National Economic Analysis of the Four Lower Snake River Dams

A review of the 2002 Lower Snake Feasibility Report/Environmental Impact Statement Economic Appendix (I)

Prepared By:

Earth Economics

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Primary Authors:

Johnny Mojica, Research Analyst, Earth Economics

Ken Cousins, PhD, Ecological Economist, Earth Economics

Tania Briceno, PhD, Ecological Economist, Earth Economics

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Production Team:

Corrine Armistead, Research Assistant, Earth Economics

Jim Waddell, P.E., retired USACE

Jessica Hanson (Editing)

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About Earth Economics

Earth Economics is a non-profit located in Tacoma, Washington, dedicated to researching and applying the economic solutions of tomorrow, today. Earth Economics provides robust, science-based, ecologically sound economic analysis, policy recommendations and tools to positively transform regional, national and international economics, and asset accounting systems. Earth Economics has extensively studied the economic benefits of outdoor recreation in Washington State, producing reports at the state, county, city, and agency level.

GLOSSARY OF TERMS USED IN THIS STUDY

AAEV – Average annual equivalent value is the average cost or benefit of owning an asset over its entire life.

aMW – average megawatt, the electricity produced by continually generating one megawatt for one year (8,760 megawatt-hours)

BC Ratio – Benefit-Cost Ratio

BPA – Bonneville Power Administration

DREW – Drawdown Regional Economic Workgroup

Ecosystem Services – Benefits people derive from nature, free of charge.

FR/EIS - Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement or Lower Snake River Feasibility Report, conducted by the USACE in 2002

HydroAmp – A measure of a dam's reliability

LSR – Lower Snake River, located in southeast Washington

NWW – Walla Walla District of USACE

O&M – Operations and Maintenance

O&M,R – Operations and Maintenance, Repair

PATH – Plan for Analyzing and Testing Hypotheses

PUV – Passive use values are the values that are not associated with actual use, but the value people place on knowing something exists, even if they will never use it.

USACE – United States Army Corps of Engineers

WRC – Water Resource Council, guidelines used by USACE for economic and social analysis

EXECUTIVE SUMMARY

This report presents a thorough analysis of the benefits and costs of the four Lower Snake River dams in both "keep dam" and "breach dam" scenarios. The dams were originally purposed for hydropower and navigation benefits, but in order to achieve a positive benefit-cost ratio, indirect benefits for navigation and power and additional credits for the use of "cheap hydroelectric power" over coal-fired plants were included.[1] Additionally, the original analysis did not account for lost direct and indirect benefits, such as the recreational benefits associated with a free-flowing river or tribal fishing benefits.

This report concludes that the benefits created by the four dams are outweighed by the costs of keeping them. Furthermore, with the possible exception of navigation and irrigation water supply, the current benefits would not be lost, but rather increased, if the dams were breached. Due to subsidies and unclear rail and barge cost data, the verdict is still out on whether there is an economic benefit to shipping by barge over rail. The four Lower Snake River dams in southeast Washington do not provide a net benefit to the nation, and they may never have.

This document should be used to inform the Army Corps of Engineers, the Walla Walla District of the Corps, key decision-makers, and concerned ratepayers.

KEY CONCEPTS AND CONCLUSIONS

- The Snake River dams have two authorized purposes: hydropower and navigation. The direct benefits of these purposes do not surpass the costs of maintaining them.
- In many years, the costs of operating the dam outweigh the value of the electricity produced; these costs are then passed on to the ratepayers. Breaching the dams would save ratepayers money.
- The current state of the four Lower Snake River dams yield a yearly benefit-cost ratio of 0.15, well below a positive return on investment.
- A free-flowing river yields a yearly benefit-cost ratio of 4.3 in term of National Economic Development (NED). These benefits are not realized with the current state of the river.
- Wild salmon are keystone species in trophic webs from the North Pacific Ocean to the far reaches of the Lower Snake River and tributaries, but their stocks are not recovering. Salmon are important for food provision, cultural value, and for sustaining other key species throughout the Pacific Northwest.

INTRODUCTION

Beginning in the early 1900s, the U.S. Army Corps of Engineers (USACE) assessed the possibility of building dams along the Lower Snake River of southeast Washington to ease navigation along its turbulent waters. These four dams were marketed to the public and the administration as providers of clean hydroelectric energy that would also allow barge access to Lewiston, effectively making it a port for inland northwest producers to gain easier access to international markets. In the early 1900's, there were several failed attempts to gain support from Congress to build the dams due to a benefit-cost ratio below one. In 1937, USACE proposed the construction of four dams along the Lower Snake River. As was the case in previous attempts to sway decision makers in favor of the dams, hydropower and navigation benefits did not come close to matching the costs related to the project.[2] In order to justify costs, proponents of the dams claimed "indirect benefits", or benefits that should not have been included in a NED analysis (and evident in the report by Corps planners) but may have provided some to the region. These benefits included recreation, water supply for irrigation purposes, and additional credits for the use of hydropower over coal-fired power plants.[1]

USACE built a series of four dams on the Lower Snake River between 1966 and 1975. At the time of construction, the dams may well have provided a net benefit to the nation, especially when indirect benefits (e.g., reservoir recreation) were considered. However, those original estimates did not account for lost indirect benefits, such as recreational or fishing opportunities associated with a free-running river. Since then, the region's sources of electrical power have become more diverse, new infrastructure and shifting markets have made other forms of transportation competitive with barge shipment, and impacts on wildlife (i.e., salmon) have become a much higher policy priority. When such factors shift so substantially, the USACE should review a project's overall balance of benefits to costs.

From 1995 to 2002, the Walla Walla District (NWW) of USACE commissioned a 33 million dollar study in an attempt to improve fish passage through the hydropower system on the four dams.[5] This study, the Lower Snake River Juvenile Salmon Migration Feasibility Report/ Environmental Impact Statement (FR/EIS), extensively reviewed the effects of four alternative scenarios aimed to improve fish passage and provide the greatest benefit to the nation. The scenarios are as follows: Alternative 1, no change; Alternative 2, maximum transport of juvenile fish; Alternative 3, major system improvements; and Alternative 4, dam breaching.[a]

The NWW found that Alternative 3, major system improvements, would improve fish passage while providing the greatest value to the nation. Since the release of the study, and even within the study itself, contradicting values have been found that drastically change the report's findings. Even the NWW found that fish passage did not improve as projected with Alternative 3, and later implemented Alternative 2,[b] maximum transport of juvenile fish, in an attempt to improve survival rates. Note that both Alternatives 2 and 3 have been implemented at this point, in addition to other programs such as spilling and the use of large numbers of hatchery fish in an attempt to raise adult returns.

[a] For a detailed description of each alternative, see Section 2.2 of the 2002 FR/EIS.

[b] The degree to which Alternative 2 was implemented is not publically known.

The purpose of this document is to unravel the economic benefits and costs of the four Lower Snake River (LSR) dams by reviewing literature. Identified studies were used in a benefit-cost analysis (BCA) that establishes the ratio of positive-to-negative economic effects of the LSR dams. Additionally, projected benefits and costs of dam removal were analyzed. Given that much of the research and the studies used to calculate the original benefit-cost analysis were convoluted and sometimes inaccurate, each benefit or cost category was examined in detail and updated where possible. When updated estimates were not available, values from the 2002 FR/EIS were used.[3] Following the 1983 Water Resource Council (WRC) Guidelines for National Economic Development (NED), this report does not include all benefits and costs regularly used in BCA today, such as impacts on ecosystem services or passive use values.[c]

[c] Recently, the Administration released a Presidential Memorandum directing all federal agencies to integrate ecosystem service values into their benefit-cost analyses.

