

APPENDIX 2I

ADDITIONAL RESULTS FROM HELL'S CORNER REACH CONTROLLED FLOW STUDY

Boater Profile Information

All participants were skilled (Class IV/V) boaters with a diversity of interests in whitewater boating. A pre-study survey asked boaters to describe their experience and skill, as well as preferences for different types of trips. Results are summarized below and in Figure I-1.

- *Kayaking experience.* Eleven boaters reported being hard shell kayakers, although only seven reported they kayaked frequently (two others kayak “rarely” and two kayak “occasionally”). Collectively, they averaged 11.8 years kayaking. Six of the seven frequent kayakers rated themselves as Class IV or V boaters. Seven boaters in the study paddled kayaks; one also paddled a kayak at some flows and on some parts of the segment (paddling in a raft at other times).
- *Inflatable kayaking experience.* Eleven boaters reported some experience with inflatable kayaks (IKs), although none reported doing this activity frequently and none used this craft in the study.
- *Rafting experience.* Sixteen boaters reported experience rafting, with 9 reporting they raft frequently. Among all rafters, 2 reported Class III skill, 8 reported Class IV skill, and 4 reported Class IV/V or V skill. Most rafters reported using 14 to 15 foot rafts, while the remainder reported using 12 to 13 foot rafts. The mean number of years rafting was 8.8. Fourteen total rafters participated in the study (but not all observed every flow).
- *Participants’ age and gender.* The average age of boaters was 37, although 35 percent were under 30 and 40 percent were over 40. There were 4 female participants and 16 males.
- *River-running preferences.* Boaters were asked to agree or disagree (on a seven-point scale with a “no opinion” midpoint) with ten statements about river-running preferences that have been used in similar studies. Responses helped characterize participants’ boating interests and offered potential explanations for variations in other responses during the study. A summary of responses to each of the following statements is given in Figure I-1.
 - I prefer running rivers with difficult rapids (Class IV and V).
 - Running challenging whitewater is the most important part of my boating trips.
 - I often boat short river segments (under 4 miles) to take advantage of whitewater play areas.
 - I often boat short river segments to experience a unique and interesting place.
 - I often boat short river segments to run challenging rapids.
 - Good whitewater play areas are more important than challenging rapids.
 - I am willing to tolerate difficult put-ins and portages in order to run interesting reaches of whitewater.
 - I prefer boating rivers that feature large waves and powerful hydraulics.

- I prefer boating steep, technical rivers.
- I enjoy boating both technical and big water rivers.

Results suggest several conclusions about the panel as a group:

- Most boaters were interested in boating short river segments if they offer whitewater playboating or opportunities to run challenging rapids. However, just under half (46 percent) reported interest in short segments for access to a unique or interesting place. The panel was clearly focused on whitewater boating rather than access.
- Most boaters reported a willingness to tolerate difficult access or portages to run interesting whitewater.
- Most boaters appear interested in challenging rapids and whitewater playboating. All the boaters who preferred playboating more than whitewater challenge were kayakers; of those, only two strongly agreed that playboating was more important than challenge.
- Most of the panel appeared interested in both “creek boating” (smaller, technical streams) and “big water” boating (stronger hydraulics and larger waves), although slightly more preferred stronger hydraulics than technical runs.
- The panel as a whole was very interested in challenging rapids, with 100 percent agreeing that they prefer to run Class IV and V rivers and 81 percent agreeing that challenge is the most important part of their trips.

