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Operation of Flaming Gorge Dam Final Environmental Impact Statement Executive Summary

U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Region
Salt Lake City, Utah

September 2005

Note to the Reader

This Executive Summary provides an overview of the proposed action analyzed in the Operation of Flaming Gorge Dam Final Environmental Impact Statement (EIS). It is intended to provide a concise report of the proposed action, alternatives, and environmental consequences which are explained and analyzed in detail in the EIS. Because a number of those on the EIS mailing list asked only for a copy of this Executive Summary, it should be noted that if more information is desired, a paper or CD-ROM copy of the EIS is available upon request; contact information is provided in the transmittal letter and in the *Federal Register* Notice of Availability of the EIS. The complete EIS, comments and responses, and appendices are also viewable on the internet. Go to <**www.usbr.gov/uc/**>, click on "Environmental Documents" in the left hand column, and click on "Operation of Flaming Gorge Dam Environmental Impact Statement."

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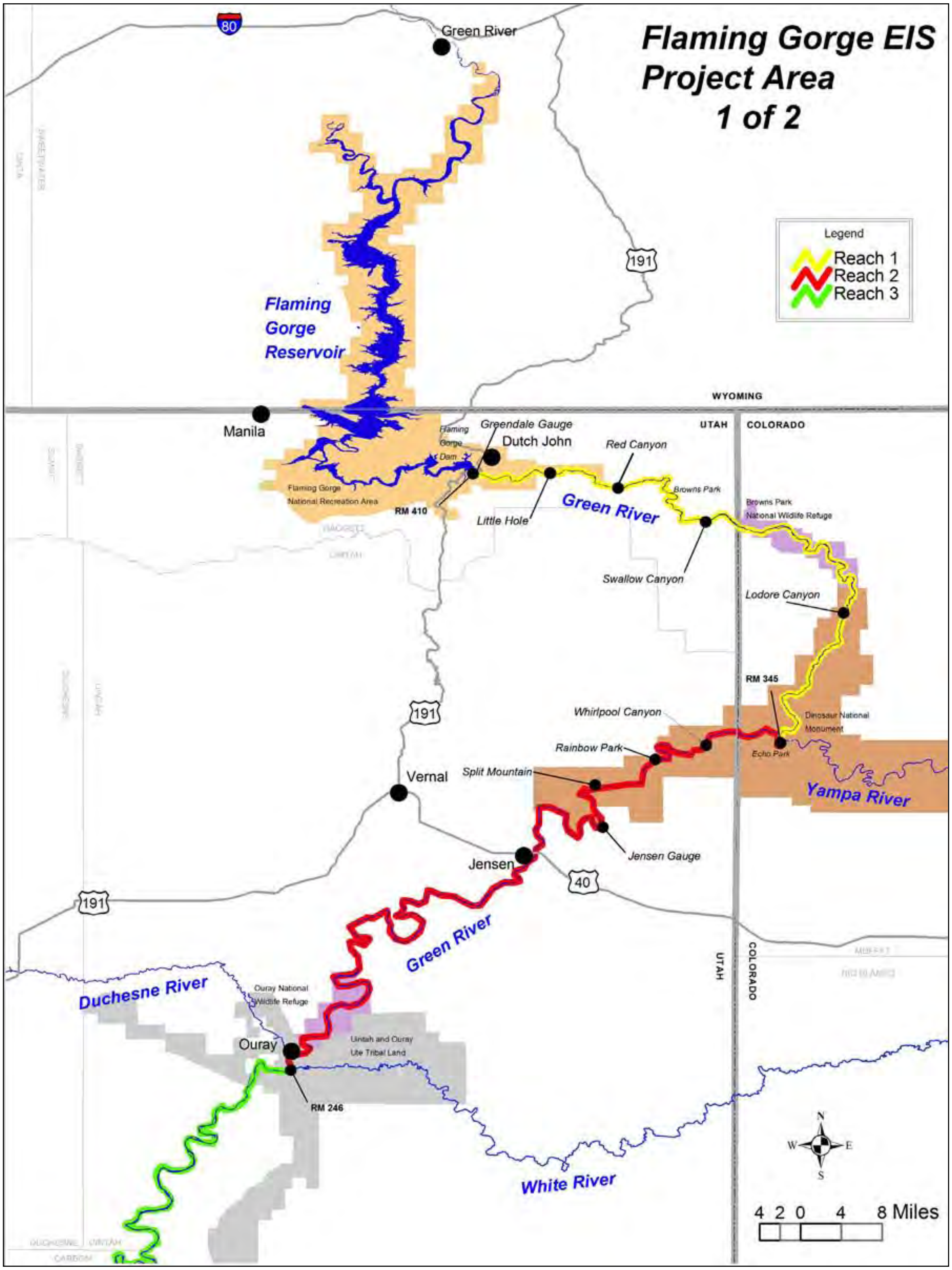
Flaming Gorge EIS
Project Area
1 of 2
Legend
Reach 1
Reach 2
Reach 3
80
Green River
Flaming
Gorge
Reservoir
191
WYOMING
UTAH
COLORADO
Manila
Flaming Gorge Dam
Greendale Gauge
Dutch John
Red Canyon
Browns Park
Flaming Gorge
National Recreation Area
RM 410
Little Hole
Green River
Browns Park
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Swallow Canyon
Lodore Canyon
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Whirlpool Canyon
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Monument
Rainbow Park
Echo Park
Split Mountain
Yampa River
Vernal
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Jensen
40
191
Green River
UTAH
COLORADO
Duchesne River
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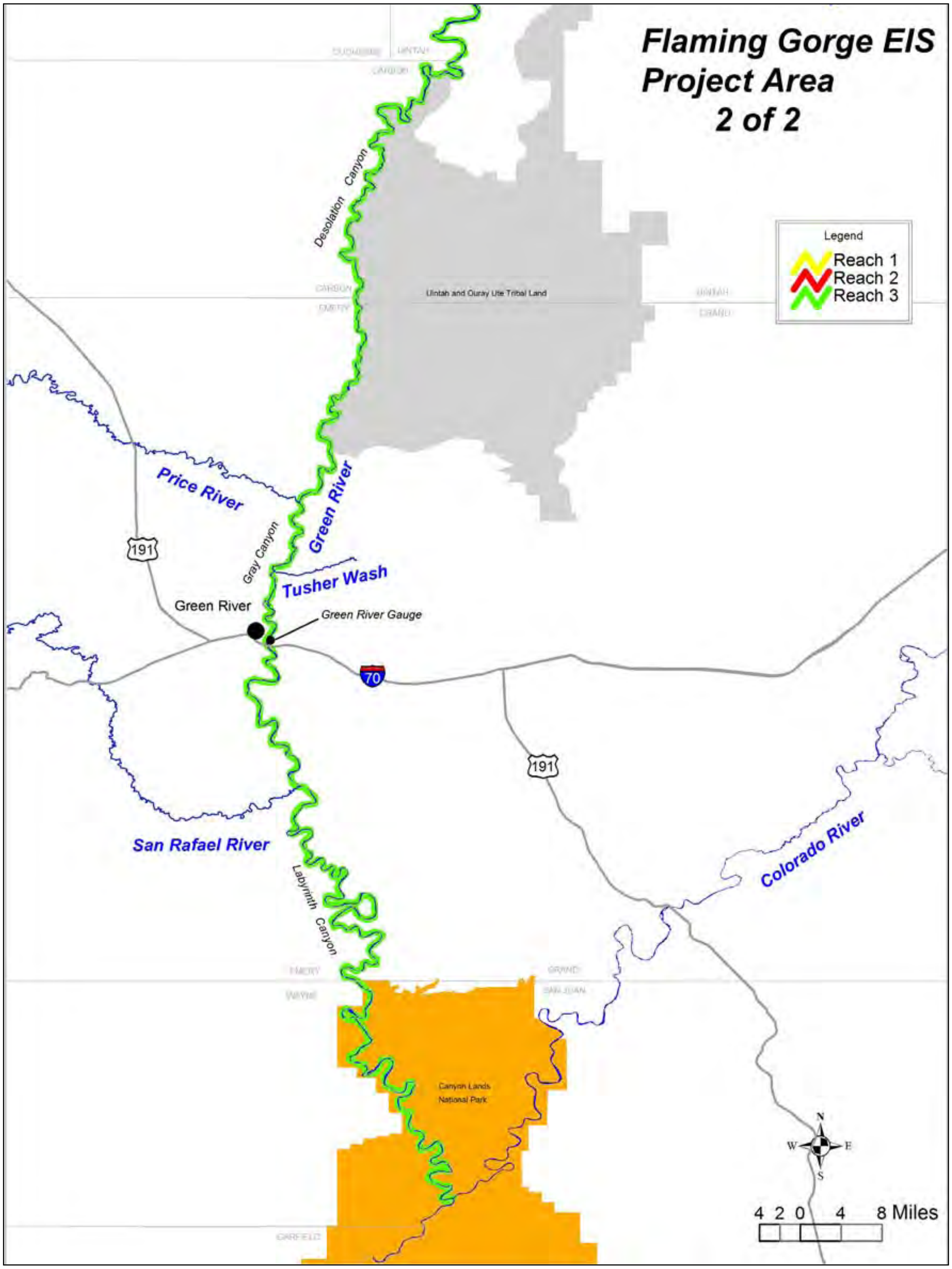

Flaming Gorge EIS
Project Area
2 of 2
Legend
Reach 1
Reach 2
Reach 3
Desolation Canyon
Uintah and Ouray Ute Tribal Land
Price River
Green River
Gray Canyon
Tusher Wash
191
Green River
Green River Gauge
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San Rafael River
Colorado River
Labyrinth Canyon
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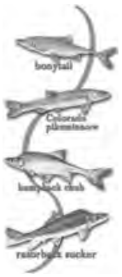

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Executive Summary

S.1 INTRODUCTION

The Secretary of the United States Department of the Interior (Secretary), acting through the Bureau of Reclamation (Reclamation), is considering whether to implement a proposed action under which Flaming Gorge Dam would be operated to achieve the flow and temperature regimes recommended in the September 2000 report *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam* (2000 Flow and Temperature Recommendations), published by the Upper Colorado River Endangered Fish Recovery Program (Recovery Program). The 2000 Flow and Temperature Recommendations specifically describe the peak flows, durations, water temperatures, and base flow criteria recommended to protect and assist in the recovery of endangered fish species.

A final environmental impact statement (EIS), of which this document is an executive summary, has been prepared pursuant to the National Environmental Policy Act of 1969 (NEPA), and the Council on Environmental Quality (CEQ) and Department of the Interior regulations implementing NEPA. The EIS addresses the environmental issues associated with, and analyzes the environmental consequences of, the one action alternative determined to meet purpose and need, as well as a no action alternative.

Reclamation is the lead agency in preparing the EIS. The eight cooperating agencies include the Bureau of Indian Affairs, Bureau of Land Management (BLM), National Park Service, State of Utah Department of Natural Resources, U.S. Fish and Wildlife Service, United States Department of Agriculture Forest Service (USDA Forest Service), Utah Associated Municipal Power Systems, and Western Area Power Administration (Western).

S.2 PROPOSED FEDERAL ACTION AND BACKGROUND

Reclamation proposes to take action to protect and assist in recovery of the populations and designated critical habitat of the four endangered fishes found in the Green and Colorado River Basins (proposed action). The four endangered fish species are Colorado pikeminnow *(Ptychocheilus lucius),* humpback chub *(Gila cypha),* razorback sucker *(Xyrauchen texanus),* and bonytail *(Gila elegans*). Reclamation would implement the proposed action by modifying the operations of Flaming Gorge Dam, to the extent possible, to achieve the flows and temperatures prescribed in the 2000 Flow and Temperature Recommendations. Reclamation's goal is to implement the proposed action and, at the same time, maintain and continue all authorized purposes of the Colorado River Storage Project (CRSP).

S.2.1 Purpose of and Need for the Proposed Federal Action

The purpose of the proposed action is to operate Flaming Gorge Dam to protect and assist in recovery of the populations and designated critical habitat of the four endangered fishes, while maintaining all authorized purposes of the Flaming Gorge Unit of the CRSP, particularly those related to the development of water resources in accordance with the Colorado River Compact. The proposed action is needed for the following reasons:

- The operation of Flaming Gorge Dam, under its original operating criteria, jeopardized the continued existence of the endangered fishes in the Green River.
- Reclamation is required to comply with the Endangered Species Act (ESA) for the operation of CRSP facilities, including Flaming Gorge Dam. Within the exercise of its discretionary authority, Reclamation must avoid jeopardizing the continued existence of listed species and destroying or adversely modifying designated critical habitat.
- The Reasonable and Prudent Alternative (RPA) to the 1992 Biological Opinion on the Operation of Flaming Gorge Dam required modification of Flaming Gorge releases to benefit the endangered fish, a 5-year study period to evaluate winter and spring flows, and reinitiation of discussions with the U.S. Fish and Wildlife Service following the study period to further refine the flow recommendations. With the results of these studies, as well as other relevant information, the Recovery Program developed and approved the 2000 Flow and Temperature Recommendations for the Green River. These recommendations are an extension of the 1992 jeopardy Biological Opinion RPA. Reclamation committed to assist in meeting flow requirements through the refined operation of Flaming Gorge and other Federal reservoirs in the 1987 agreement that formed the Recovery Program.
- Flaming Gorge Dam and Reservoir is the primary water storage and delivery facility on the Green River, upstream from its confluence with the Colorado River. The storage capacity and ability to control water releases of Flaming Gorge Dam allow Reclamation flexibility in providing flow and temperature management, to protect and assist in the recovery of endangered fish populations and their critical habitat within specific reaches of the river. Thus, the refined operation of Flaming Gorge Dam is a key element of the Recovery Program.

- ❖ The refined operation will offset the adverse effects of flow depletions from the Green River for certain Reclamation water projects in Utah, as defined by existing jeopardy Biological Opinions. Modifying the operation of Flaming Gorge Dam will also serve as the RPA, as defined by the ESA, to offset jeopardy to endangered fishes and their critical habitat that could result from the operation of numerous other existing or proposed water development projects in the Upper Colorado River Basin.

S.3 BACKGROUND

Flaming Gorge Dam, located on the Green River in northeastern Utah about 200 miles northeast of Salt Lake City, is an authorized storage unit of the CRSP. Flaming Gorge Dam was completed in 1962, and full operation of the dam and reservoir began in 1967. The powerplant, located at the base of the dam, began commercial operation in 1963 and was completed in 1964. Reclamation operates the dam and powerplant, and Western markets the power.

S.3.1 Brief History of Flaming Gorge Dam and Reservoir

S.3.1.1 Authorized Uses of Flaming Gorge Dam and Reservoir and Colorado River Development

Flaming Gorge Dam was authorized for construction by the CRSP Act of 1956 (Public Law [P.L.] 84-485). The underlying project purposes are defined by Section 1 of the Act (43 United States Code [U.S.C.] Section (§) 620):

> *In order to initiate the comprehensive development of the water resources of the Upper Colorado River Basin, for the purposes, among others, of regulating the flow of the Colorado River, storing water for beneficial consumptive use, making it possible for the States of the Upper Basin to utilize, consistently with the provisions of the Colorado River Compact, the apportionments made to and among them in the Colorado River Compact and the Upper Colorado River Basin Compact, respectively, providing for the reclamation of arid and semiarid land, for the control of floods, and for the generation of hydroelectric power, as an incident of the foregoing purposes, the Secretary of the Interior is authorized (1) to construct, operate, and maintain the following initial units of the Colorado River storage project, consisting of dams, reservoirs, powerplants, transmission facilities and appurtenant works [including] Flaming Gorge . . ..*

Section 7 of the CRSP Act of 1956 mandates the operation of CRSP powerplants to produce “. . .the greatest practicable amount of power and energy that can be sold at firm power and energy rates. . ..” However, as described in the EIS in section 1.4.3, continued Upper Colorado River Basin development of water resources and implementation of the 2000 Flow and Temperature Recommendations may affect the practicable amount of power and energy generated. The EIS analyzes these effects in sections 4.4 and 4.16.1.

The Upper Colorado River Endangered Fish Recovery Program was developed in response to the request of Colorado, Wyoming, and Utah to facilitate the continued development of their compact apportionments in light of Endangered Species Act concerns. The 2000 Flow and Temperature Recommendations, which were developed by the Recovery Program, are specifically designed, in concert with other Recovery Program actions, to accomplish recovery. By implementing the 2000 Flow and Temperature Recommendations, Reclamation would be taking the steps necessary to facilitate recovery of the fish, which will make it possible for continued and further utilization of the States' compact apportionments. Thus, by "making it possible for the States of the Upper Basin to utilize…[their Compact] apportionments," the 2000 Flow and Temperature Recommendations, which are designed to facilitate further compact development through the recovery of listed species, are within the authorized purposes of CRSP Act. Moreover, that other authorized purposes of the unit may not be fully maximized for limited durations in certain year types does not invalidate the actions of the Secretary of the Interior, as long as the overall goals of the project are being met.

In addition to this authority, the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs (including Flaming Gorge Reservoir) mandated by Section 602(a) of the 1968 Colorado River Basin Project Act (43 U.S.C. § 1501 et seq.) requires that the Annual Operating Plan for Colorado River reservoirs ". . . shall reflect appropriate consideration of the uses of the reservoirs for all purposes, including flood control, river regulation, beneficial consumptive uses, power production, water quality control, recreation, enhancement of fish and wildlife, and other environmental factors."

S.3.1.2 Authorized Uses of Flaming Gorge Dam and Reservoir: Flaming Gorge National Recreation Area

The Flaming Gorge National Recreation Area was established by the Flaming Gorge National Recreation Area Act of 1968 (P.L. 90-540). According to that act, the purposes of the Flaming Gorge National Recreation Area are to provide (1) public outdoor recreation benefits; (2) conservation of scenic, scientific, historic, and other values contributing to enjoyment, and (3) such management, utilization, and disposal of natural resources that will promote or are compatible with and do not significantly impair the purposes for which the recreation area was established. The act added about 123,000 acres to Ashley National Forest and assigned management of the entire recreation area to the USDA Forest Service. The Flaming Gorge National Recreation Area contains 207,363 acres of land and water that are almost equally divided between Utah and Wyoming.

S.4 OPERATIONAL MODIFICATIONS SINCE THE BEGINNING OF DAM OPERATIONS

Construction of Flaming Gorge Dam and Powerplant began in 1956. Filling of the reservoir began in 1962 when the dam was completed. Full operation began in November 1967. Until 1984, Flaming Gorge Dam was operated to provide for a full reservoir while maximizing power generation, providing associated ancillary services, and avoiding the use of the river outlet works or the spillway. From 1967 until 1984, flows were fluctuated as needed to meet system power demand, and consideration was given to known fish and wildlife needs.

The history of Flaming Gorge Dam operations can be divided into five phases. During the first phase, from 1962 to 1966, the reservoir was filling with water, and Green River flows downstream from the dam were reduced. The first full year of normal operations began in 1967. During the second phase, from 1967 to 1978, Flaming Gorge Dam was operated with few constraints, and water releases were made through the powerplant. The only constraint on releases during phase two began in 1974 when a 400-cubic-foot-per-second (cfs) minimum release was implemented to establish and maintain the tailwater trout fishery (1974 Interim Operating Criteria). This operating agreement between the Utah Division of Wildlife Resources and Reclamation stated:

> *A minimum flow of 400 cfs will be released from the reservoir at all times. However, for the foreseeable future and under normal conditions, a continuous flow of 800 cfs will be maintained as a minimum. To the extent the available water supply will permit and is compatible with multipurpose operations of all CRSP reservoirs, minimum flows in excess of 800 cfs will be maintained to enhance the use of the river for fishing, fish spawning, and boating.*

In 1978, the dam was retrofitted with a selective withdrawal structure to improve water temperatures for the tailwater trout fishery. During the third phase, from 1979 to 1984, operations were similar to those in the previous phase except for use of the selective withdrawal structure and the occurrence of spills in 1983 and 1984.

During the fourth phase, from 1985 to 1992, Reclamation began to constrain the operation of Flaming Gorge Dam to reduce negative impacts affecting endangered fishes in the Green River. Such constraints reduced operational flexibility and the ability to fluctuate flows to meet power system demands. In 1985, an interim flow agreement was established between Reclamation and the U.S. Fish and Wildlife Service to change Flaming Gorge Dam releases to protect critical nursery habitats for endangered fishes in the Green River downstream from Jensen, Utah. The recommended releases were based on observations made in 1985 that indicated "good" habitat conditions were available at lower flows. Reclamation also revised operational criteria at the dam to avoid spills. These changes were in place in the fourth phase, along with numerous research releases to support preparation of the Final Biological Opinion on the Operation of Flaming Gorge Dam issued on November 25, 1992. Significant financial impacts to hydropower generation, identified in the EIS, occurred mainly as a result of flow changes implemented during this fourth phase.

In the fifth phase, from 1993 to present, Reclamation began making releases from Flaming Gorge Dam in an attempt to meet the flow and temperature recommendations given in the 1992 Biological Opinion. Flows recommended in the 1992 Biological Opinion were intended to restore a more natural hydrograph and protect nursery habitats of endangered fishes downstream from the Yampa River confluence. At the same time, Reclamation continued to meet the authorized purposes of Flaming Gorge Dam.

The Green River flows recommended in the 1992 Biological Opinion were based on the most current scientific data available at the time. The opinion included several actions Reclamation could take to avoid jeopardizing the recovery of endangered fishes in the Green River. One of these actions was to collect more information about the flow and temperature needs of the endangered fishes and, subsequently, to refine or modify the flow and temperature recommendations of the 1992 Biological Opinion. A 5-year research study began in 1992, and the resulting data and refinements were included in the

2000 Flow and Temperature Recommendations. The study included periodic test flows to evaluate the effects of summer flows on endangered fishes or to test specific hypotheses.

S.5 COMPLIANCE WITH THE ENDANGERED SPECIES ACT

To comply with the ESA, an evaluation of the effects of any discretionary Federal action must be conducted by the action agency in consultation with the U.S. Fish and Wildlife Service.

During the late 1970s and early 1980s, the U.S. Fish and Wildlife Service rendered Jeopardy Biological Opinions for the Upalco, Jensen, and Uinta Units of the Central Utah Project stating that all relied on the operation of Flaming Gorge Dam to provide flows for endangered fishes. More recent Biological Opinions for the Duchesne River Basin, the proposed Narrows Project, the ongoing Price-San Rafael Salinity Control Project, and other water development-related projects in the Colorado River Basin also rely on the operation of Flaming Gorge Dam to provide flows for endangered fishes.

On February 27, 1980, the U.S. Fish and Wildlife Service requested consultation under Section 7 of the ESA for projects currently under construction in the Upper Colorado River Basin, and for the continued operation of all existing Reclamation projects in the basin (including the CRSP). Formal consultation on the operation of Flaming Gorge Dam began March 27, 1980. Issuance of a Final Biological Opinion by the U.S. Fish and Wildlife Service for the operation of Flaming Gorge Dam was delayed until data collection and studies related to habitat requirements for the endangered fishes could be completed and used to recommend specific flows in the Green River downstream from the dam. Dam operations were initially evaluated for potential effects on endangered fishes from 1979 to 1984. Reclamation served as the lead agency for this consultation, with Western becoming a party to the consultation in 1991.

Additionally, on February 27, 1980, the U.S. Fish and Wildlife Service issued a Final Biological Opinion for the Strawberry Aqueduct and Collection System, a major feature of the Central Utah Project. The Biological Opinion determined that Strawberry Aqueduct and Collection System flow depletions from the Duchesne and Green Rivers would likely jeopardize the continued existence of the endangered Colorado pikeminnow and humpback chub. This Biological Opinion included a Reasonable and Prudent Alternative stating that Flaming Gorge Dam and Reservoir would compensate for those depletions and be operated for the benefit of the endangered fishes in conjunction with its other authorized purposes.

Both the 1992 Biological Opinion and the 2000 Flow and Temperature Recommendations were designed to account for the impacts of depletions mentioned above. The 2000 Flow and Temperature Recommendations as implemented under the Action Alternative would offset the impacts of water depletions on these other projects.

S.5.1 Upper Colorado River Endangered Fish Recovery Program

The Recovery Program was initiated in 1987 as a cooperative effort among the States of Utah, Colorado, and Wyoming; environmental and water user organizations; Federal agencies including the National Park Service, Reclamation, U.S. Fish and Wildlife Service, and Western; and the Colorado River Energy Distributors Association. The goal of the Recovery Program is to protect and recover the endangered fish species of the Upper Colorado River Basin so they no longer need protection under the ESA, while the Upper Basin States continue to develop their 1922 Colorado River Compact entitlements.

Under the Recovery Program, five key elements are needed to recover the endangered fish species: (1) habitat management; (2) habitat development/maintenance; (3) native fish stocking; (4) nonnative species and sport fish management; and (5) research, data management, and monitoring. The operation of Flaming Gorge Dam is essential to successful implementation of two of these five elements: habitat management and habitat development/maintenance. Operation of the dam is one of many management actions described in the 1993 Recovery Implementation Program Recovery Action Plan (Recovery Action Plan). The plan is periodically revised to accommodate programmatic Biological Opinions and annual updates as well as the designation of critical habitat for the endangered fishes. Implementation of all Recovery Action Plan recommendations is expected to achieve recovery of the endangered fishes.

Reclamation began informing the Recovery Program Management Committee of the EIS timeline in 1999. Beginning in 2001, the Recovery Program Management Committee requested and received regular updates on EIS progress through early 2005. Additionally, throughout 1999–2003 the staff of the Recovery Program Director's office met regularly with Reclamation authors to clarify flow recommendation issues during development of the EIS document, and Reclamation also interacted with the Recovery Program biology committee on EIS matters periodically throughout this period.

S.5.2 Final Biological Opinion on the Operation of Flaming Gorge Dam and the Reasonable and Prudent Alternative

The U.S. Fish and Wildlife Service issued a Final Biological Opinion on the Operation of Flaming Gorge Dam on November 25, 1992, stating that the current operation of Flaming Gorge Dam was likely to jeopardize the continued existence of the endangered fishes in the Green River. The opinion also described elements of an RPA that, in the opinion of the U.S. Fish and Wildlife Service, would offset jeopardy to the endangered fishes. The RPA required implementing the following five elements:

(1) Refining the operation of Flaming Gorge Dam so flow and temperature regimes of the Green River more closely resemble a natural hydrograph.

(2) Conducting a 5-year research program, including implementation of winter and spring research flows, beginning in 1992, to allow for potential refinement of flows for those seasons. The research program was to be based on the Flaming Gorge Flow Recommendations Investigation and called for annual meetings to refine seasonal flows consistent with research findings and water year forecasts. Except for specific research flows during the 5-year research program, year-round flows in the Green River were to resemble a natural hydrograph described under element 1 of the RPA.

(3) Determining the feasibility and effects of releasing warmer water during the late spring/summer and investigating the feasibility of retrofitting the river bypass tubes to include power generation, thereby facilitating increased spring releases.

(4) Legally protecting Green River flows from Flaming Gorge Dam to Lake Powell.

(5) Initiating discussions with the U.S. Fish and Wildlife Service, after conclusion of the 5-year research program, to examine further refinement of flows for the specified endangered Colorado River fishes.

S.5.3 2000 Flow and Temperature Recommendations

The research program called for in the 1992 Biological Opinion concluded in 1996. At that time, the Recovery Program funded a synthesis of research and development of flow and temperature recommendations for the Green River. The final synthesis report contained the 2000 Flow and Temperature Recommendations, which provide the basis for Reclamation's Action Alternative analyzed in the EIS and for additional Section 7 consultation by Reclamation and Western with the U.S. Fish and Wildlife Service.

S.5.4 New Biological Opinion on the Operation of Flaming Gorge Dam

Reclamation and Western have consulted with the Fish and Wildlife Service, as required by Section 7 of the ESA, on the proposed action analyzed in the EIS. The Final Biological Opinion was issued on September 6, 2005, and may be found in the Final Biological Opinion Technical Appendix of the EIS.

S.6 OPERATIONAL DECISIONMAKING PROCESS AT FLAMING GORGE DAM

The process of developing an operational plan for Flaming Gorge Dam takes into consideration all resources associated with Flaming Gorge Dam identified by the Flaming Gorge Working Group. The Flaming Gorge Working Group was formed in 1993 to provide interested parties with an open forum to express their views and interests in the operation of Flaming Gorge Dam. Among others, these interests include power marketing, sport fisheries, endangered species, white water rafting, farming, land ownership, reservoir recreation, national park resources, land management, flood control, and wildlife refuge management.

The Flaming Gorge Working Group generally meets twice a year (April and August/September). These meetings are open to the public, and participants are encouraged to comment. Operational decisions are not made during the Flaming Gorge Working Group meetings; rather, these meetings are a forum for information exchange about past, current, and proposed operations at Flaming Gorge Dam. They also serve as a forum through which stakeholders can share information about specific resources of interest and the relationship between the operation of Flaming Gorge Dam and these resources. The Flaming Gorge Working Group provides input to Reclamation as well as educating various constituencies on operations at Flaming Gorge Dam.

Reclamation has sole responsibility for operations at Flaming Gorge, although the needs and expectations of stakeholders are considered in operational planning. Reclamation's priorities are first, dam safety, and second, meeting project purposes in compliance with the ESA. When conflicts in operations arise, Reclamation's approach to conflict resolution and decisionmaking includes accepting input from all stakeholders and formulating a strategy that meets the most needs possible consistent with these established priorities.

Operational decisions for Flaming Gorge Dam are made through the Colorado River Annual Operating Plan process. A document, called the *24-Month Study*, is produced monthly and contains planned monthly releases from all CRSP reservoirs. In the 24-month study, reservoir inflows are revised to reflect forecasted inflow from the National Weather Service. These forecasted inflows are input into the 24-Month Planning Model. Planned releases from Flaming Gorge are adjusted monthly to reflect changing hydrology, to meet the requirements of the ESA, and to meet CRSP authorized purposes.

Operational details and changes are coordinated as necessary with other agencies, including Western, the U.S. Fish and Wildlife Service, and the Utah Division of Wildlife Resources. Generally, a variety of requests for short-term, temporary modifications in operations are often received, and such requests are accommodated if they are reasonable, necessary, and do not interfere with dam safety, other authorized project purposes, or operations for ESA compliance.

S.7 EMERGENCY POWERPLANT OPERATIONS

Normal dam and powerplant operations under the Action Alternative or any other alternative could be altered temporarily to respond to emergencies. These emergencies may be associated with dam safety, power system conditions, or personal safety of individuals or groups associated with recreation or other activities on the river. The North American Electrical Reliability Council and the Western Electricity Coordinating Council have established guidelines and requirements for emergency operations of interconnected power systems that apply to Flaming Gorge Dam operations. Examples of system emergencies include loss of generation capacity, transmission capability, or voltage control.

S.8 PUBLIC SCOPING PROCESS FOR THE ENVIRONMENTAL IMPACT STATEMENT

The scoping process for the EIS was initiated on June 6, 2000, with the publication in the *Federal Register* of a Notice of Intent to prepare an EIS. During the public scoping period, Reclamation received both written and oral comments (oral comments were received at five public scoping meetings in Utah, Colorado, and Wyoming) which were considered in determining the scope of the EIS. The formal scoping period ended on September 5, 2000.

S.9 SCOPE OF ANALYSIS FOR THE ENVIRONMENTAL IMPACT STATEMENT

The purpose of the EIS is to identify and consider the impacts of developing and implementing dam operations guidelines that result in protecting and assisting in the recovery of the populations and designated critical habitat of the four endangered fishes living in the Green River downstream from Flaming Gorge Dam. The scope of analysis for the EIS focuses on responding to the following question:

> If Reclamation operates Flaming Gorge Dam to achieve the 2000 Flow and Temperature Recommendations needed to avoid jeopardy and to protect and assist in the recovery of the endangered fishes and their critical habitat in the Green River, consistent with CRSP purposes, then the effect(s) on other relevant resources/issues, both upstream and downstream from the dam, would be . . .

The geographic project area (as shown in the frontispiece maps), analyzed for possible impacts of the proposed action and alternatives includes Flaming Gorge Reservoir and the Green River downstream from Flaming Gorge Dam, to its confluence with the Colorado River. The Green River upstream of the reservoir would not be affected because the proposed action depends exclusively on the operation of Flaming Gorge Dam, which is dependent on inflow into Flaming Gorge Reservoir. The EIS provides full details on issues and resources that were analyzed.

S.10 RELATED AND ONGOING ACTIONS

This section describes laws and projects that affect the operation of Flaming Gorge Dam and may affect the potential impacts of the proposed action. Where applicable, these laws and projects are factored into the analysis of potential impacts under both alternatives, particularly in the cumulative impacts analysis of the EIS.

S.10.1 Regulatory Requirements

Federal statutes establish a number of responsibilities for the Secretary of the Interior. These legislated responsibilities relate to the management of numerous agencies, projects, and lands, all or some relating to the operation of Flaming Gorge Dam. In some cases, the statutes specifically require the Secretary to mandate responsibility for management of reservoirs; while in others, the statutes allow the Secretary to grant discretionary authority.

S.10.1.1 The Law of the River

As a tributary of the Colorado River, the Green River is managed and operated according to a collection of over 50 compacts, Federal and State laws, court decisions and decrees, contracts, treaties, and regulatory guidelines collectively known as the Law of the River. This collection of documents apportions the water among the seven Basin States and

Mexico and regulates and manages riverflows. Some of the statutes included within the Law of the River having a major impact on dam operations include the Colorado River Compact of 1922, the Upper Colorado River Basin Compact of 1948, the Colorado River Storage Project Act of 1956, and the Colorado River Basin Project Act of 1968.

S.10.1.2 National Parks and Recreation Areas

The affected environment for the EIS includes portions of Flaming Gorge National Recreation Area, Dinosaur National Monument, and Canyonlands National Park. Enabling legislation for these units includes:

- Flaming Gorge National Recreation Area Act of 1968 (P.L. 90-540)
- Antiquities Act of 1906, 16 U.S.C. 431-433. The Dinosaur National Monument was originally designated by President Wilson in October 1915 and was enlarged by President Roosevelt in 1938.

Management authorities include:

- National Park Service Organic Act (16 U.S.C. 1-4, 22, 43)
- National Park Service General Authorities Act of 1970 (16 U.S.C. 1a-1)
- Redwood National Park Act of 1978 (P.L. 95-250, 92 Statute 163, as amended)

S.10.1.3 Environmental Compliance

Laws and Executive orders that were designed to restore and protect the natural environment of the United States relating to air, water, land, and fish and wildlife include the following:

- National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.)
- Endangered Species Act of 1973 (16 U.S.C. 1532 et seq.)
- Wilderness Act of 1964 (16 U.S.C. 1131 et seq.)
- Wild and Scenic Rivers Act of 1968 (16 U.S.C. 1271 et seq.)
- Clean Air Act (42 U.S.C. 7401 et seq.)
- Clean Water Act of 1972 (33 U.S.C. 1251 et seq.)
- Migratory Bird Treaty Act of 1918 (16 U.S.C. 703 et seq.)
- Executive Order 11988, Floodplain Management, 1977
- Executive Order 13112, Invasive Species, 1999
- Executive Order 11990, Protection of Wetlands, 1977

S.10.1.4 Cultural Resource Laws

Laws designed to protect and preserve historic and cultural resources under Federal control include the following:

- National Historic Preservation Act (16 U.S.C. 470 et seq., 1966)
- Archaeological Resources Protection Act (16 U.S.C. 470aa et seq., 1974)

S.10.1.5 Native American Laws

Laws and policies relating to Native American consultation include the following:

- American Indian Religious Freedom Act (42 U.S.C. 1996, 1973)
- Enhancing the Intergovernmental Partnership, Executive Order 12875 of October 26, 1993 (58 *Federal Register* [FR] 58093)
- Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001)
- Consultation and Coordination with Indian Tribal Governments, Executive Order 13084 of May 14, 1998
- Protection of Indian Sacred Sites, Executive Order 13007 of May 24, 1996 (61 FR 26771)

S.10.2 Related Programs, Projects, and Activities

S.10.2.1 Recovery Program

As discussed in section S.4.1 above, the Recovery Program's goal is to protect and recover the endangered fish of the Upper Colorado River Basin, while allowing existing uses and future water development to continue in accord with the "Law of the River." The Recovery Program has a variety of programs and projects underway, concerning habitat acquisition or enhancement, levee removal, nonnative fish control, and native fish stocking, aimed at achieving that goal. The proposed action for which the EIS has been prepared—operating Flaming Gorge Dam as specified in the Recovery Program's 2000 Flow and Temperature Recommendations—would complement the other Recovery Program activities in moving toward endangered fish recovery.

S.10.2.2 Interim Surplus Guidelines and Colorado River Basin Project Act 602(a) Storage Requirement

Flaming Gorge is part of the Colorado Basin and is indirectly affected by decisions made under the December 2000 *Colorado River Interim Surplus Guidelines Final Environmental Impact Statement*. However, the effects are not measurable. In addition, Reclamation is currently preparing an environmental assessment on a proposed guideline to determine the amount of Upper Basin water required under Section 602(a) of the Colorado River Basin Project Act. This guideline could affect operations at Lake Powell but most likely would not influence operations at Flaming Gorge.

S.10.2.3 Relocation of Little Hole National Recreation Trail

The 7.2-mile segment of the Little Hole National Recreation Trail along the Green River between the Flaming Gorge Dam Spillway Recreation Complex (boat ramp launching and parking area) and Little Hole Recreation Complex (boat ramps, parking, and day use areas) will be relocated by the USDA Forest Service pending funding to prevent recurring trail damage and loss that has occurred from past high flows. Without relocation of the trail, further damage would be expected to occur under both the No Action Alternative and the Action Alternative.

This 7.2-mile trail segment provides access to the Green River for tens of thousands of annual visitors who participate in shore and boat fishing, scenic and recreational floating, hiking, and sightseeing activities. Several commercial operators also use the trail as part of their outfitting and guiding business. Annual trail use has ranged from 54,000 to 101,000 visitors over the past 11 years. Annual visitation numbers, types, and the economic value of uses along the trail are discussed and displayed in the EIS.

The USDA Forest Service completed a field assessment and report in July 2001 of trail locations along the 7.2-mile trail segment. This assessment identified trail damage and repairs that have occurred from 1979 to the present due to releases from the dam, either in response to extremely wet hydrologic years or to support endangered fish research studies. The assessment also addressed alternative trail designs, locations, and costs that would prevent recurring trail damage and loss. Depending on alternative trail locations, the design and construction cost estimates ranged from $135,000 to $308,000. The USDA Forest Service will evaluate and analyze the alternative trail designs and locations as part of a separate NEPA process and document. In addition, the USDA Forest Service will evaluate and analyze the designs and plans for reconstruction of other ramps, picnic sites, and campsites affected during high releases along the Green River. Such facilities will also be relocated, pending funding. The USDA Forest Service environmental document will tier to the EIS for the operation of Flaming Gorge Dam, as appropriate, relating to environmental, social, and economic resources and issues.

The USDA Forest Service, Reclamation, and other concerned Federal and State agencies will cooperate during the preparation of the referenced environmental document for the relocation of the trail and related facilities to ensure that issues are addressed for the operation of the dam, riverflows, user safety, and protection of natural and physical resources. Reclamation will support the USDA Forest Service in obtaining funding through the USDA Forest Service budgeting process that will be needed to complete the USDA Forest Service environmental document and the relocation of the trail and related facilities.

S.10.2.4 Browns Park Highway Environmental Impact Statement

An EIS is currently being prepared for a Daggett County, Utah, proposal to realign and pave Browns Park Road from its junction with U.S. 191 in Utah to Colorado Route 318. The existing, unpaved 16.8-mile long segment of road crosses BLM, State, and private lands. Scoping meetings were held by the Federal Highway Administration, Utah Department of Transportation, and BLM in December 1999.

S.10.2.5 Cedar Springs Marina Environmental Impact Statement

The Ashley National Forest in cooperation with the Cedar Springs Marina is currently preparing an EIS to upgrade the Cedar Springs Marina to include dedicated dry storage, maintenance shop, convenience store and restaurant, and adequate boat slippage. The upgrade will resolve the congested parking and allow the marina to fully serve the public. A Notice of Intent was published in the *Federal Register* on August 18, 2004.

S.10.2.6 Resource Management Plans and Wild and Scenic Rivers Eligibility Determinations

The BLM Vernal Field Office is preparing to scope the draft resource management plan (RMP)/EIS for approximately 1.8 million acres in northeastern Utah. This plan, known as the Vernal Resource Management Plan, will combine the existing Diamond Mountain and Book Cliffs RMPs into a single plan. The final EIS is scheduled to be completed in September 2005.

The Ashley National Forest began revisions in March 2004 of its Land and Resource Management Plan, commonly referred to as Forest Plan. The process for revision of this plan, including NEPA compliance, is expected to take 4 to 5 years. The Ashley National Forest is also currently conducting an eligibility determination study pursuant to the Wild and Scenic Rivers Act of 1968. A final report is planned for August 2005.

S.10.2.7 Federal Reserve Water Rights

Canyonlands National Park and Dinosaur National Monument have inchoate (pending use) Federal water rights to the Green River. However, the National Park Service is not actively working with the State of Utah to quantify those rights. Future plans for quantification are uncertain.

S.11 DESCRIPTION OF ALTERNATIVES

Under the No Action Alternative, Flaming Gorge Dam would be operated to achieve the flow and temperature regimes recommended by the 1992 Biological Opinion on the Operation of Flaming Gorge Dam. Depending upon the hydrologic conditions of the upper Green River Basin, forecasted flows on the Yampa River would be supplemented by releases from Flaming Gorge Dam designed to achieve the peak flow, duration, and base flow (riverflows not associated with snowmelt runoff) recommendations described in the 1992 Biological Opinion.

Under the Action Alternative, Flaming Gorge Dam would be operated to achieve the flow and temperature regimes recommended in the 2000 Flow and Temperature Recommendations.

S.11.1 Development of Alternatives

S.11.1.1 Criteria Used to Select Alternatives

Potential alternatives analyzed in the EIS were studied to determine whether they could meet the purpose of and need for the proposed action. A number of scenarios for dam operation, originally thought to be viable alternatives, were determined to be more accurately described as possible subsets of the Action Alternative. Because of the inherent need for operational flexibility in dam operations, as acknowledged by and incorporated into the 2000 Flow and Temperature Recommendations, and because any potential impacts from discreet operational scenarios are already captured by analysis of the Action and No Action Alternatives, it was determined that analyzing subtle differences in dam operations as separate alternatives would not yield meaningful information for the public or the decisionmaker.

Alternatives that are included in this analysis are those which both:

- Meet flow and temperature recommendations as described in the 2000 Flow and Temperature Recommendations
- Maintain all authorized purposes of the Flaming Gorge Unit of CRSP

S.11.1.2 Alternatives Considered but Eliminated From Detailed Study

S.11.1.2.1 Modified Run of the River Alternative – During the scoping process, the National Park Service and others requested consideration of a Run of the River Alternative. Under such an alternative, dam releases would match the reservoir inflow (unregulated) to provide a more natural flow regime including more natural variations in the daily flows of the Green River below Flaming Gorge Dam. Further analysis of this alternative led to the establishment of a Modified Run of River Alternative, where dam releases equaled 87 percent (%) of the unregulated inflow to the reservoir. This provided reservoir operators the ability to store 13% of the spring inflow volume for release to meet project purposes and flow recommendations at other times of the year. The 87% level was chosen because it was the highest percentage that provided enough water storage to achieve the base flow ranges recommended in the 2000 Flow and Temperature Recommendations. Percentages higher than 87% could not achieve the recommended base flows of the 2000 Flow and Temperature Recommendations.

Preliminary analysis of the historic inflows into Flaming Gorge did show that it might be possible to operate Flaming Gorge using a "Modified Run of River" approach to achieve the 2000 Flow Recommendations during the spring. However, it was learned through this study that the effect of water consumption above Flaming Gorge played a much more significant role than was originally thought. The Flaming Gorge model did account for the inevitability that water consumption will increase in the future. The Consumptive Uses and Losses Report, published by Reclamation, estimates that current water consumption above Flaming Gorge Reservoir is about 450,000 acre-feet per year. This is about 25% of the mean annual unregulated inflow into Flaming Gorge Reservoir. In addition to the level of water consumed, irrigation diversions, which are not entirely consumed, occur most often during the months of May through August. Such diversions are not usually completely consumed as there is a lag period before the water returns to the river. Sometimes, this lag period can be as long as several months. Water consumption and diversions can significantly decrease the unregulated inflow peaks that occur during the spring. As a result, the "Modified Run of River" approach released less water than would have been released under natural conditions. For this reason, the "Modified Run of the River" could not achieve the spring flow objectives of the 2000 Flow and Temperature Recommendations.

Water consumption on the Green River has an ever increasing effect on the inflows (and unregulated inflows) to Flaming Gorge Reservoir. Consequently, water consumption will further complicate Reclamation's ability to achieve the 2000 Flow and Temperature Recommendations in the future. This modeling study indicated that, in the case of a "Modified Run of River" approach for operating Flaming Gorge Dam, the current level of water consumption in the Green River Basin already makes it too difficult to achieve the 2000 Flow and Temperature Recommendations without having significant negative impacts on the other resources associated with Flaming Gorge Reservoir. Based on these findings, the "Modified Run of River" approach was not considered a viable alternative that could be included for analysis in the Flaming Gorge Environmental Impact Statement.

S.11.1.2.2 Decommissioning and Removing Flaming Gorge Dam – During the scoping process, a request was made to consider decommissioning the dam as an alternative to allow endangered fish to recover. This alternative was not selected for detailed study in the EIS because it does not meet the purpose of and need for the proposed action. Specifically, decommissioning the dam would prevent continuing the authorized purposes of the dam under the Colorado River Storage Project and the Flaming Gorge National Recreation Area authorizing legislation, among others.

S.11.1.3 Summary of Alternatives Analyzed in the Flaming Gorge Environmental Impact Statement

S.11.1.3.1 No Action Alternative – Under the No Action Alternative, Flaming Gorge Dam would be operated to achieve the flow and temperature regimes recommended in the 1992 Biological Opinion. These flows were intended to mimic a more natural hydrograph than occurred under previous dam operations and to protect nursery habitats of endangered fishes downstream from the Yampa River confluence.

Under normal operations, reservoir releases through Flaming Gorge Powerplant range from 800 to 4,600 cfs. These flows adhere to the interim operating criteria for Flaming Gorge Dam established by Reclamation in September 1974. Under these criteria, Reclamation agreed to provide (1) a minimum flow of 400 cfs at all times, (2) flows of 800 cfs under normal conditions and for the foreseeable future, and (3) flows exceeding 800 cfs when compatible with other CRSP reservoir operations.

Temperature requirements under the No Action Alternative, specified in the Reasonable and Prudent Alternative of the 1992 Biological Opinion (page 30), include the following:

> *Releases from Flaming Gorge beginning July 1 and continuing until November 1 should be of the warmest water available, approaching 59 degrees F (15 degrees C)[1] (highest lake levels). By releasing the warmest water available during this period, water temperatures in the upper Green River should not differ*

[1] Degrees Fahrenheit (°F); degrees Celsius (°C).

more than 9 degrees F (5 degrees C) in the Yampa River at Echo Park and should average near 72-77 degrees F (22-25 degrees C) in Gray Canyon from July 1 to August 15.

S.11.1.3.2 Action Alternative – Under the Action Alternative, releases from Flaming Gorge Dam would be patterned so that the peak flows, durations, and base flows and temperatures, described in the 2000 Flow and Temperature Recommendations for Reaches 1, 2, and 3 of the Green River, would be achieved.

- Reach 1 begins at Flaming Gorge Dam and extends 65 river miles to the confluence of the Green and Yampa Rivers. In this reach, the Green River meanders about 10 river miles into northwestern Colorado and then flows southward for about 30 river miles. This reach is almost entirely regulated by releases from Flaming Gorge Dam.
- Reach 2 begins at the confluence of the Green and Yampa Rivers in Colorado and extends 99 river miles southwest to the White River confluence near Ouray, Uintah County, Utah. In this reach, tributary flows from the Yampa River combine with releases from Flaming Gorge Dam to provide a less regulated flow regime than in Reach 1.
- Reach 3 begins at the confluence of the Green and White Rivers and extends 246 river miles south to the confluence of the Green and Colorado Rivers in Canyonlands National Park at the boundary of Wayne and San Juan Counties in southeastern Utah. In this reach, the Green River is further influenced by tributary flows from the White, Duchesne, Price, and San Rafael Rivers.

Table S-1 shows a summary of the recommended spring peak and summer-to-winter base flows from the 2000 Flow and Temperature Recommendations report for all three reaches of the Green River. Under the Action Alternative, Flaming Gorge Dam would be operated with the goal of achieving the 2000 Flow and Temperature Recommendations, while maintaining and continuing all authorized purposes of Flaming Gorge Dam and Reservoir.

The 2000 Flow and Temperature Recommendations for each reach are not integrated in such a way that a particular release from Flaming Gorge Dam could equally achieve the recommendations for all reaches simultaneously. The intent of the Action Alternative is first to meet the 2000 Flow and Temperature Recommendations for Reach 2 and then, if necessary, make adjustments to releases so that the 2000 Flow and Temperature Recommendations for Reach 1 could also be met. The Flaming Gorge Model assumes that the 2000 Flow and Temperature objectives in Reach 3 are met whenever the flow objectives are met in Reach 2.

The 2000 Flow and Temperature Recommendations focus primarily on the flow regimes in Reaches 2 and 3, which include flows from the Yampa River. However, since these river flow criteria are based solely on upper Green River hydrology, the 2000 Flow and Temperature Recommendations in Reaches 1 and 2 would most likely be achieved to varying degrees. For example, in years when the upper Green River Basin is wetter than the Yampa River Basin, meeting the 2000 Flow and Temperature Recommendations in Reaches 2 and 3 would most likely exceed the minimum target for the peak flow recommendations for Reach 1.

Table S-1.—Recommended Magnitudes and Duration of Maximum Spring Peak and Summer-to-Winter Base Flows and Temperatures for Endangered Fishes in the Green River Downstream From Flaming Gorge Dam as Identified in the 2000 Flow and Temperature Recommendations

Location	Flow and Temperature Characteristics	Hydrologic Conditions and 2000 Flow and Temperature Recommendations[1]				
		Wet[2] (0–10% Exceedance)	Moderately Wet[3] (10–30% Exceedance)	Average[4] (30–70% Exceedance)	Moderately Dry[5] (70–90% Exceedance)	Dry[6] (90–100% Exceedance)
Reach 1 Flaming Gorge Dam to Yampa River	Maximum Spring Peak Flow	\$8,600 cfs (244 cubic meters per second [m^3/s])	\$4,600 cfs (130 m^3/s)	\$4,600 cfs (130 m^3/s)	\$4,600 cfs (130 m^3/s)	\$4,600 cfs (130 m^3/s)
	Peak flow duration is dependent upon the amount of unregulated inflows into the Green River and the flows needed to achieve the recommended flows in Reaches 2 and 3.					
	Summer-to-Winter Base Flow	1,800–2,700 cfs (50–60 m^3/s)	1,500–2,600 cfs (42–72 m^3/s)	800–2,200 cfs (23–62 m^3/s)	800–1,300 cfs (23–37 m^3/s)	800–1,000 cfs (23–28 m^3/s)
Above Yampa River Confluence	Water Temperature Target	\$ 64 °F (18 °C) for 3-5 weeks from mid-August to March1	\$ 64 °F (18 °C) for 3-5 weeks from mid-August to March 1	\$ 64 °F (18 °C) for 3-5 weeks from mid-July to March 1	\$ 64 °F (18 °C) for 3-5 weeks from June to March 1	\$ 64 °F (18 °C) for 3-5 weeks from mid-June to March 1
Reach 2 Yampa River to White River	Maximum Spring Peak Flow	\$26,400 cfs (748 m^3/s)	\$20,300 cfs (575 m^3/s)	\$18,600 cfs[7] (527 m^3/s) \$8,300 cfs[8] (235 m^3/s)	\$8,300 cfs (235 m^3/s)	\$8,300 cfs (235 m^3/s)
	Peak Flow Duration	Flows greater than 22,700 cfs (643 m^3/s) should be maintained for 2 weeks or more, and flows 18,600 cfs (527 m^3/s) for 4 weeks or more.	Flows greater than 18,600 cfs (527 m^3/s) should be maintained for 2 weeks or more.	Flows greater than 18,600 cfs (527 m^3/s) should be maintained for at 2 weeks in at least 1 of 4 average years.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for at least 1 week.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for 2 days or more except in extremely dry years (98% exceedance).
	Summer-to-Winter Base Flow	2,800–3,000 cfs (79–85 m^3/s)	2,400–2,800 cfs (69–79 m^3/s)	1,500–2,400 cfs (43–67 m^3/s)	1,100–1,500 cfs (31–43 m^3/s)	900–1,100 cfs (26–31 m^3/s)
Below Yampa River Confluence	Water Temperature Target	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.
Reach 3 White River to Colorado River	Maximum Spring Peak Flow	\$39,000 cfs (1,104 m^3/s)	\$24,000 cfs (680 m^3/s)	\$22,000 cfs[9] (623 m^3/s)	\$8,300 cfs (235 m^3/s)	\$8,300 cfs (235 m^3/s)
	Peak Flow Duration	Flows greater than 24,000 cfs (680 m^3/s) should be maintained for 2 weeks or more, and flows 22,000 cfs (623 m^3/s) for 4 weeks or more.	Flows greater than 22,000 cfs (623 m^3/s) should be maintained for 2 weeks or more.	Flows greater than 22,000 cfs (623 m^3/s) should be maintained for 2 weeks in at least 1 of 4 average years.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for at least 1 week.	Flows greater than 8,300 cfs (235 m^3/s) should be maintained for 2 days or more except in extremely dry years (98% exceedance).
	Summer-to-Winter Base Flow	3,200–4,700 cfs (92–133 m^3/s)	2,700–4,700 cfs (76–133 m^3/s)	1,800–4,200 cfs (52–119 m^3/s)	1,500–3,400 cfs (42–95 m^3/s)	1,300-2,600 cfs (32–72 m^3/s)

[1] Recommended flows as measured at the United States Geological Survey gauge located near Greendale, Utah, for Reach 1; Jensen, Utah, for Reach 2; and Green River, Utah, for Reach 3.

[2] **Wet** (0% exceedance): A year in which the forecasted runoff volume is larger than almost all of the historic runoff volumes. This hydrologic condition has a 10% probability of occurrence.

[3] **Moderately Wet** (10–30% exceedance): A year in which the forecasted runoff volume is larger than most of the historic runoff volumes. This hydrologic condition has a 20% probability of occurrence.

[4] **Average** (30–70% exceedance): A year in which the forecasted runoff volume is comparable to the long-term historical average runoff volumes.

[5] **Moderately Dry** (70–90% exceedance): A year in which the forecasted runoff volume is less than almost all of the historic runoff volumes. This hydrologic condition has a 20% probability of occurrence.

[6] **Dry** (90–100% exceedance): A year in which the forecasted runoff volume is less than almost all of the historic runoff volumes. This hydrologic condition has a 10% probability of occurrence.

[7] Recommended flows \$18,600 cfs (527 m^3/s) in 1 of 2 average years.

[8] Recommended flows \$8,300 cfs (235 m^3/s) in other average years.

[9] Recommended flows \$22,000 cfs (623 m^3/s) in 1 of 2 average years.

Conversely, if the Yampa River Basin is wetter than the upper Green River Basin, meeting the 2000 Flow and Temperature Recommendations for Reaches 2 and 3 could result in falling short of the peak flow target for Reach 1. Under this scenario, the Action Alternative might require Flaming Gorge Dam releases to be increased so that the 2000 Flow and Temperature Recommendations in Reach 1 could also be met. Flows in Reaches 2 and 3 would then exceed their respective minimum 2000 Flow and Temperature Recommendations. Since only one release pattern can be selected each year, depending upon how water is distributed between the upper Green River and Yampa River Basins, each reach would achieve or exceed its respective minimum 2000 Flow and Temperature Recommendations to varying degrees.

Each year, Reclamation would work closely with the U.S. Fish and Wildlife Service and Western in developing a flow regime consistent with the 2000 Flow and Temperature Recommendations and CRSP purposes and would also consider input from the Flaming Gorge Working Group meetings. The overall effectiveness of implementing the Action Alternative would be measured by the long-term frequency of achieving flow thresholds described in the 2000 Flow and Temperature Recommendations. Consideration would be given to hydrologic conditions, operational limitations, and past operational conditions. An administrative record of the operational decisionmaking would be maintained and available to the public. This record would include analysis of previous operations and the effectiveness of achieving desired targets on a year-by-year basis.

Water release temperatures at the dam would be regulated with the objective of achieving target temperatures for upper Lodore Canyon and the confluence of the Yampa and Green Rivers during the first 2 to 5 weeks of the base flow period and/or when Colorado pikeminnow larvae are present at this confluence.

S.12 REVIEW OF FLAMING GORGE MODEL DEVELOPED FOR THE FLAMING GORGE DAM EIS

As detailed in the EIS, a river simulation model (Flaming Gorge Model) was developed for the Green River system to assess impacts of Flaming Gorge Dam operations. For both of the alternatives analyzed in the EIS, the model predicts the water surface elevation of Flaming Gorge Reservoir as well as the flows in the Green River at various points downstream from the dam.

Under the No Action Alternative, the bypass tubes would be used in 23% of all years, and the spillway would be used in 5% all of years. In comparison, for the Action Alternative, the Flaming Gorge Model predicts more frequent use of the bypass tubes and spillway at Flaming Gorge Dam. Under the Action Alternative, the Flaming Gorge Model predicts that the bypass tubes would be used in 50% of all years, and the spillway would be used in 29% of all years.

A review of the Flaming Gorge Model was performed by three authors of the 2000 Flow and Temperature Recommendations to evaluate whether the degree of bypass and spill predicted by the Flaming Gorge Model would be necessary. The main focus of the model review was the frequency of bypass and spillway use. The reviewers also examined the model's behavior and evaluated how the model simulated the year-round operation of Flaming Gorge Dam.

In most situations, the reviewers found that the Flaming Gorge Model properly simulates the operation of Flaming Gorge Dam. The reviewers found that the Flaming Gorge Model performs well in dry, moderately dry, and average years; however, the review showed that the model appeared to bypass or spill more water than may be necessary in some moderately wet and wet years.

The lack of flexibility within the operational rules of the model was the main reason bypasses and spills were higher than necessary in the Flaming Gorge model. While many model rules allow for decision trees, a model such as the Flaming Gorge Model cannot adjust to all situations or consider the balance of all available operating options.

Reclamation acknowledges that the Flaming Gorge Model may overstate bypasses and, therefore, may overstate potential effects that result from the bypassing of water. Reclamation also notes that while the Flaming Gorge Model provides good information to assess potential effects, details and flexibility that cannot be captured by modeling will be factored into operational decisionmaking each year.

S.13 OPERATIONAL DESCRIPTION

The following discussion provides further clarification on operations under the No Action Alternative and the Action Alternative, while maintaining the authorized purposes and ensuring safe operations of Flaming Gorge Dam under normal operational conditions. As noted in section S.6, operational plans could change due to malfunction of the dam and powerplant equipment and during public emergencies.

S.13.1 Safe Operation of Flaming Gorge Dam

Safe operation of Flaming Gorge Dam is of paramount importance and applies to both the No Action Alternative and Action Alternatives. To safely and efficiently operate Flaming Gorge Dam, forecasted inflows must be incorporated into the decisionmaking process. A description of this process is provided in section 1.5 of the EIS.

Inflow forecasts generated by the National Weather Service each month are used by Reclamation to plan future reservoir operations. These forecasts have some degree of error associated with them which can impact the safe operation of a reservoir. Forecast errors are attributable mostly to hydrologic variability and, to a much lesser degree, the forecasting procedure. For this reason, forecast errors will always be a factor associated with the operation of Flaming Gorge Reservoir.

Analysis of the historic forecast errors at Flaming Gorge provide the basis for estimating safe upper limit operating reservoir levels at various times of the year under varying hydrologic conditions. From this analysis, 1% exceedance forecast errors were generated and used in routing studies designed to establish safe upper limit reservoir levels. A 1% exceedance error can be expected to occur about 1% of the time or about 1 year out of every 100 years.

Safe operation of Flaming Gorge provides enough storage space in the reservoir at all times throughout the year, such that the volume of a 1% exceedance forecast error can be absorbed by the reservoir. In other words, the safe operation of Flaming Gorge Reservoir must assure that 99% of the foreseeable forecast errors can be successfully routed through the reservoir without uncontrolled spills occurring. For this reason, the reservoir elevation is intentionally drawn down during the fall and winter months.

The upper limit drawdown levels established as safe operating parameters for Flaming Gorge Reservoir under various hydrologic conditions were determined through the routing studies and are shown in table S-2. These upper limit drawdown levels apply to both the No Action and Action Alternatives.

Table S-2.—Upper Limit Drawdown Levels for Flaming Gorge Reservoir

Unregulated Inflow Forecast Percentage Exceedance Range	May 1 Upper Limit Drawdown Elevation Level
1 to 10	6023
10.1 to 30	6024
30.1 to 40	6025
40.1 to 59.9	6027

S.13.2 Reservoir Operations Process Under the No Action Alternative

S.13.2.1 Operations in May Through July (Spring Period)

Under the No Action Alternative, the April through July unregulated inflow forecast and the condition of the reservoir, would be used to establish the magnitude and duration of a spring peak release for the current year. The magnitude of the spring release would normally be from 4,000 cfs to powerplant capacity (about 4,600 cfs), unless hydrologic conditions indicated that bypasses or spills would be necessary for safe operations of the dam. Bypasses or spills would be timed to occur when the Yampa River peak flows and immediate post peak flows occur.

Reclamation would establish a range of spring operational scenarios, through consultation with the U.S. Fish and Wildlife Service and Western. These scenarios would achieve the objectives of the Reasonable and Prudent Alternative of the 1992 Biological Opinion on the Operation of Flaming Gorge Dam under one of three hydrologic conditions (dry, average, or wet). The range of scenarios would provide flexibility in operations to adjust to changing hydrologic conditions and would be based on the probable minimum and probable maximum inflow forecasts issued in April by the River Forecast Center. Timing of the spring peak release under the range of possible operational scenarios would occur with the peak flows and immediate post peak flows on the Yampa River.

When the hydrologic condition is determined to be dry, the spring peak duration would be 1 to 2 weeks. Most likely, the magnitude of the release during the spring peak in dry years would be limited to powerplant capacity and could be limited to 4,000 cfs to conserve reservoir storage. In dry years, the spring peak release would be completed no later than June 20.

When the hydrologic condition is determined to be average, the spring peak duration would be 2 to 5 weeks. The magnitude of the release during the spring peak most likely would be limited to powerplant capacity (about 4,600 cfs). The spring peak release in average years would be completed by July 10.

Wet hydrologic conditions would establish a spring peak duration of 5 weeks or greater. Peak releases in wet years could include bypass releases and possibly spillway releases, depending on conditions at Flaming Gorge Reservoir. The use of bypass tubes or the spillway would be based on the safe operating criteria for the dam. The magnitude of peak releases in wet years would be at least powerplant capacity (about 4,600 cfs), and the spring peak release in wet years would be completed by July 20.

S.13.2.2 Use of Bypass Tubes and Spillway at Flaming Gorge Dam

Under the No Action Alternative, the use of the bypass tubes or the spillway would occur only when hydrologically necessary to maintain safe operations of Flaming Gorge Dam, during emergency operations, or when the full release capacity of the powerplant is unavailable. For the No Action Alternative, under normal operations, the magnitude of peak releases for endangered fish would be limited to powerplant capacity (about 4,600 cfs). However, if Reclamation determines that bypass releases would be likely for hydrologic reasons, Reclamation would attempt to schedule these bypass releases to occur with the peak flows and immediate post peak flows of the Yampa River.

S.13.2.3 Summer and Fall Operations (Early Base Flow Period)

Under the No Action Alternative, after the spring peak release is completed, releases from Flaming Gorge Dam would be reduced so that flows of the Green River, measured at Jensen, Utah, would achieve a target flow ranging from 1,100 to 1,800 cfs. Daily average flows would be maintained as close to this target as possible until September 15. After September 15, releases from Flaming Gorge Dam could be increased so that the daily average flow measured at Jensen, Utah, would achieve a target ranging from 1,100 to 2,400 cfs while controlling the reservoir elevation within safe operating levels.

During the early base flow period (through the month of October), fluctuating releases for power production likely would occur. These fluctuating releases would be limited so that the hourly flow of the Green River, measured at Jensen, Utah, would be maintained at ±12.5% of the daily average flow of the Green River (measured at Jensen, Utah).[2]

[2] The daily average flow measured at Jensen, Utah, would be determined from the average of the instantaneous flow readings during a 24-hour period from midnight to midnight each day.

S.13.2.4 Winter Operations (Late Base Flow Period)

There are no specific flow recommendations provided by the 1992 Biological Opinion for the period from November to May. Beginning November 1, the 1992 Biological Opinion calls for releases to be low and stable near historic levels. Under the No Action Alternative, Flaming Gorge daily average releases from November through May potentially could range from 800 cfs to powerplant capacity (about 4,600 cfs). However, it is anticipated that in most years, releases during this period would range from 800 cfs to about 3,000 cfs. Releases from Flaming Gorge Dam during the late base flow period would be designed to reduce the reservoir elevation to maintain safe reservoir operations.

Under the No Action Alternative, releases would achieve an upper limit drawdown elevation on March 1 of 6027 feet above sea level. The upper limit drawdown elevations for May 1 under the No Action Alternative are the same as those under the Action Alternative.

During the late base flow period, fluctuating releases for power production could likely occur. The Reasonable and Prudent Alternative of the 1992 Biological Opinion does not specifically limit fluctuating releases during the late base flow period. Under the No Action Alternative, however, fluctuating releases would be limited, similar to the early base flow period, as they have been historically. The hourly flow of the Green River measured at Jensen, Utah, would be maintained from ±12.5% of the daily average flow measured at Jensen, Utah.

S.13.3 Reservoir Operations Process Under the Action Alternative

In general, implementation of the 2000 Flow and Temperature Recommendations into the operational plans for Flaming Gorge Dam would occur through coordination as described on pages 5-8 of the 2000 Flow and Temperature Recommendations. A Technical Working Group consisting of biologists and hydrologists involved with endangered fish recovery issues would be convened by Reclamation at various times throughout the year. Staff from Reclamation, Fish and Wildlife, and Western would be members of this group as well as other qualified individuals who choose to participate on a voluntary basis.

Reclamation would present an initial operational plan with balanced consideration of all resources associated with Flaming Gorge Reservoir and the Green River for discussion with the Technical Working Group. Reclamation would take into consideration the information described in table S-4 (page S-25) and any new information that may be available to refine the plan to best meet the needs of the endangered fish. Reclamation would comply with ESA Section 7 consultation requirements and may make refinements to the plan based on the Technical Working Group's recommendations. Reclamation could then present the new plan to the Flaming Gorge Working Group for additional discussion. Reclamation could further refine the plan based on information gathered at the Flaming Gorge Working Group Meeting. This process would ensure that the 2000 Flow and Temperature Recommendations and the authorized purposes of Flaming Gorge Dam are considered in a balanced and fair manner as each year's operational plan is developed.

Reclamation's meetings with the Technical Working Group would also provide an opportunity to discuss historic operations in terms of the accomplishments and shortcomings of meeting the 2000 Flow and Temperature Recommendations. Reclamation would maintain an administrative record of these meetings to document the planning process.

S.13.3.1 Operations in May Through July (Spring Period)

Under the Action Alternative, Reclamation would establish a hydrologic classification for the spring period (May through July) based on the April through July forecasted unregulated inflow volume. This forecast is issued by the River Forecast Center beginning in early January and is updated twice per month until the end of July. During the spring period, Reclamation would classify the current hydrology of the Green River system into one of the five hydrologic classifications described in the 2000 Flow and Temperature Recommendations (wet, moderately wet, average, moderately dry, and dry). Table S-3 describes the percent exceedance ranges that would be used for each classification under the Action Alternative.

Table S-3.—Percentage Exceedances and Hydrologic Classifications

Hydrologic Classification	Percentage Exceedance Range
Wet	<10
Moderately Wet	30 to 10.1
Average	70 to 30.1
Moderately Dry	90 to 70.1
Dry	>90

The hydrologic classification would be used to establish the range of flow magnitudes and durations that could potentially be targeted for the approaching spring release period. These targets would be incorporated into a spring operations plan. This plan would be prepared each year by Reclamation under consultation with the U.S. Fish and Wildlife Service and Western and in coordination with the Technical Working Group before the spring Flaming Gorge Working Group meeting. The factors listed in table 5.3 of the 2000 Flow and Temperature Recommendations (shown as table S-4), along with the established hydrologic classification, would be considered in the development of the operations plan.

In most years, it is expected that the flow magnitudes and durations achieved in Reach 2 each spring would be consistent with the flow magnitudes and durations described in the 2000 Flow and Temperature Recommendations for the hydrologic classification established in May of each year. However, because the factors listed in table S-4 are also considered, particularly runoff conditions in the Yampa River, there would be some years where the peak flows that occur in Reach 2 achieve the targets for either one or two classifications higher (wetter) or one classification lower (drier) than the actual classification established for the Green River.

It is anticipated that in some years, when the hydrologic classification for the Green River is average, factors listed in table S-4 could occur such that it would be possible to achieve the targets established for either the moderately wet or wet classifications. Conversely,

Table S-4.—Examples of Real-Time and Other Year-Specific Information To Be Considered in Determining Annual Patterns of Releases From Flaming Gorge Dam for Implementation of the 2000 Flow and Temperature Recommendations to Benefit Endangered Fishes in Downstream Reaches of the Green River

Onset of Spring Peak Flow	Magnitude of Spring Peak Flow	Duration of Spring Peak Flow	Onset of Summer-Winter Base Flow	Magnitude of Summer-Winter Base Flow
Forecasted and actual inflow to Flaming Gorge Reservoir	Forecasted and actual inflow to Flaming Gorge Reservoir	Forecasted and actual inflow to Flaming Gorge Reservoir	Forecasted and actual inflow to Flaming Gorge Reservoir	Forecasted and actual inflow to Flaming Gorge Reservoir
Water surface elevation of Flaming Gorge Reservoir	Forecasted and actual flow in the Yampa River and other large tributaries	Forecasted and actual flow in the Yampa River and other large tributaries	Forecasted and actual flow in the Yampa River	Forecasted and actual flow in the Yampa River
Forecasted and actual flows in the Yampa River	Desired area extent of overbank flooding in Reaches 2 and 3	Desired duration of overbank flooding in Reaches 2 and 3	Initial appearance of drifting Colorado pikeminnow larvae in the Yampa River	Elevation of sand bars in nursery areas
Presence of adult razorback sucker congregations on spawning bars	Flow conditions and extent of overbank flooding in Reaches 2 and 3 in previous year	Desired base flow magnitude	Status of endangered fish populations	Status of endangered fish populations
Initial appearance of larval suckers in established reference sites in Reach 2 (e.g., Cliff Creek)	Existing habitat conditions	Presence of razorback sucker larvae in the Green River	Temperature of water released from the dam	Temperature of water released from the dam
Existing habitat conditions (e.g., condition of razorback sucker spawning sites in Reach 2)	Status of endangered fish populations	Existing habitat conditions	Temperature differences between the Green and Yampa Rivers at their confluence	Temperature differences between the Green and Yampa Rivers at their confluence
		Status of endangered fish populations		

Source: 2000 Flow and Temperature Recommendations, table 5.3.

there would be some years classified as moderately wet when the conditions of these factors in table S-4 would be such that targets established for the wet or average classification would be met. There could also be years classified as wet where moderately wet targets would be achieved because of the conditions of these factors. It would be the responsibility of Reclamation to ensure that, over the long term, Flaming Gorge Dam and Powerplant are operated consistent with the 2000 Flow and Temperature Recommendations.

The operations plan would describe the current hydrologic classification of the Green River Basin and the hydrologic conditions in the Yampa River Basin, including the most probable runoff patterns for the two basins. The operations plan would also identify the likely Reach 2 flow magnitudes and durations that would be targeted for the upcoming spring release. Because hydrologic conditions often change during the April through July runoff period, the operations plan would contain a range of operating strategies that could be implemented. Flow and duration targets for these alternate operating strategies would be limited to those described for one classification lower or two classifications higher than the classification for the current year.

The spring operations plan would be presented to the Flaming Gorge Working Group each spring for discussion. Reclamation could modify the plan based on information gathered at the Flaming Gorge Working Group meeting.

In years classified as wet, bypass releases would usually be required both to operate the dam safely and to meet the 2000 Flow and Temperature Recommendations. Releases above powerplant capacity would be expected to be made for a period of about 4 to 9 weeks. The exact magnitude of the release and duration of the release would depend upon factors identified in table S-4. Wet years, high releases would be expected to occur from mid-May to early July (and, in very wet years, through July). The bypass and spillway releases, required in wet years, would be timed with the objective of meeting Reach 2 wet or moderately wet year targets, depending upon the hydrologic conditions in the Yampa River. The initiation of bypass and spillway releases would take place in mid- to late May coincident with the Yampa River peak. In extremely wet years, releases above powerplant capacity could be initiated in April or early May before the Yampa River peak.

In years classified as moderately wet, bypass releases usually (but not always) would be required for safe operation of the dam and to meet the 2000 Flow and Temperature Recommendations. Occasionally, some use of the spillway also might be required in moderately wet years for safe operation of the dam. The volume of the powerplant bypass in moderately wet years would be less than in wet years and would generally occur for a period of about 1 to 7 weeks. The timing of these releases would be from mid- to late May into June and sometimes extend into July. Releases from Flaming Gorge Reservoir in moderately wet years would be timed with the objective of meeting Reach 2 wet, moderately wet, or average year targets, depending upon the hydrologic conditions in the Yampa River Basin and the information contained in table S-4.

In years classified as average, bypass releases likely would not be required for safe operation of the dam but periodically would be required to meet the objectives of the 2000 Flow and Temperature Recommendations. In most average years, spring peak releases would be limited to powerplant capacity (about 4,600 cfs) with peak releases taking place for about 1 to 8 weeks, usually in the mid-May to late June (but occasionally extending into July) time period. In about 1 out of every 3 average years, bypass releases from Flaming Gorge Dam would be required to achieve the Reach 2 flow recommendation peak and duration targets. In these years, the objective would be to achieve targeted flows in Reach 2 of 18,600 cfs for 2 weeks. To conserve water, bypass releases in these average years would be made only to the extent necessary to achieve this target. It can be expected that bypass releases, when required to meet the 2000 Flow and Temperature Recommendations in average years, would be implemented for a period of less than 2 weeks. In some years classified as average, the targets achieved during the spring would be moderately wet or wet as a result of flows on the Yampa River that exceeded forecasted levels.

The objective in dry and moderately dry years would be to conserve reservoir storage while meeting the desired peak flow targets in Reach 2 as specified in the 2000 Flow and Temperature Recommendations. The bypass tubes and the spillway would not be used to meet flow targets in moderately dry and dry years but, on rare occasion, might be needed to supplement flows that cannot be released through the powerplant because of maintenance requirements. In dry years, a powerplant capacity release of 1 day to 1 week would occur during the spring, and this release would be timed with the peak of the Yampa River. In moderately dry years, a 1- to 2-week powerplant capacity release would occur during the spring and would be timed with the peak and post peak of the Yampa River.

S.13.3.2 Use of Bypass Tubes and Spillway at Flaming Gorge Dam

The bypass tubes and the spillway at Flaming Gorge Dam have been utilized historically, as needed, for safe operation of the dam. In years with high inflow, bypass releases, and sometimes spillway releases, may be required under the Action Alternative to meet the 2000 Flow and Temperature Recommendations. Bypass and spillway releases, required for safe operation of the dam and to meet the 2000 Flow and Temperature Recommendations, would be scheduled coincident with Yampa River peak and post peak flow (the mid-May to mid-June time period) with the objective of meeting flow recommendation targets in Reach 2.

There would be some years (moderately wet years and average years) when use of the bypass would not be required for safe operation but would be needed to meet the 2000 Flow and Temperature Recommendations. As part of the annual planning process discussed above, Reclamation would consult with the U.S. Fish and Wildlife Service and Western and coordinate with the Technical Working Group to make a determination whether bypasses should be attempted to achieve the targeted Reach 2 magnitudes and durations.

S.13.3.3 Operations in August Through February (Base Flow Period)

Under the Action Alternative, during the base flow period, Reclamation would classify the current hydrology of the Green River system into one of the five hydrologic classifications described in the 2000 Flow and Temperature Recommendations (wet, moderately wet, average, moderately dry, and dry). For the month of August, the hydrologic classification would be based on the volume of unregulated inflow during the spring period. For the months of September through February, the percentage exceedance would be based on the previous month’s volume of unregulated inflow. If the unregulated inflow during the previous month falls into a different hydrology classification than the assigned hydrology classification for the previous month, then the classification could be shifted by one classification (up or down) to reflect the change in hydrology. A shift would only be made when the reservoir condition indicated that the shift would be necessary to achieve the March 1 drawdown level of 6027 feet above sea level. Otherwise, the hydrologic classification for the current month would remain the same as for the previous month.

The range of acceptable base flows for Reach 2 would be selected from the 2000 Flow and Temperature Recommendations for the hydrologic classification set for the current month. Reclamation would make releases to achieve flows in Reach 2 within the acceptable range and also ensure that the reservoir elevation on March 1 would be no higher than 6027 feet above sea level.

The 2000 Flow and Temperature Recommendations during the base flow period do allow for some flexibility, and the Action Alternative accommodates this flexibility. Under the Action Alternative, the flows occurring in Reach 2 during the base flow period would be allowed to vary from the targeted flow by ±40% during the summer to fall period (August through November) and by ±25% during the winter (December through February), as long as the day-to-day change is limited to 3% of the average daily flow and the variation is consistent with all other applicable 2000 Flow and Temperature Recommendations. Reclamation would utilize the allowed flexibility to the extent possible, to efficiently manage the authorized resources of Flaming Gorge Dam. Flaming Gorge Reservoir would be operated through the base flow period so that the water surface elevation would not be greater than 6027 feet above sea level on March 1.

During the base flow period, hourly release patterns from Flaming Gorge Dam would be patterned so that they produce no more than a 0.1-meter stage change each day at the Jensen gauge, except during emergency operations.

S.13.3.4 Operations in March and April (Transition Period)

From March 1 through the initiation of the spring peak release (typically, this occurs in mid- to late May), there are no specific flow requirements specified in the 2000 Flow and Temperature Recommendations. For the Action Alternative, releases during this transition period would be made to manage the reservoir elevation to an appropriate drawdown level based on the forecasted unregulated inflow. Appropriate drawdown levels under normal operations during the transition period are those that would allow for safe operation of the dam through the spring. The upper limit drawdown levels for varying percentage exceedances are described earlier in table S-2 (page S-21). These drawdown levels apply for both the Action and the No Action Alternatives.

Table S-2 implies that upstream regulation above Flaming Gorge Reservoir remains relatively consistent with historic regulation.[3] In the event that less storage space would be available above Flaming Gorge Reservoir during the spring, these drawdown levels may have to be lower than those specified in table S-2 for safe operation of Flaming Gorge Dam. In extreme wet years, the drawdown level for May 1 could potentially be lower than that specified to maintain safe operation of the dam.

Reclamation would determine the appropriate reservoir drawdown based on the percentage exceedance of the forecasted inflow volume during the spring (April through July). The forecast is issued twice during March and twice during April. Under normal operations during the transition period, releases would be limited to a range from 800 cfs to powerplant capacity (4,600 cfs).

Hourly releases during the transition period would be patterned so that they are consistent with the hourly release patterns established during the preceding base flow period. The 2000 Flow and Temperature Recommendations do not address hourly patterns during the transition period. During the transition period, Reclamation would maintain the same fluctuation constraints as in the preceding base flow period to provide operational consistency as has been done historically.

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[3] Historically (1988-2003), there generally has been about 200,000 acre-feet of available space at Fontenelle Reservoir (above Flaming Gorge) on May 1.

S.14 ENVIRONMENTAL CONSEQUENCES

This section summarizes the EIS analyses and comparisons of predicted environmental effects under both the Action and No Action Alternatives.

S.14.1 Hydrology

Tables S-5, S-6, and S-7 present the key flow parameters and ranges described in both the 1992 Biological Opinion (No Action Alternative) and the 2000 Flow and Temperature Recommendations (Action Alternative) under dry, average, and wet hydrological conditions. The 2000 Flow and Temperature Recommendations report also provides recommended flow regimes for moderately wet and moderately dry hydrologic conditions; however, because the 1992 Biological Opinion does not address these conditions, they have been omitted from this comparative analysis.

The 1992 Biological Opinion does not specifically define the differences between wet, average, and dry hydrological conditions but, rather, suggests that Reclamation and the U.S. Fish and Wildlife Service consult each year to make this determination. The 2000 Flow and Temperature Recommendations are more specific about how the hydrology of the upper Green River Basin is to be characterized.

The hydrologic conditions of the upper Green River Basin, as described in the 2000 Flow and Temperature Recommendations, are based on the forecasted or actual volume of unregulated inflow (adjusted for storage in upstream reservoirs) into Flaming Gorge Reservoir during the period from April through July. During the spring and early summer, operational decisions would be based on forecasted inflows. After August 1, operational decisions would be based on the measured inflows that occurred during the previous month as well as on the previous April through July period.

For purposes of this analysis, and as defined by the 2000 Flow and Temperature Recommendations, dry conditions in the upper Green River Basin are identified as unregulated April-July inflow volumes that are exceeded in 9 out of every 10 years (90% exceedance value). The year 1977 was historically dry at which time the unregulated April through July inflow measured only 254,000 acre-feet. In contrast, wet conditions in the upper Green River Basin are identified as unregulated April through July inflow volumes that are exceeded in only 1 out of every 10 years (10% exceedance value). For example, 1986 was a historically wet year at which time the unregulated April through July inflow measured 2,224,000 acre-feet.

S.14.2 Water Quality, Water Temperature, and Sediment Transport

When the operation of Flaming Gorge Dam was changed to meet the requirements of the RPA of the 1992 Biological Opinion, the frequency of summer and fall reservoir drawdowns that produced algal blooms was reduced. This operational change improved the water quality of Flaming Gorge Reservoir. The analysis of the effects of the Action and No Action Alternatives shows that the frequency of reservoir drawdowns likely would not differ from drawdown conditions observed since 1992. Under either alternative, reservoir drawdowns during drought conditions would cause larger algal blooms. As an example, such a condition occurred in the fall of 2002.

Table S-5.—Dry Hydrology Scenario (Runoff Volume Exceeded 90 to 100% of the Time)

1992 Biological Opinion (No Action Alternative)	September 2000 Flow and Temperature Recommendations (Action Alternative)
Release Peak Determination	***Release Peak Determination***
The Biological Opinion calls for a peak release of 4,000 to 4,700 cfs for a duration of 1 to 6 weeks in all years. ▪ The intent of this peak release is to achieve a peak flow at Jensen, Utah, of 13,000 to 18,000 cfs for a period of 1 week in dry years. ▪ Timing of the peak release would begin during the period from May 15 to June 1 so that the peak release would coincide with the peak flow of the Yampa River.	In dry years, the 2000 Flow and Temperature Recommendations call for a peak release that should achieve the following: ▪ The combined flows of the Green and Yampa Rivers should provide a peak flow in Reach 2 that exceeds 8,300 cfs for at least 2 days. ▪ The minimum peak release from Flaming Gorge Dam should be 4,600 cfs. To target these requirements, the forecasted peak flow of the Yampa River would be supplemented by releases from Flaming Gorge Dam. The timing of the peak release should coincide with the peak and post-peak flows of the Yampa River.
Ramp Rate Determination	***Ramp Rate Determination***
The ascent rate would be limited to no more than 400 cfs per day. The decline rate would also be limited to 400 cfs per day.	The ascent rate is not specified in the 2000 Flow and Temperature Recommendations. The decline rate for a dry year should be 350 cfs per day or less.
Base Flow Determination	***Base Flow Determination***
Summer flows, after the spring peak release, would be between 1,100 and 1,800 cfs at Jensen, Utah, for all years and would be reached by June 20 in dry years. On September 15, if it is determined that the year was wetter than anticipated, the range of available target flows could be expanded to 1,100 to 2,400 cfs, if necessary.	The base flow target at Jensen, Utah, should be between 900 cfs and 1,100 cfs during dry years. Variability in flow around the established average base flow should be consistent with the variability that occurred in pre-dam flows. Accordingly, the average daily flow at Jensen, Utah, could fluctuate by 40% around the established average daily base flow target from August through November. From December through February, the average daily flow at Jensen, Utah, could fluctuate by 25% around the established average daily base flow target. Differences in average daily flows at Jensen, Utah, between consecutive days, and due strictly to reservoir operations, should not exceed 3%.
Hour-to-Hour Fluctuation Determination	***Hour-to-Hour Fluctuation Determination***
The flow at Jensen, Utah, would fluctuate no more than 12.5% of the daily average flow during the summer and fall period. Fluctuations during the winter period (November through February) would be moderated.	Flow variations resulting from hydropower generation at Flaming Gorge Dam should be limited to produce no more than a 0.1-meter (about 4 inches) stage change within a 24-hour period at the Jensen gauge.
Release Temperature Determination	***Release Temperature Determination***
Releases during the period from July 1 to November 1 would be regulated to achieve the warmest possible temperatures, approaching 59 °F (15 °C).	Release temperatures should be regulated with the objective to meet or exceed water temperatures in upper Lodore Canyon of 64 °F (18 °C) for the first 2 to 5 weeks during the base flow period (mid-June to March 1) for dry years. In addition to the above criteria, Green River temperatures at its confluence with the Yampa River should be no more than 9 °F (5 °C) colder than Yampa River temperatures during the summer base flow period.

Table S-6.—Average Hydrology Scenario
(Runoff Volume Exceeded 30 to 70% of the Time)

1992 Biological Opinion (No Action Alternative)	September 2000 Flow and Temperature Recommendations (Action Alternative)
Peak Flow Determination	***Peak Flow Determination***
The Biological Opinion calls for a peak release of 4,000 to 4,700 cfs for a duration of 1 to 6 weeks in all years. ▪ The intent of this peak release is to achieve a peak flow at Jensen, Utah, of 13,000 to 18,000 cfs for a period of 2 to 4 weeks in average years. ▪ Timing of the peak release would begin during the period from May 15 to June 1 so that the peak release would coincide with the peak flow of the Yampa River. Bypass releases, if necessary for hydrologic reasons, would be made before or during the Yampa River peak flow.	In average years, the 2000 Flow and Temperature Recommendations call for a peak release that should achieve the following: ▪ The peak release should provide a peak flow in Reach 2 that exceeds 18,600 cfs in 1 out of 2 average years. ▪ In 1 out of 4 average years, the peak flow in Reach 2 should exceed 18,600 cfs for at least 2 weeks. ▪ In all average years, the peak flow in Reach 2 should exceed 8,300 cfs for at least 2 weeks. ▪ The minimum peak release from Flaming Gorge Dam should be 4,600 cfs. To target these requirements, the forecasted peak flow of the Yampa River would be supplemented by releases from Flaming Gorge Dam. The timing of the peak release should coincide with the peak and post-peak flows of the Yampa River.
Ramp Rate Determination	***Ramp Rate Determination***
The ascent rate would be limited to no more than 400 cfs per day. The decline rate would also be limited to 400 cfs per day.	The ascent rate is not specified in the 2000 Flow and Temperature Recommendations. The decline rate for an average year should be 500 cfs per day or less.
Base Flow Determination	***Base Flow Determination***
Summer flows, after the spring peak release, would be between 1,100 and 1,800 cfs at Jensen, Utah, for all years and would be reached by July 10 in average years. On September 15, if it is determined that the year was wetter than anticipated, the range of available target flows could be expanded to 1,100 to 2,400 cfs, if necessary.	The base flow target at Jensen, Utah, should be between 1,500 cfs and 2,400 cfs during average years. Variability in flow around the established average base flow should be consistent with the variability that occurred in pre-dam flows. Accordingly, the average daily flow at Jensen, Utah, could fluctuate by 40% around the established average daily base flow target from August through November. From December through February, the average daily flow at Jensen, Utah, could fluctuate by 25% around the established average daily base flow target. Differences in average daily flows at Jensen, Utah, between consecutive days, and due strictly to reservoir operations, should not exceed 3%.
Hour-to-Hour Fluctuation Determination	***Hour-to-Hour Fluctuation Determination***
The flow at Jensen, Utah, would fluctuate no more than 12.5% of the daily average flow during the summer and fall period. Fluctuations during the winter period (November through February) would be moderated.	Flow variations resulting from hydropower generation at Flaming Gorge Dam should be limited to produce no more than a 0.1-meter (about 4 inches) stage change within a 24-hour period at the Jensen gauge.
Release Temperature Determination	***Release Temperature Determination***
Releases during the period from July 1 to November 1 would be regulated to achieve the warmest possible temperatures, approaching 59 °F (15 °C).	Release temperatures should be regulated with the objective to meet or exceed water temperatures in upper Lodore Canyon of 64 °F (18 °C) for the first 2 to 5 weeks during the base flow period (mid-July to March 1) for average years. In addition to the above criteria, Green River temperatures at its confluence with the Yampa River should be no more than 9 °F (5 °C) colder than Yampa River temperatures during the summer base flow period.

Table S-7.—Wet Hydrology Scenario (Runoff Volume Exceeded Less than 10% of the Time)

<table>
<tr><th>1992 Biological Opinion
(No Action Alternative)</th><th>September 2000 Flow and Temperature Recommendations
(Action Alternative)</th></tr>
<tr><td>Peak Flow Determination

The Biological Opinion calls for a peak release of 4,000 to 4,700 cfs for a duration of 1 to 6 weeks in all years.
▪ The intent of this peak release is to achieve a peak flow at Jensen, Utah, of 13,000 to 18,000 cfs for a period of 6 weeks in wet years.
▪ Timing of the peak release would begin during the period from May 15 to June 1 so that the peak release would coincide with the peak flow of the Yampa River. Bypass releases, if necessary for hydrologic reasons, would be made before or during the Yampa River peak flow.</td><td>Peak Flow Determination

In wet years, the 2000 Flow and Temperature Recommendations call for a peak release that should achieve the following:
▪ The peak release should provide a peak flow in Reach 2 that should exceed 26,400 cfs.
▪ Flows in Reach 2 should exceed 22,700 cfs for at least 2 weeks.
▪ Flows in Reach 2 should also exceed 18,600 cfs for at least 4 weeks.
▪ The minimum peak release from Flaming Gorge Dam should be 8,600 cfs.

To target these requirements, the forecasted peak flow of the Yampa River would be supplemented by releases from Flaming Gorge Dam. The timing of the peak release should coincide with the peak and post-peak flows of the Yampa River.</td></tr>
<tr><td>Ramp Rate Determination

The ascent rate would be limited to no more than 400 cfs per day. The decline rate would also be limited to 400 cfs per day.</td><td>Ramp Rate Determination

The ascent rate is not specified in the 2000 Flow and Temperature Recommendations. The decline rate for a wet year should be 1,000 cfs per day or less.</td></tr>
<tr><td>Base Flow Determination

Summer flows, after the spring peak release, would be between 1,100 and 1,800 cfs at Jensen, Utah, for all years and would be reached by July 20 in wet years. On September 15, if it is determined that the year was wetter than anticipated, the range of available target flows could be expanded to 1,100 to 2,400 cfs, if necessary.</td><td>Base Flow Determination

The base flow target at Jensen, Utah, should be between 2,800 cfs and 3,000 cfs during wet years.

Variability in flow around the established average base flow should be consistent with the variability that occurred in pre-dam flows. Accordingly, the average daily flow at Jensen, Utah, could fluctuate by 40% around the established average daily base flow target from August through November. From December through February, the average daily flow at Jensen, Utah, could fluctuate by 25% around the established average daily base flow target. Differences in average daily flows at Jensen, Utah, between consecutive days, and due strictly to reservoir operations, should not exceed 3%.</td></tr>
<tr><td>Hour-to-Hour Fluctuation Determination

The flow at Jensen, Utah, would fluctuate no more than 12.5% of the daily average flow during the summer and fall period. Fluctuations during the winter period (November through February) would be moderated.</td><td>Hour-to-Hour Fluctuation Determination

Flow variations resulting from hydropower generation at Flaming Gorge Dam should be limited to produce no more than a 0.1-meter (about 4 inches) stage change within a 24-hour period at the Jensen gauge.</td></tr>
<tr><td>Release Temperature Determination

Releases during the period from July 1 to November 1 would be regulated to achieve the warmest possible temperatures, approaching 59 °F (15 °C).</td><td>Release Temperature Determination

Release temperatures should be regulated with the objective to meet or exceed water temperatures in upper Lodore Canyon of 64 °F (8 °C) for the first 2 to 5 weeks during the base flow period (mid-August to March 1) for wet years. In addition to the above criteria, Green River temperatures at its confluence with the Yampa River should be no more than 9 °F (5 °C) colder than Yampa River temperatures during the summer base flow period (the 2000 Flow and Temperature Recommendations indicate that this may not be possible in wet years).</td></tr>
</table>

For the Green River below Flaming Gorge Dam, the only water quality issue of concern with respect to the Action Alternative is water temperature. The No Action Alternative would result in future water temperatures based on the recommendations of the 1992 Biological Opinion. Under the Action Alternative, release temperatures and river temperatures in Reach 1 would be somewhat warmer to meet the temperature recommendation of 64 °F (18 °C) or greater in upper Lodore Canyon. Reaches 2 and 3, because of their distance from Flaming Gorge Dam, would likely have similar water temperatures under either of the alternatives.

Sediment transport is presented in the Water Quality section of the EIS because it is an important function in the river system, with the potential to affect both riverine and riparian habitat. Table S-8 illustrates the average annual sediment transport under the No Action and the Action Alternatives as well as the estimated percent of tonnage increase under each of these alternatives for the May, June, July period.

Table S-8.—Weight and Percent Increase in Sediment Transport Under the Action Alternative Compared to the No Action Alternative

		No Action Alternative	Action Alternative	
Reach Number	Time Period	Estimated sediment load (tons)	Sediment Load Increase (tons)	Increase (percent)
Reach 1	Average Annual	92,000	+13,000	+14
	May-June-July	45,000	+25,000	+56
Reach 2	Average Annual	1.2 million	+800,000	+ 7
	May-June-July	970,000	+110,000	+11
Reach 3	Average Annual	3.5 million	+280,000	+ 8
	May-June-July	3.3 million	+290,000	+ 9

S.14.3 Hydropower

Hydropower analysis focuses on the potential impacts of the alternatives on powerplant operations at Flaming Gorge Dam. This analysis used a computer model developed by Argonne National Laboratory in collaboration with Reclamation. The model uses an estimate of the quantity of energy injected into the power grid along with a forecasted hourly electricity spot price (market price) to determine the economic value for each alternative. The model determined the revenue generated as a result of operating Flaming Gorge Powerplant to achieve each alternative over the period from 2002 to 2026. The revenues for each alternative were then discounted by 5.5% per year so that they reflected their net present value. The total net present value of the revenue generated under each alternative was then compared to determine the economic impacts to power production under the proposed alternatives. The results are summarized in table S-9 and show that

Table S-9.—Table of Comparisons of the Alternatives for Hydropower

	No Action Alternative	Action Alternative	Comparison of Action to No Action
Net Present Value	$403.1 million	$423.1 million	$20 million (5.0%)
Generation in GWh	11,904.1	11,374.3	-529.8 (-4.5%)
Wholesale Electricity Price Composite	20.72 mills/KWh[1]	20.57 mills/KWh	-0.15 mills/KWh (-0.73%)

[1] Mill per kilowatthour (KWh).

the net present value of economic benefits for the No Action Alternative simulation was $403.1 million while generating about 11,904 gigawatthours (GWh) of energy. The Action Alternative showed a net present value of about $423.1 million for the 25-year simulation, an increase of $20.0 million (5.0%) over the estimate for the No Action Alternative.

The Action Alternative would generate about 11,374 GWh of energy, about 4.5% less, compared to the No Action Alternative generation. The Action Alternative generates less energy but is able to generate more of this energy during the seasons when market prices are higher, leading to a slightly greater net present value. The Action Alternative has greater benefits with fewer GWh due to the fluctuations in the market price of energy. The Action Alternative calls for more generation in the summer months when energy sells at higher prices than in the fall when the No Action Alternative generates more power. Given recent volatility in historic prices, there is uncertainty associated with future prices. Because there is less total annual power generation with the Action Alternative, use of an alternative price set that does not assume as large a relative seasonal price difference could result in a negative rather than a positive impact. In any case, the impact is considered to be insignificant when the total value of Flaming Gorge generation is considered.

In addition to the economic analysis, a financial analysis was performed as described in the EIS. While an economic analysis shows the impacts on the national economy as a whole, the financial analysis describes the impacts to the customers who purchase wholesale electricity generated at Flaming Gorge Powerplant. The results of this analysis show that, compared to the No Action Alternative, the Action Alternative would not have a significant impact on the rate CRSP power users pay.

S.14.4 Agriculture

Under both the No Action and Action Alternatives, about 245 acres of cropland in the historic Green River flood plain could be flooded in nearly half of all years. On average, affected lands would be inundated 2 days longer under the Action Alternative, but since this incremental time would not do further crop damage compared with the No Action Alternative, there would be no differences in impacts between the two alternatives.

S.14.5 Land Use

There would be no impacts to land use around Flaming Gorge Reservoir under either alternative. In Reach 1 of the Green River, in wet years, the Action Alternative would have greater impacts to the use of campgrounds and other recreational facilities that have been built in the historic flood plain than would the No Action Alternative. In average hydrology years, the impacts to such facilities would be about the same under either alternative.

Under the No Action Alternative in Reach 2, the effects of the river on land use that have occurred over the past 10 years would continue. Under the Action Alternative, higher flows of longer duration would be expected to occur in wet years. This would result in inundation levels and durations in the historic flood plain that have not occurred in the recent past and, consequently, a temporary loss of land use in the flood plain on a more frequent basis. In Reach 3, there would not be a significant land use difference under either alternative.

S.14.6 Ecological Resources

Under the No Action Alternative, present conditions would be expected to continue for all flora and fauna around Flaming Gorge Reservoir and in the Green River.

Under the Action Alternative, both native and nonnative fish in Reach 1 would likely benefit from the 2000 Flow and Temperature Recommendations. There is the potential for both positive and negative effects to trout in the area immediately below Flaming Gorge Dam, though long-term negative effects are not expected. There is also a potential for negative impacts to trout in the Browns Park area if water temperatures in that area exceed 64 °F (18 °C).

Under the No Action Alternative, there would be continued proliferation of wetland plants and island marshes. Due to infrequent flooding, the flood plain forests of the old high water zone would continue to transition to desert. The old-growth cottonwoods would continue the trend of premature dieoff. There would be limited opportunity for establishment of cottonwoods and box elders. Under the Action Alternative, there may be erosion of wetland and riparian vegetation on islands and bars, followed by increased opportunity for cottonwood establishment. Larger floodflows may improve the health of mature cottonwoods.

Invasive species are present in all reaches and are expected to persist under the No Action Alternative. The Action Alternative could accelerate growth of some invasive species along the river. Tamarisk and giant whitetop are two such species that could increase in rate and acreage of invasion in higher flood plain settings under the Action Alternative.

In the short term, birds and animals along the Green River corridor could be negatively impacted by temporary loss of habitat due to increased flooding, but the potential impacts are not expected to be significant. In the long term, birds and animals are expected to benefit from enhancement of riparian vegetation and habitat.

S.14.6.1 Threatened and Endangered Fish

Under the No Action Alternative, existing conditions for the Colorado pikeminnow, humpback chub, and razorback sucker would be expected to continue. For both the No Action and Action Alternatives, conditions for the bonytail chub are assumed to be the same as for the other three endangered fish species. While these species would be expected to benefit from Recovery Program activities other than activities arising from implementation of the 2000 Flow and Temperature Recommendations, it is believed that continuation of No Action flow regimes would not provide enough benefit to support their recovery. Under the Action Alternative, river conditions are expected to benefit the endangered fish and their designated critical habitat.

S.14.6.2 Other Threatened, Endangered, and Special Status Species

Under the No Action Alternative, continued decline in acreage and health of native riparian vegetation would have negative effects on the southwestern willow flycatcher.

Under the No Action Alternative, continued decline in the acreage and health of native riparian vegetation would have negative effects on yellow-billed cuckoo and other State sensitive songbirds. Other threatened and endangered species are not expected to be affected under either alternative.

Under the Action Alternative, Ute ladies'-tresses could be lost in Reach 1. Suitable habitat may be lost or otherwise become unsuitable. However, additional sites of potentially suitable habitat would likely develop at new locations. Bald eagles and southwestern willow flycatcher would be benefited by long-term increases in cottonwood and native understory vegetation along the river corridor. The Action Alternative may reverse degradation of riparian vegetation in Reach 2 and upper Reach 3.

S.14.7 Cultural Resources

Adjacent to the reservoir and along the Green River, there would be no effects from dam operations to cultural resources under either alternative.

S.14.8 Paleontological Resources

Adjacent to the reservoir and along the Green River, there would be no effects from dam operations to paleontological resources under either alternative.

S.14.9 Indian Trust Assets

The No Action Alternative would not affect Indian (American Indian) trust assets. The Action Alternative would not affect agriculture and oil and gas production, or other Indian trust assets if advance notice is provided on the timing of spring peak flows. There would be no significant difference between effects on Indian trust assets under either the Action or No Action Alternatives.

S.14.10 Safety and Public Health

There is public concern over the creation of mosquito habitat along the Green River due to the flow regimes under either alternative, which are intended to inundate flood plain depressions for the benefit of endangered fish. Under the No Action Alternative, populations of mosquitoes along the river would not increase. In Reach 1, the Action Alternative could result in an increase in mosquito populations along the river. In Reach 2, the Action Alternative also could result in an increase in mosquitoes, though not as large or as often as in Reach 1. As in the past, under either alternative, Reclamation would continue to coordinate peak flow releases with State and county officials to help minimize the mosquito population in the Jensen, Utah, area to the extent possible. Under either alternative, mosquito abatement control by the county would continue. In Reach 3, there would be no significant difference for mosquito populations between the Action and No Action Alternatives.

Public safety on Flaming Gorge Reservoir is expected to be unchanged under either alternative. Public safety along the Green River could be affected under the Action Alternative due to the potential for higher flows for longer durations. Existing safety procedures for dam operations would continue to be followed, along with notification to the public of scheduled high flows.

S.14.11 Air Quality

There are no significant effects to air quality under either alternative.

S.14.12 Visual Resources

There are no significant effects on visual resources under either alternative.

S.14.13 Environmental Justice

No adverse effects to minority or low-income populations have been identified under either alternative.

S.14.14 Recreation

On average, total water-based river and reservoir visitation within Flaming Gorge National Recreation Area for the Action Alternative is not expected to measurably change compared to visitation under the No Action Alternative (only a +0.3% gain). Gains in economic value are expected to be higher (+9.5%) as a result of water levels moving closer to those under preferred conditions.

Under wet and dry conditions, each of which typically occur only 10% of the time, visitation under the Action Alternative and value on the river is expected to decline compared to that under the No Action Alternative, but the decline is more than offset by gains on the reservoir.

S.14.15 Socioeconomics/Regional Economics

The socioeconomic analysis evaluates the effect of changing expenditures on economic activity in the general vicinity of Flaming Gorge National Recreation Area. The economic impact region consists of Daggett and Uintah Counties in Utah and Sweetwater County in Wyoming. Given the minor effect on local expenditures from changes in hydropower and agricultural production, the analysis focuses exclusively on recreation expenditures. The combined river and reservoir recreation expenditure impacts of the Action Alternative appear to be positive, but minor, under all hydrologic conditions.

S.15 PREFERRED ALTERNATIVE

As a result of the analyses presented in the EIS, Reclamation considers the Action Alternative to be the preferred alternative.

S.16 CUMULATIVE IMPACTS

As defined at 40 Code of Federal Regulations 1508.7, a cumulative impact is an impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of which agency or person undertakes such actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. The Flaming Gorge EIS focuses on whether the proposed action, considered together with any known or reasonably foreseeable actions, could cause a cumulative effect for any resource.

Human use of the Green River began to have some impact on the riverine environment early in the 19th century. Later, construction of Flaming Gorge Dam (1958 through 1964) resulted in a profound change to the riverine environment, which contributed to the decline of native fish species in the Green River and native vegetation along the Green River. Also, filling of the reservoir inundated cultural and paleontological resources.

The construction of Flaming Gorge Dam established hydropower generation to serve millions of homes in the West and to provide water storage capability. The creation of Flaming Gorge Reservoir, the establishment of the Flaming Gorge National Recreation Area, and the establishment of the trout fishery below Flaming Gorge Dam constitute significant benefits to recreation and the regional economy.

The conclusion of the resource analysis in the EIS is that the Action Alternative when compared to the No Action Alternative would have either a small effect or no effect at all. When added to the cumulative effects for each resource, effects were minor or nonexistent and not enough to change direction of any cumulative effect trends. The Action Alternative would have a positive effect for habitat development overall, which should help the four endangered native fish species and other fish species including trout, especially in combination with other actions initiated by the Recovery Program.

Negative cumulative effects could include an increased rate of invasion of tamarisk and giant whitetop and possibly the displacement of Ute ladies'-tresses in Reach 1. Cumulative effects to power generation have been negative due to past operational changes and would continue to be negative on balance.

S.17 UNCERTAINTIES

The analyses presented in chapter 4 of the EIS identify impacts to resources based on the best available data. Uncertainties associated with implementing the Action Alternative are discussed in the EIS and summarized here.

The authors of the 2000 Flow and Temperature Recommendations recognized uncertainties in their general approach and in specific recommendations (2000 Flow and Temperature Recommendations). Their recommendations are based on a model which assumes that the ecological integrity of river ecosystems is linked to their dynamic character (Stanford et al., 1996; Poff et al., 1997) and that restoring more natural flow and thermal regimes is a key element to rehabilitating an impaired system. The authors recognized as well that the response of the endangered fishes of the Green River to a more natural flow regime and water temperatures remains largely unmeasured and that factors other than modifications to physical habitat are also impacting these species.

S.17.1 Hydrology

Uncertainties regarding the hydrology of Flaming Gorge Dam necessarily involve assumptions the authors made for the Flaming Gorge Model regarding historical river flow patterns which in their best judgment most nearly represented real conditions, which therefore cannot be fully addressed because, as yet, such conditions may not have occurred.

Uncertainties associated with the Flaming Gorge Model include the following:

- Determining which years to attempt to achieve the higher-level springtime flow recommendations in Reach 2 of the Green River. Actual basin indicators such as snow levels, temperature, and climate will henceforth be used in making yearly decisions.
- Obtaining matching flows of the Yampa River to achieve precise target levels to within 300 cfs in Reach 2 of the Green River under normal springtime operations.
- Predicting what resource impacts would occur as a result of future water development in the Green River above and below Flaming Gorge Reservoir.
- Achieving the flow objectives for Reach 2 to provide flows high enough to achieve the flow objectives in Reach 3 of the Green River in the future, given the expected increase in water development affecting its tributaries.
- Accounting for the remote possibility that Flaming Gorge Dam could have a physical restriction that might prevent enough water from being released to achieve the 2000 Flow and Temperature Recommendations objectives.

S.17.2 Operational Limitations for Temperature of Water Released From the Dam

The capability of releasing warmer water through the Flaming Gorge Dam selective withdrawal structure is limited at times, because release water is used to cool turbine bearings. How much additional increase to current capabilities in release temperatures could be realized would have to be determined through testing and adjustment of powerplant instruments at Flaming Gorge Dam.

S.17.3 Uncertainties Associated With Increased Spillway Use

Increased spillway use under the Action Alternative would produce a greater likelihood for degradation of concrete in the spillway. Reclamation would inspect the spillway following each period of use and evaluate the need for repairs. If damage to the spillway were to become excessive, repairs would be made and usage could be limited to operations necessary to maintain the required hydrology.

S.17.4 Fish Responses to Flow and Temperature Modifications

Uncertainties regarding nonnative fish responses to flow and temperature modifications under implementation of the 2000 Flow and Temperature Recommendations include the following:

- Determining how nonnative fish would respond to implementation of proposed changes in Flaming Gorge Dam operations. Releases of warmer water could result in the expansion of cool water nonnative fish populations in Reach 1, an area where their current populations are comparatively low. Such releases could also benefit warm water nonnative species in flood plain habitats resulting from increased overbank flooding. Continued monitoring and nonnative fish controls would be required.
- Maintaining the necessary base flows to maximize nursery habitats, since base flows vary from year to year as a function of variation in tributary inputs. Also, the effects of within-day fluctuations on nursery habitat conditions warrant further investigation.
- Determining the extent to which an increased frequency of bypassing water could result in entrainment of reservoir nonnative species into the Green River. Monitoring could include evaluating the potential for undesirable reservoir fishes, such as smallmouth bass, becoming established in the tailwater (water below the dam).
- Attaining desired temperature thresholds could improve Colorado pikeminnow survivorship. Temperature modeling indicates that, during wet years, the river may not warm enough to provide suitable conditions for year-round Colorado pikeminnow use. If warmer water could be released at the dam during wet years, Colorado pikeminnow survivorship might improve due to higher growth rates and larger sizes of the fish.

If the Action Alternative is implemented, Reclamation would coordinate with the Recovery Program in developing the appropriate studies through an adaptive management process to evaluate fish response to flow and temperature modifications.

S.17.5 Uncertainties Associated With Flood Plain Inundation

Peak flows recommended for Reach 2 were intended to provide inundation of flood plain nursery habitats in wetter years and to promote access to those flood plains by newly hatched razorback sucker larvae drifting from upstream spawning areas. This would ensure that razorback sucker juveniles overwintering in flood plains were allowed an opportunity to return to the main channel in subsequent years. The 2000 Flow and Temperature Recommendations recognized that access to flood plain habitats could be achieved through a combination of increased peak flows, prolonged peak flow duration, lower bank or levee heights, and constructed inlets. The report indicated that substantially more flood plain habitat could be inundated with lower peak flows if levees were removed.

Recent information provided in Valdez and Nelson (2004) indicates the area of depression flood plains that are potentially inundated by 13,000-cfs and 18,600-cfs flows is identical (about 2,200 acres) for the first 52 miles downstream from the only known razorback spawning bar in Reach 2. At greater distances, 18,600 cfs flows would inundate an additional 1,186 acres of depression flood plains. On the basis of the Valdez entrainment model, very few larvae are likely to be entrained at these distances from the spawning bar, and survival is likely to be low with sympatric nonnative fish populations in these flood plains.

On the basis of this information and further research, including studies in May 2005, it may be possible that connection and inundation could potentially be achieved with lower peak releases from Flaming Gorge Dam and still occur in 30% more years than with a peak flow of $\geq$18,600 cfs.

To resolve uncertainties associated with flow and nonflow actions that may be required for flood plain inundation, Reclamation would coordinate studies to test this hypothesis through the Recovery Program (see section 4.19.5 in the EIS). These studies would be conducted using an adaptive management approach as described in section 4.20.

Resolving these uncertainties along with other uncertainties in flow recommendations is a priority of the Recovery Program. The above studies would be incorporated into the flow evaluation process of the Recovery Program.

S.17.6 Riparian/Vegetation

Uncertainties involving the response of invasive species and certain native plant communities to implementation of the Action Alternative include the following:

- ❖ The effects of floodflows on tamarisk establishment on post-dam flood plain surfaces in Lodore Canyon, and on new tamarisk establishment at higher elevations
- ❖ The effects of higher base flows, coupled with several years of drought, on tamarisk establishment along base flow elevations
- ❖ The duration and magnitude of floodflows necessary to stimulate a positive response in mature cottonwoods
- ❖ The response of wetland species to the higher base flows of late summer and lower base flows of winter and early spring

S.18 ADDRESSING UNCERTAINTIES THROUGH ADAPTIVE MANAGEMENT

Uncertainties associated with operating Flaming Gorge Dam under the Action Alternative, summarized above, would be monitored and addressed through an adaptive management process if the Action Alternative is implemented. Adaptive management consists of an integrated method for addressing uncertainty in natural resource management.

The use of adaptive management does not imply establishment of a separately funded and staffed program to oversee operations at Flaming Gorge Dam. Rather, the adaptive management process would be integrated into the current framework of dam operations, while maintaining the authorized purposes of the dam. It would involve using research and monitoring to test the outcomes of modifying the hydrology and temperature of releases from Flaming Gorge Dam. It is expected that such research and monitoring would be achieved within the framework of the ongoing Recovery Program with regard to native fish and undesirable nonnative fish species and related habitat issues. As a participant in the Recovery Program, Reclamation would be involved in any identification or discussion of the need for new tasks within the Recovery Program to address Flaming Gorge Dam operational considerations or experimental flows. Issues associated with the trout fishery would be monitored by the Utah Division of Wildlife Resources as part of their management of that fishery and with ongoing consultation and coordination with Reclamation through the Flaming Gorge Working Group and interagency communication. As has occurred in the past, proposed releases for experimental purposes that deviate from the prescribed flows would be disclosed to stakeholders, including the various publics, at Flaming Gorge Working Group meetings, and would be closely coordinated with the U.S. Fish and Wildlife Service and the Utah Division of Wildlife Resources.

S.19 ENVIRONMENTAL COMMITMENTS

This section summarizes Reclamation's future commitments related to the Action Alternative. Commitments 1 through 4 and 8 would apply under either the Action Alternative or the No Action Alternative.

(1) The Flaming Gorge Working Group, which meets two times per year, would continue to function as a means of providing information to and gathering input from stakeholders and interested parties on dam operations.

(2) The adaptive management process would rely on ongoing or added Recovery Program activities for monitoring and studies to test the outcomes of modifying the flows and release temperatures from Flaming Gorge Dam. It would rely on the Flaming Gorge Working Group meetings for exchange of information with the public.

(3) Reclamation would develop a process for operating the selective withdrawal structure consistent with the objective of improving temperature conditions for the endangered native fish. Such a process would include identification of lines of

communication for planning and making changes to selective withdrawal release levels, coordination with other agencies, recognition of equipment limitations that may affect the ability to release warmer water, and the costs and equipment impacts associated with operating at higher temperatures.

(4) Reclamation would continue to annually coordinate the peak flow releases from Flaming Gorge Dam with the appropriate Federal, State, and county officials. This would include continued communication with county officials to assist in their mosquito control activities.

(5) As recommended by the Wyoming State Historic Preservation Office, Reclamation would periodically inspect eligible historic properties around Flaming Gorge Reservoir to determine whether there are any effects from the Action Alternative.

(6) Reclamation would consult with Federal, State, and local officials and the interested public to determine whether additional signage or other means of public notification of higher spring river flows are needed.

(7) A Ute ladies'-tresses recovery team geomorphology working group, consisting of the National Park Service, Reclamation, and several independent researchers, is currently in place. As part of Reclamation's efforts to monitor and understand the effects of the proposed action on Ute ladies'-tresses this group will be expanded to include interested Federal and State agency geomorphologists, riparian ecologists, and botanists who choose to participate on a voluntary basis. This working group could assist in designing and implementing a monitoring program to gain additional knowledge about Ute ladies'-tresses. Reclamation will oversee this Ute ladies'-tresses working group and insure that the working group meets regularly to discuss and prioritize monitoring, assist with data interpretation, and prioritize any needed research. As part of the development of the annual operational plan (as discussed in section 2.5 of the EIS), this working group will also provide recommendations to the Flaming Gorge Technical Working Group.

(8) Reclamation would continue to participate in the Recovery Program efforts.

(9) Reclamation would support the Recovery Program, in coordination with the U.S. Fish and Wildlife Service and Western, in developing and conducting Recovery Program studies associated with flood plain inundation.

(10) Reclamation would establish the Technical Working Group consisting of biologists and hydrologists involved with endangered fish recovery issues. The Technical Working Group would meet at various times throughout the year to comment and provide input concerning endangered fish needs to Reclamation's operational plan.

Executive Summary
Operation of Flaming Gorge Dam
Final Environmental Impact Statement
Acronyms and Abbreviations

BLM	Bureau of Land Management
CEQ	Council on Environmental Quality
cfs	cubic feet per second
CRSP	Colorado River Storage Project
EIS	final environmental impact statement
ESA	Endangered Species Act
2000 Flow and Temperature Recommendations	*Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam*
GWh	gigawatthour
kWh	kilowatthour
m^3/s	cubic meters per second
NEPA	National Environmental Policy Act
P.L.	Public Law
Reclamation	Bureau of Reclamation
Recovery Action Plan	*1993 Recovery Implementation Program Recovery Action Plan*
Recovery Program	Upper Colorado River Endangered Fish Recovery Program
RMP	resource management plan
RPA	Reasonable and Prudent Alternative
Secretary	Secretary of the Interior
U.S.C.	United States Code
USDA Forest Service	United States Department of Agriculture Forest Service
Western	Western Area Power Administration
§	Section
°C	degrees Celsius
°F	degrees Fahrenheit
%	percent

RECLAMATION
Managing Water in the West

Operation of Flaming Gorge Dam Final Environmental Impact Statement

U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Region
Salt Lake City, Utah

September 2005

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Front cover artwork courtesy of
Arizona Game and Fish Department

Operation of Flaming Gorge Dam
Colorado River Storage Project
Final Environmental Impact Statement

Cooperating Agencies:	U.S. Department of the Interior Bureau of Reclamation (lead agency) Bureau of Indian Affairs Bureau of Land Management National Park Service U.S. Fish and Wildlife Service State of Utah, Department of Natural Resources United States Department of Agriculture, Forest Service U.S. Department of Energy Western Area Power Administration Utah Associated Municipal Power Systems

Abstract:

The Secretary of the Interior, acting through the Bureau of Reclamation, proposes to take action to assist in the recovery of four endangered fish in the Green River downstream from Flaming Gorge Dam, a Colorado River Storage Project facility in northeastern Utah, with a reservoir located in Utah and Wyoming. The purpose of the proposed action is to operate Flaming Gorge Dam to protect and assist in recovery of the populations and designated critical habitat of four endangered fishes, while maintaining all authorized purposes of the Flaming Gorge Unit of the Colorado River Storage Project, particularly those related to the development of water resources in accordance with the Colorado River Compact. This final environmental impact statement has been prepared pursuant to the National Environmental Policy Act to analyze the effects of operating Flaming Gorge Dam in accordance with a set of flow and temperature recommendations developed by the Upper Colorado River Endangered Fish Recovery Program.

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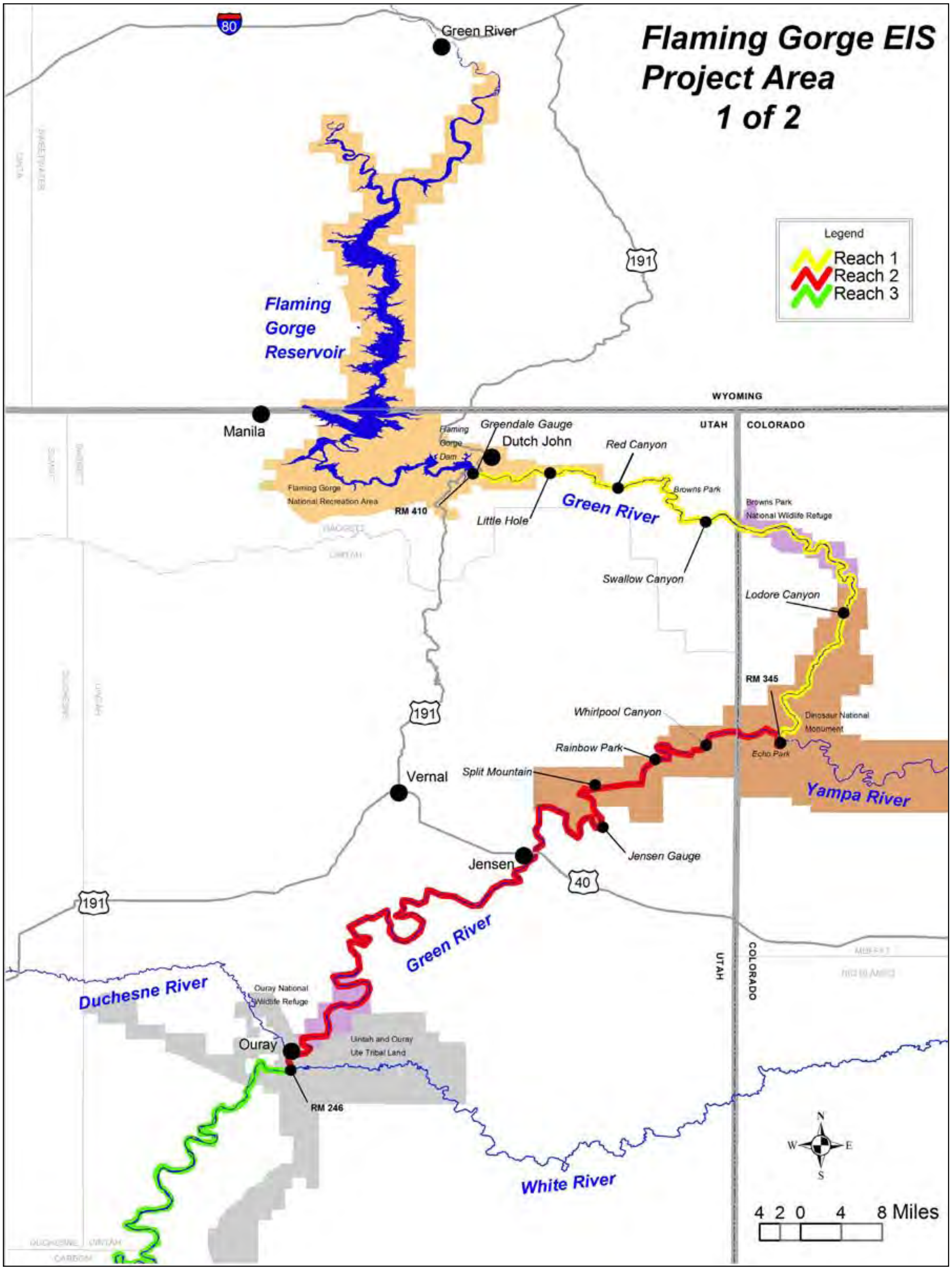
DOE Tracking Number: DOE/EIS-0315

Filing Number: FES-05-27



Flaming Gorge EIS
Project Area
1 of 2
Legend
Reach 1
Reach 2
Reach 3
80
Green River
191
Flaming
Gorge
Reservoir
WYOMING
UTAH
COLORADO
Manila
Greendale Gauge
Dutch John
Flaming Gorge Dam
Flaming Gorge National Recreation Area
RM 410
Little Hole
Red Canyon
Green River
Browns Park
Browns Park National Wildlife Refuge
Swallow Canyon
Lodore Canyon
RM 345
Whirlpool Canyon
Dinosaur National Monument
Rainbow Park
Echo Park
Split Mountain
Yampa River
Vernal
Jensen Gauge
Jensen
40
191
Green River
UTAH
COLORADO
Duchesne River
Ouray National Wildlife Refuge
Ouray
Uintah and Ouray Ute Tribal Land
RM 246
White River
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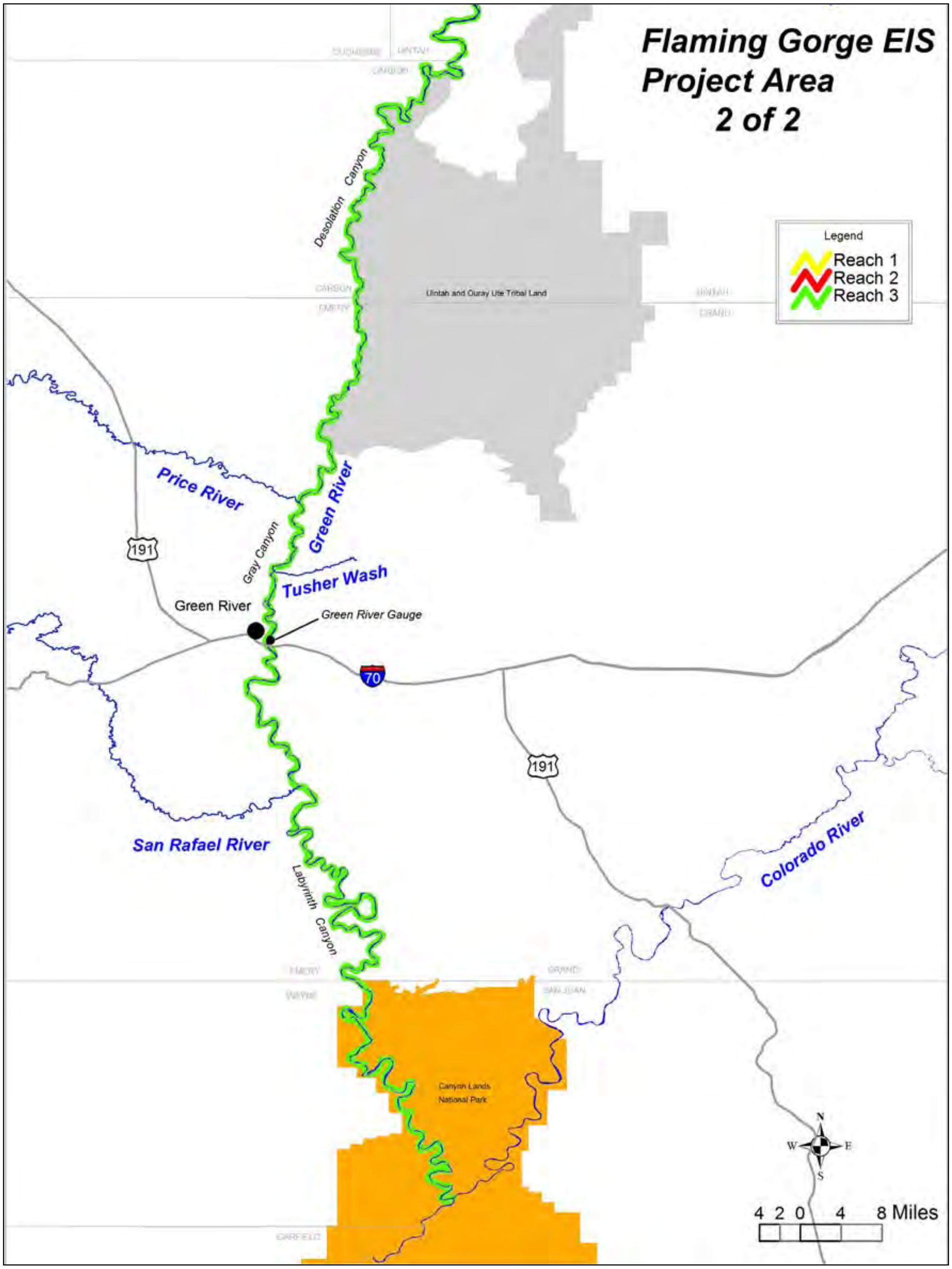

Flaming Gorge EIS
Project Area
2 of 2
Legend
Reach 1
Reach 2
Reach 3
Desolation Canyon
Uintah and Ouray Ute Tribal Land
Price River
Green River
Gray Canyon
Tusher Wash
Green River
Green River Gauge
191
70
San Rafael River
Colorado River
Labyrinth Canyon
Canyon Lands National Park
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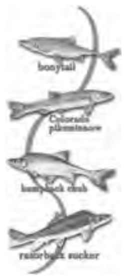

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FIGURES

FIGURES (CONTINUED)

1.0 Proposed Federal Action and Background

The Bureau of Reclamation proposes to take action to protect and assist in recovery of the populations and designated critical habitat of the four endangered fishes found in the Green and Colorado River Basins (proposed action). The four endangered fish species are Colorado pikeminnow (*Ptychocheilus lucius*), humpback chub (*Gila cypha*), razorback sucker (*Xyrauchen texanus*), and bonytail (*Gila elegans*). Reclamation would implement the proposed action by modifying the operations of Flaming Gorge Dam, to the extent possible, to achieve the flows and temperatures recommended by participants of the Upper Colorado River Endangered Fish Recovery Program (Recovery Program). Reclamation's goal is to implement the proposed action and, at the same time, maintain and continue all authorized purposes of the Colorado River Storage Project (CRSP).

