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

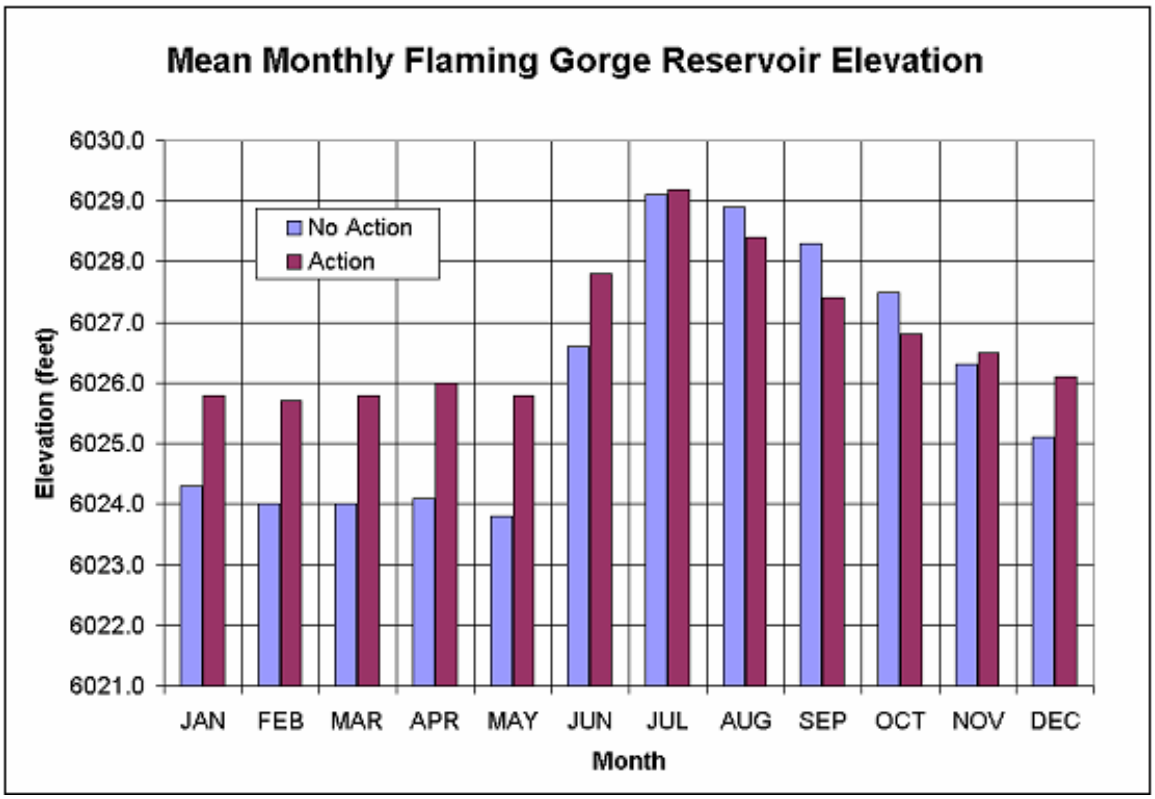

Figure 4-1.—Average End-of-Month Flaming Gorge Reservoir Elevations.

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

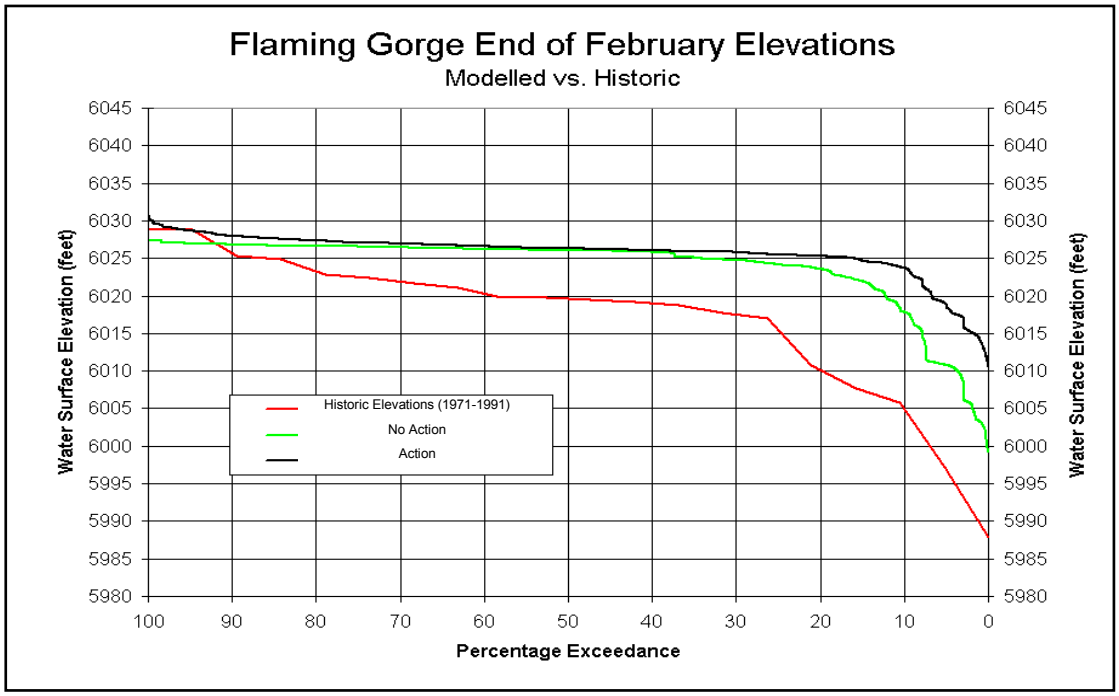

Figure 4-2.—February Reservoir Elevation Distribution Plot.

