Economics of Columbia River Initiative

Final Report to the Washington Department of Ecology and
CRI Economics Advisory Committee.

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EXECUTIVE SUMMARY

The purpose of this study is to review the economic effects of increased water use from the Columbia River in the context of Washington State's Columbia River Initiative (CRI). The CRI is designed to address the legal, scientific, and political issues related to water use from the mainstem of the Columbia River in Washington State. The economic analysis in this report is one of several kinds of information that will be used to inform the Department of Ecology's rule-making related to the Columbia River. In addition to this review, the State has contracted with the National Academy of Sciences to consider the relationship between water use and the health of salmon populations. This report focuses on the economic consequences of increased water diversions in the mainstem Columbia river in Washington State, including effects on agricultural production, municipal and industrial water supplies, hydropower generation, flood control, river navigation, commercial and recreational fishing, regional impacts, and passive use values. In addition to gauging these effects, the report includes a summary of issues related to the increased use of market transactions in water rights.

The analysis is focused on a series of five "Management Scenarios" developed by the Department of Ecology in consultation with water users. Each "scenario" incorporates a policy for issuing new water rights, and each is conditional upon an assessment of risks to anadromous fish. Water rights for roughly 4.7 million acre-feet of water for diversions from the Columbia river (including groundwater rights within1 mile of the river) are currently held in the State, with 91% going to irrigated agriculture and 9% to municipal, industrial, domestic and other users. As shown in Table E-1, the first three Scenarios increase these water rights by 1 million acre-feet (MAF) and permit existing interruptible water rights (about 3.6% of the surface water rights) to be converted to non-interruptible rights. For each of these three Scenarios, the new water rights holders must meet water efficiency standards (called Best Management Practices, or BMPs) and begin metering their withdrawals. In Scenarios 2 and 3 fees are charged ($10 or $20 per acre-foot per year) for new and converted water rights, and 300 KAF of the 1 MAF is withheld until the majority of existing water users meet the BMPs. Scenario 4 envisions no overall increase in water diversions but it permits new users to obtain rights via transfer from existing users, thus mitigating for the new diversions in time and place. Scenario 5 is the "no change" or *status quo* option.

Table E-1. Five CRI Management Scenarios

Scenario	Quantity of New Water Rights	Fees	Contingencies	Other Requirements
1	1 MAF	none	none	Meet BMPs and meter withdrawals
2	1 MAF	$10/acre-foot annually	300 KAF depends upon 80% of existing rights complying with BMPs	Meet BMPs and meter withdrawals
3	1 MAF	$20/acre-foot annual	300 KAF depends upon 80% of existing rights complying with BMPs	Meet BMPs and meter withdrawals
4	None	$30/acre-foot for transfers & conversions	New withdrawals must be fully offset by transfers, conservation or new storage.	Meet BMPs and meter withdrawals
5	Status Quo	none	Issuance of new rights follows current procedure & depends upon opinion of fishery managers.	

To evaluate the economic effects of the second and third scenarios we developed lower bound, partial allocations of the water rights. These lower bounds reflect the possibility that either the BMP & metering requirements and/or the increased fees would discourage new water applicants and keep the total new water rights allocation below the maximum of 1 MAF. For Scenario 2, the lower level was set at 700 KAF and for Scenario 3 the lower level allocation is set at 572 KAF. In assessing the impacts of these scenarios, we assume that the new water rights include 220 KAF for the Columbia Basin Project (209 KAF for irrigation and 11 KAF for municipal and industrial use), and 80.7 KAF for existing applicants for municipal and industrial (M&I) water. The remainder goes for new irrigated agricultural use. We distribute the new agricultural water among river reaches and counties in a manner reflecting the locations of applications in the existing pool of water permit applications at Department of Ecology.

A major impact of the first three scenarios occurs in the irrigated agriculture sector, where new water rights allow the expansion of crop production, mainly in the Columbia Basin

Project area and in Benton County. Assuming that crop prices remain at current levels, and that the costs of production are reflected in available crop budget studies, the gross revenue (sales value) and net revenue (sales revenue minus farm costs) of new crops was estimated for each of the Scenarios. It is important to note the results are sensitive to the assumption of crop prices remaining at current levels, as is discussed in detail in Chapter 3. The main results, detailed in Table E-2, are that agricultural production will increase with the new water allocations to generate between $349.6 and $ 779 million in gross revenue and between $11.5 and $43.7 in net revenue to farms. The gross revenue increases from Scenario 1 to Scenario 3 because we assume shifts in cropping patterns induced by the increasing fees. Most of the new crop production occurs in Benton, Douglas, Grant, and Okanogan Counties. A 65% share of the new revenue is attributed to expansion in orchards, while 4.7% is in vegetables, and 18.4% in potatoes. Under Scenario 4, we would expect some increase in value of agricultural crops as water is transferred from lower-valued to higher-vales uses. We did not estimate the magnitude of that increase.

Table E-2. Summary of Effects on Agricultural Production and Value

Scenario	Gross Revenue	Net Revenue
1	$733.1 mil.	$43.7 mil.
2	$465.4 – 757.2 mil.	$21.9 mil.- $38.3 mil.
3	$349.6 – 779.0 mil.	$11.5 mil - $32.6 mil.
4	unknown but likely >0	unknown but likely >0
5	none	none

As additional water is allocated to irrigated agriculture, we may be interested to know how much additional value is created per acre-foot of water diverted. Under the assumptions used in our analysis, the water allocated to the Columbia Basin Project generates about $11/AF in net revenues. For the non-Columbia Basin Project water, we have built in some shifts in cropping patterns, which we found to be a realistic depiction of the likely response to fees for new water rights. For the non-CBP water, the net revenue per acre-foot is in the $59 to $69 range. Overall, the average net revenue from new water diversions to irrigated agriculture ranges from $48.05 with 1 MAF of additional water under Scenario 1 to $46.05 with 700 KAF under

Scenario 2 to $43.86 with 572 KAF under Scenario 3. The net revenue estimates treat the $10/AF and $20/AF fees as an added costs to the farmers under Scenarios 2 & 3.

Because the Municipal and Industrial (M&I) use of water is a relatively small portion of the total withdrawals from the river, and because these uses tend to have relatively high values, we assume that these uses are high priority. M&I applications represent about 28.5% of existing M&I water rights, and most of those applications are from the McNary reservoir. The population of the Tri-City area, the main population center near McNary reservoir, grew by 32% in the past 10 years. Hence, we assume that M&I water use would need to increase by 30% over the period covered by the CRI process. This amounts to 80.7 KAF, which will go to high-value uses and will facilitate the expansion of towns and food processing companies in the area where agricultural production is expected to grow. Based upon records of water transactions reviewed in Chapter 4, municipal and industrial water is valued at between 0 and $452 per acre-foot.

Each new diversion will decrease the stream flow in the Columbia River downstream of the diversion point. This reduced flow will cause a reduction in hydroelectric power production at 6 Federal and 5 Public Utility District dams on the mainstem of the Columbia River. Using a simple monthly model of irrigation and M&I water withdrawal and return flow, and assuming hydropower production rates (megawatt-hours per unit of flow) remain as in the past, we estimate that the loss of hydropower associated with an increased water withdrawal of 1 MAF will amount to $18.4 million for typical water years. In dry years (such as 1976-1977) hydropower generation rates differ, and withdrawals would include interruptible rights that are converted to non-interruptible, raising the estimated hydropower loss to $20.0 million. These hydropower losses were valued using average prices forecasted for the years 2004 – 2024 by analysts at the Northwest Power and Conservation Council. Based upon these wholesale power prices, the value of diverted water for power generation ranges from a high of $38.53/AF at Grand Coulee in a dry year to a low of $5.64/AF at John Day dam in a dry year. During dry and warm climate conditions, the prices are likely to exceed these forecasts due to water shortages and high power demand.

Flood control and river navigation are important purposes served by the Federal dams in the lower Columbia and Snake rivers. The new CRI water diversions are not expected to have any perceptible effects on flood control activities, because the diversions will occur mostly during May – August, while flood control is a major factor in river operations only during the

late winter and early spring high run-off period. Shallow draft river navigation (barging) occurs in the reservoir system from Bonneville dam to the Tri-cities area, and up the Snake River as far as Lewiston, Idaho. Barging is not expected to be significantly affected because reservoir levels are maintained to exceed levels necessary for lockage at dams even in dry years. Deep-draft navigation in the lower Columbia River below Bonneville dam is not expected to be affected by the new diversions, because the minimum flow needed to maintain the shipping channel depth (70 kcfs) will not be jeopardized by the small decreases in flow caused by a 1 MAF diversion.

Commercial and recreational fishing may be harmed by the increased diversions if the salmon and steelhead runs in the Columbia and Snake rivers are negatively affected. This would occur if mortality during downstream migration of juvenile fish, or upstream migration of adult fish, increases as flows decline. Lacking a scientific consensus on flow-mortality relationships, and considering that the National Research Council committee is evaluating the risks to salmon and steelhead, we did not attempt to quantify the possible economic loss. Instead, the report summarizes existing information about the economic values of fish caught in the commercial and recreational fisheries for Columbia River fish. Those values can be used at some point in the future to assign values to estimated changes in anadromous fish runs.

The economic impact assessment notes that when the agriculture sector expands, all related economic sectors (e.g. suppliers and food processors) will expand in unison. Further, the increased incomes by wage-earners in the expanding sectors will spur increased sales of a wide variety of consumer goods, and this will cause yet additional economic expansion in the regional economy. To assess the regional economic impacts, we first estimate the “direct impacts” which encompass the increased sales of raw and processed agricultural products. Next, we assess the full effects, considering the expanding related sectors and income-driven economic expansion of the whole economy. These economic impacts are reported in three categories: Total Output, Employment, and Value-Added. The Output impact measures the change in sales of all products, including raw materials, wholesale products, plus a retail sales “margin”. This measure does not correspond to any of the standard economic indicators (e.g. a State-level equivalent to national product or national income) and is probably the least useful measure of economic impact. Employment impact is calculated from the Output impact by dividing the sales in each of 62 sectors in the State economy by a standard ratio of full-time employees per $1 million in sales. Finally, the value-added (sales minus purchases of inputs) in each sector is summed up to yield a

measure that is similar to regional income. Table E-3 displays the direct and total employment impacts and value-added impacts for each level of water diversion. To put these numbers in perspective, these impacts are relatively modest in comparison to statewide totals of $222 billion in Gross State Product in 2001 and the 3.1 million in the State workforce in 2002. Still, the impact of a 1MAF increase in water represents roughly a 20% expansion in the State's agricultural economy. These impact assessments are likely a bit on the high side because they do not incorporate the probable price-depressing effects of increased agricultural production.

Table E-3 Summary of Statewide Economic Impacts of Agricultural Expansion ($ millions)

	Employment		Value-Added	
	Direct	Total Impact	Direct	Total Impact
1 MAF	18,420	44,841	$841.2	$2,032.2
700 KAF	11,658	28,343	$531.9	$1,284.1
572 KAF	8,733	21,205	$398.2	$960.3

Beyond the market-based values of agriculture and fishing, passive use values are held by the public for all manner of economic goods, services, and conditions. Sometimes called "existence values", these represent the amount people would be willing to pay for something even if they don't plan to consume or use it. Passive use values are thought to be particularly significant for public goods that are unique and scarce. Salmon and steelhead populations in the Columbia River qualify as objects having passive use values. We reviewed economic studies that estimated values for salmon in the range of $66.28 to $268.08 per fish. The wide range of estimates reflects both variability due to the vagaries of research methods in common use and variability associated with different descriptions of the "good" to be valued (e.g. a single endangered fish run, or a basin-wide complex of species).

A different approach to assigning a value to passive use of salmon is to estimate the value the public places on various, realistic changes in the size of the anadromous fish runs, as was done by Layton, Brown, and Plummer (1999) for the Department of Ecology. While this valuation process incorporates both use and passive use values, the majority of the value estimated in the study is undoubtedly passive use value. The result is a value function, which

assigns a public value to changes in the overall fish population from the status quo level. For example, a 1/2% reduction in Columbia River anadromous fish run is estimated to cause a loss in passive use value of $7.15 million. (averaging $715 per fish). The evidence presented by that study clearly shows that passive use value held by State residents vastly exceeds the estimated commercial and recreational values of the fish, at least at recent population levels and for moderate changes in population size.

Finally, we reviewed the prospects for water markets, which are an increasingly attractive alternative to regulatory or other non-market mechanisms for resolving disputes over water use and for improving the efficiency of water use. Water markets (sometimes called water exchanges or water banks) permit willing sellers and willing buyers to transfer water, which generally shifts water from lower valued to higher valued uses. Three types of transactions can accomplish this result. Outright purchases of permanent water rights, temporary leases of diversionary water rights, and transfers of ownership of stored water (typically in a storage reservoir) all facilitate the increase in value of water use. While numerous water transfers of all types have occurred in Washington State, the expansion of water markets is slowed by three obstacles:

1. Third party effects of water transfer, due to shifts in return flows, have to be taken into consideration, possibly involving compensation or mitigation.
2. Partly due to third party impacts, the water right that can be transferred needs to be defined in terms of consumptive use, not diversionary right, and this requires documentation and measurement that may not be immediately available.
3. There is often resistance to transfer of water from a traditional use (e.g. agriculture) to another use because of impacts on local communities and cultural attachments to traditional uses.

None of these is a fatal complication, but all three issues highlight the care required in development of a water transfer institution. Washington State has made the legal changes necessary to permit water transfers. Current law requires that such transfers be submitted to the DOE for review and approval. The ability to retain water rights while temporarily transferring water use to instream flow has also been achieved in Washington. The Washington Water Trust has purchased and leased water for enhancement of instream flows in such places as Salmon Creek, a tributary of the Okanogan river. And the DOE has a water acquisition program designed to shift water from out-of-stream use to instream flow in chosen locations. All these examples

illustrate the principle that increasing transferability of water rights can, given adequate attention to the three issues listed above, work to improve economic efficiency of water use and to improve stream flows.

CONCLUSION

The Columbia River Initiative promises to encompass a number of important developments in the economy and environment of Washington's portion of the Columbia river. While considering increased diversions of water of up to 1 million acre feet, the CRI "management scenarios" also incorporate improved water efficiency and metering requirements, and they propose levying fees for new water users of $10 to $30 per acre-foot per year, with the fee level depending upon the level of threat to salmon runs. Funds from the fees would be used to mitigate the effects of water diversion on the habitat and flow conditions affecting the fish populations. The economic review shows that these increased diversions are (a) unlikely to have significant impacts on flood control or river navigation, (b) will have moderately large negative impacts on hydropower production, (c) will have very large positive impacts on the agricultural economy and on the State's regional economy, and (d) might have some negative effects on fisheries and passive use values tied to salmon and steelhead runs. To some degree, the fees proposed under the second and third management scenarios will permit the State to mitigate the effects of increased water diversion on the fish and wildlife resources. Finally, improving and facilitating the exchange of water rights among users through water markets should improve the efficiency of water use and provide opportunities to acquire water for use by fish and wildlife.

This report is limited in scope to the five Management Scenarios provided by the Department of Ecology, and it does not consider a wider range of mainstem water policies suggested by some interest groups. In addition, the scope of this research is limited to summarizing and extrapolating from existing studies. No new field data collection is incorporated in the study. The report is also limited in considering only those future changes in the economy which can reasonably be inferred from recent past information. In particular, we have not built into the analysis recent forecasts of climate trends for the Pacific Northwest. Without closer examination, it is unclear how the various economic sectors will need to adjust to predicted increases in average temperatures and earlier snow melt. Further, this report does not consider wider regional repercussions of increased water diversions in Washington State. For

example, reactions by the States of Idaho and Oregon, or by Treaty Tribes and Federal courts concerning water and fish allocations, have not been incorporated. Finally, the report is narrowly focused on a set of economic effects of the CRI program, and does not consider other potentially important social and legal ramifications of increased water use from the mainstem Columbia River.

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CHAPTER 1. INTRODUCTION

A. Columbia River Initiative (CRI) Rationale and Timeline

The purpose of this study is to review the economics of water use from the Columbia River in the context of Washington State's Columbia River Initiative (CRI). The CRI has been proposed as a way to address the legal, scientific, and political issues related to water use from the mainstem of the Columbia River in Washington State. The analysis completed herein is one of several kinds of information that will be used to inform the Department of Ecology's rule-making related to the Columbia River. In addition to this review, the state has contracted with the National Academy of Sciences to consider the relationship between water use and the health of salmon populations.

Through the CRI process the state is seeking to develop an integrated state program that will allow access to the river's valuable water resources while at the same time providing support for salmon recovery. In recent years, competition for water from the river has continued to escalate. There is little agreement on the stream flows needed to support salmon survival. Hundreds of pending applications exist for new diversionary water rights from the Columbia. Litigation has been used increasingly to try to drive public policy in widely divergent directions, but often has resulted only in additional conflict and legal bills for the parties involved. The purpose of the CRI is to establish a scientific basis for a state water management program for the Columbia River that can meet the needs of salmon populations while supporting the region's economy. The CRI will result in a policy that defines how the Department of Ecology (Ecology) will carry out its dual obligations of allocating water and preserving a healthy environment.

Ecology has proceeded with the CRI by forming two technical reviews: an economics review and a national science review. The economics review, the subject of this report, seeks to understand the economic value of water from the mainstem of the Columbia River. It will provide information about how Washington benefits from water allocations, including allocations required in protecting salmon runs. The science review will be conducted by the National Academy of Sciences (NAS) and will consist of a formal, independent review of the science of fish survival and hydrology in the Columbia River. As a part of the science review, regional scientists have been asked to help inform the NAS committee by providing information and perspectives at two public meetings. The Department of Ecology will use the information

generated by both the science and economic reviews to help develop a new water resource management program for the mainstem of the Columbia River.

The timeline for the economic review calls for the completion of the project by the end of the 2003 calendar year. A draft of this study was submitted in November 2003. Interested and affected parties commented on the draft, the study team revised the draft in producing this final version. Once all information regarding the CRI has been collected, Ecology will adopt a final rule in late 2004.

Because of the short time period for this research, this report is limited to examining the five Management Scenarios provided by the Department of Ecology. In addition, the scope of this research is limited to summarizing and extrapolating from existing studies. No new field data collection is incorporated in the study. The report is also limited in considering only those future changes in the economy which can reasonably be inferred from recent past information. In particular, we have not built into the analysis affects of future climate trends that have been predicted for the Pacific Northwest. Further, this report does not consider wider regional or national repercussions of increased water diversions in Washington State.

B. Water Rights on the Columbia River in Washington: Magnitude and Pending Applications

In response to the endangered species listing for salmon, a moratorium was placed on new diversions from the Columbia River in 1991. The moratorium was lifted in 1998 and a rule implemented requiring Ecology to consult with fish agencies before authorizing new appropriations of Columbia River water. Ecology began to process a few water right applications that had been filed before the moratorium was declared. In the fall of 2001, Ecology was set to issue the water rights specifying conditions based on information from the National Marine Fisheries 2001 biological opinion. However, early in 2002 a Benton County Superior Court judge issued an order restraining Ecology from authorizing new rights.

There are currently 754 existing surface water (SW) rights accounting for slightly more than 4.5 million acre-feet (MAF) per year along the Columbia River in Washington State. An application pool exists for SW rights accounting for slightly more than 600 thousand acre-feet (KAF) along the Columbia River in Washington State. Ground water (GW) rights and applications also exist; with GW rights accounting for about 470 KAF and GW applications accounting for 183 KAF. Some of the rights in existence are interruptible. An interruptible right is a right that Ecology can choose not to recognize during a low water year, so that less water

will be diverted, leaving more water for in-stream uses. Washington irrigators with water withdrawal permits issued after 1980 are subject to interruption when the water supply forecast at The Dalles Dam falls below 60 MAF from April through September. For SW rights, less than 1% of diversions are of interruptible status accounting for 39 KAF. For GW rights, 10.5% of diversions are of interruptible status accounting for 49 KAF.

Of the existing SW rights, 69% of the diversions occur at Grand Coulee pool, 13% at John Day pool, and 12 % at McNary pool. The remaining 6% of diversions are spread across the remaining 8 pools.

Of the existing SW rights, 91% of the diversions are for irrigation purposes, 5% are for commercial & industrial use, 2% are for domestic & municipal use, and 2% are for other purposes. A summary of existing SW rights and applications for SW rights from the Columbia River is shown below.

Table 1.1. Columbia River Existing Diversionary Rights and Pending Applications by Pool in Acre-feet

Pool	SW Rights	SW Applications
Bonneville	3,854	0
John Day	587,000	138,446
The Dalles	421	260,172
McNary	561,024	138,964
Priest Rapids	9,842	0
Rock Island	94,143	6,149
Wannapum	13,401	1,847
Rocky Reach	44,354	7,710
Wells	64,556	53,859
Chief Joseph	27,350	741
Grand Coulee	3,157,664	650
Total	4,563,608	608,540

C. Management Scenarios

The management scenarios developed by Ecology for the Columbia River Initiative represent a range of water management strategies, and they relate to levels of risk to salmon from allocating additional water rights from the Columbia River mainstem. Chapter 2 includes a more detailed explanation of the Scenarios, and of how the study team will interpret them.

Briefly, Scenario 1 assumes that the risk to salmon is low, and allows for 1 MAF of new diversions from the Columbia River per year over a 20 year period. Interruptible water rights can be converted to uninterruptible if irrigators conform to Best Management Practices (BMPs) as determined by Ecology (see Appendix A for details). All new water rights issued would also require BMPs and would also be metered. This requirement carries over to scenarios 2 through 4. There will be no fees on new diversions in Scenario 1.

Scenario 2 assumes a low to medium risk to salmon. It allows initially for 700 KAF of new diversions, and an additional 300 KAF after the majority of users (80% of total diversions) conform to BMPs. Interruptible rights can be converted to uninterruptible as in Scenario 1. New and converted rights are subject to a fee of $10 per AF, with generated funds to support mitigation of effects on salmon, through water purchases, habitat restoration and other measures.

Scenario 3 assumes a medium risk to salmon, with the potential for new rights identical to that of scenario 2. The associated fee for new and converted rights is $20 per AF, and the revenue generated will contribute to an even more robust salmon restoration, new conservation, and the exploration of storage development.

In scenario 4, the risk to salmon is considered to be medium to high, and new diversions will be allowed only if they are offset in proportion to consumption. Essentially, all new rights would offset existing water use through transfers, conservation, and/or new storage. Conversion to uninterruptible is still possible by adhering to BMPs, and new and converted rights pay a fee of $30 per AF, with the funds used to acquire mitigation water in low water years and habitat improvement in the mainstem and tributaries.

Finally, scenario 5 assumes that the risk to salmon is high, and that the potential for new diversionary rights and the conversion of interruptible rights would be based on the opinion of fish managers. No fees exist for future diversions, and mitigation would be explored on a case-by-case basis. This scenario represents the status quo.

D. Analytical Approach to Economic Effects of Scenarios

The economic effects of expanded diversionary water rights from the Columbia river in Washington are potentially complex and important. For purposes of this analysis, these effects are broken into the following categories: (1) impacts on irrigated agriculture, (2) effects of increased municipal and industrial (M&I) water use; (3) losses in the hydroelectric power generation industry; (4) impacts on flood control operations in the Columbia River; (5) impacts on shallow draft (river barges) navigation and ocean shipping in the river; (6) effects on recreational and commercial fishing; (7) regional and secondary (sometimes called "multiplier") impacts of the foregoing changes; and (8) changes in passive use values held by Washington State residents. These categories are commonly used and understood in the policy analysis field, but they specifically do not include other cultural and social effects that cannot be quantified as economic changes. For each of these categories, the economic effects are reviewed and estimated based upon pre-existing publications, agency reports, and analyses.

As a general approach, the economic effects are reckoned as changes from the status quo. That is, we are evaluating changes in the (8) categories listed above based upon the expected economic conditions without any new water policy (Scenario 5) versus the expected conditions with a new water policy (Scenarios 1 – 4). To assess each category, we must establish some basis for forecasting the economic changes that would occur due to a new water policy. For the direct water users (agriculture, municipal and industrial use, and hydropower) this is conceptually straightforward – estimate how much water will be used and how, then assign an economic value based upon an existing price forecast or economic model. For categories (4) and (5) – flood control and river navigation – we rely primarily on an understanding of how the system of dams operates. For recreational and commercial fishing, we provide only general information about the associated economic values which could be used once the scientific review is completed. The regional impacts are assessed with regard to agriculture and hydropower by using a Washington State input-output model. And for passive use values, the least well documented of the economic effects, we review and summarize information from recent studies.

CHAPTER 2. COLUMBIA RIVER INITIATIVE "MANAGEMENT SCENARIOS"

The Washington Department of Ecology developed a set of five alternative management scenarios specifying different levels of risk to salmon that might result from the diversion of water from the Columbia River. In general, the management scenarios include issuance of new surface water rights from the river, conversion of interruptible rights to non-interruptible status, mitigation funding, and mitigation measures. The scenarios reflect a range of potential water resource management strategies for the Columbia River mainstem. The Department of Ecology will finalize the features of a management program for the Columbia River after the results of the National Academy of Sciences study are understood and public review processes are complete.

To assess the magnitude of the economic impacts of the five scenarios, we need to anticipate the distribution of new rights among uses and locations. To do this, we make reasonable assumptions about the administrative process and economic demands for water. Based upon these assumptions we extrapolate from the existing pattern of water rights and applications to new water uses in specific places. The extrapolation used in this study is based on a pool of existing Washington State water permits, certificates, and applications within one mile of the mainstem Columbia river.

A. Water Allocations and Risk to Salmon

Table 2.1 below shows the magnitudes of potential new water allocations being considered under each Scenario, paired with a level of risk to salmon and steelhead. Each level of water allocation generates potential economic effects (benefits, costs, changes in employment opportunities, etc.) and each poses some potential risk to migration survival by salmon and steelhead stocks in the Columbia river. Determining the risk to salmon is the task of a review currently underway by the National Academy of Sciences (NAS). The NAS review will not be completed until early next year, and consequently cannot be incorporated in this economic study. In anticipation of that assessment, DOE has associated each Scenario with a particular risk to salmon. If the risk level exceeds that shown in the table below, the associated Management Scenario would be rejected. For example, if Scenario 1 entails high risk to salmon, DOE would not choose that option.

Table 2.1. Potential for New Water Rights by Scenario

Scenario	Risk to Salmon	Potential for New Rights
1	Low	1 MAF
2	Low to Medium	700 KAF initially, 300 KAF in the future
3	Medium	700 KAF initially, 300 KAF in the future
4	Medium to High	Transfers, conservation, & new storage only
5		None

B. Fees and Mitigation Funding

In Scenarios 2, 3, and 4, the Department of Ecology would implement mitigation measures for salmon to offset the effects of water use. The mitigation measures would be funded by per acre-foot fees paid by both new water rights recipients and by those converting from interruptible water rights to uninterruptible status. Scenarios 1 & 5 do not contemplate this kind of funding mechanism. A summary of the contributions per acre foot of water use for new rights and/or rights converted from interruptible to uninterruptible is outlined below.

Table 2.2. Potential State Revenues (Upper Bound) by Scenario

Scenario	Fee	Revenue from New Surface Water Rights	Revenue from Converted Interruptible Rights
1	$0	$ 0	$0
2	$10	$ 10,000,000	$ 1,220,808
3	$20	$ 20,000,000	$ 2,441,616
4	$30	$ 30,000,000	$ 3,662,424
5	$0	$ 0	$0

C. Water Efficiency Standards (Best Management Practices)

A water use efficiency program has been designed jointly by the Columbia Snake River Irrigators Association (CSRIA) and Ecology to help define the BMPs (see Appendix A for details). The two organizations agreed to develop the program as an option for water users with rights issued after 1980 to convert their rights to uninterruptible status. All newly issued rights would also be subject to BMPs. The proposed BMPs vary according to the number of acres

being irrigated. If a water user has fewer acres, the BMPs would be less expensive and simpler to implement compared to the BMPs of larger users. The efficiency program classifies existing water right holders into three sectors, with appropriate BMPs associated with each water user sector: Small Public Sector Irrigation, Other Small Irrigation, and Large Irrigation. The BMPs for water management and operation cover diversion and distribution systems, application systems and technology, crop and water management, new research, development and demonstration projects, and benefits for fish, wildlife, and environmental resources. In exchange for conversion to uninterruptible, the draft rule would require that water saved as a result of implementing the BMPs be transferred to Ecology or its designee for placement in the state's trust water right program.

D. Conversion of Interruptible Rights to Uninterruptible Rights

Under each of the scenarios, current holders of interruptible water rights would be provided an opportunity to convert to uninterruptible rights. An interruptible right can be directed to discontinue water withdrawals from the river during a drought year. Washington irrigators with water withdrawal permits issued after 1980 are subject to interruption when the water supply forecast at The Dalles Dam falls below 60 MAF, from April through September, as it was in 2001. About 111 groundwater rights and 213 surface water rights on the Columbia River (or within 1 mile of the river) were issued subsequent to the adoption of the instream flow rule. The conversion of the right to uninterruptible would obligate the water user to pay annual per acre-foot fees listed above in Table 2.2. Water rights holders converting to non-interruptible rights would also be required to meet the water efficiency standards discussed above.

Because the focus of this study is on surface water diversions, we considered only the surface water (SW) interruptible rights. Table 2.3 below provides a pool-by-pool summary of the amount of surface and groundwater rights currently recorded. Applying the total number of acre-feet to be converted from interruptible to uninterruptible status to the associated fee allows for extrapolation of potential State revenues. Combined with the prospective new surface water rights issued under each Scenario, the potential State revenues for mitigation projects is displayed in Table 2.2 above.

Table 2.3. Interruptible Water Rights in the Columbia Mainstem by pool.

Pool	Surface Water (AF)	Ground Water (AF)	Total (AF)
Coulee	415	1500	1915
Chief Joseph	1111	6669	7780
Wells	24316	10203	34518
Rocky Reach	1914	8185	10100
Rock Island	8491	2885	11376
Wanapum	721	0	721
Priest Rapids	0	8954	8954
McNary	53087	10112	63199
John Day	31651	1576	33227
The Dalles	374	194	568
Total	122,081	50,278	172,358

E. Mitigation Measures

Each of the scenarios outlines mitigation measures to be undertaken, based on the risk to salmon. For scenario 1, the current recovery efforts are assumed to be adequate, and Ecology would perform periodic assessment of the state's new water management program for the Columbia River to accommodate changes over time. Additionally, water transfer institutions would be encouraged.

Scenario 2 includes all of mitigation actions covered by scenario 1. In addition, the funds collected for new rights and converted rights would be used to support new levels of salmon restoration. The use of funds would be prioritized by fishery managers.

In addition to measures taken in the first two scenarios, scenario 3 would provide a more robust contribution to salmon health and survival. The state would provide financial support for new conservation and actively explore storage development.

For scenario 4, the generated funds would additionally be used to acquire mitigation water in low water years.

Scenario 5 would allow mitigation measures to be determined on a case-by-case basis in consultation with fisheries managers. Scenario 5 represents the status quo, and can be considered the "no action" scenario required by the State Environmental Policy Act.

F. Distribution of New Water Rights Among Pools and Counties

Each Scenario proposes a level of increased diversions of Columbia River surface water for use in Washington State. In Scenario 1, where risk to salmon is low, DOE would issue new permits during a 20-year window, not to exceed 1 MAF in total. Of that 1 MAF, up to 220 KAF could be allocated to the Columbia Basin Project. On top of the 1 MAF set aside for use in Washington State, 427 KAF would be legally recognized by the state to remain in the Snake River for in-stream uses, to supplement instream flow and address temperature issues. In addition to the 1 MAF and 427 KAF allocations described above, 600 KAF from the mainstem of the Columbia would be recognized as necessary to meet the needs of Oregon State. The analysis in this report considers only the new surface water rights, and associated new diversions, from the Columbia river in Washington.

Diversionary water rights can be used for a variety of different purposes. The majority of surface water diversions occur for irrigation purposes along the Columbia River. The BPA estimates that 90% of the total water withdrawn in the Pacific Northwest is for irrigation. The BPA also estimates that 8% of diversions are shared by domestic, municipal, and industrial uses.[1]

Of municipal & industrial (M&I) use of water rights within one mile of the Columbia River, about 93 KAF of water, or about 2.0% of all water rights, is used for municipal uses; while about 244 KAF, or about 5.3% is used for industrial use[2]. In the current water application pool for M&I water within one mile of the Columbia, about 69 KAF, or 11.4%, is for municipal uses; while about 7.5 KAF, or 1.2%, is for industrial uses. The relatively large application pool for municipal water might reflect the increasing demands for water in rapidly developing areas.

In order to determine the increasing needs of municipalities along the Columbia we look at population trends in the counties relevant to the study. Lacking readily available detailed data on actual M&I water use along the Columbia River, we consider existing applications for M&I water rights along the Columbia as an indicator of future use.

The Tri-Cities is the most important urban center for M&I use of Columbia River water. The area is surrounded by three counties: Benton, Franklin, and Walla Walla. Current

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[1] BPA, 1993

[2] Ecology specifies uses as Domestic/General & Municipal and Commercial & Industrial. The first category is essentially "Municipal" and the second category is essentially "Industrial."

diversionary rights allow for 269 KAF in the three counties near the Tri-Cities, and the combined population of the 3 counties is 247 thousand.[3] Furthermore, applications M&I applications from the three counties sum to almost 77 KAF, a 28.5% increase over existing M&I water rights. We assume that population growth in the area drives the need for more M&I water. The population of the three counties relevant to the Tri-Cities area has increased by 32.9% from 1990 to 2000. Extrapolating linearly suggest a rather large growth rate for the next 10 to 20 years between 32.9% and 65.8%. On the other hand, recent trends suggest that growth rates are falling off in Washington State mostly due to the stagnant economy.[4] Population growth numbers will likely come back as the economy continues to recover, but are unlikely to hit the levels of the booming 1990's. Therefore, a reasonable "guesstimate" of population growth for the Tri-Cities area might lie somewhere between 30% and 45% for the next 20 year period.

Supposing that population growth over the next 20 years is 30%, we would expect the water needs of the area to increase by the same amount over the same time period. Thus, water needs will increase by 30% from there current level. The current pending applications in the Tri-Cities area call for a 28.5% increase in M&I water, which we are assuming reflects municipal and industrial planning for future expected growth. Given our 30% growth projects, we expect to see the difference between 30% and 28.5% to be applied for sometime in the future. Thus, we extrapolate an additional 4 KAF of new M&I water right applications in the future, and we assume that these new applications will be distributed across pools and counties consistent with the distribution of existing applications. Under these assumptions, water rights for M&I use account for only 8% of the total increase in diversions, which is consistent with the BPA's findings in 1993.

To determine the amount of water going into agriculture, the study team assumed that diversions will only occur for irrigation purposes or M&I purposes. A small number of diversionary applications exist for "Other" purposes, which might include uses such as livestock, mining, and thermoelectric. These applications were ignored because they account for less than one percent of the total. So, all non-M&I new water uses are assumed to be for irrigated agriculture.

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[3] Washington State Office of Financial Management website

[4] Washington State Office of Financial Management website

We assume that M&I water is generally higher valued and will likely receive a higher priority, and that all existing and future applications for M&I will be granted rights. In addition, the Columbia Basin Project (CBP) has a claim to 220 KAF of the future water withdrawals, all of which will be taken out of Grand Coulee pool; 95% will be used for irrigation purposes, and 5% for M&I purposes.[5] The amount of water allocated to M&I purposes is fixed across all scenarios (corresponding to a 30% increase in the Tri-Cities plus 11,000 KAF to the CBP); the only thing that differs is the allocation to irrigation. Further, we assume that existing applications for irrigation water would be the first to be granted rights under Scenarios 1, 2, and 3. For scenario 1, the remaining 428 KAF of future water rights will go to irrigators and will be distributed as the pending applications for irrigation are distributed. For example, the total amount to be taken out of Grand Coulee includes 220 KAF for CBP plus an additional 1,675 AF for private irrigation applications. This extrapolation of the distribution of future SW rights is shown in Table 2.4.

