



## **Defining Recreational Flow Needs on the North Fork of the Virgin River, Utah**

### **Stream Flow-Evaluations for Whitewater Boating**

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#### **Abstract:**

Streamflows have profound impacts on the quality, quantity, and timing of on river-based recreation values, such as whitewater boating opportunities. Streamflows that provide whitewater boating opportunities for the Virgin River in Southwestern Utah and Northwest Arizona are not clearly defined. American Whitewater conducted this study of streamflows and recreation quality to help define recreational flow needs within the Virgin River basin – with emphasis on segments within Zion National Park (UT). In this study, an online survey was completed by 68 whitewater boaters who evaluated flows on the Virgin River and identified low, acceptable, and optimum streamflows for whitewater recreation. Inverse “U-shaped” curves summarize the quality of flows across the full range of representative streamflows. Respondents also reported flows that provide certain recreation experiences, from technical low water to challenging high water trips. These evaluations can prove useful in understanding how streamflows affect whitewater boating, and provide important information for management decisions that seek to protect or improve the Wild and Scenic Values <sup>1</sup>of the Virgin River and its tributaries.

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<sup>1</sup> Omnibus Public Land Management Act of 2009 (Engrossed as Agreed to or Passed by Senate) SEC. 1976.  
ZION NATIONAL PARK WILD AND SCENIC RIVER DESIGNATION

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## **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., 1992; Shelby, Brown, & Taylor, 1992; Whittaker et al., 1993). Many of the flow-recreation studies focus on whitewater floatboating, as flow often determines whether people have opportunities to take a trip and what level of challenge or social value is provided (Whittaker & Shelby, 2002). Different flow levels provide for varied floatboating 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<sup>2</sup> are used to define these flow ranges based on individual and group flow-evaluations. The various opportunities provided by different flow ranges are often described as occurring in various “niches” (Shelby et al., 1997). Mean responses to flow-evaluations provide useful descriptions of group agreement over flows, but highlight the need for sub-group evaluations, such as mean evaluations for each craft-type.

American Whitewater developed this study to assess individual flow preferences for whitewater boating, in order to help us provide the National Park Service and other land use agencies with science-based information with which to inform their management of the Virgin River. Our goal is to utilize information collected from the survey to quantify the flows needed for whitewater boating. Using the data, we identified low, acceptable, optimum, and highest safe flows for the full range of whitewater recreation opportunities. The information we collected is used to describe the flow-recreation relationships in Zion National Park and evaluate the quality of paddling experiences, ranging from technical low water to challenging high water trips.

## **II. Virgin River Whitewater Boating**

The Virgin River and its tributaries have carved spectacular vertical-walled canyons through the Navajo sandstone and surrounding sedimentary strata of Southwestern Utah, and continue to carve them today. These rivers offer whitewater paddlers magnificent and unique opportunities to experience the slot canyons and river corridors of Zion National Park. There are two primary runs in the Park Unit that appeal to paddlers – Zion Narrows and Temple of Sinawava – though additional whitewater attributes exist further downstream.

Zion Narrows, on the North Fork of the Virgin River, is reported to be the finest backcountry whitewater run in the lower 48 states, and is defined by the 1000-foot gorge through which it flows. Anecdotal and desk-top references to flow conditions for Zion Narrows suggest that flows greatly influence the quality of the run. Reports and guidebooks indicate that at flows below 450cfs (measured at the NF Virgin River near Springdale gage), the first several miles of river below Chamberlain Ranch are shallow and constricted by debris. It is reported that flows of 600cfs or greater improve the quality of the first several miles, and decrease the amount of time needed to reach the first waterfall near the confluence with Deep Creek. Once

