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A Cost-Benefit Analysis of Lower Snake River Dam Breaching

The question of whether or not to remove the four dams on the lower Snake River, for the purpose of restoring the river to its previous state, or in order to restore native salmonid populations, is one that is widely contended on a regional and federal level. Cost-benefit analyses are often used in this and other situations to outline the actual costs and savings from certain explicit actions, such as the removal of the dams themselves.

These analyses, however, fail to take into account the implicit costs and benefits of removal, without which they are virtually useless in examining the overall reasonability of certain actions. A complete economic approach, which approximates the implicit as well as the explicit costs likely to occur as a result of the action of dam removal, would more accurately portray a complete, total cost-benefit analysis. Thus, this paper will attempt to outline the theoretical model for such an analysis, tailored to the lower Snake River issue, and determine the true costs and benefits of the proposal to breach the dams.

BACKGROUND

The topic of lower Snake River dam removal has been upon the debate table since the mid-1990s. At first a radical idea limited to conservation groups and environmental coalitions, the concept developed into something more scientifically and politically palatable by the close of the 20th Century. In recent years, the removal of larger dams throughout the United States has paved the way, at least as far as feasibility, for the dams to be removed.

Collectively referred to as the lower Snake River dams, the group comprises four dams constructed, owned, and operated by the US Army Corps of Engineers (USACE), namely the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams. They lie on the lower Snake River between city of Lewiston, Idaho (which sits at the confluence of the Clearwater and Snake Rivers) and the confluence with the Columbia River, near the Tri-Cities, Washington. They are all hydroelectric projects, classified as run-of-the-river dams, with little storage capacity, which were built from 1962 to 1975.

Each of the four dams is owned by the USACE Walla Walla District, and their authorized purpose is described as "power generation and inland navigation" (USACE 2005a-d). The most downstream of the dams, Ice Harbor, is located at river mile 9.7, just upstream from the confluence with the middle reach of the Columbia River. Closest to Lewiston, is Lower Granite, at river mile 107.5, which is still about 30 river miles downstream from Lewiston. The reservoir impounded by Lower Granite works with levees in Lewiston and the neighboring town of Clarkston, Washington to create a seaport in Lewiston, which is accessible, via locks at each of the dams, by barges from the downstream Columbia and the Pacific Ocean.

The sum of the total nameplate ratings of the 24 generators (six at each of the dams) is just over 3 million kilowatts. In comparison, the McNary project near Umatilla, Oregon, on the Columbia River just below the Snake River confluence and below the Hanford Reach, also administered by the Walla Walla District, has a total nameplate rating of just under 1 million kilowatts (USACE 2005e).

In examining sources of benefits derived from the dams, other uses than the "authorized" ones must be taken into account. "Fishery and recreation" are listed as other uses for all four of the dams, and Lower Granite's official information also lists "flood control (maintain levee

freeboard at Lewiston)" (USACE 2005c). This refers to the maintenance of water levels in Lewiston below the level of the levees, so that the city does not experience flood conditions.

All of the dams are in the state of Washington, spanning Franklin, Walla Walla, Garfield, Whitman, and Columbia counties. The reservoirs impounded by the dams form a continuous shipping channel to Lewiston, and Lower Granite Lake stretches past Lewiston up the Clearwater and Snake rivers, for a total of 39.6 river miles up the Snake and to Clearwater River mile 4.6 (USACE 2005c).

The theoretical model will approximate the costs and benefits associated with dam removal and will include analyses of the industries and local economic factors which would (at least as much as can be proven) be affected by the removal of the dams. Much of the area's agricultural irrigation is derived from the dams, and a majority of the farms are owned and operated by corporations. In addition, commercial operations in Lewiston are centered on barge traffic, which is used as the primary form of transportation for agricultural products from the region.

As outlined by the USACE, the plan to remove the lower Snake River dams involves breaching the embankments at the dams, and leaving the structures in place to the side of the new river channel. Expenditures for channelization would be utilized to restore the river's channel through the breached abutments, beside the decommissioned dam structures, which would (at least under their plan) remain in place until eventually removed (USACE 2002 Summary 9). It should be noted that the terms "removal," "breaching," and "bypass" are used interchangeably to describe the possible restoration of the free-flow of the lower Snake River and the decommissioning of the dams' hydroelectric diversions, as well as the drawdown and removal of the reservoirs impounded by the projects.

All told, the four Snake River dams have many broad-reaching effects on their surroundings, not just the 140 miles of river on which they are placed. These effects, in terms of costs and benefits if the dams were to be removed, are what will be analyzed using the following theoretical model.

