously monitored. A stage-discharge rating curve would be developed, and related to changes in pH and temperature. A datalogger connected to the pressure transducer can store data on a quarterly or half-hour basis. Again this data would be downloaded according to the storage capability of the datalogger.

It is difficult to measure flow on this river system, which may only be measured at low flows. In this case, a transducer is severely limited in providing good flow measurements. Flows may have to be calculated based on known flows at Cisco, Utah or other stations. Inflows from side canyons must also be estimated. The cost of such stations are high, but maintenance can be low if they are installed properly.

Ammonia

Ammonia levels are now measured on a monthly basis at the eight Green and Colorado river sites. Samples are collected and sent to the Utah Department of Environmental Quality for analysis, and levels reported as concentration of ammonium ion in mg/L. A more frequent and timely means of obtaining ammonia information is required in light of the anticipated problem with ammonia toxicity in the vicinity of Moab on the Colorado River.

Park managers propose a monitoring program which specifically measures ammonium ion, pH and temperature on the Colorado River below the Atlas Corporation Moab Mill, and below a side wash on the Colorado River. This will be done on a weekly basis commencing after peak flow (May or June) and continuing through October. Park personnel would measure pH, dissolved oxygen, and temperature with the park's Hydrolab, and samples will be collected for ammonium ion analysis. In addition, samples would also be taken just before and soon after several thunderstorms. These samples could be analyzed in the field using an Orion ion analyzer and ammonia probe. Alternatively, samples could be preserved in the field and sent to the Utah Department of Environmental Quality. The ammonium ion level would be translated into total ammonia and into unionized ammonia units for comparison with known criteria and benchmarks.

Some initial investigations will also be done to determine the amount of upper buffering capacity present in the river water from the collection sites. Using a titration method, approved by water quality experts at U.S. Geologic Survey and National Park Service/Water Resource Division, a base such as NaOH will be added to the river water to determine how much upper buffering remains to prevent future increases in pH. This will be done before and after daily rises in pH due to algal blooms, and before thunderstorms. The idea is to begin to understand whether there is sufficient upper buffering left in the Colorado River system to prevent the pH from rising to a more persistently dangerous levels in the future.

The detailed planning, methods, and specifications for the efforts to determine upper buffering, and also concerning general field monitoring methods, Quality Assurance/Quality Control, any possible lab methods, data recording and STORET reporting and final analyses and interpretation of the data will be reviewed and approved by the National Park Service Water Resources Division in Fort Collins prior to study implementation.

Provided with substantive data, park management can determine how serious the ammonia and pH levels are and then begin to coordinate with other Colorado River parks to avoid and remediate actions which induce increases in pH levels or ammonia toxicity.

Phase II - Multi-park project

The phase I project will be completed in order to provide initial information for a phase II project. The phase II project would combine efforts of Dinosaur National Park, the Southeast Utah Group, Glen Canyon National Recreation Area, Lake Mead National Recreation Area and Grand Canyon National Park in order to predict whether or not pH is likely to rise to lethal levels along the Colorado River system.

The amount of upper buffering (the buffering that would prevent pH from moving up), pH, temperature and ammonium ion would be measured at selected sites along the Colorado and Green rivers. Phase II would utilize the data retrieved from the Phase I project and other projects like it on the Green and Colorado rivers. A multi-agency and ecosystem approach to designing the monitoring program is essential. Reliance on past data is paramount to determining site locations, and frequency of sampling.

Alternate Actions and their Probable Impacts: No action would result in a continued lack of knowledge regarding the potential threat of rising pH levels in the Colorado and Green rivers. Without monitoring ammonia park management will not be able to understand how this aspect of the water chemistry is degrading or improving as a result of a final remediation plan for the Atlas Corporation Moab Mill. At persistent levels of pH above 9.3, fish are highly stressed, and ammonia levels are toxic. This can result in the death of fish. Recovery of the endangered species would become impossible.

Personnel: This project requires: 1) a Principal Investigator to oversee the project for its entire duration, to assure that samples are properly collected and analyzed with good Quality Analysis/Quality Control, to compile and produce the detailed final report (including an analyses of what the data means relative to possible trends in pH and ammonia and possible hazards to aquatic resources), 2) a Hydrological Technician at GS-7; two days per week for 1 year; 3) two Maintenance Workers for 1 week to install stilling wells.

Compliance: CATEGORICAL EXCLUSION BASED on

Funding:
BUDGET AND FTES:

		FUNDED			
	Source	Activity	Budget($1000's)		FTEs
1st Year:	PKBASE	Maint. Worker	2.0	0.1	
2nd Year:					
3rd Year:			-------------------------------------		
		Total:	2.0	0.1	

BUDGET AND FTES:

		UNFUNDED			
	Source	Activity	Budget($1000's)		FTEs
1st Year:	WRD	Prin. Invest.	15.0	0.5	
	WRD	Hydro. Tech.	6.0	0.25	
	WRD	Equip: Ammonia	2.5		
	WRD	Equip: Datalogger & Stilling Well	22.5		
2nd Year:					
3rd Year:			--------------------------		
		Total:	46.0	0.75	

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

Project Statement ARCH-N-027.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: ASSESS CONTAMINATION OF SPRINGS FROM TAMARISK CONTROL IN ARCHES NP
Funding Status: Funded: 0.00 Unfunded: 12.8
Service Wide Issues: NO5, V04

Problem Statement: Salt Valley Wash in Arches National Park is a tributary to Salt Wash and was formed as a result of collapsed salt anticlines in the Paradox Formation. Salt Valley Spring is a perennial water source located in the headwaters of the wash and has been developed in the past for stock watering. This area has also been considered for reintroduction of pronghorn if a sufficient water source was found. The spring has been at risk of completely drying up due to invasion of tamarisk (*Tamarix ramosissima*). The National Park Servicehas been involved in a tamarisk eradication project in order to control this species. Routinely the tamarisk are cut down and the stumps sprayed with Garlon 4 to inhibit regrowth. Removal of the tamarisk reduces evapotranspiration and rejuvenates the spring by increasing discharge back to natural levels. Concern has been expressed over the use of Garlon 4 an organic herbicide in ridding the area of tamarisk.

A study to measure presence of residual herbicide levels in the surface water would determine if, in fact, contamination is occurring. Use of Garlon 4 appears to be the most effective method of controlling tamarisk; however, at the risk of contaminating an important water source for wildlife, this type of exotic weed control may have to change. The chemical name for Garlon is [(3,5,6-trichloro-2-pyridinyl) Oxy]acetic acid and has limited solubility in water and does not degrade easily. It is similar to 2,4-D and referred to as triclopyr (Hultquist, A., 1998, pers. comm.. Utah Dept. of Environmental Quality). The CAS # for triclopyr is 55335-06-3.

Triclopyr is slightly toxic to mallard (*Anus platyrhynchos*) ducks. When fed the compound, the LD50 was 1698 mg/kg. LD50 is the lethal dose which kills 50 percent of exposed organisms within a specified time period. The compound is practically non-toxic to fish. Triclopyr has a LC50 of 117 ppm for rainbow trout and a 96-hour LC50 of 148 ppm for bluegill sunfish. LC50 is the lethal concentration which will kill 50 percent within a specified time period. The compound is also non-toxic to the aquatic invertebrate *Daphnia magna*, a water flea (LC50 for the triclopyr salt of 1170 ppm) (Gersich et al., 1984). However, toxicity to other invertebrates has not been documented.

In natural soil and in aquatic environments, two of the formulations rapidly convert to the acid which in turn is neutralized to a salt. Triclopyr is not strongly adsorbed to soil particles, has the potential to be mobile, and is rapidly degraded by soil microorganisms. Concentrations of 500 ppm had no apparent effects on the growth of common soil microorganisms (Gersich et al., 1984).

The half-life in soil is from 30 to 90 days, depending on soil type and environmental conditions, with an average of about 46 days. The half-life of one of the breakdown products (trichloro-pyridinol) in 15 soils ranged from 8 to 279 days with 12 of the tested soils having half-lives of less than 90 days. Longer half-lives occur in cold or arid conditions. Breakdown by the action of sunlight is the major means of triclopyr degradation in water. The half-life is 10 hours at 25 ^{o} C. The major metabolite is trichloropyridinol.

Triclopyr is readily translocated throughout a plant after being taken up by either roots or the foliage. The estimated half-life in aboveground drying foliage, as in a forest overstory, is two to three months (Pesticide Information Notebook, 1998.)

Historical tamarisk management projects typically included root plowing and raking, dozing, mowing, prescribed burning or cut-stump treatments. Arsenal™ applied alone or with Roundup™ provided 95 percent or greater control of tamarisk (Duncan, 1997). This kind of success encourages continued use of herbicides for management of tamarisk. However, the biological control of tamarisk is forthcoming although such organisms have not been approved for release in the United States. Until such time, the parks must continue the use of Garlon 4, but also realize the ramifications of its use on the aquatic environment.

Another area where effective tamarisk control is evident is at Salt Valley Wash (SVW1 - name for water quality collection site). Here, the tamarisk were removed approximately six years ago. Multi-stemmed trunks with diameters at breast height exceeding 5 inches (12.7 cm) were not unusual. These shrubs were removed and the cut stumps sprayed with Garlon 4. The effort has been effective with few to no tamarisk present today. The water source is still minimal and stagnant during the winter months. Water quality data reveal that the pH is subneutral, the dissolved oxygen low, specific conductance high (median: 3285 μmhos/cm), and the median total ammonia is 1.325 mg/L (Long and Smith, 1996).

<u>Description of Recommended Project or Activity:</u>
The practice of tamarisk control will and must continue, but in certain areas, will be phased with assessment of Garlon 4 and its by products in the water. To avoid risk of losing ground in eradicating tamarisk, all control methods will continue. However, each time Garlon 4 is sprayed, samples will be collected from the spring. Collection will coincide with application, before application, one-half hour after application, one day after application, and one week after application.

Samples will be collected according to prescribed methodology and sent to a certified laboratory for analysis using chlorinated phenoxyacid herbicide method which is typically used to test for 2,4-D. In addition, an acute whole effluent toxicity test will be conducted. Samples of water, typically 4 liters per sample, are sent to a lab that utilizes *Ceriodaphnia sp.* and fathead minnows to test for contamination. Uncontaminated water is also collected and sent to determine if these organisms can survive in the original source. If the organisms do not survive in uncontaminated water, then native aquatic species must be used, and a procedure developed on site using native aquatic organisms. Samples must be sent the same day to the testing facility.

Since application of the herbicide is not broad, but instead specific to cut stumps, park personnel assume little contamination of the adjacent water source.

<u>Alternate Actions and their Probable Impacts:</u> No action would result in a continued lack of knowledge regarding effects of herbicide application on tamarisk near water supplies, and the indirect impacts if herbicide on aquatic organisms.

<u>Personnel:</u> This project requires: one Hydrological Technician at GS-7 for 2 days per week for 3 months. This is a two year project and requires that a technician be available at times when tamarisk control is taking place, throughout the spring and early summer months.

Compliance: CATEGORICAL EXCLUSION BASED on 516 DM2 App. 1.6 applies only to the sampling project. Application of Garlon 4 is a separate and ongoing project.

Funding:

BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:			0.0	0.0
2nd Year:				
3rd Year:			--------------	--------------
		Total:	0.0	0.0

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	Hydro.Tech.	2.4	0.1
	WRD	Chemical and Toxicity Test	5.0	
2nd Year:	WRD	Hydro.Tech.	2.4	0.1
	WRD	Chemical and Toxicity Test	5.0	
3rd Year:			--------------	--------------
		Total:	14.8	0.2

Annual Project Status and Accomplishments: This report will be initiated once work begins on this project. The report will state whether use of Garlon 4 is detectable in the water sources after spraying has occurred.

Literature Cited:

Duncan, K.W. 1997. Saltcedar (*Tamarix spp.*) Management. Woody Plant Wetland Workshop: Saltcedar, Russian Olive. September 3 & 4, 1997, Grand Junction, CO.

Gersich, F.M., C.G. Mendoza, D.L. Hopkins and K.M. Bodner. 1984. Acute and Chronic Toxicity of Triclopyr Triethylamine Salt to Daphnia magna Straus. Bulletin of Environmental Contamination and Toxicology 32:497-502.

Long, B.A. and R.A. Smith. 1996. Water Quality Data Analysis and Interpretation for Spring Monitoring Sites : Southeast Utah Group. Technical Report. National Park Service. NPS/NRWRD/NRTR-96/77.

Pesticide Information Project of Extension Offices of Cornell U., MSU, OSU, and UC-Davis. 1998. Pesticide Information Notebook. Extension Toxicology Network. http://pmep.cce.cornell.edu/profiles/extoxnet/

Project Statement CANY-N-032.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: CULINARY WATER DEVELOPMENT IN CANYONLANDS NATIONAL PARK
Funding Status: Funded: 0.00 Unfunded: 50.0
Service Wide Issues: N24

<u>Problem Statement:</u> Culinary water is a prime concern in Canyonlands National Park. Visitation to this park has risen tremendously: at Canyonlands from 60,000 in 1980 to 434,834 in 1993 (Hecox and Ack, 1996). Subsequently, the provision of water for the visitor and park personnel has risen. In the late 1970's and early 1980's several hydrogeological studies investigated the probability and the location of potential water development sites within Canyonlands and Glen Canyon National Recreation Area to meet the visitor increase. No new water sources were developed as a result of the studies. Since then visitors to the park have reached a plateau recently with numbers equaling 432,697 in 1997. However provision of water for visitors and Park personnel is still necessary.

In 1991, Canyonlands NP developed a well in the Needles District which provides park personnel with potable and adequate water. This well is referred to as NPS Needles No.4. It is 253 feet (77 meters) deep and is located near Cave Springs. Up to eight wells have been drilled in the area of the visitor center and headquarters. Of these, four are not functional and are ready for capping. Culinary water supplies for the Needles District appear adequate for the present and near future.

Both the Maze and the Island in the Sky district have their water hauled to their visitor centers. The Island in the Sky District obtains its culinary water from Arches via an 8000 gallon tanker truck. The water is stored in a 30,000 gallon storage tank. Approximately 3 truck loads per month are hauled during the high visitor use season, and one to two loads during the winter season. Huntoon (1977) recommended that development of ground water in the Island in the Sky District from the Navajo and Wingate sandstones not be considered because the rocks are well drained, receive little recharge, and lack structural traps. However, the White Rim sandstone at elevations of less than 4000 feet (1220 m) under the western parts of Horsethief and Mineral Points is saturated and will generate 25 to 100 gallons per minute. The drawback in developing this source is the water quality: total dissolved solids equal 2730 mg/L. Based on the Utah Drinking Water Standards, the maximum contaminant level for total dissolved solids is 1000 mg/L

The Maze District obtains its water from the City of Moab, Utah, four times per year. The water is hauled via a truck, and transferred to two tanks totaling 25,000 gallons. The ground water needs in this district were modest, but have increased immensely. In the 1970s, Hand (1979), recommended developing Spring No.2 one mile (1.61 kilometer) northeast of the Horseshoe Canyon Detached Unit, and Springs No.9 and No.11 west of Hans Flat. The existing Hans Flat well produces water of poor quality due to high dissolved solids (1600 mg/L taken on 7/5/78). The water quality has not changed over the years as evidenced by the park's request to cap the Hans Flat well.

<u>Description of Recommended Project or Activity:</u> In order to insure that culinary water requirements are met in the future, and to reduce or even to cease hauling water, Canyonlands should pursue an economic and engineering feasibility study of water development in the Island in the Sky and the Maze District. The Island in the Sky District has the least potential for

development, because the Navajo and Wingate sandstones are well drained units in this part of the park, and although the White Rim Formation is saturated below 4000 feet (1220 meters), the water is less than potable and would have to be treated for high dissolved solids.

There are also problems with development of water sources in the Maze District. Consequently, the greatest potential for this district lies outside the park boundary at two springs identified in Hand (1979). These springs are west of Hans Flat on Bureau of Land Management lands.

The engineering and economic feasibility study would determine whether or not these water sources could be developed economically, and more importantly, would determine whether these sources should be developed in terms of visitor use impacts and water rights. Any water rights development requires water right compliance, which needs to be completed prior to any physical development of the water resource. The Water Rights Branch of the National Park Service would assist with this aspect of the project.

Alternate Actions and their Probable Impacts: No action would result in continued reliance on off-site water sources for two districts in Canyonlands. Water would continue to be hauled from Moab, Utah, and from Arches.

Personnel: This project requires a contract with a hydrogeological consulting firm or the Denver Service Center.

Compliance: CATEGORICAL EXCLUSION BASED on 516 DM6 App. 7.4B(10) for this initial feasibility study.

Funding:

BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:			0.0	0.0
2nd Year:				
3rd Year				
		Total:	0.0	0.0

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	Contractor	45.0	1.0
	WRD	Chemical Tests	5.0	
2nd Year:				
3rd Year:				
		Total:	50.0	1.0

Annual Project Status and Accomplishments: This report will be initiated once work begins on this project. The final report will detail if and where development of water sources is possible in the Maze and Island in the Sky districts. The report will also provide economic feasibility of developing sources and whether the park should develop sources in light of their mandate to protect natural resources

Literature Cited:

Hand, F.E. 1979. Groundwater resources in the northern part of Glen Canyon national Recreation Area and adjacent lands west of the Colorado and Green rivers, Utah. University of Wyoming, Water Resources Research Institute, Dept. of Geology, Laramie, WY.

Hecox, W.E. and B.L. Ack. 1996. Charting the Colorado Plateau: an Economic and Demographic Exploration. Research Report of the Grand Canyon Trust, Flagstaff, AZ.

Huntoon, P.W. 1977. The hydrogeologic feasibility of developing ground-water supplies in the northern part of Canyonlands National Park and Bridges National Monument, Utah.