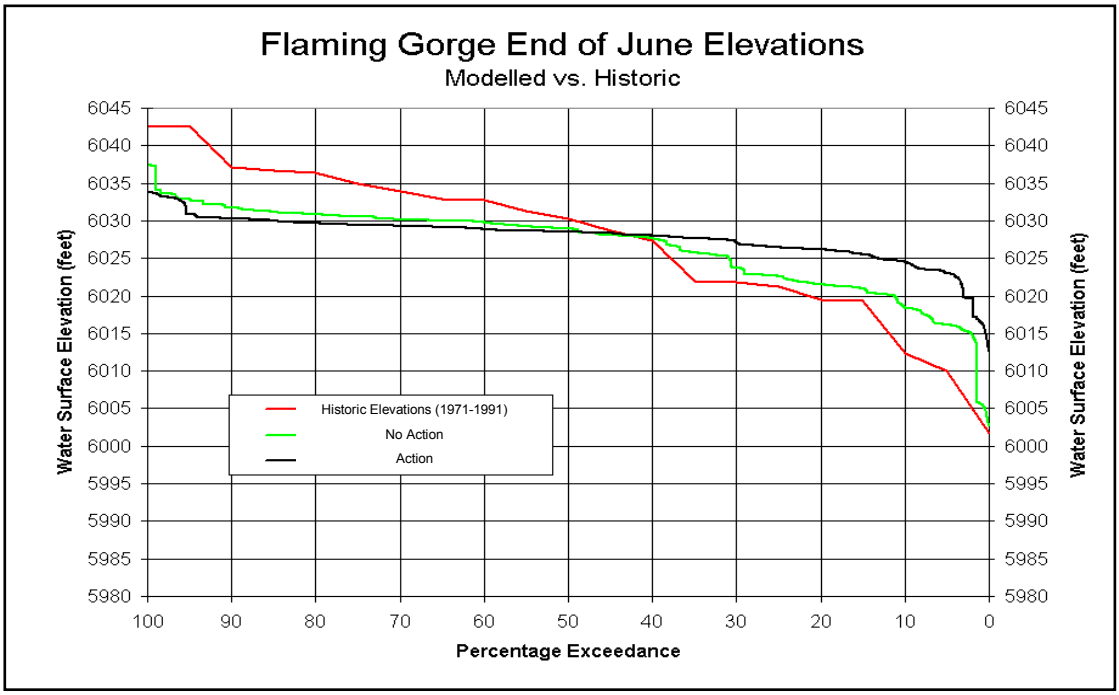

Figure 4-3.—June Reservoir Elevation Distribution Plot.

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

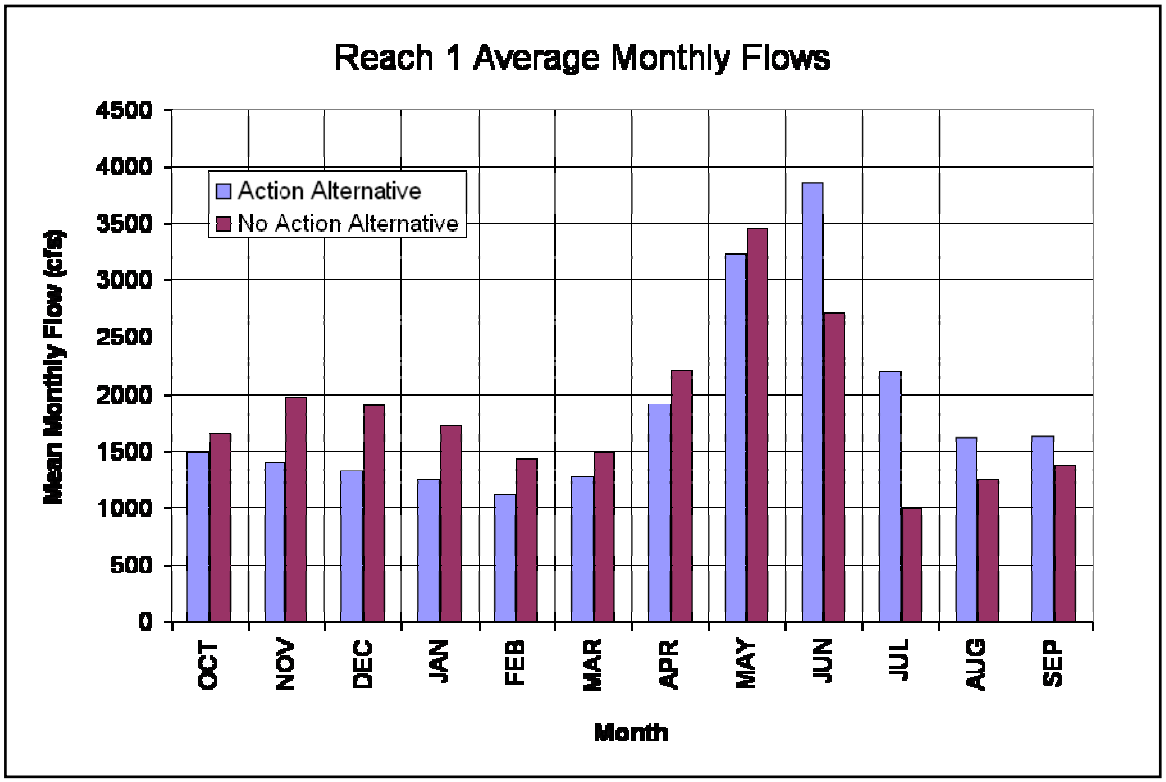

Figure 4-4.—Reach 1 Average Monthly Flows.