The extrapolation considered below can be summarized in other ways, such as allocating water rights by county or by Washington's Water Resource Inventory Areas (WRIAs). Differing needs of the various analyses performed by the study team, dictated that we use at least two variations of this water right extrapolations: one showing withdrawals by pool behind specific dams (as in Table 2.4), and one allocating water rights by county (as in Table 2.5). The allocation of new water diversions to pools is necessary for the assessment of impacts on hydropower operations and river navigation, and potentially for assessment of effects on anadromous fish. Allocation of the new water rights by county is needed in order to mess the water information with county-level irrigated agriculture information. Because counties differ in weather conditions and soil types, agricultural enterprises specialize in different crop mixes. The extrapolation of 1 MAF of new rights by county (Table 2.5), assumes that the 220 KAF of new water proposed for the Columbia Basin Project (abbreviated CBP in the table) comes out of Banks Lake and is distributed across Adams, Franklin, and Grant counties as outlined by the 1989 DEIS for Continued CBP Development.[6]

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[5] pers. comm., Shannon McDaniel of the South District of the CBP

[6] pers. comm., Richard Erickson of the East District of the CBP.

Table 2.4. Extrapolation of Future Water Rights by Pool for Scenario 1, in acre-feet.

Pool	Current Applications		Estimated Future Applications		Total New Rights by Use		Total New Rights
	Irrigation	M&I	Irrigation	M&I	Irrigation	M&I	
Bonneville	0	0	0	0	0	0	0
The Dalles	0	0	0	0	0	0	0
John Day	131,244	7,202	206,687	371	337,931	7,573	345,504
McNary	69,368	69,596	109,244	3,583	178,612	73,179	251,791
Priest Rapids	0	0	0	0	0	0	0
Wanapum	1,847	0	2,909	0	4,756	0	4,756
Rock Island	6,149	0	9,684	0	15,833	0	15,833
Rocky Reach	7,710	0	12,143	0	19,853	0	19,853
Wells	53,859	0	84,819	0	138,678	0	138,678
Chief Joseph	741	0	1,168	0	1,909	0	1,909
Grand Coulee	650	0	210,024	11,000	210,675	11,000	221,675
Total AF	271,570	76,798	636,678	14,954	908,248	91,752	1,000,000

Table 2.5. Extrapolation of Scenario 1 by County

Pool	Current Applications		Estimated Future Applications		Total New Rights by Use		Total New Rights
	Irrigation	M&I	Irrigation	M&I	Irrigation	M&I	
CBP	0	0	209,000	11,000	209,000	11,000	220,000
Adams	0	0	74,471		74,471		
Franklin	0	0	64,862		64,862		
Grant	0	0	69,667		69,667		
Adams	0	0	0	0	0	0	0
Benton	181,616	65,085	286,015	3,351	467,631	68,436	536,068
Chelan	12,250	0	19,292	0	31,543	0	31,543
Douglas	25,110	0	39,544	0	64,654	0	64,654
Ferry	0	0	0	0	0	0	0
Franklin	7,805	5,203	12,292	268	20,097	5,471	25,568
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	9,565	5	15,063	0	24,627	5	24,632
Lincoln	0	0	0	0	0	0	0
Okanagon	32,947	0	51,886	0	84,833	0	84,833
Stevens	650	0	1,024	0	1,675	0	1,675
Walla Walla	1,626	6,504	2,561	335	4,187	6,839	11,026
Total AF	271,570	76,798	636,678	14,954	908,248	91,752	1,000,000

The distribution of the additional water withdrawals over time and space will have a major influence on the economic and other impacts of the proposed new water rights. For example, if all new water rights in a given pool were diverted over a short period of time each year, this could have a noticeable effect on river levels downstream from that particular pool, which would in turn cause negative impacts on the navigation, recreation, and other river uses. The analyses described in this report assign proposed water diversions over time to be consistent with current practice, or in a simple manner intended to mimic expected practice. For example, irrigation withdrawals occur on seasonal schedules to meet water demands of crops, and municipal water withdrawals occur more-or-less continuously throughout the year.

Scenarios 2 and 3 are identical in the maximum amount of new water to be made available: 1 MAF. However, they differ in structure of issuance and fees for new and converted rights. In these two Scenarios, water rights are issued for up to 700 KAF with user fees. Contingent upon “the majority” of water users (defined by Ecology as 80% of users) meeting state-of-the-art efficiency practices (BMPs as described in Appendix A), the state would issue an additional 300 KAF of water rights. Fees for new and converted rights will be \$10/AF and \$20/AF for Scenarios 2 and 3 respectively. Economic principles suggest that as some constraint becomes more severe (i.e. fees or BMPs), users will mitigate the costs by consuming less (i.e. choosing not to apply for water). Therefore, it is unclear whether water applicants will find it in their best interests to conform to BMPs and pay the related fees. It is also unclear whether current water right holders will find it beneficial to conform to BMPs so that the additional 300 KAF will be issued. This suggests that there may be some economically determined upper and lower bounds on the amount of water to be issued for scenarios 2 and 3.

As an upper bound, the total amount of water allocated under Scenarios 1, 2 and 3 is the same – 1 million acre-feet. This upper bound for Scenarios 2 and 3 assumes that water users and interruptible right holders find it in their best interest incur the costs associated with conforming to BMPs and pay the proposed fee, and that second 300 KAF of water rights will be issued. This will result in reductions in net income to irrigators and M&I users relative to scenario 1. The \$10 million in fees collected under Scenario 1 will be transferred to the state, as will the \$393 thousand for converted rights (see Table 2.2). Similar assumptions will be made for scenario 3, with a total of 1 MAF of additional water rights at \$20/AF, totaling \$20 million transferred from irrigators to the state, and \$786 thousand for converted rights.

The lower bounds for expected water rights applications is more difficult to predict, because it is unclear to what degree users can mitigate the costs to them of meeting BMPs and paying proposed fees. With the increased costs imposed by Scenarios 2 and 3, we may not see enough water demand to take the initial 700 KAF, or even the amount of current applications plus M&I water needs plus water to be allocated to the CBP, totaling about 572 KAF.

For scenario 2, the study team assumes a lower bound water demand would take at least the initial 700 KAF which would be allocated before BMPs must be met. This supposes that 80% of current water users and interruptible right holders do not find it in there economic interest to adopt BMPs, and, therefore, that the an additional 300 KAF is not issued. Or, alternatively, the lower bound could reflect the fact that increased fees associated reduce the quantity demanded for new water, reducing the total to 700 KAF. This lower-bound water allocation will result in a transfer of $7 million from water users to the state. This lower bound estimate is not intended to be an accurate prediction of future events, but, rather, is a used as a reasonable mechanism to develop a range of possible economic effects.

In order to extrapolate the low-level water allocation, assumptions need to be made about the distribution of the new water across users. As noted above, the study team will allow for a 30% increase in M&I water needs reflecting the trend in population growth. Additionally, all of the 220 KAF set aside for CBP will be distributed to irrigation and M&I as assumed above. The remainder will be distributed to irrigated agriculture across pools and counties as the pending applications for irrigation are distributed. Tables 2.7 and 2.8 below summarize the low-level assessment for scenario 2 by pool and by county.

Scenario 3 would have costs very similar to Scenario 2, except that the fees charged for new water rights rise to $20/acre-foot; this may discourage some prospective water uses. To provide a range of possible impacts, we consider a low-level assessment of new water rights allocation of 572 KAF, which equals the existing irrigation application pool, plus future needs of M&I water, plus the proposed allocation of 220 KAF to the Columbia Basin Project. This lower bound is chosen to be below the 700 KAF lower bound adopted for Scenario 2, because the higher fee is bound to crowd out more low-valued water applications. Again, the extrapolation

Table 2.6 Lower Bound Water Rights Allocation for Scenario 2 by Pool

Pool	Irrigation	M&I	Total
Bonneville	0	0	0
The Dalles	0	0	0
John Day	192,948	7,573	200,521
McNary	101,982	73,179	175,161
Priest Rapids	0	0	0
Wanapum	2,716	0	2,716
Rock Island	9,040	0	9,040
Rocky Reach	11,335	0	11,335
Wells	79,181	0	79,181
Chief Joseph	1,090	0	1,090
Grand Coulee	209,956	11,000	220,956
Total AF	608,248	91,752	700,000

Table 2.7 Lower bound Water Rights Allocation for Scenario 2 by County

County	Irrigation	M&I	Total
Columbia Basin Project	209,000	11,000	220,000
Adams	74,471		
Franklin	64,862		
Grant	69,667		
Adams	0	0	0
Benton	267,002	68,436	335,439
Chelan	18,010	0	18,010
Douglas	36,916	0	36,916
Ferry	0	0	0
Franklin	11,475	5,471	16,946
Grant	0	0	0
Kittitas	0	0	0
Klickitat	14,061	5	14,067
Lincoln	0	0	0
Okanagon	48,437	0	48,437
Stevens	956	0	956
Walla Walla	2,391	6,839	9,230
Total AF	608,248	91,752	700,000

assumes that M&I demands (a 30% increase) are met, the existing irrigation applications are granted rights, and that CBP will be granted its 220 KAF. Tables 2.9 and 2.10 below summarize the low-level assessment for scenario 3 by pool and county respectively.

Table 2.8 Lower Bound Water Rights Allocation for Scenario 3 by Pool

Pool	Irrigation	M&I	Total
Bonneville	0	0	0
The Dalles	0	0	0
John Day	131,244	7,573	138,817
McNary	69,368	73,179	142,548
Priest Rapids	0	0	0
Wanapum	1,847	0	1,847
Rock Island	6,149	0	6,149
Rocky Reach	7,710	0	7,710
Wells	53,859	0	53,859
Chief Joseph	741	0	741
Grand Coulee	209,650	11,000	220,650
Total AF	480,570	91,752	572,322

Table 2.9 Lower Bound Water Rights Allocation for Scenario 3 by County

County	Irrigation	M&I	Total
Columbia Basin Project	209,000	11,000	220,000
Adams	74,471		
Franklin	64,862		
Grant	69,667		
Adams	0	0	0
Benton	181,616	68,436	250,052
Chelan	12,250	0	12,250
Douglas	25,110	0	25,110
Ferry	0	0	0
Franklin	7,805	5,471	13,277
Grant	0	0	0
Kittitas	0	0	0
Klickitat	9,565	5	9,570
Lincoln	0	0	0
Okanagon	32,947	0	32,947
Stevens	650	0	650
Walla Walla	1,626	6,839	8,465
Total AF	480,570	91,752	572,322

Scenarios 4 and 5 are identical in there potential (or lack thereof) for additional withdrawals. Scenario 4 assumes that additional withdrawals would be extremely damaging to salmon populations, and therefore no additional withdrawals will be granted unless they are directly supported by new storage. Any new rights granted would be required to offset water use through transfers, conservation, and utilizing new storage capacity. Scenario 5 is a no action scenario in which the existing rules governing the water resources of the Columbia River remain intact.

CHAPTER 3. IRRIGATED AGRICULTURE

A. Summary of Impacts to Irrigated Agriculture

The allocation of new water rights is of significant interest to agricultural communities and the state as a whole. As new technologies and crops emerge, growers find they are able to produce crops on land that previously had not been very productive. Examples of crops that have experienced growth in Washington State during the last decade include wine grapes, hops, new apple varieties, storage onions, sweet corn for processing, and fresh vegetables. There is also concern regarding the impact of increasing diversions on salmon species. In this section we summarize the potential benefits of allocating more water rights to irrigated agriculture from the Columbia River.

a. Issues, concerns and sensitivity analysis

We begin by discussing several issues before summarizing the results and detailing the analysis of impacts to irrigated agriculture from potential new water rights allocated from the Columbia River. First, the scope and time frame of the analysis require the use of off-the-self data to estimate the value of new water rights in irrigated agriculture (as is discussed in Section 12). Data sources include the 1997 Census of Agriculture for acreage and irrigation technology data, the Washington State University enterprise budgets for production cost data, the Washington Agriculture Statistics Service for price, yield, and acreage data, US Bureau of Reclamation water use data from AgriMet, and interviews for a variety of data needs. A weakness of using off-the-self data is a lack of region or county specific data. For example, the price, yield, cost of production and irrigation technology data is the same for all regions. As such, the results represent an average value for agriculture along the Columbia River, not region specific values. The specifics of assumptions, data use, calculations and the implications are discussed in the Sections 3.C through 3.G.

A second issue is that the analysis does not account for the potential of market constraints for using new water rights since prices are assumed to remain constant. The analysis assumes that there is sufficient market demand to absorb new production from the additional water rights since crop prices are held constant. The potential for insufficient demand to absorb additional agricultural production is a critical concern from the perspective of National and even Regional

Economic Development. If there is not sufficient demand for new production, it will simply push out existing production. As a result, from a NED or RED perspective new water rights that push out existing production have little economic value. That is, because the new production replaces existing production there is very little net gain to the region as a whole. The only gain is from the increased efficiency benefits from producing on the new acreage rather than the existing acreage region.

NED principles and guidelines refer to this as making a distinction between basic crops, ones that are only constrained by suitable acreage, and *specialty* crops which are limited by market demand, risk aversion and supply factors other than suitable land (U.S. Water Resources Council). Basic crops relevant to this analysis are identified as corn, wheat, and hay. Specialty crops in this analysis could include orchard, vegetable, potato and some of the crops in the other crop group. An example of this issue in Washington State relates to the recent increase in wine grape acreage. Though the 2003 growing season is considered to produce some of the highest quality grapes in recent years, prices have not increased. Under usual market conditions one would expect price to increase as quality increases. However, this is a situation where the increase in new acreage is beginning to push out existing acreage and prices are not increasing due to excess supply. Growers have stipulated that market conditions are likely to get worse as more than 4,000 additional acres come into production over the next few years.

The difficulty in assessing the potential impact of market saturation and constant prices on crop value for this analysis is that it requires collection of new data to estimate the efficiency benefits that would occur rather than using the increase in gross or net revenue as an estimate of the value of new water rights in specialty crops. It would also require identifying which crops should be treated as basic crops and which should be treated as specialty crops. One method of assessing specialty crops is to examine market share and price effects of Washington production. If price is correlated with the level of production in Washington, then Washington is likely to have an influential role in the production of that good. Washington is the top producer of a number of crops in the country (WASS, 2003). The best example is probably apple crops. Though Washington apple growers compete with apple producers from other states and countries, they are a primary producer of apples. As such one would expect Washington apple production to have some influence on the market price of apples. In fact, the correlation coefficient between apple production and market price for the period 1993 to 2002 is -0.79 (data is from WASS,

2003, page 76). This indicates that an increase in production is likely to result in a price decrease. The implication being that an increase in acreage will increase production and potentially drive down prices. As prices decrease the less efficient acreage will be pushed out of production. Consequently, apples are likely to be considered a specialty crop.

Since a detailed examination of this issue is beyond the scope of this analysis the only simple way to assess this is by using an ad hoc assumption regarding the level of efficiency gains in terms of $/acre values. Continuing with the example of orchard crops, if efficiency gains are $30/acre (approximately ten-percent of the $312/acre net revenue for orchards from Scenario 1, Table 3.25), the total net revenue from orchard crops would be approximately $2.7 million rather than $27.2 million. Similarly, if the efficiency gains are $78/acre (approximately 25-percent of $312/acre net revenue for orchards from Scenario 1, Table 3.25), the total net revenue from orchard crops would be approximately $6.8 million rather than $27.2 million. These values are significantly less than those found under the assumption of constant prices. Increases in total gross revenue would also be significantly less since each acre of new orchard crops that pushed out other production would be a zero gain to Washington State. The $/AF values would also be significantly lower, approximately the value of the efficiency gain divided by 3.55 AF/acre in the Benton County area where the bulk of new orchard crop acreage is extrapolated to be developed. It is important to realize these values are speculative and need to be verified by detailed market research to have true validity; however, it does indicate how sensitive the results are to the assumption of constant market prices and the ability of the market to absorb new production.

Third, conveyance and irrigation efficiency are critical variables in the analysis that only have a limited amount of available data. These efficiencies are critical since they are used to convert new water rights to new acreage, as is described in Section 3.D. A brief sensitivity analysis is run on these variables in order to gain a better understanding of the magnitude of their impact on the results. Conveyance and irrigation efficiency enter the analysis in a similar manner. Consequently, a one-percent change in conveyance efficiency has the same impact as a one-percent change in irrigation efficiency. A one-percent change in efficiency may result in a $0.08 to $2.12/acre-foot (AF) change in the value of water and a change of more than 3,731 total acres. The $/AF and acreage values are approximately linear in the efficiency variables so changes in efficiency will impact $/AF and acreage values proportionally to the values indicated. That is, a ten-percent increase in efficiency will increase the value of water by $0.80/AF to $21.20/AF and

an increase of less than 37,310 acres, other things held constant. Note that the acreage results only hold relative to the analysis. That is, if an existing grower were to increase their irrigation efficiency, they would not be able to increase their acreage. However, the $/AF value of the water would increase.

There is evidence that many growers divert less water than their paper water right allows. For example, even though a water right may be issued to provide several hundred acre-feet of water to a parcel of land, it is possible that the water user would only divert seventy or eighty-percent of the paper right. This may occur for a number of reasons. During a year with high rain fall irrigators demand less water since crops are being irrigated naturally. Irrigation efficiency has increased over time giving the potential for diverting less water to produce the same acreage of crops. A more concrete example comes from the Columbia Basin Project (CBP) where total diversions vary from 2.5 to 2.9 MAF annually. However, the paper water right is for 3.2 MAF, indicating usage ranging from 78-percent to 91-percent. The analyses assume that one-hundred percent of the new water rights are diverted, which would result in an overestimate of the acreage brought into production. For example, a one-percent reduction in water right usage would reduce total acreage by one-percent. Acreage values are linear in the quantity of water rights so any percent reduction in water use of a right results in an equal reduction of new acreage. There are two things of importance to note. First, this only holds with respect to the results of this analysis. That is, if an existing grower were to adopt a more efficient irrigation technology and use a smaller portion of their water right, it is likely the same level of acreage would be in production. Note that such a change would not affect the $/AF value as we only asses the value for diverted water.

A fifth issue relates to the Columbia River Initiative allowing interruptible water right holders to convert to uninterruptible status. However, the conversion is not included as part of the new water allocations. Though in most water years this would not increase the level of water diversions, it would increase diversions in very low flow year since these rights would no longer be interruptible. This is precisely when water is needed most instream for fish and has the highest value for agricultural production. Estimating the value of converting to uninterruptible status is beyond the scope of the analysis as these rights have a low probability of being interrupted. As such, the agricultural values estimated in this section may understate the upper value of the new water rights in that they do not account for maintaining this acreage during

periods of extreme water shortage. Similarly, the impact of converting these rights was not estimated for fisheries, which would result in an understatement of the negative impacts to fisheries. To what degree these impacts to agriculture and fisheries balance each other out is unknown and quantification of the balance is not attempted here.

Another issue relates to the use of new water rights allocated to the CBP. A significant portion of the new rights will be used to replace groundwater over-draft from aquifers in Central Washington. Only a portion of the new CBP water rights will be used to bring new acreage into production, which is what we estimate a value for here. We do not attempt to estimate the agricultural or environmental value of replacing water from the aquifer. As such, the total value of the water rights is underestimated; however, the value per acre-foot is not affected since the model estimates the value of water used in new agricultural production.

Finally, there is the issue of that the analysis does not account for the potential of acreage constraints for using new water rights. The analysis assumes that there is sufficient acreage to absorb new production from the additional water rights. If there is not sufficient acreage the level of acreage and total values would be overstated. Several calculations suggest that acreage may not be a limiting factor in the CBP and the Horse Heaven Hills area, where the bulk of the new water rights are extrapolated to be allocated. In 1993 an EIS was completed for the Bureau of Reclamation for the Continuation of the Development of the Columbia Basin Project by CH2M Hill. The study indicated there to be sufficient acreage to develop the approximately 3 million remaining AF of water rights granted to the CBP. However, the EIS did bring into question the profitability of completing this development, indicating it to have positive Regional Economic Development benefits but negative National Economic Development benefits under current prices and interest rates. A study completed by Whittlesey and Butcher in 1975 indicated potential for 250 thousand acres to have reasonably high economic feasibility and another 300 thousand plus acres to be economically feasible with the drawback of high pumping lifts. Currently there is less than 140 thousand acres being irrigated in that region, leaving significant acreage still available for private development. This study indicates a maximum of 150 thousand acres being developed in that area, as is discussed in detail below.

b. Summary of results for irrigated agriculture

At this point we review and summarize the results of the irrigated agriculture portion of the analysis. Recall that there are 5 management scenarios for the CRI analysis. Scenarios 1 through 3 result in increased surface water diversions from the Columbia River. In addition, scenarios 2 and 3 have been extrapolated to allow for a high and low range of possible outcomes. The range is to help account for water user response to the per acre-foot mitigation fees for new water diversions. Scenario 4 involves directly offsetting mitigation measures through transfers and storage and scenario 5 examines the status quo. Neither of these scenarios contemplates the potential for new diversionary water. As a result, there are 5 extrapolations being considered that address the potential for new water rights: scenario 1; scenario 2 upper bound; scenario 2 lower bound; scenario 3 upper bound; and scenario 3 lower bound.

The inclusion of water per acre-foot fees is to address mitigation costs associated diverting additional water. Scenario 1 does not call for fees for new water, and it is assumed that all of the potential water will be diverted. The only additional costs associated with scenario 1 are that new and converted water users are required to conform to BMPs. However, these costs are considered to be at the level of normal production costs, hence the assumption that all potential water rights will be allocated and diverted. Scenario 2 calls for $10/AF mitigation fees and scenario 3 calls for $20/AF mitigation fees. Fees for scenarios 2 and 3 are included in the agricultural production costs. These costs are in addition to the costs gathered from the enterprise budgets.

Scenario 1 serves as an upper bound for all scenarios. It assumes that the increased costs associated with conforming to BMPs do not reduce the demand for water or change the crop mix. Scenario 2 upper bound and scenario 3 upper bound will be identical to scenario 1 in the amount of new water withdrawn. The difference lies in the fees related to new water and the resulting reductions in the irrigator's net incomes. These upper bounds also assume that the increased costs associated with fees for water and efficiency standards do not reduce the demand for new water. However, scenario 2 lower bound and scenario 3 lower bound assume that the increased costs associated with the new water do reduce its demand. More specifically, the requirement of having the majority of existing water users adopt BMPs and the mitigation fees will reduce both limit the level of rights available and reduce the demand for new rights. These reductions in demand are monotonic downward in that scenario 3 lower bound has higher costs associated with it than scenario 2 lower bound and scenario 1.

To summarize the economic impacts of the scenarios, let us first examine the gross revenues for different crops across counties. Scenario 1 (and upper bounds for scenarios 2 and 3) lead to total gross revenue increases of just under $733 million. The largest county impact occurs in Benton County at about $408 million. The largest increase in gross revenue by crop group occurs with orchards at over $480 million. Consistent with this trend, the largest increase in gross revenues is for orchard lands in Benton County at about $237 million. The smallest impacts occur in Stevens County and for wheat. It is important to note that each of the tables below includes acreage for irrigation only; M&I water has been subtracted from the total. Table 3.1 below summarizes the gross revenue impacts for the upper bound of Scenarios 1, 2 and 3.

The lower bounds for scenarios 2 and 3 offer increasingly smaller impacts on gross revenue associated with new water diversions. Scenarios 2 and 3 have total gross revenue increases of $465 million and $350 million, respectively. Identical patterns emerge in that the largest impacts occur in Benton County and for land in orchards. Lower valued crops such as wheat still show the smallest increases in gross revenues. Tables 3.2 and 3.3 below summarize the gross revenues for the lower bounds of scenarios 2 and 3. The gross revenue figures are used as a basis for the secondary impact analysis in Section 9.

Considering revenue net of costs gives a better idea of the individual and regional benefits of new water rights. As is discussed in Section 3.F below, some net revenues are negative because they represent economic profits rather than cash or accounting profits. This means that all implicit (or opportunity) costs as well as all explicit (cash or accounting) costs are included. Production costs are higher when including opportunity costs leading to negative net revenues for low value crops. This does not affect the gross revenue figures. This represents the cost of producing crops if you were to enter the industry today without any equipment or land accumulated. Growers that have been producing for a period of time will have lower cash or accounting costs than those entering since they have accumulated equipment and land that is completely paid off or has low monthly payments. Total net revenues from Scenario 1 are just under $43.7 million. Three lower valued crops, hay, other and wheat yield negative net revenues. Stevens County has total net revenue as a negative value. Recall that these impacts are also the upper bound for scenarios 2 and 3. These results are summarized in Table 3.4 below.

For scenario 2 lower bound, negative net revenues become more frequent as acquiring new water becomes a more costly endeavor. The total impact on net revenues is $21.9 million.

Adams, Grant and Stevens Counties yield overall negative net revenues for the crop mix considered in the region. Results are summarized below. Lastly, consider net revenues for scenario 3 lower bound. Total irrigated agriculture impacts are $11.5 million. Negative values become the most frequent in this case due to the increase in mitigation fees for new water rights, although no new crops yield negative net revenues and Stevens and Adams counties yield overall negative values. These are shown in Tables 3.5 and 3.6 respectively.

Net revenue per acre-foot of water diverted is also calculated so as to compare the value of water across different crops, counties, and uses. In this section we will only discuss the value per acre-foot within agriculture by crop group for each scenario. Table 3.7 shows a range from a low of negative $91/AF for other crops to a high of $147/AF for potatoes in the non-CBP areas on an annual average basis for Scenario 1. The CBP values range from a low of negative $82/AF for other crops to a high of $129/AF for potatoes on an annual average basis for Scenario 1. The negative values relate to the fact that these net revenues represent economic profit rather than accounting profit, as discussed in Section 3.F. That is, while these values show negative economic returns they are most likely making positive accounting profits. The $/AF for orchard, potato and vegetable crops are the highest, while the value for other, wheat and hay are the lowest, as expected. The same pattern holds for scenarios 2 and 3, however the values for these scenarios are lower due to the $10/AF and $20/AF mitigation fees respectively. For the non-CBP area in Scenario 2 the annual values range from negative $95/AF to $128/AF, and for Scenario 3 they range from negative $92/AF to $119/AF, as shown in Tables 3.8 and 3.9 respectively. These values give an indication of the economic value of water in irrigated agricultural production.

It is a fair question to ask how these water values compare to water values found using other methods of analysis, specifically water transfer pricing and hedonic price analysis using differences in land values. The market price of water in Washington is generally in the range of $70/AF for water transferred to instream flow and $111/AF for water transferred within agriculture. These values are calculated from Ecology's data on the water trust program and the Yakima River Basin 2001 water bank respectively. While no hedonic price analyses were found for Washington, there was one done for Malheur County in Oregon based on land producing primarily onions, potatoes and sugar beets in 1999 (Faux and Perry). The value of water was reported to range from $9/AF to $44/AF depending on the quality of the land, where it was worth

more on high value land and less on low value land. These comparison values are discussed in detail in Section 3.F.

The remainder of Section 3 is devoted to discussing the approach and data used to estimate the gross, net, and net/AF revenue figures summarized above. First, the methodology for estimating the impacts to irrigated agriculture is given. This is followed by a discussion on crop mix, crop water use, water use efficiency, and changes in acreage. Next the enterprise budget approach to water valuation is detailed and compared to other methods of water valuation, and finally the impacts to irrigated agriculture are estimated under each scenario. Several sensitivity analyses are performed earlier in this section to assess the influence of critical variables and assumptions on the impact to irrigated agriculture. These are meant to give an indication of the robustness of the results. These should all be taken into consideration when assessing the value of new water rights to irrigated agriculture.

B. Method of Analysis for Valuing Irrigated Agriculture

The method of calculating the value of additional Columbia River water rights in this analysis is a multi-step process, as follows:

1. Estimate the quantity of water allocated to each county based on current water right applications for each scenario. This process was detailed above in Section 2.E and is the same approach used to estimate water use in each section of the report.
2. Determine which crops are likely to be grown with the potential water rights based on county crop mix that currently use Columbia River water and crop rotations.
3. Determine the diverted and applied water per acre for each crop group and county.
4. Calculate the crop acres implied by the estimated water allocation from step 1 (i.e. diversions to become applied water) and the resulting quantity of water for crop consumptive use. For example, suppose a water right that amounted to 900 acre-feet were granted, the system distribution efficiency were 85-percent, the appropriate crop mix consumptive use were 2 acre-feet, and the appropriate irrigation technology mix efficiency were 70-percent. The 900 acre-foot diversion right would support (900*0.85)/(2/0.7) = 267.75 acres of new irrigated agriculture. That indicates a figure of 0.3 acres/acre-foot of new water right. This implicitly assumes that there is sufficient

irrigable acreage and market demand to support the additional production stemming from water rights estimated in step 1.

5. Estimate the gross and net revenue of irrigated crop production per acre for a variety of crops in Eastern Washington based on enterprise budget analysis. Calculate the value of the increase in irrigated agriculture based on the per acre crop values by county and in total.

The data, assumptions and methodology for each of these steps is detailed below.

It is important to note that this methodology does not allow for the feedback effects of supply and demand. Instead, it assumes that demand increases at constant prices to meet the increased in supply. For wheat, hay and a variety of other crops this is a realistic assumption. However, for specialty crops such as vegetables and orchard crops this is a tenuous assumption. Unfortunately, developing an economic optimization model that would include feedback effects is beyond the scope and time frame of this analysis suggested by Ecology. Several sensitivity analyses are included to rectify this and assess the robustness and importance of several key assumptions. These are included in the relevant sections of the analysis.

C. Crop Mix by County (step 2)

One of the key components and challenges of valuing potential water allocations for irrigated agriculture is to identify the crop mix that uses Columbia River water in each county. There are a number of considerations and challenges. The main consideration is identifying which crops are likely to be grown with new water rights. One possibility is that primarily high value crops would be brought into production since it would not be cost effective to grow low value crops. This would certainly be the case in regions where the water would have to be lifted from the river over any significant elevation. However, this may not be the case if the water is diverted through existing irrigation canals where the marginal cost of delivering the water is low. Another possibility is that high value crops have already pushed out low value crops in many areas that would support them, leaving room in the market for new water to bring lower value crops into production. There is also the need to produce low value rotation crops with many of the high value vegetables. The result is that there is potential for both high and low value crops to be brought into production if new water rights are allocated. The assumption in this study is that the new crop mix being brought into production will be the same as the existing crop mix.

Finding the current crop mix still presents several challenges. First, counties do not keep a current record of how many acres of each crop are grown annually, making the current crop mix difficult to identify. Second, counties do not specify crop mix by water source. This is of particular concern for this analysis since the county crop mix that uses Columbia River water could be significantly different than the crop mix for the entire county. As such, we will begin by discussing what exactly Columbia River water is defined to be and to what degree each county depends on the Columbia. Then we will discuss the selected crop mix for each county in light of their dependence on the Columbia, which will take several steps.

For purposes of this study Columbia River water is defined to include surface water and groundwater within one-mile of the River. Groundwater within one-mile is considered to be hydrologically connected to the Columbia River by the DOE. The study area for irrigated agriculture consists of the regions that are served by Columbia River water east of Bonneville Dam within Washington State. The Columbia River borders 13 counties in the study area, including: Stevens, Ferry, Lincoln, Okanogan, Douglas, Chelan, Grant, Kittitas, Yakima, Benton, Franklin, Walla Walla, and Klickitat. Columbia River water is also delivered to Adams County via cannels of the Columbia Basin Project. The approach used to identify the crop mix in each county is a two step process. First, begin with 1997 census data, the last complete account of crop acreage by county. This is given below in Table 3.10. Second, update the 1997 census data according to additional county level data for specific crops and state level trends. This process gives a fair representation of the current crop mix that depends on Columbia River water. The 1997 census data presented in Table 3.10 is discussed in greater detail in Appendix B to this report.

Using crop acreage data from the 1997 census ties this analysis to using the same crop groupings as is used by the census. The crop groups for irrigated agriculture include hay, orchard, vegetable, other, potato and wheat. The hay crop group is based on alfalfa hay; orchards crops include apples, pears, sweet cherries and wine grapes; vegetables include asparagus, carrots, sweet corn, onions and peas; other crops includes hops, dry beans, corn for grain and silage, peppermint and spearmint; potatoes are based on fall potatoes; and wheat is based on spring and winter wheat. These crop groupings were used consistently for determining acreage, water use and the per acre crop values of each group.

The second step involves updating the 1997 census data by examining a number of reports with county level data that were collected since the 1997 census was released. The additional reports were produced by the Washington Agricultural Statistical Service (WASS) and are discussed in Appendix B. We need to make several assumptions to update the 1997 data. First, since there have been very few new water rights granted since the 1997 census, total acreage is assumed to remain constant or decline. Second, since there have not been any additional studies examining the Hay or Other crop categories; we allow those to adjust as needed to keep acreage constant. The remaining changes are discussed below.

Potato crop acreage was updated to year 2000 levels based on the WASS study discussed in Appendix B. Data was available for year 2001, however, since that was a severe drought year the year 2000 data was deemed to be more representative of current cropping patterns. The most significant changes were the increases in Benton, Franklin, Klickitat, Lincoln and Walla Walla counties. The remaining counties only showed small changes in potato acreage. The updated cropping acreage for potatoes and all the crop groups are shown in Table 3.11.

Updating wheat acreage was more difficult due to the inconsistency of the data available. Adams, Franklin, Grant and Walla Walla counties were updated to year 2000 levels. Benton, Douglas, and Lincoln counties were updated to 1999, as that was the most recent data. The data for the remaining counties were not changed. Discussion with the extension agents from the upper Columbia (Chelan, Ferry, Okanogan, and Stevens) confirmed that wheat acreage that depends on the Columbia River had not changed much during that time period.

The WASS gathered acreage data for many of the vegetable crops in the study. Similar to above, acreage was updated to year 2000 to avoid the drought effects of 2001. Though data was gathered for many different vegetables, data was not available for all vegetables. As such, the analysis assumes that the data gathered is representative of all vegetable crops. To update the data, the percentage change in the crops from 1997 to 2000 was calculated for each county and multiplied by the 1997 census data. For example, Adams County had a 245% increase in vegetable acreage, which was due primarily to an increase in asparagus and sweet corn. Similarly, Grant County had a six-percent decrease, which was due to a decrease in onions and sweet corn. This method was used for each county. Overall there was a ten-percent increase in vegetable acreage.

Orchard acreage was only available at the state level. The approach to update orchard data was similar to that of the vegetable data. The percentage change in the crops from 1997 to 2000 was calculated for each county and multiplied by the 1997 census data. Overall there was sixteen-percent increase in orchard acreage during the period. There were a number of exceptions however. According to extension agents from the region including Chelan, Douglas, Ferry, Okanogan, and Stevens counties there was no real increase in orchard acreage. This was primarily because there was not much low value crop acreage that could be switched into orchards. As a result, orchard acreage data for these counties were not increased.

The third step is to identify the crop mix for each county that depends on the Columbia River. It is important to determine what type of crops the Columbia River water is used for relative to the rest of the county. That is, it may not be appropriate to assume the county wide crop mix in determining the value of Columbia River water if the various water sources serve areas of the county that differ significantly in what type of crops each area can produce. For example, the overall crop mix for Klickitat County indicates the primary crops to be irrigated are hay and pasture. However, many of the crops in Klickitat County that use Columbia River water include orchards and vineyards which are considered high value crops. Consequently, the value of Columbia River water used in Klickitat County is substantially higher than that of water for the overall county crop mix.

To determine the crop mix that depends on Columbia River water we first calculated the ratio of Columbia River water rights to irrigated acreage from the 1997 Census, as is shown in Table 3.12. This approach implicitly accounts for other irrigation water sources. If the ratio of water rights to irrigated acreage is high there are likely to be few alternative water sources. If the ratio is low, there are likely to be a number of alternative water sources. The weakness of using this approach is that it ignores issues related to the difference between applied water (or diversions) and crop consumptive use, which is discussed below in the section on irrigation technology (step 3). The crop mix that is determined to depend on Columbia River water for each county is then used as a representative ratio of acreage to calculate the value of new water rights.

Benton, Douglas, and Grant counties use the Columbia River as their primary source of water, as is indicated by the high ratio of Columbia River water rights to irrigated acres in Table 3.12. Benton County also uses a significant amount of water from the Yakima River; however,

the crop mix for both water sources is similar. The Columbia River is also the primary water source for Adams County, but it is not reflected in the ratios since the water is diverted by the Columbia Basin Project in Grant County. Consequently, the county level irrigated crop mix in these counties is likely to be representative of their Columbia River water, so no further adjustment is necessary. The crop mix for these counties given in Table 3.11 will be used to calculate the value of new agricultural water rights in these counties.