Project Statement CANY-N-033.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: HYDROLOGICAL EFFECTS OF UPSTREAM DAMS ON ENDANGERED FISH IN THE COLORADO AND GREEN RIVERS
Funding Status: Funded: 0.00 Unfunded: 44.0
Service Wide Issues: N00, N02, N12

Problem Statement: The Colorado River which borders Arches, and the Colorado and Green rivers which bisect and meet in Canyonlands were designated by the U.S. Fish and Wildlife Service as critical habitat for four endangered fish species. These include the Colorado squawfish (*Ptychocheilus lucious*), humpback chub (*Gila cypha*), bonytail chub (*Gila elegans*), and the razorback sucker (*Xyrauchen texanus*). Due to relatively high densities of fish captured in backwater habitats, scientist have determined that the lower 50 miles (80.5 kilometers) of the Green River constitutes one of the most important nursery areas for Colorado squawfish in the Upper Colorado River Basin. Similarly, the Colorado River in Cataract Canyon contains the most recently discovered reproducing population of humpback chub. It is also one of only three locations in the Upper Colorado River Basin where bonytail chub have recently been reported (Valdez and Williams, 1993). In 1996, more than 170 razorback sucker larvae were documented from the lower Green River near Canyonlands (US Fish and Wildlife Service, 1996). This confirms that spawning is occurring and suggests the presence of another population of razorback sucker in the lower Green River.

The four endangered fish species have not been recovered to date nor have effective management plans been developed. Their habitat requirements are just now being understood. Flooded bottomlands have been identified as important nursery habitat for the endangered razorback sucker and are a critical component of the Habitat Restoration Program in the Recovery Program for the Endangered Fishes of the Upper Colorado River Basin (FLO Engineering, 1995). Additionally, park personnel (Wick, E., pers. comm.., National Park Service) and the Canyonlands and Arches National Park Water Resources Scoping Report (Berghoff and Vana-Miller, 1997) note that channel narrowing and vegetation encroachment have occurred to the detriment of the fish as well as the riverine ecosystem.

Canyonlands provides promise for further study of habitat requirements for the endangered fish species as well as for the study of flow regimes which effect changes in channel morphology such as channel narrowing and vegetation encroachment. In 1995, during high flow season, FLO Engineering (1996) collected hydrographic data at two sites, one of them in Canyonlands at Anderson Bottom, the other at Ouray Wildlife Refuge. FLO Engineering also analyzed U.S. Geologic Survey stream gaging data at the Jensen and Green River, Utah gages, and simulated flood levels using the Corps of Engineers (COE) HEC-2 step backwater profile method. The purpose of their study was to determine the magnitude, duration, and frequency of bottomlands flooding along the Green River at those sites.

FLO Engineering (1995) noted that the historic Green River flood plain has been disconnected from the river hydrology and has become a terrace. Mean annual discharge at the Green River, Utah gage was 32,700 cfs with a return period of 2.5 years prior to 1963; after 1963 the mean annual discharge was 22,300 cfs with a return period of 2.4 years. The average bankfull discharge in the Canyonlands study reach for current conditions is estimated at 39,000 cfs with a return period frequency of approximately 1in 15 years based on post-1963 data; for pre-1963 at the same bankfull discharge, the return period is approximately 3 years.

Changes in mean annual discharge and changes in sediment load are attributed to a reduction in the magnitude of peak flows from reservoir construction and water resource development (FLO Engineering, 1995). Andrews (1986) determined that a zone of aggradation probably extends downstream of the Green River gage to the confluence with the Colorado, although there is no data to confirm this. Above this reach, Andrews (1986) also noted a zone where mean annual supply of sediment exceeds transport and net accumulation of sediment is occurring. The effective discharge (i.e., the increment of discharge which transports the largest quantity of sediment over a period of years) has decreased for selected reaches on the Green River downstream of Flaming Gorge Reservoir. As a consequence, the bankfull channel will continue to adjust over a period of years to the prevailing effective discharge (Andrews, 1986). In other words, sediment transport at the lower end of the Green River has decreased and is most likely due to a decrease in the magnitude of the river flows and not necessarily a decrease in available sediment.

To the contrary, Lyons and Pucherelli (1992) relate that the Green River below Flaming Gorge Reservoir has reached quasi-equilibrium where the river transports the load supplied to it. The system apparently is responsive to increases in flows as evidenced by channel widening during 1983, 1984, and 1986 (years of notably high flows). The authors recommend that adjustments to channel characteristics, such as profile and dimension, be limited to responses to changes in discharge, and sediment supply and transport in the basin. Lyons and Pucherelli (1992) based their work on comparative analysis of aerial photographs, published sediment data and discharge, and data collected on the Green River during 1986 through 1988. More importantly, they note that channel margin changes (narrowing or widening of the channel) in response to change in sediment load following closure of the Flaming Gorge Dam could be slow and difficult to detect amidst the fluctuating response of channel width to discharge.

The reduction in magnitude and frequency of peak discharges and the decrease in sediment transport lead to morphological channel changes including significant vegetation encroachment, stabilization and bank attachment of sandbars within the active river channel, and narrowing of the river (Berghoff and Vana-Miller, 1997). The decreased effective discharge, reduced peak flows, the potential aggradation of sediments, a narrowing channel, and a river becoming disconnected from its flood plain bode poorly for fish species that require frequently flooded bottomlands for reproduction and nursery habitat. The Park Service must recognize that their actions cannot exacerbate the decrease in critical habitat for the four endangered fishes, and that there is no obligation for the National Park Service to actively participate in the recovery of these species through development of appropriate management practices.

To that end, Canyonlands can contribute by insuring that the re-evaluation of 21 cross-sections extending from above Millard Canyon to the Sphinx - where critical nursery habitat exists - proceeds. The re-evaluation of these transects may coincide with a 2-dimensional modeling technique to define specific flood plain features furthering the ability to model flows through this area. This will also coincide with test flows from Flaming Gorge Reservoir and refinement of a flow routing model. Moreover, the re-evaluation coupled with the modeling techniques is directed towards understanding how channel narrowing regulates flow and bed elevation, and conversely, how flow manipulation can be used to prevent further channel narrowing and vegetation encroachment.

The flow routing model will provide a means of assessing different flow regimes from Flaming Gorge Reservoir. The model anticipates effects of large releases from the reservoir and routes them through Canyonlands on the Green River. Early modeling suggests that large releases result in only small pulses of water far down stream of the reservoir (Wick, E., pers. comm.., National Park Service). Re-evaluation of the transects pre- and post- major flow releases from Flaming Gorge could be used to verify the model. Recommendations regarding flow augmentations for providing and sustaining suitable nursery habitat is an outcome of this project statement.

FLO Engineering (1995) recognizes that opportunities for enhancing flood plain nursery habitat in Canyonlands is limited, and only enhancement through the formulation of flow augmentation scenarios is possible. The efficacy of any flow augmentation scenario depends on 1) continued evaluation of channel morphology in Millard and Sphinx canyons, and 2) time lapsed photography (after Cluer, 1997) to document impacts of test flows on bed elevation and vegetation encroachment.

Description of Recommended Project or Activity: The park proposes a two-fold approach which re-evaluates the cross-sections established by FLO Engineering and studies effects of test flows on vegetation encroachment and bed elevation through the Millard to Sphinx section of the Green River in Canyonlands. Before this project commences, the National Park Service Water Resources Division will be consulted on procedure, timing of re-evaluation, and quality control and assurance aspects of the study.

Re-evaluation of transects

Re-evaluation of the cross sections will take place in coordination with known releases from Flaming Gorge Reservoir. This coupling will validate the models used to review flooding of bottomlands, changes in shoreline vegetation, and bed elevation on the Green River in Canyonlands. Each re-evaluation (pre- and post- releases) will consist of measuring 21 cross-sections prior to the seasonal rising limb, at peak flow, and at base flow in September.

Still photography of flooded bottomlands and fluvial deposits and vegetation

Two cameras, automatically programmed to take photographs on a daily basis will be placed at strategic locations along the Canyonlands study reach. These cameras can record changes in the bottomlands, fluvial deposits and changes in vegetative cover over a period of time at key sites. Cluer (1997) was able to distinguish changes in fluvial sand deposits in unregulated and regulated reaches of the Colorado River. Time lapse photography is a technique which allows the investigator to determine the extent of changes in fluvial sand deposits, or more precisely in this study, changes in flooding of bottomlands and vegetative encroachment. This technique will track flooding of bottomlands or lack thereof, shifts in fluvial deposits, and any changes in streamside vegetative cover. The time lapsed photography can be transformed into a video and therefore, provide a dynamic depiction of the changes in channel morphology, flood plains, fluvial sand deposits and vegetation.

Product

Re-evaluation of the cross section in Canyonlands coupled with fluvial sediment sampling and time lapsed photography will provide a picture of the dynamic nature of this reach of the Green River. More importantly, the report will discuss findings of the cross section re-evaluation, and relate those findings to test flows released from Flaming Gorge Reservoir. This project also provide empirical data to and validation of more sophisticated two dimensional hydrological modeling that traces large pulses of water through a river system A critical aspect of this project will tests the effects of flow releases from Flaming Gorge Reservoir on vegetative encroachment on the Green River and uses empirical data to validate the flow model. The time lapsed photography provides a daily, yet long-term, overview of how that system can change relative to flow regime and sediment load.

Alternate Actions and their Probable Impacts: No action would result in a lack of information regarding dynamics of flooded bottomlands in a part of Canyonlands which is critical to the recovery of endangered fish species and an opportunity to quantify federal reserved water rights in Utah for the Green and Colorado rivers.

Personnel: This project requires a Principal Investigator for project initiation and oversight, cross-sectional measurements, and data analysis. The Principal may be personnel from WRD or a contractor. A Hydrological Technician GS-7 for 5 days per month for 12 months will maintain the cameras and assist with cross-section evaluation.

Compliance: CATEGORICAL EXCLUSION BASED on 516 DM2 App.1.6

Funding:
BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:			0.0	0.0
2nd Year:				
3rd Year:			---------------	---------------
		Total:	0.0	0.0

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	Principal	20.0	0.5
	WRD	Hydro. Tech.	9.0	0.3
	WRD	Equip: Camera	10.0	
		Other: Film Devel. & Videography	5.0	
2nd Year:				
3rd Year:			---------------	---------------
		Total:	44.0	0.8

Annual Project Status and Accomplishments: This report will be initiated once work begins on this project. The final report will provide information and a video depicting how flow regimes shape and contribute to bottomland flooding, channel manipulation and vegetation encroachment.

Literature Cited:

Andrews, E.D. 1986. Downstream effects of Flaming Gorge Reservoir on the Green River, Colorado and Utah. Geol. Soc. of Amer. Bulletin 97:1012-1023.

Berghoff, K and D. Vana-Miller. 1997. Canyonlands National Park, Arches National Park, and Natural Bridges National Monument Water Resources Scoping Report. NPS Water Resources Scoping Report. NPS/NRWRS/NRTR-97/94.

Cluer, B.L., 1997. Eddy Bar Responses To The Sediment Dynamics Of Pool-Riffle Environments. Ph.D. Dissertation, Colorado State University, 128p.

FLO Engineering, 1995. Green River flooded bottomlands investigation: Ouray Wildlife Refuge and Canyonlands National Park , Utah. Draft Report. Flo Engineering, Inc., Breckinridge, CO.

Lyons, J.K and M.J. Pucherelli. 1992. Sediment transport and channel characteristics of a sand-bed portion of the Green River below Flaming Gorge Dam, Utah, USA. Regulated Rivers: Research & Management, 7:219-232.

US Fish and Wildlife Service. 1996. Fall 1996 Newsletter of the Recovery Program for the Endangered Fishes of the Upper Colorado. US Fish and Wildlife Service, Denver, CO.

Valdez, R.A. and R.D. Williams. 1993. Icthyofauna of the Colorado and Green rivers in Canyonlands National Park, Utah. In P.G. Rowlands, C. Van Riper III, and M.K. Sogge (eds.). Proceedings of the first Biennial Conference on Research in Colorado Plateau National Parks. Transaction and proceeding series NPS/NRNAU?NRTP-93/10, USDOI, NPS.

Project Statement CANY-N-034.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: EVALUATE IMPACTS IN SALT CREEK, HORSE, LAVENDER AND DAVIS CANYONS IN CANYONLANDS NATIONAL PARK
Funding Status: Funded: 13.5 Unfunded: 34.4
Service Wide Issues: N12, N20, N22, N24

Problem Statement: The Needles District of Canyonlands has several canyons that support riparian habitats and these areas continue to experience increases in visitor use. These canyons include Salt Creek, Lavender Canyon, Davis Canyon, and Horse Canyon. Access to and through these canyons varies. Vehicle use occurs in Horse Canyon as well as in Salt Creek up to Peekaboo campsite, with the daily number of vehicles limited through a permit system. Lavender Canyon is gated at the park boundary; vehicle access through this gate is also limited through a permit system. Park management had instituted this permit system in 1995 through its Backcountry Management Plan (National Park Service, 1995). On July 6, 1998, by federal court order, Salt Creek was closed above Peekaboo Spring to all vehicles. Below Peekaboo vehicular traffic continues to occur. Davis Canyon once had a four-wheel-drive trail in the canyon bottom, but park management has closed the canyon to vehicular use so that access is limited to hiking. These drainages are especially significant due to their status as riparian resources. Salt Creek is especially important because it is the only other perennial stream in Canyonlands besides the Green and Colorado rivers, and it has several archeological site. Lavender, Davis and Horse Canyon all support intermittent riparian areas with water present in places during parts of the year.

Mitchell and Woodward (1993) studied the impacts of four-wheel drive vehicle use in Salt Creek on the aquatic biota. They concluded that sedimentation was exacerbated using cages, which they placed upstream and downstream of road crossings (Chi -square test, $p = 0.015$). This study serves as a baseline detailing the effects of vehicular use in the streambed. Wolz and Shiozawa (1995) found a greater diversity of invertebrates and higher total numbers in a stretch of Salt Creek not impacted by four-wheel-drive traffic (0.3 miles [0.5 kilometers] below Peekaboo Spring) than in a stretch where vehicles drive directly through the creek. Although their findings are qualitative, the authors suggest that vehicle traffic influences the site’s ability to support aquatic invertebrates. They also suggest further study of the effects of vehicles on aquatic fauna. Tolisano (1996) summarized findings from a rapid riparian assessment which determined that adverse impacts to the proper functioning conditions in the riparian ecosystem in Salt Creek (Canyonlands) were more evident downstream of vehicle crossings than upstream. The author focused on sediment as the element that caused degradation of the downstream sites.

The Backcountry Management Plan was implemented in 1995, which restricts through a permit systemor through road closers, use of vehicles in Salt Creek, and Horse, Davis and Lavender canyons. The 1998 court order to close Salt Creek above Peekaboo Spring provides an opportunity to study adjustments in creek dynamics and attendant aquatic and riparian obligate organisms. The Salt Creek vehicle closure may displace four-wheel-drive users to other formerly lightly-used jeep trails that remain open. The park has initiated a program to monitor changes in Salt Creek, but has not done so for Horse, Lavender or Davis Canyon. A study of all four drainages would allow the park to assess the effects of various recreational uses such as four-wheel driving, hiking, and horseback riding within drainages and to evaluate responses to changes in use.

The park has initiated studies in Salt Creek which monitor changes in vegetation, stream channel, and aquatic invertebrates, as well as establishing a bird transect above Peekaboo Spring. No detailed studies regarding aquatic and terrestrial biota have been completed within Davis, Horse and Lavender canyons. A sampling technique may be used to assess presence of aquatic macroinvertebrates, amount of cover along the drainage, and riparian bird densities. A photographic survey may be used to document channel configuration related to various levels of recreational activity in these drainages.

Amount of cover along a drainage is important for several reasons including temperature reduction of the water and carbon inputs. In a desert environment there are organisms adapted to high temperatures even in water; however, some invertebrates that have evolved in desert stream systems may have done so in systems where vegetation always flanked the banks. Removal of this vegetation via human disturbance could cause a rise in water temperature. This same removal of vegetation reduces the amount of organic material entering the system. Without this constant source of carbon, aquatic organisms will die (i.e., they will not have enough food).

Description of Recommended Project or Activity: The park proposes a monitoring program to document condition of riparian sections of Lavender, Horse and Davis canyons. The study will include a stratified sampling approach where riparian vegetation is present and where pools of water exist. Here several macroinvertebrate samples would be collected in the same manner used for the Salt Creek assessment. A dip-net would be swept through the pool or water source for 30 seconds in order to collect invertebrates. Such collections may be limited to post-storm events.

Like the Salt Creek assessment, permanent photo points would be established at riparian areas in Horse, Lavender, and Davis canyons. These photos will represent oblique views of representative riparian areas within each drainage. The photo points will be established using rebar for permanent marking. These sites will be located using a Geographic Positioning System (GPS).

Drainage channel characteristics at riparian areas along the canyons will also be measured. The same methodology used to assess stream channel characteristics in Salt Creek will be used in Horse, Lavender, and Davis canyons. If any previous photo points or stream channel points have been established along these drainages, these will be used. New cross-sections will be established by placing rebar endpoints just outside the riparian area. A stream cross-section will be measured using a tape stretched from one endpoint to another and a rod and level for reading elevations. The permanent photos will correspond to these cross-sections.

Vegetation samples will be taken using a line intercept transect to measure cover and frequency of species. Transects will be established in riparian areas within Davis, Lavender, and Horse canyons, and correspond with the sampling procedure used in Salt Creek. One bird transect will be established in each drainage. The methodology includes a 2500 meter transect with ten points established every 250 meters. Observers will wait 2 minutes to let the birds acclimate to their presence. At each of the 10 points, observers will record number and species of bird present in a 5 minute period. The invertebrates and birds will be monitored for 3 years and the photo points and channel characterization established within one year. Revisiting the permanent photo sites and cross-sections may occur within 5 to 10 year periods.

Alternate Actions and their Probable Impacts: No action would result in the inability of the park to determine whether apparent usage of this riparian habitat is negatively affecting biota and physical characteristics of the drainage.

