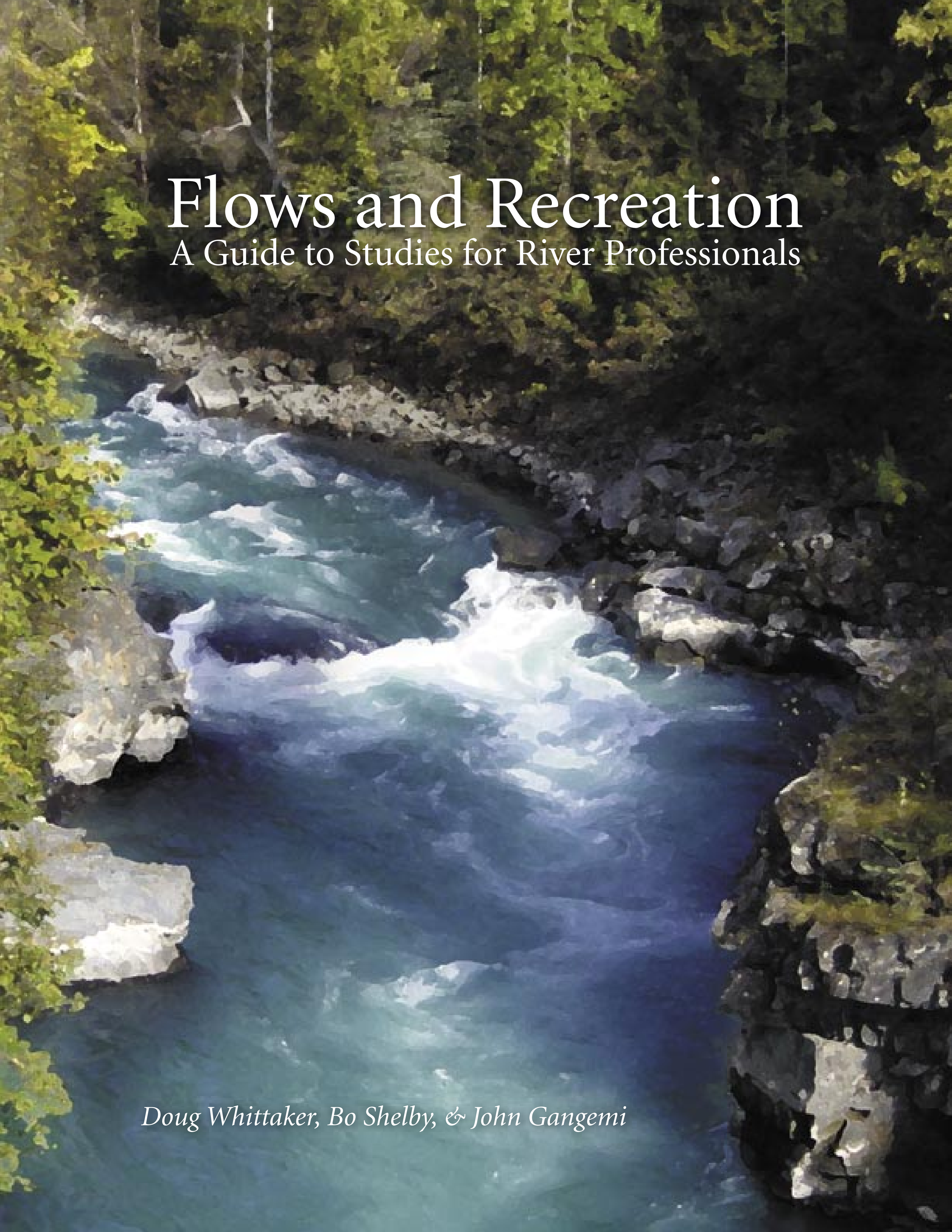

Flows and Recreation

A Guide to Studies for River Professionals

Doug Whittaker, Bo Shelby, & John Gangemi

Foreword

This guide is intended to facilitate decision-making to define flows for recreation on regulated rivers. It provides a framework and methodologies for assessing flows for recreational use. This welcome addition to the Hydropower Reform Coalition's Citizen Toolkit for Effective Participation in Hydropower Licensing (available at www.hydroreform.org/toolkit.asp) should help all participants, such as license applicants, agencies, Tribes, and citizens, satisfy the new licensing regulations of the Federal Energy Regulatory Commission. Ideally, it will be used to enhance the quality of study requests and plans, as well as the implementation of studies and resolution of disputes. The authors are recognized experts and have been involved in numerous flow studies for hydropower licensing and other water resources decisions.

The guide complements and updates an earlier NPS publication, Instream Flows for Recreation: A Handbook on Concepts and Research Methods (Whittaker et al., 1993). This new report provides more specific guidance about a phased approach and other practical aspects of conducting recreation flow assessments.

The National Park Service Hydropower Recreation Assistance program works with parties involved in licensing hydropower facilities regulated by the Federal Energy Regulatory Commission to ensure that public interests in recreation and conservation are addressed. The program draws its authority from the Federal Power Act and technical assistance provisions of the Outdoor Recreation Act of 1962, the Wild and Scenic Rivers Act of 1968, and the National Trails System Act of 1968.

Joan Harn, Hydropower Recreation Assistance Leader
National Park Service
Washington, DC
www.nps.gov/hydro

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1101 14th Street NW, Suite 1400,
Washington, DC 20005-5637
www.hydroreform.org

Address author correspondence to:
Confluence Research and Consulting
6324 Red Tree Circle
Anchorage, Alaska 99507
(907) 346-3769
www.confluence-research.com

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Doug Whittaker, Ph.D.
Confluence Research and Consulting

Bo Shelby, Ph.D.
Oregon State University

John Gangemi
American Whitewater / OASIS Environmental

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HYDROPOWER REFORM COALITION
Putting water, wildlife, and people back in rivers.

NATIONAL PARK SERVICE

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Many early flow-recreation studies focused on whitewater boating, an activity where flows have dramatic effects. Flows determine whether a river is runnable by boaters with different skills or craft, and affect the size and power of hydraulics that create interesting whitewater.

Left: Faraday Diversion Reach on Oregon's Clackamas River at 1,220 cfs.

Flow regimes have important long-term effects on a river's biophysical characteristics such as aquatic habitat, but flows also affect "fishability" or "angler habitat." Studies can define flow needs for different types of fishing opportunities.

Right: Oregon's Upper Klamath River at 350 cfs.

Introduction

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 is boatable, fishable, or swimmable, and they affect attributes such as the challenge of whitewater or the aesthetics of the "riverscape" (Brown, Taylor, & Shelby, 1991; Whittaker et al., 1993; Whittaker & Shelby, 2002). Longer term flow regimes (e.g., over a period of years) may also have effects on fish populations and other ecological resources (Bovee, 1996; Richter et al., 1997; Tharme, 2002), riparian environments (Jackson & Beschta, 1992), or channel features such as beaches, pools, and riffles (Hill et al., 1991). Many of these are critical for specific types of river recreation.

Instream flows are commonly manipulated on regulated rivers through dam releases or out-of-stream diversions; as a result, flow management has become one of the most important issues on the river conservation agenda (Stanford et al., 1996; Poff et al., 1997; Richter et al., 1997). Natural resource agencies (e.g., U.S. Forest Service, National Park Service, Bureau of Land Management, U.S. Fish and Wildlife Service) have been interested in assessing the impacts of flow regimes on recreation, and studies of flow-recreation relationships have become common in most Federal Energy Regulatory Commission (FERC) licensing processes (see sidebar on "Hydropower Licensing and Recreation"). Flow-recreation issues are also relevant in other river-related issues such as navigability or water rights adjudications, or during reviews of federal dam operations.

Considerable work on flow and recreation has occurred in the past two decades (Brown et al., 1991; Shelby, Brown, & Taylor, 1992; Whittaker & Shelby, 2002), and a variety of methods have been developed (see Whittaker et al., 1993 for a review). While these are effective approaches and methodological tools, applications and integration into decision-making processes have been uneven. For a variety of reasons, including varying study quality, recreation interests may have difficulty competing with other resources in regulated river decision-making.

Several reasons help explain varying study quality. First, studies have generally been designed to answer specific questions in arenas such as FERC licensing, water adjudications, or navigability proceedings. This means that few studies have been conducted as part of a systematic research program that could expand the scope of studies, encourage basic research, and link related elements across studies.

Second, studies are generally conducted by non-academic consultants or in-house utility staff. These professionals have fewer incentives to publish in the scientific literature, which limits information transfer. Informal "networking" remains the primary conduit for transmission of "knowledge" about how to conduct effective studies or integrate results.

Third, there has been limited guidance from agencies (FERC or others) about standards for conducting and using studies. This allows the quality and scope of studies to vary case-by-case depending upon the level of interest, expertise, and support from individual agencies, utilities, researchers, or advocacy organizations.

Some of these problems are systemic and challenging. However, clear standards for conducting and using studies would be a major improvement, particularly in FERC license proceedings. This paper offers a start toward that goal by recommending a conceptual perspective and a progression of study options, and then reviewing protocols, responsibilities, and products involved in those options.

Some recreation users are unaware that flows affect their activities. Careful studies can document how flows affect important conditions in "recreation habitats" such as this swimming area on California's Klamath River at 600 cfs.

Objectives

The overall goal of the paper is to summarize ideas for improving flow-recreation research and its integration into decision-making (particularly FERC processes on regulated rivers). Specific objectives are to:

- Provide a conceptual perspective that differentiates descriptive versus evaluative information.
- Develop a progression of study options, with increasing resolution provided at each level, to help identify research needs in specific situations.
- Review elements associated with study options, clarifying and standardizing terminology for methods or study outputs.
- Review common roles and responsibilities of agencies, utilities, consultants, and stakeholders.
- Identify study outputs or products needed at various stages in the progression to ensure that results can be integrated into decision-making processes.
- Discuss broader challenges in integrating recreation study results with those for power and non-power resources.
- Consider how study information is used to develop cost-effective and beneficial protection, mitigation, and enhancement measures (PMEs) to include in project licenses.

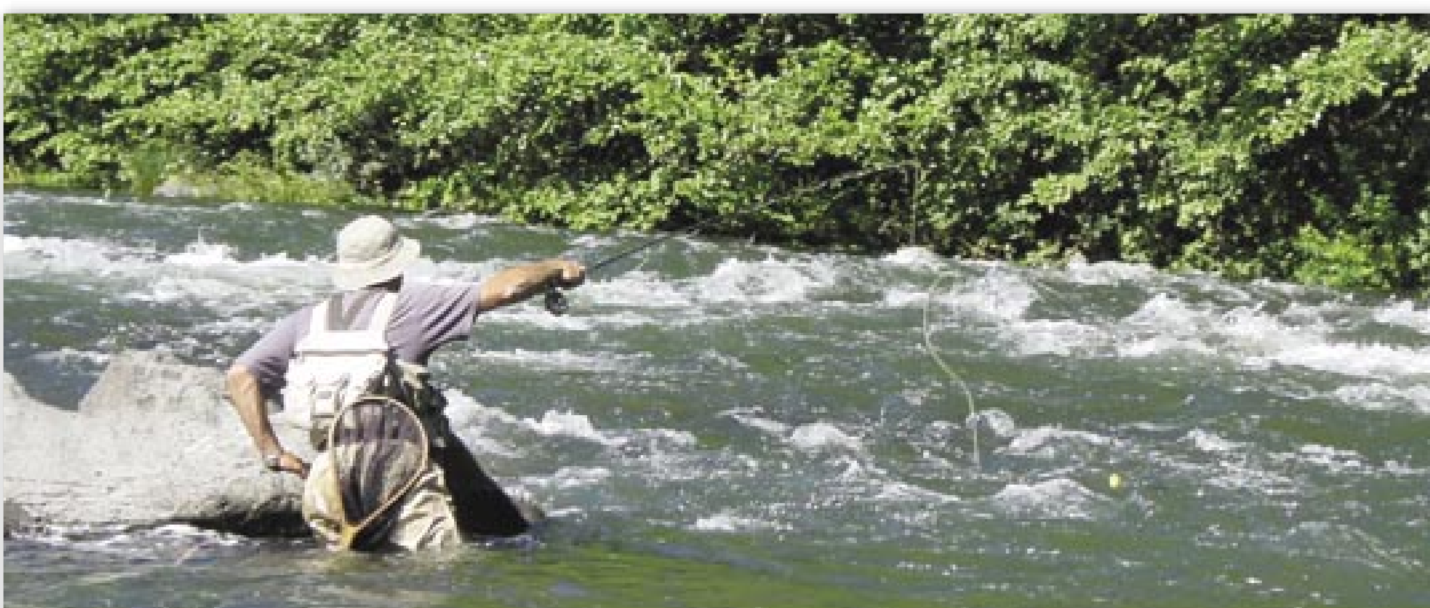
In addressing these objectives, the primary aim is to provide a common understanding of flow-recreation study issues for both researchers and "professionals" who review that research. We include researchers, consultants, and staff from interest groups, agencies, and utilities under this label, but it also extends to interested recreation users or advocates who may become involved in flow-recreation work. In order for these professionals to work together effectively, they need to be able to "speak the same language."

At the same time, we caution readers that this document does not provide all the information necessary to conduct the various study options. Quality flow-recreation studies require a range of social science and logistical skills, and experience adapting concepts and methods to specific cases. Similarly, a growing literature of technical reports may suggest examples of key study elements (e.g., question formats in a survey instrument or questionnaire), but these cannot be blindly applied. Questionnaire development is a proportionally small part of most study efforts, and the ability to tailor questions and analysis to each new case is critical. Accordingly, we have not provided example survey instruments or report findings, although these are widely available in study reports or journal articles cited in the references. Researchers interested in methodological details of various study types are urged to more closely review this literature; this document is designed for a more general audience of river professionals who might be considered the "critical consumers" of flow-recreation research.

Finally, this document focuses on studies common to FERC licensing efforts, but many of these study options are relevant in other river "decision environments" such as navigability and water rights adjudications, or reviews of federal dam operations (e.g., Corps of Engineers or Bureau of Reclamation projects). In each of these cases, the common need is to understand how flow regimes affect recreation quality or use, and then integrate that information with findings from other resource areas. Similarly, resources to study these relationships are often constrained, which puts a premium on efficient and focused studies.

Wading-based fishing is dramatically affected by flows because depths and velocities determine access to fishable water.

Below: During a flow study on California's Pit River, anglers evaluated flows from 150 to 1,800 cfs (600 cfs shown here).



