SECONDARY METHODS FOR VALUING NON-POWER BENEFITS: BENEFITS TRANSFER **CHAPTER 6**

This chapter discusses secondary methods for assessing the non-power benefits associated with FERC relicensing alternatives. The techniques discussed here are referred to collectively as "benefits transfer." Benefits transfer involves the application of unit value estimates, functions, data, and/or models from existing studies to estimate benefits associated with the resource under consideration.[1] For example, increasing flow below a dam may result in increased whitewater rafting opportunities. A benefits transfer would apply existing estimates of willingness to pay per rafting trip at other sites to the increased rafting opportunities at the new site.

Benefits transfer is considered a "secondary" valuation methodology, since it does not require primary data gathering (e.g., surveys) or other primary economic research. Benefits transfer is one of the methods designated for use in DOI guidance on recreation benefits evaluation.[2] It also is used in assessing compensable losses under DOI and National Oceanic and Atmospheric Administration rules for damage assessment [43 CFR 11.83 (c)(2)(vi) and 15 CFR 990.78 (c)].

In the context of hydropower relicensing, benefits transfer could be applied at two distinctly different levels:

- First, benefits transfer may be useful as a screening tool to target more extensive research and analysis. For example, FWS staff can develop simple benefits transfer analyses to estimate how changes in dam operation would influence the relative value of instream recreational fishing, whitewater sports, reservoir recreation, and non-use values

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[1] Note that the information "transferred" in a benefits transfer analysis does not include aggregate benefits at the reference site, only unit values (e.g., value per-day of fishing), functions, or models.

[2] U.S. DOI, *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*, U.S. Water Resources Council, 1983.

associated with increased flow. If this screening reveals, for instance, a high potential for increased use value associated with recreational fishing, primary research could be focused accordingly.

- Second, a more sophisticated benefits transfer analysis may be sufficiently rigorous for direct inclusion in an environmental impact statement (EIS) when assessing the relative merits of different alternatives.

No clear line divides these two different applications of benefits transfer. It is up to the analyst to determine whether the level of confidence in the benefits transfer is sufficient for the analysis to stand on its own, or whether primary research is needed. The choice between primary research and benefits transfer can be influenced by a number of factors, including the following:

- Because it relies on existing data, benefits transfer is generally less costly to conduct relative to primary research. Given typical constraints on research resources, benefits transfer is often the only feasible analytic option.

- The decision to use benefits transfer is often a function of the quality of data available for the analysis. Below, we discuss the factors that affect the reliability and rigor of benefits transfer estimates.

- As discussed earlier, primary research may be advisable when the relicensing involves a highly contentious project and/or exceptionally valuable river resources that warrant precise economic characterization.

It is noteworthy that benefits transfer techniques have been previously applied as input to FERC relicensing procedures. In many cases, environmental organizations or state agencies have developed reports that use benefit transfer techniques to more fully integrate non-power values into the relicensing decision process.[3] In isolated instances, FERC has relied on benefits transfer approaches to consider non-power benefits; the Brazos River case study presented in Chapter 7 of this report represents one such example. Internal policy documents developed by FERC also recognize the use of benefits transfer approaches in making relicensing decisions.[4]

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[3] See, for example, Meyer Resources Inc., *An Analysis of FERC/DEIS-0103 - Conduit Hydroelectric Project - FERC 2342-005 Washington*, prepared for American Rivers and the Yakima Indian Nation, February 1996; and Freeman, A. Myrick, *The Economic Benefits of Removing Edwards Dam*, May 31, 1995 (unpublished).

[4] See FERC, *Deciding Competing Resource Use Issues at FERC -- From Theory to Practice*, prepared by James M. Fargo, 1993.

This chapter first provides an overview of benefits transfer techniques, discussing basic analytic steps and reviewing the types of benefits transfer approaches that exist. The remainder of the chapter examines categories of benefits transfer potentially most relevant in relicensing actions, suggesting approaches and parameters that may be useful to FWS staff. Specifically, we review how benefits transfer can be used to analyze the following:

- Recreational fishing;
- Whitewater recreation;
- Other recreational activities;
- Increased instream flow; and
- Non-use values.

OVERVIEW OF BENEFITS TRANSFER

Before moving to a discussion of specific applications, it is useful to consider general concepts common to benefits transfer.[5] Below, we review:

- Steps involved in conducting benefits transfer, with an emphasis on evaluating the relevance of existing studies to the resource under consideration;
- Different types of benefits transfer, ranging from transfer of simple values to transfer of full models; and
- Limitations of benefits transfer.

Basic Steps for Conducting Benefits Transfer

Evaluating economic benefits using benefits transfer involves three basic steps. We discuss these steps in general terms below. Later in this chapter, we look at specific benefits transfer exercises that may be applicable to relicensing actions and the details of the various steps.

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[5] Portions of this discussion are based on Unsworth, Robert E. and Timothy B. Petersen, *A Manual for Conducting Natural Resource Damage Assessment: The Role of Economics,* prepared for Division of Economics, U.S. Fish and Wildlife Service, 1995.

Step 1: Identifying the Resource or Service to be Valued

The first step in a benefits transfer is to identify and characterize the resource or service flows to be valued. This step is often challenging because the resource or service may depend upon unique site conditions and complex ecological factors. For example, the benefits of passage structures that allow migration of anadromous fish may be measured in part by the value of the associated increase in recreational fishing at the site. However, the relationship between restoration of fish stocks and the level of recreational fishing is complex and will likely require professional judgment. Later in this chapter, we discuss methods for estimating changes in the level of key recreational activities such as fishing and whitewater rafting.

Step 2: Identifying and Evaluating Existing Studies

The second step of benefits transfer involves reviewing existing valuation literature to identify potentially applicable studies. In particular, this step entails identifying studies that evaluate similar resources and/or services as those affected at the policy site.[6] The studies to be examined typically include primary research of the type discussed in Chapter 5, e.g., travel cost and contingent valuation studies.

A thorough benefits transfer has three characteristics: (1) reliance on high-quality studies; (2) consistency between the resource to be valued and the resource in the study; and (3) consistency in the relevant population and the "extent of the market" for the policy site and the study site.

Quality of the Existing Study

The benefits transfer analysis should incorporate results from high-quality studies. The studies should be based on adequate data, sound economic methods, and correct empirical techniques. For example, studies that rely on population samples should use state-of-the-art sampling methods, with sample sizes and response rates sufficient to generate and obtain statistically reliable results.

Recognizing high-quality studies can be difficult. One way to ensure that quality studies are used is to rely on work published in established, peer-reviewed journals. Articles from economics journals are likely to follow accepted practices and therefore offer more reliable findings. Likewise, certain types of "gray" literature -- e.g., reports developed by state resource agencies -- may be subject to close review, although such sources generally are less reliable than journal sources.

Resource Consistency

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[6] The term "policy site" denotes the resource or location for which benefits are being considered; i.e., in this case, the policy site is the hydropower project site facing relicensing.

Evaluating the applicability of an existing study to resource valuation at a hydropower site involves comparing the characteristics of the resource or services at the dam with those in the existing study. If these characteristics differ, it will be necessary to consider whether these differences are likely to have a significant effect on the valuation, and if so, whether adjustments can be made to account for these differences.

Evaluating whether resource/service characteristics are similar enough to support a transfer between an existing study and the dam site largely depends on the judgment of the analyst and the intended use of the estimate. Such an evaluation involves consideration of all characteristics of the resources that might affect the way an individual values them. For example, a benefits transfer involving recreational fishing must consider how the study site and policy site compare in terms of the relative aesthetic quality of the sites, the predominant method of fishing, the predominant species sought, the proximity of the site to population centers, the availability of substitute fishing sites (see below), and other factors.

An especially important aspect of resource similarity involves the availability of substitute resources and the price associated with those substitutes (e.g., for recreational opportunities, the distance that must be traveled to access the site). Differences in the availability and cost of substitutes are likely to affect individuals' value for a resource and therefore have implications for the benefits transfer analysis. For example, the river below a dam may represent one of many local fishing sites that are of comparable or better quality. Restoration of fish populations in the river will not yield a significant net increase in social welfare if anglers simply substitute effort from an equivalent site. An increase in social welfare can occur if the restored site allows anglers to travel a shorter distance to fish (i.e., to pay a lower price for fishing) or if anglers increase their total amount of fishing activity (i.e., number of fishing days).

The availability of substitute sites also is of concern in considering potential non-use losses associated with dams. For example, if removal of a dam restores the river to a wild and scenic state uncommon in the region, individuals may be willing to pay more for this change than if many such rivers exist in the region. Therefore, in conducting a benefits transfer, care must be taken that the study site and the subject site are similar in this regard.