Chelan, Ferry, Klickitat, Okanogan, Walla Walla, and Stevens counties use Columbia River water, but not as their only or primary source. As such, it is necessary to verify whether the county level crop mix is representative of the crop mix that depends on Columbia River water. Extension agents for Chelan, Ferry, Okanogan, and Stevens county region indicated that Columbia River water is used primarily for orchard crops in this area. As such, the crop mix for Chelan County that uses Columbia River water is represented by the 1997 census data. The appropriate crop mix for Okanogan County that depends on Columbia River water does not contain as much hay, wheat, vegetable and other crops as is indicated by the 1997 census data. Rather, the bulk of those crops are irrigated by the Okanogan River. As a result, a crop mix similar to that of Chelan County is assumed for Okanogan County. As mentioned above, cropping acreage in Klickitat County that depends on Columbia River water does not include nearly as much hay, other, or wheat acreage is as shown in the county level crop mix of the 1997 census. It is assumed that these crops are only used as rotational crops for potatoes since Columbia River water must be lifted to produce crops in this area.

Franklin and Kittitas use very little Columbia River water relative to their other water sources. Unfortunately, little data was available on what the correct crop mix would be. As such, the figures in Table 3.11 are used to estimate the crop mix proportions. Yakima County uses such a small amount of Columbia River water that it is not considered as a potential user of new water rights in this analysis.

D. Irrigation Efficiency and Water Use (step 3)

The data available for determining conveyance and irrigation efficiency by crop and county is limited. Conveyance efficiency refers to the efficiency of moving water from the river to the field and irrigation efficiency refers to the efficiency of applying water to the field. For example, when an irrigation district conveys water from the Columbia River through one if its

primary canals to a secondary canal they can expect to lose some water. The primary canal would be considered 90-percent efficient if for every 100 acre-feet it diverted from the river, 90 acre-feet made it the secondary canal. Conveyance efficiency is cumulative, so if the secondary canal is 90-percent efficient and the secondary canal is 90-percnet efficient, the conveyance efficiency of those canals combined would be 81-percent (0.9 * 0.9 = 0.81). Conveyance efficiency ranges from below 40-percent to 100-percent across the Columbia River basin. The low range corresponds to conditions where either the water is conveyed over a long distance, passing through many systems and/or conveyance systems with low efficiencies due to seepage and similar losses from the canal. The high range corresponds to systems where the water is conveyed in pipelines or over short distances so losses are small.

The only off-the-shelf conveyance efficiency data available for the study area is for the Columbia Basin Project which estimates a system wide efficiency of 82-percent (Montgomery Water Group). Phone interviews were conducted with irrigation engineers from NRCS and IRZ Consulting, an irrigation consulting firm, to arrive at values of 99-percent and 85-percent conveyance efficiencies for the non-CBP water users below and above the CBP, respectively. The 99-percent efficiency is based on the fact that a very high percent of the irrigation below the CBP uses pressurized systems that are nearly 100-percent efficient. There are only a handful of systems that are not fully contained, thus the 99-percent efficiency. The 85-percent efficiency is based on an estimated mix of 75-percent canal systems and 25-percent pressurized. The canal systems are generally short in length compared to those in the CBP, however many of the canals are not lined.

Once water is conveyed to a field it must be applied, however, it is generally necessary to apply more water than the crop consumes to insure the crop gets enough water. The amount of water the crop needs is referred to as the consumptive use. The ratio of crop consumptive use to applied water is a measure of irrigation efficiency. Data on crop consumptive use was gathered from the United States Bureau of Reclamation AgriMet agricultural weather network and are given in Table 3.13 below. Blanks in Table 3.13 indicate the crop group is not widely grown in the region surrounding the specific weather station. Table 3.14 indicates which weather stations were used for which counties. Data on applied water by individual crop is not available. Instead, data on irrigation efficiency was used with the crop consumptive use data to calculate applied water. Irrigation efficiency data was available by crop in the 1998 Ranch and Farm Survey;

however, it was only available at the state level rather than the county level. The state level weighted average irrigation efficiency for each crop group was found by multiplying the percentage for a given crop group under a given irrigation technology by the irrigation efficiency for that irrigation technology and summing across the different technologies. These are given in Table 3.15.

Applied water for each crop was found by dividing the consumptive water use by the irrigation efficiency, and is given in Table 3.16. Applied water use is a key component to identifying the amount of acreage that new water rights could support, and is discussed in the next section.

E. New Crop Acreage (step 4)

There are a number of methods for allocating acreage that could result from a change in water rights. The most common methodology is to estimate the per acre cost of increased crop production using enterprise budgets and combine this with crop prices and yields in an economic optimization model of agricultural production. Though this analysis is based on enterprise budgets, we do not use an optimization model. Rather, we calculate the quantity of acreage that is based on the water right extrapolations completed in Section 2.E. The role of each of these approaches is to allocate acreage. The primary difference is that an optimization model simultaneously estimates price change and/or cost changes while allocating acreage to account for feedback effects between supply and demand. Developing an optimization was beyond the scope and time frame of this study. The approach here does not account for these feedback effects.

The process of determining new acreage is as follows: 1) the quantity of new water rights for a given county is determined; 2) this is multiplied by the distribution efficiency for each county to estimate the quantity of water that is available for application to crops; 3) the remaining water right is divided by the weighted average applied water for the county, which gives a total level of new acreage; and 4) the total new acreage is multiplied by the crop group proportions for the given scenario (see Table 3.17 as an example) to arrive at new acreage for each crop group for each county. Scenario 1 and upper bound Scenario 2 and 3 crop group proportions are based on the existing crop mix. Scenario 2 and 3 lower bound crop group proportions assume a slightly different crop mix with each scenario having progressively more

high value crops and fewer low value crops. This accounts for changes in cropping patterns due to the increase in water use fees for those scenarios.

Scenarios 1, 2 and 3 all assume the same upper bound for new water rights and crop mix. New acreage for the upper bound is given in Table 3.18. The underlying assumption is that required BMPs and per acre-foot water charges in Scenarios 2 and 3 do not impact water demand significantly so the full 1 MAF are allocated for agricultural production. The common upper bound of water rights also implies the requirement that the majority of existing irrigators adopt BMPs is met. While having new water rights developed using BMPs is not considered to be overly burdensome, having existing water users adopt BMPs could be. Meeting this requirement will increase instream flows if the adoption of BMPs reduces water losses like evaporation or excess applied water that does not become return flow to the hydrologic system. This analysis does not study the impact of adopting these BMPs; we only assume the majority adoption requirement is met.

No lower bound is placed on Scenario 1 since there are no BMP requirements on existing water users or additional water use fees. As such, it is possible that all water right would be used. However, it is also possible that not all 1 MAF of new water rights would be used. A lower bound can be estimated by finding a ratio of acres per acre-foot and scaling the amount of acreage appropriately.

The lower bound of new water rights for Scenario 2 is 700 KAF. The selection of this lower bound indicates that all water rights that are initially available are allocated, but the majority of existing water users do not adopt the new BMPs so the additional 300 KAF of water rights is not made available. The new acreage for the lower bound of Scenario 2 is given in Table 3.19. It is possible that less than the full 700 KAF would be requested if use of BMPs and the $10/acre-foot charge acts as a binding constraint on water use. The figures in Table 3.19 can be scaled down appropriately to find estimates of those possible cases. Note the crop mix in Table 3.19 is slightly different than that in Table 3.18. The Scenario 2 lower bound crop mix has a slightly higher percentage of orchard, vegetable, and potato crops to account for the likely change in crop mix as BMPs and the $10/acre-foot charge comes into play.

The lower bound of new water rights for Scenario 3 is 572 KAF. This lower bound corresponds to the level of existing water right applications and an additional 220 KAF allocated to the Columbia Basin Project. This indicates that not all water rights that are initially available

are allocated. That is, even though 700 KAF are made available, only the current applications are allocated because the BMPs and the $20/acre-foot charge make use of the water rights too expensive for agricultural production. In addition, the majority of existing water users do not adopt the new BMPs so the additional 300 KAF of water rights is not made available either. The new acreage for the lower bound of Scenario 3 is given in Table 3.20. It is possible that less than the 572 KAF would be requested if use of BMPs and the $20/acre-foot charge acts as a strong constraint on water use. The figures in Table 3.20 can be scaled down appropriately to find estimates of those possible cases. Note the crop mix in Table 3.20 is slightly different than that in Tables 3.12 and 3.13. The Scenario 3 lower bound crop mix has a slightly higher percentage of orchard, vegetable, and potato crops to account for the likely change in crop mix for the higher cost of water.

F. Crop Value (step 5)

There are a number of methods for valuing the change in irrigated agriculture from a change in water rights. The most common methodology is to estimate the per acre cost of increased crop production using enterprise budgets (also called farm budgets or crop budgets) and combine this with crop prices and yields and imbed this information in an economic optimization model that allows prices and/or costs to change according to the interactions between supply and demand. Though this analysis is based on enterprise budgets, it does not use an optimization model. As a result, prices and costs remain constant as new water rights are allocated to new acreage. This implies that there is sufficient demand to meet all increases in agricultural production, which is a tenuous assumption.

As stated above, using enterprise budgets is the most common basis for valuing changes in agricultural production that stem from changes in water allocation. This stems from the fact that National Economic Development (NED) principles and guidelines for valuing federal water projects call for using enterprise budgets as the basis of valuation (U.S. Water Resources Council, page 26). These guidelines were developed to "…ensure proper and consistent planning by Federal agencies in the formulation and evaluation of water and related land resources implementation studies" (Water Resources Council, page iv). Agencies to follow these guidelines include the Corps of Engineers, Bureau of Reclamation, Tennessee Valley Authority and the Natural Resource Conservation Service. As a result, enterprise budgets analysis is well

established and has been used by most if not all federal and state agencies and many academics performing analysis on changes in water resources. The analysis for this study is not required to follow the NED principles and guidelines. Other methods of analysis were considered, but were dismissed due to the level of complexity and lack of existing data to use those methods. Data for enterprise budget analysis is the most readily available and the simplest to use.

Two alternative methodologies considered were using market transactions as the basis for valuing water and hedonic price analysis of land values (also called land value analysis). It is of common agreement that there are simply not enough water transfers to use water prices as a basis for valuing the potential for new water rights from the Columbia River. In discussions with personnel at WestWater Research, one of the primary consultants on water transfers in the country, they stated that water prices vary dramatically from one location to another and even within a given basin depending on a number of factors. As a result, it would take a significant amount of data gathering and analysis to arrive at a water pricing function that would accurately account for the critical factors that vary by location. Water is not like food, clothing, equipment, automobiles, real estate or other goods that are commonly traded and have a well established market clearing price. The bottom line is that water markets are too thin to use observed prices as basis for valuing a change in water rights. In fact, there have only been two water transfers of Columbia River water documented by Ecology: one by the Bonneville Power Administration with an implied price of $24.67/AF; and one by the US Bureau of Reclamation. Both were during the 2001 drought year. WestWater Research recommends using a form of enterprise budget analysis and completed a study on water valuation in the Dungeness River basin that also compiles a very complete list of water transfers in the Northwest.

Hedonic price analysis of land values was also considered as an approach for valuing the potential change in water rights from the Columbia River. This type of analysis is complex and data intensive. These types of studies are often done as an end product, rather than a means to an end. The basic premise of the hedonic pricing method is that the price of a marketed good is related to its characteristics. For example, the price of a car reflects the characteristics of that car—transportation, comfort, style, luxury, fuel economy, etc. Therefore, we can value the individual characteristics of a car or other good by looking at how the price people are willing to pay for it changes when the characteristics change. The hedonic pricing method is most often used to value environmental amenities that affect the price of residential properties. The first step

is to collect data on property sales in the region for a specific time period. The required data include: selling price and location of properties; property characteristics such as lot size, number and size of buildings, soil quality, topography, water availability, direction of slope, etc.; regional characteristics such as taxes, type of crops grown, presence of utilities and zoning regulations; accessibility characteristics such as distances to markets, transportation alternatives for crop production, and distance to urban areas; and finally, environmental characteristics such as rain fall, mean and variance of temperature, and season durations.

Once the data are collected and compiled, the next step is to statistically estimate a function that relates property values to the property characteristics. The statistical procedure is far from simple, it is necessary to account for a variety of potential estimation biases and errors. The resulting function measures the portion of the property price that is attributable to each characteristic. Thus, the researcher can estimate the value of water availability by looking at how the value of the average home changes when the level of water availability changes. To simply compare the price of two parcels of land, one with water and one without, would be highly inaccurate and completely indefensible. We only found one recent study that used hedonic price analysis to value water in agriculture in the Northwest (Faux and Perry). They found the value of water in Malheur County, Oregon ranged from $9/AF on the least productive land to $44/AF on the most productive land. Land productivity was based on soil quality information obtained from the Natural Resources Conservation Service. Needless to say, using hedonic price analysis of land value to assess the value of new water rights was beyond the scope and timeframe of this analysis.

The per acre value of specific crop groups for this analysis is based on crop enterprise budgets developed at Washington State University. An example of an enterprise budget is given in Table 3.21. The crops within each crop group are: hay is based on alfalfa hay; orchard includes apples, pears, sweet cherries and wine grapes; vegetables include asparagus, carrots, sweet corn, onions and peas; other crops includes hops, dry beans, corn for grain and silage, peppermint and spearmint; potatoes are based on fall potatoes; and wheat is based on spring and winter wheat. The variable and fixed costs and enterprise budgets for each crop and crop group are listed in Table 3.22. Costs were brought forward to year 2002 dollars using producer price indices for farm products from the Bureau of Labor Statistics. All crop output prices and yields were gathered from the WASS 2003 Annual Bulletin. Prices were gathered from years 2000,

2001 and 2002 and were combined to form an average year 2002 dollar price using consumer price indices from the Bureau of Labor Statistics. Yields were also taken from years 2000, 2001 and 2002 and were averaged to arrive at a representative yield for each crop. Prices and yields are given in Table 3.23.

The scope of work called for using existing data on irrigated crop production data. Unfortunately, data on crop prices and costs by county or region are not available off-the-shelf. Enterprise budgets detailing production costs are available for the study region and crop prices and yields are available at the state level. This indicates that the crop value data we have is not representative of any individual grower or county, rather it represents average production values for the study area. Before we proceed to discussing the value of new water rights in irrigated agriculture we will give some background on the methodology and use of crop enterprise budgets.

It is important to make clear the intended use and interpretation of enterprise budgets before proceeding. WSU extension economists state that:

> "The purpose of the budgets is to estimate the costs and returns from producing crops for research and policy purposes. They are also used to give producers and their credit providers a tool to use in enterprise selection and financing. To construct an enterprise budget, a group of producers is assembled by the extension agent in the area. The agent and a farm management specialist from WSU work with this group to develop a consensus estimate of enterprise costs and returns. It is fully realized by those involved in this process that the resulting enterprise budget does not represent any one particular farm; however, the resulting budget is a reasonable estimate for the area" (Hinman).

This indicates the use of enterprise budgets are consistent with the goals of this analysis (note that Hinman is the primary author on the majority of the enterprise budgets used). It is important to note that research and policy analysis is not the only use of enterprise budgets. They can also be used by individual growers to be used as a template to calculate an enterprise budget of their own existing or potential production situation, as is suggested in the above passage. Therefore, if the intended use is to examine a specific county or individual grower, adjustments should be made to represent the appropriate costs. It is certainly the case that some areas will have lower costs and some will have higher costs. Similarly, crops in some areas are likely to receive higher prices than other areas due to variety of crop or timing of harvest. The goal of this analysis was

to find an average cost of production for crops in the study area. Since the enterprise budgets used are predominately for the Columbia River basin, which is the study area, and the scope called for using existing data, no adjustments were made.

Producers reviewing these published budgets often state that their own costs are significantly lower than those presented in the WSU budgets (Hinman). In fact, this is the case with crop budgets that are developed nation wide. It is not uncommon for individuals to question the validity of the crop budgets since budgets may show producers are operating at a loss. To adequately address these concerns and questions, one must understand both the difference between "economic" and "cash" or "accounting" budgets and the concept of *opportunity cost*.

Opportunity cost is the revenue lost by not investing in the next best similar risk alternative. For instance, if a producer invests $50,000 of equity capital in machinery, the producer gives up the alternative of investing this money in the stock market or paying off a current loan. Thus, if the producer is to realize an *economic profit*, the machinery investment must realize a return greater than that associated with the next best alternative. If the next best alternative happens to be paying off a current loan with 10% annual interest, *economic profits* are not realized until a net return greater than $5,000 is realized by the equipment investment.

For land that is owned, the opportunity cost that is included in the WSU budget as the net rental return that the producer would receive if the land was rented out rather than being used by the producer. In short, it is assumed that the owner of capital assets and unpaid labor wants a "fair" market return for these resources. If full economic costs are not covered, a less than "fair" market return is being realized on these resources.

It is common for producers to own a large portion of their equipment. Cash or accounting budgets show the costs for the owned equipment to be zero, while an economic budget includes the opportunity cost of that equipment. As a result, an economic budget is likely to show lower profits than cash or accounting budgets. For example, WSU enterprise budget EB1862 for irrigated wheat has a net economic return of negative $68 (see Table 3.24). For this crop the fixed costs are estimated at $206.24 and the variable costs are $191.80, as is shown in Table 3.21. The enterprise budget assumes a price of $3/bushel and a yield of 110 bushels/acre, which gives gross revenue of $330. If the grower owned all machinery and land, total costs would include variable costs and management and taxes equaling a total of $234.90/acre. This gives an accounting profit of $95.10/acre and an economic profit of negative $68/acre (see Table 3.24).

Crop enterprise budgets assembled by WSU and other extension groups are economic budgets, not cash or accounting budgets. As such, they may show negative net economic returns when growers are actually making positive net cash or accounting returns. The base per acre gross and net economic revenue figures calculated and used for Scenario 1 and the upper bounds for Scenarios 2 and 3 are given in Table 3.25. These per acre values do not vary by county. The per acre net economic revenue figures for the lower bounds on Scenario's 2 and 3 do vary by county due to the variation in consumptive water use and per acre charges for water.

The final step is to multiply the new acreage resulting from the water rights found in Section 3.E by the per acre revenue figures found in Section 3.F for each of the scenarios by crop group and county, these results are shown in Tables 3.1 through 3.6. The only additional calculation is to account for the mitigation fees of Scenarios 2 and 3. This is done by multiplying the $/AF cost by the amount of water diverted to produce the new acreage. The result is a reduction in the net revenues per acre for Scenarios 2 and 3, as is shown in Tables 3.5 and 3.6. The fees will also reduce the $/AF values for Scenarios 2 and 3, as shown in Tables 3.8 and 3.9. The gross revenue figures are not affected by the mitigation fees, as is shown in Tables 3.1 through 3.3.

Table 3.1: Scenario 1, Gross Revenue of Irrigated Acreage (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
CBP Total	11,218	19,516	7,506	8,611	25,512	4,663	77,025
Adams	2,011	3,138	1,878	3,396	12,046	3,177	25,646
Franklin	4,714	6,188	2,721	1,529	8,288	625	24,066
Grant	4,493	10,190	2,907	3,686	5,178	860	27,314
Adams	0	0	0	0	0	0	0
Benton	8,717	236,576	38,071	25,119	97,512	1,891	407,886
Chelan	276	44,404	0	0	0	0	44,681
Douglas	1,258	82,819	0	0	0	232	84,309
Ferry	0	0	0	0	0	0	0
Franklin	1,460	1,917	843	474	2,568	194	7,457
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	0	21,965	0	0	9,055	194	31,214
Lincoln	0	0	0	0	0	0	0
Okanogan	6,204	71,740	0	168	0	40	78,152
Stevens	244	43	0	68	0	19	374
Walla Walla	129	719	363	233	512	123	2,079
Crop Total	29,507	479,700	46,782	34,673	135,159	7,355	733,176

Note: These values depend critically on the assumption that market prices do not change as production changes. Only 908,247 AF are allocated to irrigated agriculture in this scenario.

Table 3.2: Lower Bound Scenario 2, Gross Revenue for 700 KAF (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
CBP Total	11,218	19,516	7,506	8,611	25,512	4,663	77,025
Adams	2,011	3,138	1,878	3,396	12,046	3,177	25,646
Franklin	4,714	6,188	2,721	1,529	8,288	625	24,066
Grant	4,493	10,190	2,907	3,686	5,178	860	27,314
Adams	0	0	0	0	0	0	0
Benton	4,307	142,851	22,988	12,410	58,880	934	242,370
Chelan	130	25,563	0	0	0	0	25,693
Douglas	602	48,442	0	0	0	111	49,155
Ferry	0	0	0	0	0	0	0
Franklin	834	1,095	481	271	1,466	111	4,257
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	0	12,696	0	0	5,234	92	18,021
Lincoln	0	0	0	0	0	0	0
Okanogan	3,122	44,119	0	85	0	20	47,345
Stevens	139	30	0	39	0	11	218
Walla Walla	68	460	232	122	327	64	1,273
Crop Total	20,419	294,770	31,207	21,536	91,420	6,006	465,358

Note: These values depend critically on the assumption that market prices do not change as production changes. Only 608,247 AF are allocated to irrigated agriculture in this scenario.

Table 3.3: Lower Bound Scenario 3, Gross Revenue for 572 KAF (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
CBP Total	11,218	19,516	7,506	8,611	25,512	4,663	77,025
Adams	2,011	3,138	1,878	3,396	12,046	3,177	25,646
Franklin	4,714	6,188	2,721	1,529	8,288	625	24,066
Grant	4,493	10,190	2,907	3,686	5,178	860	27,314
Adams	0	0	0	0	0	0	0
Benton	2,515	101,969	16,409	7,248	42,029	546	170,716
Chelan	73	17,506	0	0	0	0	17,579
Douglas	342	33,622	0	0	0	63	34,027
Ferry	0	0	0	0	0	0	0
Franklin	567	745	327	184	997	75	2,896
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	0	8,723	0	0	3,596	52	12,371
Lincoln	0	0	0	0	0	0	0
Okanogan	1,854	32,030	0	50	0	12	33,946
Stevens	94	25	0	26	0	7	152
Walla Walla	42	347	175	75	247	40	926
Crop Total	16,705	214,482	24,417	16,194	72,382	5,457	349,639

Note: These values depend critically on the assumption that market prices do not change as production changes. Only 480,570 AF are allocated to irrigated agriculture in this scenario.

Table 3.4: Scenario 1, Net Revenue of Irrigated Acreage using 1 MAF (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
CBP Total	-324	1,108	1,469	-2,433	3,794	-1,379	2,236
Adams	-58	178	368	-959	1,792	-940	380
Franklin	-136	351	533	-432	1,233	-185	1,364
Grant	-130	579	569	-1,041	770	-254	492
Adams	0	0	0	0	0	0	0
Benton	-252	13,437	7,453	-7,097	14,503	-559	27,485
Chelan	-8	2,522	0	0	0	0	2,514
Douglas	-36	4,704	0	0	0	-69	4,599
Ferry	0	0	0	0	0	0	0
Franklin	-42	109	165	-134	382	-57	423
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	0	1,248	0	0	1,347	-57	2,537
Lincoln	0	0	0	0	0	0	0
Okanogan	-179	4,075	0	-47	0	-12	3,836
Stevens	-7	2	0	-19	0	-6	-29
Walla Walla	-4	41	71	-66	76	-36	82
Crop Total	-853	27,246	9,158	-9,796	20,102	-2,175	43,682

Note: These values depend critically on the assumption that market prices do not change as production changes. Only 908,247 AF are allocated to irrigated agriculture in this scenario.

Table 3.5: Scenario 2: Net Revenue of Irrigated Acreage Using 700 KAF (in Thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
CBP Total	-1,031	943	1,310	-2,729	3,499	-1,846	146
Adams	-180	151	334	-1,065	1,652	-1,257	-365
Franklin	-451	303	465	-488	1,136	-250	715
Grant	-400	490	511	-1,176	711	-340	-204
Adams	0	0	0	0	0	0	0
Benton	-363	7,179	4,025	-3,879	8,189	-356	14,794
Chelan	-10	1,279	0	0	0	0	1,268
Douglas	-48	2,423	0	0	0	-33	2,341
Ferry	0	0	0	0	0	0	0
Franklin	-80	54	82	-86	201	-44	126
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	0	639	0	0	728	-35	1,332
Lincoln	0	0	0	0	0	0	0
Okanogan	-254	2,189	0	-24	0	-8	1,904
Stevens	-11	1	0	-11	0	-4	-25
Walla Walla	-6	23	41	-38	46	-25	41
Crop Total	-1,804	14,730	5,457	-6,767	12,662	-2,351	21,928

Source: calculated as discussed in the CRI report. These values depend critically on the assumption that market prices do not change as production changes. Note that only 608,247 AF are allocated to irrigated agriculture in this scenario.

Table 3.6: Scenario 3, Net Revenue of Irrigated Acreage Using 572 KAF (in thousands of $)

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
CBP Total	-1,737	777	1,150	-3,025	3,204	-2,313	-1,944
Adams	-302	123	301	-1,172	1,513	-1,573	-1,109
Franklin	-766	254	397	-543	1,040	-314	66
Grant	-669	400	453	-1,311	651	-425	-901
Adams	0	0	0	0	0	0	0
Benton	-351	4,457	2,533	-2,483	5,440	-255	9,341
Chelan	-10	757	0	0	0	0	747
Douglas	-45	1,454	0	0	0	-19	1,390
Ferry	0	0	0	0	0	0	0
Franklin	-92	31	48	-65	125	-38	8
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	0	383	0	0	465	-24	824
Lincoln	0	0	0	0	0	0	0
Okanogan	-248	1,360	0	-14	0	-6	1,092
Stevens	-13	1	0	-7	0	-3	-22
Walla Walla	-6	15	27	-26	32	-19	24
Crop Total	-2,502	9,234	3,759	-5,621	9,266	-2,676	11,459

Source: calculated as discussed in the CRI report. These values depend critically on the assumption that market prices do not change as production changes. Note that only 480,570 AF are allocated to irrigated agriculture in this scenario.

Table 3.7: Scenario 1, Net Revenue Per Acre-foot of Diversions

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat
CBP Avg.	-5	67	96	-82	129	-29
Adams	-5	65	111	-90	129	-30
Franklin	-4	72	78	-78	128	-29
Grant	-5	65	98	-77	130	-30
Adams	0	0	0	0	0	0
Benton	-5	87	95	-94	154	-35
Chelan	-6	84	0	0	0	0
Douglas	-6	84	0	0	0	-34
Ferry	0	0	0	0	0	0
Franklin	-4	72	78	-78	128	-29
Grant	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0
Klickitat	0	88	0	0	153	-35
Lincoln	0	0	0	0	0	0
Okanogan	-6	79	0	-95	0	-34
Stevens	-6	79	0	-95	0	-34
Walla Walla	-5	87	95	-94	154	-35
Average	-5	82	89	-91	147	-34

Table 3.8: Scenario 2, Net Revenue Per Acre-foot of Diversions Using 700 KAF

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat
CBP Avg.	-15	57	86	-92	119	-39
Adams	-15	55	101	-100	119	-40
Franklin	-14	62	68	-88	118	-39
Grant	-15	55	88	-87	120	-40
Adams	0	0	0	0	0	0
Benton	-15	77	85	-104	144	-45
Chelan	-16	74	0	0	0	0
Douglas	-16	74	0	0	0	-34
Ferry	0	0	0	0	0	0
Franklin	-14	62	68	-88	118	-39
Grant	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0
Klickitat	0	78	0	0	143	-45
Lincoln	0	0	0	0	0	0
Okanogan	-16	69	0	-95	0	-44
Stevens	-16	69	0	-95	0	-44
Walla Walla	-15	77	85	-104	144	-45
Average	-15	67	83	-95	128	-41

Table 3.9: Scenario 3, Net Revenue Per Acre-foot of Diversions Using 572 KAF

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat
CBP Avg.	-25	47	76	-102	109	-49
Adams	-25	45	91	-110	109	-50
Franklin	-24	52	58	-98	108	-49
Grant	-25	45	78	-97	110	-50
Adams	0	0	0	0	0	0
Benton	-25	67	75	-114	134	-55
Chelan	-26	64	0	0	0	0
Douglas	-26	64	0	0	0	-34
Ferry	0	0	0	0	0	0
Franklin	-24	52	58	-98	108	-49
Grant	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0
Klickitat	0	68	0	0	133	-55
Lincoln	0	0	0	0	0	0
Okanogan	-26	59	0	-95	0	-54
Stevens	-26	59	0	-95	0	-54
Walla Walla	-25	67	75	-114	134	-55
Average	-25	62	69	-103	127	-51

Table 3.10: Irrigated Acres for Counties using Columbia River Water

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	County Total
Adams	23,684	3,328	3,668	36,483	27,914	47,137	142,214
Benton	14,188	38,153	22,967	37,306	24,259	9,792	146,665
Chelan	1,101	28,603	12	0	0	0	29,716
Douglas	1,649	17,355	1,170	0	0	796	20,970
Ferry	4,648	0	0	0	0	0	4,648
Franklin	75,339	14,308	28,308	22,305	35,770	37,798	213,828
Grant	120,696	40,623	55,754	90,333	43,023	83,042	433,471
Kittitas	42,592	2,236	4,437	633	442	4,536	54,876
Klickitat	7,276	2,265	0	4,424	0	2,040	16,005
Lincoln	7,857	85	0	6,749	771	30,539	46,001
Okanogan	15,300	28,319	22	378	0	260	44,279
Stevens	5,941	167	20	1,515	0	1,192	8,835
Walla Walla	14,439	8,003	13,520	23,828	9,255	23,752	92,797
Crop Total	334,710	183,445	129,878	223,954	141,434	240,884	1,254,305

Source: 1997 Census of Agriculture. These are approximate because a few of the numbers came out slightly negative because of the way the Census reports Irrigated Acres. Those numbers were set to zero.

Table 3.11: Approximate Irrigated Acres for Counties Relevant to the Columbia River

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Total
Adams	15,459	3,854	8,987	23,814	26,000	64,100	142,214
Benton	10,187	44,189	27,705	26,785	32,000	5,800	146,665
Chelan	1,113	28,603	0	0	0	0	29,716
Douglas	1,649	17,355	0	0	0	800	19,804
Ferry	4,648	0	0	0	0	0	4,648
Franklin	78,978	16,572	28,396	23,382	39,000	27,500	213,828
Grant	129,795	47,050	52,284	97,143	42,000	65,200	433,471
Kittitas	40,214	2,590	6,339	598	600	4,536	54,876
Klickitat	0	2,623	0	0	1,900	380	4,903
Lincoln	5,972	98	0	5,130	6,000	28,800	46,001
Okanagon	15,321	28,319	0	379	0	260	44,279
Stevens	5,957	167	0	1,519	0	1,192	8,835
Walla Walla	10,414	9,269	18,229	17,185	11,600	26,100	92,797
Total	319,707	200,689	141,939	195,934	159,100	224,668	1,242,037

Source: 1997 Census of Agriculture and various WASS studies.

Table 3.12: Summary of Water Use by County

County	Columbia River Water Rights (acre-feet)[1]	Ratio of Columbia River Water Rights to Irrigated Acreage[2]	Alternative Water Sources[3]
Adams	CBP rights	--	Groundwater
Benton	922,104	5.6	Yakima River
Chelan	138,018	2.9	Wenatchee River and Lake Chelan
Douglas	194,764	4.2	Groundwater
Ferry	11,742	2.4	Kettle and Sanpoil Rivers
Franklin	83,285	0.3	Snake River
Grant	3,329,854	7.2	Groundwater
Kittitas	11,703	0.0	Yakima River
Klickitat	43,203	1.6	Groundwater
Lincoln	11,521	0.1	Spokane River
Okanogan	98,005	1.4	Okanogan River
Stevens	19,264	1.3	Spokane River
Walla Walla	170,789	1.3	Snake River
Yakima	3	0	Yakima River

[1] DOE Columbia River water rights spreadsheet.
[2] This is total Columbia River water rights divided by irrigated acreage from the 1997 census given in Table 3.7.
[3] These indicate irrigation water source alternatives to the Columbia River.

Table 3.13: Consumptive Water Use by Crop and County

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Weighted Average
Adams	2.74	2.82	1.38	1.69	2.06	1.86	1.96
Benton	3.02	2.54	1.96	1.96	2.08	1.93	2.23
Chelan	2.41	2.26					2.27
Douglas	2.41	2.26				1.67	2.25
Ferry	2.46	2.39				1.67	2.46
Franklin	3.02	2.54	1.96	1.96	2.08	1.93	2.41
Grant	2.71	2.82	1.57	1.98	2.04	1.86	2.23
Kittitas	2.71	2.82	1.57	1.98	2.04	1.86	2.50
Klickitat	2.73	2.51	1.76	2.00	2.08	1.92	2.30
Lincoln	2.78		1.82	2.15	2.09	1.93	2.08
Okanogan	2.46	2.39		1.67		1.67	2.40
Stevens	2.46	2.39		1.67		1.67	2.21
Walla Walla	3.02	2.54	1.96	1.96	2.08	1.93	2.14
Average	2.69	2.52	1.75	1.90	2.07	1.82	2.27

Source: historical water use based on AgriMet weather station. Blanks indicate the crop group is not widely grown in the region surrounding the specific weather station http://www.usbr.gov/pn/agrimet/ETtotals.html. Weighted average is based on base acreage

Table 3.14: AgiMet Weather Stations for Water Use

County	Weather Station
Adams	LIDW -- Lind, Washington and GERW -- George, Washington
Benton	LEGW -- Legrow, Washington
Chelan	MASW -- Manson, Washington
Douglas	MASW -- Manson, Washington
Ferry	OMAW -- Omak, Washington
Franklin	LEGW -- Legrow, Washington
Grant	GERW -- George, Washington
Kittitas	GERW -- George, Washington
Klickitat	HRHW -- Harrah, Washington
Lincoln	ODSW -- Odessa, Washington
Okanogan	OMAW -- Omak, Washington
Stevens	OMAW -- Omak, Washington
Walla Walla	LEGW -- Legrow, Washington

Table 3.15: Percentage of Irrigation Technology by Crop

Technology	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Technology Efficiency
Sprinkler	0.64	0.73	0.89	0.81	0.98	0.91	0.70
Gravity	0.36	0.07	0.11	0.12	0.02	0.09	0.50
Other	0.00	0.20	0.00	0.07	0.00	0.00	0.85
Weighted Average Efficiency	0.63	0.72	0.68	0.69	0.70	0.68	

Source: percentage by crop are from http://www.nass.usda.gov/census/census97/fris/tbl23.pdf and http://www.nass.usda.gov/census/census97/fris/tbl4.pdf. Irrigation efficiencies are based on http://farm-mgmt.wsu.edu/PDF-docs/misc/eb1875.pdf.

Table 3.16: Applied Water by Crop and County

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Weighted Average
Adams	4.36	3.94	2.04	2.46	2.96	2.73	2.89
Benton	4.80	3.55	2.88	2.86	2.98	2.83	3.23
Chelan	3.84	3.16					3.19
Douglas	3.84	3.16				2.44	3.19
Ferry	3.91	3.34				2.44	3.91
Franklin	4.80	3.55	2.88	2.86	2.98	2.83	3.65
Grant	4.31	3.94	2.31	2.88	2.94	2.72	3.34
Kittitas	4.31	3.94	2.31	2.88	2.94	2.72	3.90
Klickitat	4.35	3.51	2.59	2.92	2.99	2.81	3.26
Lincoln	4.41		2.68	3.13	3.01	2.82	3.08
Okanogan	3.91	3.34		2.43		2.44	3.53
Stevens	3.91	3.34		2.43		2.44	3.45
Walla Walla	4.80	3.55	2.88	2.86	2.98	2.83	3.16
Weighted Average	4.43	3.53	2.59	2.82	2.97	2.77	3.33

Source: These are values from Table 3.13 divided by figures in Table 3.15.