The recommended flows and temperatures are intended to provide water releases of sufficient magnitude and, with the proper timing and duration, to assist in the recovery of the endangered fishes and their designated critical habitat. The flow and temperature recommendations for the Green River are described in the Recovery Program's September 2000 report, *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam* (2000 Flow and Temperature Recommendations).

1.1 Purpose of and Need for the Proposed Federal Action

The purpose of the proposed action is to operate Flaming Gorge Dam to protect and assist in recovery of the populations and designated critical habitat of the four endangered fishes, while maintaining all authorized purposes of the Flaming Gorge Unit of the CRSP, particularly those related to the development of water resources in accordance with the Colorado River Compact. The proposed action is needed for the following reasons:

- ❖ The operation of Flaming Gorge Dam, under its original operating criteria, jeopardized the continued existence of the endangered fishes in the Green River.
- ❖ Reclamation is required to comply with the Endangered Species Act (ESA) for the operation of CRSP facilities, including Flaming Gorge Dam. Within the exercise of its discretionary authority, Reclamation must avoid jeopardizing the continued existence of listed species and destroying or adversely modifying designated critical habitat.
- ❖ The Reasonable and Prudent Alternative (RPA) to the 1992 Biological Opinion on the Operation of Flaming Gorge Dam required modification of Flaming Gorge releases to benefit the endangered fish, a 5-year study period to evaluate winter and spring flows, and reinitiation of discussions with the U.S. Fish and Wildlife Service following the study period to further refine the flow recommendations. With the results of these studies, as well as other relevant information, the Recovery Program developed and approved the 2000 Flow and Temperature Recommendations report for the Green River. These recommendations are an extension of the 1992 jeopardy Biological Opinion RPA. Reclamation committed to assist in meeting flow requirements through the refined operation of Flaming Gorge and other Federal reservoirs in the 1987 agreement that formed the Recovery Program.
- ❖ Flaming Gorge Dam and Reservoir is the primary water storage and delivery facility on the Green River, upstream of its confluence with the Colorado River. The storage capacity and ability to control water releases of Flaming Gorge Dam allow Reclamation flexibility in providing flow and temperature management to protect and assist in the recovery of endangered fish populations and their critical habitat within specific reaches of the river. Thus, the refined operation of Flaming Gorge Dam is a key element of the Recovery Program.
- ❖ The refined operation will offset the adverse effects of flow depletions from the Green River for certain Reclamation water projects in Utah, as defined by existing jeopardy Biological Opinions. Modifying the operation of Flaming Gorge Dam will also serve as the RPA, as defined by the ESA, to offset jeopardy to endangered fishes and their critical habitat that could result from the operation of numerous other existing or proposed water development projects in the Upper Colorado River Basin.

1.2 LEAD AND COOPERATING AGENCIES

Reclamation is the lead agency in preparing this environmental impact statement (EIS). The eight cooperating agencies include the Bureau of Indian Affairs, Bureau of Land Management (BLM), National Park Service, State of Utah Department of Natural Resources, U.S. Fish and Wildlife Service, United States Department of Agriculture Forest Service (USDA Forest Service), Utah Associated Municipal Power Systems, and Western Area Power Administration (Western).

1.3 CONTENTS OF THIS ENVIRONMENTAL IMPACT STATEMENT

This EIS consists of five chapters:

Chapter 1 describes the purpose of and need for the proposed Federal action and provides background information, a brief history of Flaming Gorge Dam and Reservoir, a scoping summary, and applicable regulatory requirements.

Chapter 2 describes the process used to formulate alternatives, discusses the alternatives considered in detail, describes the alternatives that were considered but eliminated from detailed study, and provides a summary comparison of alternatives and impacts.

Chapter 3 describes the environment and resources that could be affected by the proposed action.

Chapter 4 describes and analyzes the environmental impacts of each alternative considered in detail. It also includes other considerations required by the National Environmental Policy Act (NEPA) including environmental justice, the relationship between short-term uses of the environment and long-term productivity, and the assessment of irreversible and irretrievable commitment of resources.

Chapter 5 includes consultation and coordination with other Federal and State agencies and Native American tribes and the EIS distribution list.

This document also contains a list of preparers, conversion tables, glossary, and bibliography. A separate volume of technical appendices, "Operation of Flaming Gorge Dam Final Environmental Impact Statement Technical Appendices," is available upon request. An executive summary, "Operation of Flaming Gorge Dam Final Environmental Impact Statement Executive Summary," is also available upon request. A separate volume of public comments on the draft EIS and Reclamation's response to those comments, "Operation of Flaming Gorge Dam Final Environmental Impact Statement Comments and Responses," is also available.

1.4 BACKGROUND

Flaming Gorge Dam, located on the Green River in northeastern Utah about 200 miles northeast of Salt Lake City, is an authorized storage unit of the CRSP. Flaming Gorge Dam was completed in 1962, and full operation of the dam and reservoir began in 1967. The powerplant, located at the base of the dam, began commercial operation in 1963 and was completed in 1964. Reclamation operates the dam and powerplant, and Western markets the power.

1.4.1 Brief History of Flaming Gorge Dam and Reservoir

1.4.1.1 Authorized Uses of Flaming Gorge Dam and Reservoir and Colorado River Development

Flaming Gorge Dam was authorized for construction by the CRSP Act of 1956 (Public Law [P.L.] 84-485). The underlying project purposes are defined by Section 1 of the Act (43 United States Code [U.S.C.] Section (§) 620):

> *In order to initiate the comprehensive development of the water resources of the Upper Colorado River Basin, for the purposes, among others, of regulating the flow of the Colorado River, storing water for beneficial consumptive use, making it possible for the States of the Upper Basin to utilize, consistently with the provisions of the Colorado River Compact, the apportionments made to and among them in the Colorado River Compact and the Upper Colorado River Basin Compact,*

respectively, providing for the reclamation of arid and semiarid land, for the control of floods, and for the generation of hydroelectric power, as an incident of the foregoing purposes, the Secretary of the Interior is authorized (1) to construct, operate, and maintain the following initial units of the Colorado River storage project, consisting of dams, reservoirs, powerplants, transmission facilities and appurtenant works [including] Flaming Gorge . . ..

Section 7 of the CRSP Act of 1956 mandates the operation of CRSP powerplants to produce ". . .the greatest practicable amount of power and energy that can be sold at firm power and energy rates. . .." However, as described in this EIS in section 1.4.3, continued Upper Colorado River Basin development of water resources and implementation of the 2000 Flow and Temperature Recommendations may affect the practicable amount of power and energy generated. This EIS analyzes these effects in sections 4.4 and 4.16.1.

The Upper Colorado River Endangered Fish Recovery Program was developed in response to the request of Colorado, Wyoming, and Utah to facilitate the continued development of their compact apportionments in light of Endangered Species Act concerns. The 2000 Flow and Temperature Recommendations, which were developed by the Recovery Program, are specifically designed, in concert with other Recovery Program actions, to accomplish recovery. By implementing the 2000 Flow and Temperature Recommendations, Reclamation would be taking the steps necessary to facilitate recovery of the fish, which will make it possible for continued and further utilization of the States' compact apportionments. Thus, by "making it possible for the States of the Upper Basin to utilize…[their Compact] apportionments," the 2000 Flow and Temperature Recommendations, which are designed to facilitate further compact development through the recovery of listed species, are within the authorized purposes of CRSP Act. Moreover, that other authorized purposes of the unit may not be fully maximized for limited durations in certain year types does not invalidate the actions of the Secretary of the Interior (Secretary), as long as the overall goals of the project are being met.

In addition to this authority, the Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs (including Flaming Gorge Reservoir) mandated by Section 602(a) of the 1968 Colorado River Basin Project Act (43 U.S.C. § 1501 et seq.) requires that the Annual Operating Plan for Colorado River reservoirs ". . . shall reflect appropriate consideration of the uses of the reservoirs for all purposes, including flood control, river regulation, beneficial consumptive uses, power production, water quality control, recreation, enhancement of fish and wildlife, and other environmental factors."

1.4.1.2 Authorized Uses of Flaming Gorge Dam and Reservoir: Flaming Gorge National Recreation Area

The Flaming Gorge National Recreation Area was established by the Flaming Gorge National Recreation Area Act of 1968 (P.L. 90-540). According to that act, the purposes of the Flaming Gorge National Recreation Area are to provide (1) public outdoor recreation benefits; (2) conservation of scenic, scientific, historic, and other values contributing to enjoyment, and (3) such management, utilization, and disposal of natural resources that will promote or are compatible with and do not significantly impair the purposes for which the recreation area was established. The act added about 123,000 acres to Ashley National Forest and assigned management of the entire recreation area to the USDA Forest Service. The Flaming Gorge National Recreation Area contains 207,363 acres of land and water that are almost equally divided between Utah and Wyoming.

1.4.2 Operational Modifications Since the Beginning of Dam Operations

Construction of Flaming Gorge Dam and Powerplant began in 1956. Filling of the reservoir began in 1962 when the dam was completed. Full operation began in November 1967. Until 1984, Flaming Gorge Dam was operated to provide for a full reservoir while maximizing power generation, providing associated ancillary services, and avoiding the use of the river outlet works or the spillway. Flows were fluctuated as needed to meet system power demand, and consideration was given to known fish and wildlife needs.

The history of Flaming Gorge Dam operations can be divided into five phases. During the first phase, from 1962 to 1966, the reservoir was filling with water, and Green River flows downstream from the dam were reduced. The first full year of normal operations began in 1967. During the second phase, from 1967 to 1978, Flaming Gorge Dam was operated with few constraints, and water releases were made through the powerplant. The only constraint on releases during phase two began in 1974 when a 400-cubic-foot-per-second (cfs) minimum release was implemented to establish and maintain the tailwater trout fishery (1974 Interim Operating Criteria). This operating agreement between the Utah Division of Wildlife Resources and Reclamation stated:

> *A minimum flow of 400 cfs will be released from the reservoir at all times. However, for the foreseeable future and under normal conditions, a continuous flow of 800 cfs will be maintained as a minimum. To the extent the available water supply will permit and is compatible with multipurpose operations of all CRSP reservoirs, minimum flows in excess of 800 cfs will be maintained to enhance the use of the river for fishing, fish spawning, and boating.*

In 1978, the dam was retrofitted with a selective withdrawal structure to improve water temperatures for the tailwater trout fishery. During the third phase, from 1979 to 1984, operations were similar to those in the previous phase except for use of the selective withdrawal structure and the occurrence of spills in 1983 and 1984.

During the fourth phase, from 1985 to 1992, Reclamation began to constrain the operation of Flaming Gorge Dam to reduce negative impacts affecting endangered fishes in the Green River. Such constraints reduced operational flexibility and the ability to fluctuate flows to meet power system demands. In 1985, an interim flow agreement was established between Reclamation and the U.S. Fish and Wildlife Service to change Flaming Gorge Dam releases to protect critical nursery habitats for endangered fishes in the Green River downstream from Jensen, Utah. The recommended releases were based on observations made in 1985 that indicated "good" habitat conditions were available at lower flows. Reclamation also revised operational criteria at the dam to avoid spills. These changes were in place in the fourth phase, along with numerous research releases to support preparation of the Final Biological Opinion on the Operation of Flaming Gorge Dam issued on November 25, 1992. Significant financial impacts to hydropower generation, identified in section 4.16.2 of this EIS, occurred mainly as a result of flow changes implemented during this fourth phase.

In the fifth phase, from 1993 to present, Reclamation began making releases from Flaming Gorge Dam in an attempt to meet the flow and temperature recommendations given in the 1992 Biological Opinion. Flows recommended in the 1992 Biological Opinion were intended to restore a more natural hydrograph and protect nursery habitats of endangered fishes downstream from the Yampa River confluence. At the same time, Reclamation continued to meet the authorized purposes of Flaming Gorge Dam.

The Green River flows recommended in the 1992 Biological Opinion were based on the most current scientific data available at the time. The opinion included several actions Reclamation could take to avoid jeopardizing the recovery of endangered fishes in the Green River. One of these actions was to collect more information about the flow and temperature needs of the endangered fishes and, subsequently, to refine or modify the flow and temperature recommendations of the 1992 Biological Opinion. A 5-year research study began in 1992, and the resulting data and refinements were included in the 2000 Flow and Temperature Recommendations. The study included periodic test flows to evaluate the effects of summer flows on endangered fishes or to test specific hypotheses.

1.4.3 Compliance With the Endangered Species Act

To comply with the ESA, an evaluation of the effects of any discretionary Federal action must be conducted by the action agency in consultation with the U.S. Fish and Wildlife Service.

During the late 1970s and early 1980s, the U.S. Fish and Wildlife Service rendered Jeopardy Biological Opinions for the Upalco, Jensen, and Uinta Units of the Central Utah Project stating that all relied on the operation of Flaming Gorge Dam to provide flows for endangered fishes. More recent Biological Opinions for the Duchesne River Basin, the proposed Narrows Project, the ongoing Price-San Rafael Salinity Control Project, and other water development-related projects in the Colorado River Basin also rely on the operation of Flaming Gorge Dam to provide flows for endangered fishes.

On February 27, 1980, the U.S. Fish and Wildlife Service requested consultation under Section 7 of the ESA for projects currently under construction in the Upper Colorado River Basin and for the continued operation of all existing Reclamation projects in the basin (including the CRSP). Formal consultation on the operation of Flaming Gorge Dam began March 27, 1980. Issuing a Final Biological Opinion by the U.S. Fish and Wildlife Service for the operation of Flaming Gorge Dam was delayed until data collection and studies related to habitat requirements for the endangered fishes could be completed and used to recommend specific flows in the Green River downstream from the dam. Dam operations were initially evaluated for potential effects on endangered fishes from 1979 to 1984. Reclamation served as the lead agency for this consultation, with Western becoming a party to the consultation in 1991.

Additionally, on February 27, 1980, the U.S. Fish and Wildlife Service issued a Final Biological Opinion for the Strawberry Aqueduct and Collection System, a major feature of the Central Utah Project. The Biological Opinion determined that Strawberry Aqueduct and Collection System flow depletions from the Duchesne and Green Rivers would likely jeopardize the continued existence of the endangered Colorado pikeminnow and humpback chub. This Biological Opinion included a Reasonable and Prudent Alternative stating that Flaming Gorge Dam and Reservoir would compensate for those depletions and be operated for the benefit of the endangered fishes in conjunction with its other authorized purposes.

Both the 1992 Biological Opinion and the 2000 Flow and Temperature Recommendations were designed to account for the impacts of depletions mentioned above. The 2000 Flow and Temperature Recommendations as implemented under the Action Alternative would offset the impacts of water depletions on these other projects.

1.4.4 Upper Colorado River Endangered Fish Recovery Program

The Recovery Program was initiated in 1987 as a cooperative effort among the States of Utah, Colorado, and Wyoming;

environmental and water user organizations; Federal agencies including the National Park Service, Reclamation, U.S. Fish and Wildlife Service, and Western; and the Colorado River Energy Distributors Association. The goal of the Recovery Program is to protect and recover the endangered fish species of the Upper Colorado River Basin so they no longer need protection under the ESA, while the Upper Basin States continue to develop their 1922 Colorado River Compact entitlements.

Under the Recovery Program, five key elements are needed to recover the endangered fish species: (1) habitat management; (2) habitat development/ maintenance; (3) native fish stocking; (4) nonnative species and sport fish management; and (5) research, data management, and monitoring. The operation of Flaming Gorge Dam is essential to successful implementation of two of these five elements: habitat management and habitat development/maintenance. Operation of the dam is one of many management actions described in the 1993 Recovery Implementation Program Recovery Action Plan (Recovery Action Plan). The plan is periodically revised to accommodate programmatic Biological Opinions and annual updates as well as the designation of critical habitat for the endangered fishes. Implementation of all Recovery Action Plan recommendations is expected to achieve recovery of the endangered fishes.

Reclamation began informing the Recovery Program Management Committee of the EIS timeline in 1999. Beginning in 2001, the Recovery Program Management Committee requested and received regular updates on EIS progress through early 2005. Additionally, throughout 1999–2003 the staff of the Recovery Program Director's office met regularly with Reclamation authors to clarify flow recommendation issues during development of the EIS document, and Reclamation also interacted with the Recovery Program biology committee on EIS matters periodically throughout this period.

1.4.5 Final Biological Opinion on the Operation of Flaming Gorge Dam and the Reasonable and Prudent Alternative

The U.S. Fish and Wildlife Service issued a Final Biological Opinion on the Operation of Flaming Gorge Dam on November 25, 1992, stating that the current operation of Flaming Gorge Dam was likely to jeopardize the continued existence of the endangered fishes in the Green River. The opinion also described elements of an RPA that, in the opinion of the U.S. Fish and Wildlife Service, would offset jeopardy to the endangered fishes. The RPA required implementing the following five elements:

(1) Refining the operation of Flaming Gorge Dam so flow and temperature regimes of the Green River more closely resemble a natural hydrograph.

(2) Conducting a 5-year research program, including implementation of winter and spring research flows, beginning in 1992, to allow for potential refinement of flows for those seasons. The research program was to be based on the Flaming Gorge Flow Recommendations Investigation and called for annual meetings to refine seasonal flows consistent with research findings and water year forecasts. Except for specific research flows during the 5-year research program, year-round flows in the Green River were to resemble a natural hydrograph described under element 1 of the RPA.

(3) Determining the feasibility and effects of releasing warmer water during the late spring/summer and investigating the feasibility of retrofitting the river bypass tubes to include power generation, thereby facilitating increased spring releases.

(4) Legally protecting Green River flows from Flaming Gorge Dam to Lake Powell.

(5) Initiating discussions with the U.S. Fish and Wildlife Service, after conclusion of the 5-year research program, to examine further refinement of flows for the specified endangered Colorado River fishes.

1.4.6 2000 Flow and Temperature Recommendations

The research program called for in the 1992 Biological Opinion concluded in 1996. At that time, the Recovery Program funded a synthesis of research and development of flow and temperature recommendations for the Green River. The final synthesis report, which contained the 2000 Flow and Temperature Recommendations for endangered fishes in the Green River downstream from Flaming Gorge Dam, provided the basis for Reclamation's Action Alternative analyzed in this EIS and for additional Section 7 consultation by Reclamation and Western with the U.S. Fish and Wildlife Service.

1.4.7 New Biological Opinion on the Operation of Flaming Gorge Dam

Reclamation and Western have consulted with the Fish and Wildlife Service, as required by Section 7 of the ESA, on the proposed action analyzed in this EIS. The Final Biological Opinion was issued on September 6, 2005, and may be found in the Final Biological Opinion Technical Appendix of this EIS.

1.5 Operational Decisionmaking Process at Flamng Gorge Dam

The process of developing an operational plan for Flaming Gorge Dam takes into consideration all resources associated with Flaming Gorge Dam identified by the Flaming Gorge Working Group. The Flaming Gorge Working Group was formed in 1993 to provide interested parties with an open forum to express their views and interests in the operation of Flaming Gorge Dam. Among others, these interests include power marketing, sport fisheries, endangered species, white water rafting, farming, land ownership, reservoir recreation, national park resources, land management, flood control, and wildlife refuge management.

The Flaming Gorge Working Group generally meets twice a year (April and August/September). These meetings are open to the public, and participants are encouraged to comment. Operational decisions are not made during the Flaming Gorge Working Group meetings; rather, these meetings are a forum for information exchange about past, current, and proposed operations at Flaming Gorge Dam. They also serve as a forum through which stakeholders can share information about specific resources of interest and the relationship between the operation of Flaming Gorge Dam and these resources. The Flaming Gorge Working Group provides input to Reclamation as well as educating various constituencies on operations at Flaming Gorge Dam.

Reclamation has sole responsibility for operations at Flaming Gorge, although the needs and expectations of stakeholders are considered in operational planning. Reclamation's priorities are first, dam safety, and then second, meeting project purposes in compliance with the ESA. When conflicts in operations arise, Reclamation's approach to conflict resolution and decisionmaking includes accepting input from all stakeholders and formulating a strategy that meets the most needs possible consistent with these established priorities.

Operational decisions for Flaming Gorge Dam are made through the Colorado River Annual Operating Plan process. A document, called the *24-Month Study*, is produced monthly and contains planned monthly releases from all CRSP reservoirs. In the 24-month study, reservoir inflows are revised to reflect forecasted inflow from the National Weather Service. These forecasted inflows are input into the 24-Month Planning Model. Planned releases from Flaming Gorge are adjusted monthly to reflect changing hydrology, to meet the requirements of the ESA, and to meet CRSP authorized purposes.

Reclamation continually coordinates release schedules with Western. Occasionally, Western will request that Reclamation consider modifying scheduled releases at Flaming Gorge Dam due to power market conditions. Reclamation considers all requests from Western for modified releases. Requests for modified operations by Western are usually met, although it is common for Reclamation and Western to negotiate a compromise solution that may alleviate pressure on other resources. The operation of the selective withdrawal structure, which affects release temperature, is coordinated among Reclamation, the U.S. Fish and Wildlife Service, and the Utah Division of Wildlife Resources.

Reclamation communicates with the U.S. Fish and Wildlife Service as release schedules are adjusted. Such communication generally takes place when proposals for modified releases are made by Western or when other requests are made for release modifications, including test flows for biological studies. Communication and coordination with the U.S. Fish and Wildlife Service also takes place each spring when peak releases, as required in the 1992 Biological Opinion, are set. Consultation between Reclamation and the U.S. Fish and Wildlife Service is necessary when releases outside of the RPA of the 1992 Biological Opinion are required.

The 1992 Biological Opinion constrains releases at Flaming Gorge Dam in the summer and fall so that the Green River near Jensen, Utah, (106 river miles below the dam) does not deviate by more than 12.5 percent (%) of the daily average flow for the day. This constraint reduces the magnitude of hour-to-hour fluctuations at Flaming Gorge Dam during the summer and fall. Historically since 1992, hour-to-hour fluctuations have generally been maintained at about 800 cfs per hour with a single peak per day. However, there are no formalized constraints that require this.

The 1992 Biological Opinion states that "the goal for winter releases is to provide low, stable flows near historic levels." While no formal ramping criteria has been established for the winter and spring, the guideline the past few years has been to use the plus or minus 12.5% constraint at Jensen, Utah, for the winter and spring seasons, as well as the summer and fall, to meet the stated requirement of the 1992 Biological Opinion to provide low stable flows in the winter.

Annually, the Utah Division of Wildlife Resources requests a steady 1,600-cfs release in the late afternoon and early evening hours on 2 consecutive days to conduct electrofishing as part of its ongoing tailwater assessment. Requests for short-term modifications in releases have also come from the USDA Forest Service for search and rescue efforts and for removal of boats wedged in rocks. A variety of other requests are often received, and accommodated if they are reasonable, necessary, and do not interfere with dam safety, other authorized project purposes, or operations for ESA compliance.

1.6 Emergency Powerplant Operations

Normal dam and powerplant operations under the Action Alternative or any other alternative could be altered temporarily to respond to emergencies. These emergencies may be associated with dam safety, power system conditions, or personal safety of individuals or groups associated with recreation or other activities on the river. The North American

Electrical Reliability Council and the Western Electricity Coordinating Council have established guidelines and requirements for emergency operations of interconnected power systems that apply to Flaming Gorge Dam operations and may account for changes outside of those identified in descriptions of the alternatives. These changes in operations are intended to be of short duration as a result of emergencies at the dam or within the transmission network.

To reduce the impact to individual powerplants and transmission lines responding to system emergencies, Reserve Sharing Groups are organized among electric utilities to share resources. The CRSP resources are included in the Rocky Mountain Reserve Sharing Group and the Southwest Reserve Sharing Group under Western's membership. The sharing of resources reduces the amount of generation each CRSP powerplant would otherwise be obligated to provide as well as giving flexibility to respond to the emergency. The North American Electrical Reliability Council provides operating policies for system emergencies, of which several examples are given here.

1.6.1 Insufficient Generation Capacity

A control area is a geographical area comprised of an electric system or systems, interconnected together by transmission lines that is capable of controlling generation within the control area to maintain its interchange schedule with other control areas and that contributes to frequency regulation of the interconnection. When a control area has an operating capacity emergency, it must promptly balance its generation and interchange schedules to its load, without regard to financial cost, to avoid prolonged use of assistance provided by the interconnected power system. The emergency reserve inherent in frequency deviation is intended to be used only as a temporary source of emergency energy and must be promptly restored so the interconnected systems can withstand the next contingency. A control area unable to balance its generation and interchange schedules to its load must remove sufficient load to permit correction of its Area Control Error.

If a control area anticipates an operating capacity emergency, it must bring on all available generation, postpone equipment maintenance, schedule interchange purchases well in advance, and prepare to reduce load.

An example of insufficient generation capacity and the appropriate response could be as follows: if any coal-fired powerplant in Western's load control area was unexpectedly lost, the response would be an increase in CRSP generation or imports to compensate for the change in anticipated generation within the control area.

1.6.2 Transmission (Overload and Voltage Control)

If a transmission facility becomes overloaded or if voltage levels are outside of established limits and the condition cannot be relieved by normal means (such as adjusting generation or interconnection schedules), and a credible contingency under these conditions would adversely impact the interconnection, appropriate relief measures, including load shedding, are implemented promptly to return the transmission facility to within established limits. This action is taken by the system, control area, or pool causing the problem if it can be identified or by other systems or control areas, as appropriate, if identification cannot be readily determined.

An example of a response to an overloaded transmission system could be automatic relay tripping and taking a transmission line out of service or an increase in generation depending on the location of the overloaded transmission line. This action could cause Flaming Gorge Powerplant generation to be reduced or increased instantaneously to a predetermined level, based on the capacity or location of the line taken out of service.

1.6.3 Load Shedding

After taking all other steps, a system or control area, whose integrity is in jeopardy due to insufficient generation or transmission capacity, sheds customer load (i.e., disconnecting a load to an industrial facility or a section of a community) rather than risk an uncontrolled failure of interconnection components.

1.6.4 System Restoration

After a system collapse, restoration begins when it can proceed in an orderly and secure manner. Systems and control areas coordinate their restoration actions. Restoration priority is given to the station supply of powerplants and the transmission system. Even though the restoration should be expeditious, system operators avoid premature action to prevent a re-collapse of the system. Customer load is restored as generation and transmission equipment becomes available, while keeping load and generation in balance at normal frequency as the system is restored.

1.6.5 Emergency Information Exchange

A system control area or pool experiencing or anticipating an operating emergency communicates its current and future status to neighboring systems, control areas, or pools and throughout the interconnection. Systems able to provide emergency assistance make known their capabilities.

1.6.6 Special System or Control Area

Because the facilities of each system may be vital to the interconnection's secure operation, systems and control areas make every effort to remain connected. However, if a system or control area determines that it is endangered by remaining interconnected, it may take action as necessary to protect its system.

If a portion of the interconnection becomes separated from the remainder of the interconnection, abnormal frequency and voltage deviations may occur. To permit re-synchronizing, relief measures could be applied by those separated systems contributing to the frequency and voltage deviations.

An example of when the Flaming Gorge Powerplant might limit its response to the interconnected system would be during a search and rescue operation in the canyon where a need to control the releases exists.

Although emergency situations are infrequent, they do occur and require immediate, short-term changes in powerplant and dam operation. In general, changes resulting from emergencies at Flaming Gorge would result in decreases in flows while emergencies in the system away from the dam could result in either an increase or decrease in flows.

1.7 PUBLIC SCOPING PROCESS FOR THIS ENVIRONMENTAL IMPACT STATEMENT

The scoping process for the Operation of Flaming Gorge Dam EIS was initiated on June 6, 2000, to receive public comment to help determine the appropriate scope of the Flaming Gorge Dam EIS, consistent with requirements of NEPA. The formal scoping period ended on September 5, 2000. Scoping for this EIS was conducted for the following purposes:

- To identify relevant issues associated with the proposed action and its purpose and need.
- To help identify the geographic scope of the EIS—that is, how far upstream/downstream from the dam can impacts be meaningfully evaluated.
- To identify resources that may be affected by the proposed action.
- To identify the interested public or parties affected by the Action Alternative.
- To assist Reclamation in developing reasonable alternatives that are consistent with the purpose of and need for the proposed action.

A Notice of Intent to prepare a draft EIS and announcement of public scoping meetings was published in the *Federal Register* (FR) on June 6, 2000. A corresponding press release announcing that Reclamation was beginning the EIS process for Flaming Gorge Dam was issued the same date.

Public scoping meetings were held in July 2000 in Salt Lake City, Vernal, and Fort Duchesne, Utah; Grand Junction, Colorado; and Rock Springs, Wyoming. A total of 186 attendees registered at the five public scoping meetings, and verbal comments were received from 55 people.

In addition to the verbal comments provided at the five public scoping meetings, Reclamation received 175 form letters, 510 e-mail messages, signed petitions with a total of 1,476 signatures, and 40 letters and postcards from individuals and organizations. During the scoping process, the Forest Supervisor of the Ashley National Forest sent the Area Manager of Reclamation's Provo Area Office a position paper for the EIS (Forest Service Position Paper Technical Appendix). The comments from each oral presentation and each written statement were separated according to the particular issue or resource of concern and placed into appropriate categories. A total of 2,270 separate comments were derived from all of the comments received.

1.8 Scope of Analysis for This Environmental Impact Statement

The purpose of this EIS is to identify and consider the impacts of developing and implementing dam operations guidelines that result in protecting and assisting in the recovery of the populations and designated critical habitat of the four endangered fishes living in the Green River downstream from Flaming Gorge Dam. The scope of analysis for this EIS will focus on responding to the following question:

> If Reclamation operates Flaming Gorge Dam to achieve the 2000 Flow and Temperature Recommendations needed to avoid jeopardy and protect and assist in the recovery of the endangered fishes and their critical habitat in the Green River, consistent with CRSP purposes, then the effect(s) on other relevant resources/issues, both upstream and downstream from the dam, would be . . .

1.8.1 Geographic Scope of Analysis for This Environmental Impact Statement

The geographic area analyzed for possible impacts of the proposed action and alternatives includes Flaming Gorge Reservoir and the Green River downstream from Flaming Gorge Dam, to its confluence with the Colorado River. Because the proposed action depends exclusively on the operation of Flaming Gorge Dam, which is dependent on inflow into Flaming Gorge Reservoir, the Green River upstream of the reservoir is not affected. Please see the maps in the front of this document for a visual representation of the project area, including landmarks referenced throughout the EIS.

1.8.2 Public Issues and Concerns

Based upon scoping results, discussions with interested parties, and existing laws and regulations, Reclamation identified the following resources, issues, or concerns as potentially relevant to this EIS:

- ❖ Aquatic resources
- ❖ Biodiversity
- ❖ Cultural resources
- ❖ Disease vectors (mosquitoes)
- ❖ EIS/NEPA process (proposed action, purpose and need, scope, and alternatives)
- ❖ Environmental justice (potential impacts to low-income or minority populations)
- ❖ Facilities (dam and powerplant operation and maintenance and dam safety)
- ❖ Fish and wildlife (other than threatened and endangered species)
- ❖ Hydroelectric power generation and marketing
- ❖ Indian trust assets
- ❖ Invasive species
- ❖ Land use (agriculture, national parks)
- ❖ Reservoir limnology
- ❖ Riparian/wetlands
- ❖ River and reservoir fisheries
- ❖ River and reservoir recreation
- ❖ Socioeconomics (tourism-related jobs and income)
- ❖ Threatened and endangered species
- ❖ Water (conservation, drought, flood control, riverflows, water quality, water rights, water safety, water supply, water temperature, and water use)

Other potentially relevant resources, issues, or concerns may be identified during the process of completing this EIS and would be considered and analyzed as appropriate.

1.8.3 Resources and Significant Issues To Be Analyzed in Detail

The necessary framework to describe the affected environment and assess impacts was provided by several recent EISs, the studies resulting from the U.S. Fish and Wildlife Service's 1992 Biological Opinion, and other recent resource studies. Reclamation has used the best available data in preparing this EIS.

The EIS team consolidated and refined the issues of concern to the public and Federal, State, and tribal governments, identifying the resources and their significant issues to be analyzed in detail. The terms "resource issue" and "resource indicator" as used in this EIS are defined below:

Resource Issue: An effect or perceived effect, risk, or hazard on a physical, biological, social, or economic resource within the affected environment.

Resource Indicator: A quantification (measurement) of any environmental consequence arising from the implementation of 2000 Flow and Temperature Recommendations, which would indicate the presence of certain environmental conditions.

The following presentation summarizes the issues and resource indicators used to measure the impacts of the alternatives.

Issue 1

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect the **fish**—their life cycles, habitat, and ability to spawn?

Indicators

Status and condition of the **aquatic food base**

Reproduction, recruitment, and growth of **native fish**

Reproduction, recruitment, and growth of **nonnative fish** (including trout)

Level of interactions between **native and nonnative** fish

Issue 2

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect cultural resources in the study area?

Indicators

Number of **sites** directly, indirectly, or potentially affected

Number of **Native American traditional cultural properties and resources** directly, indirectly, or potentially affected

Issue 3

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **paleontological resources** in the study area?

Indicators

Number of **paleontological resources** directly, indirectly, or potentially affected

Issue 4

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect disease **vectors** (particularly mosquitoes) in the study area?

Indicators

Area and frequency of **flooded bottomlands**

Issue 5

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **environmental justice** in the area?

Indicators

Proportion of affected minority populations and low-income populations

Issue 6

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **operation and maintenance** of the dam and powerplant and would there be any impacts to **dam safety**?

Indicators

Operational limitations, types, and frequency of **maintenance, costs, and hazards**

Issue 7

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **any Indian trust assets**?

Indicators

Leases or rights-of-use for lands, minerals, water rights, hunting and fishing rights, other natural resources, money, or claims

Issue 8

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **recreation** in the study area?

Indicators

River and reservoir **visitation**

River and reservoir **economic value**

River and reservoir **recreation safety**

Issue 9

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **vegetation** in the river corridor?

Indicators

Condition of vegetation and species composition of **wetlands**

Condition of vegetation and species composition of **riparian habitat**

Distribution and establishment of **invasive species**

Issue 10

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **wildlife (other than endangered species)** in the river corridor?

Indicators

Quality and composition of **woody and emergent marsh plants** for wildlife habitat

Abundance of **aquatic food base** for wintering waterfowl

Issue 11

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **land uses** in the area?

Indicators

Acres for **farming or ranching**

Mineral rights accessibility

Recreation uses

Issue 12

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect the ability of Flaming Gorge Powerplant to supply **hydropower** at the lowest possible cost?

Indicators

Power operations flexibility

Power marketing resources, costs, and rates

Issue 13

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **sediment** resources throughout the study area?

Indicators

Contraction or expansion of **debris fans and rapids**

Riverbank erosion or aggradation

Sandbar development

Issue 14

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **threatened and endangered species** in the area?

Indicators

Reproduction, recruitment, and growth of the **Colorado pikeminnow, humpback chub, razorback sucker, and bonytail**

Quality, condition, and use of habitat for the **southwestern willow flycatcher**

Distribution and abundance of **Ute ladies'-tresses, bald eagle, yellow-billed cuckoo, and whooping crane**

Issue 15

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect the **amount and**

quality of water in and available from Flaming Gorge Reservoir at specific times?

Indicators

Acre-feet of **streamflows**

Frequency of volume of **floodflow and other spills**

Acre-feet of **reservoir storage**

Chemical, physical, and biological characteristics of **water quality**

Issue 16

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **visual resources**?

Indicators

USDA Forest Service **visual resource** management goals

Issue 17

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect the **sport fishery** in the Green River?

Indicators

Reproduction, **recruitment**, **growth**, **body condition**, and **population size**

Preferred **temperatures** for trout species

Preferred **habitats** of adult (spawning and non-spawning) and young trout

Food resources

Issue 18

How would operating Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations affect **socioeconomics**?

Indicators

Regional economic activity (**output, employment, income**)

1.8.4 Issues Raised During Scoping Which Are Not Analyzed in Further Detail in This EIS

During the scoping process for this EIS, concerns were expressed regarding how the proposed action might affect water rights. A review of the hydrology modeling of both alternatives confirms that neither operational alternative would affect water rights within the context of the authorized purposes of Flaming Gorge Dam.

The United States of America segregated the undeveloped portion of Water Right No. 41-2963 (A30414) and assigned it to the Utah Board of Water Resources on March 12, 1996. This segregated Water Right No. 41-3479 (A30414b) is commonly referred to as the “Flaming Gorge Right” and is being reserved for future water development.

Both the segregation application that created Water Right No. 41-3479 and the assignment documents that gave it to the Department of Water Resources make Water Right No. 41-3479 subordinate to Water Right No. 41-2963. These documents clearly show Water Right No. 41-3479 is not entitled to storage in Flaming Gorge Reservoir and is entitled to divert water only as it is being released under the Flaming Gorge Dam operations.

1.9 Related and Ongoing Actions

This section describes laws and projects that affect the operation of Flaming Gorge Dam and may affect the potential impacts of the proposed action. Where applicable, these laws and projects are factored into the analysis of potential impacts under both alternatives, particularly the cumulative impacts analysis (section 4.16).

1.9.1 Regulatory Requirements

Federal statutes establish a number of responsibilities for the Secretary. These legislated responsibilities relate to the management of numerous agencies, projects, and lands, all or some relating to the operation of Flaming Gorge Dam. In some cases, the statutes specifically require the Secretary to mandate responsibility for management of reservoirs; while in others, the statutes allow the Secretary to grant discretionary authority.

1.9.1.1 The Law of the River

As a tributary of the Colorado River, the Green River is managed and operated according to a collection of over 50 compacts; Federal and State laws; court decisions and decrees; and contracts, treaties, and regulatory guidelines collectively known as the Law of the River. This collection of documents apportions the water among the seven Basin States and Mexico, and regulates and manages riverflows. Some of the statutes included within the Law of the River having a major impact on dam operations follow:

- Colorado River Compact of 1922
- Upper Colorado River Basin Compact of 1948
- Colorado River Storage Project Act of 1956
- Colorado River Basin Project Act of 1968

1.9.1.2 National Parks and Recreation Areas

The affected environment for this EIS includes portions of Flaming Gorge National Recreation Area, Dinosaur National Monument, and Canyonlands National Park. Enabling legislation for these units includes:

- Flaming Gorge National Recreation Area Act of 1968 (P.L. 90-540)
- Antiquities Act of 1906, 16 U.S.C. 431-433. The Dinosaur National Monument was originally designated by President Wilson in October 1915 and was enlarged by President Roosevelt in 1938.

Management authorities include:

- National Park Service Organic Act (16 U.S.C. 1-4, 22, 43)
- National Park Service General Authorities Act of 1970 (16 U.S.C. 1a-1)
- Redwood National Park Act of 1978 (P.L. 95-250, 92 Statute 163, as amended)

1.9.1.3 Environmental Compliance

Laws and Executive orders that were designed to restore and protect the natural environment of the United States relating to air, water, land, and fish and wildlife include the following:

- National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.)
- Endangered Species Act of 1973 (16 U.S.C. 1532 et seq.)
- Wilderness Act of 1964 (16 U.S.C. 1131 et seq.)
- Wild and Scenic Rivers Act of 1968 (16 U.S.C. 1271 et seq.)
- Clean Air Act (42 U.S.C. 7401 et seq.)

- Clean Water Act of 1972 (33 U.S.C. 1251 et seq.)
- Migratory Bird Treat Act of 1918 (16 U.S.C. 703 et seq.)
- Executive Order 11988, Floodplain Management, 1977
- Executive Order 13112, Invasive Species, 1999
- Executive Order 11990, Protection of Wetlands, 1977

1.9.1.4 Cultural Resource Laws

Laws designed to protect and preserve historic and cultural resources under Federal control include the following:

- National Historic Preservation Act (16 U.S.C. 470 et seq., 1966)
- Archaeological Resources Protection Act (16 U.S.C. 470aa et seq., 1974)

1.9.1.5 Native American Laws

Laws and policies relating to Native American consultation include the following:

- American Indian Religious Freedom Act (42 U.S.C. 1996, 1973)
- Enhancing the Intergovernmental Partnership, Executive Order 12875 of October 26, 1993 (58 FR 58093)
- Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. 3001)
- Consultation and Coordination with Indian Tribal Governments, Executive Order 13084 of May 14, 1998
- Protection of Indian Sacred Sites, Executive Order 13007 of May 24, 1996 (61 FR 26771)

1.9.2 Related Programs, Projects, and Activities

1.9.2.1 Recovery Program

As discussed in section 1.4.4, the Recovery Program's goal is to protect and recover the endangered fish of the Upper Colorado River Basin while allowing existing uses and future water development to continue in accord with the "Law of the River." The Recovery Program has a variety of programs and projects underway, concerning habitat acquisition or enhancement, levee removal, nonnative fish control, and native fish stocking, aimed at achieving that goal. The proposed action for which this EIS has been prepared—operating Flaming Gorge Dam as specified in the Recovery Program's 2000 Flow and Temperature Recommendations—would complement the other Recovery Program activities in moving toward endangered fish recovery.

1.9.2.2 Interim Surplus Guidelines and Colorado River Basin Project Act 602(a) Storage Requirement

Flaming Gorge is part of the Colorado Basin and is indirectly affected by decisions made under the December 2000 *Colorado River Interim Surplus Guidelines Final Environmental Impact Statement*. However, the effects are not measurable. In addition, Reclamation is currently preparing an environmental assessment on a proposed guideline to determine the amount of upper basin water required under Section 602(a) of the Colorado River Basin Project Act. This guideline could affect operations at Lake Powell but most likely would not influence operations at Flaming Gorge.

1.9.2.3 Relocation of Little Hole National Recreation Trail

The 7.2-mile segment of the Little Hole National Recreation Trail along the Green River between the Flaming Gorge Dam Spillway Recreation Complex (boat ramp launching and parking area) and Little Hole Recreation Complex (boat ramps, parking, and day use areas) will be relocated by the USDA Forest Service pending funding to prevent recurring trail damage and loss that has occurred from past high flows. Without relocation of the trail, further damage would be expected to occur under both the No Action and Action Alternatives.

This 7.2-mile trail segment provides access to the Green River for tens of thousands of annual visitors who participate in shore and boat fishing, scenic and recreational floating, hiking, and sightseeing activities. Several commercial operators also use the trail as part of their outfitting and guiding business. Annual trail use has ranged from 54,000 to 101,000 visitors over the past 11 years. Annual visitation numbers, types, and the economic value of uses along the trail are discussed and displayed in section 3.11 of this EIS.

The USDA Forest Service completed a field assessment and report in July 2001 of trail locations along the 7.2-mile trail segment. This assessment identified trail damage and repairs that have occurred from 1979 to the present due to releases from the dam, either in response to extremely wet hydrologic years or to support endangered fish research studies. The assessment also addressed alternative trail designs, locations, and costs that would prevent recurring trail damage and loss. Depending on alternative trail locations, the design and construction cost estimates ranged from $135,000 to $308,000. The USDA Forest Service will evaluate and analyze the alternative trail designs and locations as part of a separate NEPA process and document. In addition, the USDA Forest Service will evaluate and analyze the designs and plans for reconstruction of other ramps, picnic sites, and campsites affected during high releases along the Green River. Such facilities will also be relocated pending funding. The USDA Forest Service environmental document will tier to the EIS for the operation of Flaming Gorge Dam, as appropriate, relating to environmental, social, and economic resources and issues.

The USDA Forest Service, Reclamation, and other concerned Federal and State agencies will cooperate during the preparation of the referenced environmental document for the relocation of the trail and related facilities to assure that issues are addressed for the operation of the dam, riverflows, user safety, and protection of natural and physical resources. Reclamation will support the USDA Forest Service in obtaining funding through the USDA Forest Service budgeting process that will be needed to complete the USDA Forest Service environmental document and the relocation of the trail and related facilities.

1.9.2.4 Browns Park Highway Environmental Impact Statement

An EIS is currently being prepared for a Daggett County, Utah, proposal to realign and pave Browns Park Road from its junction with U.S. 191 in Utah to Colorado Route 318. The existing, unpaved 16.8-mile long segment of road crosses BLM, State, and private lands. Scoping meetings were held by the Federal Highway Administration, Utah Department of Transportation, and BLM in December 1999.

1.9.2.5 Cedar Springs Marina Environmental Impact Statement

The Ashley National Forest is currently preparing an EIS to upgrade the Cedar Springs Marina to include the full spectrum of facilities that are necessary to fully serve the public. A Notice of Intent was published in the *Federal Register* August 18, 2004.

1.9.2.6 Resource Management Plans and Wild and Scenic Rivers Eligibility Determination

The BLM Vernal Field Office is preparing to scope the draft resource management plan (RMP)/EIS for approximately 1.8 million acres in northeastern Utah. This plan, known as the Vernal Resource Management Plan, will combine the existing Diamond Mountain and Book Cliffs RMPs into a single plan. The final EIS is scheduled to be completed in September 2005.

The Ashley National Forest began revisions in March 2004 of its Land and Resource Management Plan, commonly referred to as Forest Plan. The process for revision of this plan, including NEPA compliance, is expected to take 4 to 5 years. The Ashley National Forest is also currently conducting an eligibility determination study pursuant to the Wild and Scenic Rivers Act of 1968. A final report is planned for August 2005.

1.9.2.7 Federal Reserve Water Rights

Canyonlands National Park and Dinosaur National Monument have incomplete Federal water rights to the Green River. However, the National Park Service is not actively working with the State of Utah to quantify those rights. Future plans for quantification are uncertain.

2.0 Description of Alternatives

2.1 INTRODUCTION

This chapter describes the two alternatives analyzed in detail in this environmental impact statement (EIS), the No Action Alternative and the Action Alternative. This chapter also explains the criteria for selecting alternatives and discusses alternatives that were considered but not analyzed in detail.

Based on descriptions of the relevant resources in **Chapter 3.0, Affected Environment**, and the predicted effects of the alternatives in **Chapter 4.0, Environmental Consequences**, this chapter also presents a summary comparison of the predicted environmental effects of both alternatives on the quality of the human environment in section 2.6.

Under the No Action Alternative, Flaming Gorge Dam would be operated to achieve the flow and temperature regimes recommended by the 1992 Biological Opinion on the Operation of Flaming Gorge Dam. Depending upon the hydrologic conditions of the upper Green River Basin, forecasted flows on the Yampa River would be supplemented by releases from Flaming Gorge Dam designed to achieve the peak flow, duration, and base flow (riverflows not associated with snowmelt runoff) recommendations described in the 1992 Biological Opinion.

Under the Action Alternative, Flaming Gorge Dam would be operated with a goal of achieving the flow and temperature regimes recommended in the September 2000 *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam* (2000 Flow and Temperature Recommendations) report, prepared by participants of the Upper Colorado River Endangered Fish Recovery Program

(Recovery Program). The 2000 Flow and Temperature Recommendations specifically describe the peak flows, durations, water temperatures, and base flow criteria necessary for the recovery of the endangered fishes. The Action Alternative is the operational strategy that is in accord with these flow and temperature criteria and the authorized purposes of the Flaming Gorge Unit of the Colorado River Storage Project (CRSP).

2.2 DEVELOPMENT OF ALTERNATIVES

2.2.1 Criteria Used to Select Alternatives

Potential alternatives to be analyzed in this EIS were studied to determine whether they could meet the purpose of and need for the proposed action. A number of scenarios for dam operation, originally thought to be viable alternatives, were determined to be more accurately described as possible subsets of the Action Alternative. Because of the inherent need for operational flexibility in dam operations, as acknowledged by and incorporated into the 2000 Flow and Temperature Recommendations, and because any potential impacts from discreet operational scenarios are already captured by analysis of the Action and No Action Alternatives, it was determined that analyzing subtle differences in dam operations as separate alternatives would not yield meaningful information for the public or the decisionmaker.

Alternatives that are included in this analysis are those which both:

- ❖ Meet flow and temperature recommendations as described in the 2000 Flow and Temperature Recommendations
- ❖ Maintain all authorized purposes of the Flaming Gorge Unit of the CRSP

2.2.2 Alternatives Considered but Eliminated From Detailed Study

In accordance with Section 1502.14 (a) of the Council on Environmental Quality regulations implementing the National Environmental Policy Act, this section discusses alternatives that were considered but eliminated from detailed study, and briefly explains the reasons for their elimination.

2.2.2.1 Modified Run of the River Alternative

During the scoping process, the National Park Service and others requested consideration of a Run of the River Alternative. Under such an alternative, dam releases would match the reservoir inflow (unregulated) to provide a more natural flow regime including more natural variations in the daily flows of the Green River below Flaming Gorge Dam. Further analysis of this alternative led to the establishment of a Modified Run of River Alternative, where dam releases equaled 87 percent (%) of the unregulated inflow to the reservoir. This provided reservoir operators the ability to store 13% of the spring inflow volume for release to meet project purposes and flow recommendations at other times of the year. The 87% level was chosen because it was the highest percentage that provided enough water storage to achieve the base flow ranges recommended in the 2000 Flow and Temperature Recommendations. Percentages higher than 87% could not achieve the recommended base flows of the 2000 Flow and Temperature Recommendations.

Preliminary analysis of the historic inflows into Flaming Gorge did show that it might be possible to operate Flaming Gorge using a "Modified Run of River" approach to achieve the 2000 Flow and Temperature Recommendations during the spring. However, it was learned through this study that the effect of water consumption above Flaming Gorge played a much more significant role than was originally thought. The Flaming Gorge Model did account for the inevitability that water consumption will increase in the future. The *Consumptive Uses and Losses Report*, published by Reclamation, estimates that current water consumption above Flaming Gorge Reservoir is about 450,000 acre-feet per year. This is about 25% of the mean annual unregulated inflow into Flaming Gorge Reservoir. In addition to the level of water consumed, irrigation diversions, which are not entirely consumed, occur most often during the months of May through August. While irrigation diversions are not usually completely consumed, there tends to be a lag period before the water returns to the river. Sometimes, this lag period can be as long as several months. Water consumption and diversions can significantly decrease the unregulated inflow peaks that occur during the spring. As a result, the "Modified Run of River" approach released less water than would have been released under natural conditions. For this reason, the "Modified Run of the River" could not achieve the spring flow objectives of the 2000 Flow and Temperature Recommendations.

Water consumption on the Green River has an ever increasing effect on the inflows (and unregulated inflows) to Flaming Gorge Reservoir. Consequently, water consumption will further complicate Reclamation's ability to achieve the 2000 Flow and Temperature Recommendations in the future. This modeling study indicated that, in the case of a "Modified Run of River" approach for operating Flaming Gorge Dam, the current level of water consumption in the Green River Basin already makes it too difficult to achieve the 2000 Flow and Temperature Recommendations without having significant negative impacts on the other resources associated with Flaming Gorge Reservoir. Based on these findings, the "Modified Run of River" approach was not considered a viable alternative that could be included for analysis in the Flaming Gorge Environmental Impact Statement.

2.2.2.2 Decommissioning and Removing Flaming Gorge Dam

During the scoping process, a request was made to consider decommissioning the dam as an alternative to allow endangered fish to recover. This alternative was not selected for detailed study in this EIS because it does not meet the purpose of and need for the proposed action. Specifically, decommissioning the dam would prevent continuing the authorized purposes of the dam under the CRSP and the Flaming Gorge National Recreation Area authorizing legislation, among others.

2.3 Description of the Alternatives Analyzed in This Environmental Impact Statement

2.3.1 No Action Alternative

Under the No Action Alternative, Flaming Gorge Dam would be operated to achieve the flow and temperature regimes recommended in the 1992 Biological Opinion. Flows recommended in the 1992 Biological Opinion were intended to mimic a more natural hydrograph than what occurred under previous dam operations and to protect nursery habitats of endangered fishes downstream from the Yampa River confluence.

Under normal operations, reservoir releases through Flaming Gorge Powerplant range from 800 to 4,600 cubic feet per second (cfs). These flows adhere to the interim operating criteria for Flaming Gorge Dam established by Reclamation in September 1974. Under these criteria, Reclamation agreed to provide (1) a minimum flow of 400 cfs at all times, (2) flows of 800 cfs under normal conditions and for the foreseeable future, and (3) flows exceeding 800 cfs when compatible with other CRSP reservoir operations.

Temperature requirements under the No Action Alternative, specified in the Reasonable and Prudent Alternative of the 1992 Biological Opinion (page 30), include the following:

> *Releases from Flaming Gorge beginning July 1 and continuing until November 1 should be of the warmest water available, approaching 59 degrees F (15 degrees C)[1] (highest lake levels). By releasing the warmest water available during this period, water temperatures in the upper Green River should not differ more than 9 degrees F (5 degrees C) in the Yampa River at Echo Park and should average near 72-77 degrees F (22-25 degrees C) in Gray Canyon from July 1 to August 15.*

2.3.2 Action Alternative

Under the Action Alternative, Flaming Gorge Dam would be operated with the goal of achieving the 2000 Flow and Temperature Recommendations while maintaining and continuing all authorized purposes of Flaming Gorge Dam and Reservoir. The 2000 Flow and Temperature Recommendations provide targets for each of the three sections or "reaches" of the Green River below Flaming Gorge Dam.

- ❖ Reach 1 begins at Flaming Gorge Dam and extends 65 river miles to the confluence of the Yampa River. In this reach, the Green River meanders about 10 river miles into northwestern Colorado and then flows southward for about 30 river miles. This reach is almost entirely regulated by releases from Flaming Gorge Dam.
- ❖ Reach 2 begins at the confluence of the Green and Yampa Rivers in Colorado and extends 99 river miles southwest to the White River confluence near Ouray, Uintah County, Utah. In this reach, tributary flows from the Yampa River combine with releases from Flaming Gorge Dam to provide a less regulated flow regime than in Reach 1.
- ❖ Reach 3 begins at the confluence of the Green and White Rivers and extends 246 river miles south to the Colorado River confluence in Canyonlands National Park at the boundary of Wayne and San Juan Counties in southeastern Utah. In this reach, the Green River is further influenced by tributary flows from the White, Duchesne, Price, and San Rafael Rivers.

Table 2-1 shows a summary of the recommended spring peak and summer-to-winter base flows from the 2000 Flow and Temperature Recommendations report for all three reaches of the Green River. Under the Action Alternative, Flaming Gorge Dam would be operated with the goal of achieving the 2000 Flow and Temperature Recommendations while maintaining and continuing all authorized purposes of Flaming Gorge Dam and Reservoir.

The 2000 Flow and Temperature Recommendations for each reach are not integrated in such a way that a particular release from Flaming Gorge Dam could equally achieve the recommendations for each reach simultaneously. The intent of the Action Alternative is first to meet the recommended objectives for Reach 2 and then, if necessary, make adjustments to releases so that the recommended objectives for Reach 1 could also be met. It is assumed that the flow objectives in Reach 3 are met whenever the flow objectives in Reach 2 are met.

[1] Degrees Fahrenheit (°F); degrees Celsius (°C).

Table 2-1.—Recommended Magnitudes and Duration of Maximum Spring Peak and Summer-to-Winter Base Flows and Temperatures for Endangered Fishes in the Green River Downstream From Flaming Gorge Dam as Identified in the 2000 Flow and Temperature Recommendations

Location	Flow and Temperature Characteristics	Hydrologic Conditions and 2000 Flow and Temperature Recommendations[1]				
		Wet[2] (0–10% Exceedance)	Moderately Wet[3] (10–30% Exceedance)	Average[4] (30–70% Exceedance)	Moderately Dry[5] (70–90% Exceedance)	Dry[6] (90–100% Exceedance)
Reach 1 Flaming Gorge Dam to Yampa River	Maximum Spring Peak Flow	$8,600 cfs (244 cubic meters per second [m³/s])	$4,600 cfs (130 m³/s)	$4,600 cfs (130 m³/s)	$4,600 cfs (130 m³/s)	$4,600 cfs (130 m³/s)
	Peak flow duration is dependent upon the amount of unregulated inflows into the Green River and the flows needed to achieve the recommended flows in Reaches 2 and 3.					
	Summer-to-Winter Base Flow	1,800–2,700 cfs (50–60 m³/s)	1,500–2,600 cfs (42–72 m³/s)	800–2,200 cfs (23–62 m³/s)	800–1,300 cfs (23–37 m³/s)	800–1,000 cfs (23–28 m³/s)
Above Yampa River Confluence	Water Temperature Target	$ 64 degrees Fahrenheit (°F) (18 degrees Celsius [°C]) for 3-5 weeks from mid-August to March1	$ 64 °F (18 °C) for 3-5 weeks from mid-August to March 1	$ 64 °F (18 °C) for 3-5 weeks from mid-July to March 1	$ 64 °F (18 °C) for 3-5 weeks from June to March 1	$ 64 °F (18 °C) for 3-5 weeks from mid-June to March 1
Reach 2 Yampa River to White River	Maximum Spring Peak Flow	$26,400 cfs (748 m³/s)	$20,300 cfs (575 m³/s)	$18,600 cfs[7] (527 m³/s) $8,300 cfs[8] (235 m³/s)	$8,300 cfs (235 m³/s)	$8,300 cfs (235 m³/s)
	Peak Flow Duration	Flows greater than 22,700 cfs (643 m³/s) should be maintained for 2 weeks or more, and flows 18,600 cfs (527 m³/s) for 4 weeks or more.	Flows greater than 18,600 cfs (527 m³/s) should be maintained for 2 weeks or more.	Flows greater than 18,600 cfs (527 m³/s) should be maintained for 2 weeks in at least 1 of 4 average years.	Flows greater than 8,300 cfs (235 m³/s) should be maintained for at least 1 week.	Flows greater than 8,300 cfs (235 m³/s) should be maintained for 2 days or more except in extremely dry years (98% exceedance)
	Summer-to-Winter Base Flow	2,800–3,000 cfs (79–85 m³/s)	2,400–2,800 cfs (69–79 m³/s)	1,500–2,400 cfs (43–67 m³/s)	1,100–1,500 cfs (31–43 m³/s)	900–1,100 cfs (26–31 m³/s)
Below Yampa River Confluence	Water Temperature Target	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.	Green River should be no more than 9 °F (5 °C) colder than Yampa River during summer base flow period.
Reach 3 White River to Colorado River	Maximum Spring Peak Flow	$39,000 cfs (1,104 m³/s)	$24,000 cfs (680 m³/s)	$22,000 cfs[9] (623 m³/s)	$8,300 cfs (235 m³/s)	$8,300 cfs (235 m³/s)
	Peak Flow Duration	Flows greater than 24,000 cfs (680 m³/s) should be maintained for 2 weeks or more, and flows 22,000 cfs (623 m³/s) for 4 weeks or more.	Flows greater than 22,000 cfs (623 m³/s) should be maintained for 2 weeks or more.	Flows greater than 22,000 cfs (623 m³/s) should be maintained for 2 weeks in at least 1 of 4 average years.	Flows greater than 8,300 cfs (235 m³/s) should be maintained for at least 1 week.	Flows greater than 8,300 cfs (235 m³/s) should be maintained for 2 days or more except in extremely dry years (98% exceedance)
	Summer-to-Winter Base Flow	3,200–4,700 cfs (92–133 m³/s)	2,700–4,700 cfs (76–133 m³/s)	1,800–4,200 cfs (52–119 m³/s)	1,500–3,400 cfs (42–95 m³/s)	1,300-2,600 cfs (32–72 m³/s)

[1] Recommended flows as measured at the United States Geological Survey gauge located near Greendale, Utah, for Reach 1; Jensen, Utah, for Reach 2; and Green River, Utah, for Reach 3.
[2] **Wet** (0% exceedance): A year in which the forecasted runoff volume is larger than almost all of the historic runoff volumes. This hydrologic condition has a 10% probability of occurrence.
[3] **Moderately Wet** (10–30% exceedance): A year in which the forecasted runoff volume is larger than most of the historic runoff volumes. This hydrologic condition has a 20% probability of occurrence.
[4] **Average** (30–70% exceedance): A year in which the forecasted runoff volume is comparable to the long-term historical average runoff volumes.
[5] **Moderately Dry** (70–90% exceedance): A year in which the forecasted runoff volume is less than almost all of the historic runoff volumes. This hydrologic condition has a 20% probability of occurrence.
[6] **Dry** (90–100% exceedance): A year in which the forecasted runoff volume is less than almost all of the historic runoff volumes. This hydrologic condition has a 10% probability of occurrence.
[7] Recommended flows $18,600 cfs (527 m³/s) in 1 of 2 average years.
[8] Recommended flows $8,300 cfs (235 m³/s) in other average years.
[9] Recommended flows $22,000 cfs (623 m³/s) in 1 of 2 average years.

The 2000 Flow and Temperature Recommendations focus primarily on the flow regimes in Reaches 2 and 3, which include flows from the Yampa River. However, since these riverflow criteria are based solely on upper Green River hydrology, the 2000 Flow and Temperature Recommendations in Reaches 1 and 2 would most likely be achieved to varying degrees. For example, in years when the upper Green River Basin is wetter than the Yampa River Basin, meeting the 2000 Flow and Temperature Recommendations in Reaches 2 and 3 would most likely exceed the minimum target for the peak flow recommendations for Reach 1.

Conversely, if the Yampa River Basin is wetter than the upper Green River Basin, meeting the 2000 Flow and Temperature Recommendations for Reaches 2 and 3 could result in falling short of the peak flow target for Reach 1. Under this scenario, the Action Alternative might require Flaming Gorge Dam releases to be increased so that the 2000 Flow and Temperature Recommendations in Reach 1 could also be met. Flows in Reaches 2 and 3 would then exceed their respective minimum 2000 Flow and Temperature Recommendations. Since only one release pattern can be selected each year, depending upon how water is distributed between the upper Green River and Yampa River Basins, each reach would achieve or exceed its respective minimum 2000 Flow and Temperature Recommendations to varying degrees.

Each year, Reclamation would work closely with the U.S. Fish and Wildlife Service and Western Area Power Administration in developing a flow regime consistent with the 2000 Flow and Temperature Recommendations and CRSP purposes and would also consider input from the Flaming Gorge Working Group meetings. The framework for this decisionmaking process is described in section 2.5. The overall effectiveness of implementing the objectives of the 2000 Flow and Temperature Recommendations would be measured by the long-term frequency of achieving flow thresholds described in the 2000 Flow and Temperature Recommendations. Consideration would be given to hydrologic conditions, operational limitations, and past operational conditions. An administrative record of the operational decisionmaking would be maintained and available to the public. This record would include analysis of previous operations and the effectiveness of achieving desired targets on a year-by-year basis.

Water release temperatures at the dam would be regulated with the objective of achieving target temperatures for upper Lodore Canyon and the Yampa River and Green River confluence during the first 2 to 5 weeks of the base flow period and/or when Colorado pikeminnow larvae are present at this confluence.

2.4 Review of Flaming Gorge Model Developed for the Flaming Gorge Dam EIS

As detailed in section 4.3.1.1, a river simulation model (Flaming Gorge Model) was developed for the Green River system to assess impacts of Flaming Gorge Dam operations in this EIS. The model was developed using the RiverWare simulation modeling software package. The Flaming Gorge Model evaluates two alternative operations: the No Action Alternative (operation of Flaming Gorge Dam as prescribed by the 1992 Biological Opinion; U.S. Fish and Wildlife Service, 1992) and the Action Alternative (operation of Flaming Gorge Dam consistent with the 2000 Flow and Temperature Recommendations). The model takes, as input, a set of natural flow volumes and estimates what release volumes and storage volumes would occur under the two operating regimes. The model then routes these release volumes through the

Green River to the U.S. Geological Survey (USGS) streamflow gauge on the Green River at Jensen, Utah, approximately 93 miles downstream from Flaming Gorge Dam.

For the Action Alternative, the Flaming Gorge Model predicts more frequent use of the bypass tubes and spillway at Flaming Gorge Dam when compared to the No Action Alternative. Under the Action Alternative, the Flaming Gorge Model predicts that the bypass tubes would be used in 50% of all years, and the spillway would be used in 29% of all years. In comparison, under the No Action Alternative, the bypass tubes would be used in 23% of all years, and the spillway would be used in 5% of all years.

A review of the Flaming Gorge Model was performed by three authors of the 2000 Flow and Temperature Recommendations to evaluate whether the degree of bypass and spill predicted by the Flaming Gorge Model would be necessary to meet the requirements of the 2000 Flow and Temperature Recommendations (see peer review report in the Hydrologic Modeling Technical Appendix). The review did not include an evaluation of the No Action Alternative. While the main focus of the model review was the frequency of bypass and spillway use, the reviewers also examined the model's behavior and evaluated how the model simulated the year-round operation of Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations.

2.4.1 Review Findings

In most situations, the reviewers found that the Flaming Gorge Model properly simulates the operation of Flaming Gorge Dam to meet the 2000 Flow and Temperature Recommendations in Reach 2, while minimizing the effects on authorized purposes of the dam.

The reviewers found that the Flaming Gorge Model performs well in dry, moderately dry, and average years. The review did show that the model appeared to bypass or spill more water than may be necessary in moderately wet and wet years, however.

A key issue with river simulation modeling is a lack of flexibility. Rules must be 'hard coded' into the operational decisionmaking of the model. While many model rules allow for decision trees, a model such as the Flaming Gorge Model cannot adjust to all situations or consider the balance of all available operating options. The inability to program extensive flexibility into the model's rules makes precise modeling of the effects of the 2000 Flow and Temperature Recommendations more difficult.

Reclamation acknowledges that the Flaming Gorge Model may overstate bypasses and, therefore, may overstate potential effects that result from bypassing water. Reclamation also notes that while the Flaming Gorge Model provides good information to assess potential effects of operating to meet the 2000 Flow and Temperature Recommendations, details and flexibility that cannot be captured by modeling will be factored into operational decisionmaking each year. Therefore, the following section provides further clarification on operations to implement both the No Action and Action Alternatives.

2.5 Operational Description

This section describes how Reclamation would implement the Action and No Action Alternatives while maintaining the authorized purposes and ensuring safe operations of Flaming Gorge Dam under normal operational conditions as explained in section 1.6. Operational plans could change due to malfunction of dam and powerplant equipment and during public emergencies.

2.5.1 Safe Operation of Flaming Gorge Dam

Safe operation of Flaming Gorge Dam is of paramount importance and applies to both the Action and the No Action Alternative. To safely and efficiently operate Flaming Gorge Dam, forecasted future inflows must be incorporated into the decisionmaking process. (See section 1.5 for a description of the operational decisionmaking process.)

These forecasted future inflows are provided by the National Weather Service through the River Forecast Center and are issued as monthly or seasonal (April through July) volumes of unregulated inflow that are anticipated to occur during the forecast period. When a forecast does not accurately predict the actual inflow that occurs, a forecast error is associated with the forecast. A forecast error is the volume difference between the forecasted inflow volume for the period and the actual inflow volume for the period. Forecast errors are attributable mostly to hydrologic variability and, to a much lesser degree, the forecasting procedure. For this reason, forecast errors will always be a factor associated with the operation of Flaming Gorge Reservoir.

Analysis of the historic forecast errors at Flaming Gorge was performed by the Colorado River Forecasting Service Technical Committee (CRFSTC) in April of 1987. This committee reported 5% exceedance forecast errors (table 2-2). Forecast errors of this magnitude occur in 1 out of every 20 years on average, and errors of greater magnitude occur less frequently. From the information provided by the CRFSTC, forecast errors at the 1% exceedance level (1 out of every 100 years) were computed. Exceedance levels indicate the frequency of the event in question. A 5% exceedance forecast error can be expected to occur about 5% of the time or about 1 out of every 20 years. A 1% exceedance error can be expected to occur about 1% of the time or about 1 year out of every 100 years.

Table 2-2.—CRFSTC Recommended Forecast Errors for Flaming Gorge Dam

Month	5% Exceedance Forecast Errors in 1 in 20 years (1,000 acre-feet)	1% Exceedance Forecast Errors in 1 in 100 years (1,000 acre-feet)
January	760	1,065
February	680	962
March	610	862
April	550	778
May	480	680
June	410	581
July	375	531

Safe operation of Flaming Gorge Reservoir limits the risk of uncontrolled spills to 1% when the greatest foreseeable forecast error occurs. In other words, the safe operation of Flaming Gorge Reservoir must assure that 99% of the foreseeable forecast errors can be successfully routed through the reservoir without uncontrolled spills occurring. To limit this risk, vacant storage space must be maintained in the reservoir at various times of the year to absorb the additional inflow volume if a forecast error occurs. For this reason, the reservoir elevation is intentionally drawn down during the fall and winter months.

The upper limit drawdown levels established as safe operating parameters for Flaming Gorge Reservoir were determined through routing studies of forecast error scenarios. These scenarios were based on the 1% exceedance forecast errors shown in table 2-2. The scenario that had the largest risk of an uncontrolled spill was routed through the reservoir beginning in May with various reservoir elevations and various inflow volumes that were based on historic records. The highest end of May elevations, where the 1% exceedance forecast error was successfully absorbed by the reservoir without an uncontrolled spill, was established as the upper limit drawdown levels for that forecast volume.

Upper limit drawdown levels for the safe operation of Flaming Gorge Reservoir under both the Action and No Action Alternatives are shown in table 2-3.

Table 2-3.—Upper Limit Drawdown Levels for Flaming Gorge Reservoir

Unregulated Inflow Forecast Percentage Exceedance Range	May 1 Upper Limit Drawdown Elevation Level
1 to 10	6023
10.1 to 30	6024
30.1 to 40	6025
40.1 to 59.9	6027

2.5.2 Reservoir Operations Process Under the No Action Alternative

2.5.2.1 Operations in May Through July (Spring Period)

Under the No Action Alternative, the hydrologic condition of the upper Green River Basin, including the April through July unregulated inflow forecast and the condition of the reservoir, would be used to establish the magnitude and duration of a spring peak release for the current year. The magnitude of the spring release would usually be from 4,000 cfs to powerplant capacity (about 4,600 cfs), unless hydrologic conditions indicated that bypasses (or spills) would be necessary for safe operations of the dam. In such case, these bypasses (or spills) would be timed to occur when the Yampa River peak flows and immediate post peak flows occur. The bypass tubes or spillway could potentially be used to make releases when dam or powerplant equipment is unavailable due to malfunction or maintenance.

Through consultation with the U.S. Fish and Wildlife Service and Western Area Power Administration (Western), Reclamation would establish a range of spring operational scenarios that would achieve the objectives of the Reasonable and Prudent Alternative of the 1992 Biological Opinion on the Operation of Flaming Gorge Dam. These objectives include ramp rates, magnitudes, durations, and timing of a spring peak release and are described in the 1992 Biological Opinion. The range of spring operational scenarios would provide flexibility in operations to adjust to changing hydrologic conditions and would be based on the probable minimum and probable maximum Water Supply Forecasts issued in April by the River Forecast Center. These forecasts bound the range of reasonable (80% probability) runoff volumes that would likely occur during the April through July time period. Timing of the spring peak release under the range of possible operational scenarios would occur with the peak flows and immediate post peak flows on the Yampa River.

When the hydrologic condition is determined to be dry, the spring peak duration would be 1 to 2 weeks. Most likely, the magnitude of the release during the spring peak in dry years would be limited to powerplant capacity and could be limited to 4,000 cfs to conserve reservoir storage. Peak releases would be timed with the peak flows and immediate post peak flows of the Yampa River. In dry years, the spring peak release would be completed no later than June 20.

When the hydrologic condition is determined to be average, the spring peak duration would be 2 to 5 weeks. The magnitude of the release during the spring peak most likely would be limited to powerplant capacity (about 4,600 cfs). The timing of the peak releases would be with the peak flows and immediate post peak flows of the Yampa River. The spring peak release in average years would be completed by July 10.

Hydrologic conditions determined to be wet would establish a spring peak duration of 5 weeks or greater. Peak releases in wet years could include bypass releases and possibly spillway releases, depending on the hydrologic condition of Flaming Gorge. The use of bypass tubes or the spillway would be based on avoiding uncontrolled spills through an analysis of potential forecast errors. The magnitude of peak releases in wet years would be at least powerplant capacity (about 4,600 cfs). The spring peak release in wet years would be completed by July 20.

2.5.2.2 Use of Bypass Tubes and Spillway at Flaming Gorge Dam

Under the No Action Alternative, the use of the bypass tubes or the spillway would occur only when hydrologically necessary to maintain safe operations of Flaming Gorge Dam, during emergency operations, or when the full release capacity of the powerplant is unavailable. For the No Action Alternative, under normal operations, the magnitude of peak releases for endangered fish would be limited to powerplant capacity (about 4,600 cfs). However, if Reclamation determines that bypass releases would be likely for hydrologic reasons, Reclamation would attempt to schedule these bypass releases to occur with the peak flows and immediate post peak flows of the Yampa River.

2.5.2.3 Summer and Fall Operations (Early Base Flow Period)

Under the No Action Alternative, after the spring peak release is completed, releases from Flaming Gorge Dam would be reduced so that flows of the Green River, measured at Jensen, Utah, would achieve a target flow ranging from 1,100 to 1,800 cfs. Daily average flows would be maintained as close to this target as possible until September 15. After September 15, releases from Flaming Gorge Dam could be increased so that the daily average flow measured at Jensen, Utah, would achieve a target ranging from 1,100 to 2,400 cfs.

During the early base flow period, fluctuating releases for power production would likely occur. These fluctuating releases would be limited so that the hourly flow of the Green River, measured at Jensen, Utah, would be maintained at ±12.5% of the daily average flow of the Green River (measured at Jensen, Utah).[2]

2.5.2.4 Winter Operations (Late Base Flow Period)

There are no specific flow recommendations provided by the 1992 Biological Opinion for the period from November to May. Beginning November 1, the 1992 Biological Opinion calls for releases to be low and stable near historic levels. Under the No Action Alternative, Flaming Gorge daily average releases from November through May potentially could range from 800 cfs to powerplant capacity (about 4,600 cfs). However, it is anticipated that in most years, releases during this period would range from 800 cfs to about 3,000 cfs. Releases from Flaming Gorge Dam during the late base flow period would be designed to reduce the reservoir elevation to maintain safe reservoir operations. A discussion of the safe operation of Flaming Gorge is located in section 2.5.1, "Safe Operation of Flaming Gorge Dam."

Under the No Action Alternative, releases would achieve an upper limit drawdown elevation on March 1 of 6027 feet above sea level. The upper limit drawdown elevations for May 1 under the No Action Alternative are the same as those for the Action Alternative. These elevations can be found in table 2-3 in section 2.5.1.

During the late base flow period, fluctuating releases for power production would likely occur. The Reasonable and Prudent Alternative of the 1992 Biological Opinion

[2] The daily average flow measured at Jensen, Utah, would be determined from the average of the instantaneous flow readings during a 24-hour period from midnight to midnight each day.

does not specifically limit fluctuating releases during the late base flow period. Under the No Action Alternative, however, fluctuating releases would be limited, similar to the early base flow period, as they have been historically. The hourly flow of the Green River measured at Jensen, Utah, would be maintained from ±12.5% of the daily average flow measured at Jensen, Utah.

2.5.3 Reservoir Operations Process Under the Action Alternative

In general, implementation of the 2000 Flow and Temperature Recommendations into the operational plans for Flaming Gorge Dam would occur through coordination as described on page 5-8 of the 2000 Flow and Temperature Recommendations. A Technical Working Group consisting of biologists and hydrologists involved with endangered fish recovery issues would be convened by Reclamation at various times throughout the year. Staff from Reclamation, U.S. Fish and Wildlife Service, and Western would be members of the Technical Working Group as well as other qualified individuals who choose to participate on a voluntary basis.

Reclamation would develop an initial operational plan with balanced consideration of all of the resources associated with Flaming Gorge Reservoir and the Green River. Reclamation would present this initial operational plan to the Technical Working Group for discussion and take into consideration the information described in table 2-5 (later in this chapter) and any new information that may be available to refine the plan to best meet the needs of the endangered fish. Reclamation could make refinements to the plan based on the Technical Working Group's recommendations and then present the new plan to the Flaming Gorge Working Group for additional discussion. Reclamation could further refine the plan based on information gathered at the Flaming Gorge Working Group Meeting. This process would ensure that the 2000 Flow and Temperature Recommendations and the authorized purposes of Flaming Gorge Dam are considered in a balanced and fair manner as each year's operational plan is developed.

Technical Working Group meetings would also provide an opportunity to discuss historic operations in terms of the accomplishments and shortcomings of meeting the 2000 Flow and Temperature Recommendations. Reclamation would maintain an administrative record of these meetings to document the planning process.

2.5.3.1 Operations in May Through July (Spring Period)

Under the Action Alternative, Reclamation would establish the hydrologic classification for the spring period (May through July) based on the forecasted unregulated inflow to Flaming Gorge Reservoir for the April through July period. This forecast is issued by the River Forecast Center beginning in early January and is updated twice a month until the end of July. During the spring period, Reclamation would classify the current hydrology of the Green River system into one of five hydrologic classifications described in the 2000 Flow and Temperature Recommendations (wet, moderately wet, average, moderately dry, and dry). Table 2-4 describes the percent exceedance ranges that would be used for each classification under the Action Alternative.

Table 2-4.—Percentage Exceedances and Hydrologic Classifications

Hydrologic Classification	Percentage Exceedance Range
Wet	<10
Moderately Wet	30 to 10.1
Average	70 to 30.1
Moderately Dry	90 to 70.1
Dry	>90

The hydrologic classification would be used to establish the range of flow magnitudes and durations that could potentially be targeted for the approaching spring release period. These targets would be incorporated into a spring operations plan. This plan would be prepared each year by Reclamation under consultation with the U.S. Fish and Wildlife Service and Western and in coordination with the Technical Working Group prior to the spring Flaming Gorge Working Group meeting. The factors listed in table 5.3 of the 2000 Flow and Temperature Recommendations (shown as table 2-5), along with the established hydrologic classification, would be considered in the development of the operations plan.

In most years, it is expected that the flow magnitudes and durations achieved in Reach 2 each spring would be consistent with the flow magnitudes and durations described in the 2000 Flow and Temperature Recommendations for the hydrologic classification established in May of each year. However, because the factors listed in table 2-5 are also considered, particularly runoff conditions in the Yampa River, there would be some years where the peak flows that occur in Reach 2 achieve the targets for either one or two classifications higher (wetter) or one classification lower (drier) than the actual classification established for the Green River. It is anticipated that in some years, when the hydrologic classification for the Green River is average, that the conditions of factors listed in table 2-5 could occur where it would be possible to achieve the targets established for either the moderately wet or wet classifications. Conversely, there would be some years classified as moderately wet when the conditions of these factors would be such that targets established for the wet or average classification would be met. There could also be years classified as wet where moderately wet targets would be achieved because of the conditions of these factors. It would be the responsibility of Reclamation to ensure that, over the long term, Flaming Gorge Dam and Powerplant are operated consistent with the 2000 Flow and Temperature Recommendations.

The operations plan would describe the current hydrologic classification of the Green River Basin and the hydrologic conditions in the Yampa River Basin, including the most probable runoff patterns for the two basins. The operations plan would also identify the most likely Reach 2 flow magnitudes and durations that would be targeted for the upcoming spring release. Because hydrologic conditions often change during the April through July runoff period, the operations plan would contain a range of operating strategies that could be implemented under varying hydrologic conditions. Flow and duration targets for these alternate operating strategies would be limited to those described for one classification lower or two classifications higher than the classification for the current year.

As stated in section 1.5, the spring operations plan would be presented to the Flaming Gorge Working Group each spring for discussion. Reclamation could modify the plan based on information gathered at the Flaming Gorge Working Group meeting.

In years classified as wet, bypass releases would usually be required to operate the dam safely and to meet the 2000 Flow and Temperature Recommendations. In some years classified as wet, spillway releases also would be necessary for safe operation of the dam. Releases above powerplant capacity in these wet years would be expected to be made for a period of about 4 to 9 weeks. The exact magnitude of the release and duration of the release would depend upon factors identified in table 2-5. Wet year, high releases would be expected to occur from mid-May to early July (and, in very wet years, through July). The bypass and spillway releases, required for safe operation of the dam in wet years, would be timed with the objective to meet Reach 2 wet or moderately wet year targets, depending upon the hydrologic conditions in the Yampa

Table 2-5.—Examples of Real-Time and Other Year-Specific Information To Be Considered in Determining Annual Patterns of Releases From Flaming Gorge Dam for Implementation of the 2000 Flow and Temperature Recommendations to Benefit Endangered Fishes in Downstream Reaches From the Green River

Onset of Spring Peak Flow	Magnitude of Spring Peak Flow	Duration of Spring Peak Flow	Onset of Summer-Winter Base Flow	Magnitude of Summer-Winter Base Flow
Forecasted and actual inflow to Flaming Gorge Reservoir	Forecasted and actual inflow to Flaming Gorge Reservoir	Forecasted and actual inflow to Flaming Gorge Reservoir	Forecasted and actual inflow to Flaming Gorge Reservoir	Forecasted and actual inflow to Flaming Gorge Reservoir
Water surface elevation of Flaming Gorge Reservoir	Forecasted and actual flow in the Yampa River and other large tributaries	Forecasted and actual flow in the Yampa River and other large tributaries	Forecasted and actual flow in the Yampa River	Forecasted and actual flow in the Yampa River
Forecasted and actual flows in the Yampa River	Desired areal extent of overbank flooding in Reaches 2 and 3	Desired duration of overbank flooding in Reaches 2 and 3	Initial appearance of drifting Colorado pikeminnow larvae in the Yampa River	Elevation of sandbars in nursery areas
Presence of adult razorback sucker congregations on spawning bars	Flow conditions and extent of overbank flooding in Reaches 2 and 3 in previous year	Desired base flow magnitude	Status of endangered fish populations	Status of endangered fish populations
Initial appearance of larval suckers in established reference sites in Reach 2 (e.g., Cliff Creek)	Existing habitat conditions	Presence of razorback sucker larvae in the Green River	Temperature of water released from the dam	Temperature of water released from the dam
Existing habitat conditions (e.g., condition of razorback sucker spawning sites in Reach 2)	Status of endangered fish populations	Existing habitat conditions	Temperature differences between the Green and Yampa Rivers at their confluence	Temperature differences between the Green and Yampa Rivers at their confluence
		Status of endangered fish populations		

Source: 2000 Flow and Temperature Recommendations, table 5.3.

River. The initiation of bypass and spillway releases would take place in mid- to late May coincident with the Yampa River peak. In extremely wet years, releases above powerplant capacity could be initiated in April or early May before the Yampa River peak.

In years classified as moderately wet, bypass releases usually (but not always) would be required for safe operation of the dam. Occasionally, some use of the spillway also might be required in moderately wet years for safe operation of the dam. The volume of the powerplant bypass in moderately wet years would be less than in wet years and would generally occur for a period of about 1 to 7 weeks. The timing of these releases would be from mid- to late May into June and sometimes extend into July. Releases from Flaming Gorge Reservoir in moderately wet years would be timed with the objective of meeting Reach 2 wet, moderately wet, or average year targets, depending upon the hydrologic conditions in the Yampa River Basin and the information contained in table 2-5.

In years classified as average, bypass releases likely would not be required for safe operation of the dam but periodically would be required to meet the objectives of the 2000 Flow and Temperature Recommendations. In most average years, spring peak releases would be limited to powerplant capacity (about 4,600 cfs) with peak releases taking place for about 1 to 8 weeks, usually in the mid-May to late June (but occasionally extending into July) time period. In about 1 out of every 3 average years, bypass releases from Flaming Gorge Dam would be required to achieve the Reach 2 flow recommendation peak and duration targets. In these years, the objective would be to achieve targeted flows in Reach 2 of 18,600 cfs for 2 weeks. To conserve water, bypass releases in these average years would be made only to the extent necessary to achieve this target. It can be expected that bypass releases, when required to meet the 2000 Flow and Temperature Recommendations in average years, would be implemented for a period of less than 2 weeks. In some years classified as average, the targets that would be achieved during the spring would be moderately wet or wet as a result of flows on the Yampa River that exceeded forecasted levels.

The objective in dry and moderately dry years would be to conserve reservoir storage while meeting the desired peak flow targets in Reach 2 as specified in the 2000 Flow and Temperature Recommendations. The bypass tubes and the spillway would not be used to meet flow targets in moderately dry and dry years but, on rare occasion, might be needed to supplement flows that cannot be released through the powerplant because of maintenance requirements. In dry years, a powerplant capacity release of 1 day to 1 week would occur during the spring, and this release would be timed with the peak of the Yampa River. In moderately dry years, a 1-week to 2-week powerplant capacity release would occur during the spring and would be timed with the peak and post peak of the Yampa River.

2.5.3.2 Use of Bypass Tubes and Spillway at Flaming Gorge Dam

The bypass tubes and the spillway at Flaming Gorge Dam have been utilized historically, as needed, for safe operation of the dam. In years with high inflow, bypass releases, and sometimes spillway releases, may be required under the Action Alternative to meet the 2000 Flow and Temperature Recommendations. Bypass and spillway releases, required for safe operation of the dam and to meet the 2000 Flow and Temperature Recommendations, would be scheduled coincident with Yampa River peak and post peak flow (the mid-May to mid-June time period) with the objective of meeting flow recommendation targets in Reach 2.

There would be some years (moderately wet years and average years) where use of the bypass would not be required for safe operation but would be needed to meet the 2000 Flow and Temperature Recommendations. As part of the annual planning process discussed above, Reclamation would consult with the U.S. Fish and Wildlife Service and Western and coordinate with the Technical Working Group and make a determination whether bypasses should be attempted to achieve the targeted Reach 2 magnitudes and durations.

Increased use of the spillway in comparison to past operations raises potential concerns for two reasons: (1) physical damage to the spillway, caused by cavitation, and (2) entrainment of potentially harmful nonnative fish into the Green River. Cavitation is a physical process that can occur when water flows across a surface at high velocity. This process has been shown to cause excessive erosion in concrete spillway structures at other Reclamation dams. In 1984, the spillway at Flaming Gorge was retrofitted with air slots, tested, and deemed successful in reducing cavitation. However, should damage to the spillway become excessive, repairs would be made, and use of the spillway would be limited to when hydrologically necessary. Smallmouth bass, present in Flaming Gorge Reservoir, could potentially have a detrimental effect on native fish in the Green River if they survived entrainment and established populations in the river or caused an increase in populations known to exist in Lodore Canyon. The potential entrainment of nonnative fish has been identified as a potential concern of the Action Alternative. The potential entrainment of nonnative fish would be carefully monitored by the Recovery Program.

2.5.3.3 Operations in August Through February (Base Flow Period)

Under the Action Alternative, during the base flow period, Reclamation would classify the current hydrology of the Green River system into one of the five hydrologic classifications described in the 2000 Flow and Temperature Recommendations (wet, moderately wet, average, moderately dry, and dry). For the month of August, the hydrologic classification would be based on the percentage exceedance of the volume of unregulated inflow into Flaming Gorge Reservoir during the spring period. For the months of September through February, the percentage exceedance would be based on the previous month's volume of unregulated inflow into Flaming Gorge Reservoir. If the unregulated inflow during the previous month is such that the percentage exceedance falls into a different classification than the classification assigned for the previous month, then the hydrologic classification for the current month could be shifted by one classification to reflect the change in hydrology. This shift would only be made when the reservoir condition indicates that the shift would be necessary to achieve the March 1 drawdown level of 6027 feet above sea level. Otherwise, the hydrologic classification for the current month would remain the same as for the previous month.

The range of acceptable base flows for Reach 2 would be selected from the 2000 Flow and Temperature Recommendations for the hydrologic classification set for the current month. Reclamation would make releases to achieve flows in Reach 2 that are within the acceptable range that also assure that the reservoir elevation on March 1 would be no higher than 6027 feet above sea level.

The 2000 Flow and Temperature Recommendations during the base flow period do allow for some flexibility, and the Action Alternative accommodates this flexibility. Under the Action Alternative, the flows occurring in Reach 2 during the base flow period would be allowed to vary from the targeted flow by ±40% during the summer to fall period (August through November) and by ±25% during the winter (December through February), as long as the day-to-day change is limited to 3% of the average daily flow and the variation is consistent with all other applicable 2000 Flow and Temperature Recommendations. Reclamation would utilize the allowed flexibility to the extent possible, to efficiently manage the authorized resources of Flaming Gorge Dam. Flaming Gorge Reservoir would be operated through the base flow period so that the water surface elevation would not be greater than 6027 feet above sea level on March 1.

During the base flow period, hourly release patterns from Flaming Gorge Dam would be patterned so that they produce no more than a 0.1-meter stage change each day at the Jensen gauge, except during emergency operations.

2.5.3.4 Operations in March and April (Transition Period)

From March 1 through the initiation of the spring peak release (typically, this occurs in mid- to late May), there are no specific flow requirements specified in the 2000 Flow and Temperature Recommendations. For the Action Alternative, releases during this transition period would be made to manage the reservoir elevation to an appropriate drawdown level based on the forecasted unregulated inflow into Flaming Gorge for the April through July period. Appropriate drawdown levels under normal operations during the transition period are those that would allow for safe operation of the dam through the spring. These upper limit drawdown levels are described earlier in table 2-3 in section 2.5.1.

Table 2-3 implies that upstream regulation above Flaming Gorge Reservoir remains relatively consistent with historic regulation.[3] In the event that less storage space would be available above Flaming Gorge Reservoir during the spring, these drawdown levels may have to be lower than those specified in table 2-3 for safe operation of Flaming Gorge Dam. In extreme wet years, the drawdown level for May 1 could potentially be lower than that specified to maintain safe operation of the dam.

Reclamation would determine the appropriate reservoir drawdown based on the percentage exceedance of the forecasted volume of unregulated inflow into Flaming Gorge Reservoir during the spring (April through July). The forecast is issued twice during March and twice during April. Under normal operations during the transition period, releases would be limited to a range from 800 cfs to powerplant capacity (4,600 cfs).

Releases during the transition period would be patterned so that they are consistent with the release patterns established during the preceding base flow period. The 2000 Flow and Temperature Recommendations do not address hourly fluctuation patterns during the transition period. During the transition period, Reclamation would maintain the fluctuation constraints as in the preceding base flow period to provide operational consistency as has been done historically.

[3] Historically (1988-2003), there generally has been about 200,000 acre-feet of vacant space at Fontenelle Reservoir (above Flaming Gorge) on May 1.

2.6 Summary Comparison of the Predicted Environmental Effects of All Alternatives

This section summarizes and compares the chapter 4 analyses of predicted environmental effects under both the Action and No Action Alternatives.

2.6.1 Hydrology

Tables 2-6, 2-7, and 2-8 present the key flow parameters and ranges described in both the 1992 Biological Opinion (No Action Alternative) and the 2000 Flow and Temperature Recommendations (Action Alternative) under dry, average, and wet hydrological conditions. The 2000 Flow and Temperature Recommendations report also provides recommended flow regimes for moderately wet and moderately dry hydrologic conditions; however, because the 1992 Biological Opinion does not address these conditions, they have been omitted from this comparative analysis.

The 1992 Biological Opinion does not specifically define the differences between wet, average, and dry hydrological conditions but rather, suggests that Reclamation and the U.S. Fish and Wildlife Service consult each year to make this determination. The 2000 Flow and Temperature Recommendations are more specific about how the hydrology of the upper Green River Basin is to be characterized.

The hydrologic conditions of the upper Green River Basin, as described in the 2000 Flow and Temperature Recommendations, are based on the forecasted or actual volume of unregulated inflow (adjusted for storage in upstream reservoirs) into Flaming Gorge Reservoir during the period from April through July. During the spring and early

Table 2-6.—Dry Hydrology Scenario
(Runoff Volume Exceeded 90 to 100% of the Time)

1992 Biological Opinion (No Action Alternative)	September 2000 Flow and Temperature Recommendations (Action Alternative)
Release Peak Determination The Biological Opinion calls for a peak release of 4,000 to 4,700 cfs for a duration of 1 to 6 weeks in all years. ▪ The intent of this peak release is to achieve a peak flow at Jensen, Utah, of 13,000 to 18,000 cfs for a period of 1 week in dry years. ▪ Timing of the peak release would begin during the period from May 15 to June 1 so that the peak release would coincide with the peak flow of the Yampa River.	***Release Peak Determination*** In dry years, the 2000 Flow and Temperature Recommendations call for a peak release that should achieve the following: ▪ The combined flows of the Green and Yampa Rivers should provide a peak flow in Reach 2 that exceeds 8,300 cfs for at least 2 days. ▪ The minimum peak release from Flaming Gorge Dam should be 4,600 cfs. To target these requirements, the forecasted peak flow of the Yampa River would be supplemented by releases from Flaming Gorge Dam. The timing of the peak release should coincide with the peak and post-peak flows of the Yampa River.
Ramp Rate Determination The ascent rate would be limited to no more than 400 cfs per day. The decline rate would also be limited to 400 cfs per day.	***Ramp Rate Determination*** The ascent rate is not specified in the 2000 Flow and Temperature Recommendations. The decline rate for a dry year should be 350 cfs per day or less.
Base Flow Determination Summer flows, after the spring peak release, would be between 1,100 and 1,800 cfs at Jensen, Utah, for all years and would be reached by June 20 in dry years. On September 15, if it is determined that the year was wetter than anticipated, the range of available target flows could be expanded to 1,100 to 2,400 cfs, if necessary.	***Base Flow Determination*** The base flow target at Jensen, Utah, should be between 900 cfs and 1,100 cfs during dry years. Variability in flow around the established average base flow should be consistent with the variability that occurred in pre-dam flows. Accordingly, the average daily flow at Jensen, Utah, could fluctuate by 40% around the established average daily base flow target from August through November. From December through February, the average daily flow at Jensen, Utah, could fluctuate by 25% around the established average daily base flow target. Differences in average daily flows at Jensen, Utah, between consecutive days, and due strictly to reservoir operations, should not exceed 3%.
Hour-to-Hour Fluctuation Determination The flow at Jensen, Utah, would fluctuate no more than 12.5% of the daily average flow during the summer and fall period. Fluctuations during the winter period (November through February) would be moderated.	***Hour-to-Hour Fluctuation Determination*** Flow variations resulting from hydropower generation at Flaming Gorge Dam should be limited to produce no more than a 0.1-meter (about 4 inches) stage change within a 24-hour period at the Jensen gauge.
Release Temperature Determination Releases during the period from July 1 to November 1 would be regulated to achieve the warmest possible temperatures, approaching 59 °F (15 °C).	***Release Temperature Determination*** Release temperatures should be regulated with the objective to meet or exceed water temperatures in upper Lodore Canyon of 64 °F (18 °C) for the first 2 to 5 weeks during the base flow period (mid-June to March 1) for dry years. In addition to the above criteria, Green River temperatures at its confluence with the Yampa River should be no more than 9 °F (5 °C) colder than Yampa River temperatures during the summer base flow period.

Table 2-7.—Average Hydrology Scenario
(Runoff Volume Exceeded 30 to 70% of the Time)

1992 Biological Opinion (No Action Alternative)	September 2000 Flow and Temperature Recommendations (Action Alternative)
Peak Flow Determination	***Peak Flow Determination***
The Biological Opinion calls for a peak release of 4,000 to 4,700 cfs for a duration of 1 to 6 weeks in all years. ▪ The intent of this peak release is to achieve a peak flow at Jensen, Utah, of 13,000 to 18,000 cfs for a period of 2 to 4 weeks in average years. ▪ Timing of the peak release would begin during the period from May 15 to June 1 so that the peak release would coincide with the peak flow of the Yampa River. Bypass releases, if necessary for hydrologic reasons, would be made before or during the Yampa River peak flow.	In average years, the 2000 Flow and Temperature Recommendations call for a peak release that should achieve the following: ▪ The peak release should provide a peak flow in Reach 2 that exceeds 18,600 cfs in 1 out of 2 average years. ▪ In 1 out of 4 average years, the peak flow in Reach 2 should exceed 18,600 cfs for at least 2 weeks. ▪ In all average years, the peak flow in Reach 2 should exceed 8,300 cfs for at least 2 weeks. ▪ The minimum peak release from Flaming Gorge Dam should be 4,600 cfs. To target these requirements, the forecasted peak flow of the Yampa River would be supplemented by releases from Flaming Gorge Dam. The timing of the peak release should coincide with the peak and post-peak flows of the Yampa River.
Ramp Rate Determination	***Ramp Rate Determination***
The ascent rate would be limited to no more than 400 cfs per day. The decline rate would also be limited to 400 cfs per day.	The ascent rate is not specified in the 2000 Flow and Temperature Recommendations. The decline rate for an average year should be 500 cfs per day or less.
Base Flow Determination	***Base Flow Determination***
Summer flows, after the spring peak release, would be between 1,100 and 1,800 cfs at Jensen, Utah, for all years and would be reached by July 10 in average years. On September 15, if it is determined that the year was wetter than anticipated, the range of available target flows could be expanded to 1,100 to 2,400 cfs, if necessary.	The base flow target at Jensen, Utah, should be between 1,500 cfs and 2,400 cfs during average years. Variability in flow around the established average base flow should be consistent with the variability that occurred in pre-dam flows. Accordingly, the average daily flow at Jensen, Utah, could fluctuate by 40% around the established average daily base flow target from August through November. From December through February, the average daily flow at Jensen, Utah, could fluctuate by 25% around the established average daily base flow target. Differences in average daily flows at Jensen, Utah, between consecutive days, and due strictly to reservoir operations, should not exceed 3%.
Hour-to-Hour Fluctuation Determination	***Hour-to-Hour Fluctuation Determination***
The flow at Jensen, Utah, would fluctuate no more than 12.5% of the daily average flow during the summer and fall period. Fluctuations during the winter period (November through February) would be moderated.	Flow variations resulting from hydropower generation at Flaming Gorge Dam should be limited to produce no more than a 0.1-meter (about 4 inches) stage change within a 24-hour period at the Jensen gauge.
Release Temperature Determination	***Release Temperature Determination***
Releases during the period from July 1 to November 1 would be regulated to achieve the warmest possible temperatures, approaching 59 °F (15 °C).	Release temperatures should be regulated with the objective to meet or exceed water temperatures in upper Lodore Canyon of 64 °F (18 °C) for the first 2 to 5 weeks during the base flow period (mid-July to March 1) for average years. In addition to the above criteria, Green River temperatures at its confluence with the Yampa River should be no more than 9 °F (5 °C) colder than Yampa River temperatures during the summer base flow period.

Table 2-8.—Wet Hydrology Scenario
(Runoff Volume Exceeded Less than 10% of the Time)

1992 Biological Opinion (No Action Alternative)	September 2000 Flow and Temperature Recommendations (Action Alternative)
Peak Flow Determination The Biological Opinion calls for a peak release of 4,000 to 4,700 cfs for a duration of 1 to 6 weeks in all years. ▪ The intent of this peak release is to achieve a peak flow at Jensen, Utah, of 13,000 to 18,000 cfs for a period of 6 weeks in wet years. ▪ Timing of the peak release would begin during the period from May 15 to June 1 so that the peak release would coincide with the peak flow of the Yampa River. Bypass releases, if necessary for hydrologic reasons, would be made before or during the Yampa River peak flow.	***Peak Flow Determination*** In wet years, the 2000 Flow and Temperature Recommendations call for a peak release that should achieve the following: ▪ The peak release should provide a peak flow in Reach 2 that should exceed 26,400 cfs. ▪ Flows in Reach 2 should exceed 22,700 cfs for at least 2 weeks. ▪ Flows in Reach 2 should also exceed 18,600 cfs for at least 4 weeks. ▪ The minimum peak release from Flaming Gorge Dam should be 8,600 cfs. To target these requirements, the forecasted peak flow of the Yampa River would be supplemented by releases from Flaming Gorge Dam. The timing of the peak release should coincide with the peak and post-peak flows of the Yampa River.
Ramp Rate Determination The ascent rate would be limited to no more than 400 cfs per day. The decline rate would also be limited to 400 cfs per day.	***Ramp Rate Determination*** The ascent rate is not specified in the 2000 Flow and Temperature Recommendations. The decline rate for a wet year should be 1,000 cfs per day or less.
Base Flow Determination Summer flows, after the spring peak release, would be between 1,100 and 1,800 cfs at Jensen, Utah, for all years and would be reached by July 20 in wet years. On September 15, if it is determined that the year was wetter than anticipated, the range of available target flows could be expanded to 1,100 to 2,400 cfs, if necessary.	***Base Flow Determination*** The base flow target at Jensen, Utah, should be between 2,800 cfs and 3,000 cfs during wet years. Variability in flow around the established average base flow should be consistent with the variability that occurred in pre-dam flows. Accordingly, the average daily flow at Jensen, Utah, could fluctuate by 40% around the established average daily base flow target from August through November. From December through February, the average daily flow at Jensen, Utah, could fluctuate by 25% around the established average daily base flow target. Differences in average daily flows at Jensen, Utah, between consecutive days, and due strictly to reservoir operations, should not exceed 3%.
Hour-to-Hour Fluctuation Determination The flow at Jensen, Utah, would fluctuate no more than 12.5% of the daily average flow during the summer and fall period. Fluctuations during the winter period (November through February) would be moderated.	***Hour-to-Hour Fluctuation Determination*** Flow variations resulting from hydropower generation at Flaming Gorge Dam should be limited to produce no more than a 0.1-meter (about 4 inches) stage change within a 24-hour period at the Jensen gauge.
Release Temperature Determination Releases during the period from July 1 to November 1 would be regulated to achieve the warmest possible temperatures, approaching 59 °F (15 °C).	***Release Temperature Determination*** Release temperatures should be regulated with the objective to meet or exceed water temperatures in upper Lodore Canyon of 64 °F (8 °C) for the first 2 to 5 weeks during the base flow period (mid-August to March 1) for wet years. In addition to the above criteria, Green River temperatures at its confluence with the Yampa River should be no more than 9 °F (5 °C) colder than Yampa River temperatures during the summer base flow period (the 2000 Flow and Temperature Recommendations indicate that this may not be possible in wet years).

summer, operational decisions would be based on forecasted inflows. After August 1, operational decisions would be based on the measured inflows that occurred during the previous month as well as the previous April through July period.

For purposes of this analysis, and as defined by the 2000 Flow and Temperature Recommendations, dry conditions in the upper Green River Basin are identified as unregulated April-July inflow volumes that are exceeded in 9 out of every 10 years (90% exceedance value). The year 1977 was historically dry at which time the unregulated April through July inflow measured only 254,000 acre-feet. In contrast, wet conditions in the upper Green River Basin are identified as unregulated April through July inflow volumes that are exceeded in only 1 out of every 10 years (10% exceedance value). For example, 1986 was a historically wet year at which time the unregulated April through July inflow measured 2,224,000 acre-feet.

2.6.2 Water Quality, Water Temperature, and Sediment Transport

When the operation of Flaming Gorge Dam was changed to meet the requirements of the Reasonable and Prudent Alternative (RPA) of the 1992 Biological Opinion, the frequency of summer and fall reservoir drawdowns that produced algal blooms was reduced. This operational change improved the water quality of Flaming Gorge Reservoir. The analysis of the effects of the Action and No Action Alternatives shows that the frequency of reservoir drawdowns likely would not differ from drawdown conditions observed since 1992. Under either alternative, reservoir drawdowns during drought conditions would cause larger algal blooms. As an example, such a condition occurred in the fall of 2002.

For the Green River below Flaming Gorge Dam, the only water quality issue of concern with respect to the Action Alternative is water temperature. The No Action Alternative would result in future water temperatures based on the recommendations of the 1992 Biological Opinion. Under the Action Alternative, release temperatures and river temperatures in Reach 1 would be somewhat warmer to meet the temperature recommendation of 64 °F (18 °C) or greater in upper Lodore Canyon. Reaches 2 and 3, because of their distance from Flaming Gorge Dam, would likely have similar water temperatures under either of the alternatives.

Sediment transport is presented in the “Water Quality” section because it is an important function in the river system, with the potential to affect both riverine and riparian habitat. In comparison to the estimated average annual sediment load for Reach 1 under the No Action Alternative, sediment transport under the Action Alternative represents an increase of about 14%. Seasonally, during May, June, and July, sediment transport is expected to be about 56% greater under the Action Alternative relative to the No Action Alternative in Reach 1. In comparison to the estimated average annual sediment load for Reach 2 under the No Action Alternative, estimated annual sediment transport in Reach 2 under the Action Alternative represents an increase of about 7%. Sediment transport during May, June, and July under Action Alternatives conditions would average nearly 11% more than sediment transport under No Action Alternative conditions during the same season in Reach 2. Annual sediment loads in Reach 3 are expected to be about 8% greater under the Action Alternative flows relative to the No Action flows. Sediment transport in Reach 3 would average about 9% more during May, June, and July under the Action Alternative conditions related to the No Action conditions. (See table 2-9 for a summary of this information.)

Table 2-9.—Weight and Percent Increase in Sediment Load Under the Action Alternative, Above That for the No Action Alternative

Reach Number	Time Period	No Action Alternative	Action Alternative	
		Estimated Sediment Load (tons)	Sediment Load Increase (tons)	Increase (percent)
Reach 1	Average Annual	92,000	+13,000	+14
	May-June-July	45,000	+25,000	+56
Reach 2	Average Annual	1.2 million	+800,000	+ 7
	May-June-July	970,000	+110,000	+11
Reach 3	Average Annual	3.5 million	+280,000	+8
	May-June-July	3.3 million	+290,000	+9

2.6.3 Hydropower

Hydropower analysis focuses on the potential impacts of the alternatives on powerplant operations at Flaming Gorge Dam. This analysis used a computer model developed by Argonne National Laboratory in collaboration with Reclamation. The model uses an estimate of the quantity of energy injected into the power grid along with a forecasted hourly electricity spot price (market price) to determine the economic value for each alternative. The model determined the revenue generated as a result of operating Flaming Gorge Powerplant to achieve each alternative over the period from 2002 to 2026. The revenues for each alternative were then discounted by 5.5% per year so that they reflected their net present value. The total net present value of the revenue generated under each alternative was then compared to determine the economic impacts to power production under the proposed alternatives.

The results are summarized in table 2-10 and show that the net present value of economic benefits for the No Action Alternative simulation was $403.1 million while generating about 11,904 gigawatthours (GWh) of energy. The Action Alternative showed a net present value of about $423.1 million for the 25-year simulation, an increase of $20.0 million (5.0%) over the estimate for the No Action Alternative. The Action Alternative would generate about 11,374 GWh of energy, about 4.5% less, compared to the No Action Alternative generation. The Action Alternative generates less energy but is able to generate more of this energy during the seasons when market prices are higher, leading to a slightly greater net present value. The Action Alternative has greater benefits with fewer GWh due to the fluctuations in the market price of energy. The Action Alternative calls for more generation in the summer months when energy sells at higher prices than in the fall, when the No Action Alternative generates more power. Given recent volatility in historical prices, there is uncertainty associated with future prices. Because there is less total annual generation with the Action Alternative, use of an alternative price set that does not assume as large a relative seasonal price difference could result in a negative rather than a positive impact. In any case, the impact is considered to be insignificant when the total value of Flaming Gorge generation is considered.

In addition to the economic analysis, a financial analysis was performed as described

Table 2-10.—Table of Comparisons of the Alternatives for Hydropower

	No Action Alternative	Action Alternative	Comparison of Action to No Action
Net Present Value	$403.1 million	$423.1 million	$20 million (5.0%)
Generation in GWh	11,904.1	11,374.3	-529.8 (-4.5%)
Wholesale Electricity Price Composite	20.72 mills/kWh[1]	20.57 mills/kWh	-0.15 mills/kWh (-0.73%)

[1] Mills per kilowatthour.

in section 4.4.3. While an economic analysis shows the impacts on the national economy as a whole, the financial analysis describes the impacts to the customers who purchase wholesale electricity generated at Flaming Gorge Powerplant. The results of this analysis show that, compared to the No Action Alternative, the Action Alternative would not have a significant impact on the rate CRSP power users pay.

2.6.4 Agriculture

Under both the No Action and Action Alternatives, about 245 acres of cropland in the historic Green River flood plain could be expected to be flooded in nearly half of all years. On average, affected lands would be inundated 2 days longer under the Action Alternative, but since this incremental time would not do further crop damage compared with the No Action Alternative, there would be no differences in impacts between the two alternatives.

2.6.5 Land Use

There would be no impacts to land use around Flaming Gorge Reservoir under either alternative. In Reach 1 of the Green River, in wet years, the Action Alternative would have greater impacts to the use of campgrounds and other recreational facilities that have been built in the historic flood plain than would the No Action Alternative. In average hydrology years, the impacts to such facilities would be about the same under either alternative.

Under the No Action Alternative in Reach 2, the effects of the river on land use that have occurred over the past 10 years would continue. Under the Action Alternative, higher flows of longer duration would be expected to occur in wet years. This would result in inundation levels and durations in the historic flood plain that have not occurred in the recent past, and consequently, a temporary loss of land use in the flood plain on a more frequent basis. In Reach 3, there would not be a significant land use difference under either alternative.

2.6.6 Ecological Resources

Under the No Action Alternative, present conditions would be expected to continue for all flora and fauna around Flaming Gorge Reservoir and in the Green River.

Under the Action Alternative, both native and nonnative fish in Reach 1 would likely benefit from the 2000 Flow and Temperature Recommendations. There is the potential for both positive and negative effects to trout in the area immediately below Flaming Gorge Dam, though long-term negative effects are not expected. There is also a potential for negative impacts to trout in the Browns Park area if water temperatures in that area exceed 64 °F (18 °C).

Under the No Action Alternative, there would be continued proliferation of wetland plants and island marshes. Due to infrequent flooding, the flood plain forests of the old high water zone would continue to transition to desert. The old-growth cottonwoods would continue the trend of premature dieoff. There would be limited opportunity for establishment of cottonwoods and box elders. Under the Action Alternative, there may be erosion of wetland and riparian vegetation on islands and bars, followed by increased opportunity for cottonwood establishment. Larger floodflows may improve the health of mature cottonwoods.

Invasive species are present in all reaches and are expected to persist under the No Action Alternative. The Action Alternative could accelerate growth of some invasive species along the river. Tamarisk and giant whitetop are two such species that could increase in rate and acreage of invasion in higher flood plain settings under the Action Alternative.

In the short term, birds and animals along the Green River corridor could be negatively impacted by temporary loss of habitat due to increased flooding, but the potential impacts are not expected to be significant. In the long term, birds and animals are expected to benefit from enhancement of riparian vegetation and habitat.

2.6.6.1 Threatened and Endangered Fish

Under the No Action Alternative, existing conditions for the Colorado pikeminnow, humpback chub, and razorback sucker would be expected to continue. For both the No Action and Action Alternatives, conditions for the bonytail chub are assumed to be the same as for the other three endangered fish species. While these species would be expected to benefit from Recovery Program activities other than activities arising from implementation of the 2000 Flow and Temperature Recommendations, it is believed that continuation of No Action flow regimes would not provide enough benefit to support their recovery. Under the Action Alternative, river conditions are expected to benefit the endangered fish and their designated critical habitat.

2.6.6.2 Other Threatened and Endangered Species

Under the No Action Alternative, continued decline in the acreage and health of native riparian vegetation would have negative effects on the southwestern willow flycatcher. Under the Action Alternative, Ute ladies'-tresses could be lost in Reach 1. Suitable habitat may be lost or otherwise become unsuitable. Additional sites of potentially suitable habitat would likely develop at new locations under the Action Alternative. Long-term increases in cottonwood and native understory vegetation along the river corridor would benefit bald eagle and southwestern willow flycatcher. Other threatened and endangered species are not expected to be affected by either alternative.

2.6.6.3 Other Special Status Species

Under the No Action Alternative, continued decline in acreage and health of native riparian vegetation would have negative effects on yellow-billed cuckoo and other State sensitive songbirds. The Action Alternative may reverse degradation of riparian vegetation in Reach 2 and upper Reach 3.

2.6.7 Cultural Resources

Adjacent to the reservoir and along the Green River, there would be no effects from dam operations to cultural resources under either alternative.

2.6.8 Paleontological Resources

Adjacent to the reservoir and along the Green River, there would be no effects from dam operations to paleontological resources under either alternative.

2.6.9 Indian Trust Assets

The No Action Alternative would not affect Indian (American Indian) trust assets. The Action Alternative would not affect agriculture, oil and gas production, or other Indian trust assets if advance notice is provided on the timing of spring peak flows. There would be no significant difference between the Action and No Action Alternatives.

2.6.10 Safety and Public Health

There is public concern over the creation of mosquito habitat along the Green River due to the flow regimes under either alternative, which are intended to inundate flood plain depressions for the benefit of endangered fish. Under the No Action Alternative, the population of mosquitoes along the river would not increase. In Reach 1, the Action Alternative could result in an increase in the mosquito population along the river. In Reach 2, the Action Alternative also could result in an increase in mosquitoes, though not as large or as often as in Reach 1. As it has in the past, under either alternative, Reclamation would continue to coordinate peak flow releases with State and county officials to help minimize the mosquito population in the Jensen, Utah, area to the extent possible. Under either alternative, mosquito abatement control by the county would continue. In Reach 3, there would be no significant difference for mosquito populations between the Action and No Action Alternatives.

Public safety on Flaming Gorge Reservoir is expected to be unchanged under either alternative. Public safety along the Green River could be affected under the Action Alternative due to the potential for higher flows for longer durations. Existing safety procedures for dam operations would continue to be followed, along with notification to the public of scheduled high flows.

2.6.11 Air Quality

There are no significant impacts to air quality under either alternative.

2.6.12 Visual Resources

There are no significant effects on visual resources under either alternative.

2.6.13 Environmental Justice

No adverse impacts to minority or low-income populations have been identified under either alternative.

2.6.14 Recreation

On average, total water-based river and reservoir visitation within Flaming Gorge National Recreation Area for the Action Alternative is not expected to measurably change compared to the No Action Alternative (only +0.3% gain). Gains in economic value are expected to be higher (+9.5%) as a result of water levels moving closer to preferred conditions.

Under wet and dry conditions, each of which typically occur only 10% of the time, Action Alternative visitation and value on the river are expected to decline compared to the No Action Alternative but are more than offset by gains on the reservoir.

2.6.15 Socioeconomics/Regional Economics

The socioeconomic analysis evaluates the effect of changing expenditures on economic activity in the general vicinity of Flaming Gorge National Recreation Area. The economic impact region consists of the Daggett and Uintah Counties in Utah and Sweetwater County in Wyoming. Given the minor effect on local expenditures from changes in hydropower and agricultural production, the analysis focuses exclusively on recreation expenditures. The combined river and reservoir recreation expenditure impacts of the Action Alternative appear to be positive, but minor, under all hydrologic conditions.

2.7 PREFERRED ALTERNATIVE

As a result of the analyses presented in this EIS, Reclamation considers the Action Alternative to be the preferred alternative.

3.0 Affected Environment

This chapter provides a brief geographic description of the area in which the proposed action is to be undertaken. It then provides a description of the existing conditions for all resource areas that might be affected by the Action Alternative or the No Action Alternative. For a discussion of the potential consequences of each of the two alternatives, please see chapter 4.

3.1 INTRODUCTION

Flaming Gorge Dam is located in northeastern Utah, and Flaming Gorge Reservoir is located in northeastern Utah and southwestern Wyoming. The Wyoming portion of the reservoir is located in Sweetwater County and consists of high desert topography including low hills, shale badlands, and desert shrubbery. The Utah portion of the reservoir is located in Daggett County, in the Uinta Mountains, where the topography includes benches, canyons, and forest. Leaving the reservoir, the Green River flows east into Colorado, traversing the Uinta Mountains. In Colorado, the Green River turns south to its confluence with the Yampa River, turns west-southwest back into Utah, and then runs generally south to its confluence with the Colorado River. In Colorado and Utah, the Green River flows through the eastern part of the Uinta Basin, which extends south from the Uinta Mountains to the Tavaputs Plateau of the Book Cliffs. Please refer to the frontispiece map of the project area.

3.2 POTENTIALLY AFFECTED AREA

The geographic area that could be affected by the Proposed Action includes the Flaming Gorge Reservoir, which extends northward 91 miles from Flaming Gorge Dam, and the Green River downstream to the Colorado River confluence (see the frontispiece map). The Colorado River confluence is about 410 river miles south of Flaming Gorge Dam.

3.2.1 Description of Flaming Gorge Dam, Powerplant, and Reservoir

This section describes Flaming Gorge Dam, Powerplant, and Reservoir as they contribute to conditions in and along the Green River below the dam.

3.2.1.1 Flaming Gorge Dam and Reservoir

Flaming Gorge Dam is the principal feature of the Flaming Gorge Unit, one of four units of the Colorado River Storage Project (CRSP) that was authorized by an act of Congress on April 11, 1956. Completed in 1964, the dam and powerplant are operated and maintained by the Bureau of Reclamation. The reservoir began filling December 10, 1962, and filled for the first time August 1, 1974. Flaming Gorge Dam is a thin-arch concrete dam, which, from the streambed, stands 502 feet high and contains 987,000 cubic yards of concrete. The dam impounds waters of the Green River to form Flaming Gorge Reservoir, which has a total capacity of 3,788,900 acre-feet. At full elevation of 6040 feet, the L-shaped reservoir has a surface area of 42,020 acres and is 91 river miles long, with the first 32-mile-long portion roughly paralleling the Utah/Wyoming border and the remaining 59 miles extending northward into Wyoming. Flaming Gorge Dam has the capability of releasing 28,600 cubic feet per second (cfs) through the combined capacities of the powerplant, river outlet works, and spillway.

3.2.1.2 Flaming Gorge Dam River Outlet Works and Spillway

The river outlet works consist of two 72-inch-diameter steel pipes that extend through the dam and continue downstream to a valve structure located near the east abutment of the dam. The outlet works discharge directly into the Green River, bypassing the powerplant and turbines. The combined capacity of the two outlet pipes is 4,000 cfs. Normally, the outlet works are only used to release flows above the capacity of the powerplant, which is 4,600 cfs. However, on occasion, if the powerplant is out of service, water may be bypassed through the outlet works to maintain flows in the river. Since the intake for the outlet works is lower in the dam than either the penstocks (pipes that carry water from the reservoir to the turbines in the powerplant) or the spillway, outlet works water releases are typically colder than releases made through the other structures. Further information on water temperatures can be found in section 3.3.

The spillway is used to release water from Flaming Gorge Reservoir in amounts that exceed the combined release capacity of the river outlet works and the powerplant. The spillway is controlled manually by two 16¾- by 34-foot hydraulically operated fixed-wheel gates. The spillway can safely discharge up to 20,000 cfs. The reservoir level must be above 6006 feet before water can be released through the spillway. The spillway was used in 1983, 1984, and 1999 for flood control purposes. In 1997, the spillway was used instead of the outlet works when repair work was being done on the outlet works.

3.2.1.3 Flaming Gorge Powerplant

Flaming Gorge Powerplant, located at the base of Flaming Gorge Dam, first began producing hydroelectric power on

September 27, 1963. Water is conveyed to the powerplant by three 10-foot-diameter penstocks located near the center of the dam. The powerplant houses three generating units with a total capacity of about 152 megawatts (MW). On average, Flaming Gorge Powerplant generates 528,900 megawatt-hours of electrical energy per year, which is enough energy to serve about 150,000 homes. This is largely dependent on hydrologic conditions in the upper Green River Basin. The powerplant is capable of operating within the approximate range of 100 to 4,600 cfs. Under normal operating conditions, water is released through the penstocks and turbines where the energy from falling water is used to produce electricity. Water from the penstock cools the turbine bearings. When design temperatures are exceeded, turbine alarms trip, resulting in the affected generator going offline. This operating restriction has limited the ability to release warmer water downstream. Further detail is provided in section 3.3.4.1.

3.2.1.4 Flaming Gorge Dam Selective Withdrawal Structure

In 1978, Reclamation began releasing water through the selective withdrawal structure to provide warmer water for trout downstream. Prior to construction of the selective withdrawal structure, water releases were made through the penstocks. This mode of operation resulted in summertime water release temperatures ranging from 41-48 degrees Fahrenheit (°F) (5-9 degrees Celsius [°C]) which limited trout growth rates and the desired cold water sport fishery development. The selective withdrawal structure consists of a set of interlocking panels that can be manually raised to any height above the penstock intake to within 40 feet of the water surface. Around April 1 of each year, the upper gates are raised to an elevation about 40 feet below the surface of the reservoir. As inflows increase and debris approaches the intake structure, the gates are lowered to prevent the debris from entering the penstocks. As the debris dissipates, the gates are again raised to discharge warmer water into the river. Moving the gates up or down does not give an instantaneous change in the temperature. Temperature adjustment is an iterative process. Following gate movement, the discharge temperature is monitored; and if the temperature goal is not reached, another move is initiated.

3.3 WATER RESOURCES AND HYDROLOGY

This section describes the water resources in Flaming Gorge Reservoir and in the Green River downstream from Flaming Gorge Dam. It discusses basic hydrology and baseline conditions for water quality and water temperature.

3.3.1 Flaming Gorge Reservoir Hydrology

Reservoir elevations have fluctuated from a minimum of 5988 feet above sea level in January 1978 to a maximum elevation of 6044 feet above sea level in July 1983. Reservoir elevation fluctuations are the result of inflow volumes that are not matched by reservoir release volumes over a particular time period. Typically during the spring, inflow volumes exceed release volumes, resulting in increased reservoir elevations. The pattern is reversed during the fall and winter when release volumes exceed inflow volumes. Reservoirs are designed to operate this way so water can be stored when inflows are high and then released when water supplies are low and demand is high.

3.3.2 Flaming Gorge Reservoir Water Quality and Temperature

Water quality at Flaming Gorge Reservoir fluctuates with depth and location due to the interaction between underlying geologic formations, fluctuations in water volume, presence of organisms, and air. The shallow inflow area near Green River, Wyoming, receives sediments from erosion of the ancient Green River Lake deposits, as well as from the even older Mancos Sea deposits, which are also prevalent in the watershed. This sediment is laden with nutrients, particularly phosphorus, which drives large algal blooms in the northernmost 20 to 30 miles of the reservoir. However, where water depths increase, sediments, nutrients, and algae settle, forming new organic lake deposits. The water becomes nutrient depleted in the deeper portions of the reservoir closer to the dam. About 50 miles upstream of Flaming Gorge Dam, the water depth is greater than 200 feet and most of the sediment or algae have settled out. Nearly two-thirds of Flaming Gorge Reservoir has only minimal phytoplankton to support the food chain. Most of the reservoir is classified as nutrient and plankton deficient.