Characteristics of the Affected Population

In a benefits transfer, the characteristics of the population holding values for the policy resource and the population included in the existing study should be comparable. Relevant characteristics include, but are not limited to age, income, education level, proximity to the site and the level of environmental concern.

To compare population characteristics, the analyst should evaluate the means, medians and range of values for these characteristics. Significant differences in population characteristics can be accommodated if the study case estimates resource or service values as a function of these characteristics. Small differences in population characteristics are unlikely to have a significant effect on economic benefit estimates.

Extent of the Market

Each natural resource will have a geographic area over which its users are drawn.[7] An important component of economic benefits estimation is defining this market. The extent of the market determines the size of the population that values the resource and services provided, and thus has a significant effect on the magnitude of the resultant economic benefit estimate. For example, the magnitude of non-use values associated with a resource can depend on the size of the population assumed to hold values for the affected resource (e.g., local, regional, national). For instance, a study of the non-use value of a nationally known wild and scenic river would not be appropriate in estimating non-use values for a lesser-know river (even if the biological and physical qualities of the two are comparable).

To estimate the extent of the market, analysts might consider the following factors:

- How unique is the resource? Are there other resources similar to it in the area? Is the resource locally important, regionally important, nationally important?

- How many households are likely to hold direct use or non-use values for the affected resources and what is the geographic extent of these households?

- How far do people travel to use the affected resources?

Unfortunately, the benefits transfer literature has not fully addressed the issue of how differences in the size and characteristics of the market affect the transferability of benefit estimates. When using benefits transfer techniques, analysts should carefully consider the extent of the market both in the policy site and study site and whether differences in these market definitions are likely to affect the value of the resources.

[7] Defining the extent of market for a natural resource or service is a concern in applying all types of valuation methods, not just benefits transfer.

Step 3: Conducting the Benefits Transfer

The final step in benefits transfer is to calculate economic benefits (or losses). This involves application of the values, functions, data and/or models identified in Step 2. For example, Step 2 may involve a review of studies valuing recreational fishing activity similar to that found at the project site. These studies will provide an estimate of the value per day of recreational fishing. These values can be combined with information on anticipated increases in fishing activity to estimate the annual value of recreational fishing associated with the change in dam operation.

We provide more detail on Steps 1 through 3 later in this chapter when we discuss specific techniques for analyzing different categories of non-power benefits.

Types of Benefits Transfer

A benefits transfer exercise can take several forms. Below, we discuss the possible approaches.

Value Transfers

Simple transfers of resource values involve the application of existing recreational activity values, non-use values, or other values to monetize changes in natural resource services provided by resources at the policy site. The transferred value can be a value reported in an individual study or the average from a set of studies that address the same or similar categories of resources or services. For example, a set of studies may suggest that the average value per whitewater rafting trip is $40; if data suggest that rafting activity may increase by 1,000 trips per year, the annual value of this increase is $40,000 ($40 * 1,000 trips).

Transfer of Value Functions and Models

Regardless of the primary research approach used (e.g., travel cost, contingent valuation), most studies of resource value use statistical methods to estimate a relationship between a variable of interest (e.g., willingness to pay to fish) and several explanatory variables. For example, willingness to pay for a day of recreational fishing at a river may be a function of the individual's income and catch rates experienced on the river:

$$\text{WTP} = 5.0 + 0.001(\text{Income}) + 4.0(\text{Catch Rate})$$

A benefits transfer could value a day of fishing on a different river by using the full equation evaluated at the means for each of the explanatory variables. For example, if anglers at the site under consideration have an average income of $30,000 per year, and if the average catch rate on the river is one fish per day, the estimated willingness to pay per day would be $39.

The advantage of using estimated models in a benefits transfer is that factors such as site characteristics and socioeconomic characteristics of the population are incorporated explicitly, rather than assuming rough equivalence of circumstances between the site in the existing study and the site under consideration. Studies have shown that transfer of benefit functions yields more reliable and accurate results than simple transfers of average site benefits.[8] The tradeoff, of course, is that such transfers are more analytically demanding.

Transfers of Activity Data

Transfers of data, functions, or models from existing studies can be used to estimate changes in recreational activity days at an affected site. For example, data on potential levels of recreational fishing activity that will result when flows are restored in a river could be estimated based on levels of activity at comparable sites in the area. Such "fishing pressure" data (generally expressed in terms of number of participants per day per mile of river or acre of surface water body) may be transferred by considering the length of the affected stream or size of the affected water body. Because changes in activity levels are often the most uncertain element in the benefits transfer calculation, this process can be critical to the estimates developed.

Limitations and Appropriate Uses of Benefits Transfer

The preceding discussion makes it clear that a key limitation of benefits transfer lies in the ability of the analyst to locate appropriate results from pre-existing studies and apply them to the policy site in a sophisticated manner. Close attention must be paid to matching key factors - e.g., physical and geographic attributes, availability of substitutes, socioeconomic attributes -- in the study site and the subject site. Likewise, the quality of the benefits transfer will depend on the number of relevant studies, i.e., relying on average values from multiple studies is likely to be more reliable than transferring values on the basis of one or a few previous studies.

To date, relatively little formal research has been done to evaluate the reliability of benefits transfer estimates. Most benefits transfer work is performed by public agencies in support of broad policy decisions. As a result, much of the analysis resides in the "gray" literature and may not have been subject to systematic review.[9] The limited testing that has been done paints a mixed picture of the reliability of benefits transfer. On the one hand, some studies have shown a relatively good match between estimates achieved through benefits transfer and

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8 Kirchhoff, Stefanie, et al., "Evaluating the Performance of Benefit Transfer: An Empirical Inquiry," *Journal of Environmental Economics and Management*, Vol. 33, No. 1, pp. 75-93, May 1997.

9 Boyle, Kevin J., and John C. Bergstrom, "Benefit Transfer Studies: Myths, Pragmatism, and Idealism," *Water Resources Research*, Vol. 28, No. 3, pp. 657-663, March 1992.

estimates developed for the same site through primary research methods.[10] However, even when carefully crafted, a benefits transfer approach may not yield accurate benefits estimates. For example, Loomis used statistical tests to reject the hypothesis that two valuation equations for recreational fishing were identical; this test implies that the results from the one study region would lead to inaccurate estimates of recreational fishing values in the other region.[11]

☞ While the debate over the validity of benefits transfer continues, it is generally accepted that the resulting estimates are unlikely to be as accurate as estimates developed through primary research. Nonetheless, benefits transfer can be a useful screening tool. As mentioned, in the context of hydropower relicensing, benefits transfer may be used for identifying ecological services and resource uses of the greatest potential consequence. Such screening can help the Fish and Wildlife Service, FERC, and other parties target more in-depth research on the most significant non-power aspects of the project. In addition, benefits transfer may be the only analytic option available if resources for original research do not exist.

USING BENEFITS TRANSFER TO VALUE RECREATIONAL FISHING

Hydropower facilities can have profound effects on fisheries and associated recreational uses. These effects include, but are not restricted to, the following:

- Impounding water behind a dam may cause changes in sediment levels, dissolved oxygen content, and water temperature, all of which affect fish survival and reproduction.

- Diversions at the dam may create bypass reaches where instream flow is significantly depleted, reducing fish habitat and eliminating the flow needed to trigger migration responses in anadromous fish.

- Dams may physically block the upstream movement of anadromous fish attempting to reach spawning areas and may entrain fish drawn into power turbines.

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[10] Bowker, J.M., et al., "Benefits Transfer and Count Data Travel Cost Models: An Application and Test of a Varying Parameter Approach with Guided Whitewater Rafting," Working Paper, USDA Forest Service, Southern Research Station, Athens, GA, April 1997.

[11] Loomis, J.B., "The Evolution of a More Rigorous Approach to Benefit Transfer: Benefit Function Transfer," *Water Resources Research*, Vol. 28, No. 3, pp. 701-705, March 1992.

- In some cases, dams may enhance fisheries. Most notably, the creation of a reservoir may allow the establishment of fish species otherwise not present in the area.

The most prominent use value associated with healthy fishery resources is recreational fishing. As noted, anglers' willingness to pay for recreational fishing is frequently measured as part of society's overall value for fishery resources. Many EISs feature fisheries management and effects on recreational fishing as central points of concern in the relicensing decision. While the costs of dam operation alternatives such as minimum instream flow maintenance and installation of fish passage facilities is often explicitly addressed, the benefits provided by these measures are often given only qualitative consideration.

This section reviews benefits transfer methodologies for estimating the value of changes in recreational fishing. Specifically, we examine two different scenarios that may arise:

- First, we consider instances where relicensing alternatives may create or eliminate recreational fisheries, thereby changing the total amount of fishing activity in the area of the dam.

- Second, we consider methods for valuing marginal changes in the quality of a recreational fishery.