Table 3.17: Scenario 1: Portion of Crop by County

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat
Adams	0.11	0.03	0.06	0.17	0.18	0.45
Benton	0.07	0.30	0.19	0.18	0.22	0.04
Chelan	0.04	0.96	0.00	0.00	0.00	0.00
Douglas	0.08	0.88	0.00	0.00	0.00	0.04
Ferry	1.00	0.00	0.00	0.00	0.00	0.00
Franklin	0.37	0.08	0.13	0.11	0.18	0.13
Grant	0.30	0.11	0.12	0.22	0.10	0.15
Kittitas	0.73	0.05	0.12	0.01	0.01	0.08
Klickitat	0.00	0.54	0.00	0.00	0.39	0.08
Lincoln	0.13	0.00	0.00	0.11	0.13	0.63
Okanogan	0.35	0.64	0.00	0.01	0.00	0.01
Stevens	0.67	0.02	0.00	0.17	0.00	0.13
Walla Walla	0.11	0.10	0.20	0.19	0.13	0.28
Portion of Total	0.26	0.16	0.11	0.16	0.13	0.18

Source: based on 1997 Census of Agriculture and Washington Agricultural Statistical Service.

Table 3.18: New Crop Acreage for Scenario 1 and Upper Bound for Scenarios 2 and 3; 1 MAF

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Total
CBP Total	12,796	3,558	5,331	8,962	8,172	13,960	52,780
Adams	2,294	572	1,334	3,534	3,859	9,513	21,107
Franklin	5,377	1,128	1,933	1,592	2,655	1,872	14,557
Grant	5,125	1,858	2,065	3,836	1,659	2,575	17,117
Adams	0	0	0	0	0	0	0
Benton	9,943	43,133	27,043	26,145	31,235	5,661	143,160
Chelan	315	8,096	0	0	0	0	8,411
Douglas	1,435	15,100	0	0	0	696	17,230
Ferry	0	0	0	0	0	0	0
Franklin	1,666	350	599	493	823	580	4,510
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	0	4,005	0	0	2,900	580	7,485
Lincoln	0	0	0	0	0	0	0
Okanogan	7,077	13,080	0	175	0	120	20,451
Stevens	278	8	0	71	0	56	413
Walla Walla	147	131	258	243	164	369	1,312
Total	33,658	87,459	33,231	36,089	43,295	22,022	255,754

Table 3.19: New Crop Acreage for the Lower Bound of Scenario 2; 700 KAF

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Total
CBP Total	12,796	3,558	5,331	8,962	8,172	13,960	52,780
Adams	2,294	572	1,334	3,534	3,859	9,513	21,107
Franklin	5,377	1,128	1,933	1,592	2,655	1,872	14,557
Grant	5,125	1,858	2,065	3,836	1,659	2,575	17,117
Adams	0	0	0	0	0	0	0
Benton	4,912	26,045	16,329	12,917	18,861	2,797	81,860
Chelan	148	4,661	0	0	0	0	4,809
Douglas	687	8,832	0	0	0	333	9,852
Ferry	0	0	0	0	0	0	0
Franklin	951	200	342	282	470	331	2,575
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	0	2,315	0	0	1,676	274	4,265
Lincoln	0	0	0	0	0	0	0
Okanogan	3,561	8,044	0	88	0	60	11,753
Stevens	158	5	0	40	0	32	236
Walla Walla	77	84	165	127	105	193	751
Total	23,291	53,743	22,167	22,416	29,284	17,981	168,882

Table 3.20: New Crop Acreage for the Lower Bound of Scenario 3; 572 KAF

County	Hay	Orchards	Vegetables	Other	Potatoes	Wheat	Total
CBP Total	12,796	3,558	5,331	8,962	8,172	13,960	52,780
Adams	2,294	572	1,334	3,534	3,859	9,513	21,107
Franklin	5,377	1,128	1,933	1,592	2,655	1,872	14,557
Grant	5,125	1,858	2,065	3,836	1,659	2,575	17,117
Adams	0	0	0	0	0	0	0
Benton	2,869	18,591	11,656	7,544	13,463	1,634	55,756
Chelan	83	3,192	0	0	0	0	3,275
Douglas	390	6,130	0	0	0	189	6,709
Ferry	0	0	0	0	0	0	0
Franklin	647	136	233	192	319	225	1,752
Grant	0	0	0	0	0	0	0
Kittitas	0	0	0	0	0	0	0
Klickitat	0	1,590	0	0	1,152	154	2,897
Lincoln	0	0	0	0	0	0	0
Okanogan	2,115	5,840	0	52	0	36	8,043
Stevens	107	4	0	27	0	21	160
Walla Walla	48	63	124	78	79	119	512
Total	19,055	39,105	17,344	16,855	23,186	16,339	131,884

Table 3.21: Example Enterprise Budget, Cost per Acre for Soft White Winter Wheat

Item		Unit	Price or Cost Per Unit	Quantity	Cost
Variable Costs:					
Seed		Lb.	$0.16	100	$15.50
Herbicides:	Bronate	Pt.	6.27	1½	9.4
	Harmony Extra	Oz	15.2	0.3	4.56
Fertilizer	Nitrogen	Lb.	0.43	60	25.8
Repairs		Ac.	—	—	19.66
Fuel, Lubr. And Power		Ac.	—	—	31.18
Labor		Hr.	10	3.167	31.67
Machine Rent		Ac.	—	—	14.61
Irrigation District Fee		Ac.	—	—	17
Miscellaneous (util., accnt., legal, insur., etc.)		Ac.	—	—	13
Interest on Operating Capital		Ac.	10%	—	9.42
TOTAL VARIABLE COSTS					$191.80
Fixed Costs:					
Machinery (dep., interest, property taxes, housing, and insurance)		Ac.	—	—	90.2
Real Estate taxes		Ac.	—	—	15
Land (net rent)1		Ac.	—	—	72.94
Management2		Ac.	—	—	28.1
TOTAL FIXED COSTS					206.24
TOTAL COSTS					$398.04

Source: WSU extension bulletin EB1862

1. Equals $135 cash rent - $15.00 real estate taxes -$17.00 irrigation district fee - $30.07 irrigation system ownership (fixed) costs.

2. Equals 7% * value of production (110 bu. x $3.65).

Table 3.22: Enterprise Budget Data

Group	Crop	Region	Year	Variable Cost	Fixed Cost	Crop Budget
Hay						
	Alfalfa Hay	Columbia Basin	2002	518	384	EB1942E
Orchards						
	Apples	Eastern WA	1995	2,809	2,115	XB1032
			1998			EB1878E
			2002			XB1041
	Pears	Central WA	1998	3,483	2,354	EB1374
	Sweet Cherries	Central WA	2003	4,978	2,762	EB1957E
	Wine Grapes	Washington	2003	1,703	2,070	EB1955
Vegetables						
	Asparagus	Columbia Basin	2001	1,722	1,095	EB1779
	Carros, Fresh	South Col. Basin	2000	1,788	559	EB1504
	Carrots, Processing	South Col. Basin	2000	1,523	567	EB1504
	Sweet Corn, Processing	Columbia Basin	2002	405	288	EB1941E
	Onions, Storage	Columbia Basin	1999	1,816	708	EB1753
	Peas, Processing	Columbia Basin	2002	393	285	EB1941E
Other						
	Hops	Yakima Valley	1999	2,194	1,708	EB1134
	Dry Beans	Columbia Basin	2002	437	302	EB1941E
	Corn for Grain	Columbia Basin	1997	512	228	EB1667
	Corn for Silage	Columbia Basin	1997	612	239	EB1667
	Pepermint	Central WA	2001	1,271	720	EB1921E
	Spearmint, Native	Central WA	2001	1,157	559	EB1745E
	Spearmint, Scotch	Central WA	2001	1,231	845	EB1745E
Potatoes						
	Potatoes, Fall	Columbia Basin	2001	1,931	729	EB1667
Wheat						
	Spring Wheat	Walla Walla Co.	1997	179	204	EB1862
	Winter Wheat	Walla Walla Co.	1997	192	206	EB1862
	Winter Wheat	Columbia Basin	1997	294	212	EB1667

Source: WSU extension budgets, fixed costs are annualized and assumptions are the same as those given in the source.

Table 3.23: Crop Prices and Yields

Crop Group Crop	Price 2000	2001	2002	2002 Avg. Price[1]	Yield 2000	2001	2002	Average Yield
Hay								
Alfalfa Hay	98.00	114.00	108.00	109.59	5.0	4.8	5.0	4.9
Orchards								
Apples	250.00	356.00	398.00	342.72	17.7	15.1	15.7	16.1
Pears	267.00	259.00	290.00	279.47	17.4	17.9	17.1	17.5
Sweet Cherries	1630.00	1360.00	1650.00	1590.21	5.3	4.8	3.5	4.5
Wine Grapes	899.00	897.00	878.00	916.72	4.5	4.2	4.6	4.4
Vegetables								
Asparagus	73.40	71.50	71.40	74.16	34.0	36.0	37.0	35.7
Carrots, Fresh	16.10			17.01	400.0			400.0
Carrots, Processing	3.30	3.65	3.20	3.48	640.0	640.0	620.0	633.3
Sweet Corn, Proc.	3.78	3.52	3.62	3.74	171.4	179.6	188.8	179.9
Onions, Storage	8.14	8.20	12.30	9.78	550.0	550.0	560.0	553.3
Peas, Processing	11.20	10.55	9.20	10.63	44.8	44.8	40.8	43.5
Other								
Hops	1.81	1.81	1.95	1.91	1,937	1,928	2,133	1999.3
Dry Beans	0.18	0.21	0.20	0.20	2,000	1,700	2,000	1900.0
Corn for Grain	2.53	2.56	2.90	2.74	185	190.0	190.0	188.3
Corn for Silage	28.50	31.00	34.00	32.00	26.0	26.0	26.0	26.0
Peppermint	9.30	10.20	10.90	10.40	96.0	94.0	100.0	96.7
Spearmint, Native	9.10	9.10	9.20	9.39	145.0	143.0	146.0	144.7
Spearmint, Scotch	8.00	8.40	9.10	8.73	138.0	133.0	145.0	138.7
Potatoes								
Potatoes, Fall	4.25	5.85	5.55	5.35	600.0	590.0	560.0	583.3
Wheat								
Spring Wheat	2.96	3.38	4.30	3.63		81.0	73.6	77.3
Winter Wheat	2.62	3.19	4.10	3.38		114.1	93.9	104.0
Winter Wheat	2.62	3.19	4.10	3.38		114.1	93.9	104.0

Source: WASS 2003 Annual Bulletin

1. Prices brought forward to 2002 dollars using Bureau of Labor Statistic consumer price indices

Table 3.24: Net Returns per Acre for Soft White Winter Wheat

Included Costs	Cost Per Acre	Economic Profit[1]	Accounting Profit[1]
Total variable costs	192	-68	138
Total variable costs, taxes and management	235	-68	95
Total variable costs, taxes, manag. and mach.	325	-68	5
Total Cost	398	-68	-68

1. Assumes a price of $3 per bushel and yield of 110 bushels per acre

Table 3.25: Gross and Net Returns for Scenario 1 and Upper Bound for Scenarios 2 and 3

	Hay	Orchards	Vegetables	Other	Potatoes	Wheat
Gross Revenue	877	5,485	1,408	961	3,122	334
Net Economic Returns	-25	312	276	-271	464	-99

Calculated as discussed in text

CHAPTER 4. ECONOMIC VALUE OF NEW MUNICIPAL AND INDUSTRIAL WATER SUPPLIES

A. Overview of M&I Water Use

Diversions of Columbia River water to cities and industries occurs, but these diversions are small relative to irrigation and have little measurable impact on the operation of the river system. The level of M&I depletion is so small that some researchers have ignored it as a consumptive use of water altogether. The Columbia River SOR (1995) considered depletions to be insignificant in the measurement of impacts under alternative operating strategies. They cite that public water supply and domestic use account for 4% of diversions, commercial use about 2%, and industrial use about 2%. Furthermore, water withdrawn for non-agricultural use has a higher return flow than for agricultural uses, and accordingly, depletion for M&I uses was estimated at less than 2%. The BPA (1993) concludes similarly. They assert that the magnitude of M&I consumptive use in the Pacific Northwest is minor when compared to the consumptive use of agriculture. In addition, large streamflows in comparison to M&I diversions results in the BPA's conclusion that the estimate of M&I depletion is inconsequential and not required in deriving modified streamflows. They show that 97.3% of consumptive use is due to agricultural diversions.

However, despite the conclusion that diversions of M&I water results in very small changes of in-stream flows, the value of water to M&I users may be higher than the value of water to irrigators and other users of water. The fact that water is necessary for sustaining human life implies that M&I users will have a very high marginal value for water in years when water is in short supply. Conversely, in years when there is ample water, the marginal value of water to M&I users will be much lower. In any given year, the value per AF for M&I water will be greater than or equal to the value per AF for irrigation water.

To summarize M&I use for rights within one mile of the Columbia River, about 93 KAF of water, or about 2.0%, is used for municipal uses; while about 244 KAF, or about 5.3% is used for industrial use[7]. When considering applications for water, the relative amount of water used for M&I purposes increases. Of the applications for M&I water within one mile of the Columbia,

[7] Ecology specifies uses as Domestic/General & Municipal and Commercial & Industrial. The first category is essentially "Municipal" and the second category is essentially "Industrial."

about 69 KAF, or 11.4%, is for municipal uses; while about 7.5 KAF, or 1.2%, is for industrial uses. The relatively large application pool for municipal water might reflect the increasing demands for water in rapidly developing areas. As discussed in Chapter 2, nearly all of the M&I applications that exist are for counties near the Tri-Cities area. The table below summarizes rights and applications for M&I water by county.

Table 4.1 Existing M&I Rights and Applications

County	Certificates & Permits (AF)	Applications (AF)
Benton	223,081	65,085
Chelan	33,878	0
Douglas	101	0
Ferry	4	0
Franklin	7,774	5,203
Grant	2,539	0
Kittitas	62	0
Klickitat	25,416	5
Lincoln	676	0
Okanogan	2,467	0
Stevens	2,737	0
Walla Walla	38,303	6,504
Total	337,039	76,798

B. M&I Water Values

Published sources of value for municipal and industrial (M&I) water are scarce, and do not cover the wide range of conditions and uses observed. One source of information, the monthly publication "The Water Strategist", analyzes water marketing in the western United States. In 2002, Water Strategist reported 200 major water transactions, the majority of which were for M&I use -- 167 transactions. Colorado has the most highly evolved water market to date, where 116 out of 123 transactions occurred for M&I in 2002. The trend in water marketing transactions seems to be increasing, but very much dependent upon whether the year is a wet or

dry year. The largest number of transactions to date occurred during the 2001 drought—219 total transactions. The price at which water is traded is also highly dependent upon the water year. Throughout the west, the range is from $0/AF to up to $10,000/AF-$15,000/AF for M&I water in Colorado and Nevada.

Within Washington, there seem to be few reliable examples of water purchases in Washington. In all, there are only 4 transactions for M&I water in Washington since January of 2000. For example, two purchases in Washington were for M&I uses during 2001. The City of Warden purchased 2,388 AF of Grande Ronde Aquifer GW from an irrigator at a price of $452/AF in June. Also, various businesses, farms, and the Church of Latter Day Saints leased up to 2,596.5 AF of Columbia Basin Project water from the Bureau of Reclamation for $39/AF with a minimum lease of $500 in July and August of 2001. When we include transactions for M&I water in Oregon and Idaho, very little improvement is made to estimate the value of M&I water. Oregon has had no documented transaction from 1998 to 2002 for M&I purchases. Idaho has had three M&I purchases, ranging from $3.20/AF to $21/AF. Grouping Washington, Oregon, and Idaho and collectively calling this are the Pacific Northwest because of there similarities in land geography and water availability gives a range for M&I water values of $0/AF to $452/AF. The value of $0/AF reflects a 2002 transaction in Washington when a private individual donated 25 AF of water to the Town of Granger. Grouping other states in the western United States seems inappropriate due to differences in weather conditions, geography and water sources. There are a total of seven transactions for M&I water from 1998 to 2002 in the Pacific Northwest. There seems to be a large discrepancy in prices for M&I water, and its value in any given year seems highly dependent upon the weather conditions for that year and whether the transaction is for SW or GW. Nonetheless, water purchases for M&I uses seem to be an appropriate way to show a lower bound for the value of M&I water.

Many of the water transactions that occur are the exchange of water from irrigators to municipalities, confirming that the marginal value of water for M&I use is higher than the marginal value for irrigation. This provides some evidence that the value per acre foot of M&I water is greater than or equal to the value per acre foot of irrigation water.

Another way to value M&I water is through the cost of re-claiming and treating wastewater. There are a number of on-line sources we have referenced, including the EPA's Wastewater Management website, the National Onsite Wastewater Recycling Association's

(NOWRA) website, and Water and Wastewater.com. However, none of those sources address the value of reused water in terms of the cost of retreating in Washington.

Other informational sources include the John Day Drawdown report from the Corps which includes both a profile of M&I users to the John Day pool, and costs to modifying M&I water supply systems under a few scenarios. The study focuses on M&I users adjacent to the John Day pool, with a heavier emphasis on those users in the state of Oregon. The Washington users include Columbia/Goldendale Aluminum, Patterson, and other publicly and privately owned wells. The report distinguishes between SW users and GW users, of which Columbia/Goldendale Aluminum is the only SW user in Washington. The report summarizes construction and annual costs of M&I water supply facility modifications if the John Day pool was to be drawn down to its natural level, and to the spillway crest.

To summarize M&I water values, the two most appropriate ways to value M&I water given the limited number of sources is through M&I transactions which are sparse, and to assume that the value per acre foot for M&I water is at least as big as the value per acre foot for irrigation. Transactions in the Pacific Northwest provide a range of $0/AF to $452/AF. The marginal value of M&I water is highly dependent upon the weather conditions in a given year.

C. Impact of the Scenarios on M&I Water

The issuance of water rights for M&I purposes seems to be a higher priority than that of irrigation purposes because of M&I's relatively large marginal value when compared to irrigation. It seems reasonable to conclude that water applications for M&I use will be granted by Ecology as long as the municipalities requesting the water can provide evidence that there is an increasing need for M&I water due to urban expansion or population increases.

For the scenarios considered in this report, it has been shown that the most important urban area with respect to the Columbia River is the Tri-Cities. We have assumed that the Tri-Cities population trend shows roughly a 30% increase in the next 10 to 20 years, and correspondingly, a 30% increase in the need for water. Furthermore, we have assumed that in each scenario, and at the low-level assessment and high-level assessment (applicable to scenarios 2 and 3), M&I water will be granted rights ahead of irrigation water. In each case, the 30% increase in the water needs of the Tri-Cities has been a high priority. Furthermore, in a situation such as scenario 4, where new rights are permitted only through transfers and conservation

measures, it seems likely that municipalities would acquire water through leasing from irrigators when necessary.

In each of the scenarios, they same quantity of M&I water is assumed to be granted, because this high valued water use. The total of 91,752 acre-feet of water would be worth between $0 and $41.5 million (at $452/af), with a median estimate of $20.7 million.

CHAPTER 5. ECONOMIC EFFECTS ON HYDROPOWER GENERATION

The withdrawal of additional water for out-of-stream use will reduce the flow of water downstream from the diversion point, and this will reduce the potential production of hydroelectric power at all dams downstream of the diversion. For new diversions from each pool in the mainstem river from Grand Coulee to John Day we calculate the power loss and value of power loss in the following steps:

- calculate the change in flow at downstream locations caused by the new diversion amounts, diversion timing, and the expected return flows for each month of the year;
- multiply the flow change by the monthly "power factors" for each downstream hydropower dam (i.e. megawatts produced per thousand cubic feet per second (kcfs)), times hours for each month;
- multiply resulting hydropower reduction by prices forecasted for each month;

This computation is performed for an average water year (averaged over 1929 – 1978) and for a very dry year (1977). In the current version of this analysis, the power factors vary between average and dry years . The price forecasts used here were developed at the Pacific Northwest Power and Conservation Council based upon consensus assumptions about future load, generation resources, natural gas prices, precipitation patterns in the Columbia basin, and power demand (Final Draft Fifth Plan Price Forecast. R5B7 on 11/26/03). These forecasts include both "high load hour" (HLH) and "low load hour" (LLH) prices, where the high load hours are basically between 7 am and 10 pm. All the power loss estimates are based upon "flat" prices which average across all hours of operation, because we assume that water available for hydropower generation would be used in both high load and low load periods. We do not have separate price forecasts for "dry years" and average water years. If hydropower is significantly scarce in dry years, the price could be substantially higher that the forecast prices.

The three prospective levels of new withdrawals – 1 MAF, 700 KAF and 572 KAF are evaluated in order for each major water use. The irrigation and M&I water uses are separated for two reasons: (1) the M&I diversions occur more-or-less year around, rather than following the seasonal pattern of irrigation diversions, and (2) M&I uses typically involve little consumptive use; most of the water (we assume 90%) returns to the river within the pool from which it is diverted. So, the power generation rates and power prices, and the general methodology for

estimating power impacts are identical for the two water uses, but the two analyses differ in the diversion/return flow patterns. Consequently the two are presented in separate tables.

The new M&I diversions are assumed to equal 91,752 acre-feet per year under all scenarios and regardless of whether the remaining water for irrigation is completely allocated. Further, we assume that M&I diversions continue throughout the year, and simplify this even further by taking them to be constant. This involves a simplification which is unlikely to be fully accurate, as municipal and domestic irrigation for lawns and parks is likely to peak in the summer. We divide the M&I analysis into the component associated with the 11,000 KAF Columbia Basin Project and the for 73,179 KAF and 7,573 KAF for McNary and John Day reservoirs. The CBP water will be conveyed to sites within the larger project area, and wastewater will flow into canals and reservoirs where much of it can be re-used. Hence, we apply return flow patterns identical to those used for the irrigation water analysis for CBP. Again, this simplification will give us a reasonable estimate of overall hydropower costs, but will differ in minor details from the actual costs occurred by M&I water use in the CBP. As shown in Table 5.2, the power values lost through M&I allocations in the CBP range from $392 thousand for average water years to $401 thousand per year for dry years. M&I water diversions at McNary and John Day are assumed to occur uniformly throughout the year and to incur very low consumptive use rates of 10% (i.e. 90% return flow rates). The return flows are assumed to occur in the month of diversion and to the pool from which the water is diverted. As noted in Table 5.2, the overall hydropower costs of all new M&I diversions would total $1.16 million in average water years and $1.27 million in dry years.

The hydropower losses due to new diversions of 908,248 acre-feet for irrigated agriculture, and the losses due to conversion of 121K in interruptible to non-interruptible rights are displayed in Table 5.3. Both the new water rights and the converted rights permit expansion of agriculture, but the conversion of interruptible rights is assumed to increase water use from previous levels only during dry years (when the water use could be interrupted). The full cost to the hydroelectric power system of new withdrawals (distributed across reservoirs as shown in Table 2.4) varies from $18.4 million/year in average water years to $20.0 million/yr in a dry year. In addition to the loss of hydropower generation, there would be an increase power consumption associated with pumping the additional 220 kaf of water from Grand Coulee reservoir to Banks Lake for the Columbia Basin Project, worth an estimated $3.42 million per year.

Hydropower costs associated with Management Scenarios 2 and 3 are estimated in the same manner as costs listed in Table 5.3, but with modified assumptions regarding magnitude of new diversions. For example, under Scenario 2 only 700 KAF of new water rights would be allocated initially, with 300 KAF being contingent upon whether 80% of water use conforms to water efficiency Best Management Practices (BMPs). If water users meet the standards initially and the full 1 MAF in new water rights are permitted, the hydropower loss under Scenario 2 is the same as under Scenario 1. Alternatively, if either (a) the majority of water users do not meet water efficiency BMPs or (b) the costs of meeting BMPs and paying the proposed fee of $10/acre-foot per month is too high to attract the full 1 MAF of new water rights, then the hydropower cost of Scenarios 2 would be lower. If only the first 700 KAF of new water rights are allocated, and all 91,752 KAF of M&I water demand is included in this, then the new agricultural diversions will amount to 608,248 acre-feet. Then we allocate this over reservoirs by assigning the full 209 KAF for irrigation in the Columbia Basin Project and assign the remaining irrigation water among reservoirs in proportion to the amounts in the application pool. The resulting hydropower costs range from $15.8 million in an average water year to $17.4 million in a dry year (Table 5.4).

Scenario 3 is similar to Scenario 2, except that the fees charged for new water rights rise to $20/acre-foot. Again, if all 1 MAF of the proposed new water rights are taken, despite the higher fees, the hydropower impact would be the same as with Scenario 1. On the other hand, the higher fees may discourage some prospective water uses. To provide a range of possible impacts, we consider a lower-bound estimate of new water rights allocation of 572 KAF, which equals the existing application pool, minus the application for hydropower use at the Dalles (Klickitat Co PUD), plus the proposed allocation of 220 KAF to the Columbia Basin Project. This lower bound is chosen to be below the 700 KAF lower bound adopted for Scenario 2, because the higher fee is likely to discourage more low-valued water applications. The hydropower losses associated with this lower bound estimate are displayed in Table 5.5, and amount to between $14.7 million and $16.3 million per year. Also, the State may develop additional storage, which could change the timing and quantity of flows available to hydropower at some dams.

Scenario 4 would cause little or no loss of hydropower production, because all new water rights would be offset through transfers, conservation, and/or new storage. And, finally, Scenario 5 would cause no loss of hydropower from the status quo, base condition.

The overall hydropower costs of additional water allocations and converted interruptible water rights in the amounts and conditions described above are in Table 5.1 below.

Table 5.1. Hydropower Costs for Each Total New Diversion Level. Includes loss Due to Diversions, Pumping at Grand Coulee, and Conversion of Interruptible water rights.

Diversion Amount	Ave. Water Year	Dry Year
1 MAF	$18,440,952	$20,038,048
700 KAF	$15,845,545	$17,398,655
572 KAF	$14,738,172	$16,272,514

Details of these hydropower value calculations are described in the following sections.

A. Detailed Description of Power Loss Calculation Method

We adopt an approach similar to that used by John Fazio of the Northwest Power and Conservation Council (memo of May 9, 2000) to estimate hydropower system losses due to additional diversions. We calculate flows and generation losses at each affected dam. For each diversion, we identify the pool from which the water is drawn (call it dam i). So, the annual increased diversion in acre-feet at dam i is indicated by the variable, ΔD_i. These values are listed in Table 2.4, 2.6 and 2.8 above. Then we perform the following 5 steps.

1. Estimate the increased diversion in acre-feet (af) by month of the year based upon estimated seasonal distribution of diversions for the type considered. With M_{ij} representing the % of the water right that would be diverted at dam i in month j, we multiply to get the monthly diversion volume at dam i in month j, $\Delta D_i x M_{ij}$.

2. Convert the volume of water diverted in acre-feet into flow. A flow of 1 cfs for a day is equivalent to 1.98 acre-feet. So, the average in-stream flow reduction in cfs due to a diversion of ΔDM_{ij} for a month would be equal to $\Delta D_i x M_{ij} /(1.98 DAY_j)$, where DAY_j is the number of days in month j.

Table 5.2 Hydropower Losses Associated with New M&I water Diversions of 91,752 KAF annually. Each entry is loss at dam where the diversion occurs and at all downstream dams.

Dam	Diversion	MWh		Power Value	
	KAF	Ave. Year	Dry Year	Ave. Year	Dry Year
Grand Coulee	11,000	9679	9916	$392,520	$401,102
McNary	73,179	15220	17698	$600,515	$702,755
John Day	7,573	4147	4208	$170,081	$171,126
Total	91,752	29046	31822	$1,163,116	$1,274,983

Table 5.3 Summary of Estimated Power Losses Associated with 908,248 AF of new Water Rights for <u>Irrigation</u> (plus converted interruptible rights in dry years), valued at average price forecast for 2004-2024. Each entry is cumulative loss due to diversion at named dam and at all downstream dams due to that diversion.

Dam	New Diversion Acre-Feet	Converted Interruptible Rights AF	MWh Loss		Cost per Acre-foot		Lost Hydropower Value	
			Ave. Year	Dry Yr.	Ave Year	Dry Yr.	Ave Year	Dry Year
Grand Coulee	210,675	415	169,289	176,139	$37.39	$38.53	$7,876,737	$8,132,759
Chief Joseph	1,909	1,111	851	1,402	$21.85	$22.79	$41,720	$68,846
Wells	138,678	24,316	44,353	54,334	$15.65	$16.31	$2,169,882	$2,658,981
Rocky Reach	19,853	1,914	5,496	6,222	$13.56	$14.00	$269,126	$304,781
Rock Island	15,833	8,491	3,448	5,451	$10.70	$11.02	$169,344	$267,954
Wanapum	4,756	721	930	1,104	$9.60	$9.89	$45,666	$54,198
Priest Rapids	0	0	0	0	$0.00	$0.00	$0	$0
McNary	178,612	53,087	26,692	34,924	$7.46	$7.55	$1,331,800	$1,748,705
John Day	337,931	31,651	38,045	40,695	$5.72	$5.64	$1,931,928	$2,085,213
Total	908,248	121,707	289,104	320,271	$15.23	$14.88	$13,836,205	$15,321,436

Table 5.4 Hydropower Losses Associated with New water rights of 608 KAF for irrigation (plus converted interruptible rights in dry years) valued at average price forecast for 2004-2024. Each entry is cumulative loss due to diversion at named dam and at all downstream dams due to that diversion.

Dam	New Diversion Acre-Feet	Converted Interruptible Rights AF	MWh Loss Ave. Year	MWh Loss Dry Yr.	Cost per Acre-foot Ave Year	Cost per Acre-foot Dry Yr.	Lost Hydropower Value Ave Year	Lost Hydropower Value Dry Year
Grand Coulee	209,956	415	168,712	175,539	$37.39	$38.53	$7,849,873	$8,105,021
Chief Joseph	1,090	1,111	486	1,022	$21.85	$22.79	$23,821	$50,176
Wells	79,181	24,316	25,324	34,500	$15.65	$16.31	$1,238,933	$1,688,378
Rocky Reach	11,335	1,914	3,138	3,787	$13.56	$14.00	$153,662	$185,521
Rock Island	9,040	8,491	1,969	3,929	$10.70	$11.02	$96,690	$193,122
Wanapum	2,716	721	531	693	$9.60	$9.89	$26,074	$34,007
Priest Rapids	0	0	0	0	$0.00	$0.00	$0	$0
McNary	101,982	53,087	15,240	23,373	$7.46	$7.55	$760,415	$1,170,352
John Day	192,948	31,651	21,722	24,731	$5.72	$5.64	$1,103,068	$1,267,205
Total	608,248	121,707	237,122	267,574	$18.50	$17.39	$11,252,536	$12,693,781

Table 5.5 Hydropower Losses Associated with New water rights of 480.57 KAF for irrigation (plus converted interruptible rights in dry years) valued at average price forecast for 2004-2024. Each entry is cumulative loss due to diversion at named dam and at all downstream dams due to that diversion.

Pool	New Diversion Acre-Feet	Converted Interruptible Rights AF	MWh Loss Ave. Year	MWh Loss Dry Yr.	Cost per Acre-foot Ave Year	Cost per Acre-foot Dry Yr.	Lost Hydropower Value Ave Year	Lost Hydropower Value Dry Year
Grand Coulee	209,650	415	168,465	175,282	$37.39	$38.53	$7,838,411	$8,093,187
Chief Joseph	741	1,111	330	860	$21.85	$22.79	$16,184	$42,210
Wells	53,859	24,316	17,205	26,038	$15.65	$16.31	$841,728	$1,274,255
Rocky Reach	7,710	1,914	2,132	2,749	$13.56	$14.00	$104,398	$134,636
Rock Island	6,149	8,491	1,338	3,279	$10.70	$11.02	$65,691	$161,193
Wanapum	1,847	721	361	517	$9.60	$9.89	$17,715	$25,392
Priest Rapids	0	0	0	0	$0.00	$0.00	$0	$0
McNary	69,368	53,087	10,354	18,445	$7.46	$7.55	$516,624	$923,588
John Day	131,244	31,651	14,758	17,919	$5.72	$5.64	$749,422	$918,188
Total	480,570	121,707	214,943	245,090	$21.14	$19.23	$10,150,171	$11,572,649

3. Calculate the hydropower generation lost at dam i in each month j by multiplying the change in flow by the "power factor" HK_{ij}, which is the megawatt production (MW) produced under stipulated system operating rules at the dam per thousand cfs (Kcfs) of flow. The we divide by 1000 to convert to Kcfs and mulitply by 720, the number of hours in a month, to get megawatt hours of energy. In symbols, the hydropower generation loss at dam i in month j would be:

(1) $\Delta MW_{ij} = 0.72*HK_{ij} *\Delta D_i x M_{ij} /(1.98DAY_j)$.

Because the water diverted at one dam and consumed by the water user is unavailable at all subsequent dams downstream, we add up the power factors for all dams downstream of the diversion point (call this HKSUM) and substitute this for HK in equation (1) to get total system power loss:

(2) $\Delta MW^*_{ij} = 0.72 * HKSUM_{ij} * \Delta D_i x M_{ij} /(1.98DAY_j)$.

4. Because a significant amount of water returns to the river at or below the diversion point, we need to adjust the calculated power loss to account for power produced at downstream dams by return flow. Letting RFM_{ijk} be the percent of water diverted at point i that returns in month j at site k, we can calculate the power generation due to return flow from diversion at dam i in month j as:

(3) $RMW_{ij} = 0.72 * \Sigma [\Delta D_i *RFM_{ijk} /(1.98DAY_j)] \text{ x } HKSUM^*_{ij}$

where the summation is over i, downstream dam sites.

5. The value of the power loss due to diversion at dam i in month j is calculated by multiplying the change in power generation by a forecasted monthly price. These forecasts can be obtained from the Bonneville Power Administration or from technical staff at the Northwest Power and Conservation Council. The prices for mid-Columbia wholesale transactions vary across months; they vary from peak to non-peak hours; and they are expected to vary across water years. In dry years, the prices would typically be somewhat higher than in wet years. We currently do not have forecasted dry year prices. Potential power value loss is calculated as:

(4) $\Delta PV_{ij} = P_{ij} \text{ x } (\Delta MW^*_{ij} - RMW_{ij}) = P_{ij} \text{ x } [\Delta MW^*_{ij} - \Sigma RFM_{ijk} \text{ x } \Delta MW^*_{ij}]$.

B. Hydropower Loss for Diversion at the Columbia Basin Project

The diversion of an additional 210,625 AF at Lake Roosevelt for irrigation (Table 2.4) would occur over the months of the growing season, and return flows from those diversions to lower pools would be spread over the year as indicated in Table 5.6, which shows the estimated percentage distribution of diversions and return flows over months. These monthly diversion and return flow patterns are taken from Bonneville Power Administration (1993a). Overall, about 21.5% of the water diverted eventually returns to reservoirs downstream. Assuming the new diversion of 210,625 acre-feet from Lake Roosevelt and associated return flows follows that established pattern, we expect the flows to be distributed across months as shown in Table 5.6. These are calculated in accordance with the term $\Delta D_i x M_{ij} /(1.98DAY_j)$ as explained above. We assign numbers to projects starting with Grand Coulee as 1, and proceeding downstream. So, for example, Wanapum dam is site 6. The monthly flow changes are in Table 5.7. We use the system power factors (H/Ks) in Table 5.8a (or Table 5.8b for a dry year) to calculate the change in monthly hydropower production at each dam, based on equations (2), (3) and (4) above. Then we multiply each estimated Mwh change by a monthly-varying price as displayed in Table 5.9. These prices are forecasted by the Northwest Power and Conservation Council for the years 2004-2024, which covers the CRI water allocation period.

For the additional 210,625 acre-foot diversion at Grand Coulee in an average water year we get a net loss of generation at Grand Coulee and downstream dams of 181,028 MWh, which is worth $8,422,925 at the average forecast prices in Table 5.9. Return flows at Wanapum, Priest Rapids and McNary dams will generate a total of 11,739 Mwh, worth $546,188 per year at the flat rate mid-C prices. The net loss of hydropower generation value is $7,876,737 or $37.39 per acre-foot of new diversion. In a very dry year (1976-77) the power factors are slightly higher (HKSUMs) due to changes in the operation of the system to utilized a higher percentage of the water. A re-computation of hydropower losses and wholesale market value of the losses for a dry year yields a net loss of hydropower value due to new diversions from Grand Coulee reservoir to the Columbia Basin Project of $8,132,759 (or $38.53 per acre-foot of water diverted). The results are sensitive to the price assumptions. Generally, extra hydropower generated during high load hours is worth more than power generated during low load hours. If the additional water were used by hydropower plants for peaking during high low hours, then the high load hour price would be the appropriate price to represent the value of lost hydropower. Since the amount of

water in question is rather small, and because fish and wildlife provisions are tending to require more stable reservoir operations, we have assumed the water would be used to generate hydropower around the clock, and we have used average prices.