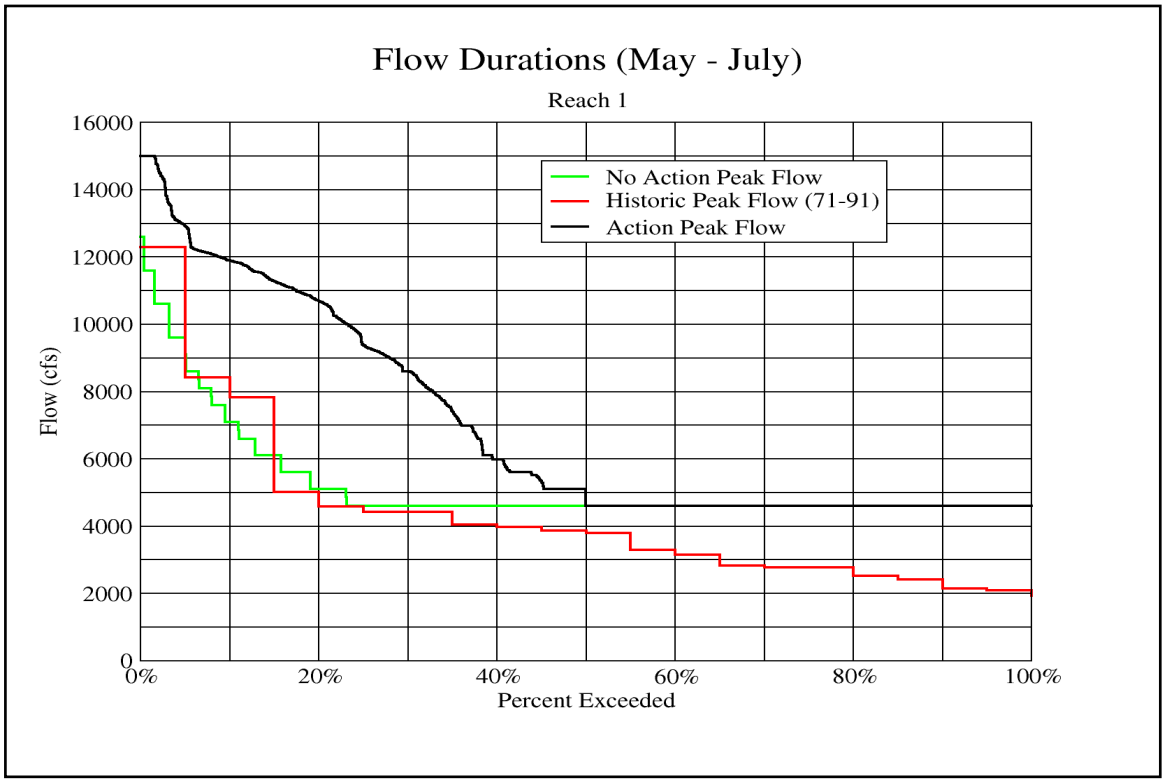

Figure 4-5.—Reach 1, 1-Day Peak Flow Distribution.

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

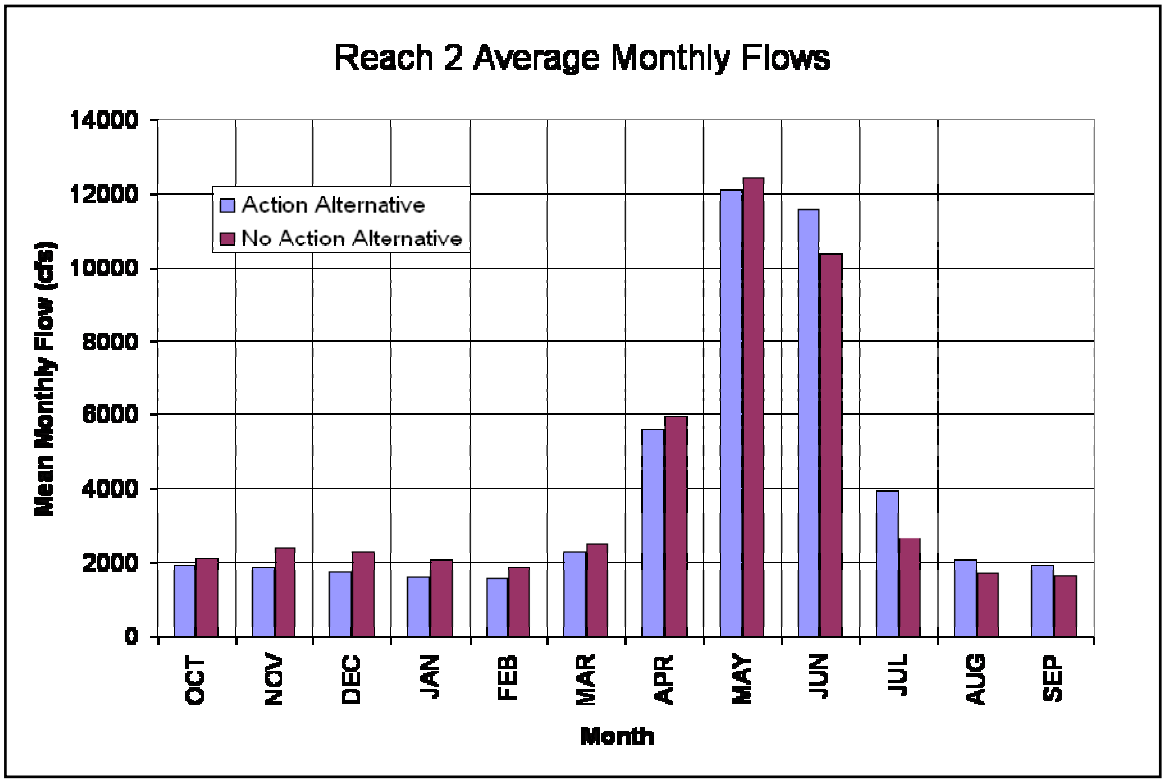

Figure 4-6.—Reach 2 Average Monthly Flows.