BENEFIT-COST ANALYSIS OF THE LOWER SNAKE RIVER

This section presents a benefit-cost analysis of the four Lower Snake River dams. Each assumption underlying the category estimates are outlined in detail. To remain consistent with the 2002 USACE study, cost and benefit trends are projected for only 20 years, after which they are assumed consistent through year 100.

There are several challenges in developing a full benefit-cost analysis for the LSR dams. The 2002 USACE study, while highly detailed, no longer reflects current conditions or management practices, as at least some of the recommendations in Alternative 2 (maximum transport of juvenile salmon) and Alternative 3 (major system improvements) were implemented following that study. An additional complication is that, with few exceptions, the 2002 study does not offer actual benefit or cost values for Alternative 1 (existing conditions); rather, the focus is on the net contributions of Alternatives 2 through 4, relative to the then-existing conditions. The reason for this is that the 2002 FR/EIS reports only the marginal[d] benefits and costs associated with Alternatives 2 through 4, without providing baseline values for "business as usual" (Alternative 1). The lack of baseline values makes estimating the total benefits or costs associated with Alternatives 2 through 4 exceptionally challenging.

In some benefit-cost categories (such as recreation), there is an opportunity cost associated with the current project. These costs are measured as the dollar value of the resources in their next best alternative use.[4] In the case of recreation, the current value of recreation should also consider the forfeited recreation opportunities from having a reservoir as opposed to a free-flowing river.

The FR/EIS took 7 years and cost $33 million.[5] Without another in-depth study focused on the benefits and costs of operating the LSR system itself, the best approach is to update those values for which current data and cost estimates are available, and to accept the remaining original values in the 2002 report (adjusted to 2015 dollars). This report attempts to reevaluate the benefit-cost ratio of the LSR dams based on the best available information from both the 2002 study and more recent analyses. This approach is consistent with USACE planning guidance in that a report of this age is in need of updates, but not too old to warrant starting from scratch.

Table 1 represents the best known point estimates for the current state of the four Lower Snake River dams and for a breach dam, free-flowing river scenario. The following section details how each point estimate was derived for each benefit/cost category. Some estimates may be under- or over-valued, and narrative is provided in the following section as to how these varying estimates may alter the benefit-cost ratio, but are not included as point estimates as further research is needed. All values are Average Annual Economic Value[e] (AAEV) over 100 years, discounted[f] at 6.875 percent. NWW used a discount

[d] Marginal values represent differences between baseline values and those associated with alternative proposals. For instance, if baseline costs are $1M per year, and annual costs of the alternative are $1.1M, the marginal cost of the alternative is $100,000 ($0.1M).

[e] Average annual equivalent is the average cost or benefit of owning an asset over its entire life.

[f] A discount rate is the cost of borrowing money. It is used to determine the present value of future cash flows or costs. The ACOE currently uses a discount rate of 6.875%.

rate of 6.875 percent in the 2002 FR/EIS, although the 2015 Federal Discount for Corps projects is 3.375 percent in economic analysis.[6] A discount rate can drastically effect a projects costs and benefits. Using a lower discount rate of 3.375 percent would cause the values to be greater, resulting in an even lower benefit-cost ratio. It should be noted that the 2016 rate is 3.125.

TABLE 1. BENEFIT-COST TABLES IN KEEP/BREACH DAM SCENARIOS (VALUES IN THOUSANDS, 2015 USD[g], AAEV)

	Keep Dams and Maintain		Breach Dams	
Benefit/Cost Category	**Benefit**	**Cost**	**Benefit**	**Cost**
Hydropower	$202,644			$0** - $261,758
Navigation	$7,574			$7,574
Recreation				
Angler	$30,890	$34,880*	$65,770	
Non-Angler	$13,993	$1,370,020*	$1,370,020	$13,993
Total Recreation	$44,883	$1,404,900*	$1,435,790	$13,993
Commercial Fishing	$2,795	$2,165*	$4,924	
Tribal Fishing	Included in commercial		Included in commercial	
Water Supply				$22,506
Implementation and O&M		$296,030		$28,832
Total	$257,860	$1,703,095	$1,440,714	$334,664
Benefit/Cost Ratios	0.1514		4.3049 – 19.7614**	

*Some costs illustrate forfeited benefits, which would be realized in the next alternative.

**Assumes the region does not have to purchase electricity from an external provider, due to the current surplus of power within the region.

As can be observed in the benefit-cost ratios[h] presented in Table 1, the benefits obtained in a scenario with breached dams far surpasses that of keeping the dams. Hydropower and navigation do not provide a positive benefit-cost ratio on their own. With the inclusion of indirect benefits (e.g., lost recreation benefits), the ratio becomes even lower in a "keep dam" scenario, producing a BC ratio of .15. Much of this is due to the foregone benefits of recreation ($1.4 billion), which could also help to revitalize the local economy by bringing in tourism dollars. Clearly, total welfare would be improved by breaching the dams. The opportunity cost of not doing so amounts to the difference in net benefits (benefits minus cost) between the two scenarios. Therefore, every year, about $2.4 billion (2015 dollars) in economic benefits are lost by keeping the dams.

Moreover, given a close examination of the studies informing these cost-benefit calculations, the difference between the scenarios may be even larger. There are still benefit-cost categories that have not been updated to show current estimates. Nor are certain categories included in the BCA at all, such as ecosystem services or passive use values, both of which would decrease the benefit-cost ratio of a "keep dam" scenario.

[g] All dollar values are adjusted from annual nominal values to 2015 $US according to the Bureau of Labor Statistics' Consumer Price Index (CPI). Available at: http://data.bls.gov/cgi-bin/cpicalc.pl.

[h] A benefit-cost ratio of 1 means that the benefits produced by a project equal the costs associated with the project. A ratio below 1 indicates that the costs are greater than benefits, which is a poor economic investment.

BENEFIT-COST TABLE EXPLANATIONS AND SOURCES

HYDROPOWER

The highest-valued economic benefit of the LSR dams is hydropower,[i] yet the Pacific Northwest has an excess of power-generating capacity, even during peak demand. Eliminating the power produced by the dams would not require additional infrastructure or place a higher demand on non-renewable sources.

The dams generate a median of 795 average megawatts[j] (aMW) of power each year (sold on the market for $203 million, 2015 dollars)[7] – seven percent of the region's overall hydropower capacity (11,600 MW).[8] Collectively, hydro supplies just over 40 percent of the Northwest's electricity, which means that the four LSR dams contribute just 2.9 percent of the region's power. However, the regional grid is overbuilt – it has a 4,600 aMW surplus, more than five times the energy supplied by LSR dams.[9] Furthermore, in 2015, the Snake River Dams produced just 748 aMW, the second lowest level in recent history.[10]

Wind generation has been growing steadily in the Pacific Northwest since first being introduced to the grid in the early 2000's, adding to the surplus of power. Further complicating the regions surplus power issues, Endangered Species Act (ESA) regulations sometimes prohibit spilling water over the dams (based on impacts of high dissolved oxygen levels on salmon); in these instances, the Bonneville Power Administration's (BPA) only option is to run water through the turbines, producing higher levels of electricity than is demanded. When high-wind periods occur in high-water years, hydropower may displace wind generation, pushing wind generators offline. In fact, in 2011 and 2012, the BPA blocked wind-farm access to their regional grid, effectively idling their wind generators.[11] After wind-farms sued for breach of contract, BPA proposed partial payments to suppliers to idle their turbines.[12]

Regionally[k], wind generation has steadily grown since 2005 (see Figure 1), even as the proportional contribution of the LSR dams has remained static. Since 2008, wind turbines have consistently produced more power than these dams – by 2013, wind contributed over twice as much electricity as the LSR dams, with the installed capacity to produce more.[l] This trend has been observed – albeit more recently – within Washington State. Wind turbines were very new to Washington in the year the NWW-USACE released its report, but have since grown dramatically (see Figure 1). The passage of Initiative 937 in 2006, which requires Washington's large utilities to obtain 15 percent of their power from renewable energy sources, specifically excludes hydropower.[13] That portfolio target has been phased in, beginning at three percent in 2012, and shifting to nine percent in 2016, before full implementation in 2020. By 2013, wind power had already generated more electricity than all four LSR dams combined. Arguments that the LSR must be retained for their power generation are incorrect. The hydropower produced by the dams already has been superseded by wind technologies.

