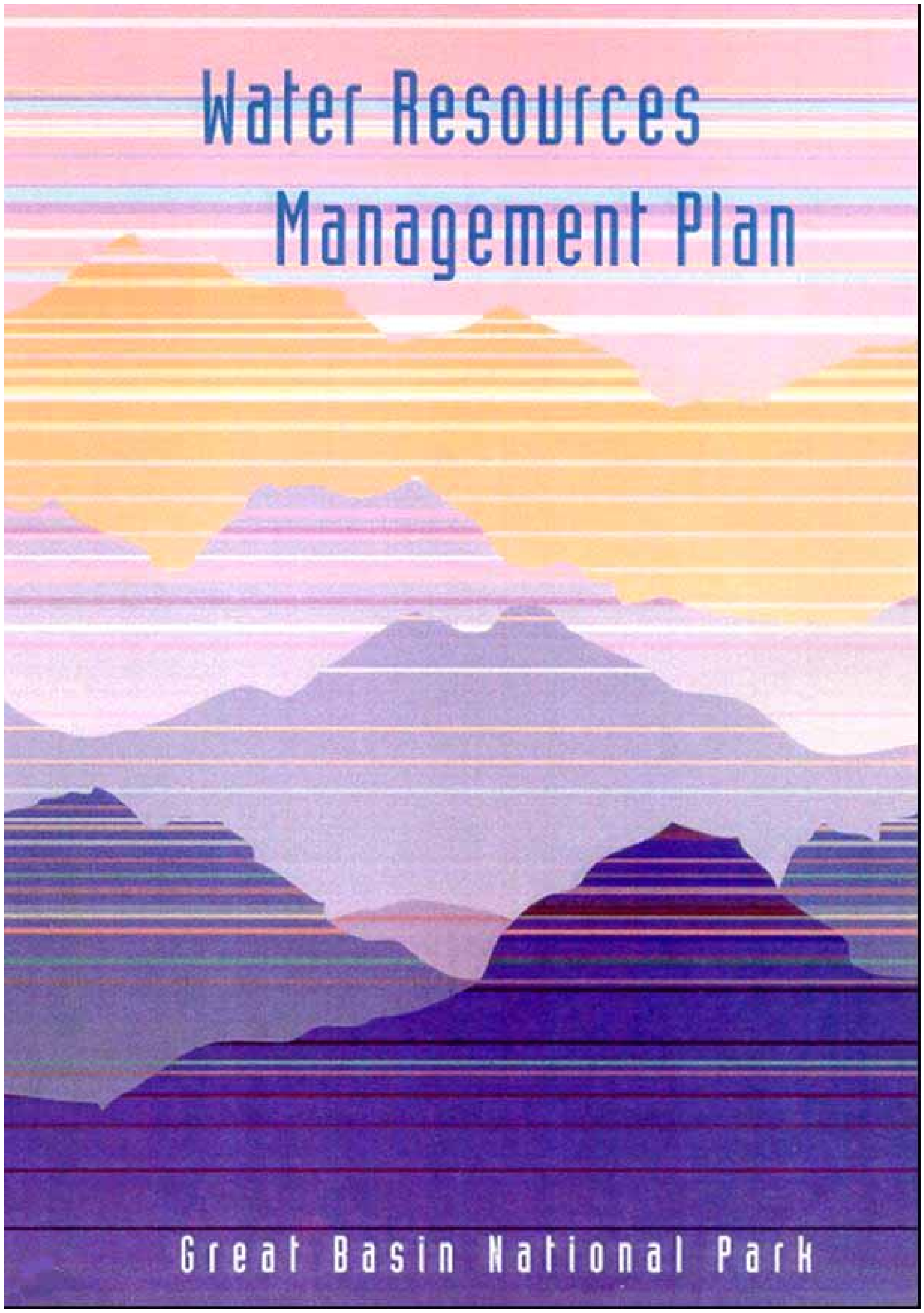
Water Resources
Management Plan
Great Basin National Park

Water Resources Management Plan
Great Basin National Park

1994

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INTRODUCTION

Great Basin National Park (Figure 1) was established by the United States Congress on October 27, 1986 in order to "...preserve for the benefit and inspiration of the people, a representative segment of the Great Basin of the Western United States possessing outstanding resources and significant geological and scenic values..." (P.L. 99-565). This 49th national park consists of approximately 31,200 ha (77,100 ac) of largely mountainous terrain located in the South Snake Range of eastern Nevada. The park contains a number of diverse ecosystems ranging from high desert to alpine, and stratified along an elevational gradient that rises from 1,890 m (6,200 ft) at the eastern border of the park floor to 3,982 m (13,063 ft) at the summit of Wheeler Peak.

The water resources of Great Basin National Park are diverse and include numerous perennial streams, six alpine lakes, over 50 springs, and extensive riparian areas and wet meadows. Five major streams *flow* eastward into Snake Valley and several smaller streams *flow* westward into Spring Valley. The two largest streams of the park, Baker Creek and Lehman Creek, arise in the Wheeler Peak area, and most developments within the park are presently contained within their drainages. Upon exiting the park and under natural conditions, most of the streams gradually percolated into the alluvium or evaporated upon reaching the adjacent valleys. Now many of the streams, upon leaving the park, are channelized or diverted into pipelines, and the waters are stored for irrigation and other purposes. Systems of surface water outside the park, in general, are greatly altered from natural conditions.

Purpose of the Water Resources Management Plan

The enabling legislation creating Great Basin National Park calls for the National Park Service (NPS) to protect, manage, and administer the park in such manner as to conserve and protect the scenery as well as the natural, geologic, historic, and archaeological resources of the park. The NPS also is to provide for the public use and enjoyment of the same in such a manner as to perpetuate these qualities for future generations (P. L. 99-565). In order to achieve these goals, NPS policies require that each unit of the National Park System develop and implement a General Management Plan (GMP). Adopted in 1993, the Great Basin National Park GMP provides the overall basis for managing the park's resources, uses, and facilities (NPS 1993).

In addition to the GMP, each park may develop various "action" plans to address specific resource needs and actions. This Water Resources Management Plan (WRMP), the first for Great Basin National Park, is such a plan. It is designed to serve as a management action plan to guide park water-related activities over the next 10 to 15 years. This WRMP is complementary to, and consistent with, other existing park management documents, including the GMP (NPS 1993) and Resource Management Plan (in review.).

Water resources planning for a unit of the National Park System typically involves several steps (Figure 2). The planning starts with consideration of the reasons for the park's establishment and identification of the exceptional water-related resource values

Figure 1. Location of Great Basin National Park.

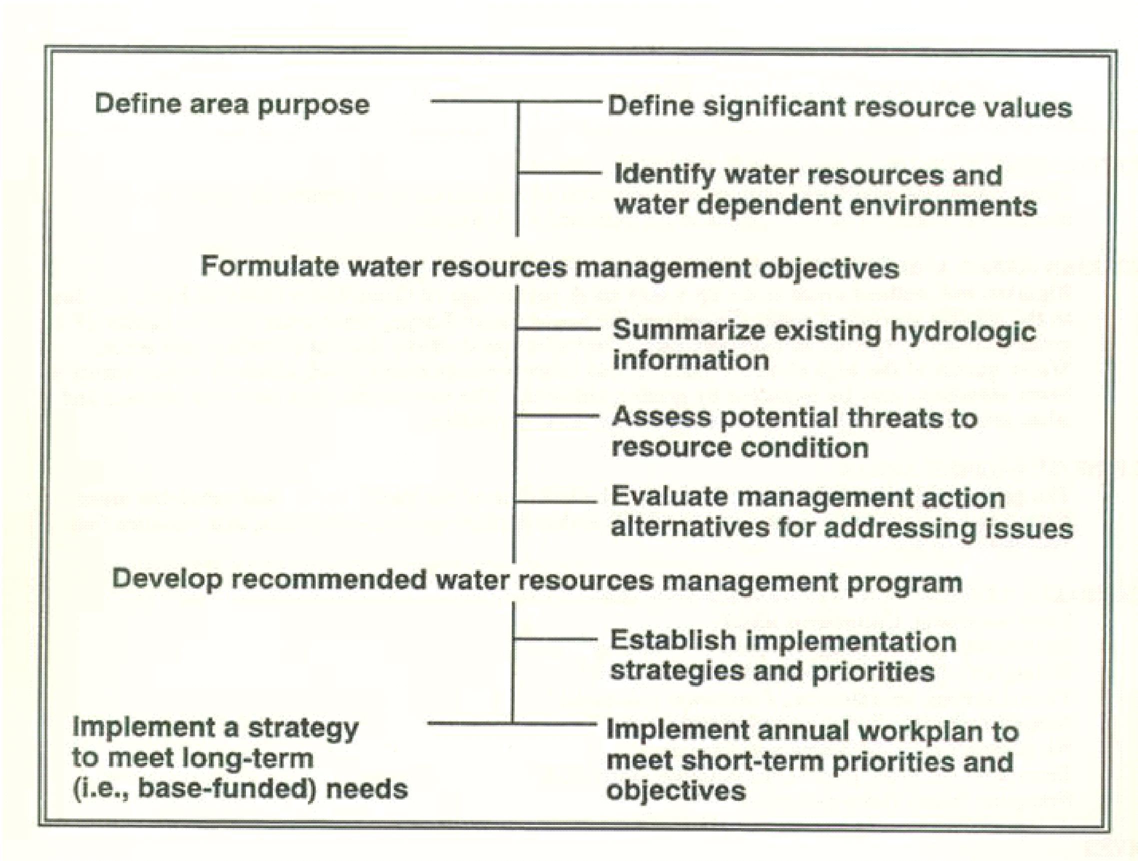

Figure 2. The water resources planning process.

of the park. These have been identified within the park's GMP (Table 1, NPS 1993). In addition, the WRMP provides resource-specific information to support the NPS decision-making process related to the protection and management of the park's water resources and water-dependent environments. The WRMP includes a review of available information about the park's water resources and water-dependent environments. It also contains descriptions of significant water-resources management issues, including constraints on water management brought about by the park's enabling legislation. Finally, the WRMP provides a recommended management program for water resources, including recommended actions for inventory and monitoring, resources management, and research. The WRMP also provides water-related project statements, which are consistent with guidelines of the NPS and designed to be incorporated into Great Basin National Park's Resource Management Plan (in prep.).

Land Status and Land Use

The NPS exercises proprietary jurisdiction in Great Basin National Park. The park lies entirely within White Pine County in east-central Nevada. The nearest town - Baker, Nevada - is inhabited by about 50 people and is about 8 km (5 mi) from park

Table 1. Exceptional resources identified in the Great Basin National Park General Management Plan (NPS 1993).

BRISTLECONE PINE *(Pima* longaeva) FORESTS

Great Basin National Park contains several stands of bristlecone pine reputed to be the most exceptional examples of this species in the National Park System.

RIPARIAN AREAS AND WATER QUALITY

Riparian and wetland areas make up a very small percentage of Great Basin National Park, yet due to the relative scarcity of water throughout the South Snake Range, these areas provide habitat of a great diversity of species and support higher biological productivity than surrounding and areas. Water quality of the high elevation streams and lakes is exceptionally good, although water quality at lower elevations may be impacted by grazing activities. The very dilute, high elevation streams and lakes are extremely vulnerable to acidic atmospheric deposition.

ALPINE/SUBALPINE AREAS

The geologic history of the Great Basin and the isolation of the park's alpine and subalpine areas from other mountainous areas have produced endemic plant species, subspecies, and varieties that exist nowhere else.

FEDERALLY LISTED OR STATE-LISTED SPECIES Snow

wavewing, *Cympoterus nivalis*
Intermountain wavewing, *Cympotencs basalticus* [2] Holmgren's
buckwheat, *Eriogonum hommgrenii* [1] Tunnel springs beardtongue,
Penstemon concinnus [1] Nevada primrose, *Primula nevadensis* [1]
Nachlinger's catchfly, *Silene nachlingerae* [1,3]
Bonneville cutthroat trout, *OncorI ynchus clarki utah* [1] Peregrine falcon
Falco peregrines

CAVES

The park contains more than 30 known cave systems, including the well known Lehman Caves.

DIVERSITY OF BIOLOGICAL COMMUNITIES

The park supports a great diversity of biological communities ranging from desert to alpine communities because of elevation, temperature, and moisture gradients within the South Snake Range.

GLACIAL FEATURES

The park contains some of the best defined glacial features within the Great Basin physiographic province. These include cirques, tarns, a remnant glacier, and a rock glacier.

EXCEPTIONAL AIR QUALITY

The existing air quality in the area of eastern Nevada that contains Great Basin National Park exceeds the highest standard in the US. Visibility from the park often exceeds 200 km (120 mi).

VISTAS

Great Basin National Park provides exceptional views of two broad basins to the east and west, and spectacular vistas of the surrounding mountain ranges.

CULTURAL RESOURCES

The park contains numerous historical sites related to ranching or mining themes. The Lehman orchard, Lehman aqueduct, and Rhodes cabin have been entered on the National Register of Historic Places. In general, the park's prehistoric resources have not been extensively investigated.

[1] Candidate mica for listing as threatened or endangered by the US. Fish and Wildlife Service.
[2] Not known to be present but habitat is suitable.
Taxon recommended for state listing by the Nevada Natural Heritage program. Classified as Endangered by the
4 U.S. Fish and Wildlife Service.

headquarters. Ninety-three percent of the boundaries of the park abuts other federal lands (78 percent U.S. Department of Agriculture, Forest Service and 15 percent Bureau of Land Management) (NPS 1993). Private lands exist in portions of the valleys surrounding the park, but most of the land in the valleys remains under management of the Bureau of Land Management.

As discussed in the GMP, the park incorporates two areas previously managed by the federal government: a 30,947-ha (76,469-ac) portion of the Humboldt National Forest of which 11,332 ha (28,000 ac) once constituted the Wheeler Peak Scenic Area and the 259-ha (640-ac) Lehman Caves National Monument managed by the NPS. Lehman Caves National Monument was established in 1922 under jurisdiction of the U.S. Department of Agriculture (USDA). In 1933, jurisdiction of the monument was transferred to the NPS. From 1924 to 1986, various proposed bills and studies were evaluated in response to interests in establishing a national park near the Wheeler Peak Scenic Area and Lehman Caves. Passage of a bill in 1986 (P.L. 99-565) following lengthy debate led to the establishment of the park in the mountainous terrain surrounding and encompassing these two areas.

Mining and livestock grazing have occurred since the late 1860's on lands now encompassed by the park. Limited crop and fruit production and logging also occurred. Cattle and sheep grazing continues within the park under a permit system involving seven allotments. Numerous unpatented mining claims exist, but there are no active mines.

Water Resources Management Goals and Objectives

Water resources are a particularly important and sensitive ecosystem component. Their physical availability and quality are critical determinants not only of aquatic resources, but of a park's overall natural resource condition. These resources also provide important linkages within ecosystems, connecting park resources with resources outside park boundaries.

For the purposes of this WRMP, water resources are broadly defined. They include the physical and chemical attributes of surface and ground waters, the biological components of the aquatic system, habitat characteristics (e.g., number and size of pools, amount of woody debris, canopy cover, and streambed materials), and the transition zone between the aquatic and terrestrial systems (e.g., riparian-wetland areas). The water resources are themselves a component of a larger natural-cultural system. Components of this larger system that are interrelated and interdependent with the water resources of the park include the climate, geology, watersheds, caves, terrestrial communities of plants and animals, and cultural features such as visitor facilities, local communities, and historic land uses.

Because of the important role of water in maintaining resource condition, it is the policy of the NPS to seek to maintain, rehabilitate, and perpetuate the inherent natural integrity of water resources and water-dependent environments occurring within units of the National Park System (NPS 1991). This is akin to preserving options and avoiding large-scale, irreversible change due to human land-use practices to the water resources and to the larger systems within which these resources reside (Bella and Overton 1972).

The following management objectives have been developed to guide actions related to priority water resources issues within Great Basin National Park:

- To manage waters of the park and water-dependent environments in a manner designed to maintain the greatest degree of biological diversity and ecosystem integrity within the provisions of the authorizing legislation.

- To maintain the pristine quality of the park's water resources.

- To establish an up-to-date water resources baseline sufficient to determine the present condition of the park's water resources and meet NPS inventory and monitoring requirements.

- To implement on-going monitoring and research activities necessary to detect water-quality changes in high-elevation lakes and streams, which are inherently vulnerable to acidic atmospheric deposition.

- To protect NPS water rights and water-related resources by protesting applications for water rights that may adversely affect the park, and by participating in general water-rights adjudications that involve park lands.

- To delineate riparian-wetland areas, and to monitor and manage these resources in a manner that will maximize their biological integrity and enhance critical habitat for fish and wildlife species.

- To develop and implement a cooperative management effort for the protection of the existing Bonneville cutthroat trout population and to expand the distribution of this population within its historic range.

- To map floodplains and implement management actions designed to reduce potential risk to public safety.

- To promote water conservation in all park facilities and to work cooperatively with local communities in addressing water and wastewater issues.

Legislative and Planning Relationships

The following state and federal statutes, regulations, and executive orders have regulatory significance regarding water resources management at Great Basin National Park. A description of the applicable tenets of each statute is provided.

Federal Legislation and Authorities

National Park Service Organic Act (1916)

The Organic Act specifies that the NPS is responsible for the preservation and conservation of natural resources in all parklands under its jurisdiction. This act was reinforced by Congress in 1970 with legislation stating that all parklands are united by a common preservational purpose, regardless of title or designation. Hence, all water resources in the National Park System are protected equally by federal law, and it is the fundamental duty of the NPS to protect those resources unless otherwise indicated by Congress.

Public Law 99-565

The legislation that established Great Basin National Park includes a number of special provisions relating to the water resources of the park. The following provisions are paraphrased from Public Law 99-565:

- Fishing is to be permitted in the park in accordance with applicable state and federal laws. Zones and periods of time may be designated, in which no fishing may be permitted, for reasons of public safety. Except in emergencies, any regulations that prescribe such no-fishing zones or times shall be enacted only after consultation with the appropriate state agency. Presently, the Nevada Department of Wildlife is that agency.

- Grazing is permitted in the park to the same extent as permitted on July 1, 1985 subject to limitations established by the Secretary of the Interior. The NPS administers all grazing in the park. The Federal Government or a grazing permittee may initiate negotiations to exchange all or part of a grazing allotment for an allotment outside the park as long as the exchange does not result in overgrazing of federal lands. Existing water-related range improvements in the park may be maintained by the park or by the permittee with reasonable regulation by the Secretary of the Interior.

- The park is closed to new mining claims, but valid existing claims that predate the park continue to exist.

- No new express or implied reservation of water or water-related rights are established by the park legislation. The park is entitled to only that expressed or implied reserved water right that may have been associated with the initial establishment and withdrawal of Humboldt National Forest and the Lehman Caves National Monument. Additional water rights in the park must be obtained in accordance with administrative and legal procedures of the State of Nevada.

- Acquisition of lands or interests in lands in the park may only take place with the consent of the owner.

Federal Water Pollution Control Act (Clean Water Act)

The Federal Water Pollution Control Act, more commonly known as the Clean Water Act, was first promulgated in 1972 and amended in 1977, 1987, and 1990. This law was designed to restore and maintain the integrity of the nation's water. Goals set by the act were swimmable and fishable waters by 1983 and no further discharge of pollutants into the nation's waterways by 1985. The two strategies for achieving these goals were a major grant program to assist in the construction of municipal sewage treatment facilities and a program of "effluent limitations" designed to limit the amount of pollutants that could be discharged.

As part of the act, Congress recognized the primary role of the states in managing and regulating the nation's water quality within the general framework developed by Congress. All federal agencies must comply with the requirements of state law for water quality management, regardless of other jurisdictional status or land ownership. States implement the protection of water quality under the authority granted by the Clean Water Act through best management practices and through water quality standards. Best management practices are defined by the U.S. Environmental Protection Agency (EPA) as methods, measures, or practices selected by an agency to meet its nonpoint control needs. These practices include but are not limited to structural and non-structural controls, operational procedures, and maintenance procedures. They can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters (Code of Federal Regulations 1990). Water quality standards are composed of the designated use or uses made of a water body or segment, water quality criteria necessary to protect those uses, and an anti-degradation provision to protect the existing water quality.

Section 404 of the Clean Water Act further requires that a permit be issued for discharge of dredged or fill materials in waters of the United States including wetlands. The Army Corps of Engineers administers the Section 404 permit program with oversight and veto powers held by the EPA. Federal legislation and regulations are generally implemented by the states with the EPA serving in an oversight role. A triennial review of a state's water quality regulatory program is conducted by each state's water quality agency to determine if its standards are adequate to meet federal requirements. These standards are then forwarded to the EPA for approval.

Federal Reserved Water Rights

When the Federal Government reserves land for a particular purpose it also reserves, commonly by implication, enough water unappropriated at the time of the reservation as is necessary to accomplish the primary purposes for which Congress or the President authorized the land to be reserved, without regard to state water law. The right to the water vests as of the date of the reservation, whether or not the water is actually put to use, and is superior to the rights of those who appropriate the water after the reservation date. Depending upon the purposes of the reservation, federal reserved rights may include water for consumptive uses, such as domestic and irrigation, as well as non-consumptive uses such as instream flow.

General adjudications are the means by which the Federal Government claims its reserved water rights and waives its immunity from suit pursuant to the Act of June 10, 1952 (66 Stat. 560, 43 U.S.C. 666) (McCarran Amendment). Commonly in a general adjudication, all water users on a stream and its tributaries must claim their water rights, and after considering evidence and testimony, the court issues the decree(s) setting forth the rights within the adjudicated area, including the federal reserved water rights. Adjudications are generally in state courts (see Section I.E.2.c.), but federal courts have concurrent jurisdiction.

Senate Report No. 999-458

Grazing is a prominent activity in the park with large potential to influence water resources. Additional legislative intent for grazing activities within the park is described separate from Public Law 99-565 as part of Senate Report No. 999-458. This report specifies that grazing is to continue in the park subject to constraints imposed by the Secretary of the Interior to ensure proper practices for rangeland management. Action to restrict grazing is warranted only if it furthers sound rangeland management. To manage grazing in the park, the park must promulgate regulations that are compatible with the grazing regulations of the USDA Forest Service. These regulations may be revised from time to time as appropriate to keep them compatible with the USDA Forest Service's grazing regulations.

High-elevation summer range and low-elevation winter range are viewed by many as essential to the economic viability of a year-round grazing operation in the region of the park. The federal land management agencies are to coordinate their regulation of grazing because the USDA Forest Service and the NPS tend to manage the high-elevation land in the South Snake Range and the Bureau of Land Management tends to manage the low-elevation land. Voluntary exchange of grazing privileges can occur and can involve lands managed by the Bureau of Land Management and the USDA Forest Service if grazing areas become available for exchange. Neither the allottee nor the park can be forced to participate in an exchange. Grazing improvements may be used to help accomplish an exchange.

Water improvements, including springs, channels, pipelines, ditches, and watering ponds, in the park are to be maintained because they are essential to grazing. These improvements are to be maintained by the permittee if the pennittee paid for them, or by the park if they were constructed with federal funds. The park is to ensure access to these improvements for maintenance purposes, including reasonable and necessary use of motorized vehicles.

Floodplain Management (Executive Order 11988, 1977)

The objective of this executive order is to require agencies to avoid to the extent possible the long- and short-term adverse impacts associated with occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative.

Protection of Wetlands (Executive Order 11990, 1977)

This order furthers the purposes of the National Environmental Policy Act by directing 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 when practicable alternatives exist. The NPS Floodplain Management and Wetland Protection Guidelines (45 FR 35916, with minor revisions in 47 FR 36718) outline NPS requirements for complying with Executive Order 11990.

Cooperative and Sound Rangeland Management

The park, in cooperation with the Bureau of Land Management and USDA Forest Service entered into a Memorandum of Understanding on July 15, 1987 with the NPS as an initial step toward coordinated resource management of livestock grazing in and around the park. Under administrative guidelines described in this agreement, the three agencies are preparing management plans for the seven livestock grazing allotments in the South Snake Range. The goal of these plans is sound rangeland management, a term that encompasses activities that provide forage and habitat for both livestock and wildlife, protect the soil base, protect watersheds, ensure quality water for both on-site and off-site users, and provide recreation, beauty, relaxation, solitude, and other aesthetic values (Society for Range Management 1992).

Other Applicable Federal Laws

National Environmental Policy Act (1969) This law requires a systematic analysis of major federal actions including a consideration of reasonable alternatives and an analysis of short- and long-term irretrievable, irreversible, and unavoidable impacts.

Endangered Species Act (1973). This act provides for the conservation, protection, restoration, and propagation of selected species of native fish and wildlife that are threatened with extinction. All entities using federal funding must consult with the Secretary of the Interior on activities that potentially effect endangered flora and fauna.

Water Quality Improvement Act (1970). This act requires federally regulated activities to have state certification that they will not violate water quality standards.

Safe Drinking Water Act (1974) and Amendments (1986). This act sets national minimum water quality standards and requires regular testing of drinking water for developed public drinking water supplies.

Mining in the Parks Act (1976) This act closed any remaining NPS units to the location of mining claims and directed the Secretary of the Interior to regulate all activities with NPS units in connection with the exercise of mineral rights on claims.

Federal Cave Resources Protection Act (1988). This act is intended to secure, protect, and preserve significant caves on federal lands for use, enjoyment, and benefit of people and to foster cooperation in use of caves on federal lands for scientific, educational, or recreational purposes.

Taylor Grazing Act (1934). This act emphasizes the livestock industry and the use of federal land for grazing purposes. Stock owners obtained privileges to the lands being grazed.

State Statutes,

State Water Quality Legislation

Nevada Water Pollution Control Law (Nevada Revised Statutes 445.131 to 445.354). The purpose of this statute is to maintain the quality of the waters of the State of Nevada consistent with public health and enjoyment, the propagation and protection of terrestrial and aquatic life, the operation of existing industries, the pursuit of agriculture, and the economic development of the state. It also encourages and promotes the use of methods of waste collection and pollution control for all significant sources of water pollution. The statute designates the Nevada Department of Conservation and Natural Resources as the state's water pollution control agency. The department has the final authority in the administration of water pollution prevention, abatement, and control in Nevada. Through the Environmental Protection Division, the department administers and enforces provisions of the law, including water quality standards for surface and subsurface water. The department also reviews plans for water treatment facilities and develops plans and programs for preventing or eliminating pollution.

Nevada Drinking Water Regulations (Nevada Administrative Code. Chapter 445-Water Pollution Control. Public Water Systems). The Nevada Drinking Water Regulations apply to all public water systems with few exceptions. The regulations specify that all public water systems must meet the requirements of NAC 445.244 to 445.262, inclusive, and of the National Drinking Water Regulations. A supplier of water must give notice to the public whenever certain chemical substances are present at or above specified levels in a public water supply. Certain chemical substances are not to be present in a public water supply above specified levels. Analysis for all public water systems are required at three-year intervals.

Nevada Water Quality Standards (Nevada Administrative Code. Chapter 445-Water Pollution Control). These regulations specify the standards for water quality in natural streams, lakes, reservoirs, and impoundments of the State of Nevada. Standards applicable to all waters are defined as well as standards for individual bodies of water based on their classification. Class A waters, which encompass the waters of Great Basin National Park, are defined as those waters located in areas of little human habitation, no industrial development or intensive agriculture and where the watershed is relatively undisturbed by man's activity. Beneficial use of class A waters are municipal or domestic supply, or both, with treatment by disinfection only, aquatic life, propagation of wildlife, irrigation, watering of livestock, recreation involving contact with the water, and recreation not involving contact with the water. Quality standards for class A waters are provided in Appendix 3.

State Water Rights

Nevada follows the Doctrine of Prior Appropriation in allocating its water resources, both surface water and ground water, whereby the person who first diverts water for a beneficial use (i.e., appropriates the water) has a prior right to use, against all other appropriators -- e.g., "first in time, first in right." Although both allocated under the prior appropriation doctrine, surface water and ground water are administered as separate sources of water. An appropriative water right is a proprietary right; it can be bought and sold, and its place of use, purpose, and point of diversion can generally be changed without loss of priority. It is also a right to the use of the water; the corpus of the water belongs to the public.

The State of Nevada uses a permit system for considering applications to appropriate, following an administrative process under the authority of the State Engineer. By state statutes, the State Engineer has been granted broad powers in the area of water allocation. To obtain an approved application (e. g., a permit), a person must file with the State Engineer (NRS 533.325). The application is advertised in a paper of general circulation (NRS 533360), giving other parties notice and the opportunity to protest (NRS 533.365). If the State Engineer feels it is warranted, a hearing on the application will be held. Following the hearing the State Engineer rules on the application (NRS 533.365). The State Engineer will reject the application if there is no unappropriated water available, the appropriation would conflict with existing rights, or the appropriation threatens to prove detrimental to the public interest. Otherwise, the State Engineer is under a positive duty to approve the application if the prescribed fees have been paid and the application is completed properly (NRS 533370). Terms and conditions may be imposed upon the application to protect existing rights or for other purposes deemed appropriate by the State Engineer. After the permit is approved, the applicant may commence water development. The priority date is the date that the original application was filed in the State Engineer's office. The applicant and protestors can appeal the State Engineer's ruling, but no new evidence can then be presented. The State Engineer's decision is considered prima facie correct and the burden is on the party appealing to prove otherwise (NRS 533.450).

Prior to the adoption of the permit system, water rights were generally obtained by placing the water to beneficial use. These rights are commonly referred to as vested rights. The priority date for a vested right is the earliest date for which a beneficial use can be shown. Vested rights are determined in a stream system adjudication; the Nevada water code describes no other mechanism for determining vested rights (NRS 533.090).

To determine the relative rights to the use of water in a stream system, a general adjudication is initiated. An adjudication may be initiated by the State Engineer or by petition of a water user on the stream system. The State Engineer will proceed with an adjudication if he finds the action justifiable. In an adjudication, all water users on the stream and its tributaries must claim their water rights (NRS 533.090)

State Legislation Specific to Flora and Fauna

Protection and Propagation of Native Fauna (NRS 503.584-503.589. inclusive). These statutes provide a program for the conservation, protection, restoration, and propagation of selected species of native fish and other vertebrate wildlife, including migratory birds. The statutes also provide for the perpetuation of the populations and habitats of such species. Species and subspecies can be listed as threatened with extinction at the state level. Any animal so declared can not be captured, removed, or destroyed at any time or by any means except under special permit issued by the Nevada Department of Wildlife.

Classification of Wildlife (NRS 501.110). This statute requires that wildlife must be classified as follows:

(a) wild mammals, which must be further classified as either game, fur-bearing, protected, or unprotected;

(b) wild birds, which must be further classified as either upland game, migratory game, protected, or unprotected;

(c) fish, which must be further classified as either game, protected, or unprotected;

(d) reptiles, which must be further classified as either protected or unprotected;

(e) amphibians, which must be further classified as either game, protected, or unprotected;

(f) mollusks, which must be further classified as protected or unprotected; and

(g) crustaceans, which must be further classified as either protected or unprotected.

Threatened and Endangered Plants (NRS 527.260-527.300. inclusive). NRS 527.260 to 527.300, inclusive provides a program for the conservation, protection, restoration, and propagation of selected species of flora and for the perpetuation of the habitats of such species. A species or subspecies of native flora can be listed as threatened if its existence is deemed to be endangered and its survival requires assistance because of over-exploitation, disease, or other factors or because its habitat is threatened with destruction, drastic modification, or severe curtailment. Once listed, no member of its kind may be removed or destroyed at any time except under special permit.

THE HYDROLOGIC ENVIRONMENT

Description of the Area

Great Basin National Park is an isolated, 31,200-ha (77,100-ac) mountainous park located in the South Snake Range in the heart of the Great Basin Physiographic Unit (Figure 3). The South Snake Range is fairly representative of the mountain ranges of the Great Basin. Its summit forms part of the division between two hydrographic subregions of the Great Basin -- the portion of the park east of the summit is part of the Bonneville Basins Subregion, and the portion west of the summit is part of the Central Basins Subregion. All valley floor of the basins adjoining the range and most of the alluvial fans at the base of the range are excluded from the park.

The Great Basin as a whole is a large physiographic unit in the western United States hydrologically characterized by the loss of surface waters only through evaporation and transpiration to the atmosphere (Fiero 1986). Summits of several mountain ranges define basin boundaries -- the Sierra Nevada to the west, Wasatch Mountains and high plateaus of southern Utah to the east, and Snake River Plains of Oregon and Idaho to the north. The drainage system of the Colorado River defines the southern boundary. The Great Basin is part of a larger geologic unit, the Basin and Range Province, which includes virtually all of the Great Basin and extends south and east through Arizona, New Mexico, and Texas, and into Mexico. This province is geologically characterized by uplifted and tilted ranges separated by broad elongated basins. In the Great Basin, these ranges tend to run north and south, with valley floors at about 1,200 to 1,500 m (4,000 to 5,000 ft) and mountain ranges up to 4,000 m (13,000 ft) (Fiero 1986).

Climate

Three precipitation regimes occur in the park -- Pacific, continental, and gulf --with accompanying storm types (Powell and Klieforth 1989, Houghton 1979). With all regimes represented, the park is less susceptible to long periods of drought than other portions of the Great Basin because of low probability that all three will be deficient in any one year (Hidy and Klieforth 1990). Orographic effects and wind speeds greatly influence the distribution and abundance of precipitation associated with the regimes, but high elevations generally receive more precipitation than low elevations.

The Pacific precipitation regime consists of frontal cyclones from the Pacific Ocean, which cause winter to be the wettest season in the western and northern Great Basin. This regime causes "warm" storms that cover large geographic areas and have freezing levels at high elevations. Heavy rainfall often occurs at elevations up to 3,000 m (10,000 ft), with heavy snowfall above this elevation. The continental precipitation regime consists of cold cyclones, mainly of Pacific air that develop east of the Sierra most often in spring and fall, causing a spring maximum of precipitation in most parts of Utah and central and eastern Nevada. The largest snowstorms in most of the Great Basin ranges, including the South Snake Range, are associated with the continental regime. The gulf precipitation regime consists of summer thunderstorms in subtropical air masses. Typically these thunderstorms are intense and local, but they can cover large

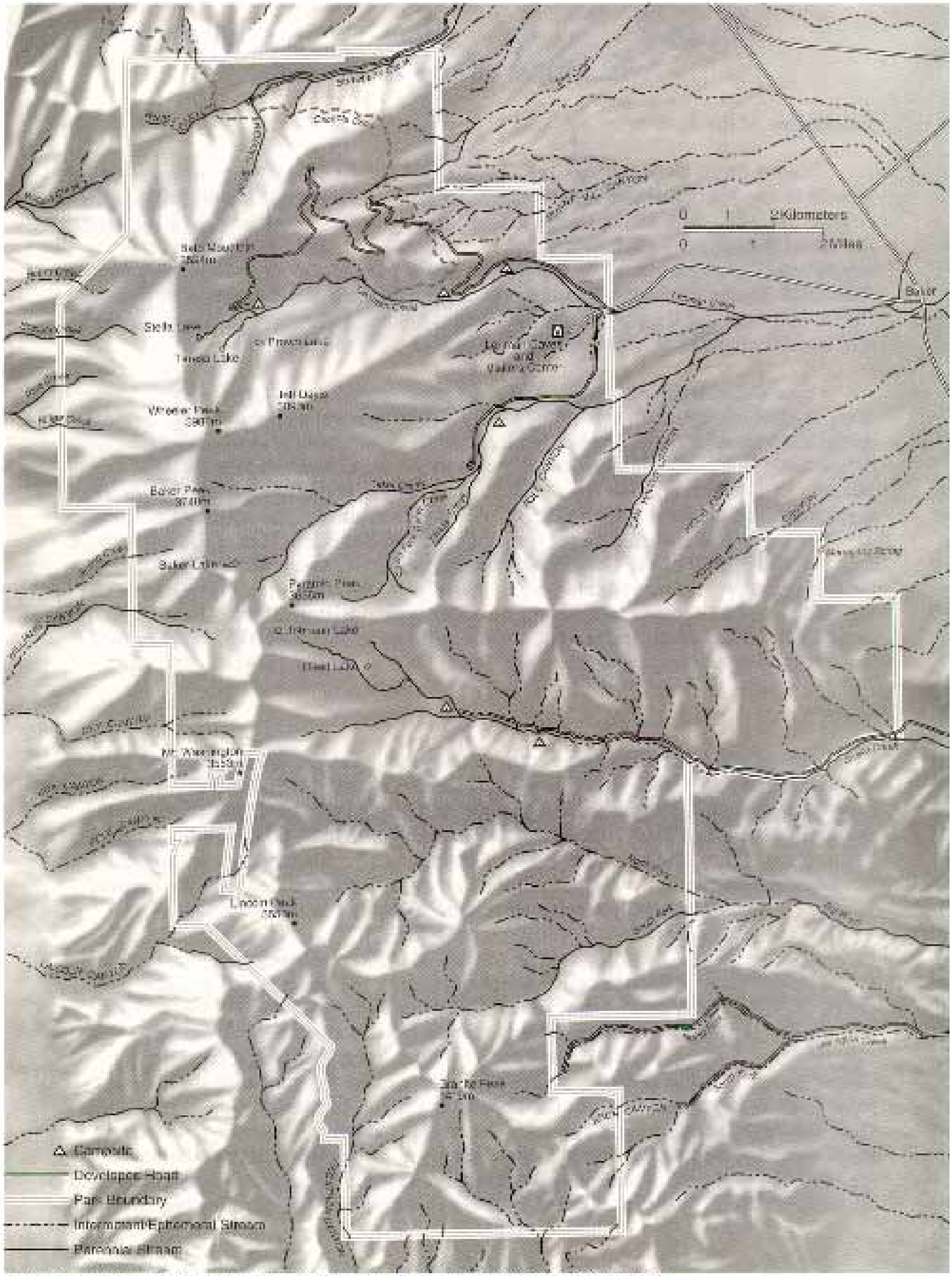

Figure 3. Locations of Streams, Lakes, and Developed Facilities of Great Basin National Park

Figure 3. Locations of Streams, Lakes, and Developed Facilities of Great Basin National Park

areas. Heavy rain often falls for a brief period over one area with no rain a short distance away. Flash floods, lightning, and hail can accompany such storms. In contrast to winter storms, the heaviest rain in thunderstorms often occurs in valleys, not in mountain ranges.

Since October 1, 1937, a cooperative weather station (Lehman Caves) has been operated on the east side of the South Snake Range at 2,080 m (6,825 ft) at the current site of the headquarters of the park. Measurements at Lehman Caves indicate that the eastern slopes of the South Snake Range are in a rain shadow for winter storms but in a more favorable location to receive precipitation from spring and summer storms (James 1987). Annual precipitation averages 330 mm/yr (13 in/yr) at Lehman Caves and is fairly evenly distributed throughout the year (Figure 4) with monthly amounts between 19 and 38 mm (0.75-15 in). *Much* of the winter precipitation at Lehman Caves is snow, which averages 1.8 m/yr (6 ft/yr). To illustrate orographic effects on snowfall, James (1987) estimated that snowfall may be one-third as much in Snake Valley and four times as *much* above 3,000 m (10,000 ft) compared to measurements at Lehman Caves.

The north-south orientation of the Snake Range and its valleys cause prevailing southerly winds during winter storms and northerlies during cold outbreaks. Without storms, nighttime mountain breezes flow down slope and daytime valley winds blow up slope. Winds resulting from thunder storms on mountain slopes can be erratic and damaging, but they seldom exceed velocities of 100 km/hr (70 mi/hr) (James 1987).

Seasonal variation of air temperature in the Great Basin is large because of the distance of the basin from oceanic influences, strong insolation during long summer days, and heat loss by terrestrial radiation during long winter nights (Hidy and Klieforth 1990). Spatial differences are large because of variations in altitude. At Lehman Caves, July and August days are the hottest with average daily maximums of 29 ^{9C} (84°F) and minimums of 13^{9}0 (56 °F) (Figure 4). December and January are the coldest months with average daily maximums of 5 r (41 °F) and minimums of -7°C (19T). For the Great Basin in general, the average decrease of temperature with altitude (lapse rate) is 6.5°C/1000 m (3.6T/1000 ft) during most of the year, but at mid-day the lapse rate on sunny mountain slopes can be about 10°C/1000 m (5.5T/1000 ft) (Hidy and Klieforth 1990). Cold-air drainage into valleys and differential radiation greatly reduce or reverse this gradient on clear calm nights, especially in winter. Inversions can form in which air temperature increases with altitude.