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

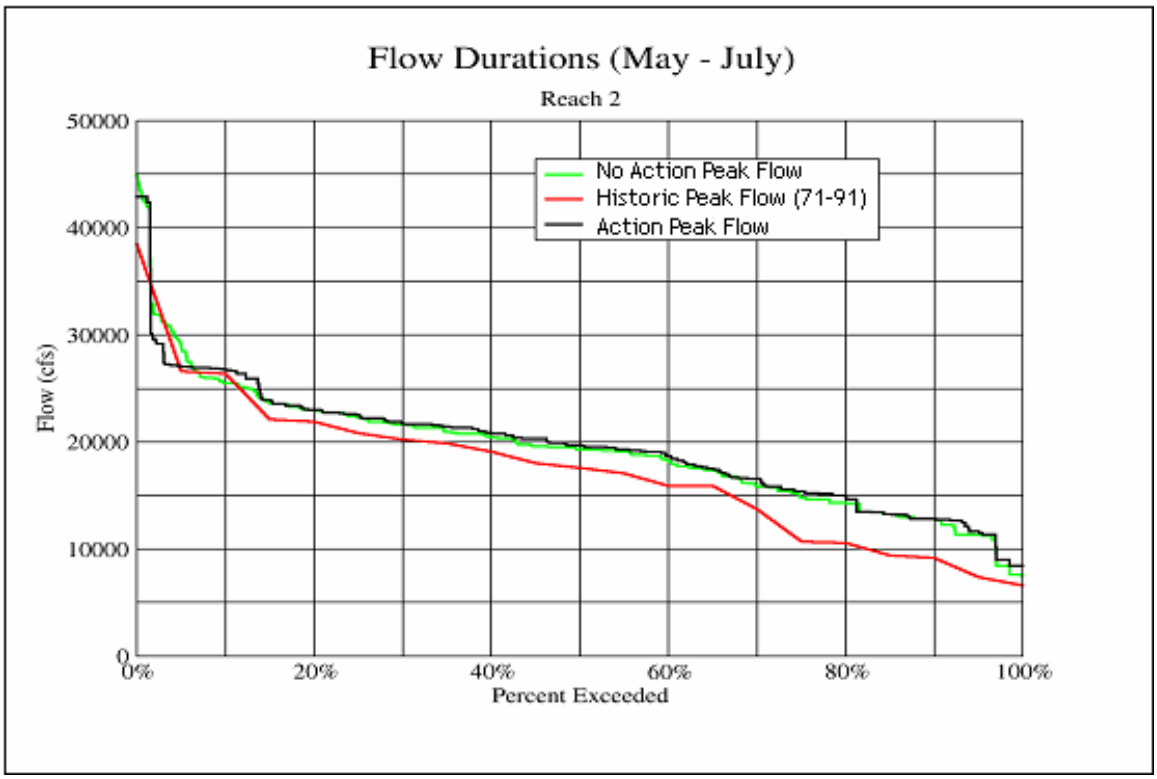

Figure 4-7.—Reach 2, 1-Day Average Peak Flow Distribution.

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.

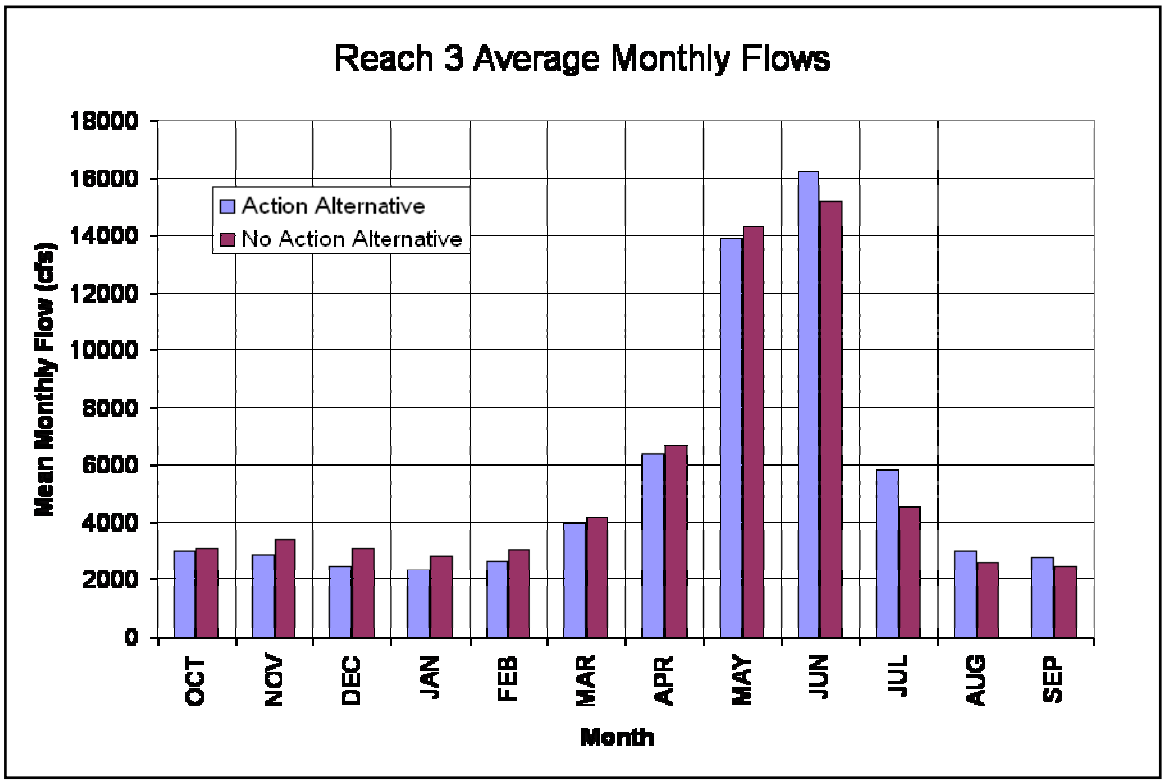

Figure 4-8.—Reach 3 Average Monthly Flows.