Valuing Changes in the Level of Recreational Fishing Activity

In some cases, changes in dam operation may increase or reduce the total amount of recreational fishing activity in the area. For example, a dam upstream from coastal waters may block the migration of anadromous fish; removal of the dam may restore the fish runs and essentially create a recreational fishing site where none previously existed. Likewise, restoration of flow in an extremely dewatered bypass reach may create new fishing opportunities. Finally, dam removal may eliminate a recreational fishery that had been established on a reservoir above the dam.

The economic implications of these scenarios can be characterized through a simple benefits transfer that estimates total net willingness to pay (i.e., consumer surplus) associated with the fishing activity that is created or eliminated. Two components are necessary to implement such an analysis:

- An estimate of the total annual fishing activity level (i.e., days or trips); and

- Estimates of the consumer surplus per day or trip.

Multiplying these two components yields a rough estimate of the total annual recreational value of the fishery.

Estimating Fishing Activity Levels

The analytic demands of estimating fishing activity levels depend upon the scenario being analyzed. Obviously, it is easier to obtain data on *existing* levels of activity than it is to estimate *potential* levels of activity. The simplest case would involve elimination of a reservoir and the associated fishing activity. The licensee or park management officials may keep records on fishing activity at the reservoir. The quality of these data will vary depending upon the survey methods used; e.g., "windshield" counts will be less accurate than park registration data.

It is more challenging to evaluate the degree of activity associated with new recreational fishing opportunities. While no single approach is widely accepted or applicable, rough estimates can be developed in a number of ways. For example, if salmon runs are re-established in a river, fishing activity could be gauged in the following ways:

- The analyst could consider fishing pressure at an analogous river in the region where seasonal salmon fishing is an attraction. For example, state fish and wildlife officials may have data on the annual fishing trips per mile of river or acre of surface water at the analogous river.[12]

- Fishing pressure could also be estimated relative to the expected magnitude of the spawning runs. Statewide or regional data may exist on fishing days per number of migrating fish; the analyst can use these data in conjunction with biological studies predicting the magnitude of spawning runs to estimate fishing activity in near-term and future years.

- Likewise, state officials in charge of fish stocking operations may also have data on the number of fishing days expected based on stocking rates or on the number of river miles stocked.

In developing estimates of fishing activity levels, it is important to bear in mind practical constraints. Most notably, physical access to the policy site is critical. For example, the availability of parking and access to the banks of the river will influence whether additional fishing can be accommodated.

Finally, in estimating how fishing activity will react to a change in dam operation, the analyst must consider the full set of behavioral changes that may occur. The most notable example involves the tradeoff between flatwater (reservoir) and river fishing. Drawing down a reservoir to enhance river flow may induce added river fishing, but may reduce fishing in the reservoir above the dam (e.g., by eliminating boat launch access at docks). If flatwater fishing opportunities are plentiful in the area, loss of consumer surplus may be minimal. However, if

[12] The analogous water body must be chosen carefully. In particular, if the comparison site is too close to the river under consideration, anglers may simply substitute one location for the other, yielding little or no increase in total consumer surplus. However, sites that are too distant may differ from the policy site in substantive ways, decreasing the reliability of the activity estimate.

flatwater opportunities are limited, the losses for these anglers may partially or even totally offset gains for river anglers. In general, when assessing changes in recreational activity, the analyst should carefully consider the full set of effects that a change in the resource may have.

Total Values per Unit of Recreational Fishing

The second element needed to estimate the value of fishing activity created or eliminated by changes in dam operation is the value per day or per trip for a recreational fishing opportunity. As noted in Chapter 5, a wealth of studies have used travel cost, contingent valuation, and other approaches to estimate anglers' net willingness to pay for recreational fishing. Because a number of these studies have been performed, many benefits transfer exercises for recreational fishing calculate average per-day or per-trip values across a relevant subset of studies, rather than attempting to match conditions at the policy site with a single study site.

Exhibit 6-1 summarizes a set of total consumer surplus estimates potentially useful in developing benefits transfer screening studies of recreational fishing values. The estimates were developed using the FWS database of sport fishing values (see description below). As shown, existing studies have generated estimates of both willingness to pay per day of recreational fishing as well as per recreational fishing trip.[13] To facilitate the use of these data in benefits transfer analyses, we have grouped the estimates according to other factors that may influence willingness to pay: species, geographic region, and lake versus river fishing (i.e., habitat).[14]

[13] Trips may range from one to many days in length. While some studies specify average trip length, others do not. Therefore, the trip values provided here apply to trips of unspecified length and should be used with caution.

[14] The number of available salmon fishing estimates is insufficient for regional division.

Exhibit 6-1

SUMMARY OF TOTAL PER-DAY AND PER-TRIP FISHING VALUES ($1997)

			Per Trip				**Per Day**			
Species	**Region**	**Habitat**	**High**	**Low**	**Median**	**Number of Estimates**	**High**	**Low**	**Median**	**Number of Estimates**
Trout	West	River	$421	$19	$136	64	$762	$11	$45	70
		Lake	$383	$102	$256	8	$169	$7	$39	37
	East	River	$198	$28	$29	4	$21	$13	$18	5
		Lake	N.A.	N.A.	N.A.	N.A.	$143	$1	$23	8
Other Freshwater	West	River	$123	$7	$31	10	$98	$17	$44	15
		Lake	$156	$7	$36	7	$98	$15	$40	25
	East	River	$198	$16	$28	6	$88	$13	$18	11
		Lake	$198	$24	$28	3	$62	$14	$22	18
Salmon	All U.S. (except AK)	River/Lake	$762	$25	$240	16	$46	$3	$23	17
		Marine/Mixed	$186	$67	$90	10	N.A.	N.A.	N.A.	N.A.

Note: N.A. denotes cases where an insufficient number of studies exist for estimates to be developed.
Source: Boyle, et al., “A Database of Sport Fishing Values”, prepared for the U.S. Fish and Wildlife Service, 1998.

As shown, available studies yield wide-ranging estimates of willingness to pay, even when we control for key factors. For example, estimates of consumer surplus associated with a day of trout fishing in western rivers ranges from a high of $760 to a low of $11.[15] Because of this variability, the exhibit provides median values for each category of estimate. It is noteworthy that values from the literature may systematically overstate willingness to pay for typical fishing resources because many of the available studies focus on the most desirable fishing resources. For example, the high estimate of $760 is based on high-income, non-resident anglers' willingness to pay for a "blue ribbon" trout fishery in Montana.

Because anadromous fish passage is frequently at issue in dam relicensing, we provide more detailed information for these species (see Exhibit 6-2). Per-day values range from $5 to $40 while per-trip values range from $26 to $187. It is noteworthy that variation can be significant, even for the same location; the two estimates for the Sacramento, California area differ by a factor of seven. This kind of variation highlights the need for sensitivity analysis (i.e., development of upper and lower bound estimates) when performing benefits transfer.

Exhibit 6-2

REPRESENTATIVE PER-DAY AND PER-TRIP FISHING VALUES FOR ANADROMOUS SPECIES ($1997)

Study	Waterbody/Location	Methodology	Per Day Consumer Surplus Value	Per Trip Consumer Surplus Value
Crutchfield, J.A. and K. Schelle (1978)	Columbia River head to Neah Bay, Washington	Contingent valuation	$40	
Huppert, D. (1989)	San Joaquin River System, Sacramento, California	Travel cost		$187
Olsen, D et al. (1991)	Puget Sound, Washington	Contingent valuation		$88
Roach, B. (1996)	Sacramento area, California	Travel cost		$26
Rowe et al. (1989)	Penobscot River, Maine	Contingent valuation	$5	

Source: Boyle, et al., "A Database of Sport Fishing Values", prepared for the U.S. Fish and Wildlife Service, 1998.

By combining estimates of the increased number of fishing days with the appropriate consumer surplus estimate, the analyst can derive a rough estimate of the net change in social welfare associated with new recreational fishing. For example, if restoration of a trout fishery in a river in Idaho is expected to create 1,000 recreational fishing days, the annual value of this restored activity would be approximately $45,000 (1,000 * $45). Note that screening analyses can be structured in a way that yields useful information without specific estimates of increased fishing activity. Most notably, the analyst can "reality check" the potential for a relicensing

[15] Note that all dollar figures presented in this chapter have been converted to a common dollar year (1997) to normalize for inflation. We used the Gross Domestic Product deflator to adjust all figures.

requirement to yield sufficient benefits by backing into an estimate of fishing activity and examining whether the increase in activity is feasible. For example, restoring a recreational fishery may require increasing minimum instream flow; the cost of this change may be $200,000 in increased power generation costs at a replacement source. If a day of fishing at the site is worth approximately $50, this implies that 4,000 fishing days must be realized per year in order for the benefits of the change to outweigh the costs ($200,000/$50 = 4,000). If the typical fishing season is 200 days per year and the bypass reach in question is two miles, this would imply about 10 anglers per mile per day. Common sense suggests that this distribution of fishing activity is feasible, assuming that the site is accessible. To provide additional context, the estimated level of fishing pressure could be compared to state averages or to other nearby sites.