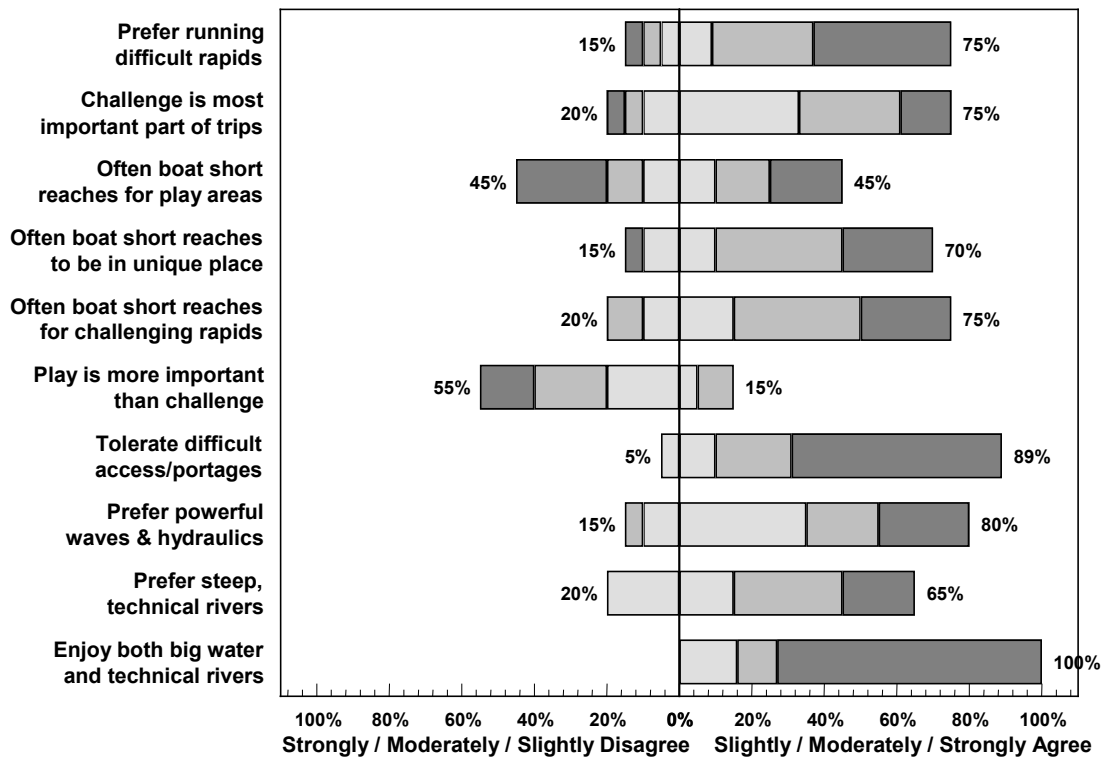


Figure I-1. Percent of Hell’s Corner reach study boaters who agree or disagree with statements about boating preferences.

Boatability Problems and Tolerances

Boatability issues refer to the ability of boaters to negotiate the reach while minimizing inadvertent contact with rocks or obstacles in the channel or becoming grounded. Boaters were asked to report the number of boatability problems (hits, stops, and boat drags as defined below) during each of their runs.

- Hits: contact with an in-channel rock without loss of momentum.
- Stops: contact that causes the boat to stop, but you can continue without getting out of your boat.
- Boat drags: requires getting out of your boat to pull it off obstacles.
- Portages: requires taking your boat out of the channel to avoid unrunnable rapids or obstacles.

Curves based on mean reported numbers of hits and stops are shown in Figure I-2. They indicate that hits decrease as flows become higher (from 40 to 60, depending upon the craft, at 730 cfs to less than 10 at 1,750 cfs). Kayakers reported less than two stops at all flows (and none at 1,750 cfs), while rafters reported an average of 8 at 730 cfs, and less than one by 1,750 cfs. (Note that hits are read from the left vertical axis in the figure, while stops are read from the right vertical axis with a different scale). Kayakers did not report any “boat drags” at any flow, and rafters did not report any at any flow but 730 cfs (when they averaged one). There were no portages for any craft at any flow.

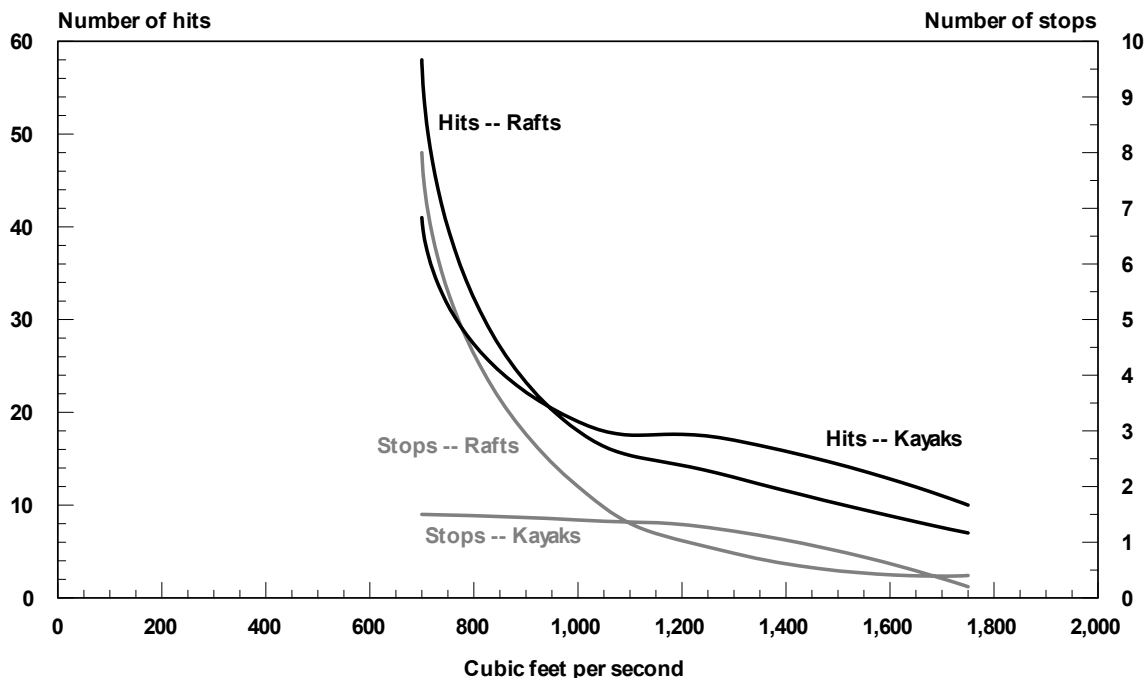


Figure I-2. Average number of “hits” and “stops” reported at different flow levels.

Hits = contact with an in-channel rock without loss of momentum.

