Appendix D2
Boating Flow Days Metrics

Appendix D2 — Boating Flow Days Metrics

1.0 Introduction

This appendix describes the method used to implement the boating flow days metric for the river and whitewater boating attribute of interest. Relationships were developed at several Upper Colorado River Basin locations to link average daily flow to the quality of boating experience. In this context, flow translates to an acceptable, optimal, or other (flows below or above the acceptable thresholds) boating day, depending on the flow magnitude and the survey respondents. The flow-experience relationships (Whittaker et al., 2005) were developed by American Whitewater based on user surveys that asked users to identify flows ranging from totally unacceptable to totally acceptable based on their skill level and craft type. Because the Colorado River Simulation System (CRSS) operates at a monthly time step and the flow-experience relationships are developed based on average daily flows, an additional step is necessary to resolve the time step discrepancy.

Significant uncertainties exist related to the use of the approach taken by American Whitewater in the Colorado River Basin Water Supply and Demand Study (Study), as there are several limitations stemming from resource constraints and the Study timeline. Nevertheless, the information resulting from this approach has been included in the Study because it provides a broad view of the impacts to river and whitewater boating under multiple future conditions. It is recommended that future efforts carefully consider the limitations and assumptions of this approach if this information is used in future efforts.

The methodology section details the process of performing user surveys and developing flow-experience relationships. Additionally, the procedure that is used to resolve the time step discrepancy between CRSS output and flow-recreation relationships is presented. The summary section describes results of the user survey procedure. A report developed by American Whitewater describing the user-survey approach and survey results is provided in attachment A.

2.0 Methodology

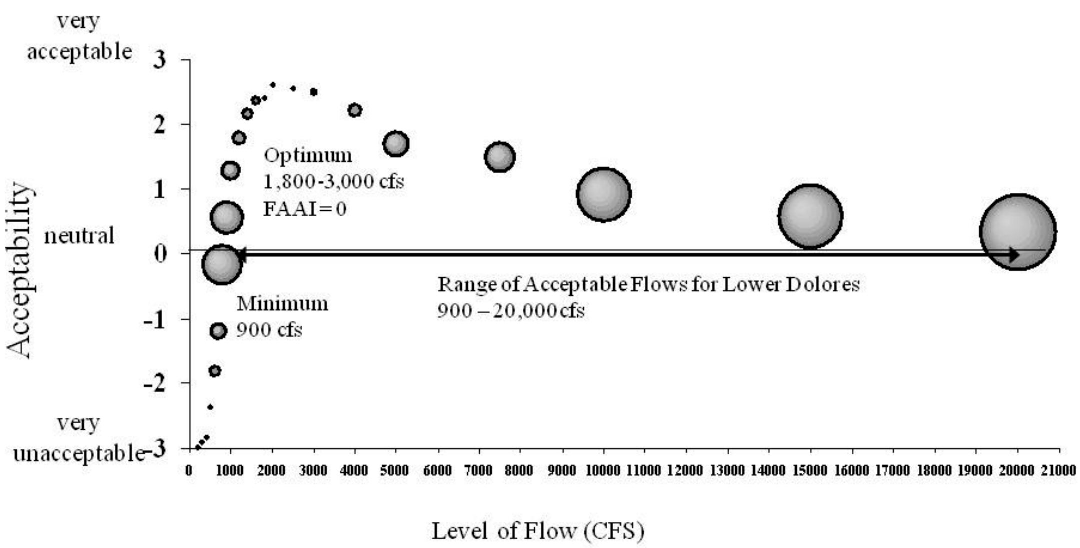
2.1 Establish Flow Ranges

To establish flow ranges for survey-based acceptable and optimal recreational opportunities, American Whitewater collected and organized personal evaluations of recreational resource conditions and recreation-relevant hydrology, consistent with standard methods (Whittaker et al., 2005). An online survey conducted during November and December 2011 involved 382 volunteer paddlers representing a range of experience and skill levels. The survey asked respondents to evaluate flows at each location, although few respondents had experience with every segment surveyed.

Study respondents were asked to evaluate overall recreation quality for each measured flow at each Study segment, using a seven-point "acceptability" scale (ranging from very unacceptable [-3] to very acceptable [3]). Using a survey-based normative approach, individual evaluations of flows were aggregated into social norms, which described the group's collective evaluation of those same stream flows (Shelby et al., 1996; Whittaker et al., 1993). Structural norm characteristics were used to graphically represent the range of acceptable flows for whitewater boating opportunities. Mean evaluation for each flow condition was plotted graphically to create the social norm or flow-acceptability curves (see figure D2-1 for an example). These curves were analyzed in terms of certain characteristics, including:

- Acceptable flows: the range of flows represented above the neutral line of the curve starting at the minimum acceptable flow
- Optimal flows: flows that are represented by the peak of the curve

FIGURE D2-1
Example Flow Acceptability Agreement Index Curve
The size of symbols represents the variability within the responses (smaller symbols represent greater relative agreement among respondents).



Impact acceptability curves and the Flow Acceptability Agreement Index (also known as Potential for Conflict Index, or FAAI) were used to help determine minimum acceptable, optimal, and the range of acceptable flows, and to estimate respondent agreement regarding the acceptability of each specific flow level. A detailed report on the methods used to determine the flow ranges is included as attachment A.

2.2 Obtain Boating Flow Days from CRSS Output

CRSS is operated on a monthly time step with flow outputs reported as average monthly flow or as monthly volumes. During the course of a month, the daily flow rates may change considerably and have a significant impact on the recreational whitewater resource. Therefore, the metric required a temporal disaggregation of modeled monthly flow volumes to daily average flow rates before computing the number of acceptable, optimal, and other boating days in a month. The disaggregated flow rates were then compared to the acceptable and optimal flow ranges for each location to develop statistics on the number of acceptable and optimal boating days in each month.

The daily disaggregation of flow was performed external to the CRSS model using software developed specifically for this metric. The disaggregation technique uses historical patterns of flow variability from observed gage data and applies the variability to the modeled monthly flow volume. Stream gages used to develop the historical patterns were evaluated for significant changes in upstream operations. Gages with significant changes over the past 30 years and gages that were projected to have significantly different flow patterns in the future (e.g., re-operation of upstream reservoir) were screened from further consideration.

Figure D2-2 shows the overall process of the temporal disaggregation using an example CRSS model output for a May flow volume. For the past 30 years of daily gage data at each location, each month was normalized by its monthly volume to develop coefficients that represent the historical pattern of variability (figure D2-2B). Each of the 30 sequences of coefficients was then applied to the simulated monthly flow to produce an ensemble of plausible daily flows (figure D2-2C). The daily flows patterns were then compared to the desired flow ranges for the specific location to develop statistics on the number of acceptable and optimal boating days in the month.

The boating flow days statistics from modeled scenarios were compared against each other to assess the relative change in the number of boating flow days to estimate the effects on the recreational whitewater resource.