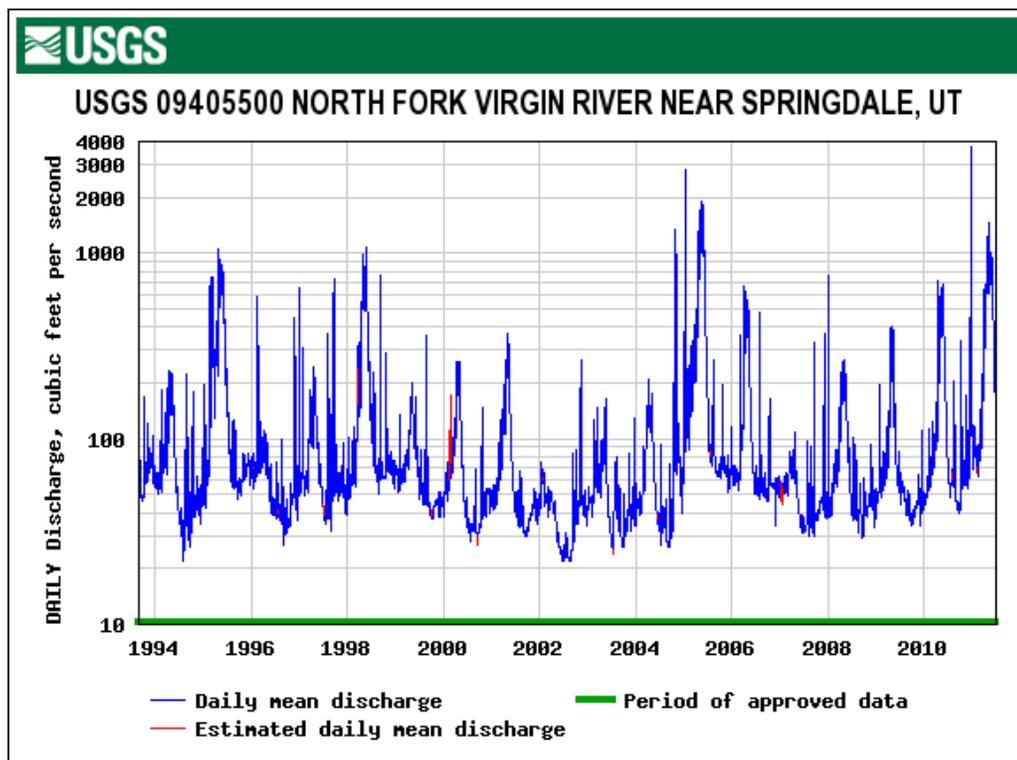
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<sup>2</sup> Whittaker, D., B. Shelby, J. Gangemi. 2005. Flows and Recreation, A guide to studies for river professionals. US Department of Interior, National Park Service, Anchorage, AK

paddlers reach the confluence with Deep Creek, the run begins to take on the characteristics of a slot canyon, and additional streamflows increase navigability. As the run nears its end at the Temple of Sinawava, the drops become more difficult. The Temple of Sinawava can be used as a take-out for the Narrows section, or paddlers can opt to take out 8.5 miles downstream at the Park’s Visitor Center.

Daily streamflows can be highly variable on the North Fork of the Virgin River. Peak annual flows normally occur in May, though individual storm events can trigger significant flows throughout the rest of the year – sometimes exceeding 1000cfs. Flood events occur most commonly from summer monsoon storms, but also from spring snowmelt, and rarely but significantly, from very large winter rain-on-snow flood events<sup>3</sup>. Table A graphically represents streamflow discharge on the North Fork Virgin River, measured at the Springdale USGS Gage.

**Table A**  
**North Fork Virgin River Daily Streamflows**



Instream flow, the amount of water in a river, fundamentally affects recreation quality in most river settings. In the short term, flows determine whether a river provides opportunities for boating, and they affect attributes such as the challenge of whitewater or trip aesthetics (Brown, Taylor, & Shelby, 1992; Whittaker et al., 1993; Whittaker & Shelby, 2002). Longer-term flow regimes may also have effects on ecological resources (Bovee, 1996; Richter et al., 1997), riparian environments (Jackson & Beschta, 1992), or channel features such as beaches, pools, and riffles (Hill et al., 1991).