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

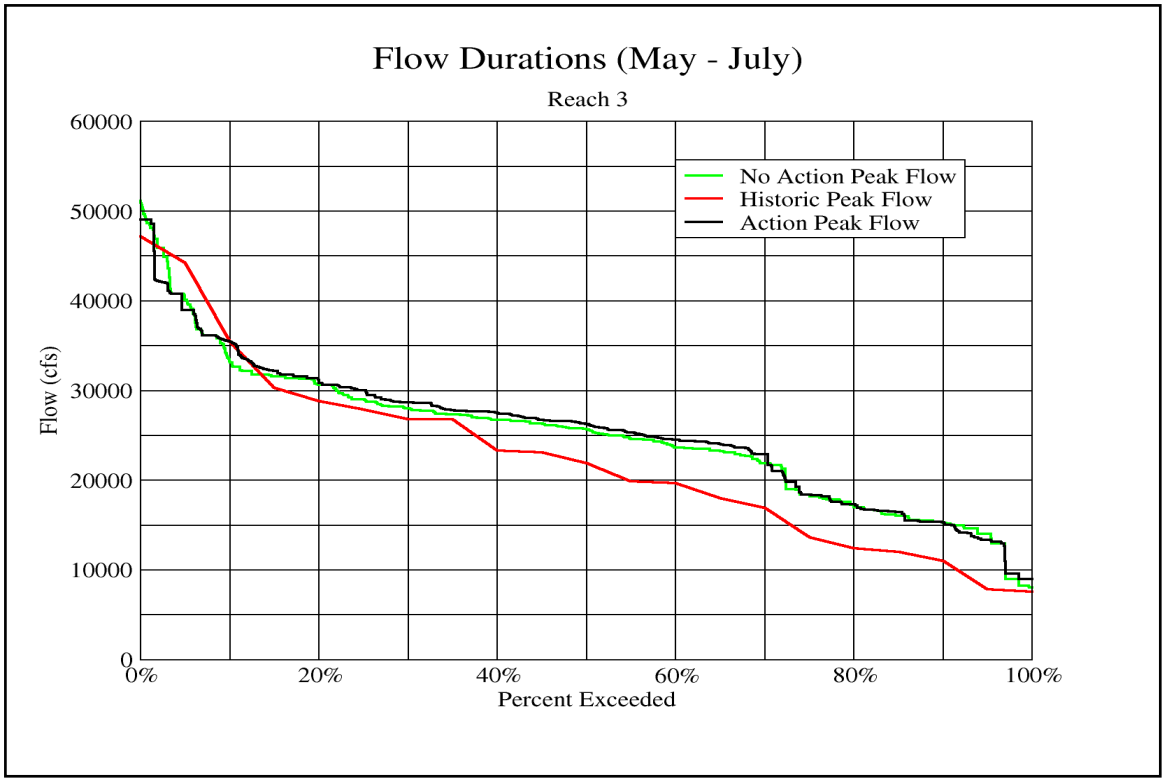

Figure 4-9.—Reach 3, 1-Day Average Peak Flow Distribution.

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.

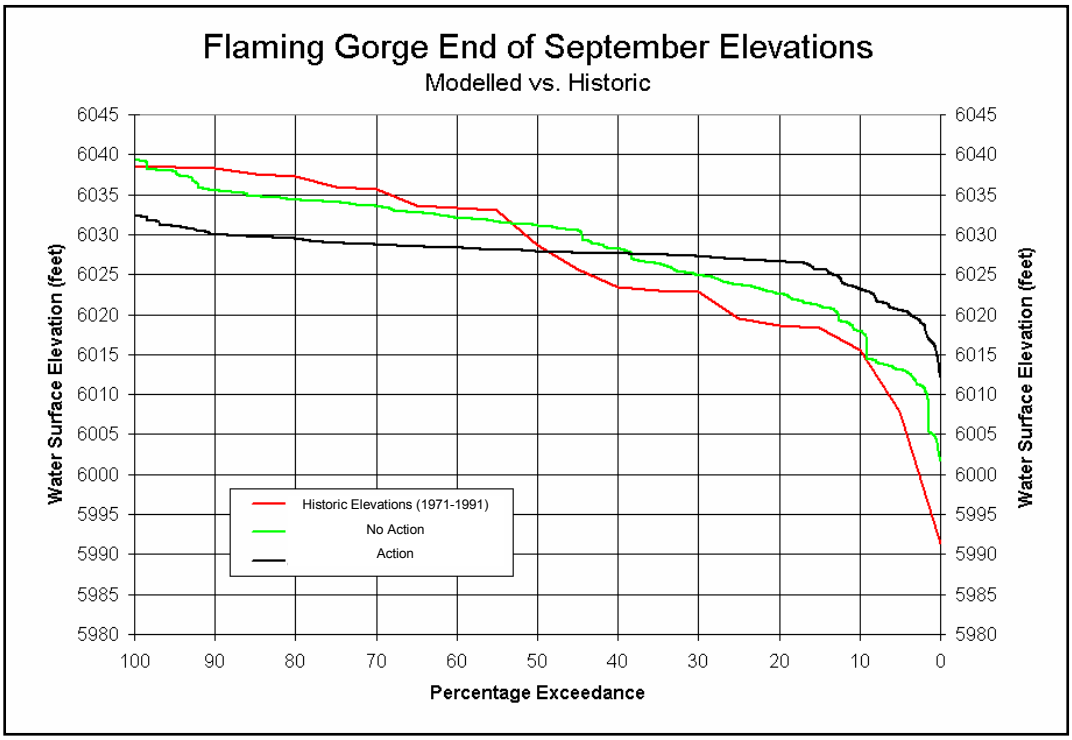

Figure 4-10.—Reservoir Elevation Comparison for the End of September.