During the 1970s and 1980s, salinity and limnological studies of Flaming Gorge Reservoir revealed two important items (Bolke and Waddell, 1975; Miller, 1984). First, drawdown of the reservoir results in re-suspension of sediments deposited during filling. This sediment scouring releases high concentrations of phosphorus that drive large blooms of noxious and potentially toxin-producing blue-green algae into the northernmost 10 to 30 miles of the reservoir (Miller, 1984). These algal blooms decrease recreation activity and reduce dissolved oxygen, which affect the fishery resources during the August to October period. Second, reservoir drawdown results in salt leaching and increased salinity.

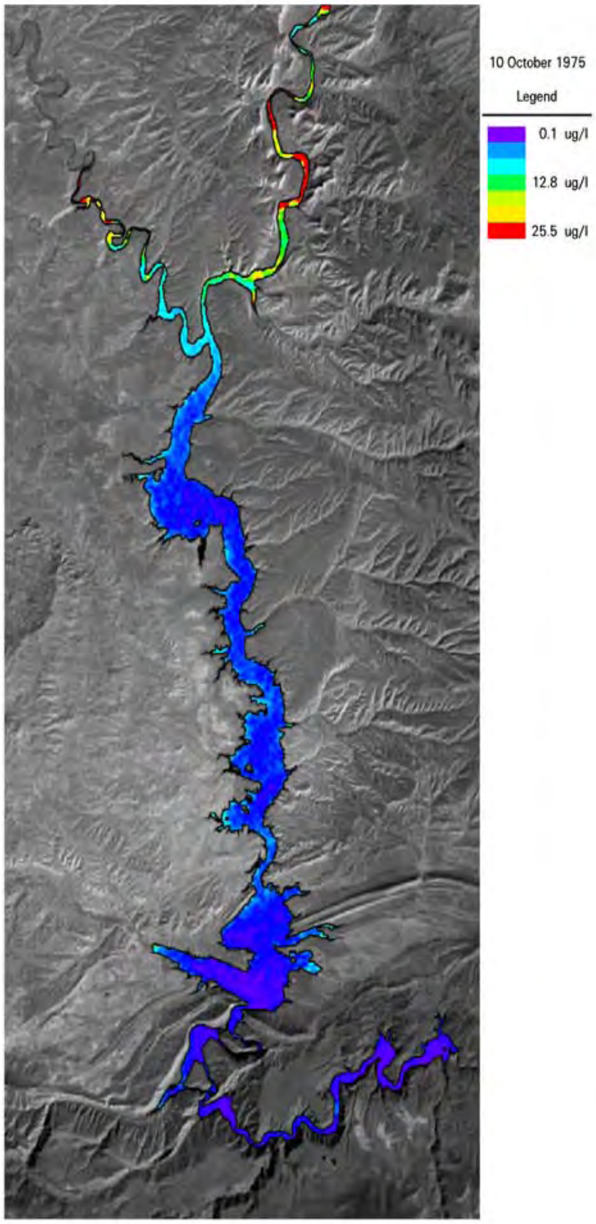
In 1978, the reservoir was drawn down to 5988 feet above mean sea level. The resulting algal blooms extended 20 to 30 miles further down the reservoir from their normal location near the Buckboard Marina and severely impacted fisheries and recreation in the Wyoming portion of the reservoir. The heaviest blue-green algal blooms occurred in October 1978, associated with the drawdown of about 50 feet.

Figures 3-1 and 3-2 are satellite images of Flaming Gorge Reservoir showing algae concentrations. The upper end of Flaming Gorge Reservoir, where the algal blooms are illustrated in red, would be classified as eutrophic (high nutrient) to hyper-eutrophic in the summer and fall. The area shown in red has chlorophyll a concentrations greater than 27 micrograms per Liter (µg/L) and can reach several hundred µg/L or hyper-eutrophic status at times in the red zones (greater than 10 being an indication of poor water quality and eutrophic conditions). The areas depicted in yellow would be classified as mesotrophic, which is generally considered a healthy environment for cold water fishery. Most of the reservoir shown in blue is oligotrophic (low nutrient) and often lacks sufficient algae to support a healthy food base.

In October 2002, the reservoir was drawn down to an elevation of 6011 feet, the lowest since 1982. This drought-induced drawdown produced a large algal bloom in the upper end of the reservoir (Miller, 2002).

The magnitude of algal blooms varies with reservoir elevation. The smaller the reservoir drawdown, the less sediment is re-suspended, and the less phosphorus is released from the sediment into the water. The combination of wet hydrology from 1983 to 1987, the test flows from 1987 to 1992, and the flow constraints implemented by the 1992 Biological Opinion resulted in decreased summer and fall reservoir drawdown. This resulted in improved water quality and decreased algal blooms.

Salinity in the reservoir can also be affected by reservoir elevations. During drawdown periods, bank storage (groundwater around the reservoir) flows back into the reservoir. Groundwater can potentially contain high levels of salt, depending on the sediment and rock formations surrounding the reservoir. It is estimated that the salt loading in Flaming Gorge Reservoir has decreased by a few



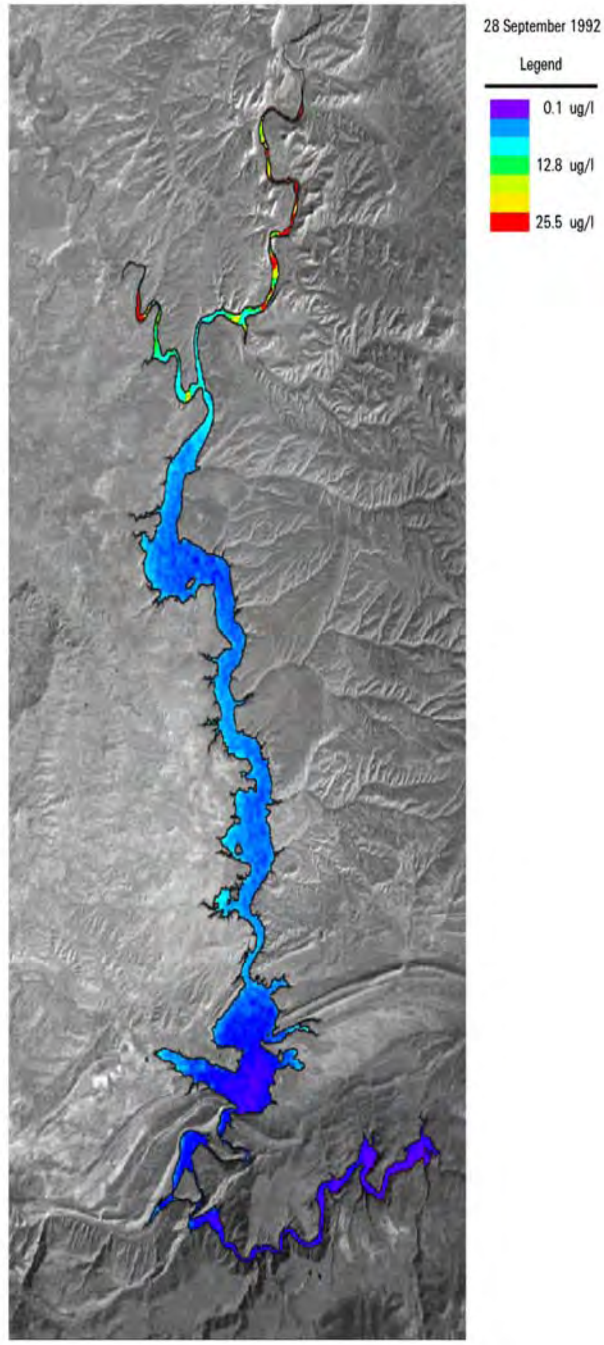


Figure 3-1 and 3-2.—Figures 3-1 and 3-2 (figure 3-2 is on the following page) depict the magnitude of algal blooms at Flaming Gorge in 1975 and in 1992 during years with minimal summer drawdown. However, in 1978 with extensive drawdown approaching nearly 60 feet, the algal blooms extended another 30 miles farther down reservoir. In 2002 with reservoir drawdown only 30 feet at elevation 6011, the algal blooms were very similar to those shown for 1978.

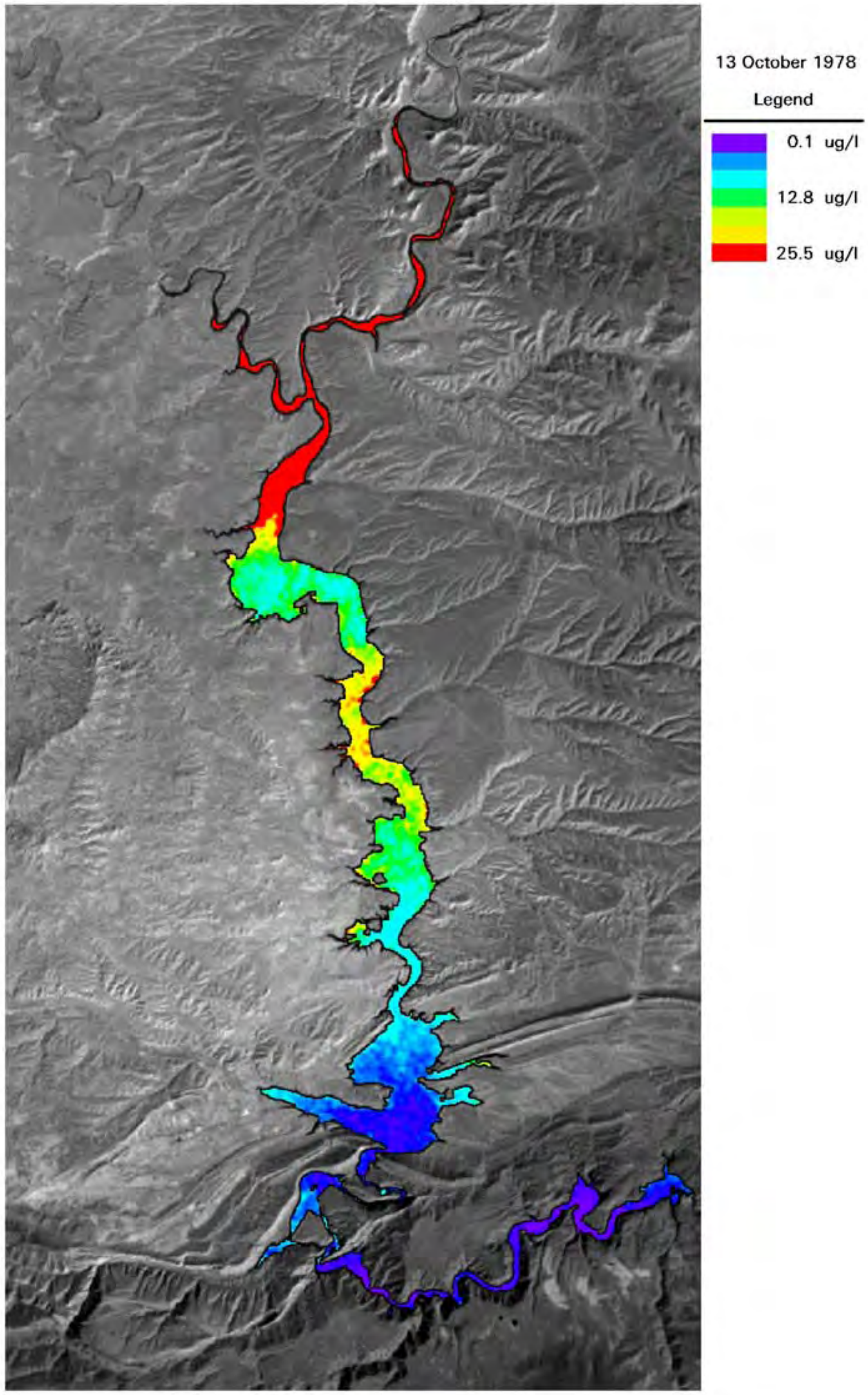


Figure 3-2.—The red and yellow depict areas with large enough blue-green algal blooms to impact both recreation and cold water fisheries. When the reservoir is drawn down, the algal blooms are much more extensive than when it is fuller. Figure 3-2 shows that the algal blooms extend nearly 20 miles farther down reservoir than they are in figure 3-1.

hundred thousand tons per year by reduced drawdown since 1983 (Miller, 2004).

3.3.3 Green River Hydrology

Most of the total annual streamflow in the Green River Basin is provided by the runoff of melting snow in the high mountains of the Uinta Range in northeastern Utah and the Wyoming and Wind River Ranges of west-central Wyoming. Prior to the construction of Flaming Gorge Dam, the hydrograph was dominated by spring peak flows from snowmelt runoff and low fall and winter base flows (Grams and Schmidt, 1999). The pre-dam spring flow typically peaked by early June and receded by mid-July. The pre-dam peak flows were typically 10,000 to 20,000 cfs, while base flows were typically 800 to 1,000 cfs (see figure 3-3).

The pattern of flows or hydrograph changed after the closure of Flaming Gorge Dam in 1962. Except for flood releases in 1983, 1984, 1986, 1997, and 1999, Green River spring peak flows were restricted to powerplant capacity at or below 4,600 cfs. Typical flows in the Green River below Flaming Gorge Dam between the mid-1960s and the early 1990s during the base flow period were 2,000 to 3,000 cfs.

From 1992 to present, Reclamation has operated Flaming Gorge Dam to meet the requirements of the Reasonable and Prudent Alternative (RPA), which included a powerplant capacity release of 1 to 6 weeks each spring followed by a period of low summer flows. The intent of these requirements was to establish flow and temperature regimes of the Green River that more closely resembled pre-dam conditions. While this change did not return the Green

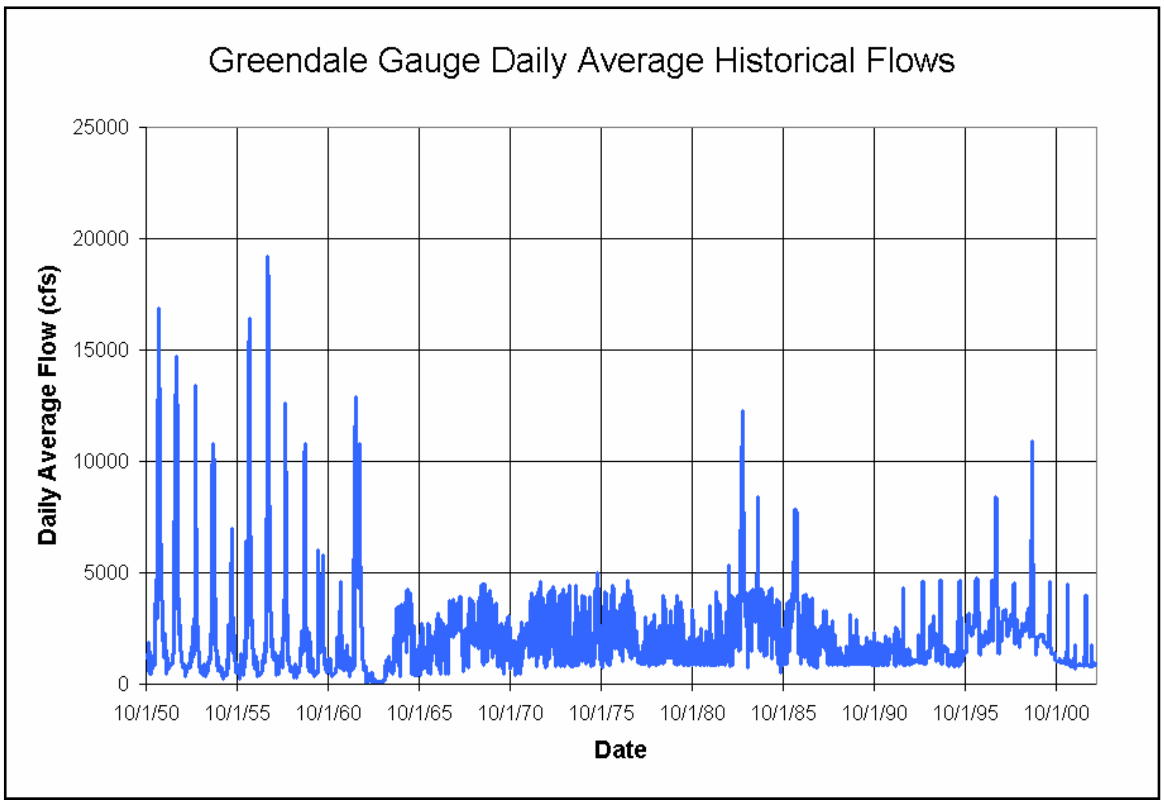


Figure 3-3.—Green River Historic Flows at Greendale, Utah, Located 0.25 Mile Downstream From Flaming Gorge Dam.

River to the flow pattern that occurred prior to closure of the dam, these changes in operation resulted in a more natural flow pattern. Peak flows, although smaller in magnitude than pre-dam peak flows, were released during the spring, and flows during the base flow period were reduced.

3.3.3.1 Reach 1

Flows in this reach are measured at the United States Geological Survey (USGS) gauge near Greendale, Utah, approximately 0.25 mile below the dam (figure 3-3). Except for usually minor flow contributions from tributary streams, flows in Reach 1 are completely regulated by Flaming Gorge Dam. While the average annual discharge (about 2,170 cfs[1]) has not been affected by Flaming Gorge Dam operations, the pattern of flows has changed. Powerplant operations prior to 1992 resulted in relatively uniform monthly release volumes with significant within-day fluctuations as compared to pre-dam conditions. Since 1992, monthly release volumes have shifted to a more natural pattern with high volumes during the spring and low volumes during the summer, fall, and winter. Within-day fluctuations have continued since 1992 but have been moderated somewhat by the requirements of the RPA of the 1992 Biological Opinion.

3.3.3.2 Reach 2

Flows in this reach are recorded at the USGS gauge near Jensen, Utah, about 29 miles downstream from the Yampa River confluence. The average annual flow of the Green River at the gauge near Jensen, Utah, is 4,370 cfs. Reach 2 exhibits a more seasonally variable flow, temperature, and sediment regime than Reach 1 because of inflow from the Yampa River. The average annual discharge of the Yampa River is about 2,150 cfs. During the spring, flows on the Green River in Reach 2 are usually dominated by the flows of the Yampa River, which can peak as high as 20,000 to 30,000 cfs in wet years or as high as 7,000 to 10,000 cfs in drier years. On average, the Yampa River peaks with a mean daily flow of 14,280 cfs. During the late summer, fall, and winter months, flows of the Yampa River do not contribute significant flows in Reach 2. In dry years, the flows of the Yampa River during these months can be as low as 100 to 200 cfs. In wet years, flows on the Yampa River during these months can reach 500 to 800 cfs. On average during the period from August through February, the flows of the Yampa River are 410 cfs. This is only 10 to 20 percent (%) of the average flow of the Green River in Reach 2 during these same months, due to releases from Flaming Gorge Dam.

3.3.3.3 Reach 3

Flows in Reach 3 of the Green River are measured at the USGS gauge located near Green River, Utah. This gauge is located about 196 river miles downstream from the USGS gauge on the Green River near Jensen, Utah, and 120 river miles upstream of the confluence of the Green River with the Colorado River. The average annual discharge of the Green River at Green River, Utah, is about 6,230 cfs. Flows in this reach are affected by tributary flows from the San Rafael, Price, White, and Duchesne Rivers. The flows on the Duchesne River have been depleted significantly through the development of the Central Utah Project (CUP) which diverts water out of the Duchesne River and transfers it to the Wasatch Front in the Great Basin. For this reason, the actual flows of the Duchesne River at the confluence with the Green River are substantially diminished from the flows that would naturally occur at this location.

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[1] Average annual discharge values for gauges described in this portion of the environmental impact statement (EIS) are gauge data summary as reported by the USGS for the entire gauge history up to, and including, water year 2000 streamflow data.

Peak flows on the Price River occur in May and have averaged about 300 cfs historically. During the winter months, flows on the Price River have averaged about 60 cfs. Peak flows on the San Rafael River typically occur at the end of May and average about 600 cfs during the peak. San Rafael River flows during the winter months have averaged about 50 cfs historically. Peak flows on the Duchesne River have averaged about 2,000 cfs during the peak which usually occurs during the month of June; however, because of the CUP, future peak flows will likely be less than those that have occurred historically. During the winter months, the flows on the Duchesne River have averaged about 400 cfs. Peak flows of the White River have historically averaged about 2,000 cfs during the peak which most often occurs in late May. Winter flows on the White River have averaged about 400 cfs historically.

3.3.4 Green River Water Quality and Water Temperature

Prior to the construction of Flaming Gorge Dam, water quality in the Green River was characterized by sediment laden spring flows, but the snowmelt water was low in dissolved solids and salts. The later summer, fall, and winter flows were somewhat turbid with higher salinity. Water quality concerns that may be affected by the proposed action are limited to water temperature.

3.3.4.1 Reach 1

Daily water temperatures measured at the Greendale, Utah, USGS gauging station just below the present site of Flaming Gorge Dam during 1956-61 (table 3-1; see also Vanicek and Kramer, 1969) allow for estimating the summer and fall thermal regime in the Green River in Flaming Gorge Canyon prior to the emplacement of the dam. This is the period of the year for which temperatures are prescribed in the 1992 Biological Opinion and also the time during which the reservoir is stratified and temperatures can be most

Table 3-1.—Pre-Dam Daily Water Temperature[1] Statistics in Degrees Celsius for the USGS Gauging Station at Greendale, Utah, Below Flaming Gorge Dam, During 1956-61

	Jun	Jul	Aug	Sept	Oct
Mean	16.7	20.3	20.2	14.8	8.0
Median	16.7	20.6	20.6	15.0	7.5
Minimum	11.1	13.3	14.4	6.7	0.0
Maximum	21.7	25.6	30.0	20.0	17.2
10^{th} Percentile	13.3	17.8	17.2	10.1	3.9
90^{th} Percentile	20.0	22.2	23.0	18.9	13.3

[1] Temperatures are in °C. Conversion from °C to °F = 9/5 x C + 32. 10% of all recorded temperatures lie below the 10^{th} Percentile value; 90% of all recorded temperatures lie below the 90^{th} Percentile value

affected by the selective withdrawal structure. The pre-dam Green River in this reach experienced freezing temperatures from November through February. By April 1, average temperatures reached approximately 41 °F (5 °C) and, by June 1, typically exceeded 52 °F (11 °C). High temperatures of approximately 86 °F (30 °C) were reached during August. Cooling was rapid during September; and by the end of October, freezing temperatures could occur.

Water temperatures in Reach 1 are controlled by the selective withdrawal structure on Flaming Gorge Dam, which typically is operated during May through September.

The potential of Flaming Gorge Dam to approximate the pre-dam water temperature regime using the selective withdrawal structure has been estimated using the CEQUAL-W2 two-dimensional reservoir model. Modeling was conducted for water years 1981-83, assuming 40 feet submergence for the selective withdrawal but using flow routing as it would occur under the Action Alternative. The years 1981-83 were chosen because they represent a wide range of inflow and reservoir elevations and, therefore, encompass a diverse set of reservoir and dam operations.

Potential release temperatures from Flaming Gorge Dam using the selective withdrawal structure are lower in early summer through

August than pre-dam water temperatures in the Green River, but they are higher during September and October (table 3-2). This lag, which is a reflection of the time necessary to stratify the reservoir and accrue heat in this large body of water, has the effect of adjusting dates at which critical temperatures are reached for warm water native fish. An average daily temperature of 61 °F (16 °C) in the pre-dam river was reached during June; but in the post-dam river with selective withdrawal releases, this average is not reached until July. Declining temperatures during fall months show the opposite relationship, with warmer temperatures persisting longer in selective withdrawal releases. Distinct differences in water temperatures are noticeable when comparing values during September and October under pre-dam (table 3-1) and post-dam selective withdrawal (table 3-2) operations. Thus, the potential exists to extend the growing season for native fish in early fall using the selective withdrawal, thereby compensating for the summer lag in warming.

Table 3-2.—Daily Statistics for Predicted Flaming Gorge Release Temperatures[1] in Degrees Celsius Based on Modeling Using CEQUAL-W2

	Jun	Jul	Aug	Sept	Oct
Mean	12.1	16.0	18.9	18.4	13.9
Median	11.7	16.9	19.9	18.4	14.1
Minimum	7.1	11.8	13.1	15.6	10.3
Maximum	16.4	19.7	20.9	20.4	15.6
10th Percentile	7.9	12.6	15.8	16.5	12.1
90th Percentile	15.8	18.8	20.6	20.1	15.4

[1] Temperatures are in °C. Conversion from °C to °F = 9/5 x C + 32.

The CEQUAL-W2 model considered only the maximum temperatures that could be released and did not take into account constraints that occur when releasing through hydroelectric turbines. Release waters are used to maintain bearing temperatures on turbines below critical values, and there are upper limits imposed on release temperatures by this dependency.

Design operating criteria for the turbine bearings at Flaming Gorge Dam have specifications for bearing oil temperatures not to exceed 140 °F (60 °C). Alarms are programmed to go off when turbine bearings exceed that temperature (*Designer's Operating Criteria*, *Flaming Gorge Dam, Powerplant and Switchyard*, Flaming Gorge Unit, Green Division, Colorado River Storage Project, November 1963). The relationship between release water temperatures and turbine bearing temperatures is affected by the volume of water released as well as the efficiency of exchange between bearing oil and release water. The uncertainty in this relationship has resulted in operation of the selective withdrawal to avoid tripping turbine alarms and subsequent downtime for generators. For these reasons, the target maximum release water temperature since the 1992 Biological Opinion has been 55 °F (13 °C) (Blanchard, 1999).

Actual Flaming Gorge release water temperatures for the months of June-October during the period 1993-2001 are best estimated by measurements at the Greendale USGS gauging station, approximately 0.25 mile below the dam (table 3-3). These data show that dam releases have reached 59 °F (15 °C) on only a few occasions during September in the period 1993-2001 and that the average values for the months of July-September have been very near the 55 °F (13 °C) limit imposed by the uncertainty in release temperatures that could cause alarms to be tripped and downtime for hydroelectric generators. It is also consistent with assumptions concerning release temperatures made by the *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam* (2000 Flow and Temperature Recommendations) in making temperature recommendations.

The 2000 Flow and Temperature Recommendations introduce a new target for Lodore Canyon of 64-68 °F (18-20 °C) or greater for 2 to 5 weeks in summer and fall, which has

Table 3-3.—Daily Statistics for Water Temperatures[1] in Degrees Celsius at the Greendale, Utah, USGS Gauging Station Below Flaming Gorge Dam During the Period 1993-2001

	Jun[2]	Jul	Aug	Sept	Oct
Mean	10.5	12.4	12.3	12.8	10.5
Median	10.4	12.6	12.4	12.7	10.8
Minimum	7.6	9.6	9.4	9.4	0.0
Maximum	14.5	14.0	14.3	17.0	14.4
10th Percentile	8.8	11.3	11.0	11.8	8.3
90th Percentile	12.8	13.3	13.4	14.2	12.3

[1] Temperatures are in °C. Conversion from °C to °F = 9/5 x C + 32.
[2] For a total of 31 days in 1997 and 1999, flows exceeded powerplant capacity with releases through the bypass tubes, which resulted in cooler downstream temperatures than were released through the selective withdrawal.

been incorporated into the Action Alternative for this EIS. Water temperatures measured at the Browns Park gauge located 38 miles below the dam provide the best retrospective data set for determining the extent to which the recommended temperatures were met during the period since the 1992 Biological Opinion. Neither daily mean or daily median temperatures in the months of June through October met this recommended target (table 3-4). Maximum recorded daily mean temperatures exceeded 64 °F (18 °C) in June, July, and August; but only in July was this temperature met or exceeded on more than 10% of the days.

Table 3-4.—Daily Statistics for Water Temperatures[1] in Degrees Celsius at the Browns Park, U.S. Fish and Wildlife Service Measuring Station During the Period 1993-2001. The Station Is Approximately 38 Miles Downriver From Flaming Gorge Dam.

	Jun	Jul	Aug	Sept	Oct
Mean	13.5	16.5	16.2	13.9	10.4
Median	13.4	16.8	16.2	14.0	10.7
Minimum	8.9	12.8	9.5	7.7	4.6
Maximum	19.8	20.4	19.5	16.7	14.6
10th Percentile	10.4	14.4	15.1	12.0	8.2
90th Percentile	17.6	18.2	17.2	15.7	12.3

[1] Temperatures are in °C. Conversion from °C to °F = 9/5 x C + 32.

3.3.4.2 Reach 2

The 1992 Biological Opinion targets water temperatures at the beginning of Reach 2 (confluence of the Green and Yampa Rivers) and recommends that summer temperatures in these two streams should not deviate by more than 9 °F (5 °C). The water temperature gauge established by the U.S. Fish and Wildlife Service in Echo Park on the Green River, above its confluence with the Yampa River, has only been operational since 1998; so the ability to measure attainment of this recommendation is limited to after 1998.

Maximum differences between the Green and Yampa Rivers exceeded 9 °F (5 °C) in each of the months of June through October during the period of record (table 3-5). The differences exceeded 9 °F (5 °C) by less than 2 °F (1 °C) in all months but July; however, in that month, the maximum difference was 13.3 °F (7.4 °C). July was the only month in which more than 10% of the recorded daily average temperatures exceeded the 9 °F (5 °C) targeted difference.

Table 3-5.—Differences in Daily Mean Temperatures[1] in Degrees Celsius Between the Green and Yampa Rivers as Measured at the Echo Park Gauging Stations Located in Both Rivers Above the Confluence. Negative Numbers Indicate Water Temperatures That Were Colder in the Green River Than in the Yampa River

	Jun	Jul	Aug	Sept	Oct
Mean	-2.2	-3.2	-3.7	-1.5	0.5
Median	-2.4	-2.9	-4.0	-1.9	0.5
Minimum[2]	1.1	0.2	-1.1	2.9	3.2
Maximum[3]	-5.2	-7.4	-5.5	-5.1	-5.8
10th Percentile	-0.4	-1.5	-2.1	-1.2	2.7
90th Percentile	-3.3	-6.4	-4.9	-3.6	-0.8

[1] Temperatures are in °C. Conversion from °C to °F = 9/5 x C + 32.
[2] Minimum differences represent the highest positive or least negative differences in water temperature between the Green and Yampa Rivers during the respective month.
[3] Maximum differences represent the highest negative differences in water temperature between the Green and Yampa Rivers during the respective month.

Release water from the reservoir will reach the ambient water temperature as it travels downstream (figure 3-4). The rate at which the water warms depends on the flow rate, the release water temperature, meteorological conditions, and the flow temperature of the tributaries. The relationship between release temperature and downstream temperature for a given location does not form a direct correlation. During late spring through summer, increasing reservoir release temperatures will result in warmer downstream temperatures.

Summer water temperatures in both the Yampa and the Green Rivers at their confluence are highly dependent upon streamflow and air temperature. The higher the flows, the lower the temperature, and vice versa. Temperatures in the Green and Yampa Rivers are similar until flows in the Yampa River begin to recede. The temperature at the confluence of the two rivers differs by less than 9 °F (5 °C) until the Yampa River flows decline to near those of the Green River. The Yampa River quickly reaches summer base flow conditions, while flows on the Green River are elevated due to the dam releases. While the Yampa River flow approaches historic conditions during snowmelt runoff, during summer base flow periods, much of its flow is diverted for irrigation. As a result, there are lower base flows and warmer temperatures in the Yampa River than occurred historically.

The temperature goal of less than 5 °C difference between the Green and Yampa Rivers will be met most of the time. The exception would be a high summer flow in the Green River coupled with a relatively low flow in the Yampa River. In June-July 1998, the maximum temperature difference between the Green and Yampa Rivers occurred when Green River summer base flows were greater than 2,000 cfs, while the Yampa River was contributing much less than that. During the extreme drought conditions of 2002, the Yampa River flow dropped to less than 10 cfs, while the Green River flowed at 800 cfs. Both rivers were very warm (70-82 °F [21-28 °C]); however, the temperature difference still did not exceed the 9 °F (5 °C) goal even on an hourly basis.

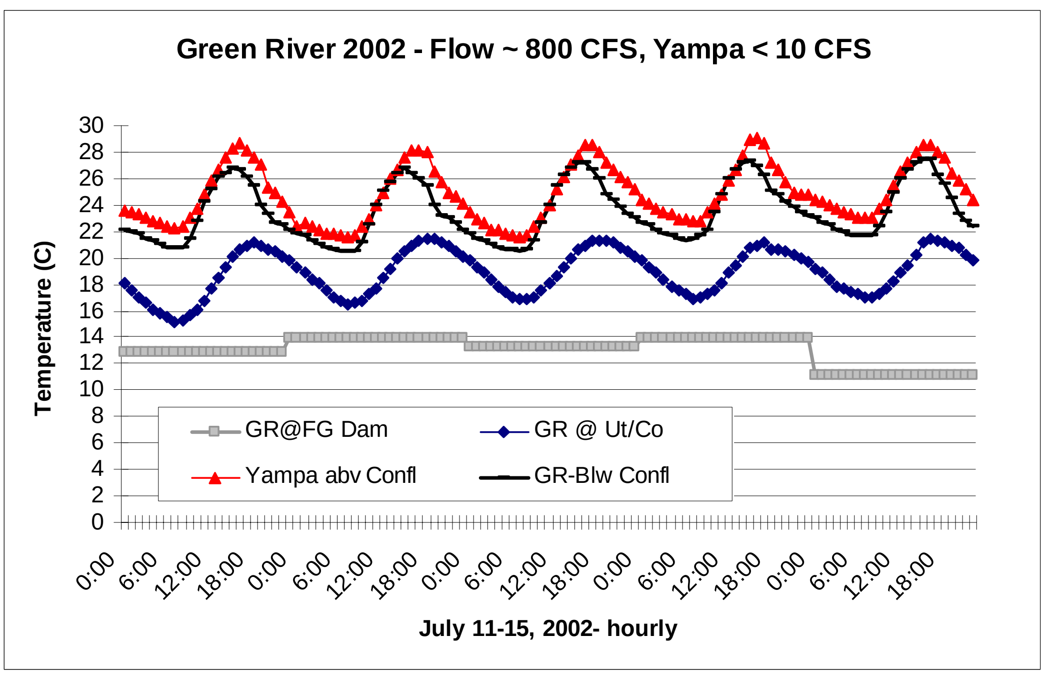

Figure 3-4.—2002 Hourly Temperature Variations From Flaming Gorge Dam to the Yampa River Confluence. Green River Flows at Approximately 800 cfs; Yampa Flows Near 10 cfs.

3.3.4.3 Reach 3

The 1992 Biological Opinion temperature requirement for the Green River at Gray Canyon calls for an average near 72-77 °F (22-25 °C) from July 1 to August 15. The extent to which this target was met is best estimated by measurements taken at the USGS gauging station at Green River, Utah, which is approximately 280 miles downriver from Flaming Gorge Dam. Records for June through October during 1993-2001 (table 3-6) show that fewer than 10% of the measurements during July and August were below 73 °F (23 °C). Inspection of these water temperatures and output of river modeling completed since the biological opinion was written (Carron, 2003) shows, however, that release temperatures from Flaming Gorge Dam have little influence on water temperatures in Reach 3 during summer months.

Table 3-6.—Daily Statistics for Water Temperatures[1] at Green River, Utah, USGS Gauging Station During the Period 1993-2001

	Jun	Jul	Aug	Sept	Oct
Mean	20.8	25.2	25.4	21.0	13.5
Median	20.5	25.0	25.0	21.0	13.3
Minimum	14.5	19.0	22.0	14.0	5.0
Maximum	28.0	30.0	30.0	26.0	20.0
10th Percentile	18.0	23.0	24.0	17.0	10.0
90th Percentile	25.0	28.0	27.0	24.0	18.0

[1] Temperatures are in °C. Conversion from °C to °F = 9/5 x C + 32.

3.3.5 Sediment Transport and Geomorphology

Prior to construction of Flaming Gorge Dam, the sediment transport regimes and characteristics of the Green River bed and bank varied greatly between canyon and fan-eddy-dominated reaches and meandering reaches (Grams and Schmidt, 2002). This variability still remains, although the decreased magnitude of peak flows due to construction of Flaming Gorge Dam has affected the quantity of sediment transported by a given flow due to alteration of the channel morphology and the availability of sediment within the channel.

Climate also influences sediment transport. Climate conditions can reduce a stream's ability to transport its supplied sediment load. Reduced upland vegetation cover due to drought reduces soil stability and increases erosion and subsequent siltation of streams. Drought followed by very wet years can also lead to increased upland erosion and stream siltation.

Recent research on the Green River has focused on the relationships between sediment transport and channel morphology over a range of flows in different geomorphic settings (Grams and Schmidt, 2002; Merritt and Cooper, 2000; Orchard and Schmidt, 2000; Allred and Schmidt, 1999; Grams and Schmidt, 1999; Martin et al., 1998; FLO Engineering, Inc., 1996). These studies include:

- Cobble and gravel deposits that are preferred spawning habitat of the endangered fishes have become less abundant and less frequently mobilized as they have aggraded with fine-grained sediment. Grams and Schmidt (2002) observed mid-channel sand deposits aggrading on deposits that, in the pre-dam era, were active gravel bars. These observations were limited to debris fan-eddy-dominated areas within Reach 1.
- Flow regulation reduced the dynamics of sediment deposition and erosion patterns. Each year, sediment deposits exposed during base flows are colonized by vegetation; and if subsequent floods do not scour these areas, a process of channel narrowing and increasing bank elevation can occur. At some point, this process becomes difficult to reverse because older, deeper-rooted vegetation is difficult to remove by all but the most extreme flood events. In Reach 1, Martin, et al. (1998) described the

re-distribution of sand in Lodore Canyon during 1995-97 when releases from Flaming Gorge Dam exceeded powerplant capacity. During a 6-day release when the flow of the Green River reached 8,600 cfs in this reach, significant erosion of eddy sandbars within this canyon reach was measured by these researchers. Merritt and Cooper (2000) described channel narrowing (11%) in Browns Park in Reach 1 during the decade immediately after closure of Flaming Gorge Dam followed by bank erosion and channel widening in Browns Park since 1977.

- Flood plains serve as important nursery habitat for growth and conditioning of endangered fish species in the Green River, particularly the razorback sucker. The frequency and extent of flood plain inundation varies considerably along the Green River and is largely a function of site-specific channel morphology (including the presence or absence of natural or human-made levees). In Reach 2, the greatest area of flood plain habitat suitable for satisfying the life-history requirements of endangered fishes is located in the Ouray National Wildlife Refuge. Under existing conditions, flood plain inundation begins to increase rapidly as flows exceed 18,600 cfs in this reach (FLO Engineering, Inc., 1996).

3.4 Hydropower Generation and Marketing

The three generating units have a total capacity of about 152 MW with a current generating capability of about 141 MW due to turbine limitations. The Flaming Gorge Powerplant has added more than 20,235 gigawatthours (GWh) of electricity into the power grid from November 1963 through the end of June 2002. While the Flaming Gorge Powerplant has generated an average of about 528.9 GWh of electricity annually, it has historically had a large amount of annual variability. Hydropower generation levels were as low as 251.6 GWh in 1990 and as high as 877.1 GWh in 1984. Generation is a result of water releases from the reservoir and is, among other things, dependent on the level of the water in the reservoir. A wet water year results in greater releases and greater power generation. Power generation is also affected by minimum streamflow levels, fluctuation restrictions, water delivery requirements, bypasses around the turbines, and water quality needs.

Power produced from the Flaming Gorge Powerplant is marketed by the Western Area Power Administration (Western) and is sold to municipalities, public utilities, and government agencies in Wyoming, Utah, Colorado, New Mexico, Arizona, and Nevada. Interconnecting transmission lines, both public and private, carry the power to major metropolitan areas and rural areas throughout the West. There are approximately 183 CRSP customers who purchase wholesale electricity from Western's CRSP-Management Center office in Salt Lake City, Utah. Electrical power from the CRSP generally serves the rural areas and small towns of the Rocky Mountain States, Colorado Plateau, and Great Basin regions of the West. The CRSP marketing area includes parts of the States of Wyoming, Utah, Nevada, Arizona, New Mexico, Colorado, and Nebraska.

CRSP power customers are: (1) small and medium-sized towns that operate publicly owned electrical systems, (2) irrigation cooperatives and water conservation districts, (3) rural electrical associations or generation and transmission co-operatives who are wholesalers to these associations,
(4) municipal joint action agencies who are wholesalers to municipal electric utilities,
(5) Federal facilities such as U.S. Air Force bases, (6) universities and other State agencies, and (7) Indian tribes. Rural electric associations that buy power from CRSP serve

the rural areas of States. In Colorado and New Mexico, for example, CRSP customers serve almost all of the geographic area of the State outside of the major metropolitan areas.

Two Native American tribes receive CRSP electrical power (the Navajo Nation in Arizona and the Ute Mountain Ute Reservation in Utah), and effective October 1, 2004, 54 tribes have the opportunity of becoming CRSP firm electric service contractors.

Generally, the price these customers pay for their CRSP electrical power is less than the wholesale market price. However, these customers serve retail load in rural areas, where the cost to provide electrical service is high. Homes, farms, and other electrical connections are spread out, so that a significant transmission line and electrical generation investment has to be repaid by fewer retail customers. Generally, this is why private electrical suppliers chose not to extend their service to these areas and why the rural electric associations were set up to "electrify" the rural areas of the Nation. The retail prices charged by CRSP customers to end users are usually higher than adjacent urban areas. For example, the retail price for electricity charged by the CRSP customers who serve rural New Mexico is above $0.11 per kilowatthour (kWh) compared to about $0.07 per kWh in Albuquerque. Moreover, these rural areas and the tribal reservations are usually characterized by lower than average incomes and higher incidences of poverty. For example, the unemployment rate among the labor force on the Uintah and Ouray Ute Reservation in Utah was 28% in 1996. The per capita income on this same reservation in 1996 was $4,280, approximately one-fourth of the national average. The people that live in these areas are then less able to pay high electrical prices. Furthermore, higher electrical prices are one of the reasons that economic development is slower in rural areas of the American West.

These conditions do not accurately depict the situation for residences of the service territories of all CRSP customers. The CRSP municipal customers that are part of larger cities charge their end users less than that of surrounding towns. Usually, the retail price for towns like Bountiful and Murray, Utah, are lower than the price charged by the private electrical supplier in Salt Lake City.

Revenues earned from the sale of the power from Flaming Gorge Dam and other CRSP facilities are used to pay for construction, operation, and maintenance of the CRSP water storage units, among other repayment responsibilities associated with the CRSP and the participating projects. Western allocates long-term firm capacity and energy from the various Federal powerplants, including the Flaming Gorge facility, collectively referred to as the Salt Lake City Area Integrated Projects (SLCA/IP).

Western's power marketing responsibility, in most cases, begins at the switchyard of Federal hydroelectric power facilities and includes Federal transmission systems, while the hydroelectric plants are operated by Reclamation. Reclamation and Western work together on a daily basis in scheduling water releases. Western dispatches power generation at each facility to ensure compliance with minimum and maximum flow requirements and other constraints set by Reclamation in consultation with other Federal, State, and local entities.

Electric capacity and energy from SLCA/IP hydropower plants, along with power purchased by Western, is provided to Western's customers under contracts. Most power agreements are long-term firm contracts that specify the amounts of capacity and energy that Western agrees to offer for sale to its customers. These amounts constitute Western's commitment levels. Firm capacity and energy levels are guaranteed to the customer. If Western is unable to supply contracted amounts of firm capacity or energy from Reclamation hydroelectric resources, it must purchase the deficit from outside resources for delivery. Depending on the type of service offered, expense for this purchased power is either shared by all contractors and leads to a general increase in the overall rate or it is passed through to individual customers.

3.4.1 Hydropower Operations

Hydropower generation rises and falls instantaneously with the load (or demand)—a pattern called load following. The amount of load on the system is determined by how many electrical devices are using power. By comparison, coal- and nuclear-based resources are less efficient and have a relatively slow response time; consequently, they generally are not used for load following. At a hydropower facility, minimum and maximum water release levels determine the minimum and maximum power generation capability.

Ramping is the change in the water release from the reservoir to meet the electrical load. Both scheduled and unscheduled ramping are crucial in load following, ancillary services, emergency situations, and variations in real-time (what actually happens compared to what was scheduled) operations. North American Electric Reliability Council (NERC) and Western Electricity Coordinating Council operating criteria require Western and Reclamation to meet scheduled load changes by ramping the generators up or down beginning at 10 minutes before the hour and ending at 10 minutes after the hour.

As a control area operator, Western regulates the transmission system within a prescribed geographic area. Western is required to react to moment-by-moment changes in electrical demand within this area. Regulation means that "automatic generation control" will be used to adjust the power output of hydroelectric generators within a prescribed area in response to changes in the generation and transmission system to maintain the scheduled level of generation in accordance with prescribed NERC criteria. Regulation depends on being able to ramp releases up or down quickly in response to system conditions. In addition, each utility is required to have sufficient generating capacity—in varying forms of readiness—to continue serving its customer load, even if the utility loses all or part of its own largest generating unit or largest capacity transmission line. This reserve capacity ensures electrical service reliability and an uninterrupted power supply. The Western Electricity Coordinating Council requires hydropower facilities to maintain 5-percent generation capacity in reserve; at Flaming Gorge, this would amount to about 7 MW (generated by a flow of about 260 cfs).

Generating capacity available that is in excess of the load on the system is called spinning reserve. "Spinning reserves" are used to quickly replace lost electrical generation resulting from a forced outage, such as the sudden loss of a major transmission line or generating unit. Additional generating units off line are also used to replace generation shortages, but they cannot replace lost generation capacity as quickly as spinning reserves.

3.5 AGRICULTURE

The highest agricultural use lands in the study area occur in Uintah County, south of Ouray and north of Green River. Uintah County, in the northeastern corner of Utah, covers about 4,477 square miles and has a total population of 25,926 people. Uintah County accounts for almost 5.5% of the total land area for the State of Utah (82,168 square miles) but only 1.1% of the total population (2000 Census of Population).

According to the 2000 Census of Population, urban dwellers (primarily in Vernal and Roosevelt) made up 45.9% of the county's population, with the remaining 54.1% of the total population being rural. The 1990 Census of Population showed that approximately 4% of the county's total population lived on farms within the county boundaries.

The number of farms in Utah has remained relatively stable from 1990 to 2000, at around 15,000 farms. Uintah County accounts for a little more than 5% of the total number of farms in the State.

3.5.1 Census of Agriculture Data

Census of Agriculture data for Uintah County, Utah, was available for 1997 and 1992. In 1997, there were 795 farms encompassing 2,268,090 acres of land, for an average farm size of 2,853 acres. The 1992 Census of Agriculture showed Uintah County as having 716 farms with an average farm size of 1,808 acres. The estimated, average market value of land and buildings for farmers in Uintah County rose from $206,510 in 1992 to $551,978 in 1997, a 167-percent gain in value.

In 1997, only about 39% of the farm residents in Uintah County listed farming as their principal occupation. The most common farm size in the county was between 10 and 49 acres. Total cropland in the county was 90,524 acres, of which 50% were in production. Idle croplands made up 5.5% of total cropland, and pastureland of all types totaled 2.1 million acres. Cropland in the county generally had a dual use, with about 76% of the total cropland acres being used for both grazing and the harvesting of a crop.

The 1997 agricultural census showed that 686 farms in Uintah County contained irrigated acreage. Total land for these 686 farms came to 2,225,467 acres of which 83,939 acres (3.8%) were irrigated. Irrigated cropland made up nearly 93% of the total harvested cropland in the county.

The primary crops produced in Uintah County included alfalfa and grass hay, barley, wheat, oats, corn grain, and corn silage. Wheat is primarily a dryland crop, with only 8% of wheat acres being irrigated. In contrast, acreage for hay and oat crops is about 95% under irrigation. Most of the barley acreage (74%) is irrigated with a small amount being dryland farmed.

3.5.2 Utah Agricultural Statistics

Information about the number of harvested acres of irrigated crops in Uintah County was obtained from the annual Utah Agricultural Statistics publication. This information source was also used for information about crop yields and price received. A 5-year average of the data was used to determine baseline crop acreage, yield, and price received.

Table 3-7 shows the irrigated crops produced in Uintah County from 1996 to 2000 and the number of acres of each harvested.

Hay is the most commonly produced crop in Uintah County, accounting for almost 87% of all the crops grown. More than 90% of all crop acres are accounted for if the corn silage acres are added to the hay acres. Alfalfa hay is clearly the dominant crop in the county with 71% of the total acreage for all the listed crops.

The next most commonly produced crop behind the hay crops (alfalfa and other hay) is corn silage, with an average of 2,100 acres. Barley more than doubled in acreage from 1996 to 1997 and has remained at that level. Corn grain showed a similar, smaller percentage increase in acreage over the same time. The number of acres planted in oats remained relatively constant over the 5-year timeframe.

Table 3-7.—Primary Crop Acreages for Uintah County, Utah, for 1996-2000

Crop	Acres Harvested 1996	1997	1998	1999	2000	5-Year Average
All Wheat	800	200	300	1,000	1,000	660
Corn Grain	700	1,000	1,400	1,000	1,100	1,040
Corn Silage	1,000	2,400	2,100	2,200	2,800	2,100
Oats	600	800	800	800	500	700
Barley	500	1,200	1,100	1,400	1,200	1,080
Other Hay	5,300	7,800	6,800	6,800	7,000	6,740
Alfalfa Hay	27,500	30,400	29,300	29,500	31,000	29,540
Total Number of Acres						41,860

Crop yields were also obtained for each of the above crops (table 3-8).

After obtaining the number of acres and yields for the crops grown in Uintah County, the price received for the crops was used to derive the total gross value of production. Prices received for the crops came from the Utah Agricultural Statistics and the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (table 3-9).

To derive the per acre gross income generated by the sale of a crop, the yield is multiplied by the price received. This product is then multiplied by the number of acres of that crop to calculate the total value of that crop to the county. Table 3-10 shows the per acre and total gross incomes for each of the crops listed in table 3-9.

3.6 LAND STATUS AND USE

Land within Flaming Gorge Reservoir is federally owned and consists primarily of Reclamation project lands acquired for the Flaming Gorge Unit of the CRSP. It is principally used for water storage. Land around Flaming Gorge Reservoir is federally owned public land, under the jurisdiction of the U.S. Department of Agriculture Forest Service (USDA Forest Service) and principally used for recreation.

Land ownership along the Green River downstream from Flaming Gorge Dam is a mixture of Federal, Indian trust, State, county, and private lands.

3.6.1 Flaming Gorge Dam and Reservoir

The reservoir lands and lands within the Flaming Gorge National Recreation Area (FGNRA) are under the jurisdiction of Reclamation and/or the USDA Forest Service. These federally owned lands have been withdrawn or acquired by fee or easement for the Flaming Gorge Unit of the CRSP. Their use is water storage, public outdoor recreation, and other purposes of the CRSP.

3.6.2 Green River Downstream From Flaming Gorge Dam

The lands along the Green River downstream from the dam have a variety of ownership and uses as outlined below. The river is divided into three reaches, as described in the following paragraphs.

Reach 1 begins just below the dam in the FGNRA, runs through Browns Park National Wildlife Refuge, and ends in the Dinosaur National Monument after traveling a distance of approximately 70 miles. The first 14 miles

Table 3-8.—Crop Yields for Uintah County, Utah, 1996-2000

Crop	Crop Yield						5-Year Average
	Yield Unit	1996	1997	1998	1999	2000	
All Wheat	Bushel	46	50	70	39	53	51.6
Corn Grain	Bushel	111	152	139	140	140	136.4
Corn Silage	Ton	23	21	19	20	17	20
Oats	Bushel	57	68	75	70	69	67.8
Barley	Bushel	98	92	88	74	64	83.2
Other Hay	Ton	3.6	4.1	4.2	4.1	3.4	3.9
Alfalfa Hay	Ton	3.8	4.5	4.5	4.5	3.7	4.2

Table 3-9.—Prices Received by Crop (1996-2000)
($)

Crop	Price Received					5-Year Average
	1996	1997	1998	1999	2000	
All Wheat	4.45	3.29	2.95	2.60	3.00	3.26
Corn Grain	3.80	3.05	2.45	2.36	2.50	2.83
Corn Silage	28.00	28.00	26.00	25.00	27.00	26.80
Oats	2.10	1.97	1.45	1.50	1.60	1.72
Barley	2.93	2.29	1.86	1.89	1.85	2.16
Other Hay	72.00	84.00	76.00	71.50	77.50	76.20
Alfalfa Hay	72.50	85.00	77.00	73.00	78.50	77.20

Table 3-10.—Average Annual Gross Income for the Crops Grown in Uintah County (1996-2000)

Crop	Acres	Yield	Price ($)	Gross Income Per Acre ($)	Total Value ($)
All Wheat	660	51.6	3.26	168.11	110,954.45
Corn Grain	1,040	136.4	2.83	386.28	401,736.19
Corn Silage	2,100	20	26.80	536.00	1,125,600.00
Oats	700	67.8	1.72	116.89	81,821.04
Barley	1,080	83.2	2.16	180.04	194,448.38
Alfalfa Hay	29,540	4.2	77.20	324.24	9,578,049.60
Other Hay	6,740	3.9	76.20	297.18	2,002,993.20
				Total Value	13,495,602.86

of this reach, located in the FGNRA, contains steep, wooded terrain and, therefore, is used mainly for limited recreational pursuits. Next, the river runs through Browns Park for approximately 16 miles. This land is more open with gentle slopes to the river and contains sage and scrub brush vegetation. The use here is mainly recreation consisting of camping, boating, and rafting. There are many unpaved access roads leading to camping spots and river access points for raft launching.

The river then enters Browns Park National Wildlife Refuge and meanders through many low wetland areas in the refuge for approximately 20 miles. Browns Park National Wildlife Refuge is managed by the U.S. Fish and Wildlife Service, and the land is used for wildlife mitigation. At this point, the river enters the Dinosaur National Monument managed by the National Park Service. This last 20 miles of Reach 1 consists mainly of a steep, rugged rock canyon called Lodore Canyon. Because of the rugged terrain, the area is a popular recreation site used for river rafting and camping.

Reach 2 begins at the confluence of the Green River and the Yampa River, in the middle of Dinosaur National Monument. After leaving the monument, the Green River flows through private lands, State of Utah lands, Federal lands managed by the Bureau of Land Management (BLM), Ouray National Wildlife Refuge, and Ute Indian tribal lands.

Within Dinosaur National Monument, the river flows through two steep, rock canyons (Whirlpool Canyon and Split Mountain Canyon) and one area with a wider river bottom and low lying meadows (Island Park and Rainbow Park). After leaving Dinosaur National Monument, the river runs through privately owned lands containing some areas of rolling hills and some low lying areas. Farms border the river corridor, mainly with pasture lands and range lands. Some development is beginning to appear in the historic flood plain areas, since the construction of Flaming Gorge Dam provides some flood control to these areas. Most of this development consists of agricultural sprinkler systems and basic farm and storage structures, although some development includes residential houses.

Next, the river flows past Stewart Lake Wildlife Refuge, managed by the State of Utah Division of Wildlife Resources, and private lands. In this area, some residential homes have been constructed in the historic flood plain or near the banks of the Green River. The river then runs through a stretch of Federal lands (managed by BLM), State of Utah lands, and private lands. These lands, in the vicinity of Horseshoe Bend, are used for public lands, agricultural development, and oil and gas development.

The last portion of Reach 2 brings the river through the following land ownerships: Ouray National Wildlife Refuge (managed by the U.S. Fish and Wildlife Service), Federal lands in trust for the Ute Indian Tribe, private lands, and BLM lands. These lands are used for wildlife mitigation, oil and gas exploration, and development and residential purposes.

There are four highway bridges crossing the Green River in Reach 2. The first bridge is on State Highway 149 and crosses the river approximately 6 miles southeast of the Dinosaur National Monument. The second bridge crosses the river on U.S. Highway 40 at Jensen, Utah. The third bridge is on State Highway 45 and crosses the Green River approximately 7 miles south of Naples, Utah. The fourth bridge crosses the river on State Highway 88 just south of Ouray, Utah.

Reach 3 begins at the confluence of the Green River and the White River. Land ownership includes some Ute Indian tribal lands; Federal, State, and county lands; and private lands. Land uses include agriculture, recreation, and oil and gas mining. Contained within this reach are the Canyonlands National Park and the Hill Creek Extension of the Uintah and Ouray Indian Reservation.

The land within Reach 3 is classified as "high desert," with elevations ranging from 3700 feet to 7200 feet above sea level. Much of the land immediately adjacent to the Green River is composed of vast sedimentary rock deposits which, over the years, have been deeply incised, creating deep canyons (particularly Desolation Canyon and Labyrinth Canyon). These rock deposits and deep canyons limit the use of the lands adjacent to the river and also limit the points of access to the river, therefore limiting the use of the river.

The areas immediately south of Ouray and north of Green River have the highest agricultural use within Reach 3. Predominant crops include corn, alfalfa, watermelon, and grain. Land use along the Green River is primarily determined by topography. Agricultural areas have a minimal slope and often abut dense riparian habitat along the river. A vast amount of Indian trust land, which is generally higher in elevation, is also used for oil and gas exploration. In these areas, there appears to be a general lack of vegetation and an abundance of collection/ distribution pipeline infrastructures running on the land surface, along with many dirt access roads.

3.7 ECOLOGICAL RESOURCES

This section describes the affected environment for plants and animals in and around the reservoir and the river. It includes information on threatened and endangered species and other special status species.

3.7.1 Flaming Gorge Dam and Reservoir

3.7.1.1 Aquatic Animals

The Flaming Gorge Reservoir fish community consists of the following nonnative species: lake trout (*Salvelinus namaycush),* brown trout (*Salmo trutta),* rainbow trout (*Oncorhynchus mykiss),* cutthroat trout (*Oncorhynchus clarki),* kokanee salmon (*Oncorhynchus nerka),* white sucker (*Catostomus commersoni),* smallmouth bass (*Micropterus dolomieui),* channel catfish (*Ictalurus punctatus),* common carp (*Cyprinus carpio),*Utah chub (*Gila atraria*), redside shiner (*Richardsonius balteatus),* and the Bear Lake sculpin (*Cottus extensus).* It is also home to small numbers of the following native species: flannelmouth sucker (*Catostomus latipinnis),* mountain whitefish (*Prosopium williamsoni),* and the mottled sculpin (*Cottus bairdi).*

Since the reservoir was filled, rainbow trout have been annually stocked in Flaming Gorge Reservoir and provide the bulk of the harvest, as well as being the most sought-after species by anglers. Kokanee salmon and smallmouth bass were stocked during the mid 1960s and have since developed naturally reproducing fisheries. After rainbow trout, kokanee are typically second in harvest and popularity with anglers. Other sport fish occasionally stocked in the reservoir include brown trout and channel catfish.

Lake trout, which drifted into Flaming Gorge from the upper Green River drainage, have also become established as a wild population. Lake trout are managed as a trophy fishery in Flaming Gorge. Regulations are designed to keep lake trout numbers in balance with populations of kokanee salmon and Utah chubs, their primary prey.

Kokanee salmon concentrate in different locations in the reservoir every year, but consistent concentration areas include Cedar Springs, Jarvies Canyon, Hideout, Red Cliffs, Horseshoe Canyon, Pipeline, Wildhorse, Squaw Hollow, Lowe Canyon, and Big Bend. Flaming Gorge Reservoir provides important shoreline spawning habitat for kokanee salmon, and most recruitment of these fish comes from shoreline spawning; however, Kokanee can spawn at water depths up to 60 feet (Gipson and Hubert, 1993). Shoreline spawning habitat areas are located on the east shore of the reservoir, which has steep slopes (greater than 20 degrees), and abundant substrate of small (less than 4 inches) shale particles extending from the water's edge to depths of more than 60 feet (University of Wyoming, 1991). Kokanee are an important sport fish in the reservoir. As the fall spawning season approaches, mature kokanee concentrate or "stage" adjacent to these spawning areas.

Smallmouth bass are found in rocky shoreline habitat throughout Flaming Gorge Reservoir. A dense population dominated by smaller fish exists from the dam north to Linwood Bay. From the Antelope Flats area north, fewer but larger bass are found. Smallmouths in Flaming Gorge Reservoir feed almost exclusively on crayfish. They spawn from late May through early July and during this period mature fish move into shallow water 2 to 20 feet in depth (Sigler and Sigler, 1996). Smallmouth bass were introduced into Flaming Gorge Reservoir to promote growth of rainbow trout by reducing the Utah chub population (Tuescher and Luecke, 1996).

3.7.1.2 Aquatic Food Base

Prior to construction of the dam, the aquatic food base was comprised mostly of coarse organic material carried into the river from the drainage basin. That material is now deposited in Flaming Gorge Reservoir. Presently, benthic algae, phytoplankton, and zooplankton are at the base of the reservoir's food web. The reservoir traps nutrients like phosphorus and nitrogen as it traps incoming suspended sediments.

3.7.1.3 Vegetation

Shoreline vegetation along Flaming Gorge Reservoir consists mainly of pinion and juniper woodlands and sagebrush communities. Fluctuating water levels, steep gradient slopes, and loss of soil through erosion combine to severely limit vegetation establishment along the shoreline. Riparian and wetland vegetation associated with the reservoir is limited to mouths of tributaries and infrequent locations along the shoreline where lower gradient slope and fine soils that retain subsurface water connections are present. Most wetland vegetation is in the rush and sedge families, with occasional presence of native and nonnative grasses, willows (*Salix* sp.), cottonwoods (*Populus* sp.), and tamarisk (*Tamarix ramosissima*).

3.7.1.4 Terrestrial and Avian Animals

Several species of game mammals, including mule deer, elk, moose, pronghorn, and bighorn sheep, occur along the Green River corridor above and below Flaming Gorge Dam. All of these species use riparian habitats as foraging and watering areas but are not restricted to riparian areas at any time of the year. Mule deer, elk, and pronghorn range widely throughout this portion of Utah and Colorado but move toward the river in the fall and use the river valley, especially Browns Park, as wintering range. Mule deer occur along the river throughout the year and are the most abundant game mammal in the area. Moose numbers are low in the region but appear to be increasing (BLM, 1990). Within the area, moose habitat occurs in Browns Park (Schnurr, 1992).

3.7.2 Green River Downstream From Flaming Gorge Dam

3.7.2.1 Aquatic Animals Overview

Historically, the Green River in the area of Flaming Gorge was an unregulated, turbid, temperate stream that exhibited wide fluctuations in flow (2000 Flow and Temperature Recommendations). Water temperature ranged from near freezing to greater than 70 °F (21 °C) annually. The river supported 12 native fish species, including 4 that are now endangered: Colorado pikeminnow, humpback chub, bonytail, and razorback sucker. Several native species, including mountain whitefish

(*Prosopium williamsoni)*, mountain sucker (*Catostomus platyrhynchus)*, mottled sculpin (*Cottus bairdi)*, and Colorado River cutthroat trout (*Oncorhynchus clarki pleuritcus)*, were likely only part-time residents in the Flaming Gorge area, preferring cooler water temperatures that were found farther upstream. The river warming that occurred naturally would have completely precluded their presence by the time the Green River reached its confluence with the Yampa River. From that confluence downstream, the remaining eight warm water species (the four endangered species plus the flannelmouth sucker (*Catostomus latipinnis)*, bluehead sucker (*Catostomus discobolus)*, roundtail chub (*Gila robusta)*, and speckled dace (*Rhinichthys osculus)* comprised the entire fish community. These species were historically found throughout the Green River and the lower reaches of its tributaries: the Yampa, White, Duchesne, Price, and San Rafael Rivers.

Earliest impacts to the Green River system came in two forms: alterations of the physical environment (channelization, diking, and pollution) and the introduction of nonnative species. The first major diversion structure placed in the main channel of the Green River was at Tusher Wash, near the town of Green River, Utah, in 1906 (Cavalli, 2000). Even considering similar diversion structures and larger storage projects on Green River tributaries, Tusher Wash Dam remained the only significant barrier to warm water fish movement and the most significant form of river regulation on the Green River until the construction of Flaming Gorge Dam.

By the early 1900s, nonnative fish populations—in particular, channel catfish (*Ictalurus punctatus*)—had become established in the main stem Colorado River. Since that time, either intentionally or otherwise, a total of 25 nonnative species representing 9 families has been introduced into the Green River and its tributaries. Nonnative fish now dominate the fish community of the entire Colorado River system and are believed to contribute to reductions in the distribution and abundance of native species through competition and predation (Carlson and Muth, 1989).

Completion of Flaming Gorge Dam in 1962 had profound effects on downstream conditions. Historic operations greatly altered the seasonal and daily flow and temperature patterns. These changes rendered sections of the Green River immediately downstream from the dam largely unsuitable for native fish. It also shifted the aquatic invertebrate community from one dominated by a diverse assemblage of warm water species (Holden and Crist, 1981) to species tolerant of cold, clear water (Vinson, 1998).

In 1962, a project to eradicate “coarse” fishes from the Flaming Gorge Reservoir basin and its tributaries was conducted to clear the way for the proposed trout sport fishery. The coarse fish referred to were the native Colorado River species. Effects of the project went beyond the intended scope (Miller, 1963; Dexter, 1965; Pearson et al., 1968) when detoxification of the fish toxicant (rotenone) failed and native fish were inadvertently killed downstream through Dinosaur National Monument (Holden, 1991). Followup reports conducted by the Wyoming Game and Fish Commission (Binns et al., 1964) indicated that razorback sucker and native chubs were collected near the dam site, but native fish populations were affected as much as 80 miles downstream.

Rainbow trout were first introduced to the Green River tailwater in 1963, and brown trout were introduced in 1965. The stocked fish survived, but growth rates were low due to cold dam releases (39 to 47 ºF [4 to 8 ºC]). Penstocks were modified in 1978 to raise release temperatures by withdrawal of water from higher reservoir depths (Holden and Crist, 1981), and growth rates of trout improved (Modde et al., 1991). Native fish also benefited from the warmer river. Within 6 months of the penstock modifications, Holden and Crist (1981) documented re-colonization and reproduction of both warm water native and nonnative fish in the Green River upstream of its confluence with the Yampa River. Adult Colorado pikeminnow and razorback sucker were observed, but no signs of successful reproduction were found.

The Upper Colorado River Endangered Fish Recovery Program (Recovery Program), established in 1987, promoted the early research that led to the flow and temperature recommendations identified in the 1992 Biological Opinion. In addition to identifying the flow needs of the endangered fish, the Recovery Program has directed effort at developing habitat, reducing nonnative species, reducing the impacts of sport fish and sport fishing, raising and stocking endangered species, and gaining public support for all these activities through an information and education program.

The Green River provides excellent habitat for the river otter. The State of Utah considers river otter a species of special concern due to declining populations and limited distribution. Reintroduction of river otter to the Green River drainage began in 1989 and 1990 with the release of 23 otters at sites below the dam (Utah Division of Wildlife Resources, 1992). Seventeen otters were released in Island and Rainbow Parks in Dinosaur National Monument in 1991 (Cranney and Day, 1993). Since then, otters have moved into the Flaming Gorge Reservoir and reaches of the river near Ouray, Utah. Fish (especially carp) make up most of this species' diet. Abandoned beaver dens, clusters of boulders, or rock crevices near the water's edge are used as shelters.

Beaver den mainly in the banks of the Green River and in wetlands created for waterfowl. These areas exist below the dam. Beaver are abundant in these areas and can affect woody plant species composition and coverage by their feeding habits. They can also negatively affect the operation of waterfowl management areas by their damming activities. Muskrat exist in abundance within the Green River below the dam.

Many species of waterbirds use the Green River below Flaming Gorge Dam. The Green River and waterfowl management areas adjacent to the river in Browns Park provide habitat for migration, breeding, nesting, and foraging activities of these birds.

3.7.2.2 Native Fish Species Overview

3.7.2.2.1 Colorado Pikeminnow – The Colorado pikeminnow was first included in the List of Endangered Species issued by the Office of Endangered Species on March 11, 1967, and subsequently received protection under the Endangered Species Act of 1973. Critical habitat was designated on March 21, 1994, and includes the entire Green River downstream from Reach 1. Threats to the species include streamflow regulation, habitat modification, competition with and predation by nonnative fish species, and pesticides and pollutants (U.S. Fish and Wildlife Service, 2002b).

This large, predatory fish is widely distributed throughout the Upper Colorado River Basin, and recent estimates of abundance indicate the population in the Green River subbasin is on the rise (McAda, 2002). Adult habitat includes deep, low velocity runs, pools, eddies, and seasonally flooded lowland habitats. Pikeminnow display fidelity to natal spawning areas, of which there are few in the Green River subbasin; one is located on the lower Yampa River, and one is located on the Green River in Gray Canyon. Pikeminnow migrate to those spawning areas during the spring, coinciding with the descending limb of the hydrograph as river temperatures warm in excess of 62 ºF (18 ºC). Spawning occurs after spring runoff at water temperatures typically between 64 and 73 ºF (18 and 23 ºC); however, there are accounts of spawning at cooler temperatures (61 ºF [16 ºC]) (Bestgen et al., 1998).

Although never visually observed due to high turbidity, researchers using radiotelemetry have determined that pikeminnow spawn over cobble-bottomed riffles (Tyus, 1990). These cobble bars are formed and maintained by various aspects of the spring peak and post-peak flows (Harvey et al., 1993). Eggs are adhesive and require a clean cobble surface for attachment (Hamman, 1981). Embryos incubate for 4-7 days, depending on river temperature; and larvae hatch and remain in the spawning substrates for an additional 6-7 days (Bestgen et al., 1998). Larvae then emerge from the substrate and are carried downstream to low velocity nursery habitats. Larvae produced in the lower Yampa River spawning bar are thought to mostly colonize backwaters between Jensen, Utah, and the Ouray National Wildlife Refuge. Larvae produced in Gray Canyon drift into habitats in Reach 3.

3.7.2.2.2 Humpback Chub – The humpback chub was first included in the List of Endangered Species issued by the Office of Endangered Species on March 11, 1967, and received protection as endangered under the Endangered Species Act of 1973. Critical habitat was designated on March 21, 1994, and included stretches of the Yampa, Colorado, and Green Rivers in the Upper Colorado River Basin. The canyon-bound reaches of the Green River between its confluence with the Yampa and Colorado Rivers (Reaches 2 and 3) were designated. Threats to the species include streamflow regulation, habitat modification, predation by nonnative fish species, parasitism, hybridization with other native chubs, and pesticides and pollutants (U.S. Fish and Wildlife Service, 2002c). This species is highly adapted to life in canyon environments. Adult habitat includes deep pools and shoreline eddies in the warmer portions of the main channel. Specific physical spawning requirements are less understood for this species than other native Colorado River fishes. Humpback chub do not display spawning migrations and appear to complete their life cycle within the confines of relatively short stretches of canyon bound river. Drift of humpback chub larvae is less extensive than for Colorado pikeminnow. Spawning coincides with the spring runoff and typically occurs very soon after the peak when main channel temperatures warm in excess of 62 ºF (17 ºC) (Chart and Lentsch, 1999; Tyus and Karp, 1989; Valdez and Clemmer, 1982). The majority of spawning occurs when temperatures range from 61 to 72 ºF (16 to 22 ºC) (U.S. Fish and Wildlife Service, 2002c). Young occupy warm, low velocity shoreline habitats but appear less specific in their nursery habitat selection than pikeminnow (Chart and Lentsch, 1999).

3.7.2.2.3 Razorback Sucker – The razorback sucker was federally listed as endangered on October 23, 1991, with critical habitat designated March 21, 1994. The entire Green River from its confluence with the Yampa River downstream to its confluence with the Colorado River (Reaches 2 and 3) was included in this designation. There is no critical habitat in Reach 1. Threats to the species include streamflow regulation, habitat modification, predation by nonnative fish species, and pesticides and pollutants (U.S. Fish and Wildlife Service, 2002d). It is found in warm water reaches of the Green River and the lower portions of its major tributaries. It occurs primarily in the low gradient reaches between the confluences of the Yampa and Duchesne Rivers in Reach 2. Adult habitat includes runs, pools, eddies, and seasonally flooded lowlands. Spawning occurs in April through June, as the river rises to its spring peak (McAda and Wydoski, 1980; Tyus, 1987; Modde and Wick, 1997; Muth et al., 1998). In recent years, spawning has occurred when average daily flows ranged between 2,754 and 22,000 cfs and temperatures ranged between 46 ºF (8 ºC) and 67 ºF (19 ºC). Razorback suckers spawn over coarse cobbles, and their eggs hatch in 6.5-12.5 days, dependent on water temperatures. Larval razorbacks are then transported downstream into off-channel nursery environments (tributary mouths, backwaters, and inundated flood plains) where quiet, warm water is found (Mueller, 1995; Paulin et al., 1989).

Declines in the abundance and distribution of razorback suckers in the Upper Colorado River Basin have been noted for decades (Wiltzius, 1978). Although there continues to be evidence of successful reproduction, the Green River population of wild razorback suckers continues to decline due to lack of sufficient recruitment and may soon be extirpated (Bestgen et al., 2002). Stocking efforts, which have been experimental in nature to date (Burdick, 2002), are scheduled to increase in the near future in an attempt to increase abundance.

3.7.2.2.4 Bonytail – The bonytail was listed as endangered under a final rule published on April 23, 1980. Critical habitat was designated on March 21, 1994, and includes Reaches 2 and 3 of the Green River. Threats to the species include streamflow regulation, habitat modification, predation by nonnative fish species, hybridization, and pesticides and pollutants (U.S. Fish and Wildlife Service, 2002a).

The bonytail was historically common to abundant in warm water reaches of larger rivers from Mexico to Wyoming, but it is now the rarest of the Colorado River endangered fishes. Life history requirements of the bonytail are poorly understood; it is considered adapted to main stem rivers where it has been observed in pools and eddies. As do other closely related fish species, bonytail probably spawn in the spring in rivers over rocky substrates. It has also been hypothesized that flooded bottomlands may provide important areas for growth and conditioning, particularly for the early life stages (U.S. Fish and Wildlife Service, 2002a).

3.7.2.2.5 Other Native Fish Species of Concern – Flannelmouth suckers are widespread in warm water reaches of larger river channels. Adults typically occupy pools and deeper runs, eddies, and shorelines and spawn in the spring prior to peak flows. Young flannelmouth suckers occupy low velocity shorelines or other seasonally flooded low velocity habitats.

Bluehead suckers are also widespread. They occur in a wider range of water temperatures, including cooler habitats than those occupied by flannelmouth sucker. The bluehead sucker is more of a fast water fish, occupying riffles or shallow runs over rocky substrates. It spawns in the spring at slightly warmer temperatures than flannelmouth suckers. Young bluehead suckers also occupy low velocity shorelines or seasonally flooded areas.

Roundtail chubs are less abundant in the Green River main stem than the native suckers but are more abundant in the smaller tributaries and in the upper reaches of the Green, White, and Colorado Rivers. Roundtail chubs are also commonly collected in the Yampa River, including its lower, canyon-bound portions (Haines and Modde, 2002). Adult habitat includes riffles, runs, pools, eddies, backwaters, and areas that provide a diversity of flows. Roundtail chubs spawn during the spring peak, typically on the descending limb as temperatures range between 62 and 70 °F (21 °C) (Chart and Lentsch, 1999). Young roundtail chubs occupy low velocity shoreline habitats.

McAda and Ryel (1999) report that in the Colorado River, larvae and young-of-the-year (YOY) of these native fishes were more abundant in years with high peak runoff than in years with low peak runoff. These three main channel dwelling species and their young likely provided the bulk of the Colorado pikeminnow diet prior to the establishment of nonnative species (Osmundson, 1999).

3.7.2.3 Reach 1

3.7.2.3.1 Aquatic Food Base – The main aquatic food base in the Green River downstream from Flaming Gorge Dam is the filamentous green alga *(Cladophora* sp.*)* and attached periphyton communities (Johnson et al., 1987) and a freshwater amphipod (*Hyallela* sp.*)* (U.S. Department of Energy, 1996). *Cladophora* serves as an indicator of productivity in the upper portion of the Green River. Algae and periphytic diatoms provide food for chironomids and amphipods, dominant invertebrates in the trout diet (Johnson et al., 1987; Modde et al., 1991). Macroinvertebrates are most abundant above the Yampa River confluence (Holden and Crist, 1981). In the tailwater and in canyons between the dam and Browns Park, large, stable substrates and clear, cold water support abundant growths of *Cladophora* and other attached algae (Holden and Crist, 1981; Gosse, 1982; Modde et al., 1991).

Low-gradient reaches within Browns Park lack *Cladophora* except where occasional rapids and riffles provide suitable hard substrates. Macroinvertebrates in these low-gradient reaches include chironomids, oligochaetes, mayfly larvae and biting midges, and sandflies (Annear, 1980; Holden and Crist, 1981; Grabowski and Hiebert, 1989). Productivity generally declines further downstream from the dam. This is likely due to increased turbidity and declining availability of nutrients like phosphorus and nitrogen.

In general, daily fluctuating flows in the river are detrimental to the food base of both native and nonnative fish and have a negative effect on algal production and abundance of aquatic invertebrates due to repeated drying and wetting of the shoreline zone. Production of *Cladophora* is lower within the fluctuating zone, and areas dewatered for greater than 12 hours do not sustain a *Cladophora*-based community.

Greater drift of macroinvertebrates occurs during fluctuating flows rather than during steady flows. Large floods can wash a great quantity of macroinvertebrates downstream. This could temporarily reduce the food base in the reaches of the river directly below the dam following a flood (Vinson, 1998).

The New Zealand mud snail (*Potamopyrgus antipodarum*) is a nonnative species that is rapidly spreading throughout the Western United States. This small snail has become extremely abundant in some ecosystems, reaching densities of 100,000 per square meter and comprising 95% of the invertebrate biomass. Trout eat the snails but may derive very limited nutritional value from them. The New Zealand mud snail has been recently detected in several river systems in Utah and was first found in the Green River below Flaming Gorge Dam in September 2001. Since that time, their distribution and abundances have increased, and this snail is currently found from the dam downstream to the State line. Their preferred habitat appears to be beds of rooted aquatic vegetation, particularly sego pondweed (*Potamogeton pectinatus*) (Vinson, 2004). Ultimate distributions, densities, and this invasive species' effect on the existing aquatic community remains uncertain.

3.7.2.3.2 Threatened and Endangered Fish –

3.7.2.3.2.1 Colorado Pikeminnow – Colorado pikeminnow historically occurred throughout Reach 1 and likely reproduced in or near Flaming Gorge Canyon (2000 Flow and Temperature Recommendations). Low velocity habitats found in Browns Park may have provided nursery habitat for larvae and other life stages. Juvenile and adult pikeminnow (greater than 400 millimeters total length) are currently found in Lodore Canyon during spring, summer, and fall. Ongoing telemetry efforts indicate that adult pikeminnow may also be spending the winter in Reach 1 (Kitcheyan, 2003). Pikeminnow abundance has increased since 1980 (Bestgen and Crist, 2000), and they are distributed as far upstream as Browns Park. Growth rates of pikeminnow in Lodore Canyon are high, presumably due to the abundance of forage (Bestgen and Crist, 2000). Although many of the native species currently found in Reach 1 successfully reproduce there (a positive response to penstock modifications and associated river warming), Colorado pikeminnow do not. Provided that suitable spawning habitat exists in Reach 1, further warming of the river would likely be necessary for pikeminnow to successfully reproduce.

3.7.2.3.2.2 Humpback Chub – The best available information suggests that prior to the construction of Flaming Gorge Dam, the upstream distribution of humpback chub in the Green River reached Flaming Gorge Canyon (Vanicek, 1967; Holden, 1991). Due to the fish eradication program of the 1960s, this species was eliminated from Reach 1. Primarily due to a combination of sub-optimal thermal regimes and this species' sedentary nature, humpback chub have not re-colonized Reach 1.

3.7.2.3.2.3 Razorback Sucker – Prior to construction of Flaming Gorge Dam, razorback suckers were found as far upstream as Green River, Wyoming (Jordan, 1891; Evermann and Rutter, 1895; Simon, 1946). This species was more common in the lower Green River and apparently rare upstream of the Yampa River confluence even before construction of Flaming Gorge Dam (Simon, 1946). Razorback suckers disappeared from the Green River upstream of the Yampa River confluence for a period following dam construction (Vanicek et al., 1970). Since penstock modification, razorback sucker adults have been collected in Reach 1 on several occasions, however always in very low numbers. Those collections have been confined in recent years to the lower portion of Lodore Canyon.

3.7.2.3.2.4 Bonytail – The last evidence of natural bonytail reproduction in the Upper Colorado River Basin was documented in the Green River of Dinosaur National Monument near Echo Park (the transition between Reaches 1 and 2 (Vanicek and Kramer, 1969). Since that time, collections of bonytail have been very rare throughout the Upper Colorado River Basin. Bonytail have not been collected during the three most recent fishery surveys conducted in the lower portions of Reach 1 (as summarized by Bestgen and Crist, 2000). Hatchery-produced bonytail have been stocked on an experimental basis (Chart and Cranney, 1993; Bedame and Hudson, 2003); and the Recovery Program intends to increase efforts in the near future. Since 2000, the State of Colorado has released 18,000 bonytail (approximately 4 inches in length) at Browns Park and 5,000 bonytail near the downstream terminus of Reach 1. Additional stocking is planned for the future. Future sampling efforts will be directed at determining the success of those releases.

3.7.2.3.3 Native Fish Species, Nonlisted – There are three common native species found in Reach 1 main channel habitats: the flannelmouth sucker, bluehead sucker, and roundtail chub. All three species were present in pre-dam and in all post-dam fisheries collections. Examination of two comparable data sets from the mid-1970s (Holden and Crist, 1981) and the mid-1990s (Bestgen and Crist, 2000) indicates that the distribution and relative abundance of flannelmouth and bluehead suckers in Lodore Canyon has changed very little, with the greatest abundances of both species found in the upper canyon. Although roundtail chub were not abundant in either study, Bestgen and Crist hypothesized that the population is declining. Possible explanations for such a decline included poor recruitment due to cooler than optimal water temperatures and a high abundance of brown trout and other predatory fish.

Although successful reproduction of these species seemed to be reduced in Reach 1 during that period of time between closure of the dam and penstock modification, Bestgen and Crist (2000) report that all three species currently reproduce there.

Perhaps of greatest concern regarding the native flannelmouth suckers in Reach 1 is the increasing incidence of their hybridization with nonnative white suckers. The white sucker is more suited to cool water temperatures, and its distribution declines in a downstream direction from the dam through Lodore Canyon. Hybridization is a chronic threat to the continued existence of the native sucker populations and appears to be increasing in several Upper Colorado River Basin locations (Bezzerides and Bestgen, 2002).

3.7.2.3.4 Nonnative Fish –

3.7.2.3.4.1 Cold Water Nonnatives (Trout) **–** The first known nonnative trout introduced to the Green River tailwater were 18,900 catchable-sized rainbow trout stocked in 1963, and brown trout were first stocked in 1965. Initial plants of Yellowstone and Snake River cutthroat trout occurred in 1967 and 1971, respectively, and brook trout were first stocked in the tailwater in 1970.

The Utah Division of Wildlife Resources currently manages the tailwater below the Flaming Gorge Dam with a combination of stocking and special regulations. Rainbow and cutthroat trout are stocked annually in the river between the dam and Little Hole, and some natural reproduction of these species occurs in this reach (Modde et al., 1991). Brown trout have not been stocked into the Green River for several years, and current populations are sustained through natural reproduction. Trout below the dam are in good physical condition.

The current management practice is to stock hatchery-reared rainbow trout about 7 inches long with the goal of having those fish reach 12 inches by end of year. Trout less than 12 inches at the end of a growing season are more likely to die during the winter than larger trout (Modde et al., 1991). Increased growth rate during the warmer period of the year increases the proportion of the trout population that survives the winter. Excessive activity during the winter can result in mortality if it causes energy reserves of individual trout to fall below critical levels. Since flow fluctuations force increased movements of trout, the potential for winter mortality increases with increasing fluctuations in flow.

Rainbow and brown trout are the co-dominant fish species from the dam to the State line. The trout fishery has been divided into three sections: the *A* section extends from the dam to Little Hole (7 miles), the *B* section from Little Hole to Taylor Flat (9.5 miles), and the *C* section from Taylor Flat to the Colorado/Utah State line (12.5 miles). The overwhelming majority of fishing occurs in the *A* section. Brown trout are present throughout Reach 1 and accounted for as much as 27% of the fish collected with electrofishing in portions of Lodore Canyon (Bestgen and Crist, 2000).

The portion of Reach 1 between Flaming Gorge Dam and Taylor Flat (16 river miles) provides the best habitat for trout in the Green River, and spawning occurs there for all species. The greatest density of redds (nests) occurs immediately below the dam and between Little Hole and Red Creek (Modde et al., 1991). Brown trout redds have been identified only downstream from Little Hole. Eddies are preferred by adult rainbow and cutthroat trout, although a variety of other habitats are used, and use changes seasonally and with changing flows. YOY trout typically inhabit shallow (less than 16 inches deep), near shore (within 2 meters of the shoreline) areas with low water velocity (less than 1 foot per second). The amount of habitat available for adult rainbow trout is strongly influenced by flow and, on the basis of field measurements, is maximized in the tailwaters at flows between 800 and 1,200 cfs (Modde et al., 1991). Research has demonstrated that the Green River tailwater contains limited juvenile habitat, particularly during high discharges (Johnson et al., 1987).

Whirling disease is the common name of the disorder caused by the parasite *Myxobolus cerebralis* that has been implicated in severe declines of some wild populations of rainbow trout in the Western United States during the 1990s. This disease has its most devastating effects on early life stages of trout. Whirling disease has not been detected in the Green River tailrace trout fishery but has recently been reported from the New Fork River, a tributary to the Green River downstream from Flaming Gorge Dam (State of Utah, Division of Wildlife Resources, letter, dated January 27, 2004). Whirling disease will likely show up in the tailrace fishery at some point in the future; but based on the State of Utah's management strategy (stocking 7-inch trout), its impact may not be as significant as in a wild trout fishery.

Fluctuating flows can result in low trout recruitment by several mechanisms. Potential spawning substrates can be reduced, eggs can be desiccated, fry can be stranded, and YOY trout can be forced from the narrow band of suitable shoreline habitat. This causes either direct mortality or increased energy expenditures and vulnerability to predation. Internal Utah Division of Wildlife Resources (UDWR) memos from November 1969 first documented the stranding and associated fish mortality due to rapid down-ramps at the dam (Brayton and Armstead, 1997). Incidents of stranding have typically occurred during emergency situations and not exclusively during spawning events. A September 1974 Interim Operating Criteria formalized the minimum flow ". . . for the foreseeable future and under normal conditions, a continuous flow of 800 cfs will be maintained as a minimum."

Trout fry are dependent on zooplankton as food. Adults feed on macroinvertebrates, decaying organic material, and fish. Brown trout tend to be more piscivorous than rainbow trout and can be significant predators on native species where they co-occur (Valdez and Hugentobler, 1993). A large portion of the diet of trout below the dam is composed of *Cladophora*, amphipods, and the other invertebrates supported by *Cladophora*. Within Reach 1, algae production is supported at all depths, because the high degree of water clarity allows sunlight to penetrate to the bottom in all areas.

Optimum temperature for growth of both rainbow and brown trout ranges from 50-61 °F (10-16 °C) (Hokanson et al., 1977; Stevenson, 1987; Brannon, 1999). When temperatures reach 68-72 ºF (20-22 °C), growth can become limited; at 77-79 ºF (25-26 °C), temperature can become lethal (Molony, 2001).

3.7.2.3.4.2 Warm Water Nonnatives (Large-Bodied: Common Carp, Channel Catfish, and Smallmouth Bass) – Common carp prefer sheltered areas with an abundance of aquatic vegetation in warm water lakes, reservoirs, and rivers. The adults are opportunistic feeders that are able to utilize any available food source (Sigler, 1958). Carp typically spawn in flooded vegetation during the months of May and June in temperate climates. Carp are tolerant of a wide range of temperatures, but production is highly correlated with the number of days greater than 68 ºF (20 °C) (Backiel and Stegman, 1968).

Adult carp are common throughout Reach 1. Although found in very low numbers near the dam, their numbers increase in a downstream direction. They comprised approximately 12% of the entire electrofishing catch in both the upper and lower portions of Lodore Canyon during 1994-1996 (Bestgen and Crist, 2000). A summary of fish collections in Reach 1 prior to closure of the dam (Gaufin et al., 1960) and during three post-dam surveys (Banks, 1964; Smith, 1966; Vanicek et al., 1970; Holden and Crist, 1981) indicates carp consistently reproduce in Reach 1.

Channel catfish prefer warmer water with a diversity of water velocities, depths, and structural features that provide cover and feeding areas. Channel catfish spawn in late spring and early summer (generally late May through mid-July) when temperatures reach about 70 ºF (21 °C) (Pflieger, 1975). The optimal temperature range for adult channel catfish growth is 79-84 ºF (26-29 °C) (Chen, 1976), and growth is poor at temperatures less than 70 ºF (21 °C) (Andrews and Stickney, 1972).

Distribution of channel catfish in rivers has generally been shown to depend on both size of fish and the season. Smaller-sized catfish in the San Juan River tend to prefer lower velocities and sand or silt substrates, which are found in the lower portions of that river (Gido and Propst, 1999). Channel catfish are predacious and have been implicated in the decline of native fishes throughout the Upper Colorado River Basin. Colorado pikeminnow are known to prey on channel catfish; however, this interaction can turn negative if the prey (catfish) becomes lodged in the throat of the predator (pikeminnow) (McAda, 1983). Researchers at a 1995 nonnative fish control workshop in Boulder, Colorado, identified channel catfish as the greatest nonnative fish threat to the endangered fish community.

In Reach 1, catfish have been found sporadically in electrofishing samples from throughout much of Lodore Canyon, with the greatest abundances reported in the lower portions of the canyon. Bestgen and Crist (2000) surmised that river warming associated with the lower and more stable base flows called for in the 1992 Biological Opinion could have resulted in their increased abundance in recent years. Channel catfish are not known to successfully reproduce in Reach 1. Therefore, this relatively recent increase in abundance in lower Lodore Canyon is likely because of immigration from Reach 2 or the Yampa River.

Smallmouth bass occur in Lodore Canyon and become more abundant further downstream. These fish are not native to the Green River and pose a threat to endangered fish species. They prey on native species, especially young. They also compete with native fish for food and cover. Smallmouth bass inhabit streams and rivers with gradients ranging from 4-25 feet per mile (Funk and Pflieger, 1975). The gradient through Lodore Canyon averages 15.3 feet per mile.

3.7.2.3.4.3 Warm Water Nonnatives (Small-Bodied Minnows: Red Shiner, Fathead Minnow, Sand Shiner, and Redside Shiner) **–** This group of minnows can attain an adult size of 1 inch in their first year and attain maximum sizes of only 2 to 3 inches throughout the course of their 2- to 3-year life span. They are all capable of spawning numerous times in a single spawning season, and each species has the potential to become extremely abundant. The redside shiner (*Richardsonius balteatus)* prefers cool water and is found in a variety of habitats. Red shiner (*Cyprinella lutrensis)*, fathead minnow (*Pimephales promelas)*, and sand shiner (*Notropis stramineus)* all prefer warmer water and low velocity habitats and are tolerant of high turbidities. They are commonly found in those habitats used by the young of native fish species.

Researchers studying the interactions of these nonnative minnows and young Colorado pikeminnow in controlled environments found negative impacts to pikeminnow from competition (Byers et al., 1994) and predation (Bestgen et al., 1997). Nesler (2002) hypothesized that, from a potential impact perspective, the relative abundance of these three species could pose more of a threat to native fish than nonnative game fish (largemouth bass [*Micropterus salmoides]*, green sunfish [*Lepomis cyanellus*], and catfishes) in the Colorado River in Colorado.

Analyzing 15 years of fall YOY fish sampling on the Colorado River, McAda and Ryel (1999) showed that catch rates of native species were negatively correlated with catch rates of red shiner, fathead minnow, and sand shiner and positively correlated with the catch of young Colorado pikeminnow. They also found that the relative abundance of these nonnative minnows was lower in years with high spring peak flows than it was in years with low spring peak flows (McAda and Ryel, 1999).

In the upper, canyon-bound stretches of Reach 1, which provide the premier trout habitat, this entire group of fish is poorly represented. Redside shiners and fathead minnows are very abundant in the Browns Park area, where shifting sandbars provide sheltered low velocity habitats during the low flow periods (Bestgen and Crist, 2000). Redside shiners become less abundant through upper and middle reaches of Lodore Canyon where suitable low velocity habitats are scarce and river temperatures are warm. Further downstream in Reach 2, summer water temperatures greatly reduce redside shiner abundance.

Displaying a greater preference for warmer water, red shiner and sand shiner were virtually absent from seine collection in the Browns Park area and in the upper and middle stretches of Lodore Canyon (Bestgen and Crist, 2000). However, in the lower reaches of Lodore Canyon (the lower boundary of Reach 1), the combination of warmer water and suitable habitats accounts for their increased abundance. Fathead minnow, red shiner, and sand shiner abundances increase downstream and dominate the fish community in low velocity habitats in Reaches 2 and 3.

Successful reproduction has been documented for all four species of nonnative minnows in Reach 1. However, based on the distribution of adults, red shiner and sand shiner reproduction is highest in the very lowest portions of the reach.

3.7.2.4 Reach 2

3.7.2.4.1 Aquatic Food Base – Gourley and Crowl (2002) described Green River productivity (food base) in Reach 2 over a 3-year period. Riverine productivity, as it directly relates to fish, was dominated by macroinvertebrates with the primary groups being Diptera (true flies, primarily midges) and Odonata (dragonflies). In addition to the dipterans, Ephemeroptera (mayflies), Trichoptera (caddisflies) and Plecoptera (stoneflies) became more abundant during the high flow periods. Zooplankton densities were always low in the main channel with the greatest densities found in backwaters (Grabowski and Hiebert, 1989).

On the flood plain, macroinvertebrates also became abundant seasonally (at times more abundant than in the main channel), and densities of zooplankton were much higher than those found in the main channel. Crowl et al. (2002) stressed the importance of maintaining the connection between the river and its flood plain in terms of overall food web structure and complexity. They stated that increased availability of both macroinvertebrates and zooplankton has repeatedly been shown to benefit fish growth by offering fish (particularly young fish) a variety of food types as their feeding preferences change.

3.7.2.4.2 Threatened and Endangered Fish – In Reach 2, except for Whirlpool and Split Mountain Canyons (the upper portion of the reach), fish sampling has been quite intensive in the more accessible low gradient, alluvial areas that account for approximately 82% of the 98.7 river miles in this reach. The Interagency Standardized Monitoring Program, which was initiated in 1986, was responsible for collections of juvenile and adult Colorado pikeminnow throughout this reach each spring and sampled all species in backwaters each fall from the mouth of Split Mountain Canyon (river mile 220) downstream through the remainder of Reach 2. The Flaming Gorge studies, which served as the basis for the 2000 Flow and Temperature Recommendations, sampled various aspects of the fish community throughout the Green River and are summarized in the 2000 Flow and Temperature Recommendations.

In more recent years, an intensive effort has been conducted to characterize the fish communities in both the inundated flood plain and the main channel. Birchell et al. (2002) focused their efforts in the Uinta Basin portion of Reach 2, sampling 12 flood plain sites and 42 contiguous river miles. The results of these long-term and intensive sampling efforts provide the basis for the following description of the affected environment.

3.7.2.4.2.1 Colorado Pikeminnow – Late juvenile and adult Colorado pikeminnow are more abundant in Reach 2 than the other two reaches of the Green River. Pikeminnow spawning has not been documented in Reach 2. Resident adults migrate either to the Yampa River spawning area about 16 miles above the Green River confluence or downstream into Reach 3 to the spawning area in Gray Canyon. Prior to spawning migrations, Colorado pikeminnow adults stage in the flooded habitats available in Reach 2.

The low gradient stretches of Reaches 2 and 3 provide nursery area for larval pikeminnow drifting downstream off the Yampa River spawning bars. As Green River flows decline from their spring peak, sandbars become exposed in the main channel. Low velocity pools or backwaters form around these sandbars and can persist throughout the base flow period if flows remain stable. These backwaters, abundant in the lower half of Reach 2, provide habitats for the young pikeminnow through their first year of life (Tyus and Haines, 1991). The summer densities of young pikeminnow have varied greatly from year to year (e.g., 0.25 fish per 100 cubic meters [m^3] sampled habitat in 1996 to as many as 177 fish per 100 m^3 in 1992). Trammell et al., (1999) intensively sampled these habitats in Reach 2 as part of the Recovery Program's Flaming Gorge Studies to better describe pikeminnow habitat and how flows create and maintain them (2000 Flow and Temperature Recommendations). This information factored heavily into both the peak and base flow components of the 2000 Flow and Temperature Recommendations.

3.7.2.4.2.2 Humpback Chub **–** Due to its affinity for the more isolated canyon bound reaches of river, it is not surprising that records of humpback chub in Reach 2 are sparse. A few humpback chubs have been reported from Whirlpool Canyon (Holden and Stalnaker, 1975; Karp and Tyus, 1990) and Split Mountain Canyons (Vanicek, 1967). However, other than some very occasional and opportunistic sampling, those canyons have not been sampled since the 1980s. The populations are not expected to be large, but their status remains relatively unknown.

3.7.2.4.2.3 Razorback Sucker **–** The population of razorbacks in Reach 2 has persisted longer than any other in the Upper Colorado River Basin. Unfortunately, this population is also in decline, and recent abundance estimates suggest the number of wild adults may have dwindled from 524 individuals reported 6 years earlier (Modde et al., 1996) to 100 (Bestgen et al., 2002). Concentrations of razorback sucker in spawning condition were located at two sites within or very near Reach 2: the mouth of the Yampa River (just upstream of the Green River confluence) and in the Green River adjacent to Escalante Ranch (river mile 302-313) (Tyus and Karp, 1990). Fish in spawning condition captured at those areas were found in runs of cobble, gravel, and sand substrates in water averaging 0.63 meter deep. More than 99% of the razorback sucker larvae collected in the middle Green River during spring and summer 1992-1996 (Muth et al., 1998) were from areas within or downstream from the Escalante Ranch. Bestgen et al. (2002) and Muth et al. (1998) provide a thorough description of flows and temperatures that coincide with razorback sucker spawning.

The occurrence of razorback sucker in the middle Green River coincides with the greatest expanse of flood plain habitat in the Upper Colorado River Basin. Historically, inundated flood plain habitats provided nursery areas for recently hatched larval razorback suckers. Tyus and Karp (1990) associated low recruitment with reductions in the availability of this habitat type since 1962 (dam construction), and Modde et al. (1996) linked increases of razorback sucker recruitment back to the high water years of 1983, 1984, and 1986. Flood plain habitats were shown to support much higher densities of zooplankton (larval razorback sucker food) than main channel habitats (Birchell et al., 2002). Modde and Irving (1998) demonstrated that most razorback sucker adults in the middle Green River moved into the flooded bottomlands soon after spawning. In Reach 2, the amount of flood plain inundation increases rapidly as flows exceed

18,600 cfs (2000 Flow and Temperature Recommendations). The timing of flood plain inundation may be of equal or greater importance than the amount and duration of the inundation and should be a factor of dam operations (Bestgen et al., 2002). Captures of larvae in Reach 2, 1997-1999, coincided only with the latter part of spring peak flows when flows were declining.

Flood plain habitats support large numbers of nonnative fish. In a recent study of these habitats in Reach 2, nonnatives comprised 99% of the total catch, which was attributed to the productivity found there (Birchell et al., 2002). Black bullhead, fathead minnow, and green sunfish dominated the flood plain nonnative fish community, which was attributed to their ability to use these habitats for reproduction. Negative interactions were expected between the nonnatives and native species (young razorback sucker in this case) in flood plain habitats, but researchers did not detect increases in riverine populations of nonnatives when the flood plain habitats drained naturally. It should be noted that populations of nonnatives in the main channel were very high prior to flood plain draining (Birchell et al., 2002). Efforts to increase the availability of flood plain habitats to benefit razorback sucker will have to account for the potential benefit to nonnatives as well.

3.7.2.4.2.4 Bonytail – In addition to the recent releases of hatchery-reared bonytail by the State of Colorado in Reach 1, there have been two experimental stockings in Reach 2. In a study to determine survival and habitat selection of hatchery reared adult bonytail, the State of Utah Division of Wildlife Resources radio-tagged and released 86 individuals in Island and Rainbow Parks in Dinosaur National Monument during 1988-1989 (Chart and Cranney, 1993). During the summer of 2002, the U.S. Fish and Wildlife Service and Utah Division of Wildlife Resources experimentally stocked several hundred thousand larval bonytail in an artificially flooded wetland along the Green River to determine survival rates in the face of nonnative competition and predation. Preliminary results indicate that some bonytail grew to 60 millimeters total length by July (Modde and Christopherson, 2003).

The Recovery Program intends to stock 5,330 hatchery-produced bonytail (greater than or equal to 200 millimeters total length) for 6 consecutive years to establish a target adult population of 4,400 adult bonytail in the middle Green River (Nesler et al., 2003). These targets are the first step in meeting criteria identified in the Bonytail Recovery Goals (U.S. Fish and Wildlife Service, 2002a).

3.7.2.4.3 Native Fish, Nonlisted – In addition to the four endangered species present in Reach 2, three other large-bodied native species are found there: the flannelmouth sucker, bluehead sucker, and roundtail chub. Flannelmouth sucker was the most abundant native fish collected in the main channel and in flood plain habitats during 1996-1999 (Birchell et al., 2002). Bluehead sucker was numerically the next most abundant species but was significantly less abundant than flannelmouth sucker and not significantly more abundant than the endangered Colorado pikeminnow. Roundtail chubs were very scarce in electrofishing samples.

Flannelmouth suckers were found to use the inundated flood plain; however, they vacated all flood plain habitats as the river dropped and the connection was lost. Although some native fish larvae were collected in flood plain habitats, the main channel appears to provide most of the nursery area for young native fish. On the Colorado River, McAda and Ryel (1999) looked at similar collection information and determined that larvae and YOY of native fishes were more abundant in years with high peak runoff than in years of low peaks. A greater understanding of the relationship between native species' reproductive success and flow and habitat in the Green River is needed.

3.7.2.4.4 Nonnative Fish –

3.7.2.4.4.1 Coldwater Nonnatives – Trout are virtually nonexistent in the main channel fish collections in Reach 2 and Reach 3. There is a very localized population of brown, rainbow, and cutthroat trout at the mouth of Jones Hole Creek, a 4-mile-long spring-fed tributary stream. Trout are abundant throughout Jones Hole Creek from Jones Hole National Fish Hatchery, located near the stream source, downstream from the Green River. The trout found in the Green River proper are an extension of the stream population taking advantage of the cool, clear tributary flows at the confluence.

Northern pike (*Esox lucius)* is classified as a coolwater species and has been collected primarily in the alluvial reaches of Reach 2 for many years. This species is similar in size and body shape to the Colorado pikeminnow and, like the pikeminnow, switches to an almost exclusive fish diet early in life. Northern pike in the Green River system apparently come from dispersal of a breeding population in the Yampa River in Colorado. Juvenile and adult pike have been found in increasing numbers throughout Reach 2 for many years. This predacious nonnative species prefers low flow areas in the spring (inundated flood plain or the mouths of tributaries/dry washes) and is known to spawn in these areas in the upper Yampa River. The Recovery Program has funded, and plans to continue to fund, specific efforts to control this species in the Yampa River in Colorado and in the Green River through the Uintah Basin of Utah.

3.7.2.4.4.2 Warm Water Nonnatives (Large-Bodied: Common Carp, Channel Catfish, and Smallmouth Bass) – In a 4-year study of the main channel and flood plain habitats throughout a 40-mile stretch of Reach 2, researchers used a variety of techniques to characterize the fish community (Birchell et al., 2002). Of 172,007 fish collected from main channel habitats, 169,473 (98.5%) were nonnative. Carp was typically the most abundant large-bodied fish collected in the main channel. Channel catfish were less abundant than large-bodied native fish (predominately native suckers), but they were collected in all areas every year.

In the flood plain habitats, in excess of a million fish were collected, with nonnative species accounting for over 99% of the total catch in most areas. Carp were collected in the flood plain but were often outnumbered by black bullhead and green sunfish. After 3 weeks of flood plain inundation, carp were found to reproduce in many of the habitats. Channel catfish did not appear to use the flood plain habitats to any great extent.

The relationship between these two abundant nonnative species and flows is not well understood. Carp will utilize flooded areas and will spawn there if the habitats persist for 3 weeks or longer. Channel catfish reproduction in canyon bound reaches may be negatively affected by high flow years, but the majority of the channel type through Reach 2 is broad and meandering.

Smallmouth bass occur throughout Reach 2. They are considered detrimental to native fish species.

3.7.2.4.4.3 Warm Water Nonnatives (Small-Bodied Minnows: Red Shiner, Fathead Minnow, Sand Shiner, and Redside Shiner) – In a 6-year study to characterize the use of low velocity habitats by young Colorado pikeminnow, Day et al. (1999) found the nonnative red shiner to be the most commonly collected species (occurring in 91% of the 945 samples). Red shiner was by far the most abundant species occupying these areas, which are the same habitats that young Colorado pikeminnow prefer during their first year of life. The second most abundant species was fathead minnow, occurring in 70% of the sites sampled, followed by sand shiner, which increased in abundance during the last 3 years of study. The nonnative species greatly outnumbered native fish in these important habitats every year. These data are consistent with less intensive, but more long-term, sampling conducted under the Interagency Standardized Monitoring Program since 1986.

During spring runoff, these small nonnative species proliferate in inundated flood plain habitats. Of the three, fathead minnow took the greatest advantage of flooded areas, often comprising greater than 50% of the total catch (often ranging from tens to hundreds of thousands) in a given habitat throughout the year. Within 3 weeks of connection to the main channel (i.e., nonnative invasion) nonnative minnows would begin to reproduce. As the riverflows receded, many of their larvae were flushed out to the main channel.

Although negative correlations between nonnative minnow densities and magnitude and duration of the spring runoff have been documented in some areas throughout the upper basin (McAda and Ryel, 1999), the relationship is confused in Reach 2, due primarily to the abundance of the flood plain habitat. Nevertheless, researchers in all areas observed that these nonnative minnows recovered quickly from any setback, whether from adverse environmental conditions or nonnative control efforts.

3.7.2.5 Reach 3

3.7.2.5.1 Aquatic Food Base – Specific investigations to describe primary (algae) and secondary productivity (aquatic insects) are lacking in Reach 3. The energy pathways described for the flood plain habitats in Reach 2 apply to similar habitats found in the very upper portions of Reach 3. The large, out-of-bank habitats that flood at flows above 18,600 cfs near Ouray, Utah, are generally lacking in the middle and lower portions of Reach 3. In Reach 3, as the river rises during the spring, it floods the mouths of tributaries and otherwise dry washes, which offer similar habitat and production as the flood plain on a much smaller scale. During the base flow period, main channel backwater habitats are presumed to be where most of the primary and secondary productivity occurs through the low gradient stretches of Reach 3—similar to the situation in Reach 2. Productivity increases in main channel areas where gradient and substrate size increase, which, in part, explains increased densities of fish in these areas. Cobble runs and riffles are found throughout the Desolation and Gray Canyon sections of Reach 3. In the lower 100 miles of the Green River, cobble bars are relatively scarce, found only at the mouths of side canyons.

3.7.2.5.2 Endangered Fish –

3.7.2.5.2.1 Colorado Pikeminnow – All life stages of Colorado pikeminnow are found in Reach 3. One of two Colorado pikeminnow spawning bars in the Green River subbasin is found in Gray Canyon in Reach 3. The other spawning location is on the Yampa River. Spawning was first documented on the Green River in the late 1980s (Tyus, 1990) near Three Fords Rapid in Gray Canyon. Since then, groups of fish in spawning condition have been collected as far as 5 miles upstream and downstream from that specific location (Chart and Lentsch, 2000), but spawning still seems centered on the Three Fords site. Harvey and Mussetter (1994) report that the spawning bars in Reach 3 are constructed at high flows, but the actual spawning habitat is created and cleansed following the peak flow when discharge ranges between 2,800 and 8,020 cfs. Adult pikeminnow have migrated as far as 180 miles, from both upstream and downstream in the Green River, and from the White River to spawn at this site in Reach 3 (summarized in Irving and Modde, 2000).

The lowermost 120 miles of the Green River typically support the greatest abundances of YOY pikeminnow found in the Green or Colorado subbasins (McAda and Rydel, 1999). Catch rates of YOY pikeminnow were greater than other reaches in 12 of the 14 years sampled, 1986-1999. Catch rates were greatest in 1988, when 5.6 YOY pikeminnow were collected per 10 square meters of sampled backwater habitat and lowest in 1997 when the catch rate dropped to 0.097. Reach 3 provides nursery habitat (backwaters) for larvae produced at the Gray Canyon spawning bar as well as those produced upstream at the Yampa River spawning bar. Backwater habitats in Reach 3 are formed by similar geomorphic processes, as described in Reach 2 (Rakowski and Schmidt, 1999) but are generally less abundant than in Reach 2. YOY pikeminnow also occupy low velocity habitats in Desolation and Gray Canyons. Three separate research efforts studying YOY pikeminnow backwater use in Reaches 2 and 3 found selection for larger, deeper, scour channel backwater habitats when they were available (Day et al., 1999; Day et al., 2000; Trammell et al., 1999). This information factored heavily in the development of the 2000 Flow and Temperature Recommendations.

Juvenile pikeminnow (ages 2-5; 100-350 millimeters) are also found in greater abundances in the lower portions of Reach 3 than farther upstream. Standardized monitoring (shoreline electrofishing) from 1986-2000 revealed that roughly 60% of the pikeminnow collected in Reach 3 were less than 400 millimeters in length, whereas only 10% collected in Reach 2 were that small (interpreted from graphs in McAda, 2002). Researchers have speculated that pikeminnow disperse upstream of the lower reaches of the Green and Colorado River (Osmundson et al., 1997) as they mature, which would account for this skewed size distribution (Tyus, 1991; McAda, 2002). Juvenile pikeminnow are collected in backwaters but are also found along quiet shoreline areas and other main channel habitats.

3.7.2.5.2.2 Humpback Chub – Reach 3 supports the greatest concentration of humpback chub in the Green River subbasin. The Desolation/Gray population was discovered by researchers in the late 1960s (Holden and Stalnaker, 1975). Monitoring to determine the distribution and relative abundance of this population of humpback chub, which also includes roundtail chubs and apparent hybrids of the two species, began in the 1980s. More recently, the Recovery Program has initiated a mark/recapture study to determine population size and how that relates to criteria outlined in the Humpback Chub Recovery Goals (U.S. Fish and Wildlife Service, 2002c). Those efforts have been hampered by low flows, and these data are preliminary at this time.

The humpback chub population in Desolation and Gray Canyons occupies 55 miles of river located roughly 210 river miles below Flaming Gorge Dam. Catch rates, which describe the number of fish collected in a net positioned in a quiet portion of the river for 1 hour, vary greatly from site to site within the canyon and have varied from year to year. Juvenile and adult chubs are most readily collected from main channel eddy and pool habitats. The Utah Division of Wildlife Resources reports an average humpback chub catch rate of 0.13 from 1993-2000 (i.e., it takes between 7 and 8 hours of netting to catch one humpback chub [derived from data provided in Utah Division of Wildlife Resources Recovery Program Project 22-C, *2000 Annual Report*]). For comparison, average catch rates in Westwater Canyon on the Colorado River for the same period of time averaged 0.33 (i.e., one might assume that humpback chub in Westwater Canyon are roughly 2.5 times as abundant as in Desolation and Gray Canyons). Conversely, catch rates in the lower Yampa River Canyon and in Cataract Canyon on the Colorado River are much lower than those reported for Desolation Canyon.

YOY chubs (both humpback and roundtail) were collected during two separate studies designed to better understand chub reproduction and recruitment in Desolation and Gray Canyons (Day et al. (2000) sampled backwaters during 1994-1996; Chart and Lentsch (2000) sampled a variety of habitats during 1992-1996). Day et al., (2000) found chubs in large and deep backwaters in Desolation Canyon. They also reported that increased turbidity was a characteristic of backwaters used by chubs. Although YOY were collected each year, survival through their first winter was not always documented. Competition and predation by abundant nonnative fishes (channel catfish in the main channel and nonnative minnows in the backwaters) may negatively impact survival of young chubs in Desolation and Gray Canyons (Chart and Lentsch, 2000). During the period of 1992-1996, YOY produced in 1993 (a high water year) were best represented in sampling as age 1+ fish the following year. During the same timeframe, survival of young channel catfish was low.

3.7.2.5.2.3 Razorback Sucker – As was mentioned in section 3.7.2.4.2.3, the abundance of wild razorback suckers throughout the Green River system is in decline. A total of 118 wild adult razorback suckers were collected during an intensive sampling effort throughout the Green River, 1996-1999. The overwhelming majority of those were collected in Reach 2 between the confluence of the White River and Split Mountain Canyon (Bestgen et al., 2002). Razorback sucker adults have been collected from Reach 3, but in very low numbers. Since 1980, only 19 wild adult razorbacks have been collected from Reach 3, including Desolation Canyon downstream to the confluence with the Colorado River (Chart et al., 1999). The last wild razorback collected in this area was captured in 1997 near the mouth of the San Rafael River, 97 miles upstream of the confluence with the Colorado River and 313 miles below Flaming Gorge Dam.

Although adult razorback suckers have been extremely rare in the lower river, larvae were present in samples every year from 1994-1999. The majority of those captures came from an area near the mouth of the San Rafael River. The presence of larvae at this location in multiple years and the relatively large size of larvae found there suggest that the San Rafael River may be an important rearing area for razorback suckers (Bestgen et al., 2002). During many years, larvae were present in Reach 3 prior to their appearance in Reach 2; this left researchers reasonably certain that those larvae captured in Reach 3 were produced there (Muth et al., 1998).

As mentioned in the Reach 2 discussion, based on the timing of razorback sucker spawning, inundated flood plain habitats likely provided important warm, food-rich areas for larvae. Equally important as the magnitude and duration of the flows is the timing of the flows. In Reach 3, larval razorback collections (spawning time) coincide with peak or pre-peak spring flows that allow the larvae to fully utilize the inundated habitats. However, low velocity habitats at any time of the year are also havens for nonnative fish. In Reach 3, the predominant nonnative predators/competitors are channel catfish and nonnative minnows. The Recovery Program has experimented with mechanical control of these species in Reach 3 with limited or no apparent success to date (Bedame, 2002; Meismer and Trammell, 2002).

3.7.2.5.2.4 Bonytail – The only wild bonytail collected in Reach 3 was reported by Tyus et al. (1987) from U.S. Fish and Wildlife Service collections in Gray Canyon, 1982-1985. The Recovery Program and the State of Utah began stocking bonytail in the lower Green River near the town of Green River, Utah, in 1999 (Bedame and Hudson, 2003). The Recovery Program's Integrated Stocking Plan (Nesler et al., 2003) calls for stocking levels to achieve Recovery Goal criteria. As stipulated in the Bonytail Recovery Goal (U.S. Fish and Wildlife Service, 2002a), populations of 4,400 adult bonytail are required in the middle Green and Colorado Rivers. A redundant population (a third population of 4,400 adults) is required in Reach 3 as insurance against a catastrophic event in one of the other recovery areas. To achieve the target and maintain it for several years, the Recovery Program intends to stock 5,330 bonytails (greater than or equal to 200 millimeters total length) for 6 years.

3.7.2.5.3 Native Fish, Nonlisted – Flannelmouth sucker, bluehead sucker, roundtail chub, and speckled dace are found throughout Reach 3. The greatest amount of native fish community data is from Desolation and Gray Canyons; data were collected while monitoring the population of humpback chub (summarized in Chart and Lentsch, 2000). Fish community information from main channel habitats downstream from Desolation and Gray Canyons is more spotty, collected by various researchers (Cavalli, 2000; Chart et al., 1999; Valdez, 1990). These studies serve as the basis for the description of the main channel fish community (native and nonnative) in Reach 3.

In Desolation and Gray Canyons (1989-1996), flannelmouth and bluehead sucker comprised approximately 20-30% of the large-bodied fishes collected in main channel habitats. Flannelmouth sucker were typically more abundant than blueheads. Bluehead sucker prefer swift flowing habitats with large substrates, which are abundant in these canyons, but they also prefer cooler temperatures and are typically more abundant in the upper reaches of the river. Collections of juvenile sized suckers (ages 1-3) varied greatly from year to year and were either low or lacking throughout the study period. However, a group of age 1 native suckers (spawned the previous year) were relatively abundant in 1994; 1993 was one of the higher flow years studied (peak flow of 25,400 cfs, recorded on May 31).

Roundtail chub were collected throughout Desolation and Gray Canyons. The relationships discussed between flow and humpback chub reproductive success apply to this species as well.

Downstream from Desolation and Gray Canyons, the river gradient drops, cobble bars become less abundant, and substrate shifts to sand as the river flows to the confluence with the Colorado River. Through this stretch, numbers of large-bodied fish in the main channel generally decline, presumably due to the reduction in productivity associated with sand substrates and high turbidity. Flannelmouth sucker is still the most commonly collected native fish in the main channel and is similar in abundance to nonnative carp and catfish. Bluehead sucker become rare in this portion of Reach 3, and roundtail chub are virtually nonexistent.

Native species comprise as much as 70% of the catch in deeper habitats of the San Rafael and Price Rivers, tributaries to the Green River in Reach 3 (Tyus and Saunders, 2001). Based on the species composition and habitat availability found in these smaller river systems, it is assumed that a significant amount of native fish reproduction occurs there. That production may, in turn, contribute to populations in the Green River main channel; however, specific data on reproductive success in these tributaries are not available to substantiate this link. In their status review of flannelmouth sucker, bluehead sucker, and roundtail chub, Bezzerides and Bestgen (2002) report that these species currently occupy only 45%, 50%, and 45% of their historical range in the Colorado River Basin, respectively. Much of that loss of range has occurred in tributaries to the Green, San Juan, and Colorado Rivers.

3.7.2.5.4 Nonnative Fish –

3.7.2.5.4.1 Cold Water Nonnatives – Trout are not found in any portion of the Green River in Reach 3 because summer temperatures are too warm. Northern pike and walleye have been collected in relatively low numbers compared to other locations in the subbasin. However, preliminary data collected in the past few years suggests that walleye are increasing in Reach 3 (Hudson, 2003). Northern pike and walleye are more commonly found in northern climes, native to rivers and lakes in Canada, though they are also found as far south as the northern portions of Alabama and Georgia. Both species spawn earlier in the spring than any of the native Colorado River species. Main channel summer maximum temperatures in Reach 2 and 3 likely become stressful for these species, but not likely lethal. The Recovery Program is currently funding efforts to control these species in upstream reaches (in Reach 2, the Duchesne River, and in the Yampa River), the likely sources of these predacious nonnative species.

3.7.2.5.4.2 Warm Water Nonnatives (Large-Bodied: Carp, Channel Catfish, and Smallmouth Bass) – Carp, channel catfish, and smallmouth bass are found throughout Reach 3. In Desolation and Gray Canyons, channel catfish were the most commonly collected species while netting and electrofishing main channel habitats, 1989-1996 (Chart and Lentsch, 2000). Channel catfish were nearly twice as abundant as native chubs. Whereas data suggests that native fish reproduction in Desolation and Gray Canyons was positively correlated with spring flow, there was some indication that channel catfish reproduction was negatively impacted during the higher flow years. Carp were also abundant during that study, with similar catch rates as native chubs. YOY and juvenile carp were not collected in large enough numbers to determine relationships with flow. Channel catfish have experienced summer die-offs in Desolation and Gray Canyons during extremely low flow years. The most recent such event occurred when Green River flows dropped below 1,000 cfs during the summer of 2002 (Hudson, message posted to Recovery Program listserver, 2002). Catfish die offs appear to be linked with the occurrence of summer storms, which result in a large pulse of sediment into an extremely warm river.

In the lower 50 miles of Reach 3, Valdez (1990) found carp and catfish the dominant species in main channel habitat sampled with electrofishing (1987 and 1988) and with nets in 1988.

The Recovery Program is currently funding efforts to remove channel catfish and smallmouth bass in Desolation and Gray Canyons. The purpose of those efforts is to reduce the perceived negative impacts this predacious nonnative species is having on humpback chubs.

3.7.2.5.4.3 Warm Water Nonnatives (Small-Bodied: Red Shiners, Sand Shiners, and Fathead Minnows) – Three nonnative species–red shiner, sand shiner, and fathead minnow–dominate the fish community in low velocity habitats throughout Reach 3. Day et al. (2000) reported negative correlations between red shiner and fathead minnow catch per unit effort in Desolation and Gray Canyons. In other words, although these species remained relatively abundant from year to year, their numbers were reduced in the higher flow years. Similarly, Trammel and Chart (1999) reported that backwater habitat availability and nonnative shiner and minnow densities in Reach 3 were lower in years with moderate to high spring peaks.

In portions of Reach 3 (Desolation and Gray Canyons, for example) densities of native fish, including chubs and pikeminnow, were also negatively correlated with the same aspects of the spring hydrograph that reduced nonnative species (Day et al., 2000). Flow manipulation alone may not be sufficient to control these nonnative species (McAda and Kaeding, 1989).

The Recovery Program has funded studies to determine the feasibility of mechanically controlling nonnative minnows in the lower Green and Colorado Rivers. Unfortunately, results of those studies did not show a measurable, lasting reduction in the densities of those species. At a recent workshop of the Recovery Program, participants were unable to identify alternative approaches to potentially improve the success of reducing these species through mechanical control (Upper Colorado River Endangered Fish Recovery Program, 2002).

3.7.2.6 Vegetation

Vegetation found along the Green River and affected by riverflows is classified as riparian and wetland vegetation. Wetlands are areas that are saturated or inundated by surface or subsurface water for at least a few weeks of the year and that support vegetation adapted to this saturated condition. Riverine wetlands occur along rivers or moving bodies of water and generally receive seasonal pulses of floodwaters that contribute to the saturated condition. The riparian zone is a transition zone between water and upland and is composed of plant species that are usually more robust than their upland counterparts and/or are composed of different species than those of adjacent areas.

Because much of the Western United States is arid, riparian zones provide the moisture and nutrients to support a greater variety of vegetation than upland areas that, in turn, support a greater diversity of wildlife. In addition to providing habitat for 75-80% of Utah's wildlife, riparian zones are important for their role in water quality improvement, flood control, recreation, and ground water recharge and discharge.

The riparian zone of the Green River changes character as the river alternately meanders through bedrock confined canyons and broad valleys. Narrow canyon reaches such as Red Canyon, Lodore, Whirlpool, and lower Labyrinth Canyon provide only limited opportunities for plant growth; yet plant communities are complex due to the diverse environmental gradients between surface types (pools, eddies, gravel bars). The wider alluvial, unconfined reaches of Browns Park, Island Park, and Ouray historically were composed of expansive and highly productive riparian plant communities. Intermediate to the above reach types are the confined alluvial reaches such as Echo Park, Grays, Desolation, and Stillwater Canyons. These areas, while still confined within a limited width of valley floor, historically also allowed for development of complex riparian zones.

The floodflows of the pre-dam period played a major role in defining species composition and location. These historic floods scoured away existing vegetation and deposited fine sediment. These actions provided the proper conditions for seedling establishment of woody riparian vegetation, namely Fremont cottonwood (*Populus deltoides* subsp. *wislizenii)* and coyote willow (*Salix exigua*). A range of vegetation responses has occurred since closure of Flaming Gorge Dam. These responses vary depending on river reach, sediment, and flow contributions from tributaries, moisture content of substrate, elevation above river, and responses during extreme drought and wet years.

Fremont cottonwood is the dominant tree species along the wide alluvial sections of the Green River, while box elder (*Acer negundo*) is the dominant tree of the canyon reaches. Both species are flood dependent. Successful establishment of cottonwood communities depends on spring peak flows and associated overbank flooding timed to correspond with seed dispersal. Under current flow regimes, the floodflows necessary to scour away existing vegetation and deposit fine loamy sediment needed for new seedbeds rarely occur.

Under post-dam conditions, stage change is small, and many newly established cottonwood seedlings, restricted to the river margin, have little prospect of long-term survival. Their location makes them susceptible to both prolonged inundation and scour from high flows and ice. If seedlings do establish at the few protected sites, they face competition from both woody and herbaceous nonnative plants that have now invaded the Green River corridor. Invasive plants, such as tamarisk (*Tamarix ramosissima, T. chinenis,* or hybrid of the two), giant whitetop, or perennial pepperweed (*Cardaria draba*), and sweet clover (*Melilotus* sp.) colonize the same opens sites necessary for cottonwood seed germination and seedling survival. Competition for water appears to be a key factor related to cottonwood survival. When water is scarce, cottonwood seedlings suffer greater stress than neighboring tamarisk and other invasive species (Cooper et al., 1999).