<sup>3</sup> National Park Service, 2010. Zion National Park Outstandingly Remarkable Values Statement

### III. Recreational Flow Assessment – Defining Whitewater Boating Stream Flow Needs

To develop standards that define whitewater boating flow needs on the North Fork of the Virgin River, American Whitewater collected and organized personal evaluations of resource conditions, and recreation-relevant hydrology consistent with NPS methodologies. An online survey conducted in 2011, involved 68 boaters who were both experienced paddlers and who had completed runs on the North Fork of the Virgin River in Zion National Park. Of 68 total respondents, 28 were identified as experienced paddlers that had paddled the Zion Narrows, while 23 were identified as experienced paddlers that had paddled the Temple of Sinawava run. The results presented only reflect the responses and flow preferences of these 51 individuals.

Respondents hailed mostly from the Rocky Mountains and all were from the western United States. States represented in the survey were Utah, Arizona, Colorado, Wyoming, Washington, Idaho, Montana, Nevada, Tennessee, Florida, New York, and California. 42% of respondents reported paddling 50+ times a year, while 23% reported paddling 20+ times a year. 97.4% of respondents reported paddling over 5 times per year. 98.5% of respondents found out about flows for their river trips utilizing the USGS online gauges. 53.9% felt “very comfortable” estimating flows, while no respondents reported feeling “uncomfortable” or even “somewhat uncomfortable” estimating flows on the study stretch. All of the individuals included in this analysis have paddled in Zion National Park and reported the overall quality of the paddling (aesthetics and whitewater combined) to be either exceptional (76.2%) or great (23.8%).

Study respondents were asked to evaluate overall recreation quality for each measured flow on the North Fork of the Virgin River, using a seven-point “acceptability” scale (unacceptable -3 and acceptable 3). 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 (Shelby et al., 1996; Whittaker, 1997). Table B describes the group evaluation of flows for the North Fork of the Virgin River. Structural norm characteristics were used to graphically represent the range of acceptable flows for whitewater boating opportunities. Mean evaluation for each flow condition is plotted graphically to create the social norm or flow-acceptability curves. This approach has been applied to stream flows for recreation in several studies, including the Colorado River (Shelby and Whittaker, 1995, Shelby et al. 1992)

#### A. Flow-Acceptability curves

Flow-acceptability curves graphically relate flow to evaluations of recreational quality. 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. Flow Acceptability Agreement Index (Potential for Conflict Index or FAAI) determines minimum acceptable flows and respondent agreement regarding the acceptability of each specific flow level (Figures 1-2 and Tables 1-2, Appendix A). Mean aggregate evaluations for the Zion Narrows and Temple of Sinawava sections of the Virgin River are summarized in Table B.

**Table B***Acceptable and Optimal Flows for Whitewater Boating - North Fork of the Virgin River*

North Fork of Virgin River Segment	Lowest Acceptable Flow (CFS)	Optimal Flows (CFS)	Highest Acceptable Flow (CFS)
1) Zion Narrows*	400	550-700	1,500+
2) Temple of Sinawava**	350	550-1000	2,000+

\* At USGS North Virgin River near Springdale, UT Gauge

\*\* At USGS Virgin River at Virgin, UT Gauge

Utilizing flow acceptability agreement index curves, we identified lowest acceptable, optimal, and high acceptable flows for paddling in each of our study segments, and described the agreement between respondents at each flow level (Appendix A). Acceptable Flows are reported as flows that provide tolerable resource conditions for boating, as compared to conditions that do not provide for boating opportunities. As conditions improve, flows are reported as having a higher level of acceptability – commonly these are represented by the peak of the Flow Curve. As flows increase in volume, it is common that boating conditions are reported as providing less acceptable conditions, until the acceptability threshold is crossed. The full range of flows that are reported as providing acceptable resource conditions is quite broad, while Optimal Flows are flows that are reported as providing the highest acceptable conditions for boating. For each of the study segments, the average lowest acceptable flows, optimum flows and the highest average acceptable flow is listed in Table B Agreement between respondents was high for most data points analyzed, however there was some disagreement on the acceptability of flows of 350-400 cfs and flows of 800-1000 cfs. There were high disagreement levels over the acceptability of flows 1100 cfs and over.