Stops = contact that causes boat to stop; progress can continue with push of paddle.

Boaters were also asked to report their tolerances for hits, stops, boat drags, and portages on a segment like the Hell’s Corner reach. Mean tolerances are given in Table I-1 and suggest that most kayakers will tolerate about 15 to 25 hits and 2 to 3 stops, but they have less tolerance for boat drags or portages. Rafters appear willing to accept 20 to 30 hits and 3 to 4 stops, with a similar lower tolerance for portages.

Comparing reported boatability problems with reported tolerances suggests that the two higher flows (1,230 cfs and 1,480 cfs) provided “acceptable” boatability. However, 960 cfs flow was probably close to marginal boatability for rafts, and 690 cfs was close to marginal for kayaking.

Table I-1. Average tolerance levels for boatability problems.

	Hits		Stops		Boat Drags		Portages	
	Kayaks	Rafts	Kayaks	Rafts	Kayaks	Rafts	Kayaks	Rafts
Mean	37	19	3.4	2.0	0.2	0.9	0.0	0.5
Median	33	10	3.0	2.0	0.0	1.0	0.0	0.0

Post-run Evaluations

Following each run, boaters were asked to rate nine attributes of their whitewater trips on a seven-point acceptability scale (1=unacceptable, 4= marginal, and 7=acceptable). The attributes included: boatability, safety, availability of technical rapids, availability of powerful hydraulics, overall challenge, availability of good playboating, aesthetics, rate of travel, and length of segment. Mean scores at each flow were used to develop flow evaluation curves for each attribute. Figures I-3 to I-6 show results for individual attributes for rafts and kayaks, as well as overall post-run evaluation curves. Discussion is organized by groups of attributes.

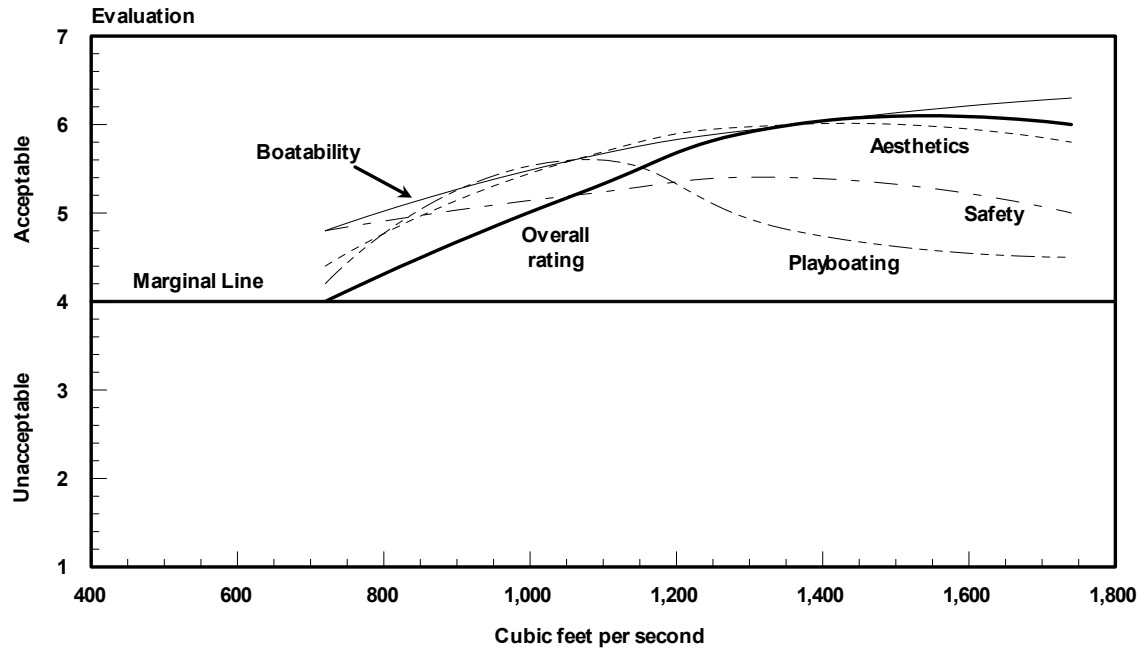


Figure I-3. Average post-run evaluation curves among kayakers for boatability, safety, aesthetics, and the availability of playboating; overall post-run evaluations are also shown.

