Yakima River Basin Integrated Water Resource Management Plan

Technical Memorandum: Preliminary Cost Allocation for the Proposed Integrated Water Resource Management Plan

U.S. Bureau of Reclamation
Contract No. 08CA10677A ID/IQ

Prepared by

HDR Engineering, Inc.

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Columbia-Cascades Area Office

State of Washington
Department of Ecology
Office of Columbia River

October 2012

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1.0 Introduction

The Proposed Yakima River Basin Integrated Water Resource Management Plan (Integrated Plan) identifies a range of projects and programs to address long-standing needs for ecological restoration and water supply in the Yakima River Basin of Washington State (Reclamation and Ecology, 2011c).

Prior technical memoranda related to the Integrated Plan estimated costs and benefits of the Integrated Plan (Reclamation and Ecology, 2011a, 2012a, 2012b). This *Preliminary Cost Allocation Technical Memorandum* is prepared as supporting technical information included in the *Framework for Implementation Report* and provides a preliminary analysis of how costs of the Integrated Plan should be allocated to the various purposes of the plan.

Funding for the projects that make up the Integrated Plan are expected to be cost shared among a wide range of partners. Even though this Study utilizes traditional economic tools and analyses (Principles and Guidelines), the Integrated Plan is not intended to be funded as a typical Reclamation project. It is anticipated that the State of Washington would continue to be a cost-share partner in funding implementation of many of the elements of the Integrated Plan, as well as local governments and other parties. At this time, however, specific cost-sharing provisions between local, State, Federal governments, as well as other partners, have not been determined.

1.1 Overview of the Integrated Plan

The Integrated Plan addresses a variety of water resource and ecosystem problems in the Yakima River Basin using a comprehensive approach to water resource management and habitat enhancement. The seven elements of the Integrated Plan and summary of all of the projects and programs under each element are listed in Table 1.

Table 1. Elements and Actions Included in Integrated Plan

Element/Action	Description
Fish Passage	
Clear Creek Dam passage	Improve upstream and downstream fish passage at Clear Lake
Cle Elum Dam passage	Add upstream and downstream fish passage facilities
Bumping Dam passage	Add upstream and downstream fish passage facilities
Tieton Dam passage	Add upstream and downstream fish passage facilities
Keechelus Dam passage	Add upstream and downstream fish passage facilities
Kachess Dam passage	Add upstream and downstream fish passage facilities
Structural and Operational Changes	
Raise Pool at Cle Elum Dam	Three-foot increase in storage pool elevation
KRD Canal Changes	Reduce seepage and enhance tributary flows
Keechelus to Kachess Pipeline	Optimize storage between two reservoirs
Subordinate Power at Roza Dam and Chandler Power Plants	Reduce water diversions to support fish migration
Wapatox Canal Improvements	Improve efficiency and consolidate diversions
Surface Water Storage	
Wymer Dam	New off-channel reservoir (162,500 acre-feet). Also investigate removal of Roza Dam
Lake Kachess Inactive Storage	Tap inactive storage volume (up to 200,000 acre-feet)
Enlarged Bumping Lake Reservoir	Enlarge reservoir to 190,000 acre-feet
Columbia River Pump Exchange with Yakima Basin Storage	Conduct feasibility study; and periodically evaluate need for additional supplies
Groundwater Storage	
Shallow Aquifer Recharge	Late winter/early spring infiltration prior to storage control
Aquifer Storage and Recovery	Off-season recharge of municipal supplies
Habitat Protection and Enhancement	
Mainstem Floodplain Restoration	Program to fund a range of fish habitat projects
Tributaries Habitat Enhancement	Program to fund a range of fish habitat projects
Targeted Watershed Protection and Enhancements	Program to acquire and protect sensitive lands, including aquatic and terrestrial habitats
Enhanced Water Conservation	
Agricultural Water Conservation	Program to fund a range of projects
Municipal Water Conservation	Program to fund a range of projects and encourage conservation by residents
Market Reallocation	
Near-term Effort	Reduce barriers to trading
Long-term Effort	Additional steps to reduce barriers

Source: Reclamation and Ecology, 2011c
Notes: KRD = Kittitas Reclamation District

2.0 Allocation Methodology

Cost allocation is undertaken for multipurpose projects in order to identify an equitable distribution of costs among the purposes. Commonly used methods for cost allocation of Federal water projects include the Separable Costs – Remaining Benefits (SCRB) method; the Alternative Joint Expenditures (AJE) method and the Use of Facilities method (Reclamation, undated). The Use of Facilities method is less capable of achieving an equitable distribution of costs and is therefore more appropriate for sub-allocations within a given purpose, rather than the primary allocation for major project purposes. For the Integrated Plan the Use of Facilities method will be reserved for possible sub-allocations that may be needed in the future and is not considered further in this technical memorandum.