The presence of tamarisk is important to note due to its contributions to channel narrowing and stabilization, soil salinity, and displacement of native riparian vegetation with accompanying reduction in biodiversity. This invasive shrub flowers and produces seeds throughout summer and into fall. Tamarisk can rapidly colonize bare, moist soils and, once established, can tolerate a range of environmental conditions.

Tamarisk invasion along the lower Green River was underway by the 1920s. Prior to dam closure, tamarisk establishment occurred in a relatively wide range of locations and elevations within the flood plain. River regulation has reduced the range of elevations suitable for establishment but has increased the availability of suitable habitat (Larson, 2004). River regulation has provided optimum establishment opportunities, especially when peak flows occur later in the summer, benefiting tamarisk over cottonwood seed germination. In canyon reaches, post-dam tamarisk establishment is prevalent on gravel bars and debris fans (Larson, 2004; Birken, 2004; Cooper et al., 2003). Under river regulation, large floods generally occur too infrequently to prevent tamarisk seedlings from reaching the age where they become highly resistant to removal by floodflows.

Russian olive (*Elaeagnus angustifolia*) is another invasive plant of concern along alluvial reaches of the Green River. Relative to willow and cottonwood, it is drought and shade tolerant at both the seedling and adult stages. Russian olive does not depend on spring flooding and disturbed soils for establishment. Due to these characteristics, it can become the dominant climax community and prevent establishment of native vegetation, especially cottonwoods (Shafroth et al., 1995).

A description of the riparian communities of the three reaches and related environments follows.

3.7.2.6.1 Reach 1 – Reach 1 is most dependent on flows from Flaming Gorge for its riparian and wetland vegetation makeup. Many species found in Reach 1 were not present pre-Flaming Gorge Dam and are not present today on similar reaches of the nearby Yampa River (Cooper, 1999). After dam closure, the riparian zone was no longer subject to high spring floodflows and low summer/fall base flows. The new, more stable flow regime led to a shift in plant community composition and location.

The zone closest to the river's edge is now composed of marsh type plants—those that can tolerate long periods of root saturation. This post-dam flood plain (Grams and Schmidt, 2002) is inundated on an almost annual basis, sometimes in 8-week stretches, by the powerplant releases of 4,600 cfs. Canyon reaches and the upper portion of Browns Park have an almost continuous narrow band of wetland plants that have established along the river's edge. Plants in the sedge and rush families dominate this zone, particularly spike rush (*Eleocharis palustris*), with coyote willow (*Salix exigua*), cattail (*Typha latifloia* and *T. angustifolia*), bulrush (*Scirpus* sp.), common reed (*Phragmites australis*), and tamarisk also present.

In the wide alluvial valley of lower Browns Park, low elevation islands are vegetated by coyote willow, spike rush, bulrush, and other marsh species. Islands are one of the few areas in this reach where expansion of wetland and riparian vegetation is occurring (Merritt and Cooper, 2000). Most of this expansion is in a downstream direction; there has been little vertical accretion of sediment. Thus, island soils are saturated by shallow ground water for most of the year, providing favorable conditions for marsh plants but precluding riparian forest species such as cottonwood.

At elevations just above this post-dam flood plain is a zone that is only rarely flooded under post-dam conditions. Inundation of this intermediate bench surface (Grams and Schmidt, 2002) generally begins above flows of 4,600 cfs. Several surface types are associated with this zone, and each surface type tends to have a distinct plant community. Tamarisk, coyote willow, and the giant whitetop are found on debris fans, islands, and cobble bars. The nonnative grass, redtop (*Agrostis stolonifera*), characterizes eddy and pool bars.

In Lodore Canyon, tamarisk invasion is especially prevalent on many debris fans. Under river regulation, decreased flood magnitudes and the formation of inset flood plains has limited tamarisk's establishment to a narrow elevation zone. This zone tends to be densely covered with tamarisk. Larson (2004) found that the majority of tamarisk in both Lodore Canyon and Yampa Canyon are located on deposits inundated less frequently than the 2-year flood (the intermediate bench surface in Lodore). Larson also found that tamarisk do not appear to establish at most base flow elevations due to the ability of even small floodflows to remove them.

Without the power of large spring flows to remove or prevent establishment of most vegetation in the active flood zone, island and mainland cobble bars are filling in with vegetation, and side channels are connecting islands to mainland. The threatened Ute ladies'-tresses orchid falls within the intermediate bench zone and the lower post-dam flood plain and is found on vegetated cobble bars in Red and Lodore Canyons and Browns Park (see section 4.7.8.2 for a full discussion of effects).

Lower Browns Park is composed of high, straight riverbanks with the post-dam flood plain inserted below these banks. Appropriate elevations and locations for cottonwood establishment are now occupied by the nonnative plants whitetop, tamarisk, sweet clover, and Canada thistle (*Cirsium arvense*), and the native scouring rush (*Equisetum* sp.) and occasional coyote willow. These areas do not receive the scouring effect of large floodflows; thus, there is little opportunity for cottonwood establishment.

The old high water terrace, a pre-dam feature found at higher elevations, is an area that, in Reach 1, does not receive floodflows in the current post-dam setting. Conifers and box elder are common in the canyon reaches with Fremont cottonwood common on the meandering wider valley reaches. Common understory species of both canyon and wider valley reaches are mostly composed of upland and desert shrub type plants: sagebrush, rabbitbrush (*Chrysothamnus nauseosa),* greasewood (*Sarcobatus vermiculatus*), desert grasses, and aster. This desert plant community is atypical of unregulated rivers of the arid and semiarid West.

In lower Browns Park, the old high water zone sits high above nearly vertical banks that line both sides of the river and prevent overbank flooding even during the infrequent post-dam high flood years. Older stands of Fremont cottonwood forests are prevalent, having become established during floodflows of the pre-dam era. Comparative studies along the Yampa River indicate that these Browns Park cottonwood forests are in various stages of premature decay. With the loss of the historical floodflows, the cottonwoods have lost their fine root system, leaving main taproots as the only means of supplying water (Williams, 2000).

There is very little successful cottonwood regeneration occurring in lower Browns Park due to a lack of unvegetated sites that provide the proper moisture, yet protection from ice and scouring high flows. The existing cottonwood community is not replacing itself and, instead, is being replaced by the nonnative tamarisk or native desert species. There has been little cottonwood establishment in Reach 1 since 1962.

3.7.2.6.2 Reach 2 – The Yampa River tempers the effects of river regulation on the riparian zone of Reach 2. As in Reach 1, there is the presence of a distinct post-dam flood plain with corresponding wetland plants. The addition of unregulated flows from the Yampa River creates greater stage changes, thereby limiting true wet meadow communities that proliferate under more stable flows.

In Whirlpool and Split Mountain Canyons, plant communities with more similarities to the Yampa River Canyon than Lodore Canyon of Reach 1 dominate the herbaceous riparian vegetation. Herbaceous communities characterized by prairie cordgrass (*Spartina pectinata)* and the sedge *(Carex emory)* are typical of the Yampa Canyon and Green River canyons of Reach 2 but are absent in Reach 1. In Lodore Canyon, the most characteristic community is dominated by redtop grass, yet this community is absent in the canyons of Reach 2. Inundation of the post-dam flood plain surfaces of Reach 2 begins at about 16,000 cfs, which is the post-dam 2-year flood.

The intermediate bench, which is only occasionally flooded in the post-dam era, is generally inundated by flows greater than 21,000 cfs. In the alluvial valley of Island Park, soil deposition is occurring in abandoned channels and oxbows, providing opportunities for cottonwood establishment. During the wetter years of 1984-1986, successful cottonwood establishment was prevalent. Old (100-year plus) cottonwoods are sparse and are located on a high terrace that sits 13-15.5 feet above base flow stage. Like Browns Park, the understory vegetation of this terrace is composed of desert shrub species (i.e., big sagebrush (*A. tridentata*) greasewood, rabbitbrush, and desert grasses). Islands range from unvegetated to densely vegetated with coyote willow and young tamarisk.

Further downriver in the wide alluvial valley of the Ouray area, the intermediate bench is heavily vegetated with tamarisk, Russian olive, and three-leaf sumac (*Rhus aromatica*) with an understory of herbaceous vegetation dominated by grasses and poverty weed (*Iva axillaris*). Side channels with silt-clay substrates that occasionally receive floodflows are currently providing seedling beds for tamarisk and Russian olive.

In the Ouray area of Reach 2, there are occasional bands of young cottonwoods that likely established with the 1983-86 floods. Other than populations within Dinosaur National Monument, this is the only age group of cottonwoods that appears to have established in Reach 2 since closure of Flaming Gorge Dam. Tamarisk established throughout the upper Green River well before river regulation (Allred and Schmidt, 1999; Birken, 2004). Following dam closure, this invasive species took quick advantage of the additional establishment opportunities that came about with the lack of scouring floodflows. This change allowed vegetation to expand further down the riverbanks, contributing to accretion and channel narrowing.

3.7.2.6.3 Reach 3 – The upper portion of Reach 3 is a continuation of the wide alluvial flood plain forests as described for Reach 2.

Throughout Reach 3, at least two distinct topographic surfaces now exist in the area of bank accretion. An intermediate elevation surface is densely vegetated with tamarisk and Russian olive, and one low elevation surface that includes one to two natural levees is densely covered with willows (Allred and Schmidt, 1999; Cooper, 1999).

In Gray Canyon, large-scale cottonwood establishment currently occurs on gravel bars. This establishment surface is a different landform than that historically occupied by cottonwood (Cooper, 1999). Cooper found that, since dam closure, cottonwoods established only in 1983 on higher Gray Canyon flood plain surfaces. The high flow years of 1984-1986 likely provided the needed moisture to insure seedling survival at these higher surfaces.

Throughout Labyrinth and Stillwater Canyons, there are ancient lakes behind the levees in all bottoms. These lakes have laminated clay soils and are surrounded by tamarisk and cottonwood but used to function as reservoirs and perhaps marshes in the years of big flows, likely prior to the 1930s (Cooper, 2002). The active flood plain is dominated by a dense thicket of sandbar willow and young tamarisk on the banks.

Thick bands of 40+ year-old tamarisk proliferate just above the active flood plain; and, in the old high water zone, stands of greasewood, three-leaf sumac, desert olive (*Forestiera* sp.), and herbaceous vegetation dominate. High terraces with 100- to 300-year-old cottonwoods are present throughout**.**

3.7.2.7 Terrestrial and Avian Animals

3.7.2.7.1 Reach 1 – Thick growth and the variety of plant species in the riparian zone provide a structural diversity that makes the Green River corridor some of the most important wildlife habitat in the region. Wider and more extensive riparian zones provide habitat for a larger and more diverse wildlife and avian community. Wetland and riparian habitats along the river serve as an oasis in a desert region where rainfall averages only about 7 inches a year. Drier habitat around the wetlands adds to the diversity of species living in the area.

Riparian vegetation supplies food and cover for insects emerging from the river, as well as its own resident invertebrate populations and their terrestrial predators (e.g., predacious insects, amphibians, reptiles, birds, and mammals). These resources, in turn, provide food for numerous fish, mammals, birds, reptiles, amphibians, and invertebrates. Terrestrial and aquatic invertebrate assemblages play a major role in both aquatic and terrestrial food webs in the system.

Many species use riparian woody plants directly as nest sites or cover. Other wildlife species (e.g., beaver [*Castor canadenis*]) use these plants as food. Waterfowl nest in emergent marsh plants and other suitable sites.

Increase in riparian habitat since construction of the dam has led to increases in both population size and species diversity within the river corridor. This new zone of vegetation provides important habitat for many native terrestrial wildlife species, including numerous species of mammals (including bats), birds, amphibians, reptiles, and terrestrial invertebrates.

Ant populations have increased after dam closure due to the reduced frequency of high bank scouring flows that removed colonies of ants from the scour zone. Willow communities support more species of insects compared to tamarisk communities.

Many passerine and/or migratory birds are dependent on this riparian vegetation for general and nesting cover and foraging areas. For insectivorous birds, riparian vegetation provides cover and food. Some species that do not nest in the riparian zone use the zone as feeding areas. At high flows during nesting season, some ground nesting birds may lose their young to inundation.

Riparian patch size is important to several bird species (e.g., southwestern willow flycatcher), and they will not use a patch that is too small. Actions that decrease riparian patch size would, therefore, affect use of these areas by these birds.

Numerous species of nongame vertebrate wildlife use riparian habitats along the Green River below Flaming Gorge Dam (Bogan et al., 1983). The greatest species diversity occurs in the riparian habitats of broad valleys such as Browns, Echo, Island, and Rainbow Parks. Wildlife is less diverse in canyon areas (e.g., Lodore, Split Mountain) because of limited riparian habitat.

Several bat species exist within the area. They are attracted to the river corridor by the insects associated with the river and riparian vegetation. Bats and birds are also important prey for raptors. The formerly endangered peregrine falcon (*Falco peregrinus*) feeds on bats, swallows and other passerine birds, and ducks within the canyons. Prey is plentiful due to the abundance of insects along the river that attract prey species for the falcon. The peregrine falcon occurs along the Green River below Flaming Gorge Dam and is most common in major canyons where potential nest and perch sites exist on cliff faces. The species nests within Dinosaur National Monument (Eason, 1992) along both the Green and Yampa Rivers. Numbers of nests have increased within the past two decades. Only 2 active nest sites were known within the monument in 1976, but 8 nesting pairs fledged a total of 13 young in 1992. There are currently 12 active eyries within Dinosaur National Monument. Each eyrie has fledged an average of one and two young per year. Although peregrines usually occur in the area only during the breeding season (March-October), some birds could occur during the winter (U.S. Fish and Wildlife Service, 1977).

Ringtail (*Bassariscus astutus*) are found in the river corridor. Human activity may increase their numbers due to the ringtail's scavenging habits in human refuse.

Several species of game mammals, including mule deer (*Odocoileus hemionus*), elk (*Cervus elaphus*), moose (*Alces alces*), pronghorn (*Antilocapra Americana*), and bighorn sheep (*Ovis Canadensis*), occur along the Green River corridor above and below Flaming Gorge Dam (BLM, 1990; Schnurr, 1992). All of these species use riparian habitats as foraging and watering areas but are not restricted to riparian areas at any time of the year. Mule deer, elk, and pronghorn range widely throughout this portion of Utah and Colorado but move toward the river in the fall and use the river valley, especially Browns Park, as wintering range. Mule deer occur along the river throughout the year and are the most abundant game mammal in the area. Moose numbers are low in the region but appear to be increasing (BLM, 1990). Within the area, moose habitat occurs in Browns Park.

The Green River and associated wetlands provide important breeding, migration, and wintering habitat for numerous waterfowl species (Aldrich, 1992). Before the river was confined by dikes and the dam, annual spring floods inundated bottomland areas in Browns Park and other broad flood plain areas along the river. These flooded bottomlands provided important foraging and breeding areas for migrating and resident water birds. Browns Park National Wildlife Refuge and Browns Park Wildlife Management Area, situated along the river corridor in Browns Park, are managed to mitigate the effects of dam-induced reductions in spring flooding on these important waterfowl habitats. Within these management areas, bottomlands are artificially flooded each year by pumping river water into diked marshlands to create suitable waterfowl habitat. Other slack water areas are attractive to waterbirds and provide habitat for them.

Waterfowl species that commonly breed along the Green River corridor include Canada goose (*Branta Canadensis*), mallard (*Anas platyrhynchos*), common merganser (*Mergus merganser*), gadwall (*Anus strepera*), green-winged teal (*Anus crecca*), and redhead (*Anthya Americana*). In addition to these species, American widgeon (*Anus Americana*), common goldeneye (*Bucephala clangula*), and American coot (*Fulica americana*) are common during migration or winter. Waterfowl use large eddies and riparian communities associated with them as nesting and brood habitat. They use ice-free areas of the river during the winter.

Canada geese are particularly susceptible to changes in flow on the Green River (Holden, 1992; Aldrich, 1992). Islands and sandbars with low vegetation (e.g., grasses and forbs) are important nesting habitat for this species, and Browns Park is the most important nesting area for Canada geese in the area (Schnurr, 1992). Most nesting occurs from March 15 to May 15.

Great blue heron (*Ardea herodias*), spotted sandpiper (*Actitis macularia*), and killdeer (*Charadrius vociferous*) forage along shoreline and riparian habitats during the breeding season (Bogan et al., 1983). The great blue heron uses large trees (e.g., cottonwood) as nesting and roosting sites along the river. Killdeer and spotted sandpiper nest on the ground above the water line.

Many species of amphibians and reptiles inhabit the river corridor. Most of these animals use both upland and riparian sites. The river is a source of abundant invertebrate food for these species. Cliff faces above the river provide escape and resting habitat for reptiles. The zone of fluctuating water level is an important foraging area for reptiles and amphibians. Dense stands of tamarisk do not usually provide suitable habitat for these animals (Jakle and Gatz, 1985). The leopard frog (*Rana pipiens*) depends on backwater and flooded bottom land habitat.

3.7.2.7.2 Reach 2 – This reach is home to herds of pronghorn, mule deer, elk, bighorn sheep, and wild horses. Mule deer are relatively common and widespread within this reach.

Bighorn sheep are common in riparian areas along the Green River within Lodore, Whirlpool, and Split Mountain Canyons. These animals are the result of reintroductions that began in 1952 after a die-off of the natural population.

Numerous species of nongame vertebrate wildlife use riparian habitats along the Green River below the Yampa River confluence. The greatest species diversity occurs in the riparian habitats of broad valleys, such as Echo, Island, and Rainbow Parks and Ouray National Wildlife Refuge. Wildlife is less diverse in canyon areas (e.g., Split Mountain) because of the lack of habitat diversity.

The Green River corridor within this reach provides habitat for a vast number of migrating waterfowl, shorebirds, and wading birds from spring through fall. Over 200 species of birds can be found within this reach. Hawks, Canada geese, falcons, and many species of songbirds are commonly seen. Bald eagles (*Haliaeetus leucocephalus*) winter along the Green River.

Other birds commonly using this area include the pied-billed grebe (*Podilymbus podiceps*), eared grebe (*Podiceps nigricollis*), western grebe (*Aechmophorus occidentalis*), Clark's grebes *(Aechmorphorus clarkia*), double-crested cormorant (*Phalacrocorax auritus*), great blue heron, snowy egret (*Egretta thula*), black-crowned night-heron (*Nycticorax nycticorax*), white-faced ibis (*Plegadis chihi*), American bittern (*Botaurus lentiginosus*), mallard, gadwall, northern pintail (*Anus acuta*), redhead, common merganser, ruddy duck (*Oxyura jamaicensis*), American widgeon, Virginia rail (*Rallus limicola*), black-necked stilt (*Himantopus mexicanus*), American avocet (*Recurvirostra Americana*), Wilson's phalarope (*Phalaropus tricolor*), Forster's tern (*Sterna forsteri*), black tern (*Chlidonias niger*), greater yellowlegs (*Tringa melanoleuca*), lesser yellowlegs (*Tringa flavipes*), willet (*Catoptrophorus semipalmatus*), killdeer, and all three species of teal. During migration, these species of birds and many others visit the Ouray National Wildlife Refuge and other wetlands, along with occasional flocks of sandhill cranes (*Grus canadensis*).

Marshlands yield abundant food, water, and shelter for migrating waterfowl. Cattails and bulrush provide nesting habitat for redhead and ruddy ducks. Most ducks, however, do not locate nests in such wet places, preferring drier sites. These include the mallard, pintail, gadwall, and cinnamon teal (*Anus cyanoptera*). Waterfowl offspring prefer concentrated, nutritious food.

Macroinvertebrates fulfill this need, and marsh waters can provide these small food parcels.

Cottonwoods grow in stands along the Green River. Although of marginal value to waterfowl, cottonwoods provide cover, food, and nesting sites for a wide variety of animals. Mule deer, raccoons (*Procyon lotor*), porcupines (*Erethizon dorsatum*), Lewis's woodpeckers (*Melanerpes lewis*), red-tailed hawks (*Buteo jamaicenis*), great horned owls (*Bubo virginianus*), yellow-rumped warblers (*Dendroica coronata*), and other wildlife frequent the cottonwood groves. Great blue herons and double-crested cormorants nest in rookeries high up in cottonwoods along the river. A blue heron rookery exists near Old Charley Wash. Cottonwoods give the area a lot of its wildlife diversity.

Many areas have salty or alkali soils; only vegetation tolerant of saline soils will flourish in these areas. Greasewood (*Sacrobatus vermiculatus*), tamarisk (*Tamarix* sp.), and saltgrass (*Distichlis spicata*) dominate the plant life. Although this habitat is not ideal for waterfowl due to its poor nesting cover, ducks such as cinnamon teal commonly nest in saltgrass if it is near water. These areas are important to mule deer as winter cover.

3.7.2.7.3 Reach 3 – The majority of terrestrial and avian animals that exist within riparian zones of the upper reaches of the affected area also exist within riparian zones of Reach 3. However, riparian habitat is much more limited in this reach than upstream reaches. Most of Reach 3 has a limited area of flood plain.

Species occupying the shrublands, grasslands, and riparian habitats near the river include the northern harrier (*Circus cyaneus*), burrowing owl (*Athene cunicularia*), ring-necked pheasant (*Phasianus colchicus*), Say's phoebe (*Sayornis saya*), western kingbird *(Tyrannus verticalis*) eastern kingbirds (*Tyrannus tyrannus*), horned lark (*Eremophila alpestris*), loggerhead shrike (*Lanius ludovicianus*), sage thrasher (*Oreoscoptes montanus*) (uncommon), vesper sparrow (*Pooecetes gramineus*), lark sparrow (*Chondestes grammacus*), and sage sparrow *(Amphispiza belli*), lazuli bunting (*Passerina amoena*), mourning dove (*Zenaida macroura*), yellow-billed cuckoo (*Coccyzus americanus*), Lewis's woodpecker (*Melanerpes lewis*), downy woodpecker (*Picoides pubescens*), hairy woodpecker (*Picoides villosus*), northern flicker (*Colaptes auratus*), black-capped chickadee (*Poecile atricapillus*), house wren (*Troglodytes aedon*), warbling vireo (*Vireo gilvus*), yellow warbler (*Dendroica petechia*), yellow-breasted chat (*Iicteria virens*), spotted towhee (*Pipilo maculatus*), northern oriole (*Icterus galbula*), marsh wren (*Cistothorus palustris*). Yellow-headed blackbird (*Xanthocephalus xanthocephalis*) breed in and around wetlands; and a few Lewis's woodpeckers nest in riverside cottonwoods. From spring through fall, Lewis's woodpecker can be found in cottonwood forests.

The river is used by beaver, northern river otter (*Lutra Canadensis*), and muskrats (*Ondatra zibethicus*). Adjacent stands of cottonwoods, willows, squawbrush (*Rhus trilobata*), and tamarisk (*Tamarix sp.*) provide cover for cottontails (*Sylvilagus auduboni*), raccoons, mule deer, bobcats (*Felis rufus*), and porcupines. Raptors, including bald and golden eagles (*Aquila chrysaetos*), great-horned owls, and several species of hawks, also use this habitat. Peregrine falcons and osprey (*Pandion haliaetus*) find refuge along the river.

Greasewood, rabbitbrush (*Chrysothamnus sp.*), and cacti compete for the limited water of the higher, drier sites. Prairie dogs (*Cynomys sp.*), jackrabbits (*Lepus sp.*), and coyotes (*Canis latrans*) are typical upland residents. Other upland species include burrowing owl (*Athene cunicularia*), short-eared owl (*Asio flammeus*), American kestrel (*Falco sparverius*), loggerhead shrike, sage thrasher, Brewer's sparrow (*Spizella breweri*), sage sparrow, Ord's kangaroo rat (*Dipodomys ordii*), black and white-tailed jackrabbit, desert cottontail (*Sylvilagus audubonii*), white-tailed antelope squirrel (*Ammospermophilus leucurus*), mule deer, and pronghorn. Many species of reptiles live in these uplands.

The river and its associated habitats provide food and cover for nesting ducks including mallards, pintails, and teal, as well as Canada geese. The area provides food for migrating waterfowl like sandhill cranes (*Grus Canadensis*) and whooping cranes (*Grus Americana*). Deer, raccoon, ring-necked pheasant, garter snake (*Thamnophis sirtalis*), Woodhouse's toad (*Bufo woodhousei*), boreal chorus frog (*Pseudacris triseriata*), and northern leopard frog (*Rana pipiens*) also benefit from the food and cover provided by these riparian habitats.

Wildlife depends on riparian zones within Desolation Canyon for habitat and water. These species include bighorn sheep, mule deer, elk, mountain lion (*Felis concolor*), black bear (*Ursus americanus*), golden eagle, prairie falcon (*Falco mexicanus*), Cooper's hawk (*Accipiter cooperii*), goshawk (*Accipiter gentiles*), American kestrel, red-tail hawk, Canada geese, bald eagle, and peregrine falcon.

3.7.3 Other Threatened and Endangered Species

3.7.3.1 Southwestern Willow Flycatcher

The southwestern willow flycatcher (*Empidonax traillii extimus*) was federally listed as an endangered species in 1995 (U.S. Fish and Wildlife Service, 1995). A final recovery plan was published in March 2003 (U.S. Fish and Wildlife Service, 2003). The U.S. Fish and Wildlife Service has designated an "administrative boundary" between subspecies of willow flycatchers until genetic and/or vocal analysis can offer a clearer distinction between the subspecies. The current administrative designation considers all resident willow flycatchers within the Colorado Plateau physiographic region south of the Uintah Basin to be southwestern willow flycatchers. Therefore, for this EIS, only Reach 3 is considered to be southwestern willow flycatcher habitat. There is no critical habitat designation within the Green River Basin.

The southwestern willow flycatcher is a small neotropical migrant bird that depends on riparian vegetation for much of its life cycle. Once common along rivers of the Southwest, rough estimates are that there are now 1,200 to 1,300 pairs left in the United States. Population declines are attributed to loss and fragmentation of riparian habitat, encroachment of exotic plants, and parasitism by brown-headed cowbirds. In Utah and Colorado, the southwestern willow flycatcher historically nested in dense willow habitat that tended to have a scattered overstory of cottonwoods. Following widespread invasion of nonnative shrubs, the southwestern willow flycatcher now also nests in tamarisk and Russian olive. Preferred nesting habitat also seems to be associated with standing water, exposed sandbars, or nearby fluvial marshes.

Using the U.S. Fish and Wildlife Service approved protocol (Sogge et al., 1997a), surveys were conducted in Reach 3 in 1999 and 2000 (Johnson et al., 1999; Howe and Hanberg, 2000; Howe, 2000). A total of eight birds were identified as southwestern willow flycatchers. The majority of suitable habitat between Ouray and Green River, Utah, occurs on islands and sandbars (Howe and Hanberg, 2000). Mainland patches of large tamarisk, often mixed with willow, characterize southwestern willow flycatcher habitat along the lower Green River. The habitat component of standing water or fluvial marshes is limited.

There is little information about the history of southwestern willow flycatcher along the Green River. Explanations as to the absence of birds are speculative. Causes are most likely due to unsuitable habitat components (i.e., geographic, temperature, predators, food resources, adjacent land uses, and lack of standing water) and effects of historic extirpation and slow colonization (Johnson et al., 1999). In addition, 2 years of surveys do not necessarily mean that birds have been extirpated from the lower Green River. Sogge et al. (1997b) have documented several instances where flycatchers disappeared from former breeding locations along the Colorado River only to return 3 to 5 years later. Suitable habitat may currently be unoccupied because the flycatcher is now so rare that there are not enough individuals to disperse into all available habitats. If so, effective management of suitable but unoccupied riparian habitats is important as these birds recover under Endangered Species Act recovery activities.

Survey results indicate that the Green River is used as a migratory stopover for northern subspecies of willow flycatchers moving farther north to breed and for possible intergrades between the subspecies. Migration is a period of extreme energy demand, and most songbirds must stop periodically during migration to replenish depleted fat stores. Based on the numbers recorded during surveys, the Green River appears to provide important stopover habitat for the willow flycatcher subspecies as well as other neotropical migrants.

3.7.3.2 Ute Ladies'-Tresses

The Ute ladies'-tresses (*Spiranthes diluvialis*) was federally listed as a threatened species on January 17, 1992 (U.S. Fish and Wildlife Service, 1992a). Critical habitat has not been designated for this species. The current range of Ute ladies'-tresses includes Colorado, Idaho, Montana, Nebraska, Utah, Washington, and Wyoming, with a historical occurrence in Nevada. Along the Green River, Ute ladies'-tresses are currently found only in Reaches 1 and 2.

The Ute ladies'-tresses is a perennial orchid which typically occurs on sandy or loamy alluvial soils mixed with gravels. Typical habitat is in mesic to very wet meadows along streams and abandoned stream meanders, riparian edges, gravel bars, and near springs, seeps, and lakeshores at elevations ranging from 4265 to 6561 feet (U.S. Fish and Wildlife Service, 1992a; UDWR, 2002; Nevada Natural Heritage Program, 2001; NatureServe, 2001). Threats to populations of Ute ladies'-tresses include modification of riparian habitats by urbanization, stream channelization (for agriculture and development) and other hydrologic changes, conversion to agriculture and development, heavy summer livestock grazing, and hay mowing. Most populations are small and vulnerable to extirpation by habitat changes or local catastrophic events (U.S. Fish and Wildlife Service, 1992a). Several historic populations in Utah and Colorado appear to have been extirpated.

Populations of Ute ladies'-tresses often are located in riparian habitats on active flood plains in unconfined river reaches below confined reaches (Ward and Naumann, 1998). Along major rivers, these habitats may be somewhat transitory, subject to erosion and deposition. Ute ladies'-tresses are often found in early mid-succession stage habitats, and adverse changes to habitat in some areas may be the result of succession resulting in tall and dense vegetation. Periodic inundation may help maintain open habitat characteristics. Although tolerant of periodic inundation, frequent scouring or deposition can eliminate Ute ladies'-tresses or preclude their establishment (Ward and Naumann, 1998).

3.7.3.2.1 Reach 1 – A large number of Ute ladies'-tresses occurs within Reach 1. The occurrence of Ute ladies'-tresses along the Green River is influenced by river channel geometry, hydrology, and depositional and erosional patterns. Surveys conducted from 1998 to 2002 located 10 sites in Red Canyon, 25 sites in Browns Park, and 81 sites in Lodore Canyon (Grams et al., 2002; Ward and Naumann, 1998). The numbers of individuals found at these locations were generally low, ranging from 1 to 50; however, several sites in Lodore Canyon contained hundreds of flowering plants.

Within Reach 1, Ute ladies'-tresses predominantly occur on features that post-date Flaming Gorge Dam: post-dam flood plains and intermediate benches (Ward and Naumann, 1998; Grams et al., 2002). The post-dam flood plains are typically flat surfaces and are inundated annually by flows of 4,600 cfs; the intermediate benches are inundated by 10,900 cfs and average 6.2 feet above the 800-cfs base flow. In Lodore Canyon, many otherwise suitable areas are invaded with tamarisk and support few or no Ute ladies'-tresses.

3.7.3.2.2 Reach 2 – Within Reach 2, riverflows are strongly influenced by the Yampa River, and suitable habitat for Ute ladies'-tresses is less common (Ward and Naumann, 1998).

In Island Park and Rainbow Park, Ute ladies'-tresses typically occur on post-dam flood plains and intermediate benches, which are inundated more frequently than in Reach 1. In this reach, the post-dam flood plains are inundated at about 16,100 cfs (the post-dam 2-year flood). The intermediate benches are likely inundated by flows exceeding 20,000 cfs (and typically above the 17,100-cfs stage). Most occurrences of Ute ladies'-tresses are found on areas approximately 3 feet above the 3,300-cfs elevation. In this reach, nine populations of Ute ladies'-tresses have been found in Island Park-Rainbow Park, five below Split Mountain (Ward and Naumann, 1998). One population in Island Park occurs on a higher terrace, averaging 14 feet above base flow, which shows no evidence of inundation.

3.7.3.3 Bald Eagle

About 50 bald eagles (*Haliaectus leucocephalus*) winter along the Green River below Flaming Gorge Dam each year (Howe, 1992; Huffman, 1992). Eagles perch in large trees, especially cottonwoods, near open, ice-free water and forage for fish and occasionally waterfowl. Concentrations of eagles occur in broad, open areas of the valley with cottonwood groves, such as Browns Park and Island Park (Huffman, 1992).

Although nesting by the bald eagle has not been observed in the vicinity of Flaming Gorge Dam or the Green River, it is possible given documented nesting activity elsewhere in Utah and Colorado (Kjos, 1992) and the availability of suitable large cottonwood trees in Browns, Island, and Rainbow Parks.

The bald eagle winters along the Green River below the dam and also around the reservoir. They feed on the abundant trout population, especially during spawning activities of winter-spawning trout. Osprey also are found in the same areas and exploit the same prey base. Riparian areas with large cottonwood trees are used for roosting and perching. There are no known bald eagle nests in the area.

3.7.3.4 Black-Footed Ferret

Black-footed ferret (*Mustela migripes*) exist in release sites in eastern Utah near the Colorado border, located near prairie dog towns in the project area. These release sites are in Coyote Basin in Uintah County southeast of Jensen, Utah. This species is very rare.

3.7.3.5 Canada Lynx

Canada lynx (*Lynx canadensis*) may exist within the project area in coniferous forests. The Uinta Mountains likely form the species' southernmost range, though recent reports have given evidence of their existence in the Manti LaSal National Forest further south. The species is considered rare in Utah.

3.7.3.6 Mexican Spotted Owl

Mexican spotted owls (*Strix occidentalis Lucida*) are found within the Green River corridor. They were listed as a threatened species in 1993. This bird nests in caves in steep-walled, usually narrow, moist canyons. Most nesting sites occur in southern Utah, but sites have been found as far north as Dinosaur National Monument (Huffman, 1992). These owls prey on a variety of animals including mice, vole, bats, birds, and beetles, but their primary prey is woodrat. The primary threat to these birds has been habitat loss due to timber harvest practices. These owls prefer diverse, multiple layered forests. They will use uniform forests, grasslands, and shrublands also. The Mexican spotted owl is a potential year-round resident in wooded canyons along the Green River in all reaches below Flaming Gorge Dam. They are found as far north as Dinosaur National Monument.

3.7.4 Other Special Status Species

3.7.4.1 Yellow-Billed Cuckoo

In July 2001, the U.S. Fish and Wildlife Service announced the designation of the western population of the yellow-billed cuckoo (*Coccyzus americanus*) as a candidate species for listing as federally endangered. The yellow-billed cuckoo is currently listed on several State wildlife lists as sensitive or threatened, including Utah (as sensitive). Biologists have generally recognized western and eastern subspecies. The eastern and western populations are considered to be discrete based on physical (geographical area), morphological, behavioral, and genetic characteristics (U.S. Fish and Wildlife Service, 2001).

Yellow-billed cuckoo were historically uncommon to rare in Utah and likely uncommon in western Colorado (Bailey and Niedrach, 1965 in U.S. Fish and Wildlife Service, 2001; Kingery, 1998 in U.S. Fish and Wildlife Service, 2001). While still relatively common east of the Rockies, cuckoos of the West have faced significant population declines due to loss or degradation of 80-95% of their habitat, increased use of pesticides (thereby reducing food sources), and low colonization rates (U.S. Fish and Wildlife Service, 2001; Hughes, 1999). Habitat degradation and loss have been attributed to the result of conversion to agriculture, grazing, dams and riverflow management, bank protection, and competition from exotic plants. Additional impacts identified on the Green River include recreation and oil and gas drilling (Howe and Hanberg, 2000).

3.7.4.1.1 Reach 1 – Current conditions in Reach 1 provide little to no suitable habitat for yellow-billed cuckoo. Instead of the dense understory of riparian vegetation that characterize cuckoo habitat, the cottonwood gallery forests of Browns Park have an understory of low desert shrubs. There is little cottonwood regeneration occurring, and the cottonwood forests are being replaced by desert shrubs. There have been no recorded sightings of yellow-billed cuckoo in Reach 1.

3.7.4.1.2 Reach 2 – The Ouray area of Reach 2 contains large patches of suitable habitat—mature cottonwood forest with dense understory. Yellow-billed cuckoo breeding was confirmed in 1992. From 1999 through 2001, additional birds were detected at four sites in the Ouray area. Breeding was not confirmed but was probable due to the presence of birds and territories during late-season surveys. Ute Indian tribal lands along Reach 2 have not been surveyed.

3.7.4.1.3 Reach 3 – Suitable habitat in Reach 3 is characterized by large blocks of vegetation having an extensive overstory of cottonwood and old-growth tamarisk with a dense understory of tamarisk and willow. Eighteen sites with potential cuckoo habitat have been identified in sections of Reach 3 from the upper end of Desolation Canyon to the lower end of Gray Canyon (Howe and Hanberg, 2000). Additional suitable habitat has been identified along the lower Green River in Canyonlands National Park (Johnson et al., 1999). Recent surveys for Reach 3 have recorded a single sighting at Mineral Bottom.

3.7.4.2 Whooping Crane

Whooping cranes (*Grus americanus*) migrate through the region of Flaming Gorge Dam and the Green River Basin in the spring and fall. These cranes belong to a population established at Gray's Lake National Wildlife Refuge in southeastern Idaho. These birds are part of a recovery program for this species (Armbruster, 1990). Efforts to establish the Gray's Lake population began in 1975. The current population consists of cranes that have not yet nested but migrate annually with sandhill cranes to wintering grounds in and around the Bosque del Apache National Wildlife Refuge (Armbruster, 1990).

Habitats used by whooping cranes during migration include agricultural fields, wetlands, and small reservoirs (Rose, 1992). Whooping cranes have been observed in the vicinity of the Green River near Jensen, Utah. Wetlands along the river could be used occasionally by migrating individuals.

3.8 CULTURAL RESOURCES

Historic properties are the subset of cultural resources including sites, districts, buildings, structures, or objects that are at least 50 years of age and are included in, or eligible for inclusion in, the *National Register of Historic Places* (NRHP). Historic properties also include properties of traditional religious and cultural importance to tribes and other communities that meet one or more of the NRHP criteria for evaluation (see Code of Federal Regulations [CFR] 60). Cultural resources also include sacred sites as defined under Executive Order 13007.

3.8.1 Definition of Affected Environment

The affected environment for cultural resources corresponds to the area of potential effect (APE), defined in 36 CFR 800.16(d) as "the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if any such properties exist." For purposes of this EIS, the APE for cultural resources includes Flaming Gorge Reservoir and the Green River flood plain downstream from Flaming Gorge Dam to the town of Green River, Utah. Though Reach 3 extends to the confluence of the Green and Colorado Rivers, Reclamation believes that the best available data (see section 4.3.2.7) about implementing flow recommendations results in such negligible changes in hydrology below the town of Green River, Utah, that this is a reasonable termination point for the determination of APE for cultural resources.

Effects to cultural resources were defined following 36 CFR 800.16(i) as any alteration to the characteristics of a historic property qualifying it for inclusion in or eligibility for the NRHP. Direct, indirect, or cumulative effects were defined using a combination of the Council of Environmental Quality regulations at 40 CFR 1508.8 and the criteria of adverse effect at 36 CFR 800.5. Direct effects are reasonably foreseeable changes in the integrity of properties believed to be caused by the proposed action and that are likely to occur at the same time and place; indirect effects were defined as those reasonable foreseeable effects caused by the undertaking that may occur later in time, be further removed in distance or be cumulative.

Reclamation reviewed existing information on historic properties and other resources within the APE in compliance with 36 CFR 800.4(a). To identify cultural resources that might be present within the APE of the proposed action, Reclamation reviewed information on file at the State Historic Preservation Offices (SHPO) of Wyoming, Colorado, and Utah, as well as information synthesized by Spangler (1995). Information regarding the locations of individual cultural resource sites is restricted in order to preserve and protect these nonrenewable resources.

Consultation regarding cultural resources has been conducted with the Northern Ute Tribe; the Southern Ute Tribe; the Ute Mountain Ute Tribe; the Northwest Band of Shoshone; the Wind River Shoshone of Fort Washakie; the Hopi Tribe; the Paiute Indian Tribe of Utah; the Pueblo of Nambe; the Pueblo of Zia; the Kaibab Paiute Tribe; the Pueblo of Laguna; and the Pueblo of Zuni.

Information was also sought from Federal land managing agencies surrounding Flaming Gorge Reservoir and lands bordering the Green River downstream from Flaming Gorge Dam to the confluence of the Green and Colorado Rivers. This section describes the cultural resources located within the Flaming Gorge Reservoir APE and within the APE downstream along Reaches 1, 2, and 3 of the Green River.

3.8.1.1 Flaming Gorge Reservoir

Historic properties near Flaming Gorge Reservoir that could be affected by the proposed action are defined by location either below or above the 6040-foot-high water level elevation of the reservoir. Sites located below this level could be directly affected, and those located above could be indirectly and cumulatively affected. For a list of cultural resource sites located in and around the reservoir, see tables 3-11 and 3-12.

3.8.1.2 Green River

The downstream APE for cultural resources includes all of Reaches 1 and 2. The APE for the proposed action on Reach 3 extends from the confluence of the Green and White Rivers to the confluence of the Green and Colorado Rivers. However, since the hydrological model showed negligible differences in stage elevations between the No Action and the Action Alternatives, the APE for cultural resources was not extended further downstream than the town of Green River, Utah.

In all three reaches, the lateral extent of the APE considered for cultural resources is the flood plain of the Green River that could be inundated or wetted by the maximum proposed releases from Flaming Gorge Dam under the No Action and Action Alternatives. The indirect and cumulative effect on downstream resources is defined by the highest historic release from the dam of 12,300 cfs.

3.8.1.2.1 Reach 1 – Potentially affected cultural resources situated below Flaming Gorge Dam in Reach 1 on the Green River were determined based on a 10,000-cfs water flow in the river. See frontispiece map for the location of Reaches 1, 2, and 3. Historic properties that could be inundated at the 10,000-cfs water level were considered to be within the APE. Those located above the 10,000-cfs water level but below the highest historic release from the dam (12,300 cfs, March 16, 1983) (Elbrock, 2004) are also considered to be within the APE because they could be indirectly and perhaps cumulatively affected. Table 3-13 lists all previously documented cultural resource sites in Reaches 1 and 2 that could be affected by the proposed action. There are 33 located in Utah, and 16 are in Colorado. Thirty-two of the sites are prehistoric, eleven are historic, five are unknown, and one is multicomponent (both prehistoric and historic). Of the 49 sites, 24 are either listed on or eligible for the NRHP.

3.8.1.2.2 Reach 2 – The APE for cultural resources in Reach 2 was also determined using hydrologic modeling information and historic flood flow information. At the beginning of Reach 2, the Yampa River adds a large volume of water to the Green River. Thus, cultural resource sites located in the flood plain, in areas that would be inundated by a flow of 25,000 cfs, could be directly affected by the proposed action. Sites at an elevation that could be inundated by flows greater than 25,000 cfs could be indirectly affected (see table 3-13).

3.8.1.2.3 Reach 3 – Reach 3 begins at river mile 165 downstream from Flaming Gorge Dam at the confluence of the Green and White Rivers and ends at river mile 411 with the confluence of the Green and Colorado Rivers.

Table 3-14 lists cultural resource sites in the Reach 3 APE. There are 24 sites—18 are prehistoric, 4 are historic, 1 is multicomponent, and 1 is unknown. Of the 24 cultural resource sites, 12 are either listed in or eligible for the NRHP. All of Reach 3 is located in Utah.

Table 3-11.—Cultural Resources Inundated by Flaming Gorge Reservoir by Prior Mitigation, Cultural Resource Site Type, Age, and NRHP Eligibility

Site No.	Prior Mitigation	Age	Cultural Resource Site Type	NRHP Eligibility
42DA026	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW009	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW010	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW011	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW012	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW013	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW014	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW015	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW016	No	Prehistoric	Lithic scatter with feature	Not eligible
48SW017	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW018	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW022	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW028	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW029	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW030	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW036	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW040	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW041	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW042	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW048	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW049	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW051	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW053	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW054	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW055	No	Prehistoric	Lithic scatter with feature	Not eligible
48SW056	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW057	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW058	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW068	Yes	Prehistoric	Lithic scatter with feature	Not eligible
48SW027	No	Prehistoric	Hearth	Not eligible
42DA002	Yes	Prehistoric	Lithic scatter	Not eligible
42DA008	Yes	Prehistoric	Lithic scatter	Not eligible
42DA009	Yes	Prehistoric	Lithic scatter	Not eligible
42DA018	Yes	Prehistoric	Lithic scatter	Not eligible
42DA019	Yes	Prehistoric	Lithic scatter	Not eligible
42DA023	Yes	Prehistoric	Lithic scatter	Not eligible

Table 3-11.—Cultural Resources Inundated by Flaming Gorge Reservoir by Prior Mitigation, Cultural Resource Site Type, Age, and NRHP Eligibility (Continued)

Site No.	Prior Mitigation	Age	Cultural Resource Site Type	NRHP Eligibility
42DA025	Yes	Prehistoric	Lithic scatter	Not eligible
42DA027	Yes	Prehistoric	Lithic scatter	Not eligible
42DA028	Yes	Prehistoric	Lithic scatter	Not eligible
42DA029	Yes	Prehistoric	Lithic scatter	Not eligible
48SW003	Yes	Prehistoric	Lithic scatter	Not eligible
48SW021	Yes	Prehistoric	Lithic scatter	Not eligible
48SW023	Yes	Prehistoric	Lithic scatter	Not eligible
48SW024	Yes	Prehistoric	Lithic scatter	Not eligible
48SW025	Yes	Prehistoric	Lithic scatter	Not eligible
48SW026	Yes	Prehistoric	Lithic scatter	Not eligible
48SW034	Yes	Prehistoric	Lithic scatter	Not eligible
48SW035	Yes	Prehistoric	Lithic scatter	Not eligible
48SW037	Yes	Prehistoric	Lithic scatter	Not eligible
48SW038	Yes	Prehistoric	Lithic scatter	Not eligible
48SW039	Yes	Prehistoric	Lithic scatter	Not eligible
48SW4242	No	Prehistoric	Lithic scatter	Not eligible
48SW4244	No	Prehistoric	Lithic scatter	Not eligible
48SW4245	No	Prehistoric	Lithic scatter	Not eligible
48SW008	Yes	Prehistoric	Lithic scatter	Not eligible
42DA001	No	Prehistoric	Rock shelter	Not eligible
42DA003	No	Prehistoric	Rock shelter	Not eligible
42DA020	Yes	Prehistoric	Rockshelter	Not eligible
48SW047	Yes	Prehistoric	Rockshelter	Not eligible
48SW045	Yes	Prehistoric	Rockshelter with rock art	Not eligible
42DA010	Yes	Prehistoric	Rockshelter with structures	Not eligible
48SW046	Yes	Prehistoric	Rockshelter with structures	Not eligible
42DA468	No	Prehistoric	Storage cist	Not eligible
48SW050	No	Prehistoric	Stratified, multicomponent	Not eligible
48SW059	No	Prehistoric	Stratified, multicomponent	Not eligible
42DA363	No	Historic	Town site	Not eligible
48SW060	No	Prehistoric	Lithic scatter with feature	Not eligible

Table 3-12.—Cultural Resources Immediately Above the Flaming Gorge Reservoir Pool by Prior Mitigation, Cultural Resource Site Type, Age, and NRHP Eligibility

Site No.	Prior Mitigation	Age	Cultural Resource Site Type	NRHP Eligibility
42DA011	Yes	Prehistoric	Lithic and ceramic scatter	Eligible
42DA012	Yes	Prehistoric	Lithic scatter	Eligible
42DA015	Yes	Prehistoric	Lithic scatter with feature	Not eligible
42DA016	Yes	Prehistoric	Lithic scatter with feature	Eligible
42DA017	Yes	Prehistoric	Lithic scatter with feature	Unevaluated
42DA497	No	Prehistoric	Lithic scatter	Unevaluated
48SW00033	Yes	Prehistoric	Lithic scatter	Not eligible
48SW00080	Yes	Prehistoric	Lithic scatter	Eligible
48SW00361	No	Prehistoric	Quarry	Not eligible
48SW04243	No	Prehistoric	Lithic scatter	Not eligible
48SW09382	No	Prehistoric	Habitation with features	Not eligible
48SW10430	No	Prehistoric	Lithic scatter with feature	Eligible
48SW13230	No	Historic	Burial	Not eligible

Table 3-13.—Cultural Resources Within the Reaches 1 and 2 Areas of Potential Effects by Direct or Indirect Impacts, Age, Cultural Resource Site Type, and NRHP Eligibility

Site No.	Effect	Age	Cultural Resource Site Type	NRHP Eligibility
42DA030	Indirect	Prehistoric	Rockshelter	Eligible
42DA040	Indirect	Prehistoric	Campsite	Eligible
42DA196	Direct	Prehistoric	Lithic scatter	Eligible
42DA203	Direct	Prehistoric	Campsite	Eligible/Tested
42DA204	Indirect	Prehistoric	Lithic scatter	Not eligible
42DA225	Indirect	Prehistoric	Lithic scatter	Not eligible
42DA332	Indirect	Multicomponent	Lithic scatter, corral	Not eligible
42DA337	Indirect	Prehistoric	Habitation	Eligible
42DA338	Indirect	Historic	Canal	Not eligible
42DA339	Indirect	Prehistoric	Lithic scatter	Not eligible
42DA341	Indirect	Prehistoric	Lithic scatter	Not eligible
42DA342	Indirect	Historic	Dugout	Eligible/Tested
42DA377	Indirect	Prehistoric	Lithic scatter	Not eligible
42DA394	Direct	Historic	Canal	Eligible
42DA485	Indirect	Prehistoric	Campsite	Eligible

Table 3-13.—Cultural Resources Within the Reaches 1 and 2 Areas of Potential Effects by Direct or Indirect Impacts, Age, Cultural Resource Site Type, and NRHP Eligibility (Continued)

Site No.	Effect	Age	Cultural Resource Site Type	NRHP Eligibility
42DA561	Indirect	Unknown	Unknown	Unknown
42DA562	Indirect	Prehistoric	Lithic scatter	Eligible
42DA564	Direct	Prehistoric	Campsite	Eligible/Tested
42DA661	Indirect	Prehistoric	Lithic scatter	Not eligible
42DA668	Indirect	Prehistoric	Rockshelter	Eligible
42DA750	Indirect	Prehistoric	Lithic scatter	Not eligible
42DA751	Indirect	Prehistoric	Lithic scatter	Not eligible
42UN0054	Direct	Prehistoric	Rockshelter	Tested
42UN0065	Indirect	Prehistoric	Lithic scatter	Not eligible
42UN0136	Direct	Unknown	Unknown	Unevaluated
42UN0256	Indirect	Unknown	Unknown	Unevaluated
42UN0265	Indirect	Prehistoric	Campsite	Eligible
42UN0267	Indirect	Prehistoric	Rock art	Eligible
42UN0271	Indirect	Prehistoric	Rockshelter	Eligible
42UN1563	Indirect	Historic	Bridge	Not eligible
42UN1600	Indirect	Historic	Structure	Not eligible
42UN1746	Indirect	Prehistoric	Campsite	Eligible
42UN260	Direct	Unknown	Unknown	Unevaluated
5MF0067	Indirect	Prehistoric	Structure	Eligible
5MF0605	Direct	Historic	Structure	Listed/Tested
5MF0840	Direct	Prehistoric	Structure	Eligible/Tested
5MF1230	Indirect	Prehistoric	Campsite	Not Eligible
5MF1233	Direct	Historic	Trash scatter	Eligible
5MF1234	Direct	Historic	Building	Eligible/Tested
5MF1238	Indirect	Prehistoric	Lithic scatter	Not eligible
5MF2357	Indirect	Historic	Inscription, cabin	Listed
5MF2388	Indirect	Historic	Cabin	Not eligible
5MF2399	Direct	Historic	Structure	Not eligible
5MF2498	Direct	Unknown	Unknown	Not eligible
5MF2964	Direct	Prehistoric	Rock art	Eligible
5MF2966	Direct	Prehistoric	Rock art	Eligible
5MF2968	Direct	Prehistoric	Rock art	Eligible
5MF3668	Direct	Prehistoric	Lithic scatter	Not eligible/Tested
5MF3669	Indirect	Prehistoric	Lithic scatter	Not eligible

Table 3-14.—Cultural Resources Within the Reach 3 Area of Potential Effects by Direct or Indirect Impacts, Age, Cultural Resource Site Type, and NRHP Eligibility

Site No	Effect	Age	Cultural Resource Site Type	NRHP Eligibility
42Cb220	Indirect	Prehistoric	Rock art	Listed
42Cb228	Indirect	Prehistoric	Lithic scatter with groundstone	Eligible
42Cb235	Indirect	Prehistoric	Rock Art	Eligible
42Cb236	Indirect	Prehistoric	Rock Art	Eligible
42Em0655	Indirect	Prehistoric	Lithic and ceramic scatter	Eligible
42Em0723	Indirect	Prehistoric	Rock art	Eligible
42Em1071	Indirect	Prehistoric	Lithic scatter	Eligible
42Gr0618	Direct	Prehistoric	Lithic scatter	Not eligible
42Gr0655	Direct	Prehistoric	Lithic scatter	Not eligible
42Gr0815	Direct	Multicomponent	Rock art, sheep camp	Eligible
42Gr2552	Indirect	Historic	Building	Not eligible
42Gr2553	Indirect	Historic	Rock alignment	Not eligible
42Gr2558	Indirect	Prehistoric	Lithic scatter	Not eligible
42Gr2559	Indirect	Prehistoric	Lithic scatter	Not eligible
42Gr2560	Indirect	Historic	Building	Not eligible
42Un0137	Indirect	Prehistoric	Lithic quarry	Not eligible
42Un0230	Direct	Unknown	No form, no card	Unevaluated
42Un0349	Indirect	Prehistoric	Rock art	Eligible
42Un0432	Indirect	Prehistoric	Lithic scatter with groundstone	Eligible
42Un0446	Indirect	Historic	Campsite (Powell)	Eligible
42Un0729	Indirect	Prehistoric	Lithic scatter with groundstone	Not eligible
42Un0869	Indirect	Prehistoric	Rock art	Not eligible
42Un0870	Indirect	Prehistoric	Lithic scatter	Not eligible
42Un0967	Direct	Prehistoric	Rock art	Eligible

It should be noted here that all of Desolation Canyon in Reach 3 was designated a National Historic Landmark in 1969. Desolation Canyon was selected based on its exceptional historic value, including the John Wesley Powell expedition which passed through the canyon in 1869.

3.9 Paleontological Resources

Paleontologists from the Utah Geological Survey assessed the geological formations and the known paleontological resources in the vicinity of Flaming Gorge Reservoir and the Green River downstream from Flaming Gorge Dam that lie within the project area for the Proposed Action (DeBlieux et al., 2002). They concluded that the most sensitive formations for paleontological resources are the Morrison, Cedar Mountain, Uinta, and Duchesne River Formations. Information about the locations of individual paleontological resources is restricted to help preserve and protect these nonrenewable resources.

The current assessment of paleontological resources was taken from DeBlieux et al. (2002). The report assessed the likelihood that paleontological resources would be found in the geologic formations along the shores of Flaming Gorge Reservoir and along the course of the Green River to the confluence of the White River within the State of Utah. The majority of rock units exposed along the shores of the reservoir and the Green River are fossil-bearing. Several geological formations contain significant fossil resources and are ranked in the *very sensitive* and *extremely sensitive* categories for paleontological resources as defined by the State paleontologist of Utah. These include the Morrison, Cedar Mountain, Uinta, and Duchesne River Formations. Several other formations have the potential to contain significant fossil resources based on the occurrence of significant fossils in these formations in other regions, and these formations are placed in the *significant sites known* category. Formations placed in this category are the Park City/Phosphoia, Moenkope, Chinle, Stump, Mowry, Mancos, Wasatch, and Green River and the Mesa Verde Group.

A 2003 pedestrian inventory of 50 miles of shoreline along Flaming Gorge Reservoir in Wyoming concluded that neither paleontological nor cultural resource sites were located between the high and low water marks in that area (Todd, 2003).

Reservoir margins are important sites for erosion and fossil exposure for several reasons. First, wave action along the shore exposes rocks even where they were previously covered by alluvial soils and vegetation. Second, fluctuating water levels expose the shore to a variety of energy and environmental conditions. Finally, reservoir shores are readily accessible to visitors, which can result in the loss of fossils and, much like cultural resources, may be disturbed, destroyed, or stolen, either by unintentional mistreatment or by intentional vandalism and theft.

The report (DeBleuix et al., 2002) involved a literature search and a search of the Utah Paleontological Database. This information was used to construct paleontological sensitivity maps, which are included in the report. A field survey of the most sensitive formation was conducted, using a boat to access potential fossil-bearing strata along the shores of Flaming Gorge Reservoir, and resulted in the discovery of several fossil sites, including a significant vertebrate track site.

Most geologic deposits along the Green River corridor in Reaches 1, 2, and 3 consist of unconsolidated river-deposited sands and gravels that are of low paleontological sensitivity. In regard to fossil sites along the Green River in Dinosaur National Monument, the Utah Geological Survey contacted the Chief of Research and Resource Management at Dinosaur National Monument (written communication, 2002) who stated that as far as park personnel are aware, no significant fossil sites are located along the river corridor within the project area.

3.10 INDIAN TRUST ASSETS

Indian trust assets are legal interests in property held in trust by the United States for Indian tribes or individuals. Examples of trust assets are lands, minerals, hunting and fishing rights, and water rights. The United States has an Indian trust responsibility to protect and maintain rights reserved by or granted to Indian tribes or Indian individuals by treaties, statutes, and Executive orders which are sometimes further interpreted through court decisions and regulations. This trust responsibility requires Reclamation to take all actions reasonably necessary to protect trust assets.

The Uintah and Ouray Reservation was established by the Executive orders of October 3, 1861, and January 5, 1882, and by Acts of Congress approved May 27, 1902, and June 19, 1902. The reservation, reaching from the Utah/Colorado border west to the Wasatch Mountain Range, consists of approximately 4.5 million acres with lands in Carbon, Duchesne, Grand, Uintah, and Utah Counties, Utah. The Northern Ute Indian Tribe of the Uintah and Ouray Reservation, with approximately 3,200 enrolled members, consists of three Ute bands: the Uintah, Uncompahgre, and Whiteriver. Tribal headquarters are located at Fort Duchesne. According to the U.S. Census, the total five-county population of the reservation was 19,182 in 2000 compared to a 1990 population of 17,224. A portion of Reach 2 of the Green River passes through the reservation in Uintah County near Ouray, Utah. Reach 3 continues through reservation lands in Uintah County and adjacent to reservation lands in Grand County. Indian trust assets of concern for this action include the rights to fish, hunt, and gather. The resources that provide for these rights to be exercised include fish, wildlife, and vegetation. In addition, land and mineral rights are important trust assets for the Ute Indian Tribe. The ability to exercise these rights (i.e., agricultural production and the development, operation, and maintenance of oil and gas wells) is of special concern for this action.

3.11 RECREATION

This section describes the geographic impact area and current conditions for recreation. The geographic impact area describes where the majority of impacts are expected to occur as well as the rationale for defining the impact area. The current conditions section presents current information on riverflows and reservoir water levels, recreation visitation, and recreation economic value.

3.11.1 Geographic Impact Area

Flaming Gorge Reservoir and the Green River for approximately 12 miles downstream from the dam comprise the Flaming Gorge National Recreation Area which is managed by the Ashley National Forest, USDA Forest Service (see map at the front of this document). After exiting the Flaming Gorge National Recreation Area, the Green River flows across BLM and State of Utah lands for approximately 18 miles before entering the U.S. Fish and Wildlife Service-managed Browns Park National Wildlife Refuge along the Utah and Colorado border, 30 miles downstream from the dam. Immediately downstream from the refuge, approximately 47 miles downstream from the dam, lies Dinosaur National Monument managed by the National Park Service. The upper portion of Dinosaur Nation Monument, upstream of the confluence with the Yampa River, reflects the end of Reach 1 of the study area.

This recreation visitation and value analysis addresses impacts to both Flaming Gorge Reservoir and the Green River downstream from Flaming Gorge Dam. The analysis focuses upon the effects on recreation visitation and economic value within Reach 1 and, specifically, within the Flaming Gorge National Recreation Area, where the majority of the potentially impacted water-based recreation occurs. Relatively little of the river-oriented recreation activity within the region initiates within the 35-mile stretch of the river between the Flaming Gorge National Recreation Area and Dinosaur National Monument.

In Dinosaur National Monument, water-based recreation is dominated by rafting activities. Rafting within the monument is managed via a permit system that covers both the Green and Yampa Rivers. If flow conditions deteriorated on the Green River to the point of adversely impacting rafting activity, the possibility exists of shifting activity to the Yampa River. While the National Park Service constrains the total number of permits for both commercial and private rafting parties across both rivers to 600 a year and the number of launches from either river to 4 per day, there still exists the potential for rafting substitution between the rivers. In addition, the majority of commercial and private rafting trips are scheduled well ahead of time. Commercial rafting operations are popular, and early reservations are often required since space on these trips tends to fill up quickly. Private rafting permits are limited to one per person annually and must be obtained via a lottery system months prior to the actual trip date. Given the degree of planning and financial commitment required for these rafting trips, a fairly strong incentive exists to take trips even when flow conditions are less than ideal. To substantiate this discussion, attempts were made to model the impact of average monthly flows on rafting visitation within Dinosaur National Monument (see the Recreation Visitation and Valuation Analysis Technical Appendix for more information on the models). Separate models were estimated for commercial and private rafting activity. These models either resulted in insignificant flow variables (commercial model) or significant flow variables with relatively minor impacts on rafting activity (private model). As a result, the assumption was made that rafting activity within Dinosaur National Monument would not vary substantially with the fluctuations in Green River flows associated with the EIS alternatives. Finally, changes in water-based recreation activity within Reaches 2 and 3, based on the EIS alternatives, were also assumed to be relatively minor either due to low levels of recreation use or the overriding effect of the combined flows from the numerous tributaries (e.g., Yampa, Duchesne, and White Rivers, etc.) as compared to dam releases. Given all of the above, the decision was made to focus the recreation visitation and value analysis on water-based effects primarily within the Flaming Gorge National Recreation Area.

The Green River portion of the Flaming Gorge National Recreation Area is located entirely within Daggett County, Utah, in the northeast corner of the State. The southernmost portions of the reservoir are also within Daggett County. This part of the reservoir is relatively narrow since the water is constricted via a series of canyons. The reservoir widens as one travels northward out of the canyons and toward the Utah/Wyoming border. The Wyoming portion of the reservoir, located entirely within Sweetwater County, is relatively wide and extends northward for many miles before narrowing at the confluence of the Green and Blacks Fork Rivers.

Potentially affected recreation facilities within the Flaming Gorge National Recreation Area along both the Green River and Flaming Gorge Reservoir include the following:

Green River:

(1) Boat ramps at the spillway below Flaming Gorge Dam and at the Little Hole recreation complex.

(2) Little Hole National Recreation Trail (from the spillway of Flaming Gorge Dam to the Little Hole recreation complex, 7 miles downstream).

(3) Fishing pier at the Little Hole recreation complex.

(4) Eighteen riverside campgrounds (seven are on BLM lands, outside Flaming Gorge National Recreation Area).

Flaming Gorge Reservoir:

(1) Eleven boat ramps (four associated with marinas).

(2) Three marinas.

(3) Three boat-based campgrounds.

(4) Four swimming beaches.

(5) Cut Through-Horseshoe Canyon Bypass (not evaluated within the recreation analysis since it has only minor impacts on recreation use).

While the Green River recreation analysis emphasizes impacts within the upper portion of Reach 1, primarily within Flaming Gorge National Recreation Area, consideration is also given to recreation facilities downstream, all the way to the confluence with the Colorado River. After passing out of Reach 1 within Dinosaur National Monument, the Green River flows across private lands, State of Utah lands, Federal lands (BLM, U.S. Fish and Wildlife Service including Ouray National Wildlife Refuge), and Ute Indian tribal lands within Reach 2. Very few recreational facilities are found in this reach. Reach 3 of the Green River starts at the confluence with the White River and ends at the Colorado River. This long stretch of river includes Ute Indian tribal lands (including Desolation Canyon), State of Utah lands (including Green River State Park), Federal lands (BLM, National Park Service including Canyonlands National Park), and private lands. Numerous recreational facilities are located within Reach 3. The following represents a list of recreational facilities found along the Green River downstream from Flaming Gorge National Recreation Area within Reaches 1, 2, and 3.

Green River – Reach 1 (downstream from Flaming Gorge National Recreation Area):

BLM:

(1) Three boat ramps (Indian Crossing, Bridge Hollow, and Swallow Canyon—a fourth ramp at the pipeline crossing below Jarvies Ranch, is being phased out).

(2) Twenty campgrounds, of which only one (at Bridge Hollow) may be impacted. Six of these are administered by the USDA Forest Service for BLM.

State of Utah:

(3) One boat ramp (Bridge Port Camp).

(4) Five campgrounds (Gorge Creek, Little Davenport, Bridge Port, Elm Grove, and Burned Tree).

U.S. Fish and Wildlife Service (Browns Park National Wildlife Refuge):

(5) Two boat ramps (Swinging Bridge, Crook).

(6) Two campgrounds (Swinging Bridge, Crook).

(7) Fishing Pier.

National Park Service (Dinosaur National Monument):

(8) Three boat ramps (Lodore, Deerlodge, and Split Mountain).

Note: Facilities located downstream from the Yampa River are technically Reach 2 (e.g., Split Mountain):

(9) Five riverside campgrounds (Lodore, Deerlodge, Echo Park, Split Mountain, and Green River).

(10) One riverside picnic area (Split Mountain).

Green River – Reach 2 (Yampa River to White River:

U.S. Fish and Wildlife Service (Ouray National Wildlife Refuge):

(1) One boat launch site.

Green River – Reach 3 (White River to Colorado River):

BLM:

(1) Five boat ramps/launch sites (Sand Wash, Swasey's Beach ramp, Nefertiti, Butler Rapid, and Mineral Bottom).

(2) One riverside campground (Swasey's Beach).

State of Utah (Green River State Park:)

(3) One boat ramp.

(4) One campground.

Private:

(5) One boat launch site (Ruby Ranch).

National Park Service (Canyonlands National Park):

(6) Eight campsites

3.11.2 Current Conditions

This section describes current conditions within the geographic impact area in terms of Green River flows and Flaming Gorge Reservoir water levels, recreation visitation, and the economic value of recreation. This information should provide some perspective when considering the recreation impacts presented under the environmental consequences section. In addition, the current condition information was used in the analysis process, providing a basis or starting point of the two applied analyses—the facility availability approach for reservoir visitation and the linear interpolation approach for river visitation, river valuation, and reservoir valuation analyses.

Recreation visitation is measured in terms of the number of recreation visits for each recreation activity. A recreation visit reflects a round trip excursion from a recreator's primary residence for the main purpose of recreation. Recreation economic value reflects the sum of individual recreator benefits aggregated across users of a site. Recreator benefits or values per visit are represented by consumer surplus that is measured by estimating recreator willingness-to-pay in excess of per visit costs.

Recreation activities studied were water based, implying they require the use of water for participation. Water-influenced activities, such as picnicking and sightseeing, which do not require water access, but typically benefit from the presence of water, were insignificant compared to the water-based activities at both the Green River and Flaming Gorge Reservoir. Activities studied on the Green River include scenic floating, guide boat fishing, private boat fishing, shoreline fishing/trail use, and boat-based camping. Activities studied on Flaming Gorge Reservoir include power boating and waterskiing, boat fishing, boat-based camping, swimming, and waterplay. These water-based activities represent virtually all of the visitation on the river and nearly 80% of the visitation at the reservoir.

3.11.2.1 Current Hydrology

This section presents information on current Green River and Flaming Gorge Reservoir hydrology in terms of average monthly riverflows and end-of-month reservoir water levels. In this analysis, all riverflows are measured in cfs, and all reservoir water levels are measured in feet above mean sea level (msl). Given that much of the information used to develop the recreation analyses were obtained from a survey conducted across the summer of 2001, and the analyses used current conditions information from the survey as a starting point in the estimation process, it was necessary to link current hydrological conditions to the survey period. The survey was conducted from May to September 2001 and asked recreators about their activity over the prior 12 months. Therefore, depending on when a recreator was contacted, riverflows or reservoir water levels from as early as June 2000 to as late as September 2001 could be relevant. In other words, current hydrology is based on riverflows and reservoir water levels during the June 2000 to September 2001 period reflected by the recreation survey.

Actual conditions allow for the assessment of impacts based on the hydrology modeling for this EIS (see section 4.3). To calculate current average monthly riverflows or reservoir water levels, the percent of the survey sample contacted each month was used as a weight (May: 11.3%, June: 20.5%, July: 29.2%, August: 15.4%, and September: 23.6%). Table 3-15 presents actual flows and water levels by month. Riverflows are included only for the months from March to October since visitation data were only available for those months.

3.11.2.2 Current Annual Recreation Visitation

Recreation visitation has been gathered by USDA Forest Service contractors from March to October on an annual basis since the early 1990s on the Green River portion of the Flaming Gorge National Recreation Area. Visitation counts on the reservoir have been less frequent, with the most recent annual estimates made in fiscal year 1997 (October 1996 to September 1997).

Table 3-15.—Current Hydrology (June 2000 Through September 2001 Survey Period)

Month	Green River Flows (cfs)	Flaming Gorge Reservoir Water Levels (feet above msl)
January	NA[1]	6020.3
February	NA[1]	6020.4
March	1,036	6020.7
April	1,145	6021.5
May	2,478	6021.8
June	1,215	6021.3
July	1,007	6021.3
August	1,122	6020.9
September	1,118	6020.6
October	1,024	6020.4
November	NA[1]	6020.6
December	NA[1]	6020.4

[1] Not applicable due to lack of visitation data.

Current visitation was calculated on a monthly basis based on USDA Forest Service data. As with the hydrology data, to allow for use in the interpolations, current visitation estimates also needed to be consistent with the time period of the recreation survey (May 2000 to September 2001). While the reservoir visitation data was for a different time period compared to the survey data, fortunately, the availability of recreation facilities along the reservoir were identical for both the October 1996-September 1997 and June 2000-September 2001 periods, implying the fiscal year 1997 visitation data could be considered representative of visitation for the survey period. USDA Forest Service monthly visitation data by recreation activity for both the river and reservoir were weighted, using the monthly sampling percentage approach described above, to come up with the estimates of current monthly visitation by activity. Table 3-16 presents estimates of current water-based recreation on the river and reservoir by month and activity.

Reviewing the Green River visitation data in table 3-16 indicates that shoreline fishing, scenic floating, and private boat fishing are the top three recreation activities on the Green River portion of Flaming Gorge National Recreation Area. Combined, these activities account for slightly over 85% of the river visitation. The top three high use months are June, July, and August, with over 60% of the total annual river visitation. As noted below, river visitation accounts for less than 14% of the combined total visitation for the river and reservoir.

Reviewing the Flaming Gorge Reservoir visitation data in table 3-16 indicates that power boating/waterskiing (62.8%) and boat fishing (31.7%) are the dominant activities accounting for nearly 95% of the total water-based reservoir visitation. From a monthly perspective, the months of May through August reflect nearly 75% of water-based visitation. Although not presented in the

Table 3-16.—Current Green River and Flaming Gorge Reservoir Visitation by Month and Activity

Recreation Activity	Months												Total	% by Activity and Site	% of Total by Activity
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec			
I. Current Green River Visitation:															
Scenic Floating	N/A	N/A	42	217	99	5,527	11,063	7,749	62	9	N/A	N/A	24,768	26.8	3.7
Guide Boat Fishing	N/A	N/A	280	1,560	2,018	2,099	1,781	1,814	1,530	318	N/A	N/A	11,400	12.3	1.7
Private Boat Fishing	N/A	N/A	1,265	3,214	3,549	1,767	1,520	1,457	4,827	932	N/A	N/A	18,531	20.0	2.8
Shoreline Fishing	N/A	N/A	1,774	5,892	4,942	5,976	7,708	5,462	2,935	793	N/A	N/A	35,482	38.4	5.3
Boat Camping	N/A	N/A	0	0	0	668	655	600	352	6	N/A	N/A	2,281	2.5	.3
River Total:	N/A	N/A	3,361	10,883	10,608	16,037	22,727	17,082	9,707	2,058	N/A	N/A	92,461	100	13.9
Percent by Month:	N/A	N/A	3.6	11.8	11.5	17.3	24.6	18.5	10.5	2.2	N/A	N/A	100		
II. Current Flaming Gorge Reservoir Visitation:															
Power Boating	583	0	2,694	21,532	57,792	77,943	84,871	49,273	28,250	25,426	6,638	4,276	359,278	62.8	54.1
Boat Fishing	293	0	1,358	10,870	29,170	39,343	42,838	24,870	14,260	12,834	3,352	2,160	181,348	31.7	27.3
Boat Camping	75	0	677	1,761	1,388	1,863	1,386	1,174	536	674	483	357	10,374	1.8	1.6
Swimming	35	0	159	1,277	3,424	4,618	5,028	2,919	1,675	1,508	393	255	21,291	3.7	3.2
Reservoir Total:	986	0	4,888	35,440	91,774	123,767	134,123	78,236	44,721	40,442	10,866	7,048	572,291	100	86.1
Percent by Month:	.2	0	.9	6.2	16.0	21.6	23.4	13.7	7.8	7.1	1.9	1.2	100		
III. Combined Total:	986	0	8,249	46,323	102,382	139,804	156,850	95,318	54,428	42,500	10,866	7,048	664,752		100
Percent by Month:	.2	0	1.2	7.0	15.4	21.0	23.6	14.3	8.2	6.4	1.6	1.1	100		

table, the most used reservoir sites from a water-based activity perspective are Lucerne Valley (52.8%), Buckboard Crossing (15.8%), and Cedar Springs (15.8%). These three sites combine for nearly 85% of the reservoir's total water-based activity.

The combined total of nearly 665,000 water-based activity visits annually is dominated by visitation to the reservoir, reflecting over 86% of the total visitation. May through August are the heaviest use months, with severe drops in visitation prior to April and after October.

3.11.2.3 Current Annual Recreation Economic Value

The current annual total value estimates by activity were developed by simply multiplying the current value estimates per visit by activity, as obtained from the recreation survey, by the estimates of total current visitation by activity, as obtained from USDA Forest Service data. All value per visit estimates were developed using a conservative, frequently applied approach of assuming survey nonrespondents had a value of zero. Table 3-17 presents the estimates of Green River and Flaming Gorge Reservoir total current value by recreation activity.

It is interesting to note the differences when comparing the percent of total visits by activity to the percent of total value by activity. The percent of total value by activity takes into account both the visitation and value per visit components. On the river, while shore fishing/trail use reflects 38.4% of river visitation, it represents only 17.4% of the river value due to the relatively low value per visit. Conversely, guide boat fishing reflects only 12.3% of river visitation, but 43.5% of the river value due to the high value per visit. The differences between the reservoir visitation and valuation percentages are less dramatic compared to those of the river. The largest differentials are for power boating/waterskiing and swimming/waterplay.

When combining Green River and Flaming Gorge Reservoir values, the river represents about 25% of the total recreation value compared to only 14% of the total visitation. This is due to the higher values per visit for river activities. The reservoir obviously still dominates, representing nearly 75% of the combined total value.

3.12 SOCIOECONOMICS AND REGIONAL ECONOMICS

This section includes a brief discussion of the geographic impact area followed by information on current conditions within the area.

3.12.1 Geographic Impact Area

As described in the recreation section (section 3.11), the recreation analysis focuses on effects at Flaming Gorge Reservoir and along the Green River primarily within the FGNRA. Access to the northern portions of the reservoir would likely involve economic activity in the Wyoming towns of Green River and Rock Springs. Conversely, access to the southern reaches of the reservoir and the Green River may involve economic activity in communities further south. Since Daggett County has only small communities, the decision was made to include Uintah County, Utah, within the impact region due to the influence of the town of Vernal. As a result, the socioeconomics geographic impact area for both the reservoir and river recreation analyses includes all three counties: Daggett and Uintah Counties in Utah and Sweetwater County in Wyoming (see the frontispiece map).

Table 3-17.—Current Green River and Flaming Gorge Reservoir Annual Value Estimates by Activity

Recreation Activity	Original Value per Visit (Survey)	No. of Responses	Full Sample	Revised Current Value per Visit	Current Number of Total Visits	% of Total Visits	Current Total Value ($1,000s)	% by Activity and Site	% of Total by Activity
I. Current Green River Valuation:									
Scenic Floating	$ 80.05	38	65	$ 46.80	24,768	3.7	$ 1,159.2	24.2	6.2
Guide Boat Fishing	$ 296.19	21	34	$ 182.94	11,400	1.7	$ 2,085.5	43.5	11.1
Private Boat Fishing	$ 85.00	37	84	$ 37.44	18,531	2.8	$ 693.8	14.5	3.7
Shoreline Fishing/ Trail Use	$ 33.55	105	150	$ 23.49	35,482	5.3	$ 833.5	17.4	4.4
Camping	$ 24.55	8	59	$ 10.78	2,281	0.3	$ 24.6	0.5	0.1
Total:					92,461	13.9	$ 4,796.5	100	25.5
II. Current Flaming Gorge Reservoir Valuation:									
Power Boating/ Waterskiing	$ 50.60	62	122	$ 25.71	359,278	54.1	$ 9,237.0	66.1	49.2
Boat Fishing	$ 57.30	55	125	$ 25.21	181,348	27.3	$ 4,571.8	32.7	24.4
Boat Camping	$ 30.10	46	106	$ 13.06	10,374	1.6	$ 135.5	1.0	0.7
Swimming/ Waterplay	$ 35.00	4	97	$ 1.44	21,291	3.2	$ 30.7	0.2	0.2
Total:					572,291	86.1	$ 13,975.0	100	74.5
III. Combined Total:					664,752	100.0	$ 18,771.5		100.0

3.12.2 Current Conditions

The latest available data for the IMpact analysis for PLANning (IMPLAN) regional input-output model used in the analysis reflects regional economic activity for calendar year 1999. (For information on the IMPLAN model, see section 4.12.1.1, "Regional Economics Modeling Methodology.") Table 3-18 presents "current" base year 1999 conditions from the IMPLAN three-county model for total industry output, employment, and labor income. The table is broken down by major aggregated industry as well as the eight most directly impacted recreation-oriented economic sectors identified in the analysis. The eight directly impacted sectors are shown separately, but under their associated major industry (e.g., "air transportation" is presented under transportation; each directly impacted sector is preceded by a dash). To estimate totals for the primary industries listed in the table, add the separately presented sectors to the major industry estimates (e.g., adding "air transportation" with "other transportation" estimates total transportation).

Reviewing table 3-18, the most important industries vary depending on the measure. From an output perspective, the top five industries include mining (33.8%), transportation (12.0%), services (9.7%), construction (8.4%), and manufacturing (8.1%). From an employment perspective, the top five industries include services (20.9%), retail trade (17.6%), government (17.3%), mining (10.8%), and manufacturing (8.3%). The top five industries from the perspective of labor income include mining (22.1%), government (16.1%), transportation (14.8%), services (13.1%), and construction (8.7%).

The eight most affected sectors, from a recreation expenditure perspective, combined to provide 5.4% of total industry output, 16.6% of employment, and 7.3% of labor income. These directly impacted sectors are fairly significant contributors to regional employment but relatively insignificant in terms of output and income. Food stores, automobile dealers and service stations, eating and drinking establishments, miscellaneous retail stores, and hotels and lodging places, in particular, combine for 16.1% of total regional employment.

3.13 PUBLIC SAFETY AND PUBLIC HEALTH

This section elaborates further on the affected environment in relation to safety and public health. The existing environment for recreation is described in section 3.11, and potential safety consequences as they relate to recreation activities are described in sections 4.11.2 and 4.11.4. This section describes elements of public safety that are not directly related to recreation, including risks associated with high riverflows and disease vectors.

3.13.1 Public Safety Considerations for the Reservoir and the River Immediately Below the Dam

Public safety at Flaming Gorge Reservoir relates to the area between the high water elevation and the elevation of the reservoir at a given point in time. Hazards on the reservoir can occur at all elevations, but generally increase as the reservoir goes down. Distances from roads and parking lots to the reservoir increase at lower reservoir elevations. Access to the reservoir at lower elevations is not developed and may be steep, uneven, and covered with rocks and debris.

When flows exceed the powerplant capacity of 4,600 cfs, there could be some additional danger to the public in the area immediately below the dam. However, public access is restricted in this area. The area between the spillway boat ramp and the dam is controlled

Table 3-18.—Current Conditions
(Impact Area Counties: Daggett and Uintah, Utah; Sweetwater, Wyoming)
(Data Year: 1999)

Primary Industries/Sectors	IMPLAN Industry Number	Total Industry Output: Millions of Dollars ($M)	Total Industry Output: % of Total	Employment: No. of Jobs	Employment: % of Total	Labor Income: Millions of Dollars ($M)	Labor Income: % of Total
Agriculture, Forestry, Fishing	1-27	50.8	1.3	1,340	3.5	15.9	1.2
Mining	28-47, 57	1,349.7	33.8	4,146	10.8	283.9	22.1
Construction	48-56	335.5	8.4	3,210	8.3	111.3	8.7
Manufacturing	58-432	322.1	8.1	1,728	4.5	85.4	6.7
Other Transportation	433-436 438-440	471.8	11.8	2,899	7.5	187.4	14.6
- Air Transportation:	437	6.4	0.2	74	0.1	2.7	0.2
Communications	441-442	45.7	1.1	194	0.5	11.1	0.9
Utilities	443-446	285.2	7.1	625	1.6	45.4	3.5
Wholesale Trade	447	89.3	2.2	1,074	2.8	36.9	2.9
Other Retail Trade	448-449 452-453	52.9	1.3	1,579	4.1	25.8	2.0
- Food Stores:	450	32.2	0.8	882	2.3	18.9	1.5
- Automotive Dealers and Service Stations:	451	55.4	1.4	1,076	2.8	25.3	2.0
- Eating and Drinking:	454	66.5	1.7	2,292	6.0	22.6	1.8
- Miscellaneous Retail:	455	17.1	0.4	921	2.4	8.4	0.7
Finance, Insurance, and Real Estate (FIRE)	456-462	206.2	5.2	1,769	4.6	27.2	2.1
Other Services	464-476 478-487 489-509	345.7	8.7	6,891	17.9	152.1	11.9
- Hotels and Lodging Places:	463	36.1	0.9	1,004	2.6	14.4	1.1
- Automobile Rental and Leasing:	477	.4	0.0	13	0.0	0.1	0.0
- Amusement and Recreation Services:	488	3.2	0.1	149	0.4	1.4	0.1
Federal, State, and Local Government	510-515 519-523	261.7	6.6	6,659	17.3	207.1	16.1
TOTAL:		3,993.7	100	38,523	100	1,283.3	100
MOST AFFECTED SECTORS:		217.3	5.4	6,410	16.6	93.8	7.3

during high use periods, which contributes to public safety. Signage along the river access road indicates that the river may fluctuate at any time up to 4 feet in elevation.

3.13.2 Public Safety Considerations for the Green River

Riverflows in Reach 1 up to 4,600 cfs do not pose any safety problems relative to structures (buildings, bridges, and roads) over or near the river. Prior to 1992, releases of 4,600 cfs for power generation occurred more often than they have since 1992. Problems can arise at the bridges that cross the Green River; high flows can inundate bridge approaches. If these areas are inundated for more than a few days, then questions of structural stability can arise. The river in Reach 1 has exceeded 8,000 cfs two times in the past 10 years and four times since the dam was constructed. The Greendale gauge was installed 12 years prior to dam construction. During that time Reach 1 exceeded 8,000 cfs in 9 of the 12 years.

Reach 2 of the Green River is greatly influenced by the essentially unregulated flows of the Yampa River. In Reach 2, the river has exceeded 18,000 cfs 5 times in the past 10 years and 10 times in the past 20 years. The effects of dam operations are even further attenuated in Reach 3. In general, higher flows in the Green River can be said to increase hazards to the public.

3.13.3 Public Health: Disease Vectors

Common vectors, such as mosquitoes, deer mice, bats, and ticks, can transmit serious diseases to people. Mosquitoes can transmit malaria, West Nile virus, and encephalitis; deer mice can transmit hanta virus; bats and other mammals can transmit rabies; and ticks can transmit Lyme disease.

During the EIS scoping sessions, individuals expressed concerns that the proposed changes to the operation of Flaming Gorge Dam may produce conditions that benefit mosquitoes and exacerbate the potential problems with the encephalitis virus. In the Jensen, Utah, area, the Saint Louis virus and the Western Equine Encephalitis virus are potential threats of the disease; and perhaps the West Nile virus may be a problem. West Nile virus was discovered in the Uintah Basin in 2003. Similar levels of concern for the nonaquatic vectors were not expressed at the scoping meetings, and it is not anticipated that the operational changes would cause similar impacts on nonaquatic vectors. Therefore, this EIS will only assess the mosquito vector. There are many species of mosquitoes living along the Green River. Two common mosquito species in the Jensen, Utah, area are the *Aedes* and the *Culex* species, which are major mosquito nuisances in the area (Romney, 2002). A common mosquito, *Culex tarsalis*, is considered to be one of the principal vectors of the Western Equine Encephalitis virus (American Mosquito Control Association, Inc., 1990). The floods that result from the operation changes may impact other aquatic vectors such as other biting insects.

Meteorological conditions such as temperature and humidity are important factors in determining the longevity of mosquitoes (American Mosquito Control Association, Inc., 1990). High temperatures and low humidity can shorten the life span of mosquitoes. Under the right conditions, mosquitoes can live many months. However, many mosquitoes do not live past 2 weeks. The number of mosquitoes present at a location is generally dependent on the amount of habitat available. A good breeding site is one where standing water is present for about 2 weeks and protected from the elements such as wind. Vegetation and shallow depressions along rivers provide good habitat for mosquitoes, especially after a rain or flood. The female mosquito requires a blood meal for egg development, and the blood meal can be taken from a variety of sources including birds, cattle, horses, and people. Diseases can be transferred at the same time the blood meal is taken. In order to transmit the encephalitis virus to people, the mosquito must make two successful feedings. One feeding must be from the infected source and the second feeding will infect the new host. A potential mosquito vector is one that lives more than 10 days and takes two or more blood meals (American Mosquito Control Association, Inc., 1990).

Procedures exist to control mosquitoes in the larval, pupal, or adult life stages. Federal, State, and local regulations govern the use of insecticides and have limited the number of chemical controls in and near waters. Applications of insecticides must comply with the labeling requirements for that product. The Uintah County Mosquito Abatement District applies *Bacillus thuringiensis* (BT) by aircraft to control mosquitoes at the larval stage. BT must be applied before the mosquito develops into the pupal stage. BT produces a toxin that kills the mosquito.

BT is a naturally occurring soil bacterium, and anyone coming in contact with soils may encounter the microorganism. BT is registered for use to control mosquito larval in waters. Current information on the toxicity and exposure data of BT indicates that the use of pesticide products containing BT should not be harmful to endangered mammals, birds, fish, and plants (U.S. Environmental Protection Agency [EPA], 1998). The use of pesticide products with BT should not pose a threat to human health (EPA, 1998). BT does show some toxicity to honey bees and water fleas (*Daphnia)* (EPA, 1998).

Irving and Burdick (1995) conducted an inventory, largely based on aerial photography, of potential flooded bottomland habitats in the Green River. They determined that approximately 1,591, 8,648, and 8,154 acres of potential mosquito habitat were present in Reaches 1, 2, and 3, respectively. In Reach 3, about 2,718 acres were present in the portion of the reach between the White River confluence and Pariette Draw, and about 1,878 acres were present in Canyonlands. They did not determine the relationship of flood plain inundation to flow.

Bell et al. (1998) used aerial photography to determine the relationship between flow and flood plain inundation in Reach 2 from Split Mountain Canyon to the White River and the upper portion of Reach 3 from White River to Pariette Draw. In Reach 2 at 19,988; 22,037; and 24,897 cfs, approximately 5,189; 8,648; and 12,108 acres, respectively, would be flooded. In the upper portion of Reach 3, Bell et al. (1998) indicated that at flows of 22,001; 24,014; and 32,490 cfs, about 655; 1,050; and 1,895 acres, respectively, would be flooded.

The Uintah County Mosquito Abatement District provides mosquito control treatment for about 50 river miles of Green River between the Dinosaur National Park boundary and Ouray, Utah (Romney, 2002). Reach 2 covers most of this area. Generally, the higher the flows in the river, the more adjacent lands will be flooded, and more mosquito habitat is created. Mosquito habitat would be sustained as long as the river is running high. The Uintah County Mosquito Abatement District has provided an estimate of the number of aggregate acres they may have to treat based on the flows in the river at the Jensen Station. Since BT has a relatively short active period, repeat treatments of the same area are usually required. The Uintah County Mosquito Abatement District indicated that within the 50-mile (80.4-kilometer) affected area, they consider treating 10,000 acres when flows reach 10,000 cfs. When flows reach 15,000; 18,000; and 26,000 cfs, treatment is considered on about 15,000; 30,000; and 40,000 acres, respectively (Romney, 2002). The acre numbers, provided by the Uintah County Mosquito Abatement District, include multiple treatments of the same area.

Since 1964, the Centers for Disease Control and Prevention reported that there have been 639 confirmed cases of Western Equine Encephalitis and 4,478 reported cases of St. Louis Encephalitis in the United States. In 1978, an outbreak of Western Equine

Encephalitis affected 68 horses in the Jensen, Utah, area (Romney, 2002). Birds are known carriers of the encephalitis virus, and monitoring chicken populations would provide important information. Since 1983, the local abatement districts employ chicken plots to monitor the incidence of the encephalitis virus in the area. The plots indicated that the Jensen, Utah, area is considered to be one of the principal areas where the virus could become established (Romney, 2002). The virus would be difficult to eliminate from the area since the encephalitis virus could be imported by migrating bird populations.

As of November 19, 2003, the Centers for Disease Control and Prevention reported 8,470 mild and severe human disease cases of West Nile virus nationwide (Centers for Disease Control and Prevention, 2003). In 2003, the virus has been reported throughout much of the United States, including the States of Utah, Colorado, and Wyoming.

3.14 AIR QUALITY

The Flaming Gorge region generally has good air quality that is affected both by weather and industry, which includes electric utility generation. Changes in pollution discharges can have an impact, but these changes are also dependent on the ability of the environment to disperse and absorb the pollutants. Electric generation by fossil-fired powerplants provides significant levels of some pollutants; any change in the production of such powerplants due to the Action Alternative can affect the air quality of the region.

This region is semi-arid, with wide variations in climate due to varying topography. It is affected by warm air masses moving from the Pacific Ocean eastward and Canadian air masses that occasionally settle over the region. Wind flows generally occur from west to east but often are modified by local topographic features. Topography also affects the speed of wind flows, with western exposed mountain slopes having high wind speeds but protected valleys experiencing relatively low wind speeds. High pressure weather systems with light wind conditions occur often. High winds occur during the winter and spring seasons.

Temperatures can vary widely through this region, depending on elevation and season of the year. Annual precipitation averages 12 inches a year, with generally higher levels in the mountain areas. Precipitation from Pacific storms occurs more often between October and April. Summer storms from the Gulf of Mexico occur between July and September. Evaporation rates are high throughout the river basins due to high temperatures, low humidity, clear skies, and moderate winds. Atmospheric dispersion of pollutants improves with increases in wind speed and precipitation.

While the air quality is generally good in this region, pockets of nonattainment of Clean Air Act standards do exist in Utah. These occur around the Salt Lake County area and other industrial portions of Utah for pollutants such as sulfur dioxide, carbon monoxide, ozone, and total suspended particulates/small particulate matter. Also, an industrial region east of the reservoir in Wyoming has nonattainment pockets for total suspended particulates/small particulate matter. From 1981 to 1990, the electric utility industry generated from 23% to 51% of the sulfur dioxide levels in the Southwestern part of the United States and from 34% to 56% of the nitrogen oxides. The electric utility industry also generated up to 39% of the total carbon dioxide levels for the six-State region in the Southwestern United States during the same timeframe. Substantial changes in output by the electric utility industry could have significant effect on the air quality around the Flaming Gorge region and the Southwestern United States area if weather patterns do not disperse these pollutants.

3.15 VISUAL RESOURCES

Flaming Gorge Reservoir is situated on the eastern slope of the scenic Uinta Mountains in northeastern Utah. The concrete arch dam was constructed during the mid-1960s. The heart of the Flaming Gorge National Recreation Area is a 91-mile long reservoir, created by Flaming Gorge Dam. There are over 300 miles of shoreline. An estimated 3,000 acres of shoreline are involved.

The Green River flows out of the dam, down through the lower reaches of Red Canyon, and into Browns Park. The stretch of river covers approximately 20 miles. An estimated 100 acres of riverbank are involved.

The landscape consists of a high plateau, about 8000 feet in elevation, covered by ponderosa pine, pinion pine, and Utah juniper, and is dissected by the Red Canyon. The Green River flows through the deep Red Canyon beginning at Flaming Gorge, near Sheep Creek Flats, and exits at Browns Park, a broad open valley near the Utah-Colorado State line. Rock formations are prominent, and soils are reddish in color. The Uinta Mountains form a high, scenic backdrop to the west.

The Wyoming portion consists of a different land type, prominent grayish ledges and bluffs, where the Green River corridor is not as deeply defined. Vegetative patterns are of a sage nature. Soils consist of shale or clay type material. Open spaces are prominent.

3.15.1 Scenic Integrity

Visual qualities are perceived by those who normally recreate or spend time in a particular area, who, in this case, would be the casual forest visitor. Much of their recreational experience relates to their concern for scenic quality and the condition of the view shed.

Scenic values and qualities within the FGNRA and along the Green River corridor are high. With a background of the Uinta Mountains and distant vistas, this is the premier scenic showcase for northeastern Utah and southwestern Wyoming.

The Recreation Opportunity Spectrum calls for this area to be managed for a Roaded-Natural or Roaded-Modified setting. The Recreation Opportunity Spectrum for the area around Flaming Gorge Dam is close to an "Urban" setting.

The Scenic Integrity Level for the southern end of the FGNRA, including Cedar Springs, the dam, Dutch John, Antelope Flats, and Little Hole, is considered high to moderate. Scenic Integrity Levels for the Wyoming portion and Green River corridor, below Little Hole, would be considered as high to moderate. The desired scenic condition for the entire FGNRA and Green River corridor would be natural appearing and cultural.

BLM-administered lands from Little Hole to the Colorado State line are being managed as Class II areas. The objective of Class II is that management actions may cause alternations to the natural settings, but they shouldn't attract the attention of the casual observer.

3.15.2 Constituent Information

Visitors to the FGNRA come from Utah, Wyoming, Colorado, and all over the United States. Most international visitors are from England, Germany, France, and Japan. They expect to view outstanding scenery, visit the dam, and catch trophy fish. The majority of recreation use occurs during the summer months, between Memorial Day and Labor Day, or approximately 100 days.

Recreational opportunities include driving for pleasure, viewing scenery, fishing, boating, floating, waterskiing, swimming, scuba diving, hunting, mountain biking, and hiking. Winter activities include cross-country skiing, snowmobiling, and ice fishing on the reservoir and stream fishing on the river. Facilities include visitor centers, boat ramps, campgrounds, trails, commercial lodges, service stations, and marinas.

3.15.3 Landscape Visibility

Most areas within the FGNRA are seen by the public from one point or another. People in boats scrutinize all parts of the reservoir and shoreline from the water level. Other forest visitors and fishermen view the reservoir from above and points around the FGNRA, such as Red Canyon Visitor Center, Flaming Gorge Dam and Visitor Center, campgrounds, marinas and dispersed areas.

People floating the Green River and hiking the trails have the perspective of Red Canyon at the water level. Only a few vista points along the river are available from roadways. These include views from Flaming Gorge Dam, spillway, boat ramp, Little Hole area, and at Browns Park.

3.16 ENVIRONMENTAL JUSTICE

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," dated February 11, 1994, requires agencies to identify and address disproportionately high and adverse human health or environmental effects of their actions on minorities and low-income populations and communities as well as the equity of the distribution of the benefits and risks of their decisions.

Table 3-19 presents population data by race and Hispanic origin for the States of Utah and Wyoming, the Uintah and Ouray Reservation, and the counties which may potentially be affected by changes in the flows of the Green River. Moffat County, Colorado, and San Juan and Wayne Counties, Utah, were not included since the lands adjacent to the Green River within those counties are publicly owned and no one lives on them. Carbon County, Utah, was not included because the lands adjacent to the Green River in this county are part of, and are included in, the data for the Uintah and Ouray Reservation. The study area is predominately white. In 1990, the white population in the area ranged from 83.3% to 98.0%. The range of percentages for 2000 changed slightly, from 81.2% to 95.6%. The American Indian and Alaskan Native population is the largest minority group in the study area, with the highest percentage of total population ranging from 15.4% in 1990 to 14.5% in 2000 on the Uintah and Ouray Reservation. The Hispanic population is a minority ethnic group which can be of any race. Sweetwater County, Wyoming, had the greatest percentage of Hispanic population—8.9% in 1990 and 9.4% in 2000.

The percentages of all people in poverty for the States of Utah and Wyoming, the Uintah and Ouray Reservation, and the study area counties are shown in table 3-20. The reservation and all of the counties, except Emery and Grand Counties, showed a decrease in the percentage of people in poverty from 1989 to 1999. All of the study area is considered to be nonmetropolitan. When compared to the percentage of people in poverty for the nonmetropolitan areas in 1999, the reservation and Grand and Uintah Counties had greater percentages of people in poverty.

Table 3-19.—Population by Race and Hispanic Origin

Area	Year	Total Population	Race							Ethnicity
			White	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Some Other Races	Two or More Races	Hispanic or Latino (of Any Race)
State of Utah	1990	1,722,850	1,615,845	11,576	24,283	25,696	7,675	37,775	(NA)	84,597
	% Total Population	100.0	93.8	0.7	1.4	1.5	0.4	2.2	(NA)	4.9
	2000	2,233,169	1,992,975	17,657	29,684	37,108	15,145	93,405	47,195	201,559
	% Total Population	100.0	89.2	0.8	1.3	1.7	0.7	4.2	2.1	9.0
Uintah and Ouray Reservation	1990	17,224	14,355	12	2,650	34	19	154	(NA)	459
	% Total Population	100.0	83.3	0.1	15.4	0.2	0.1	0.9	(NA)	2.7
	2000	19,182	15,585	25	2,780	33	19	278	462	673
	% Total Population	100.0	81.2	0.1	14.5	0.2	0.1	1.5	2.4	3.5
Dagget County	1990	600	674	–	9	5	–	2	(NA)	15
	% Total Population	100.0	97.7	–	1.3	0.7	–	0.3	(NA)	2.2
	2000	921	871	6	7	1	–	22	14	47
	% Total Population	100.0	94.5	0.7	0.8	0.7	–	2.4	1.5	5.1
Emery County	1990	10,332	10,127	4	44	30	6	121	(NA)	219
	% Total Population	100.0	98.0	–	0.4	0.3	0.1	1.2	(NA)	2.1
	2000	10,860	10,386	20	71	34	11	203	135	568
	% Total Population	100.0	95.6	0.2	0.7	0.3	0.1	1.9	1.2	5.2

Table 3-19.—Population by Race and Hispanic Origin (Continued)

Area	Year	Total Population	Race							Ethnicity
			White	Black or African American	American Indian and Alaska Native	Asian	Native Hawaiian and Other Pacific Islander	Some Other Races	Two or More Races	Hispanic or Latino (of Any Race)
Grand County	1990	6,620	6,341	7	203	19	5	45	(NA)	291
	% Total Population	100.0	95.8	–	3.1	0.3	–	0.7	(NA)	4.4
	2000	8,485	7,861	21	327	19	4	141	112	471
	% Total Population	100.0	92.6	0.2	3.9	0.2	–	1.7	1.3	5.6
Uintah County	1990	22,211	19,537	9	2,335	61	21	248	(NA)	691
	% Total Population	100.0	88.0	–	10.5	0.3	0.1	1.1	(NA)	3.1
	2000	25,224	22,130	29	2,365	56	20	264	360	894
	% Total Population	100.0	87.7	0.1	9.4	0.2	0.1	1.0	1.4	3.5
State of Wyoming	1990	453,588	427,061	3,606	9,479	2,638	168	10,636	(NA)	25,751
	% Total Population	100.0	94.2	0.8	2.1	0.6	–	2.3	(NA)	5.7
	2000	493,782	454,670	3,772	11,133	2,771	302	12,301	8,883	31,669
	% Total Population	100.0	92.1	0.8	2.3	0.6	0.1	2.5	1.8	6.4
Sweetwater County	1990	38,823	36,564	289	305	247	7	1,411	(NA)	3,470
	% Total Population	100.0	94.2	0.7	0.8	0.6	–	3.6	(NA)	8.9
	2000	37,613	34,461	275	380	240	16	1,349	892	3,545
	% Total Population	100.0	91.6	0.7	1.0	0.6	–	3.6	2.4	9.4

[1] "–" represent zero or rounds to zero.

[2] Because individuals could only report one race in the 1990 census and could report more than one race in the 2000 census, data on race for 1990 and 2000 are not directly comparable.

Source: U.S. Census Bureau, Census 1990 and 2000.

Table 3-20.—Poverty[1]

Area	1989 Percent	1999 Percent
Utah – State	11.4	9.4
Utah – Metro Areas	10.8	8.8
Utah – Nonmetro Areas	15.4	13.5
Uintah and Ouray Reservation	22.9	20.2
Daggett County	14.8	5.5
Emery County	10.5	11.5
Grand County	14.6	14.8
Uintah County	18.7	14.5
Wyoming – State	11.9	11.4
Wyoming – Metro Areas	11.0	10.3
Wyoming – Nonmetro Areas	12.2	11.9
Sweetwater County	8.0	7.8

[1] All people in poverty.
Source: U.S. Census Bureau, 1990 and 2000 Census Population.

4.0 Environmental Consequences

4.1 INTRODUCTION

This chapter presents the potential impacts of the two alternatives analyzed in detail in this environmental impact statement (EIS). It is organized by resource, giving the effects for each alternative. For some resource analyses, the discussions are organized by alternative. For other resources, a side-by-side comparative analysis yielded a clearer understanding of the potential consequences of each alternative. Where appropriate, there is an explanation of the assumptions and methodology used to assess impacts. This chapter also discusses uncertainties regarding potential impacts, as well as environmental commitments that apply to both alternatives.

4.2 FLAMING GORGE FACILITIES

4.2.1 Spillway

4.2.1.1 No Action Alternative

The spillway is used to release water from Flaming Gorge Reservoir in amounts that exceed the combined release capacity of the river outlet works and the powerplant, that is, releases greater than 8,600 cubic feet per second (cfs). Historically, this has occurred only four times, as noted in section 3.2.1.2. Under the No Action Alternative, future use of the spillway can be expected for about 15 days per year in 5 percent (%) of all years.

4.2.1.2 Action Alternative

Under the Action Alternative, the frequency of spillway use could increase to about 15 days per year in 7% of all years. Spillway use of 1 to 10 days is expected in nearly 17% of all years. With increased spillway use, there is greater opportunity for degradation of concrete in the spillway tunnel. Should damage to the spillway become excessive, repairs would be made or use of the spillway would be limited to when hydrologically necessary. While difficult to quantify, operation and maintenance costs would increase. Following each period of spillway use, it may be necessary to inspect the spillway using high-angle rope work techniques. It is estimated that one spillway inspection would cost up to $12,000. Any needed concrete repair would require cutting out existing sections and replacing these sections with new concrete; working conditions would be difficult given the steep incline of the spillway tunnels. Actual increases in operation and maintenance costs associated with the Action Alternative are unknown and would depend on the frequency of spills and the extent of concrete damage. It is estimated that concrete repair would be needed sooner under the Action Alternative than under the No Action Alternative. A minimal repair would cost about $30,000 and could increase substantially depending on the amount of concrete being repaired. It is also possible that nitrogen saturation within the tailwater area could occur during the spillway use (discussed later in section 4.7.2.4.1.2).

4.2.2 Selective Withdrawal Structure

4.2.2.1 No Action Alternative

Under the No Action Alternative, use of the selective withdrawal structure would be similar to its use over the past 11 years; therefore, no impacts to operation and maintenance of the facilities themselves are expected.

4.2.2.2 Action Alternative

To meet desired temperatures for varying flow magnitudes under the Action Alternative, it will be necessary to gain experience on equipment capabilities to release warmer water and the effects of such releases on downstream fish populations. Equipment operating limitations will need to be considered. Over the next several years, the selective withdrawal structure will be adjusted more frequently to attempt to meet desired temperatures. These added adjustments will result in an increase in operation costs. However, it is believed that, as experience is gained, the frequency of selective withdrawal structure adjustments may lessen with an associated decrease in operation costs.

4.3 WATER RESOURCES

This section addresses the potential impacts of both alternatives on water levels in the reservoir and in the river, water quality (including temperature) in the reservoir and in the river, and sediment transport, a function of riverflows that, in turn, relates to biological and other resource considerations.

4.3.1 Hydrology, Flaming Gorge Reservoir

This section addresses impacts to water resources within the affected environment at Flaming Gorge Reservoir. Only direct impacts to reservoir elevation are considered in this section. Impacts to other resources as a result of changes in reservoir elevation are reported in their respective sections.

Each alternative was simulated with a computer model of the reservoir and Green River system over a 39-year period (2002-2040) to determine a range of reservoir elevations and associated reservoir contents that could likely occur in the future.

Reservoir elevations that occurred in the model, under each alternative simulation, were analyzed to characterize the differences between the alternatives.

4.3.1.1 Evaluation Methodology

A computer model (the Flaming Gorge Model [Clayton and Gilmore, 2002]) was developed for the Green River that included all relevant river features (reservoirs, river reaches, confluences, diversions, etc.) from Fontenelle Reservoir, upstream of Flaming Gorge Reservoir, to the confluence of the Green and Colorado Rivers. For this modeling project, emphasis was placed on the details of river features directly below Flaming Gorge Reservoir and on the Yampa River. This provided the Flaming Gorge Model the ability to reliably predict the impacts to flows in the Green River in Reaches 1 and 2 as a result of operating Flaming Gorge Dam under the Action and No Action Alternatives.

Less emphasis was placed on modeling the lower tributaries of the Green River (i.e., Duchesne, White, Price, and San Rafael Rivers). This was because detailed and reliable information regarding how these rivers systems are diverted and depleted was not available at the time the Flaming Gorge Model was constructed. Given this lack of reliable information on the tributary river systems, and the fact that:

- ❖ Modeling assumptions do not always predict what actually occurs with absolute certainty.
- ❖ Compounding effects of errors caused when modeling assumptions are imposed in series.
- ❖ Impacts to flows from Flaming Gorge Dam diminish with distance from the dam.

It was decided that the Flaming Gorge Model would not be used to analyze the differing flow regimes in Reach 3 that resulted from operating Flaming Gorge Dam under the Action and No Action Alternatives.

The Flaming Gorge Model was used to study the long-range effects of operating Flaming Gorge Dam to achieve specific riverflow objectives defined in the Action and No Action Alternatives for the Flaming Gorge EIS. The flow objectives of the Action Alternative are those that would achieve the *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam* (2000 Flow and Temperature Recommendations) while maintaining the other authorized purposes of the Flaming Gorge Unit within the constraints of the model environment. The flow objectives of the No Action Alternative are those that would achieve the Reasonable and Prudent Alternative of the 1992 Biological Opinion, while also maintaining the authorized purposes of Flaming Gorge Dam within the constraints of the model environment.

A simulation was run for both the Action and No Action model to generate a set of results for comparison of the alternatives. Monthly reservoir elevation data were obtained from these model simulations. Additional information on the hydrology modeling for this EIS may be found in section 4.3.2.1 and the Hydrologic Modeling Technical Appendix.

4.3.1.2 Reservoir Average Monthly Elevations

Figure 4-1 shows the average monthly reservoir elevations that would be expected under the Action and No Action Alternatives for each month of the year. Reservoir elevations are typically at their lowest level in early spring when the Action and No Action Alternatives attempt to achieve a drawdown target. During late summer, reservoir elevations are typically at their highest level of the year as a result of storing a portion of the spring runoff.

Reservoir elevations during the months of August, September, and October typically are lower under the Action Alternative than under

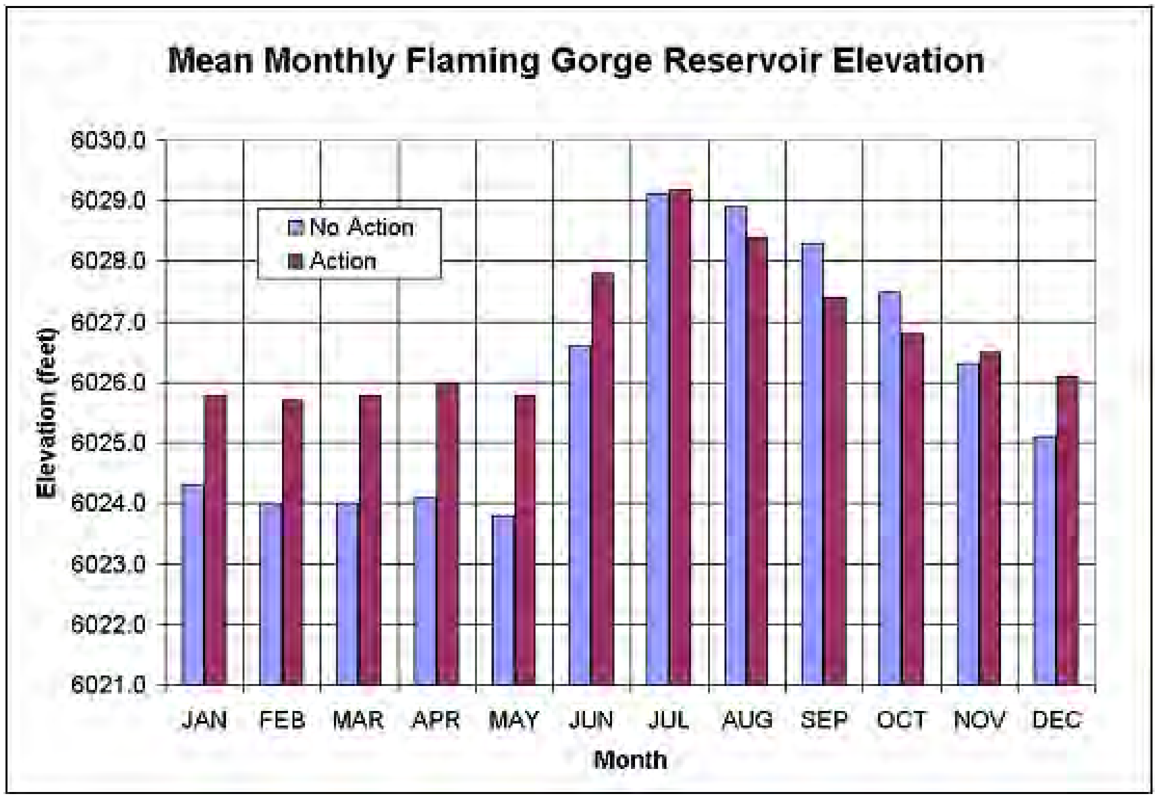

Figure 4-1.—Average End-of-Month Flaming Gorge Reservoir Elevations.

the No Action Alternative. Reservoir elevations under the Action Alternative typically are higher during all other months.

Spring peak releases under the Action Alternative are typically larger than those of the No Action Alternative. As a result, the reservoir does not store as much of the spring runoff as does the reservoir operated under the No Action Alternative. Also, under the No Action Alternative, releases after the spring peak are controlled so that flows in Reach 2 are maintained between 1,100 and 1,800 cfs until September 15. Typically, flows on the Yampa River are elevated during this time, and releases from Flaming Gorge Dam must be minimized to achieve this flow objective. The No Action Alternative typically causes the reservoir to fill to higher levels than the Action Alternative as a result of trying to achieve this flow objective.

4.3.1.3 Frequency of Reservoir Elevation

The Green River model results provided, among other things, a set of potential end-of-month reservoir elevations that could occur under the Action and No Action Alternatives during the period of analysis (2002-2040). Each set was subdivided by month and ranked from highest to lowest to determine the probability of occurrence associated with various reservoir elevations for each month of the year. Figures 4-2 and 4-3 show the distribution of reservoir elevations for the months of February and June as determined from the model results. These months are shown because reservoir elevations are typically near their lowest level of the year by the end of February and approach their highest level by the end of June.

In February, a reservoir elevation lower than 6025 feet can be expected to occur about 18% of the time under the Action Alternative

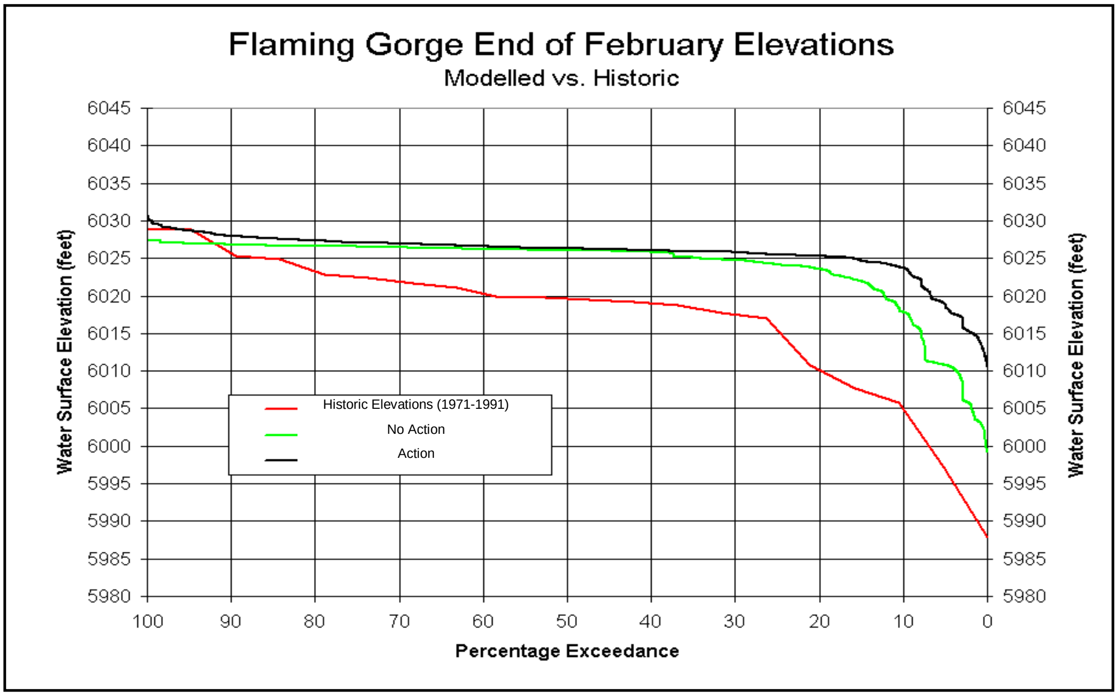

Figure 4-2.—February Reservoir Elevation Distribution Plot.

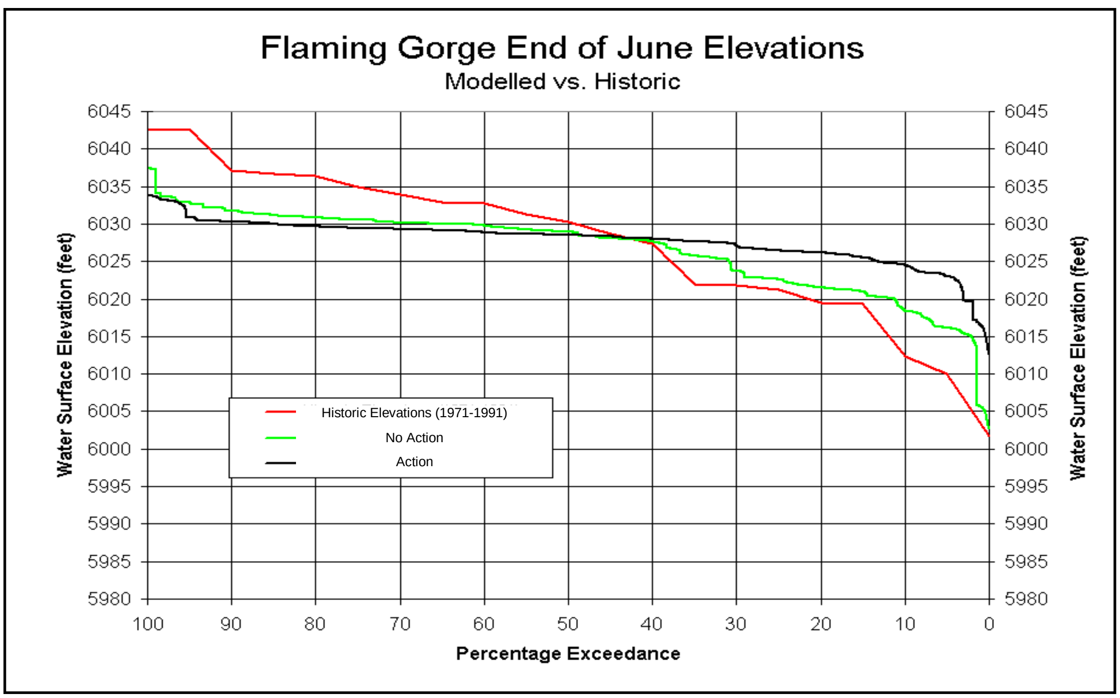

Figure 4-3.—June Reservoir Elevation Distribution Plot.

conditions and can be expected to occur about 33% of the time under the No Action Alternative conditions. Thus, reservoir elevation greater than 6025 feet would occur 82% of the time under Action Alternative operations and 67% of the time under No Action Alternative conditions during February. Similar expected frequency of occurrence estimates can be calculated for the range of elevations shown in figure 4-2 for February conditions.

In June, a reservoir elevation lower than 6025 feet can be expected to occur about 11% of the time under the Action Alternative conditions and can be expected to occur about 31% of the time under the No Action Alternative conditions. Thus, reservoir elevation greater than 6025 feet will occur 89% of the time under Action Alternative operations and 69% of the time under No Action Alternative conditions during June. Similar expected frequency of occurrence estimates can be calculated for the range of elevations shown in figure 4-3 for June conditions.

4.3.2 Hydrology, Green River

This section addresses impacts to water resources within the affected environment downstream from Flaming Gorge Dam. Only direct impacts to riverflows are considered in this section. Impacts to other resources that result from operating Flaming Gorge Dam under the Action and No Action Alternatives are reported in their respective sections.

The affected environment for hydrology on the Green River is divided into three reaches of the Green River below Flaming Gorge Dam. These reaches are described in the 2000 Flow and Temperature Recommendations and previously in this document. Flows in Reach 1 are almost entirely controlled by releases from Flaming Gorge Dam. Flows in Reach 2 can be dominated by tributary flows in the Yampa River or by releases from Flaming Gorge Dam, depending on the time of year. During the spring, flows in Reach 2 are mostly dominated by tributary flows from the Yampa River. But during the summer, fall, and winter, flows in Reach 2 are mostly affected by releases from Flaming Gorge Dam. Flows in Reach 3 are affected by tributary flows from the San Rafael, Price, Duchesne, White, and Yampa Rivers. The effect of releases from Flaming Gorge Dam on flows in Reach 3 is significantly diminished from the effect these releases have on flows in Reaches 1 and 2.

4.3.2.1 Evaluation Methodology for the Hydrologic Modeling

In terms of hydrology, the Action and No Action Alternatives were simulated using a computer model of the Green River system, referred to as the Flaming Gorge Model. For more detailed information regarding the Flaming Gorge Model, see the Hydrologic Modeling Technical Appendix. The Flaming Gorge Model provided, among other things, estimates of the flows that would likely occur in Reaches 1 and 2 from operating Flaming Gorge Dam under the Action and No Action Alternatives. The estimated flows are those that would likely occur over the next 39 years, beginning in January of 2002.

The logic and decisionmaking processes for achieving the flow objectives of each alternative were incorporated into a section of the Flaming Gorge Model called the ruleset. A unique ruleset was developed for the Action and No Action Alternatives. The most important function of the ruleset was to calculate the volume of water to be released from Flaming Gorge Dam so that the flow objectives of the alternative would likely be achieved while also maintaining the other authorized purposes of Flaming Gorge Reservoir (i.e., power production, recreation, water storage, etc.). Each ruleset monitored the available hydrologic information, including forecasted reservoir inflows and estimated future flow conditions on the Yampa River, and calculated how much water to release from Flaming Gorge Dam in order to meet the specific flow objectives in Reaches 1 and 2.

The modeled rulesets for each alternative operate Flaming Gorge Dam to control the reservoir elevation for safe operation of the dam, maximize reservoir storage, and minimize bypass releases while also attempting to meet the flow objectives of each alternative during the spring peak release as well as during the base flow period. Inflow forecasting under real world conditions has a significant level of uncertainty associated with it. Much of the time, the forecasted inflows to Flaming Gorge do not accurately predict what actually occurs. The model was designed to simulate these real world conditions by applying random errors to the forecasted inflows into Flaming Gorge and also the predicted flows of the Yampa River. For the forecasted inflows, these random errors were statistically similar to the forecast errors that have occurred historically. For the predicted flows of the Yampa River, the random errors that were introduced were those thought to create a reasonable level of uncertainty about predicting future daily flows of the Yampa River based on observed flows at the headwater gauges in the Yampa River Basin. These random errors provided a more realistic environment for simulating how Flaming Gorge would be operated under the two alternatives. The underlying modeling assumption associated with the introduction of these errors is that the actual forecasting and prediction accuracy will not improve or deteriorate in the future.

It is important to note that the Flaming Gorge Model and rulesets had limited sources of information from which to make decisions. For example, the model did not have the ability to monitor the changes in weather that usually precede changes in hydrology. In reality, a reservoir operator is able to monitor these changes in weather. In most cases, the information available in real time is much better than what the Flaming Gorge Model had for making similar operational decisions. In cases where the model had to work with less information than would be available in reality, modeling assumptions were made in order to find a workable solution that would mimic (as best as possible) what a real time reservoir operator would do. For this reason, the results of the Flaming Gorge Model represent an approximation of how Flaming Gorge would be operated under the Action and No Action Alternatives and not an exact representation of how Flaming Gorge would be operated under these alternatives.

Also, model simulation of the Action Alternative did not reflect the full level of flexibility allowed under the 2000 Flow and Temperature Recommendations. Authors of the 2000 Flow and Temperature Recommendations recognized that natural historic flows of the Green River varied during the base flow period as a result of shifting climatic patterns. Under the 2000 Flow and Temperature Recommendations, a target flow is established during the base flow period (August through February) for Reaches 1 and 2 based on the current hydrologic classification of the Green River Basin. The authors realized that historic flows in Reaches 2 and 3 did gradually migrate above and below the average flow for the base flow period. To give the 2000 Flow and Temperature Recommendations the flexibility to achieve this natural variation, the flow recommendations allow the flows in Reach 2 to vary about the established target flow by ±40% during the summer-fall period (August-November) and ±25% during the winter period (December-February) as long as the daily average flow in Reach 2 does not change by more than 3% per day and the temperature objectives of the 2000 Flow and Temperature Recommendations continue to be achieved.

Analysis of Reach 3 potential future flows resulting from operation of Flaming Gorge Dam under the Action and No Action Alternatives is also presented in this section of the EIS. The predicted future flows in Reach 3 were estimated by adding the predicted flows in Reach 2 (computed by the Flaming Gorge Model) to an estimated inflow that corresponded to the historic input from all Reach 2 and 3 tributaries. This estimate included historic losses that would have occurred along the channel of Reach 3, including evaporation, infiltration, and depletions. It was not possible to separate out each tributary inflow because the historic record for the tributary gauges was not as extensive as for the gauges on the Green River. An estimate of the historic tributary inflow was established by subtracting the historic flows of the Green River located at Greendale, Utah, from the historic flow of the Green River located near Green River, Utah, accounting for an approximate lag period of 5 days. Given the available historic gauge records, the Reach 3 flows presented in this section are the best possible estimates of what the flows in Reach 3 would be if Flaming Gorge Dam were operated under the Action and No Action Alternative.

In order to better describe the differences between the two alternatives as they apply to the environmental consequences for other resources, the following sections provide a comparative discussion rather than isolating the model results for each of the two alternatives.

4.3.2.2 Reach 1 – Average Monthly Flows

Figure 4-4 shows the average monthly flows that would likely occur under the Action and No Action Alternatives for each month of the year. On average, the lowest flows of the year in Reach 1 for the No Action Alternative occur in July. This is because the 1992 Biological Opinion requires that flows in Reach 2, measured at the Jensen gauge, be limited to a range of 1,100-1,800 cfs between the end of the spring peak release and September 15. Often, the Yampa River flows in July, and sometimes in early August, are elevated above normal base flow levels because of melting high elevation snow. To achieve the No Action Alternative required flow range in Reach 2, releases from Flaming Gorge Dam, during July and August, are often limited to the minimum required release of 800 cfs. Restrictions under the No Action Alternative are relaxed after September 15 to allow flows in Reach 2 to be as high as 2,400 cfs. Then in November, the No Action Alternative lifts these flow restrictions, and releases from Flaming Gorge Dam are set to the appropriate level so that a drawdown target can be achieved by March. Reach 1 flows, under the No Action Alternative from November to February, are noticeably higher than the Reach 1 flows that occur during the months of July through October.