Geology, Topography, and Soils

Fiero (1986) provides a recent overview of the geology of the Great Basin and Burbey and Prudic (1991), Drewes and Palmer (1957), Gale (1956), Whitebread (1969), and Halladay and Peacock (1972) discuss geology in the vicinity of the park. The South Snake Range is part of the carbonate-rock province of the Great Basin. It is characterized by a thick sequence of Paleozoic rocks. Beneath the carbonate rocks are Cambrian clastics and Precambrian basement rock. Compression, extension, intrusion, volcanism, and erosion have greatly modified the distribution and thickness of

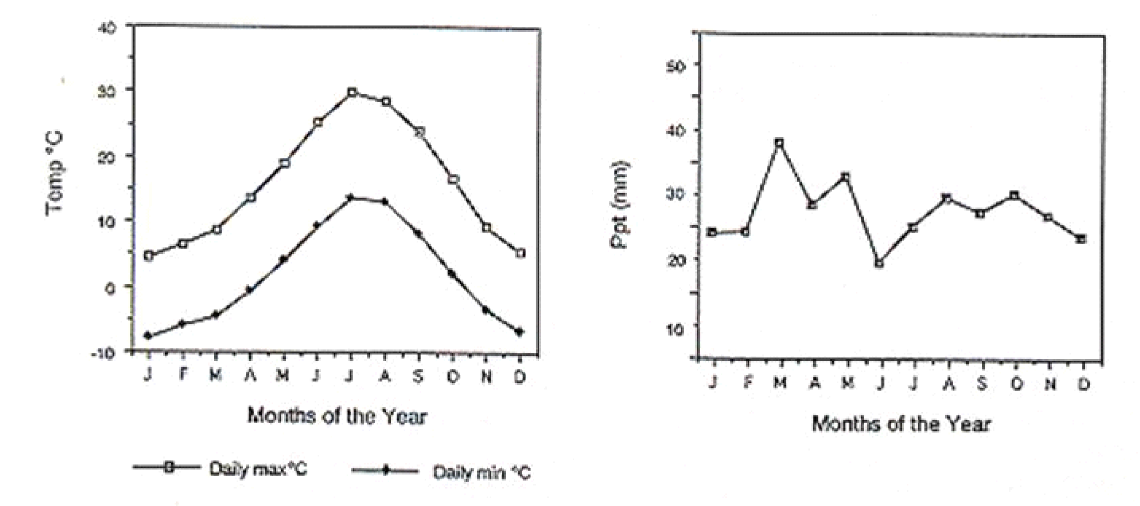

Figure 4. Measurements at Lehman Caves of mean monthly precipitation and mean daily maximum and minimum temperatures by month from 1947-1986 (adapted from James 1987).

the carbonate rocks since their deposition and emplaced a variety of rocks and deposits within and above the carbonate components.

The region that is now the eastern Great Basin was part of the North American continental shelf during the Paleozoic Era (560 to 225 million years ago). Roughly 10,000 m (30,000 ft) of marine sediments, chiefly limestone and dolomite, accumulated on this shelf. During the Mesozoic Era (225 to 67 million years ago), the region was subjected to compressional forces, culminating in several mountain-building events when Paleozoic sediments were folded, thrust faulted, and intruded by granitic magmas.

The extensive block faulting responsible for the present topography of the Snake Range and other ranges of the Great Basin began in the middle Tertiary Period about 30 million years ago and continues today. Stretching of the earth's crust caused numerous and nearly regular block faults. Large blocks slid downward to form valleys and others tilted upward to form north-south tending ranges. Sediments from eroded mountains continue to accumulate in intervening basins. Solution caverns such as Lehman Caves formed in the tilted layers of low-grade marble through the dissolving action of acidic ground water. Dissolution and deposition of minerals subsequently decorated such caves.

The Snake Range experienced mountain glaciation during the Pleistocene (Morrison 1965). Snake Valley was occupied by an arm of Lake Bonneville and Spring Valley by a smaller lake sometimes called Spring Lake. Lake Bonneville reached its maximum westward extent in the Snake Valley only 8 km (5 mi) northeast of the park.

Prominent cirques are present at the heads of Williams Canyon, Lehman Creek, Baker Creek, North Fork Baker Creek, and Snake Creek. Other prominent glacial features include moraine deposits, which occur down to 2,400 m (8,000 ft) in the valleys of Strawberry, Lehman, Baker, and Snake creeks, and a 900-m-long (3,000-ft-long) tongue-shaped glacier/rock glacier system in the cirque on Wheeler Peak at the head of Lehman Creek (Osborn 1990).

The cool, mesic habitats of the high elevations of the ranges of the Great Basin have been characterized as montane "islands" in a vast sea of sagebrush desert (Brown 1971). This sagebrush desert has not always existed as a substantial barrier to plant and animal movement. At intervals during the Pleistocene, colder climates in the Southwest forced high-elevation plant and animal species down to elevations below their present distribution. Valleys probably had a more equable climate during the last Ice Age, compared to today, although the actual composition of plant communities within valleys at the close of the Pleistocene remains in doubt. Packrat middens and pollen samples from the late Pleistocene and early Holocene indicate that limber pine *(Pinus flexilis),* bristlecone pine (P. *longaeva),* Englemann spruce *(Picea engelmannii),* and common juniper *(Junipencs communis)* occurred at lower elevations in the mountains than they do today and that a mosaic of shrub-steppe and riparian communities possibly existed in the valleys (Madsen and Rhode 1990, Thompson 1990, Thompson and Mead 1982, Wells 1983). To some extent, climate and habitat barriers for many species of plants and animals were removed, and exchange occurred between the South Snake Range and the Sierra Nevada and also between the South Snake Range and the Rocky Mountains. Natural processes, which accompanied isolation of the South Snake Range due to warming temperatures during the Holocene, and anthropogenic activities have subsequently influenced the biological communities of the park (Brown 1971, Hubbs and Miller 1948).

The surface geology of a portion of park was mapped by Whitebread (1969) to a scale of 1:48,000. The surface geology of the six 7.5-minute quadrangles that encompass the park will be surveyed and mapped at a scale of 1:24,000 starting in 1993 under an interagency agreement with the U.S. Geological Survey and Stanford University (V. Davila, Great Basin National Park, pers. comm., Aug. 1992).

Topography of the South Snake Range is diverse. The range slopes gradually toward the east and steeply toward the west, ending in large bajadas and alluvial fans that grade into Snake Valley to the east and Spring Valley to the west. Wheeler Peak (3,980 m, 13,063 ft), one of the highest peaks in the Great Basin, and several other peaks above 3,300 m (11,000 ft) are part of the park. Over 25 percent of the park is above 3,050 m (10,000 ft) elevation. Valleys are generally steep and narrow.

A soil survey of the park was conducted in the early 1990s by the Soil Conservation Service working in cooperation with other federal and state agencies (USDA Soil Conservation Service 1992). In general, soils of the region are fairly deep where formed over alluvium and shallow on hillsides. Most are well drained.

Drainages

Waters that originate in the park drain through eight major drainages into two major basins, the Snake Valley to the east and Spring Valley to the west (Great Basin National Park 1992) (Figure 3). Streams and their valleys in the park, as is true for mountainous regions in general, exhibit striking downstream discontinuities in their morphology and physical dynamics. These variations are imposed by large-scale geophysical factors, such as lithological variation, tectonic deformation, and glaciation. These variations directly and indirectly affect smaller features, such as channel size, channel stability, characteristics of bank materials, interactions of surface and subsurface waters, and riparian and aquatic community characteristics (Platts 1979, Frissell et al. 1986, Kondolf et al. 1987). Frissell and Liss (1993) classified and mapped valley segments of the park for streams with perennial flow to describe some of the diversity and patterns associated with park drainages. Valley segments are the stream channels and the portions of the adjacent valley floor and slopes with which the channels interact over a timeframe of thousands or tens of thousands of years (Frissell et al. 1986, Frissell 1992). Sites sampled in the park were selected to encompass the full range of physiographic conditions along perennial streams within the park.

Based on Frissell and Liss (1993), nine types of fluvial valley segments occur within the boundaries of the park and a tenth type occurs widely just outside park boundaries (Table 2, Appendix 4). Within the park and among the perennial streams surveyed, leveed outwash valleys are followed by alluvial valleys, alluviated canyons and alluvial fan-influenced valleys in abundance. Other segment types comprise less than 15 percent of the surveyed streams. However, roughly 30 percent of perennial streams in the region in which the park exists may occur on delta segments of alluvial fans. In effect, park boundaries currently exclude these alluvial fan deltas, which are an important valley type containing distinctive aquatic habitat and vegetation.

Cave Resources

Great Basin National Park has numerous limestone outcrops, many of which contain natural caverns. Lehman Caves, which has been popularized through tours, is only one of about 30 known caverns in the park. The Baker Creek Cave System, including Model Cave, Crevasse Cave, and several others, is completely interconnected and about 4,300 m (14,000 ft) long, nearly twice as long as Lehman Caves. Many of the known caves have not been explored *and many* more undoubtedly exist (NPS 1993). These caves or solution openings may develop wherever the requisite conditions have occurred at any time since deposition of the carbonate rocks (Hood and Rush 1965). Most of the known caves occur in a unit of Pole Canyon Limestone that has undergone substantial solution (Lange 1958, Bridgemon 1967, Aley 1991). Because of the general lack of knowledge about the location of caves in the park, all areas with the potential for underlying solution caves are considered sensitive areas (NPS 1993). The park currently lacks a Cave Management Plan. Whereas, some general guidance for cave management is presented in NPS-77 and the park's General Management Plan, the park has identified the need for eventually developing a Cave Management Plan encompassing all of the cave systems within the park (NPS 1993).

Table 2. Fluvial valley segment types that occur in and immediately adjacent to Great Basin National Park and a geomorphic description of each type (from Frissell and Liss 1993).

Competent bedrock canyon
Fluvially incised, steep-sloped canyon in competent bedrock; floodplain absent or few very small alluvial benches; floored with resistant bedrock and/or coarse alluvial lag deposits

Alluviated canyon, boulder-bedded
Fluvially incised, steep-sloped canyon with narrow, discontinuous floodplains; valley floor <50 m (165 ft) wide; formed by alluvial re-working of debris flow, flash flood deposition and/or coarse alluvial lag from slope erosion sources

Alluviated canyon, gravel- and cobble-bedded
Fluvially incised, steep-sloped canyon with narrow, discontinuous floodplains; valley floor <50 m (165 ft) wide; formed by alluvial deposition and transport through confined canyons

Bgjada-Sued canyon
Fluvially incised, steep-sloped canyon filled with alluvial aprons or coalesced alluvial fans formed largely from surface and rill erosion on adjacent slopes; small but active bajadas and fans encroach on and constrain channel; floodplains and side channels occur, but are narrow and discontinuous; valley floor <50 m (165 ft) wide

Incised moraine-filled valley
Glacial deposits dissected by deeply incised, boulder-bedded channel; very narrow and discontinuous or nonexistent floodplains; valley floor >50 m (165 ft) wide; formed by fluvial incision into coarse-textured glacial deposits

Terrace-bound valley
Fluvially incised alluvial terraces; floodplains very narrow and discontinuous, confined between high terraces; possibly indicative of uplifted or tectonically deformed alluvial valleys; valley floor >50 m (165 ft) wide

Leveed outwash valley
Wide, anabranched channel system in glacial outwash or valley train formed by continuous debris flow or flash flood deposits; valley floor >50 m (165 ft) wide; valley topography tends toward convex in transverse cross-section, and extensive natural levees and down-valley swales create potential for frequent and unpredictable channel switching

Alluvial valley
Streams with wide, continuous, active floodplains; valley width > 50 m (165 ft); terraces and alluvial fans are common, but do not encroach on channel enough to prevent development of expansive floodplains

Alluvial-fan-influenced valley
Streams tightly hemmed in or partially dammed by laterally encroaching alluvial tributary fans; valley width > 50 m (165 ft); floodplains common but variable in width and downstream extent; complex mosaic of incised fans, floodplain, and terrace landforms

Alluvial fan delta
Very large, distributary alluvial fans at mouths of mountain valleys

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Lehman Caves has been extensively developed for visitation. It was discovered in 1885 and has been open for tours since then (Unrau 1990). The cave extends several hundred meters into a limestone unit and contains numerous passages and chambers. The entrance and exit used by tour groups are excavated tunnels that begin and end at the visitor's center. The tunnels are closed with heavy doors for security and to maintain a near-natural airflow in the cave. An electrical lighting system and a hardened surface are present for easy access (NPS 1993). The cave contains a wide variety of formations, including stalactites, stalagmites, columns, shields, cave popcorn, helacites, and cave coral (Halladay and Peacock 1972). Biota of the caves have received limited study (Wheeler and Wheeler 1968, Ralston 1968).

Flora and Fauna

Because of the wide range of elevations of the park, numerous vegetation types occur -- desert shrub, mountain shrub, evergreen shrub, pinyon juniper woodland, coniferous forest, deciduous forest, meadow, alpine, and riparian (Eddleman and Jaindl 1991c). About 550 vascular plants (Great Basin National Park Files) occur in a variety of plant communities within these vegetation types.

No federally listed threatened or endangered plants are known to occur in the park, but several taxa designated as Category 2 by the U.S. Fish and Wildlife Service and listed by the State of Nevada as threatened or endangered occur in the park (Table 1). The Great Basin bristlecone pine *(Pinus longaeva)* occurs in three major groves in the park: Wheeler Peak, Mt. Washington, and the divide of Baker and Snake creeks. Many other bristlecones grow on high elevation limestone slopes and ridgelines especially in the southern part of the park (NPS 1993).

The fauna of the park is considered to be highly diverse and represents a mixture of Sierran, Great Basin, and Rocky Mountain species. Tueller et al.'s (undated) assessment was that the range in which the park resides has almost as many major patterns of plant-animal-climate associations expressed altitudinally as has the entire continent of North American expressed latitudinally. The number of species thought to occur in the park include approximately 60 <u>mammals,</u> 166 birds, 6 amphibians, 20 reptiles, and 4 fish (Great Basin National Park Files). Mule deer *(Odocoileus hemonius)* are the most abundant ungulate, elk *(Cervus elaphus)* are transient visitors, and a few Rocky Mountain bighorn sheep *(Ovis canadensis)* survive from a transplanted group of 30 animals. Carnivores include mountain lion *(Fells concolor),* bobcat *(Fells rufus)* , coyote *(Canis latrans),* badger *(Taxidea taxus)* , and several species of foxes *(Vulpes* and *Urocyon)* and weasels *(Mustela).* The park is potential habitat for the bald eagle *(Haliaeetus leucocephalus)* and peregrine falcon *(Falco peregrinus),* both federally listed endangered species, but neither are known to breed in the park. Except for fish, flora and fauna of aquatic habitats are poorly described, as is true for the Great Basin in general (Minshall et al. 1989).

Due to geologic and climatic events, the park is one of many isolated mountainous areas in the vast expanse of basinlands of the Great Basin. The lands encompassed by the park became even more isolated with their designation as a unit of the NPS. The park is an isolated unit, predominantly surrounded by other public lands of the South Snake Range, which are surrounded by public and privately owned basin lands. For "island-like" habitats in general, characteristics of biological communities, such as species composition and abundance, are influenced by size of the area, period of isolation, and proximity to other communities with similar characteristics (Wilcox 1980). As part of his studies of island biogeography, Brown (1971) examined occurrence of modern boreal small mammals on isolated mountaintops of the Snake Range and other Great Basin ranges. Some of these species of small mammals reached these "islands" during the Pleistocene. Additional colonization has not occurred since then because it is virtually impossible for small boreal mammals to migrate across large expanses of basin landscape to travel to or from the mountain tops. Natural species extinctions, which are greatly affected by size of an area and species body size, trophic level, and habitat specialization (MacArthur and Wilson 1967), have reduced the diversity of small mammal communities to present levels. The present community structure may now only be a particular point on a declining developmental projectory as the community structure collapses toward a new equilibrium.

Euroamericans began to have profound interactions with natural processes and features of the lands encompassed by the park starting about 1860 (Unrau 1990). From then on it became impossible to distinguish clearly natural changes in characteristics of biological communities from human-induced changes. In effect, humans became a predominant, pervasive, and integral component of the Great Basin system. Paleoindians (12,000 - 9,000 BC), Archaic peoples (9,000 BC - 500 AD), Fremonts (500 - 1,300 AD), and Western Shoshone Indians (1,300 AD - Ethnographic Present) are either presumed or known to have occupied sites in and around the park, but never at densities that accompanied settlement by Euroamericans (Unrau 1990). Berger and Wehausen (1991) studied some of the pervasive changes to the flora and fauna that accompanied extensive human settlement. They provided some evidence that mule deer and mountain lions were uncommon in the Great Basin prior to introduction of cattle and horses. They argue that changes in vegetation as a result of livestock grazing favored mule deer over bighorn sheep and antelope *(Antilocapra americana)*. Mule deer were relatively easy prey for mountain lions, and mountain lions increased. Mule deer are now the predominant large mammal of the Great Basin, and mountain lions are a common predator. The evidence of Berger and Wehausen (1991) is undeniably preliminary and sketchy, yet it serves as a good reminder that current conditions of a system, such as Great Basin National Park, may be very different from historic conditions.

Water Resources

Surface-Water Resources

Streams

Numerous perennial, intermittent, and ephemeral streams flow in the park between 1,800-3,200 m (6,000-10,500 ft) (Figure 3, Table 3). Only uppermost portions of streams of the west side are included in the park because of the high elevation of the park's boundary on that side of the mountain range. Many of the smaller streams flow

Table 3. Major streams of Great Basin National Park.

Streams and Major Forks	Flow Condition
Strawberry Creek	Perennial below 2,600 m. Ephemeral snow melt stream above 2,600 m except for short perennial stream below spring at 2,900 m.
Lehman Creek	Perennial.
Baker Creek Main Fork	Perennial.
South Fork	Perennial.
Timber Creek	Perennial most years; but late-summer surface flow sometimes becomes discontinuous during drought years.
Pole Canyon	Perennial most years; but late-summer surface flow sometimes becomes discontinuous during drought years.
Snake Creek	Perennial, though stream is diverted through a pipeline from 2,300 m to 2,050 m. No stream issues from Dead Lake, although a tributary to Snake Creek passes near the pond.
Big Wash North Fork	Dry except for short stream(s) (<300 m length) issuing from spring(s) at uppermost end of watershed. Erosion of dirt road adjacent to stream bed provides evidence of flood event(s) during this century.
South Fork	Perennial from 2,400 m to 2,050 m. Ephemeral snow-melt stream above 2,400 m. No surface flow near junction with North Fork but stream re-appears further down the valley.
Big Springs Wash	Ephemeral.
Decathon Canyon	Dry with ephemeral flow in short sections.
Lincoln Canyon	Main fork of the canyon is dry, though stream bed attests to surface flow in recent past. A small perennial stream occurs in one fork of the canyon outside of the park. The stream drops from 2,900 m to 2,300 m in 1.6 km and then disappears before reaching the main canyon.
Dry Creek	Intermittent. Stream flow had been observed in late summer/early fall when other streams had ceased flow.
Williams Creek	Perennial below 2,600 m; intermittent above 2,600 m.
Ridge and Pine Creeks	Perennial. Small streams (< 1 m wide).
Shingle Creek	Perennial. Slightly larger than Ridge and Pine creeks.

underground before leaving the park. Water in the streams is derived from high-altitude snowmelt, rainfall, and ground-water sources, and flows downward across the consolidated rocks of the mountains and onto the adjacent alluvial fans. Although the maximum flow of the streams may occur at various points upstream from the bedrock-valley fill contact, it is assumed that the maximum flow is at the heads of the fans. In addition to flow from the mountain canyons, occasional flow may locally develop on alluvial fans and lowlands, the latter entirely outside park boundaries, in response to heavy precipitation from thunderstorms. The larger streams usually flow onto the alluvial aprons of the valleys where they evaporate, percolate into the substratum, or are diverted for ranch use (Hood and Rush 1965, Rush and Kazmi 1965).

The portions of the streams that flow in the park are exceptional compared to most other streams in the Great Basin in that they are essentially untouched by major diversion practices. The one exception is a 4.8-km-long (3-mi-long) segment of Snake Creek. Flow through this segment was diverted several decades before the park was established, presumably because of subterranean drainage from that segment of the channel. In local terms, it was a "losing channel". Changes in riparian and channel characteristics are evident as a result of the diversion (Frissell and Liss 1993, Murray et al., in prep.)

Baker and Lehman creeks are the largest streams of the park. Gaging stations were operated from December 1947 through September 1955 on Baker and Lehman creeks near the current park boundary (USGS 1963). During this period the mean annual water yields of these creeks were 6,170 ac-ft and 3,570 ac-ft, respectively, with peak runoff occurring in June, and the lowest flows recorded in January and February (Table 4). These gaging stations were re-established in the fall of 1992. Streamflow records were intermittently collected in Snake Creek from September 1913 to September 1916. The maximum discharge for Snake Creek observed during this period was 85 cfs on June 7, 1914 and a minimum discharge of 0.5 cfs occurred on December 20, 1913 (USGS 1960). In 1992, the USGS performed seepage runs on Baker, Lehman, and Snake creeks in order to determine gaining and losing reaches of the streams (Paul Christensen, National Park Service, pers. comm., May 1993).

Based on patterns in stream systems revealed through the valley segment classification and mapping of Frissell and Liss (1993), three major stream types occur in the park and differ in geology, location, and glacial history. The first stream type includes steep, short streams draining the western face of the South Snake Range. These steep-gradient canyon-bound streams lack glaciation, although small nivation basins may be present, and they also lack wide valley floors. The typical downstream sequence of valley segments is bedrock canyon, boulder-bed alluviated canyon, gravel-bed alluviated canyon, and alluvial fan delta. Examples of this stream type are Shingle, Pine, and Ridge creeks.

The second stream type has an extensive history of alpine glaciation and coarse-grained debris flows all the way to the basin floor. Geology is dominated by quartzite and granitic rocks that yield hard, boulder-sized and cobble-sized clasts on weathering. Valley segments grade from bedrock canyons and incised moraine-filled valleys in

Table 4. Summary of streamflow in cubic feet per second at gauging stations in Baker and Lehman creeks for water years 1948-55 (from Hood and Rush 1965).

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Year	
													cfs	Acre-ft/ year
Baker Creek at Narrows near Baker, Nevada														
Average	2.98	2.82	2.12	1.87	1.66	1.95	5.23	23.9	36.6	13.7	5.89	3.48	8.53	6,200
Max. month	3.80	3.23	2.45	2.16	2.35	2.66	9.65	65.1	90.5	39.2	12.0	5.25	19.6[1]	14,200[1]
Min. month	2.40	2.30	1.69	1.50	1.07	1.23	2.36	3.64	12.2	6.40	3.66	2.43	3.87[2]	2,800[2]
Lehman Creek near Baker, Nevada														
Average	2.90	2.61	2.00	1.74	1.63	1.91	4.50	20.1	29.1	13.3	6.12	3.64	7.49	5,420
Max. month	3.80	3.23	2.45	2.16	2.35	2.72	9.65	65.1	90.5	39.2	12.0	5.25	19.6[1]	14,200[1]
Min. month	2.2	2	1.62	1.40	1.07	1.23	1.85	3.64	11.9	6.40	3.66	2.43	3.67	2,660[2]

[1] Maximum recorded water year.
[2] Minimum recorded water year.

headwater areas to leveed outwash valleys in downstream areas, finally splaying onto extensive alluvial fan deltas. Baker and Lehman creeks are the principal streams in this category.

The third stream type occurs in valley floors whose landforms are extensively shaped by alluvial processes. Geology is dominated by limestones, dolomites, and shales that weather into gravel- and sand-sized particles that are easily transported by fluvial processes. Where glaciation has occurred, deposits are relatively fine textured and grade indistinctly into fluvial and paleo-fluvial landforms. Sediment-rich channels have developed extensive alluvial fans and floodplains on wide valley floors. The typical sequence of valley segments is alluviated canyon, alluvial valley, alluvial fan-influenced valley complex, and alluvial fan delta. Scattered terrace-bound valleys, alluviated canyons, and bajada-filled canyons sometimes occur at lower elevations as well, depending on geologic structure of the slopes. Snake Creek, Strawberry Creek, and Big Wash are examples of this type.

Limited sampling of water quality of streams in and near the park has occurred using an array of methods. Sampling of some water quality characteristics was conducted at one site in Lehman Creek by the U.S. Geological Survey on three separate dates in 1987, 1988, and 1989, and the Nevada Department of Conservation and Natural Resources routinely monitored water quality of Snake Creek immediately above a fish-rearing station on the Snake Creek from 1966 through 1975. The Lehman Creek site was within the boundaries of the park, and the Snake Creek site was about 2.5 km (1.5 mi) east of the park. The park has conducted biannual measurements of pH and conductivity at several stream and lake sites since 1991 based on recommendations of Metcalf et al. (1989). De ails of the procedures used by the park are described in Pfaff (1991), and the data are available in park files. Metcalf et al. (1989) sampled several sites in the park in the winter and spring of 1989, and in August of 1992, researchers from Oregon State University sampled 11 streams where the streams intersect the park boundary and two tributaries of Baker Creek immediately above their confluence with Baker Creek (Jacobs et al. 1993).

Results from these surveys are presented in Tables 5 and 6 for several streams on the east side and one stream on the west side of the South Snake Range. Data presented in the tables depict some of the variations over time and space and do not constitute the entire data sets. Generally, streams of the park represent an integration of waters from larger and more complex watersheds than those of lakes in the park. The greater residence times of stream waters in watersheds provide greater opportunity for reaction of precipitation with basin minerals, generally resulting in higher dissolved solids, conductivity, and ionic strength. Reflective of this is a tendency for higher alkalinity values for streams than for lakes. Nutrient concentrations in streams are generally low to moderate, with some of the moderate concentrations possibly indicative of contamination. Metal concentrations of streams are generally low and below detection limits. Additional sampling is needed to further define variations in physical and chemical variables among streams of the park and to distinguish changes with elevation and season.

Table 5. Concentrations of major cations (mg/1) in selected streams and lakes of Great Basin National Park. Data were selected from Metcalf et al. (1989) and Jacobs et al. (1993) to depict some of the variation through time and space.[1]

Site	Elev(m)	Month	Year	Ca	Mg	Na	K	Al	Ba	Fe
SNAKE CK	2432	MAY	89	12.7	0.96	2.03	0.31	0.02	0.06	0.06
SNAKE CK	2316	MAY	89	13.6	1.04	2.20	0.35	0.01	0.10	0.10
SNAKE CK	2067	MAY	89	15.0	1.12	2.31	0.37	0.01	0.09	0.09
SNAKE CK	2070	MAY	89	21.4	1.97	3.73	0.46	0.01	0.07	0.07
SNAKE CK	1887	AUG	93	31.6	3.29	5.36	0.69	-[2]	-	-
SHINGLE CK	2481	MAY	89	10.1	1.72	1.73	0.19	0.02	0.03	0.03
SHINGLE CK	2469	AUG	93	10.0	1.75	1.82	0.36	-	-	-
SHINGLE CK	2152	MAY	89	11.6	2.06	2.13	0.28	0.01	0.03	0.03
LEHMAN CK	3039	MAY	89	4.9	0.69	1.32	0.20	0.16	0.01	0.01
LEHMAN CK	2993	MAR	89	4.8	0.70	1.30	0.50	0.04	0.03	0.01
LEHMAN CK	2661	MAY	89	4.5	0.78	1.11	0.15	0.25	0.04	0.04
LEHMAN CK	2341	MAY	89	4.4	0.87	1.32	0.31	0.20	0.05	0.05
LEHMAN CK	2030	AUG	93	3.9	0.81	1.30	0.31	-	-	-
TERESA LK	3127	AUG	93	2.1	0.45	055	0.31	-	-	-
TERESA LK	3127	MAY	89	1.7	0.42	034	0.22	0.11	0.05	0.05
TERESA LK	3127	MAR	89	14.8	3.10	2.40	2.10	0.11	033	0.28
STELLA LK	3164	AUG	93	4.0	0.64	1.16	030	-	-	-
STELLA LK	3164	MAR	89	25.8	4.50	3.90	2.30	0.04	0.26	0.04
STELLA LK	3164	MAY	89	2.7	0.42	0.68	0.24	0.08	0.01	0.01
JOHNSON LK	3280	AUG	93	5.1	0.31	0.77	0.05	-	-	-
JOHNSON LK	3280	MAY	89	3.7	0.22	0.61	BD[2]	BD	BD	BD
DEAD LK	2908	AUG	93	1.9	0.35	0.96	0.63	-	-	-
DEAD LK	2908	MAY	89	23	0.40	0.89	0.81	0.02	BD	BD
BROWN LK	3103	AUG	93	2.4	0.63	1.01	0.76	-	-	-
BROWN LK	3103	MAY	89	1.9	0.46	0.80	0.37	0.06	0.02	0.02
BAKER LK	3237	AUG	93	1.6	0.60	0.60	0.34	-	-	-
BAKER LK	3237	MAY	89	1.4	0.28	030	0.29	0.01	0.04	0.04

[1] Some values have been rounded to the nearest tenth or hundredth for purposes of this summary, and both studies analyzed additional chemical variables. For 1993 samples, stream samples were collected at mid-depths and lake samples were collected just below the surface.

[2] BD signifies that the value was below detection levels, and - signifies that comparable data were not available for that variable.

Table 6. Chemical characteristics of selected streams and lakes of Great Basin National Park. Data were selected from Metcalf et al. (1989) and Jacobs et al. (1993) to depict some of the variation through time and space.[1]

Site	Elev (m)	Month	Year	pH	CONDUCT /mhos/cm	SO_4, mg/l	S a mg/l	NO_3 mg/l
SNAKE CK	2432	MAY	89	7.7	84	2.9	0.61	BD
SNAKE CK	2316	MAY	89	7.8	91	3.0	0.69	0.02
SNAKE CK	2067	MAR	89	7.8	96	3.1	0.74	BD
SNAKE CK	1887	MAY	89	7.9	147	4.4	2.48	BD
SNAKE CK	1887	AUG	93	8.1	172	43	4.24	-[2]
SHINGLE CK	2481	MAY	89	7.7	78	3.0	0.60	BD
SHINGLE CK	2152	MAY	89	7.7	84	3.3	0.74	BD
SHINGLE CK	2469	AUG	93	8.2	71	0.9	0.67	-
LEHMAN CK	3039	MAY	89	7.3	37	13	0.43	BD
LEHMAN CK	2993	MAY	89	7.2	38	13	0.46	0.02
LEHMAN CK	2661	MAY	89	7.3	35	1.6	0.50	0.31
LEHMAN CK	2341	MAY	89	7.3	37	1.6	036	BD
LEHMAN CK	2341	MAY	89	7.4	38	1.6	0.56	0.23
LEHMAN CK	2030	AUG	93	73	35	OS	OS1	-
TERESA LK	3127	AUG	93	7.7	20	0.4	031	-
TERESA LK	3127	MAY	89	6.8	18	L4	0.46	0.3
STELLA LK	3164	AUG	93	7.7	34	0.3	0.49	-
STELLA LK	3164	MAY	89	7.1	24	1.1	0.38	BD
JOHNSON LK	3280	AUG	93	9.0	40	0.4	0.09	-
JOHNSON LK	3278	MAY	89	7.0	26	3.0	0.25	0.11
DEAD LK	2908	AUG	93	7.2	20	03	0.40	-
DEAD LK	2908	MAY	89	6.9	23	2.7	0.35	0.02
BROWN LK	3103	AUG	93	7.6	26	03	0.82	-
BROWN LK	3103	MAY	89	6.9	20	2.4	0.71	0.04
BAKER LK	3237	AUG	93	7.4	15	0.4	0.46	-
BAKER LK	3237	MAY	89	6.8	14	1.2	0.41	1.17

Some values have been rounded to the nearest tenth or hundredth for purposes of this summary, and both studies analyzed additional chemical variables. For 1993 samples, stream samples were collected at mid-depths and lake samples were collected just below the surface. BD signifies that the value was below detection levels, and - signifies that comparable data are not available for that variable.

A pure population of Snake Valley cutthroat trout, currently classified as the Bonneville cutthroat trout *(Oncorhynchus clarki utah),* occurs in the park on the west side of the Snake Range in Pine and Ridge creeks (Duff 1988, Loudenslager and Gall 1980, Martin and Shiozawa 1982). The U.S. Fish and Wildlife Service considers O. c. *utah a* candidate taxon for threatened status. The Snake Valley cutthroat may consistently display the degree of differentiation warranting subspecific designation of its own (Behnke 1976, Hubbs et al. 1974), but it is presently viewed as one of three divergent stocks of O. *c. utah (R.* Behnke, Colorado State University, pers. comm., Jan. 1992).

Non-native rainbow trout (O. *mykiss),* brown trout *(Salmo trutta),* eastern brook trout *(Salvelinus fontinalis),* hybrid cutthroat trout, and hybrid rainbow trout inhabit some of the streams and lakes of the park (Table 7). Several streams have a long history of stocking, and non-native fish populations persist despite cessation of stocking programs in 1986 when the park was established. In 1990 for example, Nevada Department of Wildlife (1990a,b,c) estimated that there were 423 fish per km (682 fish per mi) in Lehman Creek, 481 fish per km (776 fish per mi) in Baker Creek, and 614 fish per km (911 fish per mi) in Snake Creek. About half of these fish were over 15 cm (6 in) in length. Few fish occurred in any creek above 2,500 m (8,000 ft) elevation.

Fish other than salmonids apparently do not occur in streams of the park (Anderson 1991). Size, gradient, and other characteristics of the park's aquatic habitats appear to be unsuitable for survival of fish native to the Great Basin other than the Bonneville cutthroat trout (M. Anderson, University of Nevada, Las Vegas, pers. comm., Feb. 1992), although mottled scuplin *(Cottus bairdi)* were identified in lower sections of Snake Creek in the 1950s and 1960s (Field notes of J. Deacon, University of Nevada, Las Vegas as cited in Anderson 1991; Field notes of T.C. Frantz, 1952 available in Great Basin National Park files). Several species endemic to the Bonneville Basin survive in basin habitat near the park in Big Springs (Table 8). Spring Valley was historically devoid of fish, but some species have been introduced, including the Snake Valley (Bonneville) cutthroat trout in Pine and Ridge creeks and some endangered cyprinids in ponds outside the park (Hubbs et al. 1974, Anderson 1991).

The occurrence of amphibians in the park is poorly documented. Species that may occur in the park include tiger salamander *(Ambystoma tigrinum nebulosum* Hallowell), western spadefoot toad *(Scaphiopus hammondi intermountanus* Cope), Woodhouse's toad *(Bufo woodhousei woodhousei* Girard), leopard frog *(Rana pipiens brachycephala* Cope), boreal chorus frog *(Pseudacris trisseriata maculata* Wild), and stopped frog *(Rana pretiosa pretiosa* Baird and Girard) (Unpubl. list, W. Tanner, Brigham Young University, Utah).

Microphytes, macrophytes, and invertebrates of the streams of the park are poorly documented as is the case for the Great Basin in general (Minshall et al. 1989) (Table 9). Sheldon (1979) documented the occurrence of several species of stonefly in Baker and Lehman creeks -- *Zapada cinctipes, Doddsia occidentalis, Taenionema nigripenne, Capnia gracilaria, C. utahensis, Paraleuctra occidentalis, P. vershina, Pteronarcella badia* - possibly, *Megarcys signata,* and *Hesperoperla pacifica.*

Table 7. Occurrence of fish in Great Basin National Park (Great Basin National Park File Report dated April 7, 1992 based on surveys conducted by R. Haskins, Nevada Department of Wildlife).

Taxon	Occurrence
Bonneville cutthroat trout[s] *(Oncorhynchus clarki utah)*	Pine and Ridge creeks
Cutthroat-rainbow hybrid	Shingle and Williams creeks
Lahontan cutthroat trout *(Oncorhynchus clarki henshawi)*	Baker Lake
Rainbow trout *(Oncorhynchus mykiss)*	Lehman, Baker, Shingle, and Williams creeks and Snake Creek below the park boundary
Brook trout *(Salvelinus fontinalis)*	Lehman and Baker creeks, Snake Creek above the diversion, Baker and Johnson lakes
Brown trout *(Salmo trutta)*	Lehman and Baker creeks, Snake Creek below the diversion pip

[1]The only native species of trout in the park.

Table 8. Fish inhabiting Big Springs, Nevada (T10N, R70E, Section 33) (Anderson 1991)1

Mountain sucker	*Catostomus (Pantosteus)*
Speckled dace Redside	*platyrhynchus Rhinichthys*
shiner Mottled sculpin	*osculus*
	Richardsonius balteatus
	hydrophlox Coitus bairdi

[1]Utah chub were still present in 1975 but now appear to be extirpated.

Table 9. Relative abundance of taxa of macroinvertebrates collected at four sites in Lehman Creek in 1976 (adapted from Magnum 1976).[1]

Taxa	Abundance by Month and Station			
	June	July	August	October
Stations	1 3 4 5	1 3 4 5	1 3 4 5	1 3 4 5
Phylum Platyhelminthes (flatworms)				
Class Turbellaria				
Planaria sR,	R O R R	O R R O	R O M O	C C C O
Phylum Nematoda (roundworms)	0 0 0 0	0 0 0 0	0 0 0 0	0 M 0 0
Phylum Annelida (segmented worms)				
Class Clitellata				
Order Oligochaeta	M R M R	M M 0 R	R M R 0	R C C M
Phylum Arthropoda				
Class Arachnida				
Order Acarina (watermites)	C M R R	C M M C	A C C M	A C C M
Class Insecta				
Order Collembola (springtails)				
Podura a uatica	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0
Order Ephemergotera (mayflies)				
Family Heptageniidae				
Epeorus	M M C C	C M C C	M R C C	R M M R
Cinvgmula	C C C C	C C C C	C O A C	C C A A
Family Siphlonuridae				
Ameletus	C O R O	R R O O	O O R O	M O M O
Family Leptophlebiidae				
Paraleptophlebia sp,	0 R M R	R 0 M R	M M C R	R M A C
Family Ephemerellidae				
Eohemerella grandis	0 0 0 0	0 0 0 0	0 R 0 R	0 0 0 0
Ephemerella colorandensis	R M C M	R M M R	R R M R	0 R 0 0
Ephemerella inermis	0 0 R 0	0 R 0 0	A 0 A A	A A A A
Eohemerella doddsi	R M R R	0 R R R	C M C R	C M M R
Family Baetidae	C C A C	A C C C	A C A A	A A A A
Order Plecoptera (stoneflies)				
Family Chloroperlidae	C M M M	M M M R	C M C R	C C C C
Family Pteronarcidae				
Pteronarcella	R 0 0 0	0 0 0 0	O R O R	0 0 0 0
Family Nemouridae				
Zapada cinctipes	0 0 0 0	0 0 0 0	O O R O	O R M O
Zapada sue.	M R R O	R R O O	M O M O	A R M O
Prostoia sQ	R 0 0 0	0 0 0 R	0 0 0 0	C 0 C 0
Malenka sp.	R 0 0 0	R 0 0 0	0 0 0 0	0 0 0 0
Amphineumura	0 0 0 0	0 0 0 0	R 0 0 0	0 0 0 0
Family Capniidae	R 0 0 0	R 0 0 0	R 0 R 0	C C M 0
Family Pcrlodidae				
Isoperla sp.	R R O R	R O C R	O R O O	M O O M
Cultus ss.	O R O O	0 0 0 0	R 0 0 0	0 0 0 0
Kogotus	O O R O	0 0 0 0	0 0 0 0	0 0 0 0
Family Taeniopterygidae				
Taenionema	0 0 0 0	0 0 0 0	0 0 0 0	A A C 0
Family Perlidae				
Hesperoperla pacifica	0 0 0 R	0 0 0 M	M 0 R M	M 0 R M
Order Trichoptera (caddisflies)				
Family Hydropsychidae				
Parapsyche	R 0 0 0	R 0 0 0	O R O O	C O M O

Table 9 (continued)

Taxa	Stations	June 1	June 3	June 4	June 5	Jul 1	Jul 3	Jul 4	Jul 5	August 1	August 3	August 4	August 5	October 1	October 3	October 4	October 5
		Abundance by Month and Station															
Family Limnephilidae		R	0	R	R	R	0	0	0	R	0	R	0	R	0	0	R
Family Rhyacophilidae		C	C	C	M	C	M	C	C	C	M	C	C	C	C	A	C
Rhyacophila sue.																	
Glossosoma		O	O	R	R	0	0	0	M	0	0	0	R	0	0	0	R
Family Brachycentridae		0	0	0	M	D	O	R	M	O	C	O	M	D	O	R	M
Brachycentrus																	
Family Lepidostomatidae		0	0	R	0	R	0	R	R	0	R	R	0	R	R	R	R
Family Psychomyidae		0	0	0	0	0	0	0	0	M	0	R	0	0	0	0	0
Family Philopotamidae		0	0	0	0	0	0	0	0	0	0	0	0	C	R	0	0
Chimarra sue.																	
Order Coleoptera (beetles)		A	C	C	C	C	C	C	C	C	R	C	C	A	C	C	C
Family Elmidae																	
Family Hydrophilidae		0	0	0	R	0	0	0	0	0	0	0	0	0	0	0	0
Order Diptera (true flies)		M	R	R	R	M	R	R	R	O	O	R	R			M	R
Family Tipulidae														M	R		
Dicronota sue.																	
Holorusia grandis		O	O	R	O	R	0	0	0	R	0	0	0	O	R	R	O
Antocha		O	O	R	R	O	D	O	R	O	O	R	R	0	0	0	R
Hexatoma s .		0	0	0	0	0	0	0	0	R	R	O	R	0	0	0	0
Family Simuliidae		C	M	M	C	C	C	C	C	C	M	M	C	C	M	M	A
Family Chironomidae		A	C	A	M	A	A	C	C	A	C	A	A	A	A	A	C
Family Empididae		M	M	M	R	M	M	R	0	M	R	M	0	M	M	R	0
Family Ceratopogonidae		0	0	R	R	0	0	R	R	0	0	R	M	0	R	R	*R*
Family Psychodidae		0	0	*R*	R	R	M	0	0	R	R	M	M	R	M	C	C
Family Dixidae		0	0	0	0	R	0	0	0	0	0	0	0	R	0	0	0
Family Stratiomyidae		0	0	0	0	0	0	0	0	0	0	0	0	0	R	0	0

[1] Codes for abundance are A = > 100, C = 25 - 99, M = 6 - 24, R = 1 - 5, 0 = not detected. Sampling dates are June 1, July 1, August 2, and October 7.