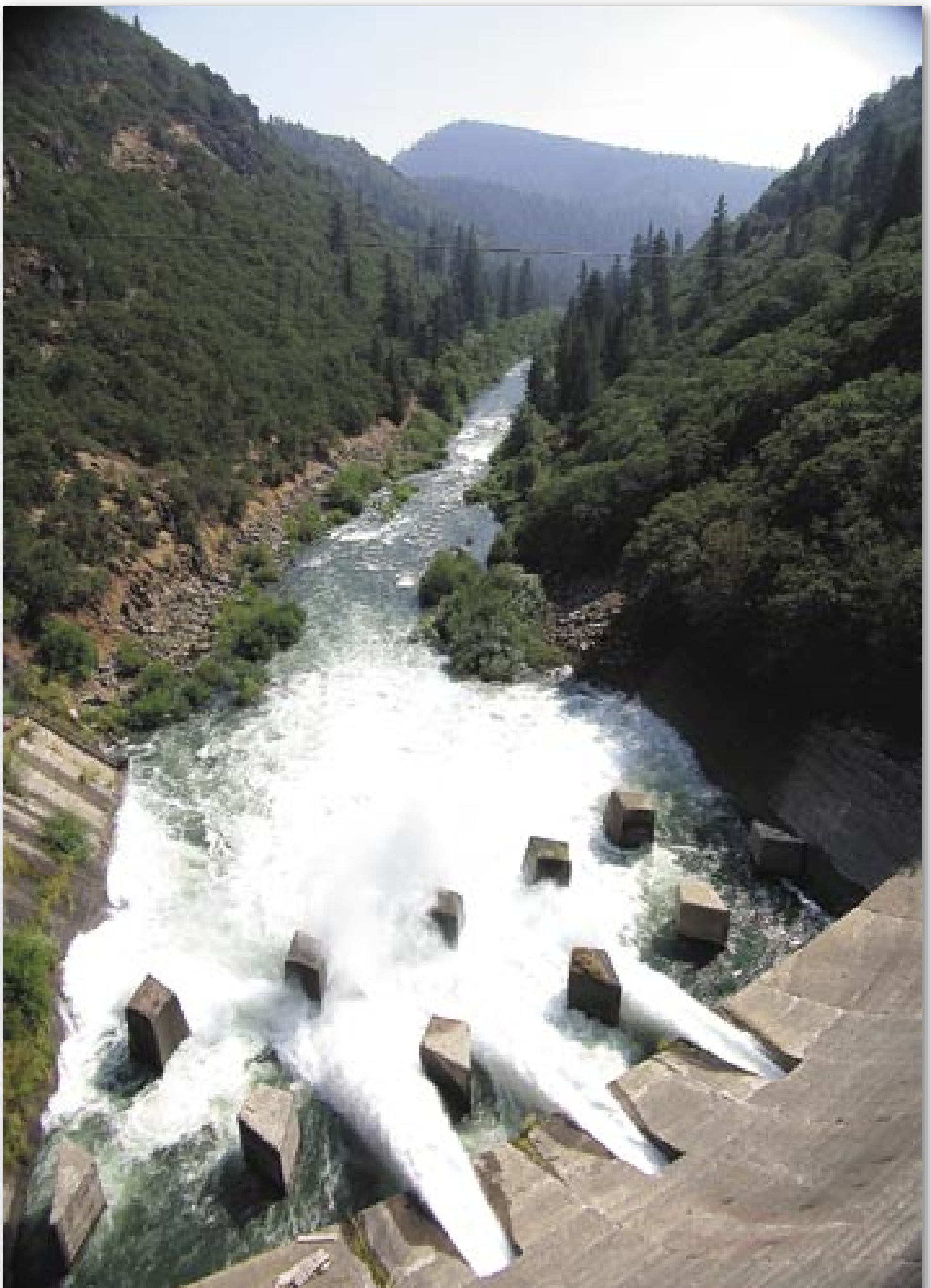
Organization

The paper is organized by sections on 1) a conceptual perspective; 2) a progression of study options; 3) a review of study options; and 4) integration, trade-offs, and inserting findings into decision-making processes.

The document also provides a series of "sidebars" interspersed through the text. These short discussions of related topics are identified by a box outline. Separate sidebars are provided on:

- Hydropower licensing and recreation
- Flow regimes, long-term effects, and recreation
- Flows and aesthetics
- Problems with "blind" flow studies
- Flows, fish habitat, and fishability
- Roles and responsibilities during fieldwork
- Study needs for new license applications

Photos illustrating key concepts or study findings are also interspersed throughout the report. Highlighting central ideas from the document, these photos and captions also convey the breadth and depth of flow-recreation studies or the issues they have addressed.



"Controlled flow studies" are a powerful tool, allowing resesarchers and recreation users to evaluate a range of flows over a short period of time. These studies are common for relicensing projects that have bypass reaches. Different study options provide different levels of resolution about flow effects on recreation; this guide helps river professionals recognize the "right tool for the job".

Left: Pit 3 Dam releases 1,800 cfs on California's Pit River; this bypass reach has historically provided base flows about 150 cfs.

Even small dams can affect hyrdaulics, riparian vegetation, and channel characteristics, which in turn affect the type and quality of recreation opportunities.

Left: This diversion dam on California's Hamilton Branch of the North Fork Feather River typically leaves base flows less than 50 cfs. This provides good fishing, but boating requires about 250 cfs. The 95 cfs release shown here was boatable on the river's upper segment, but not on the steeper lower segment.

Flows affect depths, velocities , and water quality, important attributes for swimming. Less swift flows may be better for children or less skilled swimmers, but lower flows may be too shallow or appear stagnant.

Right: Taylor Creek, a tributary to Oregon's Rogue River.

Conceptual Perspective

Assessing flows for any resource requires a conceptual framework; one option is shown in Figure 1. Flow is the variable driving the system, and it can come from natural or human-regulated sources. Flow, in turn, affects resource conditions. Immediate effects are related to hydraulics (depth, velocity, width, wetted perimeter, and turbulence), but longer-term effects occur though interactions with channel geomorphology and riparian vegetation. Taken together, hydraulics, channel morphology, and riparian vegetation form a dynamic system of resource conditions that define biophysical and recreation "habitats." Combinations of resource conditions associated with a given flow regime, in turn, provide resource outputs. Broad categories of outputs include recreation opportunities (e.g., whitewater boating, wading-based fly fishing, family swimming and wading) and biophysical resources (e.g., quality of a sport fishery, amphibian populations, beach size or abundance).

To the extent that flow regimes can be managed to produce different combinations of outputs, the final element in the framework assesses resource trade-offs. Here the framework moves from the "descriptive" arena (where scientists determine how flows affect resource conditions and outputs), to the "evaluative" arena (where decision-makers, resource managers, and interest groups consider the desirability of different combinations of outputs; Shelby and Heberlein, 1986). These evaluations are generally made in decision-making processes (such as FERC license proceedings) where social values are often central (Kennedy and Thomas 1995).

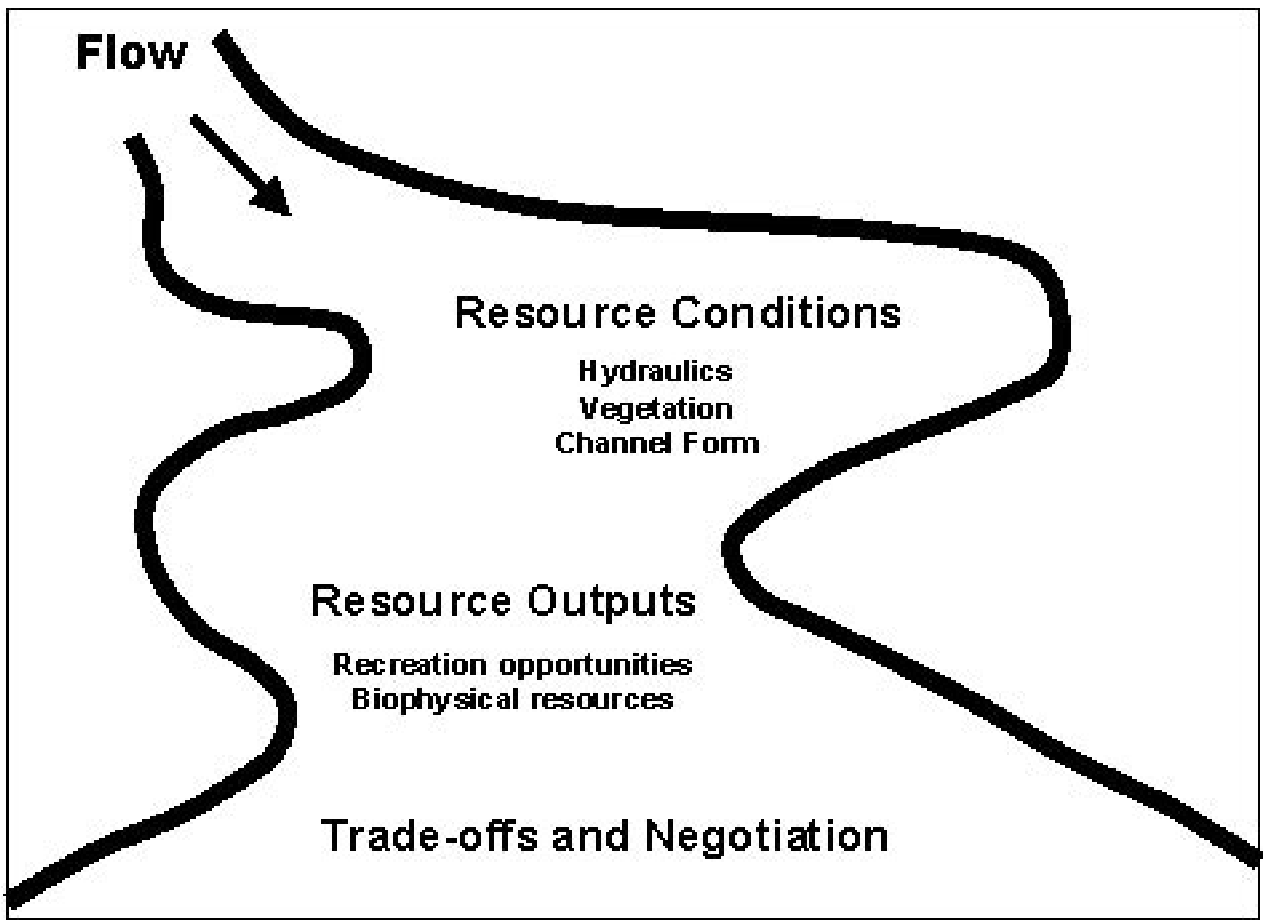


Figure 1. A framework for assessing flows for recreation or other resources.

SIDEBAR
Hydropower Licensing and Recreation

The Federal Energy Regulatory Commission regulates operating licenses for approximately 2,500 hydropower dams across the country, with most operated by private utilities or public utility districts. Licenses are usually granted for periods of 30 to 50 years; when those licenses expire, utilities must apply and receive a new license to keep operating a facility. Since 1993, FERC has issued or renewed more than 350 hydropower projects throughout the nation. Over the next decade, FERC is expected to consider licenses for an additional 200 projects.

The Electric Consumers Protection Act (ECPA, 1986) rewrote "the rules of the game" for assessing and mitigating impacts of projects, so relicensing generally requires consideration of issues that played little part in an "old" license. ECPA requires FERC to give "equal consideration to power and non-power values" when issuing hydropower licenses, so impacts on all these resources must be studied during relicensing and possibly mitigated in the new license. Reservoir and downstream river recreation qualify as "non-power values," and regulations subsequent to ECPA led to a formal role for the National Park Service to provide advice or represent recreation interests in relicensing processes. Agencies that manage land affected by hydropower projects (e.g., the U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service) have similar responsibilities to represent a variety of environmental values, including recreation.

Licensing processes are complex, multi-year resource planning and decision-making efforts that generally have three major phases, although these are handled in slightly different ways depending upon whether a "traditional" (TLP), "alternative" (ALP), or "integrated" (ILP) process is being used. Until 2004, licensees chose between traditional and alternative processes (and several of these processes are on-going and "grandfathered" in), but since that time the ILP is the "default" process (although licensees can still request to use the TLP or ALP).

The first phase involves assembling existing information about the project and potentially affected resources. This helps identify information gaps that will lead to discussions about which studies should be conducted to assess impacts for alternative operation or mitigation scenarios. With traditional or alternative processes, a "first stage consultation package" was the end point in this effort. With the ILP (and all future TLP or ALP efforts), a "preliminary application document" (PAD) is the corresponding product, and it is guided by the standard of "existing, relevant, and reasonably available information."

The second phase focuses on developing study plans, completing the studies, and integrating findings across resource areas. In traditional and alternative processes, this is usually a two- to three-year effort that culminates in draft and final license applications from the utility. In some cases, settlement discussions between utilities, agencies and stakeholders may also be a part of this phase. Most of studies described in the present document typically occur during this phase.

The third phase focuses on resolving conflicts between the utility, agencies, and stakeholders through an impact analysis conducted by FERC through a National Environmental Policy Act (NEPA) planning process. NEPA planning requires developing a range of reasonable alternatives, assessing environmental impacts for each, public involvement, and decision-making by an interdisciplinary team. In traditional and collaborative FERC processes, scoping, alternatives, and impact analyses generally evolved from studies in the second phase. In the ILP, scoping for the NEPA track starts when the PAD is released and studies are developed, but alternative development and impact analysis still typically occur after studies are completed.

The final result of a NEPA-based decision is a license to build and/or operate a project with "articles" that prescribe operations and mitigation. When settlements between utilities, agencies, and stakeholders occur, FERC generally incorporates them into the NEPA process and final license.

Detailed comparisons between these licensing processes are beyond the scope of this document, but a few other differences between the license processes are notable. With a **traditional licensing process**, utilities generally retain greater control over the contents of draft and final license applications, although there are specific consultation requirements to encourage consideration of stakeholder or agency concerns and sometimes a more collaborative hybrid process is used. When disputes arise FERC is responsible for resolving them, but this generally occurs later in the process.

With an **alternative licensing process**, utilities, stakeholders, and agencies are encouraged to develop study plans and applications in a more collaborative fashion, hopefully increasing efficiency and avoiding some of the later-stage disputes common in traditional approaches. However, collaboration can be time-consuming and labor-intensive, and consensus may still be difficult (requiring FERC dispute resolution).

The recently-developed **integrated licensing process** is an attempt to address some of these deficiencies. The ILP prescribes earlier FERC participation, more formalized agency and stakeholder collaboration or consultation roles, and an accelerated schedule that includes concurrent NEPA issue

FERC will "relicense" about 200 hydropower projects over the next decade, and many of these will affect recreation. FERC rules require utilities to assemble existing recreation information, develop study plans, conduct studies, and discuss findings with stakeholders. These efforts provide excellent opprotunities for research and planning that result in "on-the-ground" actions. Above: Release from Faraday Diversion Dam on Oregon's Clackamas River during a controlled flow study.

scoping while studies and the license application are being developed. The ILP also creates a formal process for addressing conflicts about studies requested to provide information for potential mandatory conditioning of licenses by federal and state agencies, or Tribes. This formal process includes participation from an "outside" expert for the resource area in question.

ILP regulations prescribe rigorous justifications for studies and earlier, binding approval of studies by FERC. The goal is to minimize "additional information requests" (by agencies or stakeholders) and help licensing processes stay on a tighter schedule. Study requests must include: (a) study goals and objectives; (b) resource management goals or public interest considerations; (c) existing information and the need for more information; (d) the connection between project operations, resource effects, and potential license requirements; (e) study methods consistent with generally accepted practice; (f) an assessment of study effort and costs; and (g) reasons whys the applicant's proposed studies would not be sufficient. It is premature to assess how well this new process will work.