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.

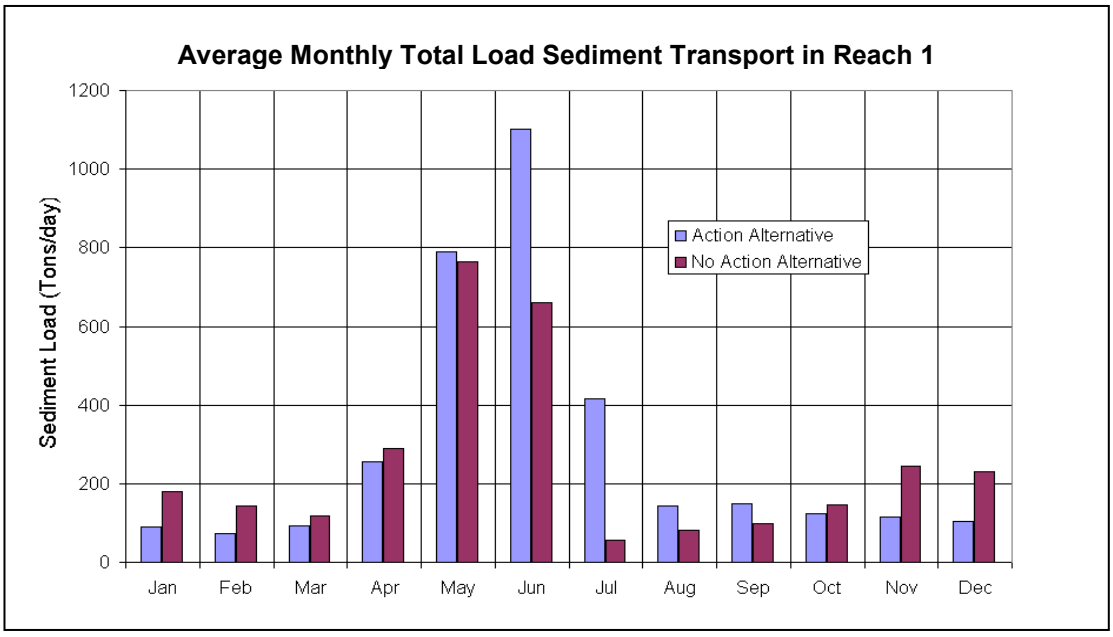

Figure 4-11.—Average Monthly Total Load Sediment Transport in Reach 1.

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.

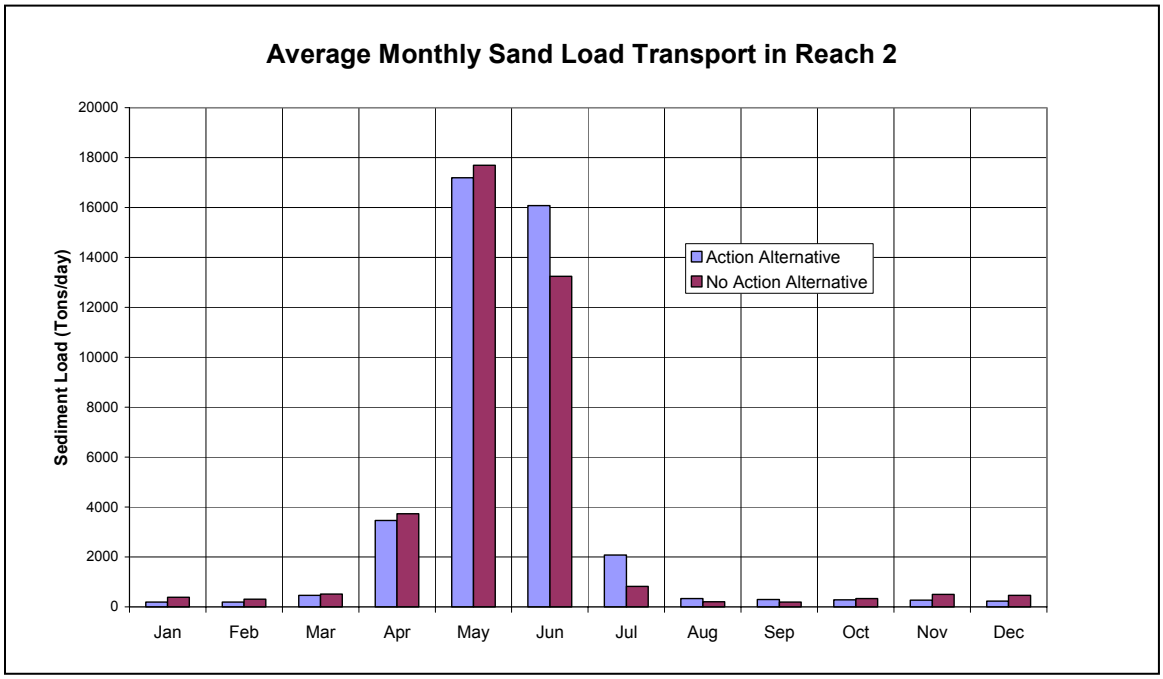

Figure 4-12.—Average Monthly Sand Load Transport in Reach 2.

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.