Magnum (1976) sampled benthic invertebrates from four stations on Lehman Creek during 1976 and observed a variety of taxa (Table 9). Stations were located between the Wheeler Peak Campground and a point just east of the turnoff from Highway 488 to Lehman Caves. Results of the 1976 sampling were compared to results obtained under similar collection procedures in 1972 and 1973. Between the 1973 and 1976 collections, pit toilets were replaced with vault toilets at campgrounds along Lehman Creek, and a sewage lagoon was incorporated into the wastewater treatment facility that serviced administrative and visitor facilities at Lehman Caves. Magnum (1976) concluded that the 1976 macroinvertebrate communities showed an increase in kinds and numbers of "clean-water" taxa and a decrease in dominance of "pollution-tolerant" taxa when compared to 1972 and 1973 communities. Based on a diversity index, he concluded that most of the 1976 macroinvertebrate communities showed an increase in diversity compared to communities sampled in 1972 and 1973. Community biomass was lower in 1976 than in 1972 and 1973 based on mean dry weight per square meter sampled. These changes were judged to indicate a return to normal conditions following removal of anthropogenic sources of nutrient enrichment.

Personnel with the Humboldt National Forest have conducted limited macroinvertebrate sampling at a few sites on the east and west sides of the South Snake Range just below the park boundary using a rapid bioassessment approach. As an example of the kind and frequency of sampling conducted, Shingle Creek was sampled at sites below the boundary of the park in September 1990 and June 1991. The sampling was limited to a single collection at no more than two sites on each date. Based on the 1990 sample, the stream was judged to be in good condition based on a biotic condition index. The macroinvertebrate biomass was estimated to be 0.8 g/m^2, which was judged to be somewhat limiting to the number and size of fish that could be supported in the stream (Humboldt National Forest 1990). Contrastingly, the June 1991 sample was taken at a higher elevation and when the stream was at flood stage. Under these flow conditions, the stream was judged to be in poor condition based on indices calculated by the Aquatic Ecosystem Analysis Laboratory (J. Whalen, Ely District, Humboldt National Forest, pers. comm., Aug. 1992). The value of this type of sampling to evaluate stream condition would be greatly improved if more samples were collected and if all sampling were conducted under comparable stream flows. The application of this procedure (e.g., Rapid Bioassessment) to the South Snake Range may also be limited as a tool to compare the quality of one stream with the quality of another because of the isolated nature of the streams and lakes within the park.

Springs and Seeps

The park has identified 77 springs and numerous seeps of which some have large quantities of water. One large spring, Cave Springs, provides water to the administrative and visitor facilities in the area of Lehman Caves. Spring and Snake valleys have numerous springs that are presumed to be linked by groundwater flow to catchment basins of the Snake Range (Burbey and Prudic 1991).

All springs and seeps and their associated riparian habitats are 2 ha (5 ac) or less in size (Great Basin National Park Files). Identification and mapping of springs and seeps is viewed as an ongoing process (K. Pfaff, Great Basin National Park, pers. comm., Aug. 1992) (Figure 5). In addition, delineation and development of a management strategy for associated riparian-wetland habitats of these springs and seeps remains a high priority.

Lakes

The park's six subalpine lakes, Stella, Teresa, Brown, Dead, Baker, and Johnson, lie near the crest of the South Snake Range (Figure 3). All are small (average size is 1 ha or 2.5 ac), and all receive most of their water from snowmelt, springs, and subsurface flow of snowmelt (Great Basin National Park 1992). Greatest lake depth occurs in the

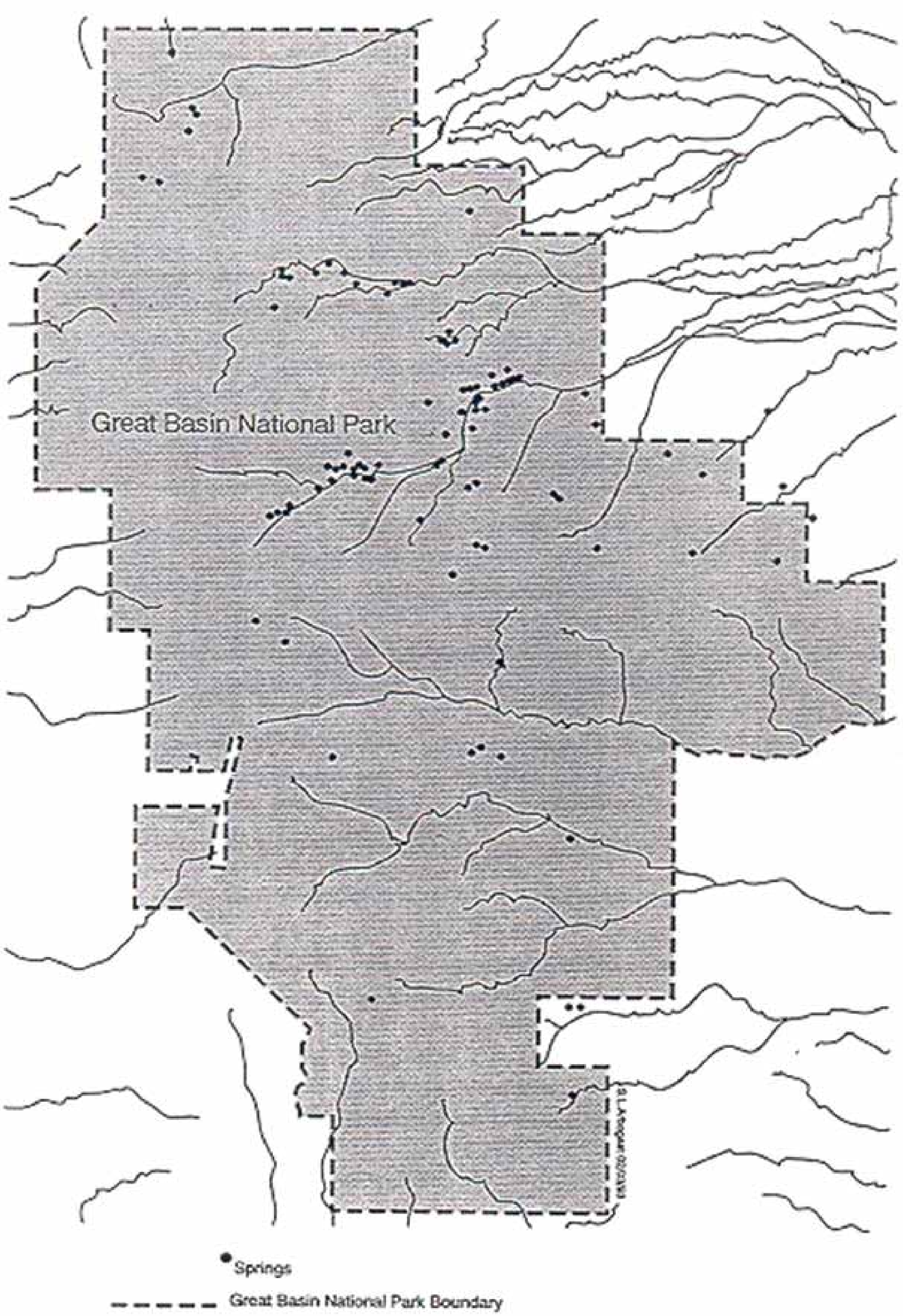


Figure 5. General locations of known springs and seeps in Great Basin National Park. This map is based on information available in the park's geographic information system in January 1992. The reader should check with the park for springs discovered and mapped since then.

springtime, at which time water flows out of several of the lakes and into streams. Additional water loss from lakes occurs through evaporation and subsurface seepage.

Physical, chemical, and biological characteristics of these resources have received little study. Chemical characteristics of the lakes were surveyed as part of the studies of Metcalf et al. (1989) and Jacobs et al. (1993). Selected data from these studies are presented in Tables 7 and 8 to depict the general characteristics of the lakes. The lakes tend to have low conductivity and near-neutral pH. Anomalously high pH (9.0) was measured once at Baker Lake by NPS staff in 1991 and once at Johnson Lake in 1993 by Jacobs et al. (1993). An anomalously high nitrate concentration of 235 ug/l was measured by Jacobs et al. (1993) in Teresa Lake. Metcalf et al. (1989) concluded that all of the lakes were sensitive to acidic depositions and precipitation, with Baker Lake being the most sensitive. Park staff continue to sample pH and conductivity twice a year to monitor for possible acidification of these aquatic systems.

Aquatic biota of these lakes were sampled concurrent with water quality sampling by Metcalf et al. (1989). Samples are being identified and data analyzed on a volunteer basis (R. Metcalf, pers. comm., Feb. 1992). Starkweather (1990) sampled invertebrate communities of lakes of the park over a three-day period in August 1987 and judged that zooplankton communities were simple in terms of species composition (Table 10) and that community size structure and species composition appeared to be strongly influenced by an array of predators, including fish, insects, and zooplankton. He described Johnson Lake as fairly productive lake with a low transparency due to high densities of coccoid green algae. Baker Lake was characterized as more transparent than Johnson Lake and contained a diverse phytoplankton assemblage, including several filamentous forms.

Fish are present in Johnson and Baker lakes as a consequence of stocking prior to 1986 (Nevada Department of Wildlife 1988, 1991). Teresa and Stella lakes may have been stocked in the past, but the lakes are shallow in the fall and winter, and fish would be subject to winterkill. Fish were surveyed in Johnson and Baker lakes in 1988 (Nevada Department of Wildlife 1988). Johnson Lake supports a reproducing population of brook trout with some fish 20 cm (8 in) in length (Nevada Department of Wildlife 1988). Winterkills of some of the population were reported in 1989 and 1990. Present in Baker Lake are Lahonton cutthroat trout (O. *c. henshawi)* of the Independence strain, which are presumed to be survivors from a group of 2,500 fry stocked in September 1985 by Nevada Department of Wildlife (Nevada Department of Wildlife 1988). Average length of these trout was about 24 cm (9.5 in) based on a sample of nine fish caught by angling and gill netting. A population of brook trout is also present in Baker Lake with average length about 25 cm (10 in) based on a sample of four fish caught by angling and gill netting.

Occurrence of amphibians in association with lakes of the park is not documented. The list of amphibians possibly associated with stream habitats (see page 30) provides a starting point for future investigations.

Table 10. Zooplankton found in lakes of Great Basin National Park during a three-day collection in August 1987 (Starkweather 1990).

Lake	Group	Species
Johnson	Crustacean	*Chydonus sphaericus*
	Crustacean	*Diaptomus coloradensis*
	Rotifer	*Hexarthra* sp. (probably *bulgarica canadensis)*
Baker[s]	Crustacean	*Chydorus sphaericus*
	Rotifer	*Brachionus urceolaris*
Brown[e]	Crustacean[3]	*Diaptomus coloradensis*
Teresa[2]	Crustacean	*Diaptomus shoshone*
		Daphnia sp.
Stella[2]	Crustacean	*Daphnia pulex*
		Daphnia Shoshone

1 Fish present.

2 Fishless but hemipteran predators are present (Grautocorixa sp. and Notonecta sp.).

3 **Contains several large species of Daphnia and a large species of Diaptomus in the spring.**

Ground-Water Resources

Characteristics of ground-water flows in the park are largely unknown. A discussion of the ground-water resources can be found in Rush and Kazmi (1965) and Hood and Rush (1965). Sedimentary rocks of Paleozoic age appear to be part of the regional hydrologic system. Interbasin flow of ground water takes place through similar rocks in eastern and southern Nevada. The clastic rocks of Paleozoic age exposed in the South Snake Range have little primary permeability, but the degree to which they have been fractured indicates that they probably can transmit moderate quantities of ground water through the fractures (Hood and Rush 1965). Ground water originates as snow and rain in the mountains primarily above 1,800 m (6,000 ft). Water in the mountains infiltrates consolidated rocks or collects in streams that discharge onto adjoining alluvial fans. Much water is lost to evapotranspiration before and after infiltration, some adds to the soil moisture, and a part percolates to the water table. Little of the precipitation on land below 1,800 m (6,000 ft) reaches the water table because this precipitation occurs in small amounts and is held by the alluvium as soil moisture and then discharged by evapotranspiration (Rush and Kazmi 1965).

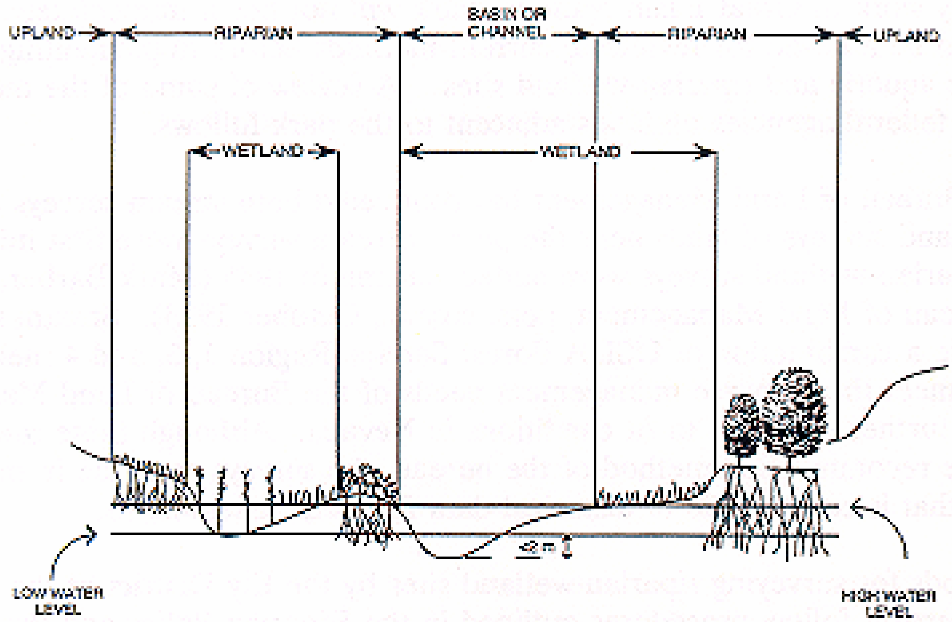
Movement of ground water is likely through complex underground patterns, but these patterns have received little study in the vicinity of the park. The ground water flow is critical in the formation and maintenance of the numerous limestone caves of the area (Ford and Williams 1989, Lange 1958, Burbey and Prudic 1991). Movement of ground water in the Snake Valley appears to be generally northeastward from the Snake Range to an ultimate discharge area -- the Great Salt Lake Desert (Rush and Kazmi 1965). Rush and Kazmi (1965) speculated that some ground water moved from the western to the eastern side of the South Snake Range.

Riparian-Wetland Sites

Following the broad wetland categories defined by Cowardin et al. (1979) for the National Wetlands Inventory conducted by the U.S. Fish and Wildlife Service, Great Basin National Park contains palustrine, riverine, and lacustrine wetlands. Riverine wetlands, particularly, are popular recreation areas for visitors to the park and are used by domestic livestock. Many of these wetlands are also adjacent to roads and trails. Use of lacustrine wetlands by domestic livestock is restricted in some areas of the park, but many of these wetlands also are popular recreation areas for visitors or exist adjacent to such popular areas. Palustrine wetlands are scattered throughout the park in association with springs and seeps and are probably heavily affected by grazing.

Major portions of these wetlands can be encompassed under the broader term of "riparian zone" (Figure 6). Wetlands associated with streams, lakes, and springs of the park are generally a subset of this broader site category. Riparian zones are a form of wetland transition between permanently saturated wetlands and upland sites. A variety of definitions exist for a riparian zone, often with an emphasis on the components present (Appendix 5), but the NPS has not formally adopted a single definition. Functionally, a riparian zone can be defined as a three-dimensional region of direct interaction between terrestrial and aquatic ecosystems. Functional boundaries of riparian zones extend outward to the limits of flooding and upward into the canopy of streamside, spring-side, or lake-side vegetation (Gregory et al. 1991). This functional view recognizes that boundaries and components of riparian zones are dynamic; dimensions of the zone of influence for any specific ecological process, such as plant community succession, sedimentation, or flooding, are determined by patterns in space and changes through time of the process (Gregory et al. 1991). Because of the similarities and overlap between riparian zones and wetlands, these sites will be referred to as riparian-wetland sites in this section of the plan.

Throughout the arid and semi-arid west, riparian-wetland sites are known for their higher productivity, diversity, and other unique factors when compared to the surrounding uplands (Kauffman and Krueger 1984). They occupy an extremely small percentage of the landscape of arid regions but often contain the highest resource values. Functions of riparian wetland sites include physical filtering of sediment, bank stability, water storage, and recharge of subsurface aquifers (Elmore and Beschta 1987, Wissmar



and Swanson 1990). Historic evidence in general indicates that most riparian-wetland sites of the arid and semi-arid west have changed dramatically within about the last hundred years, and that the chief cause has been improper livestock grazing (Elmore 1992).

Although riparian-wetland sites of the park have not been systematically identified, it can be presumed that they occur throughout the park adjacent to all aquatic habitats (streams, springs, seeps, and lakes). The U.S. Fish and Wildlife Service's National Wetlands Inventory has been completed for the region encompassed by the park at a scale of 1:250,000. Mapping at the scale most often used for the inventory (1:24,000) is not planned by the U.S. Fish and Wildlife Service for the region of the park. Researchers from the University of Nevada, Las Vegas, are engaged in a study that will result in a description and mapping of the vegetation of riparian habitats associated with stream systems of the park (Murray and Smith 1990). Eddleman and Jaindl (1991c) developed a vegetation map of the park with 43 categories identified including riparian shrub. Their distribution of the riparian shrub category was mapped using reflectance from a LANDSAT image and was not supported with systematic sampling of the flora of the areas assigned to this category.

An array of classification and inventory techniques for aquatic and riparian-wetland sites have emerged over the last several decades. Some have focused solely on aquatic systems such as lakes and streams, others have focused on wetland or riparian systems, and others have integrated aspects of both (Gebhardt et al. 1990). It is beyond the scope of this plan to review all of these techniques, but it is relevant to note that development of these techniques continues. Anticipating that additional classification and inventory work in Great Basin National Park will not begin immediately, sufficient time needs to be allowed for reviewing current methods before implementing any new programs for aquatic and riparian wetland sites. A review of some of the methods used by state and federal agencies on lands adjacent to the park follows.

The Bureau of Land Management has conducted both stream surveys and riparian-wetland surveys of lands near the park. Stream surveys were first initiated in 1976 and riparian-wetland surveys were added starting in 1985 (Mark Barber, Ely District, Bureau of Land Management, pers. comm., October 1993). Stream survey methods were a combination of USDA Forest Service Region 1, 3, and 4 methods modified to meet the resource management needs of the Bureau of Land Management in Utah and further modified to fit conditions in Nevada. Although these methods are no longer the recommended method of the bureau, the surveys continue in order to collect data that is comparable to historical data for trend assessments.

Methods for surveying riparian-wetland sites by the Ely District of the Bureau of Land Management follow procedures outlined in the Riparian Policy and Procedures Handbook published in 1989 (BLM 1989). This procedure specifies short-term techniques, which measure utilization of vegetation using a key-forage-plant method. Long-term monitoring techniques include photo points, stream surveys conducted in accordance with procedures of the Bureau of Land Management (1978), a rating of streambank condition, a species list of all riparian-wetland vegetation, estimates of percent composition of current year's growth of riparian plants, form and age classes of shrubs and trees, an estimate of percent bare ground, an estimate of total riparian acreage on public land, ocular estimates of percent of vegetative ground cover, and a general condition rating (four condition classes). More intensive surveys are recommended, including low-level aerial photography if unresolved issues are identified.

Currently the Bureau of Land Management is recommending the procedures described in Leonard et al. (1992) for classifying and inventorying riparian-wetland sites. This is a field procedure for describing and documenting ecological site information. It is an interdisciplinary team approach intended to incorporate interrelationships between soils, climate, physiography, hydrology, and vegetation for riparian-wetland resources and uplands. Members of the team are generally a soil scientist, hydrologist, botanist, and fisheries or wildlife biologist. This method is an extension of the standard site description procedures described in the National Range Handbook (U.S. Department of Agriculture 1976) for riparian-wetland sites. It has not been implemented yet by the Ely District of the Bureau of Land Management.

Inventory and monitoring of the condition of riparian-wetland habitats by the Ely District of the USDA Forest Service is mainly based on measures of utilization by domestic livestock of key forage species of vegetation. Percent utilization varies by management system for livestock use and by a subjective evaluation of the value of the riparian area. There are five categories of value of the riparian area. The highest value area meets any of the following criteria: (1) associated with a highest-value fishery habitat, (2) associated with an outstanding value recreation resource, (3) associated with highly unstable streambeds and banks, (4) associated with municipal watersheds or research natural areas, or (5) associated with highest-value wildlife habitat.

<u>Valley Segments and Floodplains,</u>

A fluvial valley segment is a stream channel and the portion of the adjacent valley floor and slopes with which the channel interacts over a time frame of thousands or tens of thousands of years (Frissell et al. 1986). Based on a partial survey of the park, nine types of fluvial valley segments exist within the park (Frissell and Liss 1993, Appendix 4). A tenth type occurs widely just outside the park (Table 11).

Of the ten types of fluvial valley segments found within the region, four are distinctly associated with canyon streams. These flow through narrow valleys that lack a broad valley floor, so there is only room for development of very narrow and discontinuous floodplains, or none at all. Canyons have limited groundwater storage capacity, and typically their steep valley gradient contributes to rapid runoff of surface and subsurface waters. The four canyon-associated types are (1) competent bedrock canyons, (2) alluviated canyons that are boulder bedded, (3) alluviated canyons that are gravel and cobble bedded, and (4) bajada-filled canyons (Appendix 4).

A second major grouping of segment types includes channels found in valleys exceeding 50 m (165 ft) in valley-floor width. Frissell and Liss (1993) identified two types of these wide fluvial valleys where channels were deeply incised into valley fill material, which prevents the formation of extensive floodplains. These two types of wide fluvial valleys include (1) incised moraine-filled valleys developed from channel downcutting through coarse-textured glacial deposits, and (2) incised terrace-bound valleys developed from downcutting through finer-textured, better-sorted planar deposits of alluvial origin. Because they lack extensive floodplains, stream channels in these wide valleys share many features in common with those in alluviated canyons. The difference is that streams in incised valleys have little direct contact with hillslopes, so their channels are dominated by fluvial rather than hillslope and colluvial processes.

Non-incised wide valleys consist of three types: (1) leveed outwash valley, (2) alluvial valley, and (3) alluvial-fan-influenced valley. Leveed outwash valleys have broad valley floors and complex, anabranched channel nets formed in glacial outwash or similar coarse-textured flood or debris-flow deposits. Valley fill is rich in boulders and large cobbles. The other two types of non-incised wide valleys, alluvial valley and alluvial-faninfluenced valley, are formed predominantly by deposition of finer-textured alluvial sediments. Alluvial valley segments have broad, flat floodplains. Their channels tend to be low in gradient, with relatively stable, sinuous, or even meandering pattern. Alluvialfan-influenced valleys, contrastingly, are extensively constrained by broad alluvial fans emanating from tributary mouths. When active, these fans can temporarily dam or divert flows in the main channel. Fan surfaces lend complexity to the valley floor topography, which complicates floodplain development, increases the frequency of channel shifting, and creates diversity in channel morphology.

Table 11. Relative abundance of valley segment types in Great Basin National Park, measured as the proportion of sites sampled that were classified in the segment type indicated (from Frissell and Liss 1993).

Valley Segment Type	Percent Within Park	Adjusted for Outside Park'
Canyons		
Competent Bedrock Canyon	1	1
Alluviated Canyon, Boulder-bed	11	8
Alluviated Canyon, Gravel-cobble-bed	16	11
Bajada-Filled Canyon	3	2
Mountain Valleys		
Incised Moraine-filled Valley	4	3
Terrace-Bound Valley	6	4
Leveed Outwash Valley	30	22
Alluvial Valley	17	11
Alluvial-Fan-Influenced Valley	12	9
Basin		
Alluvial Fan Delta	0	29

' Adjusted data for streams outside park are estimated from maps.

A tenth segment type, found entirely outside the park, is the alluvial fan delta. This basin segment type is virtually unconstrained by hillslopes, occurring as very broad, fairly steep distributary fans at the mouths of all major drainages.

Major floods occur in most of the Great Basin (Burkham 1988), including Great Basin National Park (B. Freet, Great Basin National Park, pers. comm., July 1991). Floods are caused by snowmelt, frontal rains, frontal rains on snow, and convective rainfall during localized thunderstorms (Burkham 1988). Snowmelt floods typically occur from April through June. Floods from frontal rain and frontal rain on snow generally develop during the period from November through March. Other floods result from intense rainfall during summer thunderstorms of small areal coverage. The flood hazard along definable channels in mountains primarily involves inundation, high flow velocities, erosion, and moving debris. By definition, the valley segments of the park are susceptible to flooding, but specific studies of the flooding frequency and intensity have

Not been conducted in the park. Floodplains have not been mapped throughout the park even though some of the major campgrounds occur in valley types that experience major flood events, including flash floods. Accurate floodplain mapping and developing appropriate mitigation procedures within areas used by visitors are park priorities.

WATER RESOURCES ISSUES

Current management issues related to water resources at Great Basin National Park generally fall into one of two categories: (1) needs based upon the limited amount of basic information available about the water resources of the park or (2) water-related management issues brought about by past and present land-use practices. In 1990, the National Park Service (NPS) completed a water resources scoping study designed to evaluate the status of existing information pertaining to the park's water resources as well as to identify water-related management concerns confronting the park (NPS 1991). The issues identified during this scoping process are listed below. This Water Resources Management Plan (WRMP) discusses both these issues and others identified during the development of the plan.

- Water Rights - Need for park-wide inventory of water rights, uses, and needs - Research needs for pending water-rights adjudications

- Surface Water Quality
  - limited existing inventory and monitoring information
  - Possibility of acidic atmospheric deposition affecting dilute subalpine lakes - Potential water quality and erosional impacts associated with grazing - Potential water quality impacts from abandoned mining sites
  - Potential water quality impacts from park operations and maintenance activities - Need to develop long-term inventory and monitoring

- Ground Water
  - Limited understanding of sub-surface flow and ground-water hydrology
  - Need for potable water sources for existing and proposed park developments - Potential effects of existing development on cave hydrology

- Wetlands and Riparian Habitats - Need for identification and delineation of wetland-riparian resources - Potential impacts of grazing on riparian zone

- Floodplain Management - Need to assess flooding hazard at developed visitor-use sites - Need to develop necessary flood-hazard mitigative measures

- Residual Contamination from Atmospheric Nuclear Weapons Testing - Evaluate any potential impact on park water supply.

Limited Availability of Basic Information

The limited amount of basic inventory and monitoring information about the water resources of the park is due mostly to the recent designation of the park as a unit of the National Park System, coupled with the isolated and rugged nature of the region in which the park occurs. Prior to its designation as a national park, the vast majority of the lands were part of the Wheeler Peak Scenic Area of the Humboldt National Forest. During this time, the lands were managed under a multiple-use mandate of the National Forest System, and the primary management objectives were to provide grazing allotments for domestic livestock and to provide opportunities for dispersed recreation (Unrau 1990). Intensive management for public use was limited to the 259-ha (640-ac) Lehman Caves National Monument, which included some historical features and visitor facilities for Lehman Caves and five roadside campgrounds managed by the U.S. Department of Agriculture (USDA) Forest Service along Lehman and Baker creeks.

The designation of Great Basin National Park in 1986 changed the management mandate for lands and increased the number and diversity of people using the area primarily as a recreational resource. In addition to public enjoyment and continuation of livestock grazing, the NPS is to manage the lands to conserve and protect the scenery and the natural, geologic, historic, and archaeological resources. An essential step in this process is the acquisition of basic inventory information about the resources present.

Guidance for the development of adequate natural resources inventory and monitoring activities for NPS units is found in NPS-75: Natural Resources Inventory and Monitoring Guideline (NPS 1992). From the water resources perspective, hydrologic information summarized in the preceding section (The Hydrologic Environment) satisfies many, although not all, of the recommended 'Phase I" inventory activities outlined in NPS-75. Additional information pertaining to the identification and characterization of unlocated springs and seeps, the mapping of riparian and other wetland resources, completion of flood hazard and floodplain delineations, and additional field inventories of aquatic biological resources will be necessary in order to fully comply with the water-related "Phase I" inventory requirements (NPS 1992). Project statements addressing recommended water-related "Phase I" (inventory) needs are provided in the next section (Water Resources Management Program).

Because of the exceptional value of the water resources within the park (NPS 1993) and the sensitivity of these resources to impacts from acidic atmospheric deposition and, land uses, the park has used some operational and program funds to implement limited water-related "Phase II" (monitoring) activities. These activities include "Phase II" (monitoring) of precipitation chemistry and periodic assessments of surface-water quality of the park's subalpine lakes and streams. The need to develop and implement a long-term monitoring program to assess the impacts of grazing on riparian-wetland environments has also been identified. Each of these 'Phase II" monitoring programs, as well as recommended water-related "Phase III" (special studies), are discussed in the next section (Water Resoures Management Program).

Water Resources Issues Related to Land Use

The lands comprising the park have been subject to a wide variety of uses over the last century including the farming of vegetable and fruit crops, timber harvest, livestock production, mining, roads, dispersed and concentrated recreation, water diversions, homesites, and administrative and maintenance facilities for visitor use. Some of these practices, like mining, have been discontinued, at least for the time being, but adverse consequences of historic activities persist. Conversely, some of the artifacts of these past land-use practices are considered cultural resources, and their perpetuation is desirable for historic and interpretive purposes. The Lehman Orchard, some of the old homesites, and some of the old mining structures (e.g., the Osceola Ditch) qualify as such cultural features. In the case of adverse consequences, individual effects of various activities are not easily distinguished from one another, especially in steep drainages where the cumulative effects of a practice can occur at considerable distances from the actual source. The park is concerned with site-specific effects of land uses as well as chronic and cumulative stress accumulating over many years or over large distances.

National Park Service Water Rights

Federal reserved water rights for the park are limited by the park's enabling legislation to those associated with the establishment of Humboldt National Forest and Lehman Caves National Monument. The federal reserved water rights for national forest purposes and the purposes associated with Lehman Caves are uncertain in quantity, probably more limited in extent than what reserved rights for park purposes would be, and the priority dates are junior to many of the downstream surface water rights. Thus, all water for the park's needs may not be provided via reserved water rights.

There may also be federal reserved water rights associated with the withdrawal of the Baker administrative site which was transferred from the USDA Forest Service to the NPS in 1991. The priority dates for these rights are the dates the lands were withdrawn (1911 and 1968) and are for the purposes of the withdrawals. The quantity of water associated with these reserved rights has not been determined.

The park holds state appropriative surface-water rights on Cave Springs and the administrative site near Baker. Both were decreed in the adjudication of the Lehman and Baker creek stream system in 1934 (NPS 1988). The Cave Springs right was acquired by the NPS with a private land purchase, and the administrative site water rights were transferred to the NPS in 1991, with the transfer of the administrative site from the USDA Forest Service to the NPS.

Water Rights Claimed by Others than the NPS

Surface Water

Surface water within the Lehman and Baker creek stream system is fully appropriated and the rights have been set forth as a result of a water-right adjudication and decree issued in 1934. Surface-water rights within other basins that headwater in the park have not yet been adjudicated. In general, surface water originating within the park is used downstream from the park for domestic, livestock, and irrigation purposes in compliance with state water laws (Meyer and Reynolds 1987). The priorities associated with these downstream rights are generally senior to the establishment of the park and, in many cases, the national forest.

Ground Water

Great Basin National Park is located within two hydrographic areas, within which the State Engineer manages ground water appropriation under the concept of perennial yield. The intent of this concept is to provide a stable long-term water supply. A reasonable lowering of the ground-water table is acceptable (NRS 534.110), but mining of ground-water resources is generally avoided. The State Engineer's estimates of perennial yield are generally based upon hydrologic reconnaissance studies, which examine such factors as geology, ground-water flow, and ground-water recharge and discharge. The State Engineer's estimate of perennial yield for Spring Valley is 100,000 ac-ft, and as of December 2, 1988, 35,800 ac-ft were committed to permitted ground water appropriations. The estimate of perennial yield for Snake Valley is 25,000 ac-ft with 5,247 ac-ft committed as of December 2, 1988 (Nevada Department of Conservation and Natural Resources 1988).

In October 1989, the Las Vegas Valley Water District filed applications with the State Engineer to appropriate large quantities of ground water from hydrographic areas in southern and east-central Nevada. Twenty-eight of these applications were in Snake and Spring valleys and were protested by the NPS based on potential impacts to Great Basin National Park's water rights, water resources, and related attributes. As of January of 1994, hearings on the applications had not been scheduled by the State Engineer. Because of the magnitude of these applications, the NPS has been routinely protesting applications for water rights that are later in time to the district's applications, on the contention that if the district's applications are granted, there may be no water remaining for subsequent appropriators.

Range Management

Lands encompassed by the park have been grazed by domestic livestock since the late 1860s (Unrau 1990). Although not specifically documented, it can be presumed that the number of livestock grazing lands of the park are considerably less now than numbers present around the turn of the century (Table 12, Eddleman and Jaindl 1991b). Cattle and sheep grazing continues throughout the park under a permit system involving seven allotments and five ranches (Figure 7). Cattle and sheep graze within the park from June 1 to October 10 of each year (NPS 1993, Table 13). Two of the allotments are managed entirely by the park and five allotments are jointly managed with the USDA Forest Service and, in one case, the Bureau of Land Management. Cattle graze five of the allotments and sheep graze two within the guidelines of rest-rotation or deferred-rotation grazing systems (Eddleman and Jaindl 1991a). Animal months for each grazing unit are based on an allowed use of forty-five percent of the grass and forb component for both the cattle and sheep allotments and twenty-five percent use of the shrub component in the sheep allotments in the upland communities. Livestock numbers under the present grazing system appear to be near the maximum estimated carrying capacities of the various allotments (Eddleman and Jaindl 1991a). Carrying capacities are based on estimates of production potentials for grass and forbs compared to estimates with similar range site descriptions of the Soil Conservation Service (Eddleman

Table 12. Trends in number of livestock, excluding poultry, in White Pine County, Nevada based on public records summarized in Unrau (1990).[1]

	Years							
Type of Livestock	1874	1880	1890	1900	1920	1930	1940	1954
Horses	1029	2000	3000	2000	1660	1745	978	1236[2]
Mules, asses and burros	158	475	125	150	182	73	31	---[2]
Cows	1882	3000	300	400	477	162	667	642
Calves	2700	1800	250	350	--	--	--	--[4]
Beef cattle	5970	2000	1000	0	--[3]	--	--	--[4]
Stock cattle	--	--[2]	7000	15321	10662[3]	6357	64078	25012[4]
Oxen	--	200	20	4	--	--	--	--
Bulls	--	100	300	500	380	221	174	--
Sheep and lambs	2500	10000	35000	30000	131228	113176	64078	77132
Bucks	--	--	--	--	2177	1176	764	--
Hogs and pigs	350	340	200	300	327	359	209	612
Goats	3	182	--	--	20	487	764	--

1 A category for which records are not available is indicated with double dashes and no footnote.
2 Mules, asses, and burros are included in the figure for horses.
3 Beef cattle are included in the figure for stock cattle.
4 Calves, beef cattle, oxen, and bulls are included in the figure for stock cattle.

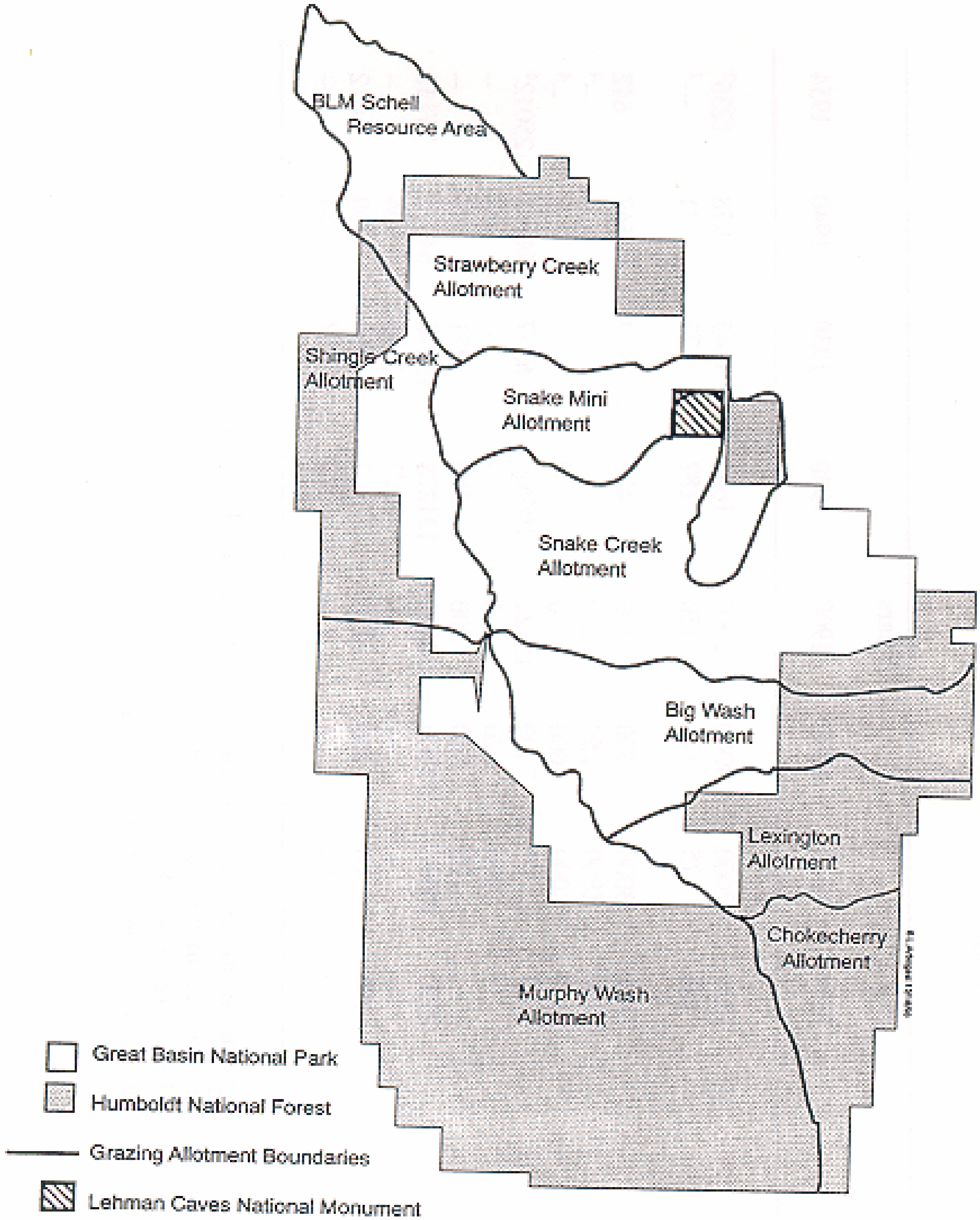


Figure 7. Location of grazing allotments for domestic livestock in the South Snake Range. The 259-ha (640-ac) area of the former Lehman Caves National Monument has been closed to grazing since the 1920s and remains closed.

Table 13. Livestock use of allotments that include lands of Great Basin National Park.

Allotment Name	Livestock Type & No.	Period of Use	Allotment Size ha (ac)	Estimated Area of Available Rangeland ha (ac)
Strawberry Creek	243 cow/calf pairs	15 Jun-15 Sep	4,226 (10,443)	1,964 (4,911)
Snake Mini	71 cow/calf pairs	16 Jun-10 Oct	4,017 (9,927)	2,166 (5,351)
Snake Creek	161 cow/calf pairs		11,718 (28,956)	4,402 (10,878)
Big Wash	40 cow/calf pairs	1 Jul-10 Oct	5,196 (12,839	807 (1,995)
Lexington	25 cow/calf pairs; 75 yearlings	1 Jul-10 Oct	3,518 (8,692)	1,388 (3,430)
Murphy Wash	1,500 dry ewes	1 Jun-10 Sep		–
Shingle Creek	1,500 dry ewes	20 Jun-10 Sep	7,319 (18,085)	3,049 (7,535)

s Based on Eddleman and Jaindl (1991a).

and Jaindl 1991c). Aquatic and riparian-wetland sites are not managed separately from upland habitats for grazing purposes. The park and the USDA Forest Service are in the process of preparing new allotment management plans, which will address many of these issues.