With all processes, agencies and stakeholders have general responsibilities to help identify recreation issues; determine study needs; assist with study design, conduct, or evaluation; help integrate study results into application proposals; and facilitate settlements between agencies, utilities, and stakeholder groups. The present document is designed to help clarify those roles and responsibilities

A Progression of Study Options

Deciding upon the appropriate "degree of resolution" is a major issue in flow-recreation studies. Some rivers have extensive recreation use that is clearly flow-dependent and affected by project operations; here more intensive and detailed efforts are necessary. On other rivers, the potential for a recreation use may be unknown (e.g., whitewater boating on a bypass reach, fishing for a species that could be reintroduced), or the use may be only marginally affected by flows that the project does not substantially affect. In these cases, less intensive studies may be required.

Given the potential diversity of situations, it is difficult to specify a single set of standards for a "sufficient" study. Instead, we recommend a progressive approach with "phased" efforts of increasing resolution. All studies have to provide similar initial information about recreation opportunities, their likely dependency on flows, and potential project effects. However, more intensive or detailed studies will only be prescribed in situations that merit them. To be effective, this approach needs 1) a clear sequential framework; 2) standardized terminology for various study options; 3) agreement about which study options provide which degree of resolution; and 4) explicit decision criteria to help determine whether the study needs to continue to the next level.

The following framework suggests three levels of resolution, with distinct study options generally linked to each level:

• **Level 1** – "desk-top" options: This is the initial information collection and integration phase. It usually focuses on "desk-top" methods using existing information, or limited interviews with people familiar with flows and recreation on the reach.

• **Level 2** – limited reconnaissance options: This increases the degree of resolution through limited reconnaissance-based studies, more intensive analysis of existing information, or more extensive interviews.

• **Level 3** – intensive studies: This substantially increases the degree of resolution through more intensive studies, which may include multiple flow reconnaissance, flow comparison surveys, or controlled flow studies.

This framework has been applied successfully in FERC relicensing proceedings, and it has the potential to improve studies or applications in several ways. First, it focuses resources on those river reaches with greater interest to the recreation community or with greater impacts from project operations, while reducing workloads on reaches with less interest and lesser project effects. This streamlines costs by prioritizing reaches more "deserving" of additional study. This is especially useful at hydropower projects with multiple dams, powerhouses, and river reaches, where prioritization and efficiency are particularly important.

Second, it provides a transparent and defensible record for all entities (e.g, Licensees, stakeholder groups, and agencies) regarding the "sufficiency" of effort. This should lead to more efficient licensing or adjudication proceedings, and limit challenges.

Third, it helps standardize methodologies and improves comparability across situations. This should improve the quality of study products and allow them to be more efficiently used in license proceedings or other decision-settings.

Fourth, the increased transparency of the phased approach allows information to be shared earlier in the process, particularly across resources. This allows an earlier discussion of potential conflicts between flow needs for different resources, which may help researchers design studies that address solutions to those conflicts. Integrating information across resources is a major challenge in licensing proceedings; the earlier potential conflicts are articulated, the more likely researchers can provide information about trade-offs or potential ways to address them.

Finally, there are efficiencies in conducting coordinated studies, particularly if controlled flow releases are part of the study design. Although it is beyond the scope of this report, there appear to be similar benefits of using a progressive approach with aesthetics, fisheries, or other resource studies, with parallel types of work at the desk-top, initial reconnaissance, and intensive study levels. Formally recognizing these levels and coordinating study needs can help reduce the costs of studies and encourage inter-disciplinary exchanges throughout the study process.

The remainder of this guide reviews elements for each study option, including 1) objectives; 2) typical approaches; 3) products; 4) typical responsibilities of agencies, utilities, and advocacy groups; 5) "additional issues" to highlight challenging tasks or suggest protocols that characterize more successful efforts; and 6) "cautions or limitations" that may restrict use of an option or require additional information from other study options.

Intensive studies are needed when recreation opportunities are flow-dependent and affected by project operations. Above: Boating on Oregon's Upper Klamath River is dramactically affected by a power-peaking regime that can fluctuate from 350 and 2,800 cfs in one day. A controlled flow study examined flows between 700 and 1,700 cfs (shown here) to more precisely specify flow ranges for different opportunities if peaking operations were constrained.

Desk-Top Options (Generally Level 1)

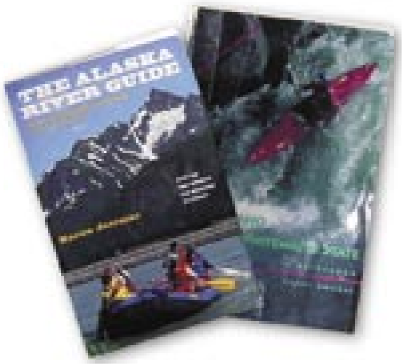
"Desktop analysis" options are useful for developing information about existing or potential recreation opportunities, facilities, physical characteristics of the river, and recreation-relevant hydrology. In some cases, desktop methods may help develop rough estimates of flow ranges for different opportunities. The three options are:

- *Literature reviews*
- *Hydrology summary*
- *Structured interviews*

While these could be done as Level 1 efforts that are part of a first-stage consultation package or pre-application document (PAD), they may also be employed more intensively as part of Level 2 efforts.

Under new ILP rules, resource agencies and FERC discourage significant analysis of existing information without a study plan (particularly if the PAD is being developed without extensive agency or stakeholder input), with the standard being "existing, relevant, and reasonably available information."

Literature Reviews

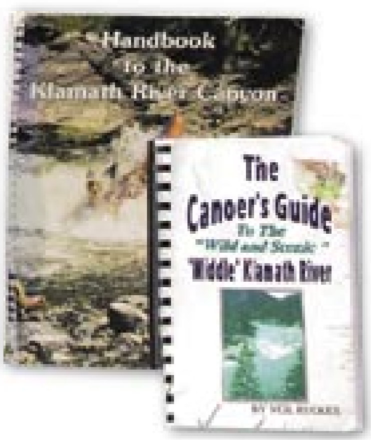


Objective
Review and summarize existing documents with information about recreation opportunities or the river's physical characteristics that make it attractive for recreation.

Typical approach
Literature searches via the web, libraries, or agency collections, with systematic documentation of sources and findings. The effort may include summaries or basic analysis of agency use information.

Product
Summary of recreation opportunities, facilities, use, and physical characteristics in a report.

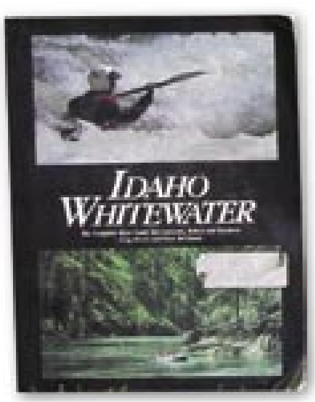
Responsibilities
Utilities (or their consultants) have primary responsibility, but agencies and stakeholders may provide documents or access to files.



Additional issues
A "brainstorming" session among agencies and stakeholders may help identify documents; physical searches of agency files sometimes produce useful "gray literature" or use statistics.

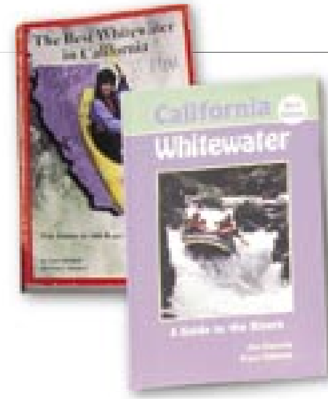
Physical characteristics that should be listed for any segment include: length, gradient, channel type, access locations, and facilities.

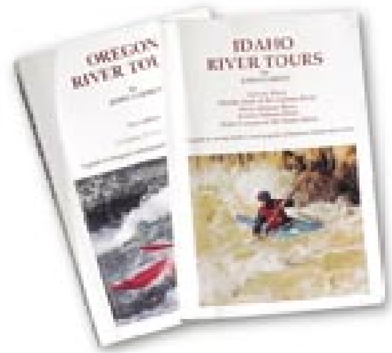
Extensive analysis of use data is usually unnecessary at this stage, but a summary of typical averages and peak levels can be helpful. Qualitative discussion of seasonal or weekly use patterns may also be important.

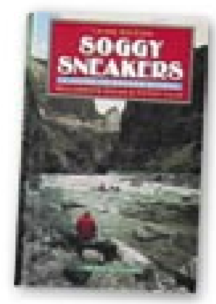


The summary should be systematic and comprehensive, organizing information by recreation opportunities and associating appropriate physical characteristics or use data with each.

Cautions & limitations:
Guidebooks are often a good "first source" for a river's physical characteristics and general description, but flow ranges or hydrology information from them should be used with caution. The level of accuracy and rigor varies considerably among guidebooks, and evaluations represent the opinion of the author(s) only.







Level 1 literature reviews include guidebooks, which provide general information about river characteristics and types of recreation opportunities. Boating guides often discuss flows and gages, and may recommend flows for different skill levels. However, guidebooks are essentially the opinion of a single author, and the "quality" of those opinions varies depending upon the author's skill, experience, and the level of detail they provide.

Objective
Summarize recreation-relevant hydrology, describe project "plumbing," and identify existing and potential operational constraints on existing or alternative flow regimes.

Typical approach
Search for relevant summary hydrology data, usually from the USGS, state water resource departments, land managing agencies, and utilities. Assemble and summarize recreation-relevant findings that may include graphs and tables for typical or example recreation seasons.

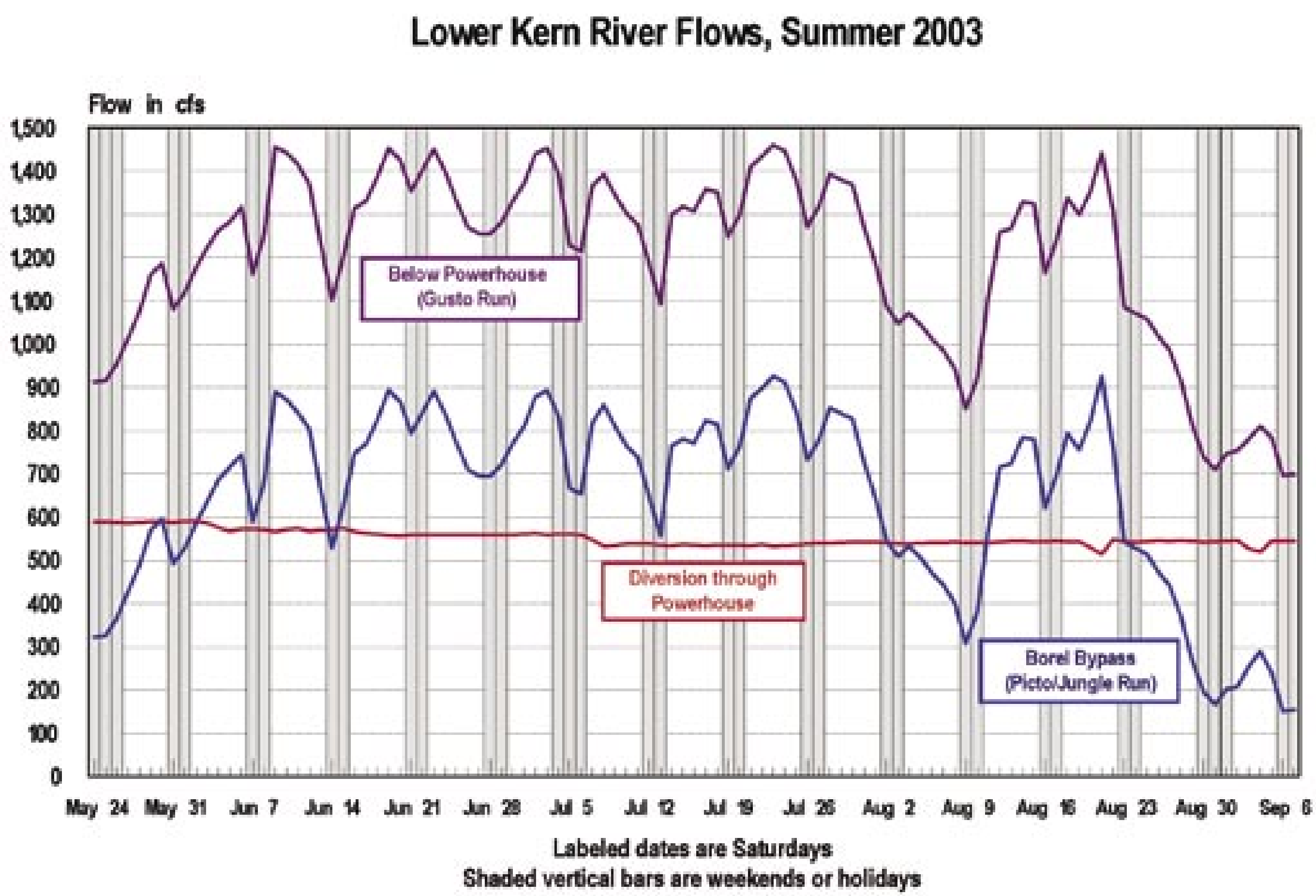
Product
Summary hydrology section in a report.

Responsibilities
Utilities (or their consultants) have primary responsibility, but agencies may be able to provide access to key hydrology data or summaries to make this effort efficient (and non-duplicative).

Additional issues
The amount of analysis and presentation involved in this task depends on the resolution needed. For a Level 1 report, summaries of existing information or example hydrographs from an average year may be adequate; more intensive analyses and presentations are usually necessary to reach a higher degree of precision common for a Level 2 or 3 effort.

Cautions & limitations
Daily, monthly, or annual averages are often used to summarize hydrology, but these statistics may be insufficient if they mask important variability. For example, averages at a daily peaking facility may not reflect a flow that occurs for any substantial length of time.

In nearly all cases, summary hydrology data for a key gage or hydrology reports for the larger relicensing effort will not be sufficient. Raw hydrology data, gage statistics, project operational constraints, and similar information commonly need to be "re-packaged" to focus on recreation-relevant flows or seasons. The goal is a clear and concise summary to illustrate how the system works or could be operated to provide flows for recreation.



Summarizing recreation-relevant hydrology usually involves re-organizing hydrology records. Above: Daily hydrographs for two segments on California's Lower Kern River illustate variable irrigation releases coupled with a steady hydropower diversion. Organizing information for an example recreation season shows how flows drop on weekends (adversely affecting boating).

Objective
Collect and organize information about "local knowledge" of the river, recreation opportunities, and potential flow effects. The source is experienced users or resource experts.

Typical approach
Identify a list of experienced recreation users or resource experts, usually through networking. Develop questions for identifying opportunities, potential flow effects, or other relevant issues. Conduct the interviews (with documentation), analyze responses, and summarize findings.

Product
Summary sections in a Level 1 report will identify existing and potential recreation opportunities, describe whether those are likely to be flow-dependent, and suggest potential flow-related issues or assessments (if possible). Lists of interviewees and systematic notes from interviews are commonly provided in appendices.