The 2000 Flow and Temperature Recommendations, on the other hand, do not focus on restricting flows during the months of July through October. Under the Action Alternative, flows during the base flow period are determined the same way each month, resulting in similar flow levels throughout the entire base flow period. Average flows under the Action Alternative appear to have a more natural pattern with high flows during the spring followed by low stable flows during the summer, fall, and winter months.

4.3.2.3 Reach 1 – Spring Peak Flows

The distributions of peak flows in Reach 1 for the Action and No Action Alternatives are shown in figure 4-5. Reach 1 peak flows are limited to powerplant capacity (approximately 4,600 cfs) under the No Action Alternative during normal operations. Only in very wet years, when releasing 4,600 cfs does not release a great enough volume to safely control the reservoir elevation, does the No Action Alternative allow a release rate above 4,600 cfs. The Action Alternative, on the other hand, attempts to achieve target flows in Reach 2 as the main priority for the spring release. Under the Action Alternative, the flows of the

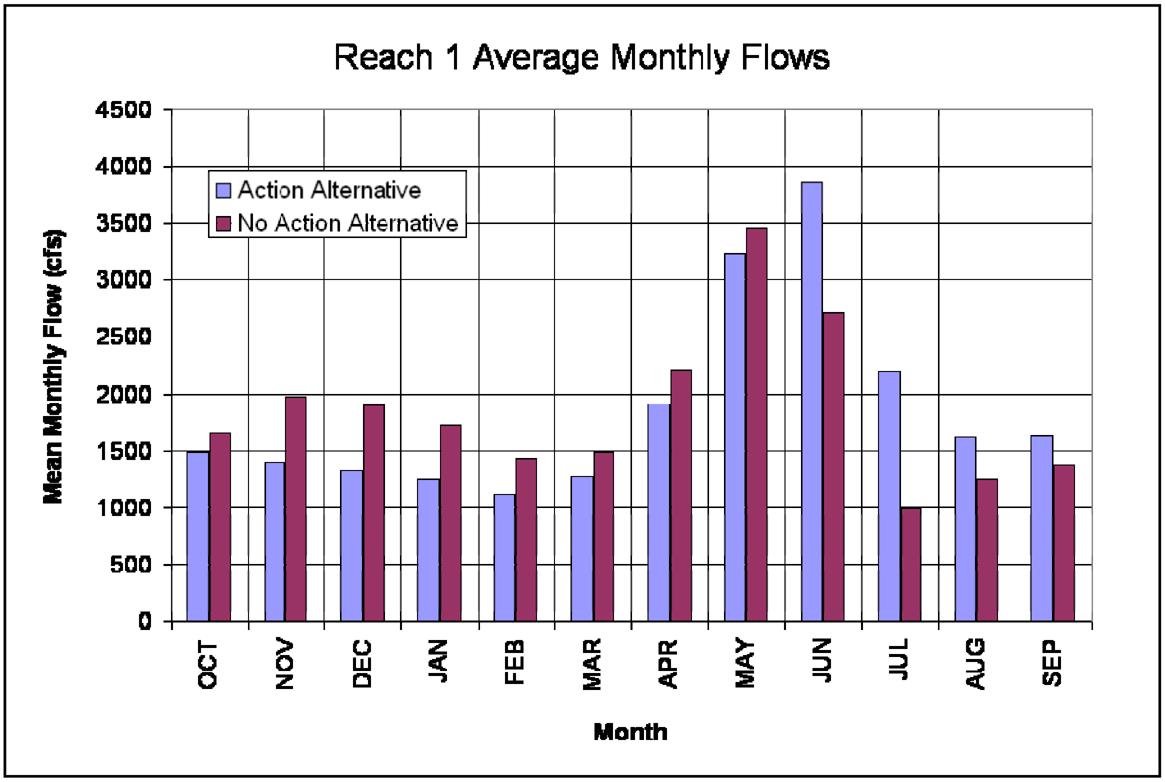

Figure 4-4.—Reach 1 Average Monthly Flows.

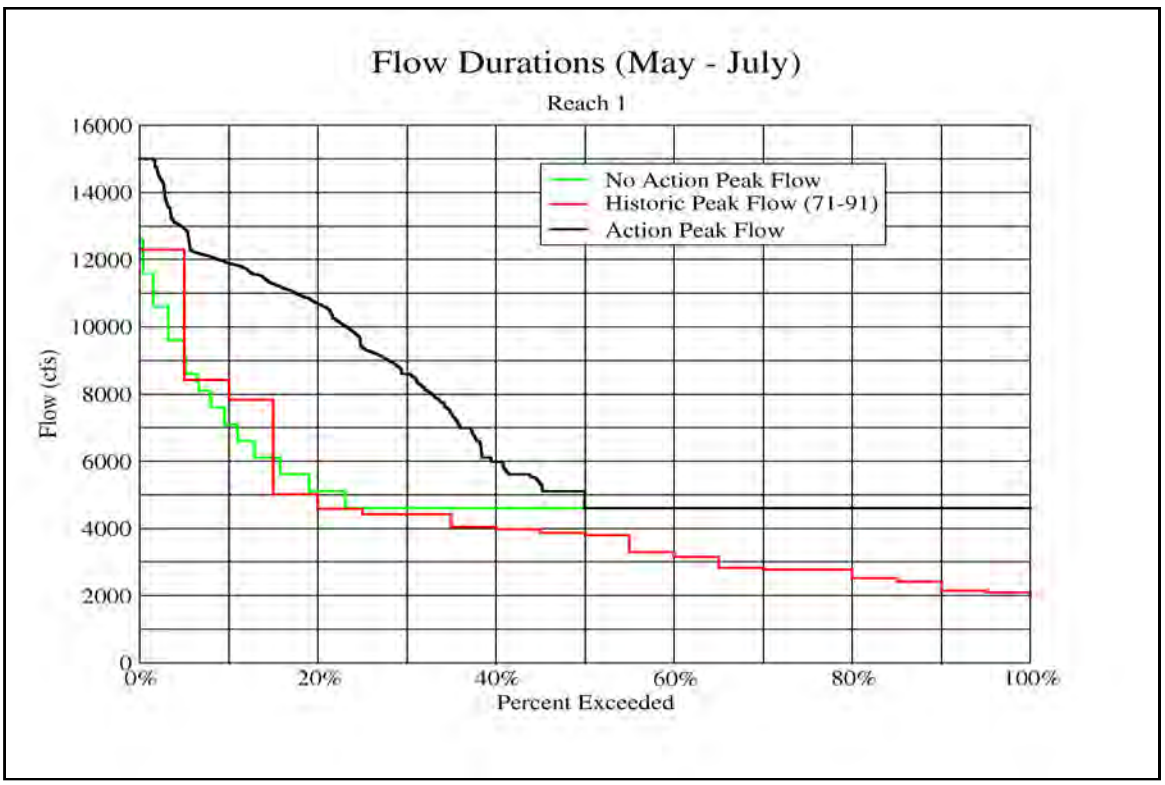

Figure 4-5.—Reach 1, 1-Day Peak Flow Distribution.

Yampa River are monitored closely during the spring, and releases are adjusted to achieve target flows in Reach 2. In most cases, the Action Alternative peak flows in Reach 1 are greater in magnitude than those under the No Action Alternative for similar hydrologic conditions.

Under the Action Alternative, the Flaming Gorge Model predicts that Reach 1 peak flows would likely exceed the capacity of the powerplant (approximately 4,600 cfs) in about 50% of all years. Under the No Action Alternative, the Flaming Gorge Model predicts that Reach 1 peak flows would likely exceed the powerplant capacity in about 23% of all years. In terms of spillway use, the Flaming Gorge Model predicts that spillway releases will occur about 29% of the time under the Action Alternative and about 5% of the time under the No Action Alternative. For the hydrologic modeling, the Action Alternative peak releases were limited to 15,000 cfs, which occurred about 1% of the time. The Flaming Gorge Model under the No Action Alternative limited peak releases to 12,600 cfs. In about 1% of all years, peak releases under the No Action Alternative achieved 12,600 cfs. Releases could exceed these thresholds on rare occasions when warranted by extreme hydrologic conditions.

The 2000 Flow and Temperature Recommendations call for peak flows in Reach 1 of 8,600 cfs or higher in at least 10% of all years and 4,600 cfs in all years. Table 4-1 shows how often the Flaming Gorge Model achieved target flows for Reach 1 under the No Action and Action Alternatives. Reservoir operations under the Action Alternative achieve the flow objectives for Reach 2 as the first priority. This explains why the peak flow targets in Reach 1 are exceeded by much more than the 10% required by the 2000 Flow and Temperature Recommendations.

4.3.2.4 Reach 2 – Average Monthly Flows

Figure 4-6 shows the monthly average flows in Reach 2 for all months of the year. The average monthly flows do not show a significant difference under the two alternatives. The average monthly flows in Reach 2 during the summer months of June and July would likely be about 1,100 cfs higher under the Action Alternative. Conversely, during the fall and winter months, flows in Reach 2 would likely be about 200-600 cfs higher under the No Action Alternative.

The pattern of flows throughout the year that was established in Reach 1 is also noticeable in Reach 2. Flows in Reach 2 during the summer months appear to be less under the No Action Alternative (as compared to the Action Alternative) and more during the fall and winter months. While these differences appear to be less significant in Reach 2, the overall pattern is similar to what occurs in Reach 1 and is a result of how releases are determined by the Action and No Action Alternatives during the summer and early fall months. While the restrictions of the No Action Alternative maintain lower flows

Table 4-1.—Reach 1 Flow Objective Comparison of Action and No Action Alternatives

Spring Peak Flow Recommendations	Target (%)	Action Ruleset (%)	No Action Ruleset (%)
Peak >= 8,600 cfs for at least 1 day	10	30.2	6.5
Peak >= 4,600 cfs for at least 1 day	100	100	100

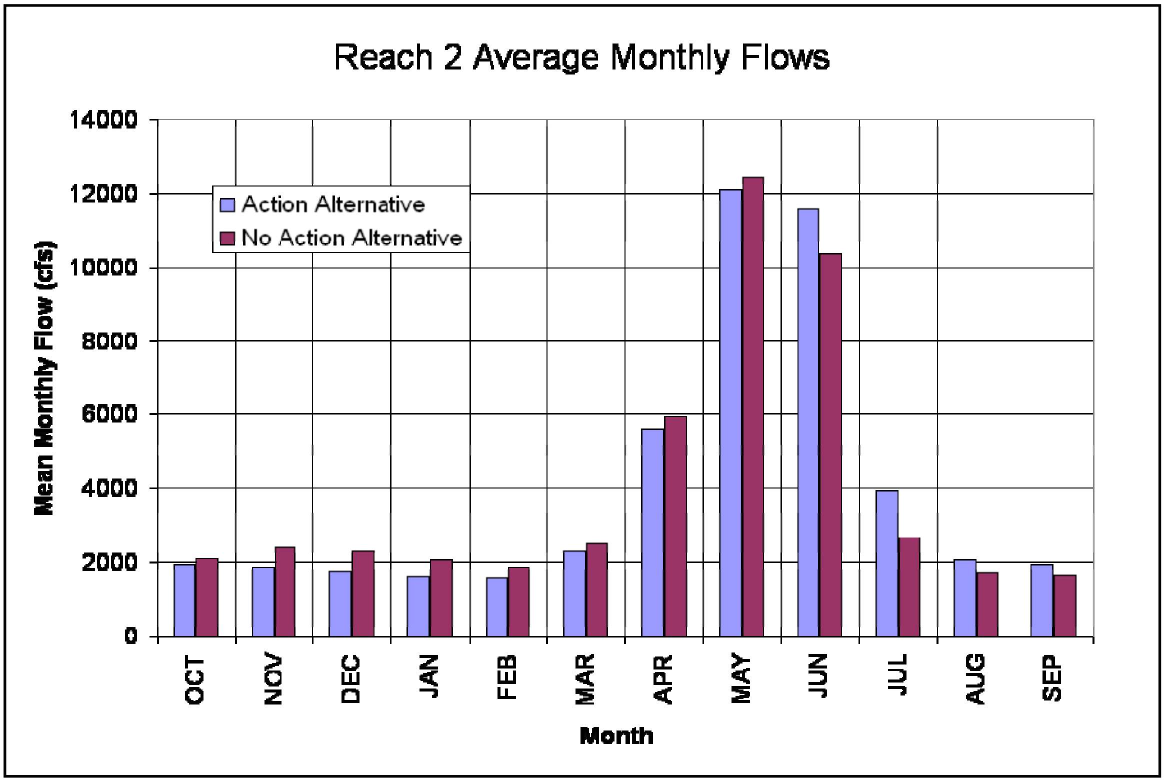

Figure 4-6.—Reach 2 Average Monthly Flows.

during these months, releases in the late fall and winter months are much higher to control reservoir storage. The Action Alternative takes a much more consistent approach to setting releases during the entire base flow period resulting in Reach 2 flow levels that change only moderately during the base flow period.

4.3.2.5 Reach 2 – Spring Peak Flows

Figure 4-7 shows the distribution of peak flows that would occur in Reach 2 under the Action and No Action Alternatives. Peak flows would be similar, despite the fact that the releases from Flaming Gorge are determined in very different ways under the Action and No Action Alternatives. In about 13% of all years, when conditions are wet, the peak flows in Reach 2 under the Action and No Action Alternatives would show a noticeable difference. The 2000 Flow and Temperature Recommendations call for peak flows in Reach 2 to exceed 26,400 cfs in at least 10% of all years. In order to achieve this, the Action Alternative monitors conditions in the Yampa River Basin. When the Yampa River is likely to flow at high levels, releases from Flaming Gorge Dam under the Action Alternative are made to achieve this target flow. In about 87% of all years, the distribution of peak flows in Reach 2 would be very similar under the two alternatives.

The 2000 Flow and Temperature Recommendations also specify several flow duration targets for Reach 2. These targets are to be achieved to various levels of frequency. Table 4-2 shows the spring flow and duration targets specified in the 2000 Flow and Temperature Recommendations and the frequencies that these targets should be achieved. The simulation of the Action Alternative of the Flaming Gorge Model predicts that the frequencies that each of

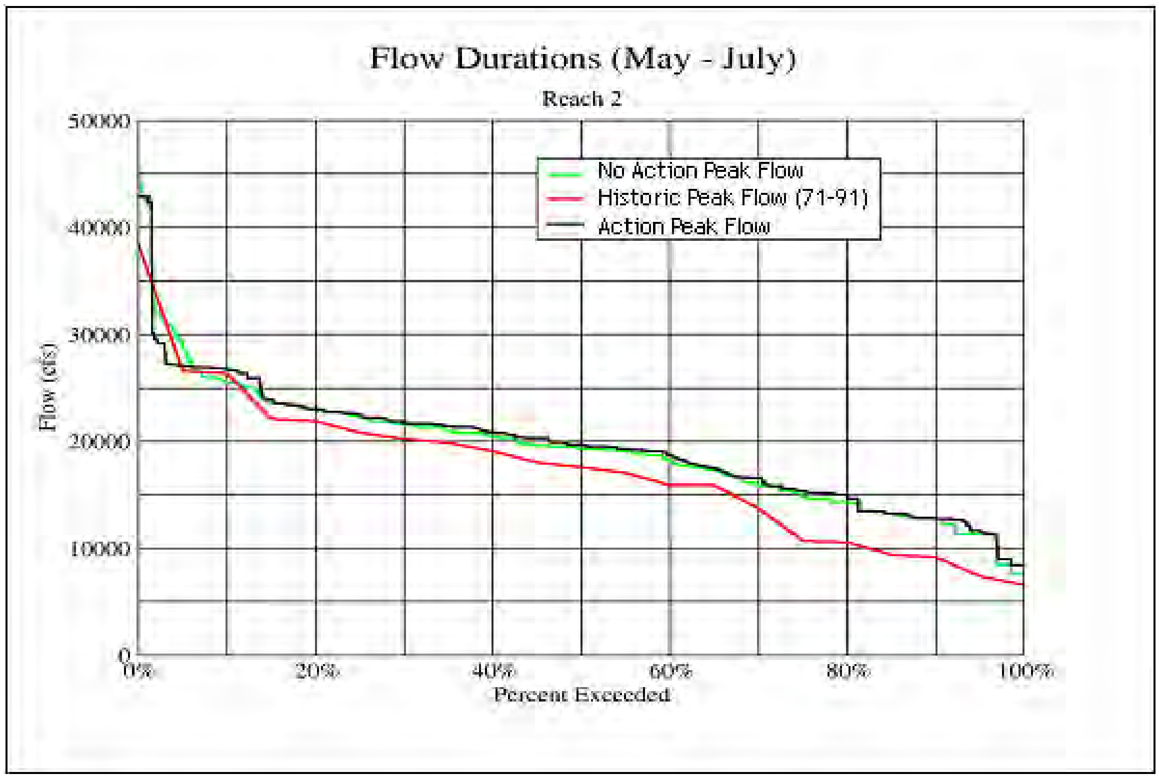

Figure 4-7.—Reach 2, 1-Day Average Peak Flow Distribution.

Table 4-2.—Reach 2 Flow Objective Comparison of Action and No Action Alternatives

Spring Peak Flow Recommendations	Target Frequency (%)	Action Ruleset (%)	No Action Ruleset (%)
Peak >= 26,400 cfs For at least 1 day	10	11.3	7.1
Peak >= 22,700 cfs For at least 2 weeks	10	10.7	4.6
Peak >= 18,600 cfs For at least 4 weeks	10	11.1	6.0
Peak >= 20,300 cfs For at least 1 day	30	46.3	42.3
Peak >= 18,600 cfs For at least 2 weeks	40	41.1	15.6
Peak >= 18,600 cfs For at least 1 day	50	60.3	59.1
Peak >= 8,300 cfs For at least 1 day	100	100	98.5
Peak >= 8,300 cfs For at least 1 week	90	96.8	96.9
Peak >= 8,300 cfs For at least 2 days except in extreme dry years	98	99.6	98.4

these targets will be achieved at the level prescribed by the 2000 Flow and Temperature Recommendations. The frequencies in which the No Action Alternative also achieves these targets are also shown.

4.3.2.6 Reach 3 – Average Monthly Flows

Figure 4-8 shows the monthly average flows in Reach 3 for all months of the year. The average monthly flows do not show a significant difference under the two alternatives. The impacts of the Action and No Action Alternatives are diminished significantly in Reach 3 as a result of tributary flows that contribute to the flow of the Green River.

As with the other reaches, flows under the No Action Alternative change during the base flow period at the end of September. During the months of July, August, and September, after the spring peak release, the No Action Alternative limits flows in Reach 2 to 1,800 cfs. In October, the No Action Alternative limits the flows in Reach 2 to 2,400 cfs. Beginning in November, releases from Flaming Gorge are not limited by the No Action Alternative and are controlled to optimize reservoir operations so that a drawdown target is achieved by the end of February. The effect of these No Action restrictions does translate into all three reaches of the Green River, causing flows in the summer months to be much lower than the flows of the Action Alternative. During the winter months when the No Action Alternative restrictions are not in effect, flows tend to be much higher under the No Action Alternative than the flows of the Action Alternative.

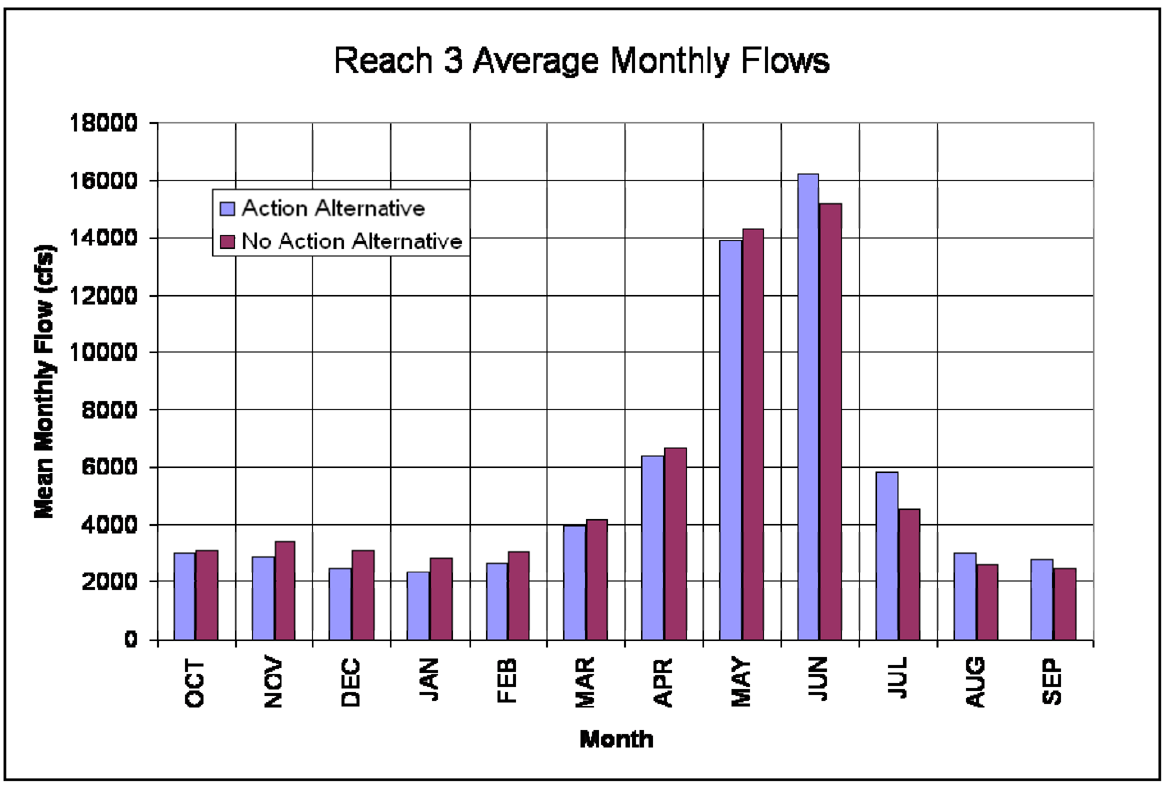

Figure 4-8.—Reach 3 Average Monthly Flows.

4.3.2.7 Reach 3 – Spring Peak Flows

Figure 4-9 shows the distribution of the estimated peak flows that would occur in Reach 3 under the Action and No Action Alternatives. Reach 3 peak flows would be quite similar under the Action and No Action Alternatives. The average single day peak flows in Reach 3 are basically the same under the two alternatives. Differences occur between the Action and No Action Alternatives in Reach 3 in the duration of peak flows. Under the Action Alternative, Reach 3 peak flow magnitudes are maintained longer than under the No Action Alternative. The amendment to the Hydrologic Modeling Report (in the Hydrologic Modeling Technical Appendix) describes in more detail the differences between the two alternatives with respect to peak flows that would occur in Reach 3.

The 2000 Flow and Temperature Recommendations specify several flow duration targets for Reach 3 in addition to the targets established for Reaches 1 and 2. These Reach 3 targets are important for the recovery of the endangered fishes in Reach 3; however, the authors of the 2000 Flow and Temperature Recommendations did recognize the limitation of operating Flaming Gorge Dam to achieve these targets. The Flaming Gorge Model did not focus on achieving any of these targets and, rather, focused on achieving the targets established for Reach 2. But as a result of achieving Reach 2 targets, all but one of the Reach 3 targets was achieved in the model results by operating Flaming Gorge Dam under the Action Alternative. Only the 1-day peak flow target of 39,000 cfs fell short of the recommended frequency. Table 4-3 shows

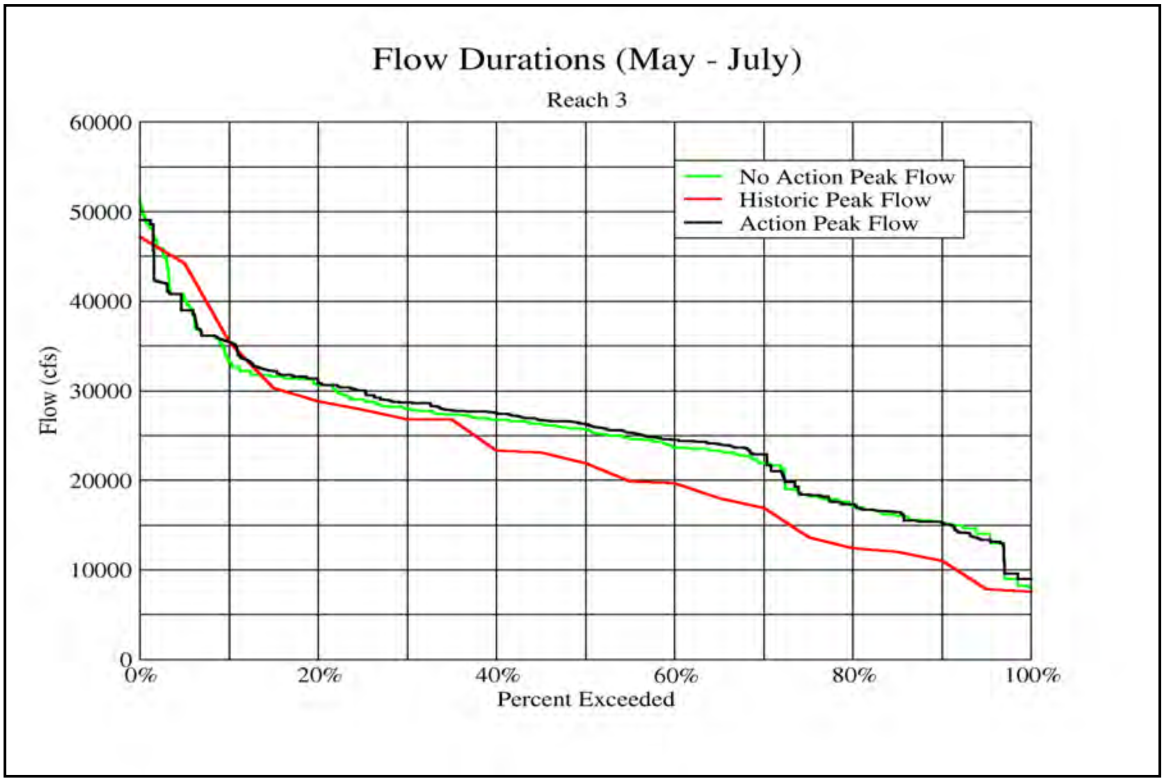

Figure 4-9.—Reach 3, 1-Day Average Peak Flow Distribution.

Table 4-3.—Reach 3 Flow Objective Comparison of Action and No Action Alternatives

Spring Peak Flow Recommendations	Target Frequency (%)	Action Ruleset (%)	No Action Ruleset (%)
Peak >= 39,000 cfs For at least 1 day	10	4.6	5.9
Peak >= 24,000 cfs For at least 2 weeks	10	22.0	14.4
Peak >= 22,000 cfs For at least 4 weeks	10	12.0	8.4
Peak >= 24,000 cfs For at least 1 day	30	65.2	59.4
Peak >= 22,000 cfs For at least 2 weeks	40	40.2	33.8
Peak >= 22,000 cfs for at least 1 day	50	70.3	69.4
Peak >= 8,300 cfs for at least 1 day	100	100	98.5
Peak >= 8,300 cfs for at least 1week	90	96.9	96.9
Peak >= 8,300 cfs for at least 2 days except in extreme dry years	98	100	98.5

the spring flow and duration targets specified in the 2000 Flow and Temperature Recommendations and the frequencies that these targets should be achieved in Reach 3. The frequencies of how the Action and No Action Alternatives will likely achieve these targets are also shown in the table.

A streamflow of 22,000 cfs in Reach 3 can be viewed as an index to the occurrence of overbank flooding in a 6-mile portion of Reach 3 from the White River confluence with the Green River to the confluence of Pariette Draw with the Green River. The frequency of flows of at least 22,000 cfs that are sustained for at least 2 weeks is greater under Action Alternative conditions relative to No Action Alternative conditions. For example, flood plain inundation lasting at least 2 weeks associated with flows of at least 22,000 cfs occurs more often under Action Alternative conditions (40% of the time) when compared to the frequency of occurrence under No Action Alternative conditions (34% of the time).

4.3.3 Water Quality, Flaming Gorge Reservoir

This section addresses impacts to water quality within the affected environment at Flaming Gorge Reservoir. Only direct impacts to water quality in the reservoir are considered in this section. Impacts to other resources as a result of changes in reservoir operations are reported in their respective sections.

4.3.3.1 No Action Alternative

Water quality in Flaming Gorge Reservoir would not deviate from current conditions as a result of operating Flaming Gorge Dam under the No Action Alternative. Since 1987, the operation of Flaming Gorge Dam to aid in the recovery of the native endangered fish downstream from the reservoir has resulted in a moderation of the annual drawdown of the reservoir elevation. This moderation significantly improved water quality in the reservoir by reducing the severity and frequency of algal blooms in the northern-most 20 to 30 miles of the reservoir. When reservoir elevations are drawn down near the elevation of 6010 feet above mean sea level (msl) (30 feet below the full pool elevation) during the late summer and fall months, large algal blooms are likely to occur. Operation of Flaming Gorge Dam to meet the flow objectives of the No Action Alternative would not likely increase the frequency that the reservoir elevation is drawn down to this level, because operations would be very similar to historic operations since 1987. This is evident in figure 4-10 which shows that, under the No Action Alternative, reservoir drawdowns by the end of September (critical time period for algal production) would likely be less than historic levels.

4.3.3.2 Action Alternative

The operation of Flaming Gorge Dam under the Action Alternative would likely reduce the frequency that the reservoir elevation is drawn down from what is expected to occur under the No Action Alternative. Figure 4-10 shows that it is not very likely that the reservoir elevation would ever be drawn down to 6010 feet above msl (less than 1% chance) under the Action Alternative during the month of September. By comparison, the reservoir elevation under the No Action Alternative would likely be drawn down to this level about 2% of the time during September. Since dam operation under the Action Alternative reduces the frequency and extent that the reservoir elevation would be drawn down to the critical level of 6010 feet above msl, water quality in Flaming Gorge Reservoir would not be adversely affected by this change in operations. Algal blooms during the fall would likely happen less often under this alternative.

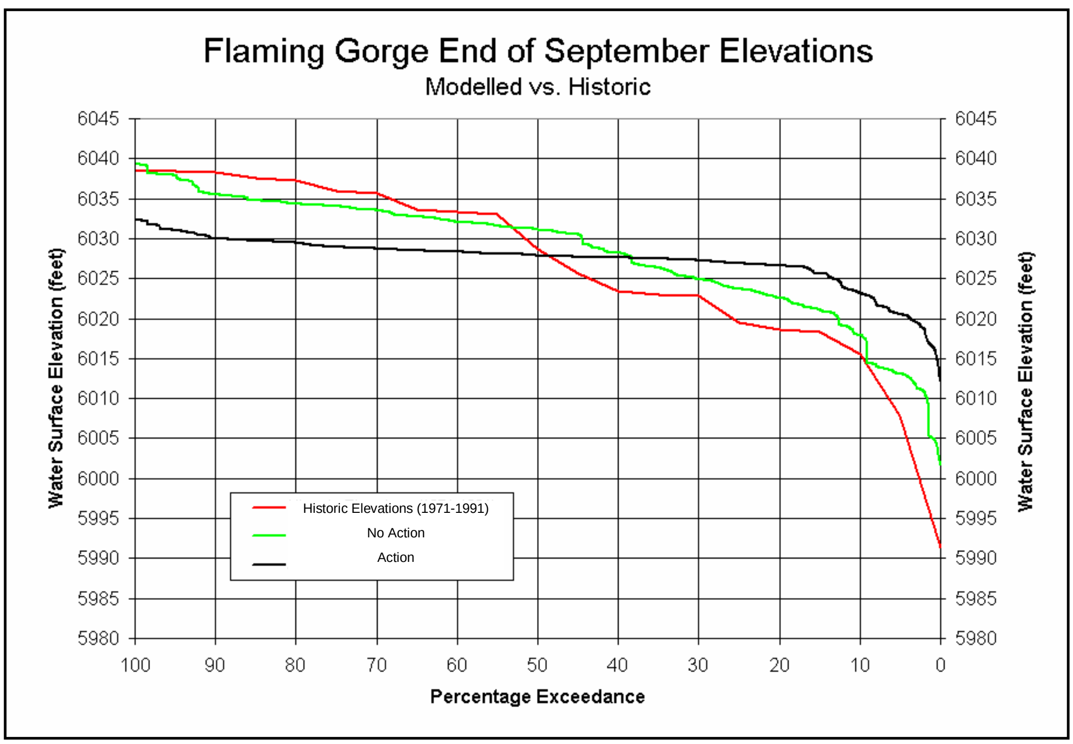

Figure 4-10.—Reservoir Elevation Comparison for the End of September.

4.3.4 Water Quality, Green River Reach 1

Water quality on the Green River in Reach 1 is associated with sediment transport and water temperature and is covered in the sediment and water temperature sections below. Water temperature impacts in Reach 1 are associated with a slight increase in release temperatures attempting to warm the river downstream for endangered fish in Upper Lodore Canyon and at the confluence with the Yampa River. These modifications and impacts are discussed in section 4.7.3.1, "Aquatic Animals" and summarized in table 4-8, later in this chapter.

4.3.4.1 Temperature Evaluation Methodology

The results of the Flaming Gorge Hydrologic Model were used to determine the consequences of operating Flaming Gorge Dam under the No Action and Action Alternatives. To determine the relationship among release volumes, release temperatures, and downstream temperatures up to 65 miles below the dam, the output of the Flaming Gorge Hydrologic Model was coupled with a River Temperature Model developed for the Bureau of Reclamation by Dr. John Carron, Hydrosphere Resource Consultants, Boulder, Colorado. This temperature model enables the prediction of main channel river temperatures at varying distances from the dam under a wide range of dam releases and water temperatures (table 4-4). For the purposes of this EIS, the temperature analysis focuses on the July/August time period under average meteorology (normal summer temperatures) and maximal meteorology (a hotter than normal summer temperatures). The model has been calibrated against various thermograph data, and its accuracy increases with closeness to the dam. Backwater temperatures, which are important to the early life stages of native fish, were not predicted with this model. The relationships between riverflows and temperatures and various aspects of the Green River fishes' life history were summarized in chapter 3, "Affected Environment," and serve as the basis for the following analyses.

4.3.4.1.1 No Action Alternative – The 2000 Flow and Temperature Recommendations for the Green River introduce a new target for Upper Lodore Canyon of 64-68 degrees Fahrenheit (°F) (18-20 degrees Celsius [°C]) or greater for 2-5 weeks in summer and fall, which has been incorporated into the Action Alternative for this EIS. Water temperatures measured at the Browns Park gauge provide the best available data for determining the extent to which the recommended temperatures were met during the period since the 1992 Biological Opinion. Neither daily mean or daily median temperatures in the months of June through October met this recommended target (table 3-4). Maximum-recorded daily mean temperatures exceeded 64 °F (18 °C) in June, July, and August, but this temperature was met or exceeded on more than 10% of days only in July.

Operating Flaming Gorge Dam to meet the water temperature requirements of the No Action Alternative would require releasing water temperature prescribed in the 1992 Biological Opinion during summer and fall months. Historically, the warmest available water temperatures have been in the range from about 54-68 °F (12-20 °C) during the months of June through October (table 3-2); however, releases have been held to 59 °F (15 °C) or less to protect turbine bearings and remain below the maximum temperature identified in the biological opinion. Under the No Action Alternative, release temperatures would be maintained near 59 °F (15 °C) as long as possible during the summer and fall. The only exception to this would be when releases are less than 1,200 cfs. When releases are this low, summer release

Table 4-4.—River Temperatures at Four Locations Downstream From Flaming Gorge Dam Under Varying Release Volumes and Release Temperatures (13 °C Represents the No Action Alternative and 15 °C Represents the Action Alternative) The release volumes correspond to the most likely base flow target for each hydrologic category (dry – wet) as identified in the Flaming Gorge Model. Results are presented for both the average meteorology and the maximal meteorology (under the "Met." heading). All temperatures represent the condition on July 15.

Site Location			Taylor Flat				Utah/Colorado State Line				Upper Lodore				Lower Lodore			
Dist. Below Flaming Gorge Dam			16 miles				29 miles				46 miles				65 miles			
Release Temperature (ºC)			13		15		13		15		13		15		13		15	
Met.	Hydrology Category	Release volume (CFS)	Average daily	Maximum daily	Average daily	Maximum daily	Average daily	Maximum daily	Average daily	Maximum daily	Average daily	Maximum daily	Average daily	Maximum daily	Avg daily	Maximum daily	Average daily	Maximum daily
Average Average Weather	Dry and moderate dry	800	16	19.8			18.3	21.4			20.3	22.7			21.3	23.7		
	Average	1,400	14.8	17.9	16.6	19.6	16.4	19	17.9	20.5	18.1	20	19.5	21.5	19.3	21.2	20.5	22.9
	Moderate Wet	2,000	14.3	16.9	16.1	18.7	15.5	17.8	17.2	19.4	16.9	18.8	18.4	20.6	18.1	21	19.4	22.9
	Wet	2,400	14.1	16.5	16	18.3	15.1	17.3	16.9	19	16.4	18.6	18	20.6	17.5	21	18.9	22.9
Maximal Hot Weather	Dry and moderate dry	800	17.1	20			20	22.3			22.5	24.7			23.7	26.2		
	Average	1,400	15.5	18	17.2	19.7	17.5	19.3	19	20.8	19.7	21.3	21	22.5	21.2	22.7	22.4	23.7
	Moderate Wet	2,000	14.8	16.9	16.6	18.7	16.3	18	18	19.6	18.2	19.3	19.6	20.8	19.6	21.1	20.9	23.1
	Wet	2,400	14.5	16.5	16.4	18.3	15.8	17.5	17.6	19.2	17.5	18.7	19	20.7	18.8	21.1	20.2	23

[1] Conversion to degrees Fahrenheit = C x 9/5 + 32.
Note: Blank cells indicate 15 ºC water temperature would not be released during dry and moderately dry years.

temperatures may be reduced to 55 °F (13 °C) to protect trout located in lower Browns Park from the effects of daily average water temperatures above 64 °F (18 °C).

When releases are this low, water temperatures increase sooner as the water moves down the river. This release temperature and volume combination would still provide the minimum 64 °F (18 °C) water temperature for endangered fish at Upper Lodore Canyon.

4.3.4.1.2 Action Alternative – Release temperatures under the Action Alternative would need to be greater than those under the No Action Alternative over a broader range of hydrologies to meet the recommended water temperatures in Upper Lodore Canyon and at the confluence of the Green and Yampa Rivers. During the summer and early fall months, release temperatures would be managed to provide daily mean water temperatures in Upper Lodore Canyon of at least 64 °F (18 °C) as the primary target.

Based on modeling results presented in table 4-4, this minimum temperature of 64 °F (18 °C) can be reached in all years during midsummer with dam releases of 800-1,200 cfs and water temperatures of 55-59 °F (13-15 °C). Higher release temperatures at these low flows jeopardize the trout fishery in Browns Park. Temperatures in Reach 2 that are too warm during low flows may also give greater advantage to nonnative fish. At flows greater than 1,200-1,400 cfs, the target release temperature would be 59 °F (15 ºC), but operational flexibility needs to maintain a range of about 57-60 °F (14-15.5 ºC). Data will need to be gathered by temperature sensors placed at appropriate locations during future operations to determine accuracy of the model's predictions and whether release temperatures above 59 °F (15 °C) are necessary to meet target water temperatures.

Analysis of the limited record of water temperatures near the confluence of the Green and Yampa Rivers suggests that a difference of less than or equal to 9 °F (5 °C) between the two flows will be achieved more consistently under the Action Alternative than the No Action Alternative.

4.3.4.2 Sediment Transport

This section addresses impacts to the transport of sediment in Reach 1 associated with operating Flaming Gorge Reservoir under the Action and No Action Alternatives. Impacts to other resources in Reach 1 that might be affected by sediment transport are assessed in other sections of this chapter.

4.3.4.2.1 No Action Alternative – Under the No Action Alternative, long-term average annual transport in Reach 1 is expected to be about 92,000 tons per year. This estimate was developed according to the procedure noted in Strand and Pemberton (1982) that requires flow duration and sediment rating curve data. This estimate was developed using the No Action flow output data from the Flaming Gorge Model described in section 4.3.2.1 and the total load sediment rating curve for the Green River near Browns Park, Colorado, as described by Martin et al. (1998). Seasonally, about 49% of the average annual sediment load, or 45,000 tons, is expected to be transported during May, June, and July under the No Action Alternative.

4.3.4.2.2 Action Alternative – Under the Action Alternative, long-term average annual transport in Reach 1 is expected to be about 105,000 tons per year. This estimate was developed according to the procedure noted in Strand and Pemberton (1982) that requires flow duration and sediment rating curve data. This estimate was developed using the Action Alternative flow output data from the Flaming Gorge Model and the total load sediment rating curve for the Green River near Browns Park, Colorado, as described by Martin, et al. (1998). Seasonally, about 67% of the average annual sediment load, or about 70,000 tons, is expected to be transported during May, June, and July under the Action Alternative. In comparison to the estimated average annual sediment load for Reach 1 under the No Action Alternative, sediment transport under the Action Alternative represents an increase of about 14%.

Seasonally, during May, June, and July, average annual sediment transport is about 56% greater under the Action Alternative relative to the No Action Alternative. Figure 4-11 illustrates the differences between monthly sediment loads in Reach 1 for both the No Action and Action Alternatives conditions.

As described in section 4.3.2.3, 1-day peak flows greater than or equal to 8,600 cfs in Reach 1 will occur much more frequently under Action Alternative conditions when compared to No Action Alternative conditions. Based on the channel erosion observations reported by Martin et al. (1998), it is likely that erosion of sandbars in portions of Reach 1 will be greater under the Action Alternative flow regime. Also, bank erosion in Reach 1 under the Action Alternative is likely to be greater than bank erosion under the No Action Alternative conditions.

4.3.5 Water Quality, Green River Reach 2

Water quality on the Green River in Reach 2 is associated with sediment transport and water temperature and is covered in the sediment and water temperature sections. Water temperature impacts in Reach 2 are associated with slight modifications in temperature attempting to warm the river downstream for endangered fish at the confluence with the Yampa River.

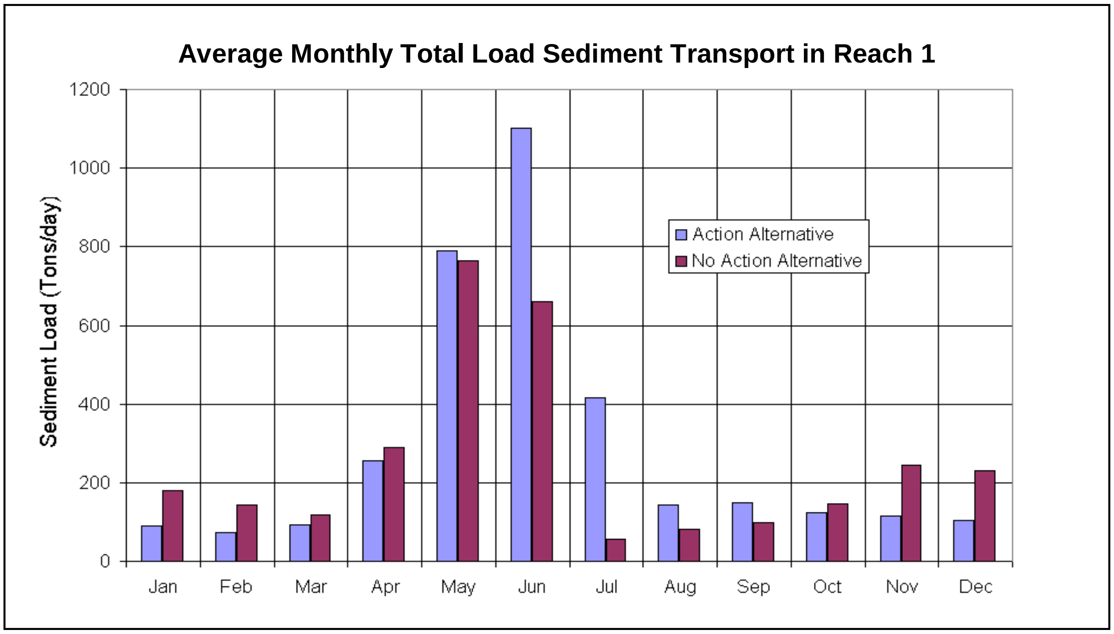

Figure 4-11.—Average Monthly Total Load Sediment Transport in Reach 1.

4.3.5.1 Water Temperature

This section discusses the potential impacts to the water temperature regime in Reach 2 of the Green River as a result of operating Flaming Gorge Dam to achieve the flow and temperature objectives of the two proposed alternatives. The primary concern for water quality in Reach 2 occurs at the confluence of the Green and Yampa Rivers where thermal shock from cold water may impact drifting larval fish emerging from the Yampa River into the Green River.

4.3.5.1.1 No Action Alternative – The desired 9 °F (5 °C) maximum difference between Green River and Yampa River waters would not be consistently attained under the No Action Alternative; however, based on past records, the deviation would seldom exceed 13.5 °F (7.5 °C). Results of research investigations on cold shock to endangered Colorado River fish (Berry, 1988; Childs and Clarkson, 1996) show that water temperature changes of less than 18 °F (10 °C) would have limited effect on drifting larvae, so minor exceedances slightly above 9 °F (5 °C) should have little consequence. Furthermore, drifting larvae would encounter these temperatures for only a brief time as they passed downstream into the combined Green River and Yampa River waters.

4.3.5.1.2 Action Alternative – Under the Action Alternative, emphasis would be placed on meeting the 64-68 °F (18-20 °C) or greater temperature minimum at Upper Lodore Canyon in Reach 1. This emphasis would result in increased Green River water temperatures at its confluence with the Yampa River and even fewer exceedances of the 9 °F (5 °C) difference in water temperatures that would be experienced by drifting larval endangered fish. The benefit experienced by larval fish from reduced temperature differences under the Action Alternative would likely be greatest in wetter hydrologies when cold temperatures persist further downstream due to higher current velocities.

4.3.5.2 Sediment Transport

This section discusses the potential impacts to the sediment transport in Reach 2 of the Green River as a result of operating Flaming

Gorge Dam to achieve the flow and temperature objectives of the two proposed alternatives.

4.3.5.2.1 No Action Alternative – Under the No Action Alternative, long-term average annual sediment transport in Reach 2 is expected to be about 1.2 million tons per year. This estimate was developed according to the procedure noted in Strand and Pemberton (1982) that requires flow duration and sediment rating curve data. In this case, a flow duration summary developed from the No Action Alternative flow output data for Reach 2 from the Flaming Gorge Model described in section 4.3.2.1 and the sand load sediment rating curve for the Green River near Jensen, Utah, as described by Andrews (1986) were used. Flow duration relationships were developed for each month of the year and coupled with the sediment rating curve, producing monthly estimates of sediment transport. These monthly estimates were summed to produce the estimate of annual sediment transport.

Seasonally, about 83% of the average annual sediment load, or about 1.0 million tons, is expected to be transported during May, June, and July under the No Action Alternative in Reach 2.

4.3.5.2.2 Action Alternative – Under the Action Alternative, long-term average annual sediment transport in Reach 2 is expected to be about 1.3 million tons per year. This estimate was developed according to the procedure noted in Strand and Pemberton (1982) that requires flow duration and sediment rating curve data. In this case, a flow duration summary developed from the Action Alternative flow output data for Reach 2 from the Flaming Gorge Model and the sand load sediment-rating curve for the Green River near Jensen, Utah, as described by Andrews (1986) were used. Flow duration relationships were developed for each month of the year and coupled with the sediment rating curve, producing monthly estimates of sediment transport. These monthly estimates were summed to produce the estimate of annual sediment transport. Seasonally, about 86% of the average annual sand load, or about 1.1 million tons, is expected to be transported during May, June, and July under the Action Alternative.

In comparison to the estimated average annual sediment load for Reach 2 under the No Action Alternative, annual sediment transport under the Action Alternative represents an increase of about 7%. Sediment transport during May, June, and July under the Action Alternative would average nearly 11% more than sediment transport under the No Action Alternative during the same season. Significant widespread changes in channel morphology trends are not expected to occur in Reach 2 under the Action Alternative relative to the No Action Alternative of flow and sediment transport.

Figure 4-12 illustrates the differences between expected monthly sediment loads in Reach 2 for both the No Action and Action Alternatives based upon the average monthly flows for Reach 2 under the No Action and Action Alternatives as described in figure 4-6.

4.3.6 Water Quality, Green River Reach 3

4.3.6.1 Water Temperature

This section discusses the potential impacts to the water temperature regime in Reach 3 of the Green River as a result of operating Flaming Gorge Dam to achieve the flow and temperature objectives of the two proposed alternatives.

4.3.6.1.1 No Action Alternative – Under the No Action Alternative, Green River temperatures will have reached an equilibrium with ambient environmental conditions by the time they travel the 264 miles from the dam to the beginning of the reach. Therefore, dam release temperatures will have no discernable effect on water temperatures in Reach 3.

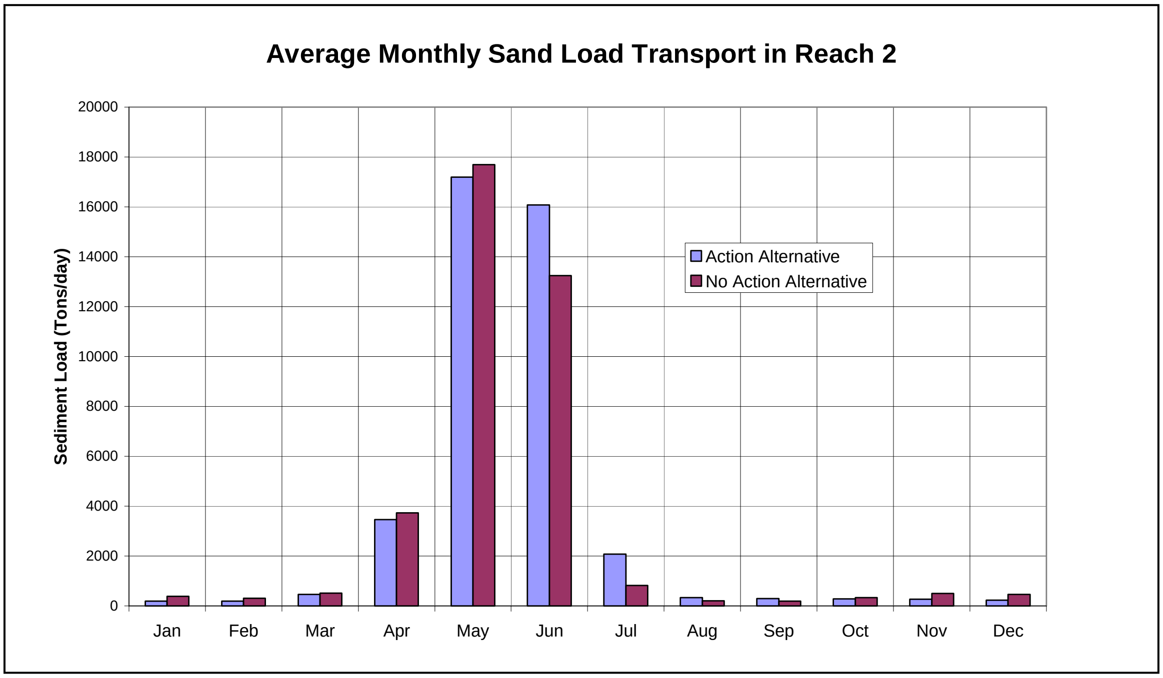

Figure 4-12.—Average Monthly Sand Load Transport in Reach 2.

4.3.6.1.2 Action Alternative – Green River temperatures in Reach 3 under the Action Alternative also will be controlled by ambient environmental conditions, due to the long travel time and distance from Flaming Gorge Dam. No discernable differences in water temperatures are expected from those that will occur under the No Action Alternative in this reach of the Green River.

4.3.6.2 Sediment Transport

This section discusses the potential impacts to the sediment transport in Reach 3 of the Green River as a result of operating Flaming Gorge Dam to achieve the flow and temperature objectives of the two proposed alternatives.

4.3.6.2.1 No Action Alternative – Under the No Action Alternative, long-term average annual sediment transport in Reach 3 is expected to be about 3.25 million tons per year. This estimate was developed according to the procedure noted in Strand and Pemberton (1982) that requires flow duration and sediment rating curve data. In this case, a flow duration summary developed from the No Action Alternative flow output data for Reach 3 from the Flaming Gorge Model described in section 4.3.2.1 and the sand load sediment rating curve for the Green River near Green River, Utah, as described by Andrews (1986) were used. Flow duration relationships were developed for each month of the year and coupled with the sediment rating curve, producing monthly estimates of sediment transport. These monthly estimates were summed to produce the estimate of annual sediment transport.

Seasonally, about 91% of the average annual sediment load, or 2.97 million tons, is expected to be transported during May, June, and July under the No Action Alternative in Reach 3.

4.3.6.2.2 Action Alternative – Under the Action Alternative, long-term average annual sediment transport in Reach 3 is expected to be about 3.5 million tons per year. This estimate was developed according to the procedure noted in Strand and Pemberton (1982) that requires flow duration and sediment rating curve data. In this case, a flow duration summary developed from the Action Alternative flow output data for Reach 3 from the Flaming Gorge Model and the sand load sediment rating curve for the Green River near Green River, Utah, as described by Andrews (1986) were used. Flow duration relationships were developed for each month of the year and coupled with the sediment-rating curve, producing monthly estimates of sediment transport. These monthly estimates were summed to produce the estimate of annual sediment transport. Seasonally, about 93% of the average annual sand load, or about 3.3 million tons, is expected to be transported during May, June, and July under the Action Alternative.

In comparison to the estimated average annual sediment load for Reach 3 under the No Action Alternative, annual sediment transport under the Action Alternative represents an increase of about 8%. Sediment transport during May, June, and July under the Action Alternative would average about 9% more than sediment transport under the No Action Alternative during the same season. Significant widespread changes in channel morphology trends are not expected to occur in Reach 3 under the Action Alternative relative to the No Action Alternative effects on flow and sediment transport.

Figure 4-13 illustrates the differences between expected monthly sediment loads in Reach 3 for both No Action and Action Alternatives, based upon the average monthly flows for Reach 3 under the No Action and Action Alternatives as described in figure 4-8.

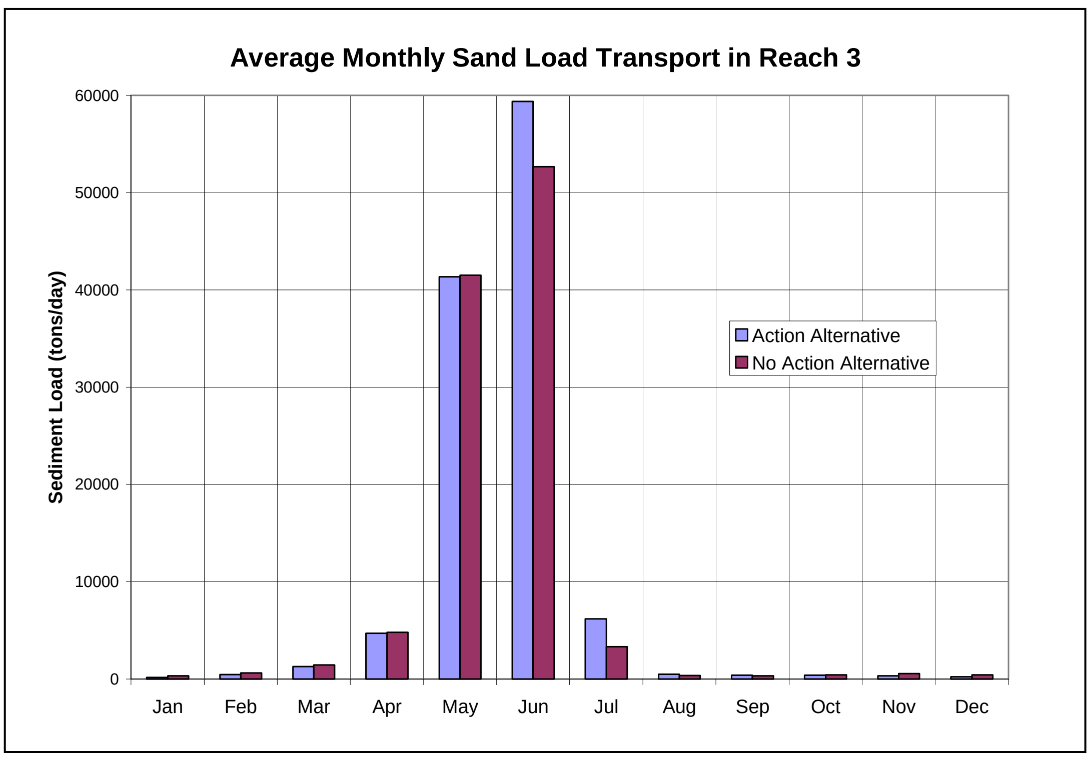

Figure 4-13.—Average Monthly Sand Load Transport in Reach 3.

4.4 HYDROPOWER GENERATION

Hydropower generation analyses are based on two methodologies. The first is an economic analysis that represents the effects on a national perspective for each alternative. The results from the economic analysis provide values that reasonably represent national economic benefits, consistent with the Federal objective. The second analysis is a financial analysis representing the impact to the wholesale rates paid by the utility customers who purchase the electricity generated by Flaming Gorge Powerplant.

Hydropower analysis focuses on the potential impacts of the alternatives on powerplant operations at Flaming Gorge Dam. Daily maximum generation occurs during peak high demand periods as much as possible while still meeting operating restrictions, such as minimum flow requirements during other times of the day. Flaming Gorge Dam and Reservoir are operated to meet a wide range of authorized project purposes. Hydropower contributes significant project benefits. In evaluating changes in power generation attributed to implementation of the 2000 Flow and Temperature Recommendations represented by the Action Alternative, consideration was given only to the change in power generation from Flaming Gorge Dam without looking at the potential impact to other generation facilities.

4.4.1 Economic Analysis Methodology

This analysis used a computer model developed by Argonne National Laboratories in collaboration with Reclamation. The model uses an estimate of the quantity of energy injected into the power grid along with a forecasted hourly electricity spot price (market price) to determine the economic value for each alternative represented by the net present value of annual cash flows. Use of historic prices would not reflect the change in demand and changes in the electrical generation industry in recent years. The hydrology provided by Reclamation consisted of a 25-year period (2002-2026) of projected daily releases under the Action and No Action Alternatives that reflected an average hydrologic trace. The same hydrology trace was used for both alternatives. The model was designed to reflect the constraints and daily flow limitations and other restrictions as identified within the description of the alternatives. For a detailed description of the analysis, please refer to "Power System Modeling" in the Power System Analysis Technical Appendix of this EIS.

Green River Reach 2 flow objectives target conditions at the gauge near Jensen, Utah. Jensen gauge flows are primarily a function of releases from Flaming Gorge Dam and Yampa River flows. Flows on the Yampa River are not controlled, requiring releases from Flaming Gorge Dam to be regulated so that gauge flows are in compliance with each alternative. However, water releases from Flaming Gorge Dam are not required to compensate for large and unpredictable changes in Yampa River flows. These variations in the Yampa River flows make it impossible to always comply with the stringent Jensen gauge constraints, but the Flaming Gorge EIS alternatives require that the general pattern of Yampa River flows should be accounted for when scheduling Flaming Gorge Dam releases. Therefore, as prescribed in the hydrology data, it was assumed in this analysis that the Yampa River flows are constant during a monthly period.

For both the No Action and the Action Alternatives, allowable flows at the Jensen gauge remain constant for each month. The allowable flows at the Jensen gauge exactly matched those given by the Flaming Gorge Model; the average daily water volumes will not change from day to day. Although gauge constraints are not specified during the winter in either of the alternatives, for this analysis, it was assumed that gauge constraints would apply during this time period. This is consistent with historic operations.

While the minimum flow requirement to establish and maintain tailwater trout fisheries is approximately 400 cfs, Flaming Gorge Dam normally releases a continuous flow of 800 cfs. A continuous release of 800 cfs requires a minimum weekly water release of approximately 11,100 acre-feet. Any water releases above this level can be used at the discretion of power dispatchers, taking into account other dam operations and downstream flow constraints. Typically, the dispatcher schedules release of water through the turbines when it has the highest economic value as determined by electricity prices.

The economic analysis model of the two alternatives imposed two restrictions on the rate of water release from Flaming Gorge. The economic model included an up- and down-ramp rate limit of 800 cfs per hour and a single daily peak "hump" restriction. The hourly ramp rate restriction imposed on the economic analysis model limited the change in the water flow rate from 1 hour to the next. For example, if the water release from Flaming Gorge Dam is 2,400 cfs at noon, then releases at 1:00 p.m. would remain within a band that ranges from 1,600 cfs to 3,200 cfs. The single daily peak "hump" restriction ramped releases up from a low release at night to a higher release during the daytime and then back down to a lower release during the following night. That is, dam releases were permitted to change the ramp directions only twice per day—once in the up direction and once in the down direction. Constant flow periods in between the up and down ramp rate phases were allowed. Intermediate up and down fluctuations were not permitted except for automatic generation control. The one-hump restriction and ramping rate reduces the economic value of the hydropower resources and limits the amount of load following.

In general, these limitations have been used at Flaming Gorge Reservoir since 1993; however, there have been times when Reclamation has relaxed these restrictions based on the conditions of the various resources that are affected by fluctuating release patterns. Reclamation sets the appropriate level of the ramp rate as part of the decisionmaking process described in section 1.4, and there are no formalized restrictions that are currently in place with regard to the ramp rates when the powerplant is fluctuating releases for power generation. These restrictions were imposed on the economic analysis model to generally mimic the more frequent pattern of operation at Flaming Gorge Dam since 1993.

Monthly reservoir inflow hydrologies, as simulated by the Flaming Gorge Model, are the same for each alternative. The hydrologies affect monthly water release volumes and reservoir elevations at Flaming Gorge Reservoir. But the reservoir elevation of each alternative is very different, and this impacts the volume of water released each month by each alternative. Therefore, operable capability blocks and associated power conversion factors were estimated for each alternative. Although the powerplant is modeled as a single entity, power conversion factors and capability blocks were based on unit-level computations. Given daily operating guidelines, a mathematical computer program was written that optimized generation and water releases through each turbine, given a total water release from the dam.

4.4.2 Economic Analysis Results

Table 4-5 shows a summary of the results of the simulation runs. Annual values were generated for both the No Action and Action Alternatives. This table shows the generation levels along with the undiscounted nominal economic value of that generation for each year. The value of generation is computed by multiplying hourly electricity production by the hourly spot market price. As can be seen, for many years, the Action Alternative generates a higher value of energy than the

Table 4-5.—Comparison of the Annual Economic Benefits of the Flaming Gorge Powerplant Between the Action and No Action Alternatives

		No Action Alternative				Action Alternative						
Year	Average Spot Market Price ($/MWh[1])	Average Power Release (cfs)	Annual Generation (GWh)[2]	Nominal Value (Millions $)	Present Value (Millions $)	Average Power Release (cfs)	Annual Generation (GWh)	Nominal Value (Millions $)	Present Value (Millions $)	Generation Above the No Action Alternative (GWh)	Nominal Value Above No Action Alternative (Million $)	Present Value Above No Action Alternative (Million $)
2002	60.0	1,548	415.8	26.0	25.1	1,631	428.9	27.4	26.6	13.1	1.5	1.5
2003	47.5	1,750	471.0	21.8	20.1	1,456	386.3	18.9	17.5	-84.8	-2.8	-2.6
2004	42.6	1,222	321.3	13.5	11.8	1,257	330.2	14.5	12.7	8.9	1.1	0.9
2005	42.7	1,233	322.3	13.3	11.0	947	245.8	11.0	9.1	-76.5	-2.3	-1.9
2006	44.9	1,036	264.6	12.3	9.6	903	233.0	10.8	8.4	-31.6	-1.5	-1.2
2007	48.6	1,760	470.1	24.2	18.0	1,981	530.2	27.2	19.4	60.0	3.0	2.2
2008	53.3	1,381	366.2	18.9	13.4	1,150	304.0	18.1	12.7	-62.2	-0.8	-0.7
2009	61.1	1,619	431.4	25.9	17.3	1,674	441.0	29.1	19.4	9.6	3.2	2.2
2010	62.3	2,540	687.0	46.0	29.0	2,452	666.2	45.8	28.9	-20.8	-0.2	-0.1
2011	64.2	1,805	484.0	27.5	16.6	1,616	432.7	26.7	16.1	-51.3	-0.8	-0.5
2012	65.4	1,771	476.4	31.5	17.8	1,981	526.6	41.1	23.4	50.2	9.6	5.5
2013	67.6	1,875	506.0	32.3	17.5	1,620	427.4	32.6	17.6	-78.6	0.3	0.1
2014	68.6	1,843	495.6	35.1	17.9	1,766	467.5	35.6	18.2	-28.0	0.5	0.3
2015	70.3	1,467	391.0	27.2	13.2	1,510	401.0	32.7	15.8	10.0	5.5	2.6
2016	70.9	2,327	630.4	44.9	20.6	2,739	728.9	56.6	26.0	98.5	11.8	5.4
2017	71.6	2,793	757.3	51.5	22.4	2,812	749.2	58.4	25.5	-8.0	7.0	3.0
2018	78.5	2,275	622.3	50.2	20.7	2,027	545.4	46.7	19.2	-76.9	-3.5	-1.5
2019	78.3	2,272	614.6	48.0	18.8	2,372	628.7	50.9	20.0	14.2	2.9	1.2
2020	79.3	2,138	580.4	46.0	17.0	1,985	528.8	50.9	18.9	-51.6	4.9	1.8
2021	79.4	2,218	602.2	46.6	16.4	2,001	534.3	48.6	17.1	-68.0	2.0	0.7
2022	79.4	1,288	335.8	27.8	9.3	887	228.2	18.1	6.0	-107.6	-9.7	-3.2
2023	79.4	1,447	385.9	32.8	10.3	1,744	461.3	46.3	14.6	75.4	13.5	4.3
2024	79.3	1,406	373.5	28.2	8.5	1,204	316.7	28.1	8.4	-56.8	-0.1	-0.1
2025	79.4	1,886	509.7	43.7	12.4	2,069	556.2	49.5	14.0	46.5	5.8	1.7
2026	79.4	1,472	389.5	30.9	8.4	1,060	275.9	24.9	6.7	-113.6	-6.1	-1.7
Total			11,904	806.1	403.1		11,374.3	850.6	423.1	-529.8	44.5	20.0

[1] MWh = megawatthour.
[2] GWh = gigawatthour.

No Action Alternative. However, this is not true for all years, as the results vary from year to year.

Table 4-5 also shows a comparison of economic results of the Action and No Action Alternatives based on net present value (NPV) calculations of the hourly value of Flaming Gorge generation over the 25-year simulation period. All NPV calculations are based on a Federal water agency discount rate of 5.5%. The economic impact of implementing the 2000 Flow and Temperature Recommendations under the Action Alternative is measured as the difference in the NPV between the Action and the No Action Alternatives. The NPV for the No Action Alternative is about $403.1 million, while the NPV for the Action Alternative is about $423.1 million. The economic benefits of the Action Alternative exceed those of the No Action Alternative by about $20.0 million. While the Action Alternative has a higher economic value, it achieved this with 529.8 gigawatthours (GWh) less generation compared to the No Action Alternative over the 25-year simulation period. This higher economic value is due to the difference in the seasonal timing of the releases (the Action Alternative releases more water when energy is valued highest), the length of the spring flows, and the differences in the other operating constraints for the alternatives. The Action Alternative generates about 4.5% less power on average but has about a 5.0% higher economic value. This is not considered to be a significant change in generation or economic value.

The Action Alternative has slightly greater benefits with fewer GWh due to the fluctuations in the market price of energy. The Action Alternative calls for more generation in the summer months when energy sells at higher prices than in the fall, when the No Action Alternative generates more power. Given recent volatility in historical prices, there is uncertainty associated with future prices. Because there is less total annual generation with the Action Alternative, use of an alternative price set that does not assume as large a relative seasonal price difference could result in a negative rather than a positive impact. In any case, the impact is considered to be insignificant when the total value of Flaming Gorge generation is considered.

Because the total NPV for each alternative is within $20 million over a 25-year period and highly dependent on the assumed price set, the difference between the alternatives should be considered to be insignificant.

4.4.3 Financial Analysis of Power Generation

The Western Area Power Administration (Western) markets electrical power from federally owned hydroelectric facilities in the Western States. The Salt Lake City Area Integrated Projects (SLCA/IP) is a group of hydroelectric facilities marketed by Western. The SLCA/IP consists of the hydroelectric facilities of the Colorado River Storage Project (CRSP), Rio Grande Project, and Collbran Project. The largest of these three projects is the CRSP. The 152-megawatt (MW) hydroelectric powerplant at Flaming Gorge Dam is a CRSP facility.

4.4.3.1 Description of the Customers Who Buy Electricity Generated at Flaming Gorge

Western provides its customers with long-term, firm, electric service. On average, about 20% of these customers total electrical needs are supplied by CRSP. This differs significantly from customer to customer. Customers purchase CRSP power from Western and add it to other electrical generation to meet the needs of their retail customers.

Currently, CRSP firm electric customers pay a “combined rate” of $0.02072 per kilowatthour (kWh). This rate is a combination of a capacity fee and an energy charge. A CRSP customer pays $4.04 per kilowatt for electrical capacity. This capacity fee is paid every month regardless of the electricity a customer actually buys. It is a fee to reserve an amount of capacity that can be called upon by the customers to generate the electricity the customer may call upon during the month. Additionally, a CRSP customer pays $0.0095 per kWh delivered. This is the charge for electrical energy.

4.4.3.2 Method for Determining the SLCA/IP Rate Impact of the Action Alternative

Western's CRSP-Management Center sets the rate for SLCA/IP firm electric service using a Power Repayment Study (PRS). PRS methods are described in the law as part of Federal regulations and policy and in accord with sound business principles as determined by Western. The PRS is a 50-year or more study to ensure that the SLCA/IP rate is adequate to meet Western's obligations to pay for irrigation projects with long repayment periods.

Since the period of time examined in the PRS is long, forecasts of operating expenses beyond the next couple of years are speculative. Electrical purchases made by Western from the electrical market to supplement hydroelectric generation in "out years" are based on average hydrological conditions and average market prices. In order to assess the impact of changed operations at Flaming Gorge Dam, it was necessary to calculate an "average" change in the timing of generation at this facility. Since the PRS includes substantial amounts of purchases of electricity in the "out years," the changed generation pattern at Flaming Gorge as a result of the Action Alternative can be characterized as an "average" change in the amount of purchases required included in the PRS.

Using the prices for electricity purchased from the market used in the PRS, Western calculated that the Action Alternative would lessen Western's SLCA/IP purchase requirements by an average of approximately $950,000. This approximate reduction in SLCA/IP requirements' purchase would not have a significant impact on the rate CRSP customers pay.

4.4.3.3 Financial Analysis Results

Using the PRS, Western calculated the SLCA/IP rate impact of reducing the purchase electrical power requirement by $950,000 in each year of the PRS. Table 4-6 describes the result.

Table 4-6.—Change in SLCA/IP Electricity Price as a Result of the Action Alternative

	No Action Alternative	Action Alternative	Change
Composite (mills per kWh)	20.72	20.57	-0.15
Energy Charge (mills per kWh)	9.5	9.43	-0.07
Capacity Fee ($ per kW per month)	4.04	4.02	-0.02

4.5 AGRICULTURE

This section presents a comparative analysis of the effects of the No Action and Action Alternatives on agriculture.

4.5.1 Introduction and Methodology

Environmental consequences to the agricultural sector are projected as changes to the number of acres of alfalfa hay produced in Uintah County. Estimates of how many acres of agricultural land might be inundated by the selected riverflows were obtained from Reclamation personnel in the Provo Area Office. This acreage is found only in Reach 2 (and possibly Reach 3).

Alfalfa hay is the predominant crop in the county in terms of acreage and total value. Thus, alfalfa hay was selected as the representative crop for this analysis. All damage estimates were based on the costs and returns of alfalfa hay, even though some pasture and grass hay acreage was identified as being impacted by the riverflows in the Action Alternative. The selection of alfalfa hay as the representative crop placed this analysis on a worst-case scenario. In other words, the damage estimates would be higher using only alfalfa hay as the damaged crop than they would if a mix of crops were used. However, it can be presumed that, because alfalfa hay is such a dominant crop in terms of acreage, it is highly likely that acres currently producing corn silage, barley, or grass hay may soon be rotated into alfalfa hay.

A simple crop cost and returns budgeting methodology was used for estimating damages to the agricultural sector. Crop cost and return information for alfalfa hay was obtained from the Utah State University published *Extension Cost and Returns* bulletins.

4.5.2 Comparison of Impacts for the No Action and Action Alternatives

Estimates of changes to crop acres were available for three observed riverflow levels: 20,000 cfs; 22,000 cfs; and 25,000 cfs. These flow levels were evaluated under both the No Action and the Action Alternatives. The difference between the two alternatives is in the probability of seeing these flow levels and the duration of the high flows. For example, under the No Action Alternative, there is a 42.8% chance of a 20,000-cfs riverflow. By comparison, the probability of a 20,000-cfs flow increases to 46.5% under the Action Alternative. The duration of a 20,000-cfs flow also increases from 11.1 days on average to 13.7 days when comparing the Action Alternative to the No Action Alternative.

Table 4-7 shows the probability and duration of riverflows for the No Action and Action Alternatives.

When the threshold flow levels are imposed, the number of crop acres affected changes. Under the 20,000-cfs flow, 245 acres of crops are inundated. When the flow levels increase to 22,000 cfs, the number of inundated acres increases to 652 acres. At the 25,000-cfs flows, 792 acres are inundated. These changes in the number of acres of crops lost assume that the duration of flooding is such

Table 4-7.—Probability of Occurrence and Average Duration of Riverflows for the No Action and Action Alternatives

		No Action Alternative		Action Alternative			
Threshold (cfs)	Acres Affected	Probability (%)	Duration (Days)	Probability (%)	Change in Probability	Duration (Days)	Change in Duration (Days)
20,000	245	42.8	11.1	46.5	+ 3.7	13.7	+ 2.6
22,000	652	26.1	9.9	28.1	+ 2.0	11.0	+ 1.1
25,000	792	13.1	9.7	13.8	+ 0.7	7.8	- 1.9

that all production would be lost from these acres for the year in which the flow threshold is reached.

From table 3-2 in chapter 3, Uintah County averages 41,860 acres of cropland. Thus, at flow levels of 20,000 cfs, one-half of 1% of the county's crop acres are affected. At the 22,000- and 25,000-cfs thresholds, 1.5 and 1.9% of the county's acres are affected, respectively.

If all 41,860 acres of cropland in Uintah County are assumed to be producing alfalfa hay (the representative crop), the gross value of production would be $13,572,700. Taking 245 acres out of production (due to the 20,000-cfs flow level) would lead to a loss in gross value of production of $79,440. This change in gross value of production is calculated by multiplying the gross value per acre for alfalfa hay ($324.24) times the number of acres affected (245 acres). Subsequent changes to the gross value of production for the 22,000- and 25,000-cfs riverflows reduce the gross values of production by $211,400 and $256,800, respectively. Percentage-wise, these reductions to the gross value of production equate to 0.6, 1.6, and 1.9%, respectively.

On a probabilistic basis, going from the No Action to the Action Alternative increases both the probability and the duration of the flooding. For example, when the No Action Alternative is compared to the Action Alternative, the probability of having a riverflow of 20,000 cfs increases from 42.8% to 46.5%—an increase of 3.7%. Over a 100-year time span, this means that, under the Action Alternative, farmers would have crop losses in 46.5 of the 100 years. If the gross value ($324.24 per acre times 245 acres) lost in each of the 46.5 years is added up, crop losses would total $3,693,900 under the Action Alternative. This compares to a cumulative loss of $3,400,000 ($324.24 per acre times 245 acres times 42.8 years) under the No Action Alternative. On a percentage basis, the Action Alternative increases economic losses to farmers by 8.64% over a 100-year period.

Any perceived difference in losses accruing to farmers when evaluating the probability of economic damages is more than offset by the duration of the flooding, however. Alfalfa hay cannot withstand long periods of inundation. In all likelihood, crop losses for the affected acres would be complete under both the No Action and the Action Alternatives. Thus, the Action Alternative cannot be identified as the sole causal agent of additional economic damages to the agricultural sector.

4.6 LAND USE

Reclamation determined land ownership, land use, and the impacts to potentially affected lands by utilizing the U.S. Geological Survey (USGS) topographic maps, county plats, inundation overlays at various riverflows, conducting site visits, and meeting with property owners and various parks and facilities managers along the river.

4.6.1 Flaming Gorge Reservoir and National Recreation Area

The operational scenarios of either the Action or No Action Alternative would have little or no significant impacts to most land use around the reservoir and in the Flaming Gorge National Recreation Area above the dam. Figure 4-1 shows that the maximum mean monthly elevations (July) for both the Action Alternative and the No Action Alternative are very similar. Therefore, the effects to the land use from any maximum elevations in the reservoir will not be significantly different from the effects experienced for the past 10 years. In the winter and early spring, there may be positive effects from the Action Alternative since it maintains a mean monthly reservoir elevation almost 2 feet greater than the No Action Alternative (figure 4-1). Damage to land and resources can occur when water levels drop below certain elevations exposing lands normally inundated or causing problems at boat ramps.

At the upper end of Flaming Gorge Reservoir, there are many roads and access points to the reservoir that may be affected by fluctuations in the water level due to operational releases mandated by either alternative. However, these effects will not be significantly different than previous effects experienced during the past 10 years.

4.6.2 Green River Reach 1

The terrain features and land ownership throughout Reach 1 (see section 3.6.2) restrict its land use to limited recreational pursuits such as camping, hiking, boating, and rafting. This section will generally address some of the impacts to the facilities associated with these activities such as campsites, boat ramps, access roads, and recreational trails. For a more detailed assessment of the impacts to these recreational facilities, see section 4.11.

According to figure 4-5, under wet conditions, some facilities (e.g., campgrounds, boat ramps, portions of the recreation trails) will be impacted more frequently under the Action Alternative than under the No Action Alternative. Throughout Reach 1, there are campgrounds that might be impacted in the No Action Alternative scenario during an average year. In the Action Alternative, during an average year, these same campgrounds have an equal chance of being impacted as in the No Action Alternative. During the wet years, access roads, boat ramps, and campsites throughout Reach 1 have a greater chance of being impacted under the Action Alternative.

4.6.3 Green River Reach 2

The unchecked influx of the Yampa River greatly affects the potential impacts to land areas in Reach 2. In the No Action Alternative, peak releases in all scenarios (dry, average, and wet hydrology) would be made with the intent of achieving peak flows at Jensen, Utah, of 13,000 to 18,000 cfs. Studies (*Green River Floodplain Habitat Restoration Investigation* and *1998 Floodplain Habitat Restoration Status Report*) have shown inundation to begin in specific areas between 13,000 and 15,000 cfs, depending on levee placement. Although there may be some impacts to some of the private agricultural lands and the oil and gas well operations (mainly restricted access), adjacent landowners have become accustomed to these flows during peak runoff times. Also, because the influx of the Yampa River is unchecked, peak flows in the Green River in Reach 2 have exceeded 18,000 cfs in some years. Therefore, the No Action Alternative has little or no significant impacts.

In the Action Alternative average hydrology scenario, releases would provide a peak flow in Reach 2 that exceeds 18,600 cfs and would exceed 18,600 cfs for a duration of at least 2 weeks in some years. In the wet hydrology scenario, releases would provide a peak flow in Reach 2 that exceeds 26,400 cfs and would exceed 22,400 cfs for a duration of at least 2 weeks in some years. Since these flows exceed the desired peak flows of 13,000 to 18,000 cfs of the No Action Alternative, there is a potential for greater serious impacts to agricultural lands and oil and gas well operations.

The difference in impact to the four highway bridge crossings when comparing the Action and No Action Alternatives is insignificant. The bridges appear to have been designed, constructed, and maintained to withstand all the flow regimes being considered in this study and have proven that over time. The pipeline crossings also appear to be sufficiently engineered and constructed to withstand all possible flows being considered in this study.

4.6.4 Green River Reach 3

The impact of Reach 2 flows, along with the influx from the White River and San Rafael River, directly affect the potential impact to land areas in Reach 3. While flows may impact private, agricultural, oil and gas, and recreation lands, adjacent landowners have become accustomed to these flows during peak runoff times. Where unchecked peak flows in Reach 2 have exceeded 18,000 cfs in some years, with little or no significant impact, it is expected that the same will hold true in Reach 3.

In the Action Alternative, assuming an average hydrology scenario, releases would provide a peak flow in Reach 3 that exceeds 24,000 cfs and would exceed 24,000 cfs for a duration of at least 2 weeks in some years and a peak flow of 39,000 cfs for at least 1 day in 4.6% of the years. With the desired peak flow being 13,000 to 18,000 cfs, there is a potential for a more serious impact to agricultural lands (see section 4.5.2) under the Action Alternative.

4.7 ECOLOGICAL RESOURCES

This section describes the potential consequences to wildlife and vegetation, both land based and aquatic, of operating Flaming Gorge Dam under both the No Action and Action Alternatives.

4.7.1 Flaming Gorge Reservoir

4.7.1.1 Reservoir Fish

4.7.1.1.1 No Action Alternative – The No Action Alternative provides fewer benefits for kokanee than the Action Alternative. Reservoir drawdown in the winter (October to April) causes mortality of kokanee salmon eggs and embryos. Since dissolved oxygen declines with increasing depth, greater survival occurs in shallower water. As this shallow water is lost due to reservoir drawdown, the most viable embryos are lost. During wet years, reservoir elevation would fluctuate more between seasons under the No Action Alternative than under the Action Alternative. Under intense dry cycles, reservoir elevations decline further under the No Action Alternative (as much as 8 feet lower). Reservoir elevation and fluctuations would not significantly affect the reservoir fishery beyond existing conditions.

Entrainment of fish has been documented during the few times water was passed over the spillways. Fish that have been entrained from Flaming Gorge Reservoir include kokanee salmon, rainbow trout, lake trout, and smallmouth bass (Schneidervin, 2003). Little is known of the fate of these fish. Bypasses above powerplant capacity (4,600 cfs) are expected to occur in 23% of all years under the No Action Alternative.

4.7.1.1.2 Action Alternative – Under the Action Alternative, the winter reservoir pool will not be drawn down below levels that have occurred in the past. Therefore, kokanee recruitment would not be reduced beyond current levels. Reservoir elevations will fluctuate less between seasons, which would benefit kokanee egg incubation by inundating favorable substrates and reducing egg desiccation.

Hydrologic modeling shows that bypasses above powerplant capacity (4,600 cfs) will occur in 50% of all years to meet the 2000 Flow and Temperature Recommendations, with use of the spillways expected in 27% of all years. In other river systems, like the Columbia River, there are accounts of large losses of kokanee to entrainment from reservoirs (Maiolie and Elam, 1998). Small numbers of kokanee have been entrained at Flaming Gorge Dam during the infrequent spills in the past. However, based on the longitudinal and vertical distribution of kokanee in Flaming Gorge Reservoir, it is not expected that increased frequency of spills associated with the Action Alternative would result in significant losses of kokanee (Schneidervin, 2003). During the spring, when the spillway would be used, Utah Division of Wildlife Resources (UDWR) has determined that the closest concentrations of the kokanee are found 5 miles from the dam near Jarvies Canyon. These spring concentrations are comprised primarily of older fish, which are less susceptible to entrainment.

UDWR has determined that rainbow trout, lake trout, and smallmouth bass have also been entrained in past spill events. Rainbow trout are not commonly found near the dam during the spring. Therefore, the reservoir population is affected minimally by spillway losses. There is a small population of smallmouth bass very near the spillway, but as this is a very territorial species, UDWR suspects relatively few are entrained as well (Schneidervin, 2003).

Whereas the increased incidence of entrainment of reservoir fishes is not expected to present a measurable impact to the reservoir fishery, there are potential impacts to the native fish in the Green River downstream from the dam (discussed in section 4.7.2.4.2).

4.7.1.2 Aquatic Food Base

4.7.1.2.1 No Action Alternative – Due to the predominantly planktonic nature of the aquatic food base in Flaming Gorge Reservoir, operation of Flaming Gorge Dam under the No Action Alternative, as it impacts water elevations, is not expected to affect the aquatic food base in the reservoir beyond existing conditions.

4.7.1.2.2 Action Alternative – A significant fraction of the Flaming Gorge Reservoir aquatic food base is comprised of planktonic productivity. Since magnitude of drawdown is expected to be slightly less under the Action Alternative, the downlake extent of noxious algal blooms is expected to be less than under the No Action Alternative. Noxious algal forms such as cyanobacteria typically contribute little to production at higher trophic levels. Therefore, operation of Flaming Gorge Dam under the Action Alternative is expected to slightly benefit the aquatic food base in the reservoir.

4.7.1.3 Vegetation

4.7.1.3.1 No Action Alternative – Vegetation around the reservoir would continue to remain limited to those areas characterized by lower gradient slope, fine soils, and shallow groundwater connections. Riparian vegetation would continue to be predominately found at tributary mouths.

4.7.1.3.2 Action Alternative – In the near term (first 10-20 years), vegetation response would remain similar to the No Action Alternative. There would be little additional development of vegetation due to fluctuating reservoir levels remaining similar to the No Action Alternative. In the long term (30-year projection), the Flaming Gorge Model predicts decreasing reservoir water elevations. Under this scenario, opportunities for expansion of vegetation would likely increase. Invasive species such as tamarisk would likely take advantage of unvegetated areas for expansion downslope. If development of fine soils occurs, clonal species in the willow and sedge families would eventually expand downslope as well.

4.7.1.4 Terrestrial and Avian Animals

Terrestrial and avian animals are mobile and capable of following water related resources as they change with reservoir water level fluctuations. The ability of these animals to reach and exploit water or water related food or habitats would not be hampered under either alternative.

4.7.1.4.1 No Action Alternative – Operation of Flaming Gorge Dam under the No Action Alternative is not expected to affect land-based animals or birds. Food and habitat provided by vegetation linked to the reservoir and its fluctuations would remain available as currently distributed, especially near water connections to the reservoir like springs, seeps, and streams. Terrestrial and avian animal populations would not be expected to change due to reservoir operations under the No Action Alternative since these operations would not change these animals' access to, or the extent of, exploitable food or habitat resources.

4.7.1.4.2 Action Alternative – Operation of Flaming Gorge Dam under the Action Alternative is not expected to affect land-based animals or birds. Fluctuations in the reservoir's water level would be slightly reduced, and average reservoir elevations would vary by 1.5 feet when compared to the No Action Alternative (see figure 4-1). These variations could have some influence on vegetation surrounding the reservoir over the long term. This slight adjustment of habitat would occur slowly, allowing animal populations sufficient time to adjust home ranges and habits to suit prevailing conditions.

4.7.2 Green River Downstream From Flaming Gorge Dam – Reach 1

4.7.2.1 Aquatic Food Base

4.7.2.1.1 No Action Alternative – Provision for releases in excess of powerplant capacity is identified in the 1992 Biological Opinion and has occurred in recent years. Monitoring of the macroinvertebrate community indicates that during these high flows *Cladophora* beds can be reduced and the macroinvertebrate community can shift from amphipod-based to aquatic insect-based. This is not necessarily bad for the resident trout, which use aquatic insects throughout the year, and the *Cladophora* typically recovers within a year (Vinson, 1998).

Cladophora production is highest in permanently wetted zones and lowest in fluctuating zones with daily exposure. *Cladophora* production is highest in the summer. *Cladophora* standing crops are expected to vary little through continued implementation of the 1992 Biological Opinion flows with rare exceptions when releases occur in excess of powerplant capacity.

New Zealand mud snails have become established in recent years; however, their occurrence is not a result of current dam operations. This species is currently increasing in distribution and abundance in Reach 1. Dr. Mark Vinson (Utah State University) speculates that habitat may not be suitable downstream into Lodore Canyon. The ultimate effect this invasive species will have on the aquatic ecosystem is not yet known.

4.7.2.1.2 Action Alternative – Productivity within the river is controlled by many factors, including light transmittance through changes in water clarity. Sediment mixing from fluctuating releases and sediment supply from tributaries both affect river water clarity. Reducing daily fluctuations would improve water clarity. Improved water clarity would improve primary production of the systems food base.

The food base for trout increases as the minimum reliable discharge increases. Higher base flows and decreased daily flow fluctuations in average and wetter years would lessen the extent of dewatering (exposure) and increase the extent of habitat available for food base organisms. Some fluctuation in flows would still occur.

The increased variability in seasonal flows and the increased incidence of flows that exceed powerplant capacity would have the potential to reduce the standing crop of *Cladophora* and biomass of macroinvertebrates in the short term. However, macroinvertebrate sampling after the high flows of 1997 and 1999 indicated that the number of species increased (Vinson, 1998). Managing for warmer releases (up to 59 ºF) immediately following these high spring releases should serve to speed recovery of the aquatic food base and should also promote species richness.

The aquatic food base would likely experience short-term declines as a result of the more frequent peak release (greater than [>] 4,600 cfs) but would recover more quickly during the recommended base flows and thermal regime. Research by Utah State University and the State of Utah found that the trout population appeared to suffer little as a result of these high flows (Vinson, 1998).

New Zealand mud snails could be negatively impacted by the increased frequency of flow in excess of powerplant capacity. This invasive species has been found in highest concentrations on rooted aquatic vegetation. Higher flows would likely reduce the standing crop of rooted aquatics, thereby reducing the number of New Zealand mud snails. Continued monitoring would be required to determine whether the Action Alternative affects this recently introduced species.

4.7.2.2 Threatened and Endangered Fish

4.7.2.2.1 Colorado Pikeminnow –

4.7.2.2.1.1 No Action Alternative – Adult and late juvenile Colorado pikeminnow would continue to utilize habitats in Reach 1 as they do currently. Pikeminnow reproduction has not been documented in Reach 1 and would not be expected to occur in the future.

4.7.2.2.1.2 Action Alternative – Reach 1 provides habitat for adult and late juvenile Colorado pikeminnow. It is unlikely that early life stages use habitats in Reach 1, but the potential exists for spawning to occur there. Greater frequency of releases in excess of powerplant capacity could serve to benefit pikeminnow in the following manner:

(1) Maintain adult habitat in Lodore Canyon

(2) Cleanse potential spawning habitat in Lodore Canyon and aid in the formation of native fish nursery areas in Island and Rainbow Parks

(3) Reduce the numbers of nonnative fishes, particularly in Lodore Canyon

Expected benefits to other native fish from reduced fluctuations during the base flow period would likely also benefit pikeminnow by increasing their food base.

Implementing the 2000 Flow and Temperature Recommendations could benefit Colorado pikeminnow greatly in Reach 1. Recent investigations suggest that Colorado pikeminnow adults may have overwintered in Reach 1 during the extremely low flow year of 2002 (Kitcheyan, 2003). During the summer of 2002, when flows were at a steady 800 cfs, the main channel warmed to an average daily temperature of 73 ºF (23 °C) in lower Lodore Canyon.

Researchers with the U.S. Fish and Wildlife Service in Grand Junction, Colorado, have characterized river reaches throughout the Upper Colorado River Basin that hold Colorado pikeminnow year round in terms of "thermal units." Thermal units were calculated based on Colorado pikeminnow's relative growth as a function of temperature. In experimental trials, pikeminnow were found to stop growing at temperatures less than (<) 55 ºF (13 ºC) and were found to maximize growth at temperatures of 77 ºF (25 ºC). Therefore, a thermal unit can be calculated (a nonlinear relationship) for daily mean temperatures. Daily means of 55 ºF (13 ºC) result in a thermal unit of "0" (no growth) ranging up to a value of "1" (optimum growth) when daily temperatures averaged 77 ºF (25 ºC)

(Osmundson, 1999). Summing these daily thermal units, they found that reaches where Colorado pikeminnow establish home ranges characteristically have 40 annual thermal units (ATU).

The Flaming Gorge Temperature Model was used to generate a thermal regime for the months of July and August at upper Lodore Canyon, and then thermal units for those days were calculated. The Green River at Browns Park and the lower Yampa River accumulate roughly 60% of their annual thermal units in an average year during the months of July and August; therefore, the threshold for this analysis was 24 ATUs (60% of Osmundon's 40 ATU threshhold). Releasing water from Flaming Gorge Dam at a temperature of 59 ºF (15 ºC) (Action Alternative) results in more ATUs in Lodore Canyon, except in wetter years (figure 4-14).

Colorado pikeminnow are expected to benefit from implementing the 2000 Flow and Temperature Recommendations in the short and long terms. Whether this shift toward the natural hydrograph and thermograph is sufficient to result in Colorado pikeminnow spawning remains uncertain and should be monitored. Combined effects of the Action Alternative (increased spill frequencies and river warming) could result in the establishment or increased abundance of nonnative species in Reach 1. This potential outcome would be detrimental to Colorado pikeminnow in Reach 1 but remains an uncertainty that should be monitored.

4.7.2.2.2 Humpback Chub –

4.7.2.2.2.1 No Action Alternative – Humpback chub have not been collected in Reach 1 since the construction of Flaming Gorge Dam. A canyon-dwelling species, the humpback chub has not re-colonized Lodore Canyon, apparently due to the depressed summer water temperatures. Continued operations under the No Action Alternative would not likely result in the re-establishment of humpback chub in this portion of the river.

4.7.2.2.2.2 Action Alternative – Based on research conducted on other humpback chub populations, increased frequency of higher releases from Flaming Gorge Dam may benefit reproductive success should they become re-established in Reach 1 in the future. The humpback chub is a very sedentary species; however, implementation of the 2000 Flow and Temperature Recommendations may attract fish from nearby populations in the Yampa River and Whirlpool Canyon. Humpback chub spawn at temperatures above 63 ºF (17 ºC), which should be achieved in Lodore Canyon during the summer months under all hydrologic scenarios (table 4-4).

4.7.2.2.3 Razorback Sucker –

4.7.2.2.3.1 No Action Alternative – Razorback sucker adults have been collected in very low numbers in Lodore Canyon, but spawning has not been documented in Reach 1. Under the No Action Alternative, it is assumed that the future abundance of adult razorback sucker in Reach 1 would be directly linked to the larger Green River subbasin population. If the population of razorback suckers increases in Reach 2 as a result of the Upper Colorado River Endangered Fish Recovery Program (Recovery Program) activities (stocking, nonnative control, and flood plain restoration), the incidence of adults in Reach 1 could be expected to also increase. Under the No Action Alternative, current flow and temperature regimes in lower Reach 1 may be adequate for main channel spawning. Razorback suckers in middle Green River (Reach 2) spawn at the same time and on similar habitats as flannelmouth sucker, as evidenced by hybridization between these two native species. Flannelmouth sucker currently spawn in Lodore Canyon; and, therefore, it is reasonable to assume that razorback sucker could as well.

More information needs to be gathered to better understand the relationship between environmental variables and reproductive

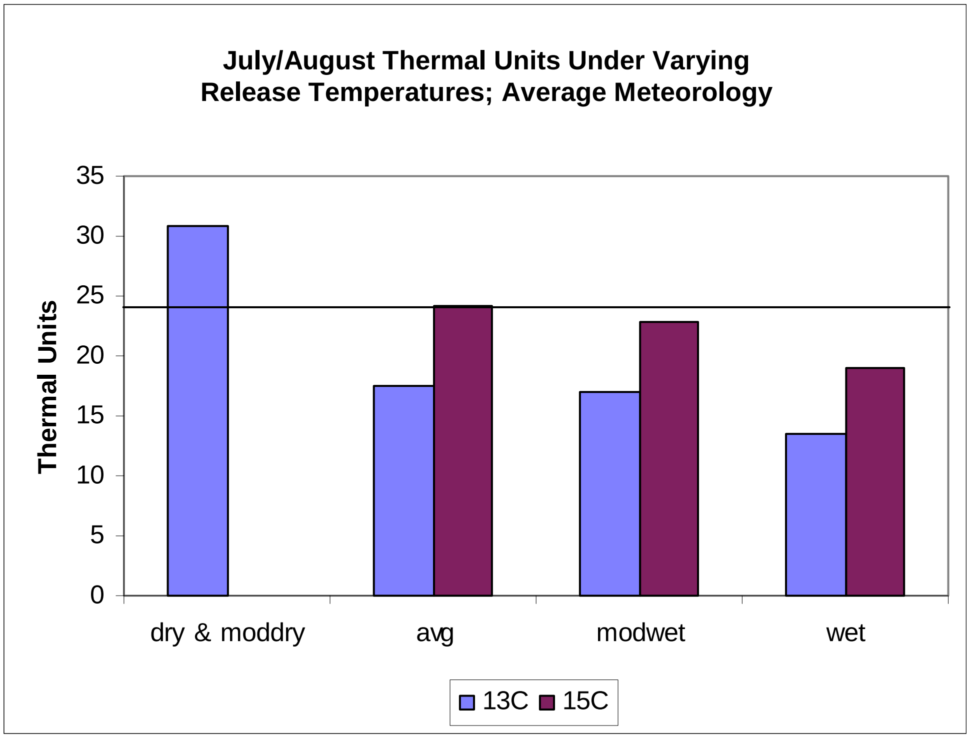

Figure 4-14.—Thermal Units Accumulated in Upper Lodore Canyon (46 Miles Below Flaming Gorge Dam) Under Various Hydrologic Scenarios. As indicated in the Flaming Gorge Model, likely base flow releases for each hydrologic category are as follows: dry and moderately dry (800 cfs); average (1,400 cfs); moderately wet (2,000 cfs); and wet (2,400 cfs). Average daily temperatures used to derive ATUs were excerpted from the Flaming Gorge Temperature Model (Dr. John Carron, Hydroshpere Resource Consultants). A horizontal line was drawn at 24 ATUs, which represents a threshold value that characterizes suitable Colorado pikeminnow home range. Note: There is no value for 59 °F (15 °C) during the dry and moderately dry years, which is consistent with the Action Alternative.

success. Based on the razorback sucker's apparent reliance on inundated flood plains to serve as nursery habitat for their young, it is unlikely that this species would ever complete its life cycle in Reach 1 under the No Action Alternative.

4.7.2.2.3.2 Action Alternative – The Green River subbasin population stands a greater chance of increasing through implementation of the flows identified in the Action Alternative (see Reach 2 discussion). As mentioned above, under the No Action Alternative, conditions may already be present for successful razorback sucker spawning. Therefore, the flows and temperatures called for under the Action Alternative would only increase the likelihood of successful razorback sucker spawning in Lodore Canyon. However, warmer releases identified in the Action Alternative could also improve conditions for razorback suckers upstream of Lodore Canyon. The alluvial channel through Browns Park and the potential flood plain habitat found there is a preferred habitat type of both young and adult razorback sucker. River warming could extend the range of razorback sucker upstream into these important habitats.

Flow and temperature management alone will not likely result in the recovery of this species. However, coupled with ongoing

Recovery Program efforts to effectively control nonnative fish, augment the existing population (stocking), and develop habitat, the 2000 Flow and Temperature Recommendations should benefit razorback sucker in the short and long terms.

4.7.2.2.4 Assumptions and Uncertainties Regarding Bonytail – The authors of the 2000 Flow and Temperature Recommendations did not factor the needs of the bonytail into their recommendations because information on the species' life history and the physical processes that affect its habitats was not available. The authors stated that "the flow and temperature recommendations that are made for the other endangered fishes would presumably benefit any bonytails that remain in the system and would not limit their future recovery potential."

4.7.2.3 Nonlisted Native Fish

4.7.2.3.1 No Action Alternative – Native suckers (flannelmouth and bluehead) and the roundtail chub occupy habitats in Lodore Canyon and likely occupy habitats in lower Browns Park. Current upstream distribution is limited by temperature more than by flow. Although all species reproduce successfully in Lodore Canyon, they are likely limited by both the current hydrology and the current thermal regime. Under the No Action Alternative, short-term changes in the distribution and abundance of these species are not expected.

There is increasing evidence of native sucker hybridization with the nonnative white sucker (Bestgen and Crist, 2000). Continued operation to meet the 1992 Biological Opinion flows and maintain the current thermal regime would likely result in a long-term increase in the incidence of native sucker/white sucker hybridization, which is expected to be detrimental to the native sucker population in Reach 1.

4.7.2.3.2 Action Alternative – Reproductive success of these three species increases during years of average and wetter spring flow in other Upper Colorado River Basin rivers and in the lower reaches of the Green River. The increased incidence of flows in excess of powerplant capacity should serve to cleanse spawning substrates for these native fish and could result in increased reproductive success.

In all but the driest years, base flows under the Action Alternative will be higher and more stable. The 2000 Flow and Temperature Recommendations call for extending these base flows through the winter, which results in lower but more stable base flows during that portion of the year when compared with the No Action Alternative. This new base flow prescription under the Action Alternative should benefit the resident native fish by creating more stable backwater habitat, increasing the aquatic food base during the summer and fall, and providing more stable overwintering habitats for young-of-the-year (YOY) native fish inhabiting Lodore Canyon and perhaps lower Browns Park.

Native suckers spawn in the spring on the ascending limb of the hydrograph when temperatures reach approximately 54-60 ºF (12-15 ºC). The current thermal regime has not likely been as limiting for spawning suckers as for roundtail chub, which prefer temperatures of 61-68 ºF (16-20 ºC) to spawn. Water temperatures in excess of 64 ºF (18 ºC) will be targeted in the upper portion of Lodore Canyon. During dry hydrology years, the minimum threshold should be exceeded by several degrees for several weeks. Temperature modeling predicts that this threshold can be met in all years. To meet the minimum 64 ºF (18 ºC), release temperatures would need to be 59 ºF (15 ºC) during average and wetter years (see table 4-4) to compensate for reduced warming rates at the higher base flows.

River warming associated with the Action Alternative is expected to benefit these native fish through an overall increase in productivity and increased growth rates. The resident population of roundtail chub in Lodore Canyon is expected to benefit from the river warming by increased reproductive success as well as increased growth rates for all life stages. During the dry hydrologies, there is potential to use high temperature to reduce brown trout, a nonnative predator in Lodore Canyon.

Hybridization between native suckers and nonnative white suckers could be reduced through implementation of the proposed temperature recommendations. White suckers prefer temperatures cooler than the native Colorado River suckers and have proliferated throughout Reach 1 in the artificially cooled waters. The return to a more natural hydrograph and thermal regime in this portion of the river may shift the distribution of nonnative white sucker upstream, reducing their overlap with the native suckers in Lodore Canyon.

Studies in other portions of the Upper Colorado River Basin suggest that speckled dace, a small bodied native species found in Lodore Canyon, would likely benefit from the return to a warmer, more variable flow regime. Mountain whitefish and mottled sculpin are categorized as cool water native species that have taken up residence in Lodore Canyon under historical dam operations. Implementation of the Action Alternative may result in restricting their distribution to the upper reaches of Reach 1, which would represent a return to more natural (pre-dam) conditions.

Overall, native species would be expected to benefit, in the long term, from a return to a more natural hydrograph and thermal regime as is proposed in the Action Alternative.

4.7.2.4 Nonnative Fish

4.7.2.4.1 Cold Water (Trout) –

4.7.2.4.1.1 No Action Alternative – Utah Division of Wildlife Resources biologists have identified concerns for the trout fishery when average daily temperatures reach and exceed 70 ºF (21 ºC) at the Colorado/Utah State line (Schneidervin, 2003). Their concerns are consistent with general temperature preferences for trout reported by researchers in other systems (see chapter 3, "Affected Environment"). Modeling indicates that the river at the Colorado/Utah State line reaches this critical level (see table 4-3) during dry years with hot summer temperatures, similar to conditions of the summer of 2002. During the summer of 2002, measured average daily temperatures at the Colorado/Utah State line warmed to approximately 66 ºF (19 ºC). Fishery data were not collected in the lower portion of the trout fishery in 2002 to determine if there were negative impacts.

The critical period for brown trout reproduction extends from early October to late May (Modde et al., 1991). Daily base flow fluctuations negatively impact reproductive success by desiccating redds (nests) and causing young fish to exert more energy in search of optimum habitats along the channel margins. Under the No Action Alternative, daily fluctuations during the summer base flow period are greater in wet years, the same as the Action Alternative in average years, and less in dry years. Fluctuations under the No Action Alternative are always less restricted during the winter.

Under the No Action Alternative, 23% of spring peak flows would be expected to exceed powerplant capacity (4,600 cfs) as compared with 50% under the Action Alternative. This reduced frequency of high flows contributes to a more stable environment, which benefits trout by providing more juvenile trout habitat and maintaining a stronger forage base.

Trout populations are expected to remain at high levels and the individual trout in good condition through maintenance of current release patterns and temperatures under the No Action Alternative.

The potential future occurrence of whirling disease in the Green River tailrace fishery is not influenced in any way by the No Action Alternative.

4.7.2.4.1.2 Action Alternative – Compared with the No Action Alternative, flows during the base flow period will vary less because restrictions that applied only to the summer and fall have been extended through the winter. Reduced flow fluctuations through the winter, particularly January through March, should greatly benefit overwinter survival of trout (Schneidervin, 2003). During the rest of the year, daily fluctuations during the base flow period would be reduced in wet years, the same as the No Action Alternative in average years, and greater in dry years.

Trout benefit from reduced daily fluctuations. A decrease in daily fluctuations (particularly during wetter years) would reduce the number of trout redds exposed and lost to these fluctuations. Lowering the number of lost or failed redds would aid in the development of a more self-sustaining trout fishery. Effects of reducing fluctuating flows are most prominent directly below Flaming Gorge Dam. Reducing frequent fluctuations reduces fish stranding, increases the potential for successful reproduction in trout, and may improve growth and condition of trout due to benefits to the food base. Another important benefit of reducing frequent fluctuations is decreased fish displacement and associated energy expenditures.

Increased summer and fall base flows during average to wet years would increase the amount of available spawning substrate for fall spawning trout. These areas would remain inundated throughout the period of egg development and hatching. Lower winter flows, particularly during January through March, should benefit the tailwater trout fishery by providing optimal winter habitat, according to Modde et al. (1991) and Johnson et al. (1987).

The increased variability in seasonal flows and the increased incidence of flows that exceed powerplant capacity under the Action Alternative would have the potential to reduce the biomass of macroinvertebrates (food base) and potentially displace young fish downstream. These impacts could be detrimental to the trout fishery.

Increased frequency of spillway releases raises concerns of nitrogen supersaturation and potential impacts to the tailrace trout fishery. UDWR biologists collected dissolved oxygen and nitrogen levels in the tailrace during spill events in the 1980s and again in 1997. The waters at the base of the dam were supersaturated with oxygen and nitrogen, 111% and 110%, respectively; however, these levels were reduced quickly downstream. The readings at the dam represent borderline levels of concern, but no adverse effects to trout were documented during the 1997 spill event in the Flaming Gorge tailrace. Fish kills due to supersaturation are generally associated with very deep plunge pools, approaching 100 feet, in the tailrace of larger river systems. It is rare to have fish kills due to gas supersaturation with shallow plunge pools in the tailrace such as Flaming Gorge Dam. It is the opinion of the UDWR fish biologists that supersaturation impacts to trout in the Flaming Gorge tailrace are a relatively minor concern (Schneidervin, 2004).

The downstream distribution of trout populations can be limited by temperature. River temperatures throughout Reach 1 are a function of the release temperature at Flaming Gorge Dam, the release volume, and ambient air temperatures (see table 4-4). In dry and moderately dry years, base flows under the Action Alternative will likely be 800 cfs. During those years, 55 °F (13 ºC) water would continue to be released from the dam, resulting in a modeled average daily temperature of 65 °F (19 ºC) in an average summer and 68 °F (20 ºC) in a hotter than normal summer at the Utah/Colorado State line. Release temperature would be raised to 59 °F (15 ºC) in average to wet years when base flows are >1,200 cfs. During those years, temperatures at the State line would likely be similar or slightly cooler than discussed above. There are always concerns for the cold water trout fishery when warming the river is discussed. However, the worst case No Action Alternative temperature scenario for the trout fishery near the State line remains the same under the Action Alternative. Warmer dam releases associated with the Action Alternative could result in increased production of macroinvertebrates (fish food) and improve trout growth, particularly in river sections closer to Flaming Gorge Dam. The benefit of increased productivity is expected to help offset the negative impact associated with higher spring releases. As is discussed under section 4.7.2.2, "Threatened and Endangered Fish," this management scenario should meet minimum temperature recommendations for native fish downstream in all years, while providing better temperatures for trout during average to wetter years.

The Action Alternative has the potential of causing both positive and negative short-term impacts to the trout fishery below Flaming Gorge Dam. In the long term, the trout fishery is not expected to be negatively impacted. Continued monitoring of this fishery by UDWR will be necessary to determine actual impacts.

The potential future occurrence of whirling disease in the Green River tailrace fishery would not be affected by operations under the Action Alternative.

4.7.2.4.2 Warm Water (Other – Large and Small Fish) –

4.7.2.4.2.1 No Action Alternative – Large nonnatives, carp and catfish, are expected to persist at current levels in the lower portion of Reach 1, primarily in Lodore Canyon. Nonnative minnows (red shiner, fathead minnow, sand shiner, and redside shiner) are abundant in the lower portions of Lodore Canyon as well. Their current distribution and abundance has likely reached an equilibrium and is not expected to change under the No Action Alternative.

4.7.2.4.2.2 Action Alternative – Resident nonnative fishes that compete with the native species could benefit during dry years from lower base flows and during wetter years from higher release temperatures. However, the higher spring releases, particularly during wetter years, would be expected to negatively impact nonnatives such as carp and catfish in Lodore Canyon.

Of additional concern is the potential for increased entrainment of nonnative reservoir species as a result of the increased frequency of spills under the Action Alternative. Most species that have been entrained in past spill events (1997 and 1999) are relatively innocuous (rainbow trout, kokanee salmon, and lake trout); however, smallmouth bass present a greater threat.

Smallmouth bass are found in Reach 1. Temperatures in Lodore Canyon would be more suitable for smallmouth bass under the Action Alternative than under the No Action Alternative (see table 4-4).

Smallmouth bass are among the species most often cited as endangering native fishes, and it has been identified as a species of increasing concern by Hawkins and Nesler (1991) and by Lentsch et al. (1996) in the Upper Colorado River Basin. Escapement from reservoirs has been identified as an important source of introduction for this piscivore (Tyus and Saunders, 1996). Smallmouth bass are problematic for endangered fish in the Green River.

Bestgen and Crist (2000) reported smallmouth bass present in very low numbers in lower Lodore Canyon in samples taken during 1994-1996. It is believed that these bass migrated up from the Yampa River. It is noted that smallmouth bass escaped from Elkhead Reservoir, an off channel impoundment in the Yampa River drainage, and became established in that river in the last 15 years. This species appears to flourish during dry years and is preying heavily on juvenile flannelmouth and bluehead suckers, roundtail chub, and speckled dace (Anderson, 2002). In a recent evaluation of the Yampa River smallmouth bass fishery, it was brought to the Recovery Program's attention that smallmouth bass had been released into the river for many years before the species became established. Only when a large release of fish from the reservoir coincided with favorable environmental conditions in the river (during a dry year when the riverflow was low and warm) did this occur (Martinez, 2003).

Flows, temperatures, and gradients available in Lodore Canyon, particularly during dry years, fall within preferred ranges for smallmouth bass. If smallmouth bass become well established in Lodore Canyon or elsewhere in Reach 1, they could have an adverse effect on the resident native fish community, including the endangered species. There are several uncertainties about the prospect for this situation (see section 4.19, "Uncertainties").

Returning the river to a more natural hydrologic and thermal regime should have similar short- and long-term impacts on the small-bodied nonnative fish. During drier years, lower releases from the dam, resulting in warmer temperatures downstream, should benefit this group of nonnatives. Due to their early maturation and ability to spawn multiple times each summer, a few individuals colonizing an unoccupied area can result in a strong local population within 1 year. Upstream expansion of these species and increased abundances in currently occupied habitat should be expected during dry years. The potential negative effects these species have on native fishes was discussed in section 3.7.2.3.4.3. In 2003, which represents the third consecutive year of extremely low and steady summer base flows (800 cfs), upstream expansion of red shiners was observed (reference *Recovery Program Project No. 115 Annual Report* online: <http://www.r6.fws.gov/crrip/arps/2003/isf/115.pdf>).

The greater frequency of high flows in Reach 1 under the Action Alternative, particularly in Lodore Canyon, should negatively impact small-bodied nonnative fish. The Recovery Program is currently studying the fish community and Colorado pikeminnow use in Lodore Canyon and lower Browns Park. Results of those studies and continued monitoring would be used to determine the effects of implementing the 2000 Flow and Temperature Recommendations in this portion of the river.

4.7.3 Green River Downstream From Flaming Gorge Dam – Reach 2

4.7.3.1 Aquatic Animals

4.7.3.1.1 Aquatic Food Base –

4.7.3.1.1.1 No Action Alternative – Productivity pathways described in Gourley and Crowl (2002) and Crowl et al. (2002) are expected to remain in place. Food items for fish in the main channel will largely come in the form of aquatic insects. Fish that can leave the main channel and access the flood plain during high flows will find aquatic insects as well as the highest densities of zooplankton found anywhere in the river ecosystem.

Backwaters are areas of high productivity in the main channel in alluvial reaches. Base flows called for in the 1992 Biological Opinion were designed to stabilize backwater habitats through Reach 2 to serve as nursery habitats for young Colorado pikeminnow and other native fish. The aquatic food base is not expected to change under the No Action Alternative.

4.7.3.1.1.2 Action Alternative – Crowl et al. (2002) stressed the importance of the connection of the Green River with its flood plain as a means of providing a diverse, rich food supply for fish (directly for young fish, which then serve as food for larger fish). The 2000 Flow and Temperature

Recommendations are designed to increase the connection of the river with its flood plain, which should represent improvement over the No Action Alternative from this perspective.

During the base flow period, backwaters are very productive habitats through Reach 2. The proposed pattern of linking the spring and summer base flows through the varying hydrologic categories in the 2000 Flow and Temperature Recommendations is, in part, designed to better create and maintain main channel backwater habitats through Reach 2. This aspect of the Action Alternative takes a concept put forth in the No Action Alternative and attempts to improve upon it. Therefore, it is assumed that the Action Alternative would increase the main channel food base and benefit the fish community more than the No Action Alternative.

Extremely abundant nonnative fish would also benefit from any increase in food base that is realized in Reach 2. The Recovery Program will need to weigh this cost against the previously mentioned benefits to determine the ultimate effect of implementing the 2000 Flow and Temperature Recommendations.

The extent of the aquatic food base in Reach 2 should increase as minimum discharge increases and daily fluctuations decrease under the Action Alternative. Higher base flows and decreased daily flow fluctuations in average and wetter years should lessen the extent of dewatering (exposure) and increase the extent of habitat available for food base organisms (Angradi and Kubly, 1993; Blinn et al., 1995).

4.7.3.2 Threatened and Endangered Fish

4.7.3.2.1 Colorado Pikeminnow –

4.7.3.2.1.1 No Action Alternative – No Action Alternative flows were based primarily on the needs of the Colorado pikeminnow and promoted a return to a more naturally shaped hydrograph. During the spring, Flaming Gorge Dam releases were timed to coincide with the Yampa River spring peak and base flow magnitudes, and fluctuations were reduced to simulate a more natural condition. The intent of base flow recommendations was primarily to stabilize important nursery habitats in the Uintah Basin (mid- and lower portion of Reach 2). Catch rate data, collected for the Interagency Standardized Monitoring Program since 1986, indicate that the abundance of Colorado pikeminnow in the Green River has increased (McAda, 2002). The general increase in abundance of Colorado pikeminnow can be attributed, at least in part, to the implementation of the 1992 Biological Opinion flows.

In contrast, the Action Alternative builds on the earlier pikeminnow research and goes on to further define the flow/habitat relationships set forth in the 1992 Biological Opinion. Reach 2 provides nursery habitat for YOY pikeminnow and pre-spawning flood plain habitat for adults in the spring. The Action Alternative would:

(1) Better define the process of developing and maintaining pikeminnow nursery habitat.

(2) Increase the magnitude and duration of flood plain connection.

Thus, continued implementation of the 1992 Biological Opinion (No Action Alternative) flows may well provide less benefit for Colorado pikeminnow populations in the Green River than can be attained under the Action Alternative.

The No Action Alternative also makes provisions for managing Green River temperature at its confluence with the Yampa River. The purpose of this recommendation is to reduce thermal shock (abrupt changes in water temperature) to Colorado pikeminnow larvae produced in the Yampa River and drifting downstream into Reach 2. Since installation of the selective withdrawal in

1978, Reclamation has targeted summer release temperatures of 55.5 ºF (13.0 ºC). Analysis of 4 years of data (1998-2002) taken from the confluence of the Yampa and Green Rivers indicates that this temperature differential has occasionally exceeded 9 ºF (5 ºC) but never reached 18 ºF (10 ºC). Research that served as the basis for this recommendation indicated that thermal shock (from warm water into cold water) of 18 ºF (10 ºC) resulted in slightly decreased larval pikeminnow mobility for several hours (Berry, 1988).

YOY Colorado pikeminnow have been collected in nursery habitats in Reach 2 every autumn since 1986 (Trammell et al., 1999); however, abundances vary greatly. Lack of a consistent temperature data set at the confluence precludes an analysis of how differences in Green and Yampa River temperatures may have factored into the varying abundances.

Future conditions under the No Action Alternative for larval Colorado pikeminnow drifting out of the Yampa River would be expected to remain the same as those experienced under operations to meet the 1992 Biological Opinion.

4.7.3.2.1.2 Action Alternative – Colorado pikeminnow spawn in the lower Yampa River and in the lower Green River (Reach 3) but have not been observed spawning in Reach 2. Larval pikeminnow drift downstream from spawning bars to occupy nursery habitats found in Reaches 2 and 3. Colorado pikeminnow use these nursery areas during their first year of life throughout the base flow period. Nursery habitats, or “backwaters,” are characteristically low velocity areas associated with main channel sandbars. Young Colorado pikeminnow prefer the deeper, more persistent backwaters in both Reaches 2 (Day et al., 1999) and 3 (Trammell et al., 1999). Rakowski and Schmidt (1999) conducted a 2-year study (1993-1994) in Reach 2 to describe the process by which backwaters were formed and maintained. They determined that a single base flow target from year to year was inappropriate because the shape of sandbars varied based on magnitude of the annual spring flood. During their study, they found that the shape and height of sandbars was defined during the relatively high runoff of 1993 (approximately 20,000 cfs); and, consequently, the base flow, needed to maximize nursery habitat availability in both years, was much greater than the base flow called for in the 1992 Biological Opinion. Peak and base flow relationships identified in each hydrologic category (dry through wet years) in the 2000 Flow and Temperature Recommendations were based on this research and are designed to optimize the formation of nursery habitats in Reaches 2 and 3. Furthermore, restrictions in seasonal and daily base flow fluctuations under the Action Alternative are designed to maintain these backwater habitats. Young pikeminnow would be expected to benefit from the increased emphasis on creation and maintenance of deep, stable nursery habitats found in the 2000 Flow and Temperature Recommendations. Rakowski and Schmidt (1999) suggested that further study of the specific base flows, needed to maximize nursery habitat annually, was warranted due to the short term of their study.

Under the Action Alternative, the duration of the spring peak is extended to increase the duration of flood plain inundation. Adult pikeminnow do not spawn in flood plain habitats; however, they use them as staging areas (warmer water prepares the adults for reproduction) and as foraging areas. Greater availability of inundated flood plains is expected to benefit Colorado pikeminnow in the short and long term.

The Action Alternative temperature recommendation at the confluence of the Green and Yampa Rivers to benefit drifting larval Colorado pikeminnow is consistent with the No Action Alternative. Under the Action Alternative, warmer water (59 ºF [15 ºC]) would be released during average to wet years, which would result in meeting this recommendation more often.

Many aspects of the 2000 Flow and Temperature Recommendations were designed specifically to benefit adult, larval, and young Colorado pikeminnow. Colorado pikeminnow are expected to benefit in the short and long term under the Action Alternative.

4.7.3.2.2 Humpback Chub –

4.7.3.2.2.1 No Action Alternative – Humpback chubs are presumed to persist in very low numbers in Whirlpool and Split Mountain Canyons in Reach 2; however, specific sampling for this species has not occurred in Reach 2 since the 1980s. The Recovery Program recently funded a study to characterize the fish community in Whirlpool Canyon. This study will provide information needed to describe the current status of this species in this portion of the Green River.

If humpback chubs still inhabit these canyon-bound portions of Reach 2, they may persist, provided all other environmental factors remain unchanged. Unfortunately, recent information suggests that the smallmouth bass population on the Yampa River may be increasing, which has been implicated (along with northern pike) in the decline of juvenile native species. If predation pressures in Whirlpool Canyon are also increasing, humpback chub would be less likely to persist, particularly if the base population is small.

4.7.3.2.2.2 Action Alternative – Based on research results from other humpback chub populations (Desolation Canyon in Reach 3 and Westwater Canyon on the Colorado River), the return to a more natural hydrograph under the Action Alternative should benefit the resident humpback chub in Reach 2, particularly during the wetter hydrologies. Studies conducted there indicated that native chub reproduction (as evidenced by collections of YOY) was more successful in years when the spring peak approximated the historical average.

Historical collections of humpback chub have come from the upper portions of Whirlpool Canyon, only a few miles downstream from the Green and Yampa Rivers confluence. Therefore, humpback chub in Whirlpool Canyon could benefit from the proposed temperature recommendations (a return to a more natural thermal regime). However, the benefits of river warming are not expected to carry downstream to Split Mountain Canyon, the next purported population.

4.7.3.2.3 Razorback Sucker –

4.7.3.2.3.1 No Action Alternative – Reach 2 of the Green River holds the last concentration of wild razorback sucker in the entire Upper Colorado River Basin. This middle Green River population is very small and has been in decline for several years. This species is believed to have persisted longer here than in any other location due to the availability of flood plain habitats and their historical role as nursery areas for larvae and juveniles.

Recovery of this species will depend upon a variety of the Recovery Program actions (nonnative control, stocking hatchery reared fish, and flood plain management) which will likely require some change in current flow management policies. The Action Alternative incorporates spring flow targets with the specific intention of increasing the duration of flood plain inundation. Although the differences in the two alternatives are not great, razorback sucker recovery is less likely under the No Action Alternative in the long term.

4.7.3.2.3.2 Action Alternative – Inundated flood plains provide key nursery habitats for razorback sucker. Razorback sucker spawning has occurred at several locations but has been focused in an area 96-107 river miles below Flaming Gorge Dam (Green River, river miles 313-302) in

Reach 2. This spawning area is immediately upstream of the bulk of floodable habitat in the vicinity of the Ouray National Wildlife Refuge.

In Reach 2, the amount of flood plain inundation increases rapidly as flows exceed 18,600 cfs. Under the Action Alternative, flows in Reach 2 would reach or exceed 18,600 cfs for at least a 2-week duration in 41% of the years, as opposed to only 16% of the years under the No Action Alternative. This major difference between the two alternatives was designed specifically to benefit razorback sucker in the long term.

Temperature recommendations for the Action Alternative are designed to benefit native fishes in Lodore and upper Whirlpool Canyons and drifting Colorado pikeminnow larvae at the confluence with the Yampa River. These temperature recommendations are designed to benefit native fish at post spring peak. The relationship between release temperature during the pre-peak period and temperatures in Reach 2 where razorback sucker spawn has not been fully investigated. There remains both spatial (distance downstream) and temporal (seasonality) uncertainty as to how much of the Reach 2 thermal regime can be affected by dam releases.

The Recovery Program is conducting or has proposed research to address the following uncertainties:

(1) The relationship between the spring flows called for under the Action Alternative and the maintenance of razorback sucker spawning habitats

(2) The importance of flood plain habitats to early life stages of the razorback sucker

(3) Whether flood plains can be managed to benefit native fish over the overwhelming numbers of nonnative fish that use these habitats

Results of these studies will provide necessary information in the evaluation of the effects of implementing the Action Alternative.

4.7.3.2.4 Nonlisted Native Fish –

4.7.3.2.4.1 No Action Alternative – Native suckers (flannelmouth and bluehead) and roundtail chub are found throughout Reach 2. Although data are lacking to clearly indicate whether their populations are stable, results of studies conducted from 1996-1999 suggest that flannelmouth sucker are common, while bluehead sucker and roundtail chub are less abundant. Continued implementation of the 1992 Biological Opinion flows would not likely result in any change to their current distribution or abundance. Continued monitoring would be required to conclusively understand the long-term effect.