In general, livestock spend a disproportionate amount of time in riparian-wetland sites when given unlimited access to these sites along with upland sites in the and and semi-arid West (Roath and Krueger 1982, Gary et al. 1983). Overuse of riparian-wetland sites often results in changes in vegetation, elimination or reduction in area of riparian-wetland sites due to channel widening, reduction of streambank stability, lowering of the water table, changes in water quality, changes in aquatic biota, and other impacts (Kauffman and Krueger 1984). Methods that have been used with varying degrees of success for management of riparian-wetland sites include exclusion of livestock grazing, alternative grazing schemes, changes in the kind or class of animals allowed to graze, managing riparian-wetland sites separately from adjacent uplands, placement of in-stream structures for mitigation, and basic range management practices placement of in-stream structures for mitigation, and basic range management practices such as salting, alternative water sources, fencing, and range riders (Elmore 1992, Kauffman and Krueger 1984, Platts 1990).

Based on extensive studies of park vegetation (Eddleman and Jaindl 1991c, Murray et al. in prep.), brief reconnaissance visits to the park by a range hydrologist (Dobrowolski 1992) and a water quality specialist (Nelson and Jacobs 1993), and classification studies of Frissell and Liss (1993), damage to some riparian wetland sites and to some aquatic habitats is occurring in the park as a result of grazing practices. In some locations, damage due to grazing is combined with damage due to recreational use, mining, roads, or other activities and developments. In some locations, damage due to these other activities is greater than any damage due to grazing. The damage is not uniformly pervasive but occurs in both sheep allotments and cattle allotments. Damage to riparian wetland sites and aquatic habitats of the park includes, but is not limited to, hedging of plants, unstable and actively eroding streambanks, lowered water tables, changes in composition of plant communities, gullying, channel widening, channel shallowing, and sedimentation. Fecal contamination of stream and spring habitats is also suspected (Nelson and Jacobs 1993).

Mines

Mining of lands encompassed by the park began about 1869 and largely involved extraction of tungsten ore from sites scattered throughout the park (Unrau 1990). Other metals sought to a lesser extent included beryllium, gold, silver, copper, lead, and antimony. Six mining districts are at least partially in the park with approximately 250 unpatented mining claims. There are no active mines in the park at present, and new mining claims are prohibited. Mining could occur again on valid mining claims with development and approval of a mining plan (NPS 1993).

Characteristics of old mine sites are diverse and range from small, inconspicuous waste heaps to large excavations in hillsides with abandoned equipment nearby. Around Johnson Lake where visual evidence of mining is most obvious in the park, an aerial cable-pulley system is still in place, and large structural timbers and old equipment are present. The west-side excavation above Johnson Lake is extensive and appears to follow an ore vein for 50-100 m (150-300 yd) traveling up the cliff. Several adits or stopes are evident, and rocks and tailings from the excavation are piled on the west slope and sweep down toward the lake. Large logs, possibly from mining structures, reside along portions of the shore.

Pollutants from abandoned mine sites can alter physical, biological, and chemical characteristics of terrestrial, riparian-wetland, and aquatic habitats (Forstner and Wittmann 1979). Potential water quality issues related to inactive mines in the park include surface erosion from disturbed soils and waste heaps, leaching of metals from waste heaps, subsurface contamination from infiltration of leachates, and toxic or stressful accumulation of metals in biota, including humans (Nelson and Jacobs 1993).

One sample of water collected in 1990 in a depression near an audit of a mine just west of the park boundary (Pole Canyon Adit of the Mount Wheeler Mine) was evaluated for chemical composition (Table 14). The level of zinc detected in this sample exceeded the criterion of 47 I g/l for safe drinking water for humans (EPA 1986). Tissue samples of trout and beetles of the family Gyrinidae taken from several lakes in the park were analyzed in 1989 and raised some concerns about possible hazards to human health (Metcalf et al. 1989). Trace metals present in the tissues in what were judged to be significant quantities included zinc, lead, copper, selenium, cadmium, nickel, silver, and chromium (Appendix 6).

Table 14. Results of trace metal analysis (ICP) of a water sample taken from an entrance to the Mt. Wheeler Mine on the west slope of Mt. Washington near Great Basin National Park (Files of National Park Service, Mining and Minerals Branch, Denver, Colorado).

Element	Result (unit is µg/l except *which is mg/1)
Aluminum	< 60
Barium	13
Beryllium	< 1
Cadmium	< 10
Calcium*	493
Chromium	< 10
Cobalt	< 10
Copper	77
Iron	< 10
Lead	<50
Magnesium*	5.7
Manganese	3
Molybdenum	< 15
Nickel	<30
Silver	< 10
Sodium*	1.7
Thallium	< 100
Vanadium	< 5
Zinc	50

Logging and Fires

Fire played a major role in the ecology of the South Snake Range largely before 1860 (Gruell et al. 1991). Fire frequencies apparently varied considerably depending on aspect, topography, and ignition source. North-facing slopes in Snake Creek and Strawberry Creek probably had what Gruell et al. (1991) considered to be a close interval of burning with 20 years or less between burns because light surface fuels were sufficient to carry fire. Drier south-facing slopes and some other slopes such as lower Shingle Creek and Big Springs Wash may have burned at intervals of 50 years or longer. Fire suppression has been the long-standing policy for fire management in the Snake Range since settlement by Euroamericans, and this policy has been carried on by the NPS. A few lightning-caused fires occur, but since 1959 they have averaged less than three fires per year, and most have been less than 1 ha (2i ac) in size. Changes in vegetation have accompanied the decrease in frequency of fire (Gruell et al. 1991). The park is developing a fire management plan.

Logging occurred in the Snake Range more or less intermittently between 1860 and 1906 (Von Wernstedt 1906). Mills were located on Williams, Strawberry, Snake, and Lexington creeks. Logging also occurred in Baker Creek and Pole Canyon, although no mills were built there (Unrau 1990). Von Wernstedt (1906) estimated that "yellow" (ponderosa) pine, Douglas fir, and "balsam" (white) fir were cut but not Engelmann spruce. Ponderosa pine seemed to be the primary species targeted for cutting.

Park Operations and Development

<u>Water Supplies</u>

Cave Springs provides water to the administrative and visitor facilities in the area of Lehman Caves (NPS 1993). Two 50,000-gallon storage tanks are associated with this water system. The water is chlorinated prior to storage, and distribution is by gravity flow. The treated water is tested on a regular basis for turbidity and bacterial contamination. High-runoff precipitation events show some influence on observed flow rate from the spring and on measured turbidity levels, indicating that the spring is influenced to some degree by hydrologic events on the surface.

The four developed campgrounds in the park each have their own water supply from a nearby spring. The water right for these springs is held by a local ranch. The waters of these campgrounds are treated by chlorination and filtration and considered safe for potable use. All of the source springs are assumed to be surface influenced. Approximately 15 sq-m (135 sq-ft) of area surrounding each spring is enclosed by fences to discourage direct contamination by grazing <u>animals.</u> However, steep slopes around most springs combined with precipitation events that result in high runoff could lead to fecal contamination from up-slope grazing <u>animals</u> (Nelson and Jacobs 1993). Extensive fecal contamination by cattle exists around some of the spring enclosures (Nelson and Jacobs 1993) and likely is the source of some of the fecal coliform and fecal streptococcus bacteria present in raw surface water (Figure 8).

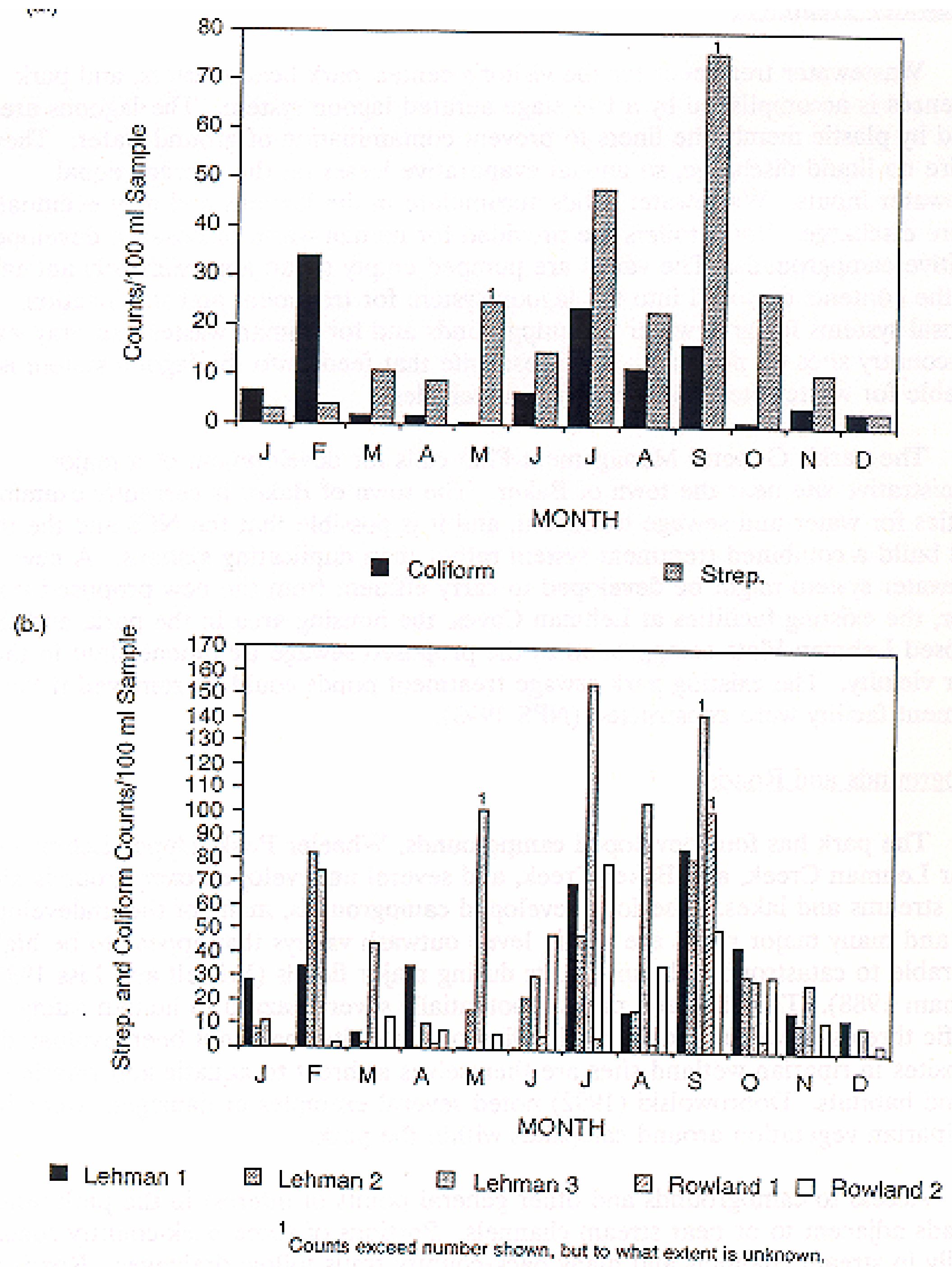


Figure 8. Fecal coliform and fecal streptococcus bacteria in raw surface water of Lehman Creek and Rowland Springs as measured at monthly intervals in 1991. (a) is mean number for the five site samples and (b) is the total number by site and month.

Wastewater Treatment

Wastewater treatment for the visitor's center, park headquarters, and park residences is accomplished by a two-stage aerated lagoon system. The lagoons are sealed by plastic membrane liners to prevent contamination of ground water. They require no liquid discharge, so annual evaporative losses on the average equal wastewater inputs. Wastewater solids accumulate in the lagoons and may eventually require discharge. Vault toilets are provided for human waste disposal in developed and primitive campgrounds. The vaults are pumped empty on an approximately annual basis, with the contents disposed into the lagoon system for treatment and stabilization. Disposal systems for gray water in campgrounds and for human wastes and gray water at back-country sites do not exist. A disposal site that feeds into the lagoon system is available for wastewater from recreational vehicles.

The park's General Management Plan calls for development of a major administrative site near the town of Baker. The town of Baker is currently examining facilities for water and sewage treatment, and it is possible that the NPS and the town could build a combined treatment system rather than duplicating systems. A new wastewater system might be developed to carry effluent from the new proposed visitor center, the existing facilities at Lehman Caves, the housing area in the park, and the proposed Lehman Flats campground to the proposed sewage treatment plant in the Baker vicinity. The existing park sewage treatment ponds could be removed if the new treatment facility were constructed (NPS 1993).

Campgrounds and Roads

The park has four developed campgrounds, Wheeler Peak, Upper Lehman Creek, Lower Lehman Creek, and Baker Creek, and several undeveloped campgrounds along other streams and lakes. The four developed campgrounds, many of the undeveloped sites, and many major roads are within levee outwash valleys that appear to be highly vulnerable to catastrophic channel shifts during major floods (Frissell and Liss 1993, Burkham 1988). This situation poses a potentially severe hazard to human safety. Specific threats to visitors posed by flooding of these sites have not been evaluated. Campsites in riparian-wetland sites are themselves a threat to aquatic and riparian-wetland habitats. Dobrowolski (1992) noted several examples of damaged streambanks and riparian vegetation around campsites within the park.

Access to campgrounds and other general points of interest in the park tend to be by roads adjacent to or near stream channels. Portions of some back-country roads are actually in stream channels and many back-country trails follow drainages. Roads and trails adjacent to streams tend to accelerate the addition of sediments to streams and reduce the cover of riparian vegetation along the stream (MacDonald et al. 1991). Evidence of these effects can be found at some locations in the park (Dobrowolski 1992).

Hazardous Materials Management

Hazardous substances can become water quality problems when improper disposal methods are used or when accidental spills occur. Park maintenance facilities, and storage buildings and yards, are the most likely locations for problems related to hazardous substances to develop. No ground-water contamination problems related to park operations are known to exist in the park (Nelson and Jacobs 1993). Several underground storage tanks for diesel fuel and gasoline near the park's maintenance yard were removed and replaced with above-ground storage tanks in 1993. Three remaining underground storage tanks near the park's visitor center were tested on July 16, 1993 and were found not to be leaking. All three contain fuel oil. Hazardous materials such as cleaning solvents are stored in sealed containers and periodically disposed of by approved methods.

Issues Considered but Not Developed in Detail

Several issues were considered for discussion in this management plan, but proposed actions were not included in the recommended Water Resources Management Program either because they could be better addressed in other planning documents or because the issue was not considered a priority.

Residual Contamination from Atmospheric Nuclear Weapons Testing,

The park is approximately 250 km (160 mi) north of the Nevada Test Site. The U.S. Atomic Energy Commission used the Nevada Test Site from 1951 through 1975 for conducting nuclear weapons tests, nuclear rocket engine development, nuclear medicine studies and for other nuclear and non-nuclear experiments. The Environmental Protection Agency's (EPA) Environmental Monitoring Systems Laboratory at Las Vegas, Nevada operates an environmental radiation monitoring program in the region surrounding the Nevada Test Site and at former test sites in several other states. The surveillance program is designed to measure levels and trends of radioactivity, if present, in the environment surrounding testing areas to ascertain whether current radiation levels and associated doses to the general public are in compliance with existing radiation protection standards. The surveillance program additionally has the responsibility to take action to protect the health and well being of the public in the event of any accidental release of radioactive contaminants. Off-site levels of radiation and radioactivity are assessed by sampling soil, water, and air; by deploying thermoluminescent dosimeters and using pressurized ion chambers; and by biological monitoring of animals, food crops, and humans. The surveillance includes a long-term hydrological monitoring program (EPA 1990).

Comparison of the measurements and sample analysis results with background levels and with appropriate standards and regulations indicted in 1990 that there was no radioactivity detected off-site by the monitoring networks and no exposure above natural background to people living in the vicinity of the test site that could be attributed to current activities at the site. Annual and ten-year trends were evaluated in the Long-term Hydrological Monitoring Program and others, and all evaluated data were consistent with previous data history. No radiation directly attributable to current activities at the Nevada Test Site was detected in any samples (EPA 1990).

Additional monitoring at Great Basin National Park by the NPS is deemed unwarranted given the extensive monitoring by the EPA. Detection of excessive levels of radiation off-site through the EPA monitoring program would provide cause to reconsider this conclusion.

Proposed Visitor Center

A new visitor center is proposed for the park (NPS 1993). The identified site is underlain by Pole Canyon Limestone, a geologic unit that contains major cave resources. Although no cave passages are known in the immediate vicinity of the visitor center, the existence of underlying caves is a possibility that should be evaluated. Such an evaluation would be proper under the park's General Management Plan or the facility's Development Concept Plan rather than in this Water Resources Management Plan.

Inventory of Caves and Cave Biota

The scoping report that was prepared as a precursor to the development of this Water Resources Management Plan (NPS 1991) contained the recommendation that this plan address the need to inventory caves and cave biota. Great Basin National Park has some of the most extensive and valuable cave resources of any unit of the National Park System in the western United States (NPS 1993; T. Aley, pers. comm., 1991). A cave inventory would be appropriate in response to the Federal Cave Resource Protection Act of 1988 (16 U.S.C. 4300-4309; 102 Stat. 4546). This act does not specifically require a comprehensive cave inventory but appears to require identification of significant caves. An inventory of cave biota would be appropriate as part of the inventory process. These activities would be better addressed in a Cave Resources Management Plan than in this plan.

WATER RESOURCES MANAGEMENT PROGRAM

This section of the Water Resources Management Plan (WRMP) provides an overview of the existing activities related to water resources of Great Basin National Park and lists specific actions to address the water resource issues described in the preceding section (Water Resources Issues). The actions are developed in the "project-statement" format currently utilized by the National Park Service (NPS) for planning and budgeting processes related to natural resources. These project statements include inventory, monitoring, resource management, and research activities. In addition, this section lists short-term (0-5 years) and intermediate-term (5-15 years) activities aimed at providing a programmatic approach to water resources management in Great Basin National Park.

Overview of Existing Activities

Park management has long recognized the exceptional water resources and water-dependent environments located within Great Basin National Park. Since the establishment of the park, some operational funding has been used to meet some of the park's most pressing water-related inventory and monitoring needs. At the same time, park staff has aggressively sought programmatic funding and technical support to address additional critical issues related to water resources. For example, the park has monitored precipitation chemistry as part of the National Atmospheric Deposition Program (NADP) since 1985. Data from this long-term monitoring program are critical for assessing changes in precipitation chemistry, which could negatively affect water quality in the park's high-elevation lakes and streams. In addition, the park has funded an important short-term assessment of water chemistry of the lakes and selected streams (Metcalf et al. 1989). The park has attempted to implement some minimal long-term monitoring of surface water following recommendations of Metcalf et al. (1989) by sampling pH and conductivity in park lakes and streams on a semi-annual basis (Pfaff 1991). A monthly sampling of indicator bacteria, as part of a compliance monitoring program, has been conducted by the park's Maintenance Division to monitor for contamination from the use and operations of the park's vault toilets and sewage lagoon (John Innes, Great Basin National Park, pers. comm., 1993). Working cooperatively with the NPS Water Resources Division, the park also has obtained support for several activities -- for example, an important assessment of water rights in the Baker and Lehman creek basins (NPS 1988), the reestablishment of discharge stations on Lehman and Baker creeks, preparation for hearings in the matter of applications for water rights by the Las Vegas Valley Water District, and the development of this plan.

The park has initiated basic inventory and monitoring programs, as well as the pressing resources management and research efforts necessary to assure the long-term protection and preservation of water resources. These efforts need to be strengthened. Essential long-term monitoring programs, which require consistent analytical procedures, periodic data evaluation, and adequate protocols for quality assurance and quality control, are currently implemented by temporary employees operating from a "soft" funding base. The likelihood of the long-term success of these programs would be greatly enhanced if the monitoring programs were consistently designed and directed by a permanent staff professional with a strong academic background and experience in the interpretation of aquatic data and the management of aquatic sampling programs. The establishment of such a permanent position depends on long-term base funding, supplemented by appropriate project-related funds. Adequate funding does not exist to support an acceptable level of inventory and monitoring of riparian-wetland sites to evaluate the impacts of grazing on these critical habitats. Additional unfunded needs are further discussed within the recommended project statements listed in Table 15.

Recommendations for Developing a Programmatic Approach to Water Resources Management

Recommended short-term and intermediate-term management activities as part of a programmatic approach to water resources management are provided below. These activities are compatible with the management objectives stated in the introductory section of the plan (see page 6). The short-term recommendations identify the most pressing water resources needs which should be implemented over the next five years. The intermediate-term recommendations address needs that are as critical to proper water resources management as the short-term needs, but *which* generally are perceived to be of less immediate concern. The intermediate-term needs should be anticipated now so that the proper amount of resources can be sought to address them in the time period starting approximately 5 years from now and ending approximately 15 years from now.

Short-term Management

Base funding for long-term inventory and monitoring programs, which are deemed critical to the long-term protection and preservation of the park's water-related resources, is needed. Additional funding will permit position management, *which* will increase the expertise available through the park staff to conduct the water resources management program. These efforts will include pursuit of adequate base funding and seasonal FIE to support critical monitoring of water resources, including riparian-wetland habitats (see Project Statements GRBA-N-004.100, Acidic Atmospheric Deposition Monitoring; GRBA-N-019.210, Monitoring of Surface-Water Chemistry; and GRBA-N-030.300, Monitoring of Riparian-Wetland Sites for Vegetation Utilization Due to Grazing.

Project funding will be aggressively pursued from WASO and regional sources with the NPS (e.g., Natural Resources Protection Program, Invenory and Monitoring, Water Resources Division, and others) in order to implement the highest-priority inventory, monitoring, resource management, and research projects identified from the array of project statements presented in this plan. Special consideration should be given to the project statements GRBA-N-019.800 (Delineation and Mapping of Riparian-Wetland Sites, and GRBA-N-019.820 (Mapping and Characterization of Springs).

Table 15. Water-related project statements recommended for inclusion in the Great Basin National Park Resource Management Plan.

GRBA-N-004.100	Acidic Atmospheric Deposition Monitoring
GRBA-N-019210	Monitoring of Surface-Water Chemistry
GRBA-N-019.800	Delineation and Mapping of Riparian-Wetland Sites
GRBA-N-019.820	Mapping and Characterization of Springs
GRBA-N-030.300	Monitoring of Riparian-Wetland Sites for Vegetation Utilization Due to Grazing
GRBA-N-036.000	Floodplain Assessment in Vicinity of Campgrounds
GRBA-N-019.500	Stream Classification
GRBA-N-018.400	Water-Right Adjudications
GRBA-N-018.500	State Administrative Proceedings to Consider Applications for Water Appropriation
GRBA-N-019.000	Inventory Water Use and Determine Water Rights
GRBA-N-008.000	Fisheries Management
GRBA-N-008.100	Bonneville Cutthroat Trout Management
GRBA-N-032.300	Effluents Associated with Abandoned Mine Sites
GRBA-N-032.200	Effects of Abandoned Mine Sites on Johnson Lake
GRBA-N-019.600	Water Quality Standards Classification
GRBA-N-018.240	Discharge Monitoring for Permit Compliance: Sewage Lagoons and Vault Toilets
GRBA-N-018.210	Hazardous Substances and Contamination of Ground Water
GRBA-N-018.230	Gray-water Disposal
GRBA-N-030.100	Assessment of Riparian-Wetland and Aquatic Habitats with and without Grazing (Exclosure Experiments)
GRBA-N-019.910	Interaction between Surface and Groundwater in the Region of the Snake Creek Diversion
GRBA-N-019.900	Lehman Caves Water Budget
GRBA-N-019.810	Delineation of Recharge Areas for Springs

The park will continue to request technical assistance and support from the Water Resources Division for the implementation and evaluation of water quality monitoring activities (GRBA-N-019.210), assessment of water needs, water uses, and water rights (GRBA-N-018.400 and GRBA-N-018.500), and floodplain and flood-hazard delineation (GRBA-N-036.000). The park will maintain a good working relationship with the NPS Wildlife and Vegetation Division and the Nevada Department of Wildlife, and seek the funding necessary to actively manage for the persistence of Bonneville cutthroat trout within the park (GRBA-N-008.100).

The park will work with the NPS Western Regional Office Hazardous Materials Coordinator and the NPS WASO Engineering and Safety Services Division to pursue support for a hazardous-substances site investigation at an abandoned mine site at Johnson Lake (GRBA-N-032.200).

Intermediate-term Management (5-15 years)

Activities to be conducted 5 to 15 years from now will be evaluated within the context of the Resources Management Assessment Program (R-MAP). This recently established program, provides an objective methodology with which to analyze base funding requirements of the ONPS and to evaluate the types and numbers of positions necessary to implement a thorough natural resources management program within NPS units. Information about resource allocation resulting from prototype R-MAP analyses indicates that the resources presently available to address water resources issues at Great Basin National Park are largely inadequate. Information about resource allocation from R-MAP analysis ultimately should provide the park with an objective assessment of requirements neeeded to thoroughly address water resources issues. A peer evaluation of the alternatives for the optimal application of these resources, prioritization of needs, and development of an appropriate request for long-term base funding from ONPS is as an intermediate-term activity in the water resources management program.

PROJECT STATMENTS

PROJECT NUMBER: GRBA-N-019.210

TITLE: MONITORING OF SURFACE-WATER CHEMISTRY

FUNDING STATUS: FUNDED: 40.0 UNFUNDED: 0.0

SERVICEWIDE ISSUES: N11 WATER QUAL-EXT N20 BASELINE DATA

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Water quality inventory and monitoring in Great Basin National Park is a resource management concern because the park's high-elevation lakes and streams contain exceptionally pure water, which could be affected by regional contaminants such as acidic atmospheric deposition. The aquatic systems could also be negatively affected by runoff of storm water and erosion from roads located adjacent to streams, erosion and other changes to the riparian zone associated with livestock grazing in the park, contaminated runoff from abandoned mine sites, and activities and developments in campgrounds located adjacent to streams.

The park initiated a simple program for monitoring surface water in 1990 based upon recommendations of Metcalf et al. (1989). This monitoring program is designed to establish baseline data for pH and specific conductance for the high-elevation waters of the park, which are thought to be the most susceptible to degradation from acidic atmospheric deposition. In addition, this monitoring program may provide an "early warning system" for detecting general deterioration of water quality before long-term damage occurs (Pfaff, 1991). Samples are collected twice each year, once in the spring and once in the fall, from Stella, Teresa, Brown, Baker, Johnson, and Dead lakes, as well as from Strawberry, Lehman, Baker, Snake, South Fork of Big Wash, Pine, Ridge, and Shingle creeks. Specific conductance is measured in the field, and duplicate water samples are collected at each site for pH measurements at park headquarters. With very slight modification, methods follow those developed for the National Lake Survey (Hillman et al. 1986).

In 1992, an additional synoptic inventory of water quality condition within park waters was conducted in conjunction with the development of the park's Water Resources Management Plan (Jacobs et al. 1993). This survey indicated that, in general, the waters of the park are poorly buffered and exhibit approximately neutral pH, low conductivity, and some differences in major ions.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

This project will design and initiate a sustainable, long-term program for monitoring water quality, and thus, establish the foundation for monitoring the park's water quality for the future. The objectives of this project include: 1) assess the potential threats to the park's water quality and determine appropriate monitoring procedures; 2) implement a sustainable program to monitor trends in base flow and event-related water quality; 3) institute procedures for management of water quality data and develop protocols for data evaluation in order to provide park management with a continuing assessment of conditions and trends; and 4) develop specific decision criteria, which would trigger intensive evaluations of potential issues identified by monitoring efforts.

Three major activities will be undertaken in order to achieve these objectives.

1. The park will hire an expert consultant to assess the potential threats and develop specific alternatives and cost estimates for long-term monitoring of water quality.

2. The park will install automated water quality monitoring devices in Baker Lake and Baker Creek to gather data on diurnal and seasonal variations in basic parameters of water quality.

3. The park will obtain the latest version of the National Park Service, Water Resources Division's database management system for water quality and develop a water resources database for the park consisting of all information available from previous and ongoing surveys.

This project will contribute to the park's ability to discontinue or redirect land-use practices to minimize effects on the water quality of the park. It will also provide quantitative documentation of some of the characteristics of the park's ecosystem and documentation of some of the variability of that ecosystem through time. The project also has the potential to provide data for use by other programs such as the Environmental Monitoring and Assessment Program of the U.S. Environmental Protection Agency, prototype monitoring programs with the National Park System, and regional and local monitoring programs conducted by state and federal agencies in the Intermountain Region of the United States.

Literature Cited

Hillman, D.C., J.F. Potter, and S.J. Simon. 1986. National surface water survey, eastern lake survey (Phase I - synoptic chemistry) analytical methods manual. EPA/600/4-86/009. U.S. Environmental Protection Agency, Las Vegas, Nevada.

Jacobs, R.W., P.O. Nelson, and G.L. Larson. 1993. Chemical characteristics of surface waters of Great Basin National Park. Report to Great Basin National Park, Cooperative Agreement No. CA-9000-8-0006 (Subagreement No. 21), Pacific Northwest Region, National Park Service, Seattle, Washington. 23 pages + appendices.

Metcalf, R. C., G. D. Merritt, M. A. Stapanian, J. R. Baker, and K. M. Peres. 1989. Chemistry of selected lakes and streams in Great Basin National Park, Nevada during winter and spring 1989. Draft Report, EPA Contract No. 68-03-3249. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nevada. 43 pages + appendices.

Pfaff, K. 1991. Overview and procedures for monitoring pH and conductivity of surface water in Great Basin National Park. Draft Report. Great Basin National Park, Baker, Nevada. 49 pages.

BUDGET AND P 1Es:

-------------------------------------- FUNDED

	Source	Act Type	Budget ($1000s)	1'rs
Year 1:	WATER-RES	MON	20.0	
	PKBASE-NR	MON		02
Year 2:	WATER-RES	MON	20.0	
	PKBASE-NR	MON		0.2
Year 3:				
Year 4:				
	Total:		40.0	0.4

---------------------------------- UNFUNDED --------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:			

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

COMPLIANCE CODE(S): EXCL

EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-004.100

TITLE: ACIDIC ATMOSPHERIC DEPOSITION MONITORING

FUNDING STATUS: FUNDED: 253 UNFUNDED: 0.0

SERVICEWIDE ISSUES: N20 BASELINE DATA

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Acidic atmospheric deposition (acid rain) is a threat to many aquatic and terrestrial systems throughout the world (Charles 1991). Pollutants commonly originate from industrial and metropolitan centers, including coal-fired power stations. Because of prevailing wind patterns, the most likely current source of pollutants that would influence Great Basin National Park come from California. However, there have been proposals in the past for additional coal-fired power stations in closer proximity to the park, which could potentially have deleterious impacts, particularly upon the dilute lakes and streams found above 3,000 m (10,000 ft).

Routine monitoring is conducted in portions of the Sierra Nevada and in Great Basin National Park for acid deposition originating from California. The park has been a participant in the National Atmospheric Deposition Program (NADP) since 1985. This program consists of a nationwide network of monitoring sites at which the chemical composition (pH, specific conductance, major cations, and major anions) of precipitation is measured on a weekly basis.

To date, no detection of chronic effects from acidic atmospheric deposition is evident in the Sierra Nevada, although short-term episodes of mildly acidified deposition do occur (Melwik and Stoddard 1991). Similarly, whereas Great Basin National Park presently does not appear to be impacted by acidic atmospheric deposition, the vulnerability of the high-elevation lakes, coupled with the possibility of future proposals for coal-fired power plants within the region, warrant the continuation of this long-term monitoring effort.

Literature Cited

Charles, D.F., editor. 1991. Acidic Deposition and Aquatic Ecosystems - Regional Case Studies. Springer-Verlag, New York.

Melwik, J.M., and J.L. Stoddard. 1991. Sierra Nevada, California. Chapter in D.F. Charles, editor. Acidic Deposition and Aquatic Ecosystems - Regional Case Studies. Springer-Verlag, New York.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

As a participant in the NADP program, the park currently monitors the precipitation chemistry on a weekly basis at a site located near park headquarters. Data from this monitoring effort are available through the NADP program. The availability of long-term data at the park will be invaluable in monitoring trends and providing background information to assess possible impacts from proposed coal-fired power stations. It is recommended that the park's participation in this monitoring program continue at its present level.

BUDGET AND FTEs:

FUNDED

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	AIR-QUAL	MON	6.00	
	PKBASE-NR	MON		0.1
Year 2:	AIR-QUAL	MON	6.00	
	PKBASE-NR	MON		0.1
Year 3:	AIR-QUAL	MON	6S0	
	PKBASE-NR	MON		0.1
Year 4:	AIR-QUAL	MON	7.00	
	PKBASE-NR	MON		0.1
	Total:		25.5	0.4

UNFUNDED

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

COMPLIANCE CODE(S): EXCL

EXPLANATION: 516 DM2 App. 2, 1.10

PROJECT NUMBER: GRBA-N-019.800

TITLE: DELINEATION AND MAPPING OF RIPARIAN-WETLAND SITES

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 0.0

SERVICEWIDE ISSUES: N12 WATER FLOW N20 BASELINE DATA

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Wetlands and riparian zones are important habitats and require particular attention of park managers for a variety of reasons. From a regulatory perspective, specific authorities for protection of wetland resources of the National Park Service (NPS) are found primarily in the NPS Organic Act, the Clean Water Act (particularly Section 404), the National Environmental Policy Act, and Executive Order 11990 -- Protection of Wetlands. A detailed listing of NPS responsibilities in regard to wetland protection is presented in the NPS Floodplain Management and Wetland Protection Guidelines, 45 FR 35916, Section 9.

The legal authorities and ensuing regulations for wetlands evolved out of recognition of the invaluable contributions of wetlands to the maintenance of hydrological and biological integrity of ecoystems. Wetlands in inland regions generally include marshes, shallows, swamps, bogs, wet meadows, and other habitats inundated or saturated by water to varying degrees. The guidelines of the NPS specify that units of the NPS are to inventory wetland areas that are subject to or potentially subject to public use or development, where the magnitude of hazard and impact of human activities is likely to be the greatest (NPS Floodplain Management and Wetland Protection Guidelines 45 FR 35916, with minor revisions in 47 FR 36718). Units of the NPS are to consult to determine if a map prepared as part of the National Wetland Inventory (NWI) is available for the vicinity of the proposed action. If the information is still inadequate, the park is to conduct an on-site analysis performed by professionals qualified to determine wetlands based on the definition in the Wetlands Executive Order.

Following the broad wetland categories defined by Cowardin et al. (1979) for the NWI conducted by the U.S. Fish and Wildlife Service, Great Basin National Park contains palustrine, riverine, and lacustrine wetlands. Riverine wetlands, particularly, are popular recreation areas for visitors to Great Basin National Park and are used by domestic livestock. Many of these wetlands are also adjacent to roads and trails. Use of lacustrine wetlands by domestic livestock is restricted in some areas of the park, but many of these wetlands also are popular recreation areas for visitors or exist adjacent to such popular areas. Palustrine wetlands are scattered throughout the park in association with springs and seeps and are probably heavily affected by grazing.

Many of these wetlands -- palustrine, lacustrine, and riverine -- fall within the broader habitat category of a "riparian zone". A variety of definitions exist for a riparian zone, often with an emphasis on the components present (Appendix 5), but the NPS has not formally adopted a single definition. Functionally a riparian zone can be defined as a three-dimensional region of direct interaction between terrestrial and aquatic ecosystems. Functional boundaries of riparian zones extend outward to the limits of flooding and upward into the canopy of streamside, spring-side, or lake-side vegetation (Gregory et al. 1991). A functional view recognizes that boundaries and components of riparian zones are dynamic; dimensions of the zone of influence for any specific ecological process, such as plant community succession, sedimentation, or flooding, are determined by patterns in space and changes through time of the process (Gregory et al. 1991). Because of the similarities and overlap between riparian zones and wetlands, these sites will be referred to as riparian wetland sites in the remainder of this project statement.

Riparian-wetland sites are known to be important components of the Great Basin Region and provide essential habitat for many species of plants and animals. Human socioeconomic values of these sites in Great Basin National Park include consumptive values, such as livestock production and clean water, and nonconsumptive values such as scenery, recreation, aesthetics, preservation of heritage, and education. Park management documents specifically recognize that riparian-wetland sites occupy a very small percentage of the park's total land base but are exceptional resources because they support a greater quantity and diversity of species than the adjoining uplands and because they provide essential ecological functions (NPS 1993). They are specifically defined as exceptional resources in the park's General Management Plan (NPS 1993), yet they continue to be subjected to a variety of land uses.

Some preliminary work has occurred in the park to characterize some of the riparian-wetland sites. From 1991-1993, researchers at the University of Nevada at Las Vegas conducted a study and provided a quantitative description of the woody riparian vegetation associated with major streams of the park (Murray et al. in prep.). They included an analysis of correlations between vegetation associations and physical characteristics of valleys using the data for physical characteristics obtained by Frissell and Liss (1993). Four primary species group and eight stand groups were identified, with both presence and abundance of species important parameters in determining species groups. The most important environmental factors associated with the distribution of species and stand groups were elevation and slope.

The U.S. Fish and Wildlife Service, through the NWI, has conducted a map-based inventory of wetlands in and around the park at a scale of 1:250,000. Additional work to map the wetlands at a scale of 1:24,000, the most common scale in the NWI, is not planned. The existing NWI inventory is not adequate to meet park management needs and regulatory policies of the NPS. Small streams, seeps, springs, and their associated riparian-wetland sites are overlooked at such a scale.

In order to meet NPS regulations, and to improve resource management's ability to protect these exceptional resources, an inventory and mapping of all park riparian-wetland sites is needed. This need is addressed in this project statement.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

The objective of the recommended project is to produce a complete and up-to-date inventory of riparian-wetland sites of Great Basin National Park. The inventory will consist of maps delineating the location of the riparian wetland sites, a digital database entered in the park's geographic information system, and a companion report providing site descriptions specifying a unique site name, physiographic features, climatic features, hydrology, vegetation ecology and production, soils, and management interpretations. The recommended project differs from the alternative project in that it specifies a procedure that not only provides an inventory of the present state of riparian wetland sites but also assesses responsiveness of riparian wetland sites to change and the reasons why a particular response occurs.

Identification of likely areas where riparian wetland sites may occur will be a time-consuming process. Low-level aerial photography will be conducted to provide an initial delineation of riparian wetland sites. Because of the steep topography of the park, this photography will be of limited use for locating and initially delineating many sites, particularly those in steep-sided canyons of the park. Therefore, other likely areas where riparian wetland sites might occur will be identified by reviewing in-house materials, such as NWI maps, U.S. Geological Survey (USGS) 1:24:000-scale topographical maps, geologic maps, soil surveys, color aerial photographs, maps of locations of known springs and seeps, and several reports -- Great Basin National Park Vegetation Analysis (Eddleman and Jaindl 1991) and Analysis and Characterization of Woody Riparian Vegetation in Great Basin National Park (Murray et al. in prep.). A review of riparian-wetland classification references such as those developed by Kovalchik (1987), Hansen et al. (1989), and Youngblood et al. (1985) will provide background information regarding development of riparian-wetland sites and associated community dynamics. All areas with topography or vegetation indicative of riparian-wetland conditions will be drawn on 1:24,000-scale topographical maps. These topographical maps will serve as field maps. All areas indicated on these field maps as possible riparian-wetland sites will be subject to a field survey.

The park will adopt an interdisciplinary approach to the actual field survey of the riparian-wetland sites following a procedure comparable to that described in the Ecological Site Inventory developed by the Bureau of Land Management (Leonard 1992). This is the procedure that is currently being recommended by the Bureau of Land Management for inventories of riparian-wetland sites and is based on procedures in the National Range Handbook, which is used worldwide to prepare site descriptions for rangelands. The procedure has been modified, tested, and validated for use in preparing site descriptions for riparian areas (Gebhardt et al. 1990). The expertise to conduct this procedure is not entirely available with park staff, and the work will require a contractual agreement with a university or agency to obtain all of the expertise. The procedure is a hierarchical approach, emphasizing relationships among ecosystem components. It requires concurrent investigations of vegetation, animals, soils, and hydrology (Leonard et al. 1992, Gebhardt et al. 1990). In addition, the study plan developed prior to implementation of this project will review and incorporate appropriate methodologies that may be adopted by land management agencies during the period between the development of this project statement and actual project funding and implementation. Training sessions are available for the procedures and should be attended prior to initiation of the inventory.

The classification of valley segments of the park (Frissell and Liss 1993) and the classification of woody riparian vegetation (Murray et al. in prep.) will serve as starting points for the classification of riparian-wetland sites. Additional levels of classification will evolve for both of these systems as riparian-wetland sites are identified and classified by the interdisciplinary team.

In the field, each riparian wetland site will be assigned to a map unit, and the location and extent of each site will be determined by locating landmarks on the field maps, taking compass readings, pacing the perimeter of the area, and drawing the boundaries onto the field map. A decision will need to be made at the time of the inventory if it is practical to use a standard closed-line delineation concept for mapping seeps, springs, and other small or narrow sites on the base map. Alternatively, an orthophotoquad base map could be enlarged, and the riparian zone-wetland units could be mapped on these enlargements (Batson et al. 1987). A third option would be to simply designate line segments on a map with a scale of 1:24,000 to represent stream segments as a map unit and to use spot symbols to depict units for other kinds of riparian wetland sites. The average width of stream segments or average area of spot symbols will have to be described in the map unit description (Leonard et al. 1992). Aerial photographs will be used to facilitate site delineation to the extent practical.