Responsibilities
Utilities (or their consultants) have primary responsibility, but agencies and stakeholders can help develop the networking sample, or review interview questions and findings. Recreation groups can be particularly helpful for finding individuals that use the river for recreation.

Additional issues
Collaborative development and review of interview lists by agencies and stakeholders is often helpful to ensure the interviewees represent a sufficient diversity of user types.

Systematic documentation of interview notes can make findings in a Level 1 report more transparent.

The number of interviews and level of coding and analysis involved in this task depends on the resolution needed. For a Level 1 report, even a few interviews, limited qualitative summaries of interview results, and occasional "personal communication" citations may be adequate. For a Level 2 or 3 report, more interviews, quantified analysis or responses, and summary statistics or graphs may be more appropriate.

Cautions & limitations
Interview panels may be small in a Level 1 effort, limiting the usefulness of statistics to represent group evaluations about flows or access. Interview information is best for learning about a river's characteristics, past use, and potential flow-related issues rather than definitive evaluations for specific groups.

"Representativeness" of panels is a major issue, especially when interviewees are developed through "self-selection" techniques (e.g., requests for interviewees made through a newsletter or on a list serve). Active networking designed to reach different parts of a recreation community is likely to be more successful.

Experienced users (right) or locals (above) may have considerable knowledge about recreation use and flow effects. Structured interviews help capture this information, but careful documentation and attention to "representativeness" are important.

Documentation Needs and Explicit Criteria for Progressing to Level 2 Studies

Some fishing opportunities are less flow-dependent than others. Shore-based fishing with spinning gear on Alaska's Kenai River (left) is excellent through a wide range, from mid-summer high flows to lower fall flows. In these situations, a well-documented Level 1 effort may be sufficient.

A Level 1 report should integrate findings from the study options above, clearly documenting information sources, summarizing findings, and linking those to raw data when appropriate. The report should identify recreation opportunities along the river, suggest whether there are flow-dependent attributes for each, and assess whether project operations are likely to have impacts on those opportunities. When there are multiple opportunities or reaches with potential project effects, these should be prioritized from those requiring more to less information.

Agency and stakeholder review is critical, but how that is accomplished depends on the licensing model in use (traditional, collaborative, or integrated; see sidebar). In general, the earlier this report can be completed and distributed, the better. This allows more time to develop intensive studies (if or when those are necessary), and can help direct resources to the opportunities and reaches that need them most. It also can serve as an "early warning" to work groups in other resource areas (e.g., fisheries, cultural) about which recreation opportunities are likely to have flow-related impacts, and it may lead to early articulation of likely flow regime requests. The exchange of information between resource work groups is among the most challenging aspects of relicensing efforts, and early Level 1 information allows that to begin sooner.

One output of the report should be explicit decisions about whether additional study is necessary for each opportunity and reach. While the utility and consultants typically make the case for these decisions in their report, review by agencies and stakeholders (via working groups) can make those decisions more collaborative, or allow early identification of disputes. This should limit additional information requests later in the process.

Ultimately, the decision is whether Level 1 information is sufficient, or if additional study is necessary. This decision rests on answers to several questions:

- Are there flow-dependent recreation opportunities on the river segments?
- Are flow-dependent opportunities affected by project operations?
- Are flow-dependent recreation opportunities "important" relative to other resources or foregone power generation? If certain recreation opportunities will not be considered when determining project operation decisions (e.g., if agencies and stakeholders agree that flow releases will be primarily driven by biological needs for an endangered species), more detailed information about flows may be unnecessary, and Level 1 information may be sufficient (assuming it documents stakeholder and agency agreement about this evaluation).
- Does Level 1 information precisely define flow ranges and potential project effects for each flow-dependent opportunity? For example, flow ranges for a commonly boated whitewater reach may be sufficiently well-known and agreed upon, and there may be no need for additional study.

If none of these questions are answered affirmatively, Level 1 information is probably not sufficient, and more intensive study (Level 2 or 3) may be necessary.

Limited Reconnaissance Options (Generally Level 2)

If recreation opportunities are flow-dependent but lack precise information about flow needs or project effects, some on-site (field) reconnaissance is typically needed. Several options are described below, offering distinct ways of enhancing information developed in Level 1. Study options for boating, fishability, and other types of recreation are discussed separately.

A limited reconnaissance of the Middle Klamath River at 650 cfs suppplemented interview information about flow ranges for different types of boating. This was a marginal flow for technical rafting through narrow rapids such as Dragon's Tooth.

On-Land Boating Feasibility Assessment

Objective
Assess the feasibility and potential quality of boating opportunities, and estimate rough flow ranges by scouting a reach (or reaches) from on-land (or by wading the channel if flows are low enough). These usually occur when the reach has no history of previous boating use.

Typical approach
Identify a short list of experienced boaters and agency staff familiar with the river to participate in the reconnaissance. Develop an evaluation form to address issues identified in Level 1. Conduct the reconnaissance by walking or driving along the reach, encouraging discussion among participants. Summarize opinions about the feasibility of boating, types of opportunities, possible flow ranges, and potential project effects.

Product
Summary of reconnaissance effort and findings. Lists of participants, evaluation results, and discussion notes may be provided in appendices.

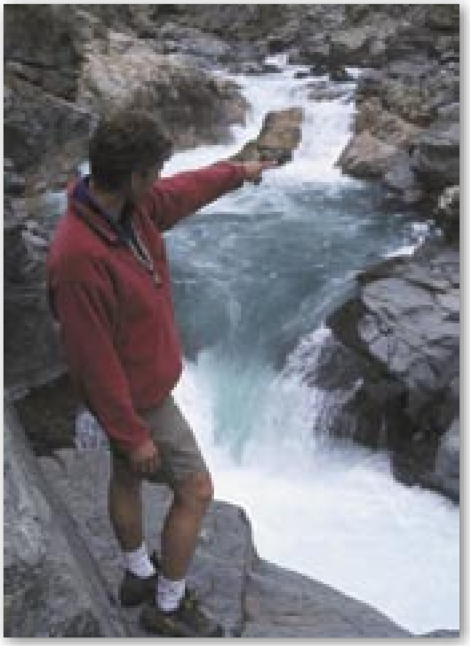
Responsibilities
Utilities (or their consultants) have primary responsibility, but agencies and stakeholders commonly participate in the reconnaissance and may be asked to formally evaluate reaches, opportunities, or flows. Recreation groups can provide valuable assistance rounding up participants. If an evaluation form is developed, working groups typically review the format and content. Logistics for the reconnaissance are usually worked out among participating utilities, agencies, and stakeholders (see sidebar on fieldwork roles and responsibilities).

Additional issues
Composition of the participants is critical. The number of participants may be small, but they should represent the diversity of recreation opportunities likely to be at issue on the reach. Stakeholder and agency agreement on composition may be useful.

Evaluating a dry or nearly dry bypass reach may be challenging, so there are advantages to scheduling reconnaissance during potentially boatable flows if possible. In some cases, flow releases for the reconnaissance may be arranged, and they can dramatically increase the power of these assessments.

The reconnaissance may lay the logistical groundwork for more detailed study at a later date. On-land boating assessments also may be a planned interim step when a controlled flow study is expected; in these cases, fewer participants and a professional judgment-level analysis rather than formalized evaluations may be sufficient and will minimize costs.

Cautions & limitations
On-land boating assessments may suggest whether a river is boatable, but they are unlikely to provide precise assessments of flow ranges. They are helpful for assessing safety issues for an on-water assessment and narrowing flow ranges for additional study, particularly on more challenging (higher gradient) rivers.



Left: An on-land study on Washington's Chelan River helped determine if whether boating was feasible in a gorge with limited access and a gradiant over 400 feet per mile. After observing three flows in a single day, participants recommended an on-water controlled flow study.

Below: During the subsequent boating study on the Chelan River, kayakers successfully ran the gorge at 275, 390 and 475 cfs. A settlement agreement between the utility and stakeholders provides for boating flows in the future.

Below: During an on-land boating feasibility study, participants hiked Alaska's Cooper Creek (below) at approximately 60 cfs. Four waterfalls (inset) were not boatable, but some sections would provide Class III-IV opportunities at flows over 100 cfs. Challenging access, the short length, and several better alternatives in the region would limit demand, so an on-water boating study was unnecessary.

On-Water Boating Feasibility Assessment

Objective
Assess the feasibility and potential quality of boating opportunities and estimate flow ranges by boating the river at a single flow.

Typical approach
Similar to an on-land boating assessment, experienced boaters usually participate in the reconnaissance, and an evaluation form may be developed to quantify findings. The difference is that the reconnaissance includes boating on the reach. Focus group discussion after the run is used to summarize opinions about the feasibility of boating, types of opportunities, possible flow ranges, and potential project effects.

Product
Summary of reconnaissance effort and findings. List of participants, evaluation results, and discussion notes may be provided in appendices.

Responsibilities
As with on-land boating assessments, utilities (or their consultants) have primary responsibility, but agencies and stakeholders commonly participate in fieldwork and review the evaluation form. Recreation groups can provide valuable assistance rounding up participants.

Additional issues
As with on-land boating assessments, composition of the participants is critical and may be improved with stakeholder and agency review.

Safety and liability issues may be important, particularly on reaches that have had little or no previous boating use, or have more challenging whitewater (see sidebar on safety and liability).

On-water boating assessments may be a planned interim step when a controlled flow study is planned; when this occurs, fewer participants and a professional judgment-level analysis rather than formalized evaluations may be sufficient and minimize costs. The feasibility assessment may lay groundwork or provide valuable logistical information for later in-depth studies.

Cautions & limitations
On-water boating feasibility assessments at a single flow may demonstrate whether boating is possible, but they are unlikely to provide precise estimates of flow ranges for boating (unless the range is narrow and reconnaissance fortuitously occurred within that range).

An on-water boating study on the Lower Carmen Bypass Reach on Oregon's McKenzie River was conducted at 330 cfs. Kayakers successfully boated the reach, but the short run had difficult access, many log portages, and less-interesting-than-expected whitewater. Additional boating studies were not recommended.

Single Flow Fishability Assessment

Objective
Assess the potential quality of fishing opportunities, and estimate flow ranges, through reconnaissance of the river at a single flow.

Typical approach
Parallel to boating feasibility assessments, experienced anglers usually participate in the reconnaissance, and an evaluation form may be used. Focus group discussion after reconnaissance helps summarize opinions about the likely availability of different fishing opportunities (defined by species, tackle, and technique), possible flow ranges, and potential project effects.

Product
Summary of reconnaissance effort and consensus findings. Lists of participants, evaluation results, and discussion notes may be provided in appendices.

Responsibilities
Utilities (or their consultants) have primary responsibility, but agencies and stakeholders commonly participate in fieldwork and review the evaluation form or list of participants.

Additional issues
Fishability assessments typically occur from land, but it may be useful to have anglers wade or boat the river if those are a common component of target opportunities.

It is challenging to assess a diversity of potential fishing locations during a short assessment period (a few hours or a day). Similarly, there are trade-offs between the number of sites and the quality of assessments, or between organized visits to specific locations and more "freelance" evaluations by individual anglers. These decisions are typically made on a case-by-case basis after considering segment characteristics, likely fishing opportunities, existing use, or other factors.

Fishability assessments may be unnecessary or less formal if a controlled flow study is expected, or anglers currently use a reach (and work can document their use patterns and flow ranges of interest). Unlike boating, the "feasibility" of fishing is usually not in question; the focus is on the quality of access to fishable water at different flows.

As with boating feasibility assessments, composition of the participants is important and may be improved by including local area guides or review by stakeholders and agencies.

Fishing assessments need to address potentially confounding evaluation issues related to longer-term fishing success or the condition of the fishery. For more information, see sidebar on "fishability, fishing, and the fishery."

Cautions & limitations
Fishability assessments at a single flow may be able to demonstrate whether a flow provides fishable water, but they are unlikely to provide precise flow ranges for different opportunities (unless the range is narrow and a flow in that range was assessed).

Fishability studies are only one component of assessing flow needs for fishing opportunities. Fishability studies generally focus on access to fishable water, offering less information about long term fishing success or effects on the fishery (see sidebar on these distinctions).

Flows for boat-based fishing may be different from flows for wading or shore-based fishing.

Right: Situk River, Alaska, where most anglers wade, but some use boats to access fishing areas.

Single Flow "Expert Judgment" Assessments for Other Recreation Opportunities

Objective
Assess the potential quality of other recreation opportunities such as swimming, tubing, or general riverside recreation, and estimate flow ranges from reconnaissance at a single flow. The types of recreation considered in these studies are rarely associated with organized advocacy groups, but they are represented by NPS in relicensing proceedings.

Typical approach
Similar to single flow boating and fishability assessments, these reconnaissance-based efforts usually involve on-site evaluations by recreation consultants familiar with the target opportunities. Participation by swimmers, tubers, or others is not common, but could be incorporated. Photos of key sites and conditions, along with rough measurements of key features (e.g., pools, current speed) are useful. If participants are involved, focus groups would also occur.

Product
Summary of reconnaissance effort and findings. A list of participants, evaluation results, photos, measurements, and discussion notes may be provided in appendices.

Responsibilities
As with other feasibility assessments, utilities (or their consultants) have primary responsibility, but agencies and stakeholders commonly participate in fieldwork and review the evaluation form.

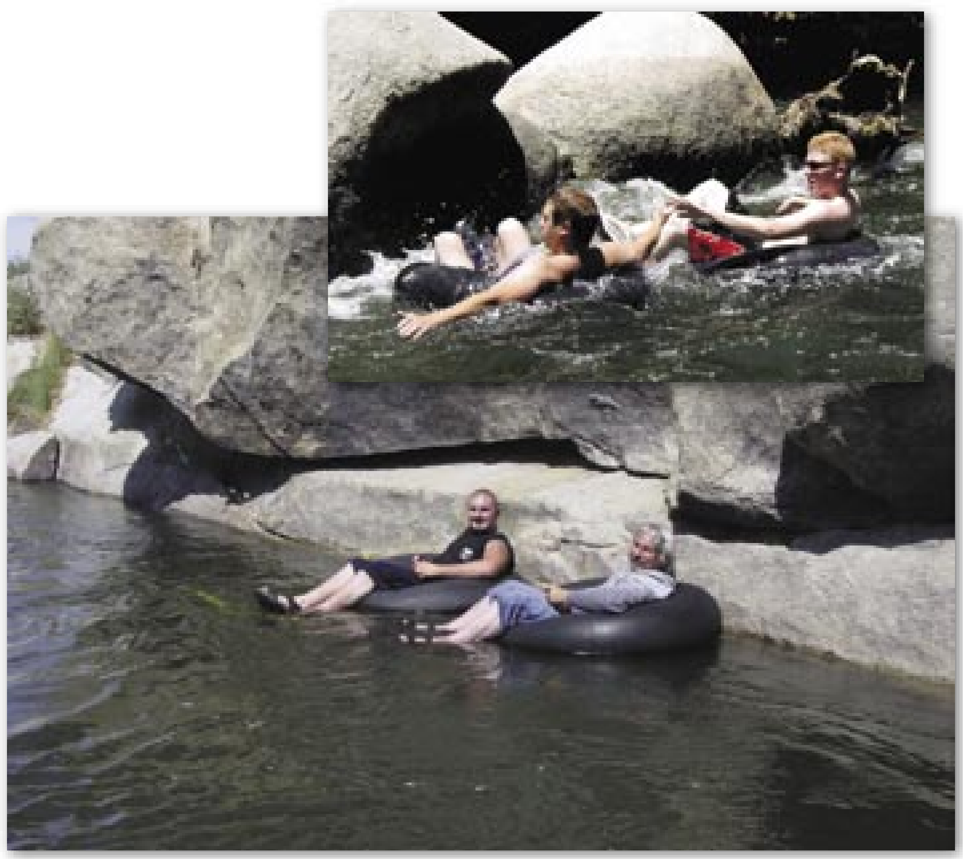
Additional issues
Participants in these activities may not be particularly flow-sensitive, so their participation is optional. However, interviews with local swimmers or tubers about their activities can be important. Defining target opportunities with sufficient specificity is probably the critical step, and can be enhanced with interview information from agencies or local users. These assessments typically occur from the shore in tandem with assessment efforts for boating and fishing. There are logistical challenges to conducting comprehensive assessments for multiple activities in a single reconnaissance.