The SCRB and AJE methods are the same in most respects. Both methods use inputs such as the economic value of the benefits produced by the project; the construction cost; interest during construction (IDC); and operations, maintenance and replacement costs (OM&R). Both methods distinguish between costs that can clearly be assigned to one purpose only; and costs that are "joint" among multiple purposes. The difference between them is that SCRB uses "separable" costs that can be assigned to a single purpose; while AJE uses "specific" costs instead. Specific costs are the costs of clearly identifiable, physical features of a project than serve only a single purpose. Separable costs include specific costs, but also include other costs that could be eliminated if a particular purpose were excluded from a multipurpose project.

Because of this difference, the use of the SCRB method is generally expected to provide more equitable results in cost allocation. However calculation of separable costs requires more extensive analysis than calculation of specific costs. The AJE method can be used when the additional expense of performing SCRB is not justified given the value of the additional precision it offers (Reclamation, undated). For purposes of a preliminary cost allocation of the proposed Integrated Plan, Reclamation determined that the AJE method is sufficient.

2.1 Application of AJE Method

In brief, the AJE method separates out the specific costs that clearly should be associated with a single purpose. It then follows a step-by-step procedure to allocate the joint costs that remain. Allocated joint costs are added to specific costs for each purpose, to determine that purpose's share of total project costs. A more complete description of steps in the procedure follows (Reclamation, undated):

1. Identify total costs to be allocated. These include construction costs, IDC and OM&R.
2. Identify the economic value of project benefits, in terms of National Economic Development (NED);
3. Describe a Single Purpose Alternative (SPA) that could achieve each project purpose without the other purposes. Estimate the cost to construct the SPA for each purpose (including construction cost, IDC and OM&R).
4. For each purpose, the lesser of Item 2 or Item 3 represents the justifiable expenditure.

5. Identify specific costs, i.e. the costs of all distinct physical features that serve only one of the project purposes.
6. Subtract specific costs from the justifiable expenditure for each purpose, to determine the remaining justifiable expenditure for each purpose.
7. Divide the remaining justifiable expenditure for each component by the sum of all remaining justifiable expenditures. This yields the percentages to be used in distributing remaining joint costs.
8. Subtract the total specific costs from the total project costs to determine the remaining joint costs.
9. Allocate the remaining joint costs among project purposes, using the percentages determined in Item 7.
10. For each purpose, add the specific costs to the allocated remaining joint costs. This sum is the portion of the total project cost that should be allocated to each purpose.

This Technical Memorandum documents how this procedure was applied to costs of the Integrated Plan.

2.2 Definition of Project Purposes

The Integrated Plan provides benefits in multiple areas. As listed in the Final Programmatic Environmental Impact Statement (Reclamation and Ecology 2012c), these include:

- Watershed protection, ecological restoration and enhancement addressing instream flows, aquatic habitat, and fish passage;
- Improved water supply reliability during drought years for agricultural and municipal needs;
- Efficient management of water supplies for irrigated agriculture, municipal and domestic uses, and power generation;
- Improved ability of water managers to respond and adapt to potential effects of climate change; and
- Improved vitality of the regional economy and environmental sustainability of the Yakima River system.

In order to perform the preliminary cost-allocation these benefits can be grouped into three primary purposes:

- Ecological Restoration
- Agricultural Irrigation
- Municipal and Domestic Water Supply

At this time the Integrated Plan does not include provision of power generation facilities. It is possible that power facilities may be added to water storage or conveyance systems at a future time, either by the Federal Government, state government or through arrangement with a privately-owned power utility. Since power features are not included at this time, it is not necessary to allocate costs to the power generation purpose.

Additional benefits of the Integrated Plan include improved recreational opportunities, especially on acquired lands; and flood damage reduction from water storage and floodplain restoration projects. However, these benefits have not been specified in terms of quantitative outcomes, and would depend on programmatic decisions that would be made in the future. Because of this, the economic value of those benefits has not yet been estimated in monetary terms. Therefore recreation and flood damage reduction are not identified as individual purposes in the preliminary cost allocation. However these benefits may be allocated at a later date if additional information is developed.