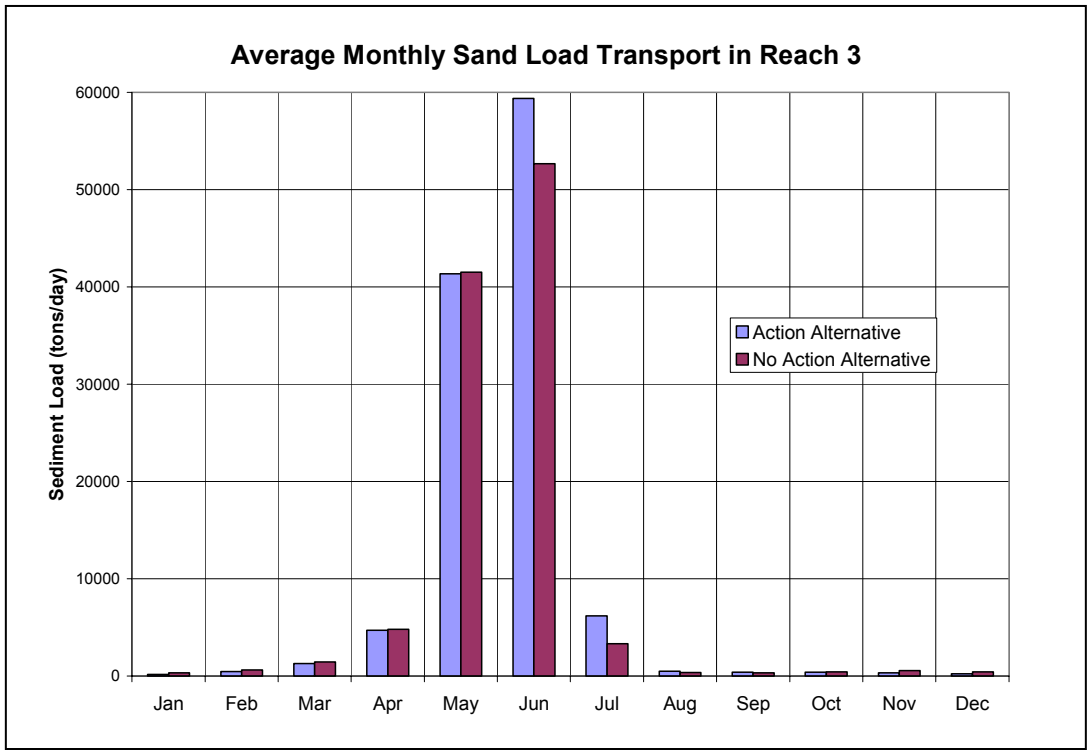

Figure 4-13.—Average Monthly Sand Load Transport in Reach 3.

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

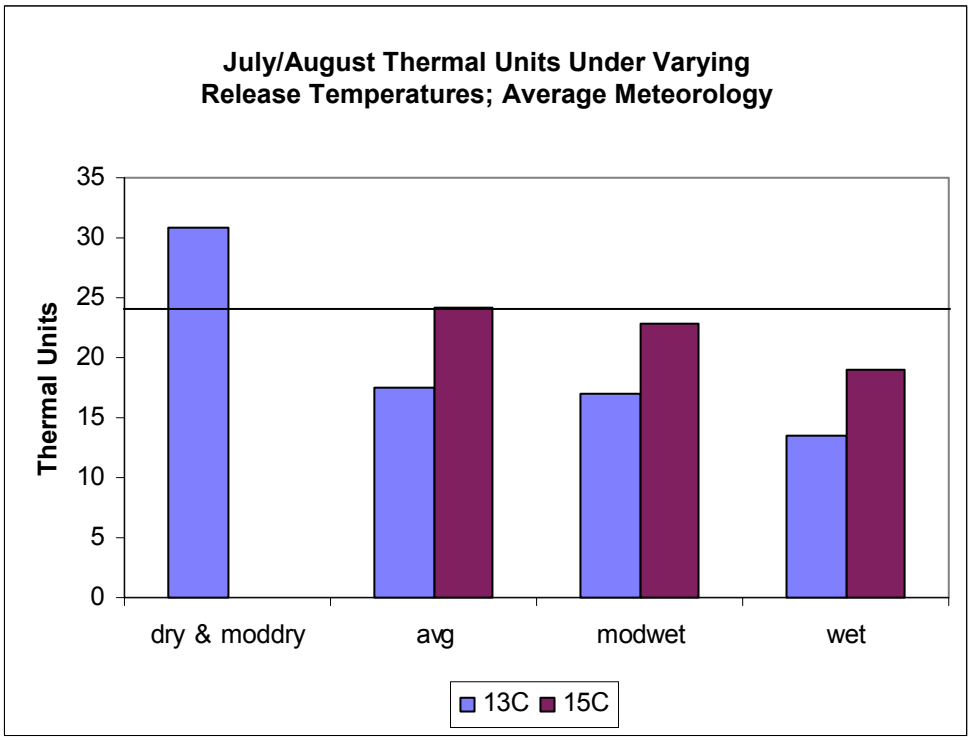

Figure 4-14.—Thermal Units Accumulated in Upper Lodore Canyon (46 Miles Below Flaming Gorge Dam) Under Various Hydrologic Scenarios. As indicated in the Flaming Gorge Model, likely base flow releases for each hydrologic category are as follows: dry and moderately dry (800 cfs); average (1,400 cfs); moderately 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		Wet Condition		Dry Condition	
	Values	% of Combined Total	Values	% of Combined Total	Values	% 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					Average Condition			Wet Condition			Dry Condition		
		Low End Threshold Flows	Current Flows	Preferred Flows	High End Kink Flows	High End Threshold Flows	Average Monthly Flows	Change from No Action Alternative		Average Monthly Flows	Change from No Action Alternative		Average Monthly Flows	Change from No Action Alternative	
								Cfs	%		Cfs	%		Cfs	%
		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.