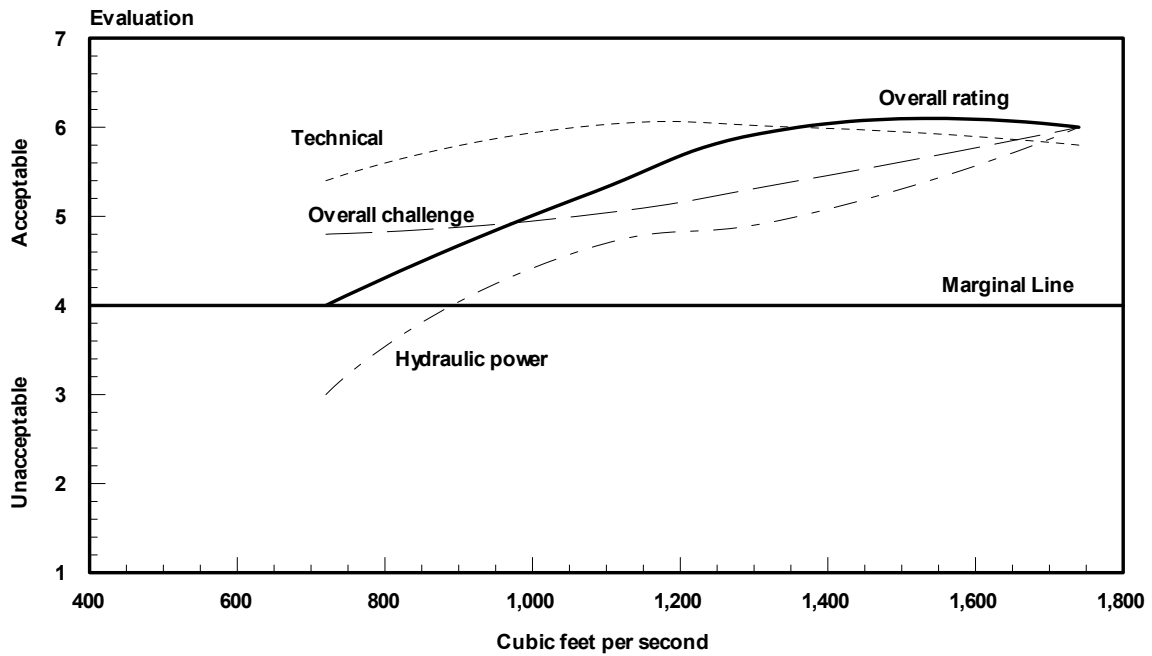


Figure I-4. Average post-run evaluation curves among kayakers for the availability of technical whitewater, powerful hydraulics, and overall whitewater challenge; overall post-run evaluations are also shown.

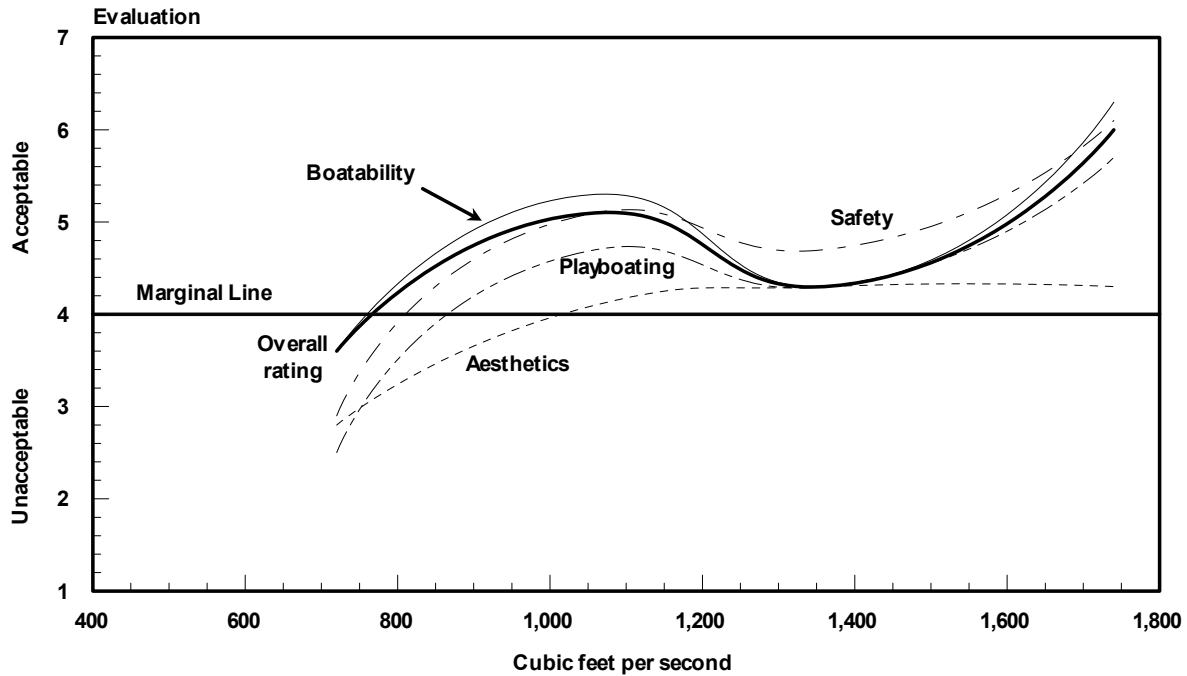


Figure I-5. Average post-run evaluation curves among rafters for boatability, safety, aesthetics, and the availability of playboating; overall post-run evaluations are also shown.