An iterative process will be followed to design or identify a map unit. Baseline information about the characteristics of each type of riparian-wetland site will be documented, including information about geomorphology, soils, vegetation, hydrology, and animals. The degree of detail of the documentation will be contingent on additional objectives other than a baseline inventory of riparian-wetland sites, and the possibility of additional objectives should be considered at the time the project statement is submitted for funding. Eventually each site will be assigned a unit designator from the final array of map units compiled by the interdisciplinary team. A written report describing the characteristics of each unit or ecological site will be prepared. Crossing-referencing to the classification system of Cowardin et at. (1979) will be included where applicable for wetland habitats. The final step of the process will be to digitize the map and incorporate it into the park's geographic information system along with appropriate documentation of site attributes.

BUDGET AND 1- I Es:

------------------------------------ FUNDED ----------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
Total:				

----------------------------------- UNFUNDED

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	SNRP	RES	65.0	
	PNR1	ADM		03
Year 2:	SNRP	RES	34.0	
	PNR1	ADM		02
Year 3:	SNRP	RES	15.0	
	PNR1	ADM		02
Year 4:				
Total:			114.0	0.7

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

Inventory Following Classification of Wetlands and Deepwater Habitats Adopted by the of the U.S. Fish and Wildlife Service:, The park will follow the same general procedure outlined in the preferred alternative but will adopt the procedures of Cowardin et al. (1979) for designation of classification units. This system is currently in use by many agencies for the general inventory and classification of wetland and deep-water habitats. The procedure is less intensive and less costly than the procedure recommended in the preferred alternative, although products from the classification can give land managers a good overview of the resource. The procedure is not designed to reflect potential natural communities or community ecology. Therefore, it does not consider responsiveness or functional processes. It can be used to describe the current state of a site but is not designed to deal with cause-and-effect relationships, which would be useful in determining potential state changes in riparian-wetland sites (Gebhardt et al. 1990). Another limitation is that all portions of a riparian zone are not considered wetlands under this classification system, and additional identifiers would have to be developed for portions of the riparian zone beyond the boundaries of wetlands and deep-water habitats.

Literature Cited

Batson, F.T., P.E. Cuplin, and W.A. Crisco. 1987. Riparian area management: The use of aerial photography to inventory and monitor riparian areas. BLM/YA/PT-87/021 + 1737. U.S. Department of Interior, Bureau of Land Management, Denver, Colorado. 16 pages.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service Biological Services Program, FWS/OBS-79/31. 103 pages.

Eddleman, L.E., and R. Jaindl. 1991. Draft National Park Service, Great Basin National Park vegetation analysis. Draft Report dated May 1, 1991. U.S. Department of Interior, Great Basin National Park, Baker, Nevada. 110 pages.

Frissell, CA., and W.J. Liss. 1993. Valley segment classification for the streams of Great Basin National Park, Nevada. Final Report. Cooperative Park Studies Unit, Oregon State University, Corvallis. 53 pages.

Gebhardt, K., S. Leonard, G., Staidi, and D. Prichard. 1990. Riparian area management: Riparian and wetland classification review. Technical Reference 1737-5. U.S. Department of Interior, Bureau of Land Management Service Center, Denver, Colorado. 56 pages.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones: Focus on links between land and water. BioScience 41:540-551.

Hansen, P., S.W. Chadde, and R. Pfister. 1989. Riparian dominance types of Montana. Montana Forest and Conservation Experiment Station, School of Forestry, University of Montana, Missoula. 411 pages.

Kovalchik, B.L. 1987. Riparian zone associations: Deschutes, Ochoco, Fremont, and Winema National Forests. U.S. Department of Agriculture, Forest Service, Ecology Technical Paper 279-87. Pacific Northwest Region, Portland, Oregon. 171 pages.

Leonard, S., G. Staidl, J. Fogg, K. Gedhardt, W. Hagenbuck, and D. Prichard. 1992. Riparian area management: Procedures for ecological site inventory-with special reference to riparian-wetland sites. Technical Reference 1737-7. U.S. Department of Interior, Bureau of Land Management Service Center, Denver, Colorado. 135 pages.

Murray, K., S.D. Smith, F.H. Landau, and A. Sala. In Prep. Analysis and characterization of woody riparian vegetation in Great Basin National Park. Great Bashi -National Park, Baker, Nevada.

National Park Service. 1993. Final General Management Plan, Development Concept Plans, and Environmental Impact Statement for Great Basin National Park, Nevada. Great Basin National Park, Baker, Nevada. 433 pages.

Youngblood, A.P., W.G. Padgett, and A.H. Winward. 1985. Riparian community type classification of eastern Idaho- western Wyoming. U.S. Department of Agriculture, Forest Service, FS/R4-ECO-85-01. Salt Lake City, Utah. 78 pages.

PROJECT NUMBER: GRBA-N-019.820

TITLE: MAPPING AND CHARACTERIZATION OF SPRINGS

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 75.0

SERVICEWIDE ISSUES: N12 WATER FLOW N20 BASELINE DATA

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Locations of more than 70 springs within the park are known, and limited information about the location of these springs is stored in the park's geographic information system. However, it is suspected that these known springs constitute only half of the springs in the park (K. Pfaff, pers. comm., June 1993). A comprehensive inventory of locations of springs in the park and other information about these springs, such as flows, chemical characteristics, and associated geologic units, is lacking. Information about the riparian-wetland sites associated with these springs is also not documented, but acquisition of this information is covered by another project statement -- Delineation and Mapping of Riparian-Wetland Sites.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

For those springs currently known, collect information on the associated geologic units, flows, water temperature, pH, alkalinity, and specific conductance. Take measurements during the same time of the year for a period of approximately three years in order to establish a baseline inventory. Additional sampling of these springs could then be conducted at five-year intervals in order to detect any changing trends in flow, chemistry, and other characteristics. Sampling at the same time of each year (within one month) is important in order to reduce the variation in the information contributed by interannual climate variations. Carefully document sampling dates and times and measure discharge and temperature in the field. The other characteristics can be analysed by collecting water samples and sending them to a water quality laboratory for processing.

Conduct a systematic search of the park for additional springs. Vegetative characteristics of known springs that are distinguished on aerial photographs could be used as one method to identify new springs. Accurately locate these springs using a global positioning system device and other appropriate mapping techniques, and collect the same information for *any* newly discovered springs as collected for known springs, again within a timeframe compatible with the one used for collection of data for known springs. Map all spring locations, and store information about the location and characteristics of the springs in the park's geographic information system.

BUDGET AND F T Es:

-- FUNDED ------------------------------------

	Source	Act Type	Budget ($1000s)	Fibs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:	0.00	0.0	

-- UNFUNDED

Year 1:	Source	Act Type	Budget ($1000s)	FTEs
	SNIM	MON	25.0	
	PKBASE-NR	MON		0.2
Year 2:	SNIM	MON	25.0	
	PKBASE-NR	MON		02
Year 3:	SNIM	MON	25.0	
	PKBASE-NR	MON		0.2
Year 4:				
	Total:		75.0	0.6

CODE(S): EXCL
EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-030.300

TITLE: MONITORING OF RIPARIAN-WETLAND SITES FOR VEGETATION UTILIZATION DUE TO GRAZING

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 160.0

SERVICEWIDE ISSUES: N06 LAND USE PRAC N11 WATER QUAL-EXT

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

The legislation that established Great Basin National Park instructed the National Park Service to adopt practices of sound rangeland management and to do so in a manner that would conform with regulations adopted for adjacent lands managed by the USDA Forest Service. Staff of the park are currently working to develop joint allotment management plans for grazing in and around the park with the Humboldt National Forest. The General Management Plan of the Humboldt National Forest specifies a standard of utilization for key species of vegetation in riparian habitats (USDA Forest Service 1986). Acceptable utilization throughout the national forest is in the range of 25 to 65 percent depending on the grazing management system and judgements about the value of the area being grazed (Table 1).

Table 1. Normal forage utilization values with maximum limits for riparian communities adopted from the draft supplement of the final environmental impact statement for the Humboldt National Forest Land and Resource Management Plan.

Area	Value of the Key Species	% Utilization of Management Area
highest to high	25-35	
moderate to limited	35-50	
	highest to high	30-45
	moderate to limited	40-55
season-long	low	50-65
deferred rotation	highest to high	35-45
	moderate to limited	45-60
rest rotation	low	55-65

The park plans to adopt the utilisation standards of the Humboldt National Forest for management of the park's riparian-wetland sites in order to comply with the park's enabling legislation. Because the riparian-wetland sites of the park are considered to be high-value habitats, the standard for utilization of key species in the park will likely be in the range of 30 to 45 percent. Grazing studies by Eddleman and Jaindl (1991) indicated that livestock grazing in several riparian areas of the park resulted in consumption of vegetation in excess of 45 percent. Eddleman and Jaindl (1991) recommended specific sites within the park for monitoring of vegetation utilization and provided additional recommendations for this monitoring. Even though specific utilization standards will not be in place until the allotment management plans are adopted, the park needs to implement vegetation monitoring to document existing utilization in preparation for implementation of the allotment management plans.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Initiate long-term monitoring of utilization of vegetation in riparian-wetland zones according to methods adapted from Eddleman and Jaindl (1991). Monitoring will take place in allotments used by cattle and those used by sheep. This monitoring will be modified to conform to requirements specified in grazing allotment management plans once those plans are adopted. This utilization monitoring is a long-term committment as long as livestock grazing continues in the park. Therefore, the park will seek an increase in base funding to support this important monitoring activity.

Literature Cited

Eddleman, L.E., and R. Jaindl. 1991. National Park Service, Great Basin National Park monitoring program. Report dated May 1, 1991. U.S. Department of Interior, Great Basin National Park, Baker, Nevada. 63 pages.

U.S. Department of Agriculture, Forest Service. 1986. Draft supplement to the final environmental impact statement for the Humboldt National Forest Land and Resource Management Plan. Humboldt National Forest, Elko, Nevada.

BUDGET AND Fl Es:

-------------------------------------FUNDED

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	PKBASE-NR	ADM		0.1
	PKBASE-NR	MON		0.1
Year 2:	PKBASE-NR	ADM		0.1
	PKBASE-NR	MON		0.1
Year 3:	PKBASE-NR	ADM		0.1
	PKBASE-NR	MON		0.1
Year 4:	PKBASE-NR	ADM		0.1
	PKBASE-NR	MON		0.1
Total:			0.00	0.8

-------------------------------------UNFUNDED

	Source	Act Type	Budget ($1000s)	l i s
Year 1:	PKBASE-NP	MON	40.0	1.0
Year 2:	PKBASE-NP	MON	40.0	1.0
Year 3:	PKBASE-NP	MON	40.0	1.0
Year 4:	PKBASE-NP	MON	40.0	1.0
Total:			160.00	1.0

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS

COMPLIANCE CODE(S): EXCL.
EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-030.100

TITLE: ASSESSMENT OF RIPARIAN-WETLAND AND AQUATIC HABITATS WITH AND WITHOUT GRAZING (EXCLOSURE EXPERIMENTS)

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 101.0

SERVICEWIDE ISSUES: N11 WATER QUALL-EXT N06 LAND USE PRAC

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Most riparian-wetland' habitats of the and and semi-arid west have changed dramatically within about the last hundred years, mainly because of improper livestock grazing (Elmore 1992). Associated aquatic habitats also have been affected greatly by the same land-use practice (Behnke 1977). In Great Basin National Park, a variety of land-use practices affect aquatic and riparian-wetland habitats, including grazing by domestic sheep and livestock. In some locations, damage attributed to livestock grazing predominates but is coupled with damage caused by recreational use, mining, roads, or other activities; in other locations, damage by livestock may be less than damage attributable to other land-use practices (Dobrowolski 1992, Frissell and Liss 1993). Damage linked to grazing is not uniformly pervasive in the park but occurs in both sheep allotments and cattle allotments. Damage to aquatic and riparian-wetland habitats of the park by livestock grazing includes hedging of plants, unstable and actively eroding soils, lowered water tables, changes in composition of riparian plant communities, gullying, and bank sloughing (Dobrowolski 1992, Frissell and Liss 1993).

In the legislation that established the park, the National Park Service (NPS) was charged with several tasks including protection, ma agement, and administration of the park in such a manner as to conserve and protect the scenery and the natural, geologic, historic, and archeological resources of the park. Riparian-wetland and aquatic habitats and their biota are part of these resources. To manage these systems with some effectiveness will require some knowledge of the condition and development of these systems under various land uses. Areas not affected by such land use are essential as reference or control areas to evaluate the effects of these practices (Rinne 1988).

With few exceptions, all aquatic and riparian-wetland habitats of the park are now available for grazing and have been grazed for decades. Exceptions include a few isolated areas, such as extremely steep canyons that are inaccessible to sheep or cattle, a small area surrounding Lehman Caves, and several zones recently designated as special-

[1] The term riparian-wetland has been adopted in this project statement in recognition of the overlap between riparian and wetland habitats. A variety of definitions for both terms are provided in Appendix 5.

use areas by the NPS (semi-primitive day-use zones, protected natural areas, and research natural areas; NPS 1993). Even in these special areas, fences or other barriers to prevent grazing are generally inadequate or sometimes not even present, and infrequent grazing of these areas by livestock continues (W. Lauritzen, Great Basin National Park, pers. comm., August 1992). Portions of some areas affected by grazing are also affected by roads, trails, well-developed campgrounds, and other facilities. Most areas surrounding the park are also affected by the same level of intensity or more of these practices than the park. With this situation, it is problematic to estimate the natural capacity of the aquatic and riparian-wetland habitats of the park, which is needed to assess if the park is meeting requirements stated in legislation that established the park.

In addition to directives about general resource management, the legislation that established Great Basin National Park also instructed the NPS to adopt practices of sound rangeland management, and to do so in a manner that would conform with regulations adopted for adjacent lands managed by the USDA Forest Service. Staff of the park are currently working with staff of the Humboldt National Forest to develop allotment management plans for grazing in and around the park. The general management plan of the Humboldt National Forest specifies a standard of utilization for key species of vegetation in riparian habitats (USDA Forest Service 1986). Acceptable utilization throughout the national forest is in the range of 25 to 65 percent depending on the grazing management system and judgements about the value of the area being grazed.

The park plans to adopt the utilization standards of the Humboldt National Forest for management of the park's riparian-wetland habitats in order to comply with the park's enabling legislation. Another project statement in this plan, Monitoring of Riparian-Wetland Sites for Vegetation Utilization Due to Grazing, addresses monitoring of vegetation at these sites until the utilization standards are adopted. Because the riparian-wetland habitats of the park are considered to be high value habitats, the standard for utilization of key species in the park will likely be in the range of 30 to 45 percent. Grazing studies by Eddleman and Jaindl (1991) indicated that livestock grazing in several riparian-wetland areas of the park resulted in consumption of vegetation in excess of 45 percent, and the park is currently monitoring grazing in plots in a few locations to continue to assess the utilization of vegetation. If areas of the park are indeed overgrazed according to these standards, the park will implement changes in grazing practices once these standards are formally adopted in allotment management plans. Grazing of some riparian-wetland and aquatic habitats by domestic livestock may not continue as a result of required changes in management practices for livestock.

Closures of riparian-wetland and aquatic habitats to livestock grazing has been used in many locations throughout the West to qualitatively and quantitatively demonstrate the effects of eliminating or reducing grazing by livestock (Duff 1977, Kauffman et al. 1983, Rinne 1988, Tiedemann et al. 1987). Changes, even in small plots, in species composition, plant growth, distribution of vegetation, and structure and function of aquatic habitats following closures can be dramatic. Documentation of such changes could be used to estimate the natural capacity of the system of the park under less-disturbed conditions than now present. This approach has some limitations because land-use practices in a watershed far removed from an exclosure can have effects on habitats within an exclosure (Duff 1977).

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Conduct a literature review as described in the alternative "Consult Literature". The park would then host a workshop to review the project and make revisions as needed to conform to current knowledge and practices.

Select one watershed in the park and identify one contiguous 1.6-km-long (1-mi-long) section of stream and riparian-wetland habitat in which grazing would be excluded starting about three years into the future. This section is referred to as the treatment section. A comparable and equal-length section of stream and riparian-wetland habitat in the same watershed would be selected. Grazing would continue in this section in accordance with existing management strategies. This section is referred to as the control section. The determination of which section would be the treatment and which would be the control would be random. At least one additional pair of grazed and ungrazed sections would be selected in another watershed within the park as a replicate. The use of paired replicates enhances the ability to use statistical methods to evaluate the differences between treatments regardless of the natural variation among the different sections. The valley-segment classification system (Frissell and Liss 1993) and other classification work in the park, including reach-level surveys, would be used to select the paired sections.

The paired treatment and control sections would be monitored for three years prior to the fencing of the treatment sections to exclude livestock. Although treatment and control sites would be selected to minimize differences between them, this pre-project calibration period would provide quantifiable data to describe the inevitable differences. Livestock would be excluded from each treatment section at the end of the calibration period, and monitoring of the condition of the treatment and control sites would commence one year after the livestock were excluded. The park would continue the monitoring program after the exclosures were in place for a minimum of 10 years.

Physical, chemical, and biological characteristics of the sections would be monitored using a combination of field sampling, photo points, and aerial photos. Vegetation sampling would be routinely conducted on portions of each watershed and other portions would be maintained as undisturbed points. As summarized in Dobrowolski (1992), methods should include use of channel cross sections placed perpendicular to stream flow to evaluate use of vegetation by grazing animals (Platts et al. 1983), stability ratin&s to assess vegetation overhang and streambank condition (Platts et al. 1987), a modified point-frame technique to evaluate streambank and floodplain surface cover (Floyd and Anderson 1982), spherical densiometer measurements to evaluate canopy closure, an in-stream water temperature model such as the one developed by Theurer et al. (1984) to evaluate light intensity reaching the stream surface, distribution of contrasting colors or mottles in soils as indicators of past riparian conditions, use of cross sections and remote sensing techniques to assess changes in distribution or area of stream bars as an indication of changes in the input of sediments to a system or changes in the flow through established channels (Plats et al. 1987), and changes in streambank stability and form using a modification of the sag tape procedure (Ray and Megahan 1978). Aquatic biota would not be surveyed as part of this approach because of the complications of unpstream and downstream influences within a single watershed on the biota.

Literature Cited

Batson, F.T., P.E: Cuplin, and WA Crisco. 1987. The use of aerial photography to inventory and monitor riparian areas. Technical Reference BLM/TA/PT-87/021 + 1737. Bureau of Land Management, Denver, Colorado. 13 pages.

Behnke, RJ. 1977. Impact of livestock grazing on stream fisheries: problems and solutions. Pages 170-173 *in* J. *W.* Menke, ed. Proceedings of the Workshop on Livestock and Wildlife-Fisheries Relationships in the Great Basin. University of California, Division of Agricultural Sciences, Special Publication 3301. University of California, Berkeley.

Dobrowolski, J.P. 1992. An assessment of grazing impacts in the riparian areas of Great Basin National Park. Final report to Oregon State University and the National Park Service. (File copy at Great Basin National Park, Baker, Nevada). 41 pages.

Duff, D.A. 1977. Livestock grazing impacts on aquatic habitat in Big Creek, Utah. Pages 129-142 *in J. W.* Menke, editor. Proceedings of the Workshop on Livestock and Wildlife-Fisheries Relationships in the Great Basin. University of California, Division of Agricultural Sciences, Special Publication 3301. University of California, Berkeley.

Eddleman, L.E., and R. Jaindl. 1991. National Park Service, Great Basin National Park allotment grazing analysis. Report dated may 1, 1991. U.S. Dept. Interior, Great Basin National park, Baker, Nevada. 93 pages.

Elmore, W. 1992. Riparian responses to grazing practices. Pages 440-455 *in* R. J. Naiman, editor. Watershed Management, Balancing Sustainability and Environmental Change. Springer-Verlag, New York, New York.

Floyd, D.A., and J.E. Anderson. 1982. A new point interception frame for estimating cover of vegetation. Vegetatio 59:185-186.

Frissell, CA, and W.J. Liss. 1993. Valley segment classification for the streams of Great Basin National Park, Nevada. Final Report. Cooperative Park Studies Unit, Oregon State University, Corvallis. 53 pages.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983. Impacts of cattle on streambanks in Northeastern Oregon. J. Range Management 36:683-685.

National Park Service. 1993. Final General Management Plan, Development Concept Plans, and Environmental Impact Statement for Great Basin National Park, Nevada. Great Basin National Park, Baker, Nevada. 433 pages.

Platts, W.D., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. USDA Forest Service General Technical Report INT-138. 70 pages.

Platts, W. S., C. Armour, G. D. Booth, M. Bryant, J. L. Bufford, P. Cuplin, S. Jensen, G. W. Lienkaemper, G. W. Minshall, S. B. Monsen, R. L. Nelson, J. R. Sedell, and J. S. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. U.S. Forest Service General Technical Report INT-221. 177 pages.

Ray, G. A., and W. F. Megahan. 1978. Measuring cross sections using a sag tape: a generalized procedure. U.S. Forest Service General Technical Report INT-47. 12 pages.

Rinne, J. N. 1988. Grazing effects on stream habitat and fishes: research design considerations. N. American J. Fisheries Management 8:240-247.

Theurer, F. D., K. A. Voos, and W. J. Miller. 1984. Instream water temperature. U.S. Fish and Wildlife Service Information Paper 16. 400 pages.

Tiedemann, A. R., D. A. Higgins, T. M. Quigley, H. R. Sanderson, and D. B. Marx. 1987. Responses of fecal coliform in streamwater to four grazing strategies. J. Range Management 40:322-329.

U.S. Department of Agriculture, Forest Service. 1986. Draft supplement to the final environmental impact statement for the Humboldt National Forest Land and Resource Management Plan. Humboldt National Forest, Elko, Nevada.

BUDGET AND FTEs:

-------------------------------FUNDED---

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	0.0

--UNFUNDED ------------------------------------

	Source	Act Type	Budget ($1000s)	1-1Es
Year 1:	NRPP	RES	35	
	PKBASE-NR	ADM		0.1
Year 2:	NRPP	RES	15	
Year 3:	NRPP	RES	36	
	PKBASE-NR	ADM		0.1
Year 4:	NRPP	MON	15	
	Total:		101	0.2

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

Paired Watershed Study: The park would begin this project by conducting a literature review of the subject of impacts of livestock grazing on aquatic and riparian habitats. The park would also host a workshop to review the recommended project, make revisions in the methodology to conform to current knowledge and practices, and finalize sampling protocols.

The park would then initiate a field study of paired watersheds following the recommendations of Rinne (1988) who rejected grazing-research designs in which control and treatment sites were within a single stream or watershed because of interactions between sites. Rinne (1988) encouraged research that included multiple pairs of treatment and control watersheds monitored for long time frames because such studies provide better opportunities to detect change than short-term, single-system studies. The park would identify at least one watershed of the park in which the majority of the riparian and aquatic systems could eventually be closed to livestock grazing. A comparable watershed would also be identified in which grazing would continue. Possibly one of these would be located outside the park's boundaries if comparable sites did not exist within the park. Several pairs of watersheds would be preferable to one set. The valley-segment classification system (Frissell and Liss 1993) and other classification work in and outside the park would be used to select the paired areas. Planned exclosures would be as large as possible and extend as far as possible into adjoining upland habitats, encompassing the entire watershed if possible. Corridors would be provided for access to water from terrestrial habitats as needed to protect legal rights to water. Parameters to be studied in the grazed and ungrazed watershed are described in the preferred alternative.

Consult Literature: The park would rely on information obtained from other locations within the Great Basin where grazing exclosures have been established. General predictions would be made about the capacity of the aquatic and riparian systems of the park in the absence of grazing based on this information and management decisions would be based on these predictions. This approach would not provide on-site evidence to the park and could be perceived as a weak basis for management decisions.

Photo-point Exclosures in Paired Watersheds: Treatment and control sections of watersheds would be selected as described in the preferred alternative. An may of photographs, including aerial photographs (Batson et al. 1987, Platts et al. 1987), would be taken at established points in these paired areas for several years prior to establishment of grazing exclosures. These photographs would provide visual and some quantitative evidence of the relative natural and induced variations in environmental conditions. After this initial calibration period, domestic livestock would be excluded from the riparian and aquatic habitats of one of each paired area. Photographs would be taken to compare changes in the treatment and control sections for a minimum of 10 years following the establishment of the exclosures.

COMPLIANCE CODE(S): EXCL

EXPLANATION: 516, DM2, App. 2, 1.6

PROJECT NUMBER: GRBA-N-036.000

TITLE: FLOODPLAIN ASSESSMENT IN VICINITY OF CAMPGROUNDS

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 60.0

SERVICEWIDE ISSUES: N20

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Major floods occur in most Great Basin watersheds (Burkham 1988) and, since Great Basin National Park was established, localized flooding has occurred of sufficient intensity to wash out sections of roads (B. Freet, Great Basin National Park, pers. comm., Jul. 1991). Floods can be caused by snowmelt, frontal rains, frontal rains on snow, and convective rainfall during localized thunderstorms. The flood hazard along definable channels in mountains primarily involves inundation, high flow velocities, erosion, and moving debris. Specific flood hazards may involve (1) inundation by sheetflow or by flow in channels, (2) deposition of and inundation by debris, (3) high water velocities in main channels, especially near the apex, and lesser velocities for the sheetflow, (4) rapidly moving debris, especially in channels near the apex, and (5) erosion. Even moderate flooding can be dangerous and potentially destructive, especially in steep narrow canyons (Burkham 1988). Some of these floods, especially those associated with localized thunderstorms can occur as flash events without warning.

Campgrounds of the park appear to be in floodplains subjected to flash flooding. These campgrounds include Lehman, Baker, and Shoshone campgrounds. Legal and policy constraints apply to floodplain and wetland management in areas of the National Park Service. Specifically, compliance with Executive Order 11988 (Floodplain Management) and Executive Order 11990 (Protection of Wetlands) is required, along with the Water Resource Council's guidelines on floodplain and wetlands management. To implement these policies, the National Park Service has issued service-wide guidelines (45 FR 35916, May 28, 1980; 47 FR 36718, Aug. 23, 1982), which specify that parks will identify floodplains and areas of flood hazard that are subject to public use or development and where the hazard or impact of human activities would be greatest. One difficulty in implementing these guidelines in Great Basin National Park is that no studies exist of the floodplain hazard of these sites.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Investigate floodplain hazards in areas occupied by campgrounds and other park facilities, including Upper Lehman Campground, Lower Lehman Campground, Baker Creek Campground, Wheeler Peak Campground, Grey Cliffs Overflow Camping Area, and primitive camping sites along Snake Creek and Strawberry Creek. If any existing facilities are found to be in hazardous locations, recommendations will be made regarding appropriate warning or mitigation. Proposed sites for any new facilities will be reviewed for flood potential. Develop signs to notify visitors of the possibility of flash flood events in the park in general, and that describe floodplain hazards of developed sites. Develop an action plan that directs measures to be taken by the park to provide for visitor safety in flood situations and that describes maintenance activities to minimize damage to park infrastructure.

Literature Cited

Burkham, D.E. 1988. Methods for delineating flood-prone areas in the Great Basin of Nevada and adjacent states. U.S. Geological Survey Water-Supply Paper 2316. 20 pages.

BUDGET AND FTEs:

--- FUNDED---

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	0.0

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Source		Act Type	Budget ($1000s)	FTEs
Year 1:	RG-NS-RES	RES	40.0	0.5
Year 2:	RG-NS-RES	MIT	20.0	0.5
Year 3:	Total:		60.0	1.0
Year 4:				

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

Routine Warning: Campground users would be routinely warned of the possibility of flash flooding in mountainous regions of the Great Basin, but this warning would not contain information specific to floodplain hazards of the park.

Comprehensive Floodplain Assessment: All drainages in the park would be scheduled for floodplain evaluation and floodplain mapping. A brochure would be developed that would summarize this information for park visitors.

COMPLIANCE CODE(S): OTHER

EXPLANATION: 516 DM2 App. 2, 2.9

PROJECT NUMBER: GRBA-N-019.500

TITLE: STREAM CLASSIFICATION

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 98.0

SERVICEWIDE ISSUES: N20 BASELINE DATA

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Streams are highly variable ecosystems, reflecting the characteristics of the watersheds they drain. In steep, montane stream systems such as those of Great Basin National Park, natural disturbances, such as flash floods and drought, are relatively frequent. Such disturbances impose potentially severe constraints on natural biota, are important in shaping floodplain soils and vegetation, and pose potential danger to humans and human installations. Predicting and planning for climatic variation and other natural disturbances is necessary to ensure that aquatic biota and riparian ecosystems can persist, and that human life is not unnecessarily threatened. Stream classification is an important tool for characterizing the form and behavior of streams and predicting the effects of management activities on stream ecosystems (Platts 1979, Frissell et al. 1986).

To date, streams in Great Basin National Park have been classified at the valley segment level for selected major streams with perennial flow. However, streams with intermittent or ephemeral flow also support aquatic organisms and riparian-wetland communities, and they are often important in the propagation of disturbances, such as debris flows from headwater areas to downstream areas. Furthermore, ephemeral stream channels on alluvial fan deltas can provide important connecting corridors between adjacent canyons for aquatic organisms during wet periods. Such streams may have served historically to maintain genetic connections between adjacent populations of Bonneville cutthroat trout and other species. Conversely, reaches that lose surface flow during dry periods can act as temporary migration barriers for aquatic life, preventing access to habitats up or down stream. Valley types that lose surface flow may retain a reservoir of ground water, which sustains some aquatic species and riparian vegetation (Kondolf et al. 1987).

Because of the importance of these patterns and processes to aquatic and riparian biota, and because of the potential for grazing, mining, road development, campground development, and other human activities to influence them, more information is needed on the organization, ecological roles, and values of various kinds of valley segments and aquatic habitats. This would entail extending classification of valley segments to channels with ephemeral or intermittent flow. It could also involve more detailed investigations linking classification of reaches, pools and riffles, and microhabitats to field studies of aquatic and riparian-wetland communities.

Classification outside the park would also benefit park management. Some stream types that are important to biota within Great Basin National Park, and that are representative of aquatic habitats in the Great Basin as a whole, are not included within the boundaries of the park. Classification can be useful in identifying these habitats and in determining their potential importance in maintaining biotic communities, sensitive species, and other resources within the park.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Develop detailed, site-specific information and classification of aquatic habitat, riparian-wetland habitat, and aquatic biota as required for specific studies, and for sites selected as locations for long-term monitoring. Incorporate consideration of stream classification into the design and interpretation of these studies. Pursue park-wide classification of valley segments along previously unsurveyed streams starting with high-priority basins where other studies, development activities, or regulatory changes are anticipated. Pursue classification and mapping in foothills and basins surrounding the park. Map and enter all of these data into the park's geographic information system. This classification and map will serve as an interpretative data layer for such comprehensive activities as mapping riparian-wetland vegetation and sources of ground water, identifying streams and riparian-wetland areas sensitive to grazing or flow diversion, identifying watershed restoration needs, mapping floodplains and areas of flash-flood hazard, assessing suitable habitat for water-dependent species, and designing cost-efficient monitoring networks for water quality, stream flow, and ground water.

As a longer-term goal, a broad-level, non-intensive survey of valley segments in selected ranges elsewhere in the Great Basin needs to be conducted to provide an assessment of the park's aquatic and riparian diversity relative to that of the region as a whole. This study could provide a valuable scientific and educational context for management and protection of the park's natural ecosystems. This need is addressed in the alternative activity, Regional Survey of Aquatic and Riparian Habitat Types. Costs of a regional survey are not included in this project statement and would need to be developed at the time the survey was further pursued.

Cost estimates for the recommended project address park-wide classification of valley segments along previously unsurveyed streams within the park and in foothills and basins surrounding the park. The estimate is based on the costs of the classification work conducted by Frissell and Liss (1993) and a rough estimate that the area covered in their work constituted approximately 15 percent of the total area to be classified within and immediately outside the park. Additional funds have been incorporated for groundtruthing the existing classification information and for entering the data into the park's geographic information system. The development of detailed, site-specific classification of aquatic and riparian habitat and aquatic biota as required for specific studies and for sites selected as locations for long-term monitoring is not practical without knowing the nature of the individual studies or monitoring programs. Some costs of reach-level surveys of habitats and biota are provided in the project statement Assessment of Riparian-Wetland and Aquatic Habitats with and without Grazing.

Literature Cited

Frissell, C. A., W. J. Liss, C. E. Warren, and M. D. Hurley. 1986. A hierarchical framework for stream habitat classification: viewing streams in a watershed context. Environmental Management 10:199-214.

Frissell, C. A., and W. J. Liss. 1993. Valley segment classification for the streams of Great Basin National Park, Nevada. Draft report prepared for the National Park Service. Department of Fisheries and Wildlife, Oregon State University, Corvallis, Oregon.

Kondolf, G. M., J. W. Webb, M. J. Sale, and T. Felando. 1987. Basic hydrologic studies for assessing impacts of flow diversions on riparian vegetation: examples from streams of the eastern Sierra Nevada, California. Environmental Management 11:757-769.

Platts, W. S. 1979. Including the fishery system in land planning. U.S. Forest Service General Technical Report INT-60.

BUDGET AND F1'Es:

-- FUNDED --------------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	0.0

------------------------------------- UNFUNDED ---------------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	SNIM	MON	98.0	
	PKBASE-NR	ADM		0.2
Year 2:				
Year 3:				
Year 4:				
	Total:		98.0	0.2

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

No Action: Under this alternative, no additional investigation of stream systems and aquatic habitat would occur and no attempt would be made to classify valley segments and aquatic habitats inside or outside the park beyond the preliminary study already completed. The consequences of this course of action would be continued uncertainty about the viability of native populations and biotic communities of aquatic and riparian-wetland species in the park, uncertainty about the risk posed to human life and developments by flash floods and other natural processes, and limited ability to anticipate or predict the effects of current or anticipated human activities inside or outside the park on aquatic and riparian-wetland ecosystems. The park's data base on stream systems would remain incomplete, covering only selected major streams.

In-park Case Studies: Under this alternative, the park would undertake site-specific case studies strictly focused on perceived management and conservation problems. Stream classification would be used primarily as a tool to provide context and focus to these site-specific studies. Studies would be those recommended under other project statements in this document, including Floodplain Assessment in Vicinity of Campgrounds, Assessment of Riparian-Wetland and Aquatic Habitat with and without Grazing, Bonneville Cutthroat Trout Management, and Mapping and Characterization of Springs. The data base on stream classification would be expanded only where required to pursue these case studies.

Regional Survey of Aquatic and Riparian Habitat Types: In addition to park-wide survey of the stream network and the extension of these surveys to foothills and basins surrounding the park, as described in the preferred alternative, classification would be pursued in selected ranges elsewhere in the Great Basin. The objectives of this work would be to 1) identify habitats adjacent and linked to aquatic habitats within the park, that are potentially critical for the migration, dispersal, and persistence of native species, and 2) characterize the diversity of stream and riparian-wetland types in the Great Basin as a whole, to assess the adequacy of current park boundaries and policies, and the relative importance of the park's ecosystems for conservation of the region's natural diversity.

COMPLIANCE CODE(S): EXCL.

EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-018.400

TITLE: WATER-RIGHT ADJUDICATIONS

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: See page 99

SERVICEWIDE ISSUES: NI3 WATER RIGHTS

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Aside from Lehman and Baker creeks, none of the drainage basins within Great Basin National Park has been adjudicated. The National Park Service (NPS) is likely to be involved in adjudicative proceedings in the future for these unadjudicated basins. During the adjudication of a drainage basin that includes parts of Great Basin National Park, the United States on behalf of the NPS must file its claims for water rights, including federal reserved rights.

The McCarran Amendment (Act of July 10, 1952; 66 Stat. 560) gave the consent of the United States to be joined as a defendant in any suit involving the general adjudication of water rights in river systems. When joined in such a proceeding, the United States must assert and defend its right to the use of water on lands administered by agencies such as the NPS. This right generally takes the form of either a federal reserved water right or a state appropriative water right.

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

Although the issue of water rights is legal or administrative in nature, field data, special studies, and literature searches may be required to support claims of the United States. A failure to address this issue when the United States has been joined in an adjudication, could lead to additional problems of unknown magnitude and complexity.

Reserved rights for Great Basin National Park are limited to those necessary for the purposes for which Lehman Caves National Monument and the Humboldt National Forest were created. Quantification of instream flows for these purposes may be required. In addition, the United States will need to claim federal reserved rights for consumptive administrative uses consistent with these purposes.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

When joined in a general adjudication of water rights, the United States will assert its claim to water rights under the Federal Reserved Water Rights Doctrine and state appropriation procedures to the extent of its need in support of the purposes of the unit. Claims shall be prepared with full consideration to congressional intent in the establishment of the park. Materials, which will assert and support claims of the United States, will be prepared and presented to the court. These materials may include decrees of water rights, proofs of appropriation, copies of supporting legislation, maps and drawings, photographs, listings of claimed quantities and schedules of flow, supporting research findings, and other ancillary materials. Some data collection might be required to support the claim of the United States for reserved water rights. This would be necessary if either of the following questions should arise as legal issues: (1) a conflict is alleged between claimed water uses in support of park purposes and state-recognized beneficial uses, or (2) the role of water in the accomplishment of the primary park purposes is alleged by the state or other parties to be different in nature or quantity from that claimed by the United States. The timing for this project is driven by the State of Nevada's schedule for adjudicating basins. Although several adjudications that involve park lands are pending, the United States has not yet been joined as a party in any of these adjudications.

BUDGET AND FTEs:

-- FUNDED ------------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
Total:			0.00	0.0

-- UNFUNDED ------------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	WATER-RES		*	
Year 2:				
Year 3:				
Year 4:				
Total:				

*Funding for this project will be provided from the water-rights funds of the NPS and will vary depending on the scope of the adjudications, the priority of this project as compared to other NPS projects dealing with water rights, and the availability of funds. Therefore, a budget and estimate of F1'rs are not available at this time.

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:
No Action: If the NPS does not fully participate in adjudications of river basins that encompass parts of the park, the legal right to make use of water for certain purposes could be forfeited. Furthermore, use of water by other appropriators may affect the ability of the NPS to accomplish its mission if the acquisition of non-federal water rights is not feasible.

COMPLIANCE CODE(S): EXCL.

EXPLANATION: 516 DM2 App. 2, 1.9

PROJECT NUMBER: GRBA-N-018.500

TITLE: STATE ADMINISTRATIVE PROCEEDINGS TO CONSIDER APPLICATIONS FOR WATER APPROPRIATION

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: See next page

SERVICEWIDE ISSUES: N13 WATER RIGHTS

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

The State Engineer in Nevada routinely considers and approves permits to appropriate surface and ground water through administrative proceedings that do not constitute adjudications. Applications for appropriation are advertised in local newspapers, and parties who feel they may be injured by the granting of the applications can protest. The State Engineer may hold a hearing to consider the information presented by protestant(s) and applicant prior to ruling on the application. The protestant(s) and applicant may be able to stipulate to an agreement, with the State Engineer's concurrence, to protect all parties' interests and thereby avoid a hearing. Based on the information presented in a hearing or stipulated agreement, the State Engineer may grant the permit with terms and conditions to protect the interests of the protestant(s) and applicant. In some cases the State Engineer may reject the application.

To ensure that it is a party in the State Engineer's proceedings, the National Park Service (NPS) must protest applications which may be injurious to Great Basin National Park. Although the water rights issue is administrative in nature, field data, special studies, and literature searches may be required to support protests of the NPS.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

The NPS Water Resources Division, in concurrence with the park, will continue to review applications by other parties to appropriate water and will protest those applications that may be injurious to Great Basin National Park. The NPS may also seek negotiated settlement with parties and terms and conditions in permits. These may take the form of limitations on the location and depth of a well or requirements for monitoring and mitigation to protect the park's interests. When protection does not seem feasible, the NPS will seek rejection of applications. When necessary, the NPS will participate in hearings before the State Engineer to ensure that the agency's concerns are considered. Information will be collected and assembled as necessary to support the NPS's case. For these efforts, the Water Resources Division, working with the Office of the Solicitor, will continue to take a lead role and serve as technical advisor to the park to ensure consistency in approach for all NPS units in Nevada.

BUDGET AND 1i'TEs:

--FUNDED------------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	WATER-RES		*	
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	0.0

--UNFUNDED--------------------------------------

	Source	Act Type	Budget ($1000s)	F1'Es
Year 1:	WATER-RES		*	
Year 2:				
Year 3:				
Year 4:				
	Total:			

A budget and estimate of I·1hs for this project will vary depending on the numbers of applications filed, analyzed for possible protest, protested, negotiated, and that go to hearing (with possible appeals). It is not possible to accurately predict these numbers. Therefore, a budget and estimate of FTEs are not available.

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:
<u>No Action;</u> The burden would be on the NPS to prove injury <u>after</u> the permit has been approved and the appropriation of water has occurred. In this situation, injury or loss of park resources and rights could occur before actions could be taken to protect them. Furthermore, collection of data needed to prove injury could be costly to the NPS.

COMPLIANCE CODE(S): EXCL.