Personnel: This project requires a Biological Technician GS-7 for 2 months per year for 3 years to collect invertebrate samples, and to conduct bird and vegetation surveys. A Hydrological Technician is required for 2 months to assist with establishing the permanent photo points and running the channel cross-sections The project will require a Principal Investigator with expertise in aquatic invertebrate identification, bird identification, vegetation analysis, some aspects of hydrology, data analysis, and report development. The Principal will also be involved with selection of permanent photo sites and channel cross-section establishment.

Compliance: CATEGORICAL EXCLUSION BASED on

Funding:
BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:	PKBASE	Bio.Tech.	4.5	0.2
2nd Year:	PKBASE	Bio.Tech.	4.5	0.2
3rd Year:	PKBASE	Bio.Tech.	4.5	0.2
		Total:	13.5	0.6

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	Principal Investigator	10.0	0.3
	WRD	Hydrological Tech.	2.4	0.1
		Equip.	1.0	
2nd Year:	WRD	Principal Investigator	10.0	0.3
		Equip.	0.5	
3rd Year:	WRD	Principal Investigator	10.0	0.3
		Equip.	0.5	
		Total:	34.4	1.0

Annual Project Status and Accomplishments: An annual report will be submitted which specifies findings, and a final report will describe impacts to the aquatic fauna Salt Creek, Horse, Lavender and Davis canyons.

Literature Cited:

Mitchell, S. and B. Woodward. 1993. Final Report: Man's effects on aquatic and riparian organisms in the canyons of Canyonlands and Arches National Parks and Natural Bridges National Monument. National Park Service. Contract No. CA 1463-5-0001.

NPS. 1995. Canyonlands National Park and Orange Cliffs Unit of Glen Canyon National Recreation Area, Backcountry Management Plan. Moab, UT.

Tolisano, J. 1996. Analysis of ecological impacts from jeep trail use on riparian communities in the Salt Creek watershed. Investigators Annual Report. Canyonlands National Park.

Wolz, E.R. and D. K. Shiozawa. 1995. Aquatic macroinvertebrates of the Needles District, Canyonlands National Park, Utah. Brigham Young University, Provo, UT.

Project Statement ARCH-N-028.000
CANY-N-035.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: WETLAND DELINEATION OF SALT CREEK IN CANYONLANDS NATIONAL PARK AND COURTHOUSE WASH IN ARCHES NATIONALPARK
Funding Status: Funded: 4.5 Unfunded: 8.7
Service Wide Issues: N20, N24

Problem Statement: Salt Creek in Canyonlands NP and Courthouse Wash in Arches are perennial stream systems and are bordered by riparian vegetation which is extremely important for stabilization of streambanks, retention of sediment, provision of organic carbon to the stream aquatic fauna, and biogeochemical cycling. Portions of the riparian areas and the actual creek bottoms may be a wetland as defined by Cowardin et. al. (1979),and may also be "jurisdictional wetlands" according to criteria set forth in the U.S. Army Corps of Engineers Wetlands Delineation Manual (the U.S. Army Corps of Engineers, 1987). Wetlands can provide important habitat for wildlife and other aquatic organisms, effect biogeochemical processing, and serve as storage sites of water for later release in late summer, among other functions. The National Wetland Inventory maps produced by the US Fish and Wildlife Service have not been produced for this area. These maps are the baseline inventory for wetlands of the United States and are based on the classification developed by Cowardin et al (1979). Thus, the park has no information regarding wetlands within its boundaries.

Salt Creek and Courthouse wash receive an enormous amount of pressure from visitors. Impacts to Courthouse Wash include bathing in the lower end, and tamarisk invasion and control. A road literally runs through Salt Creek and impacts to the aquatic environment have been documented (Mitchell and Woodward, 1993; Wolz and Shiozawa, 1995, Tolisano, 1996). The road in Salt Creek was closed above Peekaboo Spring in July of 1998. Any information regarding wetland status, use by visitors, and diversity of flora and fauna, assists management in making good decisions about future activities in these drainages.

For two reasons the Southeast Utah Group of parks must acknowledge the presence of wetlands as defined under both systems, and ensure that their disturbance either does not occur, is minimized, or is mitigated if required as a part of a permitting/compliance process. First, Section 404 of the Federal Water Pollution Control Act (the Clean Water Act 33 U.S.C. 1251, et. seq.) requires a permit for excavation and discharge of fill to jurisdictional wetlands and other waters, and secondly, National Park Service procedures for compliance with Executive Order 11990 require special documentation for proposed action with adverse impacts on wetlands [as defined by Cowardin et al (1979)].

Jurisdictional wetlands are those areas which meet three criteria as defined by the U.S. Army Corps of Engineers (1987). Such a wetland must be "…inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar area". Hydrophytic vegetation, hydric soils, and wetland hydrology must be present in order for the wetland to be considered jurisdictional. Specifically, the dominant plant species must be those adapted to life in saturated conditions (referred to as hydrophytic vegetation); the soils must be hydric; and the soils must be inundated or saturated within 12 inches (30 cm) of the soil surface for as little as 5 percent of the growing season. The Cowardin et al. (1979) system includes all jurisdictional wetlands, and also includes sites which have wetland hydrology, but lack vegetation (e.g., mud flats, some streambeds) or may not have hydric soils (e.g., rocky shorelines).

Some areas may not meet the technical criteria for classification as wetlands, but still provide some of the same functions, or may provide buffers against wetland impacts. For example, the ground water in an arid environment might not be within the specified distance to the ground surface, yet hydrophytic vegetation is present and provides good habitat for wildlife. The parks must recognize these important habitats as well. A means of protecting wetlands and related areas includes delineating the wetland and adding a buffer from the boundary to insure no impacts to that wetland complex. Physical barriers formed by vegetation buffers slow surface flow rates, and flow rates are generally slower for sheetflow versus channelized flow. Vegetated buffers of 33 to 164 feet (10 to 50 m) are adequate for reduction of sediment introduction to water systems. To maintain species diversity buffers from 33 to 295 feet (10 to 90 meters) are recommended; a 98 foot (30 meters) buffer is adequate for maintenance of aquatic organisms (Castelle et al., 1994). The parks should be most cognizant of any road construction, sewage disposal system, or other developments placed near wetlands. In effect, a delineation and development of a buffer zone around the wetland or along the wetland is the first step in insuring the protection of these wetlands.

Description of Recommended Project or Activity: The park proposes that qualified park personnel conduct a wetland delineation along the Salt Creek and Courthouse Wash areas, in Canyonlands and Arches, respectively. The delineation will be conducted according to the U.S. Army Corps of Engineers1987 manual and Cowardin et al. (1979). A Geographical Positioning system (GPS) unit will be used to locate the boundary of the wetlands. Files will be downloaded to a Geographic Information system (GIS) file, and corrected. A 100 foot (30 meter) buffer away from the delineated boundary will be established in the park Geographic Information system. Management may refer to this map regarding proposed activities within the delineated wetlands or buffer zone.

Alternate Actions and their Probable Impacts: No action would result in a lack of information regarding wetland boundaries and may prevent informed decisions regarding establishment of certain activities in these areas.

Personnel: This project requires one Biological Technician and one Hydrological Technician for 2 months, and a GIS Specialist GS-11 for 1 month.

Compliance: CATEGORICAL EXCLUSION BASED on 516 DM2 App. 1.6

Funding:

BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:	PKBASE	Bio.Tech.	4.5	0.2
2nd Year:				
3rd Year:				
		Total:	4.5	0.2

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	GIS Specialist	3.2	0.1
	WRD	Hydro. Tech.	4.5	0.2
		Equip.	1.0	
2nd Year:				
3rd Year:				
		Total:	8.7	0.2

Annual Project Status and Accomplishments: The product will be a report and a wetland GIS data layer of wetlands in Salt Creek and Courthouse Wash.

Literature Cited:

Castelle, A.J., A.W. Johnston, and C. Conolly. 1994. Wetland and stream buffer size requirements - a review. J. Environ. Qual. 23:878-882.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. US Fish and Wildlife Service Report FWS/OBS-79/31.

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Mitchell, S. and B. Woodward. 1993. Final Report: Man's effects on aquatic and riparian organisms in the canyons of Canyonlands and Arches National Parks and Natural Bridges National Monument. National Park Service. Contract No. CA 1463-5-0001.

Tolisano, J. 1996. Analysis of ecological impacts from jeep trail use on riparian communities in the Salt Creek watershed. Investigators Annual Report. Canyonlands National Park.

Wolz, E.R. and D. K. Shiozawa. 1995. Aquatic macroinvertebrates of the Needles District, Canyonlands National Park, Utah. Brigham Young University, Provo, UT.

Project Statement **ARCH-N-029.0**
CANY-N-036.000

Last Update: **3/20/98**
Initial Proposal: **3/20/98**
Title: ASSESS SALT CREEK, COURTHOUSE WASH, AND SALT WASH FOR RARE,THREATENED AND ENDANGERED SPECIES
Funding Status: **Funded: 12.0** **Unfunded: 25.7**
Service Wide Issues: N20

Problem Statement: except for the Green and Colorado rivers Salt Creek is the only perennial stream within Canyonlands , thus making the Salt Creek drainage a truly important habitat for aquatic and terrestrial organisms. This creek drains north from the Abajo Mountains which are primarily within the Manti-La Sal National Forest boundary. Salt Creek is extremely popular; a four-wheel drive road runs through the bottom of the wash which provides accesses to popular hiking areas in the upper reaches of Salt Creek. This road was closed to vehicular traffic above Peekaboo Spring in July of 1998. Studies conducted by Mitchell and Woodward (1993) and Wolz and Shiozawa (1995) showed a decrease in diversity of aquatic invertebrates at sites below road crossings as compared to those above these crossings; however, these studies are limited in their ability to test the significance of the difference between diversity at sites. In addition, these studies did not include searches for rare, threatened or endangered species. No searches for the southwestern willow flycatcher (*Empidonax traillii extimus*), a riparian obligate species, have been conducted.

In addition, no studies for rare, threatened or endangered species have been conducted in Courthouse Wash or Salt Wash in Arches . These two drainages support intermittent if not perennial flows in most years. Occurrences of riparian obligate species are possible in these two drainages, and possibly rare or even endangered species may be present.

Where habitat diversity is relatively high, such as where water occurs in a desert region, rare species are likely to be present. Consequently, survival of rare species stems from appropriate management especially if the habitat in which they live is impacted by visitors or other land use activities. Canyonlands and Glen Canyon National Recreation Area have already implemented a Backcountry Management Plan (National Park Service, 1995), in an attempt to restrict four-wheel drive travel through Salt Creek. Further, Salt Creek is closed to vehicles above Peekaboo Spring. The plan is effective in reducing overall numbers of vehicles in this drainage and also reducing the number of vehicles at any one time. Little baseline information is available regarding species diversity, abundance and distribution in Salt Creek in Canyonlands or in Courthouse and Salt washes in Arches. In an attempt to understand the structure of this particular drainage, the park proposes to assess these systems for rare, threatened and endangered aquatic and terrestrial species.

Description of Recommended Project or Activity: The park proposes to survey Courthouse Wash and Salt Wash in Arches, and Salt Creek within Canyonlands for rare, threatened and endangered species by surveying the entire riparian area, and by conducting a southwestern willow flycatcher survey in areas where adequate cover, 33 feet (10 m) square or more, is available (Sogge et al., 1997). This project includes surveying the area for obligate and facultative wetland plant species, for aquatic invertebrates, and for the southwestern willow flycatcher.

Plant Species
Within Canyonlands Salt Creek is approximately 20 miles (32 kilometers) long, and within Arches Courthouse Wash and Salt Wash are approximately 10 and 12 miles (16 kilometers and 19 kilometers)long, respectively. A 100 percent survey of each drainage is a daunting task. However, because park management needs to know what their resources encompass, a 100 percent survey will be attempted. Qualified personnel will walk the drainages, noting species, relative abundance, and location of rare, threatened or endangered plant species. Special attention will be paid to spring areas, and areas of highly unusual geology that might contribute to formation of unique soil types. These areas can be anticipated using geology maps and aerial photographs. Locations of all rare, threatened or endangered species will be entered into a Geographic Information system.

Aquatic Invertebrates
A 100 percent survey of aquatic invertebrates is impossible along these drainages, therefore the park proposes a stratified random sampling regime. The creek and washes can be classified according to 1) their substrate: bedrock sandstone, sand and cobble, sand, silt, etc. 2) their water source: perennial spring, or depression, 3) their associated vegetation, and 4) their geology. For example, a certain reach of the creek could be categorized as perennial spring, sandstone substrate with willow riparian vegetation. The number of segment types according to the various categories will be tallied. Segments will be selected and sampled on a random basis by assigning numbers to each segment within a category, and picking a percentage of those segments based on their percent contribution to the total number of segments.

Two types of samples will be taken at each site. Using a 900 micron kick net, samples will be collected using: 1) a figure eight collection which involves moving the net in a figure eight allowing water to continually flow through it, and 2) a sweep of the substrate and vegetation. Each sample will be placed in a white photo-tray, subsequently transferred to jars, and preserved with 70 percent ethanol.

The samples will be sent to experts for identification of rare, threatened or endangered species. Location of rare, threatened or endangered species will be entered into the Geographic Information system. Because invertebrates drift, and colonize areas rapidly, notation of their location is less important than understanding site characteristics.

Aquatic invertebrate collections within each of these drainages already occur as part of the water quality monitoring program. They include Salt Wash 3 (SW3), Courthouse Wash (CW1), and Bates Wilson, Crescent Arch, and Peekaboo Spring within Salt Creek . These collections as well as those collected in pools above Peekaboo Spring should serve as representative samples of the corresponding physical and biological characteristics of Salt Creek. As a result, data from these sites will be used in this part of the rare, threatened and endangered assessment.

Southwestern Willow Flycatcher
The southwestern willow flycatcher, a federally listed endangered species, is a riparian obligate species and requires dense vegetative cover, open water, cienagas, marshy seeps, or saturated soil. The southwestern willow flycatcher is one of four or five recognized subspecies in North America. Its breeding range includes southern California, southwestern Colorado, Arizona, New Mexico, extreme southern portions of Utah and Nevada, and western Texas at altitudes of less than 8500 feet (2591 meters). According to other surveys, the flycatcher utilizes a variety of dense understory and/or midstory shrubs in broad riparian flood plains (Sferra et al., 1995).

These communities can include dense monotypic or mixed stands of willows (*Salix* spp.), or exotics such as tamarisk (*Tamarix ramosissima*) (Sogge et al., 1997) which may be encountered along Salt Creek. Occupied sites always have dense vegetation in the interior, and the riparian patches used by these birds may vary in size and shape, and may be a relatively dense, linear, and contiguous stand or an irregularly-shaped mosaic of dense vegetation with open areas. They have nested in patches as small as 2.0 acres (0.8 hectares), but have not been found nesting in narrow, linear riparian habitats less than 33 feet (10 meters) wide (Sogge et al., 1997).

In order to survey for the willow flycatcher, the surveyor must obtain a federal endangered species permit and appropriate state permit, and follow the protocol outlined in Sogge et al. (1997). For the purposes of this project statement, habitat along Salt Creek, Salt Wash, and Courthouse Wash which provides dense cover greater than 10 square meters will be selected for survey. The park proposes to survey each site three times May 15 to 31, June 1 to 21, and June 22 to July 10, within the survey windows as specified in Sogge et al. (1997). Surveys must begin approximately one-half hour before sunrise and end no later than 11:00 a.m. A tape-playback technique will be used at each site. Upon arrival at the site, surveyors will wait approximately 2-5 minutes before playing the tape in order to allay initial disturbance. Thereafter, the surveyors will walk along the creek or site area playing the tape for 30 seconds, and pausing to listen for birds. In addition, the surveyors will rely on observation and the use of binoculars to view any birds using the riparian corridor. All bird sightings will be noted. Willow flycatcher sightings will be noted on the standardized survey sheet. Visible and audible locations of willow flycatchers will be recorded using a Geographical Positioning System (GPS) unit, and the locations downloaded, corrected and entered into the park Geographic Information system. Further, all brown-headed cowbird (*Molothrus ater*) sightings will be recorded.

If a nesting willow flycatcher is found, precautions to avoid disturbance to the nest site will be taken. These nest sites will also be located using a GPS, but only after the birds have fledged. Once the survey is complete, the standardized data sheets must be provided to the US Fish and Wildlife Service by the end of the survey year.

Alternate Actions and their Probable Impacts: Without completing this project, management will not have any information regarding presence or absence of rare, threatened or endangered species along Salt Creek, Courthouse Wash and Salt Wash. Human activities within these drainages may negatively affect rare, threatened, and endangered plant and animal populations, and therefore, the National Park Service will not be in compliance with the Endangered Species Act (1973).

Personnel: This project requires Principal Investigators which share the responsibility of overseeing the project, identifying plant specimens, and identifying aquatic organisms. Two Biological Technicians or Hydrological Technicians GS-7 for 3 months are required. They will be responsible for the plant survey, collection of aquatic invertebrates, and the willow flycatcher survey. A GIS Specialist GS-11 for 1 month is required for developing the species location Geographic Information system data layer.

Compliance: CATEGORICAL EXCLUSION BASED on 516 DM2 App. 1.6

Funding:

BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:	PKBASE	Bio.Tech.	12.0	0..5
2nd Year:				
3rd Year:				
		Total:	12.0	0.5

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	Principal Investigator	20.0	0.4
		GIS Specialist	3.2	0.1
		Hydro.Tech.	6.5	0.3
		Equip.	1.0	
2nd Year:				
3rd Year:				
		Total:	30.7	0.8

Annual Project Status and Accomplishments: The product will be a report detailing any rare, threatened or endangered species. Locations of such species will be included in the GIS.

Literature Cited

Mitchell, S. and B. Woodward. 1993. Final Report: Man's effects on aquatic and riparian organisms in the canyons of Canyonlands and Arches National Parks and Natural Bridges National Monument. National Park Service. Contract No. CA 1463-5-0001.

National Park Service. 1995. Canyonlands National Park and Orange Cliffs Unit of Glen Canyon National Recreation Area, Backcountry Management Plan. Moab, UT.