Valuing Changes in Fishery Quality

Many of the alternatives considered in hydropower relicensing actions involve incremental changes in the quality of a recreational fishery. For example, expanding usable habitat through increased instream flow may enhance an existing fishery by increasing the population of fish and associated catch rates for anglers. Similarly, fish passage facilities may add to the size of anadromous fish runs. These types of changes will cause marginal increases in willingness to pay for recreational fishing because of the improved quality of the experience.

Characterizing Marginal Changes in Fishery Quality

The relationship between physical improvements in the quality of a fishery and changes in the quality of the fishing experience involves several links. These include the effect of changes in dam operation on fish habitat, the effect of habitat changes on fish populations, and the effect of population changes on factors valued by anglers, such as catch rate or run size. Only a few studies have attempted to integrate biological and economic modeling to fully account for all these factors. For example, Harpman, et al. examined how different reservoir management alternatives would affect fishing values in Colorado's Taylor River.[16] Specifically, the study predicted trout population changes associated with different flow release patterns. The population changes were then translated into catch rate changes, and angler willingness to pay for increased catch was estimated using a contingent valuation approach.

In conducting benefits transfer at a screening level, the analyst will likely need to make simplifying assumptions regarding the relationship between physical/ecological changes and fishing quality. For example, resource agencies involved in hydropower relicensing often support recommendations for increased flows through estimates of changes in usable habitat for different fish species. The analyst could assume that catch rates will change in proportion to

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[16] Harpman, David A., et al., "A Methodology for Quantifying and Valuing the Impacts of Flow Changes on a Fishery," *Water Resources Research*, Vol. 29, No. 3, pp. 575-582, March 1993.

habitat expansion. If fish population changes are predicted, these estimates may provide a better indicator of likely changes in catch rates.

Values Associated with Marginal Changes

Similar to the process described above for valuing increases in fishing activity, the next step in the benefits transfer involves identifying relevant marginal consumer surplus estimates from the economics literature. Exhibit 6-3 summarizes findings from a number of studies. The studies reported in this table are just a subset of those available, chosen to illustrate the diversity of changes and conditions considered. In particular, the relevant marginal consumer surplus estimate depends on several factors:

- the commodity or change considered in the study (e.g., a percentage change in catch rate);
- the units that the change is expressed in (e.g., willingness to pay per trip, per season, etc.);
- the fish species; and
- the location and habitat in question (e.g., lake versus river fishing).

To illustrate how existing estimates could be used in a benefits transfer, consider a hypothetical relicensing where installation of fish passage facilities is expected to increase anadromous fish runs on a river in the Pacific northwest by 20 to 40 percent. This information suggests that the Johnson and Adams estimate may be relevant to apply in a benefits transfer. Furthermore, we know that 900 individuals fish the relevant river reach each year. Multiplying the number of anglers (900) by the increased willingness to pay per year for increased run size (Johnson and Adams' $12 per year) yields an annual benefit of about $11,000.

The relatively large set of factors that must be considered in choosing a surplus estimate for the benefits transfer makes it difficult to match conditions at the policy site with multiple studies from the literature (although we present only a sample of the available studies here). As a result, benefits transfer estimates for marginal changes in a fishery generally are best suited to screening analyses. Where possible, the analyst should apply ranges for key factors such as catch rate changes or consumer surplus estimates.

Exhibit 6-3

SUMMARY OF VALUES
ASSOCIATED WITH CHANGES IN FISHERY QUALITY

Study	Location	Species	Change in Resource Valued (Point Estimate of Change)	Consumer Surplus (1997$)	Units	Methodology[1]
			Values Associated with Changes in Catch Rate			
Donnelly et al. (1985)	Clearwater River, Idaho	Steelhead	Increase in catch rate, 100%	$12	per trip	CV
Morey et al. (1993)	Penobscot River, ME	Atlantic Salmon	Increase in catch rate, 100%	$667	per year	TC
Sorg et al. (1985)	Nine Idaho Reservoirs	Coldwater fish	Increase in catch rate, 100%	$18 - $103 (based on range of nine reservoirs)	per trip	CV
Brooks, R. (1990)	Cooney Reservoir, Montana	Trout and Salmon	Increase in catch rate, 100%	$105	per trip	CV
Ward, F.A. and T.M. Cohen (1989)	Bluewater Lake, New Mexico	Trout	Increase in catch rate, 100%	$62	per year	TC
Harpman et al. (1993)	Taylor River, Colorado	Brown Trout	Increase in catch rate, from one to two fish (100%)	$2	per fish kept	CV
Shaw, W.D. and M.T. Ozog (1995)	Penobscot River, Maine	Atlantic Salmon	Increase in catch rate, 50%	$190	per season	TC
Johnson, D.M. (1989)	Cache La Poudre River, Colorado	Brown and Rainbow Trout	Increase in catch rate, one fish per day (18%)	$2	per fish caught	TC

Exhibit 6-3

SUMMARY OF VALUES ASSOCIATED WITH CHANGES IN FISHERY QUALITY (continued)

Study	Location	Species	Change in Resource Valued (Point Estimate of Change)	Consumer Surplus (1997$)	Units	Methodology[1]
			Values Associated with Changes in Run Size			
Olsen et al. (1991)	Columbia River Basin, Washington and Oregon	Steelhead and Salmon	Increase in run size, 100%	$7	per month	CV
Johnson, N.S. and R.M. Adams (1988)	John Day River, Oregon	Steelhead	Increase in run size, 33%	$12	per year	CV
Berrens et al. (1993)	Willamette and Clackamas Rivers, Oregon	Chinook Salmon	Increase in run size, equivalent to increased catch of one fish per trip	$3	per fish caught	CV
			Other			
Brown, G. and R. Mendelsohn (1984)	Washington	Steelhead	Increase in fish density, 20%	$8	per fish caught	TC
Loomis, J.B. (1988)	Three Oregon Rivers in the Siuslaw National Forest	Steelhead	Increase in catchable steelhead	$34 - $153 (based on range of three rivers)	per fish caught	TC

[1] Note: CV = contingent valuation, TC = travel cost.

Additional Sources of Information on Recreational Fishing Values

In addition to the studies reviewed here, a variety of other sources of information on recreational fishing values exist. Depending on the degree of precision and defensibility sought, the analyst performing a benefits transfer for recreational fishing may wish to consult these other sources to identify studies that are more geographically relevant or otherwise better tailored to the circumstances at the hydropower site. Suggested sources of information include the following:

- The U.S. FWS has developed a database of sport fishing values incorporating estimates from over 110 published articles. FWS is using the data to develop econometric models to characterize how consumer surplus estimates vary according to estimation method, study location, and the characteristics of the study population. This effort will ultimately provide a powerful tool for developing benefits transfer estimates of recreational fishing values.

- The U.S. FWS also conducted a national contingent valuation survey to assess net economic (consumer surplus) values associated with various types of outdoor recreation.[17] The study reports average per-day consumer surplus values for bass and trout fishing in all relevant states.

- In a study for the Bonneville Power Administration, Meyer, et al. report a variety of data relevant to valuation of recreational fishing in the Pacific Northwest.[18] The data include fishing pressure, catch rates, and consumer surplus estimates for key species including salmon, steelhead, and trout.

- As part of a study on the use of contingent valuation in anadromous fisheries conservation, the National Wildlife Federation and the River Watch Network assembled results from over 30 willingness-to-pay studies focusing on recreational fishing for anadromous species.[19]

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[17] U.S. DOI, U.S. FWS, *1991 Net Economic Values for Bass and Trout Fishing, Deer Hunting, and Wildlife Watching*, October 1994.

[18] Meyer, P., et al., *Calculation of Environmental Costs and Benefits Associated with Hydropower Development in the Pacific Northwest*, prepared for Bonneville Power Administration, April 1986.

[19] Northeast Natural Resource Center of the National Wildlife Federation and River Watch Network, *Fishing for Values*, Vols. 1 and 2, June 1995.

VALUATION OF WHITEWATER RECREATION

Whitewater recreation often plays a prominent role in relicensing decisions. Interest groups such as the American Whitewater Affiliation and local rafting outfitters often petition for enhancements to whitewater sports. These improvements may include more frequent releases of impounded water or minimum flow requirements that would create or enhance opportunities for rafting, kayaking, and other whitewater activity. Such operational changes typically present a cost to the licensee in the form of foregone power.