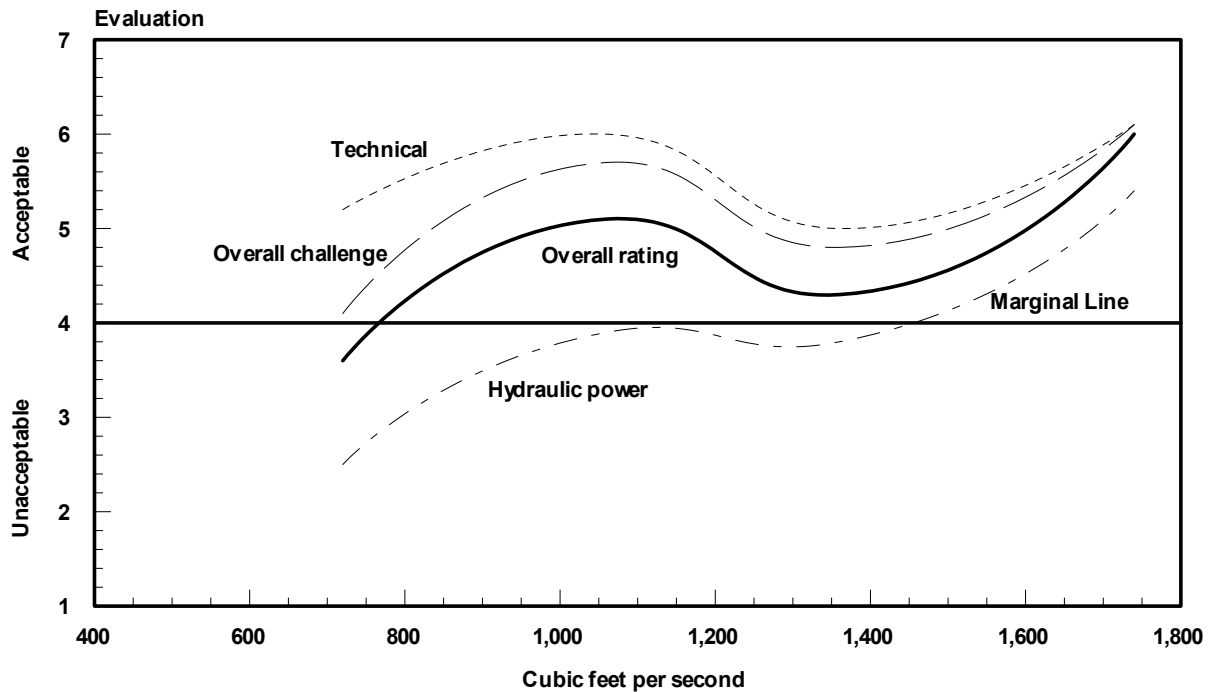


Figure I-6. Average post-run evaluation curves among rafters for the availability of technical whitewater, powerful hydraulics, and overall whitewater challenge; overall post-run evaluations are also shown.

Overall Evaluations

Overall evaluations were acceptable at all but the lowest flow (730 cfs), which was marginal for kayakers and unacceptable for rafters. For kayakers, the overall ratings increased through the range, becoming near-optimal at the highest flow (1,750 cfs). For kayakers, there is a “dip” in the curve at 1,360 cfs; this is a function of sample maintenance issues. Two rafters who generally rated flows lower were present for the 1,360 and 1,750 flows, but they did not participate at the two lower flows. Overall evaluations from the end of study surveys (after all four flows had been run) offer a more complete picture and are highlighted in the main body of the report.

Boatability and Safety

Boatability and safety ratings were similar to overall ratings, improving steadily as flows increased, but leveling off at the two higher flows (with the similar dip at 1,360 cfs for rafters). However, safety ratings for kayakers never approached near-optimal levels, indicating that the river has some safety issues at all the study flows.

Availability of Technical Rapids and Powerful Hydraulics

The availability of technical rapids was rated acceptable at all four study flows for kayaks and rafts, showing only a slight increase through the range (with the dip at 1,360 cfs for rafters). The Hell’s Corner reach has technical rapids that require precise maneuvering at most flows. In contrast, hydraulic power was rated unacceptable by rafters at the lowest flow, marginal at 1,060 cfs and 1,360 cfs, and near-optimal at 1,750 cfs. Supporting other conclusions in the report, flows that approach one turbine have substantially more whitewater “action” than flows that are below one turbine. Among kayakers, the availability of powerful hydraulics was rated unacceptable at only 730 cfs.

Whitewater Challenge and Availability of Play Features

The best kayak playboating was available at 1,060 cfs and 1,360 cfs, but ratings never approached optimal levels. The reach simply does not offer stellar playboating features at the flows studied, although some kayakers reported that they also appear at flows above 2,000 cfs. This Phase II effort was unable to confirm that.

Aesthetics

Aesthetics were rated highly acceptable at all flows among kayakers, but rafters rated it unacceptable at 730 cfs and marginal at 1,060 cfs. The major complaint voiced during focus groups was the presence of an obvious “bathtub ring” from daily peaking.

Post-run Preferences for Higher or Lower Flows

After each run, boaters were asked to indicate their preference for similar, higher, or lower flow levels (Table I-2). Results indicate that most boaters prefer higher flows than the three lowest study flows, but that a majority of the rafters thought 1,750 cfs was about right. About two-thirds of the kayakers would still prefer more flow than 1,750 cfs.

Table I-2. Post-run preferences for flow levels (percent preferring flows higher, the same, or lower).