Simple measurements of pool areas, depths, or current velocities may enhance descriptions of recreation opportunities or conditions created by flows.

There are challenges assessing a diversity of potential recreation locations during a short assessment period, with trade-offs between quantity and quality. Identifying representative locations or reaches for swimming or tubing evaluations may increase efficiency, but assumes homogeneity among locations.

Feasibility assessments for other recreation opportunities may be unnecessary if a controlled flow study is planned, or people currently use a reach for swimming, tubing, or other recreation (and can describe their use patterns and flow ranges of interest). For some opportunities, having evaluators swim or tube a reach may be useful.

Cautions & limitations
Expert judgment assessments at a single flow may ascertain whether particular activities are possible, but they are unlikely to provide precise flow ranges for opportunities (unless the range is narrow and a flow in that range was assessed).



Tubers on California's Lower Kern River illustrate differences betwen relaxed floating (bottom photo) and more challenging tubing (top photo) that have different flow needs.

Swimming areas on many rivers include "jumping rocks" that require adequate pool depths for safety. Measuring pool depths at different flows can help researchers determine how flows affect these kinds of opportunities. Above: Oregon's Rogue River

General riverside recreation is usually "enhanced" by flows rather than "dependent" on them. Left: Waders and swimmers at an undeveloped recreation area on California's Lower Kern River at 400 cfs. These activities were observed at study flows ranging from 400 to 1,200 cfs.

SIDEBAR

Flow Regimes, Long-Term Effects, and Recreation

Most of the studies in this document focus on short-term or direct effects of flows on recreation, but long-term or indirect effects of flow regimes can also be substantial (Shelby et al., 1992; Whittaker et al., 1993). For example, flow regimes may affect riparian vegetation and the extent to which it encroaches on the river channel; the size, frequency, and distribution of beaches or other channel features; water quality; and aquatic and terrestrial species that use these ecosystems. These in turn affect "habitats" for boating, angling, camping, bird watching or other recreation activities.

It is beyond the scope of this document to review research on this wide range of long-term effects; each area has a well-developed literature and research protocols. In addition, many of these biological and physical resources receive considerable attention in relicensing or other regulated river decision-making. But connections between their work and recreation impacts are seldom carefully developed or made explicit, even though effects can be profound.

A few issues deserve consideration as river professionals look for ways to integrate findings from long-term biophysical studies with recreation information.

First, most long-term effects are not observable through reconnaissance-based or controlled flow studies, so assessing these effects may default to a comparison of current and pre-project conditions (to the extent these are even known). This may be helpful for describing how the current regime has altered the biophysical environment, but it is less useful for describing the effects of alternative future operation regimes and the "habitats" they may create.

Second, recreation controlled flow studies focused largely on short term effects typically release flows well below bankfull levels, so they are probably not capable of triggering substantial geomorphic or riparian vegetation changes that researchers can study. Controlled flow studies can help model biological or physical responses to new flow regimes, but their findings depend upon the accuracy of model "assumptions." For example, fish habitat modeling has become more sophisticated during the past twenty years, but it may take multiple years before some population-level effects can even be detected, and research that verifies model precision has been sparse. Similarly, while sediment transfer and beach-building studies in Grand Canyon have been intensive and illuminating, experimental "floods" or revised operating regimes have yet to dramatically restore

Beaches provide "recreation habitat' for camping and swimming. High flows and sediment sources are needed to clean and replenish beaches, a biophysical process often affected by water development.

Above: The number and size of beaches in Grand Canyon have decreased since Glen Canyon Dam was built.

Low flow regimes can produce warm temperatures with impacts such as stagnant pools and algae blooms.

Left: California's Klamath River.

Years of low flows allow vegetation to encroach on river channels, which may affect boating safety or casting space for anglers.

Right: Vegetation obstructed visibility and blocked boating routes in California's Pit 5 Bypass Reach at 250 cfs.

beaches and other geomorphic features, and no work has addressed direct connections between these features and the quality of recreation experiences in the canyon (GCMRC, 2005).

There is a need for more research into how recreation users evaluate biological and physical conditions affected by flow regimes. For example, social science studies can identify important biophysical attributes for certain activities, compare different beach sizes or camp environments, or assess trade-offs between different types of fisheries. However, to do so they need biological and physical scientists to specify alternative futures under different flow regimes. Our experience with interdisciplinary studies suggests it will be challenging to get agreement about those potential futures, even for the purposes of studying recreation users' evaluations.

There may be reasons for restoring certain riparian vegetation types, geomorphic features, or associated biological communities to a "natural" condition, but it should not be assumed that this is possible or even desirable in all cases. On regulated rivers, all alternative flow regimes are essentially "designed" or "artificial," and it may not make sense to consider the pre-project regime as the "standard." In most cases, the trade-offs are between alternative futures with different resource conditions and ecologies, or between different combinations of recreation opportunities (Schmidt et al., 1998); a priori value judgments that label certain combinations as being more "natural" is not a scientific position. There may be good reasons to recover specific ecological attributes that were present pre-project, but these goals need to be specified explicitly rather than assumed as "inherently better."

Flow regimes have long term effects on biophysical resources such as fisheries. Modeling helps identify flow regimes to improve habitat, but doesn't predict specific changes in fish populations or anglers' fishing success.

Above: Bull trout are threatened on some western rivers, where relicensing efforts may suggest habitat improvements.

Documentation Needs and Explicit Criteria for Progressing to Level 3 Studies

A Level 2 report should document reconnaissance efforts and findings, possibly integrating them with Level 1 information in a single revised report. Major sections need to identify specific recreation opportunities, identify flow-dependent attributes, identify rough flow ranges (if possible), and assess whether project operations are likely to have impacts on those opportunities.

Agency and stakeholder review is important, and may be implemented differently in traditional, alternative, or integrated planning processes. Earlier reporting allows more time to plan additional work (if needed) or integrate findings with work from other resource areas.

The report should include explicit decisions about whether additional study is necessary for each opportunity and reach. The utility and consultants typically outline the issues in the report, but review by agencies and stakeholders (via working groups) can make those decisions more collaborative, or identify disputes.

Deciding whether to launch more intensive Level 3 studies is the critical study output; this depends on answers to the same questions discussed for the adequacy of Level 1 efforts. For opportunities where users are relatively insensitive to flows, or where project effects do not appear substantial, Level 2 information is likely to be sufficient. However, if project operations are likely to have direct and noticeable effects and flow regime changes are possible, greater precision may be necessary.

Intensive Study Options (Level 3)

For opportunities that are obviously flow-dependent and where precise information about flow needs or project effects is needed, more intensive effort is recommended. Several options for different types of recreation studies are described below.

Multiple Flow Reconnaissance Assessments

Objective
Improve precision of estimated flow ranges for recreation opportunities by assessing multiple flows. Generally applicable to boating, fishing, tubing, or swimming on reaches with logistical complications that prevent evaluations associated with controlled flow studies (see additional issues below).

Typical approach
Similar to single flow assessments, these differ by assessing multiple flows. Participation by recreation users is typically limited (see controlled flow studies below), but may be important. Quantitative ratings (by panels or experts) are commonly made for all relevant opportunities and conditions. Photos of key sites and conditions, along with rough measurements of key features (e.g., pools, current speed) may be useful, particularly for non-boating and fishing conditions. Qualitative notes or focus group discussions after are used to summarize opinions about the feasibility or quality of different types of opportunities at different flows.

Product
Summary of reconnaissance efforts and findings. A list of participants, evaluation results, photos, measurements, and discussion notes may be provided in appendices. Usually presented in a report that is supplemental to Phase 1 and 2 reports.

Responsibilities
As with other assessments, utilities (or their consultants) have primary responsibility, but agencies and stakeholders commonly participate in fieldwork and review evaluation forms.

Additional issues
Multiple-flow assessments that rely on expert judgments usually occur when logistical constraints make it difficult to assemble or maintain an evaluation panel. Example problems might include the inability to control flows (necessitating opportunistic fieldwork when natural flows are close to target levels) or difficult access to the river reaches. For some opportunities, potential participants (e.g., tubers or swimmers) may not be particularly sensitive to flow changes (or able to express preferences for specific flows), so it may be efficient and effective to have experts evaluate key conditions (which assumes the need to carefully document conditions and assumptions).

Multiple-flow assessments often focus on more than one recreation activity, which may present logistical challenges. Given trade-offs between the number of sites that can be assessed and the quality of assessments, identifying representative locations or reaches for more intensive work is critical.

Choosing the number and increments of flows is a case-by-case decision that generally depends on Phase 1 and 2 findings and requests from other resource areas (fisheries, etc.). Assessments of two to four flows are common.

Cautions & limitations
Expert judgments are often sufficient when supported with clear documentation of conditions at different flows, but user, agency, or stakeholder participation is important and powerful.

SIDEBAR
Flows and Aesthetics

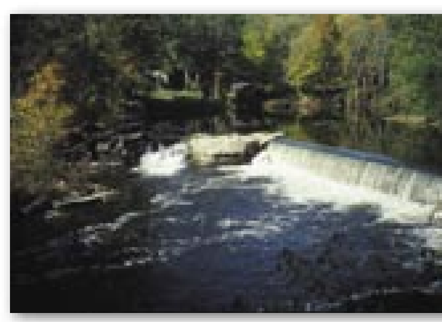
Aesthetics of river environments are important in dam relicensing, particularly when reaches have waterfalls and cascades. When aesthetics are a critical attribute, studies may need to address how flows affect them.

Flows may have a major impact on river aesthetics, but fewer studies have addressed this issue. Above: California's Kern River.

A complete review of aesthetics literature related to flows is beyond the scope of this document. However, findings from a few studies suggest interesting generalizations. In a study from the Virgin River downstream of Zion National Park, for example, respondents were shown video footage of flows ranging from 0 to several thousand cfs (Shelby, Whittaker, & Ellingham, 1994). At low flows, small increments offered dramatic improvements in aesthetic quality; once the bottom of the channel was filled, however, there was little improvement from medium to high flows. Professional judgment curves (based on onsite reconnaissance and user interviews) for Connecticut's Shepaug River suggested similar findings (Shelby & Whittaker, 1999). In this small stream, even a 5 cfs dam release improved aesthetics, and above 50 cfs, additional water provided little aesthetic improvement.

Other studies have evaluated paired photographs (Land & Water Associates, 1992), or compared evaluations among several photographs after controlling for other scenic features such as vegetation, sky, and canyon walls (Brown and Daniel, 1991). In general, very low and very high flows were rated lower, although differences were small. Computer-manipulated images now offer opportunities to control other scenic features in photographs, so evaluations focus solely on flow elements.

Methods and analysis strategies have not been standardized in this field, but advances appear likely and should improve the ability to assess how alternative flow regimes affect aesthetics. Several study options presented in this document are applicable to aesthetics, particularly multiple flow and controlled flow assessments. Many FERC relicensing efforts have included descriptive studies of aesthetics (i.e., photo or video documentation of key reaches, rapids, or falls at different flows). But fewer studies have included an evaluative component where aesthetic qualities of different flows are compared, and these have often based evaluations on professional judgments. The literature suggests that aesthetic evaluations by trained professionals may not match those of the general public, so studies that include recreation user evaluations may be important in some situations. Comparative flow surveys are probably most relevant study choice here, and representing different flows through photographic media provides an efficient way to avoid having users observe flows on-site.



Small increases in flow dramatically improve aesthetics on Connecticut's Shepaug River (Left to right : 10, 60, and 200 cfs).

Flow Comparison Surveys of Experienced Users

Objective
Improve precision of estimated flow ranges for recreation opportunities by surveying experienced users. Generally applicable to boating or fishing when users have a history of use and they are "calibrated" to an existing gage.

Typical approach
Identify panel of knowledgeable users (usually boaters or anglers) and develop contact information. Develop survey instrument with sections documenting user experience and knowledge, use patterns, and evaluations of conditions and flows. Administer survey, either by mail or telephone, and code responses. Analyze data to summarize responses, with attention to disaggregating dissimilar types of users. Summarize findings in a report.

Product
Summary of methods and findings. Methods should include descriptions of panel and instrument development, as well as potential sources of error. Findings are typically presented in both tabular and graphic forms appropriate to the analysis. The findings may be presented as a report supplemental to Level 1 and 2 reports.

Responsibilities
As with other assessments, utilities (or their consultants) have primary responsibility, but agencies and stakeholders commonly review the sampling frame, survey instrument, and analysis plans. Agencies often possess lists of guides or other knowledgeable users (if there is a permit system) to help with panel development.

Additional issues
Panel development is critical for this option and depends on the availability of knowledgeable users and an existing gage to which they are calibrated.
Networking may under-sample "lower profile" but knowledgeable users; networking that attempts to develop samples through multiple channels (e.g., guide lists, boating or angling stores, and launch registers) is one approach to minimizing these problems.
Sufficient panel sizes are important for statistical purposes, but the "minimum" number depends on the homogeneity of users and their evaluations. Sub-group panel sizes may be important if comparisons between groups are needed.

Cautions & limitations
Assessing how well users are calibrated to a gage is important with this method. Pre-testing or pre-study interviews/focus groups should be considered to probe whether users really pay attention to a gage through the range of interest. If there is confusion in how gages are used, controlled flow studies or other options may be necessary.

Some users may not independently evaluate flows, and simply repeat "conventional wisdom" about acceptable or optimal flows for a recreation opportunity. Unfortunately, this method is limited in its ability to distinguish independent evaluations from those that are "passed down" over the years. In cases where skill and equipment advances have occurred (e.g., new types of boats or fishing techniques), this method may not be appropriate.