Benefits transfer techniques can be applied to estimate the value of changes in whitewater sports, using the same approach as described for recreational fishing. Specifically, the analyst can combine estimated changes in the number of rafting days or trips with estimates of the average consumer surplus associated with each unit of activity.

In most locations, whitewater recreation is highly rationed, with demand outpacing supply of opportunities. Therefore, rafting activity is likely to expand in proportion with opportunities. This simplifies the estimation of how rafting activity might change in reaction to operational changes at the dam. For example, the following scenarios are common:

- In the simplest case, FERC or other intervenors may seek to increase the number of controlled releases made to accomodate whitewater recreation. In cases where demand is high, the analyst can assume that activity will expand in proportion to the number and length of releases. For example, if Sunday releases attract 1,000 rafters each summer, addition of Saturday releases will likely double the number of rafting days to 2,000.

- The adoption of minimum instream flow requirements may introduce rafting opportunities on river reaches where rafting was previously infeasible. In these cases, the analyst might examine rafting levels on comparable rivers in the region, taking into account flow and other factors affecting the quality of the rafting experience.

As with fishing, whitewater recreation can be valued on the basis of consumer surplus estimates developed in previous economic studies. Exhibit 6-4 summarizes per day and per trip values found in the literature. As shown, the estimates vary greatly between studies. The per-day values range from $15 to $269, with a median value of about $39 per day. The range in per-trip values is even greater, with a low of $20, a high of $1,200, and a median of $156.

The variability in willingness to pay estimates is attributable to the many factors that can affect individuals' value for whitewater recreation at a site. These factors include a variety of river attributes such as flow, the difficulty of rapids encountered, congestion along the rafting run, the length of the run (float time), and aesthetic conditions along the river. Other factors affecting individuals' willingness to pay include rafting skill level, age, and income. For example, the upper bound trip estimate of $1,200 is based on rafters' willingness to pay for trips through the Grand Canyon, a highly rationed opportunity that attracts higher-income individuals.

Exhibit 6-4

SUMMARY OF WHITEWATER RECREATION VALUES

Study	Study Location	Commodity	Methodology	Value ($1997)
Boyle et al. (1988)	Colorado River, Arizona	Rafting	Contingent valuation	$37 per day
Klemperer (1984)	Chatooga River, Georgia and South Carolina	Rafting	Travel cost	$15 per day
Rosenthal and Cordell (1984)	Salmon River, Idaho	Rafting and kayaking	Travel cost	$101 per day
Keith et al. (1982)	Salt River, Arizona	Inner tube floating	Travel cost	$41 per day
Walsh et al. (1980)	Colorado, Crystal, Roaring Fork and Yampa Rivers, Colorado	Rafting and kayaking	Contingent valuation	$24 (rafting); $28 (kayaking) per day
Bowes and Loomis (1978)	Colorado River, Utah	Rafting, kayaking and floating	Travel cost	$42 per day
Michaleson (1977)	Salmon River, Idaho	Rafting and kayaking	Travel cost	$269 per day
		SUMMARY OF PER-DAY VALUES	**HIGH:** $269	**LOW:** $15 **MEDIAN:** $39
Boyle et al. (1988)	Colorado River, Arizona	Rafting	Contingent valuation	$135 per trip
Bowker et al. (1996)	Chatooga River, Georgia and South Carolina; Nantahala River, North Carolina	Guided rafting	Travel cost	$197 per trip; $140 per trip, respectively
Bowker et al. (1997)	Gauley River, West Virginia; Kennebec River, Maine and Salmon River, Idaho	Guided rafting	Travel cost	$359 per trip; $268 per trip; $616 per trip, respectively
Boyle et al. (1993)	Colorado River, Arizona	Commercial and private rafting	Contingent valuation	$166 to $1,159 (5,000 cfs to 33,000 cfs, commercial); $145 to $832 (5,000 cfs to 28,000 cfs, private)
Kirchhoff, et al. (1997)	Rio Grande River, New Mexico	Rafting (Taos Box and Lower Gorge)	Contingent valuation	$20, $27 per trip
Duffield (1993)	Pemigewasset River, New Hampshire	Whitewater boating	Contingent valuation	$31 to $44 per trip (500-600 cfs; 1000-1100 cfs)
		SUMMARY OF PER-TRIP VALUES	**HIGH:** $1,159	**LOW:** $20 **MEDIAN:** $156
Bergstrom and Cordell (1991)	Nationwide	Rafting and tubing	Travel cost	$33 per day; $42 per trip

OTHER RECREATIONAL ACTIVITY

In addition to fishing and whitewater sports, dam licensing decisions can affect numerous other categories of recreational activity. For example, a mitigation plan may include conservation and/or restoration of nearby wetlands, influencing hunting and wildlife viewing opportunities. Likewise, changes in reservoir management may affect swimming beaches or shoreline activity such as camping. Benefits transfer approaches like those described above can be used to estimate the value of changes in these types of recreational activity.

Economists have conducted numerous studies of consumer surplus associated with various recreational activities. It is beyond the scope of this document to review the many estimates that have been developed. However, several surveys of the recreational value literature exist. Two commonly cited surveys are:

- "Benefit Transfer of Outdoor Recreation Demand Studies, 1968-1988," by Richard G. Walsh, et al., *Water Resources Research*, Vol. 28, No. 3, pp. 707-713, March 1992.

- "An Analysis of the Demand for and Value of Outdoor Recreation in the United States," by John Bergstrom and Ken Cordell, *Journal of Leisure Research*, Vol. 23, No. 1, pp. 67-86, 1991.

When developing a benefits transfer estimate for other recreational activities, the analyst may want to consult these and other studies to obtain relevant surplus estimates.

USING INSTREAM FLOW STUDIES IN A BENEFITS TRANSFER

Facility operation alternatives examined by FERC often focus on differences in flow in downstream river reaches. Participants, including FWS, may argue for enhanced river flows as a means of improving fish habitat and increasing recreational opportunities. The discussion below reviews a simple screening-level methodology that can be used to assess the costs and benefits of operation alternatives affecting streamflow.

Marginal Benefits of Instream Flow

In Chapter 5, we noted that studies of instream flow seek to determine the value of a unit of water that remains instream for recreational or aesthetic use. The value of the marginal unit of water devoted to instream flow can be compared to the marginal value of that unit of water used to generate hydropower. Such a comparison can be used to allocate the water to the highest value use.

Exhibit 6-5 presents results from a number of streamflow recreation valuation studies. The table briefly describes the resource examined and the estimation methodology used, and then presents results from each of the studies. Specifically, it reports the value per acre-foot of water at different baseline streamflow levels or for the change in flow addressed in the study. For example, the study by Duffield, et al. (1992) estimates that an additional acre-foot of water added to a base streamflow of 100 cfs in the Big Hole River is worth about $33 ($1997) when willingness to pay is aggregated across all anglers using the fishery. Note that, consistent with the concept of declining marginal benefits discussed earlier, the marginal value per acre-foot decreases at larger baseline flow levels. For example, at a streamflow of 300 cfs, Duffield et al. estimated that an additional acre-foot of water is worth only about $23, in contrast to the value of $33 at 100 cfs.

As shown, the estimated marginal value of an acre-foot of water for recreational use varies by baseline streamflow and the recreational activity underlying the marginal value. Lower streamflows will yield greater willingness to pay for additional flow. To place the marginal values on a more consistent basis, we can compare the studies that estimated marginal values at a baseline flow level of 100 cfs. Even at this common flow level, the estimated value of an additional acre foot of flow ranges from a low of $1 (Narayanan) to a high of $55 (Daubert and Young, including fishing, boating, and shoreline recreation).

This kind of variation is largely explained by the level and nature of the recreational activity underlying the marginal values. For example, the low marginal value in Narayanan's study is partly attributable to the non-unique nature of the recreational opportunities afforded by the Blacksmith River and the relatively low number of users (about 2,000 for the July through September period under consideration). In contrast, Duffield et al. (1992) estimated relatively large marginal values for maintenance of the fishery on the Big Hole River, a world-renowned fly fishing site attracting over 15,000 anglers in July and August alone (Duffield, et al., 1990). Similarly, Daubert and Young's study focused on the Cache la Poudre River in northern Colorado, a popular recreational resource attracting more than 100,000 users each year. The extensive use of this site contributes to the relatively large willingness to pay for increased flow.

Past studies have attempted to review the streamflow literature and summarize the range of instream flow values obtained. Brown found values ranging from $1 to $25 while Loomis found values averaging between $14 and $27 per acre-foot.[20] An analysis by Hansen and Hallam

[20] Brown, Thomas C., "Water for Wilderness Areas: Instream Flow Needs, Protection, and Economic Value," *Rivers*, Vol. 2, No. 4, pp. 311-325, October 1991. Loomis, John, "The Economic Value of Instream Flow: Methodology and Benefit Estimates for Optimum Flows," *Journal of Environmental Management*, Vol. 24, pp. 169-179, 1987.