4.7.3.2.4.2 Action Alternative – Native fish evolved with, and are adapted to, natural flow regimes. Studies on the middle and lower Green River suggest that native sucker and roundtail chub reproduction is positively correlated with the magnitude of the spring flood. The recommended flow patterns, ranges of flow, and peak flow frequencies of the Action Alternative more closely approximate natural flow conditions than do those of the No Action Alternative.

Native species are found throughout Reach 2 and are known to successfully reproduce there. Increased duration of over bank flooding associated with the Action Alternative will provide greater access to warm, productive flood plain habitat for all adult native fish and serve as nursery areas for young native suckers. Increased emphasis on formation and maintenance of nursery habitats for Colorado pikeminnow in the main channel during the summer, fall, and winter also should benefit other native species—particularly roundtail chub—which, like the Colorado pikeminnow, spawns on the descending limb of the hydrograph.

This group of fish is expected to have varying short-term responses to implementation of the Action Alternative, positive during average to wet years and potentially negative during dry years. In the long term, the greater interannual variation in the Green River hydrograph under the Action Alternative is expected to favor native species in Reach 2.

4.7.3.2.5 Nonnative Fish (Cold Water Species) –

4.7.3.2.5.1 No Action Alternative **–** Densities of all trout species decrease in the Green River downstream from its confluence with the Yampa River because of increases in water temperature and turbidity. Rainbow and brown trout are abundant at the confluence of the Green River and Jones Hole Creek, which supports naturally reproducing trout populations. This small localized trout population is believed to be entirely dependent on tributary flows and temperatures and will not be affected by Green River conditions. Trout distributions and abundances are not expected to change under the No Action Alternative.

As mentioned in chapter 3, “Affected Environment,” the presence of northern pike in Reach 2 has increased in recent times. Unless Recovery Program-sponsored control efforts are successful, their numbers will likely continue to increase.

4.7.3.2.5.2 Action Alternative **–** Implementing the 2000 Flow and Temperature Recommendations will not affect conditions for trout in this portion of the river due to their dependence on the tributary at Jones Hole. Conditions for coldwater species will likely be worse in Reach 2 under the Action Alternative (higher, sediment laden spring flows: probably very little change in thermal regime at this point in the river) than under the No Action Alternative. Increased flood plain inundation under this alternative will likely benefit northern pike. Whether or not their numbers increase will likely depend on the ability of the Recovery Program to control northern pike populations in the Yampa River and throughout Reach 2 of the Green River.

4.7.3.2.6 Nonnative Fish (Other – Large and Small Fish) –

4.7.3.2.6.1 No Action Alternative **–** Carp and catfish are currently the most abundant large-bodied fish species in the main channel throughout Reach 2. Unless the Recovery Program is effective with their nonnative control efforts, these species would be expected to remain dominant.

Nonnative minnows (red shiner, fathead minnow, and sand shiner) dominate low velocity habitats (backwaters, shorelines, and pools) throughout Reach 2. These species have likely reached some form of dynamic equilibrium throughout this reach. The abundance of these species has been negatively correlated with the magnitude of the spring peak, particularly in those portions of the river where the channel is confined (canyons and restricted meanders). Due to their capacity to spawn multiple times per summer, however, their numbers rebound almost immediately. Densities of these species can vary greatly in the short term but are expected to remain very high in the long term.

4.7.3.2.6.2 Action Alternative **–** The most noticeable change in the Reach 2 riverine environment as a result of implementing the 2000 Flow and Temperature Recommendations would be an increase in the duration of over bank flooding. Carp display an affinity for this type of habitat (feeding, spawning, and rearing); and unless the Recovery Program decides to increase efforts to control their access to these areas, they will likely benefit from the Action Alternative. Channel catfish use these off-channel habitats as well, but to a lesser extent than carp. In the canyon-bound areas of Reach 2 (Whirlpool and Split Mountain Canyons), the effect of high flows may result in negative impacts to these two species.

During the base flow period, managing to maximize backwater nursery habitat would likely also benefit populations of introduced fish, which may compete with native fish for food resources or prey on larval and juvenile native fish (Kaeding and Osmundson, 1988; Haines and Tyus, 1990; Karp and Tyus, 1990a; Tyus and Beard, 1990). Quiet-water habitats also are preferred by green sunfish, bluegill, and northern pike. Green sunfish and bluegill feed on a variety of food types, including larval fish, while the northern pike eats fish exclusively.

In summary, all the warm water nonnative species discussed above may be negatively impacted in the canyon-bound portions of Reach 2 during average to wet years. They may benefit during the same hydrologies in the alluvial portions of this reach. The Action Alternative flow regime does not differ enough from the current condition that the abundances and distributions of these extremely abundant species would change appreciably.

4.7.4 Green River Downstream From Flaming Gorge Dam – Reach 3

4.7.4.1 Aquatic Animals

The following impact analysis is based solely on a comparison of the predicted flows under the Action and No Action Alternatives. The proposed release temperatures under the two alternatives are not expected to result in measurable differences in the Reach 3 thermal regime.

4.7.4.1.1 Aquatic Food Base –

4.7.4.1.1.1 No Action Alternative – Considering the lack of baseline information for this resource in Reach 3, assessing environmental consequences for this resource is very difficult. The aquatic food base is expected to remain at current levels.

4.7.4.1.1.2 Action Alternative – Results of the hydrology modeling indicate that overbank flooding (which requires flows in excess of 22,000 cfs) can be sustained for a 2-week period at a slightly higher recurrence interval under the Action Alternative. However, the bulk of flood plain habitat that connects to the river is found only in the very upstream portions of Reach 3. These durations provide a greater period of time for zooplankton (fish food) to grow as was discussed in the Reach 2 section. These high flow durations provide a similar benefit in the lower Green River but on a much smaller scale where the river only floods the mouths of small tributary washes.

Under the Action Alternative, base flows in Reach 3 are expected to be a few hundred cfs higher at the 50% exceedence level during the month of September. These increased base flows are expected to maximize backwater habitat availability (a relationship based on research conducted in Reach 2). Backwaters are preferred by YOY Colorado pikeminnow, presumably because they provide good foraging areas as well as current refuge and perhaps optimum temperatures for growth. Backwater productivity, however, is directly linked to flow stability. Increases in flow during the base flow period (as results of dam operations or storm events) can re-connect backwaters, flushing abundant food items into the main channel and making them less available to young pikeminnow. The ability to ensure flow stability decreases dramatically in the Reach 3 nursery area because of storm events and tributary flow contributions.

It is believed that implementing the Action Alternative would result in a better food base in Reach 3; however, data is not available to substantiate that claim. Based on the relatively minor differences in the predicted flows under the two alternatives and the added flow variability in Reach 3, the question becomes whether these benefits would be measurable or attributable to dam operations.

4.7.4.2 Threatened and Endangered Fish

4.7.4.2.1 Colorado Pikeminnow –

4.7.4.2.1.1 No Action Alternative – YOY Colorado pikeminnow have been collected from lower Green River nursery habitats every year sampling has occurred (1986-1999). Some of those YOY may have been produced at the Yampa River spawning bar. This consistent YOY catch strongly suggests that adult Colorado pikeminnow have successfully spawned at the Gray Canyon spawning area in each of those years as well. Therefore, flows since 1992 and the flows projected under the No Action Alternative should maintain some unknown amount of spawning habitat, which is consistent with the flows identified to construct and cleanse these habitats (Harvey and Mussetter, 1994). McAda (2002), reports that catch rates of juvenile and adult Colorado pikeminnow have increased through the Green River from 1986-2000. The trend in the lower Green River data set is not as high but still is positive. Unfortunately, more recent data (preliminary at this point) indicate that catch rates of adult fish in the lower Green River have dropped, which reiterates the need for long-term monitoring to adequately describe the status of long-lived species.

If the recent decline in catch rates is real, the ability to predict the pikeminnow's response to flows under the No Action Alternative is severely compromised. If the recent catch rates fall within the existing realm of sampling variability and, more importantly, if they recover in the next several years, the forecast for Colorado pikeminnow under the No Action Alternative would be more optimistic. Regardless, these predictions only consider the effects of flow on this species and must be qualified because modeling does not take into account future depletions in the tributaries. Furthermore, other unforeseen shifts in environmental variables (e.g., further introductions of nonnative species or increased abundance of resident nonnative, further fragmentation of habitat, or degradation of water quality) could counter an otherwise positive response to flow management.

4.7.4.2.1.2 Action Alternative – Harvey and Mussetter (1994) report that the spawning bars in Reach 3 are constructed at high flows, but the actual spawning habitat is created and cleansed following the peak flow when discharge ranges between 2,800 and 8,020 cfs. The hydrology analysis indicates that peak flows (construction flows) occur with nearly the same frequency under the Action and No Action Alternatives; likewise, the lower flows on the descending limb that cleanse the spawning bars occur virtually every year. It is difficult to imagine that proposed changes in dam operation under the Action Alternative would result in a significant increase in amount or quality of spawning habitat in comparison with the No Action Alternative. Spawning habitat maintenance in Reach 3 is likely to be more dependent on tributary flow contributions than on Flaming Gorge Dam releases.

The comparative hydrologic analysis of summer base flows indicates slightly higher values in Reach 3 during average and wetter years. These higher base flows are consistent with the intent of Rakowski and Schmidt (1997) and the authors of the 2000 Flow and Temperature Recommendations to increase the availability of deep, stable backwaters. Sustaining these base flows through the winter should further benefit YOY pike-minnow. During dry years, summer base flows in Reach 3 will be lower than under the No Action Alternative, which could result in both benefits and adverse effects to the system. Lower summer flows in Desolation and Gray Canyons could result in more frequent and larger catfish die offs. However, native fish could suffer as well.

The Action Alternative will result in a more normative hydrograph throughout the river to varying degrees (greatest change in Reach 1, moderate change in Reach 2, relatively minor change in Reach 3). The Recovery Program operates under the premise that a return to a more normative hydrograph will benefit native fish. Therefore, it is assumed that implementing the Action Alternative would benefit Colorado pikeminnow over the No Action Alternative. It is likely that these benefits would be very minor in this portion of the river and may not be seen for many years.

4.7.4.2.2 Humpback Chub –

4.7.4.2.2.1 No Action Alternative – Monitoring data (1993-2000) collected by UDWR indicate that the adult humpback chub catch rates are quite low (ranging from 0.02-0.17 fish per net hour) and variable, but they do not appear to be in decline. In recent years, the Recovery Program has shifted the monitoring approach away from relying on catch indices to estimating population size through mark and recapture studies. Population estimation requires a much more rigorous sampling design but should provide a more confident assessment of how this population is doing.

YOY chubs were collected every year during a 5-year study (1992-1996). Catch rates were greatest during one of the higher water years. Chart and Lentsch (2000) reviewed all available data and observed that the wet hydrologies of the mid-1980s and mid-1990s appeared to benefit the Desolation and Gray Canyons native fish community. The hydrology analysis indicates that peak flows less than or equal to 39,000 cfs occur in Reach 3 with approximately the same frequency under the Action and No Action Alternatives. Therefore, the humpback chub population in Desolation and Gray Canyons would likely persist at current levels under the No Action Alternative flows, provided no further introductions of nonnative species or increases in resident nonnative species occur.

4.7.4.2.2.2 Action Alternative – Juvenile and adult humpback chub prefer eddy and eddy/pool habitats. Orchard and Schmidt (2000) described the availability of these habitats as a function of flows in Desolation Canyon. Their conclusion was that the total amount of these habitat types varied little as flows fluctuated, but the size and position of the eddies did. During low flows, small eddies were distributed throughout the canyon. As flow increased above 7,000 cfs, eddies increased in size and were only associated with channel constrictions. They speculated that, historically, a greater variety of habitats and substrates types were available to chubs under a wider range of flows than is currently available.

Humpback chub appear to spawn throughout the canyon, and specific habitat preferences have not been identified. Day et al. (2000) described the backwater habitats used by young chubs but recognized that they can be found in a variety of shoreline habitats at a relatively early life stage.

The 2000 Flow and Temperature Recommendations are not designed to specifically benefit a humpback chub life stage, primarily due to a lack of understanding of this species' specific habitat requirements. The high flows called for during the spring are designed to create flooded habitats in upper Reach 3 with the intention of providing habitat for larval razorback sucker and adult pikeminnow. Those same flows would assist with channel maintenance and provide large eddies for humpback chub in Desolation Canyon. The base flows are designed to benefit the early life stages of pikeminnow but are presumed to provide stable, warm habitat for young chubs as well.

The general intention of the 2000 Flow and Temperature Recommendations is to increase interannual flow variability and to restore a more natural hydrograph. Data suggest that this should benefit humpback chub in Desolation Canyon. However, based on the modeled differences between the Action and No Action Alternatives flows, implementing the 2000 Flow and Temperature Recommendations may not be enough to detect a change in the population. In Desolation Canyon, a positive shift in humpback chub populations would be more likely if the Action Alternative was implemented in combination with a successful Recovery Program nonnative control effort.

4.7.4.2.3 Razorback Sucker –

4.7.4.2.3.1 No Action Alternative **–** Razorback sucker in the upstream portions of Reach 3 are a component of the remnant population found in Reach 2. Please refer to the Reach 2 discussion in section 4.7.3.2.3 as it applies to razorback sucker in that area.

Wild razorback sucker have not been collected in Reach 3 since 1997. Sampling for larval razorback suckers was discontinued in 1999. This population was severely depleted before the 1992 Biological Opinion flows were implemented. Stocking Reach 3 with hatchery-reared fish would be necessary prior to determining any positive responses.

4.7.4.2.3.2 Action Alternative **–** The spring peak and duration flows for Reach 3 in the 2000 Flow and Temperature Recommendations are designed to increase flood plain inundation in a 6-mile stretch of the Green River between the White River and Pariette Draw. The hydrologic analysis indicates that the recommended durations would be achieved only slightly more under the Action Alternative than under the No Action Alternative. For this reason, it is assumed that razorback in this area would benefit, albeit minimally, from implementation of the Action Alternative.

Similarly, the increased duration of flooding in tributary mouth habitats should benefit razorback sucker in Reach 3. It remains uncertain whether such a small change in this type of habitat would result in a measurable response.

Throughout the Green River, recovery of this species will be contingent on the following suite of Recovery Program activities: a successful augmentation program, habitat development, flow management, and nonnative control.

4.7.4.2.4 Nonlisted Native Fish –

4.7.4.2.4.1 No Action Alternative **–** As stated in chapter 3, data are lacking to adequately describe trends in flannelmouth sucker, bluehead sucker, roundtail chub, and speckled dace in Reach 3 of the river. All species appear to successfully reproduce in this reach under the current flow regime based on consistent collections of YOY. Juvenile life stages of the larger-bodied species are not present every year, but they have been documented in various short-term studies in multiple areas (Desolation Canyon, near Tusher Wash Diversion, and in the lower Green River in Canyonlands National Park). Adult flannelmouth and bluehead suckers are routinely collected throughout Reach 3, but densities vary greatly. All life stages of roundtail chub adults are consistently collected in Desolation Canyon but are extremely rare in the remainder of Reach 3.

It is assumed that these species will persist throughout Reach 3 under the No Action Alternative. Based on the positive correlations found between flow and their reproductive success, varying short-term effects are expected, and unknown long-term responses are unknown. Considering the declines in range-wide distribution, these species have suffered in recent times (Bezzerides and Bestgen, 2002), and it would be prudent to track their response more closely.

4.7.4.2.4.2 Action Alternative **–** The differences in hydrologic modeling results for Reaches 2 and 3 reflect the intention of the authors of the 2000 Flow and Temperature Recommendations to restore a more natural hydrograph to the river. Implementing these recommendations in Reach 3 would result in slightly longer durations of moderately high flows and a more stable base flow regime. The predicted differences between the Action and No Action Alternatives are minor and are associated with a greater degree of variability in Reach 3 due to tributary inputs. The same short-term responses to varying hydrologies identified under the No Action Alternative would be expected under this alternative. However, native fish are expected to benefit in the long term under the Action Alternative.

4.7.4.2.5 Nonnative Fish (Cold and Cool Water Species) –

4.7.4.2.5.1 No Action Alternative – Northern pike use flood plain habitats in the upstream portion of Reach 3 and will continue to do so. Northern pike numbers have been reduced in this portion of the river in recent years due to the Recovery Program's active removal efforts (reference *Recovery Program Project No. 109 2003 Annual Report* online at http://www.r6.fws.gov/crrip/arpts/2003/nna/109.pdf>). In the lower Green River, northern pike have made a very small presence, probably due to the warmer temperatures and lack of extensive flood plain. Abundances of northern pike in the lower river should remain low and are not expected to increase as a consequence of the No Action Alternative.

4.7.4.2.5.2 Action Alternative – Northern pike will likely benefit from the increased durations of flood plain inundation associated with the Action Alternative in the upstream portions of Reach 3. This relatively minor change in flow could result in an increased distribution or abundance of this species throughout the remainder of the reach.

4.7.4.2.6 Nonnative Fish (Other) –

4.7.4.2.6.1 No Action Alternative – Channel catfish is the most abundant main channel species throughout much of Reach 3. Common carp are ubiquitous and often as abundant. Red shiner, fathead minnow, and sand shiners dominate all low velocity habitats throughout Reach 3.

Reproductive success of all these species appears to be negatively impacted in the short term during the wetter hydrologies. Long term, these species will likely persist at present levels unless specific Recovery Program control efforts are successful.

4.7.4.2.6.2 Action Alternative – Channel catfish have experienced die offs in Desolation Canyon during extremely low flow years. The minimum base flow target for Reach 2 under the No Action Alternative would be 1,100 cfs; under the Action Alternative (driest hydrologies), the minimum is 900 cfs. Although there is a specific base flow target for Reach 3 in the 2000 Flow and Temperature Recommendations, the Reach 2 target would likely take precedence in this situation. During the summer of 2002, a flow of 900 cfs at Jensen, Utah, (Reach 2) translated into less than 900 cfs in Reach 3 (explanation: virtually no tributary input and evaporation losses over these 246 river miles); and a channel catfish die off was reported in Desolation Canyon. For this reason, channel catfish could be negatively affected by the Action Alternative during the driest hydrologies.

As mentioned above, densities of red shiner, fathead minnow, and sand shiners in low velocity habitats are likely fluctuating around some level of carrying capacity. These species would likely thrive under the dry hydrology conditions described above.

These nonnative species have shown an ability to quickly rebound from any environmental setback. They are not expected to be affected long term by the predicted changes to Reach 3 hydrology under the Action Alternative.

4.7.4.3 Fish – Summary of Environmental Consequences

A summary of the environmental consequences of implementing the No Action and Action Alternatives to the riverine fish community is presented in table 4-8.

Table 4-8.—Summary of Environmental Consequences to the Riverine Fish Community (Most Common Species) of Implementing a No Action (1992 Biological Opinion Flows) or Action (2000 Flow and Temperature Recommendations [2000 FTR]) Alternative

Fish Species/Community Assemblage Group	Reach 1		Reach 2		Reach 3	
	No Action Alternative	Action[1] Alternative	No Action Alternative	Action Alternative	No Action Alternative	Action Alternative
Colorado Pikeminnow	Adult Colorado pikeminnow would be expected to continue to utilize habitats in Reach 1 as they do currently.	The more natural flow regime proposed in the 2000 FTR could cleanse substrates (for spawning and generally increase productivity) and reduce nonnatives. The river warming may increase the likelihood that pikeminnow would establish home ranges in Reach 1 and possibly spawn there.	Long-term monitoring indicates that the abundance of Colorado pikeminnow in the Green River has increased. The No Action Alternative represents an improvement over the pre-1992 Biological opinion operations and likely factored into that increase.	Many aspects of the 2000 Flow and Temperature Recommendations built on the 1992 BO recommendations and are designed specifically to benefit adult, larval, and young Colorado pikeminnow. Pikeminnow are expected to benefit in the short and long term under the Action Alternative.	Colorado pikeminnow appear to have successfully spawned at the Gray Canyon bar every year sampling occurred The No Action Alternative represents an improvement over the pre-1992 Biological opinion operations and likely factored into a reported increase in abundance.	Base flows are better matched with spring releases to maximize backwater habitats. Pikeminnow should benefit, but the relative increase over the No Action Alternative may not be immediately measurable.
Humpback Chub	Continued operations under this No Action Alternative are not expected to result in the re-establishment of humpback chub in this portion of the river.	Humpback chub are more likely to become re-established in Reach 1, primarily due to the river warming proposed in the 2000 FTR	Humpback chub persist in very low numbers, in Whirlpool Canyon and perhaps in Split Mountain Canyon in Reach 2. Sampling for this species in Reach 2 has been opportunistic at best and needs to be increased.	The Action Alternative should benefit the resident humpback chub in Reach 2.	Population in Desolation and Gray Canyons expected to persist at current, low level unless nonnatives increase.	Longer durations of moderately high flows and more stable base flows should benefit humpbacks, but these relatively minor changes in hydrology may not result in a measurable response.
Razorback Sucker	The abundance of adult razorback in Reach 1 would be directly linked to the larger Green River subbasin population. If the population of razorback suckers increases in Reach 2 (as result of stocking, nonnative control, and flood plain restoration), it is expected that the incidence of adults in Reach 1 would also increase.	The abundance of razorback sucker in Reach 1 will be directly linked to the larger Green River subbasin population. In Reach 1, the return to a more natural hydrograph and thermal regime could increase habitat suitability in Browns Park for various life stage of razorback sucker.	Recovery of this species is going to be contingent on a variety of actions: nonnative control, augmentation, and flood plain management, which will likely require some change in current flow management policies.	Recovery is going to require a multifaceted approach (see No Action Alternative). The increased duration of overbank flooding proposed in the 2000 Flow and Temperature Recommendations is designed to increase critical nursery habitat for razorback sucker, which is an important experiment that needs to be tested. Razorback sucker stand a better chance of recovery under the Action Alternative.	Recovery is going to require a suite of actions, not least of which is a successful augmentation program to re-establish razorback suckers in the lower river	Recovery is going to require a suite of actions, not least of which is a successful augmentation program to re-establish razorback suckers in the lower river. The longer durations at moderately high spring flows should provide more nursery habitat, but the resultant, relative increase in the lower river will be nearly insignificant.
Bonytail	The authors of the 2000 Flow and Temperature Recommendations did not choose to factor the needs of this species into their recommendations because information on the species life history and the physical processes that affect their habitats were not available. The authors go on to state ". . .the flow and temperature recommendations that are made for the other endangered fishes would presumably benefit any bonytails that remain in the system and would not limit their future recovery potential." To the best knowledge, there are no new data that would contradict the author's contention, and it would be useless to further speculate on the relative impacts of implementing one alternative over another. The hydrologic and temperature modeling indicates that the changes to the environment resulting from implementing the Action Alternative would be greatest in Reach 1, less in Reach 2, and it is assume of even less consequence in Reach 3. Therefore, based on the line of reasoning put forth in the 2000 Flow and Temperature Recommendations, it is assumed bonytail would benefit from the Action Alternative in Reaches 1 and 2.					
Nonlisted Native Species; (flannelmouth sucker, bluehead sucker, and roundtail chub)	Distribution and abundance of these species is not expected to change. However, in recent years, there is increasing evidence of native sucker hybridization with the nonnative white sucker. This trend in hybridization would be expected to continue.	These native species are expected to benefit under the return to a more natural hydrograph and thermal regime through increased reproductive success, better growth, and reduction of brown trout in Lodore Canyon. If reservoir species (smallmouth bass) become established in Reach 1, this group of fish would likely be affected most.	Native suckers and roundtail chub are found throughout Reach 2. Population trend data are lacking for these species. It is not expected that continued implementation of the 1992 BO flows would result in any change to their main channel distributions or abundances, long term.	The greater interannual variation in the Green River hydrograph under the Action Alternative should benefit the native species in Reach 2. Short-term effects could be positive during the wetter hydrologies and negative during the dry years	Native suckers and roundtail chub are found throughout Reach 3. Population trend data are lacking for these species. It is not expected that continued implementation of the 1992 BO flows would result in any change to their main channel distributions or abundances, long term.	Native suckers and roundtail would certainly benefit from a move toward a more natural hydrograph; however, the changes in Reach 3 are not likely to result in a measurable positive response.
Cold Water Nonnatives (trout and northern pike)	Trout populations are expected to remain at high levels and the individual trout in good condition.	The Action Alternative has obvious pros and cons in terms of the trout fishery below Flaming Gorge Dam. It is not expected for this resource to be greatly affected in the long term and may benefit.	Trout become extremely scarce in the lower portions of Reach 1 and are virtually nonexistent in Reach 2.	Trout are extremely scarce in Reach 2; therefore, the implementing the 2000 FTR should have no effect. Northern pike should benefit from the increased flood plain inundation (ongoing control measures should be continued)	Not applicable to trout. Northern pike will likely persist or increase unless Recovery Program control efforts are successful.	Not applicable to trout. Northern pike will benefit in the upper portions of the reach from the increased flood plain inundation. Pike are expected to increase unless Recovery Program control efforts are successful.
Warm Water Nonnatives; Large-Bodied (carp and channel catfish)	Carp and catfish would persist at current levels in the lower portion of the reach, primarily in Lodore Canyon	Carp and catfish are expected to experience short-term benefits during the drier years and as result of warmer release temperatures. Higher flows during wet hydrologies could reduce their numbers.	Carp and catfish are currently the most abundant large-bodied fish species in the main channel throughout reach 2. Unless effective control of these species is implemented, it is assumed that they would remain dominant.	Carp and catfish may be reduced in the canyon bound portions of Reach 2 during above average hydrologies. In the alluvial portions of the reach (Uintah Basin), their numbers are expected remain high.	Carp and catfish are currently the most abundant large-bodied fish species in the main channel throughout Reach 3. Unless effective control efforts are successful, it is assumed that they would remain dominant.	Similar to the No Action Alternative outcome. Channel catfish may be negatively impacted during the driest hydrologies but are not expected to be affected long term.
Warm Water Nonnative; Small-Bodied Minnows (red shiner, fathead, sand shiner, and redside shiner)	Nonnative minnows are abundant in the lower portions of Lodore Canyon. Their current distribution and abundance has likely reached some level of equilibrium and is not expected to change.	Nonnative minnow will likely benefit from the dry hydrology flows and temperatures, and the warmer releases during above average hydrologies. During the dry and moderately dry years, they could become established in Browns Park. Releases during average and wet years should serve to reduce their abundance and distribution.	Nonnative minnows dominate the low velocity habitats (backwaters, shorelines, pools) throughout Reach 2. These species have likely reached some form of dynamic equilibrium and are expected to remain abundant.	The slight increases in duration of high flows in Reach 2 under the 2000 FTR could result in short-term reductions of these nonnative minnows in the constricted channels of Whirlpool and Split Mountain Canyons. However, a significant reduction long term in the densities of these extremely abundant species is not expected.	Nonnative minnows dominate the low-velocity habitats (backwaters, shorelines, pools) throughout Reach 3. These species have likely reached some form of dynamic equilibrium and are expected to remain abundant.	This group of fish may suffer some short-term set backs during wetter period, but are not expected to be affected long term

[1] Environmental consequences that are expected to occur during the summer base flow period operating under the following temperature release schedule - during base flow releases of 800-1,200 cfs release 13-14 EC (55.4 -57.2 EF) as early as possible and maintain these temperatures as long as possible into the fall; during base flow releases >1,200 cfs release 15 EC (59EF) as early as possible and maintain this temperature through the summer and for as long as possible into the fall. It should be noted that the 1992 Biological Opinion also calls for release up to 15 EC (59 EF), and for no greater than a 5 EC (41 EF), difference between the Green and Yampa Rivers at their confluence during the month of July.

4.7.5 Vegetation

Differences between the Action and No Action Alternatives were based on the Flaming Gorge Model. Methods used to assess potential effects to vegetation involved several multiyear research projects and detailed plant surveys. These studies and surveys have occurred at specific areas along the Green River. Assumptions are made in this section that these studies and surveys are representative of the larger river. Indicators used to determine effects to vegetation were defined as changes in species composition, plant health and reproductive ability, and shifts in location. Analysis was simplified by placing plant communities in three broad landform categories, as described in chapter 3, section 3.7.2.6, "Vegetation."

(1) Post-dam flood plain composed of true wetland plants in close contact with surface and subsurface water

(2) Intermediate bench communities that proliferate just above the current operations annual floodflows

(3) The old high water zone

Research and inventories on the Green and Yampa Rivers were conducted by Colorado State University, Utah State University, USGS, Dinosaur National Monument, Reclamation, and the Bureau of Land Management (BLM).

Table 4-9, describes environmental differences between the No Action and Action Alternatives.

4.7.5.1 Reach 1

4.7.5.1.1 No Action Alternative – Under the No Action Alternative, peak flows would continue to cause erosion and sediment deposition (though to a lesser extent than in the Action Alternative) of the post-dam flood plain and intermediate bench areas. Cattail and sedge communities would infrequently be subjected to removal or burial by floodflows. With few areas scoured and deposition occurring close to the river's edge, cottonwood establishment opportunities would be few. Cottonwood seed production in Browns Park is greatly reduced compared to that of the Yampa River (Cooper et al., 1999). Without high flows necessary to maintain health of mature cottonwoods, seed production would continue to decrease as the health of these mature trees continues to decline and individual trees die. According to Merritt and Cooper (2000), the old high water zone of Reach 1 would continue to move further toward a desert community with cottonwood eventually replaced by desert shrubs. The islands of Browns Park would be maintained as wetland communities and continue to build in a downstream manner. Cottonwood establishment would not occur on these wetland islands and would continue to be extremely limited within Browns Park.

Under the No Action Alternative, base flows in Reach 1 would remain high and relatively stable, contributing to the maintenance of wet meadow communities that proliferate under stable water levels. Makeup of wetland species would remain distinct from the Yampa Canyon and from that of the vegetation community below the confluence of the Green and Yampa Rivers (Merritt and Cooper, 2000).

4.7.5.1.2 Action Alternative – The greatest potential for effects to vegetation from the Action Alternative would occur in Reach 1 due to the direct link to dam operations and to the greatest differences from current operations in both peak and base flows. The increased magnitude and frequency of floodflows in extreme wet years would likely produce the greatest changes to vegetation. Timing of peak flows under the Action Alternative would not be different from those of the No Action Alternative.

It is difficult to predict the amount of scouring/erosion that would occur during these extreme events. Erosion varies with the specific environment but tends to occur on those surfaces that are closest to the river channel—riverbanks, cobble bars, and

Table 4-9.—Summary of Effects to Vegetation Under the No Action and Action Alternatives for Reach 1 and Reach 2

	No Action	Action
Reach 1	▪ Infrequent erosion and deposition on post-dam flood plain and intermediate bench surfaces. ▪ Little to no opportunity for cottonwood establishment. ▪ Maintenance of island marshes. ▪ Wetland species remain distinct from that below confluence of Yampa River. ▪ Old high water zone continues trend toward desert community. ▪ Old-growth cottonwoods continue trend of premature die off. ▪ Invasive species presence continued with moderate increase in acreage.	▪ Increased erosion and scouring of wetland species in post-dam flood plain. ▪ Increased deposition on intermediate bench surfaces; some plant mortality, but vigorous re-growth likely for most plants. ▪ Increased opportunities for cottonwood establishment. ▪ Possible mortality of desert species in old high water zone with replacement by flood tolerant vegetation. ▪ Increased health of mature cottonwoods. ▪ Shift in location or possible accelerated expansion of invasive species.
Reach 2	▪ Infrequent flooding of flood plain forests, thereby benefiting invasive and desert type species. ▪ Limited opportunity for successful cottonwood establishment–only in extreme wet years. ▪ Islands and insert flood plains remain vegetated.	▪ Increased flooding of flood plain forests–leading to increased health of native forests. ▪ Increased opportunities for cottonwood seedling establishment. ▪ Increased removal of vegetation on islands and bars. ▪ Shift in location or possible accelerated expansion of invasive species.

islands. These are the surfaces and vegetation communities described in chapter 3 as post-dam flood plain and intermediate bench surfaces. Flows of 10,600 cfs (1999) removed vegetation in Lodore Canyon from upstream ends of gravel bars and debris fans. The greater magnitudes and velocities of the Action Alternative floodflows would result in removal of even more vegetation. Once vegetation is removed in an extreme high flow event, then smaller floodflows that follow would likely, if they occur with regularity, maintain some areas as unvegetated. Larson (2004) found that the majority of post-dam flood plain surfaces in Lodore Canyon are reworked by floodflows more frequently than the intermediate bench surfaces and, therefore, are more likely to remain unvegetated.

Response to scouring varies depending on growth form, age, and location. Stem removal would likely be highest among shallow-rooted, clonal species (those that reproduce or spread via shoots) such as cattail, common reed, sedges, and coyote willow. While stem removal may be high, the likelihood of plant survival is also high with the exception of cattail and sedge, which tend to suffer high mortality rates in large floodflow events (Stevens and Waring, 1986).

Plants with deep roots, such as tamarisk, show greatest resistance to scouring, and the presence of this anchoring root system limits scouring of neighboring plants. Once established (i.e., 3 years of age), tamarisk is extremely difficult to remove with floodflows at any location. The majority of tamarisk in Lodore Canyon is found on the intermediate bench. Larson (2004) suggests that this surface is unlikely to be reworked significantly by the moderate increases of the Action Alternative. Thus, the peak releases of the Action Alternative are unlikely to cause a large-scale decrease in tamarisk in Lodore Canyon.

The more likely effect to vegetation during flood events is burial from sediment deposition. Partial and complete burial of vegetation in Lodore Canyon was a common effect of the 1999 high flows. While erosion occurs along the river's edge, deposition occurs once flows overtop the riverbank and enter the flood plain, depositing sediment on the post-dam flood plain and on the intermediate bench surfaces. Clonal species such as willow, giant reed, and some sedges and rushes appear to respond more favorably to burial than nonclonal species (Stevens and Waring, 1986). Giant reed exhibits vigorous regrowth after burial. Coyote willow generally responds to burial with rapid colonization of newly deposited sediment beds. Tamarisk is highly resistant to burial. A Ute ladies'-tresses population in Lodore Canyon continued to produce flowers and seeds after partial burial. Many nonclonal riparian species would likely experience mortality if covered by more than half their height with sediment (Stevens and Waring, 1986). Low growing rushes and sedges that are highly susceptible to complete burial would likely face high degrees of mortality.

For floodflows maintained for 2 weeks or longer, the potential for effects from inundation exists. The more xeric (desert-type) species of the mid-elevation zone would likely experience reduced growth levels or possible mortality if inundated 4 weeks or more. Under extreme wet-year conditions, floodflows would reach the old high water zone. The desert species, such as greasewood and sagebrush, that have colonized the old flood plain in the alluvial reaches are very intolerant to flooding, with greasewood dying after 2-3 weeks of inundation. Under this scenario, replacement by more flood-tolerant species would likely occur. However, most of the extreme floodflows for Reach 1 are modeled for 1-day releases, so restoration of the old pre-dam flood plain would be highly limited.

Plants of the mid-elevation zone would likely show mixed results to extended inundation. Coyote willow exhibits high tolerance to drowning. Growth rates of tamarisk have not been affected by 4 weeks of inundation (Stevens and Waring, 1986). Immature box elder suffers high mortality rates with inundation of 85 days or more but tolerates 25-60 days of inundation (Friedman and Auble, 1999). Mature box elder typically survives the entire growing season under inundation.

The effects of extended inundation in the post-dam flood plain area would likely be minimal. These marsh type species (i.e., rushes, sedges, giant reed, and cattail) have a high tolerance to inundation and generally are adapted to extended periods of saturated soil conditions. Some species of sedge proliferate vigorously even with 1½ years of submergence.

As vegetation is removed by scouring or buried from sediment deposition, increased opportunities for establishment of riparian plants and invasive species would appear; but competition from other plants, especially nonnative, invasive species, makes cottonwood establishment tenuous. Floodflows must occur during the period of cottonwood seed rain to benefit that species. If flows are delayed, then tamarisk, giant whitetop, and yellow clover will likely have the establishment advantage.

Like tamarisk, giant whitetop can establish in a variety of disturbed site conditions. Once established, this plant spreads quickly via rhizomes. Giant whitetop is also drought and salt tolerant and appears to be on the increase in Browns Park and Island Park. Larger floodflows may shift the range of these invasive species, allowing them to establish at higher flood plain elevations. Coyote willow appears to be more successful than tamarisk in wet years or in early successional communities (Cleverly et al., 1997). Therefore, it may be that, on the post-dam flood plain surfaces, an increase in the frequency of high spring flows would favor willows over tamarisk.

Williams (2000) theorized that the lack of floodflow inundation is a probable cause of the premature die off of mature cottonwood forests of Browns Park. If this is the case, then large floodflow events would be needed for the flood plain forests of Browns Park to show an increase in the number of healthy older trees. The prolonged high flows of 1986 produced a greater growth response in the mature cottonwoods of Browns Park than the higher but shorter duration flows of 1983 and 1984 (Cooper et al., 1999a). Increased flooding also tends to reduce the population of herbivorous rodents that reside in or near the flood plain (Anderson and Cooper, 2000). These small animals can cause death and injury to young seedlings; population control by flooding would have a positive affect on the likelihood of successful cottonwood establishment.

Changes in base flows under the Action Alternative may affect the wetland plant community in several ways. With base flows higher in the latter half of the growing season, a shift in community composition may occur along with a slight shift in location or expansion upslope for some wetland species. These flows more closely resemble the regulated flows of 1971-1991, when the majority of wetlands species likely established. There is uncertainty as to what responses will result from the lower base flows of winter and early spring, especially following periods of higher fall flows. Some marsh-type species remain dormant under drawdown conditions, especially during the nongrowing season, while other species require exposure of the seedbank to trigger germination.

The rate of establishment for tamarisk near the water line of base flows is unknown but is likely to be low (Larson, 2004). With the exception of extremely dry years, the higher base flows of August and September would likely prevent tamarisk from expanding downslope. Drought conditions, especially if multiyear, would likely favor expansion of tamarisk under both the Action and No Action Alternatives.

4.7.5.2 Reach 2

4.7.5.2.1 No Action Alternative – Mature flood plain forests would continue to derive some benefits from short duration floodflows. In most locations, extended inundation of flood plains would be rare, likely giving tamarisk and other drought-tolerant species a competitive edge. Cottonwood establishment would continue to occur in accreting oxbows and abandoned channels. Scouring of bars and islands would occur under conditions of the infrequent floodflow, thereby limiting opportunities for cottonwood establishment on these formations and encouraging continued development of tamarisk stands. Fewer surfaces in high velocity areas would remain free of vegetation.

4.7.5.2.2 Action Alternative – Effects of the Action Alternative in Reach 2 are reduced but similar to those described above for Reach 1. Any increase in peak flow releases or duration would produce scouring, burial, and drowning effects similar to those of Reach 1. Deposition of sediments and, therefore, burial would increase especially in combination with sediment input from the Yampa River and other tributaries.

For there to be a measurable improvement in the health of riparian forests, floodflows must be of a great enough magnitude and duration to inundate flood plain forests for multiple days. The 2000 Flow and Temperature Recommendations include floodflows of this design. If these flows occur, there would be greater opportunities for cottonwood establishment via increased silt deposition and increased frequency of rewetting of these soils. This increase in flooding frequency, duration, and acreage would likely give cottonwoods and other native riparian species a competitive edge over the native, but more drought-tolerant, and desert shrub species that have moved into the area. For example, at the 10%-exceedence level with 2-week durations, an increase of 2,000 cfs will occur under the Action Alternative. On Ouray National Wildlife Refuge, this 2,000-cfs increase in flows equates to an increase of approximately

1,000 acres of inundated land. This change offers many benefits to native riparian forests and associated wildlife.

While increased flooding may be detrimental to desert shrubs, other invasive species, especially tamarisk and herbaceous plants such as giant whitetop and yellow clover, could spread as floodflows carry seeds into new areas. As previously mentioned, these invasive species are highly competitive with native vegetation. As described in chapter 3, Russian olive is not dependent on floodflows for establishment and appears to thrive under a wide range of conditions. Therefore, the location and rate of infestation of Russian olive under the Action Alternative is assumed to differ little from the No Action Alternative.

Increased frequency of extreme floodflows would also likely remove vegetation from some landforms that are directly in the path of high velocities and prevent re-establishment of vegetation. In Gray Canyon, the oldest tamarisk and cottonwood on gravel bars date to the 1984-86 years, indicating that during spring of 1984, the floodflows of 40,000-50,000 cfs removed all vegetation from these bars (Cooper, 2002).

4.7.5.3 Reach 3

4.7.5.3.1 No Action Alternative – Flood plain forests of the uppermost portion of Reach 3 are a continuation of those of lower Reach 2, and effects of the No Action Alternative would be similar to those described above.

Along the lower Green River, flows of 39,000 cfs are necessary to initiate inundation of flood plains in Canyonlands National Park between river mile 24 and 33 (FLO Engineering, 1996). Using a limited dataset (and, consequently, a large margin of error), hydrology modeling for Reach 3 reveals that minimum overbank floodflows would occur with less than 6% exceedence. Based on this information, it is expected that the native riparian plant community of the flood plain terraces would continue to transition into a more drought-tolerant plant community.

4.7.5.3.2 Action Alternative – Low elevation vegetation found along the river margins and islands would experience effects similar to those described for Reaches 1 and 2, increased erosion and deposition. Flood plains of the upper portions of Reach 3 would be inundated at increased durations and slightly increased frequencies. At the minimum flood plain inundation flow of 22,000 cfs, approximately 663 acres would receive floodflows more often. Effects to cottonwoods and opportunities for expansion of invasive species would be similar to those described for Reach 2.

Flows of 39,000 cfs are necessary to initiate inundation of flood plains in Canyonlands National Park. Approximately 5 acres are inundated at 39,000 cfs, but acreage increases substantially to a maximum of 400 acres at 53,000 cfs (FLO Engineering, 1996). Using very limited data, the hydrology model shows no measurable difference between the Action and No Action Alternatives. The 2000 Flow and Temperature Recommendations for the 1-day, 39,000-cfs recommended flow will not be achieved. Therefore, it is expected that the native riparian plant community of the flood plain terraces would continue to transition into a desert community.

4.7.6 Summary of Vegetation

In summary, under the No Action Alternative, erosion or scouring and deposition of vegetation would continue to occur infrequently under conditions of rare floodflows. There would be little to no cottonwood regeneration in Reach 1 and, in Reaches 2 and 3, only in extreme wet years. The old high water zone of Browns Park would continue to move toward a desert community, while the mature cottonwoods of this reach would continue their premature die off. Areas of marsh habitat would be maintained or, on islands, increase.

Under the Action Alternative, flow patterns would result in short-term effects through removal, burial, and/or possible drowning of vegetation. Most plant species would recover quickly. Burial would likely have the greatest impact to growth and mortality levels. If scoured clean, some low elevation bars and islands may remain free of vegetation. If large, overbank floodflows occur, any short-term effect would likely be offset by the opportunities provided for seedling establishment and cottonwood regeneration. There would be increased vigor in mature flood plain forests and a reduction in acres transitioning from flood plain forest to desert community. Extreme floodflows could increase the spread of invasive, nonnative species into a greater range of elevations. Most wetland and riparian species would be tolerant of late season drawdowns. During multiyear drought conditions, tamarisk may expand downslope under base flow conditions. During multiyear droughts, species with higher tolerance to drought conditions would begin to dominant the corridor.

4.7.7 Terrestrial and Avian Animals

4.7.7.1 Reach 1

Change in the riparian plant community due to operation of Flaming Gorge Dam would affect those terrestrial and avian wildlife species that are dependent on riparian habitat. Most wildlife habitat concerns can be addressed by considering the effects on riparian vegetation. Changes in riparian vegetation would follow changes in exposed sediment deposits resulting from daily water release patterns. Flood events affect vegetation and its suitability as habitat for different wildlife species. Vegetation traps sediment during high flows, and nutrients within the sediment become available for plant growth.

Most terrestrial animals would not be directly affected by daily operation of the dam. Most animals using the riparian area are mobile and would move in response to daily fluctuations.

Riparian habitats below Flaming Gorge Dam receive various levels of use from mule deer, elk, moose, pronghorn, and bighorn sheep. These species also use nonriparian habitats, thus, decreasing their reliance on riparian vegetation. Dam operations are unlikely to affect these game animals in any significant way.

Most birds (migratory or resident) use the riparian corridor as a travel lane through the desert and are not significantly affected by dam operations. Raptor populations likely are not limited within the area by lack of food. They likely are more limited by available nesting habitat. None of the alternatives would affect nest site availability. None of the alternatives would affect the river's suitability as a travel or foraging corridor for raptors.

4.7.7.1.1 No Action Alternative – Under the No Action Alternative, a trend toward a desert shrub community in the old high water zone would eventually decrease the extent and health of the riparian community within Reach 1. This decrease would negatively affect animals dependent on this riparian habitat.

4.7.7.1.2 Action Alternative – Dam operations affect flows and sediment transport that alter riparian habitats. The alteration of these riparian habitats would likely negatively impact terrestrial wildlife currently existing in the area. In time, balance would again be established with a somewhat different composition of species. Some woody vegetation and patches of emergent marsh plants would be lost through scouring or burial as sand is deposited on higher elevations during high flows of wet years. Some riparian vegetation would reestablish itself at suitable new sites in the years following such a flow.

Sudden increase in flows from steady flow patterns would negatively affect ground-dwelling, ground-nesting, and burrowing forms of wildlife by temporarily inundating occupied habitat.

Nongame wildlife species are dependent on the woody species common in the riparian zone of the Green River corridor. Reductions in riparian habitat could adversely impact nongame wildlife.

Birds that nest in the riparian zone along the river corridor would be affected to the extent that the riparian corridor is affected by the operations. Reductions in riparian vegetation should have only slight adverse effects on waterfowl because the amount of marsh available in riparian areas along the river is small compared with the thousands of acres of managed wet marsh in the nearby Browns Park wildlife refuges. The few species that prefer open shoreline habitats (e.g., killdeer and spotted sandpiper) could benefit from the increase in unvegetated shoreline that would occur.

Birds using the riparian zones as travel corridors would not be directly affected by dam operations. Bird species that nest in riparian zones would be indirectly affected by changes in area coverage of riparian plant species due to dam operation. This alternative would reduce some riparian communities in narrow canyon reaches of the Green River by increasing maximum flows that would cause more aggressive scouring of the river channel and burial of some riparian vegetation by initial maintenance floodflows. More open areas (areas with a broader flood plain) would experience some increase in riparian plant species cover and health by an increase in occurrence of flood plain inundation. As riparian zone patch size increases, species diversity and density will increase.

Wintering waterfowl could be adversely affected by a reduction in the availability of open, ice-free water. Reduced flow fluctuations discourage ice breakup once an ice cap has formed. Open, ice-free water would be maintained from the dam to the Gates of Lodore because of the relatively warm dam releases. Use of this river reach by waterfowl in the winter would continue. It is unlikely that peregrine falcon or osprey populations would be affected by this alternative.

Several bat species exist within the area. Although they are not directly affected by dam operations, they are attracted to the river corridor by the insects associated with the river and riparian vegetation. Amphibians would benefit wherever back water and flooded bottomland habitat is increased or improved due to this alternative.

4.7.7.2 Reach 2

4.7.7.2.1 No Action Alternative – Under this alternative, riparian habitat would decrease due to the continued reduction of flood plain inundation. The reduction in riparian habitat would have a negative effect on wildlife dependant on this habitat. Amphibians and riparian nesting birds would be negatively affected.

4.7.7.2.2 Action Alternative – Under the Action Alternative, inundation of the flood plain would occur on a more regular basis and cover a larger area of land. This would increase the health and extent of riparian habitats. Wildlife species dependent on these habitats would benefit. Amphibians would benefit to the extent that backwater and flooded bottomland habitat is improved or increased.

Extreme floodflows could increase the spread of invasive, nonnative species such as tamarisk into a greater range of elevations.

4.7.7.3 Reach 3

4.7.7.3.1 No Action Alternative – Effects to flows attributable to operation of Flaming Gorge Dam are negligible within this reach. This is due to the attenuating effects of distance from the dam and significant inflow of unregulated rivers, streams, and washes above and within this reach. Terrestrial and avian animals would be affected to the same extent and degree as riparian and wetland habitats. Under this alternative, the native riparian plant community would continue to transition into a more drought-tolerant community—thus, reducing important riparian wildlife habitat.

4.7.7.3.2 Action Alternative – In the Western United States, riparian habitat represents less than 1 percent of the total acreage of public lands. Approximately 80% of all terrestrial wildlife species routinely use these riparian areas for food, water, cover, or migration routs. About 30% of the region's bird species use wetlands and other aquatic areas to the exclusion of upland habitats. Wetlands and riparian habitats also support a disproportionate number of species that are of concern because they migrate to neotropical areas, have small continental populations, or are declining in numbers. Since settlement by Europeans, riparian and wetland habitats have suffered large declines due to destruction, conversion to other uses, or significant degradation in structure, function, or composition. Invasion of weed species has also decreased the health and extent of riparian wetland communities.

Effects to flows attributable to operation of Flaming Gorge Dam are less significant within this reach than upstream reaches. This is due to the attenuating effects of distance from the dam and significant inflow of unregulated rivers, streams, and washes above and within this reach. Terrestrial and avian animals would be affected to the extent and degree riparian and wetland habitats would be affected. Under this alternative, the native riparian plant community would continue to transition into a more drought-tolerant community—thus, reducing important riparian wildlife habitat.

4.7.8 Other Threatened and Endangered Species

4.7.8.1 Southwestern Willow Flycatcher

Differences between the Action and No Action Alternatives were based on the Hydrologic Modeling Report (see sections 4.3.1 and 4.3.2 on hydrology). Methodologies used to assess potential effects to southwestern willow flycatcher involved identifying presence/absence of species, identifying suitable and potentially suitable habitat, and determining where project conditions would alter these habitats. Habitat changes were then assessed in terms of their potential to adversely affect the species and the magnitude of such effect.

4.7.8.1.1 No Action Alternative – Large floodflows, though occurring with less frequency and duration than in the Action Alternative, would likely still have an impact on low elevation island habitat, burying vegetation and/or removing vegetation along island edges. With reduced frequency of larger floodflows, flycatcher habitat would remain intact for long periods of time but would eventually become unsuitable due to structural changes of aging vegetation. Opportunities for establishment of additional habitat would be infrequent. Floodflows would only rarely be of the magnitude or duration to leave behind areas of standing water. This lack of standing water is a limiting component of southwestern willow flycatcher habitat along the lower Green River.

4.7.8.1.2 Action Alternative – Implementation of the 2000 Flow and Temperature Recommendations under the Action Alternative would likely remove vegetation that constitutes southwestern willow flycatcher habitat, especially at habitat edges that interface with channel margins where erosion tends to be greatest. Three of the occupied flycatcher territories are located on a low elevation island that would likely be inundated at higher flows. With floodflows occurring more often, some edges may remain unvegetated. As described in the vegetation section, souring and deposition also create areas conducive to establishment of riparian vegetation. So although there may be short-term negative effects to willow flycatcher habitat, there may be an increase in long-term benefits through creation and maintenance of habitat. In the upper sections of Reach 3, increased frequency and duration of larger floodflows would facilitate creation and expansion of areas of standing water, an important southwestern willow flycatcher habitat component.

In summary, the Action Alternative may have short-term effects through removal or burial of habitat. However, these same disturbance events would promote vigorous regrowth and replacement of habitat. If large enough, floodflows should promote development of additional habitat.

4.7.8.2 Ute Ladies'-Tresses

4.7.8.2.1 Reach 1 –

4.7.8.2.1.1 No Action Alternative – Under No Action Alternative conditions, Ute ladies'-tresses would only rarely be subjected to erosion or deposition from infrequent high floodflows. At some suitable and potentially suitable sites, tamarisk would continue to compete and, possibly, out-compete Ute ladies'-tresses. Inundation of sites would continue at the current rate of a few days per year to 10 days per year (1-3% of the time), on average (Grams et al., 2002). These extreme floodflow events would create conditions similar to those described below for the Action Alternative; certain populations of Ute ladies'-tresses would be subjected to inundation, erosion, and partial or complete burial from sediment deposition. Some mortality of plants or populations could result. Since these extreme floodflow events would occur infrequently, populations would generally have ample time to re-establish at those areas negatively affected, and it is expected that populations would continue to proliferate under current conditions.

4.7.8.2.1.2 Action Alternative – The distribution and abundance of Ute ladies'-tresses can be affected by changes in the frequency or duration of inundation or by changes in patterns of erosion or deposition.

Depending on local geomorphologic characteristics, sediment responses at sites supporting existing Ute ladies'-tresses populations may range from increased sediment deposition to increased erosion.

Under the Action Alternative, floodflows would generally increase in magnitude and duration. Post-dam flood plain sites would be inundated for slightly longer periods under the Action Alternative, while intermediate bench sites may be inundated more frequently. Ute ladies'-tresses appear to tolerate occasional periods of extended inundation. All Ute ladies'-tresses populations inventoried in Red Canyon and Browns Park in 1999 were inundated by peak flows of 10,900 cfs held for 9 days, and most had been inundated at least 32 days (Grams et al., 2002). These populations had survived an average of 2.3 feet inundation and up to 3.9 feet at some sites. High flows in extreme wet years may result in some mortality on lower elevation surfaces, such as post-dam flood plain sites.

Deposition, resulting from peak flows, would vary depending on site location. Sediment deposition at sites supporting Ute ladies'-tresses in Red Canyon and Browns Park ranged from no deposition (majority of the sites) to less than 2 inches of very fine sediment during the high flows of 1999 (Grams et al., 2002). In Lodore Canyon, deposition did occur on occupied post-dam flood plain and intermediate bench surfaces. Partial and complete burial of Ute ladies'-tresses were recorded. Under the Action Alternative, sediment deposition may potentially increase on some occupied sites, such as in Lodore Canyon. However, occupied Ute ladies'-tresses sites tend to be located in positions with relatively low rates of sediment deposition. Ute ladies'-tresses appear tolerant of some sediment deposition. A population in Lodore Canyon flowered and produced seed after partial burial in 1999. Plants that are completely buried may not produce seed that year and/or may suffer mortality.

Increased peak flows under the Action Alternative may result in increased erosion of these Ute ladies'-tresses sites. Because occupied sites are generally characterized by stable substrates, such as cobble, that are not often mobilized, erosion and removal of Ute ladies'-tresses populations may be limited. Erosion at occupied sites in Red Canyon and Browns Park reaches is generally absent or minor. In Lodore Canyon, erosion and loss of plants did occur on post-dam flood plain and intermediate bench surfaces, on upstream portions of gravel and cobble bars, islands, and debris fans as a result of 10,900-cfs flows in 1999.

Post-dam flood plain or intermediate bench surfaces that experience erosion or deposition generally become available for development of early-succession vegetation. These sites could be colonized by Ute ladies'-tresses, and new reproductive populations could be established. However, some of these new populations might be temporary. For example, some areas that are subject to frequent disturbance from flooding (such as some post-dam flood plain surfaces) may not be stable for long enough periods for Ute ladies'-tresses establishment and reproduction (10-20 years) and may not develop beyond early-succession communities. In addition, new sites that are relatively stable for extended periods (such as some intermediate bench surfaces) may be colonized by native woody species (coyote willow, cottonwood, or invasive species such as tamarisk, whitetop, or yellow clover). Such sites may quickly become unsuitable for Ute ladies'-tresses survival due to moisture stress, shading, or other competitive forces.

New populations could become established on higher elevation sites in Red Canyon, upper Browns Park, or Lodore Canyon. Studies have indicated that Ute ladies'-tresses likely became established on the higher pre-dam terrace in Island Park following high flows in 1983 or 1984 (Grams et al., 2002). Deposition of fine sediments at these higher elevations may increase site suitability for Ute ladies'-tresses. Suitable substrates with 1-3% inundation may become available as a result of higher flows. However, some of these areas may currently support native woody species or invasive species, and shading induced by these species may prevent Ute ladies'-tresses establishment or survival.

The higher summer and early fall base flows of the Action Alternative could inundate some orchids. Inundation would not occur during the lower base flows of the No Action Alternative. Sites supporting Ute ladies'-tresses typically have a shallow water table during August. It is unknown if these higher flows would result in loss of individuals. Long-term effects may result in orchid populations establishing at slightly higher elevations. Lower base flows through the winter should not affect Ute ladies'-tresses since these flows fall outside the growing season. The month of May likely constitutes the beginning of the growing season. There is some uncertainty as to what the effects of these slightly lower early spring flows would be.

4.7.8.2.2 Reach 2 –

4.7.8.2.2.1 No Action Alternative – Conditions under the No Action Alternative for Reach 2 would be similar to those of Reach 1 (see above).

4.7.8.2.2.2 Action Alternative – Effects of flow changes in Reach 2 would be similar to those described for Reach 1. Increased peak flows in wet years could result in some mortality of Ute ladies'-tresses. Though far fewer in number than in Reach 1, sites occupied by Ute ladies'-tresses in Island Park and downstream from Split Mountain may potentially be subject to extended inundation, increased deposition, or increased erosion.

As in Reach 1, suitable sites for Ute ladies'-tresses establishment would potentially become available at higher elevations in Island Park/Rainbow Park, if suitable sediments were deposited. However, high peak flows in Reach 2 due to Yampa River input may decrease the potential suitability of some new sites on post-dam surfaces, such as intermediate bench surfaces.

4.7.8.2.3 Ute Ladies'-Tresses – Summary of Action Alternative – Reaches 1 and 2 – In summary, under the Action Alternative, occupied sites would be subject to some erosion, deposition, or extended inundation. Loss of individual plants would be expected. However, effects on many Ute ladies'-tresses populations, as a result of flow changes, would be expected to be small because of site characteristics that are protective, such as landscape position and substrate composition. The inundation zone of 1 to 3% would likely shift to a slightly higher position along the river margin, potentially resulting in losses to populations at lower elevations, such as post-dam flood plain surfaces. Locations at elevations slightly above the existing inundation zone of 1-3% would potentially become suitable for Ute ladies'-tresses establishment. Suitable substrates would potentially exist along this area or develop as a result of new deposition from changes in flow characteristics.

4.7.8.3 Bald Eagle

4.7.8.3.1 No Action Alternative – Under this alternative, the eventual loss of cottonwood tree roost sites would occur. This would negatively affect bald eagles.

4.7.8.3.2 Action Alternative – Bald eagles use trout as well as other nonnative and native fish species as food when available. However, any adverse effects of an alternative to the trout population would have little effect on the eagles due to the abundance of trout as a food item for eagles. The trout fishery would be maintained under any alternative.

Bald eagle and waterfowl could be adversely affected by steady flows during the winter. Steady flows would allow less ice-free water to be available for these species. Maintenance of ice cover during the winter protects endangered fish. This would reduce the availability of open water in important foraging areas such as Island and Rainbow Parks. Much of the river above the Gates of Lodore would remain open because the temperature of water released from the dam is sufficiently high to prevent freezing. Eagles would concentrate their use in this section of the river during the winter.

An increase in cottonwood regeneration would increase roosting habitat for bald eagles.

4.7.8.4 Black-Footed Ferret

4.7.8.4.1 No Action Alternative – Although black-footed ferret exist near the project area, their habitat requirements do not tie them to the Green River. Actions affecting the operation of the dam would have no effect on this species.

4.7.8.4.2 Action Alternative – The Action Alternative would have no effect on black-footed ferret for the same reason as the No Action Alternative.

4.7.8.5 Lynx

4.7.8.5.1 No Action Alternative – Although lynx may exist within the project area, their habitat requirements do not tie them to the Green River. Actions affecting the operation of the dam would have no effect on this species.

4.7.8.5.2 Action Alternative – The Action Alternative would have no effect on lynx for the same reason as the No Action Alternative.

4.7.8.6 Other Special Status Species

Both aquatic and terrestrial special status species occupy the Green River. Because the river is regulated by Flaming Gorge Dam, these species could be directly or indirectly affected by changes in dam operations. The effect on terrestrial species would be more indirect and occur through dam-induced changes in habitat.

4.7.8.6.1 Yellow-Billed Cuckoo – Methodologies used to assess potential effects to yellow-billed cuckoo involved identifying presence or absence of species, identifying suitable and potentially suitable habitat, and determining where project conditions would alter these habitats. Habitat changes were then assessed in terms of their potential to adversely affect the species and the magnitude of such effect. See section 3.7.2.6, "Vegetation" in chapter 3 and section 4.7.5, "Vegetation in chapter 4, for a full description of vegetation and effects to habitat from the alternatives. Differences between the Action and No Action Alternatives were based on the Hydrologic Modeling Report (see sections 4.3.1, "Hydrology, Flaming Gorge Reservoir," and 4.3.2, "Hydrology, Green River").

4.7.8.6.1.1 No Action Alternative – Reach 1 – In Reach 1, under current operations, flows would not be of sufficient magnitude or frequency to promote development of suitable habitat. The flood plain forests of Browns Park would continue to move toward a desert community with cottonwood eventually replaced by desert shrubs. There would be little opportunity for yellow-billed cuckoo colonization in Reach 1.

4.7.8.6.1.2 No Action Alternative – Reach 2 – In Reach 2, floodflows would continue to erode edges of suitable habitat, though with less frequency than under the Action Alternative. Cottonwood establishment would be limited to extreme floodflow years. Therefore, development of potential yellow-billed cuckoo habitat would occur under the No Action Alternative but would be very limited. Floodflows of sufficient duration and magnitude to maintain mature cottonwoods would continue to occur under infrequent conditions.

4.7.8.6.1.3 No Action Alternative – Reach 3 – Yellow-billed cuckoo habitat in the upper section of Reach 3 is contiguous with Reach 2, and the effects of the No Action Alternative would be very similar to those described above for Reach 1. Suitable habitat along the lower sections of Reach 3 would continue to receive floodflows only in extreme (less than 6% exceedence) wet years—limiting opportunities for maintenance of present habitat. Cottonwoods that are establishing on the lower insert flood plains are unlikely to form the large patch sizes required by yellow-billed cuckoo. The long-term effects of the No Action Alternative would likely result in a reduction of suitable habitat for yellow-billed cuckoo along the lower Green River.

4.7.8.6.1.4 Action Alternative – Reach 1 – Implementation of the Action Alternative may lead to changes in riparian vegetation that could eventually be characterized as suitable yellow-billed cuckoo habitat. The highest magnitude floodflows, as described in the 2000 Flow and Temperature Recommendations, would be required before establishment of yellow-billed cuckoo habitat could occur in Reach 1. Any changes would only contribute to the long-term development of suitable habitat; there would be no increase in suitable habitat in the short term.

4.7.8.6.1.5 Action Alternative – Reach 2 – Increased frequency of floodflows in Reach 2 would likely remove vegetation that constitutes yellow-billed cuckoo habitat. Most erosion would occur on the edges of yellow-billed cuckoo habitat, primarily affecting vegetation that would develop into potential yellow-billed cuckoo habitat with lesser effects to currently suitable habitat. If floodflow events are large enough, the more likely effect of the Action Alternative would be the creation of cottonwood and willow establishment sites through increased scouring and deposition. In addition, increased overbank flooding would contribute to maintenance of mature cottonwood and native riparian communities through increased wetting of flood plain forests. These actions would result in long-term benefits to yellow-billed cuckoo.

4.7.8.6.1.6 Action Alternative – Reach 3 – Effects to yellow-billed cuckoo habitat in the upper section of Reach 3 would be very similar to effects described above for Reach 2. Increased duration and frequency of larger floodflows would provide needed moisture and increased opportunity for development of suitable habitat.

When comparing the two alternatives, effects to yellow-billed cuckoo in the lower section of Reach 3 would be minimal. Hydrology analysis for Reach 3 demonstrate that there would be no measurable difference in floodflows between the No Action and Action Alternatives. Cottonwoods that are establishing on the lower insert flood plains are unlikely to form the large patch sizes required by yellow-billed cuckoo under either alternative. Therefore, yellow-billed cuckoo habitat would be unlikely to improve or increase in acreage under the Action Alternative.

4.7.8.6.2 Whooping Crane –

4.7.8.6.2.1 No Action Alternative – Flaming Gorge Dam operations under the No Action Alternative are not likely to adversely impact whooping crane populations. Use of the Green River by migrating cranes is low. Large areas are, and would continue to be, suitable habitat for these birds.

4.7.8.6.2.2 Action Alternative – Flaming Gorge Dam operations under the Action Alternative are not likely to impact the whooping crane because the probability that habitat along the river would be used by migrating cranes is low. The expected reduction in the amount of riparian vegetation in some reaches of the river could represent a slight adverse impact to this species if migrating birds began to use the confined canyon portions of the river corridor regularly during migration.

4.7.8.6.3 Mexican Spotted Owl –

4.7.8.6.3.1 No Action Alternative – Under the No Action Alternative, needed food and habitat sustained by riparian vegetation linked to the river and its fluctuations would remain available as currently distributed. Mexican spotted owl populations would not be expected to change due to reservoir operations under the No Action Alternative since these operations would not change these animals' access to or extent of exploitable food or habitat resources.

4.7.8.6.3.2. – Action Alternative. Under the Action Alternative, reservoir operations would have very little influence on Mexican spotted owl habitat within the Green River corridor. Mexican spotted owl habitats associated with vegetation or substrate that are dependent on the river and affected by flow fluctuations would not change in any appreciable manner that would affect owl populations. Suitable nesting sites are a much more significant limiting factor for these owls than any riparian feature. The owls' prey base would remain at levels far exceeding the owls' needs.

4.8 CULTURAL RESOURCES

4.8.1 Flaming Gorge Reservoir

Effects to cultural resources located within a reservoir pool area may be caused by a combination of factors, including topography, slope, soil type, site type, and various mechanical, biochemical, or human impact agents (Lenihan et al., 1981). These agents have the greatest adverse effects on historic properties inundated near the shoreline (the wave-action zone). Historic properties in this zone are subject to mechanical erosion caused by high energy wave action resulting from wind and boat wake activity. For Flaming Gorge Reservoir, the shoreline elevation has fluctuated over time. In average years, the normal operation, low reservoir elevation is 6025 feet above msl, and the normal operation, high reservoir elevation is 6033 feet above msl. Infrequently, very high elevation has occurred at 6040 feet above msl and very low elevation at 5988 feet above msl. As a result, historic properties from 5988- to 6040-foot elevations have been damaged by inundation and mechanical effects from wave action since full operation of the dam began in 1967.

4.8.1.1 No Action Alternative

As shown in table 3-12, 13 known historic properties are located around the reservoir. In the reservoir portion of the project, fluctuation of water levels would not differ from the normal-range levels of the past 37 years under the No Action Alternative. Historic properties are affected more by human visitors than by possible indirect geomorphic effects of dam operations.

4.8.1.2 Action Alternative

Under the Action Alternative, Reclamation anticipates no need to conduct large or unusual drawdowns on Flaming Gorge Reservoir. Fluctuations of the water levels of the reservoir would not change from what has become a normal, although flexible, operation.

There are five historic properties which are eligible for the *National Register of Historic Places* (NRHP) (see table 3-12) within the reservoir area of potential effect (APE). These historic properties are more likely to be affected by visitors than by geomorphic or hydrological processes related to reservoir dam operations. Since visitor effects are managed by the land managing agencies and are not part of dam operations, indirect effects from impacts, like increased vandalism, would not be attributable to the proposed action.

The Wyoming and Utah State Historic Preservation Offices (SHPOs) have concurred with Reclamation's finding that there would be no historic properties affected by the implementation of the Action Alternative.

4.8.2 Green River – Reaches 1, 2, and 3

4.8.2.1 No Action Alternative

Prior to the construction of Flaming Gorge Dam, historic properties located in the Green River flood plain were primarily affected by peak spring floods. Such events probably destroyed many historic properties, especially those located directly on the river banks. In contrast, those historic properties still present in 1962 may have received some benefit from dam construction because the magnitude of spring flooding was reduced and long-term channel narrowing deposited new sediments on top of remnant cultural resources.

Under the No Action Alternative, historic properties located along the banks and in the Green River flood plain would continue to be affected by the same fluvial and geomorphic processes that have occurred over time. In addition, releases from Flaming Gorge Dam could continue to inundate those historic properties listed in tables 3-13 and 3-14.

4.8.2.2 Action Alternative

Under the Action Alternative, cultural resources in Reaches 1, 2, and 3 of the Green River could be subject to direct, indirect, and cumulative effects from inundation, pooling, and raising and lowering of water levels. Through most of the flood plain, these geomorphic and hydrologic processes would not affect the majority of historic properties because these resources are located well above the high water mark and are protected by channel narrowing and sediment deposition. Recent geomorphologic studies (Grams and Schmidt, 2002) conducted within the Green River corridor indicate that the oldest soils (and plausibly the oldest historic properties) along the river most likely occur in Reach 1 in the Browns Park area.

Based on the hydrology modeling results as presented in section 4.3.2, the Action Alternative would result in more frequent inundation of the historic properties listed in tables 3-13 and 14, when compared to the No Action Alternative. However, as previously noted, these historic properties were all subject to even greater flows of longer duration prior to the construction of Flaming Gorge Dam. Therefore, Reclamation concludes that there would be no significant impacts to cultural resources in Reaches 1 and 2 from the implementation of this alternative.

Due to the attenuated nature of the flows which will occur in Reach 3, effects to a terrestrial-based resource such as cultural resource sites would be insignificant. Similar to historic conditions in Reaches 1 and 2, cultural resource sites in Reach 3 which have been impacted in the past were probably much more affected prior to the construction of Flaming Gorge Dam than they have been since the dam was completed.

In Reach 3, there would be no direct or indirect effects to historic properties under either the No Action or the Action Alternatives. The Utah SHPO concurred with this determination on December 29, 2003.

During completion of cultural resource data analysis for this project and in cooperation with the relevant land managing agencies, the verification and testing of certain known sites were conducted. In Utah, Reclamation, in cooperation with BLM and the Utah SHPO, conducted nature and extent test excavations on four sites in Daggett County.

The tested sites were chosen by the BLM. Two of the tested sites are located within the APE for the proposed project, and two are outside of the APE. Three of the tested sites were prehistoric and one was historic. All were evaluated for eligibility and effect. Artifacts recovered during the testing will be curated at the Field Museum in Vernal, Utah. All four of the sites are recommended as being eligible for the NRHP. The Utah SHPO has been consulted on the eligibility determinations of these sites and has concurred (January 13, 2004) with Reclamation's recommendations of eligibility and no adverse effect.

In Colorado, Reclamation, in cooperation with the U.S. Fish and Wildlife Service and the Colorado SHPO, tested six sites in the Browns Park National Wildlife Refuge, Moffat County, for eligibility and effect.

The Colorado SHPO was consulted March 28, 2003, on this work and concurred that three historic properties are present within the APE and that Reclamation and the U.S. Fish and Wildlife Service should continue consultation regarding effects of both natural hydrology and dam operations on two of these properties. Artifacts recovered during the testing are curated at the Rocky Mountain Arsenal National Wildlife Refuge Collections Center in Colorado Springs, Colorado.

4.8.3 Summary of Effects to Cultural Resources

Within the reservoir area, the Wyoming and Utah SHPOs have been consulted on the eligibility determinations for historic properties. Both of these SHPOs have concurred with Reclamation's determination of eligibility regarding historic properties. Also, under 36 Code of Federal Regulations (CFR) 800.4(d)(1), the Utah (December 10, 2002) and Wyoming (November 19, 2002) SHPOs concurred with Reclamation's recommendation that there will be no historic properties affected by the implementation of the project. The Wyoming SHPO recommended annual monitoring of known historic properties near the high elevation of the reservoir.

For Reaches 1, 2, and 3, in consultation with the Colorado and Utah SHPOs; land managing agencies—including the United States Department of Agriculture (USDA Forest Service), BLM, National Park Service, U.S. Fish and Wildlife Service, relevant Indian tribes, and other interested parties—Reclamation applied the criteria of adverse effect to the listed and eligible properties within the APE. Because of the minor differences between the Action and the No Action Alternative flow models and because either alternative is likely to have less effect on historic properties than the pre-dam hydrography, Reclamation recommended that there will be no adverse effect to historic properties from the proposed action.

In cooperation with both the appropriate land-managing agencies and State SHPOs, Reclamation conducted nature and extent testing and rerecording of 10 historic properties, 6 in Colorado and 4 in Utah. The Colorado SHPO sent a letter to Reclamation on March 28, 2003, concurring that three of the six historic properties are eligible for the NRHP. They recommended that Reclamation and the U.S. Fish and Wildlife Service consult further on two of the eligible historic properties within the APE. That consultation is ongoing.

For Reaches 1 and 2, including the Uintah and Ouray Ute Reservation area, the Utah SHPO (January 13, 2004) agreed with Reclamation's recommendations of No Adverse Effect. Also, in Reach 3, December 29, 2003, Reclamation received a letter from the Utah SHPO concurring with the determination of No Historic Properties Affected. See the Cultural Resources Appendix for copies of SHPO concurrence letters. For Reach 3, in compliance with CFR 800.10, consultation has been completed with the National Park Service, the Utah SHPO, and the Advisory Council on Historic Preservation concerning effects of the alternatives on Desolation Canyon which is a National Historic Landmark.

4.9 Paleontological Resources

4.9.1 No Action Alternative

For the No Action Alternative, there would be no effect to paleontological resources from the proposed project since current water releases from the dam and reservoir levels would continue to take place. Fluctuating water levels in Flaming Gorge Reservoir have exposed paleontological resources for the past 36 years.

Fossil resources located within the Green River corridor downstream from Flaming Gorge Reservoir, including Reaches 1, 2, and 3, are less likely to be impacted by fluctuating water levels than those in the reservoir pool area. Prior to dam construction, these resources were exposed to greater water flows than presently exist.

4.9.2 Action Alternative

Fluctuating reservoir levels under the Action Alternative are not expected to have an adverse impact on paleontological resources in and around the reservoir. For the Green River, there would be no effect that could be isolated from the Action Alternative, when compared to the No Action Alternative as well as pre-dam riverflows. For example, where the river passes through bedrock, such as Split Mountain in Dinosaur National Monument, the effect of riverflows under any scenario consists of polishing of exposed invertebrate fossils.

4.10 Indian Trust Assets

4.10.1 No Action Alternative

Tribal fishing rights are an Indian trust asset. The species of fish most commonly harvested by tribal members is channel catfish, a nonnative sport fish. Channel catfish are extremely abundant throughout the Green River in Reaches 2 and 3. A continuation of the 1992 Biological Opinion flows would not likely affect channel catfish catchability. As noted in section 4.6, "Land Use," the landowners adjacent to Reach 2 of the Green River have become accustomed to the flows associated with this alternative. No adverse impacts to the resources associated with Indian trust assets have been identified.

4.10.2 Action Alternative

Under the 2000 Flow and Temperature Recommendations, conditions are expected to favor native fish over nonnatives in the long term. Nonnative channel catfish may be negatively impacted in canyon bound reaches during wetter hydrologies. However, channel catfish are so abundant throughout the Green River that unless the Recovery Program can successfully reduce their numbers through an active control project, this trust asset (tribal fishing rights) likely would not be affected. Wildlife and vegetation resources would not be adversely affected by implementation of the Action Alternative; thus, tribal hunting and gathering rights would not be affected.

Under the Action Alternative, the private and reservation lands adjacent to the Green River in Uintah County would continue to experience inundation during peak runoff times as they have in the past. The adjacent landowners have become accustomed to effects to agricultural lands and the oil and gas well operations during these peak runoff times. Under the Action Alternative, in some years, flows would exceed what adjacent landowners have experienced in the past. While effects to reservation agricultural lands and oil and gas well operations could affect Indian trust assets, the Northern Ute Tribe advised Reclamation during a meeting April 20, 2004, at tribal headquarters in Fort Duchesne, Utah, that advance notice from Reclamation would resolve issues of well access and effects to cattle utilizing agricultural lands within the area of potential inundation. During the spring when high flows occur, there would be limited access just as it now occurs. There would be no significant difference between the Action and the No Action Alternatives. Thus, there would not be any adverse effects to Indian trust assets.

4.11 RECREATION

This section describes the methodology and presents the results of the recreation analysis both on the Green River and Flaming Gorge Reservoir. The recreation analyses evaluate effects by alternative in terms of visitation, recreation facility (infrastructure) availability, economic value, and recreation safety.

4.11.1 Visitation, Recreation Infrastructure, and Economic Value Methodology

The recreation visitation and value analysis compares estimates of total visitation and value by recreation activity for the Action Alternative to those of the No Action Alternative. The driving force behind the visitation and valuation analyses is changes in alternative specific hydrology as measured by riverflows and reservoir water levels. Recreation visitation, measured in terms of visits, reflects the sum of recreator round trip recreation excursions to the river or reservoir. Recreation value per visit, measured in terms of consumer surplus, reflects the increment in per visit recreator willingness-to-pay over and above actual per visit costs. Multiplying and summing hydrology influenced visits and values per visit by recreation activity for each alternative provides estimates of total recreation value by alternative. The gain or loss in recreation visitation and value, compared to the No Action Alternative, provides one measure of the Action Alternative's effect on recreation.

Initially, attempts were made to gather and apply existing information in the development of the visitation and value analyses. However, lack of adequate data led the USDA Forest Service, one of the cooperating agencies for this EIS, to contract with Colorado State University to gather additional recreation information. The contractor conducted a survey within the Flaming Gorge National Recreation Area at both the Green River and Flaming Gorge Reservoir during the summer of 2001. Recreators were contacted onsite from May through September 2001 and asked a series of questions about their recreation behavior over the past year. The survey provided information by recreation activity in terms of riverflow and reservoir water level, visitation, and value under four scenarios: current, preferred, low end, and high end. Preferred flows/water levels portray an upper bound of visitation and value. The low and high end flow/water level thresholds illustrate the point where visitation and value goes to zero due to insufficient or excess flows/water levels. In many cases, survey responses were adjusted downward using a conservative, but frequently applied, approach of assuming nonrespondents equal to zero. As a result, differences exist between certain estimates used in the analysis and those presented in the survey report (Aukerman and Schuster, 2002).

The four data points based on low end, current, preferred, and high end scenarios were used to sketch out an inverted U-shaped distribution for estimation of visitation and value through a process of linear interpolation. The "current" data point typically fell between the low end and preferred conditions data points, thereby creating a skewed or lopsided distribution. Given this would have an effect on the visitation and valuation estimates, another data point, referred to as the "high end kink," was added to the process. The high end kink was calculated to be proportional with the location of the "current" data point so as to provide a symmetric distribution. The linear interpolation process made use of all five data points when developing estimates. Linear interpolation simply involves developing estimates using percentages. For example, if an alternative's flow falls 75% of the way between the preferred and current flow data points, then that same alternative's visitation and valuation would also be estimated to fall 75% of the way between the preferred and current visitation and valuation data points. The estimates of flow/water level, visitation, and value for the five data points for both the No Action and Action Alternatives under average, wet, and dry hydrologic conditions were developed from a combination of existing data and survey data.

The average condition refers to average monthly flows and water levels across all years found in the hydrologic model output. Wet and dry conditions refer to the flows and water levels that represent the highest and lowest 10% of the hydrologic output. In all three cases, the flows and water levels do not align exactly with the average, wet, and dry water year types as described in the 2000 Flow and Temperature Recommendations. However, the intent is to measure recreation effects for each alternative using similar concepts capable of being described by the hydrologic model.

The linear interpolation procedure was used to develop all the visitation and value estimates by activity, month, alternative, and hydrologic condition for Green River analysis. The procedure also was used to develop the value per visit estimates in the Flaming Gorge Reservoir analysis. However, lack of reservoir visitation data for the relevant survey period from June 2000 through September 2001 precluded use of the interpolation approach for estimating Flaming Gorge Reservoir visitation. Instead, a facilities availability approach was used to develop reservoir visitation estimates.

The facility availability approach focuses purely on the influence of water access on recreation visitation. Water access is determined by the availability of recreation facilities as reservoir water levels fluctuate.

The basic concept that recreation visitation varies with availability of facilities is well founded, but it only applies to water-based activities. In addition, by focusing purely on access, the approach fails to consider other influential factors, such as aesthetics and safety concerns. Nevertheless, facilities availability approaches are often used to estimate changes in visitation.

The facility availability approach involves gathering information on when water-based recreation facilities become unusable due to low or high water. In the case of Flaming Gorge Reservoir, for the alternatives of interest, only the low end facility thresholds were of concern. See table 4-10 for a list of Flaming Gorge Reservoir recreation facilities and low end usability thresholds.

Comparing end-of-month water levels for each alternative and hydrologic condition, with the low end thresholds for each facility, provides an indication as to when facilities would be unavailable. Linking facility availability with recent visitation estimates by facility, month, and recreation activity provides a preliminary estimate of visitation by facility, alternative, and hydrologic condition. These initial visitation estimates were reviewed by Flaming Gorge Reservoir recreation managers from the perspective of potential facility substitution. As a given facility becomes unusable, it is likely that recreators will move or substitute to other available facilities around the reservoir. Based on information provided by recreation managers, estimates of Flaming Gorge Reservoir visitation by month, activity,

Table 4-10.—Flaming Gorge Reservoir Facility Usability Thresholds (Elevation in feet above mean sea level)

Site	Facility Type	Low End Threshold
Antelope Flat	Boat Ramp Swim Beach	6015 6012
Anvil Draw[1]	Boat Ramp	6020
Buckboard Crossing	Marina Boat Ramp	6015 6000
Cedar Springs	Marina Boat Ramp	6018 6018
Firehole	Boat Ramp Swim Beach	6019 6012
Hideout	Boat Camp	6014
Jarvies Canyon	Boat Camp	6012
Kingfisher Island	Boat Camp	6010
Lucerne Valley	Marina 2 Boat Ramps Swim Beach	6010 5994 6014
Mustang Ridge	Boat Ramp	6000
Sheep Creek	Boat Ramp	6015
Squaw Hollow	Boat Ramp	6015
Sunny Cove	Swim Beach	6018
Upper Marsh Creek	Boat Ramp	6000

[1] The Anvil Draw boat ramp was extended in 2003 such that the low end threshold changed from 6020 to 6015. This change is not reflected in the analysis because it would not substantially affect the results (impacts only this low use ramp during dry conditions).

alternative, and hydrologic condition were developed taking into account facility substitution.

In addition to the visitation and economic value analysis, evaluations were also made as to the availability of recreation facilities for each alternative. As noted above, facility availability provided the basis for estimating visitation effects for the reservoir. Although not used to estimate the visitation effects on the Green River, facility availability was also reviewed on the Green River downstream from Flaming Gorge Dam, all the way to the confluence with the Colorado River. As with the reservoir visitation analysis, high and low end usability thresholds were obtained for each facility from the various managing entities (i.e., USDA Forest Service, BLM, State of Utah, U.S. Fish and Wildlife Service, National Park Service). Average, wet (90^{th} percentile), and dry (10^{th} percentile) flows from the hydrology model for each alternative were compared to the high and low usability thresholds for each facility. In addition, the raw hydrologic output data was searched to determine the percent of time each usability threshold was exceeded for each alternative. Table 4-11 presents the high and low end usability thresholds for each potentially impacted facility on the Green River. Note that after further analysis, many of the recreation facilities identified in chapter 3, "Affected Environment," were assumed to be unaffected by riverflows given their historical use across a wide range of flow conditions. This facility availability information is presented for each alternative along with the visitation and valuation information.

For a detailed discussion of the intricacies of the Green River or Flaming Gorge Reservoir methodologies, see the Recreation Visitation and Valuation Analysis Technical Appendix.

4.11.2 Recreation Safety Methodology

Safety of recreation activities on Flaming Gorge Reservoir correlates directly with access to the reservoir's surface rather than boating on the reservoir. Boating hazards on the reservoir occur at all elevations and are a problem to boat operators at all times. Therefore, the safety of boating on the reservoir is not related directly to reservoir elevation fluctuations. The recreation safety hazards associated with changes in reservoir elevations at Flaming Gorge Reservoir are related to the recreation users' ability to safely access developed boat ramps, docks, marinas, shoreline fishing areas, and beach areas. The thresholds used for this analysis are from Aukerman and Shuster, 2002. Reservoir elevations higher or lower than these elevations would stop visitors from pursuing their primary activity. Reservoir elevations outside the identified threshold will require recreation users to find their own access, which increases the risk and safety of the recreation users.

Examples of safety concerns on the reservoir occur during launching and takeout of watercraft. When the reservoir is above the high end and below the low end thresholds, launching becomes more difficult overall. These high and low thresholds impact the marinas, beach areas, bank fishing, and swimming, because access is more difficult and the facilities were not designed to function well outside the thresholds.

4.11.3 Annual Recreation Visitation and Valuation Results

This section presents the results of the annual recreation visitation and valuation analysis for each alternative. Under each alternative,

Table 4-11.—Green River Facility Usability Thresholds

Site Name	Facility Type	Managing Entity	Low End Usability Threshold (cfs)	High End Usability Threshold (cfs)
Green River - Reach 1 (Dam to Confluence With Yampa River)				
Spillway	Boat Ramp	USDA Forest Service	600	6,000
Little Hole	Boat Ramp	USDA Forest Service	600	8,000
	Fishing Pier	USDA Forest Service	600	6,000
	Trail	USDA Forest Service	N/A	6,000
	9 of 18 Campgrounds	USDA Forest Service	n/a	5,000
Indian Crossing	Boat Ramp	BLM	800	None
Bridge Hollow	Boat Ramp	BLM	800	None
	Campground	BLM	n/a	10,000
Swallow Canyon	Boat Ramp	BLM	800	None
Bridge Port Camp	Boat Ramp	State of Utah – UDWR	800	None
Green River – Reach 2 (Yampa River to Confluence With White River)				
Ouray NWR	Boat Ramp	U.S. Fish and Wildlife Service	None	25,000
Green River – Reach 3 (White River to Confluence With Colorado River)				
Sand Wash	Boat Ramp	BLM	800	50,000
Swasey's Beach	Boat Ramp	BLM	2,000	50,000
Nefertiti	Boat Ramp	BLM	800	[1]27,000
Butler Rapid	Boat Ramp	BLM	800	[1]27,000
Mineral Bottom	Boat Ramp	BLM	800	[1]30,000
Green River State Park	Boat Ramp	State of Utah	800	25,000
	Campground	State of Utah	None	25,000
	Golf Course	State of Utah	None	19,000

[1] Access road to the facility becomes inundated, not the facility itself.

separate subsections are presented for hydrology, visitation, and value.

4.11.3.1 No Action Alternative

Monthly average Green River flows and end-of-month Flaming Gorge Reservoir water levels were obtained from the hydrology models for each alternative. Detailed tables of Green River flows and Flaming Gorge Reservoir water levels are presented to provide an indication of where No Action Alternative flows and water levels fall within the range of interpolation data points.

Within the recreation analysis, comparisons were made of recreation effects between alternatives under average, wet, and dry hydrologic conditions. The monthly average flows under average conditions simply depict the average flows for that particular month across all years within the hydrologic output. As a result, average flows do not necessarily equate to information related to average water year types presented within the context of the Green River flow recommendations. Similarly, the wet and dry flows used in the recreation analysis are not based on information by water year type but reflect the 90% and 10% thresholds associated with the output from the hydrologic model. The dry flows represent the flow threshold describing the lowest 10% of monthly flow estimates (10% flow level); the wet flows represent the flow threshold describing the highest 10% of monthly flow estimates (90% flow level).

Table 4-12 presents the average, wet, and dry Green River monthly flows for Reach 1 for the No Action Alternative. The table includes the five flow data points used in the interpolations. Comparing the alternative flows to the data points indicates where the alternative flow falls within the inverted U-shaped flow distribution. For example, the No Action Alternative average condition flow of 1,484 for scenic floating in March falls between the current flow data point (1,036) and the preferred flows data point (2,170). The visitation interpolation for the No Action Alternative scenic floating March average condition would, therefore, also result in estimates falling between the current and preferred visit data points.

Although applying the same overall interpolation approach, the value interpolations were based on the annual current and high end kink data point flows as presented at the bottom of table 4-12. For the valuation analysis, the average March flow for scenic floating of 1,484 also falls between the current (1,096.9) and preferred (2,170) flow valuation interpolation data points.

End-of-month Flaming Gorge Reservoir water levels were also obtained from the hydrology models for each alternative. As with the river hydrology, reservoir water levels were obtained by alternative for average, wet, and dry hydrologic conditions.

Table 4-13 presents the average, wet, and dry reservoir water levels by month for the No Action Alternative. Note that the Flaming Gorge Reservoir recreation analysis was conducted across all months and not only March through October, as was the case for the river analysis.

4.11.3.1.1 Annual Recreation Visitation and Infrastructure – Based on the approaches described above under the methodology section, table 4-14 presents annual water-based visitation estimates by recreation activity for the No Action Alternative under average, wet, and dry hydrologic conditions for both the Green River and Flaming Gorge Reservoir.

Visitation at the reservoir far surpasses that of the river, representing from 87 to 96% of the combined total depending on the hydrologic condition. Power boating/waterskiing and boat fishing on the reservoir are the dominant activities accounting for 80 to 90% of the combined total visitation and nearly 95% of visitation on the reservoir. Shoreline fishing/trail use, scenic floating, and private boat fishing account for most of the visitation on the river. These three activities, while significant on the river given they reflect from 82 to 87% of river visitation, account for, at most, about 11% of the combined total visitation. Boat camping and swimming are relatively minor activities across all conditions.

For Flaming Gorge Reservoir, all facilities were expected to be available based on end-of-month water levels across all months under No Action Alternative average and wet conditions. However, under No Action Alternative dry conditions, several facilities are expected to be unusable. The Anvil Draw boat ramp has a low end usability threshold of 6020 and becomes unusable on average for all months except April during dry conditions. The Cedar Springs marina and boat ramp are expected to experience problems under dry

Table 4-12.—No Action Alternative, Green River Reach 1 Average Monthly Flows (in cfs) by Hydrologic Condition

Month	Recreation Activity	Interpolation Data Points					No Action Alternative		
		Low End Threshold Flow	Current Flow	Preferred Flow	High End Kink Flow	High End Threshold Flow	Average	Wet	Dry
		Monthly Oriented Flow Data Points for Visitation Analysis Interpolation							
March	Scenic Floating	953	1,036.0	2,170	3,786.7	3,905	1,484	1,898	800
	Guide Boat Fishing	854	“ ”	1,837	3,380.3	3,731	“ ”	“ ”	“ ”
	Private Boat Fishing	879	“ ”	1,808	3,343.7	3,656	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	825	“ ”	1,624	3,158.4	3,709	“ ”	“ ”	“ ”
	Camping	836	“ ”	2,000	3,273.7	3,538	“ ”	“ ”	“ ”
April	Scenic Floating	“ ”	1,145.0	“ ”	3,631.3	“ ”	2,207	3,290	800
	Guide Boat Fishing	“ ”	“ ”	“ ”	3,170.3	“ ”	“ ”	“ ”	“ ”
	Private Boat Fishing	“ ”	“ ”	“ ”	3,126.9	“ ”	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	“ ”	“ ”	“ ”	2,874.0	“ ”	“ ”	“ ”	“ ”
	Camping	“ ”	“ ”	“ ”	3,129.7	“ ”	“ ”	“ ”	“ ”
May	Scenic Floating	“ ”	1,954.0	“ ”	2,478.0	“ ”	3,463	5,100	1,400
	Guide Boat Fishing	“ ”	1,504.3	“ ”	“ “	“ ”	“ ”	“ “	“ “
	Private Boat Fishing	“ ”	1,471.2	“ ”	“ “	“ ”	“ ”	“ “	“ “
	Shore Fishing/Trail Use	“ ”	1,296.7	“ ”	“ “	“ ”	“ ”	“ “	“ “
	Camping	“ ”	1,638.2	“ ”	“ “	“ ”	“ ”	“ “	“ “
June	Scenic Floating	“ ”	1,215.2	“ ”	3,531.2	“ ”	2,710	5,917	800
	Guide Boat Fishing	“ ”	“ ”	“ ”	3,035.1	“ ”	“ ”	“ ”	“ “
	Private Boat Fishing	“ ”	“ ”	“ ”	2,987.3	“ ”	“ ”	“ ”	“ “
	Shore Fishing/Trail Use	“ ”	“ ”	“ ”	2,690.8	“ ”	“ ”	“ ”	“ “
	Camping	“ ”	“ ”	“ ”	3,037.0	“ ”	“ ”	“ ”	“ “
July	Scenic Floating	“ ”	1,007.0	“ ”	3,828.0	“ ”	983	1,200	800
	Guide Boat Fishing	“ ”	“ ”	“ ”	3,436.2	“ ”	“ ”	“ ”	“ “
	Private Boat Fishing	“ ”	“ ”	“ ”	3,401.4	“ ”	“ ”	“ ”	“ “
	Shore Fishing/Trail Use	“ ”	“ ”	“ ”	3,234.1	“ ”	“ ”	“ ”	“ “
	Camping	“ ”	“ ”	“ ”	3,312.1	“ ”	“ ”	“ ”	“ “
Aug	Scenic Floating	“ ”	1,122.2	“ ”	3,663.7	“ ”	1,251	1,531	931
	Guide Boat Fishing	“ ”	“ ”	“ ”	3,214.2	“ ”	“ ”	“ ”	“ ”
	Private Boat Fishing	“ ”	“ ”	“ ”	3,172.1	“ ”	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	“ ”	“ ”	“ ”	2,933.3	“ ”	“ ”	“ ”	“ ”
	Camping	“ ”	“ ”	“ ”	3,159.8	“ ”	“ ”	“ ”	“ ”
Sept	Scenic Floating	“ ”	1,118.0	“ ”	3,669.7	“ ”	1,374	1,639	1,039
	Guide Boat Fishing	“ ”	“ ”	“ ”	3,222.3	“ ”	“ ”	“ ”	“ ”
	Private Boat Fishing	“ ”	“ ”	“ ”	3,180.5	“ ”	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	“ ”	“ ”	“ ”	2,944.3	“ ”	“ ”	“ ”	“ ”
	Camping	“ ”	“ ”	“ ”	3,165.3	“ ”	“ ”	“ ”	“ ”
Oct	Scenic Floating	“ ”	1,024.0	“ ”	3,803.8	“ ”	1,654	2,075	1,039
	Guide Boat Fishing	“ ”	“ ”	“ ”	3,403.5	“ ”	“ ”	“ ”	“ ”
	Private Boat Fishing	“ ”	“ ”	“ ”	3,367.6	“ ”	“ ”	“ ”	“ ”
	Shore Fishing/Trail Use	“ ”	“ ”	“ ”	3,189.7	“ ”	“ ”	“ ”	“ ”
	Camping	“ ”	“ ”	“ ”	3,289.6	“ ”	“ ”	“ ”	“ ”
		Annually Oriented Flow Data Points for Valuation Analysis Interpolation							
		Low End Threshold Flow	Annual Current Flow	Preferred Flow	Annual High End Kink Flow	High End Threshold Flow			
All months	Scenic Floating	953	1,096.9	2,170	3,699.8	3,905	Monthly flows are as above		
	Guide Boat Fishing	854	1,359.0	1,837	2,757.9	3,731			
	Private Boat Fishing	879	1,373.3	1,808	2,672.7	3,656			
	Shore Fishing/Trail Use	825	1,298.6	1,624	2,473.1	3,709			
	Camping	836	1,115.5	2,000	3,168.7	3,538			

Table 4-13.—No Action Alternative, Flaming Gorge Reservoir Average End-of-Month Water Levels (in Feet Above msl) by Hydrologic Condition

Month	Recreation Activity	Annually Oriented Water Level (WL) Data Points for Valuation Analysis Interpolation					No Action Alternative Water Levels		
		Low End Threshold WL	Annual Current WL	Preferred WL	Annual High End Kink WL	High End Threshold WL	Average	Wet	Dry
January	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6024.3	6028.1	6017.4
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5	"………"	"………"	"………"
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7	"………"	"………"	"………"
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7	"………"	"………"	"………"
February	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6024.0	6026.8	6017.8
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
March	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6024.0	6027.9	6019.0
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
April	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6024.1	6028.5	6020.1
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
May	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6023.8	6029.4	6017.6
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
June	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6026.6	6031.7	6018.5
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
July	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6029.1	6035.5	6019.3
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
August	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6028.9	6036.0	6018.5
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
September	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6028.3	6035.5	6017.9
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
October	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6027.5	6034.9	6017.3
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
November	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6026.3	6032.9	6017.5
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
December	Power Boating/Skiing	"………"	"………"	"………"	"………"	"………"	6025.1	6030.3	6017.3
	Boat Fishing	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Boat Camping	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"
	Swimming/Waterplay	"………"	"………"	"………"	"………"	"………"	"………"	"………"	"………"

Table 4-14.—No Action Alternative Annual Water-Based Visitation[1]

Recreation Activity	Average Condition		Wet Condition		Dry Condition	
	Visits	% of Combined Total	Visits	% of Combined Total	Visits	% of Combined Total
I. Green River Visitation:						
Scenic Floating	20,885	3.2	20,349	3.2	85	0.0
Guide Boat Fishing	10,108	1.5	7,548	1.2	3,606	.6
Private Boat Fishing	16,309	2.5	13,360	2.1	7,600	1.3
Shoreline Fishing/Trail Use	33,927	5.2	26,722	4.2	10,509	1.9
Boat Camping	2,229	.3	1,674	.3	458	.1
Total:	83,458	12.7	69,653	10.9	22,258	3.9
II. Flaming Gorge Reservoir Visitation:						
Power Boating/Waterskiing	359,278	54.8	359,278	56.0	340,615	60.2
Boat Fishing	181,348	27.7	181,348	28.2	171,969	30.4
Boat Camping	10,374	1.6	10,374	1.6	10,374	1.9
Swimming and Waterplay	21,291	3.2	21,291	3.3	21,.034	3.7
Total:	572,291	87.3	572,291	89.1	543,992	96.1
III. Combined Total:	655,749	100	641,944	100	566,250	100

[1] Numbers may not add due to rounding.

conditions during January, February, May, and September through December. The Firehole boat ramp would only be available under dry conditions during March, April, and July. Finally, the Sunny Cove swim beach follows a pattern similar to Cedar Springs during dry conditions experiencing problems in January, February, May, and September through December. The problems of facility unavailability, tempered by the potential for facility substitution, results in the reduced Flaming Gorge visitation estimates under dry conditions. While facility availability is presented across all months, the analysis takes into account low visitation levels during the winter months.

Although unrelated to the interpolation based Green River visitation analysis, for comparison purposes with reservoir facilities, an analysis of facility availability was also conducted for Green River recreation facilities. Within Reach 1, all river facilities were expected to be available based on average monthly flows across all months under No Action Alternative average and dry conditions. However, under No Action Alternative wet conditions, 9 of the 18 riverside campgrounds were expected to be unavailable in May and June due to high flows. Facility unavailability due to low water levels on the reservoir implies little damage to the facilities; however, facility unavailability on the river due to high flows can imply substantial damage. River facility unavailability was based on the point where significant impacts were expected to occur. However, in most cases, erosion damage begins prior to the significant impact flow level (e.g., impacts begin at: 4,200 cfs to Little Hole ramp foundations; 5,000 cfs to trail tread/boardwalk footings and campground banks and vegetation; and 6,000 cfs to spillway boat ramp protective riprap and foundations).[1] Within Reach 2, the boat ramp at Ouray National Wildlife Refuge remains available under average, dry, and wet conditions across all months for the No Action Alternative. Within Reach 3, all facilities remain available under average conditions for the No Action Alternative. However, under dry conditions, the Swasey's Beach boat ramp would be unavailable during the months of January, February, and July through December. Under wet conditions, the facilities at Green River State Park would be affected during May and June (golf course during both May and June and the campground and boat ramp during June).

4.11.3.1.2 Annual Recreation Valuation – Table 4-15 presents annual water-based valuation estimates by recreation activity for the No Action Alternative under average, wet, and dry hydrologic conditions for both the Green River and Flaming Gorge Reservoir.

As with the visitation estimates, reservoir valuation far surpasses that of the river, representing from 81 to 86% of the combined total valuation depending on the hydrologic condition. Power boating/waterskiing and boat fishing on the reservoir are the dominant activities accounting for over 80% of the combined total valuation and nearly 99% of valuation on the reservoir. The dominant activities in terms of value vary on the river depending on the hydrologic condition. Scenic floating and guide boat fishing are most significant under average and wet conditions (65% of river value); but guide boat fishing, private boat fishing, and shoreline fishing/trail use account for nearly all of the value (99%) under dry conditions. These activities, while significant on the river, do not account for more than 14% of the combined total valuation under any hydrologic condition. Boat camping and swimming are relatively minor activities across all conditions.

4.11.3.2 Action Alternative

This section describes recreation effects for the Action Alternative in terms of hydrology, visitation, and value. Action Alternative results are compared to the No Action Alternative to estimate the impact of implementing the alternative.

Green River average monthly flows and Flaming Gorge Reservoir end-of-month water levels are described in this section for the Action Alternative. The implications of these flows and water levels in terms of changes in visitation and value will be discussed in subsequent sections.

Table 4-16 presents average Green River flows by month for the Action Alternative under average, wet, and dry hydrologic conditions. Information is also presented on the difference between the Action and No Action Alternatives in terms of flow (cfs) and percentage. Also included in the table are the five flow data points used in the interpolations. Comparing the alternative flows to the data points indicates where the alternative flow falls within the inverted U-shaped flow distribution. For example, the Action Alternative average condition flow for March of 1,270 cfs falls between the current flow data point (1,036 cfs or 1,096.9 cfs) and the preferred flow data point (2,170 cfs) for scenic floating. The scenic floating visitation and value interpolation for the Action Alternative March average condition would, therefore, also result in estimates falling

[1] Although not directly related to the rest of the analysis, the monthly frequency across all years where the five most impacted Flaming Gorge Reservoir facilities (Anvil Draw boat ramp, Cedar Springs marina and boat ramp, Firehole boat ramp, and Sunny Cove swim beach) may be unavailable ranges from 7.4% (once very 13.5 years) to 15.9% (once every 6.3 years) under the No Action Alternative. For the Green River facilities, within Flaming Gorge National Recreation Area, the unavailability percentage ranges from 0 to 15.5% (once every 6.5 years). For a detailed presentation of the monthly unavailability percentages for all reservoir facilities, see the Recreation Visitation and Valuation Analysis Technical Appendix. (Corresponding table is on the following page.)

Table 4-15.—No Action Alternative Annual Valuation ($1,000s)[1]

Recreation Activity	Average Condition Values	Average Condition % of Combined Total	Wet Condition Values	Wet Condition % of Combined Total	Dry Condition Values	Dry Condition % of Combined Total
I. Green River Valuation:						
Scenic Floating	1,013.6	4.0	1,174.9	5.9	3.8	.1
Guide Boat Fishing	1,600.9	6.3	1,283.0	6.4	425.9	7.4
Private Boat Fishing	636.7	2.5	620.2	3.1	174.8	3.0
Shoreline Fishing/Trail Use	691.8	2.7	661.4	3.3	192.1	3.3
Boat Camping	22.7	.1	20.0	.1	2.8	.1
Total:	3,965.7	15.6	3,759.5	18.8	799.3	13.8
II. Flaming Gorge Reservoir Valuation:						
Power Boating/Waterskiing	14,723.6	58.1	11,341.7	56.8	3,567.6	61.6
Boat Fishing	6,281.9	24.8	4,646.3	23.3	1,368.2	23.6
Boat Camping	197.8	.8	151.1	.8	49.7	0.9
Swimming and Waterplay	173.1	.7	83.5	.4	8.8	.2
Total:	21,376.3	84.4	16,222.6	81.2	4,994.4	86.2
III. Combined Total:	25,342.0	100	19,982.1	100	5,793.7	100

[1] Numbers may not add due to rounding.

Footnote Table:

No Action Alternative High Recreation Season Selected Facility Unavailability Percentages

Site	Area	Facility	Threshold	Mar	Apr	May	June	July	Aug	Sept	Oct
Flaming Gorge Reservoir	Anvil Draw	Boat Ramp	6020	12.3	9.7	15.9	11.2	12.7	12.6	12.6	12.7
	Cedar Springs	Marina	6018	8.1	7.4	10.5	8.2	9.2	9.2	10.5	10.7
		Boat Ramp	6018	8.1	7.4	10.5	8.2	9.2	9.2	0.5	10.7
	Firehole	Boat Ramp	6019	10.0	7.9	12.0	10.6	9.4	11.1	11.6	12.2
	Sunny Cove	Swim Beach	6018	8.1	7.4	10.5	8.2	9.2	9.2	10.5	10.7
	Buckboard Crossing	Marina	6015	7.4	6.0	4.8	2.1	4.7	7.1	9.1	9.1
		Boat Ramp	6000	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
	Lucerne Valley	Marina	6010	3.2	2.9	2.1	1.5	1.5	1.5	1.6	3.0
		Boat Ramps	5994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Green River	Spillway	Boat Ramp	6000	0.0	0.0	6.3	9.9	0.0	0.0	0.0	0.0
	Little Hole	Boat Ramp	8000	0.0	0.0	2.8	4.0	0.0	0.0	0.0	0.0
		Fishing Pier	6000	0.0	0.0	6.3	9.9	0.0	0.0	0.0	0.0
		Recreation Trail	6000	0.0	0.0	6.3	9.9	0.0	0.0	0.0	0.0
		9 of 18 Riverside Campgrounds	5000	0.0	0.0	10.3	15.5	0.0	0.0	0.0	0.0

[1] Thresholds: Reflects low end water level (msl) for reservoir and high end flow (cfs) for river.

between the current and preferred visit and value data points. Also note that the Action Alternative March average flow condition is 214 cfs less than the No Action Alternative. This implies that the Action Alternative March average condition visitation and value estimates will be less than those of the No Action Alternative since No Action Alternative March flows are closer to the preferred flow. Generally speaking, the closer an alternative's flow is to the preferred flow, the higher the visitation and value estimate.

Comparing the average condition flows between the Action and No Action Alternatives indicates that from June through September, Action Alternative average flows exceed No Action Alternative flows. The largest differences occur in June and July where the Action Alternative flow exceeds the No Action Alternative flow by more than 1,000 cfs.

During wet conditions, Action Alternative average flows exceed No Action Alternative flows across the entire March through October period. The largest difference occurs in July where the Action Alternative exceeds the No Action Alternative by 3,400 cfs or 283%.

During dry conditions, the difference between the alternatives is less severe in terms of both cfs and percentage. In 4 of the 8 studied months (May, August, September, October), No Action Alternative average monthly flows exceed those of the Action Alternative. The largest difference (-600 cfs, -42.9%) occurs in May.

Table 4-17 presents end-of-month Flaming Gorge Reservoir water levels for the Action Alternative under average, wet, and dry hydrologic conditions as obtained from the hydrology model. Information is presented on the difference between the Action and No Action Alternatives in terms of water levels.

Comparing average condition end-of-month water levels between the Action and No Action Alternatives indicates very little difference between the two alternatives. The largest difference occurs in April and May with the Action Alternative only 2 feet higher than the No Action Alternative.

Water levels under wet conditions were not evaluated within the reservoir visitation analysis since they do not create any problems in terms of recreation access. However, water level differences were evaluated via the interpolation procedure within the reservoir valuation analysis. Action Alternative water levels fell below those of the No Action Alternative in 8 of the 12 months, with the most significant differences being in July through November.

Under dry conditions, Action Alternative water levels in the reservoir exceed those of the No Action Alternative across all months. The differences between the alternatives range from a low of 2.9 feet to a high of 6.0 feet. These differences are substantially greater than those seen under average conditions and may be more significant given the lower water levels.

4.11.3.2.1 Annual Recreation Visitation and Infrastructure – Table 4-18 presents information on annual water-based visitation combined for both the Green River and Flaming Gorge Reservoir for the Action Alternative under average, wet, and dry conditions. Reservoir visitation accounts for anywhere from 87 to 98% of the total, depending on the hydrologic condition. For information on what these changes in recreation visitation mean in terms of expenditures, jobs, and other measures of regional economic activity, see section 4.12, "Socioeconomics and Regional Economics."

For the Action Alternative average condition, the combined visitation barely changes from the No Action Alternative average condition.

Table 4-16.—Action Alternative Green River Reach 1 Flows (in cfs) by Hydrologic Condition and Month

Month	Recreation Activity	Interpolation Data Points: Low End Threshold Flows	Interpolation Data Points: Current Flows	Interpolation Data Points: Preferred Flows	Interpolation Data Points: High End Kink Flows	Interpolation Data Points: High End Threshold Flows	Average Condition: Average Monthly Flows	Average Condition: Change from No Action Alternative: Cfs	Average Condition: Change from No Action Alternative: %	Wet Condition: Average Monthly Flows	Wet Condition: Change from No Action Alternative: Cfs	Wet Condition: Change from No Action Alternative: %	Dry Condition: Average Monthly Flows	Dry Condition: Change from No Action Alternative: Cfs	Dry Condition: Change from No Action Alternative: %
		Monthly Oriented Data Points for Visitation Interpolation													
March	Scenic Floating	953	1,036.0	2,170	3,786.7	3,905	1,270	-214	-14.4	2,030	132	7.0	800	0	0
	Guide Boat Fishing	854	“ ”	1,837	3,380.3	3,731	“ ”			“ ”			“ ”		
	Private Boat Fishing	879	“ ”	1,808	3,343.7	3,656	“ ”			“ ”			“ ”		
	Shore Fishing/Trail Use	825	“ ”	1,624	3,158.4	3,709	“ ”			“ ”			“ ”		
	Camping	836	“ ”	2,000	3,273.7	3,538	“ ”			“ ”			“ ”		
April	Scenic Floating	953	1,145.0	2,170	3,631.3	3,905	1,904	-303	-13.7	3,981	691	21.0	800	0	0
	Guide Boat Fishing	854	“ ”	1,837	3,170.3	3,731	“ ”			“ ”			“ ”		
	Private Boat Fishing	879	“ ”	1,808	3,126.9	3,656	“ ”			“ ”			“ ”		
	Shore Fishing/Trail Use	825	“ ”	1,624	2,874.0	3,709	“ ”			“ ”			“ ”		
	Camping	836		2,000	3,129.7	3,538	“ ”			“ ”			“ ”		
May	Scenic Floating	953	1,954.0	2,170	2,478.0	3,905	3,233	-230	-6.7	5,537	437	8.6	800	-600	-42.9
	Guide Boat Fishing	854	1,504.3	1,837	“ ”	3,731	“ ”			“ ”			“ ”		
	Private Boat Fishing	879	1,471.2	1,808	“ ”	3,656	“ ”			“ ”			“ ”		
	Shore Fishing/Trail Use	825	1,296.7	1,624	“ ”	3,709	“ ”			“ ”			“ ”		
	Camping	836	1,638.2	2,000	“ ”	3,538	“ ”			“ ”			“ ”		
June	Scenic Floating	953	1,215.2	2,170	3,531.2	3,905	3,862	1,152	42.5	7,038	1,121	19.0	893	93	11.6
	Guide Boat Fishing	854	“ ”	1,837	3,035.1	3,731	“ ”			“ ”			“ ”		
	Private Boat Fishing	879	“ ”	1,808	2,987.3	3,656	“ ”			“ ”			“ ”		
	Shore Fishing/Trail Use	825	“ ”	1,624	2,690.8	3,709	“ ”			“ ”			“ ”		
	Camping	836	“ ”	2,000	3,037.0	3,538	“ ”			“ ”			“ ”		
July	Scenic Floating	953	1,007.0	2,170	3,828.0	3,905	2,185	1,202	122.2	4,600	3,400	283.3	893	93	11.6
	Guide Boat Fishing	854	“ ”	1,837	3,436.2	3,731	“ ”			“ ”			“ ”		
	Private Boat Fishing	879	“ ”	1,808	3,401.4	3,656	“ ”			“ ”			“ ”		
	Shore Fishing/Trail Use	825	“ ”	1,624	3,234.1	3,709	“ ”			“ ”			“ ”		
	Camping	836		2,000	3,312.1	3,538	“ ”			“ ”			“ ”		
Aug	Scenic Floating	953	1,122.2	2,170	3,663.7	3,905	1,626	375	29.9	2,131	600	39.2	906	-25	-2.7
	Guide Boat Fishing	854	“ ”	1,837	3,214.2	3,731	“ ”			“ ”			“ ”		
	Private Boat Fishing	879	“ ”	1,808	3,172.1	3,656	“ ”			“ ”			“ ”		
	Shore Fishing/Trail Use	825	“ ”	1,624	2,933.3	3,709	“ ”			“ ”			“ ”		
	Camping	836		2,000	3,159.8	3,538	“ ”			“ ”			“ ”		
Sept	Scenic Floating	953	1,118.0	2,170	3,669.7	3,905	1,639	265	19.3	2,239	600	36.6	939	-100	-9.6
	Guide Boat Fishing	854	“ ”	1,837	3,222.3	3,731	“ ”			“ ”			“ ”		
	Private Boat Fishing	879	“ ”	1,808	3,180.5	3,656	“ ”			“ ”			“ ”		
	Shore Fishing/Trail Use	825	“ ”	1,624	2,944.3	3,709	“ ”			“ ”			“ ”		
	Camping	836		2,000	3,165.3	3,538	“ ”			“ ”			“ ”		
Oct	Scenic Floating	953	1,024.0	2,170	3,803.8	3,905	1,487	-167	-10.1	2,172	97	4.7	800	-239	-23.0
	Guide Boat Fishing	854	“ ”	1,837	3,403.5	3,731	“ ”			“ ”			“ ”		
	Private Boat Fishing	879	“ ”	1,808	3,367.6	3,656	“ ”			“ ”			“ ”		
	Shore Fishing/Trail Use	825	“ ”	1,624	3,189.7	3,709	“ ”			“ ”			“ ”		
	Camping	836	“ ”	2,000	3,289.6	3,538	“ ”			“ ”			“ ”		
		Annually Oriented Data Points for Valuation Interpolation													
		Low End Threshold Flow	Annual Current Flow	Preferred Flow	Annual High End Kink Flow	High End Threshold Flow									
All	Scenic Floating	953	1,096.9	2,170	3,699.8	3,905	Monthly Flow Information as Above.								
	Guide Boat Fishing	854	1,359.0	1,837	2,757.9	3,731									
	Private Boat Fishing	879	1,373.3	1,808	2,678.7	3,656									
	Shore Fishing/Trail Use	825	1,298.6	1,624	2,473.1	3,709									
	Camping	836	1,115.5	2,000	3,168.7	3,538									

Table 4-17.—Action Alternative Flaming Gorge Reservoir Water Levels (in Feet Above msl) by Hydrologic Condition and Month

Month	Recreation Activity	Annually Oriented Water Level Data Points for Valuation Interpolation					Action Alternative Water Levels					
							Average Condition		Wet Condition		Dry Condition	
		Low End Threshold Water Level	Annual Current Water Level	Preferred Water Level	Annual High End Kink Water Level	High End Threshold Water Level	Average Monthly Water Levels	Change from No Action Alternative (Feet)	Average Monthly Water Levels	Change from No Action Alternative (Feet)	Average Monthly Water Levels	Change from No Action Alternative (Feet)
January	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6025.8	1.5	6028.4	.3	6023.4	6.0
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
February	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6025.7	1.7	6028.0	1.2	6023.7	5.9
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
March	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6025.8	1.8	6027.9	0	6023.5	4.5
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
April	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6026.0	1.9	6028.5	0	6023.0	2.9
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
May	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6025.8	2.0	6029.2	-.2	6022.8	5.2
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
June	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6027.8	1.2	6030.3	-1.4	6024.5	6.0
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
July	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6029.2	.1	6030.7	-4.8	6024.7	5.4
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
August	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6028.4	-.5	6030.5	-5.5	6023.8	5.3
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
September	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6027.4	-.9	6030.0	-5.5	6023.2	5.3
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
October	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6026.8	-.7	6029.8	-5.1	6023.1	5.8
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
November	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6026.5	.2	6029.5	-3.4	6023.3	5.8
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						
December	Power Boating/Skiing	6016.7	6021.2	6029.0	6035.2	6038.8	6026.1	1.0	6029.1	-1.2	6023.3	6.0
	Boat Fishing	6017.3	6021.2	6029.1	6034.7	6037.5						
	Boat Camping	6017.1	6021.1	6028.9	6034.0	6036.7						
	Swimming/Waterplay	6017.4	6021.2	6028.9	6034.1	6036.7						

Table 4-18.—Annual Water-Based Visitation for Green River and Flaming Gorge Reservoir for Action Alternative[1]

Site	Recreation Activity	Action Alternative Visitation by Hydrologic Condition								
		Average			Wet			Dry		
		Visits	Change from No Action Alternative Average Condition		Visits	Change from No Action Alternative Wet Condition		Visits	Change from No Action Alternative Dry Condition	
			Visits	%		Visits	%		Visits	%
Green River	Scenic Floating	23,434	2,549	12.2	9,694	-10,655	-52.4	0	-85	-100
	Guide Boat Fishing	9,151	-957	-9.5	4,521	-3,027	-40.1	1,526	-2,080	-57.7
	Private Boat Fishing	16,116	-193	-1.2	9,515	-3,845	-28.8	1,614	-5,986	-78.8
	Shoreline Fishing/ Trail Use	34,803	876	2.6	13,876	-12,846	-48.1	6,552	-3,957	-37.7
	Boat Based Camping	1,772	-507	-22.7	1,038	-636	-38.0	594	136	29.7
	Total:	85,226	1,768	2.1	38,644	-31,009	-44.5	10,286	-11,972	-53.8
Flaming Gorge Reservoir	Power Boating/ Waterskiing	359,278	0	0	359,278	0	0	35,9278	18,663	5.5
	Boat Fishing	181,348	0	0	181,348	0	0	181,348	9,379	5.5
	Boat Based Camping	10,374	0	0	10,374	0	0	10,374	0	0
	Swimming/ Waterplay	21,291	0	0	21,291	0	0	21,291	257	1.2
	Total:	572,291	0	0	572,291	0	0	572,291	28,299	5.2
Both Sites	Combined Total:	657,517	1,768	.3	610,935	-31,009	-4.8	582,577	16,327	2.9

[1] Numbers may not add due to rounding.

The Action Alternative's approximately 1,770 additional visits represent less than a 1% change compared to the No Action Alternative. This change in visitation from the No Action Alternative was not considered significant. Since the facility availability approach indicated no visitation changes on the reservoir, the gains in visitation are completely attributable to the river. Gains in scenic floating and shoreline fishing/trail use in July and August slightly outweigh losses to guide boat fishing, private boat fishing, and boat-based camping which occur primarily in June.

To evaluate gains or losses on the river, one needs to compare Action Alternative flows to No Action Alternative flows as well as to the interpolation data points. Reviewing table 4-16, July and August flows for the Action Alternative average condition (2,185 and 1,626, respectively) exceed those of the No Action (983 and 1,251, respectively). More importantly, Action Alternative average condition flows for July and August are closer to the preferred flows for each recreation activity, thereby resulting in gains compared to the No Action Alternative. The opposite is true for the month of June, thereby resulting in losses compared to the No Action Alternative. Another factor that needs to be considered in estimating the degree of impact is the amount of visitation occurring in each month. For example, a low percentage change in a high use month may outweigh a high percentage change in a low use month.

For the Action Alternative wet condition, combined visitation declines about 31,000 or nearly 5% compared to the No Action Alternative wet condition. This change in visitation from the No Action Alternative was not considered significant, especially given that wet conditions are expected to occur not more than 10% of the time. Since the facility availability approach indicated no visitation changes on the reservoir, all of this decline stems from visitation losses experienced on the river. While these losses could be considered significant exclusively from the perspective of the river (nearly a 45% loss), the river accounts for only 6% of the total visitation under wet conditions. All river activities were estimated to experience losses compared to the No Action Alternative with the majority of the losses (over 75%) accruing to scenic floating and shoreline fishing/trail use. Across all river activities, the months of April and July generate the largest losses. Both April and July involve situations where Action Alternative flows exceed the high end threshold for all activities, therefore implying zero visitation; whereas, No Action Alternative flows do not exceed the thresholds implying positive visitation.

For the Action Alternative dry condition, combined visitation is estimated to increase by over 16,300 visits or just under 3% compared to the No Action Alternative dry condition. This change in visitation from the No Action Alternative was not considered significant, especially given that dry conditions are expected to occur not more than 10% of the time. Visitation on the reservoir is estimated to increase by about 28,300 visits; whereas, visitation on the river is estimated to decline by nearly 12,000 visits. The largest gains are expected for reservoir power boating and boat fishing during the months of May, September, and October, with the largest losses expected for river private boat fishing and shoreline fishing/trail use during the month of May. Gains in reservoir visitation under Action Alternative dry conditions occur due to improved facility availability compared to No Action Alternative conditions. On average, all reservoir facilities are expected to be available across all months under Action Alternative dry conditions.[2] Losses in river visitation under Action Alternative dry conditions occur mainly in the month of May due to the -600-cfs flow differential compared to No Action Alternative conditions.

As noted above, an analysis of facility availability was also conducted for Green River recreation facilities. Within Reach 1, all river facilities were expected to be available based on average monthly flows across all months under Action Alternative average and dry conditions. However, under wet conditions, the following USDA Forest Service facilities are expected to be unavailable in June due to high flows: the spillway boat ramp, fishing pier, trail, and 9 of 18 riverside campgrounds. In addition, 9 of the 18 riverside campgrounds are also expected to be unavailable in May under wet conditions. The June unavailability of the spillway ramp, the Little Hole fishing pier, and the recreation trail reflect additional facility unavailability compared to the No Action Alternative (also see footnote for information across all years). Erosion of river facilities is similar to that discussed under the No Action Alternative but occurs to a greater degree due to higher flows. Within Reach 2, the boat ramp at Ouray National Wildlife

[2] Although not related to the rest of the analysis, the monthly frequency across all years where the five most impacted Flaming Gorge Reservoir facilities (Anvil Draw boat ramp, Cedar Springs marina and boat ramp, Firehole boat ramp, and Sunny Cove swim beach) may be unavailable ranges from 1.2% (once every 83.3 years) to 6.7% (once every 14.9 years) under the Action Alternative. These unavailability percentages are considerably lower than those of the No Action Alternative. For the Green River facilities within the Flaming Gorge National Recreation Area, the unavailability percentage ranges from 0 to 27.2% (once every 3.7 years). These unavailability percentages for the Green River are somewhat higher than those of the No Action Alternative. For a detailed presentation of the monthly unavailability percentages for all reservoir facilities, see the Recreation Visitation and Valuation Analysis Technical Appendix. (Corresponding table is on the following page.)

Refuge remains available under average, dry, and wet conditions across all months for the Action Alternative. This implies no change in facility availability within Reach 2 between the alternatives. Within Reach 3, all facilities remain available under average conditions for the Action Alternative. However, under dry conditions, the Swasey's Beach boat ramp would be unavailable during the months of January, February, and July through December. Under wet conditions, the facilities at Green River State Park would be affected during May and June (golf course during both May and June and the campground and boat ramp during June). The facility unavailability for the Action Alternative within Reach 3 mirrors that of the No Action Alternative, implying no change in facility availability between the alternatives within Reach 3.

4.11.3.2.2 Annual Recreation Valuation – Table 4-19 presents the sum of the annual Green River and Flaming Gorge Reservoir recreation values for the Action Alternative under average, wet, and dry conditions. In addition to the total values by hydrologic condition, the table also presents changes from the No Action Alternative both in terms of values and percentage.

For the Action Alternative average condition, the combined valuation was estimated at $27.7 million. This reflects nearly a $2.4-million or 10% increase from the No Action Alternative average condition. Gains in value occur on both the river and reservoir with the largest gains accruing to scenic floating on the river and power boating/waterskiing on the reservoir. The majority of the gains on the river occur from July through September and on the reservoir from April through June.

Footnote Table:

Action Alternative High Recreation Season Selected Facility Unavailability Percentages

Site	Area	Facility	Threshold[1]	Mar	Apr	May	June	July	Aug	Sept	Oct
Flaming Gorge Reservoir	Anvil Draw	Boat Ramp	6020	5.0	2.9	3.2	3.0	1.9	2.3	3.8	5.4
	Cedar Springs	Marina	6018	3.0	2.0	2.5	1.9	1.2	1.5	1.8	2.1
		Boat Ramp	6018	3.0	2.0	2.5	1.9	1.2	1.5	1.8	2.1
	Firehole	Boat Ramp	6019	4.3	2.4	3.0	1.9	1.5	1.7	2.4	3.2
	Sunny Cove	Swim Beach	6018	3.0	2.0	2.5	1.9	1.2	1.5	1.8	2.1
	Buckboard Crossing	Marina	6015	2.1	1.5	1.5	0.4	0.2	0.2	0.4	0.5
		Boat Ramp	6000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Lucerne Valley	Marina	6010	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Boat Ramps	5994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Green River	Spillway	Boat Ramp	6000	0.0	0.0	7.5	14.6	7.0	0.0	0.0	0.0
	Little Hole	Boat Ramp	8000	0.0	0.0	4.2	8.5	1.2	0.0	0.0	0.0
		Fishing Pier	6000	0.0	0.0	7.5	14.6	7.0	0.0	0.0	0.0
		Recreation Trail	6000	0.0	0.0	7.5	14.6	7.0	0.0	0.0	0.0
		9 of 18 Riverside Campgrounds	5000	0.0	0.0	13.0	27.2	2.8	0.0	0.0	0.0

[1] Thresholds: Reflects low end water level for reservoir and high end flow for river.