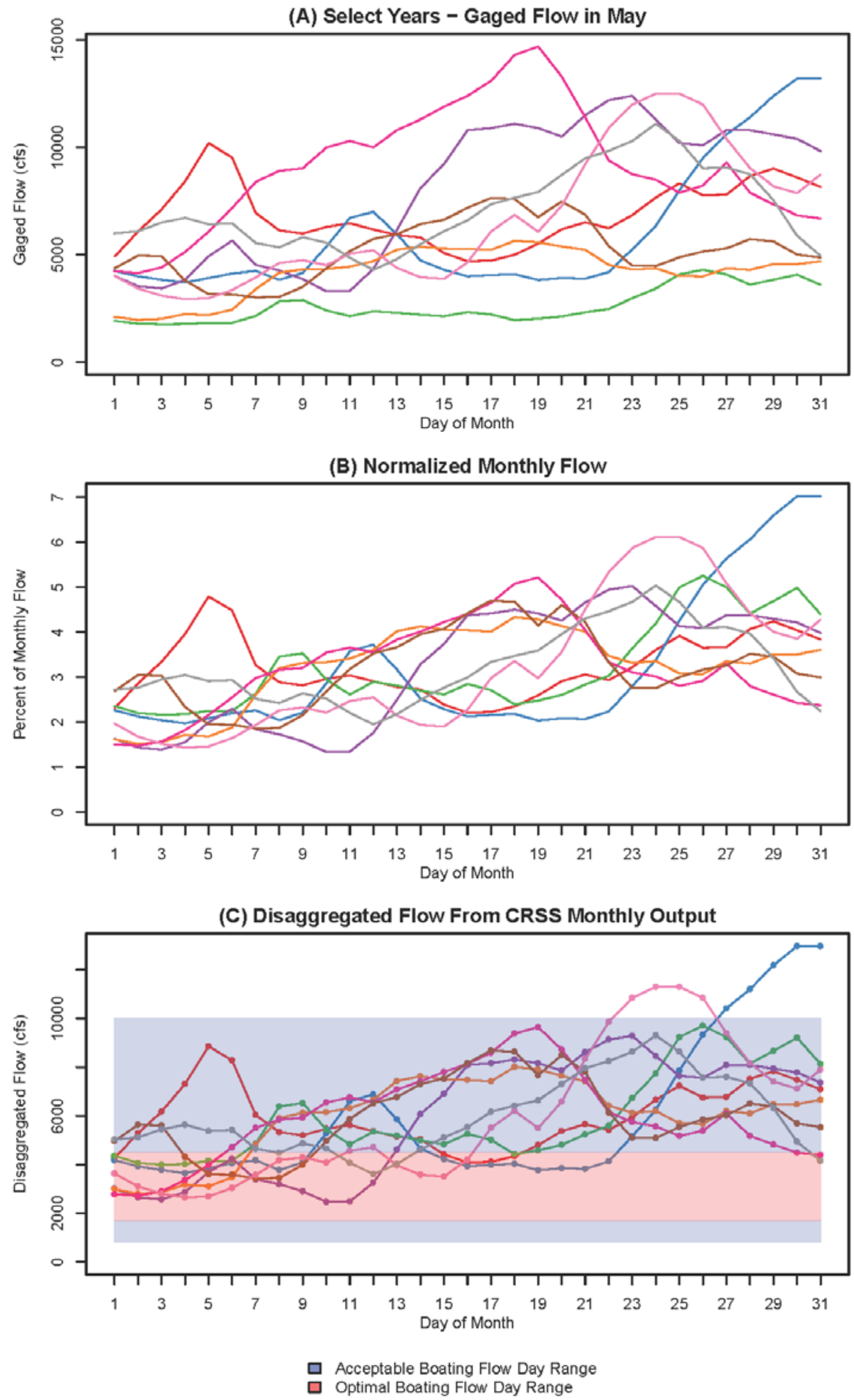
FIGURE D2-2
Example Steps for Computing Number of Boating Flow Days from CRSS Monthly Output
9 years from the 1981–2010 gage record are shown as an example.

1) Select all Mays from 1981-2010 daily gage record **(A)**

2) Normalize daily flows by monthly volume **(B)**

3) Apply normalized coefficients to monthly output from CRSS to create ensemble of plausible daily flows **(C)**

4) Generate statistics on the number of acceptable and optimal boating flow days **(C)**



3.0 Summary

Table D2-1 summarizes the number of respondents for each surveyed location and the acceptable and optimal flow ranges as identified by the user surveys. Locations immediately below Taylor Reservoir and the Aspinall Unit were excluded from the process due to the current representation of the operating logic of these reservoirs in CRSS. The Colorado River near Cameo, Colorado; Colorado River near the Colorado–Utah state line; Green River near Green River, Wyoming; White River near Watson, Utah; Gunnison River near Grand Junction, Colorado; and the Green River at Green River, Utah, were not included as metrics because there was not adequate user response to the surveys at these locations. Whittaker et al. (1993) recommends approximately 30 respondents for statistical significance. For all other locations, high levels of agreement on optimal flows were recorded and minimum acceptable flows were identified for each segment by the respondents. For many segments, respondents reported no maximum acceptable flow, defining a wide range of acceptable flows, up to 100,000 cubic feet per second (cfs) for certain high-volume reaches.

The boating flow days metric made it possible to quantify the relative trade-offs among recreation opportunities and between recreation and other resources during the System Reliability Analysis. The daily flow patterns are not meant to predict actual daily flows in the future; instead, they are an intermediate step in estimating the number of boating flow days in a month that were then compared across scenarios.

TABLE D2-1
Summary of the Surveyed Locations, Respondent Numbers, and Acceptable and Optimal Flow Ranges

Attribute Location	Whitewater Boating Resource	Acceptable Boating Flow Range (cfs)	Optimal Boating Flow Range (cfs)	Respondent Numbers
Colorado River at Glenwood Springs, Colorado	GW Playpark South Canyon	1,600–50,000	7,000–20,000	42 Responses – 328 Skipped
Colorado River near Cameo, Colorado	Big Sur	20,000–50,000	27,500–50,000	26 Responses – 364 Skipped
Colorado River near Colorado-Utah state line	Ruby-Horsethief Westwater	Not Applicable	Not Applicable	No data
Gunnison River near Grand Junction, Colorado	Lower Gunnison Dominguez-Escalante	900–15,000	2,000–12,500	7 Responses – 383 Skipped
Dolores River near Cisco, Utah	Lower Dolores	900–20,000	1,800–3,000	48 Responses – 342 Skipped
Colorado River near Cisco, Utah	Hittle Bottom Moab Daily	1,800–100,000	4,000–15,000	35 Responses – 355 Skipped
Green River near Green River, Wyoming	Green River Whitewater park	Not Applicable	Not Applicable	6 Responses – 384 Skipped
Green River near Greendale, Utah	Lodore Canyon	1,000–12,000	2,000–8,000	93 Responses – 199 Skipped
Yampa River near Maybell, Colorado	Little Yampa Canyon Cross Mountain Canyon	800–10,000	1,700–4,500	22 Responses – 270 Skipped 51 Responses – 241 Skipped
Yampa River at Deerlodge Park, Colorado	Yampa Canyon	1,500–20,000	5,000–15,000	102 Responses – 190 Skipped
Green River at Jensen, Utah	Split Mountain Canyon	1,200–50,000	2,500–25,000	32 Responses – 358 Skipped
White River near Watson, Utah	Lower White	Not Applicable	Not Applicable	2 Responses – 388 Skipped
Green River at Green River, Utah	Gray, Desolation, Labyrinth, and Stillwater Canyons	1,600–50,000	3,000–20,000	26 Responses – 364 Skipped
San Juan River near Bluff, Utah	Lower San Juan	800–50,000	1,400–7,500	37 Responses – 353 Skipped

4.0 References

Shelby, B., J.J. Vaske, and M.P. Donnely. 1996. “Norms, standards and natural resources.” *Leisure Sciences*, 18:103–123.

Whittaker, D., B. Shelby, and J. Gangemi. 2005. *Flows and Recreation, A Guide to Studies for River Professionals*. U.S. Department of the Interior, National Park Service.

Whittaker, D., B. Shelby, W. Jackson, and R. Beschta. 1993. *Instream Flows for Recreation: A Handbook on Concepts and Research Methods*. U.S. Department of the Interior, National Park Service.

Appendix D2

Attachment A
American Whitewater Draft Report

DRAFT SUMMARY REPORT

Evaluating Recreational Flow-Needs in the Upper Colorado River Basin

Defining Low, Acceptable, and Optimal Flows for Whitewater Boating

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Abstract:

Effects of in-stream flows on river-based recreational attributes, such as whitewater boating, have profound impacts on recreation opportunities. In many watersheds, streamflows necessary to provide the full range of whitewater boating opportunities are often not clearly defined - presenting a challenge to resource managers seeking to balance water supply and demand strategies. In this study, an online survey was designed and conducted to allow whitewater enthusiasts to evaluate flows for whitewater boating on rivers within the Upper Colorado River basin, and identify low, acceptable and optimum flows for 10 targeted river segments. Flow Acceptability Agreement Index curves summarizes the quality of boating opportunities for each measured stream-flow. Respondents also reported flows that provide certain recreation experiences, from technical low water to challenging high water trips. American Whitewater conducted this study to provide information on flows needed to sustain the whitewater boating resource in the Upper Colorado River basin. This information is being reported with the express intent of developing a quantitative metric for evaluating impacts to existing recreational flow-needs under various management opportunities currently being investigated under the US Bureau of Reclamation's Colorado River Basin Study.

Contents

I. Introduction

Whitewater boating is a flow dependent recreational use of rivers, and considerable work evaluating flow-recreation relationships has occurred over the last several decades (Brown et al., 1991; Shelby, Brown, & Taylor, 1992; Whittaker and Shelby, 2002). Many of the flow-recreation studies focus on whitewater boating, such as rafting, kayaking, and canoeing, as flow often determines whether people have opportunities to take a trip and what level of challenge or social value is provided (Whittaker & Shelby, 2000). Different flow levels provide for varied whitewater boating opportunities. As flows increase from zero, different paddling opportunities and challenges exist within ranges of flows on a spectrum: too low, minimal acceptable, technical, optimal, high challenge, and too high. Standard methodologies are used to define these flow ranges based on individual and group flow-evaluations. The various opportunities provided by different flow ranges are described as occurring in "niches" (Shelby et al., 1997).