Response option	730 cfs		1,060 cfs		1,360 cfs		1,750 cfs	
	Kayaks	Rafts	Kayaks	Rafts	Kayaks	Rafts	Kayaks	Rafts
Prefer much lower	0	0	0	0	0	0	0	0
Prefer lower	0	0	0	0	0	0	11	6
Prefer the same	0	0	20	0	20	20	17	57
Prefer higher	0	18	40	86	40	83	67	43
Prefer much higher	100	82	40	14	20	17	17	0

Post-Run Likelihood of Return

Boaters were also asked whether they would be likely to return at the flow level they just ran (Table I-3). Results suggest that the two higher flows are likely to attract many return visits, and particularly the highest study flow. Discussion in focus groups indicated that although lower flows were boatable, the hydraulic power and lack of boatability issues at higher flows would make those much more enticing.

Table I-3. Post-run likelihood of returning for future boating.

Response option	730 cfs		1,060 cfs		1,360 cfs		1,750 cfs	
	Kayaks	Rafts	Kayaks	Rafts	Kayaks	Rafts	Kayaks	Rafts
Would not return	60	36	0	0	0	0	0	0
Possibly return	20	46	40	71	20	33	0	0
Probably return	20	18	60	0	20	33	33	14
Definitely return	0	0	0	29	60	33	67	86

Survey Comments

The following are verbatim comments written by boaters on their survey forms. The comments are organized by flow. The type of craft used by the respondent is also noted.

Type of Boater	Comment
730 cfs	
Rafter	Still fun, but more boater skill and strength necessary. Must have good guide (ours was). Not recommended for commercial tourists.
Rafter	I had two paddlers. They hit their paddles on the bottom a lot. Many oar hits for me. You have to use your crew more. The guide has to do a lot more work. This is about the bottom of the barrel for a 13-14 foot raft.
Rafter	Flow was marginal and unsafe due to extreme number of rock hits, stops and need to pull off rocks. River was UGLY with numerous large exposed boulders, double bathtub ring from 1 and 2 generator flows. River was barely runnable at this flow. River required extensive maneuvering, scouting of rapids and expert boating skills. Would not recommend this flow for anyone. If anyone floats this at this level in a raft they need to be experts! Largely a flat-water pool/drop river at 700 cfs.
Raft guide	Not a good run for commercial boating. It was difficult to pick a safe line through channels; those channels picked were either boulder choked or low filled with shallow debris. This is not an ideal, optimal, or possibly safe flow for any future commercial boating.
Raft guide	This flow could not be rafted commercially. Scraping and dragging rafts over rocks at this flow was not fun. I would not raft this flow again even for fun (as a private trip).
Raft guide	Much more technical. I see a lot of possible danger for commercial passengers with not a lot of skill. One danger that was fairly significant was just plain paddling. Each paddle stroke has the possibility of contact with rocks or wedging the paddle in between rocks therefore pulling possibly launching the passenger out of a raft.
Kayaker	Flow was slow lots of time to pick a line. Continuous but much less exciting. Thought it was considerably easier than higher flows. Besides the occasional rock slam the run felt more like a splashy class III. I think a common flow for all boaters, and adjust your fun level from there.
Kayaker	Even tech boating lost its appeal. Little power, lots of rocks. Caldera was the exception, still constricted enough to be interesting.
Raft guide	Good for guides and fooling around, would be terrible for commercial guests.
1,060 cfs	
Rafter	Rafting was suprisingly fun at this level. Ability of raft captain is very important.
Rafter	Caldera Rapid was fun and a challenge. Had to run left at the first ledge drop. Ran left at Mushroom Rock all three flows. I like low flow running okay, but prefer higher [than this].
Rafter	More technical today, not as pushy but more exciting than 1700. More risky for non-experienced boaters, more obstacles. Aesthetically, bathtub ring is visible.
Raft guide	Definitely raftable as a commercial outfitter looking at the possibility of running at this level. We would probably have to run smaller boats. Less people. Would definitely have to incorporate some more intense screening within our office. At the lower level than one turbine flow, the technicality is much greater, therefore requiring paddlers with more skill and ability. In the long run this would obviously lower profitability for a commercial company, as less people would be able to run the river.

Kayaker	Many hits and stops due to inexperience and poor line choice. Caldera was very fun and relatively clean. Very technical and rocky. Pushed to the limit of my ability.
Kayaker	Flow was acceptable, more technical. For safety I would prefer more water. The extra hits made a play boat a less favored option. Definitely happier in a high volume boat.
Kayaker	Great tech boating. Rocks came out and the places with water became more obvious. Lines were easy to get to and rocks easy to miss. Things coming at you slowly.
Kayaker	1000 cfs was a good technical flow for experienced kayakers. Well-defined features, not too trashy with weird rock placements.
1,360 cfs	
Rafter	Bad shuttle.
Raft guide	Not a great commercial flow.
Kayaker	I think this was a comfortable level for intermediate kayakers. Now that I know the river I would appreciate the higher flows.
Kayaker	Very splashy, big waves.
1,750 cfs	
Rafter	Lots of algae foam at bottom of Caldera. Totally fun run, with few rocks uncovered. Good waves, strong hydraulics and push. Got plenty of play.
Rafter	Lower water level, smaller waves, more exposed rocks, greater chances for bumps leading to ejection's, or dangerous swims. Much more flat water between rapids and rapids were not as exciting to run. More maneuvering required. Would not want to swim rapids at this level. Much more chance of injury.
Rafter	Shuttle sucks.
Raft guide	Great. Perfect raw flow.
Raft guide	Good flow for commercial rafting.
Kayaker	1,700 cfs seems like a good flow! The character of river does not provide many play spots. Besides hit on the run (difficult). Safety would be difficult also due to the width of river. Much better with raft support.
Kayaker	Flipped in Satan's Gate, no hits underwater, whew!