Table 4-19.—Annual Water-Based Activity Valuation for Green River and Flaming Gorge Reservoir for Action Alternative ($1,000s)[1]

Site	Recreation Activity	Action Alternative Valuation by Hydrologic Condition								
		Average			Wet			Dry		
		Total Value	Change from No Action Alternative Average Condition		Total Values	Change from No Action Alternative Wet Condition		Total Value	Change from No Action Alternative Dry Condition	
			Value	%		Value	%		Value	%
Green River	Scenic Floating	1,933.9	920.3	90.8	897.6	-277.2	-23.6	0	-3.8	-100
	Guide Boat Fishing	1,890.9	289.8	18.1	991.1	-291.9	-22.8	31.4	-394.4	-92.6
	Private Boat Fishing	851.6	2,14.9	33.8	531.9	-88.4	-14.2	6.1	-168.7	-96.5
	Shoreline Fishing/ Trail Use	1,012.0	320.2	46.3	383.0	-278.4	-42.1	25.7	-166.4	-86.6
	Boat-Based Camping	22.5	-.2	-.9	14.2	-5.8	-29.2	1.6	-1.1	-41.6
	Total:	5,710.7	1,745.0	44.0	2,817.7	-941.8	-25.1	64.8	-734.5	-91.9
Flaming Gorge Reservoir	Power Boating Waterskiing	15,203.7	480.1	3.3	15,301.0	3,959.3	34.9	11,743.1	8,175.5	229.2
	Boat Fishing	6,428.6	146.7	2.3	6,462.5	1,816.1	39.1	5346.1	3,977.9	290.7
	Boat-Based Camping	207.7	9.9	5.0	212.8	61.7	40.8	166.0	116.3	233.8
	Swimming/ Waterplay	185.6	12.5	7.2	178.2	94.8	113.6	96.5	87.7	998.2
	Total:	22,025.5	649.2	3.0	22,154.5	5,931.9	36.6	17,351.8	12,357.4	247.4
Both Sites	Combined Total:	27,736.2	2,394.2	9.5	24,972.2	4,990.1	25.0	17,416.6	11,622.9	200.6

[1] Numbers may not add due to rounding.

Note that total values for the Action Alternative average condition increased compared to the No Action Alternative for both guide boat and private boat fishing on the river, despite the losses in visitation displayed in table 4-18. This result stemmed from the fact that the annual loss in visitation included certain months with gains (mainly July, August, and September) as well as the months with losses (mainly June). As it turns out, the losses in visitation were associated with months of relatively low value per visit and the gains with months of high value per visit.

As previously stated, values per visit increase when flows approach the preferred flow level for each activity. When combined, the influence of the higher values per visit outweighed the influence of the lost visitation.

Given the insignificant increase in visitation for the Action Alternative average condition, virtually all of the increase in value stems from increases in value per visit. While the facility availability approach predicts no change in reservoir visitation for the Action Alternative average condition compared to the No Action Alternative, the interpolation approach predicts sometimes sizable gains in reservoir values per visit. This highlights a disadvantage of the facility approach in that this access issue only approach cannot predict potential increases in visitation beyond the water level where all facilities are available. Comparing the visitation and valuation analyses, it becomes evident that the facility availability approach is much less sensitive to changes in water levels compared to the interpolation approach.

For the Action Alternative wet condition, combined valuation was estimated at nearly $25 million. This reflects an increase of almost $5 million or 25% compared to the No Action Alternative wet condition. Despite no change in reservoir visitation, the

$5.9-million increase in reservoir value, due to increases in value per visit associated with higher water levels, outweighs the $940,000 loss in river value. Power boating/waterskiing and boat fishing on the reservoir account for the majority of the increase in value. The largest gains on the reservoir occur in the months of June through October. Losses on the river are seen across all activities with the majority occurring in the month of July.

For the Action Alternative dry condition, combined valuation is estimated at $17.4 million. This reflects an increase of over $11.6 million or 200% compared to the No Action Alternative dry condition. The nearly $12.4 million of increased value for the reservoir outweighs the $735,000 of lost value on the river. Power boating/waterskiing and boat fishing on the reservoir account for the majority of the increase in value. The largest gains in value occur on the reservoir in the months of May through October. Losses on the river are seen across all activities with the majority occurring in the month of May.

4.11.3.2.3 Summary of Visitation and Value Analysis – Based on the applied methodologies, the Action Alternative combined visitation across both the Green River and Flaming Gorge Reservoir did not vary significantly from the No Action Alternative regardless of the hydrologic condition. The average condition showed hardly any change in total visitation. The wet and dry conditions resulted in minor losses (-4.8%) and gains (+2.9%), respectively. Given the wet and dry conditions are each only expected to occur no more than 10% of the time, these changes were considered insignificant.

The Action Alternative combined valuation across the river and reservoir increased under all hydrologic conditions compared to the No Action Alternative. For average and wet conditions, the gain was approximately 10 and 25%, respectively; whereas, under dry conditions, the gain was 200%. Keep in mind the 200% gain associated with the dry condition is in comparison to the low No Action Alternative dry valuation and would be expected to occur not more than 10% of the time.

As mentioned above, the facility availability approach used to estimate Flaming Gorge Reservoir visitation tends to understate visitation when water levels rise beyond the low end usability thresholds of all facilities. Since this was the case under all Action Alternative hydrologic conditions, it is possible that reservoir visitation estimates may be somewhat understated based on the facility availability analysis. Should this be the case, one could surmise that visitation gains compared to the No Action Alternative might accrue to the Action Alternative under average and wet conditions. Furthermore, additional gains in visitation under the Action Alternative dry condition may also be possible. These potential visitation gains would have the effect of amplifying the gains in valuation already identified.

4.11.4 Flaming Gorge Reservoir Recreation Safety Results

Safety of recreation activities on Flaming Gorge Reservoir correlates directly with access to the reservoir's surface rather than boating on the reservoir. Boating hazards on the reservoir occur at all elevations and are a problem to boat operators at all times. Therefore, the safety of boating on the reservoir is not related directly to reservoir elevation fluctuations. The recreation safety hazards associated with changes in reservoir elevations at Flaming Gorge Reservoir are related to the recreation users' ability to safely access developed boat ramps, docks, marinas, shoreline fishing areas, and beach areas. The thresholds used for this analysis (table 4-20) are from a recreation survey conducted during the summer of 2001 (Aukerman and Shuster, 2002). Reservoir elevations higher or lower than these thresholds would stop visitors from pursuing their primary activity and impact recreation opportunities at the reservoir. Reservoir

Table 4-20.—Percent of Time Flaming Gorge Reservoir Recreation Activities Are Unsafe (When Water Levels by Alternative Fall Outside Usable Thresholds)

Recreation Activity (Usability Thresholds)	Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Motor Boating	No Action	9.3	9.1	7.5	7.4	8.2	6.8	7.9	9.2	10.8	11.1	12.4	9.6
Usable Elevation: 6017 to 6039	Action	2.9	2.9	2.9	1.8	1.5	1.4	0.5	0.7	1.5	1.9	1.8	2.8
	Difference	+6.4	+6.2	+4.6	+5.6	+6.7	+5.4	+7.4	+8.5	+9.3	+9.2	+10.6	+6.8
Guide Boat Fishing	No Action	10.4	10.4	8.0	7.4	11.1	8.2	10.2	10.2	14.8	13.5	17.5	10.7
Usable Elevation: above 6018	Action	3.9	4.5	3.0	2.9	2.5	1.9	1.2	1.5	1.8	2.2	2.1	3.1
	Difference	+6.5	+5.9	+5.0	+4.5	+8.6	+6.3	+9.0	+8.7	+13.0	+11.3	+15.4	+7.6
Private Boat Fishing	No Action	9.3	9.1	7.5	7.4	8.8	6.8	8.9	10.2	13.5	12.4	12.4	9.6
Usable Elevation: 6017 to 6038	Action	2.9	2.9	2.9	1.8	1.5	1.4	0.5	0.7	1.5	1.9	1.8	2.8
	Difference	+6.4	+6.2	+4.6	+5.6	+7.3	+5.4	+8.4	+9.5	+12.0	+10.5	+10.6	+6.8
Bank Fishing and Sightseeing	No Action	10.6	9.1	9.1	7.4	16.0	42.7	43.3	65.8	64.7	55.4	55.5	23.1
Usable Elevation: 6017 to 6030	Action	6.8	2.9	2.9	1.8	3.1	16.7	73.4	27.1	11.8	10.4	10.4	4.6
	Difference	+3.8	+6.2	+6.2	+5.6	+12.9	+26.0	-33.1	+38.7	+52.9	+45.4	+45.5	+18.5
Kayaking/ Canoeing, Sailing, Wildlife Viewing	No Action	12.1	12.2	12.5	9.7	23.7	47.1	68.2	68.2	68.1	56.6	58.6	26.0
Usable Elevation: 6018 to 6030	Action	6.6	7.2	5.0	2.9	4.8	18.3	74.8	28.7	14.1	10.6	14.0	8.4
	Difference	+5.5	+5.0	+7.5	+6.8	+18.9	+28.8	-6.6	+39.5	+54.0	+46.0	+44.6	+17.6
Waterskiing	No Action	10.4	10.4	8.0	7.4	11.5	9.2	10.9	17.1	16.4	15.4	15.4	10.7
Usable Elevation: 6018 to 6037	Action	3.9	4.5	3.0	2.9	2.5	1.9	1.2	1.5	1.8	2.2	2.1	3.1
	Difference	+6.5	+5.9	+5.0	+4.5	+9.0	+7.3	+9.7	+15.6	+14.6	+13.2	+13.3	+7.6
Jet Skiing	No Action	8.9	8.6	7.4	6.6	8.0	7.5	60.5	47.3	41.3	33.2	33.2	10.7
Usable Elevation: 6016 to 6033	Action	2.5	2.9	2.8	1.7	1.5	3.9	1.2	2.1	0.6	1.2	1.1	1.8
	Difference	+6.4	+5.7	+4.6	+4.9	+6.5	+3.6	+59.3	+45.2	+40.7	+32.0	+32.1	+8.9
Swimming and Camping	No Action	9.3	9.1	7.5	7.4	8.8	8.4	9.6	17.1	16.3	14.3	14.3	9.6
Usable Elevation: 6017 to 6037	Action	2.9	2.9	2.9	1.8	1.5	1.4	0.5	0.7	1.5	1.9	1.8	2.8
	Difference	+6.4	+6.2	+4.6	+5.6	+7.3	+7.0	+9.1	+16.4	+14.8	+12.4	+12.5	+6.8
House Boating	No Action	12.1	12.2	12.5	9.7	23.7	47.1	68.2	68.2	68.1	58.6	26.0	12.1
Usable Elevation: 6020 to 6030	Action	6.6	7.2	5.0	2.9	4.8	18.3	74.8	28.7	14.1	13.9	14.0	8.4
	Difference	+5.5	+5.0	+7.5	+6.8	+18.9	+28.8	-6.6	+39.5	+54.0	+44.7	+12.0	+3.7

elevations outside the identified threshold will impact recreation users by requiring them to find their own access, which increases the risk and safety of the recreation users since 79% of those using the reservoir use the boat ramp, 42% use the beaches, 35% use the floating docks, and 62% use the marinas (Aukerman and Schuster, 2002).

4.11.5 Green River Recreation Safety Results

Impacts to the safety of recreation activities on the Green River below Flaming Gorge Dam within the Flaming Gorge National Recreation Area will occur when identified flows in the Green River would stop visitors from pursuing their primary activity. When flows in the Green River exceed the upper and lower identified thresholds shown on table 4-21 for each identified activity, the recreation users will no longer recreate on the river because of perceived safety concerns. The thresholds used for this analysis are from a recreation survey conducted during the summer of 2001 (Aukerman and Shuster, 2002).

Examples of impacts to safety concerns on the Green River would be those activities that occur during launching and takeout of floating water craft which are hurried activities and require greater attention at higher flows; also, the swifter water limits the boaters' ability to control the water craft and increases encounters with floating debris. The higher the riverflows, the deeper the water and more dangerous the currents. These higher riverflows increase the displacement of riverbanks for shoreline fishermen and shoreline camping. Low riverflows create problems with exposed rocks and boulders that cause difficulties for boaters.

4.12 SOCIOECONOMICS AND REGIONAL ECONOMICS

This section provides detailed results of a regional economic analysis. The analysis ultimately attempts to describe effects of changes in recreation activity upon the overall economy as well as possible alternative preferences of commercial operators.

This EIS includes two types of economic analyses—one measuring economic benefits and the other regional economic impacts. Regional economic impacts, presented in this section, are based on recreation effects. Economic benefits are described separately for agriculture (section 4.5), hydropower (section 4.4), and recreation (section 4.11).

Regional economic impact analyses attempt to measure changes in total economic activity within a specified geographic region stemming from changes in within-region expenditures. Regional economic impacts are typically described using such general measures as total industry output, labor income, and employment.[3] Conversely, economic benefits attempt to measure

[3] Regional Economic Impact Measures:

Total Industry Output: Dollar value of production (sales revenues and gross receipts) from all industries in the region. Total industry output includes the value of interindustry trade of intermediate goods prior to final manufacture and sale.

Total Labor Income: Employment income derived at the workplace, including wages and benefits (employee compensation) plus self-employed income (proprietary income).

Employment: Total of hourly wage, salary, and self-employed jobs (part-time and full-time), measured in terms of jobs, not full-time equivalents.

Table 4-21.—Percent of Time Green River Recreation Activities Are Unsafe (When Flows by Alternative Fall Outside Usable Thresholds[1])

Recreation Activity	Alternative	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Scenic Floating	No Action	57.8	44.2	78.6	75.4	55.2	22.7	30.8	81.9	97.3	99.8	69.5	65.1
	Action	53.5	46.8	65.3	57.1	40.9	21.9	48.5	89.3	84.7	76.8	69.2	59.7
	Difference	+4.3	-2.6	+13.3	+18.3	+14.3	+0.8	-17.7	-7.4	+12.6	+23.0	+0.3	+5.4
Guide Boat Fishing	No Action	58.0	46.6	80.3	74.6	51.5	22.0	30.9	95.2	100.0	100.0	72.0	68.7
	Action	54.6	47.2	71.1	58.0	41.3	36.7	69.5	91.3	84.7	77.4	69.8	60.2
	Difference	+3.4	-0.6	-9.2	+16.6	+10.2	-14.7	-38.6	+3.9	+15.3	+22.6	+2.2	+8.5
Private Boat Fishing	No Action	56.6	45.9	79.1	74.7	51.0	21.5	30.8	95.2	100.0	100.0	70.8	66.3
	Action	54.3	47.1	69.3	57.5	41.5	36.6	69.6	90.7	90.5	77.3	69.7	60.2
	Difference	+2.3	-1.2	+10.6	+17.2	+9.5	-15.1	-38.8	+4.5	+9.5	+22.7	+1.1	+6.1
Shoreline Fishing/ Trail Use	No Action	58.5	47.1	80.6	74.7	51.5	21.9	30.9	95.2	100.0	100.0	73.8	69.7
	Action	54.8	47.3	71.8	58.4	41.7	36.6	69.6	94.4	90.7	77.5	69.9	60.3
	Difference	+3.7	-0.2	+8.8	+16.3	+9.8	-14.7	-38.7	+0.6	+9.3	+22.5	+3.9	+9.4
Kayaking/ Canoeing	No Action	54.4	41.7	78.7	73.4	50.4	20.5	30.8	81.9	97.3	99.8	70.6	62.1
	Action	53.5	46.9	65.5	54.7	40.6	21.3	47.2	89.3	84.7	76.9	69.2	60.3
	Difference	+0.9	-5.2	+13.4	+18.7	+9.8	-0.8	-16.4	-7.5	+12.6	+22.9	+1.4	+1.8
Camping	No Action	57.2	43.7	80.4	74.2	50.7	21.1	30.9	95.2	100.0	100.0	70.2	68.1
	Action	54.8	47.2	71.4	57.1	40.7	35.7	68.4	91.7	90.6	77.5	69.8	60.2
	Difference	+2.4	-3.5	+9.0	+17.1	+10.0	-14.6	-37.5	+3.5	+9.4	+22.5	+0.4	+7.9

[1] Preferred Flow/Usability Thresholds by Recreation Activity:
- Scenic Floating (953 to 3,905 cfs)
- Guide Boat Fishing (854 to 3,731 cfs)
- Private Boat Fishing (879 to 3,656 cfs)
- Shoreline Fishing/Trail Use (825 to 3,709 cfs)
- Kayaking and Canoeing (950 to 3,500 cfs)
- Camping (836 to 3,538 cfs)

changes in societal or national welfare based on net value concepts including consumer surplus and producer profitability.[4]

One way to visualize the difference between regional economic impacts and economic benefits is to consider how each reacts to increases in regional expenditures. Regional economic impacts typically increase as in-region expenditures increase; whereas, consumer surplus/profitability benefits tend to decrease as costs or expenditures alone increase. It should be noted that regional economic impacts and benefits often move in unison, since they both typically rise or fall with levels of production (including recreation visitation). On the benefit side, as production changes, so do both production costs/expenditures and revenues/total consumer benefits; the net effect is that benefits generally move in the same direction as production changes. Nevertheless, there are many situations where changes in benefits and economic impacts diverge. This potential for divergence, along with the fact that different user groups are often interested in different economic measures, creates a need for both analyses.

Theoretically, nationally oriented economic benefit analyses attempt to provide a broader geographic focus compared to regional economic impact analyses. Unfortunately, in practice, the geographic difference between the analyses may be less pronounced, given the difficulty in evaluating national implications of an action. If an action is relatively small from a national perspective, repercussions outside the directly impacted area may be insignificant. If the opposite is true, nationwide displacement or substitution effects may need to be taken into consideration. The difficultly lies in trying to estimate these substitution affects. For this analysis, the changes in economic benefits within the directly affected areas were assumed to be small enough so as not to create significant changes in national benefits. As a result, evaluation of nationwide substitution effects was deemed unnecessary.

Given the above discussion, the basic objective of the regional economic analysis is to measure changes in total economic activity within the affected region for the Action Alternative as compared to the No Action Alternative. The Action Alternative potentially affects regional economic activity through changes in:

(1) Costs of agricultural production due to flooding effects on irrigated acreage

(2) Recreational expenditures due to the effects of changes in reservoir water levels and riverflows on recreation visitation

(3) Costs of electricity as the timing and production of hydropower varies with the fluctuation in releases from Flaming Gorge Dam

Flooding effects upon agricultural lands along the Green River proved to be relatively minor and were, consequently, dropped from the regional analysis. Regional impacts due to losses in hydropower generation were also deemed to be relatively insignificant locally, given any increased costs of power generation would be distributed across thousands of power users throughout the Western United States. Also, given that this EIS is primarily a reservoir re-operation study, the lack of structural adjustments to the dam implies that construction costs would be minimal. Other typically encountered project purposes, such as municipal and industrial uses, were either not applicable or not significantly affected. The only factor used to evaluate changes in regional economic activity was the changes in recreation expenditures.

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[4] For consumers, economic welfare reflects the value of goods and services consumed above what is actually paid for them. Such consumer welfare estimates are measured in terms of willingness-to-pay in excess of cost, otherwise referred to as consumer surplus. For producers or businesses, economic welfare is generally reflected in terms of gross revenues minus operating costs, otherwise referred to as profitability.

Regional economic impacts were measured using input-output analysis. Input-output estimates regional economic impacts based on a region's inter-industry trade linkages. The analyses present changes in total economic impact as measured by the sum of direct effects (impacts to initially affected industries), indirect effects (impacts to industries providing inputs to directly impacted industries), and induced effects (impacts from employees spending wages within the region), all caused by the initial change in demand. For example, if $1,000 in agricultural product is lost from irrigated acreage idled by flooding (direct effect), the farmer buys $500 less in seed and fertilizer from the local store (indirect effect), the farm workers spend $100 less for household goods and services within the region (induced effect), then the total loss in regional agricultural output is $1,000, but the total regional output loss is $1,600.

The majority of the regional analysis discussion is based on the results of a regional modeling effort. In addition to the regional modeling results, a brief discussion is presented at the end of the Action Alternative section on the results of surveys conducted with commercial guide operators on both the Green River and Flaming Gorge Reservoir. It was anticipated that commercial guide operators, particularly those on the Green River, may be adversely affected by the Action Alternative. Because the regional analysis focused on a three-county area, impacts to commercial guide operators would not be directly discernable. As a result, surveys of commercial guide operators were conducted to identify impacts. Other tourist oriented sectors, such as lodging and restaurants, were not anticipated to be as adversely affected as commercial guide operators since they cater to both river and reservoir recreators.

4.12.1 Methodology

This section describes the methodology used to measure both recreational regional economic impacts and commercial operator impacts.

4.12.1.1 Regional Economics Modeling Methodology

The regional economic impact analysis involves running alternative specific estimates of recreation expenditures through the IMpact analysis for PLANning (IMPLAN) input-output model of the three-county regional economy. As stated in chapter 3, the regional economy was defined as Sweetwater County, Wyoming, and Daggett and Uintah Counties, Utah. The IMPLAN model was originally developed back in the late 1970s by the USDA Forest Service to assist in land and resource planning. This personal computer-based software has been updated several times and now is widely used for the development of regional economic analyses.

Input-output analysis is a procedure for examining relationships both between businesses and between businesses and consumers. The analysis captures all the monetary market transactions within a specified region for a given period of time via the interindustry transaction table. The resulting mathematical formulas allow for examination of the effects of a change in one or more economic activities upon the overall regional economy (Minnesota IMPLAN Group, Inc., 2000).

Regional economic effects stemming from river and reservoir recreational activities within the three-county area are driven by levels of within region recreation expenditures. The recreation analysis developed visitation results by month and activity for each alternative and hydrologic condition (i.e., average, dry, and wet water conditions). This information, combined with estimates of recreational expenditures per visit by month and activity for each alternative and hydrologic condition, allowed for calculation of total within-region recreational expenditures by alternative and hydrologic condition. Changes in recreational expenditures for the Action Alternative compared to the No Action Alternative for each hydrologic condition were entered into the IMPLAN model. The resulting differences in regional economic activity between the Action Alternative and No Action Alternative for each hydrologic condition provide a measure of the regional economic impacts associated with the Action Alternative.

As described under the affected environment current conditions section, the latest available IMPLAN data reflects regional economic activity during 1999. While the total recreation expenditure information reflects visitation and per visit expenditures during 2000-2001, the difference in years was considered insignificant from the perspective of economic development within the region. The assumption was made that the 1999 version of the regional economy was reflective of the No Action Alternative. Given that 1999 was a wet year for both the river and reservoir, the underlying picture of the economy was considered analogous to the No Action Alternative wet condition. To estimate regional economic conditions for the No Action Alternative under average and dry conditions, differences in recreation expenditures for the No Action Alternative average and dry conditions were estimated as compared to No Action Alternative wet conditions. The expenditure differences were entered into IMPLAN to calculate regional economic activity under No Action Alternative average and dry conditions. As noted above, the differences in Action Alternative expenditures compared to No Action Alternative expenditures under average, wet, and dry conditions were run through IMPLAN to estimate impacts for the Action Alternative.

Average per visit current total recreation expenditures by activity within the region were obtained from the recreation survey described within the recreation section. Information was also gathered from the survey as to the breakdown of expenditures by expenditure category. Expenditure categories include camping fees, lodging, restaurants, groceries and liquor, gasoline, recreation supplies, guide services, car rental, other rentals, public transportation, and other. Expenditure categories varied somewhat by activity. For example, guide boat fishing was the only activity that included guide services.

In addition to the current recreation expenditure information, the survey also asked if the recreator’s length of visit might increase under preferred riverflow and reservoir water level conditions. The results of this preferred conditions length of trip question were adjusted downward using the conservative, but often applied, approach of assuming nonrespondent responses would be equal to zero. The preferred conditions length of visit was divided by the current average length of visit to estimate a percentage increase in length of visit under preferred conditions for each recreation activity. These activity specific percentage increases were applied to current per visit expenditures to estimate per visit expenditures by activity under preferred conditions.

Low end and high end thresholds, points where riverflows or reservoir water levels were so low or high as to prevent use, were also obtained from the survey. As with the recreation analysis, current and preferred conditions, along with the low and high end thresholds, were used to develop recreation expenditures per visit by activity for each alternative using an interpolation approach. Assuming length of stay per visit—and, consequently, expenditures per visit—peak under preferred conditions, an inverted U-shaped distribution, was assumed to hold for recreation expenditures as it did for recreation visitation and value. A high end kink expenditure estimate was developed as in the recreation analysis. The high end kink was assumed to fall the same percentage distance from the preferred flow/water level as the current conditions data point. If current conditions fell 75% of the way between preferred conditions and the low end threshold, then the high end kink was also assumed to fall 75% of the way between preferred conditions and the high end threshold. Including the high end kink, five data points now exist for conducting a linear interpolation of per visit recreation expenditures.

Instead of interpolating using all five data points, a modified interpolation was done using only the current conditions, preferred conditions, and high end kink data points. The logic for this was that, below current conditions or above high end kink conditions, the full scale interpolation would predict recreation expenditures per visit to fall below current expenditures. While this may sound reasonable, at the extremes where conditions approach the low or high end thresholds, per visit expenditures would be estimated to approach zero. While the values per trip used in the recreation analysis may indeed approach zero for the last few visits taken, the expenditures for those visits will obviously not decline to zero. As a result, the decision was made to only interpolate between current conditions and the high end kink. This results in expenditures per visit falling within the range of current conditions to preferred conditions (note that the expenditures for the high end kink are equivalent to current conditions). For cases where riverflows or reservoir water levels fall below current conditions or above high end kink conditions, the expenditures per visit were assumed to hold at current/high end kink levels. For more detailed discussion of the expenditure interpolation methodology, see the Socioeconomics Technical Appendix.

4.12.1.2 Commercial Operator Survey Methodology

Because the regional analysis focused on a three-county area, and lack of county specific expenditure data precluded the development of county level regional economic impact models, potential adverse impacts to commercial guide operators concentrated within Daggett County would not be directly discernable. As a result, surveys of commercial guide operators were conducted to identify impacts. The results of the surveys of both Green River and Flaming Gorge Reservoir recreational commercial operators are presented at the end of the Action Alternative subsection in terms of:

(1) Average visitation and revenue

(2) High end, low end, and preferred flows/water levels

(3) Preferred flow/water level visitation and revenue

Unfortunately, the survey data did not provide enough information to estimate impacts by alternative. However, the high end, low end, and preferred flows/water levels obtained from the survey were compared to flows and water levels from March to October for each alternative under average, wet, and dry conditions. Attempts were made to evaluate which alternative would be preferred for each commercially supported recreation activity.

4.12.2 Results

This section presents the results of both the regional economic analysis and the commercial operator analysis.

4.12.2.1 Results of Regional Economic Analysis

This section presents the results of the recreation expenditure based regional economic analysis. For a discussion of recreation visitation and values, see section 4.11 on recreation. The results are presented by alternative, starting with the No Action Alternative.

4.12.2.1.1 No Action Alternative – Information on No Action Alternative total recreation expenditures by expenditure category, hydrologic condition, site (river versus reservoir), and recreation activity are presented in table 4-22. These estimates portray the product of recreation visits from the recreation analysis times the expenditures per visit from the expenditure interpolations. Due to the large volume of recreation expenditure estimates by expenditure category, recreation activity, month, alternative, and hydrologic condition, the individual monthly estimates are not presented.

Given that the IMPLAN 1999 base data is considered reflective of No Action Alternative wet conditions, table 4-22 also includes estimates of the differences in No Action Alternative average and dry expenditures as compared to No Action Alternative wet conditions. The gain in No Action Alternative average condition expenditures compared to No Action Alternative wet condition expenditures of $23.6 million reflects almost a 20% increase. The decline in No Action Alternative dry condition expenditures compared to No Action Alternative wet condition expenditures of $39 million reflects a 32.6% decline.

These expenditure differences were run through the IMPLAN model to estimate regional economic conditions under No Action Alternative average and dry hydrologic conditions. As presented in table 4-23, differences in the overall three-county regional economy were insignificant between No Action Alternative average, wet, and dry conditions. Looking at employment, the most volatile regional economic measure on a percentage basis indicates that the 330 and 908 job declines compared to average conditions under wet and dry conditions, respectively, reflect only a 0.9 and 2.3% reduction in overall employment.

Focusing on the overall economy is important, but it can gloss over industry-by-industry changes. To address this issue, reviews were also made of the eight most affected economic sectors, those sectors directly impacted by changing recreational expenditures. Comparing employment for the No Action Alternative from average to wet conditions shows a minor decline of 294 jobs or 4.4% within the eight most affected sectors. The loss of 805 jobs from average to dry conditions for these sectors was more noticeable reflecting a 12.0% drop. The nearly 44% decline in recreation expenditures under dry conditions compared to average conditions generated a much less severe decline in regional economic activity, even for the eight most affected sectors, implying that a significant share of recreation expenditures must pass through the economy without creating much impact. This is not surprising since the three-county economy has a relatively small manufacturing base, suggesting much of the inputs to the most affected sectors likely come from outside the region.

4.12.2.1.2 Action Alternative – This section describes changes in regional economic activity associated with implementing the Action Alternative under average, wet, and dry conditions. For each hydrologic condition, changes in annual recreation expenditures compared to the No Action Alternative were run through the IMPLAN model. As a result, impacts are measured for the Action Alternative compared to the No Action Alternative within the context of the same hydrologic condition. In no instances are impacts measured across hydrologic conditions.

Table 4-24 presents recreation expenditures by category, recreation activity, site, and hydrologic condition for the Action Alternative. The table presents total expenditures as well as changes compared to the No Action Alternative in both dollar and percentage terms. Under all three hydrologic conditions, total Action Alternative expenditures are higher than those of the No Action Alternative. The gain in expenditures is about 5.6% under average conditions, 13.7% under wet conditions, and 22.7% under dry conditions.

While the overall change in annual expenditures is positive, this doesn't imply consistent expenditure gains for both the river and reservoir. The change in Action Alternative expenditures for the Green River follow the direction of the change in visitation, positive for the average condition and negative for the wet and dry conditions. Annual losses in river recreation expenditures compared to the No Action Alternative were estimated at 38% and 60% under wet and dry conditions, respectively. Conversely, changes in annual Action Alternative expenditures for Flaming Gorge Reservoir were estimated to be positive under each hydrologic condition despite the lack of visitation change under average and wet conditions. This seemingly odd result is due to the use and interaction of the facility availability and interpolation approaches within the analysis.

Recreation expenditures are estimated by multiplying visitation by expenditures per trip. The facility availability approach, used to measure changes in reservoir visitation, is less sensitive than the interpolation approach for measuring gains in visitation as water levels rise. Once water levels rise above the low end usability threshold of all reservoir facilities, no additional increase in reservoir visitation would be estimated by the facility availability approach. For this reason, no changes in visitation were estimated for the reservoir under average and wet conditions. However, expenditures per trip are based on an interpolation, which allows for variation across the entire range of water levels. Expenditures per trip rise due to increased length of stay as water levels approach preferred conditions. When applied to unchanging visitation levels, the increasing expenditure per trip results in gains in recreation expenditures at the reservoir under both average and wet conditions. Under wet conditions, these gains in reservoir expenditures exceeded the losses in river expenditures leading to the odd situation of an estimated overall loss in visitation coupled with an overall gain in expenditures. Under dry conditions, gains in reservoir visitation and expenditures outweigh losses on the river.

While the overall level of expenditures shows gains compared to the No Action Alternative, the individual expenditure categories include both gains and losses. This is because expenditure categories vary by recreation activity; and the visitation by activity varies by month, alternative, and hydrologic condition. Some activities may post gains, while others show losses. The potential for both gains and losses in recreation visitation and recreation expenditures per trip across activities and months creates the possibility of both positive and negative expenditures in comparison to No Action Alternative expenditures. For example, losses in recreator expenditures for river guides under wet and dry conditions are not offset because they are applicable only to the guide boat fishing activity.

The impacts of the Action Alternative under average, wet, and dry conditions are described in three separate tables to allow for presentation of totals by industry and the changes compared to the No Action Alternative in terms of both dollars/jobs and percentage for all three regional economic impact measures.

Table 4-25 reports the effects of the Action Alternative under average conditions. The "total" columns for total industry output, employment, and labor income portray overall estimates of economic activity for each industry and for the economy as a whole. The "change from No Action" columns depict changes in both dollars/jobs and percent.

The overall change in Action Alternative total output, employment, and income compared to No Action Alternative average conditions was

TABLE 4-22.—No Action Alternative Recreation Expenditures ($1,000s)
(Impact Area Counties: Daggett and Uintah, Utah; Sweetwater, Wyoming)
(2000–2001 $)

Hydrologic Condition	Site	Recreation Activity	Expenditures Categories											
			Camping Fees	Lodging	Restaurants	Groceries	Gas	Supplies	Guides	Car Rental	Other Rentals	Public Transit	Other	Total
Average	Green River	Scenic Floating	565.9	1,440.6	1,125.5	1,254.9	1,228.5	731.8	0	516.5	435.1	224.2	201.5	7,724.4
		Guide Boat Fishing	221.3	563.1	439.9	490.6	480.3	286.1	4,796.5	202.0	170.1	87.7	78.7	7,816.2
		Private Boat Fishing	318.0	809.2	632.2	705.0	690.1	411.1	0	290.2	244.5	126.0	113.2	4,339.5
		Shoreline Fishing/Trail Use	385.7	981.8	767.1	855.4	837.5	499.0	0	352.0	296.7	152.8	137.4	5,265.6
		Boat Based Camping	23.7	0	0	52.6	51.5	30.7	0	0	18.2	0	8.4	185.0
		Total:	1,514.6	3,794.7	2,964.8	3,358.4	3,287.9	1,958.7	4,796.5	1,360.7	1,164.6	590.6	539.3	25,330.7
	Flaming Gorge Reservoir	Power Boating/Waterskiing	8,928.7	8,029.1	11,261.9	18,292.6	27,470.6	5,769.5	0	0	2,961.1	0	7,170.2	89,883.7
		Boat Fishing	2,491.3	2,241.3	3,143.0	5,104.1	7,668.6	1,609.2	0	0	826.8	0	2,002.7	25,087.0
		Boat Camping	203.5	0	0	416.9	626.2	131.4	0	0	67.6	0	163.5	1,609.2
		Swimming/Waterplay	168.2	0	0	344.4	517.5	108.6	0	0	55.9	0	135.0	1,329.6
		Total:	11,791.7	10,270.4	14,404.9	24,158.1	36,282.9	7,618.7	0	0	3,911.4	0	9,471.4	117,909.4
		FGNRA[1] Total:	13,306.3	14,065.1	17,369.7	27,516.5	39,570.8	9,577.4	4,796.5	1,360.7	5,076.0	590.6	10,010.7	143,240.1
		Change from No Action Wet:	+2200.6	+2185.4	+2846.9	+4534.4	+6643.2	+1514.7	+977.7	+125.8	+792.4	+54.6	+1703.1	+23,578.3
Wet	Green River	Scenic Floating	546.0	1,389.9	1,086.0	1,210.8	1,185.3	706.0	0	498.3	419.8	216.3	194.4	7,453.0
		Guide Boat Fishing	176.2	448.3	350.2	390.6	382.4	227.8	3,818.8	160.8	135.4	69.8	62.7	6,223.1
		Private Boat Fishing	290.2	738.5	577.0	643.5	629.9	375.3	0	264.8	223.2	114.9	103.4	3,960.6
		Shoreline Fishing/Trail Use	340.7	867.1	677.5	755.4	739.6	440.7	0	310.9	262.0	134.9	121.4	4,650.1
		Boat Based Camping	18.1	0	0	40.2	39.4	23.5	0	0	14.0	0	6.5	141.6
		Total:	1,371.2	3,443.9	2,690.7	3,040.5	2,976.6	1,773.2	3,818.8	1,234.9	1,054.4	536.0	488.2	22,428.4
	Flaming Gorge Reservoir	Power Boating/Waterskiing	7,223.2	6,494.8	9,110.0	14,796.4	22,221.2	4,667.5	0	0	2,395.7	0	5,801.1	72,709.9
		Boat Fishing	2,157.6	1,941.0	2,722.1	4,420.2	6,640.7	1,393.5	0	0	716.0	0	1,734.0	21,725.1
		Boat Camping	196.8	0	0	403.1	605.5	127.1	0	0	65.3	0	158.1	1,555.8
		Swimming/Waterplay	157.2	0	0	321.9	483.7	101.4	0	0	52.2	0	126.2	1,242.6
		Total:	9,734.8	8,435.8	11,832.1	19,941.6	29,951.0	6,289.5	0	0	3,229.2	0	7,819.4	97,233.4
		FGNRA Total:	11,106.0	11,879.7	14,522.8	22,982.1	32,927.6	8,062.7	3,818.8	1,234.9	4,283.6	536.0	8,307.6	119,661.8
Dry	Green River	Scenic Floating	2.2	5.7	4.4	4.9	4.8	2.9	0	2.0	1.7	.9	.8	30.4
		Guide Boat Fishing	75.2	191.4	149.5	166.8	163.3	97.3	1,630.5	68.7	57.8	29.8	26.8	2,657.0
		Private Boat Fishing	138.0	351.3	274.5	306.1	299.6	178.5	0	126.0	106.1	54.7	49.2	1,883.9
		Shoreline Fishing/Trail Use	119.6	304.6	238.0	265.4	259.8	154.8	0	109.2	92.0	47.4	42.6	1,633.5
		Boat Based Camping	4.7	0	0	10.5	10.2	6.1	0	0	3.6	0	1.7	36.9
		Total:	339.9	853.0	666.4	753.6	737.8	439.5	1,630.5	305.8	261.3	132.8	121.0	6,241.7
	Flaming Gorge Reservoir	Power Boating/Waterskiing	5,361.2	4,819.7	6,761.2	10,981.4	16,492.5	3,464.0	0	0	1,778.0	0	4,305.3	53,963.3
		Boat Fishing	1,767.8	1,590.7	2,230.4	3,621.6	5,441.1	1,141.9	0	0	586.4	0	1,420.5	17,800.4
		Boat Camping	180.7	0	0	370.1	555.9	116.7	0	0	60.0	0	145.1	1,428.6
		Swimming/Waterplay	147.0	0	0	301.0	452.2	94.9	0	0	48.8	0	118.0	1,161.9
		Total:	7,456.8	6,410.4	8,991.6	15,274.1	22,941.7	4,817.5	0	0	2,473.2	0	5,988.9	74,354.3
		FGNRA Total:	7,796.7	7,263.4	9,658.0	16,027.7	23,679.5	5,257.0	1,630.5	305.8	2,734.5	132.8	6,109.9	80,596.0
		Change from No Action Wet:	-3,309.3	-4,616.3	-4,864.8	-6,954.4	-9,248.1	-2,805.7	-2,188.3	-929.1	-1,549.1	-403.2	-2,197.7	-39,065.8

[1] FGNRA = Flaming Gorge National Recreation Area.

Table 4-23.—No Action Alternative
(Impact Area Counties: Daggett and Uintah, Utah; Sweetwater, Wyoming)
(Data Year: 1999)

Primary Industries/Sectors	IMPLAN Industry Number	Average Condition			Wet Condition			Dry Condition		
		Total Industry Output ($M)	Employment (Jobs)	Labor Income ($M)	Total Industry Output ($M)	Employment (Jobs)	Labor Income ($M)	Total Industry Output ($M)	Employment (Jobs)	Labor Income ($M)
Agriculture, Forestry, Fishing	1-27	50.8	1,340	15.9	50.8	1,340	15.9	50.8	1,339	15.9
Mining	28-47, 57	1,349.8	4,146	283.9	1,349.7	4,146	283.9	1,349.6	4,146	283.9
Construction	48-56	335.6	3,212	111.3	335.5	3,210	111.3	335.2	3,207	111.2
Manufacturing	58-432	322.2	1,729	85.4	322.1	1728	85.4	322.0	1,727	85.4
Other Transportation	433-436, 438-440	472.0	2,901	187.5	471.8	2,899	187.4	471.5	2,894	187.3
- Air Transportation:	437	6.4	74	2.7	6.4	74	2.7	6.3	72	2.7
Communications	441-442	45.9	195	11.1	45.7	194	11.1	45.4	192	11.0
Utilities	443-446	285.4	626	45.4	285.2	625	45.4	284.8	623	45.3
Wholesale Trade	447	89.4	1,076	36.9	89.3	1,074	36.9	89.0	1,070	36.8
Other Retail Trade	448-449, 452-453	53.0	1,582	25.9	52.9	1,579	25.8	52.7	1,574	25.7
- Food Stores:	450	33.4	914	19.6	32.2	882	18.9	30.4	833	17.9
- Automotive Dealers and Service Stations:	451	56.8	1,103	25.9	55.4	1,076	25.3	53.5	1,038	24.4
- Eating and Drinking:	454	69.0	2,382	23.5	66.5	2,292	22.6	62.0	2,139	21.1
- Miscellaneous Retail:	455	17.5	945	8.7	17.1	921	8.4	16.4	883	8.1
Finance, Insurance, and Real Estate (FIRE)	456-462	206.8	1,776	27.3	206.2	1,769	27.2	205.0	1,754	27.0
Other Services	464-476, 478-487, 489-509	346.4	6,907	152.4	345.7	6,891	1,52.1	344.6	6,864	151.5
- Hotels and Lodging Places:	463	39.4	1,096	15.7	36.1	1004	14.4	30.2	838	12.0
- Automobile Rental and Leasing:	477	0.5	14	0.1	.435	13	0.1	0.2	5	0.0
- Amusement and Recreation Services:	488	3.8	177	1.6	3.2	149	1.4	1.9	91	0.8
Federal, State, and Local Government	510-515, 519-523	261.8	6,660	207.2	261.7	6,659	207.1	261.5	6,657	207.1
TOTAL:		4,008.8	38,853	1,288.2	3,993.7	38,523	1,283.3	3,966.4	37,945	1,275.1
Change from Average Condition ($M, Jobs):					-15.1	-330	-4.9	-42.4	-908	-13.1
(Percent):					-0.4	-0.9	-0.4	-1.1	-2.3	-1.0
MOST AFFECTED SECTORS:		226.9	6704	97.8	217.3	6410	93.8	200.8	5899	87.0
Change from Average Condition ($M, Jobs):					-9.6	-294	-4.0	-26.1	-805	-10.8
(Percent):					-4.2	-4.4	-4.1	-11.5	-12.0	-11.0

Table 4-24.—Action Alternative Recreation Expenditures ($1,000s)
(Impact Area Counties: Daggett and Uintah, Utah; Sweetwater, Wyoming)
(2000–2001 $)

Hydrologic Condition	Site	Recreation Activity	Expenditures Categories											
			Camping Fees	Lodging	Restaurants	Groceries	Gas	Supplies	Guides	Car Rental	Other Rentals	Public Transit	Other	Total
Average	Green River	Scenic Floating	722.2	1,838.7	1,436.6	1,601.7	1,568.1	934.1	0	659.2	555.2	286.0	257.1	9,858.9
		Guide Boat Fishing	236.0	600.6	469.2	523.2	512.3	305.1	5,116.0	215.4	181.4	93.5	84.0	8,337.0
		Private Boat Fishing	363.9	926.0	723.6	806.9	789.9	470.5	0	332.1	279.8	144.2	129.6	4,966.4
		Shoreline Fishing/Trail Use	475.5	1,210.2	945.7	1,054.4	1,032.3	615.0	0	433.9	365.6	188.3	169.4	6,490.3
		Boat Based Camping	19.5	0	0	43.3	42.4	25.2	0	0	15.0	0	7.0	152.3
		Total:	1,817.1	4,575.7	3,575.0	4,029.5	3,944.9	2,350.0	5,116.0	1,640.6	1,397.1	712.0	647.0	29,805.0
	Flaming Gorge Reservoir	Power Boating/Waterskiing	9,216.0	8,286.3	11,623.3	18,878.6	28,351.9	5,954.2	0	0	3,057.0	0	7,400.8	92,768.1
		Boat Fishing	2,545.3	2,289.7	3,211.3	5,214.7	7,834.2	1,644.3	0	0	844.8	0	2,045.6	25,629.9
		Boat Camping	207.2	0	0	424.4	637.4	133.8	0	0	68.8	0	166.4	1,637.9
		Swimming/Waterplay	169.9	0	0	347.9	522.7	109.7	0	0	56.5	0	136.4	1,343.0
		Total:	12,138.4	10,575.9	14,834.6	24,865.6	37,346.2	7,841.9	0	0	4,027.0	0	9,749.2	121,378.9
	FGNRA[1] Total:		13,955.5	15,151.6	18,409.6	28,895.1	41,291.1	10,191.9	5,116.0	1,640.6	5,424.1	712.0	10,396.2	151,183.9
	Change from No Action Alternative:	$:	649.2	1,086.5	1,039.9	1,378.6	1,720.3	614.5	319.5	279.9	348.1	121.4	385.5	7,943.8
		%:	4.9	7.7	6.0	5.0	4.4	6.4	6.7	20.6	6.9	20.6	3.9	5.6
Wet	Green River	Scenic Floating	312.3	795.2	621.3	692.7	678.2	403.9	0	285.2	240.1	123.7	111.2	4,263.8
		Guide Boat Fishing	119.4	303.7	237.3	264.6	259.1	154.3	2,587.1	108.9	91.7	47.3	42.5	4,216.0
		Private Boat Fishing	216.6	551.3	430.8	480.4	470.2	280.1	0	197.7	166.6	85.8	77.1	2,956.7
		Shoreline Fishing/Trail Use	173.7	442.2	345.5	385.3	377.2	224.8	0	158.5	133.6	68.8	61.9	2,371.6
		Boat Based Camping	12.0	0	0	26.7	26.1	15.5	0	0	9.2	0	4.3	93.8
		Total:	834.0	2,092.5	1,634.9	1,849.6	1,810.8	1,078.7	2,587.1	750.3	641.3	325.6	296.9	13,901.8
	Flaming Gorge Reservoir	Power Boating/Waterskiing	9,273.5	8,338.4	11,696.1	18,997.0	28,529.7	5,991.8	0	0	3,076.5	0	7,446.6	93,349.6
		Boat Fishing	2,557.7	2,300.7	3,227.0	5,239.7	7,872.4	1,652.2	0	0	849.1	0	2,055.9	25,754.5
		Boat Camping	209.1	0	0	428.2	643.3	135.0	0	0	69.4	0	167.9	1,652.9
		Swimming/Waterplay	169.0	0	0	345.8	519.6	109.0	0	0	56.1	0	135.6	1,335.1
		Total:	12,209.2	10,639.1	14,923.0	25,010.7	37,565.0	7,888.1	0	0	4,051.0	0	9,806.0	122,092.1
	FGNRA Total:		13,043.2	12,731.6	16,557.9	26,860.3	39,375.8	8,966.8	2,587.1	750.3	4,692.3	325.6	10,102.9	135,993.9
	Change from No Action Alternative:	$:	1,937.2	851.9	2,035.1	3,878.2	6,448.2	904.1	-1,231.7	-484.6	408.7	-210.4	1,795.3	16,332.1
		%:	17.4	7.2	14.0	16.9	19.6	11.2	-32.3	-39.2	9.5	-39.3	21.6	13.7
Dry	Green River	Scenic Floating	0	0	0	0	0	0	0	0	0	0	0	0
		Guide Boat Fishing	31.3	79.6	62.2	69.3	67.9	40.4	677.7	28.5	24.0	12.4	11.1	1,104.4
		Private Boat Fishing	29.0	73.7	57.6	64.2	62.9	37.5	0	26.4	22.3	11.5	10.3	295.4
		Shoreline Fishing/Trail Use	69.0	175.6	137.2	153.0	149.8	89.2	0	63.0	53.1	27.3	24.6	941.7
		Boat Based Camping	6.1	0	0	13.6	13.3	7.9	0	0	4.7	0	2.2	47.9
		Total:	135.4	328.9	257.0	300.1	293.8	175.1	677.7	117.9	104.1	51.2	48.2	2,489.3
	Flaming Gorge Reservoir	Power Boating/Waterskiing	7,150.4	6,428.6	9,018.6	14,647.6	21,998.2	4,620.8	0	0	2,371.6	0	5,741.7	71,977.5
		Boat Fishing	2,147.9	1,933.0	2,709.7	4,400.4	6,611.7	1,387.8	0	0	713.0	0	1,726.6	21,630.2
		Boat Camping	191.9	0	0	393.1	590.4	123.9	0	0	63.7	0	154.1	1,517.2
		Swimming/Waterplay	157.8	0	0	323.0	485.3	101.9	0	0	52.5	0	126.7	1,247.1
		Total:	9,647.9	8,361.6	11,728.3	19,764.1	29,685.7	6,234.4	0	0	3,200.8	0	7,749.1	96,371.9
	FGNRA Total:		9,783.3	8,690.5	11,985.3	20,064.2	29,979.5	6,409.5	677.7	117.9	3,304.9	51.2	7,797.3	98,861.2
	Change from No Action Alternative:	$:	1,986.6	1,427.1	2,327.3	4,036.5	6,300.0	1,152.5	-952.8	-187.9	570.4	-81.6	1,687.4	18,265.2
		%:	25.5	19.7	24.1	25.2	26.6	21.9	-58.4	-61.5	20.9	-61.5	27.6	22.7

[1] FGNRA = Flaming Gorge National Recreation Area.

Table 4-25.—Action Alternative Average Condition
(Impact Area Counties: Daggett and Uintah, Utah; Sweetwater, Wyoming)
(Data Year: 1999)

Primary Industries/Sectors	IMPLAN Industry Number	Total Industry Output: Total ($M)	Total Industry Output: Change from No Action Alternative $M	Total Industry Output: Change from No Action Alternative Percent	Employment: Total (Jobs)	Employment: Change from No Action Alternative Jobs	Employment: Change from No Action Alternative Percent	Labor Income: Total ($M)	Labor Income: Change from No Action Alternative $M	Labor Income: Change from No Action Alternative Percent
Agriculture, Forestry, Fishing	1-27	50.8	.0058	0.0	1,340	0	0	15.9	.0021	0.0
Mining	28-47, 57	1,349.8	.0185	0.0	4,146	0	0	284.0	.0039	0.0
Construction	48-56	335.7	.0538	0.0	3,213	1	0.0	111.4	.0257	0.0
Manufacturing	58-432	322.2	.0273	0.0	1,729	0	0	85.5	.0052	0.0
Other Transportation	433-436 438-440	472.1	.0744	0.0	2,902	1	0.0	187.5	.0266	0.0
- Air Transportation:	437	6.4	.0353	0.6	74	0	0	2.8	.0151	0.6
Communications	441-442	46.0	.0623	0.1	195	0	0	11.2	.0151	0.1
Utilities	443-446	285.5	.0848	0.0	626	0	0	45.5	.0158	0.0
Wholesale Trade	447	89.5	.0570	0.1	1,076	1	0.1	37.0	.0235	0.1
Other Retail Trade	448-449 452-453	53.0	.0343	0.1	1,583	1	0.1	25.9	.0165	0.1
- Food Stores:	450	33.7	.3547	1.1	923	10	1.1	19.8	.2085	1.1
- Automotive Dealers and Service Stations:	451	57.2	.3713	0.7	1,111	7	0.7	26.1	.1692	0.7
- Eating and Drinking:	454	70.0	.9469	1.4	2,414	33	1.4	23.8	.3219	1.4
- Miscellaneous Retail:	455	17.7	.1414	0.8	952	8	0.8	8.7	.0700	0.8
Finance, Insurance, and Real Estate (FIRE)	456-462	207.1	.240	0.1	1,779	3	0.2	27.3	.0320	0.1
Other Services	464-476 478-487 489-509	346.7	.2458	0.1	6,913	6	0.1	152.5	.1155	0.1
- Hotels and Lodging Places:	463	40.7	1.303	3.3	1,132	36	3.3	16.2	.5181	3.3
- Automobile Rental and Leasing:	477	.55	.0792	16.8	16	2	16.8	.2	.0229	16.8
- Amusement and Recreation Services:	488	4.0	.2212	5.9	187	10	5.9	1.7	.0945	5.9
Federal, State, and Local Government	510-515 519-523	261.9	.0428	0.0	6,660	0	0.0	207.2	.0146	0.0
TOTAL:		4,014.6	5.72	0.1	38,974	120	0.3	1,289.9	1.72	0.1
MOST AFFECTED SECTORS:		230.3	3.45	1.5	6,810	107	1.6	99.3	1.42	1.5

positive but quite small, reflecting less than a 1% change. Looking at the sum of the eight most directly affected sectors, the gains are somewhat higher in percentage terms, indicating about a 1.5% change. The largest percentage change (gain) occurred in the automotive rental and leasing and the amusement and recreation services sectors, both small sectors in the three-county economy. From an employment perspective, the largest numeric gains are seen in the hotel and eating/drinking sectors. These gains in economic activity associated with the Action Alternative under average conditions were considered insignificant from both the overall and most affected sector perspectives.

Table 4-26 reports the effects of the Action Alternative under wet conditions. The overall change in Action Alternative total output, employment, and income compared to No Action Alternative wet conditions was also positive but very small, again reflecting less than a 1% change. Looking at the sum of the eight most directly affected sectors, the gains were slightly higher in percentage terms, indicating nearly a 3% change. The largest percentage change (loss) occurred in the automotive rental and leasing and the amusement and recreation services sectors, both small sectors in the three-county economy. From an employment perspective, the largest numeric gains are seen in the hotel and eating/drinking sectors. These gains in economic activity associated with the Action Alternative under wet conditions were considered insignificant from both the overall and most affected sector perspectives.

Table 4-27 reports the effects of the Action Alternative under dry conditions. The overall change in Action Alternative total output, employment, and income compared to No Action Alternative wet conditions was again positive but very small, reflecting less than a 1% change. Looking at the sum of the eight most directly affected sectors, the gains were slightly higher in percentage terms, indicating about a 3.5% change. The largest percentage change occurred in the automotive rental and leasing, hotel and lodging places, and the amusement and recreation services sectors. The hotel and lodging places sector is relatively large compared to the other two sectors. From an employment perspective, the largest numeric gains are seen in the hotel and eating/drinking sectors. These gains in economic activity associated with the Action Alternative under dry conditions were considered insignificant from both the overall and most affected sector perspectives.

While the lack of expenditure data by county precluded county specific analyses, it is possible that certain impacts could be centered within certain counties. For example, negative impacts estimated for the amusement and recreation services sector under the Action Alternative during wet and dry conditions stem from losses in guide boat fishing services expenditures which appear to be centered in and around the town of Dutch John in Daggett County. A corresponding loss of jobs during wet and dry conditions, while not overly apparent from a three-county perspective, could occur in Daggett County including Dutch John.

4.12.2.2 Results of Commercial Operator Analysis

As mentioned in the introduction to the socioeconomic section, it was anticipated that commercial guide operations, particularly those on the Green River, could be adversely affected by the Action Alternative. Because the regional analysis focused on the three-county area, impacts to commercial guides were not directly discernable. As a result, surveys of commercial guide operations on both the river and reservoir were conducted during the summer of 2001 to identify impacts.

Commercial operations on the Green River include rafting/scenic floating and boat fishing guides. Commercial operations on Flaming Gorge Reservoir include fishing guides and marinas.

Table 4-26.—Action Alternative Wet Condition
(Impact Area Counties: Daggett and Uintah, Utah; Sweetwater, Wyoming)
(Data Year: 1999)

Primary Industries/Sectors	IMPLAN Industry Number	Total Industry Output: Total ($M)	Total Industry Output: Change from No Action Alternative $M	Total Industry Output: Change from No Action Alternative Percent	Employment: Total (Jobs)	Employment: Change from No Action Alternative Jobs	Employment: Change from No Action Alternative Percent	Labor Income: Total ($M)	Labor Income: Change from No Action Alternative $M	Labor Income: Change from No Action Alternative Percent
Agriculture, Forestry, Fishing	1-27	50.8	.0098	0.0	1,340	0	0	15.9	.0035	0.0
Mining	28-47, 57	1,349.7	.0299	0.0	4,146	0	0	283.9	.0064	0.0
Construction	48-56	335.6	.0933	0.0	3,211	1	0.0	111.3	.0441	0.0
Manufacturing	58-432	322.1	.0466	0.0	1,729	0	0	85.5	.0087	0.0
Other Transportation	433-436 438-440	471.9	.1217	0.0	2,900	2	0.1	187.5	.0426	0.0
- Air Transportation:	437	6.3	-.0465	-0.7	73	-1	-0.7	2.7	-.0199	-0.7
Communications	441-442	45.8	.1086	0.2	194	1	0.3	11.1	.0263	0.2
Utilities	443-446	285.4	.1505	0.1	625	0	0	45.4	.0279	0.1
Wholesale Trade	447	89.4	.1008	0.1	1,075	1	0.1	36.9	.0416	0.1
Other Retail Trade	448-449 452-453	53.0	.0624	0.1	1,581	2	0.1	25.8	.0301	0.1
- Food Stores:	450	33.2	.9785	3.0	909	27	3.0	19.5	.5752	3.0
- Automotive Dealers and Service Stations:	451	56.8	1.337	2.4	1,102	26	2.4	25.9	.6092	2.4
- Eating and Drinking:	454	68.3	1.846	2.8	2,356	64	2.8	23.2	.6275	2.8
- Miscellaneous Retail:	455	17.5	.3703	2.2	941	20	2.2	8.8	.1832	2.2
Finance, Insurance, and Real Estate (FIRE)	456-462	206.6	.4156	0.2	1,773	5	0.3	27.2	.0541	0.2
Other Services	464-476 478-487 489-509	346.2	.4243	0.1	6,901	10	0.1	152.2	.1980	0.1
- Hotels and Lodging Places:	463	38.2	2.097	5.8	1,062	58	5.8	15.2	.8336	5.8
- Automobile Rental and Leasing:	477	.3	-.1360	-31.3	9	-4	-31.3	.1	-.0393	-31.3
- Amusement and Recreation Services:	488	2.9	-.2642	-8.3	137	-12	-8.3	1.2	-.1129	-8.3
Federal, State, and Local Government	510-515 519-523	261.8	.0797	0.0	6,659	1	0	207.2	.0266	0.0
TOTAL:		4,001.8	8.15	0.2	38,724	201	0.5	1,286.5	3.17	0.2
MOST AFFECTED SECTORS:		223.5	6.2	2.8	6,588	178	2.8	96.5	2.66	2.8

Table 4-27.—Action Alternative Dry Condition
(Impact Area Counties: Daggett and Uintah, Utah; Sweetwater, Wyoming)
(Data Year: 1999)

Primary Industries/Sectors	IMPLAN Industry Number	Total Industry Output			Employment			Labor Income		
		Total ($M)	Change from No Action Alternative		Total (Jobs)	Change from No Action Alternative		Total ($M)	Change from No Action Alternative	
			$M	Percent		Jobs	Percent		$M	Percent
Agriculture, Forestry, Fishing	1-27	50.8	.0117	0.0	1,339	0	0	15.9	.0042	0.0
Mining	28-47, 57	1,349.6	.0362	0.0	4,146	0	0	283.9	.0077	0.0
Construction	48-56	335.3	.1102	0.0	3,208	2	0.1	111.2	.0523	0.1
Manufacturing	58-432	322.0	.0551	0.0	1,728	1	0.0	85.4	.0104	0.0
Other Transportation	433-436, 438-440	471.6	.1471	0.0	2,896	2	0.1	187.4	.0519	0.0
- Air Transportation:	437	6.3	-.0122	-0.2	72	0	0	2.7	-.0052	-0.2
Communications	441-442	45.5	.1277	0.1	193	1	0.3	11.1	.0309	0.3
Utilities	443-446	285.0	.1765	0.1	624	1	0.1	45.4	.0328	0.1
Wholesale Trade	447	89.1	.1184	0.1	1,072	1	0.1	36.8	.0489	0.1
Other Retail Trade	448-449, 452-453	52.8	.0725	0.1	1,576	2	0.1	25.8	.0349	0.1
- Food Stores:	450	31.5	1.0228	3.4	861	28	3.4	18.5	.6012	3.4
- Automotive Dealers and Service Stations:	451	54.8	1.3160	2.5	1,063	26	2.5	25.0	.5995	2.5
- Eating and Drinking:	454	64.1	2.1127	3.4	2,212	73	3.4	21.8	.7182	3.4
- Miscellaneous Retail:	455	16.8	.3922	2.4	904	21	2.4	8.3	.1940	2.4
Finance, Insurance, and Real Estate (FIRE)	456-462	205.5	.4913	0.2	1,760	6	0.3	27.1	.0646	0.2
Other Services	464-476, 478-487 489-509	345.1	.5011	0.1	6,875	12	0.2	151.7	.2343	0.2
- Hotels and Lodging Places:	463	32.7	2.5646	8.5	909	71	8.5	13.0	1.0197	8.5
- Automobile Rental and Leasing:	477	.1	-.0523	-40.0	3	-2	-40.5	.0	-.0151	-30.5
- Amusement and Recreation Services:	488	1.8	-.1192	-6.6	85	-6	-6.6	.8	-.0510	-6.2
Federal, State, and Local Government	510-515, 519-523	261.6	.0921	0.0	6,658	1	0.0	207.1	.0309	0.0
TOTAL:		3,976.6	10.23	0.3	38,185	240	0.6	1,278.8	3.67	0.3
MOST AFFECTED SECTORS:		208.1	7.2	3.6	6111	212	3.6	90.0	3.1	3.5

Green River boat fishing and scenic floating operators within Reach 1 are similar in some ways to the commercial rafting operations within Dinosaur National Monument. They both require special use permits which limit the number of outfitters. The number of daily launches is limited in both areas. Guests must make long-term commitments when making reservations. However, differences exist between Green River Reach 1 fishing and floating recreators and Dinosaur National Monument white water rafters, primarily in terms of flow preferences. Generally speaking, fishermen and floaters within Reach 1 typically prefer lower flows.

The survey response rate was fairly good overall, and the results were deemed sufficiently representative for presentation purposes. Despite the reasonable response rates, the survey data did not provide enough information to estimate impacts by alternative since not all respondents answered all the questions. While it would have been useful to separately identify impacts to commercial operations on both the river and reservoir, it should be noted that the regional modeling analysis incorporates, but does not specifically identify, most of the impacts to the commercial operators by addressing changes in visitation and recreation expenditures (including guide fees and marina rentals). The difficulty with the regional modeling results is that they are aggregated by economic sector and industry and do not provide detailed impacts for specific businesses.

For both the river and reservoir, the surveys did provide some useful commercial operator information by recreation activity in terms of:

(1) Average visitation and revenue

(2) High end, low end, and preferred flows/water levels

(3) Preferred flow/water level visitation and revenue

The site and activity specific high end, low end, and preferred flow/water level information was compared to average flow/end-of-month water level information for each alternative under average, wet, and dry conditions for the months from March to October to evaluate alternative preferences (see tables 4-28 and 4-29).

In addition, assuming historical averages for visitation and revenue reflect No Action Alternative average conditions, the additional visitation and revenue under preferred conditions may provide an indicator of possible impacts under average conditions. In the typical case where Action Alternative flows/water levels are closer to preferred flows/water levels than the No Action Alternative, the difference between average and preferred conditions presented below could be used as an upper bound on possible Action Alternative visitation and revenue impacts. In cases where No Action Alternative flows/water levels are closer to preferred flows/water levels, the additional visitation and revenue data presented below provide little information.

In table 4-28, for Green River scenic floating operations, the survey indicated that preferred flows for Reach 1 from Flaming Gorge Dam to the confluence with the Yampa River averaged 4,040 cfs with a range from 2,000 to 10,000 cfs. High end and low end thresholds, depicting the points where flows are either too high or too low for rafting, averaged 15,200 and 715 cfs, respectively.

Comparing the high end/low end flow thresholds to average condition flows for both the No Action and Action Alternatives indicates that average flows for both alternatives for the March through October months fall within the usable range for scenic floating. For each month, an evaluation was also made as to which alternative's flows were closer to the preferred flow (monthly comparison). Of the 8 months studied, no preference resulted since each alternative would be preferred for 4 months. Finally, differences between the preferred flow and both the No Action and Action Alternatives flows were calculated for each month. The absolute value of these differences was summed, and the alternative with the lowest total difference was considered preferred (seasonal comparison). The Action Alternative was judged to be the preferred alternative by commercial rafters based on this seasonal comparison.

The Action Alternative was deemed to be the preferred alternative by commercial rafting operators under wet conditions. Both alternatives fell within the usable flow ranges for all months. The results suggest the Action Alternative would be preferred under wet conditions based on both the overall seasonal flow difference as well as 6 of the 8 months studied.

Conversely, the No Action Alternative would appear to be preferred by commercial rafting operators under dry conditions. Both alternatives fell within the usable flow ranges for all months. It appears the No Action Alternative would be preferred, based both on the overall seasonal flow difference as well as 4 of the 6 months indicating differences.

Rafting operators indicated an average of 40 boat trips a year with a range from 10 to 90. Note that boat trips would include multiple rafters. Average annual revenues were estimated at about $235,000 with a range from $35,000 to $476,000. Average additional annual trips under preferred flows were estimated at about 17 trips with a range from zero to 54. Some operators noted that visitation is controlled within Dinosaur National Monument so that the number of trips could not increase under preferred flows, but the number of clients per trip could increase. Average additional annual revenues under preferred flows were estimated at about $39,000 (+16.6%) with a range from $0 to $90,000.

For Green River boat fishing operations, table 4-28 indicates that preferred flows for the portion of Reach 1 associated with boat fishing (from Flaming Gorge Dam to the Utah/Colorado State line) averaged 2,338 cfs with a range from 1,400 to 2,800 cfs. High and low end thresholds for boat fishing averaged 7,530 and 1,030 cfs, respectively. Based on comments received from the Green River Outfitter and Guide Association, the low end threshold was further reduced to 800 cfs.

The Action Alternative was deemed to be the preferred alternative by commercial boat fishing operators on the Green River under average conditions based on comparisons to preferred flows since both alternatives fell within the usable range across all months. The comparisons to preferred flows resulted in the Action Alternative being preferred, based on the overall seasonal flow difference. Individual monthly comparisons resulted in no obvious preference since 4 of the 8 months were preferred by each alternative. The lower use months of March and October showed a preference for No Action, implying the higher use months of April thru September preferred the Action Alternative.

The No Action Alternative was deemed to be the preferred alternative by commercial boat fishing operators under wet conditions. Both alternatives fell within the usable flow ranges for all months. The preferred flow comparisons resulted in the No Action Alternative being preferred, based on the overall seasonal flow difference; but both alternatives appear to be equally attractive based on the monthly comparisons. Looking at the higher use months of April thru September, the No Action Alternative would be preferred.

Similarly, the No Action Alternative would appear to be preferred by commercial boat fishing operators under dry conditions. While both alternatives fall within the usable range in all months, the No Action Alternative would be preferred by commercial boat fishing operators based on comparisons to preferred flow. The No Action Alternative

Table 4-28.—Green River Commercial Operator Hydrology Comparisons

Recreation Activity	Flow Levels	Month	Average Conditions					Wet Conditions					Dry Conditions				
			No Action Alternative Flow	Beyond Usable Range?	Action Alternative Flow	Beyond Usable Range?	Closest to Preferred Flow	No Action Alternative Flow	Beyond Usable Range?	Action Alternative Flow	Beyond Usable Range?	Closest to Preferred Flow	No Action Alternative Flow	Beyond Usable Range?	Action Alternative Flow	Beyond Usable Range?	Closest to Preferred Flow
Scenic Floating	Preferred: 4,040	Mar	1,484	No	1,270	No	No Action	1,898	No	2,030	No	Action	800	No	800	No	Same
	High End: 15,000	Apr	2,207	No	1,904	No	No Action	3,290	No	3,981	No	Action	800	No	800	No	Same
	Low End: 715	May	3,463	No	3,233	No	No Action	5,100	No	5,537	No	No Action	1,400	No	800	No	No Action
		June	2,710	No	3,962	No	Action	5,917	No	7,038	No	No Action	800	No	893	No	Action
		July	983	No	2,185	No	Action	1,200	No	4,600	No	Action	800	No	893	No	Action
		Aug	1,251	No	1,626	No	Action	1,531	No	2,131	No	Action	931	No	906	No	No Action
		Sept	1,374	No	1,639	No	Action	1,639	No	2,239	No	Action	1,039	No	939	No	No Action
		Oct	1,654	No	1,487	No	No Action	2,075	No	2,172	No	Action	1,039	No	800	No	No Action
						Overall:	Action				Overall:	Action				Overall:	No Action
Boat Fishing	Preferred: 2,338	Mar	1,484	No	1,270	No	No Action	1,898	No	2,030	No	Action	800	No	800	No	Same
	High End: 7,530	Apr	2,207	No	1,904	No	No Action	3,290	No	3,981	No	No Action	800	No	800	No	Same
	Low End: 800	May	3,463	No	3,233	No	Action	5,100	No	5,537	No	No Action	1,400	No	800	No	No Action
		June	2,710	No	3,962	No	No Action	5,917	No	7,038	No	No Action	800	No	893	No	Action
		July	983	No	2,185	No	Action	1,200	No	4,600	No	No Action	800	No	893	No	Action
		Aug	1,251	No	1,626	No	Action	1,531	No	2,131	No	Action	931	No	906	No	No Action
		Sept	1,374	No	1,639	No	Action	1,639	No	2,239	No	Action	1,039	No	939	No	No Action
		Oct	1,654	No	1,487	No	No Action	2,075	No	2,172	No	Action	1,039	No	800	No	No Action
						Overall:	Action				Overall:	No Action				Overall:	No Action

Table 4-29.—Flaming Gorge Reservoir Commercial Operator Hydrology Comparisons

Recreation Activity	Reservoir Levels	Month	Average Conditions: No Action Alternative Flow	Beyond Usable Range?	Action Alternative Flow	Beyond Usable Range?	Closest to Preferred Flow	Wet Conditions: No Action Alternative Flow	Beyond Usable Range?	Action Alternative Flow	Beyond Usable Range?	Closest to Preferred Flow	Dry Conditions: No Action Alternative Flow	Beyond Usable Range?	Action Alternative Flow	Beyond Usable Range?	Closest to Preferred Flow
Boat Fishing	Preferred: 6029	Mar	6024.0	No	6025.8	No	Action	6027.9	No	6027.9	No	Same	6019.0	No	6023.5	No	Action
	High End: 6040	Apr	6024.1	No	6026.0	No	Action	6028.5	No	6028.5	No	Same	6020.1	No	6023.0	No	Action
	Low End: 6006	May	6023.8	No	6025.8	No	Action	6029.4	No	6029.2	No	Action	6017.6	No	6022.8	No	Action
		June	6026.6	No	6027.8	No	Action	6031.7	No	6030.3	No	Action	6018.5	No	6024.5	No	Action
		July	6029.1	No	6029.2	No	No Action	6035.5	No	6030.7	No	Action	6019.3	No	6024.7	No	Action
		Aug	6028.9	No	6028.4	No	No Action	6036.0	No	6030.5	No	Action	6018.5	No	6023.8	No	Action
		Sept	6028.3	No	6027.4	No	No Action	6035.5	No	6030.0	No	Action	6017.9	No	6023.2	No	Action
		Oct	6027.5	No	6026.8	No	No Action	6034.9	No	6029.8	No	Action	6017.3	No	6023.1	No	Action
						Overall:	Action				Overall:	Action				Overall:	Action
Marinas	Preferred: 6031	Mar	6024.0	No	6025.8	No	Action	6027.9	No	6027.9	No	Same	6019.0	Yes	6023.5	No	Action
	High End: 6035	Apr	6024.1	No	6026.0	No	Action	6028.5	No	6028.5	No	Same	6020.1	Yes	6023.0	No	Action
	Low End: 6023	May	6023.8	No	6025.8	No	Action	6029.4	No	6029.2	No	No Action	6017.6	Yes	6022.8	Yes	Range
		June	6026.6	No	6027.8	No	Action	6031.7	No	6030.3	No	Same	6018.5	Yes	6024.5	No	Action
		July	6029.1	No	6029.2	No	Action	6035.5	Yes	6030.7	No	Action	6019.3	Yes	6024.7	No	Action
		Aug	6028.9	No	6028.4	No	No Action	6036.0	Yes	6030.5	No	Action	6018.5	Yes	6023.8	No	Action
		Sept	6028.3	No	6027.4	No	No Action	6035.5	Yes	6030.0	No	Action	6017.9	Yes	6023.2	No	Action
		Oct	6027.5	No	6026.8	No	No Action	6034.9	No	6029.8	No	Action	6017.3	Yes	6023.1	No	Action
						Overall:	Action				Overall:	Action				Overall:	Action

would be preferred in 4 of 6 months with preferred flow based differences.

Two of the four boat fishing operators who responded to the survey indicated an average of 210 boat trips a year. Average annual revenues across all four operators were estimated at about $245,600 with a range from $32,000 to $500,000. Average additional annual trips under preferred flows were estimated at about 54 trips with a range from 23 to 108. Average additional annual revenues under preferred flows were estimated at about $17,000 (+6.9%) with a range from $7,200 to $35,000.

In table 4-29, for Flaming Gorge Reservoir boat fishing operations, preferred water levels averaged 6029 feet above msl. High and low end thresholds averaged 6040 and 6006, respectively.

The Action Alternative was deemed to be the preferred alternative by commercial boat fishing operators on Flaming Gorge Reservoir under average conditions. Both alternatives fell within the usable water level ranges for all months. The comparisons to preferred water levels resulted in the Action Alternative being preferred, based on the overall seasonal water level difference and in 4 of the 8 months in comparison.

The Action Alternative was deemed to be the preferred alternative by commercial boat fishing operators under wet conditions. Both alternatives fell within the usable water level ranges for all months. The preferred water level comparisons resulted in the Action Alternative being preferred, based on the overall seasonal water level difference and in 6 of 6 months indicating differences.

The Action Alternative would appear to be preferred by commercial boat fishing operators under dry conditions. Both alternatives fell within the usable water level ranges for all months. The Action Alternative would be preferred, based on both the overall seasonal water level difference and the monthly comparisons for all months studied.

Reservoir boat fishing operators indicated an average of 107 clients a year with a range from 20 to 220. Average annual revenues were estimated at about $12,800 with a range from $4,000 to $38,000. Average additional annual trips under preferred water levels were estimated at 5 trips with a range from 0 to 18. Average additional annual revenues under preferred water levels were estimated at only $650 (5.1%) with a range from $0 to $2,250.

For Flaming Gorge Reservoir marina operations, table 4-28 indicates preferred water levels across all boat-based activities averaged 6031 feet. High and low end thresholds averaged 6035 and 6023, respectively.

The Action Alternative was deemed to be the preferred alternative by commercial boat fishing operators on Flaming Gorge Reservoir under average conditions. Both alternatives fell within the usable water level ranges for all months. The comparisons to preferred water levels resulted in the Action Alternative being preferred, based on the overall seasonal water level difference and in the 5 of the 8 months in comparison.

The Action Alternative was deemed to be the preferred alternative by commercial boat fishing operators under wet conditions. No Action water levels for July through September fell outside the usable range. The preferred water level comparisons resulted in the Action Alternative being preferred based on the overall seasonal water level difference and in 4 of 5 months indicating differences.

The Action Alternative would appear to be preferred by commercial boat fishing operators under dry conditions. This is primarily because the No Action Alternative falls outside the usable water level range in all months compared to only 1 month (May) for the Action Alternative.

Marina operators responded with an average of 97,200 clients a year. Average annual revenues were estimated at about $915,800. Average additional annual trips under preferred water levels were estimated at 10,600 trips. Average additional annual revenues under preferred water levels were estimated at $225,400 (+24.6%). These additional revenues include cost savings associated with reduced operation and maintenance related to moving and shoring up docks, moorings, etc., under preferred water levels. In general, the cost of operating and maintaining marinas, boat ramps, and boat camps increases as water levels drop below preferred water levels. The annual operation and maintenance costs savings under preferred conditions at the two marinas averaged $46,000.

Comparing the high and low end thresholds provided by the commercial operators to those from the recreator surveys for the same recreation activity indicates that, generally speaking, the commercial operators were willing to pursue visits over a wider range of flows/water levels. In other words, the high end thresholds were higher and the low end thresholds were lower for the commercial operators. The preferred flows/water levels for the commercial operators were higher than those from the recreator surveys.

4.13 PUBLIC SAFETY AND PUBLIC HEALTH

This section presents the environmental consequences to public safety and public health of operating Flaming Gorge Dam under the No Action and Action Alternatives. This section focuses on the risk to public health and safety for workers, residents, and the general public who may be traveling in the area but not necessarily participating in recreational activities associated with the Flaming Gorge facility. A discussion of potential impacts to recreation safety can be found in section 4.11.5.

4.13.1 Public Safety on Flaming Gorge Reservoir

The analysis of the hydrologic modeling of the Action and No Action Alternatives indicates that fluctuation of the reservoir elevation would occur less frequently under the Action Alternative. Unsafe conditions around Flaming Gorge Reservoir and at Flaming Gorge Dam increase as a result of the changing environment when the reservoir elevation changes. It is likely that these unsafe conditions would occur less often under the Action Alternative because of the reduced magnitude and frequency of reservoir elevation fluctuations.

Risks to dam workers under the Action Alternative do not appear to be greater than under the No Action Alternative. Bypass releases may be more frequent under the Action Alternative; however, they would tend to be of less magnitude and would be systematically scheduled under the operating procedures at the dam. Existing safety procedures are adequate, and no additional workplace safeguards would be needed under either the Action or No Action Alternative.

4.13.2 Public Safety on the Green River

The risks to public safety associated with high flows along the Green River are not substantially different under the Action and No Action Alternatives. Under both alternatives, public notification of anticipated riverflows would be provided through communication channels established within the Flaming Gorge Working Group.

High flows have the potential to cause erosion around the abutments of bridges and pipelines that cross the river. Under the Action Alternative, high flows would likely occur more often and for longer durations than would occur under the No Action Alternative. It is not anticipated, however, that the increased frequency and duration of high flows in the Green River under the Action

Alternative (compared to the No Action Alternative) would have an impact on the structural integrity of these bridges and pipelines that cross the Green River.

There are several trailer homes located in the flood plains near Jensen, Utah. These homes are susceptible to flooding when riverflows exceed 18,000 cfs. Under the Action Alternative, it is likely that these homes could be impacted by flooding more often than under the No Action Alternative, as a result of releases made from Flaming Gorge Dam that attempt to achieve target flows in Reach 2 that exceed 18,000 cfs. It is not anticipated, however, that there would be an increased risk to the health and safety of people inhabiting these homes because notification of potential high flows will allow ample evacuation time.

4.13.3 Disease Vectors

Both the No Action and Action Alternatives would result in temporary elevated flows in Reaches 1 and 2 of the Green River in the May-July period. At the end of the targeted peak flows period, the river elevation should drop, inundated flood plains should drain, and most of the new mosquito habitat would vanish. Some small depressions may continue for a time and provide habitat, but they also would dry up.

Reclamation has no control over the management of the mosquito problem in the Jensen, Utah, area. It is expected that existing State and county mosquito control programs would continue. This section analyzes the impacts of the Action and No Action Alternatives on mosquito populations in Reaches 1 and 2.

4.13.3.1 No Action Alternative

4.13.3.1.1 Reach 1 – Irving and Burdick (1995) conducted an inventory, largely based on aerial photography, and determined that about 1,591 acres of potential flooded bottomland habitat exist in Reach 1 of the Green River. Under the No Action Alternative, existing flows would not change; and the flooded bottomlands should continue to produce the same number of mosquitoes.

4.13.3.1.2 Reach 2 – As in Reach 1, flows in the Green River should not change. Irving and Burdick (1995) conducted an inventory, largely based on aerial photography, and determined that about 8,648 acres of potential flooded bottomland habitat exist in Reach 2 of the Green River. Under the No Action Alternative, existing flows would not change, and the flooded bottomlands should continue to produce the same numbers of mosquitoes.

In Reach 2, the Uintah County Mosquito Abatement District provides mosquito control treatment for about 50 river miles of Green River between the Dinosaur National Park boundary and Ouray, Utah. The amount of mosquito control greatly depends on the volume and duration of flows in the Green River. The Uintah County Mosquito Abatement District’s mosquito control is not expected to change.

4.13.3.1.3 Reach 3 – As in Reaches 1 and 2, implementing the No Action Alternative would not change the amount of bottomlands flooded and the mosquito breeding areas. Irving and Burdick (1995) conducted an inventory, largely based on aerial photography, and determined that about 8,154 acres of potential bottomlands were present in Reach 3, including 2,718 areas between the White River confluence and Pariette Draw and 1,878 acres in Canyonlands.

4.13.3.2 Action Alternative

4.13.3.2.1 Reach 1 – In most cases, implementing the Action Alternative would increase the peak flows in Reach 1. Peak release in Reach 1 that reaches 8,600 cfs for 1 day occurs about 27% and 6.5% of the time in the Action Alternative and No Action

Alternative, respectively. The 1-day duration peak flows should create most of the flood plain mosquito habitat in Reach 1 for the flood plain mosquitoes, such as *Aedes* sp. Implementing the Action Alternative would increase the amount of adjacent flood plains inundated and provide adequate habitat for many different species of mosquitoes.

The longer duration flows in the Action Alternative would benefit the mosquitoes that lay their eggs on water surfaces. In those areas where there are adequate environmental conditions, such as standing water in depressions or along vegetative areas, mosquitoes would be expected to be productive. There are many species of mosquitoes that lay their eggs on water surfaces, including the *Culex* sp. mosquitoes that are responsible for the transmission of the encephalitis virus. In some mosquito producing areas, environmental conditions and fish could reduce mosquito populations.

4.13.3.2.2 Reach 2 – Generally, the 1-day duration flows in the Action Alternative and the No Action Alternative are about the same. However, the highest targeted peak flows in Reach 2, 1-day duration at 26,400 cfs, should occur about 14% and 7% in the Action Alternative and No Action Alternative, respectively. Implementing the Action Alternative for the 1-day duration peak flows would not have a major impact on the mosquito production in most years (14% versus 7%). The targeted 2-week and 4-week duration peak flows are generally higher under the Action Alternative. Targeted 2-week peak flows of 18,600 cfs in Reach 2 should occur about 41.1% and 15.6% for the Action Alternative and No Action Alternative, respectively. The Uintah County Mosquito Abatement District estimated that, at a flow of 18,000 cfs, they can expect to treat about 30,000 acres of mosquito habitat. The 30,000 acres include repeated treatments of the same area. The Uintah County Mosquito Abatement District would need to provide treatment at this level nearly three times as often under the Action Alternative (41.1% versus 15.6%). Implementing the Action Alternative would increase mosquito habitat production in Reach 2 in some years, but not as large or as often as in Reach 1.

4.13.3.2.3 Reach 3 – In nearly all cases, implementing the Action Alternative would slightly increase the frequency of higher flows in Reach 3 and flood river bottom lands more often. Flooding river bottom lands has the potential to create good mosquito habitat. It is expected that large numbers of mosquitoes could be produced in both the Action and No Action Alternatives. Implementing the Action Alternative in Reach 3 should not have a major impact on the mosquito populations in the area when compared to existing conditions.

4.13.4 Air Quality

Negative impacts on regional air quality from reductions in output from the Flaming Gorge Powerplant could occur if losses of energy from this source are replaced by other sources in the region that generate high levels of pollutants. One advantage of hydropower is that it is a clean source of power relative to other sources, especially coal-fired powerplants. Variations in air pollutants from electricity generation are dependent on the source of the power. Reduction in the generation from hydropower or increase in the generation from other sources such as coal-fired powerplants can increase pollution levels.

Changes in air quality are dependent on changes in energy prices, production levels of other powerplants, purchases from outside the region, other generation factors, and the weather. While the results from the simulation of power output from the Flaming Gorge Powerplant show that the Action Alternative would generate slightly fewer megawatthours on average, the difference appears to be insignificant, and the level of difference would vary depending on many conditions. This reduction in output would be less than 5% of the generation at Flaming Gorge powerplant and a small fraction of 1%

of the sales for the SLCA/IP customers. Due to the size of the region and number of generators supplying power to the region's grid, any emission changes would be spread over a large area and likely have an insignificant effect on regional air quality or air quality in one location.

4.14 VISUAL RESOURCES

4.14.1 Flaming Gorge Reservoir

The desired visual resource management goal on the national recreation area would be for a "naturally appearing" landscape. There is a "cultural" setting where concentrations of people and developments exist, such as the Cedar Springs area, at Flaming Gorge Dam, and the Dutch John townsite.

At the heart of discussion is the visual difference between the No Action Alternative operating levels and the Action Alternative operating levels during the summer recreational season, which is considered by the USDA Forest Service from Memorial Day to Labor Day, or approximately 100 days.

People do notice the draw down level of the reservoir, along with the white line, but it does not detract from their recreational experience in the area. The low water marks and white line effects are only noticeable along some segments of the entire 300 miles of shoreline. During winter months, any visual impacts are naturally mitigated with a covering of snow.

4.14.1.1 No Action Alternative

The reservoir high water line is at 6040 feet above msl. Under the No Action Alternative, average monthly water levels for May, June, July, and August range between 6023.8 and 6029.1 (see section 4.3). The high water elevation during the same timeframe was 6038.6. Present water levels are around 6013. For the past 10 years, the average reservoir water level was managed at approximately 11 to 16 feet below high water level.

4.14.1.2 Action Alternative

The average monthly water levels for May, June, July, and August would range between 6025.8 and 6029.2 under Action Alternative conditions. The minimum water elevation would be 6008.5. The maximum water elevation would be 6033.8 (see section 4.3).

The difference from the No Action Alternative in the average end-of-month elevations would be 2 feet higher than minimum levels and essentially the same at average high levels. This would result in slightly less exposed overall shoreline.

Under both alternatives, there would be about 11-16 feet of exposed shoreline. The difference of 0-2 feet in exposed shoreline is negligible.

4.14.2 Green River

The USDA Forest Service visual management goal for the Green River corridor would be for a "natural appearing landscape character."

The BLM visual resource management goal, downstream from the forest boundary to Browns Park, is Class II management. Some altering of the landscape can occur, but management activities and structures should not attract a viewer's attention.

4.14.2.1 No Action Alternative

The average riverflows for May, June, July, and August range from 983 to 3,463 cfs under No Action riverflow conditions. The low flows would be about 800 cfs, and the high flows could reach 12,600 cfs (see section 4.3).

There are few to no visual effects on the streambanks, from the perspective of the casual visitor. In many cases, vegetation is growing in the zone between high and low water flows. Some mud banks and exposed rocks stick out of the water; however, they appear as a natural occurrence under low water conditions. Very few indications of a white mineral buildup are apparent on the cobble rocks or along the streambanks.

4.14.2.2 Action Alternative

The average riverflows for May, June, July, and August under Action Alternative conditions would range between 1,626-3,862 cfs. The low flows would be 800 cfs, and the high flows could reach 15,000 cfs (see section 4.3).

As compared with the No Action Alternative, low flows would go to 800 cfs. The average riverflow would range from 643 to 399 cfs above the No Action Alternative. The proposed high flows would be 2,400 cfs higher than the No Action Alternative.

The result of visual impacts would be less exposed streambank during the recreation season. The difference in visual impact from the No Action Alternative is considered negligible.

4.15 ENVIRONMENTAL JUSTICE

The Council on Environmental Quality's *Environmental Justice Guidance Under the National Environmental Policy Act* states minority population should be identified where either the minority population of the affected area exceeds 50% or the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population. Data from the U.S. Census of Population 1990 and 2000 were used to determine the minority population in the project area. *U.S. Census Bureau Estimates for People of All Ages in Poverty for 1989 and 1999* were used as a proxy for low income. Professional expertise and judgment were used to review impacts of implementing the Action Alternative to determine whether minority or low-income populations would be disproportionately adversely affected.

The minority populations of the study area are less than 50% of the total population; however, any potential adverse impacts to the Indian population must be considered.

4.15.1 No Action Alternative

The current trends for minority and low-income populations would continue.

4.15.2 Action Alternative

No adverse impacts with the potential to affect minority and low-income populations have been identified at Flaming Gorge Reservoir.

As discussed in section 3.6.2, lands within Reach 1 adjacent to the Green River are publicly owned. Since no one lives on these lands, there would not be any adverse environmental justice impacts in Daggett County or this portion of Uintah County.

All of Reach 2 is located within Uintah County. Public lands within the Dinosaur National Monument compose the first part of Reach 2. As described in section 3.6.2, the lands adjacent to the Green River downstream from Dinosaur National Monument to the Ouray National Wildlife Area are privately owned. The remainder of Reach 2 and the first portion of Reach 3 are Uintah and Ouray Reservation lands in Uintah County. Under the No Action Alternative, the private and reservation lands adjacent to the Green River in Uintah County would continue to experience inundation during peak runoff times as they have in the past. The adjacent landowners have become accustomed to impacts to agricultural lands and the oil and gas well operations during these peak runoff times. Under the Action Alternative, in some years, flows could exceed what adjacent landowners have experienced in the past. While impacts affecting reservation agricultural lands and oil and gas well operations have the potential to be an adverse environmental justice impact, the Northern Ute Tribe advised Reclamation during a meeting in April 2004 that advance notice from Reclamation would resolve issues of well access and impacts to cattle utilizing agricultural lands within the area of potential inundation. During the spring when high flows occur, there would be limited access just as it now occurs. There would be no significant difference between the Action and the No Action Alternatives. Thus, there would not be any adverse environmental justice impacts.

4.16 CUMULATIVE IMPACTS

This section analyzes the potential cumulative effects of the proposed action. As defined at 40 CFR 1508.7, a "cumulative impact" is an impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. It focuses on whether the proposed action, considered together with any known or reasonable foreseeable actions by Reclamation, the Recovery Program, other Federal or State agencies, or some other entity combined to cause an effect. There is no defined area for potential cumulative effects.

Historically, human use of the Green River presumably began to have some impact on the riverine environment in the 19th century. Greater impacts likely began occurring with the construction of the Tusher Wash diversion near Green River, Utah, in 1906. Construction of Flaming Gorge Dam from 1958 through 1964 resulted in a profound change to the riverine environment, which contributed to the decline of native fish species in the Green River and native vegetation along the Green River. The filling of Flaming Gorge Reservoir also inundated an unknown number of cultural and paleontological resources.

Alternatively, the creation of Flaming Gorge Reservoir, the establishment of the Flaming Gorge National Recreational Area, and the establishment of the trout fishery below Flaming Gorge Dam constitute significant benefits to recreation and the regional economy. Additional benefits were realized with the establishment of hydropower production and water storage capability.

Recognizing that construction of Flaming Gorge Dam caused both adverse and beneficial outcomes, implementation of the Action Alternative would, along with other Recovery Program efforts discussed in this document, improve the riverine environment for native fish, including the four threatened and endangered species, without causing significant impacts to any of the other resources potentially affected by the Action Alternative. Operations under the No Action Alternative could also benefit the endangered fish and the riverine environment, but the beneficial effects might not be sufficient or timely in assisting with the recovery of the four endangered Colorado River fish species.

The following sections address cumulative impacts by resource. These analyses focused on the Action Alternative considered in combination with related and ongoing actions identified in chapter 1 and other relevant activities or conditions. The question addressed in this section is whether the Action Alternative causes or contributes to a significant cumulative effect.

4.16.1 Water Resources and Hydrology

4.16.1.1 Water Consumption

The 2000 Flow and Temperature Recommendations for Reaches 1, 2, and 3 are based on the needs of the endangered fish, and they do not account for any future change in water consumption. As consumption increases over time, it may become more difficult to achieve the 2000 Flow and Temperature Recommendations through the re-operation of Flaming Gorge Dam. Because of increasing water consumption in the tributaries of the Green River below Flaming Gorge Dam, it is anticipated that releases from Flaming Gorge Dam will have to be greater in the future than what would be required now to achieve the 2000 Flow and Temperature Recommendations under similar hydrologic conditions. Increasing release requirements would reduce the ability of Flaming Gorge Dam to store water during wet periods. During dry periods, drawdown conditions would become more severe as a result of increased release requirements to meet downstream flow recommendations.

With increased water consumption in the basin, flows in Reaches 2 and 3 during the base flow period might achieve the 2000 Flow and Temperature Recommendations at lower levels than would occur at current water consumption levels. Increased pressure on reservoir storage could cause Reclamation to target lower flows within the range of acceptable flows for Reaches 2 and 3 to reduce the impact to reservoir storage. During the transition period, releases potentially could be lower in the future than they would be now as a result of increasing water consumption.

Water consumption above Flaming Gorge Reservoir is also expected to increase, and this could reduce the inflows to Flaming Gorge Reservoir. With less water flowing into Flaming Gorge Reservoir, pressure on water storage could increase in the future.

It is noted that the Action Alternative is a component of the Recovery Program's overall effort to recover the four endangered fish species. As such, the Action Alternative would contribute to offsetting the impacts of continued development and consumption of water resources while maintaining compliance with the Endangered Species Act.

4.16.1.2 Water Temperature

Past, present, and reasonably foreseeable future actions that could affect the thermal environment in the Green River below Flaming Gorge Dam include diversions and depletions of water from the Green River and its tributaries above and below Flaming Gorge Dam. Most depletions are interceptions of flow that are held in storage reservoirs, whereas diversions move water out of stream channels for offsite uses. Water usually is accumulated in storage reservoirs during the spring runoff period, whereas diversions occur over a lengthier period of time. Irrigation diversions occur during growing seasons for crops; municipal and industrial diversions can occur year round.

The thermal environment of the Green River below Flaming Gorge Dam has been highly impacted by perennial releases of cold water from the dam. Construction and operation of the selective withdrawal structure has diminished this effect, and the Action Alternative would further improve the thermal regime by increasing release temperatures. Depletions held in storage reservoirs are expected to have little effect on Green River water temperatures during spring runoff except in extremely dry years. Water released from the depths of these reservoirs during summer would likely be cooler than if it were not impounded, but this effect will persist only for a limited distance downstream from the reservoir. Little effect is anticipated on Green River temperatures from reservoirs releases in its tributaries.

Diversions from the Green River, or its tributaries, during summer could have a greater effect on water temperature. Diversions that decrease base flow would increase downstream water temperatures by reducing flow volume. If these diversions occur on the Yampa River, the relationship between the Green River and Yampa River water temperatures could be affected (warmer Yampa River temperatures). Additional instances of exceeding the recommended 9 °F (5 °C) temperature difference would likely occur. Similar responses may occur downstream at confluences of other tributaries, such as the Duchesne, White, and Price Rivers.

4.16.1.3 Sediment Transport and Channel Morphology

The construction of Flaming Gorge Dam significantly reduced the sediment source area for downstream reaches of the Green River by trapping the entire incoming sediment load. Flow frequency and sediment transport conditions downstream from Flaming Gorge Dam under the Action Alternative will not return to pre-reservoir conditions partly because of the continued existence of Flaming Gorge Dam and its sediment-trapping role. The Action Alternative represents a change from existing conditions of flow frequency and sediment transport for each reach, although the relative effect in these reaches will differ.

Within Reach 1, channel narrowing in Lodore Canyon has been associated with decreased sediment loading and decreased flow magnitude following completion of Flaming Gorge Dam. Under the Action Alternative, more frequent occurrence of high flows during the snowmelt runoff season will occur in Reach 1. In Lodore Canyon, channel areas that have become vegetated under present-day Flaming Gorge Dam operations could be eroded upon implementation of the Action Alternative. Thus, under the Action Alternative, channel width in Lodore Canyon may not approach pre-dam conditions but could be increased relative to existing conditions of channel width.

Within Reach 2, channel narrowing following initiation of water storage at Flaming Gorge Dam has been documented. In Reach 2, average annual sediment loading would be slightly increased under the Action Alternative. The Action Alternative targets flood plain habitats in Reach 2 by increasing the frequency of bankfull discharges. The increased frequency of bankfull flow conditions, when coupled with local levee removals under consideration by the Colorado River Recovery Program within the Green River channel and flood plain, could result in local channel changes including width, depth, and pattern beyond similar changes anticipated to occur as a result of the Action Alternative flow changes alone. These geomorphic adjustments could result in local changes in velocity and direction of flow as well as the duration of inundation for flood plain areas.

Former flood plains in portions of Reach 3 are no longer connected to the main channel of the Green River. With vegetation encroachment on these natural levees and a diminished frequency of overbank flooding under post-dam flow conditions, only extremely rare, high magnitude flows can reach these areas. Changes in flow frequency and sediment transport in Reach 3 under the Action Alternative are expected to be similar to those described for Reach 2. The modified frequency of high flows attributable to the Action Alternative alone is not likely to result in a reconnection between the Green River channel and its flood plain in Reach 3.

4.16.2 Hydropower

To analyze cumulative effects, additional hydropower analysis was performed to simulate the economic benefits from Flaming Gorge Dam and Reservoir operation, assuming a removal of most of the biological constraints. This simulation is generated for comparison purposes only and is not an alternative under consideration. Instead, it reflects the impacts from changes made in operations since 1973 and represents a cumulative impact of all constraints imposed in the past. This simulation used the same modeling as was used in the No Action and Action Alternatives, except for modifications in the reservoir operation policies, to reflect the lack of biological constraints.

This simulation is not restricted by any flow constraints except for a minimum flow rate of 800 cfs. This analysis reflects the increased operational flexibility, yielding more water being released during the summer months, when power prices are highest. With constraints removed, the economic value of the output over a 25-year simulation is greater, compared to the No Action and Action Alternatives.

The 25-year simulation of operations with few biological constraints shows that the economic value of the generation from Flaming Gorge powerplant would be greater than under the two alternatives with only slightly greater generation. This greater economic value would occur due to the lack of restraints on operation of the reservoir. This difference in economic value represents a simulation of changes since 1973. It does not reflect actual differences as the model made no attempt to calculate actual economic value for the hypothetical scenario since 1973, but used the forecasted model from the two alternatives as the basis for this simulation. Actual prices or generation (under the alternatives) since 1973 are not known or used. If actual prices from 1974 to 2000 time period had been used, the economic value for the hydropower cumulative impact may have been substantially less.

Table 4-30 provides the results. The data in the No Action and Action Alternatives columns are the same data shown previously in this chapter and presented for comparison purposes. The next column represents the summary of results from the "cumulative impacts" run. As shown, the cumulative impacts run simulates almost 29% more economic value compared to the No Action Alternative, with a $521.4-million output of power. This larger economic value occurs with only 2.7% increase in generation, due to the ability to simulate generation when prices are highest. In effect, the generators are run with almost no constraints other than to follow demand for electricity in the marketplace.

While the economic analysis is based on the benefits accrued to the Nation as a whole and the financial analysis refers to the cost of the power sold to customers of SCLA/IP, there is similarity in the results of the two analyses. The economic analysis shows that the value of the generation of electricity for the Action Alternative is greater than the value of the No Action Alternative by a small percentage based on the simulations. Similarly, the financial analysis shows a reduced cost to the customers of this power under the Action Alternative, reflecting this increased economic value that the customers would receive. Because of the increased economic value of the generation, the customers would receive higher valued power under the Action Alternative, requiring Western's purchases of electricity in the out years to be lower valued electricity, on average.

The fewer the constraints on the operation of the hydropower plant at Flaming Gorge Reservoir, the more likely that the market purchases of electricity by Western for the customers will be lower cost electricity.

4.16.3 Land Use

When considering the Action Alternative in conjunction with past, present, and reasonably foreseeable actions, there are no unacceptable cumulative effects for land use around the reservoir and along the Green River.

Table 4-30.—Comparisons of the Alternatives and a Cumulative Impact Simulation

	No Action Alternative	Action Alternative	Cumulative Impacts	Comparison of Cumulative Impacts to No Action Alternative
Net Present Value	$403.1 million	$423.1 million	$521.4 million	-29.3%
Generation in GWh	11,904.1	11,374.3	12,229.7	2.7%

4.16.4 Ecological Resources

4.16.4.1 Native Fish

Impacts to the native fish in the Green River Basin come in many forms and were present long before the Colorado pikeminnow was recognized as an endangered species some 35 years ago. To assess the cumulative effects (both negative and positive) associated with these impacts, it is necessary to consider historical, present, and reasonably foreseeable projects and actions. For the purposes of this cumulative analysis, impacts have been described in six general categories (flow depletions, loss/entrainment of fish at diversions structures, water quality, loss or fragmentation of habitat, Flaming Gorge Dam operations, and interactions with nonnative species). The cumulative effect of these impacts through time and into the reasonably foreseeable future are discussed below and summarized in table 4-31.

4.16.4.1.1 Flow Depletions – The U.S. Fish and Wildlife Service has recognized, in multiple biological opinions, that flow diversions and depletions have affected the Colorado River fishes and contributed to the original listing of the four endangered species. Flow depletions affect the ability of the river to create and maintain habitat.

Reductions in peak flows can also affect the behavior of fish that key in on rising flows to spawn during that time of the year. Through State and Federal laws, the Upper Basin States are entitled to develop 7.5 million acre-feet of Colorado River flows, and water development will no doubt continue. Historic and reasonably foreseeable future depletions have been summarized in table 4-31. The most profound effects of these depletions have occurred in the Duchesne River and some of the other tributaries to the Green River.

In 1987, the Recovery Program was established and since has served as the major offset for the impacts of historic and future water development projects in the Upper Colorado River Basin.

One of the specific objectives of the Recovery Program Green River Action Plan is the re-operation of Flaming Gorge Dam to provide flows needed for endangered fish recovery. The Recovery Program has also developed flow recommendations for the Yampa and the Duchesne Rivers, and is in the process of developing recommendations for the White and Price Rivers. Implementation of the Yampa River flow recommendations is underway as the U.S. Fish and Wildlife Service and the States of Colorado and Wyoming complete environmental compliance of their *Management Plan for Endangered Fishes in the Yampa River Basin*.

The Recovery Program will seek to secure, enhance, and protect recommended flows on many of the Green River tributaries.

In summary, flow depletions can have a significant cumulative effect on Colorado River fish populations. Re-operation of Flaming Gorge Dam is expected to contribute to other Recovery Program activities in supporting the recovery of the four endangered fish species.

Table 4-31.—Cumulative Impacts on Native Fish (Including Threatened and Endangered Species)[1]

Impact Category	Past	Present	Proposed Action	Reasonably Foreseeable	Cumulative
Flow Depletions[2]		(--)		(---)	(---)
Yampa[3]		125,271acre-feet per 10.9%		53,562 acre-feet additional; 178,833 acre-feet per 15.5% total	(-)
Duchesne[4]		567,000 acre-feet per 73.8%		25,300 acre-feet additional; 592,000 acre-feet per 77.1.% total	(---)
White[5, 6]		131,456 acre-feet per 22%		Unknown; 22% total	(-)
San Rafael[5, 7]		89,000 acre-feet per 44.5%		Unknown; 44.5% total	(--)
Price[8]		82,412 acre-feet per 52.4%		5,717 acre-feet additional; 88,219 acre-feet per 56% total	(--)
Green Reach 1[5]		372,331 acre-feet per 19.7%		42,100 acre-feet	(-)
Green Reach 2[9]		497,602 acre-feet		95,662 acre-feet (Reach 1 and Yampa)	(-)
Green Reach 3[5]		1,583,960 acre-feet per 32%		126,679 acre-feet (Yampa, Reach 1, Duchesne, and Price)	(-)
Loss of entrainment of native fish at diversions structures	(-)	(-)	(+)	(+)	(+)
Water Quality	(-)	(-)	(+)	(+)	(+)
Habitat Loss					
Diversions/Dams	(--)	(+)	(+)	(+)	(+)
Flood Plain Diking	(--)	(-)	(+)	(+)	(+)
Flaming Gorge Operations	(---)	(+)	(++)	(+)	(++)
Nonnative Species	(---)	(---)	(-,+)	(+)	(--)

[1] Negative effects to native fish are represented as follows: (-) relatively minor, (--) moderate, (---) strongly negative. Positive effects are presented in a similar format.

[2] Presented as average annual depletions in acre-feet per % of average annual natural flow–periods of record vary by basin.

[3] *Draft Management Plan for the Endangered Fishes in the Yampa River Basin.*

[4] Depletion estimates from Final Biological Opinion, Duchesne River Basin, Utah (6-UT-97-F-007), July 29, 1998. Average annual pre-depletions flow (768,000 acre-feet) reported in *Flow Recommendations for the Duchesne River with a Synopsis of Information Regarding Endangered Fish* (Modde and Keleher, 2003).

[5] Depletion estimates from Final Biological Opinion on the Operation of Flaming Gorge Dam, November 25, 1992.

[6] Average annual flow from Schmidt et al., 2002 Draft Report.

[7] Average annual flow from Price-San Rafael Rivers Unit, Utah; *Planning Report/Final Environmental Impact Statement*, December 1993.

[8] Biological Opinion for the Proposed Narrows Project – A Small Reclamation Project Act Loan, August 24, 2000.

[9] Represents the sum of the depletion figures used for Reach 1(Green River above Flaming Gorge Dam) and the Yampa River.

4.16.4.1.2 Entrainment/Loss of Native Fish at Diversion Structures – An unknown number of native fish has been entrained at irrigation diversions throughout the Upper Colorado River system for many years. Although this impact poses less of a threat to the fishes in the Green River than those in other parts of the Colorado River system where diversions are more plentiful, the threat remains. The Recovery Program has constructed screens on diversion structures in parts of the Colorado River Basin and has recently decided to screen the Tusher Wash diversion on the Green River in Reach 3. Tusher Wash, which diverts between 600-700 cfs, likely poses the greatest threat for native fish entrainment in the Green River Basin. In addition, the higher base flow targets associated with the Action Alternative would result in a smaller percentage of the Green River being diverted at Tusher Wash. If Tusher Wash is screened and the 2000 Flow and Temperature Recommendations are implemented, this threat to the native fish of the Green River system will have been removed.

4.16.4.1.3 Water Quality – Water quality in the Colorado River watershed, particularly in tributaries, has been degraded as a result of human uses and depletions. To address this threat to both humans and biological communities, salinity control efforts (Colorado River Water Quality Improvement Program) and selenium remediation programs (National Irrigation Water Quality Program) have been implemented to improve water quality in the Green River and the Colorado River system as a whole. In addition, higher base flows requested under the Action Alternative during most years would improve water quality in Reaches 2 and 3. The degree to which these efforts would result in water quality improvement, in light of ongoing depletions, remains to be seen.

4.16.4.1.4 Habitat Loss – The loss of aquatic habitat, due to river regulation, comes in many forms, including barriers to migration, construction of levees and dikes, thermal modification, and the inundation of riverine habitat during reservoir filling. The completion of Flaming Gorge Reservoir inundated over 90 miles of the Green River. The majority of that distance was occupied by native fish. Cold, hypolimnetic (bottom) releases from the dam subsequently rendered 65 miles of river downstream unsuitable for native fish. Similar types of habitat loss (on a smaller scale) have occurred on the White and Duchesne Rivers. Penstock modifications at Flaming Gorge Dam and temperature release recommendations implemented as a result of the 1992 Biological Opinion have improved conditions in Reach 1. It is likely that implementation of the 2000 Flow and Temperature Recommendations would substantially improve conditions for native fish in that portion of the river.

The Recovery Program, Utah Reclamation Mitigation and Conservation Commission, and local water user groups are currently investigating the benefits of providing fish passage at some of the smaller, low head diversion structures on the Duchesne River and other tributaries. Since native fish have been eliminated from many miles of historic habitat throughout the Green River Basin, efforts are being made to address the threat of continued habitat loss.

Aquatic habitat loss often stems from manipulations of streamside habitats (diking levee construction) that were altered to prevent lowland flooding of agricultural and livestock grazing lands. Flooded bottomlands provide important habitats for the native fish. Near Ouray, Utah, in excess of 2,500 acres of flood plain have been disconnected from the Green River when flows are less than 18,000 cfs. Another more natural form of diking, which is more prevalent in the lower Green River, is caused by the encroachment of nonnative vegetation (tamarisk). During the past 10 years, the Recovery Program has successfully acquired riverside properties, removed levees, and, as a result, restored portions of this important rearing habitat for native fish. The Recovery Program is planning similar efforts to secure and protect more of these flood plain areas. The spring peak flow and duration targets in the 2000 Flow and Temperature Recommendations are designed to create longer periods of flood plain inundation. Proposed Recovery Program efforts and implementation of the Action Alternative would further restore flood plain connectivity, reversing, to some degree, the loss of this crucial habitat. However, a confounding aspect of flood plain restoration is that nonnative species can also benefit; therefore, it is recommended that the cumulative effects of these efforts be monitored.

4.16.4.1.5 Flaming Gorge Dam Operations – Historical operations at Flaming Gorge Dam greatly impacted native fish by reducing and, in some years, eliminating spring peaks' elevating base flows and altering the temperature regime of the Green River. The 1992 Biological Opinion restored a more natural hydrograph through spring, summer, and fall and partially restored water temperatures to their pre-dam state. Implementing the Action Alternative would take the 1992 Biological Opinion a step further by prescribing year-round flows for the entire river and manipulating temperatures throughout a larger reach of the river. Although there are uncertainties associated with the Action Alternative, as there are with any large system experiment, the expected outcome is an increased benefit to native fish populations. Flaming Gorge Dam operations have been greatly improved over the course of the past 40 years.

4.16.4.2 Nonnative Fish

The 2000 Flow and Temperature Recommendations reported that introductions of 25 species of nonnative fish in the Green River Basin seriously impacted native fish. In recent years, the States of Colorado and Utah have adopted the Nonnative Fish Stocking Procedures, which were developed by the Recovery Program to eliminate introductions of additional nonnative species. Unfortunately, recent data show that the range and abundance of nonnative species in the system have expanded during the drought that is currently being experienced in the Western States. To address this threat, the Recovery Program has conducted studies to identify effective methodologies to control invasive fish species. Recovery Program efforts are currently underway to determine if some of the more problematic species can be effectively controlled in portions of the Green River Basin. The 2000 Flow and Temperature Recommendations are intended to benefit native fish; however, certain aspects may actually benefit nonnatives in the short term. At the present time and in the reasonably foreseeable future, nonnative fish pose a critical threat to the native fish and, as such, are a primary concern for the Recovery Program.

4.16.4.2.1 Trout – Construction of Flaming Gorge Dam created Flaming Gorge Reservoir which has become famous for its fishing opportunities. The clear, cool, deep water produces populations of large lake trout, brown trout, and rainbow trout. The reservoir also supports populations of cutthroat trout, kokanee salmon, smallmouth bass, and channel catfish.

The Green River below the dam is famous for trout fishing. The clear, cold tailwater releases provide excellent conditions for trout. Implementation of the 2000 Flow and Temperature Recommendations would likely improve conditions for this trout fishery by reducing daily flow fluctuations. Reducing flow fluctuations would reduce energy expenditures for these fish, thus reducing stress levels.

4.16.4.2.2 Summary of Cumulative Impacts to Fish – The Green River ecosystem has been and continues to be greatly altered. Long-term monitoring indicates that populations of Colorado pikeminnow and humpback chub in the Green River are relatively stable. Wild populations of razorback sucker and bonytail have been functionally extirpated. Hatchery-produced fish are surviving in the river and will hopefully respond to recovery actions. The

Action Alternative represents an effort to benefit native fish species. The Recovery Program and others are trying to address threats to the endangered fish on a variety of fronts. Whether future implementation of the Action Alternative and the other recovery efforts of the Recovery Program and others are sufficient to lead to the eventual recovery of these species remains an uncertainty. Specific uncertainties associated with implementation of the Action Alternative are identified in section 4.19 and will be monitored through an adaptive management approach.

4.16.4.3 Vegetation

4.16.4.3.1 Riparian/Wetland – Historical impacts and changes to riparian and wetland systems in the Colorado Plateau have been ongoing for many years. Grazing and streamflow depletion and regulation have been the major activities affecting riparian and wetland systems. With closure of Flaming Gorge Dam, the riparian community along the Green River began to change in character, with decreases in cottonwood regeneration especially notable. Water depletions in the Uinta Basin have led to reductions in size and quality of riparian and wetland areas. In addition, changes in hydrology and lowered water tables have encouraged the expansion of nonnative species that are more tolerant of altered, drier environments. With additional depletions planned for most streams in the region, the downward trend in quantity and quality of riparian and wetland systems is likely to continue. Under the Action Alternative, implementation of the recommended flows could result in small, positive changes for riparian and wetland areas and, therefore, would not contribute to a cumulative effect.

Tamarisk began to invade the lower Green River in the 1920s and continued to spread upstream before river regulation. This invasion is expected to continue throughout the region. Implementation of the Action Alternative may contribute to the spread of tamarisk in the higher flood plain areas and result in a cumulative effect. Giant whitetop seeds could also be expected to spread under the Action Alternative and contribute to a cumulative effect. It is unlikely that there would be a cumulative effect associated with Russian olive and the Action Alternative.

4.16.4.4 Terrestrial Wildlife

Present and future actions that alter stream channel and flow characteristics have and will continue to have negative impacts on the riparian habitat of terrestrial and avian species that depend on these areas. Although it is unlikely that re-operation of Flaming Gorge Dam will completely compensate for the effects of all future and past water projects, the implementation of the 2000 Flow and Temperature Recommendations will likely prove to be beneficial to wildlife species that use riparian, wetland, flood plain, and riverine habitats.

4.16.4.5 Other Threatened and Endangered Species

4.16.4.5.1 Southwestern Willow Flycatcher – Implementation of the Action Alternative would not contribute to a cumulative effect for southwestern willow flycatcher. Regional cumulative effects are largely those associated with loss of riparian habitat. As stated above, historical water depletions and regulation along the tributaries to the Green and Colorado Rivers have led to a substantial decrease in the amount and quality of native riparian habitat. Because southwestern willow flycatchers are dependent on riparian corridors to fulfill a significant portion of their lifecycle, the loss of streamside vegetation had adversely affected these populations in the Colorado River watershed. Proposed increases in oil and gas drilling may also contribute to a decrease in suitable habitat. At present, suitable habitat is not seen as a limiting factor for southwestern willow flycatcher on the Green River. As recovery of the species occurs and populations rebound, increasing the amount of suitable habitat may become increasingly important.

4.16.4.5.2 Ute Ladies'-Tresses – Historical impacts to Ute ladies'-tresses sites in the Uinta Basin and Colorado Plateau have largely stemmed from agricultural activities. Water depletions in the region have resulted in, and are likely to continue to result in, reductions in size and quality of riparian wetlands, upon which Ute ladies' -tresses depends. Additionally, continued water depletions have decreased water tables causing a reduction in the amount of riparian areas, allowing more drought tolerant and upland vegetation communities to dominate. Floodflows, as well, have been reduced on some Green River tributaries, thereby limiting the resetting of vegetation succession—a component needed for establishment of Ute ladies'-tresses. Flow alteration projects, such as that proposed in the Action Alternative for the re-operation of Flaming Gorge Dam, provide stable summer flows and have likely contributed to the persistence of Ute ladies'-tresses at some sites. Under pre-dam conditions, colonies likely winked in and out of existence over long time periods as rivers migrated back and forth throughout their flood plains.

The U.S. Army Corp of Engineers' proposed restoration of Ashley Creek in the Uinta Basin may have a temporary negative effect on Ute ladies'-tresses. The draft Ute ladies' tresses recovery plan is supportive of a restoration project and states that loss of any single Ute ladies'-tresses colony or group of colonies is acceptable if the ecosystem is benefited as a result of the action. In summary, the proposed Action Alternative, combined with continued regional impacts, may result in a cumulative effect to Ute ladies'-tresses.

4.16.4.6 Special Status Species

4.16.4.6.1 Yellow-Billed Cuckoo – Long-term and regional cumulative effects to yellow-billed cuckoo are largely those associated with the loss of riparian habitat. As stated in chapter 3, historical water depletions, water regulation, and livestock grazing along the tributaries to the Green and Yampa Rivers have led to a substantial decrease in the amount and quality of riparian habitat, especially cottonwood forests. Little cottonwood regeneration occurs on most tributaries in the region. Grazing has altered otherwise suitable habitat through the loss of or reduction in the thick shrub understory that characterizes suitable habitat for nesting yellow-billed cuckoo. With additional depletions planned for most streams in the region, the downward trend in quantity and quality of riparian and wetland systems is likely to continue.

Under the Action Alternative, positive benefits to riparian vegetation in Reach 2 and the upper portion of Reach 3 may provide a small reprieve in the rate of cottonwood forest decline in the region. The lower portion of Reach 3 would continue to decline in quality and quantity of suitable habitat. The results would likely be a cumulative effect for this section of the river.

4.16.5 Cultural Resources

To accurately assess cumulative effects, Reclamation has evaluated its operation of Flaming Gorge Dam over time and under the Action Alternative, combined with long-term actions and plans issued by other land managing agencies. Baseline conditions of cultural resources in 1984 and 1994 were addressed in two management plans issued by the BLM*: The Final EIS on the Book Cliffs Resource Management Plan*, issued in November 1984, and the *Diamond Mountain Resource Area Resource Management Plan and Record of Decision*, 1994.

4.16.5.1 Flaming Gorge Reservoir

Cultural resource sites located within the normal range of fluctuation were already impacted by inundation from Flaming Gorge Reservoir and will not be subjected to a new or different change in impacts due to Flaming Gorge Dam operation under the Action Alternative. The surrounding greater Flaming Gorge Reservoir area may receive more visitors in the future. This has the potential to cause more unintentional and/or intentional alterations to sites; however, as the land management agency at Flaming Gorge Reservoir, the USDA Forest Service has responsibility for the protection of cultural resources. There are no effects from the proposed action that would affect visitation or visitor impacts. No past, present, or reasonably foreseeable actions are expected to result in cumulative impacts to sites located in and around Flaming Gorge Reservoir. Thus, there would be no cumulative effects to cultural resources from the Action Alternative.

4.16.5.2 Reaches 1 and 2

Inundation from the highest historical release from Flaming Gorge Dam defines the past impact to cultural resources from dam operations. The highest historical release from Flaming Gorge Dam was 12,300 cfs in July 1983, which defined the largest area affected along Reaches 1 and 2 in the past 37 years since Flaming Gorge Reservoir filled. Based on the hydrology modeling results presented in chapter 4, under the Action Alternative, statistically there is a 6% chance of exceeding the 12,300-cfs high release over the next 100 years in Reach 1; less of a chance for exceeding the 12,300-cfs threshold exists in Reach 2. In other words, there is a chance of exceeding the highest historical release for at least 1 day six times over the next 100 years. Therefore, there is very little chance of a cumulative impact of the Action Alternative resulting in additional impacts to cultural resources in Reaches 1 and 2.

4.16.5.3 Reach 3

Cumulative effects in Reach 3 from either the No Action or the Action Alternative will be negligible since the area in which it is located is so far removed from Flaming Gorge Reservoir. Cultural resources in parts of this reach have been analyzed by the BLM in the 1984 and 1994 reports previously mentioned in this section. Measures proposed by the BLM for the Green River corridor addressed in these two documents would be beneficial in the long term for cultural resources.

4.16.6 Paleontological Resources

According to the sensitivity assessment maps produced for this project (DeBlieux et al., 2002), the Flaming Gorge Reservoir pool area has the most sensitive paleontological areas within the Action Alternative area for this project. Paleontological sites exposed along the shoreline of the reservoir will not be exposed to cumulative impacts which are accelerated beyond what has occurred for the past 37 years. The most precarious situation for paleontological resources exposed by fluctuating water levels in the reasonably foreseeable future may be the exposure to unintentional and intentional vandalism from visitation. In the future, occasional surveys of the shoreline around Flaming Gorge Reservoir are planned by the Ashley National Forest. Such surveys may locate significant sites which would add valuable knowledge to what is presently known about paleontology in the Flaming Gorge Dam region.

4.16.7 Indian Trust Assets

The development and operation of oil and gas wells associated with tribal mineral rights, which have also been identified as Indian trust assets, are expected to continue. No present or reasonably foreseeable actions are expected to result in adverse cumulative impacts to Indian trust assets. Thus, there would be no adverse cumulative impacts to Indian trust assets from implementation of the Action Alternative.

4.16.8 Recreation

The BLM (Vernal Office) and USDA Forest Service (Ashley National Forest) have initiated several resource and river management plans along the Green River over the past 25 years. All of these efforts appear to have had either a negligible or positive effect on water-based recreation on or along the river. None of the plans appear to have impacted recreation at Flaming Gorge Reservoir in any significant way. As a result, the cumulative effects of the Action Alternative, in conjunction with these past actions appears insignificant. In addition, the only current action other than the Action Alternative that is likely to significantly affect water-based recreation within the Flaming Gorge National Recreation Area is the proposed relocation of the Little Hole National Recreation Trail along the Green River immediately downstream from Flaming Gorge Dam. The recreation analysis found in this report assumes the trail will be relocated, thereby reducing river access problems during high water conditions. As a result, the recreation analysis already reflects cumulative effects of both the Action Alternative and the proposed relocation of the recreation trail. Actual relocation of this trail is dependent on adequate funding to the Ashley National Forest through the USDA Forest Service budgeting process. In addition, the Ashley National Forest, USDA Forest Service unit charged with managing recreation activities within Flaming Gorge National Recreation Area, will be revising its Land and Resource Management Plan in the near future. Given recreation is one of the primary objectives of a national recreation area, it is assumed that the management plan revision will likely result in improved conditions for recreation, including water-based recreation.

4.16.9 Socioeconomics

The small town of Dutch John, Utah, originally developed as a staging area during the construction of Flaming Gorge Dam, has recently been the focus of a legislative exchange between Reclamation, USDA Forest Service, and Daggett County, whereby most land, infrastructure, and utilities were transferred from the two U.S. Government agencies to Daggett County. Daggett County now has the responsibility of administering the majority of Dutch John. The county is presently developing a planning process for Dutch John, with the overall goal of making the community self-sufficient in terms of economic opportunities for its residents as well as generating the necessary tax base for maintenance of public facilities. Since the town is completely surrounded by Flaming Gorge National Recreation Area, it is assumed that the majority of economic development will cater to tourist activities. Furthermore, on average, the Action Alternative is expected to result in increased recreation visitation and expenditures compared to the No Action Alternative on both the river and reservoir. It is therefore likely that the Action Alternative and the legislative exchange of Dutch John could result in increases in regional economic activity. During wet and dry conditions, while the overall result in terms of recreation expenditures is positive, it is not possible to determine whether the gains on the reservoir would outweigh the losses on the river from the perspective of Dutch John.

4.16.10 Public Safety

4.16.10.1 Vectors

The principle health concern related to this action and past, present, or reasonably foreseeable actions in the Green River Basin is the establishment of West Nile virus, a neurological pathogen that, in severe cases, can cause encephalitis or meningitis in humans. Discovered in Africa and the

Middle East in the 1930s, West Nile virus was first reported in the United States in 1999. The virus is being spread primarily by blackbirds from the east coast of the United States to the west coast and is creating, and will likely continue to create, a major public health concern. It is possible that mosquitoes and other vectors are already present in the United States, which may transmit other diseases to animals and people. It is not expected that the Action Alternative would have a significant increase in the mosquito population, which could, in turn, lead to an increase risk of exposure to West Nile virus.

4.16.11 Environmental Justice

No present or reasonably foreseeable actions have been identified that would significantly impact minorities or the income levels of populations around or downstream from Flaming Gorge Dam and Reservoir. Implementation of the Action Alternative would not create any cumulative effects to minority and low-income populations. Thus, there would be no cumulative impacts to environmental justice from implementation of the Action Alternative.

4.17 RELATIONSHIP BETWEEN SHORT-TERM USES OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

Operating Flaming Gorge Dam under the Action Alternative would generally result in higher spring peak flows, for longer periods of time, than operating the dam under the No Action Alternative. During periods of high flow on the river, recreational use of the river corridor might be precluded for periods of 1 day to several weeks. Long-term productivity of the river corridor would be enhanced under the Action Alternative for the endangered fish species as well as for nonnative fish and riparian vegetation and habitat.

4.18 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

Water released from the dam through the bypass tubes or spillway to meet the recommended spring peak flows under the Action Alternative would constitute an irreversible and irretrievable loss of that water for electrical generation.

4.19 UNCERTAINTIES

The analyses presented in this EIS identify impacts to resources based on the best available data. Uncertainties regarding both Reclamation’s ability to meet flow and water temperature targets specified for the Action Alternative and the potential effects of meeting those flow and temperature targets are identified throughout the EIS. This section summarizes the uncertainties associated with implementing the Action Alternative. Section 4.20, below, sets forth an adaptive management process for addressing these uncertainties under future operations.

The authors of the 2000 Flow and Temperature Recommendations recognized uncertainties in their general approach and specific recommendations (2000 Flow and Temperature Recommendations). Their recommendations are based on a model that the ecological integrity of river ecosystems is linked to their dynamic character (Stanford et al., 1996; Poff et al., 1997) and that restoring more natural flow and thermal regimes is a key element to rehabilitating an impaired system. They recognized, however, that the response of the endangered fishes of the Green River to a more natural flow regime and water temperatures remains largely unmeasured and that factors other than modifications to physical habitat are impacting these species.