Whitewater Boating is enjoyed in different crafts, such as canoes, kayaks, and rafts. Different craft types provide different opportunities for river-based recreation, from individual or small group trips, to large group multi-day excursions. Flows that provide greater social value for one type of craft, such as canoes, may not provide equivalent social value for rafting. Changes in streamflow can have direct effects on the quality of whitewater boating, for every craft type. Direct effects may change quickly as flows change, such as safety in running rapids, number of boat groundings, travel times, quality of rapids, and beach and camp access (Brown, Taylor, & Shelby, 1991; Whittaker et al., 1993; Whittaker & Shelby, 2002). Indirectly, flow effect wildlife viewing, scenery, fish habitat, and riparian vegetation over the long term as a result of changes in flow regime (Bovee, 1996; Richter et al., 1997; Jackson & Beschta, 1992; Hill et al., 1991).

Streamflow is often manipulated through controlled reservoir releases, unanticipated spills from dams, and in-channel diversions. Additional scenarios, such as climate change and drought, water rights development, or conservation and the associated decreases in water demands, can all impact flows and recreation quality. Decision-makers within land and resource management and regulatory agencies, are increasingly interested in assessing the impacts of flow regimes on recreation resources. This has been most notable in the Federal Energy Regulatory Commission's (FERC) relicensing process, and where decision-makers, resource managers, and interest groups consider the extent that flow regimes can be managed to provide desirable recreational resource conditions. Appendix C lists a subset of projects where Whitewater Boating Flows have been analyzed. In these decision-making settings, specific evaluative information on how flow affects recreation quality is critical, particularly where social values are often central to decision-making (Kennedy and Thomas 1995).

Researchers collecting and organizing evaluative information, often employ a normative approach using survey-based techniques. This approach is particularly useful for developing thresholds, or standards, that define low, acceptable, and optimal resource conditions for whitewater boating. Thresholds are crucial elements in any effective management or decision-making process (Shelby et al. 1992). The approach examines individuals' evaluations of a range of conditions (personal norms). Social Norms, defined by aggregate personal norms, describe a group's collective evaluation of resource conditions. This approach has been used to understand streamflows for whitewater boating on the Grand Canyon (Shelby et al. 1992), as well as several others rivers in Colorado (Vandas et al. 1990, Shelby & Whittaker 1995, Fey & Stafford 2009, Fey & Stafford 2010).

American Whitewater designed and conducted this study to collect evaluative information on whitewater boating attributes for 10-targeted recreational resources in the Colorado River Basin. Using overall flow-evaluation data, we developed flow-evaluation curves that identify low, acceptable, and optimum flows for whitewater boating. In addition, specific flow evaluations were collected to aid in "calibrating" points along each curve. The present paper integrates both types of information in order to assist the Protect the Flows Campaign and the U.S. Bureau of Reclamation, in the development of quantitative recreational System Reliability Metrics that can be implemented in the Colorado River Basin Study.

II. Recreational Flow Assessment – Locations and Methods

To define normative standards for whitewater boating flows in the Upper Colorado River basin, American Whitewater collected and organized personal evaluations of recreational resource conditions, and recreation-relevant hydrology, consistent with NPS methodologies[1]. Using a web-based survey tool[2], American Whitewater designed two sets of questions asking respondents to evaluate flows for ten rivers, relative to specific U.S. Geological Survey streamflow gage locations and Colorado River Simulation System Nodes.

Table A: Recreational Whitewater Attribute Locations

Whitewater Resource Location	USGS Gage	Whitewater Boating Attribute
Colorado River At Glenwood Springs	9072500	Glenwood Springs Playpark & South Canyon
Colorado River Near Cameo – CO	9095500	Big Sur
Gunnison River Near Grand Junction	9152500	Lower Gunnison (Dominguez-Escalante)
Dolores River Near Cisco - UT	9180000	Lower Dolores River
Colorado River Near Cisco – UT	9180500	Hittle Bottom & Moab Daily
Green River Near Green River - WY	9217000	Green River Whitewater Park
Green River at Jensen – UT	9261000	Split Mountain Canyon
White River Near Watson – UT	9306500	Lower White River
Green River At Green River – UT	9315000	Desolation-Gray, Labyrinth & Stillwater Canyons
San Juan River Near Bluff - UT	9379500	Lower San Juan

An online approach to the flow comparison survey was used in this study for several reasons:
- The study timeframe was too short to use other approaches, such as mail-in surveys or in-person ballots.
- Many whitewater boaters that have taken trips on these target rivers hail from around the United States. An online approach makes it easier to access this knowledge base.
- Electronic announcements and links to the survey website facilitate broader participation and higher respondent numbers.

The Flow-Evaluation Survey was based on the normative approach discussed above. One set of survey questions was used to develop overall flow-evaluations curves, and another set of questions helped identify and explain various points on those same curves. Overall Flow evaluation questions asked respondents to evaluate overall recreation quality for specific measured flows on each study segment, using a seven-point "acceptability" scale (unacceptable -3 and acceptable 3). This type of Survey contrasts with surveys that evaluate a single flow, or surveys conducted while flows are manipulated by controlled releases over a short period of time (Whittaker et al. 1993).

Another set of six specific flow evaluation questions asked respondents to report: 1) the minimum whitewater flow, 2) lowest preferred whitewater flow, 3) technical whitewater flow, 4) optimal whitewater flow, 5) high whitewater flow, and 6) highest safe whitewater flow. Each respondent reported flows with respect to their preferred craft-type. A copy of the online Flow-

[1] Whittaker, D., B. Shelby, J. Gangemi. 2005. Flows and Recreation, A guide to studies for river professionals. US Department of Interior, National Park Service, Anchorage, AK

[2] www.surveymonkey.com

Evaluation Survey, including both sets of questions, is attached as Appendix A.

An announcement of the flow-evaluation study was sent to over 5,000 American Whitewater members, including a link to the online survey website. The announcement was also posted to several online river-related discussion forums and various regional paddling club websites. The online format allowed whitewater boaters of all skill-levels and craft-types to report personal evaluations. The survey sample included outfitters currently permitted to operate commercially on targeted rivers, and non-commercial boaters. Because there were few differences between these groups, the data was combined in the analysis.

In all, 382 volunteer paddlers responded to the survey, although very few respondents had experience with every segment in the study. Table B summarizes the number of survey responses for each study segment. For this study, 93% of respondents identified themselves as private paddlers, 78% of respondents identified themselves as advanced or expert paddlers, and 73% reported paddling at least 20+ days per season. A wide-range of craft types was surveyed, with rafters (23%), kayakers (72%), canoeists (5%) all represented.

Most respondents (42%) reported living in six Colorado basin states, such as Wyoming, Colorado, Utah, New Mexico, Arizona, and Nevada, though paddlers from 38 states participated in the survey. 65% of respondents felt “very comfortable” estimating flows in cfs (cubic feet per second) on targeted river segments, while no respondents reported feeling “uncomfortable” or even “somewhat uncomfortable” estimating flows on their favorite stretch.

Table B:

Recreational Whitewater Attribute Locations and Respondent Numbers

Whitewater Boating Location	USGS Gage	Whitewater Boating Attribute	Respondent Numbers
Colorado River At Glenwood Springs	9072500	Glenwood Springs - South Canyon	42 Responses
Colorado River Near Cameo	9095500	Colorado River - Big Sur	26 Responses
Gunnison River Near Grand Junction	9152500	Lower Gunnison Dominguez-Escalante	7 Responses
Dolores River Near Cisco	9180000	Lower Dolores	48 Responses
Colorado River Near Cisco	9180500	Hittle Bottom- Moab Daily	35 Responses
Green River Near Green River WY	9217000	Green River Whitewater Park	6 Responses
Green River at Jensen	9261000	Split Mountain Canyon	32 Responses
White River Near Watson	9306500	Lower White	2 Responses
Green River At Green River UT	9315000	Desolation-Gray, Labyrinth & Stillwater Canyons	26 Responses
San Juan River Near Bluff	9379500	Lower San Juan	37 Responses

For most segments studied, responses provided sufficient information to proceed with data analysis and organization. For both the Green River Whitewater Park, and Lower White River Attributes, not enough information was provided to develop FAAI curves. While responses for the Lower Gunnison River were less than 10 in aggregate, most evaluations show a high level of agreement, and supported flow-curve development.