Sferra, S.J., R. A. Meyer, and T.E. Corman. 1995. Arizona partners in flight 1994 southwestern willow flycatcher survey. Final Technical Report 69. Arizona Game and Fish Department, Phoenix, AZ.

Sogge, M.K., R.M. Marshall, S.J. Sferra, and T. J. Tibbitts. 1997. A willow flycatcher natural history summary and survey protocol. Technical Report NPS/NAUCPRS/NRTR-97/12, Colorado Plateau Research Station, NAU, Flagstaff, AZ.

Wolz, E.R. and D. K. Shiozawa. 1995. Aquatic macroinvertebrates of the Needles District, Canyonlands National Park, Utah. Brigham Young University, Provo, UT.

Project Statement ARCH-N-030.000
CANY-N-037.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: LOCATION OF ABANDONED MINE LANDS, ACTIVE OIL AND GAS LEASES, EXISTING MINING CLAIMS, AND COAL MINES WITHIN AND NEAR PARK BOUNDARIES
Funding Status: Funded: 3.8 Unfunded: 20.0
Service Wide Issues: N10

Problem Statement: The State of Utah mining heritage is rich, long, and cyclic. The boom and bust cycle associated with mining in and near Canyonlands and Arches have left these two parks with uncertainty regarding contamination of ground water, radiological contamination, and basic safety issues associated with mine adits (mine openings). The Canyonlands and Arches National Parks Water Resources Scoping Report (Berghoff and Vana-Miller, 1997) identifies concerns regarding the Atlas Moab Mill site in Moab. This site harbors uranium tailings piles and has been marked for remediation. High ammonia levels in the Colorado River downstream of the tailings pile is only one of the major concerns regarding in situ remediation. The location of the tailings and mill site make obvious the problems associated with the mining industry. Less obvious are the number of abandoned mine lands, and active coal mines, oil and gas leases, and mineral claims in or near the two parks.

Abandoned mine lands host a number of mine adits which can emit alpha and beta particles causing a definite health hazard to visitors. Also these mines may have ground water seepage emanating from the mine adit. Contamination of nearby water sources may occur. The National Park Service has closed 21 mine adits in Canyonlands. Typically, radiological hazards were sited as the reason for closing these mine openings; however, water samples taken from the closed Lathrop Canyon Mines reveled contamination. Gross alpha, gross beta, and radium 226 exceeded state standards. Burghardt (1988) also expressed concern with trace elements in the mine waters and increases in contamination downstream of the mine openings. The data were insufficient to determine if the increase was due to the abandoned uranium mines.

The parks are concerned about active mining claims, oil and gas leases, and coal mines near park boundaries. Impacts to ground water and visitor safety are the foremost concerns. Surface runoff and pollution from uranium mines can result in elevated levels of heavy metals, radionuclides and other toxic elements. To that end, this project statement outlines a means of obtaining the history of the mining districts, and locating abandoned mine lands, active mineral claims, oil and gas leases, and coal mines. There are three mining districts near Arches: the Yellowcat, the Seven Mile and the Richardson-Dewey districts. Canyonlands now incorporates the Inner River District which is inactive. Also near Canyonlands are the Indian Creek, Lower Kane Springs, Lisbon Valley and the Dolores Mining District (Venticinque, S., 1998, pers. comm., Bureau of Land Management). History of these districts may be found in different editions of the Four Corners Geological Society Guide. Location of all inactive and active mines and leases is more difficult, but the information is available from several sources.

Having a database which identifies and locates abandoned mines, active claims, and leases provides key information management can use to determine impacts to park resources. For instance, the addition of land to the northeast portion of Arches will include the Yellowcat Mining District. Topographic maps reveal a number of abandoned mines in this area. Including these sites in the park's own Geographic Information System serves two purposes. The parks will have this data layer available to add to boundary maps, or other maps, and the park can predict or anticipate where water resource problems may occur with respect to the location of abandoned mines. Likewise, park management needs to be aware of active claims near the park in order to participate in project reviews, and again, to anticipate potential water resource problems. For example, in 1995 Summo USA Corporation submitted to the Bureau of Land Management, Moab District a proposed Plan of Operations to develop a copper mine in Lisbon Valley, which is east of the Canyonlands Needles District. A heap leach sulfuric acid process would extract copper from formally milled tailings and from ore. The Environmental Impact statement and further study related that ground water contamination would not occur, and that ground water moved essentially to the north and east away from the Needles District (Bureau of Land Management, 1997; Adrian Brown Inc., 1998). Having the locations and attribute data on active mines begins a process which helps the park anticipate problems.

Description of Recommended Project or Activity: This project involves collecting historical information on the mining districts located near the parks. Historical information may be found in different editions of the Four Corners Geological Society Guide and elsewhere. A report should be generated which includes the name of each mining district, its location, past and present activity, minerals mined, and an area map.

The other aspect of this project involves locating all abandoned mine lands, inactive oil and gas wells, active mineral claims, active coal mines, and oil and gas leases in or near Canyonlands and Arches. These locations will be included in data layers of the Geographic Information System. Since the status of mines and leases change, these layers will be dynamic in nature.

Abandoned mine lands
To determine the location of abandoned mine lands the following must be reviewed:

- 7.5 minute topographic quads - many times these note the location of mine adits
- Mill Industrial Locating System
- Utah Mineral Occurrence System
- University of Utah - old papers of underground workings
- EPA - mine sites in Utah where no further action is required

Active mineral claims
Locations and types of mines can be obtained from the Utah Division of Oil and Gas, and Mining, and the Bureau of Land Management. Location of mines on private property may be difficult to find. A list from the Utah Division of Oil and Gas, and Mining has already been received for the purposes of this project statement and are included in Appendix D.

Oil and gas leases
Location of leases may be found at the School and Institutional Lands with the State of Utah, and with the Bureau of Land Management.

Active coal mines
Location of active mines was obtained from the Utah Division of Oil and Gas, and Mining. (Appendix E).

Abandoned oil and gas wells
Determining the location of abandoned oil and gas wells may be difficult, but records can be obtained from oil and gas companies, from water quality reports, from Hand (1979), Huntoon (1977), Richter (1980), and from the Utah Division of Oil and Gas, and Mining .

Once researched and located all of this information will be entered into the Giographic Information System at the Southeast Utah Group headquarters.

<u>Alternate Actions and their Probable Impacts:</u> No action will result in a lack of information regarding mining, oil and gas leasing near the two parks.

<u>Personnel:</u> GS-9 for 6 months, and a GIS Specialist for 3 months will complete the project. The GS-9 will compile the historical information and locate sites of active mines, coal mines, abandoned mine lands, and oil and gas leases. The GIS specialist will enter these sites into the Geographic Information System and will develop a data layer or layers with this information.

<u>Compliance:</u> CATEGORICAL EXCLUSION BASED 516 DM2 App.1.6

<u>Funding:</u>
BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:	PK-BASE	GIS Specialist	3.8	0.1
2nd Year:				
3rd Year:				
		Total:	3.8	0.1

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:				
	WRD	GS-9	20.0	0.6
2nd Year:				
3rd Year:				
		Total:	20.0	0.6

<u>Annual Project Status and Accomplishments:</u> The product will be a Geographic Information System data layer or layers identifying abandoned mine lands, active coal leases, active oil and gas leases, active mineral claims, and abandoned gas and oil wells. Further, a report of the historical location of mining activities in and around Canyonlands and Arches will be compiled.

<u>Literature Cited</u>

Adrian Brown. 1998. Project Annual Update of the Lisbon Valley Hydrogeologic System Evaluation Vol. 1. Summo USA Corporation, Denver, CO.

Berghoff, K and D. Vana-Miller. 1997. Canyonlands National Park, Arches National Park, and Natural Bridges National Monument Water Resources Scoping Report. NPS Water Resources Scoping Report. NPS/NRWRS/NRTR-97/94.

BLM. 1997. Final Environmental Impact Statement Lisbon Valley Copper Project, Moab District, Moab, UT.

Burghardt, J.E. 1988. Canyonlands National Park: Lathrop Canyon Abandoned Uranium Mine Closures, Evaluation and Recommendations. National Park Service, Mining and Minerals Branch, Denver ,CO.

Hand, F.E. 1979. Groundwater resources in the northern part of Glen Canyon national Recreation Area and adjacent lands west of the Colorado and Green rivers, Utah. University of Wyoming, Water Resources Research Institute, Dept. of Geology, Laramie, WY.

Huntoon, P.W. 1977. The hydrogeologic feasibility of developing ground-water supplies in the northern part of Canyonlands National Park and Bridges National Monument, Utah.

Richter, Jr., H. R. 1980. Ground water resources in the part of Canyonlands National Park east of the Colorado River and contiguous Bureau of Land Management Lands, UT. , MS U. of Wyoming.

Project Statement ARCH-N-031.000
CANY-N-038.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: INVENTORY OF LAND USE ACTIVITIES EXTERNAL TO PARKS
Funding Status: Funded: 19.00 Unfunded: 16.0
Service Wide Issues: N11

Problem Statement: Land uses outside of the Arches and Canyonlands boundaries have the potential to affect water resources, both quality and volume entering the park. The major river systems, the Colorado and Green rivers, flow through Canyonlands, and the Colorado River flows by Arches. Courthouse Wash, Salt Wash, Salt Creek and Indian Creek are other surface waters which flow through Arches and Canyonlands. These rivers and creeks can be affected by any surface or underground activity which encourages release of sediments directly to the sources or induces flow of material through side drainages to creeks and rivers. External land use impacts to ground water sources within the park are much more difficult to anticipate, typically because the aquifers are localized within certain formations, and recharge to these areas is variable. Ground water may be found in any number of geologic units including the Navajo, Wingate, White Rim, Cedar Mesa Sandstone in Canyonlands NP, and emanating from the Dewey Bridge Member and the Slick Rock Member of the Entrada in the Arches. In order to predict contamination of ground water sources in the park, Land use must be identified and analyzes. An example would be the analysis of mining activities carried out by consultants to Summo Usa Corporation on the proposed Lisbon Valley Copper Mine; here they modeled geology and ground water movement in the area.

To the north and east of Arches, many abandoned mines dot the desert; impacts to water sources from these mine adits may be minimal if they store no water or are not connected to an aquifer. However, the National Park Service Minerals and Mining Branch investigates these abandoned mines, and recommends closure where radiological or water quality threats are high. Closure of several adits has occurred in the past. Location of all abandoned land mines is addressed in another project statement (ARCH-N-030.00 & CANY-N-038.00), and that project links to this one nicely by providing a data layer that notes type of land use activity (i.e., abandoned mine lands).

Active mining claims, active oil and gas leases and active coal mines are also a potential threat to water resources if located near the park boundary or on drainages upstream of the park. The inclusion of this information into an overall land use map is essential (see project statements ARCH-N-030.000 and CANY-N-037.000). Thorough coverage may include assessment of Bureau of Land Management records regarding potential developable oil and gas and mineral sources.

Throughout the western United States, cattle grazing dominates the landscape, and has done so since the mid-1800s. Impacts to water resources from improper grazing include sedimentation, increased fecal coliform counts, increased nitrate and phosphorus levels, streambank damage, and reduction of overall vegetative cover. A data layer outlining all Bureau of Land Management and U.S. Forest Service grazing allotments would assist management with understanding the ownership of cattle in trespass situations, and overall management of lands near park boundaries.

Recreational activities especially near Moab have increased many-fold over the last fifteen years. Biking, hiking, and boating all impact water resources. Sheer numbers of people increase the chance that human wastes are not disposed of properly in at-large campsites outside park boundaries. Increased use of roads and trails can contribute to greater erosion and sedimentation of nearby streams and rivers. This project includes developing a Geographic Information systems data layer that notes frequently used biking and hiking trails on land outside the parks, and ad hoc campsites which serve as relief areas to designated campsites within the parks.

The tremendous increase in recreational activity in the Moab area brings with it an increase in the base population of the area. More privately owned large properties and state land may be converted to residential areas. A Geographic Information Systems data layer identifying city and county boundaries, and residential and agricultural lands would allow administrators to predict where the next growth area may occur. This layer is particularly important for understanding the dynamics of the immediate Moab area.

Land status including private, National Park Service, Bureau of Land Management, U.S. Forest Service, tribal lands, State lands, should also be a part of the GIS.

Description of Recommended Project or Activity

Having an adjacent land use activities layer in a Geographic Information System allows for a dynamic management tool for the Park Superintendent or Chief of Resources Management. This data layer or series of layers allows management to speculate on various techniques which may reduce impacts to water resources.

This project entails gathering existing data layers and developing new data layers. The park Geographic Information System needs to be searched for land status data layer, hydrography, and watershed information. These layers may include agency boundaries adjacent to the park, U.S. Geologic Survey watershed boundaries, and a hydrography layer that is already a component of the park Geographic Information Systems. Bureau of Land Management and U.S. Forest Service allotment boundaries must be included as another data layer. The project statement ARCH-N-030.000 & CANY-N-037.000 included documenting active mines and mining claims, coal leases, oil and gas leases, and abandoned mine sites. The information from that project is a component of this land status project. Aerial photographs will be used to identify trails and roads outside of the park boundaries. County Geographic Information System data layers may be useful in noting where development is occuring. Development projects near Moab that may impact water resources at Arches or Canyonlands need to be identified in digital form so this information can be included in a data layer. The product is a multi-layer land status data set.

Alternate Actions and their Probable Impacts: If no action is taken, information regarding external land use activities will always be sought from outside sources.

Personnel: GIS Specialist GS-11 for 6 months will evaluate data and enter as appropriate. A GS-9 Hydrological Technician for 6 months will assist with initial research and digitizing.

Compliance: CATEGORICAL EXCLUSION BASED on 516 DM2 App. 1.6

Funding:
BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:	PK-BASE	GIS Specialist	19.0	0.5
2nd Year:				
3rd Year:				
		Total:	19.0	0.5

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	Hydrological Technician	16.0	0.5
2nd Year:				
3rd Year:				
		Total:	16.0	0.5

Annual Project Status and Accomplishments: The product will be a GIS data layer or layers of land use activities.

Project Statement CANY-N-039.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: ASSESS LOCATION OF BACKCOUNTRY CAMPSITES RELATIVE TO FLOOD PLAINS
Funding Status: Funded: 0.00 Unfunded: 16.0
Service Wide Issues: N12

Problem Statement: To reduce impacts to flood plains, to adhere to National Park ServiceFlood Plain Management Guidelines (National Park Service, 1993b), and more importantly to insure the safety of its visitors, the parks should move designated backpack campsites out of the flood plain. Road campsites have already been moved out of flood plains, and some work has been completed on backpack campsites. In order to determine which designated backpack campsites are within the flood plain, specifically the 100-yr flood plain, the parks request that a flood plain assessment of the sites be completed. Within Canyonlands there are 21 designated backpacking campsites, in addition to at-large campsites within certain zones of each district. Arches NP has no designated backpacking campsites, but instead at-large camping within prescribed areas. If the park requires and recommends that people use designated backpack/backcountry campsites, then the park is responsible for insuring that those sites are in safe locations.

Description of Recommended Project and Activity: The park requests assistance with a floodplain assessment of designated backpack campsites within Canyonlands. The campsites are listed in Table 1.

Table 1. Designated backcountry campsites in Canyonlands National Park.[a]

District	Campsite
Island in the Sky	Syncline
Needles District	Chesler Park , CP1-5
	Upper Elephant UE1-2
	Big Spring, BS1-2
	Squaw Canyon, SQ1-2
	Lost Canyon, LC1-3
	Salt Creek, SC1-4
	DP1
	ME1
Maze District	no designated backpack campsites

[a] Source: Canyonlands National Park: Planning Your Visit. 1997. General Information Newspaper. Canyonlands National Park. Canyonlands National Park and Orange Cliffs Unit of Glen Canyon National Recreation Area Backcountry Management Plan, 1995.

The Colorado Plateau region experiences monsoon weather conditions from July through September. As a result, thunderstorms of high intensity and short duration cause flash floods in arroyos and canyons frequently used by park visitors. These flash floods carry high flows and debris and can easily surprise hikers and campers. To avoid injury to visitors at campsites, backpack campsites should be moved out of the flood plain where these flash floods may occur.

Not all of these sites require assessment, and initial screening must rely on park staff knowledge of potential threats, aerial photos and other available information. If a backcountry site is considered to be within a 100-yr flood plain or within an area of high potential danger, the park must consider moving or removing that campsite, or providing educational information regarding the nature of thunderstorms and the speed at which flood conditions may arise within the canyon country.

Alternate Actions and their Probable Impacts: If no action is taken, the potential exists for severe safety issues to arise. Further, mismanagement of flood plains and riparian habitats may negatively affect water quality and wildlife.

Personnel: Technical assistance requested from the WRD.

Compliance: CATEGORICAL EXCLUSION BASED on 516 DM2 APP.2, 1.6

Funding:
BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:			0.0	0.0
2nd Year:				
3rd Year:				
		Total:	0.0	0.0

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	Hydrologist	16.0	0.5
2nd Year:				
3rd Year:				
		Total:	16.0	0.5

Annual Project Status and Accomplishments: The product will be a flood assessment report and recommendations concerning removal or re-location of some designated backcountry campsites.

Literature Cited:
NPS. 1993b. Flood Plain Management Guidelines. Interior Special Directive 93-1, July 1, 1993.

NPS. 1995. Canyonlands National Park and Orange Cliffs Unit of Glen Canyon National Recreation Area, Backcountry Management Plan. Moab, UT.