4.19.1 Hydrology

There are many uncertainties associated with the Flaming Gorge Model that were dealt with through modeling assumptions. This section details the assumptions inherent to the Flaming Gorge Model that are, in reality, uncertainties that cannot be fully characterized.

There was an inherent assumption in the Flaming Gorge Model that it would be possible to select the most ideal candidate years for achieving the high level spring flow recommendations in Reach 2. The Flaming Gorge Model used post processed information for making these decisions. In reality, making the decision of which years to attempt to achieve the higher level spring flow recommendations will be difficult. In general, the Flaming Gorge Model was optimized so that the high level objectives were targeted only when the most ideal Yampa River runoff patterns occurred. Basin indicators such as snow levels, temperature, and climate will be useful for making the yearly decision in the future; however, it is uncertain how accurately these decisions will be made when under real time operation.

During the spring peak release under the Action Alternative, it would be necessary to match the flows of the Yampa River optimally to achieve specific targets in Reach 2 of the Green River. The Flaming Gorge Model had an inherent assumption that daily average releases could be managed to achieve targets in Reach 2 to within 300 cfs. It is uncertain that this level of precision can be obtained under normal springtime operations.

The Flaming Gorge Model assumed that water development in the Upper Green River Basin and the Yampa River Basin would continue at the rate projected by the Upper Colorado River Commission. The Flaming Gorge Model achieved the flow objectives of the 2000 Flow and Temperature Recommendations independent of the level of future water development in the Yampa River Basin. Under the Action Alternative, as development in this basin increases, the releases required to meet the flow objectives increase. It is uncertain what resource impacts would occur as a result of future water development in the Green River Basin above and below Flaming Gorge Reservoir.

The analysis of Reach 3 flows, presented in this EIS, was an aggregation of the predicted Reach 1 flows from the Flaming Gorge Model and the estimated historic inflow from all tributaries on the Green River. In the future, water development in these tributaries will be at a higher level than in the past. It is uncertain that achieving the flow objectives for Reach 2 will provide flows high enough to achieve the flow objectives for Reach 3 in the future as shown in this EIS.

The Flaming Gorge Model inherently assumed that releases from Flaming Gorge Dam could be made from the powerplant, bypass tubes, and spillway at all times during the model run. While it is unlikely that these water release methods would not be available under real time operations, it is a possibility which could impact how Flaming Gorge Dam would be operated under the Action Alternative. There is a remote possibility that under real time operations, Flaming Gorge Dam could have a physical restriction that might prevent enough water from being released to achieve the 2000 Flow and Temperature Recommendations objectives. The Flaming Gorge Model did not account for this remote possibility.

4.19.2 Operational Limitations for Temperature of Water Released From the Dam

Reservoir modeling using CEQUAL-W2 shows that desired reservoir water temperatures for endangered fish are available for release when needed through the Flaming Gorge Dam selective withdrawal structure. Because release water is used to cool turbine bearings, temperature limitations associated with the turbine bearings may at times limit the ability to release warmer water. Recent (2002) changes in lubricants used to cool the bearings and maintenance of screens through which these waters pass have allowed warmer water to be released from the dam. An additional increment of warming might be gained by adjusting the temperature levels at which alarms are tripped in the powerplant without compromising dam operations. (Vermeyen). How much additional increase in release temperatures can be realized would have to be determined through testing at Flaming Gorge Dam.

4.19.3 Uncertainties Associated With Increased Spillway Use

Under the Action Alternative, with increased spillway use, there is greater opportunity for degradation of concrete in the spillway. The potential magnitude of this degradation is difficult to quantify. Reclamation would inspect the spillway following each period of use and evaluate the need for repairs. If damage to the spillway were to become excessive in operations under the Action Alternative, repairs would be made or, if necessary, usage would be limited to hydrologically necessary operations.

Nitrogen saturation within the tailwater area is a phenomenon that has occurred during spillway use at other dams and could occur at Flaming Gorge Dam. The potential for nitrogen saturation to affect the trout fishery would need to be assessed. Reclamation would consult with the UDWR to ascertain whether monitoring, as part of their ongoing management of the trout fishery, would provide the necessary information to identify any potential problems.

4.19.4 Fish Responses to Flow and Temperature Modifications

Reclamation would coordinate with the Recovery Program in developing the appropriate studies through an adaptive management process to evaluate effects of increased release temperatures on the downstream fish community. Section 4.7 of this EIS discussed the uncertainty as to how the fish community, in particular the nonnative fish community, would respond to the proposed changes in Flaming Gorge Dam operations. The proposed 2000 Flow and Temperature Recommendations in the Action Alternative would benefit both native species and nonnative species. It is possible that releases of warmer water could result in the expansion of cool water nonnatives in Reach 1, an area where their current populations are comparatively low; and warm water nonnative species could benefit from the increased warm water flood plain habitats that will result from increased overbank flooding. The authors of the 2000 Flow and Temperature Recommendations recommended to the Recovery Program that continued monitoring of these uncertainties, including the response of the endangered species to their proposed flow and temperature recommendations, would be required. Reclamation agrees that future monitoring through the Recovery Program would be appropriate if the Action Alternative is implemented. Nonnative fish control, which presently is being undertaken by the Recovery Program, would also be an important future component if nonnative fish species benefit from the proposed 2000 Flow and Temperature Recommendations.

Nonnative fish colonization of flood plain depressions inundated through the Action Alternative may interfere with survival of endangered fish in those habitats.

Christopherson and Birchell (2004) documented survival of both razorback sucker and bonytail larvae in a flood plain depression in the presence of nonnative fish. The study simulated conditions in a "reset" flood plain whereby both native and nonnative fish are entrained into a previously dry depression. Valdez and Nelson (2004) identified interactions with nonnative fish as an uncertainty in the success of flood plain management and advocated periodic desiccation of key flood plain depressions to alleviate those interactions. Reclamation would thus coordinate with the Recovery Program in developing the appropriate studies and actions through an adaptive management process to address management of nonnative fish in flood plain depressions.

The 2000 Flow and Temperature Recommendations also recognized uncertainty with their base flow recommendations. They felt relatively confident with the general relationship between the spring peaks and the necessary base flows to maximize nursery habitats, but they understood that base flows could vary from year to year as a function of variation in tributary inputs. They also mentioned that the effects of within-day fluctuations on nursery habitat conditions warranted further investigation. The Recovery Program and Western are currently funding research to better understand these relationships.

An uncertainty that arose during the development of this EIS was the extent to which operations under the Action Alternative, specifically the increased frequency of bypassing water, would result in increased entrainment of reservoir nonnative species. If the Action Alternative is implemented, Reclamation believes that future monitoring through the Recovery Program would be appropriate. The 2000 Flow and Temperature Recommendations, including monitoring their effects on the fish community in Reach 1 would be evaluated. This Reach 1 monitoring should include specific efforts to evaluate the potential for establishing undesirable reservoir fishes, such as smallmouth bass, in the tailwater. Nonnative fish control, which presently is being undertaken by the Recovery Program, would also be an important future component in determining the extent to which nonnative fish species benefit from the proposed flow and temperature recommendations.

Regarding temperature preferences for Colorado pikeminnow, temperature modeling indicates that, during wet years, releasing 59 ºF (15 ºC) water at Flaming Gorge Dam will result in barely meeting the minimum threshold of 64.5 ºF (18.0 ºC) in Upper Lodore Canyon (table 4-3). Furthermore, an analysis of accumulated thermal units (figure 4-15), as derived from Green River temperature modeling, indicates the river may not warm enough during wet years to provide suitable conditions for year-round Colorado pikeminnow use. If warmer water could be released at the dam during wet years, the Green River would approach the threshold of 24 ATUs (July/August timeframe) in a greater number of years. Attaining this threshold potentially could improve Colorado pikeminnow survivorship due to higher growth rates and larger size of the fish.

Reclamation personnel consulted with the authors of the 2000 Flow and Temperature Recommendations for some clarification on why they identified "releasing up to 59 ºF (15 ºC) at the dam" to meet their temperature recommendation. The authors stated that their intent was to get as much warming in Lodore Canyon as possible without harming the trout fishery. They wrote the document with the understanding that 59 ºF (15 ºC) water was all that was available at the dam, which represented the best available information at that time. Recent reservoir temperature modeling indicates that warmer water is available in Flaming Gorge Reservoir (section 3.3.2) and can be released through the selective withdrawal structure. An analysis of releasing 61 ºF (16 ºC) water indicates that conditions for adult Colorado

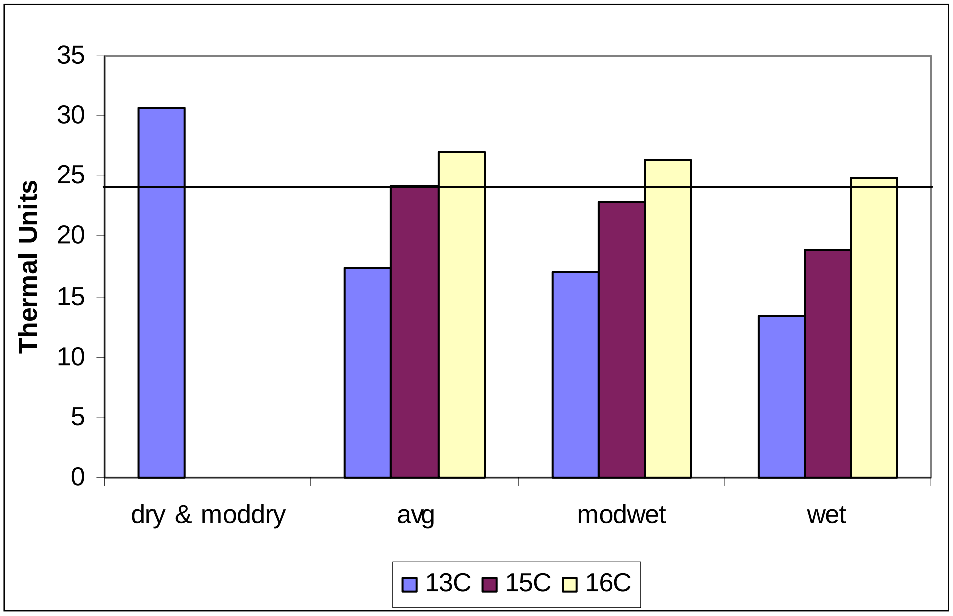

Figure 4-15.—Thermal Units Accumulated in Upper Lodore Canyon (46 Miles Below Flaming Gorge Dam) Under Various Hydrologic Scenarios. Hydrologic categories: dry and moderately dry (moddry) = 800 cfs; average (average) = 1,400 cfs; moderately wet (modwet) = 2,000 cfs; and wet = 2,400 cfs. Average daily temperatures used to derive ATUs were excerpted from the Flaming Gorge Temperature Model (Dr. John Carron, Hydrosphere Resource Consultants). A horizontal line was drawn at 24 ATUs, which is used to represent a threshold value that characterizes suitable Colorado pikeminnow home range. There are no values for 15 °C (or 16 °C) during the dry and moderately dry years, which is consistent with the Action Alternative as described.

pikeminnow could be improved in Lodore Canyon during wetter years (figure 4-12). This release temperature has not been included in the Action Alternative because it exceeds what was specified the 2000 Flow and Temperature Recommendations. However, subsequent communication from the authors of the 2000 Flow and Temperature Recommendations indicates they likely would have recommended a higher release temperature if they had known it was possible to do so. The 61 ºF (16 ºC) release temperature analysis is discussed here to illustrate the potential added benefit of exceeding the 59 ºF (15 ºC) release temperature identified in the Action Alternative.

4.19.5 Uncertainties Associated With Flood Plain Inundation

Peak flows recommended for Reach 2 were intended to provide inundation of flood plain nursery habitats in wetter years and to promote access to those flood plains by newly hatched razorback sucker larvae drifting from upstream spawning areas. Specific frequencies of flood plain connection to the main channel were recommended to ensure that razorback sucker juveniles overwintering in flood plains were allowed an opportunity to return to the main channel in subsequent years.

The 2000 Flow and Temperature Recommendations recommended that peak flows in Reach 2 should have the magnitude, timing, and duration that would provide flood plain inundation for at least 2 weeks in 40% of all years. Under average hydrologic conditions, the recommendations call for instantaneous peak flows ≥18,600 cfs in 50% of average years and peak flows ≥18,600 cfs for at least 2 weeks in 25% of average years. In moderately wet years, the recommendations call for flows ≥18,600 cfs for 2 weeks or more. In wet years, it was recommended that flows ≥22,700 cfs be maintained for 2 weeks or more and that flows ≥18,600 cfs be maintained for at least 4 weeks. The 2000 Flow and Temperature Recommendations also state that the duration of peak flows <18,600 cfs should be limited, because the area of flood plain habitats was greatly increased at flows above this level on the basis of aerial photographs, flood plain elevations, and site reconnaissance (Irving and Burdick, 1995; Irving and Day, 1996; Bell [undated]; Bell et al., 1998; Cluer and Hammack, 1999). These studies identified potentially inundated areas but did not determine direct surface connection with the main channel.

In general, most drifting larvae are present over a period of approximately 2 weeks (2000 Flow and Temperature Recommendations). Because larvae will likely starve within days (Popoulias and Minckley (1990, 1992) if they are not entrained into suitable nursery habitats, it is imperative that these habitats are connected to the river when larvae are drifting. This 2-week period of drift is the basis of the recommendation that flows of at least 18,600 cfs be maintained for a period of 2 weeks or more in 40% of years.

The 2000 Flow and Temperature Recommendations recognized that access to flood plain habitats could be achieved through a combination of increased peak flows, prolonged peak flow duration, lower bank or levee heights, and constructed inlets. Although their recommendations were based on the relationships for inundation with levees in place, they identified the relationships between flood plain inundation and flow with and without existing levees in place. Their report indicated that substantially more flood plain habitat could be inundated with lower peak flows if levees were removed.

Studies conducted since publication of the 2000 Flow and Temperature Recommendations have led to a better understanding of the flood plain habitats that are most important as razorback sucker nursery habitats and how those habitats could be managed to improve survival of native fish. In addition, a number of important flood plain habitats have been altered to allow inundation to occur at lower peak flows. This information recently has been summarized and incorporated into a flood plain management plan for the Green River subbasin (Valdez and Nelson, 2004). This new information and these developments identify potential flood plain habitats available at flows other than the peak flow recommendations of the 2000 Flow and Temperature Recommendations.

Flood plain habitats in the Green River can be classified as depression flood plains or terrace flood plains (Valdez and Nelson, 2004). Depression flood plains are considered to be far more valuable as razorback sucker nursery areas than terrace flood plains. Depression flood plains are typically separated from the main channel by an elevated levee (natural or constructed). Terrace flood plains are sloping features that are separated from the main channel only by elevation (Valdez and Nelson, 2004). Both of these flood plain habitat types may become inundated during annual spring peak flows. As peak flows recede, depression flood plain habitats retain water at an elevation determined by the elevation of associated levee features. Some depression flood plains can hold water through one or more years. For these habitats, subsequent spring peak flows of sufficient magnitude reconnect the habitat to the main channel before the water in the habitat has been entirely depleted. In contrast, terrace flood plains drain as flows recede, do not retain water for long, and dry out each year once peak flows recede.

When the Flaming Gorge 2000 Flow and Temperature Recommendations were developed, recommended peak flow levels were based on the relationship between flow and the total area of flood plain habitat inundated with levees in place. This relationship did not differentiate between depression and terrace flood plain types and did not consider the duration with which these habitats would hold water. Valdez and Nelson (2004) compiled site-specific information on depression and terrace flood plains in the middle Green River, and this new information suggests that 13,000 cfs may provide sufficient and comparable levels of connection and inundation of depression flood plain habitats relative to 18,600 cfs.

Valdez also developed a model (Valdez and Nelson, 2004) to evaluate the potential for flood plain habitats to entrain drifting larvae. The model indicates that the probability of entrainment decreases exponentially in a downstream fashion and predicts that only about 1% of the drifting larvae would be available for entrainment 36 miles downstream from the spawning bar.

The information provided in Valdez and Nelson (2004) indicates that the area of depression flood plains potentially inundated by 13,000-cfs and 18,600-cfs flows is identical (about 2,200 acres) for the first 52 miles downstream from the only known razorback spawning bar in Reach 2 (figure 4-16). At greater distances, 18,600-cfs flows would inundate an additional 1,186 acres of depression flood plains.

Inundation and connection of priority depression flood plains might be provided in

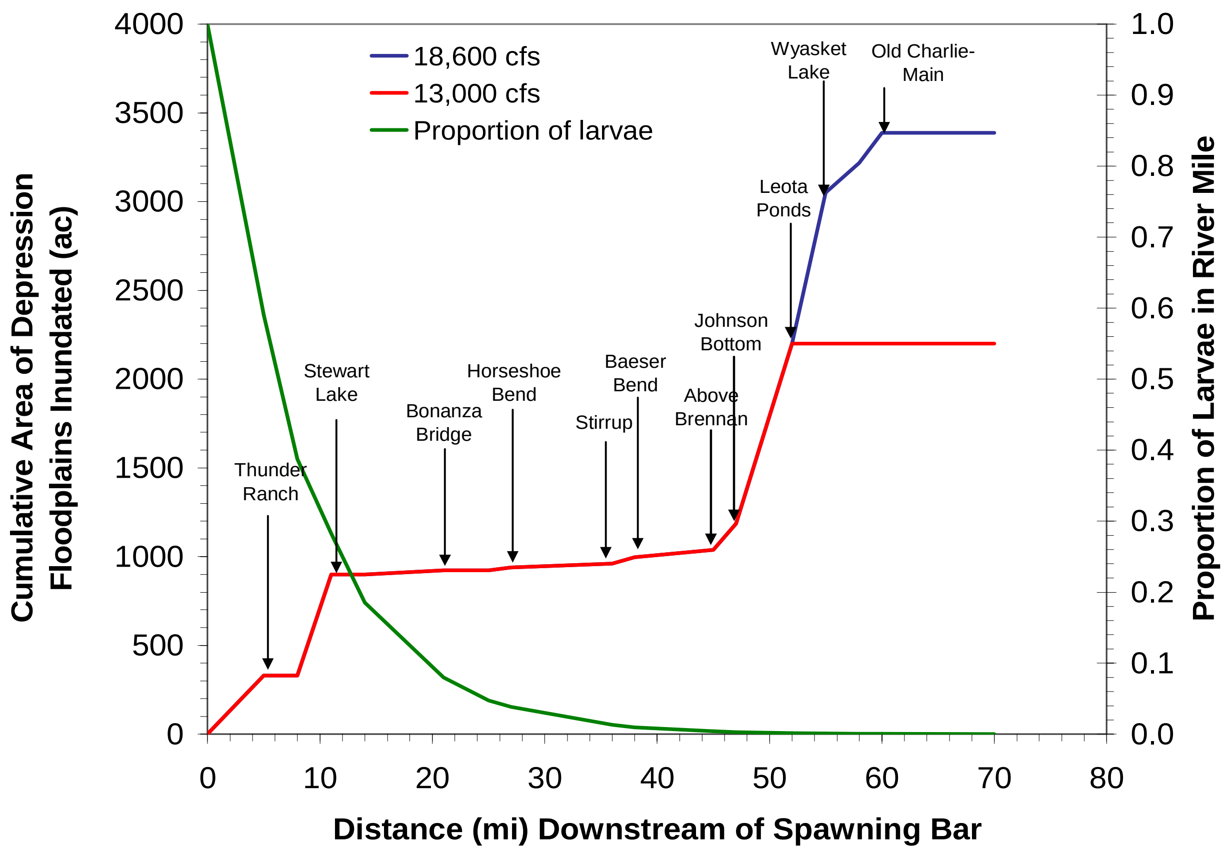

Figure 4-16.— Cumulative Area of Priority Depression Flood Plain Inundated at 13,000 cfs and 18,600 cfs and Proportion of Larvae Entering River Mile According to Distance Downstream From the Razorback Spawning Bar. Source: Modified from Valdez and Nelson (2004).

most years (about 70%) with a release of ≥13,000 cfs. Thus, connection and inundation could potentially be achieved with ≥13,000 cfs would have a corollary benefit of requiring fewer bypasses or spills at Flaming Gorge Dam, thus reducing conflicts with other authorized purposes of the dam.

While information in Valdez and Nelson (2004) suggests that it may be possible to inundate considerable acreage of flood plain depression wetlands at elevations below those identified in the 2000 Flow and Temperature Recommendations, it is uncertain that other flow recommendation objectives (native fish habitat, channel maintenance, nutrient exchange, and natural variability in the hydrograph) can be met if flood plain inundation were the only criteria for spring flow elevations. In response to the issue of inundation at flow levels below those identified in the 2000 Flow and Temperature Recommendations, Recovery Program biologists believe that assumptions underlying predictions of Valdez and Nelson (2004) regarding downstream declines in larval density and larval entrainment rates have not been validated and, in some cases, conflict with existing data (Muth, 1995). Also, functions apart from flood plain inundation for razorback sucker larvae also have direct links with habitat for other endangered fishes such as backwaters for early life stages of Colorado pikeminnow and bonytail. Thus, testing hypotheses of flood plain inundation at any flow elevation would need to occur as part of an adaptive management process and in consultation with the Recovery Program.

To resolve uncertainties associated with flows and nonflow actions that may be required for flood plain inundation, Reclamation would coordinate these studies through the Recovery Program. These studies would be conducted using an adaptive management approach as described in section 4.20. Topics that would be addressed include, but are not limited to:

- ❖ Expected differences in the area of depression flood plains inundated at different flows with levees removed, notched, or modified
- ❖ Flow and stage at which flood plains with levee breaches actually become sufficiently inundated to provide nursery habitat for razorback suckers
- ❖ Total flood plain area inundated at 13,000 cfs and 18,600 cfs
- ❖ Area of depression flood plain habitat inundated at 13,000 cfs and 18,600 cfs
- ❖ Area of flood plain depression habitat that persists after peak flows recede and the relationship, if any, between that and the magnitude of the peak flow
- ❖ Abundance of drifting razorback sucker larvae as a function of distance from the razorback sucker spawning bar
- ❖ Entrainment of larvae into flood plain nursery habitats as a function of distance from the razorback sucker spawning bar
- ❖ Entrainment and retention of larvae into flood plain nursery habitats as a function of the physical characteristics of the habitat including size, volume, local hydraulic conditions, inlet(s), and outlet(s)
- ❖ Temporal relationships between drifting larvae and hydrology during the runoff period with special attention to the duration needed to entrain most drifting larvae.

Resolving these uncertainties along with other uncertainties in flow recommendations is a priority of the Recovery Program. The above studies would be incorporated into the flow evaluation process of the Recovery Program. To increase the effectiveness of resolving these uncertainties, controlled experiments, and associated studies could be performed that capitalize on hydrologic conditions in a given year and that address as many topics as practicable in any one year. For instance, some differences between 13,000 cfs and 18,600 cfs could be tested in a given year if flows were stepped such that 13,000 cfs and 18,600 cfs were provided for sufficient time to test differences. Uncertainties and research needs are identified in Valdez and Nelson (2004) and provide an overview of research needs to better understand the relationship of riverflow to proper functioning flood plains. The completion of controlled experiments, gathering and analyzing data, and the modification of flow recommendations, if warranted, could be completed in 3 to 5 years, depending on hydrological conditions.

4.19.6 Riparian/Vegetation

As discussed in section 4.7.5, there are uncertainties associated with the response of invasive species to the Action Alternative. Recent research suggests that the floodflows may prevent additional tamarisk establishment on post-dam flood plain surfaces in Lodore Canyon but may push establishment to higher elevations. Information is lacking on the degree to which these responses would occur. In addition, there are concerns that the higher base flows, if coupled with several years of drought, will promote extensive tamarisk establishment along base flow elevations.

Uncertainties were described in section 4.7.5 for response of certain native plant communities to the Action Alternative. Such uncertainties include duration and magnitude of floodflows necessary to stimulate a positive response in mature cottonwoods and response of wetland species to the higher base flows of late summer and lower base flows of winter and early spring.

4.20 ADDRESSING UNCERTAINTIES THROUGH ADAPTIVE MANAGEMENT

The uncertainties associated with operating Flaming Gorge Dam under the Action Alternative, summarized in section 4.19 above, would be monitored and addressed through an adaptive management process if the Action Alternative is implemented. This adaptive management process would consist of an integrated method for addressing uncertainty in natural resource management. It is an ongoing, interactive process that not only reduces but benefits from uncertainty (Holling, 1978).

The use of adaptive management does not imply establishment of a separately funded and staffed program to oversee operations at Flaming Gorge Dam. Rather, the adaptive management process would be integrated into the current framework of dam operations, while maintaining the authorized purposes of the dam. It would involve using research and monitoring to test the outcomes of modifying the hydrology and temperature of releases from Flaming Gorge Dam. It is expected that such research and monitoring would be achieved within the framework of the ongoing Recovery Program with regard to native fish and undesirable nonnatives and related habitat issues. For example, results of Recovery Program research on flood plain inundation and larval entrainment, conducted during the 2005 spring peak runoff season, would be incorporated into the ongoing adaptive management process, and any new information yielded by this research could be applied to refinement of the recommended releases under the Action Alternative.

As a participant in the Recovery Program, Reclamation would be involved in any identification or discussion of the need for new tasks within the Recovery Program to address Flaming Gorge Dam operational considerations or experimental flows. Issues associated with the trout fishery would be monitored by the Utah Division of Wildlife Resources as part of their management of that fishery and with ongoing consultation and coordination with Reclamation through the Flaming Gorge Working Group and interagency communication. As has occurred in the past, proposed releases for experimental purposes that deviate from the prescribed flows would be disclosed to stakeholders at Flaming Gorge Working Group meetings and closely coordinated with the U.S. Fish and Wildlife Service and the Utah Division of Wildlife Resources.

4.21 ENVIRONMENTAL COMMITMENTS

This section summarizes Reclamation's future commitments related to the Action Alternative. Commitments 1 through 4 and 8 would apply if either the Action or No Action Alternative is implemented.

(1) The Flaming Gorge Working Group, which meets two times per year, would continue to function as a means of providing information to and gathering input from stakeholders and interested parties on dam operations, as described in section 1.5.

(2) The adaptive management process would rely on ongoing or added Recovery Program activities for monitoring and studies to test the outcomes of modifying the flows and release temperatures from Flaming Gorge Dam. It would rely on the Flaming Gorge Working Group meetings for exchange of information with the public.

(3) Reclamation would develop a process for operating the selective withdrawal structure consistent with the objective of improving temperature conditions for the endangered native fish. Such a process would include identification of lines of communication for planning and making changes to selective withdrawal release levels, coordination with other agencies, recognition of equipment limitations that may affect the ability to release warmer water, and the costs and equipment impacts associated with operating at higher temperatures.

(4) Reclamation would continue to annually coordinate the peak flow releases from Flaming Gorge Dam with the appropriate Federal, State, and county officials. This would include continued communication with county officials to assist in their mosquito control activities.

(5) As recommended by the Wyoming State Historic Preservation Office, Reclamation would periodically inspect eligible historic properties around Flaming Gorge Reservoir to determine if there are any effects from the Action Alternative.

(6) Reclamation would consult with Federal, State, and local officials and the interested public to determine whether additional signage or other means of public notification of higher spring riverflows are needed.

(7) A Ute ladies'-tresses recovery team geomorphology working group, consisting of the National Park Service, Reclamation, and several independent researchers, is currently in place. As part of Reclamation's efforts to monitor and understand the effects of the proposed action on Ute ladies'-tresses, this group will be expanded to include interested Federal and State agency geomorphologists, riparian ecologists, and botanists who choose to participate on a voluntary basis. This working group could assist in designing and implementing a monitoring program to gain additional knowledge about Ute ladies'-tresses. Reclamation will oversee this Ute ladies'-tresses workgroup and insure that the workgroup meets regularly to discuss and prioritize monitoring, assist with data interpretation, and prioritize any needed research. As part of the development of the annual operational plan (as discussed in section 2.5 of the EIS), this workgroup will also provide

recommendations to the Flaming Gorge Technical Working Group.

(8) Reclamation would continue to participate in the Recovery Program efforts.

(9) Reclamation would support the Recovery Program, in coordination with the U.S. Fish and Wildlife Service and Western, in developing and conducting Recovery Program studies associated with flood plain inundation identified in section 4.19.5.

(10) Reclamation would establish the Technical Working Group consisting of biologists and hydrologists involved with endangered fish recovery issues. The Technical Working Group would meet at various times throughout the year to comment and provide input concerning endangered fish needs to Reclamation's operational plan.

5.0 Consultation, Coordination, and Public Involvement

This chapter details the consultation and coordination between the Bureau of Reclamation and other State, Federal, and local agencies, Native American tribes, and the public in the preparation of this environmental impact statement (EIS). Since the Notice of Intent to prepare this EIS was published in June 2000, input has been actively solicited from a broad range of public constituencies as part of the ongoing public involvement process. Comments and involvement in the planning for and preparation of the Flaming Gorge EIS were generally sought through two broad efforts: communication and consultation with a variety of Federal, State, and local agencies, Native American tribes, and interest groups; and the formal EIS scoping process and draft EIS comment process, both of which invited input from the general public.

5.1 Consultation and Coordination With Other Agencies and Organizations and Native American Tribes

In June and July 2000, Reclamation invited a number of State and Federal agencies and the Northern Ute Tribe to become cooperating agencies in the preparation of this EIS. The eight agencies that agreed to become cooperating agencies for this EIS are listed in section 1.2. Reclamation has hosted periodic cooperating agency meetings throughout the preparation of this EIS, to ensure that all of the agencies were informed of and involved in the issues and analyses related to the EIS. Other interested tribes, government agencies, and public organizations and individuals have been kept informed on the status and progress of EIS preparation, as requested.

In July 2000, Reclamation initiated consultation under various cultural resource laws, Executive orders, and regulations with the following tribes: the Southern Ute Tribe, the Ute Mountain Tribe, the Northern Ute Tribe, the Northwest Band Shoshone Tribe, the Wind River Shoshone Tribe, the Hopi Tribe, the Paiute Indian Tribe of Utah, the Kaibab Paiute Tribe, the Pueblo of Nambe, the Pueblo of Zia, the Pueblo of Laguna, and the Pueblo of Zuni. Consultation with interested tribes has been an ongoing process and included a briefing on the EIS for the Northern Ute Business Council and a field visit with representatives of the Wind River Shoshone Tribe. None of the tribes expressed concerns regarding either traditional cultural properties or sacred sites within the area of potential effect.

5.2 PUBLIC INVOLVEMENT

Section 1.3 details the scoping process for this EIS. As stated during the scoping hearings, meetings with Reclamation staff were available to the interested public throughout the period of EIS scoping and preparation. Throughout the preparation of this EIS, the Flaming Gorge EIS Home Page on the Upper Colorado Region, Bureau of Reclamation Web site has been updated and available to all with Internet access. In November 2001, a newsletter regarding the development of the EIS was sent to those on the EIS mailing list.

The draft EIS was mailed to the interested public for review and comment in early September 2004, and a Notice of Availability of the draft EIS was published in the *Federal Register* on September 10, 2004. The 60-day review and comment period for the draft EIS ended on November 15, 2004.

During the public comment period, five public hearings were held to receive oral comments on the draft EIS: Moab, Utah, October 12, 2004; Salt Lake City, Utah, October 13, 2004; Rock Springs, Wyoming, October 19, 2004; Dutch John, Utah, October 20, 2004; and Vernal, Utah, October 21, 2004. All written and oral comments received during the comment period were considered in preparing the final EIS. These comments, along with Reclamation's responses, may be found in the separate volume, Comments on the Draft Environmental Impact Statement and Responses.

This final EIS, like the draft EIS, has been mailed to the over 600 agencies, organizations, and individuals on the mailing list (see section 5.3 below), and notice of its availability has been published in the *Federal Register*. It has also been made available on the Flaming Gorge EIS Web page. A Record of Decision, to be prepared no sooner than 30 days after publication of this final EIS, will also be published in the *Federal Register*, mailed to the interested public, and posted on the Flaming Gorge EIS Web page.

5.3 DISTRIBUTION LIST

This EIS has been sent to the following agencies, groups, and individuals for their information and review. Those who commented on the draft EIS are noted with an asterisk (*).

Federal Agencies

Advisory Council on Historic Preservation
Department of Agriculture
    USDA Forest Service
    Natural Resources Conservation Service
Department of Army
    Corps of Engineers

Department of Energy
- Office of Policy, Safety, and Environment
- *Western Area Power Administration
- Argonne National Laboratory

Department of the Interior
- Bureau of Indian Affairs
- Bureau of Land Management
- *National Park Service
- *U.S. Fish and Wildlife Service
- U.S. Geological Survey

*Environmental Protection Agency
Office of Management and Budget

U.S. Congressional Delegation

Colorado
- Representative John Salazar, 3rd District
- Senator Wayne Allard
- Senator Ken Salazar

Utah
- Representative Chris Cannon, 3rd District
- Representative Rob Bishop, 1st District
- Representative James Matheson, 2nd District
- Senator Bob Bennett
- Senator Orrin Hatch

Wyoming
- Representative Barbara Cubin
- Senator Mike Enzi
- Senator Craig Thomas

American Indian Tribal/National Governments

Kaibab Paiute Indian Reservation, Pipe Spring, Arizona
Northern Ute Tribe of the Uintah and Ouray Reservation, Fort Duchesne, Utah
Pueblo of Zuni, Zuni, New Mexico

State Legislators

Colorado
- Representative Al White, District 57, Denver
- Senator Jack Taylor, District 8, Denver

Utah
- Representative John G. Mathis, District 55, Naples
- Representative Gordon E. Snow, District 54, Roosevelt
- Representative David Ure, District 53, Kamas
- Senator Beverly Evans, Altamont
- Senator Allen M. Christenson, North Ogden

Wyoming
- Representative John M. Hastert, District 39, Green River
- Representative Mick Powers, District 18, Lyman
- Representative Marty Martin, District 48, Rock Springs
- Representative Stephen Watt, District 17, Rock Springs
- Representative Bill Thompson, District 60, Green River
- Representative Pete Jorgenson, District 16, Rock Springs
- Senator Tex Boggs, District 13, Rock Springs
- Senator Stan Cooper, District 14, Kemmerer
- Senator Rae Lynn Job, District 12

State Agencies

Arizona
- Governor
- Arizona Department of Water Resources, Phoenix

Colorado
- Governor
- Local Affairs Department/Division of Local Government, Department of Law, Denver
- *Colorado Department of Natural Resources, Denver

Utah
- Governor
- Department of Natural Resources, Salt Lake City
- *Governor's Office of Planning and Budget, Salt Lake City
- *Office of the Attorney General, Salt Lake City
- State of Utah Trust Lands, Salt Lake City
- State Parks and Recreation, Salt Lake City

*Utah Associated Municipal Power Systems, Salt Lake City
Utah Division of Water Resources, Salt Lake City
Utah Division of Wildlife Resources, Salt Lake City
Utah Farm Bureau Federation, Payson
Utah State Clearing House, Salt Lake City
Utah State University, Logan, Utah
*Utah State University Extension, Vernal

Wyoming
*Governor
Wyoming Department of Environmental Quality, Cheyenne
Wyoming Department of State Parks and Cultural Resources, Cheyenne
Wyoming Division of Economic and Community Development, Cheyenne
*Wyoming Game and Fish, Cheyenne, Wyoming, and Green River, Utah
Wyoming Office of Federal Land Policy, Cheyenne
*Wyoming State Engineer's Office, Cheyenne
*Wyoming State Geological Survey, Laramie
Wyoming State Historic Preservation Office, Cheyenne

Local Agencies

*Daggett County Commission, Manila, Utah
Uintah Basin Association of Governments, Roosevelt, Utah
*Rock Springs Chamber of Commerce, Rock Springs, Wyoming
Sweetwater Commission, Green River, Wyoming
*Town of Manila, Utah
*TriCounty Health Department, Vernal, Utah
*Uintah County Commission, Vernal, Utah
*Uintah County Mosquito Abatement District, Vernal, Utah
Uintah County Public Lands, Vernal, Utah

Irrigation Districts and Water Users Organizations

Carbon Water Conservancy District, Helper, Utah
*Central Utah Water Conservancy District, Orem, Utah
Colorado River Board of California, Glendale, California
Colorado River Commission of Nevada, Las Vegas, Nevada
*Colorado River Energy Distributors Association (CREDA), Tempe, Arizona
*Colorado River Water Conservation District, Glenwood Springs, Colorado
Colorado River Water Users Association, Coachella Valley Water District, Coachella, California
Colorado Water Conservation Board, Denver, Colorado
*Duchesne County Water Conservancy District, Roosevelt, Utah
Metropolitan Water District of Southern California, Los Angeles, California
Moon Lake Water Users Association, Roosevelt, Utah
Provo River Water Users Association, Orem, Utah
*Sweetwater County Conservation District, Rock Springs, Wyoming
Upper Colorado River Commission, Salt Lake City, Utah
Utah Water Users Association, Murray, Utah

Libraries

Colorado
Denver Public Library, Denver
Mesa County Public Library, Grand Junction
Norlin Library, University of Colorado, Boulder

Utah
Daggett County Library, Manila
Duchesne County Library, Roosevelt
Grand County Library, Moab
Green River City Library, Green River
Harold B. Lee Library, Brigham Young University, Provo
J. Reuben Clark Law School, Brigham Young University, Provo
Merrill Library, Utah State University, Logan
Salt Lake City Public Library, Salt Lake City

Uintah County Library, Vernal
Ute Indian Tribe Library, Fort Duchesne

Wyoming
Hay Library, Western Wyoming Community College, Rock Springs
Rock Springs Library, Rock Springs
Sweetwater County Library, Green River
White Mountain Library, Rock Springs

Interested Organizations

Action Network Activist, Eden Prairie, Minnesota
American Fisheries Society, Garden City, Utah
American Rivers, Lincoln, Nebraska; Washington, DC
Basin Sports, Vernal, Utah
Boyle Engineering, Lakewood, Colorado
*Burnell Slaugh Ranch, Jensen, Utah
Cedar Springs Marina, Flaming Gorge, Utah
Clipper Publishing Company, Bountiful, Utah
Colorado Energy Distributors Association, Tempa, Arizona
Colletts Recreation Service
Cooper Printing and Publishing, Magna, Utah
Dinosaur Expeditions, Park City, Utah
Dinosaurland Travel Board, Vernal, Utah
Don Hatch River Expeditions, Vernal, Utah
*Eagle Outdoors Sports, Kayesville, Utah
Eagle Outfitters Inc., Layton, Utah
Engineering and Planning Consultants, Loveland, Colorado
Flaming Gorge Chapter-PFUSA, Rock Springs, Wyoming
Flaming Gorge Corporation, Manila, Utah
Flaming Gorge Lodge, Dutch John, Utah
Flaming Gorge Yacht Club, Bountiful, Utah
Foundation of North American Wild Sheep, Salt Lake City, Utah
*Franson Noble Engineering, Provo, Utah
Future Resources, Vernal, Utah
Grand Canyon Monitoring and Research Center, Flagstaff, Arizona
Grand Canyon River Guides, Flagstaff, Arizona
Grand Canyon Trust, Flagstaff, Arizona
Green River Drifters Inc., Dutch John, Utah
*Green River Outfitters, Dutch John, Utah
*Green River Outfitter and Guides Association, Dutch John, Utah
Holiday Expeditions, Salt Lake City, Utah
Interstate Stream Commission, Santa Fe, New Mexico
JBR Environmental Consultants, Murray, Utah
*Living Rivers, Colorado Riverkeeper, Moab, Utah
National Parks Conservation Association, Visalia, California; Long Branch, New Jersey
*Old Moe Guide Service, Dutch John, Utah
Questar, Rock Springs, Wyoming
Pinedale Roundup, Pinedale, Wyoming
Quad/Photo, New York, New York
Red Canyon Lodge, Dutch John, Utah
Rocky Mountain Elk Foundation, Missoula, Montana
Southwest Rivers, Flagstaff, Arizona
Sweetwater Economic Development Association, Rock Springs, Utah
The Nature Conservancy, Boulder, Colorado; Arlington, Virginia; Madison, Wisconsin
*Thunder Ranch, LLC, Jensen, Utah
Tidal View, West Tremont, Maine
*Trout Bum 2, Park City, Utah
*Trout Creek Flies, Dutch John, Utah
*Trout Unlimited, Salt Lake City, Utah
*Uintah Mountain Club, Vernal, Utah
Utah Associated Municipal Power Systems, Salt Lake City, Utah
Utah Council Trout Unlimited, South Weber, Utah
Utah Farm Bureau Federation, Payson, Utah
Utah Habitat Council, Salt Lake City, Utah
Utah Municipal Power Agency, Spanish Fork, Utah
Utah Rivers Council, Salt Lake City, Utah
Utah Water Project Trout Unlimited, Sandy, Utah
*Utah Waters, Salt Lake City, Utah
*Water Consult Engineering and Planning Consultants, Loveland, Colorado
*Western Resource Advocates and The Nature Conservancy, Boulder, Colorado
*Western Rivers Flyfisher, Salt Lake City, Utah
White Water Canoe Colorado, Greeley, Colorado

Interested Individuals

*G. Howard Abplanalp, Vernal, Utah
Brad Adams, Greensboro, North Carolina
*Deloy Adams, Dutch John, Utah
*Lew Albright
*John and Mickey Allen, Rangely, Colorado
*Mark Allen, Orem, Utah
Jeanelle Adamson, Rock Springs, Wyoming
Patrick Adcock, Norfork, Arkansas
Evan Albright, San Luis Obispo, California
Cheryl Alfakyani, Melrose, Maryland
Thomas Allgaier, Palm Bay, Florida
Joe Alston, Page, Arizona
*Dick Apedalle
Michael H. Anderson, Sr., Ohatchee, Alabama
Warren Anderson, Rock Springs, Wyoming
Nicholas Angarone, Hamilton, New Jersey
Angelde Armendi, Miami, Florida
Dave Armstrong, Salt Lake City, Utah
Cheryl Arredondo, Apache Junction, Arizona
Jim Aton, Cedar City, Utah
Gina Baker, Star City, Indiana
Scott Baker, Draper, Utah
D. Barbero, Rock Springs, Wyoming
*Justin Barker, Pleasant Grove, Utah
*Lynn Barlow
Terry Barnes, Jr., Funkstown, Maryland
Scott Barnes, Redlands, California
M. Dale Barningham, Bountiful, Utah
Cliff Barrett, Stansbury Park, Utah
Kevin Barry, Carlsbad, California
G. Basham-Barnes, Rogers, Arkansas
Karl Bass, Glen Gardner, New Jersey
Marcia Battles, Pontiac, Michigan
Yasmin Bauer, Houston, Texas
Tony R. Bavry, Columbus, Ohio
Mark Belles, Rowlett, Texas
Nathan Bennett, Selinsgrove, Pennsylvania
Rebecca Bennett, Delhi, Louisiana
Tina Bennington, Manila, Utah
*Enos Bennion, Brigham City, Utah
Marilyn Bennion, Brigham City, Utah
Harriet N. Bensen, Long Branch, New Jersey
Rich Bergmann, Orlando, Florida
Jennifer Berry, Aiken, South Carolina
Robert Blackiston, Sewell, New Jersey
Jason Boccaccio, Arvada, Colorado
Charles Bock, Layton, Utah
Paul Borokhov, Chatham, New Jersey
*Nancy Bostick-Ebbert, Vernal, Utah
Chris Boswell, Green River, Utah
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Cache Citizen, Logan, Utah
Casper Star Tribune, Green River, Wyoming
Daily Rocket-Miner, Rock Springs, Wyoming
Daily Spectrum, St. George, Utah
Deseret News, Salt Lake City, Utah
Hilltop Times, Hill Air Force Base, Utah
Journal Publications, Springville, Utah
KVEL Radio 920, Vernal, Utah
Lakeside Review, Layton, Utah
Logan Herald Journal, Logan, Utah
Millard County Chronicle Progress, Delta, Utah
Newtah News Group, American Fork, Utah
Orem-Geneva Times, Orem, Utah
Park Record, Park City, Utah
Provo Daily Herald, Provo, Utah
Richfield Reaper, Richfield Utah
Salt Lake City Weekly, Salt Lake City, Utah
Salt Lake Tribune, Salt Lake City, Utah
San Juan Record, Monticello, Utah
Spanish Fork Press, Spanish Fork, Utah
Sun Advocate, Price, Utah
The Event News Weekly, Salt Lake City, Utah
The Leader, Tremonton, Utah
The Ogden Standard Examiner, Ogden, Utah
The Orem Daily Journal, Springville, Utah
The Times Independent, Moab, Utah
Tooele Transcript Bulletin, Tooele, Utah
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Operation of Flaming Gorge Dam
Final Environmental Impact Statement
Conversion Tables

U.S. Customary to Metric

Multiply	By	To Obtain
inches(inches)	25.4	millimeters
inches (inches)	2.54	centimeters
feet (ft)	0.3048	meters
miles (mi)	1.609	kilometers
square feet (ft^2)	0.0929	square meters
acres	0.4047	hectares
square miles (mi^2)	2.590	square kilometers
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02832	cubic meters
acre-feet	1,233.0	cubic meters
pounds (lb)	0.4536	kilograms
tons (ton)	0.9072	metric tons

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows: °C = 5/9 (°F - 32)

Metric to U.S. Customary

millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (L)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters (m^3)	0.0008110	acre-feet
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	1.102	tons

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) as follows: °F = 1.8 (°C) + 32

Other Useful Conversion Factors

acre-feet	43,560	cubic feet
acre-feet	325,851	gallons
cubic feet per second (cfs)	1.98	acre-feet per day

Glossary

A

Acre-foot: The volume of water that would cover 1 acre, 1 foot deep.

Age-0, age 1: The first and second full years of life, respectively.

B

Base load: Demand level of a utility that is continuous throughout the season.

Biological opinion: A document stating the opinion of the U.S. Fish and Wildlife Service or National Oceanic and Atmospheric Administration – Fisheries (NOAA Fisheries) on whether or not a Federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

Bypass tubes: Two 8-foot diameter conduits through Flaming Gorge Dam that are used to release water in addition to the releases made through the powerplant. These conduits, each with a rated capacity of 2,000 cfs each, are controlled by hollow jet valves that control the flow.

C

Candidate species (candidate): A plant or animal species for which the U.S. Fish and Wildlife Service or NOAA Fisheries has on file sufficient information on biological vulnerability and threats to support a proposal to list as endangered or threatened.

Capacity: The amount of electric power for which a generating unit is rated by the manufacturer.

Cavitation: A physical process that can occur when water flows across a surface at high velocity.

Consumer surplus: A measure of recreation value based on the increment of recreator willingness-to-pay over and above the incurred cost per visit.

Control area: An area comprised of an electric system or systems, bounded by interconnection metering and telemetry, capable of controlling generation to maintain its interchange schedule with other control areas, and contributing to frequency regulation of the interconnection.

Critical habitat: Specific geographic areas, whether occupied by a listed species or not, that are essential for its conservation and that have been formally designated by rule published in the *Federal Register*.

Cubic foot per second (cfs): Rate of streamflow; a cubic foot of water passing a reference section in 1 second of time; 1 cfs = 0.0283 cubic meters per second.

Cultural resources: Any buildings, sites, districts, structures, or objects significant in history, architecture, archaeology, culture, or science.

Cyanobacteria: Blue green algae.

E

Economic benefits: Economic benefits attempt to measure changes in societal or national welfare based on net value concepts, including consumer surplus and producer profitability.

Employment: Total of hourly wage, salary, and self-employed jobs (part-time and full-time), measured in terms of jobs, not full-time equivalents.

Endangered species: An animal or plant species in danger of extinction throughout all or a significant portion of its range.

Energy: Electric capacity generated and delivered over time, usually measured in kilowatthours.

Entrainment: Process by which fish or plankton are transported by strong water currents.

F

Facility availability approach: A methodology used to calculate reservoir recreation visitation. The approach evaluates changes in visitation as a function of changing facility availability as water levels fluctuate.

Facility substitution: The potential for recreators to move between facilities at a site as a given facility becomes unusable.

***Federal Register* (FR):** The official daily publication for actions taken by the Federal Government, such as rules, proposed rules, and notices of Federal agencies and organizations, as well as Executive orders and other Presidential documents.

Formal consultation: The required process under section 7 of ESA between the U.S. Fish and Wildlife Service or NOAA Fisheries and a Federal agency or applicant conducted when a Federal agency determines its action is likely to adversely affect a listed species or its critical habitat; used to determine whether the proposed action is likely to jeopardize the continued existence of listed species or adversely modify critical habitat. This determination is stated in a biological opinion.

G

Gigawatt (GW): 1,000 megawatts or 1 billion watts.

Gigawatthour (GWh): A unit equal to 1,000 megawatthours.

H

Historic properties: Any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the *National Register of Historic Places* maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe and that meet the *National Register of Historic Places* criteria.

I

Indian tribe: An Indian tribe, band, nation, or other organized group or community, which is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians.

Inflow: Water that flows into a body of water. The amount of water entering a reservoir expressed in acre-feet per day or cubic feet per second.

Input-Output (IO) analysis: IO estimates regional economic impacts based on a region's interindustry trade linkages. The analyses present changes in total economic impact as measured by the sum of direct effects (impacts to initially affected industries), indirect effects (impacts to industries providing inputs to directly impacted industries), and induced effects (impacts from employees spending wages within the region), all caused by the initial change in demand.

Insectivorous: Feeding on insects.

Invertebrate: Animals lacking a spinal column.

J

Jeopardy biological opinion: A U.S. Fish and Wildlife Service or NOAA Fisheries section 7 biological opinion determining that a Federal action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat.

Jeopardize the continued existence of: To engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species.

K

Kilowatt (KW): Unit of electric power (capacity) equal to 1,000 watts, or 1.34 horsepower.

Kilowatthour (KWh): Basic unit of electric energy equaling an average of 1 kilowatt of power applied over 1 hour.

L

Larvae: Plural form of larva; the early, immature form of any animal.

Limnology: The study of freshwater ecosystems.

Linear interpolation approach: A procedure used in the recreation analysis to calculate visitation and value. The procedure uses percentages based on five data points (low end thresholds, current conditions, preferred conditions, high end kink conditions, and high end thresholds), measured in terms of river flows/reservoir water levels, visitation, and valuation. If an alternative's flows fall 75 percent of the way between current and preferred flow conditions, the procedure calculates visitation and value to also fall 75 percent of the way between the current and preferred visitation and value data points.

Listed species: A species, subspecies, or distinct population segment that has been added to the Federal list of endangered and threatened wildlife and plants.

Littoral: Pertaining to the shore.

Littoral zone: The zone or strip of land along the shoreline between the high and low water marks. That portion of a body of freshwater extending from the shoreline lakeward to the limit of occupancy of rooted plants.

M

Mean sea level: Average level of the ocean between high and low tide.

Megawatt (MW): 1,000 kilowatts or 1 million watts.

Megawatthour (MWh): A unit equal to 1,000 kilowatthours.

Mesic: Characterized by moderately moist conditions; neither too wet nor too dry.

N

National Register of Historic Places (NRHP): A federally maintained register of districts, sites, buildings, structures, architecture, archaeology, and culture.

Net present value: The total current value determined from a comparison of costs and benefits from different time periods, such that all dollar amounts are discounted to present time, using an appropriate discount rate. The sum of the present value of the costs is subtracted from the sum of the present value of the benefits to determine the net present value. The appropriate discount rate is the rate that equates the value of a dollar in the present time with the value of a dollar in another time.

Non-jeopardy biological opinion: A U.S. Fish and Wildlife Service or NOAA Fisheries section 7 biological opinion that determines that a Federal action is not likely to jeopardize the existence of a listed species or result in the destruction or adverse modification of critical habitat.

Nonrenewable resources: Resources such as prehistoric campsites which will not be regenerated in the future. These resources are finite.

P

Paleocene: Relating to the oldest series or epoch of the Tertiary period (57,000,000 to 65,000,000 year B.P.).

Paleontology: Study of life in past geological periods by means of fossil remains.

Passerine birds: Songbirds of perching habits.

Penstock: A pipeline or conduit designed to withstand pressure surges leading from a forebay or reservoir to power-producing turbines or pump units. Conduit used to convey water under pressure to the turbines of a hydroelectric plant. A pressurized pipeline or shaft between the reservoir and hydraulic machinery.

Piscivorous: Feeding on fishes.

Planktonic: Relating to small plant and animal organisms that float or drift in great numbers in freshwater or saltwater.

Power: Electrical capacity generated, expressed in kilowatts.

Powerplant capacity: Maximum flow that can pass through the turbines, given a full reservoir.

Preference: Priority access to Federal power by public bodies and cooperatives.

Preference customers: Publicly owned systems and nonprofit cooperatives that, by law, have preference over investor-owned systems for purchase of power from Federal projects.

Profitability: Total revenue minus operating costs.

R

Ramp rate (ramping): The rate of change in instantaneous output from a powerplant. The ramp rate is managed to prevent undesirable effects due to rapid changes in loading or discharge. Changes in ramp rate often are implemented to protect habitat and the public from undesirable effects caused by large, sudden changes in riverflows.

Reasonable and prudent alternative (RPA): A recommended alternative action identified during formal consultation that can be implemented in a manner consistent with the intended purpose of the action, that can be implemented consistent with the scope of the Federal agency's legal authority and jurisdiction, that is economically and technologically feasible, and that the U.S. Fish and Wildlife Service or NOAA Fisheries believes would not jeopardize the continued existence of listed species or the destruction or adverse modification of designated critical habitat.

Reasonable and prudent measure (RPM): An action that the U.S. Fish and Wildlife Service or NOAA Fisheries believes necessary or appropriate to minimize the impacts (the amount or extent) of incidental take caused by an action that was subject to consultation.

Recovery: The process by which the decline of an endangered or threatened species is stopped or reversed, or threats to its survival neutralized so that its long-term survival in the wild can be ensured, and it can be removed from the list of threatened and endangered species.

Recovery plan: A document drafted by the U.S. Fish and Wildlife Service, NOAA Fisheries, or other knowledgeable individual or group that serves as a guide for activities to be undertaken by Federal, State, or private entities in helping to recover and conserve endangered or threatened species.

Recreation value per visit: Recreator benefits or values per visit are represented by consumer surplus, measured by estimating recreator willingness-to-pay in excess of costs per visit.

Recreation valuation: Recreation valuation reflects the sum of individual recreator benefits or values aggregated across users of a site.

Recreation visit: A recreation visit reflects a round trip excursion from a recreator's primary residence for the main purpose of recreation.

Recreation visitation: Sum of recreation visits across users of a site.

Recruitment: Survival of young plants and animals from birth to a life stage less vulnerable to environmental change.

Redd: The nest that a spawning female salmon digs in gravel to deposit her eggs. Depression in riverbed or lakebed dug by fish to deposit eggs.

Regional economic impacts: Regional economic impacts attempt to measure changes in total economic activity within a specified geographic region, stemming from changes within region expenditures. Regional economic impacts are typically described using such general measures as total industry output, labor income, and employment.

Resource indicator: A quantification (measurement) of any environmental consequence arising from the implementation of flow and temperature recommendations that would indicate the presence of certain environmental conditions.

Resource issue: An effect or perceived effect, risk, or hazard on a physical, biological, social, or economic resource within the affected environment.

S

Sacred site: See Executive Order 13007. Any specific, discrete, narrowly delineated location on Federal land that is identified by an Indian tribe or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, an Indian religion, provided that the tribe or appropriately authoritative representative of an Indian religion has informed the agency of the existence of such a site.

Spot price: Market price of energy at a given moment at a point of exchange.

Sympatric: Occurring in the same area.

T

Tailwater: The water in the natural stream immediately downstream from a dam. The elevation of water varies with discharge from the reservoir. Applied irrigation water that runs off the lower end of a field.

Take: To harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct; may include significant habitat modification or degradation if it kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Terms and conditions: Required actions described in an Incidental Take Permit under section 10 or Incidental Take Statement intended to implement the reasonable and prudent measures under section 7.

Threatened species: An animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Total industry output: Dollar value of production (sales revenues and gross receipts) from all industries in the region. Total industry output includes the value of inter-industry trade of intermediate goods prior to final manufacture and sale.

Total labor income: Employment income derived at the workplace including wages and benefits (employee compensation) plus self-employed income (proprietary income).

Traditional cultural property (TCP): A site or resource that is eligible for inclusion in the NRHP because of its association with cultural practices of beliefs of a living community.

U

Unregulated inflow: Within the context of Flaming Gorge Reservoir, the naturally occurring inflows to Flaming Gorge Reservoir if Fontenelle Dam and other diversions did not exist upstream.

V

Vertebrate: Animal species with a spinal column.

Bibliography

Aldrich, T., 1992. Letter from T. Aldrich, of the Utah Department of Natural Resources, Waterfowl Program, Salt Lake City, Utah, to R.A. Van Lonkhuyzen of Argonne National Laboratory. Argonne, Illinois, November 2, 1992.

Allred, T.M., and J.C. Schmidt, 1999. "Channel Narrowing by Vertical Accretion Along the Green River Near Green River, Utah" in *GSA Bulletin*, December 1999, vol. 111, No. 12, pp. 1757-1772.

American Mosquito Control Association, Inc., 1990. Cited at <www.mosquito.org>, copyright date of 2003.

Anderson, D.C., and D.J. Cooper, 2000. "Plant Herbivore-Hydroperiod Interactions: Effects of Native Mammals on Floodplain Tree Recruitment" in *Ecological Applications*, vol. 10, pp. 1384-1399.

Anderson, R.A., 2002. *Riverine Fish Flow Investigations*, Federal Aid Project F-289-R5 Job Progress Report. Colorado Division of Wildlife, Fish Research Section, Fort Collins, Colorado.

Andrews, E.D., 1986. "Downstream Effects of Flaming Gorge Reservoir on the Green River, Colorado and Utah" in *Geological Society of America Bulletin*, vol. 97, pp. 1012-1023.

Andrews, J.W. and R.R. Stickney, 1972. "Interactions of Feeding Rates and Environmental Temperature on Growth, Food Conversion, and Body Composition of Channel Catfish" in *Transactions of the American Fisheries Society*, vol. 101(1), pp. 94-99.

Angradi, T.R. and D.M. Kubly, 1993. "Effects of atmospheric exposure on chlorophyll a, biomass and productivity of the epilithon of a tailwater river" in *Regulated Rivers: Research and Management*, vol. 8, pp. 345-358.

Annear, T.A., 1980. "A Characterization of Yampa and Green River Ecosystems," Masters of Science thesis. Utah State University, Logan, Utah.

Aquatic Species Nuisance Task Force, 1994. *Findings, Conclusions, and Recommendations of the Intentional Introductions Policy Review: Report to Congress*. Aquatic Nuisance Species Task Force, U.S. Fish and Wildlife Service, Washington, DC.

Arizona Game and Fish Department, 1993. *Glen Canyon Environmental Studies Phase II 1992 Annual Report*, prepared for the Bureau of Reclamation, Glen Canyon Environmental Studies. Arizona Game and Fish Department, Phoenix, Arizona.

_________, 1994. Glen Canyon Environmental Studies Phase II, 1993 Annual Report, (Draft Report), prepared for Bureau of Reclamation. Arizona Game and Fish Department, Phoenix, Arizona.

Armbruster, M.J., 1990. *Characterization of Habitat Used by Whooping Cranes During Migration*, Biological Report 90(4). U.S. Fish and Wildlife Service, Washington, DC, May.

Aukerman, R., and E. Schuster, 2002. *Green River Recreation In-Stream Flow and Flaming Gorge Reservoir Drawdown Assessment*. U.S. Department of the Interior, Bureau of Reclamation in cooperation with U.S. Department of Agriculture Forest Service.

Axtell, J., 1981. *The European and the Indian: Essays in the Ethnohistory of Colonial North America*. Oxford University Press, Oxford.

Backiel, T. and K. Stegman, 1968. "Temperature and Yield in Carp Ponds" in *Proceedings of the World Symposium on Warm Water Pond Fish Culture*, FAO Fish Report 44, vol. 4, pp. 334-342.

Banks, J.L., 1964. "Fish Species Distribution in Dinosaur National Monument During 1961-1962," Masters thesis. Colorado State University, Fort Collins, Colorado.

Barnes, F.A., 1991. "Update – Rivera's 1765 Expedition" in *Canyon Legacy* vol. 10, p. 31.

Barton, J.D., 1999. Fort Davey Crockett. <http://eddy.media.utah.edu/medsol/UCME/t/FORTDAVEYCROCKETT.html>. December 2, 1999.

Beckstead, J.H., 1991. *Cowboying: A Tough Job in a Hard Land*. University of Utah Press, Salt Lake City, Utah.

Bedame, P.V. and M.J. Hudson, 2003. *Reintroduction and Monitoring of Hatchery-Reared Bonytail in the Colorado and Green Rivers: 1996-2001*, Project 25 Final Report to the Upper Colorado River Endangered Fish Recovery Program, Utah Division of Wildlife Rescources, Moab, Utah.

Bell, A. Undated. Green River Flooded Bottomlands and Backwater Habitat Mapping. Memorandum from A. Bell, Bureau of Reclamation, to M. Pucherelli, Bureau of Reclamation.

Bell, A., D. Berk, and P. Wright, 1998. "Green River Flooded Bottomlands Mapping for Two Water Flows in May 1996 and One Water Flow in June 1997," Technical Memorandum No. 8260-98-07. Bureau of Reclamation, Technical Services Center, Denver, Colorado.

Berry, C.R., Jr., 1988. "Effects of Cold Shock on Colorado Squawfish Larvae" in *The Southwestern Naturalist*, vol. 33, pp. 193-197.

Bestgen K.R., D.W. Byers, G.B. Haines, and J.A. Rice, 1997. *Recruitment Models for Colorado Squawfish: Tools for Evaluating Relative Importance of Natural and Managed Processes*, Final Report of Colorado State University Larval Fish Laboratory. U.S. National Park Service Cooperative Parks Study

Unit and U.S. Geological Survey Midcontinent Ecological Science Center, Fort Collins, Colorado.

Bestgen, K.R., G.B. Haines, R. Brunson, T. Chart, M. Trammell, R.T. Muth, G. Birchell, K. Christopherson, and J.M. Bundy, 2002. "Status of Wild Razorback Sucker in the Green River Basin, Utah and Colorado, Determined from Basinwide Monitoring and Other Sampling Programs," Colorado State University Larval Fish Laboratory Contribution No. 126. Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Bestgen, K.R., and L.W. Crist, 2000. *Response of the Green River Fish Community to Construction and Re-regulation of Flaming Gorge Dam, 1962–1996*, Final Report to Colorado River Recovery Implementation Program Project Number 40, Larval Fish Laboratory Contribution 109. Colorado State University, Fort Collins, Colorado.

Bestgen, K.R., R.T. Muth, and M.A. Trammell, 1998. *Downstream Transport of Colorado Squawfish Larvae in the Green River Drainage: Temporal and Spatial Variation in Abundance and Relationships with Juvenile Recruitment*, Final Report of Colorado State University Larval Fish Laboratory. To the Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Bezzerides, N. and K. Bestgen, 2002. *Status Review of Roundtail Chub Gila robusta, Flannelmouth Sucker Catostomus latipinnis, and Bluehead Sucker Catostomus discobolus in the Upper Colorado River Basin*, Final Report. Colorado State University, Larval Fish Lab Contribution 118.

Binns, A., F. Eiserman, F.W. Jackson, A.F. Regenthal, and R. Stone, 1964. "The Planning, Operation, and Analysis of the Green River Fish Control Project." Utah State Department of Fish and Game, Wyoming Game and Fish Commission.

Birchell, G.J., K. Christopherson, C. Crosby, T.A. Crowl, J. Gourley, M. Townsend, S. Goeking, T. Modde, M. Fuller, and P. Nelson, 2002. *The Levee Removal Project: Assessment of Floodplain Habitat Restoration in the Middle Green River*, Final Report, Publication No. 02-17. Utah Division of Wildlife Resources to the Upper Colorado River Endangered Fish Recovery Program, Salt Lake City, Utah.

Birken, A., 2004. "Processes of Tamaix Invasion and Floodplain Development During the 20th Century Along the Lower Green River, Utah," Masters of Science thesis, Colorado State University, Fort Collins, Colorado.

Blanchard, W., 1999. Personal communication, Flaming Gorge Environmental Impact team meeting, early 1999.

Blinn, D.W., J.P. Shannon, and L.E. Stevens, 1992. *The Effects of the Glen Canyon Dam on the Aquatic Foodbase in the Colorado River Corridor in Grand Canyon, Arizona*, Glen Canyon Environmental Studies Technical Report. Northern Arizona University, Flagstaff, Arizona.

Blinn, D.W., J.P. Shannon, L.E. Stevens, and J.P. Carder, 1995. "Consequences of Fluctuating Discharge for Lotic Communities," in *Journal of the American Benthological Society* vol. 14, pp. 233-248.

Bogan, M.A., et al., 1983. "Baseline Studies of Riparian Vertebrates of the Yampa and Green River Corridors Within Dinosaur National Monument, June and July, 1982." U.S. Fish and Wildlife Service, Fort Collins, Colorado, in cooperation with the U.S. National Park Service, Rocky Mountain Region, Denver, Colorado, March 3, 1983.

Bolke, E.L., and K.M. Waddell, 1975. *Chemical Quality and Temperature in Water in Flaming Gorge Reservoir,* *Wyoming and Utah, and the Effect of Reservoir on the Green River*. Geological Survey Water Supply Paper 2039-A. U.S. Government Printing Office, Washington, DC, 26 pp.

Brannon, E.L., 1991. "Trout Culture" in *Culture of Salmonid Fishes,* R.R. Stickney, editor. CRC Press, Inc, Boca Raton, Louisiana, pp. 21-56.

Brayton, S. and K. Armstead, 1997. *Stocking Success as a Function of Discharge in the Flaming Gorge Tailwater, Utah. 1996-1997,* Final Report, Publication No. 97-18. Utah Division of Wildlife Resources, Northeast Regional Office, Salt Lake City, 26 pp.

Breternitz, D.A., 1965. *Archaeological Survey in Dinosaur National Monument, Colorado-Utah,* 1963-Multilith report. Submitted to National Park Service, Midwest Region, Omaha, Nebraska.

Bruder, J.S., and L.E. Rhodes (editors), 1991. "Kern River Pipeline Cultural Resources Data Recovery Report, Wyoming Segment," Draft Report. Dames and Moore, Phoenix, Arizona, submitted to Federal Energy Regulatory Commission, Washington, DC.

Burdick, B.D., 2002. "Monitoring and Evaluating Various Sizes of Domestic Reared Razorback Sucker Stocked in the Upper Colorado and Gunnison Rivers: 1995–2001," Draft Report. Prepared for the Upper Colorado River Endangered Fish Recovery Program by the U.S. Fish and Wildlife Service, Grand Junction, Colorado

Bureau of Land Management, 1990. "Diamond Mountain Resource Management Plan, Management Situation Analysis," unpublished working document. Diamond Mountain Resource Area, Vernal District, Vernal, Utah.

Bureau of Reclamation, 1963. "Designer's Operating Criteria, Flaming Dam Powerplant and Switchyard, Flaming Gorge Unit, Green Division, Colorado River Storage Project," November 1963.

_________, 1995. *Operation of Glen Canyon Dam Colorado River Storage Project, Coconino County, Arizona, Final Environmental Impact Statement*. Upper Colorado Region, Salt Lake City, Utah.

_________, 2000. *Colorado River Interim Surplus Criteria Final Environmental Impact Statement*. Lower Colorado Region, Boulder City, Nevada.

Byers, D.W., R.T. Muth, and M.S. Farmer, 1994. *Experimental Evidence of Competition Between Larvae of Colorado Squawfish and Fathead Minnow,* Final Report of Colorado State University Larval Fish Laboratory. To Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Callaway, D., J. Janetski, and O.C. Stewart, 1986. "Ute in Great Basin," edited by Warren L. D'Azevedo in *Handbook of North American Indians*, *Volume 11*, W.G. Sturtevant, general editor. Smithsonian Institution, Washington, DC.

Carlander, K., 1977. "Smallmouth Bass" in *Handbook of Freshwater Fish Biology,* vol 2. Iowa State University Press, Ames, Iowa, pp. 152-191.

Carlson, C.A., and R.T. Muth, 1989. *The Colorado River: Lifeline of the American Southwest*, Canadian Special Publication of Fisheries and Aquatic Sciences, vol. 106, pp. 220-239.

Carothers, S.W., and C.O. Minckley, 1981. *A Survey of the Fishes, Aquatic Invertebrates, and Aquatic Plants of the Colorado River and Selected Tributaries from Lees Ferry to Separation Rapids*, Final Report to the Water and Power Resources Service. Museum of Northern Arizona, Flagstaff, Arizona.

Carron, J.C., 2003. "Flaming Gorge Temperature Model Update." Hydrosphere Consultants, Inc., Boulder, Colorado.

Cater, J.D, R.A. Gruebel, and S. Chandler, 2001. *Flaming Gorge Dam Flow Recommendations: Historic Properties*. Prepared for the Bureau of Reclamation, Upper Colorado Region, Provo Area Office, Provo, Utah.

Cavalli, P.A., 1999. *Fish Community Investigations in the Lower Price River, 1996-1997*, Final Report. Utah Division of Wildlife to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

_________, 2000. *An Evaluation of the Effects of Tusher Wash Diversion Dam on Movement and Survival of Juvenile and Subadult Native Fish*, Final Report. Utah Division of Wildlife to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado

Centers for Disease Control and Prevention, 2001. "Fact Sheet: Western Equine Encephalitis." July 13, 2001.

_________, 2001. "CDC Answers Your Questions About St. Louis Encephalitis." July 13, 2001.

_________, 2003. West Nile Virus 2003 Human Cases, by clinical sysndrome as of November 19, 2003, 3 a.m. Mountain Standard Time, August 19, 2003.

Cavalli, P.A., 2000. *An Evaluation of the Effects of Tusher Wash Diversion Dam on Movement and Survival of Juvenile and Subadult Native Fish*, Final Report. Utah Division of Wildlife to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado

Chart, T.E., and S.J. Cranney, 1993. *An Evaluation of Hatchery Reared Bonytail Chub (Gila Elegans) Released in the Green River of Utah: 1988–1989*, Publication No. 93-12. Utah Division of Wildlife Resources to the Bureau of Reclamation, Salt Lake City, Utah.

Chart, T.E. and L.D. Lentsch, 1999. *Flow Effects on Humpback Chub (Gila Cypha) in Westwater Canyon*, Final Report. Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

_________, 2000. *Reproduction and Recruitment of Gila spp. and Colorado Pikeminnow (Ptychocheilus lucius) in the Middle Green River 1992-1996*, Final Report. Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Chart, T.E., D.P. Svendson, and L.D. Lentsch, 1999. *Investigations of Potential Razorback Sucker (Xyrauchen texanus) and Colorado Pikeminnow (Ptychocheilus lucius) Spawning in the Lower Green River, 1994 and 1995*, Final Report. Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Chen, T.H., 1976. "Cage Culture of Channel Catfish in a Heated Effluent for a Power Plant, Thomas Hill Reservoir," PhD. Dissertation. University of Missouri, Columbia, 98 pp.

Christopherson, K., G. Birchell and T. Modde, 2004. *Larval Razorback Sucker and Bonytail Survival and Growth in the Presence of Nonnative Fish in the Stirrup Flood Plain Wetland*, Final Report. Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Clark, Ray, 1997. *Considering Cumulative Effects Under the National Environmental Policy Act*. Council on Environmental Quality, Office of the President.

Clayton, Rick and A. Gilmore, 2002. *Flaming Gorge Flaming Gorge Draft Environmental Impact Statement Hydrologic Modeling Report*. On file, Bureau of Reclamation, Upper Colorado Region, Provo Area Office, Provo, Utah.

Cleverly, J.R., S.D. Smith, A. Sala, and D.A. Devitt, 1997. "Invasive Capacity of *Tamarix ramosissima* in a Mojave Desert Floodplain: the Ole of Drought" in *Oecologia*, 1997, vol. 111, pp. 12-18.

Cluer, B. and L. Hammack. 1999. Hydraulic analysis of Green River flows in Dinosaur and Canyonlands National Park Units: preliminary results dated February 19, 1999. National Park Service, Water Rights Branch, Water Resources Division, Fort Collins, Colorado.

Cooper, D.J., 1999. Written communication, December 21, 1999.

_________, 2002. Written communication, July 18, 2002.

_________, 2003. Written communication.

Cooper, D.J., D.C. Andersen, and R.A. Chimner, 2003. "Multiple Pathways for Woody Plant Establishment on Floodplains at Local to Regional Scales" in *Journal of Ecology*, vol. 91, pp. 182-196.

Cooper, D.J., C. Arp, and D.C. Andersen, 1999a. *Importance of 1997 Flaming Gorge Dam Bypass Flows for Native Ecosystem Maintenance Along the Green River in Browns Park and Lodore Canyon, Colorado*. Report to the Bureau of Reclamation.

Cooper, D.J., D.M. Merritt, D.C. Andersen, and R.A. Chimner, 1999. "Factors Controlling the Establishment of Fremont Cottonwood Seedlings on the Upper Green River, USA" in *Regulating Rivers:Research Management*, vol. 15, pp. 419-440.

Cranney, J.S., and W.K. Day, 1993. *Green River Otter Reintroduction 1992 Progress Report*. Utah Division of Wildlife Resources, Northeaster Region Office, June 1993.

Creasman, S.D., and L.J. Scott, 1987. "Texas Creek Overlook: Evidence for Late Fremont (Post A.D. 1200) Occupation in Northwest Colorado" in *Southwestern Lore*, vol. 53 (4), pp. 1-16.

Crowl, T.A., J.L. Gourley, and M. Townsend, 2002. "Invertebrate and Productivity Responses" in *The Levee Removal Project: Assessment of Floodplain Habitat Restoration in the Middle Green River*, Final Report, Publication No. 02-17. Utah Division of Wildlife Resources to the Upper Colorado River Endangered Fish Recovery Program, Salt Lake City, Utah.

Crowl, T.A., J.A. Gourley, M. Townsend, and S.A. Goeking, 2000. *The Levee Removal Project*, Final Report. To the Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin.

Day, K.C. and D. Dibble, 1963. "Archaeological Survey of the Flaming Gorge Reservoir Area, Wyoming-Utah," University of Utah Anthropological Papers Number 65 (Upper Colorado Series 9). Salt Lake City, Utah.

Day, K.S., K.D. Christopherson, and C. Crosby, 1999. "An Assessment of Young-of-the-Year Colorado Pikeminnow (*Ptychocheilus Lucius*) Use of Backwater Habitats in the Green River, Utah," Upper Colorado River Endangered Fish Recovery Program Project No. FG-33, Final Report in *Flaming Gorge Studies: Assessment of Colorado Pikeminnow Nursery Habitat in the Green River*, Publication No. 99-30. Utah Division of Wildlife Resources, Salt Lake City, Utah.

_________, 2000. "Backwater use by young of the year chub (*Gila spp*.) and Colorado pikeminnow (*Ptychocheilus lucius*) in Desolation and Gray Canyons of the Green River, Utah." Report B in *Reproduction and Recruitment of Gila spp. and Colorado Pikeminnow in the Middle Green River*, Final Report. Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

DeBlieux, D.D., M.C. Hayden, and J.I. Kirkland, 2002. *Paleontological Sensitivity Assessment for Flaming Gorge Reservoir and the Green River Corridor in Northwestern Utah*. Bureau of Reclamation, Upper Colorado Region, Provo Area Office, Provo, Utah.

Dexter, W.D., 1965. "Some Effects of Rotenone Treatment on the Fauna of the Green River, Wyoming." *Proceedings of the Annual Conference of the Western Association of State Game and Fish Commissions*, vol. 45, pp. 193-197.

Dunn, R.A., L.M. Smith, H.H. Allen, and H.M. Taylor, 1996. *Managing Historic Properties in Drawdown Zones at Corps of Engineers Reservoirs: Three Case Studies*, Technical Report EL-96-14. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Eason, N.J., 1992. Letter from N.J. Eason of the National Park Service, Dinosaur National Monument, Dinosaur, Colorado to R.A. Van Lonkhuyzen of Argonne National Laboratory, Argonne, Illinois, September 30, 1992.

Elbrock, B., 2004. Personal communication. Flaming Gorge Dam plant supervisor. Information on highest historic release from Flaming Gorge Reservoir.

Evermann, B.W., and C. Rutter, 1895. "The Fishes of the Colorado Basin." *U.S. Fish Commission Bulletin*, vol. 14(1894), pp. 473-486.

FLO Engineering, Inc., 1996. *Green River Flooded Bottomlands Investigation, Ouray Wildlife Refuge and Canyonlands National Park, Utah*. Final Report of FLO Engineering, Inc. to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Friedman, J.M., and G.T. Auble, 1999. "Mortality of Riparian Box Elder From Mobilization and Extended Inundation" in *Regulating Rivers: Resource Management*, vol 15, pp. 463-479.

Funk, J.L. and W.L. Pflieger, 1975. "Courtois Creek, a Smallmouth Bass Stream in the Missouri Ozarks" in *Black Bass Biology and Management*, H. Clepper, editor, Sport Fish Institute, Washington, DC., pp 224-237.

Gaufin, A.R., G.R. Smith, and P. Dotson, 1960. "Aquatic Survey of the Green River and Tributaries Within the Flaming Gorge Reservoir Basin, Appendix A" in *Ecological Studies of the Flora and Fauna of Flaming Gorge Reservoir Basin, Utah and Wyoming,* A.M. Woodbury, editor, University of Utah Anthropological Papers 48, pp. 139-162.

Gido, K.B, and D.L. Propst, 1999. "Habitat Use and Association of Native and Nonnative Fishes in the San Juan River, New Mexico and Utah," in *Copeia* (Gainseville), May, vol. 2, pp. 321-332.

Gipson, R.D. and W.A. Hubert, 1993. "Spawning-site Selection by Kokanee Salmon Along the Shoreline of Flaming Gorge Reservoir, Wyoming-Utah," in *North American Journal of Fisheries Management*, vol. 13, pp. 475-482.

Gosse, J.C., 1982. *Microhabitat of Rainbow and Cutthroat Trout in the Green River below Flaming Gorge Dam*, Volume 1, Aqua-Tech Biological Consulting Firm, Contract No. 81-5049, Logan, Utah, Final Report. To Utah Division of Wildlife Resources, Salt Lake City, Utah.

Gourley, J.L., and T.A. Crowl. 2002. "Pelagic Primary Productivity in an Arid Zone Temperate River: the Green River, Utah" in *The Levee Removal Project: Assessment of Floodplain Habitat Restoration in the Middle Green River*, Final Report, Publication No. 02-17. To the Upper Colorado River Endangered Fish Recovery Program, Utah Division of Wildlife Resources, Salt Lake City, Utah, Grabowski, S.J., and S.D. Hiebert, 1989. *Some Aspects of Trophic Interactions in Selected Backwaters and the Main Channel of the Green River, Utah, 1987-1988,* Final Report. Bureau of Reclamation Research and Laboratory Services Division, Applied Sciences Branch, Environmental Sciences Section, Denver, Colorado, to Upper Colorado Regional Office, Salt Lake City, Utah.

Graf, W.L., 1978. "Fluvial Adjustment to the Spread of Tamarisk in the Colorado Plateau Region" in *Geological Society of America Bulletin*, vol. 89, pp.1491-1501.

Grams, P.E., and J.C. Schmidt, 1999. "Geomorphology of the Green River in the Eastern Uintah Mountains, Dinosaur National Monument, Colorado and Utah" in *Varieties of Fluvial Form*, A.J. Miller, editor. John Wiley and Sons, New York, New York.

_________, 2002. "Streamflow Regulation, Multi-Level Plain Formation, and Riparian Vegetation: Channel Narrowing on the Aggrading Green River in the Eastern Uinta Mountains, Colorado and Utah" in *Geomorphology.*

Grams, P.E., J.C. Schmidt, and T. Naumann, 2002. "Geomorphic Adjustment of the Green River and Habitat Distribution of the Ute Ladies'-Tresses Orchid in Red Canyon and Browns Park, Colorado and Utah," Draft Final Report. January 9.

Haines, B. and T. Modde, 2002. *Humpback Chub Monitoring in Yampa Canyon, 1998-2000,* Final Report Project No. 22a4. U.S. Fish and Wildlife Service, Vernal, Utah.

Haines, G., and H.M. Tyus, 1990. "Fish Associations and Environmental Variables in Age-0 Colorado Squawfish Habitats, Green River, Utah" in *Journal of Freshwater Ecology*, vol. 5(4), pp. 427-435, December.

Hamman, R.L., 1981. "Spawning and Culture of Colorado Squawfish in Raceways" in *Progressive Fish Culturist*, vol. 43, pp. 173-177.

_________, 1982. Spawning and Culture of Humpback Chub" in *Progressive Fish Culturist*, vol. 44, pp. 213-215.

Harvey, M.D., R.A. Mussetter, and E.J. Wick, 1993. "A Physical Process Biological-Response Model for Spawning Habitat Formation for the Endangered Colorado Squawfish" in *Rivers,* vol. 4, pp 114-131.

Harvey, M.D., and R.A. Mussetter, 1994. *Green River Endangered Species Habitat Investigations*. Resource Consultants and Engineers, Fort Collins, Colorado, RCE Ref. No. 93-166.02.

Hawkins, J., and T.P. Nelser. 1991. *Nonnative Fishes of the Upper Colorado River Basin: An Issue Paper*, Final Report. Colorado State University Larval Fish Laboratory to the Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Hlohowskyj, I., and J.W. Hayse, 1995. *Potential Effects of Four Flaming Gorge Dam Hydropower Operational Scenarios on the Fishes of the Green River, Utah and Colorado*, Argonne National Laboratory Report No. ANL/EAD/TM-11. Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois.

Holden, M., 1992. Letter from Holden of Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City, Utah, to J.W. Hayse of Argonne National Laboratory, Argonne, Illinois; information for Western Area Power Administration Environmental Impact Statement, Utah. October 30, 1992.

Holden, P.B, 1991. "Ghosts of the Green River: Impacts of Green River Poisoning on Management of Native Fishes" in *Battle Against Extinction: Native Fish Management in the American Southwest,* W.L. Minckley and J.E. Deacon, editors. University of Arizona Press, Tucson, Arizona, pp. 43-54.

Holden, P.B., and L.W. Crist, 1981. *Documentation of Changes in the Macroinvertebrate and Fish Populations in the Green River Due to Inlet Modification of Flaming Gorge Dam*, Final Report PR-16-5. BIO/WEST, Inc., Logan, Utah.

Holden, P.B., and C.B. Stalnaker, 1975. "Distribution and Abundance of Fishes in the Middle and Upper Colorado River Basins, 1967–1973" in *Transactions of the American Fisheries Society*, vol. 104, pp. 217-231.

Hokanson, K.E., C.F. Kleiner, and T.W. Thorsland, 1977. "Effects of Constant Temperature and Diel Fluctuations on Growth, Mortality, and Yield of Juvenile Rainbow Trout, *Salmo gairdneri*" in *Journal of the Fisheries Research Board of Canada*, vol. 34, pp. 639-648.

Holling, C.S., editor, 1978. *Adaptive Environmental Assessment and Management*. John Wiley and Sons, Inc., New York, New York.

Holmer, R.N., 1979. *Final Report: Split Mountain Cultural Study Tract*. University of Utah, Department of Anthropology, Archaeological Center, Salt Lake City, Utah, submitted to the Bureau of Land Management, Vernal, Utah.

Howe, F., 1992. Letter from F. Howe, Utah Department of Natural Resources, Division of Wildlife Resources, Nongame Avian Program, Salt Lake City, Utah, to R.A. Van Lonkhuyzen of Argonne National Laboratory. Argonne, Illinois, October 30.

_________, 2000. *Southwestern willow flycatcher and yellow-billed cuckoo surveys along the Green River (Sand Wash-Swaseys Beach) Utah, 1997–1999*, Utah Division of Wildlife Resources, Publication No. 00-8. Report to the Bureau of Reclamation and Bureau of Land Management, 32 pp.

Howe, F.P., and M. Hanberg, 2000. *Willow Flycatcher and Yellow-Billed Cuckoo Surveys Along the Green and San Juan Rivers in Utah, 2000*, Utah Division of Wildlife Resources, Publication No. 00-31. Report to the Bureau of Reclamation and Bureau of Land Management, 53 pp.

Hudson, M., 2003. Phone conversation. Utah Division of Wildlife Resources, Moab, Utah, August 19, 2003.

Huffman, D.K., 1992. Letter from D.K. Huffman, Dinosaur National Monument, Dinosaur, Colorado, to R.L. Van Lonkhuyzen of Argonne National Laboratory. Argonne, Illinois, October 28.

Hughes, J.M., 1999. "Yellow-Billed Cuckoo" in *The Birds of North America*, No. 418, 1999, A. Poole and F. Gill, editors. Cornell Laboratory of Ornithology and the Academy of Natural Sciences.

Irving, D.B., and B.D. Burdickm, 1995. *Reconnaissance Inventory and Prioritization of Existing and Potential Bottomlands in the Upper Colorado River Basin, 1993–1994*, Final Report. U.S. Fish and Wildlife Service to the Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Irving, D.B. and K. Day, 1996. *Bottomland property inventory between Pariette Draw and Split Mountain on the Green River, Utah, 1995*, Final Report. U.S. Fish and Wildlife Service and the Utah Division of Wildlife Resources, Vernal, Utah, to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Irving, D.B., and T. Modde, 2000. "Home-Range Fidelity and Use of Historic Habitat by Adult Colorado Pikeminnow

(*Ptychocheilus lucius*) in the White River, Colorado and Utah" in *Western North American Naturalist*, vol. 60(1), pp. 16-25.

Jackle, M.D., and T.A. Gatz, 1985. "Herpetofaunal Use of Four Habitats of the Middle Gila River Drainage, Arizona" in *Riparian Ecosystems and Their Management: Reconciling Conflicting Uses*, R.R. Johnson et al., technical coordinators, Forest Service General Technical Report RM-120, pp. 355-358.

Johnson, J.E., R.P. Kramer, E. Larson, and B.L. Bonebrake, 1987. *Flaming Gorge Tailwater Fisheries Investigations: Trout Growth, Harvest, Survival, and Microhabitat Selection in the Green River of Utah, 1978–1982*, Final Report Publication No. 87-13. Utah Division of Wildlife Resources, Salt Lake City, Utah.

Johnson, M.J., A. Brand, H. English, C. Michaud, and B. Moore, 1999. *Southwestern Willow Flycatcher and Yellow-Billed Cuckoo Surveys Along the Colorado and Green Rivers, Utah (Park Boundaries – Colorado-Green Confluence): 1999*, Final Report. To the Utah Division of Wildlife Resources (Contract No. 976465), Colorado Plateau Field Station/Northern Arizona University, 34 pp.

Jordan, D.S., 1891. *Report of Explorations in Utah and Colorado During the Summer of 1889, with an Account of Fishes Found in Each of the River Basins Examined*, Bulletin of the U.S. Fish Commission, vol. 9, pp. 1-40.

Kaeding, L.R., and D.B. Osmundson, 1988. "Interaction of Slow Growth and Increased Early-Life Mortality: An Hypothesis on the Decline of the Colorado Squawfish in the Upstream Regions of Its Historic Range" in *Environmental Biology of Fishes*, vol. 22 (4), pp. 287-298.

Karp, C.A., and H.M. Tyus, 1990a. "Behavioral Interactions Between Young Colorado Squawfish and Six Fish Species" in *Copeia*, pp. 25-34.

_________, 1990b. "Humpback Chub (*Gila cypha*) in the Yampa and Green Rivers, Dinosaur National Monument, with Observations on Roundtail Chub (*G. robusta*) and Other Sympatric Fishes" in *Great Basin Naturalist*, vol. 50, pp. 257-264.

Kjos, C.G., 1992. "Bald Eagle Numbers Continue to Rise" in *Endangered Species Technical Bulletin*, vol. 17(1-2), pp. 3-4. U.S. Fish and Wildlife Service.

Kitcheyan, C., 2003. "Movement, Migration, and Habitat Use of Colorado Pikeminnow in Lodore Canyon." Presentation at Upper Colorado River Endangered Fish Recovery Program: 24th Annual Researchers Meeting, January 15-16, 2003, Grand Junction, Colorado.

Kubly, D.M., 1990. "The Endangered Humpback Chub (*Gila Cypha*) in Arizona: a Review of Past Studies and Suggestions for Future Research," Draft Report. Prepared by Arizona Game and Fish Department for the Bureau of Reclamation, Salt Lake City, Utah.

Larson, G., 2004. "Hydrogeomorphic Controls on Tamrisk's Distribution in Dinosaur National Monument: Comparing the Effects of Regulated and Unregulated Flow Regimes." Masters of Science thesis, Utah State University, Logan, Utah.

Lenihan, D.J., T.L. Carrell, S. Fosberg, L. Murphy, S.L. Rayl, and J.A. Ware, 1981. *The Final Report of the National Reservoir Inundation Study*, vol. 1 and 2. U.S. Department of the Interior, National Park Service, Southwest Cultural Resource Center, Santa Fe, New Mexico.

Lentsch, L.D., R.T. Muth, P.D. Thompson, B.G. Hoskins, and T.A. Crowl, 1996. *Options for Selective Control of*

Nonnative Fishes in the Upper Colorado River Basin, Final Report. Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Lilieholm, R.J., and R.S. Krannich, 2001. 2000 Statewide Survey of Utah Anglers. Utah State University, Logan, Utah.

Lyons, J.K., M.J. Pucherelli, and R.C. Clark, 1992. "Sediment Transport and Channel Characteristics of a Sand-bed Portion of the Green River below Flaming Gorge Dam, Utah, U.S.A." in *Regulated River: Research and Management*, vol. 7, pp. 219-232.

MacRae, P.S.D. and D.A. Jackson, 2001. "The Influence of Smallmouth Bass (*Micropterus dolomieu*) Predation and Habitat Complexity on the Structure of Littoral Zone Fish Assemblages" in *Canadian Journal of Fisheries and Aquatic Sciences*, vol. 58, pp. 342-351.

Madsen, David B., 1989. *Exploring the Fremont*. University of Utah Occasional Publication No. 8. Utah Museum of Natural History, Salt Lake City.

Maiolie, M, and S. Elam, 1998. *Kokanee Entrainment Loss at Dworshak Reservoir, Dworshak Dam Impacts Assessment and Fisheries Investigation Project, Annual Progress Report*. January-December, 1996. Report to Bonneville Power Administration, Contract No. 1987BP35167, Project No. 198709900, 18 electronic pages.

Marsh, P.C., 1985. "Effect of Incubation Temperature on Survival of Embryos of Native Colorado River Fishes"in *The Southwestern Naturalist*, vol. 30, pp. 129-140.

Martin, J.A., P.E. Grams, M.T. Kammerer, J.C. Schmidt, 1998. *Sediment Transport and Channel Response of the Green River in the Canyon of Lodore Between 1995–1997, Including Measurements During High Flows, Dinosaur National Monument, Colorado,* Draft Final Report, Utah State University Cooperative Agreement CA 1268-1-9006 and CA-1425-97-FC-40-21560. Prepared for the National Park Service and Bureau of Reclamation, 190 pp.

Martinez, P., 2003. "A Look at the Smallmouth Bass Scenario in the Yampa River Basin." Presentation at Upper Colorado River Endangered Fish Recovery Program: 24th Annual Researchers Meeting, January 15-16, 2003, Grand Junction, Colorado.

Matson, R.G., 1991. *The Origins of Southwestern Agriculture*. University of Arizona Press, Tucson.

McAda, C.W., 1983. "Colorado Squawfish, *Ptychocheilus Lucius* (Cyprinidae), with Channel Catfish, *Ictalurus Punctatus* (Ictaluridae), Lodged in Its Throat" in *The Southwestern Naturalist*, vol. 28(1), pp. 119-120.

__________, 2002. *Subadult and Adult Colorado Pikeminnow Monitoring; Summary of Results, 1986–2000*, Final Report Recovery Program Project No. 22. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

McAda, C.W., and L.R. Kaeding, 1989. "Relations Between Maximum-Annual River Discharge and the Relative Abundance of Age-0 Colorado Squawfish and Other Fishes in the Upper Colorado River." U.S. Fish and Wildlife Service, Grand Junction, Colorado.

McAda, C.W., and R.J. Ryel, 1999. *Distribution, Relative Abundance, and Environmental Correlates for Age-0 Colorado Pikeminnow and Sympatric Fishes in the Colorado River*, Final Report, Project No. 45. Upper Colorado River Endangered Fish Recovery Program.

McAda, C.W. and R.S. Wydoski, 1980. *The Razorback Sucker, Xyrauchen texanus, in the Upper Colorado River Basin, 1974-1976,* Technical Papers 99. U.S. Fish and Wildlife Service.

Mehls, S.F., 1987. *Dinosaur National Monument Historic Resources Study*. Western Historical Studies, Inc., Boulder, Colorado.

Meismer, S. and M. Trammell, 2002. "Nonnative Cyprinid Removal in the Lower Green and Colorado Rivers, Utah," Draft Report. Utah Division of Wildlife Resources, Moab, Utah.

Merritt, D.M., and D.J. Cooper, 2000. "Riparian Vegetation and Channel Change in Response to River Regulation: A Comparative Study of Regulated and Unregulated Streams in the Green River Basin, U.S.A." in *Regulated Rivers: Research and Management*, vol. 16, pp. 543-564.

Miller, J., 1984. *Intermountain West Reservoir Limnology and Management Options*, Lake and Reservoir Management, EPA 440/4/84-001. U.S. Environmental Protection Agency, Washington, DC, pp. 272-276.

Miller, J., 2002. Bureau of Reclamation Upper Colorado River Regional Water Quality Scientist, personal communication following the Flaming Gorge Reservoir limnological survey in October 2002.

Miller, J., 2004. Bureau of Reclamation Upper Colorado River Regional Water Quality Scientist, personal communication.

Miller, R.R., 1963. "Is Our Native Underwater Life Worth Saving?" in *National Parks Magazine*.

Minckley, W.L., 1991. "Native Fishes of the Grand Canyon Region: an Obituary?" in *Colorado River Ecology and Dam Management*. Proceedings of a Symposium, May 24-25, 1990, Santa Fe, New Mexico. National Academy Press, Washington, DC, pp. 124-177.

Minckley, W.L., and G.K. Meffe, 1987. "Differential Selection for Native Fishes by Flooding in Streams of the Arid American Southwest" in *Ecology and Evolution of North American Stream Fish Communities*, W.J. Matthews and D.C. Heins, editors. University of Oklahoma Press, Norman, Oklahoma, pp. 93-104.

Minckley, W.L., P.C. Marsh, J.E. Brooks, J.E. Johnson, and B.L. Jensen, 1991. "Management Toward Recovery of the Razorback Sucker" in *Battle Against Extinction: Native Fish Management in the American West*, W.L. Minckley and J.E. Deacon, editors. University of Arizona Press, Tucson, Arizona, pp. 303–357.

Minnesota IMPLAN Group, Inc., 2000. IMPLAN Professional, Version 2.0, User's Guide, Analysis Guide, Data Guide. Stillwater, Minnesota.

Modde, T., 1993. Telecommunication from T. Modde of the U.S. Fish and Wildlife Service, Vernal, Utah, to I. Hlohowskyj of Argonne National Laboratory, Argonne, Illinois. August 17, 1993.

Modde, T., and K., Christopherson, 2003. Personal communication, Recovery Program Biology Committee meeting. September 22, 2003.

Modde, T., D.A. Young, and D.L. Archer, 1991. *Evaluation of Factors Influencing Population Characteristics and Habitat Utilization of Trout in the Flaming Gorge Tailwater, 1987-1989*, Publication No. 91-10, Flaming Gorge Tailwater Studies. Utah Division of Wildlife Resources, Salt Lake City, Utah.

Modde, T., K.P. Burnham, and E.J. Wick, 1996. "Population Status of the Razorback Sucker in the Middle Green River" in *Conservation Biology*, vol. 10, pp. 110-119.

Modde, T., and D.B. Irving, 1998. "Use of Multiple Spawning Sites and Seasonal Movements by Razorback Suckers in the Middle Green River, Utah" in *North American Journal of Fisheries Management*, vol. 18, pp. 318-326.

Modde, T., and E.J. Wick, 1997. *Investigations of Razorback Sucker Distribution, Movements and Habitats Used During Spring in the Green River, Utah*, Final Report. U.S. Fish and Wildlife Service, Vernal, Utah, to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Moeller, K.L., L.M. Malinowski, and J.F. Hoffecker. *Analysis of Potential Impacts of Flaming Gorge Dam Hydropower Operations on Archaeological Sites*. Environmental Assessment Division, Argonne National Laboratory, Argonne, Illinois.

Molony, B., 2001. *Environmental Requirements and Tolerances of Rainbow Trout (Oncorhynchus mykiss) and Brown Trout (Salmo trutta) With Special Reference to Western Australia: A Review*, Fisheries Research Report No. 130. Department of Fisheries, Government of Western Australia.

Mueller, G., 1995. "A Program for Maintaining the Razorback Sucker in Lake Mohave," in *American Fisheries Society Symposium*, vol. 15, pp. 127-135.

Muth, R.T., G.B. Haines, S. Meismer, E.J. Wick, T.E. Chart, D.E. Snyder, J.M. Bundy, 1998. *Reproduction and Early Life History of Razorback Sucker in the Green River, Utah and Colorado, 1992–1996*, Final Report. Colorado State University Larval Fish Laboratory to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Muth, R.T., 1995. "Development of a Standardized Monitoring Program for Basin-wide Evaluation of Restoration Activities for Razorback Sucker in the Green and Upper Colorado River Systems," Draft Report. Submitted to the Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Muth, R., L. Crist, K. La Gory, J. Hayse, K. Bestgen, T. Ryan, J. Lyons, and R. Valdez, 2000. *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam*, Final Report. To the Upper Colorado River Endangered Fish Recovery Program, Project FG-53, September 2000.

NatureServe, 2001. "Spiranthes diluvialis – Sheviak, Ute Ladies'-Tresses," NatureServe Explorer: An online encyclopedia of life [web application],Version 1.6. Arlington, Virginia, <htttp://www.natureserve.org/explorer>, accessed September 13, 2002.

Nesler, T.P., 2002. *Interactions Between Endangered Fishes and Introduced Gamefishes in the Colorado River, Colorado, 1986–1991*, Final Report, Colorado River Recovery Implementation Program Project No. 91-29. Colorado Division of Wildlife, Fort Collins, Colorado.

Nesler, T.P., K. Christopherson, J.M. Hudson, C.W. McAda, F. Pfeifer, and T. Czapla, 2003. An Intergrated Stocking Plan for Razorback Sucker, Bonytail, and Colorado Pikeminnow for the Upper Colorado River Endangered Fish Recovery Program: Addendum to State Stocking Plans. Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado, 12 pp.

Nevada Natural Heritage Program, 2001. "*Spiranthes diluvialis Sheviak*, Ute Ladies'-Tresses, Rare Plant Fact Sheet."

Orchard, K.L., and J.C. Schmidt, 2000. "A Geomorphic Assessment of the Availability of Potential Humpback Chub Habitat in the Green River in Desolation and Gray Canyons, Utah," Report A in *Flaming Gorge Studies: Reproduction and Recruitment of Gila spp. and Colorado Pikeminnow (Ptychocheilus lucius) in the Middle Green River*, Final Report. Utah Division of Wildlife Resources to Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado.

Osmundson, D.B., 1999. *Longitudinal Variation in Fish Community Structure and Water Temperature in the Upper Colorado River*, Final Report Recovery Implementation Program Project No. 48-A. U.S. Fish and Wildlife Service, Grand Junction, Colorado.

Osmundson, D.B., and L.R. Kaeding, 1991. *Recommendations for Flows in the 15-Mile Reach During October–June for Maintenance and Enhancement of Endangered Fish Populations in the Upper Colorado River*, Final Report. U.S. Fish and Wildlife Service, Colorado River Fishery Project, Grand Junction, Colorado.

Osmundson, D.B., R.J. Ryel, and T.E. Mourning, 1997. "Growth and Survival of Colorado Squawfish in the Upper Colorado River" in *Transactions of the American Fisheries Society*, vol. 126, pp. 687-698.

Papoulias, D. and W.L. Minckley, 1990. "Food limited survival of larval razorback sucker, Xyrauchen texanus, in the laboratory" in *Environmental Biology of Fishes*, vol. 29, pp. 73-78.

Papoulias, D. and W. L. Minckley. 1992. "Effects of food availability on survival and growth of larval razorback suckers in ponds" in *Transactions of the American Fisheries Society*, vol. 121, pp. 340-355.

Paulin, K.M., C.M. Williams, and H.M Tyus. 1989. *Responses of Young Razorback Sucker and Colorado Squawfish to Water Flow and Light Intensity*, Final Report. U.S. Fish and Wildlife Service Colorado River Fishery Project, Vernal, Utah

Pearson, W.D., R.H. Kramer, and D.R. Franklin, 1968. "Macroinvertebrates in the Green River Below Flaming Gorge Dam, 1964-1965 and 1967" in *Proceedings of the Utah Academy of Science, Arts, and Letters*, vol. 45, pp. 148-167.

Peterson, C.S., 1998. Livestock Industry. <http://eddy.media.utah.edu/medsol/UCME/ LIVESTOCK.html>, accessed August 28, 1998.

Pflieger, W.L., 1975. *The Fishes of Missouri.* Missouri Department of Conservation, Jefferson City, Missouri.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg, 1997. "The Natural Flow Regime: a Paradigm for River Conservation and Restoration" in *BioScience*, vol. 47, pp. 769-784.

Pollack, M.M., 1998. "Plant Species Richness in Riparian Wetlands – a Test of Biodiversity Theory." January 1998.

Pucherelli, M., and A. Bell, 1999. Mapping provided by the Bureau of Reclamation Remote Sensing and Geographic Information Group, Denver, Colorado. This data contains sensitive cultural resource information belonging to the U.S. Government and is not available for public release.

Pucherelli, M.J., R.C. Clark, and R.D. Williams, 1990. *Mapping Backwater Habitat on the Green River as Related to the Operation of Flaming Gorge Dam Using Remote Sensing and GIS*. Bureau of Reclamation, vol. 90 (18), pp. 1-11.

Purdy, W.M., 1959. *An Outline of the History of the Flaming Gorge Area*, University of Utah Anthropological Papers No. 37, Upper Colorado Series No. 1. Salt Lake City, Utah.

Rakowski, C.L., and J.C. Schmidt, 1999. "The Geomorphic Basis for Colorado Pikeminnow Nursery Habitat in the Green River Near Ouray, Utah," Report A in *Flaming Gorge Studies: Assessment of Colorado Pikeminnow Nursery Habitat in the Green River*, Trammell, M.A., and seven other authors. Publication No. 99-30. Utah Division of Wildlife Resources, Salt Lake City, Utah.

Reed, A.D., 1994 "The Numic Occupation of Western Colorado and Eastern Utah During the Prehistoric and Protohistoric Periods" in *Across the West: Human Population Movement and the Expansion of the Numa*, D.B. Madsen and D. Rhode, editors. University of Utah Press, Salt Lake City, Utah.

Rhodenbaugh, M., and V. Newton, 2001. *Ethnographic Overview for the Flaming Gorge Dam Environmental Impact Statement: Native American Contacts and the Identification of Traditional Cultural Places*, SWCA Archaeological Report No. 01-134. SWCA Environmental Consultants, Salt Lake City, Utah, submitted to the Bureau of Reclamation, Upper Colorado Region, Provo Area Office, Provo, Utah.

Roberts, N.K., and B.D. Gardner, 1964. "Livestock on Public Lands" in *Utah Historical Quarterly*, vol. 32(3), pp. 285-300.

Robins, W.H. and H.R. MacCrimmon, 1974. *The Black Bass in America and Overseas*. Biomanagement and Research Enterprises, Sault Ste. Marie, Ontario, 196 pp.

Romney, Steve, Dr., 2002. Personal communication, May 22, 2002. Followup call on August 7, 2002.

Rood, R.J., and M.C. Pope, 1993. "1992 Archaeological Excavations Along the Kern River Gas Transmission Line, Southwestern Wyoming: Data Recovery at Sites 48UT1447, 48UT786, and 48UT186," Contract No. 1188RLB026. Alpine Archaeological Consultants, Inc., submitted to Kern River Gas Transmission Company, Salt Lake City, Utah.

Rose, K.L., 1992. Letter from K.L. Rose of the U.S. Fish and Wildlife Service, Grand Junction, Colorado, to I. Hlohowskyj of Argonne National Laboratory, Argonne, Illinois. January 8, 1992.

Schirer, D.L., 1998a. Fort Duchesne, <http://eddy.media.utah.edu/medsol/ UCME/f/ DUCHESNE.html>, accessed August 28, 1998.

_________, 1998b. Fort Thornburgh, <http://eddy.media.utah.idu/medsol/UCME/f/ FORTTHORNBURGH.html>, accessed August 28, 1998.

Schneidervin, R., 2003. Personal communication. Utah Division of Wildlife Resources, Flaming Gorge Project Leader, March 11, 2003.

Schnurr, P.M., 1992. Letter from P.M. Schnurr of the Colorado Department of Natural Resources, Division of Wildlife, Denver, Colorado, to R.A. Van Lonkhuyzen of Argonne National Laboratory. Argonne, Illinois. October 29, 1992.

Schroeder, A.H., 1965. "A Brief History of the Southern Utes" in *Southwestern Lore*, vol. 30 (4), pp. 53-78.

Schroedl, A.R., 1991. "Paleo-Indian Occupation in the Eastern Great Basin and Northern Colorado Plateau" in *Utah Archaeology*, vol. 4(1), pp. 1-15.

_________, 1977. "The Paleo-Indian Period on the Colorado Plateau" in *Southwestern Lore*, vol. 43(3), pp. 1-9.

Scott, W.B. and E.J. Crossman, 1973. "Freshwater Fishes in Canada" in *Journal of the Fisheries Research Board of Canada*, Bulletin 184, 966 pp.

Shafroth, P.B., G.T. Auble, and M.L. Scott, 1995. "Germination and Establishment of Native Plains Cottonwood (*Populus deltoides* Marshall subsp. *monilifera*) and the Exotic Russian-Olive (*Elaeagnus angustifolia* L.)" in *Conservation Biology*, vol. 9, pp. 1169-1175.

Sigler, W.F., 1958. *The Ecology and Use of Carp in Utah*. Utah State University Agricultural Experimental Station Bulletin 405, 63 pp.

Sigler, W.F., and J.W. Sigler, 1996. *Fishes of Utah: a Natural History*. University of Utah Press.

Simms, S.R., 1990. "Fremont Transitions" in *Utah Archaeology*, vol. 3(1), pp. 1-18.

Simon, J.R., 1946. *Wyoming Fishes*, Wyoming Game and Fish Department Bulletin vol. 4, pp. 1-129.

Smith, G.R., 1966. *Distribution and Evolution of the North American Catostomid Fishes of the Subgenus, Pantosteus, Genus Catostomus*, miscellaneous publication of the Museum of Zoology, University of Michigan, vol. 129, pp. 1-132.

Smith, P.W., 1979. *The Fishes of Illinois*, Illinois State Natural History Survey. University of Illinois Press, Urbana, Illinois.

Sogge, M.K., R.M. Marshall, S.J. Sferra, and T.J. Tibbetts, 1997a. *A Southwestern Willow Flycatcher Natural History Summary and Survey Protocol*, Technical Report, NPS/NAUCPRS/TR-97/12.

Sogge, M.K., T.J. Tibbitts, and J.R. Petterson, 1997b. "Status and Breeding Ecology of the Southwestern Willow Flycatcher in Grand Canyon" in *Western Birds*, vol. 28, pp. 142-157.

Stanford, J.A., J.V. Ward, W.J. Liss, C.A. Frissell, R.N. Williams, J.A. Lichatowich, and C.C. Coutant, 1996. "A General Protocol for Restoration of Regulated Rivers" in *Regulated Rivers: Research and Management*, vol. 12, pp. 391-414.

Stevens, L.E., and G.L. Waring, 1986. *Effects of Post-Dam Flooding on Riparian Substrates, Vegetation, and Invertebrate Populations in the Colorado River Corridor in Grand Canyon, Arizona*. Glen Canyon Environmental Studies, Bureau of Reclamation, 166 pp.

Stevenson, J.P., 1987. *Trout Farming Manual*, Second Edition. Fishing News Books, Farnham, 259 pp.

Strand, R.I., and E.L. Pemberton, 1982. *Reservoir Sedimentation, Technical Guideline for Bureau of Reclamation*. U.S. Department of the Interior, Bureau of Reclamation, Sedimentation and River Hydraulics Group, Denver, Colorado, 48 pp.

Sturtevant, William C., 1986. *Handbook of North American Indians, Great Basin, Volume 11*. Smithsonian Institution, Washington, DC.

Talbot, R.K., and J.D. Wilde, 1989. "Giving Form to the Formative: Shifting Settlement Patterns in the Eastern Great Basin and Northern Colorado Plateau" in *Utah Archaeology*, pp. 3-18.

Tennent, W.L., 1981. *John Jarvie of Brown's Park*, Number 7. Bureau of Land Management, Salt Lake City, Utah.

Teuscher, D. and C. Luecke, 1996. "Competition Between Kokanees and Utah Chub in Flaming Gorge Reservoir" in *Transactions of the American Fisheries Society*, vol. 125, pp. 505-511.

Todd, Chauncie, 2003. Personal communication. Ashley National Forest. Information and documentation on

50-mile survey on the shoreline of Flaming Gorge Reservoir completed in 2003.

Trammell, M.A., et al., 1999. *Flaming Gorge Studies: Assessment of Colorado Pikeminnow Nursery Habitat in the Green River,* Publication No. 99-30. Utah Division of Wildlife Resources, Salt Lake City, Utah.

Trammell, M.A., R. Valdez, H. Johnstone, and L. Jonas, 2002. *Non-Native Fish Control in Backwater Habitats in the Colorado River,* Final Report. SWCA, Inc., Environmental Consultants, Flagstaff, Arizona.

Truesdale, J.A., 1991. *Archaeological Investigations at Two Sites in Dinosaur National Monument: 42UN1724 and 5MF2645*. U.S. Department of the Interior, National Park Service, Rocky Mountain Region, Division of Cultural Resources Management, Selection Series, Denver, Colorado.

Tyus, H.M., 1987. "Distribution, Reproduction, and Habitat Use of the Razorback Sucker in the Green River, Utah, 1979–1986" in *Transactions of the American Fisheries Society*, vol. 116, pp. 111-116.

_________, 1990. "Potamodromy and Reproduction of Colorado Squawfish in the Green River Basin, Colorado and Utah" in *Transactions of the American Fisheries Society*, vol. 119, pp. 1035-1047.

_________, 1991. "Movements of and Habitat Use of Young Colorado Squawfish in the Green River, Utah" in *Journal of Freshwater Ecology,* vol. 6, pp. 43-51.

Tyus, H. M., and J. Beard, 1990. "*Esox Lucius* (Esocidae) and *Stizostedion Vitreum* (Percidae) in the Green River Basin, Colorado and Utah" in *Great Basin Naturalist*, vol. 50, pp. 33-39.

Tyus, H.M., B.D. Burdick, R.A. Valdez, C.M. Haynes, T.A. Lytle, and C.R. Berry, 1982. "Fishes of the Upper Colorado River Basin: Distribution, Abundance, and Status" in *Fishes of the Upper Colorado River System: Present and Future*, W.H. Miller, H.M. Tyus, and C.A. Carson, editors. Western Division, American Fisheries Society, Bethesda, Maryland, pp. 12-70.

Tyus, H.M., R.L. Jones, and L.M. Trincam 1987. *Green River Rare and Endangered Fish Studies, 1982-1985,* Final Report. U.S. Fish and Wildlife Service Colorado River Fishes Monitoring Project, Vernal, Utah.

Tyus, H.M., and C.A. Karp, 1989. *Habitat Use and Streamflow Needs of the Rare and Endangered Fishes, Yampa River, Colorado*. U.S. Fish and Wildlife Service Biological Report, vol. 89(14), pp. 1-27.

_________, 1990. "Spawning and Movements of Razorback Sucker, Xyrauchen Texanus, in the Green River Basin of Colorado and Utah" in *Southwestern Naturalist*, vol. 35, pp. 427-433.

_________, 1991. *Habitat Use and Streamflow Needs of Rare and Endangered Fishes, Green River, Utah*, Biological Report, vol. 89(14), pp. 1-27. U.S. Fish and Wildlife Service, Vernal Utah.

Tyus, H.M., C.W. McAda, and B.D. Burdick, 1982. *Green River Fishery Investigations: 1979-1981*, Final Report. To the U.S. Fish and Wildlife Service and the Bureau of Reclamation, Salt Lake City, Utah.

Tyus, H.M., and G.B. Haines, 1991. "Distribution, Habitat Use, and Growth of Young Colorado Squawfish in the Green River Basin, Colorado and Utah" in *Transactions of the American Fisheries Society*, vol. 120, pp. 79-89.

Tyus, H.M. and J.F. Saunders III, 1996. "*Nonnative Fishes in the Upper Colorado River Basin and a Natural Ecosystems and a Strategic Plan for Control of Nonnatives in the Upper Colorado River Basin,"* report to Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin. University of Colorado, Boulder, Colorado.

_________, 2001. *An Evaluation of the Role of Tributary Streams for Recovery of Endangered Fishes in the Upper Colorado River Basin, with Recommendation for Future Recovery Actions*, Final Report, Project No. 101. Upper Colorado Endangered Fish Recovery Program, Center for Limnology, University of Colorado at Boulder, Boulder, Colorado, 121 pp.

Tyus, H.M., and N.J. Nikirk, 1990. "Abundance, Growth, and Diet of Channel Catfish, *Ictalurus punctatus*, in the Green and Yampa Rivers, Colorado and Utah" in *Southwestern Naturalist*, vol. 35(2), pp. 188-198.

University of Wyoming, and Utah Cooperative Fish and Wildlife Research Unit, 1991. *Assessment of Spawning-Habitat Mitigation in the Green River and the Potential Influence of Reservoir Drawdown on Kokanee Reproduction in the Flaming Gorge Reservoir System, Wyoming-Utah.* Completion Report for the Bureau of Reclamation, Laramie, Wyoming, and Logan, Utah.

Upper Colorado River Endangered Fish Recovery Program. 2002. Nonnative Fish Control Workshop; Summary, Conclusions, and Recommendations. Prepared by the Program Director's Office, Upper Colorado River Endangered Fish Recovery Program, Lakewood, Colorado.

U.S. Census Bureau, 2000. United States Census 2000. Internet site: <www.census.gov>. U.S. Department of Commerce.

_________, 1990 and 2000. Census 1990 and 2000.

_________, 1994. Census of Agriculture – 1992. U.S. Department of Commerce. Washington, DC.

_________, 1999. Census of Agriculture - 1997. U.S. Department of Commerce. Washington, DC.

U.S. Department of Energy, 1995. *Impacts of Western Area Power Administration's Power Marketing Alternatives on Electric Utility Systems,* ANL/DIS/TM-10. Argonne National Laboratory, Decision and Information Sciences Division, March 1995.

_________. *Relationships Between Western Area Power Administration's Power Marketing Program and Hydropower Operations at Salt Lake City Area Integrated Projects*, ANL/DIS/TM-11. Argonne National Laboratory, Decision and Information Sciences Division.

U.S. Department of Energy, Western Area Power Administration, 1996. *Salt Lake City Area Integrated Projects Electric Power Marketing Final Environmental Impact Statement*, Volume II: Sections 1-16, DOE/EIS-0150. Salt Lake City, Utah, January 1996.

_________, 1996. *Salt Lake City Area Integrated Projects Electric Power Marketing Final Environmental Impact Statement*, Volume III, Appendix A, DOE/EIS-0150. Salt Lake City, Utah.

_________, 1996. *Salt Lake City Area Integrated Projects Electric Power Marketing, Final Environmental Impact Statement*, Volume IV, Appendixes B–D, DOE/EIS-0150. Salt Lake City, Utah, January 1996, pp B1-21.

U.S. Environmental Protection Agency, 1998. "A Biopesticide Fact Sheet: Bacillus Thuringiensis subspecies Israelensis Strain EG2215." October 1998.

U.S. Fish and Wildlife Service, 1977. "American Peregrine Falcon Recovery Plan (Rocky Mountain and Southwest Populations)." Washington, DC, August 3, 1992.

__________, 1992a. "Final Rule to List the Plant Spiranthes diluvialis (Ute Ladies'-Tresses) as a Threatened Species." *Federal Register*, vol. 57, pp. 2048-2054

__________, 1992b. Final Biological Opinion on the Operation of Flaming Gorge Dam. Fish and Wildlife Service, Mountain-Prairie Region, Denver, Colorado, November 25, 1992.

__________, 1995. "Final Rule Determining Endangered Status for Southwestern Willow Flycatcher." February 27, 1995, *Federal Register*, vol. 60, pp. 10694-10715.

__________, 1997. "Final Determination of Critical Habitat for the Southwestern Willow Flycatcher." *Federal Register*, vol. 62, pp. 39129-39147.

__________, 2001. "Twelve-Month Finding for a Petition to List the Yellow-Billed Cuckoo (*Coccyzus Americanus*) in the Western Continental United States." July 25, 2001, *Federal Register*, vol. 66, No. 143, pp. 38611-38626

__________, 2002a. "Bonytail (*Gila Elegans*) Recovery Goals: Amendment and Supplement to the Bonytail Chub Recovery Plan." U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

__________, 2002b. "Colorado Pikeminnow (*Pytchocheilus Lucius*) Recovery Goals: Amendment and Supplement to the Colorado Squawfish Recovery Plan." U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

__________, 2002c. "Humpback Chub (*Gila Cypha*) Recovery Goals: Amendment and Supplement to the Humpback Chub Recovery Plan." U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

__________, 2002d. "Razorback Sucker (*Xyrauchen Texanus*) Recovery Goals: Amendment and Supplement to the Razorback Sucker Recovery Plan." U.S. Fish and Wildlife Service, Mountain-Prairie Region (6), Denver, Colorado.

__________, 2003. "Final Recovery Plan for Southwestern Willow Flycatcher." March 5, 2003, *Federal Register*, vol. 68, p. 10485.

Utah Department of Agriculture and Food**,** 1996. *Utah Agricultural Statistics and Utah Department of Agriculture and Food Annual Report*. Salt Lake City, Utah.

__________, 1997. *Utah Agricultural Statistics and Utah Department of Agriculture and Food Annual Report*. Salt Lake City, Utah.

__________, 1998. *Utah Agricultural Statistics and Utah Department of Agriculture and Food Annual Report*. Salt Lake City, Utah.

__________, 1999. *Utah Agricultural Statistics and Utah Department of Agriculture and Food Annual Report*. Salt Lake City, Utah.

__________, 2000. *Utah Agricultural Statistics and Utah Department of Agriculture and Food Annual Report*. Salt Lake City, Utah. Website at <http://www.r6.fws.gov/crrip/arpts/2000/rsch/22c-00.pdf>.

Utah Division of Wildlife Resources, 1992. *The Reintroduction of River Otter to the Green River, Utah: Progress Report II.* A cooperative study between Utah Division of Wildlife Resources, Non-Game Section; Brigham Young University; U.S. Forest Service, Ashley

National Forest; and Bureau of Land Management. Salt Lake City, Utah, May 1992.

_________, 2002. "Ute Ladies'-Tresses, *Spiranthes diluvialis* Fact Sheet."

Utah State University Cooperative Extension, 1997. Utah Crop Enterprise Budgets. Logan, Utah.

Valdez, R.A., 1990. *The Endangered Fishes of Cataract Canyon*, Final Report. BIO/West, Inc. to the Bureau of Reclamation, Salt Lake City, Utah.

Valdez, R.A. and G.C. Clemmer, 1982. "Life History and Prospects for Recovery of the Humpback and Bonytail Chub" in *Fishes of the Upper Colorado River System: Present and Future,* W.H. Miller, H.M. Tyus, and C.A. Carlson, editors. Western Division, American Fisheries Society, Bethesda, Maryland, pp. 109-119.

Valdez, R.A., and M. Hugentobler (editors), 1993. *Characterization of the Life History and Ecology of the Humpback Chub (Gila Cypha) in the Grand Canyon,* Annual Report 1992. BIO/WEST Report No. TR-250-06 to the Bureau of Reclamation, Logan, Utah, 168 pp. plus appendices.

Valdez, R.A., and W.J. Masslich, 1989. *Winter Habitat Study of Endangered Fish - Green River: Wintertime Movement and Habitat of Adult Colorado Squawfish and Razorback Suckers,* Report No. 136-2. BIO/WEST Inc., Logan, Utah, April.

Valdez, R.A. and P. Nelson. 2004. *Green River Subbasin Floodplain Management Plan*, Final Report. To the Upper Colorado River Endangered Fish Recovery Program, Denver, Colorado, Project No. C-6.

Vanicek, C.D., 1967. "Ecological Studies of Native Green River Fishes Below Flaming Gorge Dam, 1964-1966," Doctoral dissertation. Utah State University, Logan, Utah

Vanicek, C.D., and R.H. Kramer, 1969. "Life History of the Colorado Squawfish, *Ptychocheilus Lucius*, and the Colorado Chub, *Gila Robusta*, in the Green River Dinosaur National Monument 1963-1966" in *Transactions of the American Fisheries Society*, vol. 98, pp. 193-208.

Vanicek, C.D., R.H. Kramer, and D.R. Franklin, 1970. "Distribution of Green River Fishes in Utah and Colorado Following Closure of Flaming Gorge Dam" in *Southwestern Naturalist*, vol. 14, pp. 297-315.

Vinson, M., 1998. *Aquatic Macroinvertebrate Assemblages Downstream of Flaming Gorge Dam*, Final Report. Bureau of Land Management National Aquatic Monitoring Center, Fisheries and Wildlife Department, Utah State University, Logan, Utah, to the Bureau of Reclamation and Utah Division of Wildlife Resources, Salt Lake City, Utah.

_________, 2004. Personal communication, Department of Aquatic, Watershed, and Earth Resources. Utah State University, correspondence date March 18, 2004.

Walters, C., 1986. *Adaptive Management of Renewable Resources*. Macmillan Press, New York, New York.

Ward, J., and T. Naumann, 1998. Ute Ladies'-Tresses Orchid (*Spiranthes Diluvialis Sheviak*) Inventory. Dinosaur National Monument and Browns Park National Wildlife Refuge.

Ware, J., 1989. *Archaeological Inundation Studies: Manual for Reservoir Managers*, Contract Report EL-89-4. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.

Waters, Michael R., 1992. *Principles of Geoarchaeology: A North American Perspective*. The University of Arizona Press, Tucson, Arizona.

Wilder, G., 1998. Browns Park. <http://eddy.media.utah.edu/medsol/ UCME/b/ BROWNS PARK.html>, accessed August 1998.

Williams, C.A., 2000. "A Comparison of Floodplain Hydrology and Cottonwood Water Relations on a Regulated and Unregulated River in Northwestern Colorado," Masters of Science thesis. Colorado State University, Ft. Collins, Colorado, 183 pp.

Wiltzius, W.J., 1978. *Some Factors Historically Affecting the Distribution and Abundance of Fishes in the Gunnison River*, Final Report. Colorado Division of Wildlife to the Bureau of Reclamation.

Woodling, J., 1985. *Colorado's Little Fish, a Guide to the Minnows and Other Lesser Known Fishes in the State of Colorado*. Colorado Division of Wildlife, Denver, Colorado, June 1985.

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Operation of Flaming Gorge Dam
Final Environmental Impact Statement
Acronyms and Abbreviations

APE	area of potential effect
ATU	annual thermal units
BLM	Bureau of Land Management
CFR	Code of Federal Regulations
cfs	cubic feet per second
CRFSTC	Colorado River Forecasting Service Technical Committee
CRSP	Colorado River Storage Project
CUP	Central Utah Project
EIS	environmental impact statement
ESA	Endangered Species Act
FGNRA	Flaming Gorge National Recreation Area
2000 Flow and Temperature Recommendations	*Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam*
FR	*Federal Register*
GWh	gigawatthour
IMPLAN	IMpact analysis for PLANning
km	kilometer
kWh	kilowatthour
m^3/s	cubic meters per second
msl	mean sea level
MW	megawatt
NEPA	National Environmental Policy Act
NERC	North American Electrical Reliability Council
NPV	net present value
NRHP	*National Register of Historic Places*
P.L.	Public Law
PRS	Power Repayment Study
Reclamation	Bureau of Reclamation
Recovery Action Plan	*1993 Recovery Implementation Program Recovery Action Plan*
Recovery Program	Upper Colorado River Endangered Fish Recovery Program
RPA	Reasonable and Prudent Alternative
Secretary	Secretary of the Interior
SHPO	State Historic Preservation Office
SLCA/IP	Salt Lake City Area Integrated Projects
UDWR	Utah Division of Wildlife Resources
U.S.	United States
U.S.C.	United States Code
USDA Forest Service	United States Department of Agriculture Forest Service
USGS	United States Geological Survey
Western	Western Area Power Administration
YOY	young-of-the-year
§	section
°C	degrees Celsius
°F	degrees Fahrenheit
%	percent