III. Results and Discussion

A. <u>Overall Flow Evaluations</u>

Mean responses from the overall flow evaluation questions were plotted for each flow level, and connected to create a curve. In most cases, the curves show inverted U shapes where low flows and high flows provide low quality recreation conditions, while medium flows provide more optimal conditions. Utilizing Flow Acceptability Agreement Index (FAAI) curves, the range of acceptable and optimal flows for whitewater boating were identified for most segments. Table B summarizes overall flow-evaluations for whitewater boating, including all craft-types.

Table C: *Acceptable and Optimal Flows for Whitewater Boating*

Whitewater Boating Attribute	Minimum Flow (cfs)	Optimal Flows (cfs)	Acceptable Flows (cfs)
Glenwood Springs Playpark & South Canyon	1600	7,000-20,000	1,600-50,000
Big Sur	20,000	27,500-50,000	20,000-50,000
Lower Gunnison (Dominguez-Escalante)	900	2,000-12,500	900-15,000
Lower Dolores River	900	1,800-3,000	900-20,000
Hittle Bottom & Moab Daily	1800	4,000-15,000	1,800-100,000
Green River Whitewater Park		Insufficient data	
Split Mountain Canyon	1200	2,500-25,000	1,200-50,000
Lower White River		Insufficient data	
Desolation-Gray, Labyrinth & Stillwater Canyons	1600	3,000-20,000	1,600-50,000
Lower San Juan	800	1,400-7,500	800-50,000

For two study reaches (Green River Whitewater Park (WY), and Lower White River (UT)), response numbers were too low and did not provide sufficient data for curve development. For all other study segments, where evaluations of higher flows never drop below the neutral line, recreation quality may decline but may not drop below acceptable levels. Open response questions, discussed in Section B, were used to help identify flows that provide minimum, optimal, and high acceptable flows for each segment.

The Flow Acceptability Agreement Index determines respondent agreement regarding the acceptability of each specific flow level (Figures and Tables 1-8, Appendix B). FAAI statistics show extremely high agreement levels for optimal flows (FAAI statistics range between 0 complete agreement, to 1 complete disagreement) while some level of disagreement between respondents exists in regard to the range of acceptable flows. The level of disagreement can be attributed to variability between craft types, although other factors likely play a role including preferred experience and skill levels of respondents. Results show that for most study segments, acceptable flows for kayaks may not provide equal value for rafts.

Table D lists acceptable and optimal flows for both rafts and kayaks to illustrate the variability by craft-type.

Table D
Colorado River Basin Segments FAAI Summary
Minimum, Optimal and Acceptable Flows by Craft-Types

Colorado River Basin Segment		Minimum Flow (CFS)	Optimal Flows (CFS)	Acceptable Flow (CFS)
Glenwood Park & South Canyon	Raft	1000	2800-16000	1000-25000
	Kayak	1600	12000-25000	1600-50000
Big Sur	Raft	NA	NA	NA
	Kayak	20000	25000-50000	20000-50000
Lower Gunnison	Raft	800	2000-12500	800-20000
	Kayak	NA	NA	NA
Lower Dolores	Raft	1000	2000-4000	1000-20000
	Kayak	800	1400-2500	800-20000
Moab Daily	Raft	1800	5000-40000	1800-100000
	Kayak	1800	5000-20000	1800-100000
Split Mountain	Raft	1200	4000-25000	1200-50000
	Kayak	1000	2000-20000	1000-50000
Desolation/Gray	Raft	1600	5000-20000	1600-50000
	Kayak	1400	4000-30000	1400-50000
Lower San Juan	Raft	1000	2000-7500	1000-20000
	Kayak	800	1800-1000	800-20000

For most study segments, respondents reported flows for both rafts and kayaks. Results show that for most segments, kayaks identify lower flows as more acceptable than similar flows for rafts. These results are typical for smaller craft-types where lower flows are sufficient for acceptable whitewater boating opportunities, while low flows do not provide enough flow for larger crafts, like rafts. Results for Glenwood Whitewater Park and South Canyon do not show similar results between craft types. Empirical data describe kayak evaluations as targeting key experiences at the Glenwood Wave, while rafting flows were evaluated for a longer downriver experience, where lower flows are sufficient for floating through South Canyon.

B. Specific Flow Evaluation

In order to further refine the overall flow-evaluation curves, a second set of single-flow evaluations were presented to survey respondents. For each study segment, survey respondents reported a single flow value that provides a distinct paddling experience or “niche” along a spectrum: minimum, low, technical, optimal, high challenge, and highest safe flow. These “niches” relate stream flow to the full range of whitewater boating opportunities and aid in refining the flow-recreation relationship described in each Flow-Curve. Overlaying the specific and overall flow-evaluation results is a helpful approach to analyzing the results of specific flow-evaluations.

With single preference norms reported as specific flow evaluations, measures of central tendency, such as the mean and median, are useful representations of the flow in question. Median flow evaluations for each study segment are described in Table E. For comparison, mean flow evaluations are summarized in Table F.

Table E

MEDIAN Minimum, Low, Technical, Optimal, High and Maximum Flows

Whitewater Boating Attribute	Minimum Flow (CFS)	Low Flow (CFS)	Technical Flow (CFS)	Optimal Flow (CFS)	High Flow (CFS)	Maximum Flow CFS)
1) Glenwood Springs & South Canyon	1000	2000	1500	4000	20000	30000
2) Big Sur	20000	20000	20000	22000	30000	30000
3) Lower Gunnison (Dominguez-Escalante)	700	900	800	3000	9000	15000
4) Lower Dolores River	700	1000	800	1500	3500	5000
5) Hittle Bottom & Moab Daily	1200	2000	1600	4000	20000	40000
- Green River Whitewater Park	-	-	-	-	-	-
6) Split Mountain Canyon	900	1300	1100	3000	20000	30000
- Lower White River	-	-	-	-	-	-
7) Desolation-Gray, Labyrinth & Stillwater Canyons	1200	2200	1100	5000	20000	35000
8) Lower San Juan	650	1000	900	2000	7000	20000

Table F

MEAN Minimum, Low, Technical, Optimal, High and Maximum Flows

Whitewater Boating Attribute	Minimum Flow (CFS)	Low Flow (CFS)	Technical Flow (CFS)	Optimal Flow (CFS)	High Flow (CFS)	Maximum Flow CFS)
1) Glenwood Springs & South Canyon	2281	3412	2502	6009	17624	29175
2) Big Sur						
3) Lower Gunnison (Dominguez-Escalante)	686	1286	1083	2743	9167	14833
4) Lower Dolores River	783	1048	847	1549	3978	6788
5) Hittle Bottom & Moab Daily	1379	2588	2029	5372	23933	42306
- Green River Whitewater Park	-	-	-	-	-	-
6) Split Mountain Canyon	1053	1745	1346	3843	14603	19089
- Lower White River	-	-	-	-	-	-
7) Desolation-Gray, Labyrinth & Stillwater Canyons	1354	2757	1633	6631	20857	38181
8) Lower San Juan	709	1070	930	2594	8050	15432

Note: mean flow-values have been rounded to the nearest whole number.