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[j] An average megawatt (aMW) is the electricity produced by continually generating one megawatt for one year (8,760 megawatt-hours).

[k] Defined as those states contributing at least a portion of their electrical generation directly to BPA's grid (Idaho, Montana, Nevada, Oregon, Washington, and Wyoming).

[l] Washington had 3,075 MW of installed wind power capacity as of 2015.

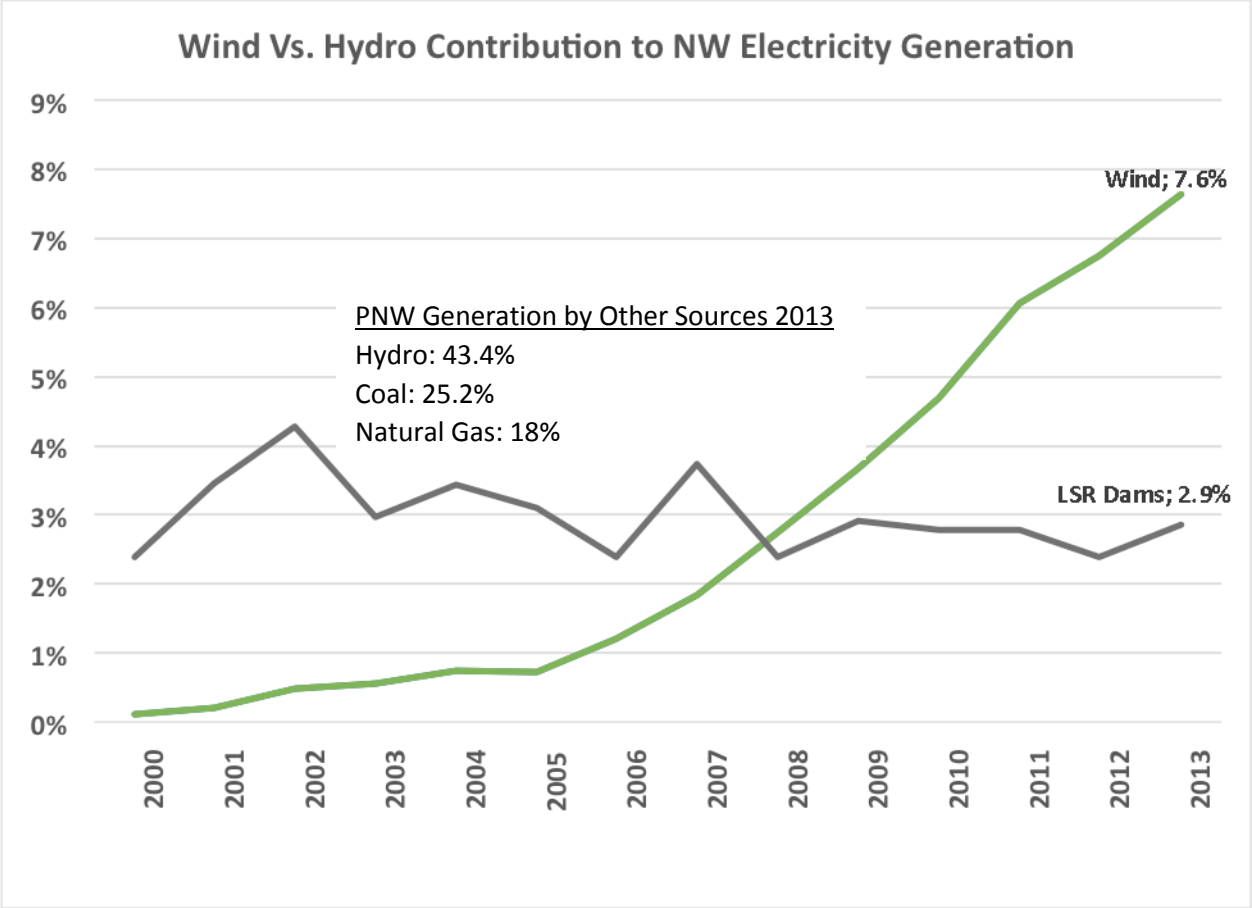

FIGURE 1: CONTRIBUTION TO NW ELECTRICITY GENERATION[14]

One counter argument worth considering is the relative reliability of wind energy. Wind generators are imperfect sources for electricity – most significantly, their output varies substantially from hour to hour. Yet the output of hydroelectric dams, despite their "always on" status, also varies widely from year-to-year, following larger-scale weather and climate dynamics. In fact, the LSR dams generally produce less and less power each year (R^2 = 0.1348, Coefficient = -0.0011).[m] Additionally, the FY 2016-2017 Integrated Program Review released by BPA in 2014 proved that the dams' reliability has decreased over the past years (shown by their HydroAmp Scores, a measure of reliability), and an aging infrastructure and non-routine maintenance make budget restrictions even more worrisome.

Although wind power is often critiqued for its hour-to-hour variability, year over year production data shows it to be more predictable than hydro (R^2 = 0.88, Coefficient = 0.0045). Even during droughts, winds continue to blow. Another factor stems from the scale of the technology – each LSR dam houses only six turbines, whereas windfarms typically include scores, if not hundreds, of turbines. When

[m] The root cause is unclear, but annual LSR dam electrical generation has generally been declining since the mid-1970s (Lower Granite Dam, the last LSR dam constructed, began operations in April of 1975). Signs point towards decreased reliability in addition to gradually diminishing streamflow. See US Geological Survey, 2015, National Water Information System, Site 13334300 (Snake River near Anatone, WA), available at: http://nwis.waterdata.usgs.gov/nwis.

turbines need to be pulled offline for maintenance or replacement, the proportional impact is likely to be much greater for conventional hydroelectric dams. This report does not suggest that all hydropower in the region be taken offline, but merely observes that decommissioning the four LSR dams would not increase the risk of power shortages, as wind generation – a relatively new source since the 2002 study – already produces more than three times the electricity of the LSR dams.

With Dams

According to Jones (2015), between 2009 and 2014, the LSR dams produced a median amount of 795 aMW, based on Mid-Columbia (MIDC)[n]. A report released on the revenue of the LSR dams states that the average revenue from FY 2010-2015 was $202.6 million. However, in both 2011 and 2012, higher-than-average spring flow increased the power generated by the LSR dams, requiring wind generators to be idled at times. In 2015, the Snake River Dams produced just 748 aMW, the second lowest level in recent history.[15] According to the NWW, [16] this level of power generation yielded only $144.5 million in electricity for the FY.