For angling, it may be challenging to keep evaluations of fishability (e.g., wadeability, access to fishing water) separate from evaluations of flows for the fishery (i.e., their impressions of biological needs). In these cases, controlled flow studies may be more useful. For more information on this potential confound in any fishability study, see the associated sidebar.

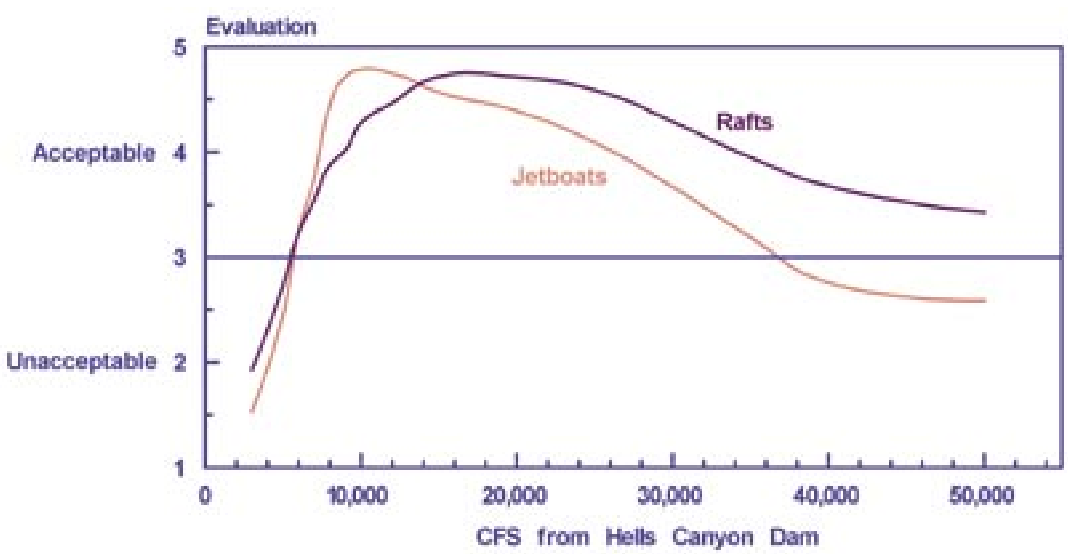
"Boat dragging" on Alaska's Gulkana River at low flows. Data from research trips at different flows supplemented boater survey information in this study for a water rights adjudication.

Far Left: Rafters pushing a boat into the Colorado River in Grand Canyon after overnight flow fluctuations left it "high and dry." Flow comparison surveys of experienced boaters helped define fluctuation tolerances.

Inset: The Snake River through Hells Canyon has similar daily flow fluctuations based on power demand. Surveys showed that rafters and jetboaters preferred fluctuations of less than 3,000 cfs per day, but could tolerate 6,000 to 9,000 cfs. Current operations fluctuate 12,000 cfs in some seasons. Inset: Consequences are greater for larger boats.

Far Right: Lava Falls in Grand Canyon at about 35,000 cfs. Experienced boaters are often knowledgeable about the flows that produce different types of recreation opportunities. Flow comparison studies draw on this accumulated knowledge.

Right: A commercial jetboat runs Wild Sheep Rapid in Hells Canyon at 9,000 cfs. Flow comparison surveys were used to develop overall flow evaluation curves for rafts and jetboats (below). Minimum flow needs were similar, but higher flows are better for rafts than jetboats.



Objective

Improve precision of estimated flow ranges for boating opportunities by having a panel of boaters evaluate several known (usually controlled) flows. Generally applicable to rivers without a gage or little history of previous use, the idea is to manipulate the independent variable – flow – which introduces a quasi-experimental format to evaluations. Assembled panels may also offer opportunities to roughly explore regional "supply" of similar rivers or "demand" for similar opportunities.

Typical approach

Level 1 and 2 information is used to determine flow range and opportunities of interest. Target flow increments are chosen and arranged for a short period of time (if possible). In some cases, the study may capitalize on natural flows instead of controlled flows. Boaters complete a pre-fieldwork survey on their experience and boating preferences, run the river at each flow, and evaluate flows and participate in a focus group after each run. After all flows have been observed, participants make overall evaluations using a "flow comparison" format. Photos and video footage of key rapids and conditions can provide useful documentation, particularly in combination with qualitative focus group notes and quantitative data from surveys. Quantitative ratings (by panels or experts) are commonly made for all relevant opportunities and conditions (see Whittaker et al. (1993) and Whittaker and Shelby (2002) for more detailed information about survey instruments and analysis options).

Products

Summary of methods and findings in a report. Methods should include descriptions of panel and instrument development. Findings typically include tables and graphs appropriate to the analysis. Appendices typically include a list of participants, focus group notes, photo gallery, and survey instruments. The methods and findings may be presented as a report supplemental to Phase 1 and 2 reports. Some utilities produce an edited video that highlights study findings with footage of key flow effects and interviews/focus group comments; these need to be coordinated and consistent with report findings.

Responsibilities

These studies are more complicated and typically require substantial participation by utilities, their consultants, agencies, and stakeholders. Utilities (or their consultants) have primary responsibility, but agencies and stakeholders also play key roles (see sidebar with more detail on these potential roles).

Additional issues

There are several important issues in conducting controlled flow studies efficiently and effectively (Shelby et al, 1998). Some of these issues become even more challenging on higher gradient rivers with little previous use (Shelby et al. 2004). It is beyond the scope of this document to provide details on these issues, but key considerations are listed below:

Study output. The relative precision of qualitative and quantitative data may vary depending upon the size of the panel and how data is analyzed. More precise "flow evaluation curves" or "optimal ranges" come from quantitative surveys of participants, but professional judgments by researchers may be sufficient if maintenance of a panel is difficult. More precise quantitative output becomes important when potential for controversy is high. Other resource studies typically generate specific incremental relationships between flows and resource values (e.g., IFIM studies), so parallel information for recreation is needed if careful assessments of trade-offs between resources are anticipate d.

Sample. Sample issues trade-off "representativeness" against potential cost or logistical complexity. More participants improve precision, but they also increase complexity and make it difficult to maintain participation through a multi-day study. Most studies use "purposive sampling," inviting participants based on their 1) skill and safety record, 2) proximity to the river, and 3) ability to evaluate a diversity of whitewater opportunities. This requires close coordination with stakeholder groups.

Flow control. This includes technical limitations of dams as well as administrative, political, and legal constraints, which should not be underestimated (Shelby et al., 2004). Technical limitations on releasing precise flows or narrow increments can be more problematic on higher gradient rivers, because small changes in flow may create substantial changes in difficulty. Lack of upstream storage may also constrain flow control (insufficient water in dry years; too much in wet years). Many studies require careful timing and contingency plans, which also may have administrative, political, or legal constraints.

Flow choice. Choosing the number and increments of flows is a case-by-case decision that generally depends on Level 1 and 2 findings and requests from other resource specialists (e.g., fisheries researchers, etc.). Three to four flows are commonly assessed in these studies.

Impacts on other resources. Timing of boating flows may be a major concern for other resources. If possible, releases should be timed to minimize adverse impacts to aquatic biota and power generation schedules, or at least to assess potential impacts (which may include biophysical benefits such as building beaches, cleaning spawning beds, introducing woody material, or removing encroaching vegetation).

Study complexity. This increases with the number of flows, length of the reach, number of participants, and types of craft or opportunities under consideration. Controlled flow studies work best when they are focused on discrete flow ranges where more precision is needed, and where boating is expected to be possible and safe. Rugged terrain associated with challenging rivers may increase the logistical challenges and safety/liability risks, which may affect panel and analysis considerations. Safety priorities may also preclude examination of flows near the high or low ends of acceptable ranges, or increase costs if additional emergency equipment or expertise is needed.

Cautions & limitations

Controlled flow studies are most useful where river segments are short, flows can be definitively controlled, river access is easy, and users are readily available (Shelby et al. 1998). These characteristics are commonly found on bypass reaches at hydropower projects. Applying this method to longer reaches without flow control is more problematic.

Controlled flow studies for boating focus on immediate effects on hydraulics, but they may not document longer-term indirect effects that may be important for boating or other recreation. These studies also may not address a diversity of flows through a season unless there are resources to examine many flows. They are better suited as a tool to identify specific flows that may be released as an augmentation for one or two opportunities.

California's Pit 5 Bypass Reach during a controlled study (1,260 cfs shown here).
The study examined six flows from 250 to 1,840 cfs. Optimal ranges started about 1,200 cfs for kayaks and 1,500 cfs for rafts.

Hells Corner rapid on the Upper Klamath River at 730 cfs (top) and 1,750 cfs (bottom) show differences between "technical" rock-dodging trips and "standard" trips with better whitewater and more route options. A commercial rafting industry has developed here because daily peaking regimes produce at least 1,500 cfs on most summer days, providing superb whitewater "action." Lower flows are under consideration in relicensing, but the boating study showed that flows less than 1,300 cfs require smaller boats with fewer passengers, which are less commercially viable.

During controlled flow boating studies, participants report boatability problems such as "stops" and "boat drags." Above: At 400 cfs on California's Kern River, "stuck" boats created "raft jams" as upstream boaters waited for rapids clear. At 800 cfs, boatability problems were rare.

SIDEBAR

Problems with “Blind” Controlled Flow Studies for Boating

When controlled flow studies for boating are proposed, the quasi-experimental nature of the effort sometimes leads agency staff or stakeholders to suggest that evaluations should be conducted “blind” (without boaters knowing which flow they are assessing). Although blind studies may increase “confidence” that evaluations are only based on the observed flow, there are several disadvantages (discussed below) that out weigh that advantage.

There may be safety concerns in not knowing flows, or the amount of change from one study flow to another, particularly on challenging rivers. Although boaters in a blind study would probably know immediately whether a subsequent flow was higher or lower, information about the magnitude of change could be crucial for deciding whether they have the skill to handle it. Boaters are accustomed to estimating how specific flow changes affect the level of challenge on other rivers; they need similar information on a study river.

Knowledge of study flows allows boaters to interpolate between flows or extrapolate beyond them for the flow comparison survey at the end of a study. If they don’t know the flows they evaluated, flows between or outside the study flows cannot be evaluated.

Boaters often think in terms of cfs, and it is one of the basic metrics they use in describing a boating run (along with gradient, and the height or width of specific drops). Asking them to evaluate a reach and flow without this metric reduces their ability to do so. Just as surfers pay attention to the height of waves or skiers to the depth of snow, quantitative information is something river runners integrate into their description of what they observed. Eliminating this variable is likely to make them less systematic in their evaluations.

Boaters often have a working knowledge of flows on many rivers that may be similar to the study reach; blind studies don’t allow participants to capitalize on that knowledge. For example, it may be valuable to have boaters discuss how 500 cfs on the study reach is similar to or different from 500 cfs on another reach (something they can’t do if they don’t know the flow).

Withholding flow information during a study may encourage participants to think the utility or researchers don’t “trust” boaters. Accurate data provided to boaters as soon as it is available generally creates a greater sense of cooperation.

Blind studies are probably not necessary to alleviate concerns about “strategic bias” (respondents answer questions in line with how they think data will be used). There has been little evidence to suggest strategic biases occur in recreation studies in general, or flow studies in particular. Based on focus group discussions and analyses of study results, differences in evaluations appear to reflect skill, equipment, or type of boating preferences rather than strategic biases. In addition, participants appear to understand that results could be used to develop flow releases, but they also know that requests for higher flows generally work against the likelihood of frequent releases. It is generally in their best interest to evaluate flows accurately so they can determine the lowest flow that provides a particular recreation opportunity.

Boaters can make more informed comparisons when they know the flows during studies.

Right: California’s Pit 5 bypass reach at 1,840 cfs (boaters rated six flows from 250 to 1,840 cfs).

Controlled Flow Studies for Fishability

Objective
Improve precision of estimated flow ranges for fishing by having a panel of users evaluate several known (usually controlled) flows. Generally applicable to rivers where historical fishing has adapted to an existing controlled flow regime and modifications of that regime are considered. Assembled panels may also provide opportunities to help roughly explore regional "supply" of similar rivers or "demand" for similar opportunities.

Typical approach
Similar to boating controlled flow assessments, Level 1 and 2 reports are used to determine flow range and opportunities of interest. Target flow increments are chosen and arranged for a short period of time (if possible). Anglers complete a pre-fieldwork survey on their experience and angling preferences, observe or fish the river at each flow (usually at a sample of locations), and evaluate flows and participate in a focus group after each flow. After all flows have been observed, participants make overall evaluations using a "flow comparison" format. Photos and video footage of key fishing areas and conditions can provide useful documentation.

Product
Summary of methods and findings in a report. Methods should include descriptions of panel and instrument development. Findings will typically include tables and graphs appropriate to the analysis. Appendices typically include a participant list, focus group notes, photo gallery, and survey instruments. Video or photographic documentation may supplement report information.

Responsibilities
These studies are more complicated and typically require substantial participation by utilities, their consultants, agencies, and stakeholders. Utilities (or their consultants) have primary responsibility, but agencies and stakeholders also play important roles (see sidebar with more detail on these roles).

Additional issues
In addition to issues for boating controlled flow studies, fishability studies have other complexities.

Representativeness of the panel may be particularly important because anglers who fish for certain species or use certain techniques may be poor evaluators of flows for other species or types of fishing (e.g., wading-based trout angling with flies vs. boat-based salmon fishing with bait). This requires close coordination with stakeholder groups to represent target opportunities.

Anglers can evaluate specific locations as a group at each flow, or independently decide which locations to assess (which might change at different flows). There are advantages and disadvantages of each strategy, depending on the length of the reach, homogeneity of its physical characteristics, and the time anglers will have to assess flows.

Cautions & limitations
As with boating controlled flow studies, fishability studies are most useful where river segments are short, flows can be definitively controlled, river access is easy, and anglers will participate.