## B. Specific Flow Evaluation

Survey Respondents reported flows that provide different paddling experiences, or “niches” along a spectrum: minimum low, technical, standard, high challenge, and highest safe flow (Table C). These “niches” relate stream flow to the full range of whitewater boating opportunities and are useful in further defining the flow-recreation relationship for our study segments. Using median responses we identified the lowest flow level that paddlers would return for, technical flows, standard flows, high challenge flows, and highest safe flows. This analysis reveals that while technical flows in Zion Narrows and the Temple of Sinawava are reported as boatable for some, these flow levels do not encourage return visitation by paddlers. Additionally, the data reveals that at flows above 1200-1300 cfs, flow conditions begin to present a risk to paddler safety.

**Table C**  
*North Fork Virgin River*  
*Median Lowest Acceptable, Technical, Standard, High Challenge and Highest Safe Flows*

	Technical Flow (CFS)	Lowest Acceptable Flow (CFS)	Standard Flow (CFS)	High Challenge Flow (CFS)	Highest Safe Flow (CFS)
Zion Narrows	375	475	600	950	1200
Temple of Sinawava	300	400	500	900	1300

These specific flow evaluations coupled with the Impact Acceptability Curves and the FAAI help further describe the characteristics that define the relationship between flows and whitewater recreation experience. Overlaying the results from the Specific Flow evaluations with the Overall flow curves, can provide a useful approach to understanding these relationships. For example, the Lowest Acceptable Flow for Zion as defined by the impact acceptability curve was 400cfs (Table B). The lowest acceptable flow as defined by the specific flow evaluations was 475cfs (Table C). The FAAI at the 500cfs point on the acceptability curve was .04, indicating very high levels of agreement that 500cfs is indeed an acceptable flow. At 450cfs however, the FAAI was .19, identifying a lower level of agreement that 450cfs is an acceptable flow. With all of these considerations we can conclude that 475cfs belongs at or near the very bottom of the acceptable flow range for whitewater paddling.

C. Additional Questions related to Zion Narrows

In this survey, American Whitewater presented four additional sets of paddler-experience related questions to help decision makers understand the flow-recreation relationship for the Zion Narrows run. The first set of questions asked respondents how flows above 600cfs would affect boating conditions. Data reveals that 88% of survey respondents felt that flows greater than 600 cfs would make the top six miles of the run, above Deep Creek, easier to navigate. 100% of respondents felt that flows greater than 600 cfs would make the top six miles of the run, above Deep Creek, less likely to break your boat. 94% felt that flows greater than 600 cfs would make it easier to paddle the entire run in a day.

Survey respondents were also asked how they would personally rate the overall difficulty of paddling the Zion Narrows on the International Scale of River Difficulty [\(see Section VI of the Safety Code of American Whitewater for complete descriptions\)](#). The responses are reported in Table D.

**Table D**  
**Percentage of Respondents Rating the Overall Difficulty of the Virgin River**

River Reach	Class IV	Class III+/IV-	Class III	Class II
Zion Narrows	26%	47%	21%	2.2%

In a third question, respondents were asked about the length of their trip paddling the Zion Narrows. 67% reported finishing the run in one day, 27% reported finishing the run in two days and 1 respondent reported finishing the run in three days. 89% reported finishing the run in their planned number of days. 2 respondents reported spending extra days in the canyon. All respondents reported putting on before 11 a.m. and 83% reported putting on before 10 a.m. 83% advised other groups to put in before 8 a.m.

Finally, when asked questions about how participants prepare for their trip, most individuals came highly prepared for the run, as is reflected in Table E. Most individuals also have some expectation of being rescued if an injury or accident occurs while boating on public land.