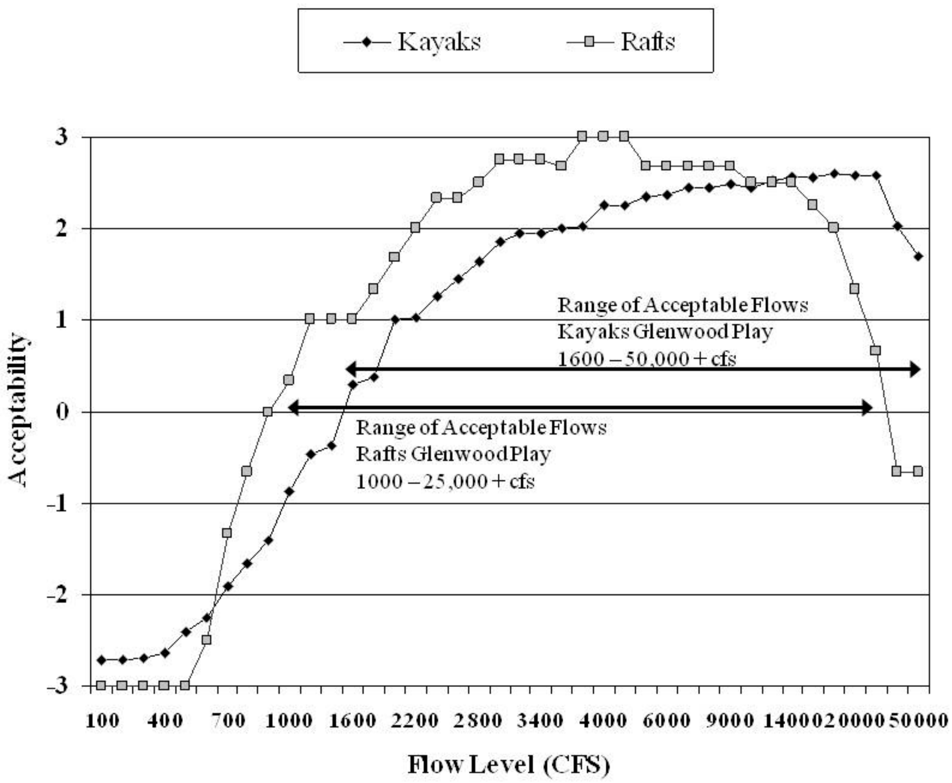
C. Discussion

For most segments, single-flow evaluations are shown to closely mimic relative values identified by the FAAI curves for minimum acceptable, optimal, and maximum acceptable flows. While differences between mean and median flow evaluations for open-ended responses have been established, these values help describe specific flow-dependant “niches” for whitewater boating experiences along each FAAI curve. For the Green River Whitewater Park and Lower White River attributes, insufficient data provided during the study period precluded analysis of FAAI curves, and did not provide enough data to analyze specific flow-evaluations for those attributes.

Overlaying the specific and overall flow-evaluation results is a helpful approach to analyzing the results of the study. An example of this integration, using the Glenwood Springs and South Canyon Attribute is provided in Figure A. Following along the curves for both kayaks and rafts, the mean flow identified for minimum whitewater boating, for both craft-types is 1000 cfs (average of both flow-curves). This is close to the point on the overall flow-evaluation curve (Figure 1, Appendix B) where the neutral line between un-acceptable and acceptable valuation is crossed. Integrating results from both overall and specific flow-evaluation questions provides more information than either format by itself. For more on integrating the results from Overall and Specific Flow Evaluations, refer to the Final Report of our Flow-Evaluation Study.

Figure A

Flow Acceptability Curves for Kayaks and Rafts - Glenwood Wave and South Canyon



IV. Conclusion

To establish flow ranges for acceptable and optimal recreational opportunities, American Whitewater collected and organized personal evaluations of recreational resource conditions, and recreation-relevant hydrology, consistent with standard methodologies. An online survey conducted in 2011, involved 382 volunteer paddlers representing a range of experience and skill level.

Study respondents were asked to evaluate overall recreation quality for each measured flow at each study segment, using a seven-point “acceptability” scale. Using a survey-based normative approach, individual evaluations of flows are aggregated into social norms, which describe the group’s collective evaluation of those same stream flows. Impact Acceptability Curves and the Flow Acceptability Agreement Index were used to help determine minimum, optimal and the range of acceptable flows, and respondent agreement regarding each specific flow level. For each of the river segments surveyed, high levels of agreement on optimal flows were recorded. Minimum acceptable flows were identified for each segment. For many segments, respondents reported no maximum acceptable flow; defining a wide range of acceptable flows, up to 100,000 cfs for certain high volume runs.

Good whitewater conditions require higher flows than those identified as providing minimum boatable flows. Good whitewater conditions for each target river segment have been identified in this study. For each study segment, the median response for minimum whitewater corresponds to the point where the overall flow-evaluation crosses the neutral line. The median response for optimal flows however corresponds with the peak of the curve where ratings are highest. Overall Flow-evaluation curves are relatively flat at the top of most segments, which is attributed to the multiple tolerance norms captured in the study results.

Whitewater flow-preferences described in this summary report make it possible to analyze and evaluate the impacts to whitewater boating under future water supply scenarios being developed under the U.S. Bureau of Reclamation's Colorado River Basin Study. A quantitative metric of "boatable days" can be developed using the reported flow-evaluations from this study. This metric can aid in developing a relative comparison (boatable days) to quantify effects of flow manipulation under various scenarios for future supply and demand scenarios in the Colorado River basin.

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Appendix A- Online Flow-Evaluation Survey

Appendix A presented screen shots of the online flow-evaluation surveys. To save paper, the screen shots have not been reprinted. The survey can be viewed online at http://www.americanwhitewater.org/content/Article/view/articleid/31219/.

Appendix B – Overall Flow Evaluation Results

Figure 1

Flow Acceptability Agreement Index Curve for Glenwood Springs and South Canyon
(Flows represented are at the USGS Colorado River At Glenwood Springs, CO*)*

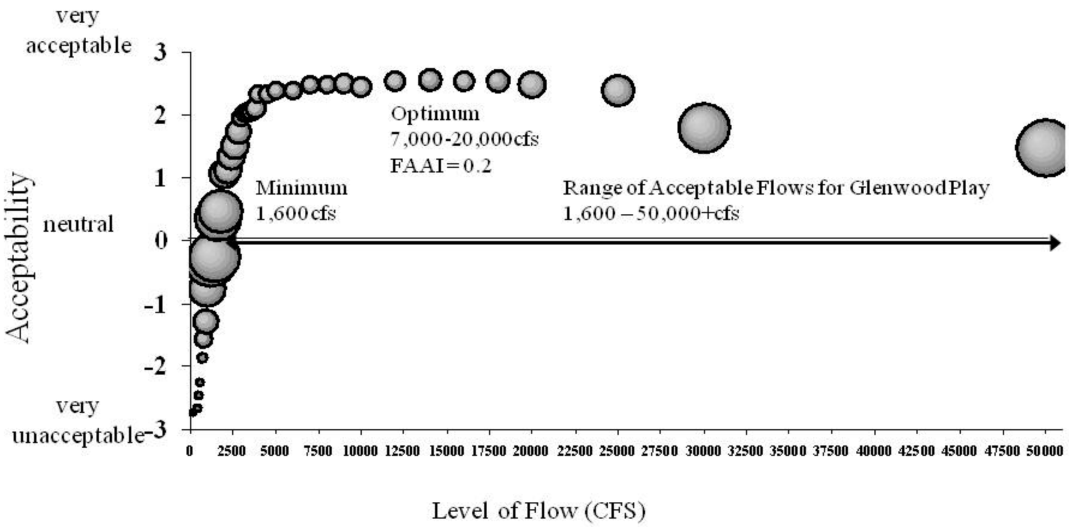

Table 1

Glenwood Springs and South Canyon

Mean Acceptability Scores and Flow Acceptability Agreement Index

Specific Flow CFS	Mean Acceptability	FAAI
100	-2.74	0.06
200	-2.74	0.06
300	-2.71	0.06
400	-2.66	0.08
500	-2.46	0.08
600	-2.26	0.08
700	-1.86	0.11
800	-1.56	0.20
900	-1.29	0.27
1000	-0.77	0.38
1200	-0.34	0.53
1400	-0.26	0.55
1600	0.35	0.50
1800	0.46	0.46
2000	1.06	0.31
2200	1.12	0.30
2400	1.35	0.29
2600	1.51	0.30
2800	1.73	0.27
3000	1.95	0.19
3200	2.03	0.19
3400	2.03	0.19
3600	2.06	0.21
3800	2.11	0.21
4000	2.32	0.18
4500	2.32	0.19
5000	2.38	0.18
6000	2.39	0.19
7000	2.47	0.19
8000	2.47	0.19
9000	2.5	0.20
10000	2.45	0.22
12000	2.53	0.23
14000	2.55	0.24
16000	2.53	0.23
18000	2.53	0.25
20000	2.47	0.29
25000	2.39	0.33
30000	1.78	0.54
50000	1.47	0.61