Project Statement ARCH-N-032.000
CANY-N-040.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: EVALUATE AND REDUCE CONTRIBUTION OF DISSOLVED SOLIDS TO MAJOR RIVER SYSTEMS
Funding Status: Funded: 3.8 Unfunded: 3.2
Service Wide Issues: N24

Problem Statement: Salinity (dissolved solids) is one of the most pervasive water quality problems throughout Colorado River Basin. Some $750 million of damage to agricultural crops and residential water systems occurs in the Lower Basin states as a result of high total dissolved levels in the Colorado River (Bureau of Reclimation, 1997). The Upper Basin states provide an unlimited source of dissolved solids that eventually reach the Colorado River. Nearly half of the salinity or dissolved solid load to the Colorado River is from natural sources such as saline springs, erosion of geologic formations, and saline or alkaline soils associated with surface runoff. Hydrological modifications comprised of the smallest diversion on tributaries to the Colorado River to large reservoirs such as Flaming Gorge Reservoir on the Green River increase the naturally high salt levels in these two river systems. Net evaporative losses from reservoirs tend to increase the dissolved solids concentration of the released water. Additionally, bank storage water, associated with the reservoir after draw down, may have a high concentration of dissolved solids if it has been in contact with soluble minerals that are typical for soils in the Upper Basin. Also transmountain exports of headwaters, low in dissolved solids, reduce the dilution effect and result in increased dissolved solids downstream. Lastly, abandoned oil and gas wells may serve as a source of saline waters if left uncapped and used for non-culinary waters. Little is known about the presence of these types of wells in Caynonlands and Arches National Parks, and the issue is addressed in an earlier project statement (ARCH-N-300.000 and CANY-N-037.000) which addresses location of these wells.

Irrigated agriculture is the next largest contributor to salinity in the Colorado River system. Surface runoff from irrigated areas contributes approximately 3.4 tons of salt annually to the river system (Bureau of Reclimation, 1997). Salinity in the Colorado River is also highly dependent on streamflow and may be partially offset by reservoir releases in the Upper Colorado River Basin (U.S. Geologic Survey, 1996). The Colorado Salinity Control Forum has actively sought to reduce salinity loading to the Colorado River from natural and irrigation sources. In Colorado, the Grand Valley Salinity Control Project directed lining of all ditches to reduce dissolution of salts into the ditch water. Success is inferred from comparisons between predicted reduction of salinity resulting from lining projects, and trends in annual dissolved solid loads at the Colorado-Utah border (Station 09163500). Decreases in annual dissolved solid loads downstream of the control project during 1986 to 1993 were, in part, caused by salinity control projects (Butler, 1996) . Butler (1996) also described the efficacy of plugging oil wells in reducing dissolved solid loading to the White River near the Meeker Dome, Colorado.

The Forum has asked the Bureau of Land Management in Utah to reduce salt loading by encouraging best management practices such as increasing vegetative cover and managing grazing and oil and gas exploration more effectively (Barnett, J. 1995 pers. comm.., Colorado River Salinity Control Forum). The Forum views the National Park Service in a similar light whereby park management can implement the above practices if applicable. The Colorado

Salinity Control Forum has also developed a map depicting watersheds of the Upper Basin states which contribute to salinity loading (Figure 13).

The potential for significant salinity loading to the Colorado River system exists within Arches and Canyonlands National Parks. Several springs noted in the table below reveal high total dissolved solids. These sources can flow directly into the Colorado and Green rivers or make their way to the rivers via tributaries. Increased use and erosion of roads and trails also encourage mobilization of soluble materials into nearby water sources. Trampling by trespass cattle around park springs also activates dissolution of minerals into water resources. Many of the park geologic formations have a high concentration of dissolvable solids as a result of their deposition in marine environments. Fossil fuels are generally associated with marine shales and extraction of oil, gas, and coal results in increased dissolution of soluble minerals. Increased salinity can be caused by leaching of spoils, discharge of saline ground water , and increased erosion from surface disturbance. The parks have the ability to reduce salinity loading by determining location of highly saline springs, implementing control of erosion around these springs, and reduction of disturbance and control of erosion of alkaline or saline soils.

Description of Recommended Project and Activity: The recommended project is threefold and includes 1) reviewing the watershed map developed by the Colorado Salinity Control Forum; 2) locating all saline springs and wells as a Geographic Information System data layer and relating those springs to roads, trails and developed areas, and 3) instituting management tools to reduce human induced erosion of saline soils near water springs and streams.

Table 1. Mean total dissolved solids and ranges for saline springs and streams in Arches National Park and Canyonlands National Park. Standard deviations in parentheses where sample size > 1. Levels above 1200 mg/L are considered saline based on Standards of Quality for Waters of the State of Utah (Utah Department of Environmental Quality, 1997) for agricultural use.

Site	Park and District	Mean	Range
Salt Valley Wash (SVW1)	ARCH	3513(199.4) [a]	3372-3654
Salt Wash (SW3)	ARCH	2050(134.7) [a]	1924-2180
Salt Spring (SW5)	ARCH	2476(651.4) [a]	1746-2998
Winter Camp Spring	ARCH	5560 [c]	
Shafer Spring (SHS1)	CANY - Island in the Sky	1616 [a]	1616
Lathrop Canyon (WR1)	CANY - Island in the Sky	3970 [b]	
Sheep Spring	CANY - Island in the Sky	1410 [b]	
Hardscrabble Spring	CANY - Island in the Sky	2730 [b]	
Lower Jump Spring	CANY- Needles	2180 [d]	

Sources: [a] Long and Smith (1996); [b] Huntoon (1977); [c] Sumsion, 1971; [d] Richter (1980)

Management tools to reduce erosion and control movement of soluble minerals into nearby water include development of buffer zones between development, trails, and roads and the springs or streams noted above or additional water resources deemed important. Buffer zone distances are based on preservation of various ecological functions. For example, vegetated buffers control erosion by blocking the flow of sediment, by promoting infiltration, and by stabilization of streambanks and wetland edges. Physical barriers formed by vegetation buffers slow surface flow rates, flow rates are generally slower for sheetflow versus channelized flow. Vegetated buffers of 33 to 164 feet (10 to 50 m) are adequate for reduction of sediment introduction to water systems (Castelle et al., 1994). A quantitative relationship between salinity and sediment is not established here, but is assumed to exist. If vegetation and the soils including the microbiotic crusts remain intact around water sources, then the possibility of increased dissolved solids loading is reduced.

The parks will not consider closure of springs that release saline waters as these are part of the natural environment in the parks. The parks also consider highly saline soils as a feature of the parks, and natural processes which change or erode soils are protected by National Park Service policies.

The parks should take measures to insure that trespass cattle do not continue to trample spring areas. Arches continues to fence its boundaries and Canyonlands may consider such action in problem areas.

Where areas have been disturbed and have potential for surface runoff and erosion, efforts towards revegetation should occur. Revegetation of disturbed sites in an arid climate is difficult at best and long-term in nature. At the least, all efforts should be made to prohibit continued disturbance to these areas.

The Needles District in Canyonlands has a network of trails. The Backcountry Management Plan (National Park Service, 1995) prohibits camping and staking of saddle and pack stock within 300 feet (88 meters) of water sources. Pack and saddle stock use should be monitored to ensure that disturbance of this nature is reduced and eliminated near water sources that could contribute minerals to the Colorado River.

Water sources in the Island in the Sky District in Canyonlands reveals some of the highest levels of total dissolved solids (i.e., Lathrop Spring, 3970 mg/L). Again reduction of salinity loading to the Colorado River involves reduction of disturbance of land around the spring.

The product of this project includes a composite Geographic Information System data layer depicting saline springs, roads, trails, and soil types. This tool will be used in a document which describes priority areas targeted for erosion reduction, revegetation, or removal of the disturbance factor (i.e., campsite, trail section, or road).

<u>Alternate Actions and their Probable Impacts:</u> If no action is taken, elevated contribution of dissolved minerals to the Colorado River system will continue and in effect make the United States obligation to Mexico of no more than 800 mg/L of total dissolved solids more difficult.

<u>Personnel:</u> This project requires a Biologist or Hydrologist with the ability to review past water quality data and develop a salinity loading reduction plan for the parks, and a GIS Specialist to develop the appropriate GIS data layers.

<u>Compliance:</u> CATEGORICAL EXCLUSION BASED 516DM6, App. 7.4 E(4)

Funding:
BUDGET AND FTES:

	Source	FUNDED Activity		Budget($1000's)	FTEs
1st Year:	PK-BASE	GIS Specialist	3.8	0.1	
2nd Year:					
3rd Year:					
		-	--------------------------		
		Total:	3.8	0.1	

BUDGET AND FTES:

	Source	UNFUNDED Activity		Budget($1000's)	FTEs
1st Year:					
	WRD	Hydro. Tech.	3.2	0.1	
2nd Year:					
3rd Year:					

		Total:	3.2	0.1	

Annual Project Status and Accomplishments: The product will be an assessment of impacts to soils around saline springs, reduction in erosion to these areas, restoration of these areas, and protection of vegetative buffer zones near saline springs. Erosion reduction costs and restoration of impacted areas will be defined for years 2 and 3 after proper techniques are determined.

Literature Cited:

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Division of Water Quality. 1997. Standards of quality for waters of the state: R317-2, Utah Administrative Code. Utah Dept. of Environmental Quality.

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Richter, Jr., H. R. 1980. Ground water resources in the part of Canyonlands National Park east of the Colorado River and contiguous Bureau of Land Management Lands, UT. , MS U. of Wyoming.

Sumsion, C.T. 1971. Hydrologic investigations in Arches National Monument. USGS, Salt Lake City, UT.

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Project Statement ARCH-N-033.000
CANY-N-041.000
Last Update: 3/20/98
Initial Proposal: 3/20/98
Title: EVALUATE THE STRUCTURE AND FUNCTION OF THE COLORADO AND GREEN RIVER CORRIDORS
Funding Status: Funded: 108.0 Unfunded: 342.0
Service Wide Issues: N12, N20, N22, N24

Problem Statement: The Colorado and Green rivers are integral water resources of Canyonlands and Arches; they join in Canyonlands National Park, and the Colorado River forms the southeastern boundary of Arches National Park. The Colorado and Green River system drains 241,988 mi^2 (626,750 $km^{2)}$ of the western United States. The Colorado flows for 48 miles (77 kilometers) through Canyonlands National Park and borders Arches National Park for approximately 12 miles (7.5 kilometers). The Green River flows 61 miles (98 kilometers) through Canyonlands. Both rivers are laden with sediment, and confined within entrenched meanders at the bottom of 1000 to 2000 foot (300-600 meters) canyons of the upper Paleozoic and lower Mesozoic sandstone (Rigby et al. 1971). The narrow riparian zone along the river corridors support peachleaf willow (*Salix amydaloides*), tamarisk (*Tamarix ramosissimum*), and infrequent groves of Fremont cottonwood (*Populus fremonti*). The following outlines several issues regarding these two river systems.

Visitor Use
Visitors within both parks can access these rivers and do so readily. Impacts from visitor use to these system is perhaps outweighed by cumulative effects of dams such as Flaming Gorge Reservoir on the Green River, mill tailings, mining, agriculture runoff, wastewater disposal from upstream towns, toxic spills on highways such as Highway 128 to Moab, and oil and gas developments. Visitor impacts to these systems are regulated and mitigated by pack-in, pack-out policies for boating trips, and by restricting numbers of boating parties. River runners must carry out human waste. Backcountry vehicle campers must use designated campsites, which have toilets, in the Needles and Island in the Sky Districts, and must carry portable toilets in the Maze District. Backcountry hikers are less restricted and are not required to carryout human wastes when camped near the two rivers. They are however, restricted from camping within 300 feet (231 meters) of any water source. In this latter situation, human waste can result in resource impacts and public health issues. Transgressions by boaters are less likely due to regulations and the type of waste containers they must use. The Canyonlands NP Backcountry Management Plan (National Park Service, 1995) recognizes the potential for a problem with human waste disposal and hikers. The plan suggests more stringent policies regarding hikers if smaller group sites and fewer permits do not control the human waste problem. The Southeast Utah Group wishes to determine if there is a problem with human waste at primitive camping sites along the Green and Colorado rivers.

Sediment and Channel Dynamics
Numerous studies cover a realm of chemical, physical, and biological topics related to the dynamics of these two sediment-laden systems. Much of the research on these systems stems from the initiation of the Endangered Fish Recovery Program begun in the 1980's in order to insure that four endangered fish species including the Colorado squawfish (*Ptychocheilus lucious*), humpback chub (*Gila cypha*), bonytail chub (*Gila elegans*), and the razorback sucker (*Xyrauchen texanus*) thrive once again in the Colorado and Green rivers. Their decline is

attributed to the introduction of non-native fish , as well as construction of dams on these rivers and their tributaries which have reduced and changed timing of peak flows, and reduced inundation of flood plains necessary for juvenile rearing. For example, FLO Engineering (1995) determined that although mean annual flows for the Green River remain relatively the same pre- and post- dam construction, annual peak flows have changed dramatically. Pre-dam annual peak flow on the Green River in Canyonlands equaled 32,700 cfs pre-dam construction versus 22,300 cfs under post-dam conditions.

Additionally, FLO Engineering (1995) determined that flows required to initiate over bank flooding on the Green River in Canyonlands NP would be 39,000 cfs under current channel conditions. A 53,000 cfs peak flow could inundate 500 acres of flood plain habitat. The recurrence interval for this type of flow on the Green River is 100. Channel changes on the Green River in Canyonlands NP include vegetation encroachment, reduced sediment load, and conversion of flood plains to terraces. A narrower channel results in a higher stage favorable to inundating flood plains with lower discharges. Unfortunately, as a result of channel narrowing and lower peak flows, vegetation including tamarisk, a particularly noxious invader, is not readily disturbed (FLO Engineering, 1992).

Many hydrologists studying the Green and Colorado rivers conclude that channel narrowing has reduced habitat for endangered fish species. Andrews and Nelson (1989) note the most significant process which causes channel narrowing is aggradation of channel bars and the resulting attachment of those bars to the bank. Other considerations for the Green River include important work by Andrews (1986). He found that effective discharge (i.e., the increment of discharge which transports the largest quantity of sediment over a period of years) has decreased for selected reaches downstream of Flaming Gorge Reservoir on the Green River, and as a consequence, the bankfull channel will continue to adjust over a period of years to the prevailing effective discharge. In other words, sediment transport at the lower end of the Green River has decreased and is most likely due to a decrease in the magnitude of the river flows and not necessarily a decrease in available sediment. To the contrary, Lyons and Pucherelli (1992) relate that the Green River below Flaming Gorge Reservoir has reached quasi-equilibrium where the river transports the load supplied to it.

Some analysis of sediment load and transport have been accomplished for the Colorado River (Thompson, 1984a). Changes in flows and sediment load were attributed to the closure of Blue Mesa Reservoir in 1966. Cluer (unpublished) brought together literature of the Green River. In his review, he finds that Research Consultant Inc. (1990) cites Schumm et al. (1987) and Schumm and Gellis (1989); these papers discuss the reduction of sediment load in the Colorado River since the 1920's. The declining sediment load was attributed to drought in critical areas of the drainage basin (Thomas, 1993); 2) changes in sediment sampling procedures by the U.S. Geologic Survey (Schumm et al., 1987), 3) major reductions in livestock numbers and implementation of erosion control efforts on grazing (Hadley, 1974), and 4) the cycle of sediment storage in entrenched channels and arroyos following the widespread occurrence of channel entrenching in the later part of the 19th century (Graf et al., 1987; Schumm and Gellis (1989). Perhaps decreases in sediment load, whatever the cause, may have been occurring well before closure of Blue Mesa Dam on the Gunnison River, tributary to the Colorado River. If so, park management may wonder if channel narrowing and degradation is not an artifact of several processes and not just dam construction. The Southeast Utah Group wishes to document further changes in sediment transport and channel dynamics.

Tamarisk and Cottonwood Establishment

Tamarisk (*Tamarix ramosissima*) spread along the Colorado and Green rivers in Canyonlands NP between 1925 and 1931 (Graf 1978). Lower than normal flow conditions prior to 1935 left bare sand surfaces available for colonization by tamarisk. This species remains well established today because it readily stabilized the bare depositional sites long ago. Graf (1978) suggested that channel narrowing or restriction of the channel was a result of establishment of tamarisk. However, today others focus on bar attachment resulting from diminished flows in the Colorado and Green rivers as a cause for channel narrowing. Flow velocity may also play a role. Regardless, tamarisk invasion has reduced habitat to a monoculture in some areas and covered suitable habitat that could be colonized by other species such as cottonwood and willow. Graf (1978) remarked that without human intervention, climatic change or catastrophic flood, established tamarisk stands would not be disturbed. His remark remains true.

Cottonwood establishment has been studied by Cooper et al. (in press) on the Yampa and Green rivers. Several requirements must be met for establishment and they include 1) timing of peak flow to precede seed release, 2) removal of tamarisk canopy, 3) riverine landforms which contain sandy loam, loam, or silt loam 15 cm in thickness within the upper 45 cm surface layer, and 4) adequate soil moisture for cottonwood seedlings under 3 years to insure successful competition with tamarisk. Cottonwood establishment has not been studied on the Colorado River to the extent that it has on the Green River. The Southeast Utah Group is interested in determining specifics of cottonwood establishment along the Colorado River by Arches NP and in Canyonlands with respect to recreational use and tamarisk competition.

Structure and Function of the River Corridor

Prior to human induced alterations, the Colorado River system was characterized by tremendous fluctuation in flow and turbidity. Miller (1961) cites flows recorded in the Colorado River at Yuma, Ariz., ranging from 18 cfs in 1934 to 250,000 cfs in 1916. The drainage basin, in recent geologic time lacked large natural lakes, so the native fishes have not continued to adopt specializations for lacustrine environments. Thus, the riverine environment molded the bizarre morphologies of several fish. The Colorado River near Arches NP and in Canyonlands, and the Green River in Canyonlands NP were designated by the US Fish and Wildlife Service as critical habitat for four federally endangered fish species - the Colorado squawfish (*Ptychocheilus lucious*), humpback chub (*Gila cypha*), bonytail chub (*Gila elegans*), and the razorback sucker (*Xyrauchen texanus*). A multitude of studies are a result of plans to recover the fish. The parks have contributed to these efforts and will continue to do so. A project statement which designs studies to assess inundated flood plains for nursery habitat is already presented by the parks.