THEORETICAL MODEL

The hardest part of crafting a model for a sound cost-benefit analysis of the question of whether or not to remove the lower Snake River dams is determining the myriad sources of costs and benefits that would be associated with the project. The theoretical model for determining the effects of the dams on their surroundings will in turn be used to estimate the approximate monetary costs and benefits represented by these relationships. In short, the theoretical model will determine the economic relationships used to make the analysis. Scientific and economic principles will be used to profile and assemble this theoretical model.

Many of the cost-benefit relationships are explicit, as mentioned above, meaning that they have a known, traceable relation to the removal of the dams. For example, the actual costs of removing the dam structures (breaching and removal of the concrete portions of the dams) are explicit. They can be estimated and are clearly a direct cost of the dam removal project.

Other costs and benefits, however, are based upon more indirect relationships. An example, one which will undoubtedly figure into any discussion of dam removal on the lower Snake River, is that of salmonid population restoration. The benefits associated with dam removal, therefore, must include the implicit benefits derived from the restoration of salmonid populations. Finding the implicit costs and benefits that can be proven to be associated with dam removal, however, is the ultimate issue. Cataloguing these will also prove to be difficult, based

solely upon the nature of the issue, which spans a large region and affects many different industries, economies, and populations, both within its reach and downstream.

Cataloguing the Explicit and Implicit Costs and Benefits

The first step is to compile a list of costs and benefits which are likely to be incurred by the removal of the lower Snake River dams. These general categories will then be used to determine specific analyzable aspects which can be built into the cost-benefit function. Table 1 outlines the specific categories which were determined.

Table 1 - Cost and Benefit Sources

Category	Sources
Industrial	Barging
	Rail freighting
	Trucking
	Port retrofits
Commercial	Passenger navigation
	Recreation and tourism
Agricultural	Irrigation supply
	Freight costs
Direct Removal Costs	Decommissioning
	Structure breaching
	Structure removal
	Site restoration and cleanup
	Lost revenue on sale of power
Avoided Costs	Elimination of maintenance costs
Employment	Dam employees and operators
Environmental	Restoration of salmonid populations
	Free-flowing river restoration
	Recovery of riparian zones

A cursory overview of these sources reveals that they are themselves broad in concept and in the range of associated potential costs and benefits. Examination of each of the main categories in particular will help to determine which of the costs and benefits are able to be estimated, and therefore will be included in the analysis. Before costs or benefits from a specific category or issue are included, however, they must be proven to be related to the issue. The degree to which the included factors are proven to be relevant to the issue will be directly related to the feasibility and overall integrity of the study.

Analyzing the Costs and Benefits – Explicit Costs of Dam Removal

For the purposes of categorization of costs and benefits, they must be defined in relation to the project. Costs will be defined as any outflow of resources from any agency (e.g., the USACE's

expenditures for actual dam removal), economy, or the difference in pre-removal levels (of production for instance) and the estimated levels after the removal of the dams. Benefits are those things that involve an inflow of resources to an agency, an economy, or a measurable increase in some resource or population whose value can be ascertained and which increase can be determined to be a result of dam removal.

Costs and benefits must also be categorized based on their nature. Some, such as the real costs of removal of the dam structures, are one-time costs. Others are annual costs or benefits, which will be realized over a long period of time. Therefore, to provide an accurate picture, they will be categorized separately.

Table 2 – Estimated Implementation Costs of Dam Removal

Cost Category	Estimated Amount	
Real Estate (Excessing Property)	$	841,000
Project Dam Decommissioning	$	5,006,000
Cultural Resources Protection	$	5,999,000
Cattle Watering Facilities	$	6,030,000
Drainage Structred Protection	$	8,830,000
Lyons Ferry Hatchery Modifications	$	9,047,000
HMU Modification	$	8,841,000
Recreation Access Modification	$	12,509,000
Railroad Relocations	$	21,913,000
Power House Turbine Modifications	$	30,952,000
Reservoir Revegetation	$	26,336,000
Temporary Fish Handling Facilities	$	37,018,000
Bridge Pier and Abutment Protection	$	48,321,000
Railroad and Roadway Damage Repair	$	95,538,000
River Channelization	$	123,446,000
Dam Embankment Removal	$	158,775,000
Reservoir Embankment Protection	$	184,432,000
Mitigation Costs	$	25,696,000
Total	$	809,530,000

USACE LSR Juvenile Salmon Feasability Study, I-33

By far the easiest to examine are the costs and benefits directly related to the removal of the dams. By directly related, it is meant that they are incurred by the very act of removing the dams, and thus their relevance is not suspect. These are categorized further as explicit costs, because their values can be readily determined in a way that is relevant to the removal of the dams. Shown in Table 2 are the estimated explicit costs of the removal of the four lower Snake River dams, as laid out in Appendix I of the USACE's Lower Snake River Juvenile Salmon Migration Feasibility Study. In this study, the proposal to breach the dams and restore the river to a free-flowing state is examined alongside three other alternatives (USACE 2002 Summary 22).

