BENEFIT-COST ANALYSIS OF THE YAKIMA BASIN INTEGRATED PLAN PROJECTS

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Executive Summary

The Yakima River Basin lies in semi-arid south central Washington and supports a growing population as well as $3 billion agricultural industry that is heavily dependent on irrigation for production. The river system historically supported large runs of salmon and steelhead, but a variety of stressors both internal and external to the basin have reduced those populations substantially since the early 20th century. A reservoir system supplies water through the operation of five reservoirs with a combined storage totaling just over a million acre-feet (af). Stream flow is primarily derived from the spring snowmelt runoff. Precipitation in this area is winter-dominant, and is stored in the snowpack as a natural but seasonally declining reservoir for spring and summer water use. Water rights in the basin are over-appropriated such that a number of droughts in the last few decades have led to curtailment of water to junior water rights holders.

Historical drought impacts, concerns over the effects of climate change on snowpack, the potential for increasing anadromous fish abundance in the basin, and future municipal water demands have been the impetus for the development of the Yakima River Basin Integrated Water Resource Management Plan ("IP"). The IP includes the following elements:

- Reservoir Fish Passage
- Fish Habitat Enhancement
- Modifying Existing Structures and Operations
- Surface Storage
- Market-Based Reallocation
- Groundwater Storage
- Enhanced Water Conservation

Fish passage projects, habitat enhancements, and instream flow augmentation are designed to support increases in salmon, steelhead, and other fish populations in the basin. Proposed infrastructure and water market development are intended to mitigate instream and out-of-stream drought impacts through increased storage and improved water trading, respectively. In particular, the surface water and groundwater storage projects would increase cumulative water storage by 500,000 af for a total of 1.5 million af in the basin.

Many analyses of the IP and its components have been published to date. One of them, the "Four Accounts analysis" (2012), compares the net benefits of the IP as a whole against a no-IP alternative, and reports benefits ranging from $6.2 billion to $8.6 billion, and costs ranging from $2.7 billion to $4.4 billion. The reported Benefit/Cost (B/C) ratios are 1.4 and above, suggesting that the benefits of the IP as a whole outweigh its costs in aggregate net present value. These B/C results are provided for the full proposed implementation of the IP, but with limited exceptions, existing studies do not provide estimates of the net benefits of the individual components of the IP.

Section 5057 of the State of Washington Capital Budget for 2013 charges the State of Washington Water Research Center "to prepare separate benefit-cost [B-C] analyses for each of the projects proposed in the 2012 Yakima River basin water resource management plan [IP]". It further stipulates that "To the greatest extent possible, the center must use information from existing studies, supplemented by primary research, to measure and evaluate each project's benefits and costs." This report is in response to and framed by this charge.

Existing hydrologic and water management models of the Yakima River basin are used to examine the impact of proposed IP water storage projects, conservation, and proposed instream flows on drought impacts under a limited set of climate scenarios. A crop production model is used to assess the potential economic impact of IP projects and water market development on the economic risk of water curtailment. Municipalities in the basin are slated to receive water rights for future population growth under the IP, and

these benefits to municipalities are estimated. The net benefits of fish passage for the five reservoirs in the basin, proposed IP instream flows, and habitat restoration in the basin for salmon and trout are assessed.

Because each of the proposed IP projects would operate within the Yakima Basin hydrologic system, there are extensive interdependencies among projects, so that the benefits of one project are often dependent on the implementation status of other projects. We show that the value of any given water storage projects is highest when no other water storage project is implemented, and that water market development also affects the value of water storage projects. The economic tradeoffs between instream flows for fish and out-of-stream water uses are also dependent on these factors. Selected results include the following:

- *A snapshot of IP benefit estimates for moderate climate, water market, and baseline fish scenarios.*
  - Agricultural irrigation benefits: $117 million.
  - Municipal and domestic benefits: $32 million.
  - Fish benefits: $1 to $2 billion.
- *When implemented together as part of the IP, the major water storage projects as a group do not pass a B-C test.* Net present value for out-of-stream benefits (NB) from the IP range from -$2.2 to -$2.7 billion (B/C ratios from 0.02 to 0.20) depending on market and climate assumptions. Estimated benefits of proposed instream flow increases cannot make up for this shortfall.
- *No individual water storage project provides positive net benefits for out-of-stream uses when implemented as part of the full IP, even under the most adverse climate and restrictive market conditions.*
- *Net benefits for out-of-stream use of individual water storage projects implemented with no other projects implemented are negative, with some exceptions under the most adverse climate and water market conditions.* Based on moderate climate and market outcomes, storage infrastructure projects implemented alone and without proposed IP instream flow augmentation result in the following estimated out-of-stream net present value and B/C ratios, none of which passes a B-C test:
  - Bumping Lake Expansion: NB=-$371 million; B/C ratio of 0.18.
  - Cle Elum Pool raise: NB= -$6 million; B/C ratio of 0.62. Under the most adverse climate scenario and moderate market conditions, NB=$5 million with a B/C ratio is 1.35. It is also the most likely of the storage projects to satisfy a B-C test under moderate climate based on the sum of out-of-stream and instream use value.
  - Keechelus to Kachess Conveyance: NB= -$110 million; B/C ratio of 0.20.
  - Kachess Drought Relief Pumping Plant: NB= -$107 million; B/C ratio of 0.46. Under the most adverse climate considered, Keechelus to Kachess Conveyance and Kachess Drought Relief Pumping Plant together provide net benefits of $6 million and a B/C ratio of 1.02.
  - Passive Aquifer Storage and Recovery: NB=-$82 million; B/C ratio of 0.35.
  - Wymer Dam and Reservoir: NB= -$1,217 million; B/C ratio of 0.09.
  - Due to diminishing economic returns to water in the basin, increasing the number of IP storage projects reduces the value of each water storage project implemented.
- *Instream flow benefits are insufficient to support the full suite of IP water storage projects given the net benefit shortfall in out-of-stream benefits, but proposed instream flows may be supportable through market purchases.*
  - Purchases of senior water rights to implement proposed IP instream flows would be less expensive than providing instream flows via IP storage infrastructure, with estimated costs ranging from $85 million to $500 million depending on water market and climate conditions.

- Because of its low cost, Cle Elum pool raise is most likely to satisfy a B-C test under moderate climate based on the sum of estimated out-of-stream and instream benefits.

- *Reservoir fish passage projects are likely to provide positive net benefits through their pivotal role in supporting wild sockeye reintroduction into the basin.* Fish passage is estimated to provide benefits ranging from about $0.95 to $1.7 billion and cost a total of $0.35 billion for all fish passage projects, which provide B/C ratios ranging from 2.7 to 4.9 for the individual fish Passage projects.
- *Fish habitat restoration is unlikely to satisfy a B-C test.* Results for the net benefits of instream flow purchases and restoration investment together range from about $48 million to $294 million, which fall below their estimated combined costs of $450 million. IP restoration costs are estimated at $338 million, so our results suggest that restoration does not satisfy a B-C test. However, insufficient evidence exists to estimate the contribution of habitat restoration to fish passage productivity, which may affect the value of restoration.
- *Water markets show potential for reducing the impacts of basin-wide curtailment.* We estimate that potential net gains from trade net of estimated transaction costs range between $216 million and $1.4 billion depending on climate, the extent of market development, and the extent of IP development. We show that markets act as a substitute for IP water storage infrastructure in that more active markets reduce the value of IP water storage infrastructure.

This report is not intended as a review of prior benefit-cost assessments of the IP, but it does utilize and extend existing IP analyses, and sheds some light on the sources and accuracy of previous B-C estimates. The Four Accounts analysis estimates agricultural benefits of 0.8 billion, municipal benefits of 0.4 billion, fish benefits ranging from $5 to $7.4 billion, and costs ranging from $2.7 billion to $4.4 billion, which together provide positive net benefits and B/C ratios of 1.4 and higher. Our estimated benefits are lower for each category for a host of reasons. Notably, the assumed climate regime has substantial consequences for agricultural benefits, and the baseline salmonid abundance in the Columbia River Basin has important consequences for fish benefits.

Despite differences in results, there are important similarities in our findings. Fish passage projects alone comprise a small percentage of median IP costs but provide about 75% to 80% of the estimated benefits of the IP. In contrast, IP investments for instream and out-of-stream uses account for about 66% of median costs but provide a small fraction of benefits, although this breakdown is not explicit in the Four Accounts analysis. This distribution of costs and benefits drives the strong results for fish passage.

In accordance to the legislative charge, this report focuses sharply on Benefit-Cost analysis to assess the economic efficacy of individual projects. It does not include an economic *impact analysis* to assess the indirect economic impact of IP investments on the local economy or the statewide impacts of the potential use of state funds to support the IP. Nor does this report cover costs and benefits from ongoing, non-IP programs within the basin whose outcomes may impact IP benefit metrics, such as fish translocation or hatchery operations.

Due to data limitations, the majority of the results are based on simulation methods rather than statistical analysis, though statistical analysis is provided when feasible and useful. The consequence is that the majority of our results do not lend themselves to statistical confidence assessment, although robustness analyses are performed. Many necessary tradeoffs were made with respect to modeling approaches due to the dimensionality and scope of this research mandate. As is always true of modelling exercises, refinements are certainly possible and may provide more precision and accuracy for various aspects of this analysis.