COSTS TO MAINTAIN THE DAMS – HYDROPOWER

According to the 2002 FR/EIS,[17] 91 percent of total operations and maintenance costs can be attributed to hydropower operations. The 100 year AAEV Operations and Maintenance (O&M) costs are $296 million (2015 dollars), $269 million of which can be attributed to hydropower operations. Assuming benefits of $279 million (2015 dollars), the dams are barely breaking even when evaluating the benefits and costs of hydropower alone, see Table 2 below. In years of low generation, the costs to the NWW and BPA are greater than the value of the hydroelectric power produced.

Breach Dams

Electricity is a homogenous good, and therefore the source of production has little impact on the market, but rather an impact on the overall supply. Because the Northwest has a surplus of power, the energy produced by the dams will be immediately replaced by other electricity-generating resources that often do not operate due to the oversupply.

Should the LSR dams be decommissioned, the cost of replacing the power they generate would vary by source. Technologies for electrical generation are rapidly evolving, and markets – and pricing – are responding accordingly. Although not required from a capacity standpoint, wind and solar generation are becoming increasingly cost-competitive with more traditional generation modes. Both wind and solar energy production are expected to rise consistently for the foreseeable future, while the costs continue to decline.[18]

Due to the region's power surplus, new infrastructure would not need to be built. The NWPCC 7th Northwest Power Plan[19] states that efficiency gains could cover all increased demand, with the grid remaining in surplus for at least the next 20 years. Therefore, for this report, we assume that for the first 20 years, power is purchased on the open market at a cost of $262.5 million. For the remaining years, the replacement cost of solar power[o] ($259 million) is used in combination with open market

[n] The closest trading hub for the Lower Snake River Dams is the Mid-Columbia (MIDC) trading hub. (Jones, 2015)

[o] Solar generation capacity is greatest in the summer months, when daylight is longest. Coincidentally, power generation is lowest for the LSR dams during the summer months when demand is high, especially in Eastern Washington.

purchases.[p] The 100 year AAEV for replacing the power generated by the Lower Snake River Dams is therefore $262 million. Because the cost to produce the hydropower on the Snake River is greater than the value produced, there may be a small reduction in residential bills. These estimates are static. Alternatively, due to the surplus there is no need to purchase additional power. There will be no additional cost to the nation. Therefore a value of $0 is also given in the benefit-cost table.

As can be seen in Table 2 below, the cost of producing the power supplied by the LSR dams is greater than the cost of purchasing power on the open market.

TABLE 2. COST OF MAINTAINING THE LSRD VS. REPLACEMENT POWER COSTS (VALUES IN THOUSANDS, 2015 USD)[20]

Total Annual Cost to Keep LSRD*	Open Market Purchases (Years 1-19) and Solar Generation (Years 20-100)	
	Purchase Cost	Total Difference
$269,387	$261,758	-$7,629
Estimated Monthly Difference In Residential Bills	**-$0.027**	

*Assumes 91% of total O&M is attributed to hydroelectric power

NAVIGATION

Overall, freight volumes passing through the Ice Harbor locks (the lowest on the Snake River) have declined 20 percent since the 2002 study. Barges on LSR reservoirs are used to transport wood chips, wheat and barley, pulses (e.g., garbanzo beans), and rapeseed (canola). Commodity producers can choose shipping via rail or road. Since 2008, in large part a pipeline has moved petroleum to a refinery in Salt Lake City. Container-on-barge shipping down the Columbia effectively ended after container ships abandoned the Port of Portland in 2015.

The cost differentials between barges and rail have halved since the 2002 FR/EIS. The greater flexibility of rail makes it a more viable choice for sellers, greatly increasing the pool of potential buyers. Barge transportation decline is especially true for wood chips, which declined 63 percent (by volume) from the 1992 to 1997 study period. (See Table 3.) Of far greater significance, grains (chiefly wheat and barley) have been somewhat more stable, having declined by 8 percent. The NWW incorrectly projected that grain shipments would actually increase 72% by 2017 (See Appendix A for projections).[21] Additionally, construction of a pipeline to a refinery in Salt Lake City has led to the near collapse of petroleum shipments by river (an 87 percent decline). Farmers are also building their own rail systems and train loaders. This has decreased shipments by barge.

[p] This value can be found by multiplying actual generation numbers of the dams by Avista and Idaho Power avoided cost rates of 35.10 per MWh. (Jones, 2015)

TABLE 3: TONNAGE BY COMMODITY GROUP (000 TONS)

Commodity	1987-96[22]	1992-97[23]	2010-14[24]	Percent change 1987-96 to 2010-14	Percent change 1992-97 to 2010-14
Wood chips	550.5	634.0	236.0	-57%	-63%
Grain	3,051.4	3,038.0	2,800.0*	-8%	-8%
Petroleum	116.4	120.0	15.8	-86%	-87%
Total	**3,718.3**	**3,792.0**	**3,051.8**	-18%	-20%

*Only 2012 figures were available.

WITH DAMS

With decreased shipments on the Lower Snake River, the total benefits of shipping by barge have also decreased. The benefits barge shippers once realized between cost per ton-mile for truck/rail and truck/barge have also diminished, see Table X below. As this gap narrows, what was once a $20.1 million (1998 dollars) benefit to barge shippers in 1998 is now only a $7.6 million (2015 dollars) benefit. The AAEV of this benefit also equates to $7.6 million (and a net present value (NPV) of $110.4 million). Note that these benefits are static.

TABLE 4 SHIPPING COSTS COMPARISON (RME[24])

Shipping Cost Per Ton Mile			
Mode	**1998**	**2015**	**% Change**
Truck	$0.1000	$0.1400	40%
Rail	$0.0500	$0.0633	26.6%
Barge	$0.0100	$0.0393	293%

Furthermore, a recalculated analysis[25] of the benefits of navigation presented in the 2002 FR/EIS finds that the additional rail rate charged to farmers is only seven cents per ton more than barging, reducing benefits to $0.44 million. Overall, regardless of calculation methods, use of the LSR locks and channels has decreased significantly, barge costs have nearly tripled and the corrected O&M,R costs are significantly higher. Therefore, the benefits have also decreased.

COSTS TO MAINTAIN THE DAMS – NAVIGATION

The NWW assigns nine percent of total O&M costs to maintaining the navigational channels and locks. According to Waddell,[26] $26.6 million of the total $296 million (2015 dollars) 100-year AAEV O&M costs is attributable to navigational purposes.

BREACH DAMS

Since the 2002 study was published, petroleum movement has shifted from barge to pipeline, effectively ending that portion of demand for LSR navigation. Container shipping through the Port of Portland has also effectively ended. The cost of navigation for a free-flowing river is therefore assumed to mirror the benefits under current conditions, as calculated by Jones (2015). That amounts to an AAEV of $7.6 million per year (NPV of $110.4 million).

RECREATION

A free-flowing Lower Snake River would provide immense recreational benefits that are not currently realized with the reservoirs. These benefits would be a net gain for the nation that could boost the regional economy. Recreation benefits (or costs) are measured in two ways in the FR/EIS: National Economic Development (NED) and Regional Economic Development (RED) values. The RED account focuses on changes in economic activity within the region. These benefits include values such as jobs and income produced. RED benefits are not valued at the national level because WRC guidelines assume that increased economic activity in one region is mirrored with decreased economic activity in others. Recreation value for the NED account is assessed as the consumer surplus, or the value that a recreation consumer receives above what they actually paid for. This method follows the WRC guidelines and was used by the USACE in the in the 2002 FR/EIS.

Recreational benefits along the Lower Snake River are considered indirect benefits of the dams. The dams were not intended to provide recreational benefits, but do nonetheless. However, the dams' construction also led to loss of recreational benefits. Most of the activities associated with a free-flowing Lower Snake River are not possible with the reservoirs. A free-flowing Lower Snake would provide greater recreational benefits than the reservoirs.