Jordan et al. (1997) studied the macroinvertebrate population of the Colorado and Green rivers in Canyonlands. They sampled these rivers down to Cataract Canyon where rapids precluded sampling. Jordan et al. (1997) determined that the riverine invertebrate communities in Canyonlands are complex. Apparently no significant difference exists between the Green and Colorado rivers for densities of macroinvertebrates. However, three substrates, backwaters, sand beaches, and sand runs revealed significant differences. Backwaters generally contained higher numbers and diversity of organisms. Discharge and days since peak discharge significantly affected densities of organisms. The authors recommended further sampling and have evaluated a rapid assessment technique of the sand benthos (Jordan et al. 1997; Bray and Shiozawa, 1997). Further sampling may determine whether the distribution of *Stempellina* in the Green River and *Paracladopelma and Orthocladius* in Colorado remain peculiar to their respective rivers.

What has not been studied are organisms along the Colorado and Green rivers that require riparian habitat. Surveys for southwestern willow flycatchers, small mammals, and terrestrial invertebrates have not been completed recently, nor have the interactions between these organisms been studied. Since these two rivers are integral to the parks, the park should conduct studies which determine presence and absence of rare and endangered species, as well as monitoring for small mammals, other birds, reptiles and amphibians, and terrestrial invertebrates associated with riverine habitats. Park studies should address hoe these organisms interact, and the flow of energy through the riparian ecosystem.

Water Quality
The parks continue to monitor water quality on the Green and Colorado rivers. The program as it exists now is adequate. Park scientists collect samples at two Green River sites and six Colorado River sites 3 to 4 times a year, and have done so for the past ten years. The sites are listed in Appendix f.

<u>Description of Recommended Project or Activity:</u> The park proposes a many-fold project coordinated by an overall principal investigator, with sub-investigators concentrating on specific topics. The focus of the study is to review, research, and combine knowledge regarding river ecology and hydrology within the parks. Some of this information will serve as baseline data, other information may provide insight into how certain aspect of large riverine systems function. The issues range from visitor impacts to sediment load to endangered species within the river corridors of the Green and Colorado. The topics are spread among a variety of disciplines. A Lead Principal Investigator is required to oversee compilation of information and to analyze the results of such a broad effort.

Visitor Use
This component of the project assesses the impacts of human waste disposal in the river corridors. Boaters are not necessarily the focus of this study. Instead, hikers and those who can access the rivers by vehicle may incur the greatest local impact with regards to human waste and garbage. Although hikers are restricted to camping away from streams, they are not required to carry out human wastes. Education continues to be the key here, but also the park is interested in determining whether waste accumulation is occurring along the Colorado and Green river access points. A biological technician can access these sites and determine the extent to which human wastes are a problem at these sites. Because boaters have stringent regulations regarding disposal of wastes including the types of containers they use, the focus is on those who access the rivers by land. This aspect of the study can be coordinated with other projects including water quality sampling, spring and seep sampling or bighorn sheep observation.

Sediments and Channel Dynamics
To date, Cluer (unpublished) has developed an annotated bibliography of work completed on the Green River. Much of the sediment section of the problem statement above references his material. The first step involves developing a similar document for the Colorado River within the parks. This document can dictate research needs for the Colorado River in the same manner that Cluer (unpublished) does for the Green River.

A second component of this section includes placement of still photography cameras along the Colorado and Green rivers. Cameras that are automatically programmed to take photographs on a daily basis will be placed at strategic locations in association with water quality sampling sites. The still photography results in excellent documentation of channel changes with respect to abiotic factors including changes in dam operations, climatic changes such as droughts, and catastrophic occurrences. Photos will be taken once per day with film being changed on a monthly basis.

Cross-sectional measurements of the rivers at these sites will also occur. Permanent cross-sections will be placed at the sampling locations so that changes in channel conformation can be directly measured. Two hydrological technician under the guidance of a principal investigator will conduct this project.

Tamarisk and Cottonwood Establishment

Above Cataract Canyon and along the Colorado River near Arches NP, the riparian zone is dominated by peachleaf willow (*Salix amydaloides*), tamarisk (*Tamarix ramosissimum*), and infrequent groves of Fremont cottonwood (*Populus fremonti*). The Southeast Utah Group is interested in defining the relationship between these species, and determining the specific requirements for cottonwood and willow establishment within the parks. The proposed study includes aging existing cottonwood groves, determining various age classes of tamarisk and willows, and establishing test plots for studying the establishment of Fremont cottonwood and peachleaf willows. This study would be coordinated with the cross-section measurements of the river channel, thus serving as a basis for instream flow assessment and hydrological requirements of various plant species. This aspect of the overall study of the Green and Colorado river systems would further be defined by proposals from prospective investigators. The study would provide the parks with information that may be helpful in managing the riparian corridor. A Hydrological Technician and Biological Technician will assist with this project.

Structure and Function of the River Corridor

Since so much work has been completed regarding the endangered fish species no studies are offered here. Instead, the Southeast Utah Group proposes to survey for the southwestern willow flycatcher (*Empidonax traillii extimus*), an endangered species, within appropriate habitat according to Sogge et al. (1997). Additionally, the Group proposes to conduct rare and endangered species, bird, small mammal, amphibian and reptile, and terrestrial invertebrate surveys along the river corridors.

The rare and endangered species survey along the rivers should encompass a 100% survey; however, due to the length of the two rivers and lack of accessibility, the survey must be stratified by land formation, and other abiotic or biotic factors.

Bird and small mammal surveys have been conducted in Canyonlands, but the proposed surveys will be located along the rivers in both Canyonlands and Arches, mirroring techniques from previous surveys which include a station to station technique for birds, and a web of 100 traps for small mammals. Site locations will depend on previous studies and access.

Relationships between these organisms and transfer of energy through food webs has not been clarified for riparian organisms along the Green and Colorado rivers. Development of a food web and energy budget for these organisms is one outcome of this aspect of the study. The scope of the study would further be defined by proposals from prospective investigators.
The size of the project reflects the size of the system which is being inspected. In order to understand the importance of the river corridor in terms of biodiversity, energy flow, sediment transport, population dynamics, one element cannot be studied to the exclusion of the other. Thus, the Southeast Utah Group proposes an ecosystem approach to studying the Green and

Colorado rivers. The project supervisor would be responsible for overseeing the various aspects of the project, and would develop the final report.

Alternate Actions and their Probable Impacts: No action would result in a continued lack of knowledge regarding the biological and physical characteristics of the Green and Colorado rivers in Canyonlands and the Colorado River bordering Arches NP, and the inability to provide basic information to other river corridor parks.

Personnel: This project requires a river project coordinator, three principal investigators, two Hydrological Technicians, and two Biological Technicians. The project is a multi-year project. In the first year the sediment and channel dynamics literature review will be completed, cameras put in place and cross-sections measured. The tamarisk and structure and function components each will require 3 years of study. The first year will require site locations as well as collection and experiments. The third year will incorporate development of the report by the Head Principal Investigator.

Compliance: CATEGORICAL EXCLUSION BASED on 516 DM2 App. 1.6

<u>Funding:</u>

BUDGET AND FTES:

	Source	FUNDED Activity	Budget($1000's)	FTEs
1st Year:	PKBASE	Bio. Tech.	24.0	1.0
	PKBASE	Bio. Tech.	12.0	0.5
2nd Year:	PKBASE	Bio. Tech.	24.0	1.0
	PKBASE	Bio. Tech.	12.0	0.5
3rd Year:	PKBASE	Bio. Tech.	24.0	1.0
	PKBASE	Bio. Tech.	12.0	0.5
		Total:	108.0	4.5

BUDGET AND FTES:

	Source	UNFUNDED Activity	Budget($1000's)	FTEs
1st Year:	WRD	Project Supervisor	25.0	0.5
	WRD	Prin. Investigator (Sediments)	25.0	0.5
	WRD	Prin. Investigator (Tamarisk and Cottonwood)	20.0	0.4
	WRD	Prin. Investigator (Structure and Function)	50.0	1.0
	WRD	Hydro. Tech.	24.0	1.0
	WRD	Hydro. Tech.	12.0	0.5
	WRD	Equipment (Cameras, Surveying Equipment)	10.0	
2nd Year:	WRD	Project Supervisor	25.0	0.5
	WRD	Prin. Investigator (Sediments)	10.0	0.2
	WRD	Prin. Investigator (Tamarisk and Cottonwood)	20.0	0.4
	WRD	Prin. Investigator (Structure and Function)	50.0	1.0
	WRD	Hydro. Tech.	24.0	1.0
	WRD	Hydro. Tech.	12.0	0.5
	WRD	Equipment	10.0	
3rd Year:	WRD	Project Supervisor	25.0	0.5
	WRD	Prin. Investigator (Sediments)	10.0	0.2
	WRD	Prin. Investigator (Tamarisk and Cottonwood)	20.0	0.4
	WRD	Prin. Investigator (Structure and Function)	50.0	1.0
	WRD	Hydro. Tech.	24.0	1.0
	WRD	Hydro. Tech.	12.0	0.5
	WRD	Equipment	10.0	
		Total:	498.0	11.1

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Appendix A: Representatives at the Water Resources Scoping Meetings

Attendees of the Water Resources Issues Scoping Meeting held in Moab, Utah on 888 prior to the development of the Water Resources Scoping Report

Name	Affiliation
Kevin Berghoff	NPS, Glen Canyon National Recreation Area
Karen McKinley-Jones	NPS, Arches National Park
Bruce Rodgers	NPS, Southeast Utah Group
Jim Webster	NPS
Dave Wood	NPS, Southeast Utah Group

Attendees of the Water Resources Issues Scoping Meeting held in Moab, Utah on September 18, 1997.

Name	Affiliation
David Ariotti	Division of Environmental Quality, State of Utah
Kevin Berghoff	NPS, Glen Canyon National Recreation Area
Lewis Boobar	NPS, Glen Canyon National Recreation Area
Brian Cluer	NPS, Water Resource Division, Water Rights
Walter Dabney	NPS, Southeast Utah Group, Superintendent
Jim Harte	BLM, Hydrologist
Craig Hauke	NPS, Southeast Utah Group
Roy Irwin	NPS, Water Resources Division
Barry Long	NPS, Water Resources Division
Karen McKinlay-Jones	NPS, Arches National Park
Mark Page	NPS, Division of Water Rights, State of Utah
Bruce Rodgers	NPS, Southeast Utah Group, Chief, Resources Mgmt.
George Smith	US Fish and Wildlife Service
Don Weeks	NPS, Planning and Evaluation Division
Ed Wick	NPS, Fishery Biologist
Dave Wood	NPS, Southeast Utah Group, Planner

Appendix B: Consultation, Coordination, and Acknowledgments

The following individual provided valuable input to the planning process through their participation in a Water Resources Issues Scoping Meeting held in Moab, Utah on September 18, 1997.

Name	Affiliation
David Ariotti	Division of Environmental Quality, State of Utah
Kevin Berghoff	NPS, Glen Canyon National Recreation Area
Lewis Boobar	NPS, Glen Canyon National Recreation Area
Brian Cluer	NPS, Water Resource Division, Water Rights
Walter Dabney	NPS, Southeast Utah Group, Superintendent
Jim Harte	BLM, Hydrologist
Craig Hauke	NPS, Southeast Utah Group
Roy Irwin	NPS, Water Resources Division
Barry Long	NPS, Water Resources Division
Karen McKinlay-Jones	NPS, Arches National Park
Mark Page	NPS, Division of Water Rights, State of Utah
Bruce Rodgers	NPS, Southeast Utah Group, Chief, Resources Mgmt.
George Smith	US Fish and Wildlife Service
Don Weeks	NPS, Planning and Evaluation Division
Ed Wick	NPS, Fishery Biologist
Dave Wood	NPS, Southeast Utah Group, Planner

Additional Consultation

L. Armandt	BLM
M. Jack Barnett	Colorado Salinity Control Forum
John Burghardt	NPS, Division Minerals and Mining
Frank Darcey, III	NPS, Arches National Monument
Pat Flanigan	NPS, Canyonlands National Park, Maze District
Tim Graham	BRD, Research Scientist
Lynn Jackson	BLM
John Johnson, Needles	NPS, Canyonlands National Park, Needles District
John Jones	NPS, Canyonlands National Park, Island in the Sky
Bill Moellmer	Division of Water Quality, State of Utah
Brent Northrup	BLM
Sal Venticinque	BLM

Acknowledgments
A special thanks goes to Bill Moellmer, Division of Water Quality, for visiting the parks and discussing water quality issues and triennial review processes. Roy Irwin, Brian Cluer, and Ed Wick were especially helpful in developing some of the project statements in this document. Kevin Berghoff and David Vana-Miller provided the basis for much of this management plan, and for that I am appreciative.

Appendix C: List of Preparers

Written by

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Kevin Berghoff, Glen Canyon National Recreation Area
David Vana-Miller, National Park Service

Contributors
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Roy Irwin, National Park Service
Patrick Magee, Western State College
Don Weeks, National Park Service
Ed Wick, National Park Service

Photography
Robert Filmore, Ph.D., Western State College, Gunnison CO.
Cover photo provided by Canyonlands Nationl Park

Appendix D: Draft Water Resources Management Plan, Copies Distributed for Review

Name	**Affiliation**
David Ariotti	Division of Environmental Quality, State of Utah
Kevin Berghoff	NPS, Glen Canyon National Recreation Area
Bill Moellmer	Division of Water Quality, State of Utah
Mark Page	NPS, Division of Water Rights, State of Utah
Resource Area Manager	BLM
Bruce Rodgers	NPS, Southeast Utah Group, Chief, Resources Mgmt.
George Smith	US Fish and Wildlife Service
Water Resources Division	NPS
Don Weeks	NPS, Planning and Evaluation Division
Ed Wick	NPS, Fishery Biologist
San Juan County Commissioner	
Bureau of Reclamation	

Revised: October 7, 1997

ACTIVE COAL MINE LIST
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Salt Lake City, Utah 84114-5801
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****

COMPANY NAME	MINE NAME
AMAX COAL COMPANY *John Pappas, Sr. Environmental Engineer P.O. Drawer PMC Price, Utah 84501 (801) 637-2875 (801) 636-2289 (John Pappas) Fax (801) 637-2247	**Castle Gate Mine--ACT/007/004 (Reclamation)**
ANDALEX RESOURCES, INC. *Mike Glasson, Sr. Geologist 6750 Airport Road P.O. Box 902 Price, Utah 84501 (801) 637-5385 Fax (801) 637-8860 Dave Shaver Jean Semborski	**Centennial Project--ACT/007/019** **Wildcat Loadout--ACT/007/033** **West Ridge--PRO/007/041 (Proposed)**
BEAVER BROOK COAL, LLC *Greg Hunt, Vice President 5367 East Mineral Circle Littleton, Colorado 80122 Phone & Fax (303) 660-3488 (303) 850-0525 (Donald Brown)	**Beaver Brook--EXP/007/040 (Exploration)**
BHP PETROLEUM AMERICAS *Scott Sanders, Manager Health, Safety, & Environment 1360 Post Oak Blvd., Suite 500 Houston, Texas 77056 (713) 961-8500 Fax (713) 961-8400	**Knight Mine--ACT/041/005 (Reclamation)** Copy Inspection to: Kent Wheeler Industrial Health Inc. 640 East Wilmington Ave. SLC, Utah 84106 (801) 466-2223
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SALT LAKE OFFICE *Richard Pick, President & CEO Canyon Fuel Company, LLC 6955 Union Park Center, Suite 540 SLC, Utah 84047 (801) 596-7111 Fax (801) 596-4799	
SUFCO MINE *Ken May, General Manager Canyon Fuel Company, LLC 397 South 800 West Salina, Utah 84654 (801) 637-4880 Fax (801) 636-4499	**SUFCO Mine--ACT/041/002**

HIAWATHA COAL COMPANY *Elliot Finley, Resident Agent 3212 South State Street Salt Lake City, Utah 84115 (801) 637-1778	**Hiawatha Complex--ACT/007/011**
HORIZON COAL COMPANY *Vicky Bailey EarthFax 7324 South Union Park Ave. Midvale, Utah 84047 (801) 561-1555 Fax (801) 561-1586	**Horizon Mine--ACT/007/020** Denise Dragoo, Resident Agent Van Cott, Bagley, Cornwall, & McCarthy 50 South Main Street, Suite 1600 SLC, Utah 84111-1495 (801) 532-3333 (801) 532-0465 Direct Fax (801) 534-0058
INTERMOUNTAIN POWER AGENCY *William W. Engels Department of Water and Power City of Los Angeles 111 North Hope Street, Room 1107 P.O. Box 111 Los Angeles, California 90051 (213) 367-0289 Toll Free (800) 331-7748 Fax (213) 367-0269	**Horse Canyon--ACT/007/013 (Reclamation)**
MOUNTAIN COAL COMPANY *Paige B. Beville, Manager Environmental, Health, & Safety ARCO Coal Company 555 17th Street, Room 2170 Denver, Colorado 80202 (303) 293-7913 Fax (303) 293-4073	**Gordon Creek #2, #7, & #8 ACT/007/016 (Reclamation)** **Gordon Creek #3 & #6--ACT/007/017 (Reclamation)** **Huntington Canyon #4--ACT/015/004 (Reclamation)** Consultant: Dan Guy Blackhawk Engineering 214 East 1st North Price, Utah 84501
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NORTH AMERICAN EQUITIES (Dissolved) *Jack Otani, Landowner Star Route Clearcreek Box 555 Helper, Utah 84526	**Blazon #1--ACT/007/021 (Reclamation)** Steve Tanner (Landowner) Route #1 Box 146G3 Helper, Utah 84526
PACIFICORP *Chuck Semborski, Environmental Supervisor Energy West P.O. Box 310 Huntington, Utah 84528 (801) 687-2000 General (801) 687-4720 Chuck Semborski (801) 687-4822 Dick Northrup (801) 687-4725 Dennis Oakley	**Des Bee Dove--ACT/015/017 (Temporary Cessation)** **Deer Creek--ACT/015/018** **Cottonwood/Wilberg--ACT/015/019** **Trail Mountain--ACT/015/009**
SAVAGE INDUSTRIES, INC.	