An additional issue is the power consumed in pumping the new water allocation for 220 kaf for the Columbia Basin Project. This water would be pumped from the reservoir to Banks Lake for distribution down canals to irrigation districts in the project area. According to estimates by John Fazio, the power demands (in Mwh) per thousand acre-feet are as listed in Table 5.6. Multiplying these power demands times the diversions per month (first column of Table 5.6) times the Mid-C average prices (for Low-Load Hours) yields a hydroelectric cost of $3,441,630. That cost could be added on to the value of lost hydropower production in calculating the overall hydropower cost of the new diversion. The total for the 221.6 KAF diversion would then be $11.71 million in average water years and $11.98 million in dry years.

C. Hydropower loss calculations for dams below Grand Coulee

Unlike the Columbia Basin Project, the other irrigation projects along the mainstem river do not deliver water to farms located far, and at much higher elevation than, the diversion site. Hence, the pattern of return flows from these diversions is less complicated. We adopt the simple assumption that return flows from diversions below Grand Coulee return to the reservoir from which they originate. Using computations from BPA's (1993a) "Modified Streamflows 1990 Level Irrigation, Columbia River and Coastal Basins 1928-1989", the total estimated return flow for irrigation projects at Chief Joseph through Wanapum is 14.98% of the diverted water, while the estimated return flows from projects at McNary and John Day is 16.4% of the diverted water. Estimated monthly patterns of diversions and return flows for irrigation projects from reservoirs ranging from Chief Joseph dam down to John Day dam are listed in Table 5.10. To obtain the net amount of water diverted from each reservoir, we multiply each monthly net diversion % times the acre-feet of new diversions (from Table 2.4). Then we convert this to monthly flow, megawatts of power lost, and value of power lost using equation (4) listed above. We use the system power factors (HKSUMS) from Tables 5.8a & b and prices from Table 5.9. The results for each reservoir are listed in Tables 5.2 through 5.5.

Table 5.6 Seasonal distribution of diversions for the Columbia Basin Project, and return flows to downstream reservoirs. (derived from BPA's Modified Flows report, 1990).

Month	Grand Coulee Diversion	Power Demand[1]	Return Flows Wanapum	Return Flows Priest Rapids	Return Flows McNary	Total
j	M_{11}	per cfs	RFM_{1j6}	RFM_{1j7}	RFM_{1j8}	
Jan.	0.0%	120	0.14%	0.40%	0.75%	1.3%
Feb.	0.0%	460	0.13%	0.32%	0.72%	1.2%
Mar.	3.6%	400	0.13%	0.34%	0.94%	1.4%
April	16.2%	340	0.18%	0.49%	1.22%	1.9%
May	16.9%	340	0.18%	0.55%	1.20%	1.9%
June	15.6%	340	0.17%	0.47%	1.29%	1.9%
July	18.2%	295	0.21%	0.51%	1.52%	2.2%
August	14.5%	450	0.25%	0.64%	1.57%	2.5%
Sept.	9.7%	120	0.26%	0.60%	1.65%	2.5%
Oct.	5.3%	460	0.24%	0.66%	1.37%	2.3%
Nov.	0.0%	400	0.18%	0.43%	0.70%	1.3%
Dec.	0.0%	340	0.16%	0.37%	0.58%	1.1%
Total	100%		2.21%	5.78%	13.50%	21.5%

[1] from Fazio, 2000.

Table 5.7. Estimated change in monthly flow rates (cfs) due to new 210,675 AF water right for diversion at Grand Coulee and associated return flows downstream of Grand Coulee.

Month	Grand Coulee Diversion cfs	Return Flows Wanapum	Return Flows Priest Rapids	Return Flows McNary
	$\Delta D_1 x M_{1j}$ /(1.98DAY$_j$)	$\Delta D_i x RFM_{1j6}$ /(1.98DAY$_j$)	$\Delta D_i x RFM_{1j7}$ /(1.98DAY$_j$)	$\Delta D_i x RFM_{1j8}$ /(1.98DAY$_j$)
Jan.	0.0	4.9	14.0	26.5
Feb.	0.0	4.8	12.2	25.6
Mar.	125.3	4.5	12.0	33.5
April	574.6	6.2	17.5	43.4
April	574.6	6.2	17.5	43.4
May	578.8	6.1	19.4	42.5
June	552.7	6.2	16.6	45.7
July	624.1	7.2	17.5	53.8
August	498.8	8.4	44.0	55.5
August	498.8	8.4	44.0	55.5
Sept.	342.6	9.0	21.4	58.5
Oct.	182.9	8.1	22.8	48.5
Nov.	0.0	6.2	15.2	24.7
Dec.	0.0	5.9	12.5	20.6

Table 5.8a Monthly System Power Factors[1] (MW/Kcfs) for an average water year. Each factor is the cumulative power at the named dam plus all downstream dams per kcfs. Average for 1929 – 1978 flows and hydropower under 2000 Biological Opinion.

	Grand Coulee	Chief Joseph	Wells	Rocky Reach	Rock Island	Wanapum	Priest Rapids	McNary	John Day
Sept.	86.3	61.8	49.0	44.0	37.3	34.4	28.7	22.9	17.7
Oct.	85.7	61.2	48.5	43.6	37.0	34.2	28.4	22.7	17.6
Nov.	85.7	61.4	48.7	43.8	37.2	34.3	28.6	22.9	17.8
Dec.	84.5	60.7	48.0	43.2	36.7	33.9	28.2	22.6	17.6
Jan.	81.5	58.7	46.2	41.6	35.2	32.5	27.0	21.8	17.0
Feb.	82.3	60.1	47.4	42.6	36.1	33.4	27.7	22.2	17.3
Mar.	81.9	60.0	47.3	42.4	35.9	33.1	27.4	21.9	17.2
April 1	78.7	57.0	44.5	39.7	33.3	30.7	25.1	19.7	16.0
April 2	65.5	44.3	31.9	27.6	22.1	19.9	16.8	14.9	12.0
May	61.5	40.5	28.7	24.9	19.8	17.7	14.8	13.1	10.5
June	65.3	42.3	30.1	26.0	20.3	18.2	15.4	13.1	10.4
July	68.8	44.4	32.0	27.8	22.0	19.9	17.2	14.1	10.1
Aug. 1	69.9	45.6	33.0	28.6	22.5	20.3	17.5	14.4	10.0
Aug. 2	71.3	47.2	34.5	29.8	23.3	20.7	17.9	14.6	9.8

Table 5.8b Dry Year Monthly System Power Factors[1] (MW/Kcfs), the sum of the HKs for each dam plus all downstream dams. (using 1977 water year as the dry year).

	Grand Coulee	Chief Joseph	Wells	Rocky Reach	Rock Island	Wanapum	Priest Rapids	McNary	John Day
Sept.	84.2	59.4	46.7	42.0	35.6	32.9	27.2	21.7	17.1
Oct.	85.6	60.8	48.1	43.2	36.8	33.9	28.2	22.6	17.4
Nov.	85.5	61.3	48.6	43.7	37.1	34.3	28.6	22.9	17.8
Dec.	84.6	61.3	48.5	43.7	37.1	34.3	28.5	22.9	17.8
Jan.	83.9	61.2	48.5	43.7	37.1	34.3	28.5	22.9	17.8
Feb.	84.5	62.3	49.5	44.4	37.7	34.8	29.1	23.3	18.2
Mar.	84.7	62.4	49.6	44.4	37.8	34.8	29.1	23.3	18.2
April 1	85.4	61.6	48.8	43.7	37.1	34.4	28.6	22.8	17.8
April 2	69.5	45.3	32.6	28.2	22.6	20.3	17.2	15.1	12.1
May	66.6	42.5	30.0	25.8	20.5	18.3	15.2	13.2	10.5
June	68.3	43.7	31.0	26.3	20.1	17.9	14.9	12.2	10.0
July	71.7	46.8	34.1	29.4	23.4	21.3	18.4	15.0	9.7
Aug. 1	71.2	46.9	34.2	29.5	23.3	21.1	18.2	14.8	9.6
Aug. 2	72.1	48.1	35.4	30.5	24.0	21.3	18.4	15.0	9.8

[1] These values assume the system operates in compliance with the 1998 biological opinion.

Table 5.9 Average (Levelized) Monthly Energy Prices,
Mid-C Price Forecast for 2004-2024.In 2002 $ per MWh

	Average Price
September	33.30
October	31.83
November	32.99
December	28.89
January	28.89
February	27.95
March	35.51
April 1	54.00
April 2	99.07
May	99.07
June	39.61
July	37.93
August 1	34.67
August 2	33.94

Source: NWPPC. 2003. (via J. King, Dec.9 2003)

Table 5.10. Distribution of diversions and return flows from reservoirs below Grand Coulee

	Chief Joseph, Wells, Rocky Reach, Rock Island and Wanapum dams			McNary and John Day		
Month	Diversion	Return Flow	Net Depletion	Diversion	Return Flow	Net Depletion
SEP	4.0%	1.8%	2.2%	11.0%	2.1%	8.9%
OCT	1.0%	1.3%	-0.3%	3.0%	2.0%	1.0%
NOV	0.0%	0.7%	-0.7%	0.0%	1.5%	-1.5%
DEC	0.0%	0.7%	-0.7%	0.0%	1.3%	-1.3%
JAN	0.0%	0.6%	-0.6%	0.0%	0.5%	-0.5%
FEB	0.0%	0.6%	-0.6%	0.0%	0.5%	-0.5%
MAR	0.0%	0.4%	-0.4%	0.0%	0.5%	-0.5%
AP1	1.0%	0.3%	0.7%	3.5%	0.2%	3.3%
AP2	1.0%	0.3%	0.7%	3.5%	0.2%	3.3%
MAY	17.0%	1.6%	15.4%	16.0%	1.5%	14.5%
JUN	28.0%	2.1%	25.9%	21.0%	2.0%	19.0%
JUL	31.0%	2.2%	28.8%	24.0%	2.0%	22.0%
AG1	8.5%	1.0%	7.5%	9.5%	1.2%	8.3%
AG2	8.5%	1.0%	7.5%	9.5%	1.2%	8.3%
	100.0%	15.0%	85.0%	101.0%	16.7%	84.3%

CHAPTER 6. EFFECTS ON FLOOD CONTROL

Flood Control is an important use of the regulated Columbia River system of dams, especially the storage dams run by the Federal agencies (Grand Coulee, Libby and Hungry Horse in Montana, Dworshak in Idaho). Locations within the Columbia River basin in Idaho, Montana, Washington, and Oregon are particularly vulnerable to flooding.[8] Some proposed methods of operation could increase flood risk to these areas.

As flood waters exceed the river banks and flow onto nearby developed properties, damages occur. Generally, the deeper and longer water stands on structures, the greater the damage. Similarly, greater damage is caused by larger floods which inundate more structures.[9] Flood damages could have severe economic impacts on communities, and flood damages will be different for different types of property. For example, residential structures, commercial property, industrial areas, agricultural land, and public areas will all have different economic setbacks as a result of flood damage. All damage reaches will not necessarily contain all categories of land use. In the event of a flood, further economic impacts would occur in the form of increased spending for emergency aid, including expenditures essential to the preservation of life and property, such as clearance of debris and wreckage, emergency repair or temporary replacement of private and public facilities, evacuation assistance, and the like.[10] Flood damage potential is greatest in the lower Columbia from the Portland-Vancouver area to the mouth of the river. This area is susceptible to both rain-produced and snowmelt floods.

A. How the System Works

There are two principal flood seasons in the Pacific Northwest. November through March is the rain-produced flood period that most frequently occurs on streams west of the Cascade mountain range. May through July is the snowmelt flood period which predominates east of the Cascades. The worst snowmelt floods occur when extended periods of warmer

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[8] U.S. Army Corps of Engineers, Columbia River System Operation Review

[9] U.S. Army Corps of Engineers, Columbia River System Operation Review

[10] U.S. Army Corps of Engineers, Columbia River System Operation Review

weather combine with a large accumulation of winter snow. Many streams in the basin remain uncontrolled; however, reservoirs on the major rivers reduce flood damage in many areas.[11]

The objective of any flood control operation is to capture enough runoff in reservoirs to keep streamflows from reaching damaging levels. Timing is critical and there is a significant amount of uncertainty. When runoff is highest, reservoir levels must be reduced the most. The greater source of flood potential—snowmelt—can be predicted several months in advance. Thus, flood control space is made available primarily in those months when flood risk exists, and the amount of storage space needed depends on expected runoff based on long-term weather forecasts. This makes it possible to use reservoir space for other uses such as hydropower, fish flows, irrigation, and recreation during periods of low flood risk. The flood control objective is two-fold: operating the total reservoir system to minimize damaging flows on the lower Columbia River, and operating individual reservoirs to minimize damage to local areas.[12]

System operators have developed flood control rule curves specifying the amount of storage that must be evacuated during the fall and winter to meet the objectives above. These rule curves have a fixed component and a variable component. The fixed component typically defines operation from September through December when less predictable rainfall floods occur. This curve is based on a statistical analysis of historical events because accurate forecasts of runoff are not available. The variable component of flood control rule curves defines operation from January through April. Forecasts of seasonal volume runoff become available in January, and these forecasts define the variable portion of the rule curve. It is based on the runoff volume expected to occur and thus indicates the amount of storage space needed to control floods for the snowmelt season. Uncertainty of weather forecasts is an issue, and for this reason flood control curves are updated monthly as revised forecasts become available, somewhat reducing the amount of uncertainty.[13]

To summarize the reservoir operation system, there are three seasons of operation. In September through December, there is a fixed drawdown based on historical patterns when the volume of the next spring runoff is unknown. From January through April there is a variable drawdown based on spring runoff forecasts that guide operations through the runoff and refill

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[11] BPA, The Columbia River System: The Inside Story

[12] BPA, The Columbia River System: The Inside Story

[13] BPA, The Columbia River System: The Inside Story

season. From April through July, operators focus on capturing enough runoff to refill reservoirs by the end of July. When runoff is low, reservoirs may not refill and operations will be shaped by how low reservoir levels are on July 31.[14] Flood control involves storage reservoir drawdown in the autumn/winter, and refill in the spring. Additional withdrawals from the river will reduce flow into reservoirs, which will not negatively affect flood control.

B. Impact of the Scenarios on the System

All scenarios in the report involve increased diversion of Columbia River water, which won't be detrimental to flood control. Increased diversions mean leaving less water in-stream, which if anything, might improve the opportunity for flood control. This improved opportunity might be imperceptible as pools will still maintain MOP by federal mandate for functions such as anadromous fish passage. However, it is important to note that increasing diversions will change the seasonal pattern of return flow. Because the vast majority of the 1 MAF will be diverted for irrigation in the summer months implies that we will have increased return flow in the winter months. This could increase the flood possibility in the runoff season as pools have potentially less space to capture runoff. This increase in flood probability will be marginal at best considering the amount of return flow to the system.

The greatest chance for damages from flooding would occur in scenario 5, the no action scenario. Under this scenario, the existing flood control management strategy should be examined to see if any economic impacts will occur as a result of potential flood damages to communities along the Columbia River.

The lower Snake River dams were not and are not operated to provide flood control benefits because flood control is not a Congressionally authorized project use.[15] The projects are physically capable of providing a minor flood control benefit under a partial drawdown operation strategy, but only when coupled with major reconstruction of the projects. Reconstruction would be needed to continue current congressionally authorized uses and operation of fish passage facilities. The Dworshak project located upstream on the Clearwater River currently provides

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[14] BPA, The Columbia River System: The Inside Story

[15] Lower Snake River Juvenile Salmon Migration Study

congressionally authorized flood control benefits for the lower Snake River and further downstream on the Columbia River.[16]

The major elements of the Columbia River flood control system occur at the following dams: Mica, Arrow, Duncan, Libby, Hungry Horse, Grand Coulee, Dworshak, Brownlee, and John Day. Only two of these, Grand Coulee and John Day are directly relevant to the mainstem of the Columbia in Washington State. All others are located outside of Washington State, and all are located on tributaries, except for Mica and Arrow which are on the mainstem in British Columbia. All of these dams located outside of Washington State provide flood control for the entire downstream system, but Grand Coulee and John Day dams have the most direct effects to this study. Grand Coulee provides for 5.2 MAF and John Day provides for .5 MAF of primary flood control space.[17]

Another concern is the trade-off that occurs between flood control and other purposes, such as hydropower. Flood control became the major objective of the river system after the tragic flood of 1948 that destroyed Vanport, Oregon.[18] Some would argue that the law regarding flood control is too conservative. For example, leaving less space available in pools for flood control purposes leaves areas more susceptible to flood damages, but provides more benefits in the form of increased hydropower capabilities. Being less conservative with respect to flood control in a year when there is a very low probability of flooding will lead to net benefits in the form of increased hydropower, with no costs to flood control. However, there is significant uncertainty. A major problem with loosening the flood control standards is that the decision to leave more water in dams for other benefits will be based on a long-term weather forecast which is subject to error. If a dry year is predicted, and water is left in pools for other benefits, and the year is wetter than predicted, flooding may occur leading to astronomical damages compared to the relatively modest benefits from less stringent flood control standards. Conversely, if a wet year is predicted, and pools are drawn down in anticipation of high water levels, and the year is drier than predicted, there could be a significant detrimental affect on other uses, such as anadromous fish populations.

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[16] U.S. Army Corps of Engineers, Columbia River System Operation Review

[17] U.S. Army Corps of Engineers, The Effects of VARQ at Libby and Hungry Horse On Columbia River System Flood Control

[18] BPA, The Columbia River System: The Inside Story

The Army Corps of Engineers (Corps) has examined this topic in more detail by describing the impact to Columbia River system flood control operation resulting from modifying the flood control requirements at Libby dam and Hungry Horse dam. This modified flood control regulation is called VARQ and was designed to improve the multi-purpose operation of the reservoirs by defining a more flexible flood control operation.[19] Columbia River management activities have changed as a result of the Endangered Species Act (ESA). Flow augmentation operations have been described by Biological Opinions resulting in releases of water from Libby and Hungry Horse during the annual reservoir refill period in excess of that envisioned in the current flood control plans. As a result, the likelihood and frequency of refill has been reduced. The Corps developed the VARQ flood control procedure to address this imbalance. VARQ reduces system flood control space required at Libby and Hungry Horse and allows outflows during refill to vary based on the water supply forecast. VARQ can accommodate the higher releases required for endangered species while maintaining current flood protection and improving the ability to refill the reservoirs.[20] However, the Corps will not increase the flood risk without significant study of the impacts, and a significant study will be a costly endeavor. The Corp's Walla Walla district is in the process of writing a Reconnaissance Report on the Columbia River's flood control system. Whether or not the Corps will initiate an extensive significant study partly depends on the recommendations of the Reconnaissance Report.

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[19] U.S. Army Corps of Engineers, The Effects of VARQ at Libby and Hungry Horse On Columbia River System Flood Control

[20] U.S. Army Corps of Engineers, The Effects of VARQ at Libby and Hungry Horse On Columbia River System Flood Control

CHAPTER 7. EFFECTS ON RIVER NAVIGATION

Navigation on the Columbia and Snake Rivers has for many years provided a route of access for barge and vessel traffic into and from the Columbia and Snake River basins. Historically, the recognition of the economic importance of a well functioning navigation system led to early navigation improvements in the form of the construction of dams and locks on the Columbia and Snake Rivers in the 20th Century.[21]

A. How the System Works

The Columbia-Snake Inland Waterway is a 465-mile-long system formed by eight mainstem dams and lock facilities on the lower Columbia and Snake rivers. The waterway provides waterborne navigation up and down the river from Lewiston, Idaho, to the Pacific Ocean. The system is used for commodity shipments by barge, as well as smaller commercial and recreational vessels, from inland areas of the Northwest and as far east as North Dakota.[22] Dams along the Columbia upstream of McNary Dam are irrelevant to navigation because those dams do not have lock passage facilities. The Columbia-Snake River navigation system consists of two segments: the downstream portion below Bonneville Dam, which provides a deep-draft shipping channel, and the upstream portion above Bonneville Dam, which is a shallow-draft channel with a series of navigation locks.

The presence of the Columbia-Snake River system has led to the development of a large and significant river-based transportation industry in the region. Port district managed facilities and various other public and private entities are located on the pools created by the dam system. The number of port facilities on all eight reservoirs totals 54, with 34 on the lower Columbia River (McNary and below) and 20 on the lower Snake River (Lower Granite Reservoir and below). The geographic distribution of port facilities reflects concentration of shipping activity near Lewiston on the Lower Granite Pool and Pasco on the McNary Pool. Grain terminals are the most common facilities accounting for nearly half of all terminals within the study area, and minimum water depths or minimum operating pool (MOP) alongside these facilities range from 10 to 40 feet for active facilities.[23]

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[21] U.S. Army Corps of Engineers, Columbia River SOR

[22] Lower Snake River Juvenile Salmon Migration Feasibility Report

[23] U.S. Army Corps of Engineers, Columbia River SOR

The Columbia River authorized ship channel begins at the Columbia River entrance (River Mile [RM] 4) and extends through the Tri-Cities area in Washington. Authorization provides for a 40-foot-deep, 600-foot-wide ship channel from the Columbia River Bar to Vancouver, Washington (RM 106). From Vancouver to The Dalles Dam, the authorized channel is 27 feet deep and 300 feet wide, however, the channel is typically dredged only to 17 feet reflecting the maximum depth requirement from commercial traffic through this reach of the river. A 14-foot-deep channel 250 feet wide is maintained from The Dalles Dam, through McNary Dam, and up to the various ports in the vicinity of the Tri-Cities, Washington and from the mouth of the Snake River to Lewiston, Idaho.[24]

Optimal conditions for the navigation of the system are those which (a) allow for the use of the channels, navigation locks, and associated facilities at or in excess of their present level of use, (b) without increased maintenance costs, (c) or compromised safety of vessels. Since the largest vessels using the waterway above Bonneville Dam are barges used to haul grain, a minimum "optimal condition" is one that allows a vessel with a 14-foot draft to move unimpeded through the locks of the dams on the Columbia and Snake Rivers.[25]

The locks on the Columbia and Snake River dams lift or lower vessels, on average, 100 feet above the lock's downstream and/or upstream entrances. Each lock has an operating range determined not only by its hydraulic lift but also by the depth of the sill, the base of the navigation lock, at the upstream and downstream entrances to the locks.[26]

The passage of commercial or recreational vessels in the Columbia-Snake River system is limited by sill depths at the navigation locks. At most of the projects upstream sills are at 15 feet below relative to MOP. MOP provides the clearance needed for barge drafting 14 feet, the typical draft barges operating in the fleet of vessels on the system.[27]

B. Magnitude of Waterborne Commerce

Waterborne Commerce is among the most valuable use of navigation locks along the system. Consider first the Columbia River deep-draft channel below Bonneville dam. Within

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[24] U.S. Army Corps of Engineers, Columbia River SOR

[25] U.S. Army Corps of Engineers, Columbia River SOR

[26] U.S. Army Corps of Engineers, Columbia River SOR

[27] U.S. Army Corps of Engineers, Columbia River SOR

the region, a variety of commodities are produced. Of those industries within the region that generates waterborne commerce, agriculture dominates, particularly with respect to production of grains such as wheat and barley. Corn, which is produced primarily outside of the region, represents a significant volume of shipments from export terminals on the lower Columbia River. Other industries that use water to transport products include aluminum, pulp and paper, petroleum products, and logs and wood products. Wheat and corn represent the majority of total commodities shipped on the deep draft segment of the Columbia River channel. Some other notable products are automobiles, containerized products, and chemicals. Countries involved in the region's export trade are Japan, Korea, and Taiwan, as well as other Pacific Rim countries.[28]

Products shipped on the shallow draft segment of the system consist primarily of grain, wood products, logs, petroleum, chemicals, and other agricultural products. Bulk shipments make up much of the waterborne traffic on the upstream channel. A number of commodities, principally non-grain agricultural and food products and paper products, are shipped via container. Nearly all of the downriver-bound container shipments are destined for Portland, Oregon, with the small fraction of remaining goods going to Vancouver, Washington. The bulk of upriver barge shipments have been made up of petroleum products.[29]

Commodity movement on the lower Snake River is dominated by grain (mostly wheat and barley), which comprised of 75% of the tonnage passing through Ice Harbor lock from 1992 to 1997. During the same period, wood products, including wood chips and logs, accounted for 16%, petroleum products accounted for another 3%, paper and pulp accounted for 2%, and all other commodities accounted for the remaining 3%.

Table 7.1 Domestic Traffic for Selected U.S. Inland Waterways in 2001

Waterway	Length in Miles	Millions of Short Tons
Columbia River System, OR, WA, and ID	596	20.2
Vancouver, WA to The Dalles, OR	85	9.8
The Dalles Dam to McNary Lock and Dam	100	8.9
Above McNary L & D to Kennewick, WA	39	6.7

Source: Waterborne Commerce Statistical Center

[28] Economics of Lower Snake River Juvenile Salmon Migration Feasibility Report

[29] Economics of Lower Snake River Juvenile Salmon Migration Feasibility Report

C. Increased Diversions and Flow Impacts

Consider the largest amount of water that could be diverted as a result of the management scenarios. 1 MAF of additional withdrawals will reduce river flows. Further, assume that all potential interruptible SW rights could be converted into uninterruptible rights resulting in a total of about 1.04 MAF of additional withdrawals. A summary of the resulting diversions in AF (based on an extrapolation of existing applications for water rights) by pool is shown below.

Table 7.2 Estimated Distribution of New Water over Uses and Pools

Pool	New Irrigation Rights	New M&I Rights	Converted SW Rights (Dry Year)
Bonneville	0	0	0
The Dalles	0	0	374
John Day	337,931	7,573	31,651
McNary	178,612	73,179	53,087
Priest Rapids	0	0	0
Wanapum	4,756	0	721
Rock Island	15,833	0	8,491
Rocky Reach	19,853	0	1,914
Wells	138,678	0	24,316
Chief Joseph	1,909	0	1,111
Grand Coulee	210,675	11,000	415
Total AF	908,248	91,752	122,081

The water will not be diverted all at once—the right holder will choose to divert certain amounts over the year based on the purpose of use. Most water is used for irrigation, so the typical pattern of diversions follows a distribution in which the largest diversions occur in the summer months of June, July, and August. Other users of water include municipalities, industries, and domestic users. Although these users might also follow a seasonal distribution, it is certainly less extreme than that of irrigation water users. The distribution of diversion was broken into three slightly different groups: the river above Priest Rapids pool, the river below Priest Rapids pool, and the Columbia Basin Project (CBP) at Grand Coulee. Furthermore, the

distribution will differ depending on whether water is diverted for irrigation or M&I purposes. This is the same pattern of distribution that was considered in Chapter 5.

The three diversionary distributions reflect the nature of crops grown in the regions, the climatic conditions, and the type of water users in the region. Pools above the navigable waters of the Columbia need to be considered because diversions upstream will reduce flow of the entire downstream system.

There will also be return flows from upstream diversions to different locations downstream and at different times. The timing of return flow is a difficult question to consider. For purposes of this study, return flow occurs on a relatively short time frame. Where the return flow occurs is also a difficult question that depends on the watershed, geography and geology of the region water was diverted from. Depletion is defined as diversion minus return flow. This means that in a time when diversions are low, depletion might be negative if return flow is larger than the amount of diversion.

Additionally, there will be return flows from the Columbia Basin Project that pumps water out of Bank's Lake. Return flows are assumed to occur at three pools downstream of the project: Wanapum, Priest Rapids, and McNary pools. For purposes of navigation, the return flows will be summed to McNary pool, where navigation is relevant. Table 5.4 above summarizes the diversions and return flow for the Columbia Basin Project.

A diversion for M&I will have different return flows and pattern of distribution than irrigation water. M&I generally has a much higher return flow follows a more uniform distribution across months. All M&I diversions will assume a uniform pattern of distribution across months. M&I diversions at McNary and John Day pools will assume 90% return flow. M&I diversions at Grand Coulee for the CBP will not assume 90% return flow; they will assume the same consumptive use as irrigation in the CBP. This is because runoff for M&I returns to canals and to reservoirs (like the Potholes reservoir) for reuse by irrigation.

To summarize how these tables of diversions, return flows, and depletion will be used to create a table of monthly flows, an aggregate flow will be created at each dam which incorporates the mainstem flow, minus upstream diversions, plus return flows from local diversions and from the CBP diversion on a monthly basis. Therefore at McNary, where navigation becomes relevant, we will have an aggregate flow based on both local and CBP return flows -- essentially a flow based on all upstream depletions. Flows will be calculated by

determining net depletion upstream of McNary pool from the three distributions above. Depletions from Grand Coulee will be added to depletions from Chief Joseph thru Priest Rapids Dams. Then we add the depletions at McNary itself to the total. Convert this total to cfs for each month and the result is change in flows on a monthly basis.

We will begin by examining flows by choosing a low flow year where additional diversions might create a problem for the navigation system. The drought year 1977 was chosen as a low water year. The flows from that year are based on a model from John Fazio, and are meant to be approximate monthly flows only. Below is a table showing flows at McNary and below for the year 1977.

Table 7.6 Flows WITHOUT additional diversions, 1977

Month	McNary	John Day	The Dalles	Bonneville
Sept	149,224	143,354	148,188	155,434
Oct	127,343	122,136	127,112	133,493
Nov	112,270	109,550	115,709	121,136
Dec	124,063	120,091	125,480	133,837
Jan	122,722	118,303	123,618	131,961
Feb	88,906	84,694	89,335	94,571
March	86,551	82,658	87,331	94,106
April	132,534	132,188	136,323	143,886
May	193,246	190,653	195,649	200,324
June	156,263	152,128	156,439	163,355
July	114,908	109,250	113,336	118,892
Aug	120,262	114,841	118,905	125,037

Now Columbia river flow with the 1 MAF of additional diversions is created taking into account both diversions and aggregate return flow. It is shown below.

Table 7.7 Flows WITH 1 MAF of additional diversions and converted rights, 1977

Month	McNary	John Day	The Dalles	Bonneville
Sept	148,595	142,219	147,053	154,299
Oct	127,198	121,933	126,909	133,290
Nov	112,368	109,731	115,890	121,317
Dec	124,145	120,245	125,634	133,991
Jan	122,781	118,388	123,703	132,046
Feb	88,969	84,786	89,427	94,663
March	86,484	82,617	87,290	94,065
April	131,749	131,028	135,163	142,726
May	191,739	188,345	193,341	198,016
June	154,232	149,013	153,324	160,240
July	112,673	105,801	109,887	115,443
Aug	119,021	113,142	117,206	123,338

Now, with the initial flows and the reduced flows due to additional diversions, we can calculate the percentage change in flows for the navigable waters of the shallow draft portion of the river and notice that there is a very small percentage decrease in river flows, which surely won't affect the navigation system.

This summary of flow changes and its impacts on the navigation system has shown that the diversion in question results in very modest changes in river flow. Therefore, the river height will not be affected for two reasons. First, flows help to determine stage height. If flow is not reduced substantially, neither will river height. Second, river height can be and is controlled by the operation of the dams. If the river height is not affected by the diversions, the shallow draft navigation system will not be affected.

Table 7.8 Percent Change in Flows with Additional Diversions

Month	McNary	John Day	The Dalles	Bonneville
Sept	-0.42%	-0.79%	-0.77%	-0.73%
Oct	-0.11%	-0.17%	-0.16%	-0.15%
Nov	0.09%	0.17%	0.16%	0.15%
Dec	0.07%	0.13%	0.12%	0.11%
Jan	0.05%	0.07%	0.07%	0.06%
Feb	0.07%	0.11%	0.10%	0.10%
March	-0.08%	-0.05%	-0.05%	-0.04%
April	-0.59%	-0.88%	-0.85%	-0.81%
May	-0.78%	-1.21%	-1.18%	-1.15%
June	-1.30%	-2.05%	-1.99%	-1.91%
July	-1.95%	-3.16%	-3.04%	-2.90%
Aug	-1.03%	-1.48%	-1.43%	-1.36%

However, the question remains: At what flow level will the navigation system be affected? Due to the dependent nature of flow and river height, at some point, if flows are low enough the river height can not be controlled by the operation of the dams and the navigation system will not be operational. It is unclear whether there is a good answer to the following question: What is the minimum flow required to maintain the navigation system Minimum Operating Pool level of 14 feet?

Below Bonneville dam the authorized channel increases in depth which allows deep draft ocean going vessels to access the ports at Portland, OR and Vancouver, WA. Channel depths on the deep draft portion of the river depend on more than just river flow; depths will depend on spillage from dams (flow), tidal currents, surface water runoff, and melting snow. Below Longview, WA the deep draft channel depth is driven almost entirely by tidal currents, implying that decreased flows out of Bonneville is only a concern between Longview and Portland. For that section of the river, navigational disruptions might occur if the flow out of

Bonneville dam falls below 70,000 cfs.[30] The reduced flows resulting from the increased diversions examined in this study will not have an impact on the navigation system. Referring to Table 7.7, the lowest flow in this dry year occurs in March, when the resulting flow with new diversions is 94,000 cfs, well above the flow at which navigational impacts will occur.

D. Impact of the Scenarios on Navigation

For many of the scenarios examined there is likely to be no economic effect on the current navigation system should new water be diverted for out-of-stream use. Consider the least conservative scenario in terms of water use, scenario 1, in which 1 MAF of additional water is to be made available for out-of-stream use every year. If there is no economic effect on the navigation system in this scenario, there will surely be no economic effect on more water conservative scenarios, as larger amounts water is to be left in-stream in scenarios 2 through 5.

There are other things to consider in terms of economic value besides commercial barge traffic. The first thing to note is that if any one navigation lock is unable to operate due to insufficient water levels on the river because of the additional water withdrawals, the entire system is shut down upstream of that particular lock, and there will be no economic benefits from the navigation system upstream. Should the navigation system cease to operate due to substantial decreases of in-stream flow, there are alternative modes of transportation. With loss of access to the Columbia-Snake River system, in the short-run it is likely that shipments would be delayed because the infrastructure required to support a short-run switch to a new mode of transportation does not exist. In the long-run, commodities would move by the next least costly available mode, such as rail direct to export elevators on the lower Columbia or by truck to river elevators located on the pools. These alternative modes of transportation are fraught with infrastructure issues and costs. Expenditures on transportation infrastructure would be required to increase the capacity of the system prior to additional diversions of water if the Columbia-Snake River system were to become no longer operational.[31]

Secondly, in a low water year, lock operators will wait until the lock is full of vessels before allowing passage. In the case of commercial barges, this is not an issue, because the

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[30] Per conversation with Army Corps of Engineers hydrologist Peter Brooks.

[31] Economics of Lower Snake River Juvenile Salmon Migration Feasibility Report

barges are designed to fit one tow per lock. A tow enters the lock, fills it, and is permitted to pass through. However, in the case of smaller recreational vessels, waterborne travelers need to wait until the lock is filled with other smaller vessels before passage is allowed in order to maintain pool levels in a low water year. In a high water flow year, this is not a problem for smaller vessels as there are sufficient pool levels, and vessels are allowed through on demand. During the time that recreational lockages are restricted, the locks are typically operated on a published schedule. In 2001, the U.S. Army Corps of Engineers set limited lockage schedules at all lower Snake River and Columbia River dams. The schedule applied only to recreational boats from May 15 to September 15. Upstream lockages were set for 9 A.M., 2 P.M., and 7 P.M., while downstream lockages were set for 9:30 A.M., 2:30 P.M., and 7:30 P.M. This reduced the amount of water lost when boats passed through, and provided more water for power used in the Pacific Northwest. Because the locks are operated on a published schedule, boaters are able to time their activities accordingly, and for that reason there is unlikely to be any delay and therefore no lost time to the boater as a result of the added constraint.

Lastly, if there is a significant decrease in river levels such that barge traffic is impeded due to the increased diversions could mean that barges have to lightload a tow, thus increasing transportation costs. In this case, navigation would be maintained, but costs increase as barges haul fewer goods and make more trips.

Consider the extrapolation of scenario 1 in which future surface water (SW) diversions are extrapolated from existing SW permits, certificates, and applications. Assume that Ecology grants all existing SW applications accounting for approximately 348 KAF.[32] Further assume that Ecology grants 652 KAF future applications to total 1 MAF additional Columbia River diversions.