Exhibit 6-5

SUMMARY OF STUDIES ESTIMATING THE MARGINAL VALUE OF INSTREAM FLOW

Study	Method	Site	Recreational Activity and Other Relevant Conditions	Aggregate Marginal Value	
				$ per acre-foot ($1997)	**Flow Basis[1]**
Values Based on Recreational Fishing					
Duffield, et al. (1992)	Contingent valuation; model integrates both participation and quality effects	Big Hole and Bitteroot Rivers (MT)	Big Hole offers world-renowned fly fishing (brown and rainbow trout)	$33.23 $22.97 $19.65 (Big Hole)	100 cfs 300 cfs 500 cfs
Johnson and Adams (1988)	Combined use of fishery production model and contingent valuation	John Day River (OR)	Steelhead and chinook salmon recreational fishing; relatively small number of anglers (888 anglers each year). Marginal values apply to summer (low-flow) months.	$0.74 $3.29	204 cfs (instream recreation only) 204 cfs (including out-of-basin benefits)
Daubert and Young (1981)	CV using photos of different flow levels	Cache la Poudre River (CO)	Survey sample included anglers, shoreline recreationalists, and white-water enthusiasts; marginal values include only fishing. Marginal values apply to May through October fishing season (average of 228 anglers per day).	$25.86 $11.86 -$2.16[2]	100 cfs 300 cfs 500 cfs
Walsh, et al. (1980)	CV; model integrates both participation and quality effects	Nine sites on Colorado rivers	Sites in Colorado River Basin in Northwest Colorado; figure reflects fishing only	$28.71	35% of max. pre-existing flow
Harpman (1990)	CV	Taylor River (CO)	Brown trout fishery	$2.40	40 cfs (critical low winter flow)

Exhibit 6-5

SUMMARY OF STUDIES ESTIMATING THE MARGINAL VALUE OF INSTREAM FLOW (continued)

Study	Method	Site	Recreational Activity and Other Relevant Conditions	Aggregate Marginal Value: $ per acre-foot ($1997)	Aggregate Marginal Value: Flow Basis
Values Based on Other Recreational Activities					
Narayanan (1986)	Travel cost model to estimate recreational demand and CV to determine effect of flow on visitation	Blacksmith River (UT)	Recreational activities include fishing and shoreline recreation (hiking, camping). Total of 1,988 visits in July-September period. Marginal benefits estimated by determining willingness to pay for additional flow at hypothetical levels below baseline flow.	$0.80	100 cfs
Ward (1987)	Travel cost	Rio Chama (NM)	Fishing and boating	$40.04	low boating flow (1,000 cfs)
Duffield, et al. (1992)	Contingent valuation; model integrates both participation and quality effects.	Big Hole and Bitteroot Rivers (MT)	Bitteroot offers fishing and general shoreline recreation	$13.46 $10.23 $8.94 (Bitteroot)	100 cfs 300 cfs 500 cfs
Loomis and Creel (1992)	Travel cost	San Joaquin and Stanislaus (CA)	Fishing, wildlife viewing, and hunting; San Joaquin River used more extensively than Stanislaus.	$50.58-$130.38 $12.34-$14.61	San Joaquin (dry year) Stanislaus (dry year)
Daubert and Young (1981)	Contingent valuation using photos of different flow levels	Cache la Poudre River (CO)	Survey sample included anglers, shoreline recreationalists, and white-water enthusiasts	$17.65 $11.04	100 cfs; shoreline use 100 cfs; boating
Walsh, et al. (1980)	CV; model integrates both participation and quality effects	Nine sites on Colorado rivers	Sites in Colorado River Basin in Northwest Colorado; survey sample included rafters and kyakers	$4.42 $8.83	Rafting Kyaking 35% of max. pre-existing flow

[1] **cfs = cubic feet per second**

[2] Figure negative due to decreasing marginal willingness to pay for additional flow, i.e., high flow levels detract from fishing experience.

Note: Some figures drawn from Brown, Thomas C., "Water for Wilderness Areas: Instream Flow Needs, Protection, and Economic Value," *Rivers*, Vol. 2, No. 4, pp. 311-325, October 1991; and Loomis, John, "The Economic Value of Instream Flow: Methodology and Benefit Estimates for Optimum Flows," *Journal of Environmental Management*, Vol. 24, pp. 169-179, 1987.

used cross sectional analysis across the lower 48 states to determine that marginal values of flows for fishing are generally below $10 per acre-foot, although regional values can be significantly higher.[21]

Overall, available studies suggest that at depleted baseline flow levels, the marginal value of instream flow can be segmented into two categories:

- For rivers that either offer high-quality recreational opportunities or are used extensively for recreation, willingness to pay may be in the range of $10 to $50 per acre foot of water.

- For rivers that offer conventional recreational opportunities or receive only a modest number of visitors, lower values of about $1 to $10 per acre-foot may be more typical.

Estimates of willingness to pay for instream flow must be interpreted carefully. First, as discussed, the estimates are very sensitive to differences in use levels and the underlying value per day for recreation at the site. Duffield, et al. reviewed a number of studies of instream flow and concluded that comparing the marginal values requires correcting for key differences in activity levels, value per day of activity, and the baseline flows on which the marginal values are based.[22]

Second, all of the instream flow studies cited here were conducted for rivers in the West. Seasonal water shortages are of greater concern in arid regions and may heighten concern over flows, thereby influencing willingness to pay estimates obtained in CV studies. Furthermore, most of the study rivers are in relatively undeveloped areas. Eastern rivers may be affected by other factors (e.g., shoreline development) that influence the recreational experience and willingness to pay. Overall, the available studies may overstate the value of flow in many rivers in the eastern U.S.

Finally, it is important to understand how the policy context of the instream flow studies differs from the current context of hydropower dam effects. Most of the studies consider competition between downstream recreational uses and consumptive uses. True consumptive uses such as irrigation and drinking water involve withdrawals that, to a great degree, are never

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[21] Hansen, LeRoy T. and Arne Hallam, "National Estimates of the Recreational Value of Streamflow," *Water Resources Research*, Vol. 27, No. 2, pp. 167-175, February 1991. Note that Hanson and Hallam considered values for marginal flow evaluated at current river flow levels nationwide. The marginal values estimated generally are lower than those found in other studies because the study did not focus on rivers subject to periodic or chronic low flow.

[22] Duffield, John, et al., *Instream Flows in the Missouri River Basin: A Recreation Survey and Economic Study*, prepared for Montana Department of Natural Resources and Conservation, July 1990.

returned to the river. In contrast, hydropower facilities generally affect flow by diverting water around by-pass reaches; the water ultimately is returned to the river.[23] The point at which the water is returned to the river, however, may be several miles downstream, affecting the ecology and uses of the bypass reach. Therefore, the size of the river reach affected becomes an important consideration when examining the applicability of existing instream flow studies to dam sites. While few of the studies specifically state the size of the river under consideration, it is possible that the studies apply to areas bigger than typical bypass reaches. Because the magnitude of benefits estimated for increased streamflow are a direct function of the degree of recreational use of the river (i.e., large reaches may be used more by more recreationalists), an instream flow valuation study for a bypass reach may find lower benefits per unit of flow than is found in the existing literature.

In contrast, it is noteworthy that many existing studies may *under*estimate the value of increased streamflow because they look exclusively at changes in willingness to pay among current river users. In addition to this effect, increased streamflow may attract new users to the site. The addition of new users increases the overall value of increased flow. The studies that have developed separate estimates of quality and participation effects have found that impacts on participation can add significantly to overall streamflow values.[24]

Marginal Cost of Foregone Power

As noted earlier, estimates of the marginal value of an acre-foot of water for recreation can be compared to the marginal value of an acre-foot of water used to generate hydroelectric power to determine the most efficient allocation of the resource. To make this comparison, we must determine the marginal social cost imposed by foregoing one acre-foot of water at the dam. In most cases, the real marginal social cost will be the additional cost incurred to generate the lost electricity at the next best replacement power source. That is, the real cost is difference in the marginal cost of generating the power at the replacement source rather than the dam.

[23] Note that impoundment of water and subsequent evaporative losses may be significant at some projects.

[24] Duffield, John W., et al., "Recreation Benefits of Instream Flow: Application to Montana's Big Hole and Bitteroot Rivers," *Water Resources Research*, Vol. 28, No. 9, pp. 2169-2181, September 1992.

To determine the marginal value of an acre-foot of water at the dam, we must first determine how much electricity an acre-foot of water generates. An acre-foot of water is estimated to generate 0.87 kilowatt hours of power per foot of head at the dam.[25] For example, at a dam with 200 feet of head, an acre-foot of water will generate 174 kilowatt hours of electricity (200 * 0.87 = 174).