WITH DAMS

ANGLING

Recreational angling benefits in the USACE 2002 study[3] are found in Table 3.2-10 (page I3-68). Upon completion of the FR/EIS, the Walla Walla District implemented Alternative 3 (major system improvements). Because the effectiveness of system improvements on endangered wild salmon species was overestimated, the NWW has since also implemented Alternative 2 (maximum fish transport). Because Alternative 3 provided the greatest recreational benefits with the LSR dams in place, the value of $21.2 million ($30.9 million in 2015 dollars) per year is used here, as seen in table 3.2-10 of the FR/EIS.

GENERAL RECREATION

The USACE's 2002 AAEV value of $31.6 million (1998 dollars; $46 million in 2015 dollars) per year[27] for general recreation (non-angling) on LSR reservoirs is based on a 1999 study by Agricultural Enterprises, Inc. (AEI) in collaboration with the University of Idaho.[28] The value of $31.6 million was derived by conducting five recreation visitor-use surveys on existing users to obtain trip data such as the main reason for visitation, number of trips taken, and the associated trip expenditures. The surveys conducted in 1999 were used to assess the willingness to pay for general reservoir recreation (non-angler) and visitor days demanded.

However, John McKean, the lead author of the 1999 AEI study, re-conducted his analysis in 2005[29]using the same survey data that was used in the 1999 study. McKean's recalculation yielded an annual consumer surplus value of only $9.6 million (1998 dollars; $14.0 million in 2015 dollars) for general recreation on the reservoirs as opposed to $31.6 million. Part of the confusion has to do with the interpretation of survey results, which can have a drastic impact on the estimate of the value of non-angler recreation. One survey in particular, designed to assess non-anglers' willingness-to-pay (WTP) to visit the LSR reservoirs, received a substantial number of responses from those expressing a "high preference for fishing" (85 of 417 usable surveys, or 20 percent), thereby representing anglers rather

than non-anglers. Based on all 417 surveys, the 1999 study estimated a WTP of $71.31 per trip. With an average trips per year of 8.4, the total WTP was estimated at $31.6 million per year ($45.0 million in 2015 dollars), based on the estimated 52,984 unique non-anglers per year. These 417 "non-anglers" did in fact include those expressing a "high preference for fishing".

When McKean (2005) excluded those respondents who had indicated a high preference for fishing (effectively dropping 85 respondents assumed to be anglers, leaving a population of 332 non-angler respondents), he calculated the WTP at $24.65 per trip ($29.96 in 2015 dollars), or $206.17 per non-angler per year ($250.55). This results in a total non-angler recreational value for the LSR reservoirs of only $9.6 million per year ($13.7 million in 2015 dollars). The distinction is important – recreationists who value fishing as one of their highest priorities should not have been included in the non-angler dataset. Their presence overstates the WTP estimates for non-anglers by $46.66 per trip, and the annual AAEP values by $22.0 million – well over three times the corrected value. Table 5 below shows the differences in interpretation of survey responses between the AEI study used in the 2002 FR/EIS and McKean's updated study in 2005.

TABLE 5: CORRECTING BIAS IN SURVEY RESULTS FOR NON-ANGLER RECREATION

	AEI et al 1999 (1998$)	**2015$**	**McKean et al 2005 (1998$)**	**2015$**
WTP per trip, all surveys (417 responses)	$71.31	$101.59	--	--
WTP per trip, excluding likely anglers (332 responses)	--	--	$24.65	**$35.12**
Average trips per year	8.364 (417 responses)		7.36 (332 responses)	
WTP per recreationist per year	$596.44	$849.68	$181.42	**$258.45**
Unique non-anglers visiting the LSR	52,984			
AAEV of non-anglers visiting the LSR	$31,601,610*	$45,019,760	$9,612,569	**$13,693,930**
Net Present Value (NPV)		$653,976,070		**$198,926,423**

**The difference with the value reported in USACE 2002 ($31.578M) appears to stem from rounding error.*

Thus, given the existing studies and assumptions behind the derivation of different values, we would recommend using McKean's 2005 work, a single demand function which provides the average WTP value across all non-angling activities, $181.42 per person per year ($220.47 in 2015 dollars). This value is found by multiplying the WTP per trip ($24.65) by the estimated trips per non-angler per year (7.36 for the corrected non-angler survey respondents). Further investigation into the validity of multiple demand functions for this dataset would be required to include those values in a direct comparison with the regression used in AEI 1999 study and 2002 LSR feasibility report.

TOTAL RESERVOIR RECREATION

Assuming that all angler-related estimates are accurate, correcting for the bias in the 1999 interpretation of the non-angler survey responses (subtracting for high fishing preference) results in a total contribution of recreational activities of $30.8 million ($44.9 million in 2015 dollars). Table 3.2-10 summarizes the values provided in the original study, those adjusted for McKean's' 2005 update to the value of recreation, and then values adjusted to 2015 dollars.

TABLE 6. ADJUSTING RESERVOIR RECREATION VALUES

Table 3.2-10 FR/EIA - Annualized (AAEV) Value of Recreation Benefits over 100 Years ($ millions) (1998 dollars) (6.875 percent discount rate)	2002 FR/EIS (Alt 3, 1998$)	Adjusted Estimate (1998$)	2015$
General Recreation	$31.60	$9.61	$14.00
Angling			
Resident and Steelhead	$2.08	$2.08	$3.03
Steelhead-Tributaries	$18.96	$18.96	$27.61
Salmon-Tributaries	$0.18	$0.18	$0.26
Total Recreational Fishing	$21.21	$21.21	$30.89
Total General Recreation and Angling	**$52.81**	**$30.83**	**$44.90**

BREACH DAMS

ANGLING

Angling benefits in a dam breach scenario were estimated using information from the 2002 FR/EIS. It should be noted that more current studies have shown greater angling benefits from the removal of the Lower Snake River Dams than presented in the FR/EIS. These studies, however, are not directly comparable with the FR/EIS due to methodological differences in terms of the chosen study area and estimation methods. Nevertheless, newer studies estimate that the type of activities that would take place and the amount of fish present would increase the value gained by recreationalists above that of the NWW's original 2002 estimates.[30]

For this report, angling benefits of $86.8 million ($126.4 million in 2015 dollars) are assumed. These estimates are considered to be conservative given the findings of more current studies. Further information on this point estimate can be found in Table 3.2-10 on page I3-68 of the FR/EIS.

GENERAL RECREATION

A free-flowing Snake River would open up new recreational opportunities such as jet-boating, rafting, and increased wildlife viewing, camping and hiking. When the original FR/EIS was conducted, the Drawdown Economics Workgroup produced four estimates for recreation based on a rigorous survey. This survey was conducted in Washington, Idaho, Oregon, Montana, and California and was used to identify the type and number of recreation users that would visit a free-flowing Lower Snake River. Survey recipients were asked whether they would "Definitely Visit", "Probably Visit", "Probably Not Visit", or "Definitely Not Visit" a free-flowing Lower Snake River. From this, a consumer surplus value can be obtained from survey respondent's willingness to pay through a travel cost demand model, referred to as the "High NED" value. The total NED value is the product of consumer surplus and total general recreation visits.

The FR/EIS uses an NED value that assumes visitation only by survey respondents that indicated they 'definitely' or 'probably' would visit, but assumes that survey non-respondents would not visit. This estimate was considered the "Middle Use 2" estimate, or the middle-high estimate. The FR/EIS also negated the findings of the travel cost demand model, and assumed a consumer surplus value obtained from the reservoir fishing analysis, which is referred to as the "Low NED" value. The point estimate used in the FR/EIS is $86.5 million (2015 dollars, $59.5 million in 1998).