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Soldier Canyon Mine--ACT/007/018
Banning Siding Loadout--ACT/007/034
Dugout Mine--PRO/007/039 (Proposed)

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Canyon Fuel Company, LLC
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Skyline Mine--ACT/007/005

CONSOLIDATION COAL COMPANY
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Hidden Valley Mine--ACT/015/007 (Reclamation)
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Trail Canyon Mine--ACT/015/021 (Reclamation)
Bear Canyon--ACT/015/025

CYPRUS PLATEAU MINING CORP
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Willow Creek--ACT/007/038

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Davies Coal Mine--PRO/017/001 (Proposed)

GENWAL RESOURCES, INC.
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Crandall Canyon Mine--ACT/015/032

SUMMIT COAL COMPANY (Bankrupt)
*Helen Blonquist
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Boyer Mine--INA/043/008 (Reclamation)

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Summit #1 Mine--INA/043/008
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99 West Main #202
Lehi, Utah 84043
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Sunnyside--ACT/007/007 (In Forfeiture Reclamation)

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WHITE OAK MINING & CONSTRUCTION
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Scofield Route
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(801) 448-9456 Dennis Dyches
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White Oak Mine #1 & #2 Loadout--ACT/007/001

WESTERN STATES MINERALS CORP.
*E.M. Gerick, V.P. of Operations
250 South Rock Blvd., Suite 130
Reno, Nevada 89502
(702) 856-3339
Fax (702) 856-1818

J.B. King Mine--ACT/015/002 (Reclamation)

Permit Numbers: ♥♥♥/□□□/♣♣♣

♥♥♥:	STATUS	□□□:	COUNTY CODE	♣♣♣:	MINE NUMBER
ACT	Active Mine	007	Carbon		
PRO	Proposed	015	Emery		
INA	Inactive	017	Garfield		
REC	Reclaimed By AML	025	Kane		
		041	Sevier		
		043	Summit		

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cc: dth, jch, pgl, vb, th, ls, PFO
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10/07/97

DIVISION OF OIL, GAS & MINING
(801) 538-5291

Joelle

MINEID	MINE_STAT	NAME	OPERATOR	RSEW			MINERALS	CONTACT	ADD1	ADD3	APHON
M015006	RET	RED CHIP MINE	ADAMS MINING COMPANY	20S	8E	SEC35	U	ADAMS	BOX 375	FERRON UT 84523	
M015007	RET	BROWN MOUNTAIN MINE	ADAMS MINING COMPANY	20S	8E	SEC13	U	ADAMS	BOX 375	FERRON UT 84523	
M015013	SUS	SNOW MINE	SAN RAFAEL ENERGY, INC.	21S	14E	SEC22	U	GARY L. JACOBSON	PO BOX 605	MOAB UT 84532	8012595447
M015014	SUS	FOUR CORNERS	SAN RAFAEL ENERGY, INC	21S	14E	SEC22	U	GARY L. JACOBSON	PO BOX 605	MOAB UT 84532	8012595447
M015018	RET	SMITH'S FEE GROUND - RETIRED	CHINOOK CONSTRUCTION CO.	22S	14E	SEC 5	U	MR. ED GAUTHIER	1202 WEST PENDER STREET	VANCOUVER BC 00000	8015648818
M015019	RET	FLAT TOP MINE - RETIRED	MINEX CORPORATION	24S	11E	SEC32	U	MICHAEL J. SKOPOS	3901 MOSS CREEK CIRCLE	FAIR OAKS CA 95628	8013842533
M015020	RET	DELTA MINE	UTAH WEST MINING & DEVELOPMENT	26S	9E	SEC 9	U	MR. LLOYD MEDHAM	867 NORTH 8 EAST	PRICE UT 84501	8016377001
M015024	RET	MOUNTAIN KING - RETIRED	EKKER, RITTER & DEY	29S	11E	SEC 3	U	MR. DON EKKER	4280 PARKWAY DRIVE	GRANGER UT 84120	8019694951
M015026	RET	SAHARA	ENERGY FUELS NUCLEAR	20S	14E	SEC15	U	MR. WILLIAM ALMAS	ONE TABOR CENTER, ST. 250	DENVER CO 80202	3031871831
M015028	RET	ATOMIC MUD MINE	MUD DOG MINING, INC.	20S	8E	SEC 7	U	WILLIAM SCHEMBARI	1919 NORTH REDWOOD ROAD	SALT LAKE CITY UT 84116	8013222452
M015029	RET	ROCKY MINE	MUD DOG MINING, INC.	19S	9E	SEC13	U	WILLIAM SCHEMBARI	1919 NORTH REDWOOD ROAD	SALT LAKE CITY UT 84116	8013222452
M015030	REC	SINBAD MINE	SINBAD MINING CORP.	22S	10E	SEC35	U	MR. W.L. WILSON	101 S 3RD ST STE 101	GRAND JUNCTION CO 81501	3032413700
M015033	PRO	WHITE CAP #8	GYPSUM MINE ASSOCIATES	19S	10E	SEC23	GYPSUM	MR. A. J. CORRELL	PO BOX 1240	CASTLE DALE UT 84513	8013811559
M015034	RET	GYPSUM MINE	MID-AMERICA DEVELOPMENT CORP.	19S	10E	SEC34	GYPSUM	CHERYLL E. AUSTIN	2119 MOUNTAIN VILLAGE DRI	ECKERT CO 81418	3033856634
M015041	ACT	DKG QUARRY/B & J PLACER CLAIMS	DIAMOND K	22S	9E	SEC29	GYPSUM	PHIL PALMER	1600 S RIVERVIEW DR	RICHFIELD UT 84701	8018968667
M015050	ACT	EAGLE CANYON QUARRY/SAN RAFAEL	GEORGIA PACIFIC CORPORATION	22S	9E	SEC19	GYPSUM	RICHARD HOPE	PO BOX 570080	SIGURD UT 84657-0080	8018966340
M015061	ACT	LAST CHANCE #25 & #26	WESTERN CLAY COMPANY	25S	6E	SEC 8	BENTONITE/ZEOLITE	NEAL MORTENSEN	PO BOX 127	AURORA UT 84620	8015299328
M015062	ACT	PAGANO CLAY[EAST CARBON CLAY]	ECDC ENVIRONMENTAL, LC	14S	11E	SEC 1	CLAY	STEVE NOBLE	PO BOX 69	EAST CARBON CITY UT 84520	8018888445
M015072	ACT	HEBE 1,8,9,10 & 11	WESTERN CLAY COMPANY	24S	7E	SEC14	GYPSUM	NEAL MORTENSEN	PO BOX 127	AURORA UT 84620	8015299328
M015075	PRO	SAN RAFAEL QUARRY	UNITED STATES GYPSUM COMPANY	23S	8E	SEC21	GYPSUM	LEE TAYLOR - PLANT MNGR	PO BOX 570160	SIGURD UT 84657	8018966245
S015003	SUS	PROBE MINE	SAN RAFAEL ENERGY, INC.	21S	14E	SEC14	U	GARY L. JACOBSON	PO BOX 605	MOAB UT 84532	8012595447
S015036	SUS	BROWN ROSE	BROWN ROSE MINING	20S	14E	SEC15	AU, AG	MS. SHIRLEY ROSE	BOX 272	ROOSEVELT UT 84066	8017222990
S015037	PAB	PRIMROSE 2	AMERICAN MINERALS DISCOVERY	21S	14E	SEC 5	AU, AG	MR. L. E. TOLMAN	1902 ADDISON AVE EAST	TWIN FALLS ID 83301	2087333959
S015038	SUS	DENALI MINE/GOLDEN ROSE	DENALI MINING CORP.	18S	14E	SEC23	AU, AG	MR. TOM MOUREY/S. ROSE	BOX 451	GREEN RIVER UT 84525	8015644615
S015039	SUS	ROSEBUD MINE	ROSEBUD MINING	17S	14E	SEC19	AU, AG	MS. SHIRLEY ROSE	BOX 272	ROOSEVELT UT 84066	8017222990
S015040	ACT	ROCK TOBBY/ROCKLAND MINE	MIRACLE ROCK MINING AND RESRCH	23S	8E	SEC 2	HUMIC SHALE	DAVID TAYLOR	PO BOX 28	FERRON UT 84523	8012866727
S015042	RET	IVIE 22/RABBIT 19 - RETIRED	DEMAR PERKINS	23S	6E	SEC23	AU, AG	DEMAR PERKINS	BOX 248	MONTICELLO UT 84535	
S015043	ACT	MILLER ROCK/BRET CLARK MINE	HUB RESEARCH & DEVELOPMENT CO	22S	6E	SEC26	HUMIC SHALE	BRET CLARK	6790 S 400 W	MIDVALE UT 84047	8015466550
S015044	SUS	WHITECLOUD MINE	SUTHERLAND BROTHERS, INC.	24S	13E	SEC15	GYPSUM	LEE SUTHERLAND	PO BOX 888	NUCLA CO 81424	9708647566
S015045	SUS	GOLDEN GIRL PROJECT	BIRCH, MARION	24S	17E	SEC 8	AU, AG	MARION BIRCH/BERT SHIMK	2300 SE COAL CREEK RD	PRICE UT 84501	8016370093
S015046	ACT	DADDY DEAREST 1-9/BLACKHAWK	THOMAS J. CLARK AND COMPANY	22S	6E	SEC29	HUMIC SHALE	THOMAS J CLARK	1145 NORTH 1100 WEST	ST GEORGE UT 84770	8016344030
S015047	SUS	WHITE CAP #8	GYPSUM RESOURCE DEVELOPMENT	19S	10E	SEC23	GYPSUM	CURTIS LARKIN	415 EAST HWY 10	HUNTINGTON UT 84528	8016877984
S015048	RET	WHITE CAP #11 - RETIRED	GYPSUM RESOURCE DEVELOPMENT	19S	10E	SEC14	GYPSUM	SCOTT CROWLEY	60 E SOUTH TEMPLE	SALT LAKE CITY UT 84111	8013...
S015049	RET	BJ-2&3 - RETIRED SEE S/015/041	SAVIALL CORP - JOHN WELSH	22S	9E	SEC29	GYPSUM	JOHN WELSH	4780 DONALD ST	HOLLADAY UT 84117	8012776665
S015051	ABD	DRY WASH #1	WRIGHT, RONALD E	21S	7E	SEC34	S, FE, HUMATE	RONALD E WRIGHT	P O BOX 58	CLAWSON UT 84516	8013842200
S015052	ACT	CO-OP PLACER PROJECT	CO-OP MINING COMPANY/STODDARD	23S	6E	SEC 3	HUMIC SHALE	CARL KINGSTON	3212 S STATE ST	SALT LAKE CITY UT 84115	8014855145

MINEID	MINE_STAT	NAME	OPERATOR	NSEW	MINERALS	CONTACT	ADD1	ADD3	NPHON
5015053	ACT	CLARK MINE/EMERYIDE	CLARK, ROBERT L.	27S 6E SEC26	TRACE MINERALS	ROBERT L. CLARK	1758 SOUTH 900 EAST	SALT LAKE CITY UT 84105	8014666443
5015054	RET	HIGH RIDGE CLAIMS - RETIRED	DAVIS, GARY	22S 7E SEC18		GARY DAVIS	540 EAST CENTER	NEPHI UT 84648	8016233320
5015055	RET	ALA #1-15 CLAIMS - RETIRED	STOCKS, WINSTON	25S 14E SEC 3		WINSTON STOCKS	PO BOX 492	MOAB UT 84532	8012599867
5015056	ACT	PLACER #1 AND #2 PROJECT	STAR LIGHT MINING COMPANY	22S 18E SEC36		DON IRVINE	BOX 147	GREEN RIVER UT 84525	
5015057	PAB	R-MANCA RIDGE CLAIMS/ROY WANDA	MANCOS MINING COMPANY	21S 7E SEC 4	AU,AG	ALFORD A. HARRELL/S. ROSE	PO BOX 272	ROOSEVELT UT 84066	8017222990
5015059	ARC	TEMPLE MTN/VANADIUM KING (ARC)	GOLDEN CHEST INC.	24S 11E SEC28	U, V	JOHN W BEASLEY	167 N RAYMOND AVE	FULLERTON CA 92831	71
5015060	SUS	RANGE CREEK PROJECT	RANGE CREEK MINES, LTD	17S 16E SEC36	AU,AG,HG	GEORGE D FEHR	10 EXCHANGE PLACE	SALT LAKE CITY UT 84111	8013633680
5015063	RET	BEN & BENT PROJECTS - RETIRED	WALKER, JIMMIE	18S 13E SEC21	BENTONITE/CLAY	JIMMIE WALKER	261 WALKER DR	MOAB UT 84532	8012597560
5015064	SUS	CLAY KING SOUTH	EMERY INDUSTRIAL RESOURCES	16S 11E SEC32	BENTONITE CLAY	DAN OR GERALD POWELL	967 S 680 W	PAYSON UT 84651	8014657743
5015065	SUS	POWELL BENTONITE	POWELL, CLARK R.	19S 12E SEC16	BENTONITE	CLARK R. POWELL	PO BOX 763	HUNTINGTON UT 84528	8016877634
5015066	SUS	CHIMNEY ROCK II	CHIMNEY ROCK CORPORATION	19S 11E SEC11	LIMESTONE	STEPHEN POWELL	105 E 400 N	CASTLE DALE UT 84513	8013811575
5015067	SUS	BLUE HILL PROJECT	BRANNON, ARNOLD/EARLE, DENNIS	21S 15E SEC32	PRECIOUS METALS	ARNOLD BRANNON	3802 B SOUTH MAPLEWOOD	TULSA OK 74135	9180653541
5015068	ARC	WILD HORSE CREEK - FILE RETIRE	WILD HORSE STRATEGIC MINERALS	23S 11E SEC10	??	CRAIG BOYCE	311 DUKE RD #12	LEXINGTON KY 40502	6062954999
5015069	ARC	HANNI CLAIMS - FILE RETIRED	JACKSON, JOHN D	24S 8E SEC36	??	JOHN D JACKSON	HC 70 BOX 130	CAINEVILLE UT 84775	
5015070	ARC	DIRTY DEVIL - FILE RETIRED	JACKSON, NEAL GEORGE	24S 8E SEC35	??	NEAL GEORGE JACKSON	HC 70 BOX 120	CAINEVILLE UT 84775	
5015071	ACT	STRONTIUM KING #2	HATCH, H. STEVEN	23S 7E SEC22	BLUE CELESTITE CALCITES, BARIT	H. STEVEN HATCH	PO BOX 27	HANKSVILLE UT 84734	8015423379
5015073	SUS	SUMMERVILLE	KALATZES, BRENDA MEGLIACCIO	18S 13E SEC13	GALLIUM & PLACER GOLD	BRENDA KALATZES	434 E 200 S	PRICE UT 84501	8016372087
5015074	ACT	NUMBER 1 CLARK MINE	CLARK, ROBERT L.	27S 6E SEC 2	HUMIC SHALE - TRACE MINERALS	ROBERT L. CLARK	1758 SOUTH 900 EAST	SALT LAKE CITY UT 84105	8014666443
M017001	SUS	TONY M/LUCKY STRIKE	NUCLEAR FUEL SERVICES/PLATEAU	33S 11E SEC21	U	FREDERICK M MACDONALD ESQ	1850 BENEFICIAL LIFE TWR	SALT LAKE CITY UT 84111	8015311844
M017002	RET	DAISY JUNE	GARNER-EKKER MINING CO.	31S 12E SEC31	U	MR. HAL E. GARNER		DUCHESNE UT 00000	
M017004	RET	LUCKY STRIKE COMBINED W/17/001	HYDRO-JET SERVICES, INC.	33S 11E SEC27	U	GARY EKKER	PO BOX 608	AMARILLO TX 84525	
M017005	RET	JETS 1-84	HYDRO-JET SERVICES, INC.	35S 11E SEC14	U	GARY EKKER	PO BOX 608	AMARILLO TX 84525	
M017006	RET	ACE 1-329	HYDRO-JET SERVICES, INC.	36S 11E SEC 5	U	GARY EKKER	PO BOX 608	AMARILLO TX 84525	
M017007	RET	COPPER CREEK	HYDRO-JET SERVICES, INC.	32S 11E SEC 1	U	GARY EKKER	PO BOX 608	AMARILLO TX 84525	
M017008	RET	ANTLER MINE	DIATOMITE PRODUCTS INC.	36S 5W SEC 3	OTHER	MR. K. W. BRINKERHOFF	BOX 276	PANGUITCH UT 84759	8016762995
M017009	RET	PROSPECTOR'S DREAM - RETIRED	UNKNOWN	32S 10E SEC34	CU		UNKNOWN	00000	
M017014	RET	ZIRCONIUM MINE	CONSOLIDATED MINE & MILLING	34S 11E SEC30	OTHER	MR. DALE WHITELOCK	1304 WEST CENTER	OREM UT 84057	8012255958
M017016	RET	SHOOTARING CANYON MILL	PLATEAU RESOURCES	36S 11E SEC 3	U	ROGER BERG	PO BOX 511	TICABOO UT 84734	8017788272
M017018	RET	STRAIGHT CREEK	ENERGY FUELS NUCLEAR	32S 11E SEC 1	U	WILLIAM ALMAS	ONE TABOR CENTER STE 2500	DENVER CO 80202	3036235831
M017020	RET	PENCOL PLACER - RETIRED	PENCOL MINING COMPANY	33S 11E SEC26	AU	MR. MICHAEL JELEN	PO BOX 305	GOLDEN CO 80401	3032794956
M017021	RET	FARLEY PROJECT	ATLAS MINERALS	34S 11E SEC33	U	RICHARD E BLUBAUGH	370 SEVENTEENTH STREET	DENVER CO 80202-5631	3038251170
S017017	SUS	FRANK M MINE	NUCLEAR FUEL SERVICES/PLATEAU	35S 11E SEC 2	U	FREDERICK M MACDONALD ESQ	1850 BENEFICIAL LIFE TOWR	SALT LAKE CITY UT 84111	8015311844
S017022	SUS	PROJECT 38	PLACER CONSULTANTS LTD	31S 10E SEC36	AU	RICHARD J CLAUS	3901 INDIAN SCHOOL RD NE	ALBUQUERQUE NM 87110	5052659316
S017023	RET	GOLD QUEEN - RETIRED	RITER EKKER	31S 11E SEC28	AU	RITER EKKER	PO BOX 94	HANKSVILLE UT 84734	8015423413
S017024	RET	CRESENT CREEK #3 - RETIRED	DARYS EKKER	31S 11E SEC26	AU	DARYS EKKER	120 SOUTH CENTER	HANKSVILLE UT 84734	8015423226
S017025	SUS	MAGIC MOUNTAIN	MAGIC MOUNTAIN MINING, INC.	32S 10E SEC 4	AU,AG,PT,PI	LEWIS BLACKHAM	10320 N 6800 W	LEHI UT 84043	8017681137