To value the foregone power, we need to know the difference in the marginal cost of generating the power at the dam versus the cost of generating at the replacement source. While hydropower facilities involve a large initial capital investment, the cost of generating small additional units of power is essentially zero; i.e., to simplify, we can assume that the marginal cost of generation at the dam is zero. Therefore, the incremental cost is simply the marginal cost to generate the power at the replacement source. To summarize, the marginal instream benefit of an acre-foot of water can be compared to the marginal cost of foregone power, where the marginal cost is estimated as:

MC = (Head * 0.87) * Marginal cost of generation at the replacement source

Comparing Benefits and Costs of Streamflow

The approaches to estimating the benefits and costs of increased streamflow described above can be combined to develop a simple screening analysis of optimal resource allocation. This screening analysis can help determine whether more detailed analysis is warranted in a FERC relicensing action.

Marginal Analysis

Exhibit 6-6 presents a simple illustration of how marginal benefits and costs of streamflow can be compared. In the example, the dam produces 87 kWh of electricity for each acre foot of water. The avoided replacement cost of power is $0.03 per kWh, meaning that the cost of foregone power is $2.61 per acre foot. Assume that the depleted river reach currently has flows of only 50 cfs, but has the potential to offer high-quality recreational fishing and rafting at higher flow levels. Therefore, the potential value per acre foot for recreation is likely in the higher range noted earlier -- $10 to $50 per acre foot. This simple comparison suggests that overall economic welfare would be enhanced if power generation is decreased and instream flow increased, i.e., further research on recreational values may be justified.

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[25] Loomis, John, and Marvin Feldman, "An Economic Approach to Giving 'Equal Consideration' to Environmental Values in FERC Hydropower Relicensing," *Rivers*, Vol. 5, No. 2, pp. 96-108; the figure is originally drawn from Gibbons, D., *The Economic Value of Water*, Resources for the Future, Washington, DC, 1986.

Exhibit 6-6 ILLUSTRATION COMPARING MARGINAL BENEFITS AND COSTS OF INCREASED STREAMFLOW	
Head at dam (feet)	100
kWh per acre foot per foot of head (constant)	0.87
kWh per acre foot	87
Marginal cost of replacement power ($/kWh)	$0.03
Marginal cost of replacement power ($/acre foot)	$2.61
Range of potential recreational benefits ($/acre foot)	$10 to $50

Aggregate Analysis

FWS participants in the relicensing process may also encounter situations where the licensee estimates the aggregate costs of higher instream flow. For example, the licensee may estimate that increasing river flows from 50 to 100 cfs for six months each year would reduce revenues by $20,000 per year. In these cases, FWS may wish to simply estimate aggregate potential recreational benefits that are comparable to aggregate costs. Provided that the streamflow changes are relatively small, the marginal values reviewed above can be used to estimate total potential benefits associated with the increased streamflow.

The first step in this type of aggregate analysis will be to convert streamflow changes, generally expressed in cfs, to changes in additional acre feet released to the river. Continuing the example, increasing streamflow from 50 to 100 cfs for six months each year translates to 18,050 additional acre feet of water flowing through the river. Specifically, one cfs per day equals 1.9835 acre feet. If an additional 50 cfs are released over 182 days (six months), this translates to 18,050 acre feet.[26]

The next step would be to select a per-acre-foot value that is applicable to the river in question. If the affected river has characteristics similar to a river examined in one of the marginal value studies discussed above, the appropriate value could be applied. In most cases, however, it will be prudent to apply one of the general ranges of estimates discussed earlier. If the affected river offers the potential for average fishing and general streamside recreation, a marginal value in the $1 to $10 range will likely be appropriate. Multiplying the total acre feet added to flow (18,050) by this range yields an estimated instream recreational benefit of between roughly $18,000 and $180,000. The estimated cost of the increased flow ($20,000) falls at the low end of this range, suggesting that the benefit of the increased flow may outweigh the costs. More detailed research on likely recreational effects of flow increases would be warranted.

☞ As we review in our case study chapter, FERC applied this approach in relicensing the Morris Sheppard Dam in north Texas.

[26] 50 * 1.9835 * 182 = 18,050

ESTIMATING NON-USE VALUES USING BENEFITS TRANSFER

As discussed, non-use values represent another potential major category of non-power benefits. Several contingent valuation studies are potentially relevant in inferring non-use and total (use and non-use) value for FERC relicensing alternatives. This section first provides brief summaries of these studies and then discusses how these estimates can be applied in a benefits transfer to obtain screening-level estimates of potential non-use values.

Relevant Contingent Valuation Studies

The relevant contingent valuation studies can be separated into two groups: those that value the removal of a hydroelectric dam and those that value either increased river flows or the preservation of current flows. We summarize these studies in Exhibits 6-7 and 6-8 and in the discussion below.

Dam Removal Studies

Two studies have explicitly considered individuals' willingness to pay for removal of dams. First, Loomis (1996) valued the removal of two Olympic Peninsula dams, the Elwha Dam and the Glines Canyon Dam, in Washington State. According to DOI, removal of the two dams would significantly improve the area's salmon and steelhead populations. A contingent valuation mail survey was used in valuing the removal of the two dams. The sample population consisted of three groups, residents of Clallam County on the Olympic Peninsula, residents of Washington State outside of Clallam County, and U.S. residents outside of Washington State. Estimated mean annual willingness to pay per household for the three groups was about $60, $74, and $69 respectively.

☞ A case study in Chapter 7 of this report provides details on the approach and findings of the Loomis study.

Exhibit 6-7

STUDIES OF WILLINGNESS TO PAY FOR DAM REMOVAL

Study	Resource Valued	Survey Type	Population	Annual WTP per Household ($1997)
Loomis, 1996	Removal of Elwha and Glines Canyon dams, Washington State	Mail	Clallam County households	$60
			Washington State	$74
			Other U.S. States	$69
Gilbert *et al.*, 1996	Removal of Newport No. 11 Diversion Dam, Vermont	Telephone	Orleans County	$67
			Vermont, excluding Orleans County	$52

Second, Gilbert et al. (1996) valued the removal of Newport No. 11 Diversion Dam on the Clyde River near Newport, Vermont. A contingent valuation telephone survey was used to value dam removal and restoration of landlocked salmon to the 1/4 mile portion of the Clyde River closest to Newport. The sample population was divided into households from local Orleans County and households from the rest of Vermont. Respondents were first asked a dichotomous choice question wherein they agreed to either an $80 or $130 annual payment. Funds collected would go into a trust fund set up especially for funding the dam removal. After answering the dichotomous choice question, respondents were asked to report the most they would be willing to pay for the program, a special type of open-ended question. Due to complications resulting from the small number of bids, value estimates were based on the second, open-ended response. The estimated mean annual willingness to pay was $67 for the Orleans County group and $52 for the rest of Vermont.

River Flow Studies

A second set of contingent valuation studies examines willingness to pay for restoration or preservation of river flow (see Exhibit 6-8). First, Clonts and Malone (1990) valued the preservation of flows in fifteen free-flowing rivers in Alabama, a state where only 20 percent of the nearly 12,000 miles of streams and rivers remain free-flowing. Through several questions on Alabama river-related activities, users and non-users were identified. Mean annual willingness to pay to maintain the fifteen study rivers in their natural condition was estimated to be about $96 for the user households and $59 for non-user households.

Sanders, et al. (1990) valued the preservation of flows in sections of eleven Colorado rivers. Preservation would be accomplished by designating the sections protected under the Federal Wild and Scenic Rivers Act (1968). The survey asked respondents to report their willingness to pay for protecting flows on their favorite of the eleven rivers, their top two choices, top three choices, top four choices, and for all eleven rivers. Mean annual willingness to pay for the most important river was $26.52; for the three most important rivers, $59.91; and for all eleven rivers, $155.36.

Berrens et al. (1996) valued the protection of minimum instream flows on New Mexico rivers. The survey explained to respondents the legal use of water in New Mexico and how current consumption and diversion threatens eleven fish populations considered either threatened or endangered. Respondents were asked to state their willingness to pay into a special trust fund designated for purchasing water to maintain instream flows. The mean willingness to pay for the protection of minimum instream flows in all New Mexico rivers was estimated to be $94. Part of the sample was first asked a question about their willingness to pay to protect flows in a single river, the Rio Grande, where only one of the eleven fish populations would benefit. The estimated willingness to pay for this more limited commodity was about $30.