Figure 2

Flow Acceptability Agreement Index Curve for Big Sur

(Flows represented are flow levels at USGS Colorado River near Cameo, CO*)*

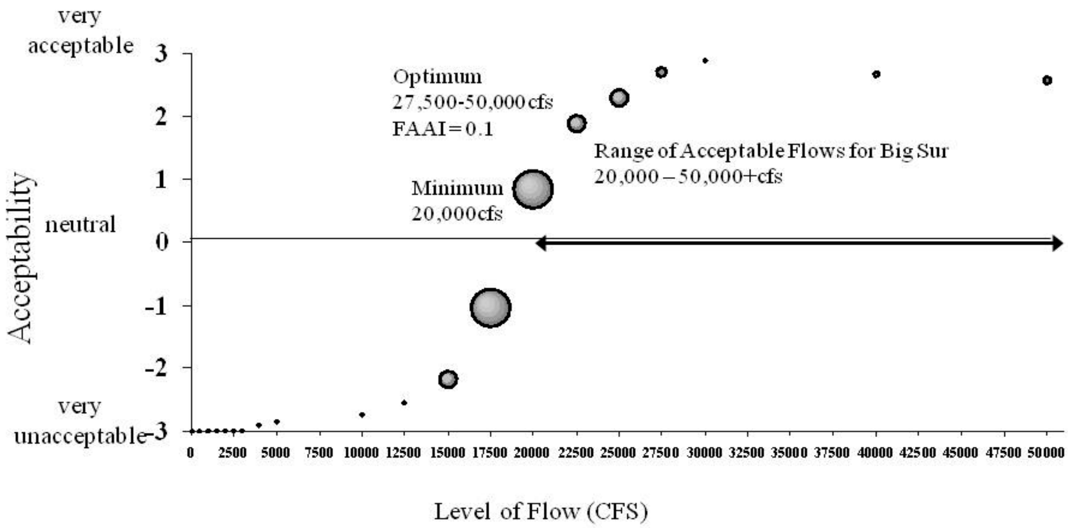

Table 2

Big Sur Mean Acceptability Scores and
Flow Acceptability Agreement Index

Specific Flow CFS	Mean Acceptability	FAAI
100	-3	0.00
500	-3	0.00
1000	-3	0.00
1500	-3	0.00
2000	-3	0.00
2500	-3	0.00
3000	-3	0.00
4000	-2.91	0.00
5000	-2.86	0.00
10000	-2.73	0.00
12500	-2.55	0.03
15000	-2.18	0.18
17500	-1.04	0.41
20000	0.83	0.42
22500	1.88	0.19
25000	2.29	0.18
27500	2.71	0.11
30000	2.88	0.04
40000	2.67	0.06
50000	2.57	0.08

Figure 3

Flow Acceptability Agreement Index Curve for Lower Gunnison

(Flows represented are at the USGS Gunnison River Near Grand Junction, CO*)*

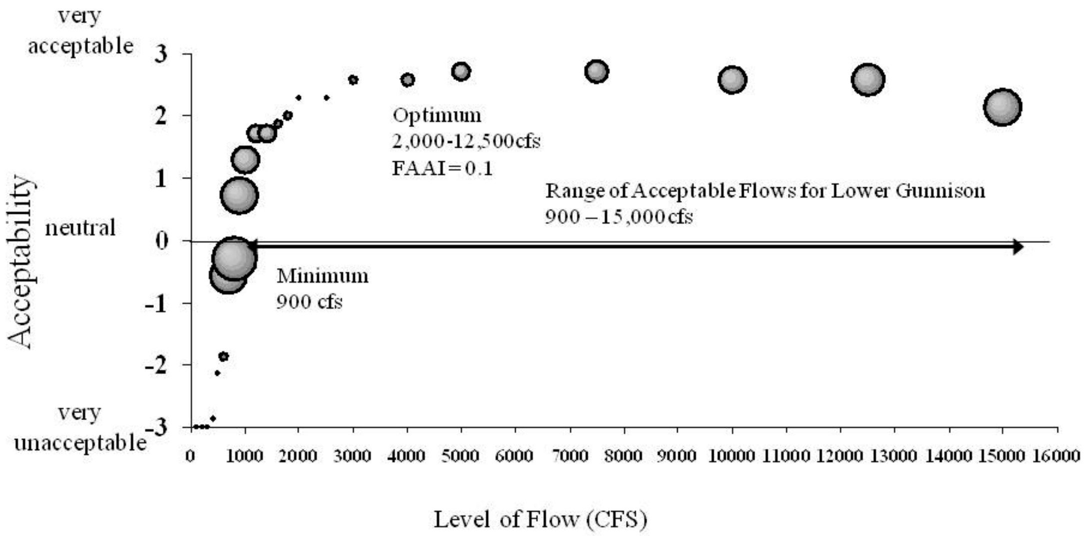

Table 3

Lower Gunnison

Mean Acceptability Scores and Flow Acceptability Agreement Index

Specific Flow CFS	Mean Acceptability	FAAI
100	-3	0.00
200	-3	0.00
300	-3	0.00
400	-2.86	0.00
500	-2.14	0.00
600	-1.86	0.10
700	-0.57	0.38
800	-0.29	0.48
900	0.71	0.38
1000	1.29	0.29
1200	1.71	0.19
1400	1.71	0.19
1600	1.86	0.10
1800	2	0.10
2000	2.29	0.00
2500	2.29	0.05
3000	2.57	0.10
4000	2.57	0.14
5000	2.71	0.19
7500	2.71	0.24
10000	2.57	0.29
12500	2.57	0.33
15000	2.14	0.38

Figure 4
Flow Acceptability Agreement Index Curve for Lower Dolores (Flows represented are flow levels at the USGS Dolores River Near Cisco, CO*)*

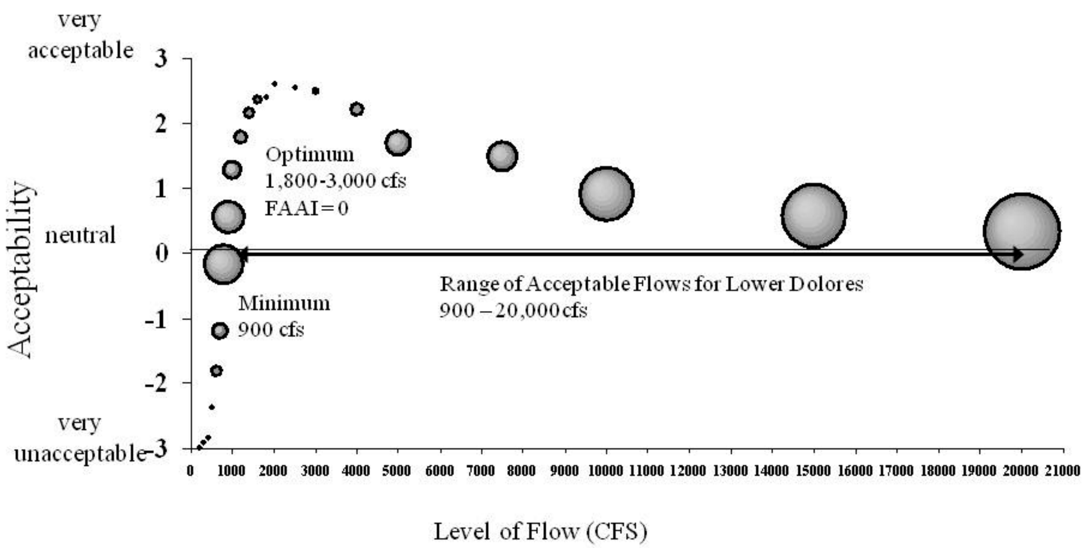

Table 4
Lower Dolores
Mean Acceptability Scores and Flow Acceptability Agreement Index

Specific Flow CFS	Mean Acceptability	FAAI
100	-3	0.00
200	-2.98	0.00
300	-2.9	0.00
400	-2.83	0.02
500	-2.37	0.05
600	-1.8	0.11
700	-1.2	0.16
800	-0.16	0.42
900	0.56	0.34
1000	1.28	0.19
1200	1.79	0.14
1400	2.16	0.11
1600	2.36	0.08
1800	2.4	0.05
2000	2.6	0.03
2500	2.56	0.04
3000	2.5	0.06
4000	2.22	0.14
5000	1.69	0.27
7500	1.5	0.32
10000	0.92	0.56
15000	0.58	0.68
20000	0.34	0.79