The final item outlined in Table 2, "Mitigation Costs," is defined as those costs that include fish and wildlife habitat mitigation efforts, preservation of cultural resources, and protecting habitat and cultural sites. The numbers for each of the cost categories are irrelevant when considering the theoretical model, which seeks to include all of the costs and benefits associated with the project. They will be referenced in the calculations and application of the cost-benefit function, however, and the important conclusion is that they are all unique, unavoidable, and real costs that must be figured into the analysis as explicit costs of dam removal. It should be further noted that the figures in Table 2 are evaluated at a discount rate of 6.875%, meaning that the interest costs of the implementation have already been accounted for, so no further financing cost calculations should be necessary.

In Table 3, the annual project-related costs are outlined, again from the USACE study of Salmon Migration Feasibility. These costs reflect additional annual costs as a result of the removal of the lower Snake River dams. The USACE estimated "Avoided Costs" for the project at $29,178,000 annually, a number that reflects the costs of continued operation of the dams, which would not be expended after the implementation of the dam removal alternative (USACE 2002 I-38). The sum of the costs outlined in the table, minus the avoided costs, will yield the net annual costs of project operations, which shall be deemed explicit annual costs of dam removal, and which will be included in the cost-benefit function.

Table 3 - Annual Estimated Costs with Dam Removal

Cost Category	Estimated Amount	
Anadromous Fish Evaluation Program	$	38,428,000
BOR Water Purchase	$	43,300,000
Wildlife Monitoring	$	179,000
Vegetation Monitoring	$	382,000
Fish Monitoring Costs	$	32,442,000
Water Quantity Monitoring Costs	$	6,094,000
Air Quality Monitoring Costs	$	504,000
Sedimentation Monitoring Costs	$	1,553,000
Total	$	122,882,000

USACE LSR Juvenile Salmon Feasability Study, I-35

Analyzing and determining the benefits of dam removal is not as clearcut or as easy as reading the USACE's latest estimates. There is

much debate as to the nature and evaluation of indirect or implicit benefits of dam removal (such as the effect on salmon runs). In addition, for each assumption made, there are others that must follow. For example, an increase in salmon populations would likely lead to an increase in recreational fishing, so that the recreational fishing sector of the local economy might show increases that are (indirectly) a result of dam removal. Estimating this web of relationships, both with costs and benefits, is perhaps the most difficult part of building an effective cost-benefit function. For without sound relations between the parts of the function, and without sound evidence of a relationship with the issue (in this case, with the dam removal project itself), the results are meaningless.

Estimating Implicit Costs and Benefits

To provide for the estimation of these related costs and benefits, which are related to the removal of dams on the lower Snake River, but cannot be directly estimated due to the mysterious nature of the relationships between the dams and these certain biological and economic processes, an empirical analysis of the problem will be attempted.

One of the largest suggested benefits of dam removal is that of restored salmon runs in the basin, due to the fact that salmon would have fewer impediments blocking their upstream and downstream migrations. Several studies have suggested that the presence of the dams on the lower Snake River has resulted in a large decrease in salmon runs, and a high mortality rate of the existing runs due to the increased risks of fish passage through dams. While four of the eight dams would still exist under the proposed plan for dam breaching, the free-running river stretch, in addition to the halving of the number of projects fish would have to pass through, is considered tantamount to the eventual restoration of the salmon populations, which are listed on the roll of Endangered Species.

Valuing these runs, however, is another complex question. Even if we were to assume that the runs would eventually be completely restored to their historical (pre-lower Snake River dam) levels, which is not necessarily the most likely situation, analyzing this eventual increase in terms of monetary valuation is seemingly impossible. Measurable effects of dam removal, however, include increased salmon fisheries on the river and a boom in the recreational fishing sector, which would likely result in economic growth in the region. There is still another factor, however, that should be included in the overall cost-benefit analysis, a sort of "goodwill" figure that represents the passive use value of the river, given the increased salmon runs, in addition to the environmental integrity that would be restored to the river basin with the restoration of riverine species and riparian vegetation.