Focus Group Notes

1,750 cfs (first run, first day)

Advantages

More power
More hydraulics than p.m. flow
Exciting
Speed if you fall in water
2 turbines is a blast, but this is fun
Rate of time is better
Deeper
Less hits
More aesthetic
More route options
Sticky rocks
Caldera is a flume at this level.

Disadvantages

Not as good as 2 turbines
More technical than at 2 turbines
More continuous at 2 guns
Bigger waves
less time to rest
constant action
sea of confusion at 2 guns

1,360 cfs (first day, second run)

Advantages

Play was a little better
Liked waves and eddy lines
Defined rapids
Caldera had some eddy spots
Closer to Class III than IV
Cleaner lines and waves
Less chaos in major rapids
Good flow to learn the lines
Easier to eddy out
Different type of challenge – more technical

Disadvantages

More exposed rocks
Play at both flows was weak
Hit more rocks
More flat water between rapids
Could be good or bad – depending

What will it be like at 1,000 cfs?

More technical
Will take more time
Slower
Smaller and less waves

1,060 cfs (second day; only study flow)

Advantages

Challenging – technical
Something different
Not as pushy
Still fun and splashy
Not pushy
Opened up some play opportunities
Lots of play – surfy for rafts
Upper part – more play
Lower not as good
Top of Caldera, could run a left run
Caldera was fun and clean
Passable everywhere
Easier to see channel
Harder to read at higher
Slows it down

Disadvantages

Still some waves in the faces
Hard to use playboat
Need a creek boat
Less of a splash factor (not as much; lots less)
Need a better raft guide (joke)
Need competent crew
Need less people – lighter boat
Need better qualified crew
Guides: I can take anyone at this level
Need A+ paddle skills
Participation – size of boat ok
Need less than six paddlers – need 4-5
6 pack needs highly skilled paddlers
More maneuvering
More hits, more swimmers
Not as pretty – low

Other comments:

You hit more “sleeper” rocks.

You could get into a sieve situation in a few places.

If we had more runs at 1,000 – we’d get the lines figured out.

But there were some unexpected oar hits.

What will tomorrow’s (700 cfs) flow look like?

Probably very, very bony.

Last turn in Hell’s Corner will be tricky -- take different line than today.

May still be runnable.

Not much whitewater, small waves.

700 cfs (third day, only study flow)

Advantages

Slower
Slower if you swim
Easier than 1,000 for kayak
Eddies everywhere: kayak
Splashy Class III: kayak
More of a workout
Improved technical boating
Caldera had some action

Disadvantages

Rocks, rocks, rocks
Sucks! (rafter)
Hell's Corner tough to get through
Safety hazards: foot entrapments
Hazardous for commercial
1,300 anyone?
Have to screen passengers
No way to run six packs
Easy to wedge paddle in rocks – danger
Pile up of rafts
Multiple hits & stops x5 from 1000-700
No power in hydraulics
More maneuvering
No surfing
“bone garden” in kayak

Other comments

As flows drops so does the fun factor.
If lower, Hell's Corner, Rainbow Rock, and Dance Hall will all involve hits or worse.
Probably couldn't run at fish flow without drags and in channel portages.
Expectations of commercial passengers: look for excitement. This doesn't have it.

What is point between 700-1,000 cfs when the river becomes unacceptable?

Reasonable tech boating at these flows, but not good quality.
1,000 is runnable for commercial with small boats and crews.
But 700 is too technical and won't work at all for commercial.
Breakpoint is 900, not 800 (some discussion).
Not as aesthetic as higher flows either.
Time to go look at ugly rocks and foam and water.
Down to less pleasing aspects at low.

Angler Profile Information

Six anglers provided profile information. Three reported they were strictly fly anglers (average years of experience: 4.7 years), while the other three reported they fly, spin, and bait fish (average years of experience: 13 years of fly angling; 30 years of spin angling, and 20 years of bait angling). All but one angler reported that fly angling was the most important type of fishing they do.

Two anglers had familiarity with the Hell's Corner reach only (both CA and OR sections), while the other four had experience on the Boyle and Keno reaches as well. Only one angler reported fishing extensively on the Boyle reach; four reported fishing more on the Oregon section of Hell's Corner, and one reported fishing more on the CA section of Hell's Corner.

Average reported size of fish in the Oregon section of Hell's Corner was 11 inches, compared with 12 inches on the California reach (and 9 inches on the Boyle reach). The average number of fish that anglers report catching in a typical 2-hour period was 13 on the Oregon reach, 5 on the California reach, and 13 on the Boyle reach. Small sample sizes urge caution when using these data except for broad context.