Exhibit 6-8

STUDIES OF WILLINGNESS TO PAY FOR IMPROVEMENT OR PRESERVATION OF RIVER FLOWS

Study	Resource Valued	Survey Type	Population	Annual WTP per Household ($1997)
Clonts and Malone, 1990	Preservation of Flows in 15 Alabama Rivers	Telephone	River Users	$96
			Non-Users	$59
Sanders et al., 1990	Designation as Wild and Scenic of up to 11 Colorado Rivers	Mail	Colorado Households	$27[a]
				$60
				$155
Berrens et al., 1996	Minimum Instream Flows in all New Mexico Rivers (to protect fish species)	Telephone	New Mexico Households	$30[b]
				$94
White River Valuation Study, 1998	Preventing Hydro Development of White River in Vermont	Mail	White River Households	$52
			Other Vermont Households	$19
			Non-user White River	$24[c]
			Non-user Other	$15[c]
Welsh et al., 1995	Reducing Flow Fluctuations on the Colorado River, Glen Canyon Dam	Mail and Telephone	U.S. Households	$21[d]
			Salt Lake City Households	$30

a. The estimates provided are for preservation of the most important, three most important, and the entire set of eleven rivers.
b. The first estimate coincides with a valuation scenario that would protect a single fish species in one river whereas the second estimate pertains to preservation of eleven fish species on all New Mexico Rivers.
c. Estimates are of the median willingness to pay.
d. The study provided three alternatives for reduced flow fluctuations. This estimate is associated with the greatest reduction.

The National Wildlife Federation (1998) valued the prevention of obstructions and diversions on Vermont's White River. The White River is one of only two Vermont rivers that flows free of obstructions or diversions for its entire length. Half of the survey sample was from households located along the White River (locals) and the other half of the sample was drawn from households located in other areas of Vermont (state). Respondents were first asked about their use of the White River, allowing identification of users and non-users for both the local and state populations. Respondents then were asked about their willingness to pay to prevent any reduction in White River flow levels using first a dichotomous choice question and then a follow-up open-ended question. Prior to the valuation questions, Estimates of mean annual willingness to pay was $52 for the local population and $19 for the state population. For the separate user and non-user groups only median willingness to pay, as opposed to the mean, was provided. The estimated medians for users and non-users within the local population are $83 and $24, respectively. For the state population the estimated median willingness to pay for users and non-users was $45 and $15, respectively.

Finally, Welsh et al. (1995) valued the reduction of flow fluctuations on the Colorado River resulting from operation of the Glen Canyon Dam. A contingent valuation mail survey was administered to households in the Salt Lake City area and to other U.S. households. A follow-up telephone survey was administered to mail survey non-respondents. Three alternative flow regimes were considered for both the Salt Lake and national population: (1) moderate fluctuating flow; (2) low fluctuating flow; and (3) seasonally adjusted steady flow. For the Salt Lake population the means of payment was through increased utility bills; the national population was presented with an increase in taxes. For the national population, the estimated means of household willingness to pay were (1) $14, (2) $21, and (3) $21. For the Salt Lake population, the estimated means were (1) $23, (3) $22, and (3) $30.

Applying Existing Estimates in Benefits Transfer

One simple application of the non-use value estimates described above would entail the following steps:

- Identification of an applicable willingness to pay estimate based on the commodity under consideration (e.g., dam removal);
- Determination of the relevant number of households that hold values for the river resource in question; and
- Estimation of an aggregate willingness to pay estimate, multiplying the chosen per-household estimate by the appropriate number of households.

Below, we discuss these steps in more detail for dam removal and flow restoration.

Several caveats to this type of benefits transfer are noteworthy. First, when analyzing multiple benefit categories (e.g., non-use values and recreational fishing values) the analyst must be sensitive to issues of double-counting. Unless explicitly separated, the studies discussed above capture total value, that is, use and non-use value. In some cases, the distinction between users and non-users can be inferred from the segment of the population surveyed. For example, the residents of the county in which the river is located are more likely to be users than are state or nationwide respondents. The analyst should be cautious not to combine, for example, estimated angler consumer surplus estimates with total use estimates for households located near the river.

Furthermore, given the limited set of existing studies, it is almost certain that no single study will be a perfect match for a benefits transfer policy site. Thus it makes sense to consider generating estimates from more than one study if possible, or perhaps adjusting an existing estimate. The major advantage of using multiple estimates is the ability to arrive at a range of potential benefits that can then be used to aid in the decision whether original research is warranted.

Benefits Transfer for Valuing Dam Removal

In cases where the primary relicensing alternative is dam removal, Loomis (1996) and Gilbert et al. (1996), are the obvious candidates for consideration in benefits transfer. The first factor to consider in choosing between the two studies is how well the study site conditions after dam removal match either of the existing study site conditions. The Loomis study valued a very high-profile resource, one with national significance due to the dam's proximity to Olympic National Park. The ecological improvements associated with removal of the Elwha River dams were also expected to be quite significant. On the other hand, the Clyde River study involved a resource of regional significance with a much smaller affected area (1/4 of a mile), although this area was adjacent to the town of Newport. The Loomis study estimates could be used to establish an upper range for major resource improvements that are of national significance. For resources of regional significance, the Gilbert study estimates are more applicable or perhaps a fraction of the estimates from Loomis study.

To identify the number of households holding non-use value for the affected river resource, the analyst should consider the "extent of market" questions reviewed earlier; i.e., how unique is the resource and what geographic area is likely to care about the resource? For example, if the resource is of regional significance, then the total number of households statewide minus the number of households in the immediate area (i.e., those most likely to hold use values) is probably most applicable.[27] Note that the relevant set of households holding non-use values may not be well reflected by state boundaries; the count of total households may include counties in neighboring states.

As an example, suppose that the alternative of removing a hydroelectric dam in Washington State is being considered. Dam removal is expected to result in fish population increases similar to those in the Loomis study for an affected area smaller than in the Loomis study, but larger than in the Gilbert study. A reasonable upper-bound value might be $65 per household, based on the Loomis findings, adjusted down for the difference in the significance of the resource. A lower bound of $50 per household from the Gilbert study could also be applied. Suppose that the number of Washington State households is 14 million and the immediate study area consists of 750,000 households. If only non-use values are at issue, then the upper bound estimate is obtained by multiplying 13.25 million and $65; the lower bound is obtained by

[27] Recall that consumer surplus estimates from most of the available studies reflect use and non-use value. If no other methods are being considered for use benefits, then total use and non-use benefits could be derived for the local households by multiplying the Loomis or Gilbert county estimates by the number of households in the immediate county. If other benefits transfer methods are being used, then it is advisable to avoid applying these local estimates to avoid double-counting.

multiplying the number of households by $50. A preliminary range of non-use benefits is then $662 million to $861 million.

In addition, when considering non-use benefits on a screening level, the analyst could also "back into" useful estimates as described for recreational fishing. For example, dam removal costs and the present value of gross power benefits may total $40 million. We may also know that one million households have non-use values associated with dam removal. The analyst can then ask what willingness to pay per household figure would make the present value of the non-use benefits to exceed the dam removal costs. In this example, willingness to pay per household would only need to be about $3.30 (assuming a 30-year period and seven percent discount rate) for the benefits of dam removal to exceed the costs. Placing this minimum willingness to pay in the context of existing estimates suggests that non-use values would likely exceed dam removal costs.

Finally, note that dam removal options may occasionally affect resources of national significance. The practice of multiplying the number of U.S. households by an existing consumer surplus estimate is potentially appropriate in these cases. However, serious consideration of dam removal for a resource of national significance will likely warrant original research, eliminating the need for benefits transfer.

Benefits Transfer for Valuing Restoration of River Flow

In applying willingness to pay estimates from studies valuing flow changes, guidelines similar to those discussed for dam removal apply. Several additional factors must be considered. First, the existing studies consider flow preservation or restoration that represent major changes relative to operations at most hydroelectric dams.[28] Thus, for minor changes in flow that do not significantly affect river ecology, the existing estimates provide little insight into potential non-use values.

Second, the estimates from the existing studies often reflect values for more than one river, and so must be applied carefully. The Clonts and Malone study exclusively considered the preservation of fifteen rivers and would not be directly applicable when only a single river is involved, although an adjustment of this estimate is possible. The Sanders et al. study as well as the Berrens et al. study focused primarily on the preservation of multiple rivers; these studies do, however, provide estimates for preserving or increasing flows to a single river.

When considering significant flow restoration, the analyst can estimate approximate non-use values by combining willingness to pay ranges from the studies with the applicable number of households as described above. Based on results in the Clonts and Malone, Sanders, and White River studies, a reasonable range of non-use values for households not immediately located on the river would be $5 to $25. Specifically, the Clonts and Malone non-user value

[28] The Welsh, et al. study did consider a moderate fluctuating flow, but the study site, Glen Canyon Dam on the Colorado River, is far from typical.

($59) divided by 15 rivers equals about $4; the Sanders single-river value is about $27; and the White River non-user values are between $15 and $24.