Earth Economics conducted a thorough analysis of the study used in the FR/EIS and recommends a point estimate that falls between the high and middle-high estimate. This estimate assumes that visitation will be the greatest during the first four years following dam removal, by assuming that all respondents indicating they would "definitely" and "probably" visit, would in fact visit. In years 5-100, California respondents that marked they would "definitely" visit would visit, while "probably" (yes) respondents would not visit. Response assumptions for Washington, Idaho, Oregon, and Montana stay consistent through years 1-100, assuming visitation by "definitely" and "probably" (yes) responses.

Based on these assumptions, we recommend using NED benefits for general river recreation of $1.4 billion[31] per year (2015 dollars; $942 million in 1998). This estimate conforms to current and established best practices on survey-derived data.

TOTAL RECREATION

Assuming angling recreation benefits of $126.4 million and general river recreation benefits of $1.4 billion per year, the new point estimate for AAEV over 100 years at a 6.875 percent discount rate is now $1.5 billion.

COMMERCIAL FISHING

The current value of commercial fishing has not been calculated, and the PATH and DREW workgroups that conducted the estimates used in the FR/EIS report provided only projections of fish counts, and the marginal contribution of Alternatives 2 through 4. However, based on these values, it is possible to approximate the actual economic contributions of each alternative. By dividing the marginal benefit of Alternatives 2 through 4 (Table 7) by the marginal increases in harvest levels for each (see Table 8), it is possible to calculate a per-fish value for each commercial fishery for each alternative (see Table 9). Applying the average value per fish to the original harvest estimates, it is possible to re-estimate the average annual contribution for all four alternatives (see Table 10).

TABLE 7: ESTIMATED NET AVERAGE ANNUAL COMMERCIAL FISHING EFFECTS (1998 DOLLARS)[32]

AAEV @ 6.875% Discount Rate	Alt2	Alt3	Alt4
Ocean	$0	$12,340	$380,650
In-river	$159,770	$145,530	$1,105,800
Total	$159,770	$157,870	$1,486,450

Table 8: Projected Harvest for Commercial Fisheries for Year 25 (USACE 2002)[32]

Commercial Harvest (number of fish)	Alt1	Alt2	Alt3	Alt4
Ocean	3,596	3,596	4,329	30,050
Marginal gains		***0***	***733***	***26,454***
In-river				
Non-treaty	2,387	2,655	2,852	20,078
Hatchery	51,679	60,533	57,986	132,257
Treaty Indian	101,869	108,491	106,792	169,125
Subtotal_In-river	*155,935*	*171,679*	*167,630*	*321,460*
Marginal gains		***15,744***	***11,695***	***165,525***
Subtotal_Commercial	*159,531*	*175,275*	*171,959*	*351,510*
Total marginal gains		***15,744***	***12,428***	***191,979***

TABLE 9: ESTIMATED VALUE PER FISH (1998 DOLLARS)

Value per fish	Alt2	Alt3	Alt4	Average value per fish
Ocean		$16.83	$14.39	**$15.61**
In-river	$10.15	$12.44	$6.68	**$9.76**

TABLE 10: ESTIMATED AVERAGE ANNUAL COMMERCIAL FISHING EFFECTS (1998 DOLLARS)

AAEV @ 6.875% Discount Rate	Alt1	Alt2	Alt3	Alt4
Ocean	$56,141	$56,141	$68,481	$449,131
In-river	$1,521,527	$1,681,297	$1,826,827	$2,932,627
Total	$1,577,668	$1,737,438	$1,895,308	$3,381,758
(2015 dollars)	*$2,297,162*	*$2,529,795*	*$2,759,661*	*$4,924,006*

WITH DAMS

Table 7 in the previous section illustrates the benefits commercial fisheries receive with dams. Because commercial fishing values have not been updated, benefits under Alternative 3 (major system improvements) are assumed to be accurate. Given this assumption, we recommend using a point estimate from commercial fishing of $1.9 million (2.8 million in 2015 dollars). It should be noted that although reported salmon counts have increased since 2000, wild salmon stocks have not recovered as predicted under Alternative 3 and have in fact declined, even with the additional implementation of Alternative 2.[33] The increase in total salmon counts is a result of increased hatchery production.

BREACH DAMS

Table 7 in the previous section illustrates the benefits commercial fisheries would receive without the dams. Due to commercial fishing values not being updated, benefits under Alternative 4 (dam breaching) are assumed to be accurate. This analysis uses a point estimate from commercial fishing of $3.4 million ($4.9 million in 2015 dollars).

TRIBAL FISHING

In the 2002 USACE study, information on Treaty Indian fisheries was based on the work of the DREW Anadromous Fish Workgroup. The DREW workgroup includes In-river Treaty Indian Fisheries within the Commercial Fisheries category. However, what was not economically accounted for in the 2002 study were the costs incurred by traditional native peoples. The reservoirs prevent the full breadth of historical traditions such as fishing, hunting, harvesting berries and roots, and religious and cultural ceremonies.

WATER SUPPLY

Approximately 34,000 acres of irrigated farmland use the reservoirs produced by the Lower Snake River dams for water supply. Should the dams be breached, these farms would either need to drill wells to reach the aquifers or modify their water withdrawal systems. The water supply values do not reflect the value of the water that is supplied, but the modification costs that would be incurred if the dams were to be breached. Because of this, there are no costs or benefits associated in the "with dams" scenario.

WITH DAMS

Although the Snake River reservoirs provide irrigation to approximately 37,000 acres of farmland, the costs versus benefits have not been calculated as the 2002 FR/EIS assessed this as a net change over the existing with dam condition.

BREACH DAMS

There have been no additional studies conducted on the cost of not having a reservoir for irrigation, and therefore the point estimate used in the analysis is the $15.4 million ($22.5 million in 2015 dollars)[34] estimate from the 2002 FR/EIS. However, review to date indicates that the pumping capacity used to calculate these increased pumping costs is significantly overstated. The FR/EIS shows that the increased pumping costs would yield 1 foot of water across 37,000 acres every 19 days. The FR/EIS also assumes that the land would no longer be used for crop production, as opposed to switching to crops that demand less water, e.g., wheat or wine grapes.

IMPLEMENTATION, OPERATIONS, AND MAINTENANCE

Costs associated with the dam are all considered costs of either hydropower or navigation. According to the 2002 FR/EIS,[35] 91% of the costs can be attributed to the dams for hydropower purposes, with the remaining 9% being allocated to navigation. Although these costs vary by dam, this report looks at the costs and benefits associated with all four Lower Snake River Dams, and therefore an average is used (91%/9%).

Our analysis uses updated cost values to the 2002 FR/EIS. Waddell (2015) reevaluated Appendix E of the 2002 FR/EIS, which outlines the cost estimates of maintaining the existing Snake River system and implementing Alternative 3, major systems improvements. To arrive at updated cost values, Waddell synthesized data collected from the NWW Civil Works Activities report (2012), Bonneville Power Administration's Integrated Program Review (2014), and the Lower Snake River Programmatic Sediment Management Plan (2014). Without transparent cost reporting from NWW and BPA, the inclusion of estimates by Waddell provides the best available updated picture of costs. Should further data become available, an independent assessment of operating costs should be undertaken.