EXPLANATION: 516 DM2 App. 2, 1.9

PROJECT NUMBER: GRBA-N-019.000

TITLE: INVENTORY WATER USE AND DETERMINE WATER RIGHTS

FUNDING STATUS: FUNDED: 0.00 UNFUNDED: 100.00

SERVICEWIDE ISSUES: N13 WATER RIGHTS

CULTURAL RESOURCE TYPECODE: N/A

10-238 PACKAGE NUMBER

PROJECT STATEMENT:

The legislation creating Great Basin National Park stipulates that the park is entitled to only those express or implied reserved water rights which had been associated with the establishment of Humboldt National Forest and Lehman Caves National Monument. The act excluded the creation of new federal reserved water rights for national park purposes.

The Cave Spring water system currently supplies water for the major developments in the park, including the visitor center, administrative offices, maintenance facilities, and residential area. Campgrounds in the park are supplied by spring sources.

Nevada law recognizes both livestock watering (NRS 533.485-505) and wildlife watering (NRS 533.030(2)) as beneficial uses of water. Furthermore, Nevada law recognizes the recreational value of wildlife (NRS 501.100(2)) and the need to provide wildlife with water (NRS 533357). In 1988, the Nevada Supreme Court found that the U.S. Government may appropriate water for stock and wildlife watering, even though it owns neither the livestock nor the wildlife that are watered on federal land, because such use would constitute beneficial use of the land which is owned and managed by the U.S. Government (State of Nevada vs. Peter G. Morros, State Engineer, et al., Adv. Op. No. 117, Dec. 21, 1988). Before the park can appropriate water for these and other uses, it must inventory current water use and determine the park's uses and needs.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Complete an inventory of existing water sources, developments, uses, and needs. All potential means for acquiring or developing water to meet the management needs of Great Basin National Park will be identified, and appropriate uses will be addressed.

Files and records held by other government agencies will be examined, field surveys initiated, and information and opinions from the Office of the Solictor and the Western Regional Office Water Resources Board will be requested.

BUDGET AND FTEs:

----------FUNDED----------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
Total:			0.00	0.0

----------UNFUNDED

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	RG-RM-NAT	RES	25.00	0.0
Year 2:	RG-RM-NAT	RES	25.00	0.0
Year 3:	RG-RM-NAT	RES	25.00	0.0
Year 4:	RG-RM-NAT	RES	25.00	0.0
Total:			100.00	0.0

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:
No Action: The NPS would not have adequate information on which to support water-rights adjudications.

COMPLIANCE CODE(s): EXCL

EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-008.000

TITLE: FISHERIES MANAGEMENT

FUNDING STATUS: FUNDED: 0.00 UNFUNDED: 55.00

SERVICEWIDE ISSUES: N20 BASELINE DATA N24 OTHER

CULTURAL RESOURCE TYPE CODE N/A

10-238 PACKAGE NUMBER

PROBLEM STATEMENT:

Fishing is authorized in the enabling legislation for Great Basin National Park, and fish occur in a wide variety of locations throughout the park. Fish stocking and recreational fishing have historically been most evident in Lehman, Baker, and Snake creeks and in Baker and Johnson lakes. These aquatic systems are inhabited by non-native rainbow trout *(Oncorhynchus mykiss)*, brown trout *(Salmo tnstta)*, eastern brook trout *(Salvelinus fontinalis)*, and apparent hybrids of cutthroat and rainbow trout. Not all species or hybrids occur in all streams and lakes of the park. The only salmonid native to the park is the Snake Valley form of the Bonneville cutthroat trout *(Oncorhynchus clarki utah). A* genetically pure population of this trout occurs in Pine and Ridge creeks on the west side of the park. Bonneville cutthroat trout are considered to be native to streams on the east side of the park (Haskins 1987, Duff 1988) and reportedly occurred in some of these streams in the early part of this century (Frantz 1953). On the other hand, it is unlikely that Bonneville cutthroat trout are native to Pine Creek, Ridge Creek, *and* other creeks on the west side of the range (Hubbs et al. 1974), although conclusive evidence regarding the absence of trout in these streams is lacking. Fish other than salmonids apparently do not occur in portions of streams within the park, possibly because size, gradient, and other characteristics of the aquatic habitats within the park are limiting (Anderson 1991).

Several streams and lakes of the park have a long history of stocking, and exotic fish populations persist despite cessation of stocking efforts in 1986 when the park was established. Lehman and Baker creeks were stocked at a rate of 750 fish per stream per month with brown trout from June through August of each year prior to 1985. They were stocked at the same rate with rainbow trout in 1985 and 1986. Snake Creek received 1,000 rainbow trout per month in June, July, and August up until 1985. Brook trout in Johnson Lake persisted without stocking following the initial stocking to establish the species. Baker Lake was restocked with cutthroat trout once every three years (Nevada Dept. Wildlife, unpubl. stocking records, Ely, Nevada.) With establishment of the park, the National Park Service and the Nevada Department of Wildlife agreed not to stock any park stream with fish in futherance of management policies of both agencies. The Nevada Department of Wildlife, with the aid of park staff, conducted surveys of fish populations in Johnson and Baker lakes, and Williams, Shingle, Strawberry, Baker, Lehman, and Snake creeks from 1988 through 1990 (Nevada Department of Wildlife 1988; 1990a,b,c). Species composition of fish communities was determined for these streams and lakes, and estimates of population densities were made for Baker, Lehman, and Snake creeks).

The park's enabling legislation and the General Management Plan clearly recognize the recreational value of fishing in the park. Fishing will continue in the park in accordance with applicable state and federal laws. Zones and periods of time may be designated in which no fishing may be permitted with justification and after consultation with the Nevada Department of Wildlife. Development of a fisheries management plan is necessary to manage the fish and the fishery in accordance with state and federal policies. This general need is addressed in this project statement. A separate statement, Bonneville Cutthroat Trout Management, addresses the need to develop a specific plan for this fish as a subcomponent of the fisheries managment plan.

DESCRIPTION OF RECOMENDED PROJECT OR ACTIVITY:

Work with the Nevada Department of Wildlife to confirm the species composition of fish communities in streams and lakes of the park. Distributions of individual fish species should be delineated. Conduct a literature review to determine current information on fisheries managment practices in eastern Nevada. Using these information sets, write a cooperative fisheries managment plan between Great Basin National Park and the Nevada Department of Wildlife which contains information on managment of the fishery and monitoring of the distribution and abundance of fish within the park. The feasibility of reestablishing populations of Bonneville cutthroat trout in streams on the eastern slope of the park should be addressed as a subcomponent of the fisheries management plan.

Literature Cited

Anderson, M. 1991. Great Basin National park non-salmonid endemic fish survey. Final Report (project conducted through University of Nevada, Las Vegas). Great Basin National Park, Baker, Nevada. 13 pages.

Duff, D.A. 1988. Bonneville cutthroat trout: Current status and management. American Fisheries Society Symposium 4:121-127.

Frantz, T.C. 1953. Unpublished reports on streams, lakes, and fish populations in the South Snake Range, produced for the Nevada Department of Wildlife. On file in Great Basin National Park.

Haskins, R.L. II. 1987. Bonneville cutthroat trout species management plan. State of Nevada State-wide Fisheries Program, Federal Aid Project No. F-20-23, Job No. 207.2. Nevada Department of Wildlife, Reno, Nevada. 28 pages.

Nevada Department of Wildlife. 1988. Johnson and Baker lake status and trend inventory conducted by Richard L. Haskins II, Gene Weller, and Micah Weller on August 2-4, 1988. Ely District, Nevada Department of Wildlife, Ely, Nevada. 5 pages.

Nevada Department of Wildlife. 1990a. Baker Creek population survey conducted by R.L. Haskins II, G. Weller, G. Zunino, and K. Pfaff on July 19-20 and August 8, 1990. Ely District, Nevada Department of Wildlife, Ely, Nevada. 14 pages.

Nevada Department of Wildlife. 1990b. Lehman Creek population survey conducted by R.L. Haskins II, G. Welder, G. Zunino, and K. Pfaff. 1990. Ely District, Nevada Department of Wildlife, Ely, Nevada. 12 pages.

Nevada Department of Wildlife. 1990c. Snake Creek population survey conducted by R.L. Haskins II, G. Welder, G. Zunino, and K. Pfaff. 1990. Ely District, Nevada Department of Wildlife, Ely, Nevada. 10 pages.

BUDGET AND 1 1'Es:

FUNDED

	Source	Act Type	Budget ($1000s)	F1'Es
Year 1:				
Year 2:				
Year 3:				
Year 4:				
Total:			0.00	0.0

UNFUNDED

	Source	Act Type	Budget ($1000s)	P'1Es
Year 1:	RG-NS-RES	RED	40.00	0.0
	RG-NS-RES	ADM	5.00	0.5
Year 2:	RG-NS-RES	RES	5.00	0.0
	RG-NS-RES	ADM	5.00	0.5
Year 3:				
Year 4:				
Total:			55.00	1.00

COMPLIANCE CODE(s): EA

EXPLANATION:

PROJECT NUMBER: GRBA-N-008.100

TITLE: BONNEVILLE CUTTHROAT TROUT MANAGEMENT

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 98.0

SERVICEWIDE ISSUES: NO2 T&E ANIMAL N17 BIODIVERSITY

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

A genetically distinct population of Snake Valley cutthroat trout, currently classified as *(Oncorhynchus clarld utah)*, occurs in the park on the west side of the Snake Range in Pine and Ridge creeks. The U.S. Fish and Wildlife Service considers O. *c. utah a* candidate taxon for threatened status (Duff 1988), and the State of Nevada classifies it as a gamefish and a sensitive fish species (Haskins 1987). The Snake Valley cutthroat may consistently display the degree of differentiation warranting subspecific designation of its own although it continues to be classified as one of three divergent stocks of Bonneville cutthroat trout (Behnke 1976).

The Bonneville cutthroat trout is native to the Bonneville Basin of western Utah and eastern Nevada. It was dispersed throughout the basin during the Pleistocene when now-isolated streams were linked by pluvial Lake Bonneville. The subspecies was extirpated from much of its range during the twentieth century due to habitat alteration and introductions of non-native trout (Duff 1988). Streams on the east side of Great Basin National Park drain to the Bonneville Basin and are considered to be within the original range of the Bonneville cutthroat trout. Long-term Snake Valley residents reported catching cutthroat trout in Baker and Snake creeks in the early part of the century (Frantz 1953),. but cutthroat trout no longer occur in any streams on the east side of the park.

Reportedly pure populations of Bonneville cutthroat occur in only about 20 streams and one lake of Nevada, Utah, and Wyoming (Hickman 1978, Loudenslager and Gall 1980, Martin and Shiozawa 1982). Populations currently identified as having genetic characteristics consistent with the Snake Valley form occur in 4 streams in Nevada and 11 streams in Utah. One of these locations is the system of Pine and Ridge creeks on the west slope of Great Basin National Park. These creeks are considered as one system or location because they are artificially connected by an irrigation ditch below the park boundary. The Pine-Ridge system drains into the Springs Valley basin, which might have been barren of fish prior to Euroamerican settlement (Hubbs et al. 1974). Records of stocking apparently do not exist, and it is possible that cutthroat were introduced from Lehman Creek through a ditch built for placer mining in the 1880's (Haskins 1987).

As summarized in Haskins (1987), the Pine-Ridge system has a combined length of approximately 8 km (5 mi) on lands managed by the Humboldt National Forest and the National Park Service before entering a ditch that flows onto land managed by the Bureau of Land Management. Technically, the headwaters of the Pine-Ridge system, which are in the park, are closed to grazing, but enforcement of the closure is virtually nonexistent due to the remoteness of the area (W. Lauritzen, Great Basin National Park, pers. comm., Aug. 1992). The USDA Forest Service manages the system below the park boundary and does not have a closure in effect. Domestic sheep currently are permitted to graze and water in and around the creeks. The system is open to grazing by domestic sheep outside the park. The Pine-Ridge system has been damaged several times by the holder of the water right in conjunction with trespass operations to clean the drainage ditch. A survey by the state in 1984 revealed no evidence of grazing abuse and densities of 256 cutthroat per km (413 per mi) and 196 cutthroat per km (316 per mi) in Pine and Ridge creeks, respectively. The National Park Service (NPS) has documented abuse to the system, including placement of salt on rocks in mid-stream to simultaneously salt and water sheep herds, and utilisation of forage in the associated riparian habitats in excess of 60 percent (Great Basin National Park Files).

Optimal cutthroat trout habitat in streams is characterized by clear and cool water, a silt-free rocky substrate in the riffle-run area, approximately a 1:1 pool-riffle ratio with areas of slow and deep water, well-vegetated stream banks, abundant instream cover, and relatively stable water flow, temperatures, and stream banks (Hickman and Raleigh 1982). Introductions of multitudes of non-native trouts and habitat alterations following settlement of the basin, including appropriation of water for mining and irrigation and livestock grazing, are blamed for the catastrophic declines in range and abundance of cutthroat trout in Nevada and elsewhere (Behnke 1976, Behnke and Zarn 1976, Chapman and Knudson 1980).

Because of the limited distribution and abundance of Bonneville cutthroat trout and because of ongoing threats to its habitat, the Nevada Department of Wildlife adopted a Bonneville cutthroat trout management plan in 1987 (Haskins 1987). The Director of the Western Region of the NPS reviewed the plan and in a letter dated February 13, 1987 expressed strong support for several activities listed in the plan (Appendix 7). The plan's primary objective is "to insure the perpetuation and the genetic integrity of the Snake Valley form of the Bonneville cutthroat trout in the State of Nevada". A secondary objective is to evaluate and develop the sport fishery potential of this unique trout. The perpetuation and enhancement of existing populations of Bonneville cutthroat trout are given priority status under the plan. Specific actions described in the plan include population expansion within and outside the historic range of the Bonneville cutthroat, population protection measures, and population enhancement measures (Appendix 8).

The preferred management alternative of the park's General Management Plan (NPS 1993) addresses cutthroat trout management with proposals that are compatible with the general management objectives of the plan adopted by the State of Nevada. Specific actions of the state's plan are also compatible with NPS policy, except possibly for introduction of Bonneville cutthroat to streams within interior drainage basins of White

Pine County, including Board, Shingle, Willard, and Williams creeks in Spring Valley. These creeks might be outside the native range of any species of fish (Hubbs et al. 1974), and introduction of Bonneville cutthroat trout might, therefore, be considered introduction of a non-native species. The status of Bonneville cutthroat trout in the Spring Valley basin should be examined in greater detail before action is taken in this area. In general, the NPS strives to protect and preserve all species of native flora and fauna within all management areas. Non-native plants and animals are not introduced into natural zones except in rare cases (NPS Management Policies, Section 4:11-12). Non-native, exotic, introduced, and alien are synonymous terms in natural resources management by the NPS and include any species occurring in a given place as a result of direct or indirect, deliberate, or accidental actions by humans (NPS 1991).

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Adopt and implement a plan,. in cooperation with the Nevada Department of Wildlife, to reestablish the Snake Valley stock of the Bonneville cutthroat trout into selected streams of the park. It is likely that the Nevada Department of Wildlife would assist with the costs to evaluate the existing habitat, eradicate non-native fish, and rear, transport, release, and monitor Bonneville cutthroat trout after they are released. The park, in cooperation with the NPS Division of Wildlife and Vegetation, will prepare the necessary environmental compliance documents, as well as work with the state in the development and implementation of the reintroduction plan.

This plan would be a subcomponent of the park's fisheries management plan. This reestablishment would be based on NPS-77 guidlines for natural resources management. Prior to implementation of the plan, the specific actions proposed should be reviewed by a panel of experts and modifications should be made to assure that the actions conform to current methods.

The population of Bonneville cutthroat trout in the Pine and Ridge system on the west side of the park would be protected from human-caused influences. Cutthroat in this system would be available for stocking in other streams if such translocations did not jeopardize survival of the population in the system. The drainages of Pine and Ridge creeks within the park would be zoned as protected natural areas, and domestic livestock grazing, concentrated recreation, mining, and other potentially threatening activities would be prohibited to minimize the possibility of adverse effects on the aquatic and riparian habitats. In addition, the NPS would actively work with the Nevada Department of Wildlife to establish other general regulations to ensure protection for the Bonneville cutthroat trout in these streams and others in which the fish was reintroduced.

Literature Cited

Behnke, R.J. 1976. Monograph of the native trouts of the genus *Salmo* of western North America. Report to Region 6, U.S. Department of Interior, Fish and Wildlife Service. 215 pages.

Behnke, RJ., and M. Zarn. 1976. Biology and management of threatened and endangered western trouts. U.S. Department of Agriculture, Forest Service, General Technical Report RM-28. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 45 pages.

Chapman, D.W., and E. Knudsen. 1980. Channelization and livestock impacts on salmonid habitat and biomass in western Washington. Transactions, American Fisheries Society 109:357-363.

Duff, D.A. 1988. Bonneville cutthroat trout: Current status and management. American Fisheries Society Symposium 4:121-127.

Frantz, T.C. 1953. Unpublished reports on streams, lakes, and fish populations in the South Snake Range, produced for the Nevada Department of Wildlife. On file in Great Basin National Park.

Haskins, R.L. III. 1987. Bonneville cutthroat trout species management plan. State of Nevada State-wide Fisheries Program, Federal Aid Project No. F-20-23, Job No. 207.2. Nevada Department of Wildlife, Reno, Nevada. 28 pages.

Hickman, T.J. 1978. Systematic study of the native trout of the Bonneville Basin. Masters thesis, Colorado State University, Fort Collins. 122 pages.

Hickman, T., and R.F. Raleigh. 1982. Habitat suitability index models: cutthroat trout. U.S. Department of Interior, Fish and Wildlife Service FWS/OBS-82/10.5. 38 pages.

Hubbs, C.L., R.R. Miller, and L.C. Hubbs. 1974. Hydrographic history and relict fishes of the north-central Great Basin. Memoirs of the California Academy of Sciences VII. California Academy of Science, San Francisco, California. 259 pages.

Loundenslager, EJ., and G. Gall. 1980. Biochemical systematics of Nevada trout populations. Final Report to Nevada Department of Wildlife, Reno, Nevada. 79 pages.

Martin, MA., and D.K Shiozawa. 1982. The electrophoresis of isolated trout populations from selected Utah streams. Final Report to Utah Division of Wildlife Resources, Salt Lake City, Utah. 27 pages.

National Park Service. 1991. NPS-77: Natural resources management guideline. U.S. Department of Interior, National Park Service, Washington, D.C. 609 pages + appendices.

National Park Service 1993. Final General Management Plan, Development Concept Plans, and Environmental Impact Statement for Great Basin National Park, Nevada. Great Basin National Park, Baker, Nevada. 433 pages.

BUDGET AND FTEs:

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	0.0

-- UNFUNDED

	Source	Act Type	Budget ($1000s)	r'1'Bs
Year 1:	NRPP	MIT	50.0	0.5
Year 2:	NRPP	MIT	25.0	03
	NSTA	MIT	15.0	
Year 3:	NRPP	MIT	3.0	0.1
	NSTA	MIT	1.0	
Year 4:	NRPP	MIT	3.0	0.1
	NSTA	MIT	1.0	
	Total:		98.0	1.0

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

No Action: Bonneville cutthroat trout may continue to persist in Pine and Ridge creeks but declines would be expected if land-use practices or a natural disaster altered the condition of the riparian and aquatic habitats to the detriment of the fish or if exotic fish were introduced. Current population size and distribution may be inadequate for long-term survival even under relatively natural conditions.

Adopt the Nevada Department of Wildlife Plan: The park would cooperate with the Nevada Department of Wildlife to implement the state's plan for those areas mentioned in the plan that are under the jurisdiction of the NPS. This would result in: (1) measures to protect the population of Bonneville cutthroat that occurs in the Pine and Ridge system, (2) introduction of Bonneville cutthroat to four streams that flow partially in the park and that are not part of the fish's historic range following eradication of exotic salmonids, and (3) reintroduction of Bonneville cutthroat to Big Wash Creek, which is within the historic range of the fish and which is fed by tributaries that flow within the park, following eradication of exotic salmonids. Stream inventories would be conducted to assess the quality of aquatic and riparian habitats prior to introductions or reintroduction. Improvements, including changes in land-use practices, would occur as needed to provide suitable habitat for survival of Bonneville cutthroat trout. Monitoring would occur to assess the success of any introductions.

COMPLIANCE CODE(S): EA

EXPLANATION:

PROJECT NUMBER: GRBA-N-032.300

TITLE: EFFLUENTS ASSOCIATED WITH ABANDONED MINE SITES FUNDING

STATUS: FUNDED: 0.0 UNFUNDED: 5.0

SERVICEWIDE ISSUES: Nil WATER QUALL-EXT

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

A variety of metals have been mined in the South Snake Range, including gold, silver, lead, tungsten, and beryllium. Mining began in the 1860's and continues to the present day. There are seven mining districts and over 1,000 claims on the range, including 247 unpatented claims within the park and 15 patented claims or claim groups adjacent to the park and encompassing approximately 400 ha (1,000 ac). There are no active mines in the park at present, and new mining claims are prohibited. Mining could occur on valid pre-existing mining claims, however, with development and approval of a mining plan.

Abandoned mine sites in the park include a large number of hand-dug prospect pits, adits, shafts, bulldozer scrapes, waste-rock and tailings piles, ditches and other water diversions, cabins, mills, barrels, cables, pipes, and various other structures and discarded material. Many mine sites are in close proximity to streams and lakes. An adit in Lincoln Canyon is 1,200 m (4,000 ft) long and is associated with a large pile of waste rock that extends from the mouth of the adit to the stream bed below. At the Bonita Mine, alluvium from the bed of Snake Creek was excavated, screened, and milled in a search for placer tungsten deposits. At the Johnson Mine site, which is the focus of a separate project statement, the workings are located on the cirque wall above Johnson Lake, and the mill site is located on a slope above one fork of Snake Creek.

Adverse effects of residuals and metals from mine sites include direct, indirect, chronic, and acute toxicity (Forstner and Wittmann 1979). These effects can be manifested as death or loss of vigor and reproductive potential among plants and animals, and neurologic and physiologic disorders in animals (Blus et al. 1989, Henny et al. 1991, Laws 1981, Sorensen 1991). Differential tolerance to these compounds can result in changes in species composition.

The park has identified the location of many abandoned mine sites and numerous tailing piles. The tailing piles especially constitute a non-point source of water pollution of concern to park management. Effluent from the Mt. Wheeler Mine, on the west flank of Mt. Washington, was tested in 1990 and found to be innocuous except for reasonably high levels of zinc and copper.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Assess the threat posed by effluent from abandoned mine sites by conducting on-site examinations of each known mine site as early as possible in the spring or summer when effluents are most likely to be present to ensure that the park is meeting requirements for control of any non-point sources of water pollution. Collect and analyze samples of effluents for trace metals following standard procedures (APHA 1989). If the analysis reveals hazardous levels of one or more metals, identify remedial actions, which may include isolating and stabilizing the source of the effluent, removal and disposal of the offending material, excluding visitors and wildlife from the site, and continued monitoring.

Literature Cited

APHA. 1989. Standard methods for the examination of water and wastewater, 17th ed. American Public Health Association, Washington, D.C. 1460 pages.

Blus, L.J., R.K. Stroud, B. Reiswig, and T. McEneaney. 1989. Lead poisoning and other mortality factors in trumpeter swans. Environmental Toxicology and Chemistry 8:263-271.

Forstner, R., and G.T.W. Wittman. 1979. Metal Pollution in the Aquatic Environment. Springer-Verlag, New York. 486 pages.

Henny, CJ., L.J. Blus, D. Hoffman, R. Grove, and J. Hatfield. 1991. Lead accumulation and osprey production near a mining site on the Coeur d'Alene River, Idaho. Archives of Environmental Contamination and Toxicology 21:415-424.

Laws, E.A. 1981. Aquatic Pollution. John Wiley and Sons, New York. 482 pages.

National Park Service. 1993. Final General Management Plan, Development Concept Plans, and Environmental Impact Statement for Great Basin National Park. Great Basin National Park, Baker, Nevada. 434 pages.

Sorensen, E.M. 1991. Metal Poisoning in Fish. CRC Press, Boca Raton, Florida. 374 pages.

Unrau, H.D. 1990. A history of Great Basin National Park, Nevada. Historic Study, U.S. Department of Interior, National Park Service, Washington, D.C. 690 pages.

BUDGET AND 1 I Es:

-- FUNDED --

Source	Act Type	Budget ($1000s)	F1'Es
Year 1:			
Year 2:			
Year 3:			
Year 4:			
Total:		0.00	0.0

--UNFUNDED--

Source	Act Type	Budget ($1000s)	FTEs
Year 1: SVC-OTHER	MON	5.0	0.2
Year 2:			
Year 3:			
Year 4:			
Total:		5.0	0.2

COMPLIANCE CODE(S): EXCL

EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-032.200

TITLE: EFFECTS OF ABANDONED MINE SITES ON JOHNSON LAKE

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 20.0

SERVICEWIDE ISSUES: N11 WATER QUALL-EXT

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

The Johnson Mine is located on a steeply inclined cirque wall, 140 m (450 ft.) above Johnson Lake. The workings consist of several partially collapsed adits with a combined length, including drifts, of over 425 m (1,400 ft.) (Kluender 1983, USGS 1991). Waste heaps extend from the adits several hundred feet down the slope toward the lake. The remains of a cable tramway system, formerly used to haul ore, and other types of iron, steel, and wooden debris are strewn around the lake shore. Ore from the Johnson Mine was processed at a small mill and gravity concentrator located roughly 1.6 km (1 mi) east of the lake. Several log structures and what appears to be a small tailings pile remain at the mill site, which is located on a slope above the Johnson Lake fork of Snake Creek. At the mine site, mineralization occurs in pegmatitic veins that cut through Jurassic quartz monzonite and granodiorite bedrock. Assays from samples collected at the site show tungsten values ranging from 0.01% to 0.04%, with minor amounts of antimony, lead, copper, and silver (Kluender 1983). The granitic bedrock itself appears to contain "unusually high amounts of thorium and rare-earth elements" (Kluender 1983:9).

The degree to which mining-related pollution can affect aquatic ecosystems is well documented (Cohen and Gorman 1991, Forstner and Wittman 1979, Rail 1989, Sorensen 1991). Potential water quality issues related to the Johnson mine and mill sites include erosion from waste heaps *and* an abandoned road, leaching of metals from waste heaps and tailings, and pollution from mining debris (Nelson and Jacobs 1993). The park has virtually no quantitative data on the amount and types of debris in the lake and on the concentrations of metals and other potential toxins in waters and aquatic biota. Metcalf and others (1992) found "significant amounts" of zinc and other trace metals in trout and beetle specimens taken from Johnson Lake, but they cautioned that no conclusions could be drawn from their preliminary analysis.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Work with the Western Regional Office Hazardous Materials Coordinator and the WASO Engineering and Safety Services Division in order to request that a hazardous materials site investigation (SI) be conducted at this site.

Such an investigation would include obtaining water column and sediment core samples from Johnson Lake for analysis of trace metals. Water would be sampled from the hypolimnion or about 1 m (3 ft) above the lake bottom, from any inlet streams, and from the lake outlet. The water samples would be analyzed to determine concentrations of suspected heavy metals, including Fe, Mn, Cu, Pb, Zn, W, and Ag, as well as temperature (field), pH (field and lab), conductivity, alkalinity, and major ion chemistry. The sediment cores would be analyzed to determine concentrations of suspected heavy metals (Fe, Mn, Cu, Pb, Zn, W, and Ag) at 5-cm (2-in) intervals to obtain a vertical profile.

The site investigation should also include a detailed visual inspection of Johnson Lake using scuba diving equipment to determine the extent and nature of discarded debris or wastes from mining activities. Any materials thought to be visually unsightly or possibly hazardous should be removed. Contents of any sealed drums or other containers should be tested for hazardous materials and disposed of in a proper manner.

In addition, the site investigation should include a screening of metals in edible fish tissue following the methods described under the alternative Heavy Metals in Fish, and development of a public education program if there are indications that consumption of the fish tissue may be hazardous to human health.

Literature Cited

Cohen, R.R.H., and J. Gorman. 1991. Mining-related non-point source pollution. Water Environment and technology 3(6):55-59.

Forstner, R., and G.T.W. Wittman. 1979. Metal Pollution in the Aquatic Environment. Springer-Verlag, New York. 486 pages.

Kluender, S.E. 1983. Mineral investigation of the Wheeler Peak Road-less Area, White Pine County, Nevada. U.S. Bureau of Mines Open File Report MLA 56-83.

Metcalf, R.C., G.D. Merritt, MA Stapanian, J.R. Baker, and K.M. Peres. 1989. Chemistry of selected lakes and streams in Great Basin National Park, Nevada, during winter and spring 1989. Draft Report, EPA Contract No. 68-03-3249. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nevada. 43 pages + appendices.

Nelson, P.O., and R.W. Jacobs. 1993. An assessment of several water-quality issues in Great Basin National Park and recommended actions for addressing these issues. Final Report. Cooperative Park Studies Unit, Oregon State University, Corvallis, Oregon. 11 pages.

Rail, C.D. 1989. Groundwater Contamination: Sources, Control, and Preventive Measures. Technomic Publishing Co., Inc. Lancaster, Pennsylvania. 139 pages.

Sorensen, E.M. 1991. Metal Poisoning in Fish. CRC Press, Boca Raton, Florida. 374 pages.

U.S. Geological Survey. 1991. Mineral Resources Data System (MRDS) records for the southern Snake Range, White Pine County, Nevada. U.S. Geological Survey Minerals Information Office, Reno, Nevada.

BUDGET AND 1.1'Es:

---FUNDED---

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	0.0

--------------------------------------- UNFUNDED --------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	SVC-OTHER	MIT	20.0	
	WATER-RES	ADM		0.1
	PKBASE-NR	MIT		0.1
Year 2:				
Year 3:				
Year 4:				
	Total:		20.0	02

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

Heavy Metals in Fish: The park would assess possible health hazards associated with eating fish caught from Johnson Lake by collecting brook trout of several different age classes from the lake and analyzing edible tissues for metal concentration. Public education programs would be developed if the analyses indicated a potential health hazard from consumption of the trout.

CODE(S): EXCL

EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-019.600

TITLE: WATER QUALITY STANDARDS CLASSIFICATION FUNDING

STATUS: FUNDED: 0.0 UNFUNDED: 0.0 SERVICEWIDE ISSUES: N11

WATER QUALL-EXT CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

The Environmental Commission of the State of Nevada classifies waters of the state for purposes of water quality management. Baker, Lehman, Ridge, and Pine creeks of the park are specifically classified as Class A waters. Class A waters include waters or portions of waters located in areas of little human habitation with no industrial development or intensive agriculture and where the watershed is relatively undisturbed by man's activity. The beneficial uses of class A waters are municipal or domestic supply, or both, with treatment by disinfection only, aquatic life, propagation of wildlife, irrigation, watering of livestock, recreation including contact with the water and recreation not involving contact with the water (Nevada Statutes 445.122). All lakes and streams of the park likely fit this classification and should be managed to meet water quality criteria of Class A waters.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Petition the State of Nevada to designate all streams and lakes of Great Basin National Park as Class A waters. Formal designation by the state of the park's waters as Class A will remove any doubt as to the appropriate standards.

BUDGET AND I· I Es:

--FUNDED-------------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	0.0

---UNFUNDED -----------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	PKBASE-NR	ADM		0.1
	WATER-RES	ADM		0.1
Year 2:				
Year 3:				
Year 4:				
	Total:			0.2

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

CODE(S): OTHER

EXPLANATION: NEVADA WATER QUALITY STANDARDS

PROJECT NUMBER: GRBA-N-018240

TITLE: DISCHARGE MONITORING FOR PERMIT COMPLIANCE: SEWAGE LAGOONS AND VAULT TOILETS

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 1.0

SERVICEWIDE ISSUES: N11 WATER QUAL-EXT

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

The NPDES discharge permit for the park's sewage lagoon system and vault toilets specifies that the park conduct monthly sampling to assess concentrations of fecal coliform (FC) and fecal streptococci (FS) bacteria in untreated surface waters of Lehman Creek and Rowland Springs. The objective of this sampling is to indicate if any contamination is entering these aquatic systems from either the sewage lagoons or vault toilets serving the park's developed campgrounds.

The park has monitored bacteria in these untreated surface waters since 1988. Currently samples are collected at monthly intervals from three points on Lehman Creek and two points associated with Rowland Springs. Samples are sent to a laboratory in Reno, Nevada for processing to determine concentrations of FC and FS bacteria. Concentrations of FC and FS are generally less than 100 per 100 ml of water for the samples from the park, indicating no current contamination problem exists.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

It is necessary that the park continue this monitoring in order to remain in compliance with the State of Nevada discharge permit required to operate the park's sewage lagoon system and vault toilets.

Continuation of this required monitoring effort is recommended, although it would be appropriate that the funding for this effort be incorporated into base funding for park operations.

BUDGET AND FTEs:

--FUNDED --------------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	- -			
Total:			0.00	0.0

--- UNFUNDED

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	PKBASE-MAINT	MON	1.0	0.1
Year 2:	PKBASE-MAINT	MON	1.0	0.1
Year 3:	PKBASE-MAINT	MON	1.0	0.1
Year 4:	PKBASE-MAINT	MON	1.0	0.1
	- -			
Total:			4.0	0.4

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

COMPLIANCE CODE(S): OTHER

EXPLANATION:

Monitoring is required to meet regulatory requirements of the State of Nevada discharge permit for the park's sewage lagoon system and vault toilets. The state has the authority to issue these permits and require necessary compliance monitoring under the auspices of the Clean Water Act.

PROJECT NUMBER: GRBA-N-018.210

TiTLE: HAZARDOUS SUBSTANCES AND CONTAMINATION OF GROUND WATER

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 5.0

SERVICEWIDE ISSUES: N11 WATER QUALL-EXT N22 VIS USE-DEV ZN CULTURAL

RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Hazardous substances can become water quality problems when improper disposal methods are used or when accidental spills occur (Rail 1989). Under present management practices, park maintenance facilities, storage buildings, and storage yards are the most likely locations for problems related to hazardous substances to develop (Nelson and Jacobs 1993). No ground water contamination problems are known to exist in the park at this time. However, the location of several underground storage tanks in close proximity to Lehman Caves is a management concern. Other possible sources of contamination of ground water include leaking wastewater collection or treatment systems, and accidental spills of contaminants.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Review the park's contingency plan for response to hazardous substance spills and ensure that those involved in contingency response are knowledgeable about response procedures and their specific roles. As part of this process, prepare a pamphlet for distribution to all park personnel, contractors, and vendors that summarizes proper handling and disposal practices for hazardous substances in the park, lists forbidden practices and substances, and clearly states the consequences of noncompliance.

Maintain the park's dedicated storage facility for hazardous substances, including petroleum-based solvents and pesticides. Complete ongoing inspection, removal, or replacement of underground storage tanks for fuels and oils following standards of the U.S. Environmental Protection Agency and State of Nevada. Similarly, complete the removal of hazardous substances or materials stored in the park, including used paints, paint thinners, and batteries, non-functional electrical transformers, and outdated pesticides. Maintenance practices and the handling of fuels, oils, and other hazardous substances need to comply with accepted procedures (e.g. Occupational Safety and Health Administration and State of Nevada).

Literature Cited

Nelson, P. O., and R. W. Jacobs. 1993. An assessment of several water-quality issues in Great Basin National Park and recommended actions for addressing these issues. Final Report. Cooperative Park Studies Unit, Oregon State University, Corvallis, Oregon. 11 pages.

Rail, C. D. 1989. Ground water Contamination: Sources, Control, and Preventive Measures. - Technomic Publishing Co., Inc., Lancaster, Pennsylvania. 139 pages.

BUDGET AND r1 Es:

------......... --------------- ...... --..... -----FUNDED ---------------------------------

	Source	Act Type	Budget ($1000s)	r-1 Es
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	0.0

--UNFUNDED----------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	SVC-OTHER	PRO	5.0	0.2
Year 2:				
Year 3:				
Year 4:				
	Total:		5.0	02

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

COMPLIANCE CODE(S): EXCL

EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-018.230

TITLE: GRAY-WATER DISPOSAL

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 5.0

SERVICEWIDE ISSUES: N06 LAND USE PRAC C17 CTRL ENV IMPAC

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

No disposal systems are available for gray waters in campgrounds of the park. Visitors probably dispose of this water on the ground or in adjacent streams. In addition, there is probable illegal dumping of gray water from recreational vehicles. Those visitors with recreational vehicles with holding tanks may retain their gray water for disposal at the dump site provided by the park.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Conduct a feasibility study to develop a gray-water disposal system for the major campgrounds of the park (Wheeler Peak, Upper Lehman Creek, Lower Lehman Creek, Baker Creek, Snake Creek, Shoshone, and Gray Cliffs). These systems should be one or a combination of these three possibilities: external drains into the vault toilets, external drains into a central holding tank at each campground, or construction of drainage pits at each campground. If the latter is constructed, no drainage pit should be closer than 30 m (90 ft) from surface water (Nelson and Jacobs 1993). Develop notices for posting in campgrounds and distribution to campers which inform visitors of the proper methods for disposal of gray water and describes consequences of improper disposal.

Literature Cited

Nelson, P.O., and R.W. Jacobs. 1993. An assessment of several water-quality issues in Great Basin National Park and recommended actions for addressing these issues. Final Report. Cooperative Park Studies Unit, Oregon State University, Corvallis, Oregon. 11 pages.

BUDGET AND 1˙1 Es:

--- FUNDED---

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
	Total:		0.00	0.0

-- UNFUNDED --------------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	REP-REHAB	MIT	5.0	0.1
Year 2:				
Year 3:				
Year 4:				
	Total:		5.0	0.1

COMPLIANCE CODE(S): EXCL

EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-019.910

TITLE: INTERACTION BETWEEN SURFACE AND GROUND WATER IN THE REGION OF THE SNAKE CREEK DIVERSION

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 0.0

SERVICEWIDE ISSUES: N12 WATER FLOW N13 WATER RIGHTS

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Snake Creek is one of the principal eastward draining streams in Great Basin National Park. A portion of the stream crosses Pole Canyon Limestone, a geologic unit that has undergone substantial solution and in which many of the cave resources of the park are located (Bridgemon 1967, Lange 1958, Whitebread 1969). Under natural conditions, a portion of the flow in the stream segment underlain by the limestone probably recharges the ground water system.

Prior to establishment of the park, a buried system of concrete and culverts about 5 km (3 mi) long was constructed to bypass the stream segment underlain by the Pole Canyon Limestone. The capacity of the culvert is sufficient to divert all streamflow around a 5-km (3-mi) stream segment except during periods of moderate to high flows (Aley 1991). The apparent rationale for construction of the diversion was to increase the amount of surface water available to downstream users, primarily agricultural, in the Garrison, Utah area. The assumption seemed to be that water that entered the ground-water system along the segment did not return to Snake Creek. Relevant data on effects of the project, if they were collected, no longer exist. One change appears to be a substantial decrease in the presence of riparian vegetation, particularly phreatophytic vegetation, along the bypassed segment (Alley 1991). If the diversion reduced recharge to the karst ground water system, caves associated with that system may also have been affected (Aley 1991). It remains unknown to what extent the water from Snake Creek entered the karst ground water system in the bypassed stream segment. If Snake Creek water entered the ground-water system, where did this occur, what were the volumes of water involved, and where did the water from this segment flow if it entered the karst system?

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

Quantify recharge rates in the bypassed stream segment and identify major outflow and inflow zones for ground water. This assessment will involve a series of measurements of stream flow, commonly referred to as a seepage run, during a period when surface flow exists along most or all of the length of the bypassed stream segment. Several seepage runs will be conducted if a portion of the bypassed water can be diverted back into the stream segment for several days. Fluorescent ground-water tracer dyes should be used to determine which springs and caves in the region are fed by water that sinks into the ground water in the region of the diversion. Activated carbon samplers should be used to allow for continuous sampling. The sampling should also include use of a spectrofluorophotometer operated under a synchronous scan protocol rather than a filter fluorometer. Based on these studies, evaluate the effect of retaining the bypass on surface water, ground water, cave resources, and the riparian corridor. Legal and administrative opportunities for effecting a change in the bypass will be analyzed, if the effects of the bypass are judged to be largely negative.

Literature Cited

Aley, T. 1991. Project statements for Great Basin National Park. Report to Cooperative Park Studies Unit, Oregon State University, Corvallis, 21 pages.

Bridgemon, R. R. 1967. Baker Creek cave system, White Pine County, Nevada - Final report on grotto project. Arizona Caver 4(1):2-10.

Lange, A. L. 1958. Stream piracy and cave development along Baker Creek, Nevada. Western Speleological Institute Bulletin 1, Santa Barbara, Calif. 20 pages + illustrations.

Whitebread, D. H. 1969. Geologic map of the Wheeler Peak and Garrison Quadrangles, Nevada and Utah. U.S. Geologic Survey, Miscellaneous Geologic Investigations, Map I-578.