The largest percentage increase in diversions would occur at Wells dam, which nearly triples the amount of diversions based on current water rights. This dam is far enough upstream to allow for a substantial amount of return flow to the lower Columbia where navigation is relevant. The other significant increases in diversions based on this extrapolation are McNary and John Day dams that both increase by about 50%. Both of these increased diversions are a

[32] Based on cubic feet per second (cfs) as stated on the application multiplied by 1.98 Acre Feet per 1 cfs, multiplied by 183 days (6 months) for an irrigation season.

concern to the navigation system as they are substantial diversions and are located on the lower Columbia. The lower Columbia is a much larger, deeper, and wider river than the upstream mainstem, and because of this, could allow for more diversions. Return flow won't be much of a factor because the dams are further downstream. Additional diversions of this distribution will not affect the navigation system because the amount of additional diversions is quite small relative to the total amount of water in the system, and therefore would not have a measurable impact on navigation. Reduced flows as a result of additional diversions have been developed in this chapter, and the resulting changes in flows were shown to be miniscule. Because there is no affect on the least water conservative scenario, there will not be any affect on more water conservative scenarios, as more water is being left in-stream. Hence, there will be no affect on navigation in all scenarios examined in this study.

In summary, there is unlikely to be any economic affects on the current Columbia-Snake River navigation system from additional withdrawals of mainstem water due to the relatively small amount of increased diversions. Even in the least conservative scenario with respect to water, scenario 1, river levels will only be drawn down modestly. Because of this, the current navigation system will not be affected in scenario 1. Scenarios 2 through 5 involve the diversion of less and less water, and consequently will not be affected either.

CHAPTER 8. ECONOMIC EFFECTS ON COMMERCIAL AND RECREATIONAL FISHING AND OTHER RECREATION

Additional diversions of water from the mainstem Columbia River will slightly reduce the average river flows (as indicated above in Chapters 5 and 7). The reduced flows could affect survival rates of salmon and steelhead populations that are listed as threatened or endangered under the Endangered Species Act. As noted in Chapter 2, these risks to salmon species are being assessed by a National Research Council Committee sponsored by Washington Department of Ecology. Because this report precedes the NRC report, we are unable to use the results of their assessment in this study. Still, there have been many studies aimed at identifying the relationships between river flow, temperature, migration travel time, and survival of out-migrating smolts (e.g. Cada, et al. 1995; Giorgi, et al. 1997; Giorgi et al. 2002; Muir, et al. 2001a; Muir, et al. 2001b; Smith, et al. 2002; Smith et al. 2003). Additional studies have attempted to establish what flow conditions improve survival of adult salmon during their upstream migrations. Because the NRC Committee is considering the best science available for assessing effects of flow conditions on salmon survival, this report will not attempt to estimate specific changes in economic values or impacts associated with effects of the water rights allocations on the fish stocks. Instead, this study provides a review of the concepts, methods, and existing literature concerning economic value of commercial and recreational fisheries for Pacific salmon of the Columbia basin.

A. Trends in the Commercial Pacific Salmon Fishery Values

During the past two decades the major trend affecting the commercial salmon fishery was the burgeoning supply of fresh salmon from the salmon farming industry. As indicated in Figure 8.1 below, the aggregate harvest of Pacific salmon has remained at relatively high levels (mainly in Alaska), while world farmed production has grown rapidly, eventually exceeding the total harvest by the fishery. One major consequence of this development was a substantial drop in the price paid to fishermen for salmon. This drop in price affects both farmed salmon and fishery harvests of salmon, and was made possible by the rapid technological advances in salmon farming that fostered lower production costs and effective marketing techniques (Guttormsen, 2002). The average market value of farmed salmon dropped from roughly $6,000/metric ton to

less than $3,000/metric ton between 1987 and 2001. This world-wide trend in price is the major cause of reduced earnings and crisis in salmon fishing communities in Alaska and the Pacific Northwest.

Many salmon of Columbia river origin are caught in the ocean fishery north of Cape Falcon, Oregon, and in the fishery occurring in the river itself. Harvests in these fisheries have fluctuated widely around a declining trend, until an upturn in catch during the last two years. During the period from 1987 to 2002, the average exvessel price of ocean-caught salmon (coho and chinook combined) dropped from roughly $5/lb. to just over $1/lb. (Figure 8.2) Similarly, the in-river gillnet commercial salmon fishery (see Figure 8.3) has suffered a substantial decline in total volume of harvests and in price since the mid-1980s. The reduced harvests during the mid-1990s did not bring the positive price response that one would typically expect, mainly because the Pacific coast salmon are sold to the world market which is flooded with farmed salmon and Alaska's Pacific salmon.

Looking in more detail at prices for species and sub-species of salmon (Table 8.1), we can readily see that, while all the prices fell substantially, the price for spring chinook caught in the river have held up to a respectable $2.50 per pound, the other prices have fallen rather drastically.

Table 8.1 Average Price per Pound (2002 $). By Species, all Columbia River Commercial Fisheries.

	Chinook			Coho	Chum
	Spring	Fall	Tule		
1988-1997	$4.07	$1.23	$0.39	$1.32	$0.43
1998	$2.75	$0.58	$0.20	$0.71	
1999	$2.97	$0.71	$0.09	$0.89	$0.24
2000	$2.66	$0.75	$0.13	$0.54	$0.22
2001	$2.08	$0.32	$0.13	$0.27	$0.18
2002	$2.50	$0.27	$0.11	$0.32	

Source: Pacific Fishery Management Council. 2003. Pacific Salmon Fishery Management Plan. Chapter IV "socioeconomic Assessment of the 2002 Ocean Salmon Fisheries". Portland, OR.

The effect of price reductions on incomes to fishing firms is fairly obvious. Incomes from fishing are reckoned as gross exvessel revenue minus costs of fishing fleet operation and maintenance. Detailed public knowledge of fishing costs is relatively obscure. Given the amounts of money and effort spent on management, augmentation, and restoration of the salmon fishery, remarkably little effort has been expended to collect the information necessary to gauge the incomes earned in the fishery. Hence, most economic assessments of the fishery focus on gross sales value of the fish, with occasional attention to rough estimates of earnings. Some studies (Rettig and McCarl 1984, Radtke and Davis 1994) have attempted to assess the net earnings from salmon fishing, usually by looking at a sample of vessels and roughly estimating the proportion of revenues that go into direct costs of fishing. In the early and mid-1990s, it was typical to gauge the incomes earned as roughly 50% of the gross sales value of the fish (Huppert, et al. 1996). However, with the substantial drop in prices recently, and assuming that fishing costs have remained constant or increased somewhat, one would have to conclude that there is now little or no net income being generated by the commercial fishery. Only the spring chinook price is still greater than 50% of the average price during 1988-1997 (Table 8.1).

The price trends in commercial fishing suggest that harvests of Pacific salmon from the Columbia River or ocean areas will make smaller contributions to the value of seafood supply and to local incomes in the future. Further, any enhancement in run sizes for commercial harvests, whether due to hatchery operations or other factors, will make relatively small contributions to the economic incomes for local communities.

B. Trends in the Recreational Fishery

The recreational fishery supported by Columbia river salmon includes the ocean fishery north of Cape Falcon, the estuary and lower river fishery, and various fisheries farther upstream and in tributaries. The ocean and lower river fisheries have been highly variable, both in terms of catch and level of participation (as measured by annual angler trips taken). The ocean recreational catch averaged 137,000 fish (coho plus chinook) during 1986-2002, while varying between 150,000 and 200,000 in the late 1980s and early 1990s, dropping to zero in 1994 and recovering to a respectable 232,000 in 2001. The lower river and estuary fishery had an average annual catch of 142,000 fish during 1981-2000. Like the ocean fishery, the river fishery catch was relatively high in the late 1980s and early 1990s, dropped to a record low in 1994, and has

recovered to about half of the earlier high levels in 2000. Recreational catch data for the river has not been released yet for 2001 and 2002.

While the fishery agencies do not regularly monitor the economic value of the recreational fishery, it is typically the case that overall expenditure on recreational fishing is closely correlated with trips taken. The expenditures per trip are largely unrelated to actual catch of salmon. On the other hand, studies of economic value of fishing trips to anglers (e.g. Huppert 1989) suggest that higher catch rates (catch per fishing trip) increase the demand for, and value of fishing. Hence, a rough interpretation of the available data suggests that trends in angler trips are driven, at least in part, by trends in catch/trip – a variable which, in turn, is influenced by fish abundance and bag limits. Hence, it is unsurprising that total angler trips is positively correlated with catch/trip (as depicted in Figures 8.4).

Economic surveys of recreational salmon fishers seek to determine the net value of recreational fishing (i.e. the value to anglers of fishing trips minus the cost of taking those trips). The most directly relevant study for Columbia River salmon fishing is a 12-year-old study by Olsen, Richards, and Scott (1991). In that study, the authors determine that average net value per fishing trip in 1989 was $111.46 ($147.63 in 2002 $) in the Columbia river basin, and $89.47 ($118.50 in 2002 $) in the Oregon-Washington coastal fishery. While these values will undoubtedly vary over time (especially as catch rate varies), we could roughly gauge the value of the recreational fishery by multiplying angler days by this estimated average value. This procedure yields an average annual value of $11 million in the No. of Cape Falcon ocean recreational salmon fishery (using data for 1986-2002), and an annual value of $27.3 million for the lower river/estuary recreational fishery (using recorded trips for 1981-2000).

In considering the value of changes in the size of the salmon runs, one could assume that the allowable catch increases with the run size, and that number of angler trips increases in proportion. This would be accurate only if allowable recreational catch is a constant fraction of total run and angler catch/trip is unaffected by run size. Given the average catch/trip of 1.13 in the Columbia river, this procedure says that for each increase in 1 fish caught, the recreational fishery would increase by (1/1.13) = 0.89 trips, and the value of recreational fishing in the river would increase by 0.89*$149.63 = $131.20. The equivalent value for increased harvest of ocean salmon would be (1/1.14)*$118.50 = $84.4. To obtain a rough measure of recreational value associated with increasing (or decreasing) salmon/steelhead run sizes we would also have to

know the fishing mortality rate (fraction of run caught). For example, if 33% of the fish run is caught by recreational anglers, then the change in recreational value due to a change in run size could be roughly estimated as $84.4*.333 = $28.10 times the change in run size.

As noted above, economic effects of additional Columbia river diversions could occur if decreased flows in the river (especially during spring and summer) cause increased mortality of juvenile salmon migrating downriver and adult salmon migrating upriver. The review of economic values contained in this chapter could be used to assess the economic values gained or lost as a result of the additional water diversions, given a thorough and quantitative scientific report detailing the mortality effects.

C. Other Recreation

There are other opportunities along the river and within the reservoirs for recreational activity that are not related to fishing. Activities such as boating, rafting, windsurfing, and swimming make direct use of the water, and activities such as shoreline recreation, picnicking, hiking, and bird hunting are enhanced by there proximity to water. This report has already shown that the increased diversions contemplated in this report will only modestly reduce flows (see chapters 5 and 7). Furthermore, the amount of reduction in flows considered will not impair the ability to control reservoir levels. For non-fish related recreation, one needs to consider the surface area of water for the recreational boater or swimmer. If that is reduced, the opportunity for the recreational activity will be reduced. Because reservoir levels will not be affected by the increased diversions, the value of a non-fish related activity will not be reduced within reservoirs.

There are a limited number of studies that consider other recreational activities. In many cases, recreation is grouped generally in terms of fishing, boating, swimming, and shoreline recreation combined, for example. The Columbia River SOR from 1995 includes a review of recreational activity and how it would be affected by a number of drawdown scenarios. Duffield et al examines the recreational value of in-stream flow for the Big Hole and Bitterroot Rivers of Montana. Lastly, Frederick et al considers the economic values of freshwater throughout the United States for multiple in-stream and diversionary purposes. It is important to note that the Columbia River region considered in this report is quite different from the smaller rivers of Montana studied by Duffield and from the more general regions considered by Frederick.

The Columbia River SOR is an environmental impact statement that includes economic and social impacts on recreation for a number of drawdown scenarios. Appendix O of the report summarizes the economic and social impacts, while Appendix J summarizes recreation. The economic impacts to recreation were determined using a recreational demand model based on travel costs, water levels at a particular project, water levels at alternative projects, socio-economic characteristics, and a time variable. By using travel cost methodology, individual demand curves were estimated based on the results from a 1993 mail-out survey. Respondents were asked to define their behavior contingent on different hypothetic water levels. Recreation visitation and consumer surplus were then estimated for each scenario considered in the report and represent an average over the 50 water years considered in the analysis. Some projects—such as Chief Joseph, McNary, The Dalles, and Bonneville—were not modeled because recreation impacts were judged to be minimal. The only projects that are reported which are relevant to the Columbia River in Washington were the Lake Roosevelt (Grand Coulee) and John Day. The tables below show annual recreation days by activity and consumer surplus for all activities over the summer months. The study reports the annual consumer surplus over the summer recreation season May through August. Consequently, total annual consumer surplus is underestimated by these values. Reported here are the values given for the baseline or "status quo" scenario.

Table 8.2 Estimated Annual Recreation Days by Activity for the Status Quo Scenario

Columbia River SOR

Activity	Lake Roosevelt	John Day
Boating	436,222	675,900
Fishing	308,629	580,073
Camping	362,906	512,355
Picnicking	403,155	510,056
Swimming	159,325	277,004

Table 8.3 Average Annual Summer Consumer Surplus for the Status Quo Scenario

Columbia River SOR	
	Consumer Surplus
Lake Roosevelt	$121,730,000
John Day	$38,160,000

Duffield provides a general framework for estimating the recreational value of instream flow. The model incorporates the influence of instream flow on both the quality of the recreational experience and on the participation level. The paper utilizes a dichotomous choice contingent valuation survey to estimate the value of a recreational trip on Montana's Big Hole and Bitterroot Rivers. The researchers note that there are differences between the two rivers that provide opportunity for comparisons: The Big Hole is very well known nationally for its fishery, while the Bitterroot is less well known outside the local area, and receives more use from general shoreline recreation. Therefore, we would not expect the same marginal value of recreation for both rivers due to location and structural differences. The same would apply to recreation along the Columbia. The results of Duffield's study provide a range for the marginal recreational value at different levels of instream flow. Marginal values on the Big Hole range from $25/AF at low flows to zero at very high flows, while the marginal values on the Bitterroot range from $10/AF at low flows to zero at high flows.

Frederick examines the economic values of freshwater in the United States for a variety of uses including both instream and diversionary across 18 different water resource regions. Related to recreation he examines collectively the use category recreation/fish & wildlife habitat. The estimates within the report come from both published and unpublished sources based on studies performed under a wide range of supply and demand conditions over the last several decades. The values presented in this report might not be transferable to specific sties within a region such as the Columbia River. However, the report does provide important information for understanding the role of water in the economy and the potential benefits among different water uses. Results indicate that the range of estimated recreation values varies widely both within and across different regions. Recreational values are generally higher in the western states, with averages of recreation water values from zero to $1/AF in the Pacific Northwest to $597/AF in the Lower Colorado Basin. In the Pacific Northwest, the report considers 13 different values for

the recreational value of water, with a maximum value $3/AF. Information on what studies the 13 values came from is unavailable. Again, the fact that supply and demand conditions are crucial to the marginal value of recreation might suggest that an average value is not particularly useful. For the categories within the use group, fishing range in value from $0 to $2,642/AF, wildlife refugee ranged from $1 to $404/AF, whitewater recreation ranged from $5 to $12/AF, and shoreline recreation ranged from $17 to $21/AF.

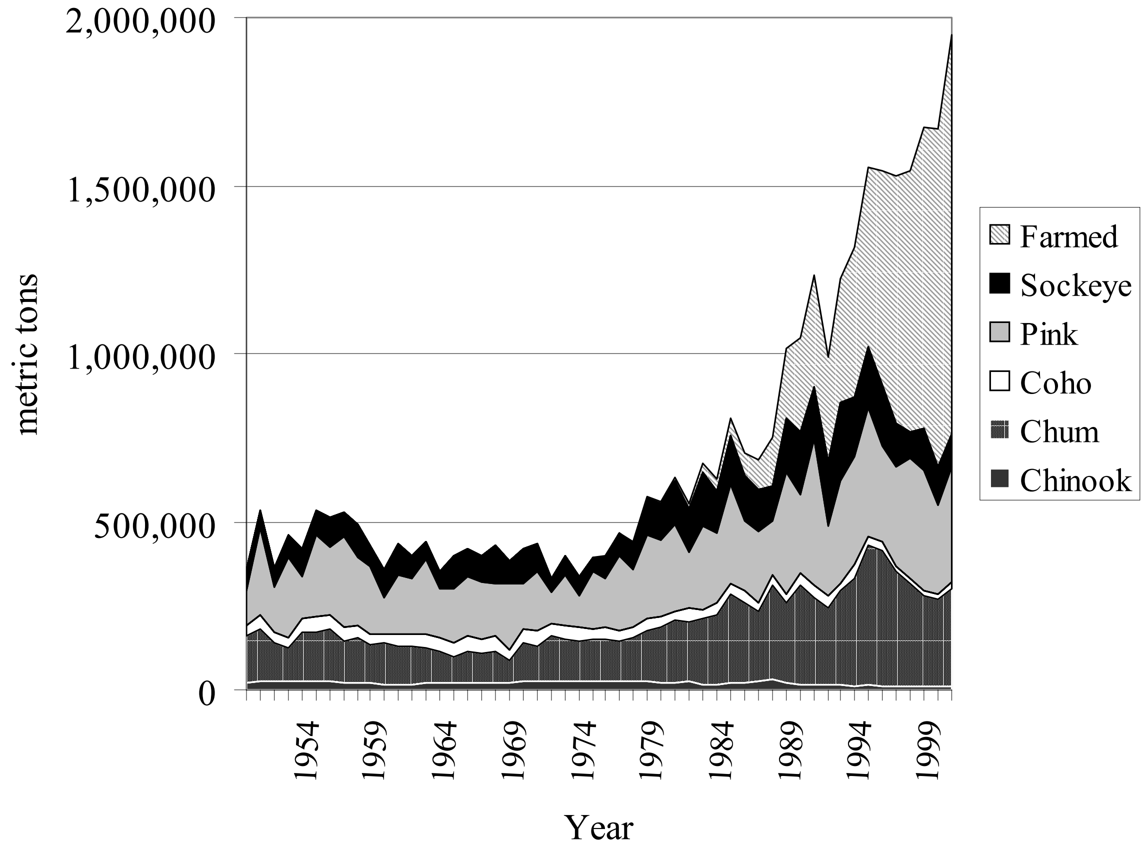

Figure 8.1. Pacific Salmon Harvest and World Farmed Salmon Production.
Source: FAO FishStats database, July 2003.

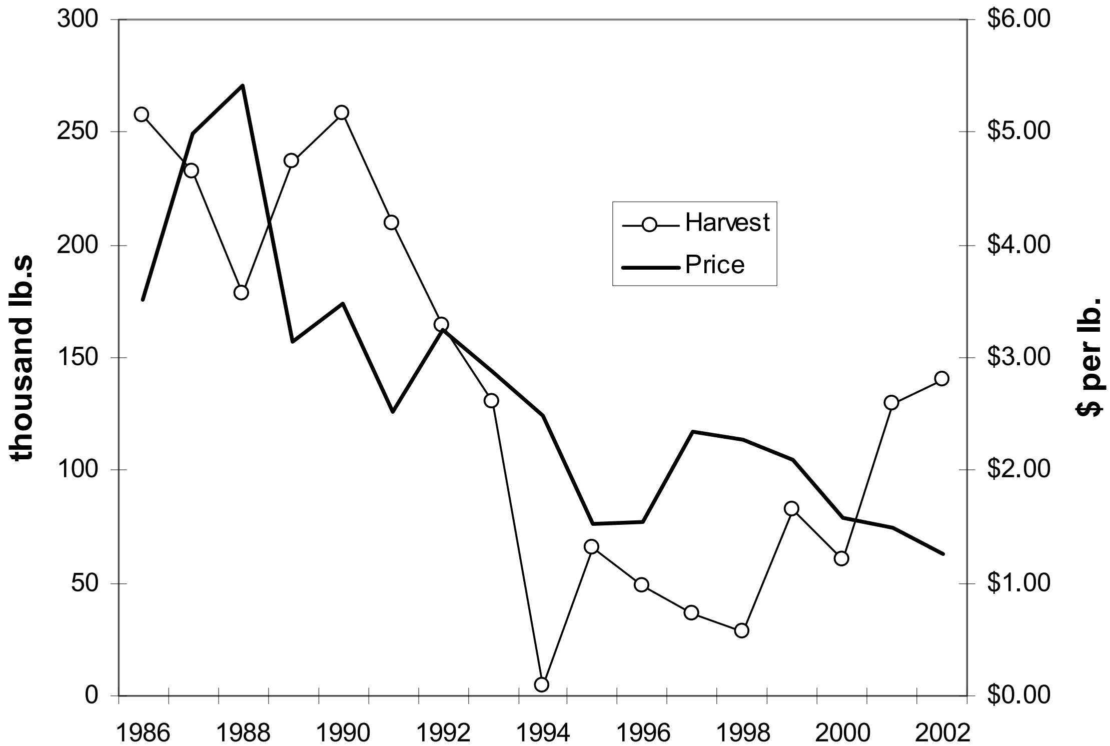

Figure 8.2. US Ocean Salmon Fishery north of Cape Falcon. Total fish caught and exvessel price/lb. Source: PFMC Pacific Salmon Management Plan 2003. Append. A

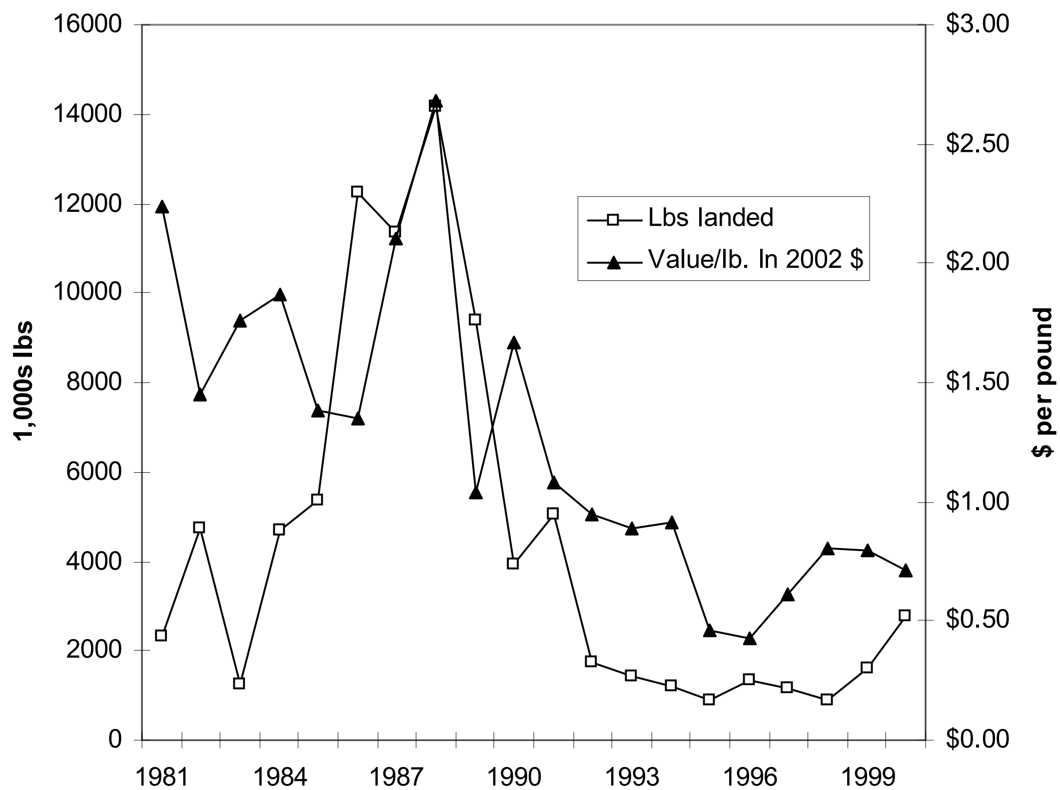

Figure 8.3. Columbia River Commercial Salmon Fishery, above and below Bonneville dam (Zones 1-6), average price per pound for coho and chinook salmon combined.
Source: WDFW and OPDFW. 2002. Status Report: Columbia River Fish Runs and Fisheries

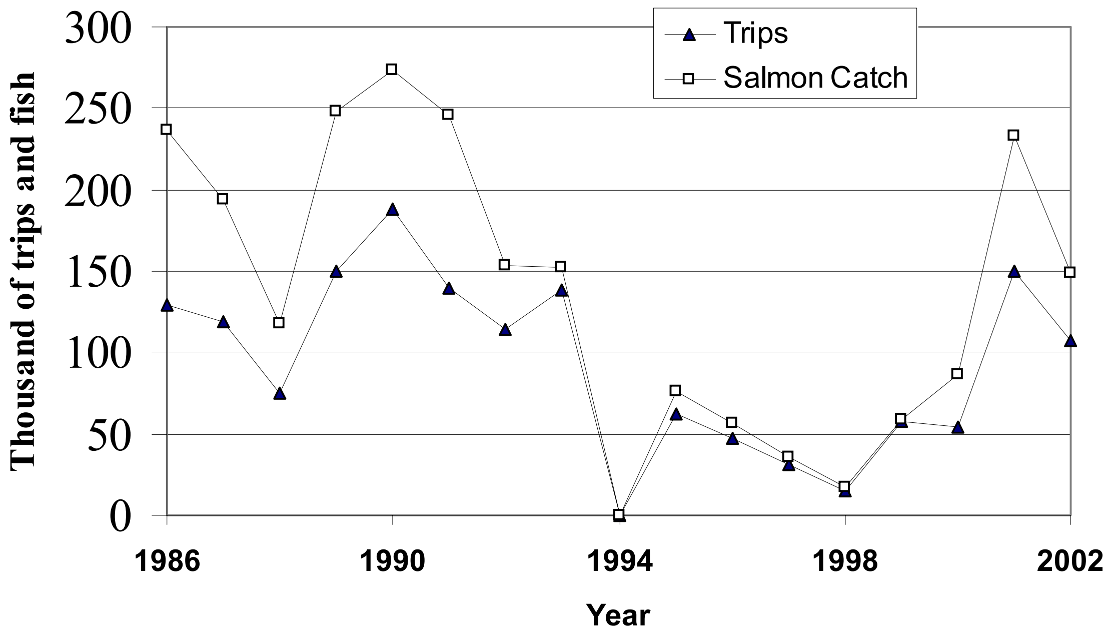

Figure 8.4. Ocean Recreational Salmon Fishery north of Cape Falcon, Oregon.

Source: PFMC Pacific Salmon Management Plan 2003. Append. A

CHAPTER 9. REGIONAL AND SECONDARY IMPACTS OF CRI SCENARIOS

We have used the 1987 Washington Input-Output model to estimate economic impacts of the CRI agriculture and electrical power production scenarios.[33] This model contains 62 sectors, including a field and seed crop sector, a vegetable and fruit sector, and an electric power sector. Each of these sectors is impacted by the CRI initiative. We formulated a spreadsheet version of the 1987 model that took current (assuming year 2002 dollar values as that is the latest year for which deflators were available) estimates of direct impacts, and calculated indirect and induced impacts of the scenarios for agriculture and electrical power. Updated estimates of employment per million dollars of production were utilized, reflecting productivity improvements since the 1987 model was constructed. Price deflators for each sector were estimated. Current values of final demand, direct purchases, and value added were deflated to 1987 dollars, and then indirect and induced impacts were calculated. The format of the model utilized here separated the final demand values from the direct purchases by sector, and the indirect and induced effects were calculated utilizing a (composite) vector of direct requirements for each scenario. The resulting impacts were then re-expressed as $2002, by applying sectorally specific price indices.

A. Agricultural Impacts

Three scenarios for agricultural production were modeled. The goal in the modeling was to produce a level of output in the field crops and vegetables and fruit sector that was equal to (or approximately equal to) the values estimated by G. Green. Both field crop and vegetable and fruit production is absorbed (in part) by various processing sectors. The most significant linkages are with the grain mill, canning & preserving, and beverages sectors. Following the sales distribution in the 1987 Washington model, 2.5% of field crop output was assumed to be absorbed by grain mills, and 2.3% sold to the beverages sector. Within the 1987 Washington model a substantial fraction of field crop output is sold to the livestock sector. However, the agriculture scenarios assumed that there would be no induced development of livestock. Therefore we did not consider the final demand consequences of absorptions of field crops by

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[33]Robert A. Chase, Philip J. Bourque, and Richard S. Conway, Jr. Washington State Input-Output 1987 Study. State of Washington Office of Financial Management Forecasting Division.

the livestock sector, and instead sent this output to final demand. Thus, 95.2% of the output of the field crop sector was assumed to be final demand. Within the vegetable and fruit sector, the 1987 Washington model has 36% of the output being absorbed by the canning and preserving sector. We modified this percentage slightly, sending 34% to canning and preserving, 2% of beverages (wine production), and treated the remaining 64% of output as final demand.

The absorption of field crops and vegetables and fruits by the food products processing sector means that a part of the output from the CRI initiative would be a derived demand from these processing sectors. Thus, we needed to have levels of final demand within the processing sectors that would produce (directly and indirectly) the levels of demand for the agricultural sectors found in the three agriculture scenarios. These demands would be the combination of agricultural output sold directly to final demand, and agricultural output demanded in the processing sectors. We utilized the 1997 benchmark national input-output table to determine the share of field crop input per dollar of output in grain milling, because Washington grain mills utilize a large share of grains imported from other states. If we utilized the absorption coefficient in the 1987 Washington model we would have overstated dramatically the value of output in grain mills associated with Washington field crop output being absorbed by Washington grain mills. This national coefficient is .467; thus estimated sales to grain mills in the various scenarios were divided by this coefficient to obtain a first approximation of grain mill output. We utilized the 1987 Washington model coefficients for the absorption of vegetables and fruit (.187), and relied on the national input-output model wine sector to estimate the relationship between beverage (wine) output and the purchase from the vegetables and fruit (grapes) sector (.138). It should be noted that the wine industry in Washington State has blossomed significantly since the 1987 Washington input-output table was constructed. Our estimate of the share of the output in the vegetables and fruit sector absorbed by beverages vs. canning and preserving should be regarded as provisional.

Table 9.1 contains the initial allocations of output in the various agricultural and food products processing sectors. The total values for field crops and vegetables and fruits in this table differ from the output figures in the agricultural scenarios, as the input-output multipliers pick up the derived demands for the agricultural output estimated to be absorbed by the food products processing sectors.

Table 9.1 Initial Allocations of Output by Scenario (current $ in millions)

Scenario 1	Grain Mills	Canning & Preserving	Beverages	Final Demand
Field Crops	0.922	0.000	0.848	35.093
Vegetables & Fruit	0.000	236.746	13.926	445.641
Canning	0.000	0.000	0.000	1266.024
Grain Mills	0.000	0.000	0.000	1.973
Beverages	0.000	0.000	0.000	100.915
Scenario 2	**Grain Mills**	**Canning & Preserving**	**Beverages**	**Final Demand**
Field Crops	0.661	0.000	0.608	25.157
Vegetables & Fruit	0.000	149.237	8.779	280.917
Canning	0.000	0.000	0.000	798.059
Grain Mills	0.000	0.000	0.000	1.415
Beverages	0.000	0.000	0.000	63.613
Scenario 3	**Grain Mills**	**Canning & Preserving**	**Beverages**	**Final Demand**
Field Crops	0.554	0.000	0.510	21.098
Vegetables & Fruit	0.000	111.342	6.550	209.585
Canning	0.000	0.000	0.000	595.412
Grain Mills	0.000	0.000	0.000	1.186
Beverages	0.000	0.000	0.000	47.460

Table 9.2 contains the direct impact values used to drive the input-output model, which along with the direct requirements estimates contained in Table 9.3 yield the economic impact estimates presented below. Table 9.2 indicates output figures that are the same as in Table 9.1 except for field and seed crops. Because of the complex patterns of interdependence captured in the input-output inverse matrix output estimates in this sector exceeded the production levels forecast in the various agricultural scenarios. In order to control for this effect, final demand in field crops was reduced to a level that resulted in an output effect that was approximately equal to the production levels in the agricultural scenarios.

Table 9.2 Scenario 1 Direct Impact Values.

	Output		Value Added
	Mils. $2002	Employment	Mils. $2002
1 Field & Seed Crops	24.380	373	13.488
2 Vegetables & Fruit	445.641	10263	332.268
10 Canning & Preserving	1266.024	7569	449.808
11 Grain Mill	1.973	4	0.469
12 Beverages	100.915	211	45.205
Total	$1838.933	18420	$841.239

The direct requirements estimates contained in Table 9.3 cover the three agricultural scenarios. These were derived by multiplying the output estimates in Table 9.2 by the direct requirements coefficients for these sectors in the 1987 Washington input-output model. The values for the individual sectors were combined to produce the direct requirements estimates contained in Table 9.3.

The direct requirements estimates presented in Table 9.3 was multiplied against the direct, indirect, and induced requirements matrix to calculate indirect effects. These impacts were then added to the direct impacts contained in Table 9.2 to obtain the total impacts that are reported in Table 9.4. Output impacts were used to calculate indirect employment and value added impacts, which were added to the direct impacts contained in Table 9.2.

Table 9.5 presents results in a more compact form than in Table 9.4, summarizing impacts by broad categories of sectors. The impact estimates indicate multipliers in the range of 2.3 to 2.4 for the three measures included in this table.