According to Waddell,[36] the 2002 FR/EIS underestimated the costs of keeping the dams with improvements by at least $224.0 million per year (2015 dollars) and overestimated the costs of breaching the dams by $38.6 million (2015 dollars)[q]. Waddell's analysis does include the Bureau of Reclamation flow augmentation costs[r] noted in the FR/EIS, but these cost have substantially increased since the agreements were signed around 2005.[37]

With Dams

Cost estimates for maintaining the dams include six major cost categories: Improving Fish Passage (system improvement costs as required by the Endangered Species Act), Operations and Maintenance Costs, Turbine Rehab Costs, Lower Snake River Compensation Plan Cost, BPA Power Service Cost, and Navigation and Flow Conveyance Dredging.[s]

Waddell's updated cost for maintaining the Lower Snake River dams is $296 million (in 2015 dollars) based on an annual average equivalent over 100 years with a discount rate of 6.875%, beginning in 2015. The NWW originally estimated that maintaining the dams would only cost $56.5 million per year ($72.0 million in 2015 dollars). The NWW underestimated the cost of maintaining the dams by $224.0 million (2015 dollars) per year.

Breach Dams

If the NWW were to breach the dams, Waddell finds that the annual average equivalent cost would be $28.8 million (in 2015 dollars). Most of the costs of breaching would arise within the first 10 years. Once major construction and mitigation programs have ended, maintenance costs from river recreation upkeep would remain.

ADDITIONAL CONSIDERATIONS

The 2002 FR/EIS made assumptions concerning the 40,000 acres of project lands that precluded any analysis of economic benefits that could be derived through return of some of this land to agricultural use, which was mostly viniculture and orchards. (Prohibition caused a shift to nearly all orchard). While a detailed evaluation of the possible benefits was beyond the scope of effort contained in this report, Waddell conducted a cursory review to establish the economic plausibility of such reuse while allowing for maximum restoration and preservation of riparian and other adjacent lands providing ecological service to the natural flora and fauna. Review of the 1934 surveys, historical research and other information contained in the FR/EIS shows that 4-5000 acres could be put back into high value, (e.g., viniculture and orchards). This land, once transferred to the state, could yield at least $20 million/year in leases based on unirrigated acreage suitable for viniculture and nearly twice that if irrigated. Since viniculture requires only a fraction of the 34,000 acres of irrigation noted for the crops currently under irrigation on Ice Harbor pool, more than sufficient water and water rights are available to offset the FR/EIS claim of a $15 million year cost through lost irrigation. However, this number is based on excessive water use. It should be noted that under Washington State Department of Natural Resource ownership, the lease or income from land sales could be used to fund education expenses in the state. In addition to this direct benefit to the state's education budget and thus the taxpayer, additional direct,

[q] Assumes AAEV breaching costs of $67.318M ($31.6M, 1998 dollars).
[r] Contracts to ensure a specified amount of water flows downstream to the Snake River Dams.
[s] System Improvements and Turbine Rehab do not occur in every year, while the other costs are ongoing.

indirect and tax revenues what be realized from a vibrant viniculture and associated infrastructure such as rustic inns, restaurants, and float tasting tours in the Lower Snake Valley. This is all in addition to the recreation benefits noted elsewhere in this report. Further study will be conducted to determine the full scope of these benefits.

CONCLUSIONS

This report provides a benefit-cost analysis of two scenarios: keeping the four LSR dams in place or breaching the dams. It is clear that keeping the dams is no longer beneficial to the nation, Northwest ratepayers, or the regional economy. The recreation and tourism values alone trump any benefit that may be provided by hydropower and navigation benefits to farmers from removing the dam. As was found in the accompanying RED analysis, the jobs provided by a thriving recreation community could easily replace any jobs lost by the removal of the four dams. In addition, the removal of the dams will give the dwindling wild salmon species the fighting chance needed to combat issues surrounding climate change. It is clear that the four LSR dams do not provide sufficient benefit to the nation or to the regional economy. The river should thus be restored to its near natural state.

APPENDIX A: INFLATED SHIPMENT PROJECTIONS FOR LOWER SNAKE RIVER WATERWAY BY WALLA WALLA DISTRICT IN THE FR/EIS

	Observed										Projected				
	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	2002	2007	2012	2017	2022
Grain	2906	3981	2532	3109	3241	2612	2706	3135	3471	2821	3647	3799	3798	3892	4052
Wood Chips and Logs	461	394	320	304	375	500	854	910	857	530	694	694	694	694	694
Petroleum	117	105	115	108	106	108	129	137	144	95	127	136	145	156	167
Wood Products	46	52	45	42	74	61	45	58	68	28	66	79	101	128	148
Other	96	127	203	166	159	80	57	74	82	85	97	110	128	148	167
Total	3626	4659	3215	3729	3955	3361	3791	4314	4622	3559	4631	4818	4866	5018	5228

APPENDIX B: CONTRIBUTION ANALYSIS BY COUNTY

VALUES IN THOUSANDS, 2015 USD

		Totals	Asotin	Columbia	Franklin	Garfield	Walla Walla	Whitman
Year 1	Expenditures	$501,100	$120,374	$23,607	$141,785	$30,149	$50,468	$134,717
	Leakages	-$117,285	-$9,100	-$10,301	-$32,600	-$13,734	-$6,489	-$50,680
	Direct Contribution	$287,787	$81,605	$11,004	$84,980	$13,716	$30,444	$66,038
	Indirect Contribution	$47,851	$14,942	$1,306	$11,200	$1,662	$5,797	$9,097
	Induced Contribution	$48,177	$14,727	$996	$13,004	$1,037	$7,737	$8,902
	Total Contribution	$383,815	$111,274	$13,307	$109,185	$16,415	$43,978	$84,037
Year 5	Expenditures	$291,557	$74,505	$13,138	$77,419	$19,536	$28,830	$78,130
	Leakages	-$88,505	-$24,535	-$5,808	-$17,361	-$9,067	-$4,319	-$30,453
	Direct Contribution	$152,485	$36,577	$6,058	$46,743	$8,747	$16,961	$37,399
	Indirect Contribution	$24,932	$6,674	$713	$6,151	$1,046	$3,193	$5,085
	Induced Contribution	$25,635	$6,718	$558	$7,164	$676	$4,357	$5,192
	Total Contribution	$203,052	$49,969	$7,330	$60,058	$10,470	$24,511	$47,677
Year 10	Expenditures	$347,944	$86,848	$15,955	$94,739	$22,392	$34,652	$93,357
	Leakages	-$103,441	-$27,526	-$7,017	-$21,461	-$10,323	-$4,903	-$35,896
	Direct Contribution	$183,623	$43,423	$7,389	$57,033	$10,084	$20,589	$45,106
	Indirect Contribution	$30,096	$7,931	$873	$7,510	$1,212	$3,894	$6,165
	Induced Contribution	$30,784	$7,968	$676	$8,735	$773	$5,266	$6,191
	Total Contribution	$244,504	$59,322	$8,938	$73,278	$12,070	$29,749	$57,461
Year 20	Expenditures	$373,112	$75,222	$10,487	$89,523	$14,055	$38,910	$69,816
	Leakages	-$110,107	-$11,725	-$831	-$10,345	-$1,271	-$6,822	-$7,988
	Direct Contribution	$197,522	$46,478	$7,983	$61,625	$10,681	$22,208	$48,546
	Indirect Contribution	$32,401	$8,492	$944	$8,116	$1,286	$4,207	$6,646
	Induced Contribution	$33,083	$8,526	$729	$9,437	$817	$5,672	$6,636
	Total Contribution	$263,005	$63,497	$9,656	$79,178	$12,784	$32,088	$61,828

Endnotes

[1] USACE Portland District, 1947. Special Report on Selection of Sites Lower Snake River. Oregon, Washington and Idaho. Dated March 14, 1947. Portland, Oregon. Page 134, Paragraph 395. "If credit were taken for indirect navigation and power benefits which admittedly are great and if additional credit were taken for the use of cheap hydroelectric power over electrical power produced by the next most economical means, full economic justification of this project on the inflated 1946 cost index would be assured." Print.