**Table E**  
**Personal Assessment of Preparedness**

Pack food and gear to spend one night	78%
Trained in swiftwater rescue	78%
Trained in First Aid	95%
Carry a breakdown paddle	95%
Read guidebooks/websites prior to trip	95%
Talk to others who had done the run	72%
Reviewed Park Service information about run	78%

**Table F**  
**Expectation of Rescue While Paddling on Public Lands**

Never	35%
If serious injury	60%
If spending 2 or more nights out unexpectedly	42%
If spending 1 night out unexpectedly	6%
If lost boat/gear	12%

#### **IV. Conclusion**

The purpose of the Flow-Evaluation Study conducted by American Whitewater, is to develop a baseline set of information that describes the relationship between streamflows and whitewater recreation in the North Fork of the Virgin River. The Study was based on two approaches to evaluating flows and recreation quality and includes personal evaluations of recreation quality and the structural norm approach, a technique used to graphically represent social norms. This approach has been utilized to identify flows needed to sustain the full range of whitewater boating opportunities on river stretches across the United States and Canada for over twenty years. The graphic representation, referred to as Flow-Evaluation or Impact Acceptability Curves, is used to describe optimum flows, ranges of acceptable flows, norm intensity and level of norm agreement.

For both of the river segments included in this analysis, high levels of agreement on optimal flows were recorded, and a full range of acceptable flows were identified. 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. For most segments, specific-flow judgments are shown to closely mimic relative values identified by the FAAI curves for minimum acceptable, optimal, and maximum acceptable flows. Median flow values for single flow judgments help describe specific flow-dependant “niches” for whitewater boating experiences along each FAAI curve.

Whitewater flow-preferences described in this summary report make it possible to analyze and evaluate the impacts that management decisions based of flow conditions may have on whitewater boating opportunities in Zion National Park. Additionally, this report can be utilized when evaluating future water management actions or risk management strategies. 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 and management strategies in the Virgin River Basin.

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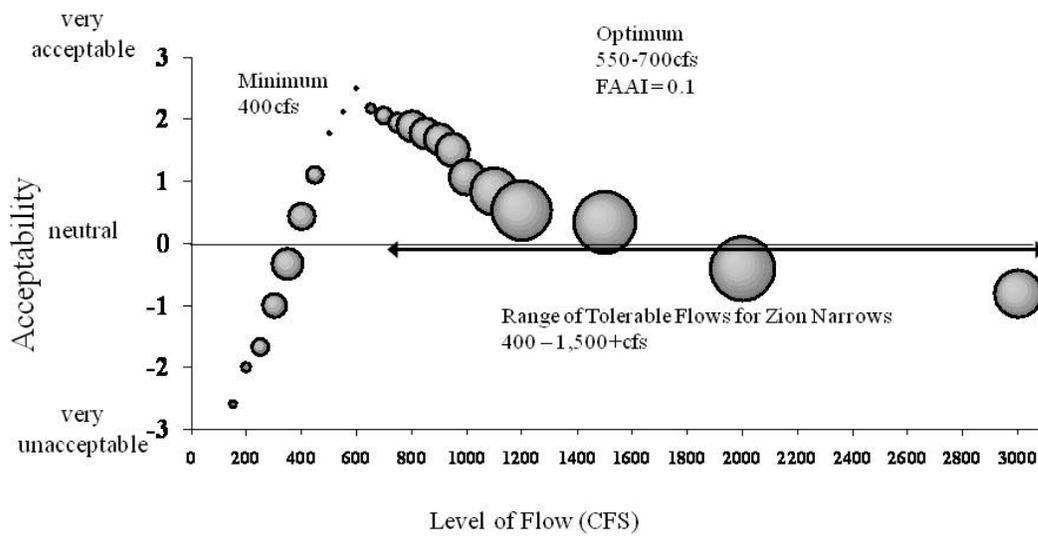
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**Appendix A**

**Figure 1**

*Flow Acceptability Agreement Index Curve for Zion Narrows*

*(Flows represented are at the USGS NORTH FORK VIRGIN RIVER NEAR SPRINGDALE, UT gauge)*