Table 9.3 Direct Requirements Estimates

Direct Requirements	Scenario 1	Scenario 2	Scenario 3
1 Field & Seed Crops	4.764	3.162	2.481
2 Vegetables & Fruit	241.051	151.950	113.366
3 Livestock	8.148	5.159	3.867
4 Other Agriculture	2.159	1.361	1.015
5 Forestry	0.000	0.000	0.000
6 Fisheries	58.040	36.586	27.296
7 Mining	0.896	0.569	0.428
8 Meat Products	2.786	1.757	1.312
9 Dairy Products	3.785	2.386	1.780
10 Canning & Preserving	22.184	13.984	10.433
11 Grain Mill	2.523	1.591	1.187
12 Beverages	1.884	1.191	0.891
13 Other Foods	9.807	6.182	4.613
14 Textiles	0.000	0.000	0.000
15 Apparel	0.424	0.268	0.200
16 Logging	0.000	0.000	0.000
17 Sawmills	0.000	0.000	0.000
18 Plywood	0.000	0.000	0.000
19 Other Wood	5.932	3.739	2.790
20 Furniture	0.000	0.000	0.000
21 Pulp Mills	0.000	0.000	0.000
22 Paper Mills	0.018	0.013	0.011
23 Paperboard	31.337	19.755	14.739
24 Printing	6.745	4.252	3.172
25 Industrial chemicals	11.161	7.177	5.462
26 Other Chemicals	0.062	0.039	0.029
27 Petroleum	14.479	9.230	6.965
28 Glass Products	20.620	12.998	9.698
29 Cement & Stone	0.000	0.000	0.000
30 Aluminum	0.000	0.000	0.000
31 Other Primary Metals	0.000	0.000	0.000
32 Structural Metals	0.000	0.000	0.000
33 Fabricated Metals	25.568	16.122	12.032
34 Industrial Machinery	0.719	0.454	0.339
35 Computer Equip	0.000	0.000	0.000
36 Electric Machinery	0.000	0.000	0.000
37 Aerospace	0.000	0.000	0.000
38 Motor Vehicles	0.352	0.223	0.167
39 Ship & Boat Bldg	0.000	0.000	0.000
40 Instruments	0.631	0.398	0.297

Table 9.3, continued	7.429	4.683	3.494
	0.000	0.000	0.000
41 Other Manufacture	5.516	3.498	2.626
42 Hwy Construction	3.721	2.357	1.767
43 Other Construction	1.408	0.889	0.664
44 Railroad Transport	27.161	17.144	12.808
45 Local Transport	0.578	0.365	0.272
46 Trucking	2.304	1.458	1.093
47 US Post Service	1.368	0.862	0.643
48 Water Transport	0.000	0.000	0.000
49 Air Transport	0.212	0.133	0.100
50 Pipeline	15.457	9.769	7.307
51 Transport Services	11.003	6.936	5.175
52 Electric Companies	7.441	4.715	3.536
53 Gas Companies	5.914	3.736	2.793
54 Other Utilities	110.166	69.536	51.949
55 Communications	0.513	0.323	0.241
56 Wholesale Trade	1.816	1.155	0.869
57 Eating & Drinking	5.991	3.799	2.851
58 Other Retail Trade	29.854	18.827	14.053
59 FIRE	0.000	0.000	0.000
60 Business Services	10.495	6.655	4.996
61 Health Services	847.165	535.745	401.026
62 Other Services	Scenario 1	Scenario 2	Scenario 3
Value added			

Table 9.4 Scenario 1, Impact Estimates

	Output Mils. $2002	Employment	Labor Income Mils. $2002
1 Field & Seed Crops	36.869	565	19.879
2 Vegetables & Fruit	696.899	16050	507.290
3 Livestock	25.906	504	9.312
4 Other Agriculture	5.154	100	3.817
5 Forestry	3.352	24	2.532
6 Fisheries	61.625	448	27.599
7 Mining	5.878	40	2.546
8 Meat Products	19.482	85	1.515
9 Dairy Products	16.395	72	2.278
10 Canning & Preserving	1293.862	7735	388.376
11 Grain Mill	10.234	19	2.903
12 Beverages	114.581	240	44.096
13 Other Foods	23.927	105	13.024
14 Textiles	0.812	13	0.692
15 Apparel	2.780	46	1.176
16 Logging	6.460	26	1.693
17 Sawmills	10.373	42	2.909
18 Plywood	0.853	3	0.234
19 Other Wood	11.795	48	3.452
20 Furniture	1.401	12	0.639
21 Pulp Mills	0.277	1	0.070
22 Paper Mills	9.927	43	4.185
23 Paperboard	46.730	202	17.714
24 Printing	33.793	237	16.112
25 Industrial Chemicals	23.341	90	14.023
26 Other Chemicals	2.758	11	1.083
27 Petroleum	58.919	41	9.823
28 Glass Products	22.696	142	10.718
29 Cement & Stone	2.208	14	1.003
30 Aluminum	2.491	5	0.452
31 Other Primary Metals	2.909	5	0.927
32 Structural Metals	0.998	7	0.398
33 Fabricated Metals	30.527	204	11.466
34 Industrial Machinery	1.879	12	1.398
35 Computer Equipment	0.395	2	0.333
36 Electric Machinery	0.918	8	0.547
37 Aerospace	0.254	1	0.066
38 Motor Vehicles	1.115	6	0.606
39 Ship & Boat Bldg	5.424	44	1.660

Table 9.4 , continued	Output		Labor Income
40 Instruments	4.201	37	2.437
41 Other Manufacture	12.258	107	5.790
42 Hwy Construction	0.127	1	0.054
43 Other Construction	44.032	240	15.755
44 Railroad Transport	6.911	69	3.108
45 Local Transport	7.745	77	5.429
46 Trucking	46.947	469	25.391
47 US Post Service	6.081	61	4.732
48 Water Transport	4.955	50	2.203
49 Air Transport	8.862	89	3.401
50 Pipeline	0.213	2	0.147
51 Transport Services	1.335	13	0.701
52 Electric Companies	125.197	145	71.986
53 Gas Companies	30.074	43	14.793
54 Other Utilities	28.756	41	14.207
55 Communications	52.379	213	48.454
56 Wholesale Trade	194.129	2415	131.883
57 Eating & Drinking	99.524	1238	40.405
58 Other Retail Trade	257.809	3208	150.429
59 FIRE	201.865	1341	91.288
60 Business Services	86.310	612	48.726
61 Health Services	226.260	2908	94.558
62 Other Services	220.695	4211	127.791
Total	4262.862	44841	2032.212

Table 9.5 Summary Measures of Impact, Scenario 1.

Output (Mils. $2002)	**4262.862**
Manufacturing	1776.972
Nonmanufacturing	2485.890
Wholesale and Retail Trade	551.462
Services	735.130
Other	1199.298
Employment	**44841**
Manufacturing	1408
Nonmanufacturing	43433
Wholesale and Retail Trade	6861
Services	9072
Other	27500
Value Added (Mils. $2002)	**2032.212**
Manufacturing	563.797
Nonmanufacturing	1468.414
Wholesale and Retail Trade	322.716
Services	362.363
Other	783.335

Scenarios 2 and 3 were approached in the same manner as scenario 1, and Tables 9.6 through 9.11 present results of calculations for these scenarios. Scenario 2 is a lower level of production than scenario 1, and scenario 3 and even lower level of production than scenario 2. Thus, the magnitude of the impacts as presented in these tables decreases with regard to these scenarios, but not in an exactly proportional manner due to changing crop mixes.

Table 9.6 Scenario 2, Final Demands

	Output Mils. $2002	Employment	Value Added Mils. $2002
1 Field & Seed Crops	$ 18.380	17.380	$ 281
2 Vegetables & Fruit	280.917	261.502	6470
10 Canning & Preserving	798.059	4771	283.544
11 Grain Mill	1.415	3	0.336
12 Beverages	63.613	133	28.496
Total Direct	$1162.384	11658	$531.995

Table 9.7 Scenario 2, Direct, Indirect & Induced Impacts

	Output Mils. $2002	Employment	Value Added Mils. $2002
1 Field & Seed Crops	26.432	405	14.052
2 Vegetables & Fruit	439.307	10117	319.783
3 Livestock	16.376	319	5.886
4 Other Agriculture	3.252	63	2.408
5 Forestry	2.115	15	1.598
6 Fisheries	38.849	282	17.399
7 Mining	3.714	25	1.609
8 Meat Products	12.305	54	0.957
9 Dairy Products	10.352	45	1.438
10 Canning & Preserv	815.615	4876	244.823
11 Grain Mill	6.629	13	1.866
12 Beverages	72.248	151	27.806
13 Other Foods	15.104	66	8.221
14 Textiles	0.512	8	0.437
15 Apparel	1.756	29	0.743
16 Logging	4.076	17	1.068
17 Sawmills	6.545	27	1.836
18 Plywood	0.539	2	0.148
19 Other Wood	7.437	30	2.177
20 Furniture	0.885	8	0.403
21 Pulp Mills	0.175	1	0.045
22 Paper Mills	6.267	27	2.642
23 Paperboard	29.468	127	11.170
24 Printing	21.338	149	10.174
25 Indust Chemicals	14.878	57	8.938
26 Other Chemicals	1.742	7	0.684
27 Petroleum	37.300	26	6.219
28 Glass Products	14.309	90	6.757
29 Cement & Stone	1.395	9	0.634
30 Aluminum	1.571	3	0.285
31 Oth Primary Metals	1.836	3	0.585
32 Structural Metals	0.630	4	0.251
33 Fabricated Metals	19.253	129	7.232
34 Indust Machinery	1.186	7	0.883
35 Computer Equip	0.250	2	0.210
36 Electric Machinery	0.580	5	0.345
37 Aerospace	0.161	0	0.042
38 Motor Vehicles	0.705	4	0.383
39 Ship & Boat Bldg	3.422	28	1.047
40 Instruments	2.653	23	1.539

Table 9.7, continued			
41 Other Manufacture	7.732	67	3.652
42 Hwy Construction	0.080	0	0.034
43 Other Construction	27.833	152	9.959
44 Railroad Transport	4.372	44	1.966
45 Local Transport	4.893	49	3.429
46 Trucking	29.640	296	16.031
47 US Post Service	3.841	38	2.989
48 Water Transport	3.133	31	1.393
49 Air Transport	5.597	56	2.148
50 Pipeline	0.135	1	0.093
51 Transport Services	0.843	8	0.443
52 Electric Companies	79.092	92	45.476
53 Gas Companies	18.978	27	9.336
54 Other Utilities	18.183	26	8.983
55 Communications	33.091	134	30.611
56 Wholesale Trade	122.563	1525	83.264
57 Eating & Drinking	62.882	782	25.529
58 Other Retail Trade	162.906	2027	95.053
59 FIRE	127.553	847	57.682
60 Business Services	54.490	387	30.763
61 Health Services	142.965	1838	59.748
62 Other Services	139.466	2661	80.756
Total	$ 2693.433	28343	$ 1284.058

Table 9.8 Scenario 2, Summary Impacts

Total Impact	Washington
Output (Mils. $2002)	**$2693.433**
Manufacturing	1120.852
Nonmanufacturing	1572.581
Wholesale and Retail Trade	348.351
Services	464.474
Other	759.756
Employment	**28343**
Manufacturing	889
Nonmanufacturing	27454
Wholesale and Retail Trade	4334
Services	5732
Other	17388
Value Added (Mils. $2002)	**$1284.05**8
Manufacturing	355.638
Nonmanufacturing	928.420
Wholesale and Retail Trade	203.846
Services	228.949
Other	495.625

Table 9.9 Scenario 3 Final Demands

	Output Mils. $2002	Employment	Value Added Mils. $2002
1 Field & Seed Crops	$ 16.020	245	$ 8.863
2 Vegetables & Fruit	209.585	4827	156.266
10 Canning & Preserving	595.412	3560	211.545
11 Grain Mill	1.186	2	0.282
12 Beverages	47.460	99	21.260
Total	$869.664	8733	$398.216

Table 9.10 Scenario 3 Lower Bound, Direct, Indirect & Induced Impacts

	Output Mils. $2002	Employment	Value Added Mils. $2002
1 Field & Seed Crops	22.165	339	11.649
2 Vegetables & Fruit	327.760	7548	238.585
3 Livestock	12.253	239	4.404
4 Other Agriculture	2.428	47	1.798
5 Forestry	1.580	11	1.193
6 Fisheries	28.986	211	12.982
7 Mining	2.778	19	1.203
8 Meat Products	9.200	40	0.715
9 Dairy Products	7.736	34	1.075
10 Canning & Preserving	608.516	3638	182.658
11 Grain Mill	5.083	10	1.420
12 Beverages	53.918	113	20.752
13 Other Foods	11.284	49	6.142
14 Textiles	0.382	6	0.326
15 Apparel	1.312	22	0.555
16 Logging	3.043	12	0.797
17 Sawmills	4.887	20	1.371
18 Plywood	0.402	2	0.110
19 Other Wood	5.550	23	1.624
20 Furniture	0.662	6	0.302
21 Pulp Mills	0.131	1	0.033
22 Paper Mills	4.683	20	1.974
23 Paperboard	21.994	95	8.337
24 Printing	15.948	112	7.604
25 Industrial Chemicals	11.226	43	6.744
26 Other Chemicals	1.302	5	0.511
27 Petroleum	27.951	19	4.660
28 Glass Products	10.678	67	5.042
29 Cement & Stone	1.044	7	0.475
30 Aluminum	1.173	2	0.213
31 Other Primary Metals	1.371	3	0.437
32 Structural Metals	0.471	3	0.188
33 Fabricated Metals	14.372	96	5.398
34 Industrial Machinery	0.887	5	0.660
35 Computer Equip	0.187	1	0.157
36 Electric Machinery	0.433	4	0.258
37 Aerospace	0.121	0	0.031
38 Motor Vehicles	0.528	3	0.287
39 Ship & Boat Bldg	2.555	21	0.782
40 Instruments	1.983	17	1.150

Table 9.10, continued

	Output Mils. $2002	Employment	Value Added Mils. $2002
41 Other Manufacture	5.772	50	2.727
42 Hwy Construction	0.060	0	0.025
43 Other Construction	20.825	113	7.451
44 Railroad Transport	3.274	33	1.472
45 Local Transport	3.658	37	2.564
46 Trucking	22.149	221	11.979
47 US Post Service	2.872	29	2.235
48 Water Transport	2.345	23	1.043
49 Air Transport	4.184	42	1.606
50 Pipeline	0.101	1	0.070
51 Transport Services	0.630	6	0.331
52 Electric Companies	59.140	69	34.004
53 Gas Companies	14.175	20	6.973
54 Other Utilities	13.609	20	6.723
55 Communications	24.744	100	22.890
56 Wholesale Trade	91.587	1139	62.220
57 Eating & Drinking	47.027	585	19.092
58 Other Retail Trade	121.840	1516	71.092
59 FIRE	95.398	634	43.141
60 Business Services	40.718	289	22.987
61 Health Services	106.922	1374	44.685
62 Other Services	104.319	1990	60.405
Total	$ 2014.309	21205	$ 960.320

Table 9.11 Scenario 3, Summary Impacts

Total Impact	Washington
Output (Mils. $2002)	**$ 2014.309**
Manufacturing	836.783
Nonmanufacturing	1177.526
Wholesale and Retail Trade	260.454
Services	347.356
Other	569.716
Employment	**21205**
Manufacturing	665
Nonmanufacturing	20541
Wholesale and Retail Trade	3240
Services	4287
Other	13013
Value Added (Mils. $2002)	**$ 960.320**
Manufacturing	265.516
Nonmanufacturing	694.804
Wholesale and Retail Trade	152.405
Services	171.218
Other	371.182

B. Electrical Power

Section 5 presents estimates of losses of hydropower output, presumed to be losses in export sales due to the various scenarios. These scenarios are based on an average value per MWH of about $47.8. In 1987 (the year against which the input-output model is benchmarked), export sales value for hydropower was approximately $17 per MWH. Estimates for total losses in hydropower represent about 1% of exports in 1987, and about 0.1% of total production in that year. Clearly, these impacts are small in magnitude compared to the direct impacts of added agricultural production.

In estimating the impacts of lost power production, the electrical industry direct requirements coefficients in the i/o matrix was modified to estimate direct purchase requirements. The 1987 model has a rather sizeable transaction within the electrical power production sector, representing wholesale sales from generators such as Bonneville to retail

utilities in the region (such as City Light). There would not be this intraindustry transaction in the scenario being modeled here. Value added was increased by 90% of the magnitude of this intraindustry coefficient, and the intraindustry direct requirements coefficient was set at 10% of the value in the 1987 input-output model.

Tables 9.12 and 9.13 present summary impact estimates for these small reductions in hydropower exports. These scenarios would lead to job reductions in the 154 to 205 range, output losses of $28 to $38 million, and reductions in value added of $17 to $23 million. Clearly, the negative impact estimates contained in Table 9.12 and 9.13 are several orders of magnitude smaller than the positive impact estimates reported above in the section on agriculture.

Table 9.12 Maximum Loss of Hydropower ($20.0 million)

Total Impact	Washington
Output (Mils. $2002)	-37.68
Manufacturing	-1.88
Nonmanufacturing	-35.80
Wholesale and Retail Trade	-4.67
Services	-7.71
Other	-23.43
Employment	-205.05
Manufacturing	-6.03
Nonmanufacturing	-199.02
Wholesale and Retail Trade	-58.30
Services	-96.49
Other	-44.23
Value Added (Mils. $2002)	-22.76
Manufacturing	-0.66
Nonmanufacturing	-22.10
Wholesale and Retail Trade	-2.60
Services	-3.76
Other	-15.74

Table 9.13 Impacts of Minimum Loss of Hydropower ($14.7 million)

Total Impact	Washington
Output (Mils. $2002)	-28.23
Manufacturing	-1.41
Nonmanufacturing	-26.82
Wholesale and Retail Trade	-3.50
Services	-5.77
Other	-17.55
Employment	-153.89
Manufacturing	-4.59
Nonmanufacturing	-149.30
Wholesale and Retail Trade	-43.64
Services	-71.20
Other	-32.16
Value Added (Mils. $2002)	-17.05
Manufacturing	-0.49
Nonmanufacturing	-16.55
Wholesale and Retail Trade	-1.95
Services	-2.82
Other	-11.79

10. PASSIVE USE VALUES ASSOCIATED WITH CRI SCENARIOS

In addition to economic values associated with recreational and commercial fishing, economists define and occasionally measure values associated with the simple presence of a fish population. The value is reckoned as the amount that people (defined appropriately) would be willing to pay to assure the existence of something even if they do not directly use it. The something could be a fish stock, and the passive use value would be the public's willingness to pay for a specified increase in the fish stock. These values are separate and additional to values for harvesting fish. Hence the term "passive use" value, which is sometimes replaced with synonyms like "existence values" or "non-use values". In theory, passive use values could exist for any conceivable product, resource, or condition. For example, some people value open space, healthy ecosystems, and archaeological sites. Others might place value on the continued existence of hydropower dams, fish hatcheries, or farming as a way of life. While the measurement and use of passive use values in natural resources damage assessment and benefit cost analysis continues to provoke controversy (see Diamond and Hausman 1994), many environmental economists have come to terms with the difficulties of measurement (Hanneman, Loomis and Kanninen, 1991; Layton, Brown and Plummer 1999; Loomis 1996a; Loomis 1996b; Loomis 1999; McFadden 1994; Olsen, Richards, and Scott 1991). The most likely source of passive use value associated with the CRI scenarios is due to potential changes in the salmon and steelhead runs in the mainstem of the Columbia river.

A. Passive Use Values for Salmon

Olsen, Richards and Scott (1991) found that people who claimed no intention to catch or eat salmon from the Columbia river were still willing to pay on average $26.52 per year per household ($35.12 in 2002$) to obtain a doubling of the salmon run size. These passive use values are non-exclusive, meaning that everyone who values the fish run obtains this value simultaneously (as contrasted with consumptive use values which accrue only to those catching fish in competition with others). Hence, assuming (1) that all households enjoy this non-use value, (2) that a doubling of the fish run means 2.5 million fish per year, and (3) that there are

roughly 2.0 million households in the relevant region*, that value of doubling the run would be $70.24 million/year.

More recently, the US Army Corps of Engineers Study of Snake R Salmon Migration (1999) uses an amalgam of previous estimates to show that a reduction of 428 in Snake R salmon run causes a reduction of $97,360 in passive use value--equivalent to $66.28 per fish. Estimates of passive use values specifically applicable to the mainstem salmon populations most likely to be affected by the CRI water diversions are not available.

B. Total Economic Values for Salmon

Some studies of economic value do not attempt to divide values into use value and non-use (or passive use) values (Randall and Stoll 1983; Sanders, Walsh, and Loomis. 1990). Instead, they aim directly to estimate directly the total value of a change in an environmental condition or animal population. Recently, Layton, Brown and Plummer (1999) have estimated an individual value function for a variety of fish categories (including Columbia basin migratory fish) among Washington residents. Completed for the Washington Department of Ecology, that study developed a means of estimating willingness to pay for any given increase in fish population from an assumed current level, and for two different "baseline" fish population projections. For example, for a current fish population of 2 million and a projected stable future population of 2 million in the Columbia basin, Layton, et al. find that the typical Washington household would be WTP $119.04 per year for a 50% increase in the migratory fish population. This represents the total (use plus non-use) value for the fish population increase. With a total of 2 million households holding such values, the overall value per fish is a remarkable $238.08. This particular estimate pertains to a rather broad class of fish, including all the salmon and steelhead stocks in the Columbia basin.

The information collected by Layton, Brown and Plummer can, and has, been used to estimate a value function which assigns a total state-wide value to a change in Eastern Washington migratory fish populations from the current, or baseline level. Based upon the estimated function, a relationship like that depicted in Figure 10.1 below shows how total

* Olsen, et al. take this as roughly the number of households in the Washington, Oregon, Idaho region in 1989.

statewide value placed upon the fish population would rise as the population grows from the estimated current state (acknowledgement to Mark Plummer). In this particular figure, the current state was adjusted to reflect improvements in salmon habitat and other enhancement efforts that are expected to cause a 5.53% increase from the level prevalent at the time of the survey. Of more relevance to this study, the value function can also show how total statewide value will decrease if the population of fish declines. For example, a 1/2% decline in Columbia migratory fish populations (10,000 fish) would cause a $7.15 million decline in annual value ($715 per fish) placed on those fish populations.

C Role of Passive Use value in Water Policy Decisions

As a matter of principle, any economic assessment of water policy should give equal consideration to passive use value and recreational/commercial use values. That this is rarely done is largely due to two underlying factors: (1) the credibility of passive use value estimates is often called into question, and (2) the methods for accurately estimating passive use values (contingent valuation being the predominant method) are costly and demanding. The credibility issue is partly due to the public disbelief in measures of value that are not routinely and commonly understood – such as market prices and personal income – and partly due to the lack on consensus in the economics profession concerning adequate measurement standards (Hausman and Diamond). While the burden of estimating passive use values may be accepted in extreme cases, such as in the multi-million dollar lawsuits over the Exxon Valdez oil spill in 1989, for routine decision making over water rights and river operations, the time delay and cost of undertaking passive use values (involving sampling of public opinion via surveys or polls) generally excludes their use. However, general valuation models, such as that developed by Layton, Brown and Plummer (1999), may offer the promise of low-cost inclusion of passive use values and recreational values in agency decision processes.

Finally, the inclusion of passive use values for salmon and other fish species, when there are no comparable estimates of other passive use values, may bias decisions involving numerous changes to resources and communities. Given the uncertainty surrounding various passive use values that may be relevant to an economic assessment, a judgment call must be made regarding the inclusion of passive use values for some policy consequences and not for others. It may be judged that passive use values are more significant for public resources and environmental

conditions than for marketed commodities and production equipment, in part because they have no comparable market prices or income-related measures of economic value. Since salmon and other migratory fish species have market prices and recreational values, some may find that passive use values are superfluous. Others (Loomis 1996a and 1996b), focusing on the unique and endangered character of the salmon populations, may conclude that passive use values are widely held by the public and are an essential feature of a full economic assessment of water policies. We tend to side with this latter view, that the most likely significant passive use values affected by increased diversions of water from the mainstem Columbia river will pertain to changes in the salmon and steelhead runs. And the size of these changes, if any, are being investigated by the NRC Committee mentioned in Chapters 1 and 8. Finally, we recommend that any reliable estimates of impacts on salmon and steelhead should be assigned values based upon the methodology developed in Layton, Brown, and Plummer (1999).

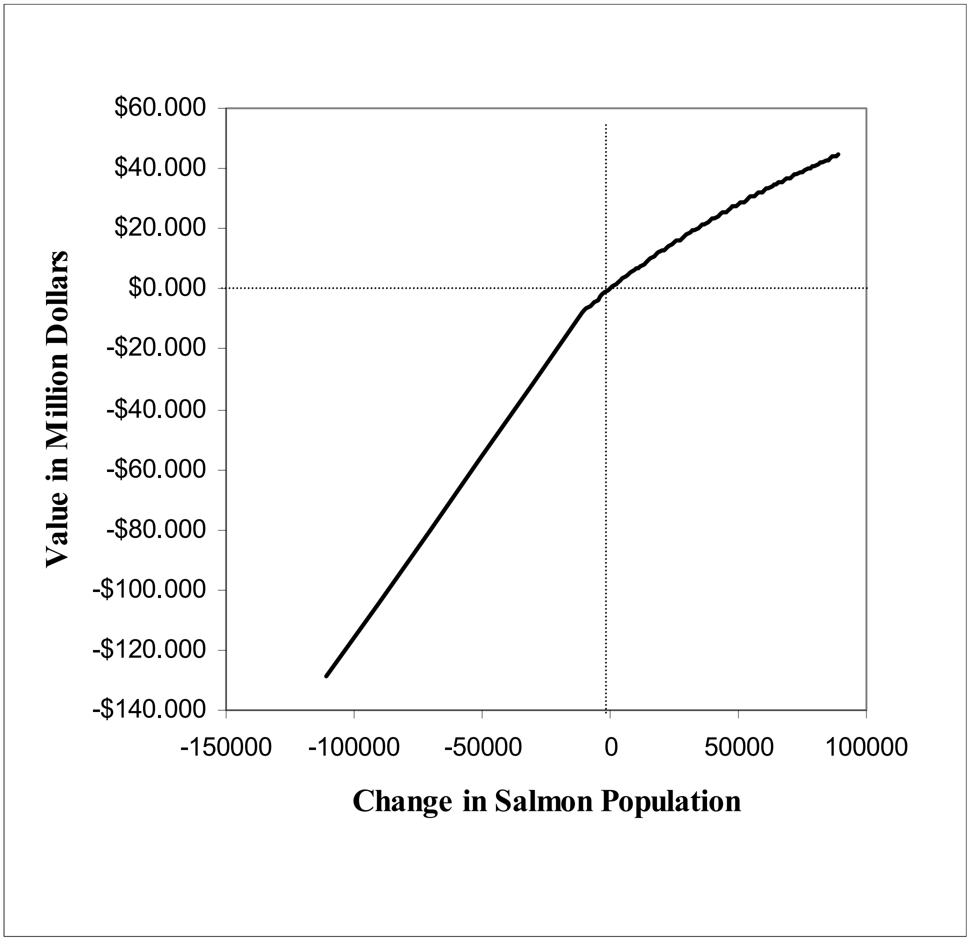

Figure 10.1. The value function showing how total economic value is influenced by the size of the migratory fish population (mainly salmon).

CHAPTER 11. WATER MARKETS: PROMISE AND PROSPECTS

Water scarcity is a growing problem in Washington State. Regional economies have developed and society has become more concerned with the environmental benefits of maintaining instream water flow. Historically water scarcity was alleviated by building large water storage projects to capture water during periods with high flow to be used during periods with low water flow. The expense and environmental concern associated with storage projects have turned attention to other means of coping with water scarcity. One approach is to encourage the transfer of water from low to high value uses, thereby increasing the benefit derived from available water resources and encouraging water conservation. In many river basins there is little incentive, and few institutionalized mechanisms for water transfers by water rights holders. However, this is changing as many States in the arid West have developed some forms of water marketing institutions.

In the western United States most individuals and groups that divert water for out-of-stream uses have been allocated water by State governments based on the prior appropriations doctrine. The prior appropriations doctrine can generally be characterized by two criteria, "first in time, first in right," and "beneficial use." First in time, first in right indicates that existing and future rights to water resources are based on the historical pattern of water use. Individuals who have been using water the longest (the "senior rights holders") have the highest priority for receiving water supplies. Since many rivers are fully appropriated, new water users are not able to secure reliable water rights regardless of the value of its use; thereby limiting the benefit derived from scarce water resources. The beneficial use clause of the doctrine calls for the forfeiture of a water right that is not put to beneficial use; and is often referred to as the "use it or lose it clause." Water users that admit they have excess water to transfer often fear they may lose their right to that water if they put it up for transfer. During the last several decades a number of states have enacted legislation to recognize water transfers as a beneficial use. This allows water right holders to transfer their water rights without fear of losing them.

Historically, drought and water supply variability have been the primary factors that lead to competition for water resources. Under prior appropriations, water users with a low priority right are left short of water when supplies are, low regardless of use. Water transfers have been proposed as a way to reduce the allocative inefficiencies of the prior appropriations doctrine (Burness and Quirk, 1979; Howe et al., 1986; and Colby, 1990). Water transfers have received

the most attention during drought periods to move water within agriculture (Dinar and Letey, 1991) or to urban uses (Taylor and Young, 1995; Michelsen and Young, 1993). However, more recent attention has been given to transferring water for environmental uses (Fadali and Shaw, 1998; Weinberg et al., 1993). Most water transfer studies have focused on the implementation of water markets; however, water banking and leasing programs are more common in practice (Howitt, 1991; MacDonnell et al., 1994, p. 1-3).

Water markets, leases, and banks are often promoted in the hope they will encourage more efficient water use. The idea of free market transactions — willing-seller/willing-buyer — is that water will flow to those who can make the most productive use of it. A water user will weigh their value of using the water against what another water user would be willing to pay for that water. In this sense, the use value of their water is the opportunity cost of transferring that water to another water user. This encourages water to move from low to high value uses, thereby increasing the benefit derived from limited water resources. This also encourages water users to conserve water if they are allowed to sell their reduction in water use. However, it is critical that reductions in water use by one user do impact the water supply of other users through hydrologic linkages within the river basin (Green and Hamilton, 2000). More specifically, water conservation must be defined in terms of reductions in consumptive use, not diversions, to insure other water users are not affected by conservation measures. This issue will be discussed in more detail in section 11.A.

The primary water transfer mechanisms include: water markets, which generally facilitate the permanent transfer of water rights; water leases, which facilitate the temporary transfer of flow water rights; and water banks, which facilitate the temporary transfer of storable water. There is slight disagreement regarding the terms water leases and water banks. It is not uncommon for temporary storage water transfers to be labeled leases, as has been done in the publication Water Strategist. Similarly, all transfers that are facilitated by an agent or broker may be referred to as banking, as is the case in MacDonnell (1995). Regardless, these are simply different titles for essentially the same activity. There are also a number of variations on these, such as split season transfers, contingent transfers, and direct trading of commodities like hay for water. Water banking and leasing may be more attractive to many water right holders since they are able to maintain control over future use of the water and opportunities that may arise from having that right. The temporary aspect of these institutions helps traders to become accustom to

water transfers without making an irreversible decision regarding their water right, which removes the all-or-nothing nature of a permanent transfer.

Water transfer institutions serve as intermediaries that help to reduce the cost of transferring water between users. These costs fall within two categories; the cost of physically transferring water and the implicit cost of matching willing sellers and willing buyers. A water bank works to reduce these costs by acting as a broker to bring buyers and sellers together in an institution with publicly known procedures. It determines the parameters of the trade, including the portion of the water that may be transferred. Water transfer policies have been used for many years in various forms; however, their primary intent has been to move water within a given system. Using water banks as a mechanism to transfer water between water systems and to emerging water users marks an important change in the role of transfers for reallocating water.

Water transfers are not a new idea and have been occurring in Washington State for many years. However, these transfers have historically been between agricultural users. Trading between different types of water users is relatively new and is where water transfer institutions can help the most as intermediaries. These types of trades include transferring water from agriculture to municipal, industrial and environmental uses. Most water transfers involve agricultural water users since they have approximately 85-percent of the water rights in Washington.

Water transfers have worked effectively in many regions of the Western United States. Below we will discuss several of the issues that must be addressed when developing water transfer institutions. We will review a number of the water transfers that have already taken place in Washington. We finish by looking at the potential for water transfers in the Columbia River Basin.

A. Issues in Water Marketing

Unfortunately instituting water transfers face several hurdles, both physical and social. First, water users are not independent of each other. It is common that not all diverted water will be consumptively used and a portion of the water that is not consumptively used will become return flow that supplies other water users. As a result, water transfers may impact individuals that are not involved in the exchange, making it necessary to distinguish between consumptive and non-consumptive use. Second, local communities often depend on the tax base and employment

generated by agricultural and industrial water use. If a large portion of a region's water rights are transferred to another region or use that does not generate the same tax base the community could be lose its primary source of funding. Finally, to many individuals the idea of transferring water between uses is new. The perception of significant changes in water allocation may be met with skepticism and distrust, which could hinder the implementation of water transfer policy. Each of these issues can make designing and implementing water transfer policy a difficult task.

A key factor in designing water transfer policy is that water users are not independent of one another. Water users generally divert more water than is consumptively used. The excess diversions are then either lost or return to the system. The excess diversions that return to the system are called return flow and act as a water supply to other water users. As a result, it is important that water users are only allowed to transfer the consumptively used portion of their water right. Otherwise, they could be transferring water that is usually used by another water user. For example, suppose a water user usually diverts 100 acre-feet, consumes 50 acre-feet, 30 acre-feet become return flow, and the remaining 20 acre-feet are lost through evaporation and other irretrievable losses. In this case, the water user would only be able to transfer 70 acre-feet to another water user. The 30 acre-feet of return flow would need to remain protected instream until the point where it had provided water supply to the hydrologic system.

Defining the consumptively used portion of a water right is a technical issue that has important ramifications for whether a transfer policy will work effectively or not. The agency in charge of regulating water transfers sets a procedure for calculating the consumptively used portion and this is used in the transaction. Most states allow only the consumptively used portion of a water right to be transferred between water users.

Conserved water is often cited as a source for water transfers, where conserved water may arise from changes in irrigation technologies, cropping patterns or improvements in distribution systems. Instituting water transfer policy may encourage water users to use their water more efficiently if they are able to sell the conserved water. However, third party impacts are likely to arise if conservation projects reduce diversions without reducing consumptive use and the reduction in diversions are then transferred. Returning to the example sited above, suppose the water user invests in a new production technology such that only 70 acre-feet are diverted (rather than 100); 50 acre-feet are still used consumptively, 15 acre-feet become return flow (rather than 30 acre-feet), and 10 acre-feet are lost (rather than 20). Even though diversions are reduced by 30

acre-feet, there is only a 10 acre-foot reduction in losses. In such a case, the water user could only transfer 10 acre-feet. The remaining 20 acre-feet would consist of 15 acre-feet that would remain instream until the point where it was deemed to be a supply to other users under the original use pattern and 5 acre-feet would still be considered an irretrievable loss. In this example, the water user paid to reduce diversions by 30 acre-feet, but could only transfer 10 acre-feet. As a result, the opportunity to transfer conserved water may not be as strong as one would think at first glance. As a side note, it should be recognized that the 15 acre-feet that are left instream before replacing reduced return flow could provide benefit to instream uses like habitat restoration or hydropower production. Though early attempts at water transfer policy did not recognize the importance of defining consumptive use, it has been recognized in existing case law (Benningfield v. DOE, PCHB No. 87-106, 1987).

A number of established economies depend on the income generated by agricultural and industrial production that depends on the existing water rights allocation. The communities depend directly via employment, sales and taxes, and indirectly through multiplier effects. Transferring water rights to different uses in different regions could reduce the regional employment and tax base, leaving the community with out the ability to continue providing quality education, police and fire protection, and other publicly provided services. While the willing seller is just as well or better off, the remaining community is impacted through no action of their own. Portions of Western Washington have experienced this with the large reduction in the timber industry in the late 1980's. As less timber was harvested, fewer raw logs were milled, and the level of unemployment increased dramatically. This spilled over into the local business community as there was a much lower demand for goods and services.

How much of an issue this is depends on the amount of water that is traded from the region. The example of timber communities above was quite severe; however, it was being driven by a dramatic change in technology. For water transfers to cause a similar impact it would be necessary for enormous amounts of water to leave the region. There were similar fears in California's San Joaquin Valley during the drought of the early 1990's. The California drought water bank established a mechanism to transfer water from agriculture to municipal water use in Los Angeles. There was great concern the water demand in Los Angeles would devastate small communities in San Joaquin Valley. It turned out that more water right holders were willing to sell their water then there was demand for water in Los Angeles in spite of the relatively low

amount that was placed in the water bank. While the level of municipal and industrial water demand in Eastern Washington is not likely to drive any significant amount of water transfers, there is concern that environmental demand could be significant. However, it is likely that the environmental demand will be wide spread, pulling water from many areas rather than concentrating on any one specific area. This would result in a reduction of low value agriculture while leaving high value agriculture along the Columbia River in tact. To what degree this would impact the surrounding communities depends on the level of demand and what restrictions are placed on the quantity of transfers.

The final issue with regard to water transfer policy relates to how individuals and groups perceive the affects of water transfer. Perception of significant changes in current law may be met with anxiety and skepticism, especially by current water rights holders. In particular, current water law assures security of access to senior rights holders, and any perceived threat to security will be resisted. Water is perceived to belong as much to the historic user class (agriculture, hydropower, etc.) as to the putative property rights holder. That is, water used in agriculture may be perceived to "belong" to agriculture, or even to a particular farm use, rather than to the individual holder of the property right. This ideology is enshrined in the beneficial use aspect of the appropriation doctrine which assigns a water right for a particular use, at a particular location, in perpetuity. The idea of transferring water may therefore be seen by some as more than the movement of property from one owner to another; it may be seen as a change in the moral order. As a result, water users that transfer water to other types of water users may be vilified by others in the community and reduce the incentive to participate in water transfer programs. Examples of this include the Methow River basin in Washington and the Kalmath River basin in California.