[2] Peterson, K., Reed, M., ND. Controversy, Conflict and Compromise: A History of the Lower Snake River Development. Available at: http://www.nww.usace.army.mil/Portals/28/docs/history/CCC_aHistoryOf%20LSRdevelopment_OCR.pdf (Pg. 78, paragraph 4)

[3] USACE 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report / Environmental Impact Statement, Appendix I: Economics, available at: www.nww.usace.army.mil/Library/2002LSRStudy.aspx

[4] Hansen, W., Badger, D., 1991. National Economic Development Procedures Manual – Recreation. Volume IV. Evaluating Changes in the Quality of the Recreation Experience. U.S. Army Corps of Engineers Water, Resources Support Center, Institute for Water Resources. Fort Belvoir, Virginia. Available at: http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/91-R-7.pdf

[5] Waddell 2016. (Personal communication, January 12, 2016)

[6] USACE, 2014. Memorandum for Planning Community of Practice. Available at: http://planning.usace.army.mil/toolbox/library/EGMs/EGM15-01.pdf

[7] USACE-NWW, 2016. Snake River Production to Northwest Residential Use- Negating Aug Sep 2015. Available at: http://www.nww.usace.army.mil/Portals/28/siteimages/Missions/Snake%20River%20Production%20to%20Northwest%20Residential%20Use%20-%20Negating%20Aug%20%20Sep%202015.pdf

[8] EIA, 2015. Table 5. Electric power industry generation by primary energy source, 1990-2013. Available at: http://www.eia.gov/electricity/state/washington/

[9] Jones, A. 2015. Lower Snake River Dam Alternative Power Costs., citing BPA, 2014 Pacific Northwest Loads and Resources Study, January 2015, Table 1-6, PNW Regional Resources, OY 2016, 1937-Critical Water Conditions, pp.12, and RME.

[10] US Energy Information Administration. 2015. *State Electricity Profiles, Table 5. Electric power industry generation by primary energy source, 1990-2013.* Available at: www.eia.gov/electricity/state.

[11] Murphy, K. 2011. "Wind power and water power collide in the Northwest." *Los Angeles Times*, June 14; Smith, E. 2012. "Ratepayers Paying Wind Farmers Not to Produce Electricity - $2.7 Million So Far This Year," *Washington State Wire*, September 19.

[12] Stepankowsky, A. 2012. "BPA releases plan to reimburse wind energy producers," *The Daily News* (Longview, WA), February 8.

[13] Washington Initiative 937. 2006. Available at: www.sos.wa.gov/elections/initiatives/text/i937.pdf (p 5, lines 13-21).

[14] US Energy Information Administration. 2015. *State Electricity Profiles, Table 5. Electric power industry generation by primary energy source, 1990-2013.* Available at: www.eia.gov/electricity/state.

[15] US Energy Information Administration. 2015. *State Electricity Profiles, Table 5. Electric power industry generation by primary energy source, 1990-2013.* Available at: www.eia.gov/electricity/state.

[16] USACE NWW, 2015. Intercom. Vol. 44 No. 1 Jan – Dec 2015. Pg. 11. Available at http://www.nww.usace.army.mil/Portals/28/docs/media/intercom/jan_Dec2015_IntercomSpreadsRevised.pdf

[17] USACE 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report / Environmental Impact Statement, Appendix I: Economics, p I12-3. Available at: www.nww.usace.army.mil/Library/2002LSRStudy.aspx.

[18] U.S. Energy Information Administration 2015. Annual Energy Outlook 2015 with projections to 2040. Available at: http://www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf

[19] Northwest Power and Conservation Council, 2015. Draft Seventh Northwest Conservation and Electric Power Plan. Available at: https://www.nwcouncil.org/media/7149683/7thplandraft_full_20151020.pdf

[20] Jones, A. 2015. Lower Snake River Dam Alternative Power Costs, Table 6, p 18.

[21] USACE 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report / Environmental Impact Statement, Appendix I: Economics, p I3-95, Table 3.3-5 available at: www.nww.usace.army.mil/Library/2002LSRStudy.aspx.
[22] USACE 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report / Environmental Impact Statement, Appendix I: Economics, p I3-93, available at: www.nww.usace.army.mil/Library/2002LSRStudy.aspx.
[23] DREW 1999 Transportation Analysis, p. 84 available at: www.nww.usace.army.mil/Library/2002LSRStudy/DREW.aspx.
[24] Jones, Anthony 2015 Lower Snake River Dam Navigation Study, p 9-23, available at: www.wildsalmon.org/images/stories/PDFs/Fact_Sheets/LSD.Navigation.Study.2015.Final.pdf.
[25] Waddell, J., 2015. Commercial Navigation on the Lower Snake River: Two wrongs don't make a right.
[26] Waddell, 2015. The Costs of Keeping the Four Lower Snake River Dams: A Reevaluation of the Lower Snake River Feasibility Report.
[27] USACE 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report / Environmental Impact Statement, Appendix I: Economics, Table 3.2-4 (pp I3-54), available at: www.nww.usace.army.mil/Library/2002LSRStudy.aspx
[28] McKean, J. et al. 1999. Outdoor Recreation Demand and Expenditures: Lower Snake River Reservoirs. Agricultural Enterprises, Inc., University of Idaho Department of Agricultural Economics and Rural Sociology.
[29] McKean, J. et al. 2005. Willingness to Pay for Non Angler Recreation at the Lower Snake River Reservoirs. Agricultural Enterprises, Inc., University of Idaho Department of Agricultural Economics and Rural Sociology
[30] University of Idaho, ND. Revenue Stream. Available at: http://www.webpages.uidaho.edu/fish510/PDF/revenuestream8.pdf
[31] Briceno, T., Mojica, J., 2015. Review of the Lower Snake River Juvenile Salmon Migration Feasibility Report/ Environmental Impact Statement. Section I3-49 through I3-81 of the Economic Appendix (I). Earth Economics, Tacoma, WA.
[32] Based on USACE 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report / Environmental Impact Statement, Appendix I: Economics, Table ES-8 (pp I ES-13), available at: www.nww.usace.army.mil/Library/2002LSRStudy.aspx
[33] Christianson, C., Grace, J., Waddell, J., 2015. The Case for Breaching the Four Lower Snake River Dams to Recover Wild Snake River Salmon. Available at: https://srkwcsi.files.wordpress.com/2015/11/snake-river-endangered-salmon-white-paper-11-15-15.pdf
[34] USACE 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report / Environmental Impact Statement, Appendix I: Economics, Table 3.4-16 (pp I3-147), available at: www.nww.usace.army.mil/Library/2002LSRStudy.aspx
[35] USACE 2002 Lower Snake River Juvenile Salmon Migration Feasibility Report / Environmental Impact Statement, Appendix I: Economics, p I12-3. Available at: www.nww.usace.army.mil/Library/2002LSRStudy.aspx.
[36] Waddell, 2015. The Costs of Keeping the Four Lower Snake River Dams: A Reevaluation of the Lower Snake River Feasibility Report.
[37] Domenici, 2004. Senate Reports Nos. 374-407. Mediator's Term Sheet. Snake River Flow Component. Pages 18-24. Electronic Document.