Figure 5

Flow Acceptability Agreement Index Curve for Colorado River above Moab

(Flows represented are flow levels at the USGS Colorado River Near Cisco, CO*)*

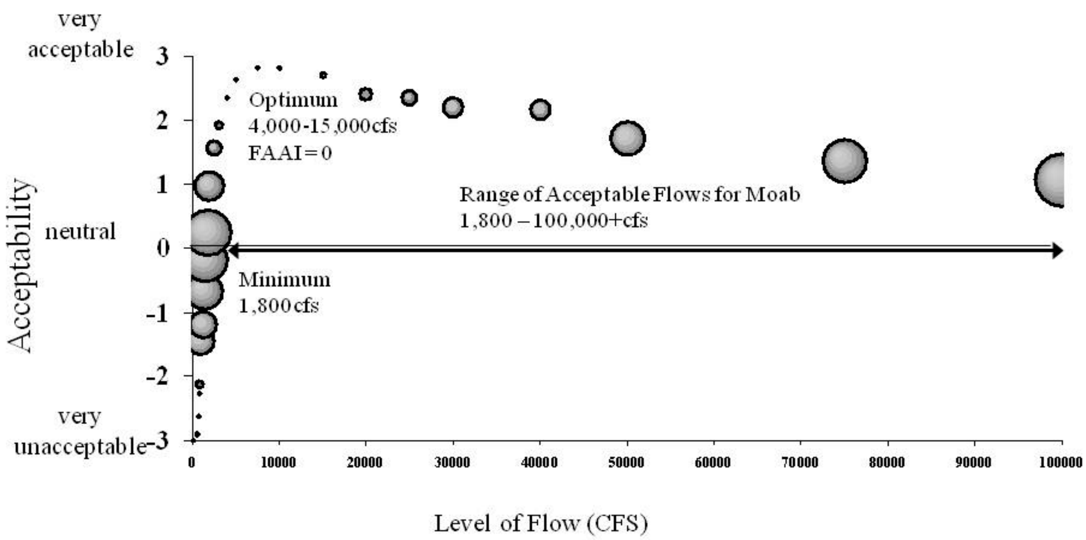

Table 5

Colorado River above Moab

Mean Acceptability Scores and Flow Acceptability Agreement Index

Specific Flow CFS	Mean Acceptability	FAAI
100	-3	0.00
500	-2.91	0.00
700	-2.63	0.00
900	-2.13	0.08
1000	-1.45	0.28
1200	-1.19	0.29
1400	-0.67	0.40
1600	-0.18	0.46
1800	0.24	0.48
2000	0.97	0.31
2500	1.56	0.16
3000	1.91	0.08
4000	2.35	0.04
5000	2.62	0.01
7500	2.82	0.02
10000	2.82	0.03
15000	2.71	0.06
20000	2.41	0.13
25000	2.34	0.17
30000	2.19	0.22
40000	2.16	0.22
50000	1.72	0.38
75000	1.36	0.48
100000	1.07	0.58

Figure 6

Flow Acceptability Agreement Index Curve for Split Mountain

(Flows represented are flow levels at USGS Green River at Jensen, UT*)*

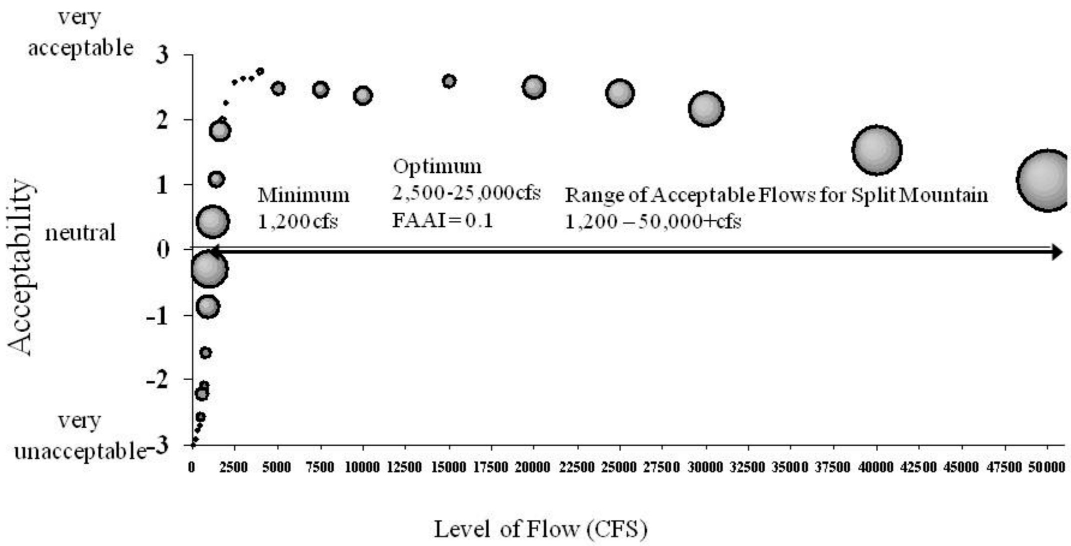

Table 6

Split Mountain

Mean Acceptability Scores and Flow Acceptability Agreement Index

Specific Flow CFS	Mean Acceptability	FAAI
100	-3	0.00
300	-2.78	0.00
500	-2.57	0.09
700	-2.09	0.09
900	-0.87	0.23
1000	-0.29	0.39
1200	0.43	0.35
1400	1.08	0.17
1600	1.83	0.22
1800	2	0.06
2000	2.25	0.03
2500	2.58	0.04
3500	2.63	0.04
4000	2.74	0.06
5000	2.48	0.15
7500	2.46	0.15
10000	2.36	0.20
15000	2.59	0.15
20000	2.5	0.25
30000	2.16	0.37
40000	1.53	0.51
50000	1.06	0.65

Figure 7

Flow Acceptability Agreement Index Curve for Desolation and Gray Canyons
(Flows represented are flow levels at USGS Green River at Green River, UT*)*

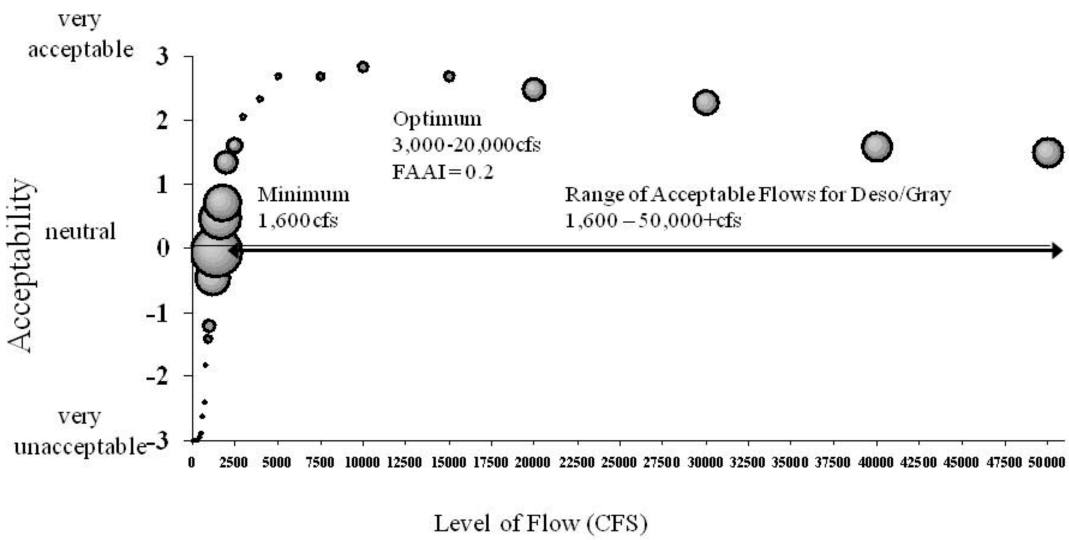

Table 7

Desolation and Gray Canyons
Mean Acceptability Scores and Flow Acceptability Agreement Index

Specific Flow CFS	Mean Acceptability	FAAI
100	-3	0.00
300	-3	0.00
400	-2.94	0.00
500	-2.88	0.00
600	-2.63	0.00
700	-2.41	0.00
800	-1.82	0.04
900	-1.41	0.08
1000	-1.22	0.15
1200	-0.47	0.36
1400	-0.06	0.56
1600	0.47	0.46
1800	0.71	0.39
2000	1.35	0.24
2500	1.61	0.17
3000	2.05	0.07
4000	2.33	0.06
5000	2.68	0.07
7500	2.68	0.09
10000	2.84	0.11
15000	2.68	0.12
20000	2.47	0.245614
30000	2.28	0.2777778
40000	1.59	0.3137255
50000	1.5	0.3125

Figure 8
Flow Acceptability Agreement Index Curve for Lower San Juan
(Flows represented are flow levels at the USGS San Juan River Near Bluff, CO*)*