B. Water Marketing in the Washington

Despite the complications of implementing water transfer policy discussed above, there are a number of examples of water transfers in the Northwest. A thorough review of transfers through out the Northwest is appears in a study done for Ecology (WestWater Research). Washington State water law allows voluntary transfers between willing buyers and sellers provided that third parties are not injured as a consequence of the transfer. Water can be transferred between

agricultural, environmental, industrial and municipal uses.[34] Any proposed transfer in place or manner of use of an existing water right must be approved by DOE[35] and a formal application for change of water right must be submitted providing detailed information about the present and proposed water uses and the existing water right certificate. The application must be published for public review to allow third parties that may be impacted by the transfer to interject.[36] The formal transfer procedures can be avoided for temporary changes in point of diversion of place of use, but not manner of use

There have long been water transfers with irrigation districts for agricultural use. These transfers often occurred during drought periods when some growers had excess water while others were water short. There have also been transfers from agriculture to municipal and for habitat restoration. For example, in the Yakima River basin a program has been enacted by the United States Congress to encourage conservation and water acquisition for environmental uses. The DOE has also established a water acquisition program to acquire water to augment instream flow for restoration of salmon habitat. The Washington Water Trust, a private non-profit group, operates to purchase and lease water to increase instream flow. These examples indicate that water transfers in Washington are becoming more common and many of the initial hurdles are being overcome.

a. Water Transfers within Irrigation Districts

The best record of water transfers within irrigated agriculture is the Yakima River Basin 2001 Drought Water Bank. Severe drought was experienced during the 2001 growing season which resulted in water scarcity for all uses. The water bank was established to help all water users gain access to water to alleviate water shortages. There were twenty-five transfers not including donations, twenty-one were within agriculture. The highest price paid was $125/AF and the lowest was 69.68. The average price was $113/AF with a standard deviation of $16/AF. The bulk of the trades were to the Roza Irrigation District. Though this indicates the potential for water transfers it is important to reiterate that this occurred during a severe drought.

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[34] RCW 90.14.03(2) and RCW 90.54.020(1).

[35] RCW 90.03.390.

[36] RCW 90.03.280.

It is important to note that water transfers under drought conditions differ from those under regular water supply conditions. First, scarcity brings more people to trading, as such; it does not give evidence of market sustainability. It simply indicates that during periods of shortage there are people that have to have water and what is available of their right is not sufficient. Second, during drought conditions the short-term (within-growing season) demand for water drives the transfer quantity and price, these to not represent long-term or permanent water values. That is, it is not likely that a grower would be willing to pay this amount each year. Instead this demand is to meet short-term shortfalls. For example, an apple grower would be willing to pay more than their usual market value for water to insure their orchard received sufficient water supplies since long-term multi-season damage can occur to the orchard if it is water stressed during drought. However, it is unlikely they would be able to pay that price for water every year. As such, these water prices reflect the high end of what irrigators are willing to pay in the Yakima River Basin.

Three other irrigation districts, the Wenatchee, the Yakima-Tieton and the East Columbia, were identified as areas in Washington where water transfers are relatively commonplace. The Wenatchee Irrigation District has been facilitating water transfers for over sixty years. The major restriction on transfers is that all water transfers must be upstream in order to minimize negative third-party impacts. The district representative reports that they have had no third party complaints about transfers; however, parties do get annoyed when the district blocks downstream transfers. Farmers negotiate sales of permanent rights (shares) themselves, including setting their own prices. The district management is interested in the final allocation of shares in order to complete its share assessment billing, and to deliver water to the correct location. All transfers must be within the district's service area.

The physical distribution system in the Yakima-Tieton Irrigation District is unique in that water is delivered to diversion points in pressurized, underground pipes. Because of this, the district avoids controversies over return flows from conveyance losses. Water is transferred through exchange of shares that vary from year-to-year, depending on water availability for a given year. Water transfers are supposed to be permanent; leasing of water is not a sanctioned activity. Transfers must remain in the district. There are no constraints on the direction (upstream or downstream) of transfer, but farmers cannot hold more than 1.5 shares per irrigable acre. The selling of small fractions of shares is said to be quite common, for example, when people go on a municipally supplied domestic water system.

The East Columbia Irrigation District has a water bank that allows irrigators who hold an early and late service water contract to "buy" additional water for the June-July period. Price for this additional water is the per acre-foot operation and maintenance assessment cost of the banked water, plus an administrative fee, plus a peaking water charge. Irrigators "depositing" water into the bank avoid payment of their operation and maintenance charge, but make no additional profit on the water transfer. These are just several examples found, further investigation would likely turn up more.

b. Water Transfers for Environmental Purposes

The Washington Water Acquisition Program was designed specifically to encourage water conservation for transfer to environmental uses. The state has targeted 16 watersheds in the region with vulnerable salmon and trout populations. The program is a voluntary initiative offering monetary compensation to water right holders and is focused on increasing stream flows in the basins experiencing chronic water shortages, and therefore "at risk" fish populations. The program is designed to allow for participants to contribute to salmon recovery efforts by transferring their rights. State agencies involved in the program include the departments of Ecology, Fish and Wildlife, and Washington Conservation Commission. Ecology has $5.5 million in state and federal funds to acquire water rights.

Program sponsors are offering a variety of ways for farmers, ranchers, and other right holders to participate including selling, leasing, or donating all or part of a water right. Priority will be given first and foremost to right holders that wish to permanently transfer their right to the state water trust. Compensation will be negotiated by the involved parties by determining the fair market price of the right into perpetuity. Long-term leases will be given the next highest priority, followed by short term leases. The program will allow for different types of leasing, such as "split-season" or "dry-year" leases. Again, program sponsors will work with right holders to determine a fair market price for the specified terms of the lease. Leasing might be a particularly attractive option to right holders who are reluctant to make a permanent transfer of their right in that there is no risk of relinquishing the water placed in the program. Another option for participation in the program is for a right holder to donate all or some of a water right. This donation may be a tax-deductible charity, and the donated amount will be returned at the end of the donation period. A final and less direct way that one could participate in the program

is through the state Water Irrigation Efficiencies Program. Users may voluntarily place all or part of the water saved into trust. Under specific conditions of the program, a mechanism exists to determine the portion of a block of conserved water that can be transferred to other beneficial uses (Washington State Department of Ecology, 1992).

DOE will determine and negotiate the fair market value of each water transfer proposal using various valuation methods. The right will be priced based on the character of the right, its value to fish, the type on transaction, and the length on transaction. In many cases, the price is determined by an independent water right appraiser. Although the department evaluates each acquisition proposal on a case by case basis, DOE will generally only pay for consumptive use of the water.

Another example includes the Yakima River Basin Water Projects. In 1994, the United States Congress enacted Title XII of Public Law 103-434, the Yakima River Basin Water Enhancement Project (YRBWEP). This authorized the YRBWEP to protect, mitigate, and enhance fish and wildlife and to improve reliability of the water supply for irrigation through improved water conservation and management. More specifically, Sections 1203 and 1205 authorize the purchase or lease of land, water or water rights from anyone willing to limit or forego water use on a temporary or permanent basis to secure instream flows for the benefit of anadromous fish. The United States Bureau of Reclamation (BOR) has been charged with implementing the YRBWEP.

In 1995, BOR started a pilot program investigating the legal and institutional aspects of acquiring water and transferring it to environmental uses. In 1996, BOR continued the pilot program and executed three irrigation water lease contracts for a total of 9 cubic feet per second (cfs) on the Teanaway River, a tributary of the Yakima. The cost of the 9 cfs ranged from $23 to $40 per acre-foot. In 1997, BOR implemented the water acquisition program authorized under the YRBWEP and executed four water lease contracts for approximately 20 cfs, primarily on the Teanaway River. Price ranged from $23 to $35 per acre-foot.

The Teanaway was chosen because: it historically was a large producer of Spring Chinook, Coho and Steelhead; it is periodically dewatered for irrigation; and it is an "usual and accustomed fishing site" for the Yakima Indian Nation. The dominate crop in the area is Timothy hay. The land associated with the water leases were fallowed during the term of the lease. In addition to leasing and acquiring water rights, a long-term goal of the YRBWEP is to install

water conservation systems to help increase instream flows and the reliability of irrigation water. Smaller tributaries such as the Teanaway are generally targeted for water transfer programs since modest water purchases can make a significant improvement in fish survival rates.

Within the Yakima Basin there is also an effort being made to establish a water bank. DOE has initiated an effort to define the elements of a Yakima Basin water bank, reach basic understanding and acceptance of water banking as a tool and to determine what type of water banking has a good chance of success in the Yakima region. As a fundamental part of this effort DOE will involve Yakima water bank stakeholders in exploring the boundaries and opportunities that a water bank will face. Involving stakeholders is necessary to make sure the bank is active once it is institutionalize.

The Washington Water Trust (WWT) was established in 1998 to restore instream flows in Washington's rivers and streams. The private, non-profit organization uses market based tools by acquiring existing water rights from willing sellers through purchase, lease, or gift, with the intent to improve water quality, fisheries and recreation in the state's rivers and streams. The organization works cooperatively with farmers, ranchers, irrigation districts, tribes, public agencies, land trusts, and other governmental and non-governmental agencies. WWT's focus is on small streams and tributaries where returning a small amount of water could yield significant restoration benefits. The WWT views its market based solution as mutually beneficial to salmon, water quality and the agricultural community. WWT sees water marketing as a restoration strategy that will ease water use conflicts by compensating the agricultural community in voluntary exchange for a water right to be left instream to benefit salmon restoration. A couple of examples of WWT projects include Salmon Creek and Big Valley Ranch.

For many years the lower 4.3 stream miles of the Salmon Creek has been dry except during spring runoff. During the irrigation season, the entire stream flow has been diverted by the diversion dam, discouraging fish migration. Through the creation of a Salmon Creek Trust Water Right water was left instream in 2000, allowing for higher flows, smolt migration, and improved fall and winter conditions. A water bank was established by the Okanagon Irrigation District (OID) in order to increase instream flows. 42 irrigators accounting for 330 acres of land signed up to participate, with the entire amount of water accumulated in the bank left instream, accounting for 990 AF. The Bonneville Power Administration provided funds for the lease. The project has persisted and grown, allowing for approximately 1716 and 1869 AF in 2001 and

2002 respectively. Prices paid for the water were based on assessments and were $135 per acre in 2000, $145 in 2001, and $175 in 2002. The Salmon Creek project has led to some issues that need to be worked out. The temporary nature of the leases has caused some inconsistency in implementation. The three years that the program has been in effect have been drought years in the Okanogan. There has also been some controversy over the project's impact on water levels in Conconully Lake (Salmon Lake). The program is not yet a permanent institution and there will be no leases in 2003. This has caused problems for some irrigators who had planned on the trust water payments. OID and WWT are discussing changes, including depositing future leases in the trust water rights program for the duration of the lease, to provide sustainability of the project and for protection for OID.

c. Water Transfers for Municipal Use

The publication "The Water Strategist" summarizes exchanges of water rights throughout the west for different purposes. Limited records exist of water purchases for M&I uses in Washington. For example, two purchases in Washington were for M&I uses during 2001 where the City of Warden purchased 2,388 AF of Grande Ronde Aquifer GW from an irrigator at a price of $452/AF in June. Also, various businesses, farms, and the Church of Latter Day Saints leased up to 2,596.5 AF of Columbia Basin Project water from the Bureau of Reclamation for $39/AF with a minimum lease of $500 in July and August of 2001. There seems to be a large discrepancy in prices for these two purchases. M&I water will play an increasingly important role in water markets as the need for M&I water increases with population increases. Perhaps municipalities could work in coordination with hydropower and fish habitat restoration in that M&I water, although diversionary, is generally a non-consumptive use since return flows are so high.

C. Prospects for Water Markets in the Columbia River

The discussions above indicate there has been a significant amount of water transfer activity in Washington State. There are also examples of water transfers in the Dungeness, Walla Walla, Touchet, Methow, and Columbia River Basins. All of these examples indicate that there is significant promise for a successful water transfer program in the Columbia River Basin. Institutionalizing such a program will provide information for potential buyers and sellers in the

market and reduce transactions costs. Based on the emergence of new high value agricultural, environmental, municipal and industrial water uses, there are willing buyers. The existence of low value crops gives evidence that there are likely to be willing sellers. Institutionalizing the transfer process will allow more trading to occur between agricultural users, agricultural and municipal users, and agricultural and environmental uses, increasing the benefit from existing scarce water resources. This will not be without difficulties. Unfortunately the Columbia River Basin has a significant amount of return flow, complicating the water transfers as was discussed above. The institutional structure will need to account for potential impacts between traders, and externalities to non-traders. An institutionalized water transfer program in the Columbia River Basin has promise and potential, but not without caution and complications.

CHAPTER 12. DISCUSSION AND CONCLUSIONS

The purpose of this study is to review the economics of water use from the Columbia River in the context of Washington State's Columbia River Initiative (CRI). The CRI has been proposed as a way to address the legal, scientific, and political issues related to water use from the mainstem of the Columbia River in Washington State. Through the CRI process the state is seeking to develop an integrated state program that will allow access to the river's valuable water resources while at the same time providing support for salmon recovery. The analysis described herein is one of several kinds of information that will be used to inform the Department of Ecology's rule-making related to the Columbia River. In addition to this review, the state has contracted with the National Academy of Sciences to consider the relationship between water use and the health of salmon populations. The Department of Ecology will use the information generated by both the NAS science review and this economic review to develop a new water resource management program for the mainstem of the Columbia River.

The CRI contemplates 5 different water management scenarios corresponding to different levels of risk to salmon populations. The table below outlines the scenarios considered in the report. In each of the scenarios in which new water is to be made available (scenarios 1 through 3), 220 KAF of the 1 MAF of potential new water is allocated to the Columbia Basin Project (CBP). Scenario 1 serves as an upper bound for the analysis: it allocated the most water to new water rights, and it imposes the lowest costs on recipients of new water rights. The only costs associated with it are that all new right holders and converted (from interruptible to uninterruptible) rights need to conform to water efficiency Best Management Practices (BMPs). In analyzing Scenario 1, we assume that the entire 1 MAF of water rights offered will granted to water users. Given the existing 4.7 MAF of surface water and groundwater rights (within one mile of the river), this amounts to a 21.2% increase in water diversion and pumping rights.

Table 12.1 Elements of the 5 CRI Management Scenarios

Scenario	First Tier of New Water Rights	Second Tier of New Water Rights	Interruptible Rights
1	1MAF no fees, + new rights must meet BMPs & be metered	None	May be converted to non-interruptible, must conform to BMPs & be metered
2	700 kaf initially +$10/af annual fee + meet BMPs & be metered	300 kaf after 80% of users conform to BMPs + $ 10/af annual fee for all new rights	May be converted to non-interruptible, must conform to BMPs & be metered +$10/af annual fee
3	700 kaf initially +$20/af annual fee + meet BMPs & be metered	300 kaf after 80% of users conform to BMPs + $20/af annual fee for all new rights	May be converted to non-interruptible, must conform to BMPs & be metered +$20/af annual fee
4	All new withdrawals must be offset in proportion to consumption through transfers, conservation, and/or new storage. + fee of $30/af annual fee for new rights	none	May be converted to non-interruptible, must conform to BMPs & be metered +$30/af annual fee
5	Based on opinion of fish managers	none	Based on opinion of fish managers

Scenarios 2 and 3 impose additional costs on water users, but are identical in their potential for new water—1 MAF. The costs of metering water, complying with water efficiency standards, and paying fees for new water should encourage water users will curtail water use. Further, allocation of 300 KAF is contingent on the majority of all water users meeting water efficiency BMPS. Hence, it is not certain that the entire 1 MAF of water will be sought or permitted. To provide for a range of possible outcomes, the study team has constructed lower bounds water allocations for Scenarios 2 and 3. For both scenario 2 and 3 the upper bound estimate is equivalent to that of Scenario 1.

For Scenario 2, with a fee of $10/AF, it is assumed that the last 300 KAF of the full 1 MAF will not be actually be permitted, because the majority of users will not adhere to BMPs. Alternatively, the lower bound could reflect the notion that the increased costs associated with

the proposed fees reduce the quantity demanded for new water such that there is insufficient demand for available water. So, for the lower bound estimate under Scenario 2 we have a new allocation of 700 KAF of water; an increase in water diverted of 15%. The lower bound for Scenario 3, where the annual fee rises to $20/AF, we assumed that water demand falls to a level equal to the current application pool plus the 220 KAF for CBP. This amounts to a total of 568 KAF, a 12% increase in water rights in the mainstem Columbia river in Washington State.

Under Scenarios 4 and 5 there would be essentially no additional withdrawals. Scenario 4 calls for all new withdrawals to be offset, based upon consumptive use, by mitigating transfers or conservation or new storage. Scenario 5 is a no action scenario in which the existing rules governing the water resources of the Columbia River remain intact.

IRRIGATED AGRICULTURE

A large portion of the benefits of new water rights will be reaped by the agricultural sector. In a county-by-county assessment, we assume that the new water rights for agriculture will go into a crop mix reflecting that counties recent past production. It is unclear whether new water being made available will go into high-value or low-value crops. Examples of crops that have emerged during the last decade include wine grapes, hops, new apple varieties, storage onions, sweet corn for processing, and fresh vegetables. As a general rule, production of crops that are becoming more valuable will increase (and prices will subsequently decline) until the market becomes saturated. There will always be certain crops that are the fad of the day whose value is high and acreage increases to the point that it is no longer high valued.

To summarize the results of this study, Benton County emerges with the lion's share of increased gross and net revenues to irrigators. However, this is simply driven by the assumptions made in the extrapolation of pending applications for water rights. It is possible that insufficient irrigable land exists in the county to allow for the extrapolation considered in this report. Perhaps irrigators in the county are unable to get that much water into production, in which case the water might go to some other county for production of a different crop mix, allowing for different gross and net revenues.

Before summarizing the values of gross and net revenues for irrigated agriculture, it is important to reiterate the problem associated with crop budgets and net revenues. It is a perennial problem associated with agricultural economics involving the use of full economic

(opportunity) costs versus cash or accounting costs. Net revenues are frequently negative values when using full economic costs as the crop budgets do.

Gross and net revenues due to a 908 KAF increase in irrigation water are the same for all three Scenarios. The gross revenue is $733 million and net revenue is $44 million under the assumptions of these scenarios. For the Scenario 2 lower bound, gross and net revenues are $465 million and $22 million, respectively. For Scenario 3 lower bound, gross and net revenues are $350 million and $11 million, respectively.

M&I WATER VALUES

Diversions of water for municipal and industrial (M&I) use occurs, but the amount of water diverted is very small relative to irrigation diversions. Furthermore, M&I water tends to have a very high return flow associated with it. For these reasons, M&I water is generally not considered a consumptive use of water by many researchers.

Exact values of M&I water have been difficult for the study team to determine because few reliable sources exist regarding it. Information pertaining to recent transactions for M&I water provides a wide range (from $0 to $452 per acre foot) of prices. Generally, this report has assumed that M&I water is a higher valued use than water used for irrigation. Furthermore, M&I water seems to be a higher priority than water for other uses because to the increasing needs of water for growing urban areas in the state. The study team has assumed that in each scenario, and at the low-level assessment and high-level assessment (applicable to scenarios 2 and 3), M&I water will be granted rights ahead of irrigation water. In each scenario this corresponds to a 30% increase in M&I water rights to the Tri-Cities area corresponding to a 30% increase in population over the next couple of decades. The M&I impacts will be the same for each scenario, and therefore will be constant when comparing any two scenarios.

HYDROPOWER COSTS

Because additional withdrawals of water from the Columbia river will reduce flows downstream through the numerous hydroelectric power plants, the economic effects on the hydropower system are all negative; they incur costs. For Management Scenario 1, which adds 1 million acre-feet of new diversions -- 908,248 acre-feet of which is for irrigated agriculture -- the full cost to the hydroelectric power system of new surface water withdrawals (distributed across

reservoirs as shown estimated in Table 2.4) varies from $18.4 million/year in average water years to $20.0 million/yr in a dry year. In addition to this lost of hydropower, the new 220 kaf of water proposed for the Columbia Basin Project will cost an estimated $3.44 million in power for pumping water up to Banks Lake.

Hydropower costs associated with Management Scenarios 2 and 3 are the same as for Scenario 1 if the entire 1 MAF of water rights are allocated to applicants. This would happen if the water is worth at least $10/acre-foot (Scenario 2) or $20/acre-foot (Scenario 3) to new water rights users so that they would take the full 1 MAF and if the majority of all water rights holders comply with the draft water efficiency best management practices (BMPs). In case the second of these conditions is not met, 300 thousand acre-feet of the 1 MAF will not be issued to new water rights applicants. In that case the hydropower cost drops to $15.8 million to $17.4 million dollars. An even smaller amount of water may actually be applied for if the last 300 kaf is not allocated and the $20/acre-foot fees discourage some applicants. We estimate a low level impact of $14.7 million to $16.3 million for a final water rights allocation of 568 kaf.

Scenarios 4 and 5 will entail essentially no new hydropower costs because there would be no net increased in the amounts of water being allocated from the Columbia river.

FLOOD CONTROL IMPACTS

The Columbia River flood control system involves the drawdown of pools in the late autumn and winter to allow for enough storage space for refill in the spring by snowmelt. Each of the scenarios contemplated involves the diversion of more water from pools, allowing for more space for the refill period. In this sense, each of the scenarios will have no effect on the flood control system. The status quo, scenario 5, involves the highest risk of negative impacts to the flood control system.

IMPACTS ON RIVER NAVIGATION

River Navigation occurs along the lower Columbia and Snake rivers, and consists of two sections: the shallow-draft area upstream from Bonneville dam, and the deep draft navigation area downstream from Bonneville dam. The shallow-draft navigation system is dependent upon stage (river) height to allow for barge traffic to move through the locks unimpeded. Stage height, in turn, is dependent upon river flows. To a large degree, stage height can be and is controlled

by the operation of the dams by the Army Corps of Engineers (Corps). The deep-draft navigation system is dependent upon several factors, including spillage from upstream dams, tidal currents, and melting snow.

This report has shown that even in the scenario involving the most amount of diversions, and thus the largest reduction in flows, navigation will be unaffected because river flows are only modestly negatively impacted. Such a reduction in flows will not hinder the Corps from maintaining sufficient stage height at the dams. Discussions with Corps Hydrologists have confirmed that such a reduction in river flows will not affect the deep-draft portion of the river, where navigational disruptions might occur if the flow out of Bonneville dam falls below 70,000 cfs. The reduced flow resulting from the increased diversions is a minimum of 90,000 cfs during March of the dry year examined, well above the flow at which navigational impacts will occur. The scenarios considered in this report will not affect the navigation system of the Columbia River.

COMMERCIAL AND RECREATIONAL FISHING

Additional water diversions from the Columbia river will reduce stream flows slightly, and, depending upon magnitude and timing, these changes in stream flow could affect the survival of migrating salmon and steelhead in the mainstem Columbia river. Whether there is likely to be a significant effect on migratory fish is uncertain, and this is being investigated by a special National Research Council Committee operating under the title "Columbia River Water Resources Management: Instream Flows for Salmon Survival". Consequently, this report contains no estimates of the effect that changes in Columbia river instream flow will have on the salmon and steelhead runs. Instead, we provide a review and summary of economics information that can be used to value the changes in fish populations that are described by the eventual scientific report. Larger salmon or steelhead runs in the Columbia typically trigger increases in the fishing seasons and catches for both commercial and recreational fisheries. Hence, the value of the fisheries would respond to run size change. The question is "how much"?

Over the past two decades the commercial fishery has experienced wide fluctuations in harvests but steadily declining exvessel prices, largely due to rapid expansion of the salmon farming industry. Because of its higher price ($2.50/lb. in 2002), spring chinook salmon populations have the greatest potential for contributing to incomes and market value of the

fishery. Low prices for up-river fall chinook (brights) and lower river fall chinook (tules) ($0.27 to $0.11/lb. in 2002) suggest that there is little net economic value (exvessel price minus fishing costs) associated with changes in fall chinook populations and fishery harvest. Similarly, coho salmon prices have dropped to $0.32/lb., making the that fishery relatively unprofitable. Overall, changes in the size of the salmon runs caused by stream flow effects of water diversions are likely to generate little significant change in the commercial value of salmon supplied to the market and little change in incomes generated by the fishery.

Because recreational fishing values do not decline along with the commercial fishery prices, we would expect the economic value of recreationally caught salmon and steelhead to respond proportionately to moderate changes in run size. One study of the Columbia river and ocean salmon fishery shows a net economic value of $131.40 per fish caught in the ocean, and $84.40 per fish caught in the river (values updated from 1989 to 2002 dollars). To estimate a value of changes in salmon run size due to recreational fishing, we would need to multiply these values per fish by the fraction of fish caught by anglers.

REGIONAL AND SECONDARY IMPACTS

An updated 1987 Washington Input-Output model was used to estimate economic impacts of changes in hydropower and agriculture production, and the resulting estimates were updated to 2002 dollars. For the Management Scenario 1 allocation of 1 MAF of new diversion rights, we estimate a direct impact of statewide agricultural output of $2,032 million, an increase in employment of 18,420 and an expansion of value-added in the State economy of $841 million. These direct impacts represent the direct value of increased agricultural production. Because the agricultural sector is linked to suppliers of agricultural inputs (equipment, fertilizers, etc.) and to processors of agricultural products, a change in agricultural production triggers change in the amount of economic activity in these linked sectors. These changes are called “secondary impacts”. Finally, the increase in incomes caused by direct and secondary income impacts will drive consumer demand for all products, thus causing a tertiary effect, called “induced impacts”. The sum total of all three impact elements on Washington State employment and value-added, called “total impact”, is listed in the following table.

Table 12.1 Summary of Direct and Total Economic Impacts of Agricultural Sector Expansion ($ millions)

	Employment		Value-Added	
	Direct	Total Impact	Direct	Total Impact
Scenario 1 (1 MAF)	18,420	44,841	$841.2	$2,032.2
Scenario 2 (700 KAF)	11,658	28,343	$531.9	$1,284.1
Scenario 3 (569 KAF)	8,733	21,205	$398.2	$960.3

The economic impact of changes in the hydropower system would stem from reductions in the export of hydropower from the Pacific Northwest, mainly to California during the summer and fall seasons. The reduced sales revenues by Bonneville Power Administration and by the Public Utility Districts along the mid-Columbia river would result in either increased rates or reduced expenditures by the associated public entities. Estimated economic impacts are a reduction in regional "value added" of $17 to $23 million, and reduced employment of 154 to 205 jobs.

PASSIVE USE VALUES

Passive use values are held by the public for all manner of economic goods, services, and conditions. These are thought to be particularly significant for public goods that are unique and scarce. Salmon and steelhead populations in the Columbia river qualify as targets for assessment of passive use values. A 1991 estimate of passive use values for salmon and steelhead suggests that a doubling of the fish runs in the Columbia would generate as passive use value of roughly $70 million/year (in 2002 $). A more recent study sponsored by the US Army Corps of Engineers estimates a passive use value for a reduction or 428 in Snake river salmon of $97,360, or $66.28 per fish. Finally, a recent study sponsored by the Washington Department of Ecology estimates a value function that indicates total value (use plus non-use value) for migratory fish populations in the Columbia river basin in Washington State. Applying that value function to a

doubling of the fish runs, and extrapolating across the whole population of Washington State, generates a value of $268.08 per fish. This total value would presumably capture both recreational and passive use value.

A different approach to assigning a value to passive use of salmon is to estimate the value the public places on various, realistic changes in the size of the anadromous fish runs, as was done by Layton, Brown, and Plummer (1999) for the Department of Ecology. While this valuation process incorporates both use and passive use values, the majority of the value estimated in the study is undoubtedly passive use value. The result is a value function, which serves to assign a value to changes in the overall fish population from the status quo level. For example, a 1/2% reduction in Columbia river anadromous fish run is estimated to cause a loss in passive use value of $7.15 million. (averaging $715 per fish). The evidence presented by that study clearly shows that passive use value held by State residents vastly exceeds the estimated commercial and recreational values of the fish, at least at recent population levels and for moderate changes in population size.

Once we have an estimate of the likely run size changes caused by increased diversions of water from the mainstem Columbia river, these passive use value estimates could be used to gauge the non-fishery economic values associated with changes in the salmon and steelhead runs. These estimated values should be given weight in decision processes only after careful consideration of passive use values that might attach to other features of the river system and human resources that are affected by the CRI scenarios.

WATER MARKETS

Water markets are an increasingly attractive alternative to regulatory or other non-market mechanisms for resolving disputes over water use and for improving the efficiency of water use. By permitting willing sellers and willing buyers to transfer water, markets will generally shift water from lower valued to higher valued uses. Three types of transactions can accomplish this result. Outright purchases of permanent water rights, temporary leases of diversionary water rights, and transfers of ownership of stored water (typically in a storage reservoir) all facilitate the increase in value of water use. While numerous water transfers of all types have occurred in Washington State, the expansion of water markets is slowed by three obstacles:

1. Third party effects of water transfer, due to shifts in return flows, have to be taken into consideration, possible involving compensation or mitigation.
2. Partly due to third party impacts, the water right that can be transferred needs to be defined in terms of consumptive use, not diversionary right, and this requires documentation and measurement that may not be immediately available.
3. There is often resistance to transfer of water from a traditional use (e.g. agriculture) to another use because of impacts on local communities and cultural attachments to traditional uses.

None of these is a fatal complication, but all three issues highlight the care required in development of a water transfer institution.

Washington State has made the legal changes necessary to permit water transfers. Current law requires that such transfers be submitted to the DOE for review and approval. The ability to retain water rights while temporarily transferring water use to instream flow has also been achieved in Washington. Among other example, we have noted that the Washington Water Trust has purchased and leased water for enhancement of instream flows in such places as Salmon Creek, a tributary of the Okanogan river. And the DOE has a water acquisition program designed to shift water from out-of-stream use to instream flow in chosen locations. All these examples illustrate the principle that increasing transferability of water rights can, given adequate attention to the three issues listed above, work to improve economic efficiency of water use and to improve stream flows.

VALUE PER ACRE-FOOT FOR ALTERNATIVE WATER USES

For purposes of comparing water allocations among uses, and for informing decisions concerning marginal shifts in water, it can be useful to view the economic values (at wholesale level) for the various uses. In this sub-section, we summary these value per acre-foot for agricultural, hydropower, and M&I use in various categories.

For irrigated agriculture, under the assumptions used in our analysis, the water allocated to the Columbia Basin Project generates about $10.70/AF in net revenues. For the non-Columbia Basin Project water, we have built in some shifts in cropping patterns, which we found to be a realistic depiction of the likely response to fees for new water rights. For the non-CBP water, the net revenue per acre-foot is much higher -- $62.47 to $69.41. Overall, the net value of new water

diversions to irrigated agriculture ranges from $48.09 with 1 MAF under Scenario 1 to $46.05 with 700 KAF under Scenario2 to $43.86 with 572 KAF under Scenario 3. The value per acre foot drops as the total water allocation increases because a larger fraction of the new water is going to the lower-valued agriculture in the Columbia Basin Project. These figures do not include the farmer's cost for the proposed fees for new water under Scenarios 2 & 3. With the $10 and $20/AF fees under Scenarios 2 and 3, the after-fee net values would be lower, obviously.

Table 12-. Net Revenue per Acre-Foot of New Water Allocation

	3 Levels of New Water Rights		
	1 MAF	700 KAF	572 KAF
CBP	$10.70	$10.70	$10.70
Non-CBP	$62.47	$64.56	$69.41
Overall	$50.56	$46.05	$43.86
Minus Fees	$40.6	$36.05	$23.86

The value of water left instream for generation of hydropower varies by location, as explained in Chapter 5, because the total elevation and generation efficiency of downstream dams determines the amount of electricity generated. An acre-foot of water in Roosevelt lake above Grand Coulee dam will generate an average of $37.39 worth of electricity if left instream rather than diverted through the Columbia Basin Project. An acre-foot of water at Wells dam is worth $15.65 to the hydropower system, and an acre-foot of water at McNary dam is worth $7.46 per acre-foot. These are cumulative values of all hydropower produced system wide as the water runs downstream past the Bonneville dam.

As noted in Chapter 4, we have much less reliable information for estimating specific values for water diverted into municipal and industrial use. But the scarce water transactions data gives us a range of prices from $0 up the $452 per acre-foot, with a median estimate of $226.

CONCLUSION

The Columbia River Initiative promises to encompass a number of important developments in the economy and environment of Washington's portion of the Columbia river. While considering increased diversions of water of up to 1 million acre feet, the CRI "management scenarios" also incorporate improved water efficiency and metering requirements, and they propose levying fees for new water users of $10 to $30 per acre-foot per year, with the fee level depending upon the level of threat to salmon runs. The economic review shows that these increased diversions are (a) unlikely to have significant impacts on flood control or river navigation, (b) will have moderately large negative impacts on hydropower production, (c) will have large positive impacts on the agricultural economy and on the regional economy that encompasses agriculture, and (d) might have some negative effects on fisheries and passive use values tied to salmon and steelhead runs. To some degree, the fees proposed under the second and third management scenarios will permit the State to mitigate the effects of increased water diversion on the fish and wildlife resources. Finally, improving and facilitating the exchange of water rights among users through water markets should improve the efficiency of water use and provide opportunities to acquire water for use by fish and wildlife.

TIMING OF ECONOMIC EFFECTS OF WATER ALLOCATION

Because the allocation of new water rights by the Department of Ecology will follow processes that take time, and because many of the prospective new water rights holders will need to invest in water conveyance facilities or land improvements before using the water rights, we do not expect the water rights to be utilized immediately. The water rights certification and utilization will play out over the future on a pace and schedule determined by administrative and economic factors which are difficult, if not impossible, to forecast accurately. Consequently, the economic effects discussed in the foregoing sections do not consider the timing issue, but represent the full effects that would not occur at some future date when the water rights are actually fully implemented. A complete review and approval of the DOE decisions under the Columbia River Initiative may be subject to requirements under the State Environmental Review Act that seek a more detailed explanation of the time path of water allocations and economic effects. The following is a first-cut suggestion as to how these actions may play out over time.

The rule-making process is likely to take up at least one to two years. Water allocations for the first level of irrigation water during the following two years could cover at least the

existing pool of applications – which amounts to 271,570 AF for irrigation. The applications for 76,798 AF for M&I (Table 2.4) might be utilized over incrementally over the 7 years from 2004 through 2010. The proposed 220 AF allocation to the Columbia Basin Project cannot be utilized until additional conveyance facilities are developed within the project, and these require Federal funding, which we expect to take several years. Then construction of new facilities would begin utilizing the new water in approximately 5 years. The full CBP allocation might be utilized by the end of 10 years. The remaining water rights are associated with users who have not yet been identified, and whose plans cannot be even approximately anticipated. In the absence of a severe downturn in agricultural prices or a new endangered species action which could prohibit new water diversions, we would expect that the additional new water rights for irrigation would be absorbed into the irrigated farm sector steadily over the 18 years (42.4 KAF/yr.).

If these assumptions and projections are taken together, we would expect the allocation of 1 MAF of new water to play out over time in a manner roughly as follows:

Table 12.2. Timing of 1 MAF of Water Rights Allocations. Amounts of Water that would be certified during each 5 year period in the future.

Time Period	M&I Water KAF	Irrigation Water KAF
2004 – 2005 (2 yrs.)	10.8	271.6
2006 – 2010 (5 yrs.)	27.0	209 (CBP) + 142.6
2011 – 2015 (5 yrs.)	27.0	142.6
2016 – 2020 (5 yrs.)	27.0	142.6

If less than 1 MAF of water rights are eventually permitted, as in our lower bound estimates of 700 KAF and 572 KAF, the entries for years beyond the first year for irrigation water would be reduced. For the 700 KAF lower bound, the last two entries for irrigation (142.6 KAF fro each 5-years) would become 0, and the 142.6 KAF in 2006-2010 would become 128 KAF. For the 572 KAF lower bound, all three of the 142.6 KAF increments for irrigation water from 2006 onward would become 0.

This schedule of water rights creation is obviously just a reasoned guess regarding the future course of events. But it does help to illustrate how the administrative and economic planning and investment needs are likely to stretch out the period over which the economic effects will occur.

SOME LIMITATIONS IN THE SCOPE OF THIS STUDY

This report is limited in scope to the five Management Scenarios provided by the Department of Ecology, and it does not consider a wider range of mainstem water policies suggested by some interest groups. The report is also limited in considering only those future changes in the economy which can reasonably be inferred from recent past information. In particular, we have not built into the analysis affects of future climate trends that have been predicted for the Pacific Northwest. Without closer examination, it is unclear how the various economic sectors will need to adjust to predicted increases in average temperatures and higher snow levels. Further, this report does not consider regional repercussions of increased water diversions in Washington State. For example, reactions by the States of Idaho and Oregon, or by Treaty Tribes and Federal courts concerning water and fish allocations, have not been incorporated. Finally, the report is narrowly focused on a set of economic effects of the CRI program, and this leave out other potentially important social and legal ramifications of increased water use from the mainstem Columbia river.

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