Anglers' heights ranged from 5 feet 7 inches tall to 6 feet 2 inches; height did not appear to play a large role in wading evaluations as taller anglers rated high flows lower than some shorter anglers.

Average age of the six anglers was 47 (ages ranged from 32 to 60). All were males.

Single-day Flow Evaluations

At each flow that anglers observed, they were asked to rate the pools, runs, pocket water/riffles for different types of fishing, as well as rate the wadeability and provide an overall evaluation. Ratings were on a seven-point acceptability scale (1=unacceptable, 4=marginal, and 7=acceptable). Small sample sizes for each flow limit the utility of the individual ratings, but results are broadly instructive. For fly fishing, only the base flow (350 cfs) received a rating of 7, while the average score for 1,700 cfs was 3.5 (sub-marginal), and ratings for intermediate flows (700 cfs, 1,000, and 1,300 cfs) was 4.3. Similarly, wadeability was rated 6.0 at base flows, but only 3.0 at intermediary flows (700 to 1,300 cfs) and 2.5 at 1,700 cfs.

For spin and bait fishing, however, base flows were rated lower (3.0 for spinning; 5.0 for bait), than 1,000 cfs (5.5 for spinning and 7 for bait angling). Results are consistent with the close-out survey findings discussed in the main report.

Angler Comments

Name	Comment
350 cfs	
Vince Cloward	<p>I mostly fish from shore – either walk-in or access by inflatable kayak from Stateline down. At low flows, it is easier to wade. Fishing is okay as it rises or falls, but best fishing is closer to base levels.</p> <p>Has not fished 700 cfs specifically; fished up to a full turbine or down from a full turbine. At higher flows the fish hunker down net to the bank, and the character of the fishing changes from wading based options to shore-based options.</p> <p>Worried that improved fishing flows will attract more angling use and fishing pressure would hurt the fishery.</p>
Brad Emery	<p>Flows from base levels up to about 500 cfs are best – especially down at Frain. Good wading access.</p>
Darin Rembert	<p>Base flows are better for fly fishing. Easy wading and better visibility. Colder water. Less cow poop. But spin fishing slows down.</p>
~700 cfs	
James Finses	<p>Somewhat high compared to average summer flows. I estimate today's flow to be over 1,000 cfs. (Actual flow appeared to be about 700 cfs)</p> <p>I have learned from six years of fishing on any stretch of the Klamath below Boyle (both OR and CA) that the only time to fish is when flows are minimal. I always stop when the river rises. For me, the spin cast fishing goes from excellent to very marginal when the river level changes (rises). Hence, before I fish I always check the Boyle release information. Note I will normally catch 12 to 16 fish in over two hours in Oregon, but less in CA. I attribute that not to river levels but to fishing pressure.</p> <p>I also fish the Klamath as it empties into Copco (by boat). This fishery is not as productive as bank fishing. I usually catch 2 to 4 trout in a normal outing. This is only reachable when Copco lake levels are near full pool. Again, the bite slacks off during higher flows. And not as much of the river is accessible by boat. Perch also become a hassle as one fishes in the early stages of lake/river. I do not fish this fishery during periods of high flow.</p> <p>Today I caught nine trout in 2 hours. Smallest was 9 inches and largest was 14 inches. Average about 11 inches. Best results were in pools. Fast flows produced zero fish. Most trout were tight to the shoreline in the slower water. Several additional hits received when I fished with crawdad lures and rooster tails. Crawdad bait caught all the fish.</p> <p>Provide one low flow for 3 to 4 hours per day and it is okay to provide any other flow for other users' needs (rafters, electricity, fish passage, etc.).</p>
Justin Straus	<p>I usually can only fish in evenings, and it is often too high in recent years. Variation in flows is not the problem. I usually see it on its way down, and it is better when it is all the way down (base flows). The fish start to move then. I can wade across at low flows, not if it's up. I wade across from the powerhouse road in the Frain Ranch area.</p>

1,000 cfs	
Brad Emery	Fishing starts to be possible at this level. But you have to use heavy nymphs.
1,300 cfs	
Mark McGinnis	Advantage: better access to fishing holes, but still not optimal. Disadvantage: difficult to wade and hard to reach fish.
Steve Godshall	No advantages to this flow either. Still can't cross river – same as 1,700 cfs.
1,700 cfs	
Steve Godshall	Very difficult to wade back and forth across river. The fish lies at this flow were very narrow and focused.
Mark McGinnis	Limited access to good fishing areas. Primarily bank fishing possible at this flow. Too deep and hard to reach fish with flies.
Darin Rembert	Advantage: Good flow for spin fishing. The warm water forces the fish into water about 2 feet deep that is still moving. Warm water means less oxygen, so they have to go to the moving water with more oxygen. Fish want oxygen. At night, spring flow has okay oxygen. Disadvantage: Swift water makes wading difficult. Also deeper, less visibility. Not good for fly fishing.
Brad Emery	This flow is fishable, but I don't usually do it. Fast and deeper. Fish are deep.