[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			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	.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			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	.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					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
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

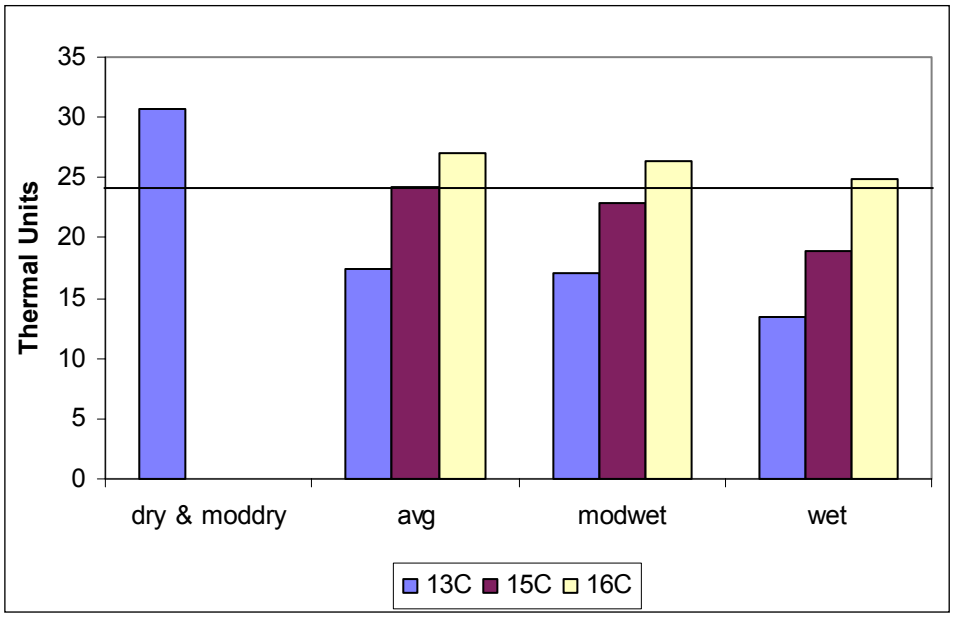

Figure 4-15.—Thermal Units Accumulated in Upper Lodore Canyon (46 Miles Below Flaming Gorge Dam) Under Various Hydrologic Scenarios. Hydrologic categories: dry and moderately dry (moddry) = 800 cfs; average (average) = 1,400 cfs; moderately wet (modwet) = 2,000 cfs; and wet = 2,400 cfs. Average daily 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

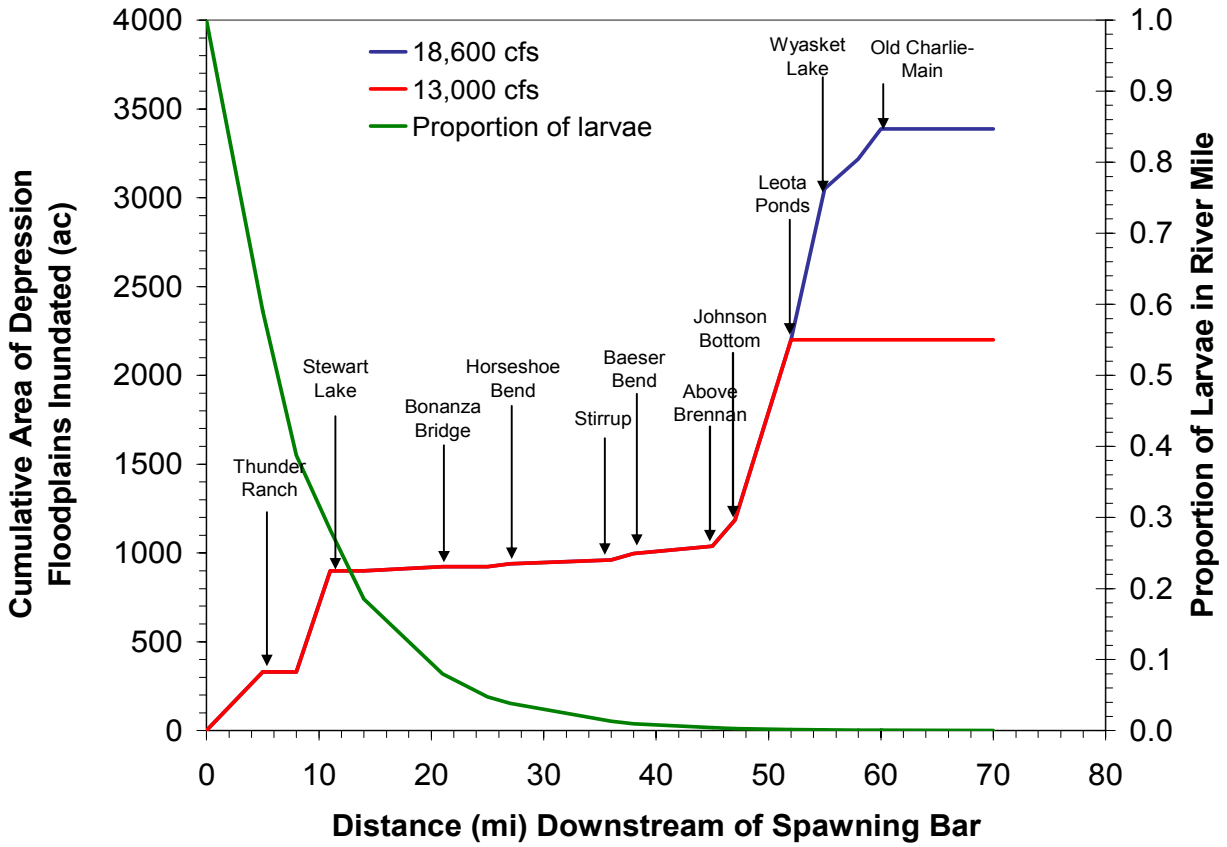

Figure 4-16.— Cumulative Area of Priority Depression Flood Plain Inundated at 13,000 cfs and 18,600 cfs and Proportion of Larvae Entering River Mile According to Distance Downstream From the Razorback Spawning Bar. Source: Modified from Valdez and Nelson (2004).

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.