BUDGET AND FTEs:

-- FUNDED--------------------------------------

	Source	Act Type	Budget ($1000s)	Firs
Year 1:				
Year 2:				
Total:			0.00	0.0

- -

---UNFUNDED

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:	WATER-RES	RES	40.0	0.1
PKBASE-NR		RES		02
Year 2:				
Year 3:				
Year 4:				
Total:			40.0	0.3

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

COMPLIANCE CODE(S): OTHER

EXPLANATION: Valid existing water right

PROJECT NUMBER: GRBA-N-019.900

TTTLE: LEHMAN CAVES WATER BUDGET

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 60.0

SERVICEWIDE ISSUES: N21 CAVE RESOURCES N12 WATER FLOW

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Maintenance of a natural moisture budget is essential to the maintenance of a cave's natural integrity particularly in arid regions such as the Great Basin (Aley and Aley 1992). Activities conducted at caves open for public tours, such as Lehman Caves, routinely result in unnatural moisture losses from these caves (McLean 1976). These activities include, alteration of natural entrances, construction of additional entrances, connection of previously unconnected or poorly connected passages and chambers, and enlargement of passages that previously limited air exchange. All of these activities have occurred at Lehman Caves (Halladay and Peacock 1972). Such modifications tend to increase the rate of air exchange between the cave and the surface, which then increases the rate of loss of cave moisture.

The soil and bedrock surfaces in the vicinity of Lehman Caves are highly irregular (Aley 1991). Solutional activity in about the upper 10 m (30 ft) of the bedrock has resulted in highly corroded, localized areas. Some of these areas are open, others are partially to completely filled with soil. This highly corroded bedrock zone, called the epikarstic or subcutaneous zone, is critically important in detaining and storing water (Ford and Williams 1989). This stored water subsequently infiltrates into underlying and adjacent cave passages.

Fire played a major role as an ecological factor in pinyon juniper communities of the park before approximately 1860 (Gruell et al. 1991). Thereafter, grazing of domestic livestock, active fire suppression, and other factors contributed to a reduction in the frequency of fire (Gruell 1986), which at least partially explains a marked increase in the density and distribution of pinyon juniper communities in the Snake Range and elsewhere in the arid west (Gruell et al. 1991). Historically, the vegetative cover over and around Lehman Caves was probably primarily sagebrush (Blackburn and Tueller 1970; B. Freet, pers. comm., June 1991). Now the vegetation is primarily pinyon juniper woodland with some sagebrush in the understory (Eddleman and Jaindl 1991). This vegetative change has undoubtedly increased evapotranspiration and, thereby, probably has reduced the quantity and timing of infiltration of moisture into underlying and adjacent cave passages (Aley 1991).

Recent ground-water tracing studies elsewhere in the United States demonstrated that substantial lateral movement of water often occurs through the epikarstic zone before the water finally enters cave passages (Aley and Aley 1992). If similar water movement occurs in the park, small valleys in the vicinity of Lehman Caves may be important water supply zones for the cave. The valley immediately behind the administrative building is one example (Aley 1991).

Since the discovery of Lehman Caves, it is probable that development and use of the cave for tours has increased the rate of moisture loss from the cave to the surface (Aley 1991). Vegetative changes associated with fire suppression and grazing have probably reduced the quantity of water infiltrating into the cave (Aley 1991). The net result of these changes is that Lehman Caves may be drier now than it was under natural conditions. This desiccation would affect the relative humidity of the cave air and the amount of moisture on speleothems, in cave pools, and in cave sediments. Under natural conditions, much of the deposition of speleothems is the result of carbon dioxide degassing of cave waters (Ford and Williams 1989). Some deposition occurs due to evaporation (Hill and Forti 1986). The deposition resulting from carbon dioxide degassing and that resulting from evaporation can be significantly different. Therefore, changing the ratio of the two processes could result in changes in the condition and growth of speleothems in Lehman Caves.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

As suggested by Aley (1991, 1993), conduct several studies to develop management strategies to maintain the cave under near-natural moisture conditions. Determine the water budget for Lehman Caves based on existing conditions and compared to an estimated water budget based on estimated conditions at the time of cave discovery (Aley and Aley 1988). Determination of water budgets will require measurements of temperature and precipitation on surfaces above the cave, and information about airflow, humidity, and evaporation in the cave under varying weather conditions. Temporary passage closures may be used to replicate conditions of air flow in the cave prior to development of the cave for tours.

Undertake ground-water tracing studies to determine if any of the small valleys in the area contribute water to known portions of Lehman Caves. Sampling should utilize activated carbon samplers to ensure continuous sampling, and analysis should use a spectrofluorophotometer operated under a synchronous scan protocol rather than a filter fluorometer. Conduct other studies to estimate effects of changes in surface vegetation on the cave water budget.

Literature Cited

Aley, T. 1991. Project statements for Great Basin National Park. Report to Cooperative Park Studies Unit, Oregon State University, Corvallis. 21 pages.

Aley, T. 1993. Preliminary cost estimates for proposed studies at Great Basin National Park. Report to Coperative Park Studies Unit, Oregon State University, Corvallis. 8 pages.

Aley, T., and C. Aley. 1988. Restoration of the natural microclimate in Oregon Caves, Oregon Caves National Monument. Contract Report to U.S. Department of Interior, National Park Service. Ozark Underground laboratory, Protem Missouri. 107 pages.

Aley, T., and C. Aley. 1992. Delineation and hazard area mapping of areas contributing water to significant caves. Proceedings of the National Cave Management Symposium, Bowling Green, Kentucky, October 1991.

Blackburn, W.H., and P.T. Tueller. 1970. Pinyon and juniper invasion in black sagebrush communities in east-central Nevada. Ecology 51:841-848.

Eddleman, L.E. and R. Jaindl. 1991. National Park Service, Great Basin National Park vegetation analysis. Report dated May 1, 1991. U.S. Dept. Interior, Great Basin National Park, Baker, Nevada. 110 pages.

Ford, D., and P. Williams. 1989. Karst geomorphology and hydrology. Unwin Hyman Publisher, London, England. 601 pages.

Gruell, G.E., L.E. Eddleman, and R. Jaindl. 1991. National Park Service, Great Basin National Park fire history of the pinyon juniper type. Report dated May 1, 1991. U.S. Dept. Interior, Great Basin National Park, Baker, Nevada. 20 pages.

Gruell, G.E. 1986. Post-1900 mule deer irruptions in the Intermountain West: Principle cause and influences. General Technical Report INT-206, U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. 37 pages.

Halladay, O.J., and V.L. Peacock. 1972. The Lehman Caves story. Lehman Caves Natural History Association, Baker, Nevada. 27 pages.

Hill, C.A., and P. Forti. 1986. Cave minerals of the world. National Speleological Society, Huntsville, Alabama. 238 pages.

McLean, J.S. 1976. Factors altering the microclimate of Carlsbad Caverns, New Mexico. U..S. Geological Survey Open-File Report 76-171. 56 pages.

BUDGET AND 1- lEs:

-----FUNDED-----

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
Total:			0.00	0.0

-----UNFUNDED

	Source	Act Type	Budget ($1000s)	N'1'Es
Year 1:	NRPP	RES	20.0	
	WATER-RES	ADM		0.1
	PKBASE-NR	RES		02
Year 2:	NRPP	RES	20.0	
	WATER-RES	ADM		0.1
	PKBASE-NR	RES		02
Year 3:	NRPP	RES	20.0	
	WATER-RES	ADM		0.1
	PKBASE-NR	RES		02
Year 4:				
Total:			60.0	0.9

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

COMPLIANCE CODE(S): EXCL

EXPLANATION: 516 DM2 App. 2, 1.6

PROJECT NUMBER: GRBA-N-019.810

TITLE: DELINEATION OF RECHARGE AREAS FOR SPRINGS

FUNDING STATUS: FUNDED: 0.0 UNFUNDED: 30.0

SERVICEWIDE ISSUES: N12 WATER FLOW

CULTURAL RESOURCE TYPE CODE: N/A

PACKAGE NUMBER: 10-238

PROBLEM STATEMENT:

Cave Springs provides water to the administrative and visitor facilities in the area of Lehman Caves. The area that contributes water to this spring (recharge area) is unknown, which places limits on site-specific management actions to protect water quality. Cave Springs discharges from alluvium, but important flow routes may lie in buried flow routes within the Prospect Mountain Quartzite, which forms the bedrock above and around the springs (Miller and Grier 1993). One possibility is that an important component of the flow at Cave Springs is derived from Lehman Creek (Aley 1991). This creek is about 150 m (400 ft) from the spring. If this were the case, segments of Lehman Creek that contribute to the flow of Cave Springs are probably downstream from campgrounds.

The ground-water discharge point for waters from Lehman Caves also is unknown. Rowland Springs, located near the eastern border of the park and south of the main access road into the park, has been suggested as a possible discharge point for the cave (Aley 1991). Isotopic analyses of water samples from Lehman Caves, Lehman Creek, and Rowland Springs were conducted in 1989 (Ingraham and Chapman 1989). Samples from Lehman Creek and Rowland Springs had stable isotopic ratios, similar to one another but significantly different from samples from Lehman Caves. Ingraham and Chapman (1989) concluded that little hydrologic connection was evident between the cave and the surface waters of Lehman Creek and Rowland Springs based on these results.

Rowland Springs is itself an important park resource, possibly affected by park developments. The park's sewage disposal system is potentially in the recharge area of this spring, and many of the park's administrative facilities and the visitor center may lie in the recharge area for the spring. If so, Rowland Springs would be an important point for monitoring effects of administrative and visitor facilities on water quality. Such a monitoring point would be valuable in the event of a leak or spill of water contaminants as well as for routine monitoring of water quality. Other possibilities are that Rowland Springs is not associated with Lehman Caves or Rowland Springs may be hydrologically connected to Cave Springs.

DESCRIPTION OF RECOMMENDED PROJECT OR ACTIVITY:

The primary objective of this inventory effort is to delineate the recharge areas for the springs in order to protect areas above and around the principle recharge zone from unintententional degradation due to facility development.

In order to accomplish this, Aley (1991) recommended ground-water tracing studies using fluorescent tracer dyes to identify recharge areas for Cave Springs and Rowland Springs. This could be conducted with small quantities of fluorescein and Rhodamine WT if continuous samplers of activated carbon were used. To ensure reliable results, all analyses should use a spectrofluorophotometer operated under a synchronous scan protocol rather than a filter fluorometer. A weir or flume to provide data on the flow rates of Rowland Springs may be constructed if tracing of ground water demonstrates that Lehman Caves or the administrative and visitor facilities are within the recharge area for this spring. Delineate the recharge areas for Cave Springs and Rowland Springs based on the results of the ground water tracing studies and flow rate estimates (Aley and Aley 1992). Based on these results, the park will consider reclassifying some or all of the recharge area for Cave Springs as a springhead protection zone, a federal protection strategy for supplies of drinking water.

Literature Cited

Aley, T. 1991. Project statements for Great Basin National Park. Report to Cooperative Park Studies Unit, Oregon State University, Corvallis. 21 pages.

Aley, T., and C. Aley. 1992. Delineation and hazard area mapping of areas contributing water to significant caves. Proceedings of the National Cave Management Symposium, Bowling Green, Kentucky, October 1991.

Ingraham, N., and J. Chapman. 1989. Stable isotope feasibility study of Lehman Caves, Great Basin National Park, Nevada. Unpublished research proposal on file in Great Basin National Park, Baker, Nevada.

BUDGET AND 1- 1Es:

---FUNDED----------------------------------

	Source	Act Type	Budget ($1000s)	FTEs
Year 1:				
Year 2:				
Year 3:				
Year 4:				
			- -	
	Total:		0.00	0.0

--UNFUNDED----------------------------------

	Source	Act Type	Budget ($1000s)	F1Es
Year 1:	WATER-RES	RES	31.0	0.1
	PKBASE-NR	RES		0.1
Year 2:				
Year 3:				
Year 4:				
			- -	
	Total:		31.0	0.2

(OPTIONAL) ALTERNATIVE ACTIONS/SOLUTIONS AND IMPACTS:

COMPLIANCE CODE(S): EXCL
EXPLANATION: 516 DM2 App. 2, 1.6

LITERATURE CITED

APHA. 1989. Standard methods for the examination of water and wastewater, 17th ed. American Public Health Association, Washington, D.C. 1460 pages.

Aley, T. 1991. Project statements for Great Basin National Park. Report to Cooperative Park Studies Unit, Oregon State University, Corvallis. 21 pages.

Aley, T., and C. Aley. 1988. Restoration of the natural microclimate in Oregon Caves, Oregon Caves National Monument. Contract Report to U.S. Department of Interior, National Park Service. Ozark Underground Laboratory, Protem Missouri. 107 pages.

Aley, T., and C. Aley. 1992. Delineation and hazard area mapping of areas contributing water to significant caves. Proceedings of the National Cave Management Symposium, Bowling Green, Kentucky, October 1991.

Anderson, M. 1991. Great Basin National Park non-salmonid endemic fish survey. Final Report (project conducted through University of Nevada, Las Vegas). Great Basin National Park, Baker, Nevada. 13 pages.

Batson, F.T., P.E. Cuplin, and W.A. Crisco. 1987. The use of aerial photography to inventory and monitor riparian areas. Technical Reference BLM/TA/PT-87/021 + 1737. Bureau of Land Management, Denver, Colorado. 13 pages.

Behnke, R.J. 1976. Monograph of the native trouts of the genus *Salmo* of western North America. Report to Region 6, U.S. Department of Interior, Fish and Wildlife Service. 215 pages.

Behnke, R.J. 1977. Impact of livestock grazing on stream fisheries: Problems and solutions. Pages 170-173 *in* J.W. Menke, ed. Proceedings of the Workshop on Livestock and Wildlife-Fisheries Relationships in the Great Basin. University of California, Division of Agricultural Sciences, Special Publication 3301. University of California, Berkeley.

Behnke, R.J., and M. Zarn. 1976. Biology and management of threatened and endangered western trouts. U.S. Department of Agriculture, Forest Service, General Technical Report RM-28. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 45 pages.

Bella, D.A., and W.S. Overton. 1972. Environmental planning and ecological possibilities. Journal of Sanitary Engineering Division SA3:579-592.

Berger, J., and J.D. Wehausen. 1991. Consequences of a mammalian predator-prey disequilibrium in the Great Basin Desert. Conservation Biology 5:244-248.

Blackburn, W.H., and P.T. Tueller. 1970. Pinyon and juniper invasion in black sagebrush communities in east-central Nevada. Ecology 51:841-848.

Blus, L.J., R.K. Stroud, B. Reiswig, and T. McEneaney. 1989. Lead poisoning and other mortality factors in trumpeter swans. Environmental Toxicology and Chemistry 8:263-271.

Bridgemon, R.R. 1967. Baker Creek cave system, White Pine County, Nevada. Final Report on Grotto Project. Arizona Caver 4(1):2-10.

Brown, J.H. 1971. Mammals on mountaintops: Nonequilibrium insular biogeography. American Naturalist 105:467-478.

Bureau of Land Management. 1978. 6671 manual for stream surveys. Release No. NSO 6-38. Bureau of Land Management, Nevada State Office, Reno, Nevada. 60 pages.

Bureau of Land Managment. 1989. Riparian policy and procedures handbook. Bureau of Land Management, Ely District, Ely, Nevada. 80 pages.

Burkham, D.E. 1988. Methods for delineating flood-prone areas in the Great Basin of Nevada and adjacent states. U.S. Geological Survey Water-Supply Paper 2316. 20 pages.

Chapman, D.W., and E. Knudsen. 1980. Channelization and livestock impacts on salmonid habitat and biomass in western Washington. Transactions, American Fisheries Society 109:357-363.

Charles, D.F., editor. 1991. Acidic Deposition and Aquatic Ecosystems - Regional Case Studies. Springer-Verlag, New York.

Cohen, R.R.H., and J. Gorman. 1991. Mining-related non-point source pollution. Water Environment and Technology 3(6):55-59

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service Biological Services Program, FWS/OBS-79/31. 103 pages.

Dobrowolski, J.P. 1992. An assessment of grazing impacts in the riparian areas of Great Basin National Park. Final Report to Oregon State University and the National Park Service. (File copy at Great Basin National Park, Baker, Nevada). 41 pages.

Drewes, H., and A.R. Palmer. 1957. Cambrian rocks of the Southern Snake Range, Nevada. American Association of Petroleum Geology Bulletin 41(1):104-120.

Duff, D.A. 1977. Livestock grazing impacts on aquatic habitat in Big Creek, Utah. Pages 129-142 *in* J. *W*. Menke, ed. Proceedings of the Workshop on Livestock and Wildlife-Fisheries Relationships in the Great Basin. University of California, Division of Agricultural Sciences, Special Publication 3301. University of California, Berkeley.

Duff, D.A. 1988. Bonneville cutthroat trout: Current status and management. American Fisheries Society Symposium 4:121-127.

Eddleman, L.E., and R. Jaindl. 1991a. Draft National Park Service, Great Basin National Park allotment grazing analysis. Draft Report dated May 1, 1991. U.S. Department of Interior, Great Basin National Park, Baker, Nevada. 93 pages.

Eddleman, L.E., and R. Jaindl. 199 lb. Draft National Park Service, Great Basin National Park range analysis. Draft Report dated May 1, 1991. U.S. Department of Interior, Great Basin National Park, Baker, Nevada. 84 pages.

Eddleman, L.E., and R. Jaindl. 1991c. Draft National Park Service, Great Basin National Park vegetation analysis. Draft Report dated May 1, 1991. U.S. Department of Interior, Great Basin National Park, Baker, Nevada. 110 pages.

Eddleman, L.E., and R. Jaindl. 1991d. National Park Service, Great Basin National Park monitoring program. Report dated May 1, 1991. U.S. Department of Interior, Great Basin National Park, Baker, Nevada. 63 pages.

Elmore, W. 1992. Riparian responses to grazing practices. Pages 440-455 *in R.* Naiman, ed. Watershed Management. Springer-Verlag, New York.

Elmore, W., and R. S. Beschta. 1987. Riparian areas: Perceptions in management. Rangelands 9:260-265.

EPA. 1986. Quality criteria for water: 1986. U.S. Environmental Protection Agency, Office of Water Regulations and Standards. Washington, D.C. 398 pages.

EPA. 1990. Offsite environmental monitoring report: Radiation monitoring around United States nuclear test areas calendar year 1990. Environmental Monitoring Systems Laboratory EPA 600/4-91/030, DOE/DP00539-063, Las Vegas Nevada. 171 pages.

Frantz, T.C. 1953. Unpublished reports on streams, lakes, and fish populations in the South Snake Range, produced for the Nevada Department of Wildlife. On file in Great Basin National Park.

Fiero, B. 1986. Geology of the Great Basin. University of Nevada Press, Reno. 198 pages.

Floyd, D.A., and J.E. Anderson. 1982. A new point interception frame for estimating cover of vegetation. Vegetatio 59:185-186.

Ford, D., and P. Williams. 1989. Karst geomorphology and hydrology. Unwin Hyman Publisher, London, England. 601 pages.

Forstner, R., and G.T.W. Wittmann. 1979. Metal Pollution in the Aquatic Environment. Springer-Verlag, New York. 486 pages.

Frissell, C.A. 1992. Cumulative effects of land use on salmon habitat in southwest Oregon coastal streNns. Ph.D. Dissertation. Oregon State University, Corvallis. 227 pages.

Frissell, C.A., and W.J. Liss. 1993. Valley segment classification for the streams of Great Basin National Park, Nevada. Final Report. Cooperative Park Studies Unit, Oregon State University, Corvallis. 53 pages.

Frissell, C.A., W.J. Liss, C.E. Warren, and M.D. Hurley. 1986. A hierarchical framework for stream habitat classification: Viewing streams in a watershed context. Environmental Management 10:540-551.

Gale, B.T. 1956. Geological report, Wheeler Peak Area, Nevada. U.S. Department of Interior, National Park Service. 6 pages.

Gary, H.S., S.R. Johnson, and S.L. Ponce. 1983. Cattle grazing impact on surface water quality in a Colorado Front Range stream. Journal of Soil and Water Conservation 38:124-128.

Gebhardt, K., S. Leonard, G. Staidi, and D. Prichard. 1990. Riparian area management: Riparian and wetland classification review. Technical Reference 1737-5. U.S. Department of Interior, Bureau of Land Management, Denver, Colorado. 56 pages.

Great Basin National Park. 1992. Resource baseline inventory - Proceedings of a resource baseline inventory workshop, January 19-21, 1988, University of Nevada, Las Vegas. Great Basin National Park Special Publication No. 1 NPS/WR GRBA/92-01. 56 pages.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian zones: Focus on links between land and water. BioScience 41:540-551.

Gruell, G.E. 1986. Post-1900 mule deer irruptions in the Intermountain West: Principle cause and influences. General Technical Report INT-206, U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station, Ogden, Utah. 37 pages.

Gruell, G.E., L.E. Eddleman, and R. Jaindl. 1991. National Park Service, Great Basin National Park fire history of the pinyon juniper type. Draft Report dated May 1, 1991. U.S. Department of Interior, Great Basin National Park, Baker, Nevada. 20 pages.

Halladay, O.J., and V.L. Peacock. 1972. The Lehman Caves story. Lehman Caves Natural History Association, Baker, Nevada. 27 pages.

Harris, R.R. 1988. Associations between stream valley geomorphology and riparian vegetation as a basis for landscape analysis in the eastern Sierra Nevada, California, USA. Environmental Management 112:219-228.

Haskins, R.L. 1987. Bonneville cutthroat trout species management plan. State of Nevada State-wide Fisheries Program, Federal Aid Project No. F-20-23, Job No. 207.2. Nevada Department of Wildlife, Reno, Nevada. 28 pages.

Henny, C.J., LJ. Blus, D. Hoffman, R. Grove, and J. Hatfield. 1991. Lead accumulation and osprey production near a mining site on the Coeur d'Alene River, Idaho. Archives of Environmental Contamination and Toxicology 21:415-424.

Hickman, T.J. 1978. Systematic study of the native trout of the Bonneville Basin. Masters Thesis. Colorado State Univeristy, Fort Collins. 122 pages.

Hickman, T., and R.F. Raleigh. 1982. Habitat suitability index models: Cutthroat trout. U.S. Department of Interior, Fish and Wildlife Service FWS/OBS-82/10.5. 38 pages.

Hidy, G.M., and H.E. Klieforth. 1990. Atmospheric processes and the climates of the Basin and Range. Page 17-46 *in* C. B. Osmond, L. F. Pitelka, and G. M. Hidy, editors. Plant Biology of the Basin and Range. Ecological Studies 80. Springer-Verlag. New York.

Hill, C.A., and P. Forti. 1986. Cave minerals of the world. National Speleological Society, Huntsville, Alabama. 238 pages.

Hillman, D.C., J.F. Potter, S.J. Simon. 1986. National surface water survey, eastern lake survey (Phase I - synoptic chemistry) analytical methods manual. EPA/600/4-86/009. U.S. Environmental Protection Agency, Las Vegas, Nevada.

Hood, J.W., and F.E. Rush. 1965. Water-resources appraisal of the Snake Valley Area, Utah and Nevada. Technical Publication No. 14. Utah State Engineer, Salt Lake City, Utah. 43 pages plus plate.

Houghton, J.G., C.M. Sakamoto, and R.O. Gifford. 1975. Nevada's weather and climate. Nevada Bureau of Mines and Geology, Univ. Nevada, Reno. 78 pages.

Houghton, J.G. 1979. A model for orographic precipitation in the north-central Great Basin. Monthly Weather Review 107:1462-1475.

Hubbs, C.L., R.R. Miller, and L.C. Hubbs. 1974. Hydrographic history and relict fishes of the north-central Great Basin. Memoirs of the California Academy of Sciences VII. California Academy of Science, San Francisco, California. 259 pages.

Hubbs, C.L., and R.R. Miller. 1948. Correlation between fish distribution and hydrographic history in the desert basins of western united States. Pages 20-166 in The Great Basin, with emphasis on glacial and postglacial times. Bulletin of the University of Utah, Biological Series.

Humboldt National Forest. 1990. Aquatic ecosystem inventory - macroinvertebrate analysis annual progress report. U.S. Department of Interior, Forest Service, Intermountain Region, Humboldt National Forest, 36-Oct.91.

Ingraham, N., and J. Chapman. 1989. Stable isotope feasibility study of Lehman Caves, Great Basin National Park, Nevada. Unpublished research proposal on file in Great Basin National Park, Baker, Nevada.

Jacobs, R.W., P.O. Nelson, and G.L. Larson. 1993. Chemical characteristics of surface waters of Great Basin National Park. Final Report to Great Basin National Park. Cooperative Park Studies Unit, Oregon State University, Corvallis. 26 pages.

James, J.W. 1987. Climate of Lehman Caves, Nevada. Climatological Summary by the Office of the Nevada State Climatologist. 4 pages.

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications - a review. Journal of Range Management 37:430-438.

Kauffman, J.B., W.C. Krueger, and M. Vavra. 1983. Impacts of cattle on streambanks in Northeastern Oregon. Journal of Range Management 36:683-685.

Kluender, S.E. 1983. Mineral investigation of the Wheeler Peak Road-less Area, White Pine County, Nevada. U.S. Bureau of Mines Open File Report MLA 56-83.

Kondolf, G.M., J.W. Webb, M.J. Sale, and T. Felando. 1987. Basic hydrologic studies for assessing impacts of flow diversions on riparian vegetation: Examples from streams of the eastern Sierra Nevada, California, USA. Environmental Management 11:757-769.

Lange, A.L. 1958. Stream piracy and cave development along Baker Creek, Nevada. Bulletin 1, Western Speleological Institute, Santa Barbara, California. 20 pages + illustrations.

Laws, E.A. 1981. Aquatic Pollution. John Wiley and Sons, New York. 482 pages.

Leonard, S., G. Staidl, J. Fogg, K. Gedhardt, W. Hagenbuck, and D. Prichard. 1992. Riparian area management: Procedures for ecological site inventory - with special reference to riparian-wetland sites. TR 1737-7. U.S. Department of Interior, Bureau of Land Management Service Center, Denver, Colorado. 137 pages.

Loundenslager, E.J., and G. Gall. 1980. Biochemical systematics of Nevada trout populations. Final Report to Nevada Department of Wildlife, Reno, Nevada. 79 pages.

MacArthur, R.H., and E.O. Wilson. 1967. An equilibrium theory of island biogeography. Princeton University Press, Prrinceton, New Jersey.

MacDonald, L, A. Smart, and R. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. U.S. Environmental Protection Agency EPA 910/9-91-001, Seattle, Washington. 166 pages.

Madsen, D.B., and D. Rhode. 1990. Early Holocene pinyon *(Pinus monophylla)* in the northeastern Great Basin. Quaternary Research 33:94-101.

Magnum, F.A. 1976. Annual water quality report for Lehman Creek, Humboldt National Forest. Water Quality Lab, Provo, Utah. 214 pages.

Martin, M.A., and D.K. Shiozawa. 1982. The electrophoresis of isolated trout populations from selected Utah streams. Final Report to Utah Division of Wildlife Resources, Salt Lake City, Utah. 27 pages.

McLean, J.S. 1976. Factors altering the microclimate of Carlsbad Caverns, New Mexico. U..S. Geological Survey Open-File Report 76-171. 56 pages.

Meehan, W.R., F.J. Swanson, and J.R. Sedell. 1977. Influences of riparian vegetation on aquatic ecosystems with particular references to salmonid fishes and their food supply. Pages 137-145 *in* R.R. Johnson and D.A. Jones, editors. Importance, Preservation and Management of Riparian Habitats: A Symposium. U.S. Department of Agriculture, Forest Service General Technical Report RM-43. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Melwik, J.M., and J.L. Stoddard. 1991. Sierra Nevada, California. Chapter 15 *in* D.F. Charles, editor. Acidic Deposition and Aquatic Ecosystems - Regional Case Studies. Springer-Verlag, New York.

Metcalf, R.C., G.D. Merritt, M.A. Stapanian, J.R. Baker, and K.M. Peres. 1989. Chemistry of selected lakes and streams in Great Basin National Park, Nevada during winter and spring 1989. Draft Report, EPA Contract No. 68-03-3249. Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nevada. 43 pages + appendices.

Meyer, M.D., and L.C. Reynolds. 1987. Great Basin National Park water right assessment, Nevada Department of Conservation and Natural Resources, Division of Water Planning.

Minshall, G.W., S.E. Jensen, and W.S. Platts. 1989. The ecology of stream and riparian habitats of the Great Basin Region: A community profile. U.S. Fish and Wildlife Service Biological Report 85(7.24). 142 pages.

Miller, E.L., and S.P. Grier. 1993. Geologic map of Lehman Caves Quadrangle, White Pine County, Nevada. U.S. Geological Survey Open-File Report 93-209.

Morrison, R.B. 1965. Quaternary geology of the Great Basin. Pages 265-285 *in* H. E. Wright, Jr., and D. G. Frey, editors. The Quaternary of the United States. VII Congress of the International Association for Quaternary Research. Princeton University Press, Princeton.

Murray, K.J., and S.D. Smith. 1990. Analysis and characterization of riparian vegetation in Great Basin National Park. Proposal to the National Park Service prepared at the University of Nevada, Las Vegas. 16 pages.

Murray, K., S.D. Smith, F.H. Landau, and A. Sala. In Prep. Analysis and characterization of woody riparian vegetation in Great Basin National Park. Great Basin National park, Baker, Nevada.

National Park Service. 1988. Hydrologic characterization and inventory of water rights, uses and requirements at Great Basin National Park, Nevada. Water Resources Division, Water Rights Branch, Fort Collins, Colorado.

National Park Service. 1991. Scoping report: Great Basin National Park water resources management plan. Technical Report NPS/NRWRD/NRTR-91/05. U.S. Department of Interior, National Park Service, Washington, D.C. 11 pages.

National Park Service. 1991. NPS-77: Natural resources management guideline. U.S. Department of Interior, National Park Service, Washington, D.C. 609 pages + appendices.

National Park Service. 1993. Final general management plan, development concept plans, and environmental impact statement for Great Basin National Park, Nevada. Great Basin National Park, Baker, Nevada. 433 pages.

Nelson, P, and R.W. Jacobs. 1993. An assessment of several water-quality issues in Great Basin National Park and recommended actions for addressing these issues. Final Report. Cooperative Park Studies Unit, Oregon State University, Corvallis. 11 pages.

Nevada Department of Conservation and Natural Resources, Division of Water Resources and Water Planning, 1988. Hydrographic Basin Statistical Summary, Ground Water Basins 001-232.

Nevada Department of Conservation and Natural Resources, Division of Water Resources, 1991. Nevada Water Laws, Title 48-Water, Chapters 532 to 538, 540, 543, and 544.

Nevada Department of Wildlife. 1988. Johnson and Baker lake status and trend inventory conducted by Richard L. Haskins II, Gene Weller, and Micah Weller on August 2-4, 1988. Ely District, Nevada Department of Wildlife, Ely, Nevada. 5 pages.

Nevada Department of Wildlife. 1989. Trip report by Richard L. Haskins II for Job 208-1991 White Pine County. Ely District, Nevada Department of Wildlife, Ely, Nevada. 1 page.

Nevada Department of Wildlife. 1990a. Baker Creek population. Report prepared by Rich Haskins of a fish population survey conducted on July 19-20 and August 8, 1990. Ely District, Nevada Department of Wildlife, Ely Nevada. 14 pages.

Nevada Department of Wildlife. 1990b. Lehman Creek population. Report prepared by Rich Haskins of a fish population survey conducted on July 18 and August 7, 1990. Ely District, Nevada Department of Wildlife, Ely Nevada. 12 pages.

Nevada Department of Wildlife. 1990c. Snake Creek population. Report prepared by Rich Haskins of a fish population survey conducted on July 16-17 and August 8, 1990. Ely District, Nevada Department of Wildlife, Ely Nevada. 10 pages.

Osborn, G. 1990. The Wheeler Peak cirque and glacier/rock glacier. Report to Great Basin Natural History Association, Baker, Nevada.

Pfaff, K. 1991. Overview and procedures for monitoring pH and conductivity of surface water in Great Basin National Park. Draft Report. Great Basin National Park, Baker, Nevada. 49 pages.

Platts, W.S. 1979. Including the fishery system in land planning. U.S. Department of Agriculture, Forest Service General Technical Report INT-60.

Platts, W.S. 1990. Managing fisheries and wildlife on rangelands grazed by livestock: A guidance and reference document for biologists. Don Chapman Consultants, Boise, Idaho. 433 pages.

Platts, W.S., W.F. Megahan, and G.W. Minshall. 1983. Methods for evaluating stream, riparian, and biotic conditions. U.S. Department of Agriculture, Forest Service General Technical Report INT-138. 70 pages.

Platts, W.S., C. Armour, G.D. Booth, M. Bryant, J.L. Bufford, P. Cuplin, S. Jensen, G.W. Lienkaemper, G.W. Minshall, S.B. Monsen, R.L. Nelson, J.R. Sedell, and J.S. Tuhy. 1987. Methods for evaluating riparian habitats with applications to management. U.S. Department of Agriculture, Forest Service General Technical Report INT-221. 177 pages.

Powell, D., and H. Klieforth. 1989. Weather and climate. Pages 3-26 *in* C. Hall, editor. The Natural History of the White-Inyo Range, Eastern California. University California Press, Berkeley.

Prudic, D.E., J.R. Harrill, J.R., and T.J Burbey. 1993. Conceptual evaluation of regional ground-water flow in the carbonate-rock province of the Great Basin, Nevada, Utah, and adjacent states. U.SGS Open file report 93-170 (Revision of open-file report 90-560). 103 pages.

Rail, C.D. 1989. Groundwater Contamination: Sources, Control, and Preventive Measures. Technomic Publishing Co., Inc., Lancaster, Pennsylvania. 139 pages.

Ralston, G.L. 1968. The occurrence of mammals in Lehman Caves. Pages D-1 to C-4 *in* Final Report on Lehman Caves Studies. Contract Report to U.S. Department of Interior, National Park Service. Desert Research Institute, Reno, Nevada.

Ray, GA, and W.F. Megahan. 1978. Measuring cross sections using a sag tape: A generalized procedure. U.S. Department of Agriculture, Forest Service General Technical Report INT-47. 12 pages.

Rinne, J.N. 1988. Grazing effects on stream habitat and fishes: Research design considerations. North American Journal of Fisheries Management 8:240-247.

Roath, L.R., and W.C. Krueger. 1982. Cattle grazing influence on a mountain riparian zone. Journal of Range Management 35:100-104.

Rush, E.F., and S.A. Kazmi. 1965. Water resources appraisal of Spring Valley, White Pine and Lincoln counties, Nevada. Nevada Departament of Conservation and Natural Resources, Ground-water Resources Reconnaissance Series, Report 33. 36 pages.

Schneiter, R. W., E. J. Middlebrooks, and R. Sletten. 1984. Wastewater lagoon sludge characteristics. Water Research 18(7):861-864.

Sheldon, A. L. 1979. Stonefly (Plecoptera) records from the Basin ranges of Nevada and Utah. Great Basin Naturalist 39:289-292.

Starkweather, P. 1990. Zooplankton community structure of high elevation ponds: biogeographic and predator-prey interactions. Verh. Internat. Verein. Limnol. 24:513-517.

Society for Range Management. 1992. Policy and position statements. Trailboss News (December):4-5.

Sorensen, E.M. 1991. Metal Poisoning in Fish. CRC Press, Boca Raton, Florida. 374 pages.

Theurer, F.D., K.A. Voos, and W.J. Miller. 1984. Instream water temperature. U.S. Fish and Wildlife Service Information Paper 16. 400 pages.

Thompson, R.S. 1990. Late Quaternary vegetation and climate in the Great Basin. Pages 200-239 *in* J. B. Getancourt et al., editors. Packrat middens--The last 40,000 years of biotic change. University of Arizona Press, Tucson.

Thompson, R.S., and J.I. Mead. 1982. Late Quaternary environments and biogeography in the Great Basin. Quaternary Research 17:39-55.

Tiedemann, A.R., D.A. Higgins, T.M. Quigley, H.R. Sanderson, and D.B. Marx. 1987. Responses of fecal coliform in streamwater to four grazing strategies. Journal of Range Management 40:322-329.

Tueller, P.T., N.L. Archbold, S.A. Bamberg, H.E. Klieforth, F.A. Ryser Jr., A. McLane, D. Fowler, and I. Sack. Undated. An evaluation of the research possibilities of the Snake Range in Eastern Nevada. Report by an Ad Hoc Faculty Committee of the University of Nevada, Reno. 46 pages.

U.S. Department of Agriculture. 1976. National Range handbook, as amended. Soil Conservation Service, Wahington, D.C.

U.S. Department of Agriculture, Forest Service. 1986. Draft supplement to the final environmental impact statement for the Humboldt National Forest Land and Resource Management Plan. Humboldt National Forest, Elko, Nevada.

U.S. Department of Agriculture, Forest Service. 1991. Aquatic ecosystem inventory - Macroinvertebrate analysis. Annual Prograss Report. U.S. Forest Service, Intermountain Region, Humboldt National Forest, Elko, Nevada.

U.S. Department of Agriculture, Soil Conservation Service. 1992. Soil survey of Great Basin National Park, Nevada. 197 pages + unnumbered tables and maps.

U.S. Geological Survey. 1960. Compilation of records of surface waters of the United States through September 1950. Part 10. The Great Basin. U.S. Geological Survey Water Supply Paper 1314.

U.S. Geological Survey. 1963. Compilation of records of surface waters of the United States, October 1950 to September 1960. Part 10. The Great Basin. U.S. Geological Survey Water Supply Paper 1734.

U.S. Geological Survey. 1991. Mineral Resources Data System (MRDS) records for the southern Snake Range, White Pine County, Nevada. U.S. Geological Survey Minerals Information Office, Reno, Nevada.

Unrau, H.D. 1990. A history of Great Basin National Park, Nevada. Historic Resource Study, U.S. Department of Interior, National Park Service, Washington, D.C. 690 pages.

Von Wernstedt, L. 1906. Report on the proposed Ely, Steptoe, Osceola, and Snake National Forests, Nevada. General Land Office, Division "R," National Forests, Nevada, Record Group 49. Records of the Bureau of Land Management, National Archives and Records Administration, Washington, D.C. (as cited in Unrau 1990).

Wells, P.V. 1983. Paleobiology of montane islands in the Great Basin since the last glaciopluvial. Ecological Monographs 53:341-382.

Wells, P.V., and R. Berger. 1967. Late Pleistocene history of coniferous woodland in the Mojave Desert. Science 155:1640-1647.

Wheeler, J., and G.C. Wheeler. 1968. Invertebrates found in Lehman Caves. Pages C-1 to C-4 *in* Final Report on Lehman Caves Studies. Contract Report to U.S. Department of Interior, National Park Service. Desert Research Institute, Reno, Nevada.

Whitebread, D.H. 1969. Geologic map of the Wheeler Peak and Garrison Quadrangles, Nevada and Utah. U.S. Geologic Survey, Miscellaneous Geologic Investigations, Map I-578.

Wilcox, B.A. 1980. Insular ecology and conservation. Pages 95-117 *in* M. Soule and B. Wilcox, editors. Conservation Biology-An Evolutionary-Ecological Perspective. Sinauer Associates, Sunderland, Massachussets.

Wissmar, R.C., and F.J. Swanson. 1990. Landscape disturbances and lotic ecotones. Pages 65-89 *in* R. J. Naiman and H. Decamps, editors. The Ecology and Management of Aquatic-Terrestrial ecotones. UNESCO, Paris, and Parthenon Publishing Group, Carnforth, United Kingdom.

APPENDICES

Appendix 1. List of preparers and acknowledgments.

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Figure 3 is an adaptation of the official map of Great Basin National Park, originally prepared by the National Park Service's Division of Publications. The cover graphic has been provided through the courtesy of Nevada Senator Richard Bryan and is used by the park with Senator Bryan's permission.

Appendix 2. Planning Objectives for Great Basin National Park as stated in the General Management Plan adopted in 1993.

Manage the park to maintain the greatest degree of biological diversity and ecosystem integrity within the provisions of the authorizing legislation.

Eliminate or mitigate any impacts that threaten biological resources.

Determine the extent of plant and animal diversity, monitor the changes that are occurring, and identify the sources of change; eliminate or mitigate any identified adverse impacts, recognizing that native populations fluctuate naturally.

Monitor and evaluate biological diversity in relation to the influences of major climatic and environmental change, particularly those caused by man.

Protect threatened, endangered, and endemic species and restore them within their natural ranges.

Manage the grazing program to minimize effects on natural processes; adhere to the best range management practices, with an emphasis on protecting sensitive species.

Determine the natural role of wildland fire in the South Snake Range ecosystem, and manage the park to restore and maintain this process.

Develop a fire management plan.

Maintain the pristine quality of air, water, geologic, and scenic resources in the park.

Establish a baseline to determine resource conditions, monitor changes, and identify. sources of change; eliminate or mitigate any human-caused impacts that threaten abiotic and scenic park resources.

Restore previously disturbed and abandoned areas (site of mining activity, undesignated roads and trails, etc.) to natural conditions.

Continue to allow actions associated with valid existing mineral rights under regulated conditions as long as there is no direct or indirect impact on exceptional resource values; if such actions are determined to be detrimental to exceptional resource values, notify and petition Congress for the funds to acquire the mineral estate.

Maintain an adequate supply of potable water to meet the present and future needs of park visitors and management.

Protest water right applications by others that may impact park water rights, water resources and related attributes. Participate in general water right adjudications involving streams within the park.

Preserve and protect caves and cave systems in the park.