First, some determination must be made as to which implicit values should be included in the study and the cost-benefit analysis. In a study from the consulting firm ECONorthwest, completed in 1999, on the economic effects of dam removal on the lower Snake River, a list of implicit effects was compiled, dealing both with the costs and benefits monetarily, but also with the effects on the job market in the region and on employment in general. In the report, implicit effects are examined in the sectors of Recreation, Irrigated Agriculture, the Transportation System, Electricity Consumption, and Water Users (ECONorthwest 11-12). The result is a list of costs associated with necessary expenditures for these sectors, and response options including additional expenditure programs for which specific monetary costs were not established. Table 4 outlines the findings for these groups.

In addition to the costs and benefits laid out here, other implicit costs should be considered. ECONorthwest estimates the "passive use values for the increase in anadromous fish is about $1 billion," which is specified in an appendix to the report to be the incremental value

for households in the Pacific Northwest and California (ECONorthwest D-7) . This figure represents the annual amount that households would be willing to pay on average to preserve the salmon runs. This average is then applied to the total number of households in the region to yield the figure above. While being only an estimate of the passive use values (as they can only be estimated, because of their very nature of being "passive"), this serves to bring a monetary figure to the concept of salmon preservation, and the value upon which the region's people place on this benefit of dam removal.

Dr. John Loomis, in his examination of the passive use values of the lower Snake River dam breaching possibility for the USACE's 2002 study, places the mid-range of the passive use value for salmon at between $142 and $508 million, and the study also points out that "based on existing literature" there appears to be a passive use value for the free-flowing stretch of the lower Snake River (recreational uses) of around $420 million (Loomis 7). These values will be contrasted with ECONorthwest's evaluation before determining which to use for the overall cost-benefit analysis.

Regional Jobs and Their Role in the Analysis

While each of the categories in Table 4 include an estimate of the total job effect of dam removal in on the lower Snake River, they fail to estimate the value of these jobs, and what this means for the overall economy and overall spending. While it can be surmised that negative job growth as a result of the breaching would mean a negative economic effect, it is hard to determine the exact valuation, more so because of the vague classifications of "long-term" and "short-term." Therefore, for the purpose of this study, it will be assumed that the economic effects of job loss

Table 4 - Economic Findings and Response Opportunities by Sector

Sector	Findings	Proposed Response Programs
Recreation	Middle estimate for increase in sales (annually) from recreational activities is $230 million. 779 reservoir related jobs will be lost, but 3126 will be created with the estimated increase in recreation. **Passive use values for the increase in anadromous fish is about $1 billion.**	No response is necessary. Dam breaching will build local and regional quality-of-life assets that will enhance the competitive advantages of the local and regional economies in the competition for future jobs and business growth. These benefits extend far beyond recreation.
Irrigated Agriculture	13 farming operations, covering 37,000 acres will lose current access to pool of water behind Ice Harbor Dam. Value of affected farmland is $134 million. 2256 jobs would be lost if these lands are removed from production entirely, the worst-case scenario.	Response options include: subsidization of access to groundwater to avoid agricultural production loss; buy-out of farms; and the expansion of worker retraining programs, should the land be taken out of production.
Transportation System	Grain transportation costs will rise about $18.6 million per year. The decrease in farm spending will cause the loss of 239 jobs, but increased rail/truck transport will create 475 long-term jobs. Net job impacts are an increase of 236 jobs. Highway and rail infrastructure expansion will cost $145-267 million. The expansion will generate 2554-4362 short-term jobs	Response options include: subsidization of transportation infrastructure (road and rail); targeting of projects that maintain competitive pressure on transportation prices. Additionally, the general population would benefit from the expanded infrastructure, and the breaching of the dams would eliminate a $10 million annual taxpayer subsidy of the barge transportation system.
Electricity Consumers	Hydropower costs will increase average monthly residential electricity rates between $1.07 and $5.30 per household. Reduced disposable income will cause a loss of 1534 long-term jobs.	Response options include: Subsidy programs for residents on fixed income and irrigated-agricultural producers (who have high volumes of electricity consumption).
Water Users	Modifications to municipal and industrial pump stations would cost $11.5-55.2 million. Modifications to privately owned wells would cost $56.4 million. Modifications would create 1467 short-term jobs.	Response options include: subsidization of modification costs.

Adapted from ECONorthwest, 11-12

and gain the region are negligible, given the overall job market and the fact that the net job change is a positive one in the short term (many short-term jobs are created with the project), while few are lost in the long term due to dam employees and possible farm employees being unemployed.