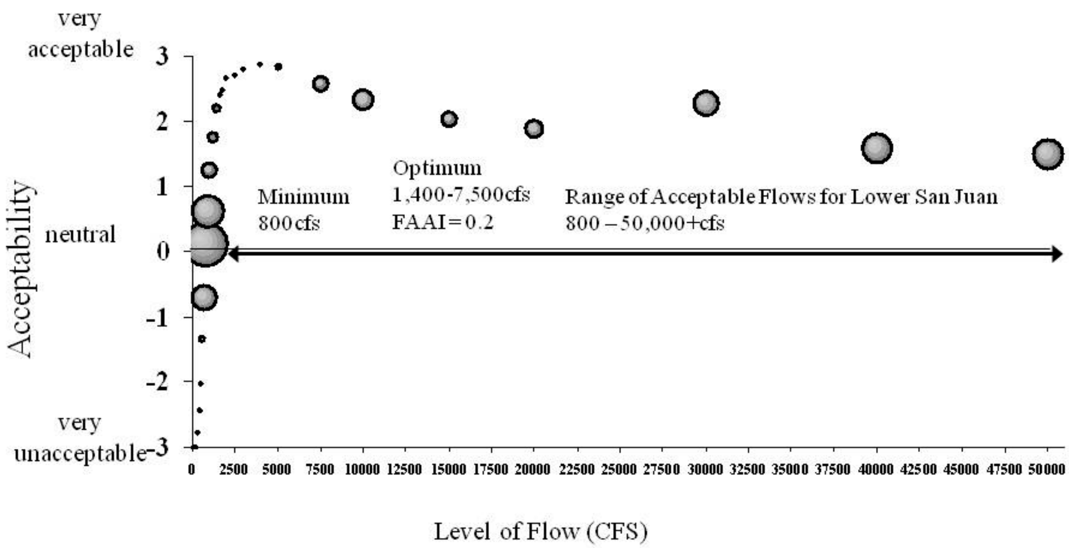

Table 8
Lower San Juan
Mean Acceptability Scores and Flow Acceptability Agreement Index

Specific Flow CFS	Mean Acceptability	FAAI
100	-3	0.00
300	-2.77	0.00
400	-2.45	0.00
500	-2.03	0.02
600	-1.35	0.06
700	-0.71	0.26
800	0.12	0.46
900	0.61	0.34
1000	1.25	0.17
1200	1.75	0.13
1400	2.19	0.09
1600	2.4	0.04
1800	2.48	0.04
2000	2.67	0.02
2500	2.7	0.03
3000	2.8	0.02
4000	2.87	0.03
5000	2.84	0.06
7500	2.57	0.15
10000	2.32	0.21
15000	2.04	0.17
20000	1.88	0.19
30000	2.28	0.28
40000	1.59	0.31
50000	1.5	0.31

Appendix C

A subset of FERC regulated hydropower projects at which discrete usable boating days have been scheduled and/or provided as mitigation for impacts to whitewater boating, and/or analyzed as part of a whitewater flow study.

River	Project Name	State	FERC Project #
COOSA RIVER	JORDAN DAM	AL	00618
COOSA RIVER	MITCHELL	AL	00082
BUTTE CREEK	FORKS OF BUTTE	CA	06896
FEATHER RIVER	FEATHER RIVER	CA	02100
KERN RIVER	BOREL	CA	00382
KERN RIVER	ISABELLA	CA	08377
KERN RIVER	KERN CANYON	CA	00178
KERN RIVER	KERN RIVER NO 1	CA	01930
KERN RIVER	KERN RIVER NO 3	CA	02290
KINGS RIVER	PINE FLAT	CA	02741
MIDDLE FORK AMERICAN R	MIDDLE FORK AMERICAN RIVER	CA	02079
MIDDLE FORK STANISLAUS RIVER	BEARDSLEY/DONNELLS	CA	02005
N FK KINGS R	HAAS-KINGS RIVER	CA	01988
NORTH FORK FEATHER RIVER	POE	CA	02107
NORTH FORK FEATHER RIVER	ROCK CREEK-CRESTA	CA	01962
NORTH FORK FEATHER RIVER	UPPER NORTH FORK FEATHER RIVER	CA	02105
NORTH FORK MOKELUMNE RIVER	MOKELUMNE RIVER	CA	00137
PIRU CREEK	SANTA FELICIA	CA	02153
PIT RIVER	MCCLOUD-PIT	CA	02106
PIT RIVER	PIT 3, 4, & 5	CA	00233
PIT RIVER	PIT NO. 1	CA	02687
SAN JOAQUIN R	KERCKHOFF	CA	00096
SAN JOAQUIN RIVER	BIG CREEK NO 3	CA	00120
SAN JOAQUIN RIVER	BIG CREEK NO 4	CA	02017
SAN JOAQUIN RIVER	BIG CREEK NO.1 & NO.2	CA	02175
SOUTH FORK AMERICAN R	UPPER AMERICAN RIVER	CA	02101
SOUTH FORK AMERICAN RIVER	CHILI BAR	CA	02155
SOUTH FORK FEATHER RIVER	SOUTH FEATHER POWER	CA	02088
SOUTH FORK OF THE AMERICAN RIVER	EL DORADO	CA	00184
SOUTH YUBA RIVER	DRUM-SPAULDING	CA	02310
SOUTH YUBA RIVER	YUBA-BEAR	CA	02266
STANISLAUS R MIDDLE FORK	SAND BAR	CA	02975
STANISLAUS RIVER	SPRING GAP-STANISLAUS	CA	02130
WEST BRANCH FEATHER RIVER	DESABLA-CENTERVILLE	CA	00803
TALLULAH RIVER	NORTH GEORGIA	GA	02354
BEAR RIVER	BEAR RIVER	ID	00020

DEAD RIVER	FLAGSTAFF STORAGE	ME	02612
KENNEBEC RIVER	INDIAN POND	ME	02142
MAGALLOWAY RIVER	AZISCOHOS [?]	ME	04026
RAPID RIVER	UPPER & MIDDLE DAMS STORAGE	ME	11834
S BR PENOBSCOTT R	CANADA FALLS	ME	
W BR PENOBSCOT R	PENOBSCOT	ME	02458
W BR PENOBSCOT R	RIPOGENUS	ME	02572
SWAN RIVER	BIGFORK	MT	02652
WEST ROSEBUD CREEK	MYSTIC LAKE	MT	02301
PIGEON RIVER	WALTERS	NC	00432
TUCKASEGEE RIVER	DILLSBORO	NC	02602
WEST FORK TUCKASEGEE RIVER	WEST FORK	NC	02686
NANTAHALA RIVER	NANTAHALA	NC	02692
EF TUCKASEGEE	EAST FORK	NC	02698
ANDROSCOGGIN RIVER	PONTOOK	NH	02861
PEMIGEWASSET RIVER	AYERS ISLAND	NH	02456
HOOSIC RIVER	HOOSIC	NY	02616
MONGAUP RIVER	RIO	NY	09690
MOOSE RIVER	MOOSE RIVER	NY	04349
RAQUETTE RIVER	[STONE VALLEY REACH]	NY	
RAQUETTE RIVER	PIERCEFIELD	NY	07387
SACANDAGA RIVER	STEWARTS BRIDGE	NY	02047
SALMON R	SALMON RIVER	NY	11408
SARANAC RIVER	SARANAC RIVER	NY	02738
BEAVER RIVER	BEAVER FALLS	NY	02593
BEAVER RIVER	BEAVER RIVER	NY	02645
BLACK RIVER	GLEN PARK	NY	04796
BEAVER RIVER	LOWER BEAVER FALLS	NY	02823
BLACK RIVER	WATERTOWN	NY	02442
KLAMATH RIVER	KLAMATH	OR	02082
SOUTH FORK ROGUE RIVER	PROSPECT NO 3	OR	02337
SUSQUEHANNA RIVER	HOLTWOOD	PA	01881
SALUDA RIVER	SALUDA	SC	00516
WATEREE RIVER	CATAWBA-WATEREE	SC	02232
LITTLE TENNESSEE RIVER	TAPOCO	TN	02169
DEERFIELD RIVER	DEERFIELD RIVER	VT	02323
LITTLE RIVER	WATERBURY	VT	02090
LAKE CHELAN	LAKE CHELAN	WA	00637
SPOKANE RIVER	SPOKANE RIVER	WA	02545
SULLIVAN CREEK	SULLIVAN LAKE (STORAGE)	WA	02225
SULTAN RIVER	HENRY M JACKSON (SULTAN)	WA	02157
TIETON RIVER	TIETON DAM	WA	03701
BLACK RIVER	HATFIELD	WI	10805
CHIPPEWA RIVER	JIM FALLS	WI	02491
GAULEY RIVER	SUMMERSVILLE	WV	10813