**Table 1**

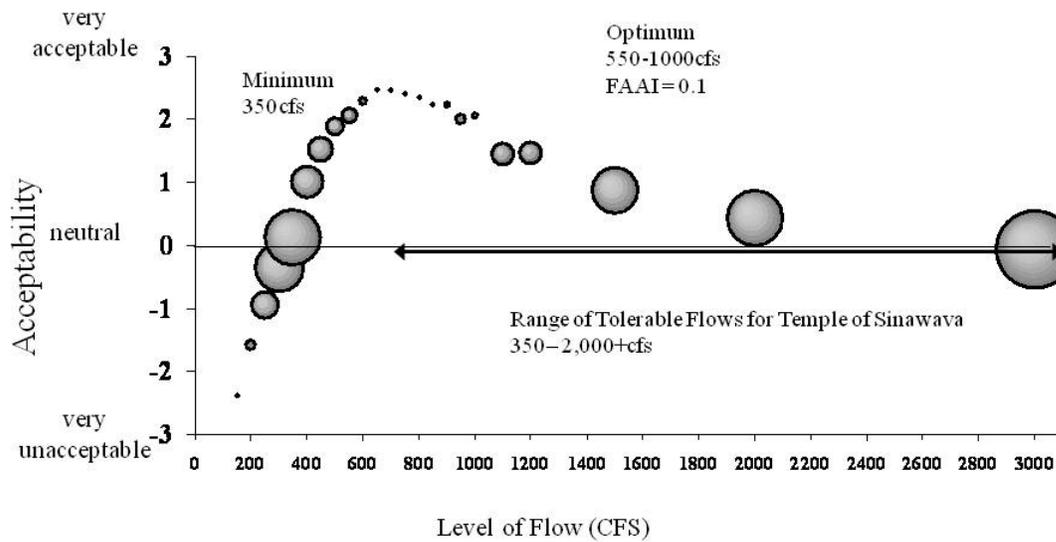
*Zion Narrows Mean Acceptability Scores and Flow Acceptability Agreement Index*

*(Flows represented are at the USGS NORTH FORK VIRGIN RIVER NEAR SPRINGDALE, UT gauge)*

Specific Flow CFS	Mean Acceptability	FAAI
150	-2.59	0.08
200	-2	0.11
250	-1.67	0.19
300	-1	0.26
350	-0.33	0.33
400	0.44	0.30
450	1.11	0.19
500	1.78	0.04
550	2.11	0.04
600	2.5	0.00
650	2.17	0.11
700	2.06	0.19
750	1.94	0.22
800	1.89	0.33
850	1.78	0.33
900	1.67	0.35
950	1.5	0.37
1000	1.06	0.39
1100	0.83	0.52
1200	0.53	0.65
1500	0.33	0.67
2000	-0.41	0.69
3000	-0.82	0.51

**Figure 2**

*Flow Acceptability Agreement Index Curve for Temple of Sinawava  
(Flows represented are flow levels at USGS VIRGIN RIVER AT VIRGIN, UT gauge)*



**Table 2**

*Temple of Sinawava Mean Acceptability Scores and Flow Acceptability Agreement Index  
(Flows represented are flow levels at USGS VIRGIN RIVER AT VIRGIN, UT gauge)*

Specific Flow CFS	Mean Acceptability	FAAI
150	-2.38	0.00
200	-1.59	0.12
250	-0.94	0.30
300	-0.35	0.51
350	0.12	0.59
400	1	0.35
450	1.53	0.27
500	1.88	0.20
550	2.06	0.16
600	2.29	0.08
650	2.47	0.00
700	2.47	0.00
750	2.41	0.00
800	2.35	0.00
850	2.24	0.04
900	2.24	0.06
950	2	0.13
1000	2.07	0.07
1100	1.44	0.25
1200	1.47	0.24
1500	0.88	0.50
2000	0.44	0.60
3000	-0.06	0.83