ANALYZING THE COSTS AND BENEFITS

As the list of factors has now been assembled, the task remains to analyze the costs and benefits of lower Snake River dam removal, and to make a judgment as to whether these numbers are indicative (either positively or negatively) of a clear answer to the question of whether the benefits of dam removal outweigh the immediate costs. Through the inclusion of "fringe" costs and benefits, which are definitely related to dam removal and are a direct result of it, the analysis should be complete and definite in its assertions.

What remains is to assemble the costs and benefits in a manner that displays the recurring annual costs together, separate from the one-time implementation costs. Table 5 does this, and totals within each category the costs and benefits, side by side. Any place where a range was presented, the number used was the average of the range's endpoints (the midrange), and the ECONorthwest figure for passive use value for salmon was used, based on its property of being set at one of the extremes.

Indeed, it can be seen from analysis of the bottom line ("Grand Total Annual Net Benefit") that the majority of the benefits that outweigh the annual costs substantially are the passive use values for recreation. This large number, $420 million of the $516 million total benefit derived from dam removal, equates to just over 80 percent of the total benefit. In addition, the large reduction in implementation costs offset by the initial salmon restoration passive use value (PUV) of $1 billion substantially decreases the amortized amount of

implementation costs. So, the point is that a smaller PUV for either Salmon Restoration or for Recreation would result in a lower total annual benefit from the calculation.

Seeing as how different estimates of the PUV also find much lower numbers (as low as $66 million according to one USACE figure; Loomis 7), the annual net benefit could easily be drastically reduced. Therefore, the calculation should be taken with some advice, and with some hesitance. Any examination of the costs and benefits even remotely associated with such a wide-reaching project should be scrutinized for their scientific connectedness with the issue at hand and for the accuracy of the figures used in the study.

Table 5 - Cost and Benefit Analysis

Cost Category	Estimated Amount	Benefit Category	Estimated Amount
Implimentation	$ 809,530,000	Salmon Restoration PUV	$ 1,000,000,000
Highway and Rail Infrastructure	$ 206,000,000		
Agricultural Buyout	$ 134,000,000		
Modifications to Water Resources	$ 89,750,000		
Total Costs	$ 1,239,280,000	Total Benefits	$ 1,000,000,000
Total Implimentation Net Cost			**$ (239,280,000)**
Transportation Costs	$ 18,600,000	Avoided Costs (Dam Operation)	$ 29,178,000
Project Related Operations Costs	$ 122,882,000	Recreation Sales Increases	$ 230,000,000
		Recreation PUV	$ 420,000,000
Total Costs	$ 141,482,000	Total Benefits	$ 679,178,000
Total Annual Net Benefit			**$ 537,696,000**
Amortized Net Annual Implimentation Cost (Over 20 Years at 6.875%)			$ (21,474,836)
Grand Total Annual Net Benefit			**$ 516,221,164**

CONCLUSIONS AND SUGGESTIONS

From looking at the amounts presented, the conclusion seems simple: the breaching of the Snake River dams would create an economic and social benefit that outweighs its costs. However, such a bland and strict analysis does not do justice to the complexity of the situation. There are biological concerns, such as cleanup of sediments washed downstream, restoration of riverine

and riparian habitats, and problems such as soil erosion and air contamination from the formerly submerged reservoir bed. While most of these are taken into account in the monetary calculations, as most are provided for in the direct operating costs associated with the project, the potential downstream effects are not widely known, and could cause unforeseen cleanup and restoration costs at other sites and in other sub-regions.

Indeed, much of the argument is unknown, and many of the figures represented above are speculations by leading engineers and scientists, both governmental and independent. Their biggest conclusion (and an admission on the part of the USACE) is that the effects on salmon populations and passive use values from recreation and salmon restoration must be taken into account when determining the *true* benefits and costs of dam removal. While the real costs are great, the question of whether the intrinsic benefits are greater is that which must be addressed.

More studies on the subject are needed, and a complete cost-benefit analysis, performed by the leading economists of the region, should take all aspects of the regional economy that are dependent on the dams on the lower Snake River into account. In addition, the passive use values should be isolated, through regression and other techniques, and applied to the entire concerned population of the Pacific Northwest in order to uncover the true passive use value of salmon preservation.

Only after all of the aspects of dam removal are taken into account will the problem be able to be solved in a rational and logical way. Lower Snake River dam removal is a question that should be decided only after careful deliberation and the most exhaustive examination possible of all likely effects.

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