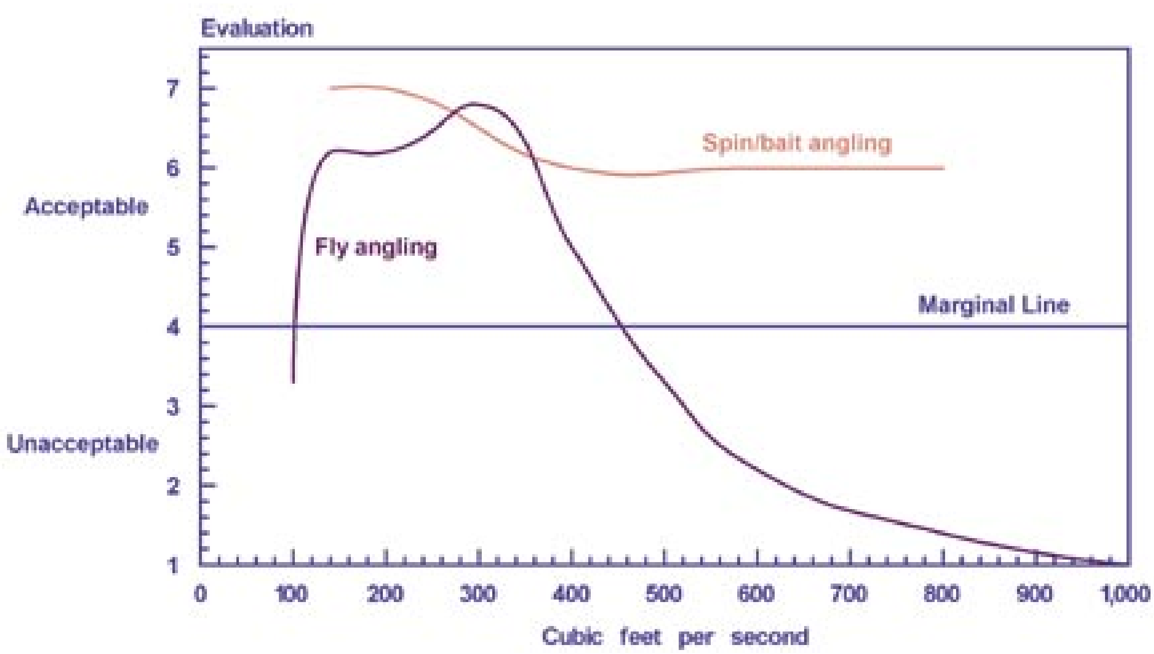
Fishability studies are only one component of assessing flow needs for fishing opportunities. Fishability studies focus on access to fishable water, offering less information about long term effects on fishing success, the fishery, or biophysical conditions (see separate sidebar on these distinctions).

Left: Anglers evaluated a different flow each day during a fishability study on California's Pit River. At the end of the multi-day study, a "close-out" survey compared all the flows.

Wadeability is critical for some types of angling, but depths and velocities also affect tackle and technique choices. Higher flows require heavier tackle to reach fish that are "holding" lower in the river, but this increases the risk of snagging. Right: Idaho's Salmon River.

California's Pit 4 bypass reach has Project-induced base flows of 150 cfs, allowing anglers to cross the river and fish away from encroaching vegetation. The 420 cfs study flow (left) made wading and crossing difficult, dramatically reducing "fishable water."

Angling flow evalution curves for California's Pit 4 reach. Optimal flows for wading-based fly fishing are between 150 and 350 cfs. with a sharp decline at higher flows. In contrast, spin/bait angling was good at all study flows because it doesn't require wading.



SIDEBAR

Flows, Fish Habitat, and Fishability

High quality fishing obviously starts with good habitat and a healthy fishery, but these may not be sufficient. For some anglers, catching fish may be less important than broader experiential benefits such as "exploration," "experiencing natural environments" or the "challenge of fishing" (Knopf et al. 1973; Fedler and Ditton 1994). A "blue ribbon" fly-fishing stream, for example, has a good fishery and good water to fish (e.g. wadeable access to riffles and pocket water, sufficient casting space away from riparian vegetation, and non-turbid water). While anglers appear able to adapt to different flow conditions, they often have preferences for specific conditions and fishing techniques (Whittaker et al. 1993); these can be affected by changes in flow that anglers can help evaluate.

"Fishability" studies have been developed to address this issue, and they have become important in some relicensing efforts where licensees and stakeholders consider changes in flow regimes, whether for boating, habitat, or other values. Value judgments about choices of recreation outputs require good information about impacts on all resources.

In conducting fishability studies, it is important to separate evaluations of "angler habitat" from evaluations of "fish habitat," and it is clear that these habitats may not be equivalent. Flows that optimize high quality angler habitat may sacrifice fish habitat, just as flows that maximize numbers of target fish species may sacrifice important elements of anglers' experiences. For example, would wading-based fly anglers prefer higher catch rates or larger fish if it required fishing from a boat or using spinning gear? Would anglers prefer "easier" fishing conditions (e.g. wadeable low flows where fish are concentrated) to those that are "harder," even if harder conditions increase the number or size of fish by a certain amount?

Fishability studies only address immediate effects that anglers can evaluate; they do not provide information about immediate or long-term biophysical effects. Anglers in fishability studies consistently note concerns about flow effects on fish populations, feeding behavior, spawning success, and the overall health of the fishery. However, most anglers are not the appropriate "experts" to assess these impacts. We suggest that the best way to prevent these biophysical concerns from confounding fishability evaluations is to discuss them in a pre-evaluation focus group. This gets these issues "out on the table" and allows anglers to voice their opinions, but then narrows the focus to attributes anglers are best equipped to evaluate: access to fishable water (wading, from the bank, or by boat) and use of fishable water (tackle and technique considerations).

It is difficult to evaluate fishing success at different flows during a controlled flow effort if study flows are provided for only a few hours. Most anglers develop evaluations of fishing conditions over multiple visits that vary where they fish or the tackle and techniques they use, as well as larger factors such as weather, season, time of day, and availability of a hatch. In addition, fish may not have "adjusted" to study flows, so anglers don't know if fish are behaving as they would over the long term.

Fishability studies also need to carefully specify the type of fishing opportunity under consideration; in some relicensing efforts, the choice may be between different types of angling rather than more subtle changes in one type. Even on the same river, for example, boating-based fishing for salmon may have flow needs substantially different from wading-based fly angling for trout. It is also important to recognize that anglers may be "committed" to a certain type of fishing associated with a particular flow regime. New flows may change the type of fishing, and anglers may not want to "lose" the old

In fishability studies, anglers evaluate important attributes such as wadeability and access to fishable water.

Right: Wading "experiments" during a study on California's Upper North Fork Feather River showed differences in individuals' "willingness to wade," but the controlled flow study showed general agreement about the flows that produced high quality fishing conditions.

opportunity. Well-designed fishability studies can address these different opportunities and evaluations, but may require more care in developing evaluation panels and focusing on appropriate variables.

Integrating fish habitat and fishability information is also complex. As discussed in the conceptual framework (Figure 1), tradeoffs among resource outputs are related to resource conditions that may change over time. But one should not assume that the choices are to provide for one or the other (not both). There may well be "elegant" solutions where flow regimes provide critical fishery benefits at some times and optimize fishability at others. In all cases, good fisheries management requires consideration of the full range of social and biophysical outputs and their potential trade-offs (Ditton 2004).

Social scientists have begun developing models for assessing complex tradeoffs inherent in fisheries management decisions (Aas et al. 2000; Gillis and Ditton 2002), but none have been applied to flow issues. Social science can help determine anglers' preferences for different types of fishing opportunities affected by flows. However, the opportunities must be carefully specified with both social and biophysical information. Preferences will probably shift depending upon 1) the abundance, size, and distribution of the current versus "new" fishery; 2) whether the new fishery will include new species (e.g. salmon and/or steelhead); 3) how new species might affect existing species; 4) relationships between flow regimes and fishing success; and 5) how flow regimes would affect the way anglers fish (technique and tackle, and whether it was boat, shore, or wading-based). To assess angler preferences, biophysical scientists need to specify how flow regimes affect the fishery and social scientists need to develop data from anglers to consider the trade-offs. This is an area for truly interdisciplinary work.

In "angler habitat" or fishability studies, it is critical to carefully define the type of fishing (species, tackle type, and technique), just as fish habitat studies assess needs for different species and life stages. For example, king salmon (left inset) and sturgeon (right inset) fishing are relatively "flow-insensitive" because anglers often fish from boats in deeper water using bait or heavy spinning gear. Wading-based fly fishing for trout (bottom) is more "flow-sensitive" and has a narrower "fishable range."

SIDEBAR

Roles and Responsibilities During Controlled Flow Studies

The following is a list of typical tasks during a controlled flow study (for boating, fishability, or aesthetics), along with typical roles and responsibilities. These tasks may also apply in multiple flow reconnaissance efforts. The list may offer a good starting point for agreements during a study, but negotiations and flexibility are possible. Depending upon the skills, experience, and resources of utilities, their consultants, agencies, or stakeholder groups, there may be efficiencies in "trading" tasks.

Providing flows
Utilities are usually responsible for controlled flow releases (when feasible), although these may need to be coordinated with other agencies or water administrators. Complexities here should not be underestimated; there may be technical, administrative, or legal challenges in scheduling and then achieving target flows (or capitalizing on natural variation). It is particularly important for researchers and utility relicensing staff to work closely with project operations staff; these on-the-ground staff know whether requested flows are possible, and they will ultimately be the ones responsible for providing them. Additional coordination may also be necessary with researchers from other resource areas that would like to capitalize on the availability of controlled flows. Early interdisciplinary communications to identify and coordinate goals may pay dividends.

Flow measurement / development of flow models
Some reaches may not have existing gages, so flow measurements to ensure accurate knowledge of controlled flows are important. Coordination between agencies and the utility may suggest roles, but ultimately the utility is responsible for ensuring this task is completed. USGS or state water resource agencies may offer other options. In the case of new licenses, the development of hydrology models may be necessary to allow studies to capitalize on natural variation.

Panel development and organizing participants
Stakeholders for boating or fishing "communities" may be able to provide names or organize groups for the study, although consultants sometimes assume this role. Depending upon the size of the panel and the number of flows to be evaluated, this task can be considerable (especially for studies that are conducted with intervals between flows). Agencies and utilities generally review lists to ensure representativeness for each opportunity of interest.

Safety plan
Utilities usually develop a safety plan in collaboration with participants and the stakeholder requesting the study. Although there may be exceptions for particularly challenging reaches, safety plans are typically only a few pages long. Contents typically cover equipment and skill expectations for participants, communications equipment provided by the utility, communication and rescue protocols, and lists

Safety is always important during fieldwork. Safety plans identify potential problems and ensure that equipment and expertise are available during a study.

Left: Boaters on Oregon's Clackamas River were able to quickly free this raft using commonly-carried safety gear.

It is important to know flows during a study. Releases from dams are seldom precise, so accurate gages or field measurements (right) may be necessary.

Stakeholder participation helps ensure study success.

Left : Forest Service staff discussing conditions during the Pit River boating study.

of authorities to notify about the study. Safety plans do not usually describe protocols for addressing specific rescue situations at specific locations.

Liability waivers
Utility lawyers usually develop these forms; consultants and stakeholders usually review them. All participants are typically required to complete them during assessments or other fieldwork.

Survey instruments
Consultants usually develop the survey instruments; utilities, agencies, and stakeholders usually review them.

Liaison with the public or other users
The utility is usually responsible for informing other users of flow changes during a study. In some cases, restricting other uses during the study may be necessary to reduce risks. If media interest is high, some opportunity to exchange information between researchers, participants, and the media may be arranged.

Logistics
There are several tasks possible in this "catch-all" category, including shuttle/ transportation logistics, locations for meetings, meals and snacks for participants, access, coordinating public or media interest, coordination with local search and rescue organizations, camping or accommodation for participants during a longer study, and so on.

In general, the utility or its consultants are responsible for organizing and supporting these tasks, although coordination with agencies and stakeholders may suggest efficiencies or cost-savings. Most utilities provide shuttles and lunches/snacks during studies, but not all provide accommodation, pay travel costs (mileage), or cover evening meals.

Surveys provide quantitative data and focus groups add qualitative information, but effectively organizing, conducting, and documenting these data collection efforts requires skill and care.

Above: Boaters complete surveys (inset) and participate in a focus group during a controlled flow study on California's Kern River.

Supply and Demand Assessments

Objective
More precisely describe regional availability of similar recreation opportunities (supply), regional demand for opportunities, or likely use levels if new opportunities were to be created by project enhancements. Regional supply and demand information can be helpful for deciding the scale or extent of potential enhancements.

Typical approach
Level 1 and 2 efforts commonly list regional recreation opportunities to provide context for more focused flow-recreation studies. Similarly, information from interviews, focus groups, and surveys can help identify lists of "substitute" opportunities, demand for certain types of opportunities, comparative ratings among different river reaches, or likelihood of use. This Level 3 effort involves more comprehensive assessments that integrate multiple sources of information.
Supply studies develop a database of regional river segments and characteristics; analyses can quantify the number of segments that meet specific criteria (e.g., Class IV boating segments within 3 hours of city X), or describe reaches that meet those criteria.
Demand studies also integrate multiple sources (e.g., national, state, or regional participation surveys; regional equipment sales; estimates from recreation leaders) to predict participation and trends. In some cases, this information may be used to help estimate use levels for specific recreation opportunities. Surveys of regional groups (e.g., local anglers) are another option that may make sense if potential project effects include the development of a new resource (e.g., a restored salmon fishery).

Product
Summary report of supply, existing or projected demand, and estimates of use. The report includes descriptions of methods, sources and their limitations, and findings.

Responsibilities
These studies are led by utilities or their consultants. Agencies and stakeholders may participate in reviewing supply database variables, suggesting potential demand assessment sources, reviewing surveys, or reviewing draft reports.

Additional issues
These studies require integrating several sources of information, each with limitations or assumptions of varying certainty. Quality assessments will clearly identify sources, limitations, assumptions, and how information is combined to form conclusions.

Cautions & limitations
Assessments of existing regional opportunities (supply) can be quite accurate, depending upon the resources available for the development of a database and the quality of analysis. Analyzing basic guidebook information can provide useful summaries of nearby opportunities and help assess how a

Some recreation activities are extremely popular, creating crowding or competition. Demand and supply assessments attempt to predict future use levels, which is challenging even with good information.

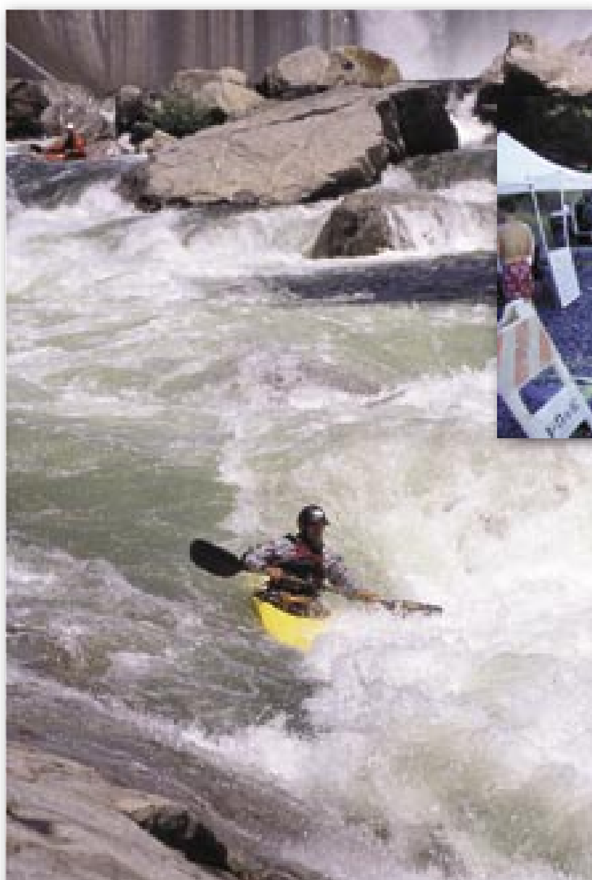
Left: "Combat fishing" for sockeye (red) salmon on Alaska's Upper Kenai River.

proposed enhancement might increase regional supply. However, "list-oriented" assessments usually do not provide sufficient information. Although research on substitution is sparse, there are complexities in how recreation users consider and compare substitute resources and activities (Brunson and Shelby, 1993).