Identify, inventory, and classify caves and cave systems, and eliminate or mitigate impacts on cave resources.

Avoid potentially harmful development in, above, or adjacent to caves unless it can be demonstrated that such development would not significantly affect natural cave conditions.

Minimize the adverse visual impacts of human activity on the Snake and Spring valleys through active, early consultation with government agencies and private interests; eliminate or mitigate the effects of any development or activity within the park boundary that intrudes on visitors' views of the park's scenic resources.

Allow only those recreational activities that contribute to understanding and appreciation of the park's resources and only to the extent that natural, cultural, and scenic values are not impaired.

Provide recreation information about other public lands in the region for visitors wishing to participate in high-impact activities or activities that are otherwise incompatible with the NPS mission.

Establish and maintain a broad spectrum of management zones and subzones to avoid limiting visitor use to the extremes of "paved and primeval."

Develop an interpretive initiative, including facilities, programs, and activities, that makes Great Basin National Park the primary area for interpreting the theme of the Great Basin physiographic region.

Provide strategically located orientation media that meets the information needs of visitors.

Design an interpretive operation that recognizes and serves a wide range of visitors, including special populations.

Provide some interpretive programs and media designed to foster active visitor involvement.

Provide programs and media that heighten visitor awareness of the interrelationships of people and their environment; encourage a higher degree of personal responsibility for environmental concerns.

Preserve and interpret selected cultural resources that best illustrate significant aspects of the park's history and prehistory.

Encourage concessioner to market items that enhance visitor understanding and appreciation of the Great Basin's ecosystem and history.

Provide a sense of anticipation for visitors before they reach the park.

Design a park entry and associated road corridor that contribute aesthetically to the park experience and to the learning experience of each visitor.

Encourage the production and distribution of previsit information materials in the region that encourage visitors to discover the park and prepare them to visit this remote area.

Locate NPS management facilities outside park boundaries whenever the management functions can be adequately supported from such locations.

Work with local communities and assist them in meeting community goals.

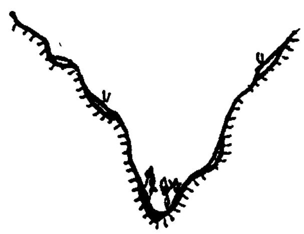
Work with adjacent communities to help them maximize economic benefits.

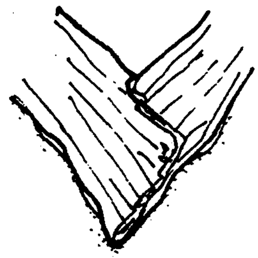
Appendix 3. Water quality standards for Class A Waters of the State of Nevada (Nevada Statutes 445.122).

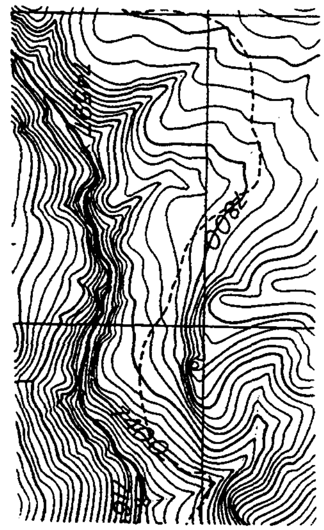
Item	Specifications
Floating solids, sludge deposits, tastes or odor-producing substances.	None attributable to man's activities.
Sewage, industrial wastes or other wastes.	None.
Toxic materials, oils, deleterious substances, colored or other wastes.	None.
Settleable solids.	Only amounts attributable to man's activities which will not make the waters unsafe or unsuitable as a drinking water source or which will not be detrimental to aquatic life or for any other beneficial use established for this class.
pH.	Range between 6.5 to 8.5.
Dissolved oxygen.	Must not be less than 6.0 milligrams/liter.
Temperature.	Must not exceed 20°C. Allowable temperature increase above natural receiving water temperature: None.
Fecal coliform.	The fecal coliform concentration based on a minimum of 5 samples during any 30-day period, must not exceed a geometric mean of 200 per 100 milliliters nor may more than 10 percent of total samples during any 30-day period exceed 400 per 100 milliliters.
Total phosphate.	Must not exceed 0.15 mg/1 in *any* stream at the point where it enters any reservoir or lake, nor 0.075 mg/1 in any reservoir or lake, nor 030 mg/1 in streams and other flowing waters.
Total dissolved solids.	Must not exceed 500 mg/1 or one-third above that characteristic of natural conditions (whichever is less).

Appendix 4. Fluvial valley segment types of Great Basin National Park based on Frissell and Liss (1993).

The illustrations and summaries of valley segment types that follow constitute Appendix 3. Each figure includes a typical transverse cross section of the valley form and vegetation (drafted from field notes and not to scale), an oblique sketch depicting landform arrangement and channel pattern, and an example of the valley segment type from a topographic quadrangle (scale of 1:24,000, contour interval of 40 feet). Unless otherwise stated, data are derived from field surveys in Great Basin National Park. Geology is based on Whitebread (1969). Surface hydrology indicates whether surface flow within segments is typically gaining, steady, or losing in a downstream direction. Losing reaches reflect flow loss to evapotranspiration and groundwater, and gaining reaches reflect emergence of groundwater at the surface (Kondolf et al. 1987). Bank stability is measured as the proportion of sampled reaches in which some banks were actively or recently eroded and not vegetated. Inclusions refer to other valley forms that sometimes occur as short reaches (< 100 m) within mapping units.







<u>BRC Competent Bedrock Canyon</u>

Geomorphic Description: Fluvially incised, steep-sloped canyon in competent bedrock; floodplain absent, or few very small alluvial benches. Floored with resistant bedrock and/or coarse alluvial lag deposits.

Valley Slope: 7-28%, median 18%.

Landscape Position: Near headwater areas of mountains, and at lower elevations where streams incise outcrops of highly resistant rock.

Elevation Range: >2300m.

Geology: Associated with Precambrian quartzite and argillite, and harder units of the Pole Canyon limestones.

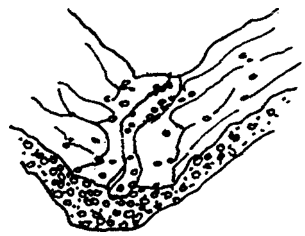
Surface Hydrology: Steady (many are dry).

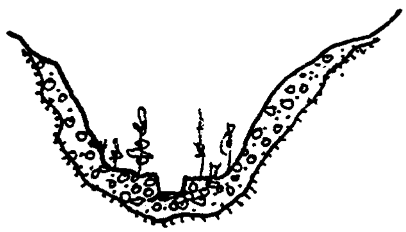
Channel Pattern: Straight.

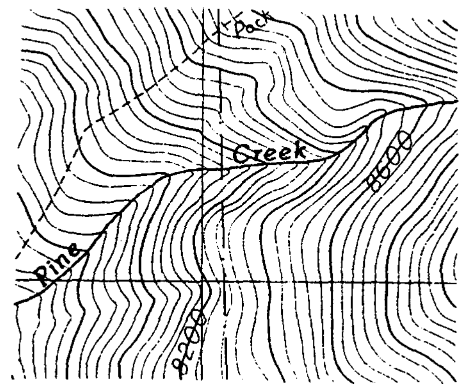
Channel Substrate: Boulder and cobble lag, or bedrock. Bank

Stability: Stable, no active bank erosion.

Inclusions: Occasional ACB, ACG







<u>ABC Alluviated Canyon. Boulder-Bedded</u>

Geomorphic Description: Fluvially incised, steep-sloped canyon with narrow, discontinuous floodplains. Valley floor <50m wide. Formed by alluvial re-working of debris flow, flash flood deposition and/or coarse alluvial lag from slope erosion sources.

Valley Slope: 6-32%, median 14%.

Landscape Position: Near headwater areas of mountains, and at lower elevations where channels bifurcate resistant rock formations.

Elevation Range: 2200-3300m.

Geology: Occurs in most rock types, most common in quartzite and massive limestone formations that tend to generate large weathering clasts.

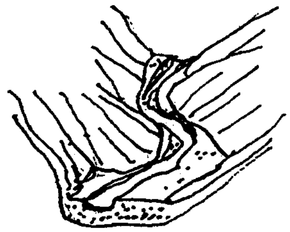
Surface Hydrology: Highly variable, gaining and losing reaches about equal. Channel

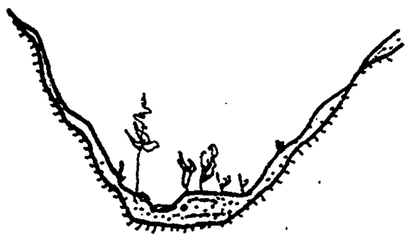
Pattern: Straight or slightly sinuous.

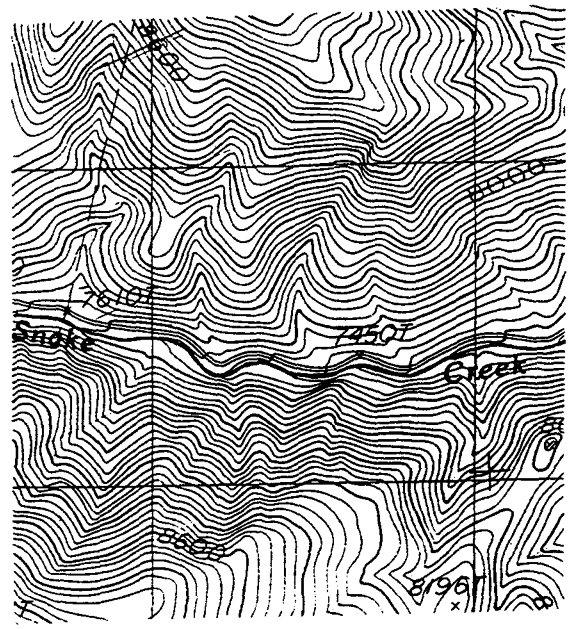
Channel substrate: Boulder and cobble lag.

Bank Stability: Stable, only 14% of reaches had active bank erosion. Inclusions:

Occasional IMV, ACG, BRC.







ACG Alluviated Canyon. Gravel- and Cobble-Bedded

Geomorphic Description: Fluvially incised, steep-sloped canyon with narrow, discontinuous floodplains. Valley floor <50m wide. Formed by alluvial deposition and transport through confined canyons.

Valley Slope: 4-31%, median 10%.

Landscape Position: Near headwater areas of mountains, and at lower elevations where channels bifurcate resistant rock formations.

Elevation Range: 2200-3100m.

Geology: Occurs in most rock types

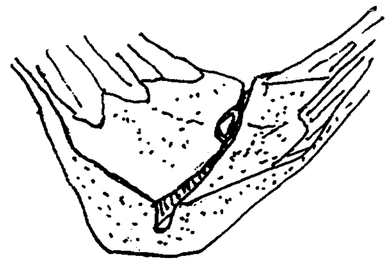
Surface Hydrology: Highly variable, tending to be dominated by losing reaches. Channel Pattern:

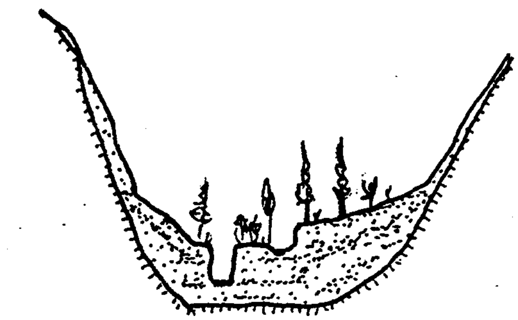
Straight or slightly sinuous.

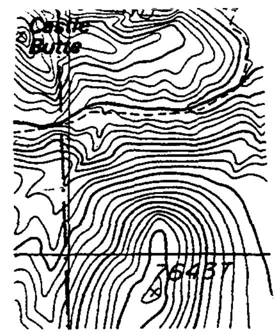
Channel Substrate: Alluvial cobbles and gravels.

Bank Stability: Moderately unstable, 40% of reaches had active bank erosion. Inclusions:

Occasional ACB, BFC.







BFC Bajada-Filled Canyon

Geomorphic Description: Fluvially incised, steep-sloped canyon filled with alluvial aprons or coalesced alluvial fans formed largely from surface and rill erosion on adjacent slopes. Small but active bajadas and fans encroach on and constrain channel. Floodplains and side channels occur, but are narrow and discontinuous. Valley floor <50 m wide.

Valley Slope: 3-12%, median 5%.

Landscape Position: Occur in canyons where surface erosion on adjacent slopes is very rapid and a thick mantle of alluvium develops in lower slope positions.

Elevation Range: 2200-2400m.

Geology: To date mapped only in Lincoln Peak Formation, a thin-bedded, shaley limestone. Surface

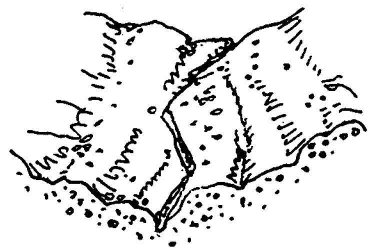
Hydrology: Strongly dominated by losing reaches.

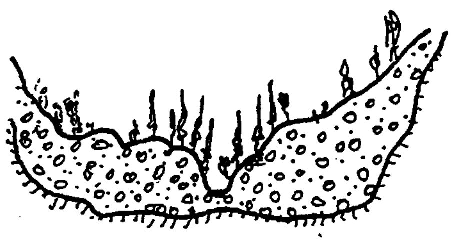
Channel Pattern: Straight or slightly sinuous.

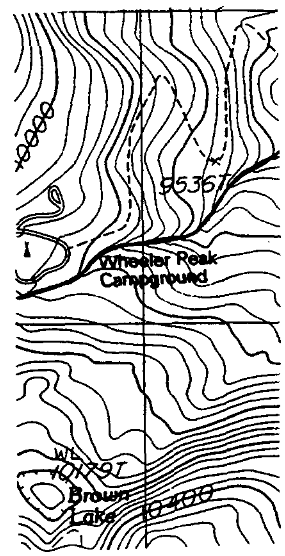
Channel Substrate: Sandy and gravelly alluvium, highly unstable bed.

Bank Stability: Extremely unstable, all reaches surveyed had actively eroding banks. Inclusions:

Occasional ACG, AFV.







<u>IMV Incised Moraine-filled Valley</u>

Geomorphic Description: Glacial moraine deposits dissected by deeply incised, boulder-bedded channel. Very narrow and discontinuous or nonexistent floodplains. Valley floor > 50m wide. Formed by fluvial incision into coarse-textured glacial deposits.

Valley Slope:9-20%, median 12%.

Landscape Position: Upper portions of glacially-shaped valleys. Elevation

Range: 2700-3300 m.

Geology: Occur in glaciated basins of granitic geology (quartz monzonite or quartzite), where glacial moraines are dominated by coarse-textured till.

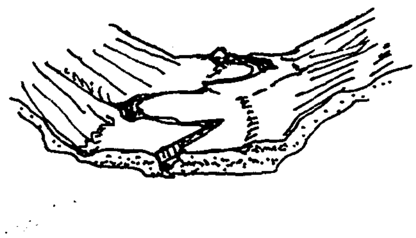
Surface Hydrology: Mostly steady. Small seeps common. Channel

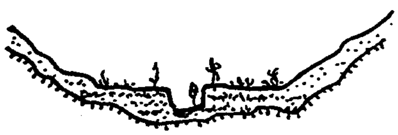
Pattern: Straight or slightly sinuous.

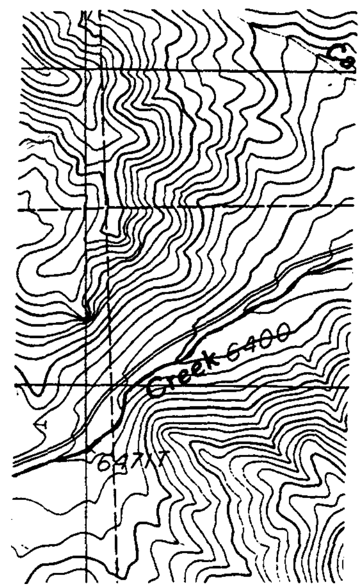
Channel substrate: Boulder-cobble lag.

Bank Stability: Very stable, no active bank erosion. Inclusions:

Common LOV.







<u>TBV Terrace-Bound Valley</u>

Geomorphic Description: Fluvially incised alluvial terraces. Valley floor >50m wide. Floodplains very narrow and discontinuous, confined between high terraces. Possibly indicative of uplifted or tectonically deformed alluvial valleys.

Valley Slope: 4-10%, median 5%.

Landscape Position: In mountain valleys, intermingled with alluvial valleys and alluvial-fan-influenced valleys.

Elevation Range: 2000-2700m.

Geology: Quaternary alluvium.

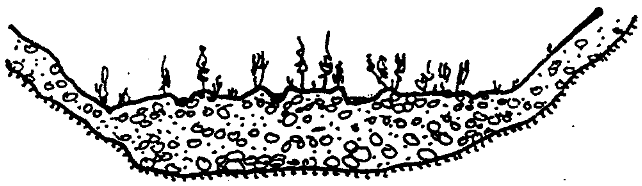
Surface Hydrology: Most reaches steady, net gain in some. Channel

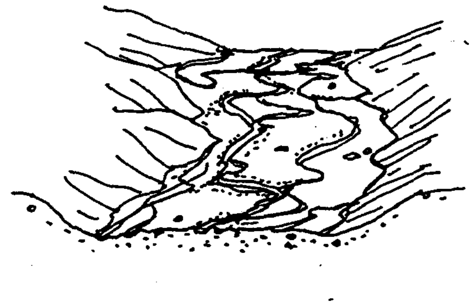
Pattern: Sinuous, occasionally meandering.

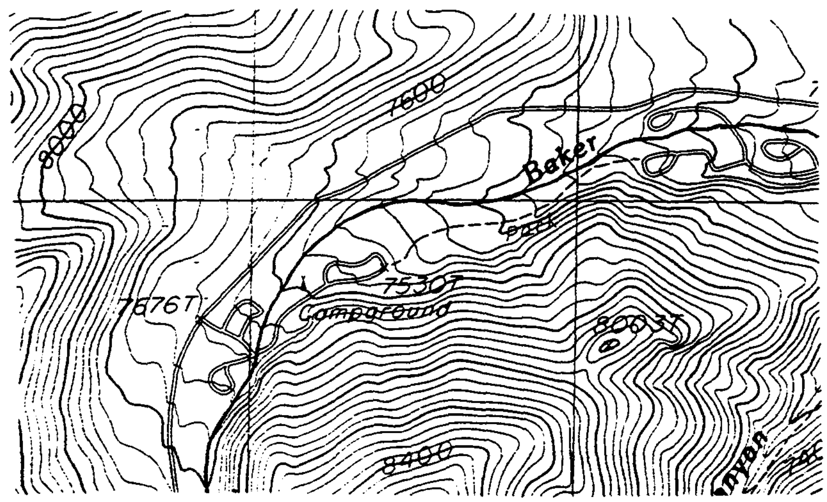
Channel Substrate: Gravelly alluvium.

Bank Stability: Unstable, 52% of reaches had active bank erosion. Inclusions:

Occasional AFV, AV.







LOV Leveed Outwash Valley

Geomorphic Description: Wide, anabranched channel system in glacial outwash or valley train formed by continuous debris flow or flash flood deposits. Valley floor > 50m wide. Valley topography tends toward convex in transverse cross-section, and extensive natural levees and down-valley swales create potential for frequent and unpredictable channel switching.

Valley Slope: 4-16%, median 10%.

Landscape Position: In mountain valleys, below glacial deposits or colluvium-filled hollows. Elevation Range:

2100-3300 m.

Geology: Quaternary alluvium, local glacial moraines. Best developed in basins with extensive alpine glaciation and granitic rock types that produce boulder and cobble-sized clasts.

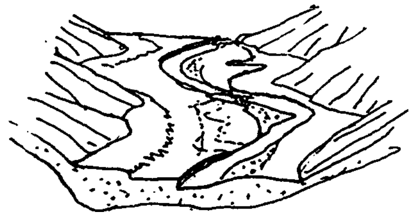
Surface Hydrology: Variable, most steady, more gaining than losing reaches. Frequent spring sources and seeps.

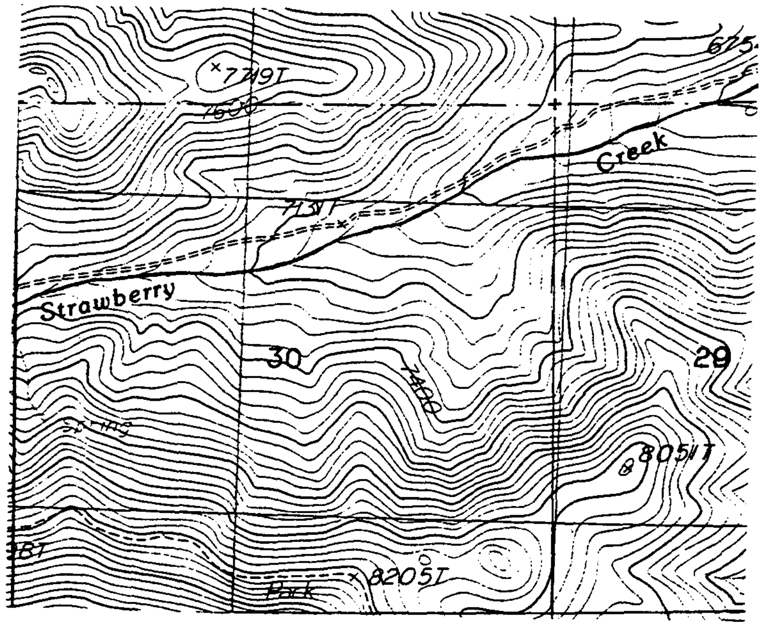
Channel Pattern: Anabranching, multiple active channel threads. Channel

Substrate: Coarse cobble and small boulder lag.

Bank Erosion: Stable, only 12% of reaches had actively eroding banks. Inclusions:

Occasional IMV.





AV Alluvial Valley

Geomorphic Description: Streams with wide, continuous, active floodplains. Terraces and alluvial fans are common, but do not encroach on channel enough to prevent development of expansive floodplains. Valley width >50 m.

Valley Slope: 6-18%, median 6%.

Landscape Position: Alluviated mountain valleys.

Elevation Range: 2100-3000 m.

Geology: Quatemary alluvium.

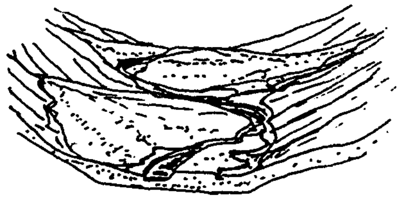
Surface Hydrology: Highly variable, but tends toward net gain.

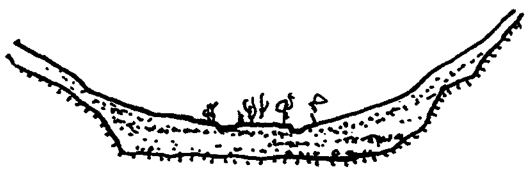
Channel Pattern: Sinuous, occasionally meandering. Seeps and floodplain springs common. Channel Substrate:

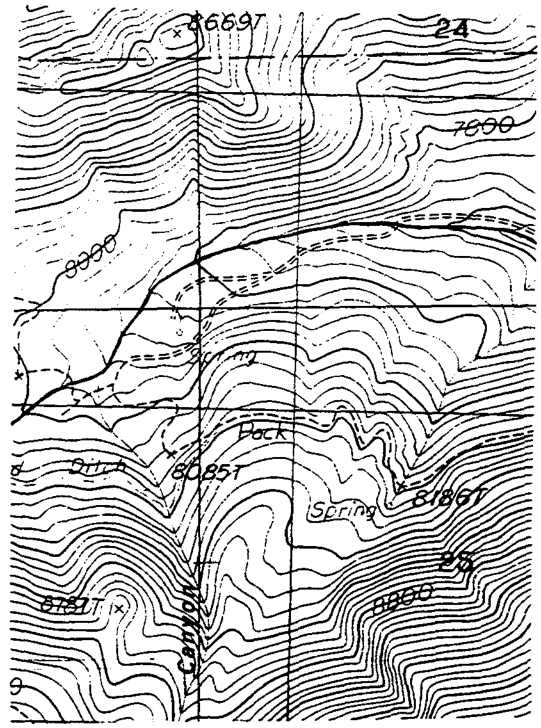
Gravelly alluvium.

Bank Stability: Unstable, 58% of reaches had active bank erosion.

Inclusions: Frequent API and TBV.







<u>AFV Alluvial-Fan-Influenced Valley</u>

Geomorphic Description: Streams tightly hemmed in or partially dammed by laterally encroaching alluvial tributary fans. Valley width >50 m. Floodplains common but variable in width and downstream extent. Complex mosaic of incised fans, floodplain, and terrace landforms.

Valley Slope: 4-14%, median 8%.

Landscape Position: Alluviated mountain valleys. Occasionally mapped in small, headwater basins filled with alluvial fan deposits from adjacent slopes and gully networks.

Elevation Range:2000-3000 m.

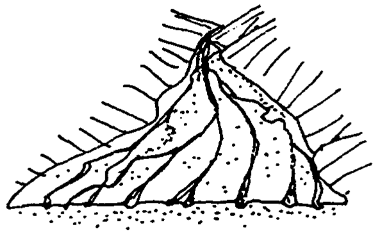
Geology: Quaternary alluvium.

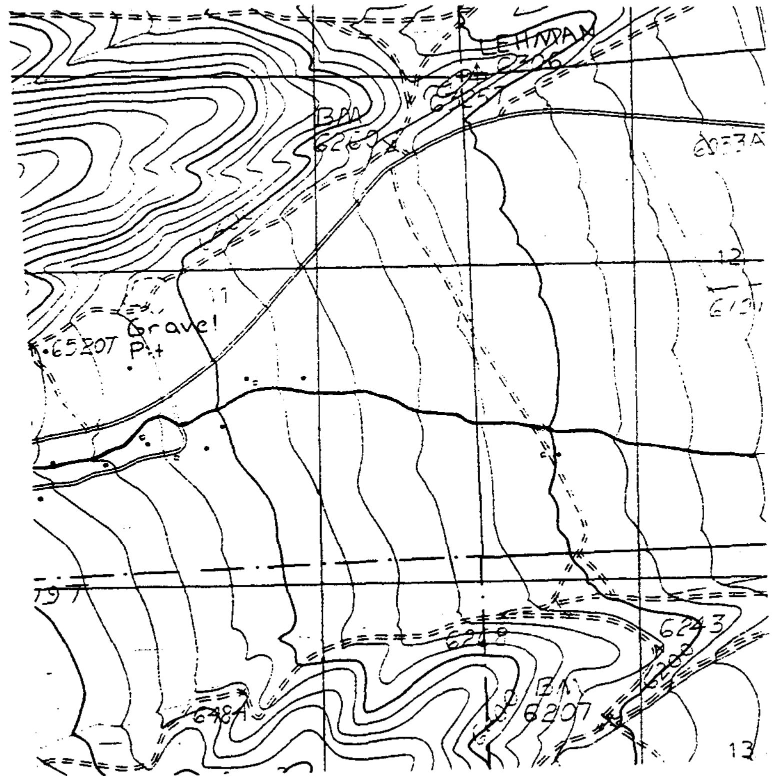
Surface Hydrology: Variable, most reaches steady. Others tend toward net gain. Springs and seeps common, but highly clustered.

Channel Pattern: Sinuous or anabranched, occasionally straight. Channel shifts common. Channel Substrate:

Gravelly and sandy alluvium. Bank Stability: Unstable, 52% of reaches had active bank erosion.

Inclusions: Mapped as "AFV complex," with numerous AV and TBV inclusions comprising up to half of segment length.





AFD Alluvial Fan Delta

Note: This distinctive valley segment type was not sampled in the field because it is located outside of Great Basin National Park boundaries.

Geomorphic Description: Very large, distributary alluvial fans at mouths of mountain valleys. Valley Slope: 5-

15%, estimated median 10% (data from topographic maps).

Landscape Position: Coalescing alluvial fans form expansive aprons between mountain ranges and pluvial lake basins.

Elevation Range:<2600 m on east side of Park, < 2300 m on West side. Geology:

Quaternary and Tertiary alluvium.

Surface Hydrology: Rapidly losing surface flow.

Channel Pattern: Sinuous, divergent or distributary.

Channel Substrate: Gravelly, porous alluvium.

Channel Stability: Channel location and morphology highly unstable, prone to channel switching, gullying, and extensive flash flooding. Almost universally channelized for irrigation diversion and other uses.

Inclusions: None.

Appendix 5. Examples of riparian definitions.

The riparian ecosystem is the transitional area between the aquatic ecosystem and terrestrial ecosystem, identified by soil characteristics and distinctive vegetation communities that require free or unbound water. - U.S. Department of the Interior, Bureau of Land Management

The term riparian is intended to include vegetation, habitats, or ecosystems that are associated with bodies of water or are dependent on the existence of perennial, intermittent, or ephemeral surface or subsurface water drainage.
- Arizona Riparian Council

A riparian area is defined as an aquatic or terrestrial ecosystem that is associated with bodies of water, such as streams, lakes or wetlands, or is dependent upon the existence of perennial, intermittent, or ephemeral surface or subsurface water drainage.
- Arizona Riparian Habitat Task Force

Riparian habitat is land inclusive of hydrophytes and/or with soil that is saturated by ground water for at least part of the growing season within the rooting depth of potential native vegetation. - Minshall et al., 1989

Riparian ecosystems are associated with surface and subsurface drainage systems that include perennial, intermittent, and ephemeral stream channels and ponds, lakes, reservoirs, seeps, springs, and sinks. They are characterized by structural and functional properties of, and interactions between, both aquatic and terrestrial components. These systems are generally physically bounded at a) the terrestrial edge by the uppermost floodplain or the extent of associated lateral groundwater available to vegetation and b) the water's edge as measured during low surface water level or the channel bottom in ephemeral or intermittent streams. Substrates characteristically have hydric or aquic properties and have the potential to support hydrophytic or phreatophytic vegetation. Palustrine wetlands as defined by Cowardin et al. (1979) for the National Wetlands Inventory are considered a subset of riparian ecosystems.
- U.S. Environmental Protection Agency, Environmental Monitoring and Assessment Program (arid lands), 1990

In addition to riparian, several definitions have been formulated at the Federal level to define "wetland" for various laws, regulations, and programs. These major Federal definitions are cited below in reference to their guiding document.

The following definition of wetland is the regulatory definition used by the EPA and US. Army Corps of Engineers (CE) for administering the Section 404 permit program:

> Those areas that are 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 areas.

The following wetland definition is used by the Soil Conservation Service (SCS) for identifying wetlands on agricultural land in assessing farmer eligibility for U.S. Department of Agriculture program benefits under the "Swampbuster" provision of this Act:

> Wetlands are defined as areas that have a predominance of hydric soils and that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in

> saturated soil conditions, except lands in Alaska identified as having a high potential for agricultural development and a predominance of permafrost soils.

The U.S. Fish and Wildlife Service (FWS) in cooperation with other Federal agencies, State agencies, and private organizations and individuals developed a wetland definition for conducting an inventory of the nation's wetlands. This definition was published in the FWS's publication "Classification of Wetlands and Deepwater Habitats of the United States" (Cowardin et. at 1979):

> Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Summary of Federal Definitions

The CE, EPA, and SCS wetland definitions include only areas that are vegetated under normal circumstances, while the FWS definition encompasses both vegetated and nonvegetated areas. Except for the FWS inclusion of nonvegetated areas as wetlands and the exemption for Alaska in the SCS definition, all four wetland definitions are conceptually the same; they all include three basic elements--hydrology, vegetation, and soils--for identifying wetlands.

Appendix 6. Metal concentrations in trout and beetles sampled in lakes of Great Basin National Park (from Metcalf et al. 1989).

	Brook Trout[s]	Cutthroat Trout[s]	Beetle[2]
Lake	Johnson	Baker	Dead
Length	148 mm	273 mm	7mm
Weight	32 g	158 g	0.05 g
Tissue Sampled	3g	4g	0.14 g
Dilution Factor	8.33	6.25	178i
Ca	68,000	120,000	340,000
Mg	29,000	43,000	79,000
Na	120,000	160,000	760,000
K	360,000	240,000	480,000
Fe	2,300	1,900	10,700
Al	580	380	7,900
Sb	not detected	not detected	1,900
As	not detected	not detected	590
Ba	40	360	1,300
Be	not detected	not detected	not detected
Cd	130	30	170
Cr	50	120	390
Co	not detected	not detected	not detected
Cu	550	1,900	17,500
Pb	120	not detected	910
Mn	130	150	3,700
Ni	190	110	1,700
Se	190	1,100	1,200
Ag	30	60	2,100
Th	not detected	not detected	430
V	not detected	44	230
Zn	5,100	5,900	11,300

[t]Fish samples are: liver, kidneys, brain, and parts of two flanks blended in deionized water to 120 ml, then digested according to ICP-MS digestion methods.

[2]Three beetles (Family Gyrinidae), blended in deionized water to 120 ml, then digested according to the ICP-MS digestion methods.

[3]The very large tissue dilution factor indicates the results for the beetles are less reliable quantitatively than those for the fish. This lack of reliability is confirmed by the measured concentrations which sum to more than 1,000,000 micrograms per gram, which is not possible. For this reason, the beetle results are considered semi-quantitative at best.

Appendix 7. Letter from the Director, Western Region, National Park Service to the Nevada Department of Wildlife regarding management of Bonneville cutthroat trout.

NATIONAL PARK SERVICE WESTERN REGION
450 GOLDEN GATE AVENUE, BOX 36063 SAN' FRANCISCO. CALIFORNIA 94102

IN REPLY REFER TO:
N1423 (WR-RN)

February 13, 1987

Mr. William A. Molini
Director
Nevada Department of Wildlife
1100 Valley Road, P.O. Box 10678
Reno, NV 89520-0022

Dear Mr. Molini:

The following are our comments on the Preliminary Nevada Department of Wildlife's Bonneville Cutthroat Trout Species Management Plan. We appreciate the opportunity to respond to this draft document and apologize for the lateness of this response.

The National Park Service would like to cooperate with the Nevada Department of Wildlife and other interested/affected agencies in the implementation of a Bonneville Cutthroat Trout Management Plan. We feel that an interagency plan in which the proposed actions reflect a consensus of goals and objectives of all agencies involved is optimal. As the U.S. Fish and Wildlife Service may propose the listing of this species as "threatened", we would like to see this agency involved at an early date.

Of the five management alternatives proposed in your plan, our preferred alternative for management of the Bonneville trout within Great Basin National Park is a combination of alternatives II and III. Alternative II - Protection of Existing Populations. - is in line with National Park Service goals and management policies on native species populations. Specifically, we strongly support:

II A. the *prohibition* on stocking of competitive or hybridizing salmonid species in streams which currently or potentially will support Bonneville Cutthroat trout,

II B. the protection of trout populations from any adverse effects associated with *mining* activity, livestock use, road development, water diversions or other activities,

II C. restrictive *fishing* regulations, and

III B/C. eradication of competitive or hybridizing salmonid populations with the same stream and in adjacent or closely associated streams.

Eradication of alien species must follow our NPS Integrated Pest Management (IPM) directives which require a detailed plan of action with alternative control methods outlined. While, chemical means of control within NPS units are not prohibited, we do seek other methods if available and feasible. Pesticide use requires approval from the NPS Washington office IPM coordinator along with the above-mentioned plan of action.

Item III-A:
We would be willing to cooperate in stream habitat surveys to determine the status of the fish populations and their environments. According to the NPS Management Policies (1978) we "strive to maintain the natural abundance, behavior, diversity and ecological integrity of native animals" and as such, generally do not support habitat enhancement and/or artificially increasing populations to favor individual species. However, temporary measures carried out as part of a species restoration effort would be acceptable.

Bonneville Cutthroat Trout Activity Program:
Pine and Ridge Creeks, on the western slope of the Snake Range are located outside the historical range of the Bonneville Cutthroat Trout, and contain introduced populations. According to NPS Management Policies (1978), native species which have moved into an area "directly or indirectly as the result of human activities" are not native and therefore not managed as such. In addition, it is not clear whether these trout populations actually occur within the boundaries of Great Basin National Park or are located within the Humboldt National Forest. This will be resolved by the proposed surveys.

Several creeks on the eastern slope of the Snake Range located in Great Basin National Park are within the historical range of the Bonneville Cutthroat Trout. Baker Creek and Lehman-Creek are currently stocked with alien fishes. Although not a part of your preliminary proposal, we strongly support inclusion of these streams, and others within Great Basin National Park which historically supported Bonneville Cutthroat trout populations, in your proposed activity program for future introductions of this species. We will be willing to cooperate with the Nevada Department of Wildlife in this endeavor subject to our availability of funding.

Sincerely,

Howard H. Chapman

Howard H. Chapman
Regional Director, Western Region

cc:
Larry Barngrover, Region II Supt., Great Basin National Park

Appendix 8. Selected management alternatives for Bonneville cutthroat trout (from Haskins 1987).

SELECTED MANAGEMENT ALTERNATIVES

A PROGRAM TO MANAGE AND IMPROVE BONNEVILLE CUTTHROAT TROUT IN NEVADA

BONNEVILLE CUTTHROAT TROUT ACTIVITY PROGRAM

I - Population Protective Measures

A. Stocking prohibition of competitive or hybridizing salmonid species will continue.

B. Input into land use and planning processes to avoid adverse impacts will continue.

C. Protective measures through the fishing season and regulation process will be developed if problems related to angler use are identified.

II - Population Enhancement Measures

A. The identification of habitat problems will be accomplished on a scheduled basis by stream. Habitat problems on streams containing Bonneville Cutthroat trout will be identified and a timetable will be established to implement the necessary actions for improvement. This will be done in cooperation with the land management agencies through the appropriate AMP or HMP planning process. Habitat and population surveys will be scheduled to identify problem areas and to document improvement efforts.

1986 - Habitat and population inventory, Hendries Creek. NDOW/USFS
- Habitat and population inventory, Goshute Creek. NDOW/BLM

1987 - Habitat and population inventory, Hampton Creek. NDOW/USFS/BLM
- Habitat and population inventory, Pine-Ridge Creeks. NDOW/USFS/BLM

B. The eradication of competitive or hybridizing species in streams which currently contain Bonneville Cutthroat trout.

1987 - Eradicate rainbow population below barrier falls, in Hendries Creek. NDOW

C. The eradication of competitive or hybridizing species in streams adjacent to Bonneville Cutthroat trout populations. With follow-up introductions of Bonneville Cutthroat trout.

1987 - Evaluate and if appropriate, initiate steps for approval of the eradication of salmonid species in Board, Shingle, Willard and Williams Creeks, in Spring Valley. NDOW/USFS/BLM

1988 - Eradicate Board, Shingle, Willard and Williams Creeks, in Spring Valley. NDOW

1989 - Confirm eradication efforts, and begin introductions from Pine-Ridge Creeks (or other sources if suitable). NDOW

1990 - Continue introduction efforts. NDOW

1991 - Continue introduction efforts. NDOW

1992 - Continue introduction efforts. NDOW

III - <u>Population Expansion Within The Historic Range of The Bonneville Cutthroat Trout.</u>

A. Introduction of Bonneville Cutthroat trout into streams within its historic range, which are currently occupied by other salmonids. This action will necessitate the eradication of competitive or hybridizing species, and the reintroduction of Bonneville Cutthroat trout.

1988 - Evaluate and if appropriate, initiate steps for approval of the eradication of salmonid species in Big Wash Creek and Smith Creek drainage. NDOW/USFS/BLM

1989 - Eradicate salmonid species in the Smith Creek drainage. NDOW

1990 - Confirm eradication efforts and introduce Bonneville Cutthroat trout. NDOW

1991 - Eradicate salmonid species in Big Wash Creek. NDOW

1992 - Confirm eradication efforts and introduce Bonneville Cutthroat trout. NDOW

IV - <u>Population Expansion Outside Historic Range</u>

A. Introduction of Bonneville Cutthroat trout into barren streams within interior drainage basins of White Pirie County.

1986 - Evaluate summer flows of First, Second, Third and Fitzhugh Creeks, (Schell Creek Range, Steptoe Valley). In conjunction with Goshute Creek survey, secure fish for transplant into Indian Creek (Cherry Creek Range). NDOW/USFS/BLM

1987 - If suitable waterflows are found in First, Second, Third and Fitzhugh Creeks, initiate stocking program with Bonneville Cutthroat trout. NDOW

1988 - Continue introduction efforts. NDOW

1989 - Continue introduction efforts. NDOW

1990 - Continue introduction efforts. NDOW

B. Introduction of Bonneville Cutthroat trout into interior drainage basin streams of White Pine County, which currently contain other salmonid species. (see II - C for additional streams)

1990 - By 1990 select candidate stream for further evaluation of "game fish value", and initiate steps for approval of the eradication of current salmonid species. NDOW/USFS/BLM

1991 - Eradicate competitive of hybridizing species from candidate streams. NDOW

1992 - Confirm eradication and introduce Bonneville Cutthroat trout. NDOW

1993 - Initiate monitoring program to evaluate success. NDOW

Note: The introduction schedule is contingent upon the availability of suitable numbers of pure Bonneville Cutthroat trout. Fish for transplanting will be removed from the lower reaches of streams where periodic losses occur or from streams with known suitable population numbers.