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MINE_ID	MINE_STAT	NAME	OPERATOR	NSE#		MINERALS	CONTACT	ADD1	ADD2	PHON
S017026	RET	CEDAR #1-4 & RAINBOW #1	COTNER, KIP	33S 11E	SEC 1	AU	KIP COTNER	PO BOX 66	FIRRON UT 84523	8013844229
S017027	RET	COPPER KING PROJECT - RETIRED	EKKER, DARYS F	31S 13E	SEC34	AU, AG, CU	DARYS F EKKER	PO BOX 111	HANKSVILLE UT 84734	8015423328
S017028	RET	DOUBLESHOE #1 - RETIRED	HORST, STEVE	31S 11E	SEC30	GOLD DREDGING	STEVE HORST	7533 N PINEBROOK ROAD	PARK CITY UT 84060	8016499624
S017029	SUS	JUDY	BEHNKE, RICHARD C	33S 11E	SEC28	??	RICHARD C BEHNKE	11828 HAYNES ST	NORTH HOLLYWOOD CA 91606	8188985082
S017030	ACT	CRESCENT CREEK #7 & GOLD QUEEN	SUNDANCE MINING COMPANY, INC.	31S 11E	SEC29	AU?	BENJAMIN LEE TERRY	PO BOX 369	LOA UT 84747-0369	8018363245
S017031	ACT	BROMIDE BASIN	KAIBAB INDUSTRIES	31S 10E	SEC34	AU	KIM WILSON	PO BOX 192	HANKSVILLE UT 84734-0192	8015423343
S017032	SUS	MT. PENNEL	HUNT MINING	33S 10E	SEC18	??	GREGORY HUNT/CLAY KOWBYL	449 GORDON DRIVE	CASTLE ROCK CO 80104	3036880348
S017033	ACT	PYSERTS CABIN	GOLD TREK INT.	31S 11E	SEC28	AU	MICHAEL D. TERRY	PO BOX 369	LOA UT 84747	8018363245
S017034	RET	HOLT & GOLDEN BELL - RETIRED	HUNT, CARL	31S 10E	SEC35	??	CARL HUNT, WENDELL CHAPEL		HANKSVILLE UT 84734	8015423376
S017035	SUS	GOLD QUEEN	GREEN RIVER HOLDINGS INC	31S 11E	SEC28	AU	BRAD RAMSEY, AGENT	198 N MAIN ST	RICHFIELD UT 84701	8018966927
S017036	ACT	MAY DAY 1,3,4	DUBOIS, ANTHONY	31S 11E	SEC30	??	ANTHONY DUBOIS	PO BOX 216	HANKSVILLE UT 84734	8017771522
S017037	ACT	JDS OLD #7	DUBOIS, ANTHONY	31S 11E	SEC28	PLACER	ANTHONY DUBOIS	PO BOX 216	HANKSVILLE UT 84734	7027771522
S017038	SUS	KAIBAB GOLD - MILLSITE	KAIBAB INDUSTRIES	31S 12E	SEC31	AU	KIM E WILSON	PO BOX 192	HANKSVILLE UT 84734-0192	8015423343
S017039	ACT	LONG GULCH II	SOUTHWEST STONE	38S 4E	SEC 6	GYPSUM - ALABASTER	MIKE DETTAMANTI JOON WOOD	PO BOX 291	KANAB UT 84741	8016444681
S017040	PRO	GOLDEN BELLE	CHAPPELL, WENDELL	31S 10E	SEC35	GOLD	WENDELL CHAPPELL	BOX 1364	LYMAN UT 84749	8014836263
S017041	ACT	CALF CANYON -ESCALANTE PROJECT	JR MINERALS	36S 3E	SEC17	ZIRCON & ILMENITE (TITANIUM)	ROBERT G. REEVES	121 E 200 S	SPRINGVILLE UT 84663	8014893379
M019001	RET	TIBBETTS PLACER MINE	LUKI MILLING CORPORATION	22S 24E	SEC28	AU	MR. C.J. HART	BOX 1075	VERNAL UT 84078	8017898513
M019002	RET	BLACKSTONE MINE	DAVIS, HOMER	22S 22E	SEC32	U	HOMER E. DAVIS	BOX 65	GREEN RIVER UT 84525	8015644252
M019003	RET	MOAB URANIUM MILL	ATLAS MINERALS	25S 21E	SEC27	U	RICHARD E BLUBAUGH	370 SEVENTEENTH STREET	DENVER CO 80202-5631	3038255125
M019005	ACT	CANE CREEK POTASH MINE	MOAB SALT INCORPORATED	26S 20E	SEC28	SALINES/POTASH	ERIC YORK	PO BOX 1208	MOAB UT 84532	8012597717
M019006	RET	THORNBURG MEMORIAL - RETIRED	WESTERN STATES RESOURCES	24S 20E	SEC27	U	MICHAEL D. SHUMWAY	350 PARK ROAD	MOAB UT 84532	8012599868
M019007	RET	CANE CREEK- RETIRED	ATLAS MINERALS	26S 21E	SEC30	U	RICHARD E BLUBAUGH	370 SEVENTEENTH STREET	DENVER CO 80202-5631	3038255125
M019009	RET	CACTUS RAT	ATLAS MINERALS	22S 22E	SEC33	U	RICHARD E BLUBAUGH	370 SEVENTEENTH STREET	DENVER CO 80202-5631	3038255125
M019010	RET	MINERAL CANYON	LAMMERT MINING COMPANY	26S 18E	SEC16	U	JAMES L. LAMMERT	PO BOX 86	MOAB UT 84532	8012596667
M019012	RET	HARLEY DOME HUMUS MINE	WESTWATER, INC.	19S,25E	SEC22	OTHER	MR. HAROLD K. KOBAYASHI	PO BOX 15	HAWTHORNE NV 89415	7029455282
M019014	RET	BRYSON #4	MURPHY, T.J.	16S 24E	SEC 5	TAR SANDS	T J MURPHY	HANCOCK COVE P. O. BOX 42	ROOSEVELT UT 84066	
M019016	RET	TAYLOR PLACER - RETIRED	CRATER EXPLORATION, INC.	23S 24E	SEC 7	AU	WILFORD RUF	1924 SOUTH PIONEER ROAD	SALT LAKE CITY UT 84104	8012865258
M019017	RET	CATO PLACER - RETIRED	CRATER EXPLORATION, INC.	23S 24E	SEC 8	AU	WILFORD RUF	1924 SOUTH PIONEER ROAD	SALT LAKE CITY UT 84104	8012865258
S019018	SUS	SURESHOT #1	GRAMLICH EXPLORATION COMPANY	26S 23E	SEC23	AU, AG	MR. PHILIP GRAMLICH	77 EAST 300 NORTH	MOAB UT 84532	8012598734
S019019	SUS	OLD ROCK FARM	MISSION ROCK	23S 17E	SEC18	STONE	GARY THOMPSON/ELMER STAND	8400 SOUTH 2300 EAST	SALT LAKE CITY UT 84121	8012734524
S019020	RET	GOLDEN HOPES	ROBERT L ZIMMERMAN	26S 23E	SEC 5	AU	ROBERT L ZIMMERMAN	4-329 COLORADO AVENUE	GRAND JUNCTION CO 81501	3032431296
S019021	RET	PAY LODE #21 - RETIRED	COLLINS, FRANCIS	19S 26E	SEC 6	AU, AG	FRANCIS A COLLINS	3306 DELICIOUS DRIVE	CLIFTON, CO 81520	9704344032
S019022	SUS	DRD #17 AND DRD #20	ADAMS, JOHN	25S 23E	SEC25	AU	JOHN ADAMS	130 SOUTH 3RD EAST, APT	MOAB UT 84532	8012594490
S019023	PNB	HOBO #1	BURR, DELBERT	27S 25E	SEC17	AU	DELBERT BURR	1029 WINDSOR DRIVE	PROVO UT 84604	8013731658
S019024	REC	C & R MINERALS MILL	C & R MINERALS	22S 24E	SEC29	AU	KEN COOPER	PO BOX 44	MACK CO 81525	
S019025	RET	LOB #43 - RETIRED	C & R MINERALS	18S 25E	SEC33	AU, AG	KEN COOPER	PO BOX 44	MACK CO 81525	

MINEID	MINE_STAT	NAME	OPERATOR	TRS			MINERALS	CONTACT	ADD1	ADD3	NPHON
S019026	SUS	G.R.I.	AMERICAN STONE	22S	16E	SEC25	TRAVERTINE	LON THOMAS, OWNER	4040 SOUTH 300 WEST	SALT LAKE CITY UT 84107	8012624[illegible]
S019027	SUS	WHITE WASH MINE	AMERICAN STONE	23S	17E	SEC22	TRAVERTINE	LON THOMAS, OWNER	4040 SOUTH 300 WEST	SALT LAKE CITY UT 84107	8012624[illegible]
S019028	RET	DRY FORK CLAIMS - FILE RETIRED	U S BORAX & CHEMICAL CORP	26S	20E	SEC 9	LI, MG	WILLIAM H PENNELL	255 GLENDALE AVE	SPARKS NV 89431	702358950
S019029	PAB	DELORES DREDGING PROJECT	TYLER, JOHN	23S	24E	SEC11	AU	JOHN TYLER	122 NORTH	SALT LAKE CITY UT 84103	801521344
S019030	ACT	PUSSYCAT 1-8/KELLI 20 1-22	PENE MINING	20S	25E	SEC22	PRECIOUS METALS	RONALD PENE	BOX 4017	GRAND JCT CO 81502	9702434[illegible]
S019031	SUS	CISCO SPRINGS #1	JONES, MIKE	20S	23E	SEC16	AU	MIKE JONES	9600 S HIGHWAY 191	MOAB UT 84532	[illegible]
S019032	RET	MANCOS SHALE - RETIRED	BRANNON, ARNOLD/EARLE, DENNIS	21S	21E	SEC16	PRECIOUS METALS	ARNOLD BRANNON	3602 B SOUTH MAPLEWOOD	TULSA OK 74135	9186635[illegible]
S019033	RET	PETRIFIED TREE #8	UNITED MINERALS CORPORATION	24S	25E	SEC34	U, V	MILTON DERRICK	2764 COMPASS DR STE 230	GRAND JUNCTION CO 81506	970245[illegible]
S019034	ACT	MYSTERY/ML 45848	HILL, JAMES W	24S	20E	SEC 2	GEMSTONES	JAMES W HILL	741 BITTLE LANE	MOAB UT 84532	801259775
S019035	PRO	AMMI MINE - DOLORES RIVER	ABSOLUTE MINING & MINERALS INC	23S	24E	SEC11	TAILINGS	DON DALLAPE	1350 E 145 SOUTH	LEHI UT 84043	801768331
S019036	ACT	ROBERTS BOTTOM PLACER	MINING EXPL & DEVELOP INC.	23S	24E	SEC 9	AU, AG	ROGER T. MAHONEY	544 30 1/2 RD	GRAND JUNCTION CO 81503	970245347
S019037	SUS	MILLER PROJECT - #1	MILLER, EDGAR M	19S	25E	SEC15	HUMATE	EDGAR M. MILLER	795 HAMMOND DR STE 801	ATLANTA GA 30328	404255080
S019038	SUS	MILLER PROJECT - #2	MILLER, EDGAR M	19S	25E	SEC27	HUMATE	EDGAR M. MILLER	795 HAMMOND DR STE 801	ATLANTA GA 30328	404255080
S019039	ACT	THE SANDRA J	PEACOCK MINING CO, INC.	18S	26E	SEC32	GOLD, SILVER, PLATINUM	KERMET BOHRER	14761 WELD CO RD 3	LONGMONT CO 80504	303678797
S019040	ACT	BUNNELL 22	R & S ENTERPRISES	20S	21E	SEC25	PRECIOUS METALS	S.A. LANDRY	12602 FM 1484	CONROE TX 77303	409756616
S019041	ACT	STATE SECTION 13	WIND RIVER RESOURCES CORP	20S	25E	SEC13	METALLIFEROUS MINERALS	TOM BACHTELL	3245 835 SPRUCE WAY	PARK CITY UT 84098	
S019042	PRO	BUNNELL PROCESSING FACILITY	R & S ENTERPRISES	22S	24E	SEC26	PROCESSING	S. A. LANDRY	12602 FM 1484	CONROE TX 77303	409756616
S055001	RET	LUNA MESA II - RETIRED FILE	DENNIS LIERD	27S	7E	SEC17	AU	DENNIS LIERD	BOX 340	CAINEVILLE UT 84775	80
S055002	SUS	T W I, II, III, IV	NOLAN WALKER	27S	7E	SEC16	AU	NOLAN WALKER	BOX 1250	BEAVER UT 84713	801438289
S055003	RET	WIDOWMAKER	JONES, CASEY	27S	7E	SEC15	AU	CASEY JONES	PO BOX 97	HANKSVILLE UT 84734	801542320
S055004	SUS	EDDIE,DIANE,CHANCE,RED,DONALD	JONES, CASEY	27S	7E	SEC22	AU	CASEY HUNT	PO BOX 97	HANKSVILLE UT 84734	801542320
S055005	SUS	CRYSTAL GYP	COTNER, KIP	27S	7E	SEC 9	CRYSTAL GYPSUM	KIP COTNER	PO BOX 66	FERRON UT 84523	801384275
S055006	SUS	FACTORY BUTTE MINERAL PROJECT	DICK SHUMWAY	27S	9E	SEC 2	HUMIC SHALE	DICK SHUMWAY	1810 SHUMWAY	MOAB, UT 84532	801259789
S055007	RET	UNPERMITTED - RETIRED	SHIELDS, DESMOND	28S	8E	SEC11		DESMOND SHIELDS	2868 E 2180 S	SALT LAKE CITY UT 84109	
S055008	ACT	PEACOCK PROJECT	THOMAS EXCAVATING	29S	5E	SEC30	PICTURE STONE	TIM THOMAS	PO BOX 179	TORREY UT 84775	801425351
S055009	PRO	LUCKY MIKE/LONG JOHN SILVER	BOULDER MOUNTAIN MINING CO	30S	3E	SEC10	?	MICHAEL TERRY/JOHN OSBORN	PO BOX 216	HANKSVILLE UT 84737	801425360
S055010	ACT	SUNDANCE MINING MILL	SUNDANCE MINING COMPANY, INC	28S	3E	SEC33	AU	BENJAMIN LEE TERRY	PO BOX 369	LOA UT 84747-0369	801836245
S055011	SUS	LUCKY JOHN #1-4	OSBORN, JOHN R	30S	6E	SEC18	??	JOHN R. OSBORN	PO BOX 502	ROMEO CO 81148	303843368
S055012	ACT	TORRY BUFF	YOUNG, JON R	29S	5E	SEC16	SANDSTONE	JON R. YOUNG	3402 BROADVIEW COURT	SANDY UT 84092	801571955
S055013	SUS	ORGANA CLAIMS	ORGANA MINERALS PRODUCTS INC	27S	9E	SEC11	FERROUS OXIDE	KENNETH D. WESTWOOD	2114 HIGHWAY 6-50	GRAND JUNCTION CO 81505	970242859
S055014	SUS	JLW 33	JLW RESOURCES, INC	31S	10E	SEC33	AU,AG,PD,MS	JACK LEEDS/LEWIS BLACKHAM	800 BOONE AVE N	MINNEAPOLIS MN 55427	801738137
S055015	RET	ROCKY RIDGE #1	HORROCKS, GAROLD/MACDONALD, JO	27S	3E	SEC21	AU, AG	GAROLD HORROCKS, MACDONALD	PO BOX 16	FREMONT UT 84747	801836270
S055016	ACT	TORRY (AM STONE 100 & 101)	AMERICAN STONE	29S	5E	SEC 6	UNIQUE STONE	LON THOMAS, OWNER	4040 SOUTH 300 WEST	SALT LAKE CITY UT 84107	801262410

8064939651

RET - [illegible]
SUS - Suspension
PRE - [illegible]
NOT - [illegible]
PAB - [illegible] abandon[illegible]
PRO - [illegible]
ACT - [illegible]

Appendix F. Present Day Water Quality Sampling Sites for Southeast Utah Group in Canyonlands and Arches National Parks.

<u>Arches National Park</u>

Courthouse Wash	CW1
Freshwater Spring	FW1
Sleepy Hollow	SH1
Willow Spring	WS1
Salt Wash	SW1

<u>Canyonlands National Park</u>

Needles District

Cave Spring	SQ3
Little Spring Canyon	LS2
2.4 Mile Loop	BS2
Bates-Wilson	SC9
Crescent Arch	SC10
Peekaboo	SC12

Maze District

Maze Overlook	SF3
Chocolate Drops	SF4
Horseshoe Canyon-Moonshine	new

<u>River Sites</u>

Colorado River

Potash

Below Moab at Salt Canyon

Lathrop Canyon

Indian Creek

Above confluence with Green River

Green River

Mineral Bottom

Above confluence with Colorado River