Assessments of demand or estimates of use are even more challenging, particularly when they are intended to apply thirty to fifty years into the future. Recreation participation in specific activity categories is not always stable or predictable, and new activities develop over time. Other factors such as population growth and demographic trends, economic trends, new technologies, and age and the "participation cycle" also affect recreation participation and confound easy predictions. These complexities don't mean assessments are worthless, but their limits should be acknowledged.

Demand or supply assessments provide context for utilities, agencies, and stakeholders to consider the relative value of existing or potential recreation opportunities and associated mitigation or enhancement measures. However, their limitations (see above) can be substantial, and the scarcity or abundance of regional opportunities or potential users are not the only criteria for protecting, enhancing, or mitigating recreation opportunities.

The popularity of "playboating" has made kayaking a rapidly growing river sport. Above: Oregon's Clackamas River.



Relicensing sometimes produces a new "supply" of recreation opportunities. The number of boaters (far right) using whitewater flows on the North Fork Feather River (right) exceeded most predictions, creating management issues that demand studies help anticipate.

SIDEBAR

Study Needs for "New" License Applications

Most of this document focuses on study options for rivers where flows are already regulated (e.g., FERC re-licensing projects, water rights adjudications, or reviews of dam operations). When applied to "new" (as yet unbuilt) hydropower projects, researchers and others may find several additional challenges.

- New hydropower projects are generally proposed for currently unregulated rivers, so impacts are potentially greater than for an existing project (where decisions are limited to alternative operation scenarios). Advocates may argue for higher standards defining "acceptable" impacts because new projects are "irreversible." This suggests studies with Level 3 precision, but this may be challenging for a variety of reasons (discussed below).

- New projects may have limited hydrology information, with insufficient data to assess wet, dry, and normal years with and without the project. Hydrology modeling is the usual solution to this problem (typically applying information from a nearby drainage), but these models are generally less precise.

- Rivers with proposed projects may be in relatively remote or limited access areas, with little history of recreation use. Recreation opportunities may not be well-known or described in guidebooks or other literature, and studies are more speculative (e.g., anticipating how changed access from a new project might induce new use).

- Remote or limited access areas complicate logistics and the ability to involve recreation users in studies (as members of reconnaissance-based assessments, participants in multiple flow assessments, or interviewees for flow comparison surveys).

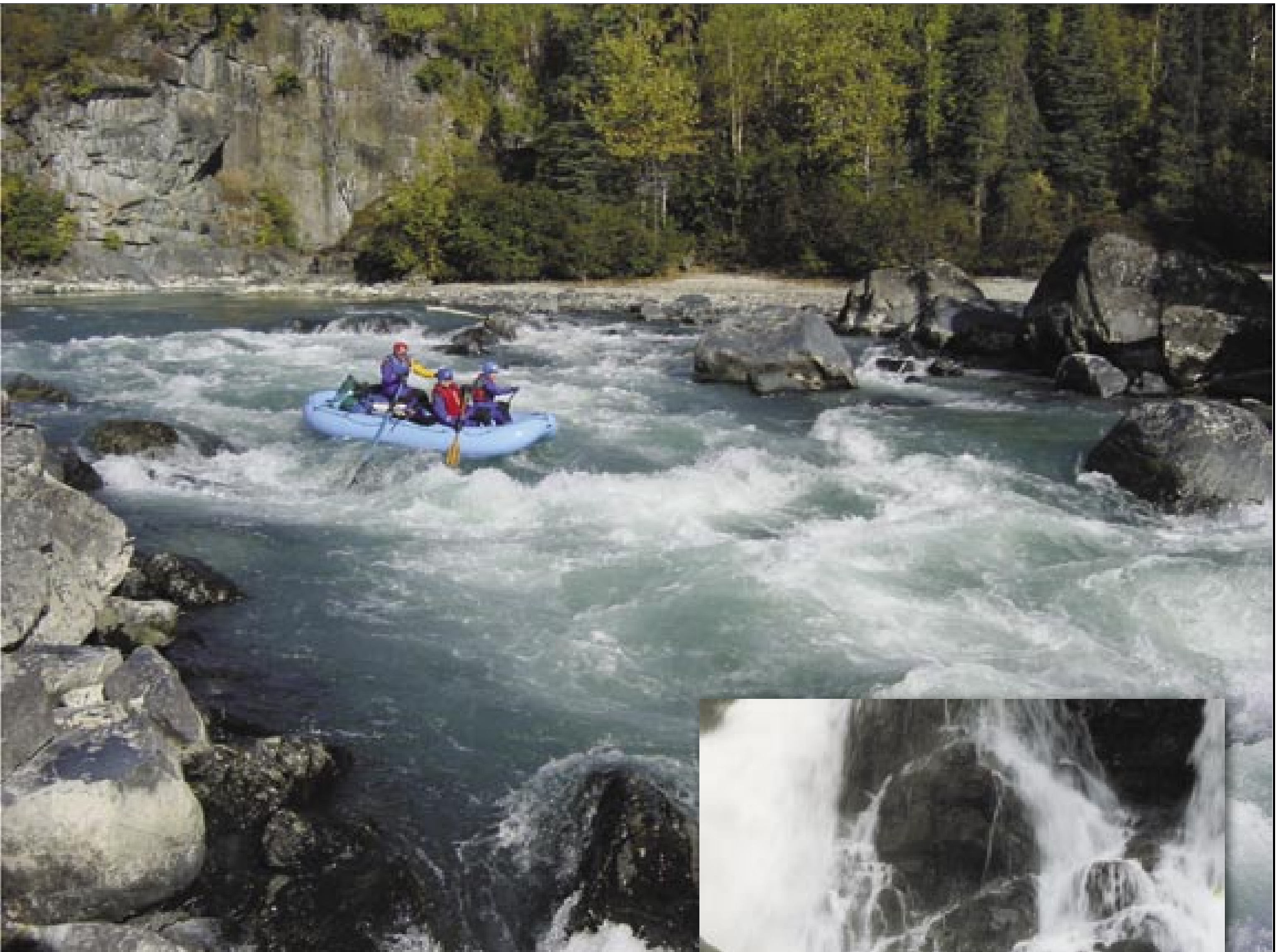
- Because flows are generally unregulated, a common study option is a multiple-flow assessment that capitalizes on natural flow variation. However, this can be challenging when compounded with limited hydrology information, limited access, and limited users – particularly in a two year study period prescribed by FERC rules.

- Flow-recreation studies for projects with these kinds of constraints may be limited to reconnaissance-based, expert judgment methods (Whittaker et al., 1993, p. 59). Compared to other methods that involve users and more precise hydrology information, it is even more important that researchers have experience with the types of river recreation at issue.

- Long-term impacts on vegetation, geomorphology, or aquatic and terrestrial species are likely to play a larger role for new projects. Many long term impacts from regulated flow regimes have already occurred by the time of relicensing, and the choices for studying additional impacts due to operations choices are more limited. With a new project, the magnitude of change is likely to be larger but the ability to predict effects is more limited (especially in a two year study period). Researchers may resort to qualitative descriptions of alternative outcomes by referring to existing literature from other rivers, recognizing that applicability to new situations will be less precise.

- Estimating demand for recreation on rivers with new projects is particularly problematic if access is limited. In general, the farther a river is from population centers, the more difficult it will be to estimate demand – especially for longer planning horizons common in licensing (50 years). As an illustration, population levels in small Rocky Mountain towns (e.g., Vail, Telluride) in 1960 were small and about 1% of the national population participated in winter downhill activities such as skiing. Nearly 50 years later, amenity-based economies anchored by ski area development have created "boom towns," about 15% of a much larger national population now ski or snowboard, and considerable societal resources are dedicated to ski industry infrastructure. The point is that predicting use over long planning horizons can be very challenging, particularly for areas where access has been limited in the past.

- Finally, new projects may need to consider trade-offs of losing wilderness/primitive recreation opportunities to less primitive opportunities on regulated, more accessible rivers. Studies that assess these trade-offs may require assessments of potential use, existence, option, and bequest values through "travel cost" or "contingent valuation" studies. These types of economic studies are beyond the scope of this document, but there is a substantial literature on recreation valuation that may apply to new hydropower proposals (Loomis and Walsh, 1997).

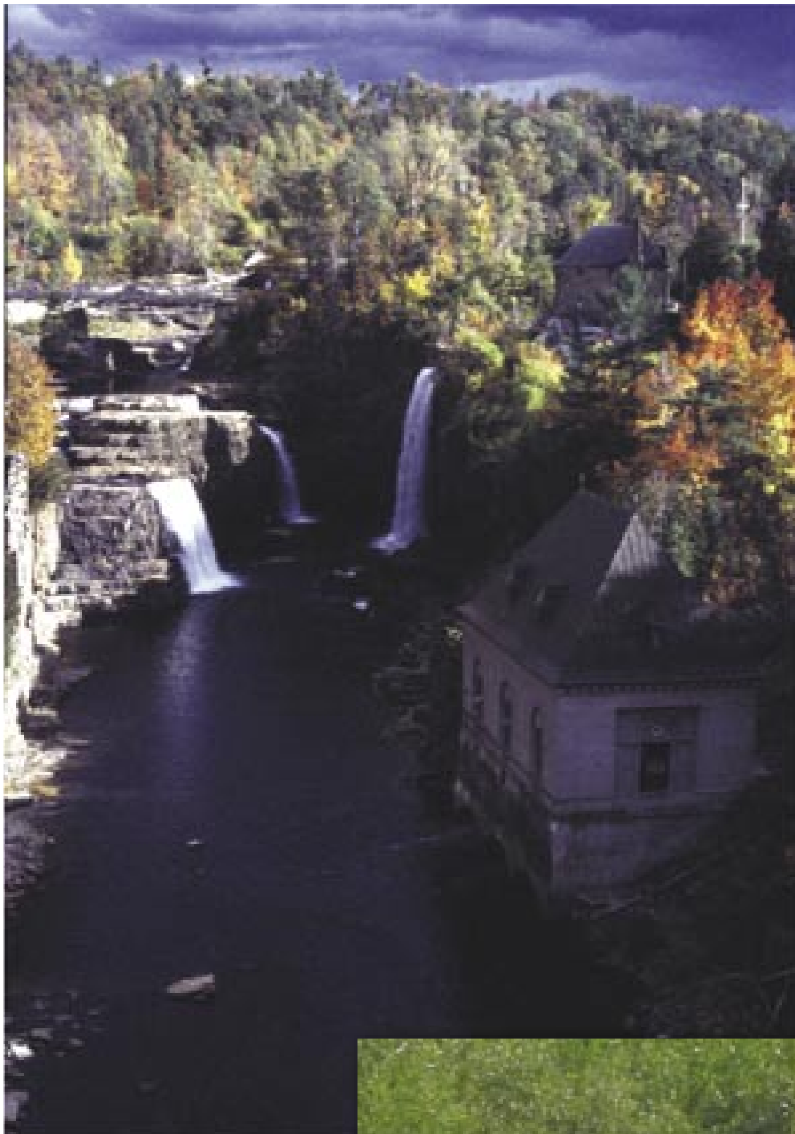


Remote rivers are likely to have limited hydrology data, poor information about recreation use, and challenging logistics for conducting studies.

Above: Alaska's Talkeetna River has fly-in access, no permits or use information, and a gage distant from the whitewater segment.

New water projects are particularly challenging to study because development and recreation use will change substantially, and predictions of supply and demand are speculative.

Right: Upper falls on Falls Creek bordering Alaska's Glacier Bay National Park at 80 cfs. A licensed but unbuilt hydroelectric project would improve access to the falls and increase visitation, but reduced flows may decrease aesthetic value.



Early discussion across resource disciplines is necessary to integrate studies and search for "elegant solutions" that provide for multiple resources. (Left) Rainbow Falls Powerhouse on New York's Ausable River, site of a 2005 controlled flow study.

Above: Studies on Oregon's Klamath, a National Wild and Scenic River, may help design a flow regime that balances several "outstandingly remarkable" ecological and recreation values.

Relicensing activities may put water back in rivers. Right: Whitewater releases are planned for this segment of California's Pit River (1,850 cfs is shown).

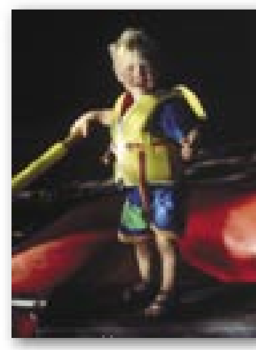
Integration and Trade-Offs: Combining Resource Values

The ultimate usefulness of studies depends on whether high quality information is provided to utilities, agencies, and stakeholders so it can be integrated with findings from other resource areas. A common shortcoming is that true "integration" is not specifically designed into relicensing processes. Most relicensing efforts include substantial numbers of meetings designed to track the overall effort, but these tend to focus on decision-making structures and reviews of study progress (e.g., schedules, budgets). They often fall short on sharing findings or implications across resource areas, and sometimes miss opportunities to work across disciplinary boundaries and seek "elegant solutions."

Within resource areas, work groups tend to focus on specific findings and implications, rarely scheduling time to consider how those dovetail with information from other work groups. Periodic "cross-pollination" sessions focused on other resource areas would be helpful.

The timing of these sessions is also important. Integration that only occurs toward the end of the process as a massive license application is put together (with findings from dozens of studies) is less likely to be successful. In addition to encouraging consistent cross-discipline terminology and core information, earlier information sharing may provide opportunities for researchers in one area to assess flow regimes that researchers in another resource area are considering. In an ideal world, sufficient information about the effects of any flow regime would be prepared for each resource area; in reality, scientific information can only address a limited number of alternative "scenarios." The challenge is developing "relevant" alternatives early in the process.

Earlier discussion among work groups also encourages less adversarial integration of findings and aids in the search for "elegant solutions" that may provide for multiple resources. If agencies and stakeholders only hear proposals from work groups at the end the relicensing process, positions may already be "hardened." The sooner everyone learns about potential proposals (or the range of potential proposals), the easier it is to systematically design studies to address the issues and clarify advantages and disadvantages.



A final consideration in effectively using flow-recreation information is encouraging distinct roles among participants. One challenge here is to ensure that scientific information is developed by researchers who are not advocates. Utilities, agencies, or stakeholders then use that information to inform their positions, which may be competing or adversarial. While utilities are responsible for collecting flow-recreation information or hiring consultants to conduct associated studies, it is important that all parties perceive those studies as unbiased. The study options discussed in this paper suggest ways that utilities, agencies, and stakeholders can participate in these efforts.

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Flow-recreation studies also may be important in water rights and navigability adjudications.
Above: Studies formed the basis for a water rights settlement that protects flows for recreation opportunities, aquatic habitat, and beach formation on five National Wild and Scenic Rivers in Idaho (the Main Salmon shown here).

Flows in Grand Canyon have profound effects on whitewater, camping, beaches, time for exploring, and naturalness. Flow-recreatoin studies were pioneered here in the early 1980's and they continue today.