3.0 Integrated Plan Benefits

This section summarizes the benefits, in monetary terms, of the three project purposes listed in the prior section. The benefits were estimated through analysis of the effects that implementation of the Integrated Plan would have on National Economic Development (NED). The NED effects are documented in a separate technical memorandum (Reclamation and Ecology 2012b).

3.1 Ecological Restoration Benefits

The Integrated Plan would increase future salmon/steelhead populations in the Yakima River Basin through the combined effects of many actions. Improvements in stream flows and habitat would be accomplished through:

- Investments to provide fish passage around all five of the major dams in the Yakima River Basin.
- Structural and operational changes at existing facilities that would improve streamflow conditions.
- Development of new surface water storage to increase water supplies and improve streamflow conditions.
- Development of ground water storage that would improve streamflow conditions.
- Targeted watershed protections and enhancements that would improve habitat in forested watersheds.
- Mainstem floodplain and tributary habitat enhancements.
- Promotion of municipal and domestic water conservation and direct investment in agricultural conservation that would improve streamflows.

Current production of salmon and steelhead in the Columbia River Basin is on the order of 2 million fish per year, on average (Fish Passage Center, 2011; Oregon Department of Fish and Wildlife 2012). Biological modeling indicates that, when fully implemented, the Integrated Plan would increase the number of adult salmon and steelhead in the Columbia River Basin by approximately 180,000 to 470,000 fish a year (Hubble, 2012).

A large component of the value of fisheries in the Yakima River Basin is “non-use” value. By its nature, non-use value cannot be determined from market conditions. Therefore alternative means for estimating fisheries value are necessary. The basis for the calculation of economic value of fisheries under the Integrated Plan is a valuation model derived from survey-based research, which estimates households' willingness to pay for future increases in fish populations in the Columbia River Basin. Approximately 1,600 households from throughout Washington State completed surveys in the original study. For purposes of evaluating the Integrated Plan, results were extrapolated to include Oregon households. The National Economic Development account analysis applied the willingness to pay model to the expected range of increases in salmon and steelhead populations over the next 100 years. The improvement in fish populations has an estimated value of $5.0 billion to $7.4 billion, expressed as present value[1] in 2012 dollars (Reclamation and Ecology, 2012b). For this preliminary cost allocation, a mid-point value of $6.2 billion was used.

The Integrated Plan would have additional benefits in the ecological restoration category that have not been estimated in monetary terms. These include the unquantifiable cultural and spiritual values that members of the Yakama Nation and others associate with increases in salmon/steelhead populations; benefits of the Integrated Plan for other species, including bull trout, which has been listed as threatened under the Endangered Species Act; and increases in the net value of recreational opportunities. These benefits have not been quantified, so are not included in the cost allocation procedure.[2]

3.2 Agricultural Irrigation Benefits

Irrigated agriculture is the largest user of water in the Yakima River Basin. Most of the water used for irrigation is provided by the Yakima Irrigation Project operated by Reclamation. The Integrated Plan would generate two types of irrigation-related benefits that were considered in the economic analysis: (1) it would stimulate market-based reallocation of water between irrigators, resulting in more transfers than otherwise would occur, and moving water from production of lower-valued crops to higher-valued crops; and (2) it would increase the supply of water available to irrigators during a severe drought. The economic analysis describes the anticipated annual net farm earnings under two scenarios, with and without the Integrated Plan, and projects those benefits over the next 100 years.

The results of this analysis show that, once fully implemented, the Integrated Plan could increase annual net farm earnings during a severe drought year to very near the values expected during an average non-drought year without the Integrated Plan. Over the next 100 years, the overall present value of the Integrated Plan's irrigation-related benefits, discounted at 4.0 percent, is about $800 million in 2012 dollars (Reclamation and Ecology, 2012b).

Additional benefits to irrigated agriculture were not estimated in the NED analysis. These include benefits to irrigators who would have a more reliable water supply in years with less than a severe drought; improved resiliency and adaptability of the water system; and potential benefits

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[1] "Present value" is a standard concept used in economics to compare costs or benefits that will occur at different times in the future. It is computed by discounting future costs and benefits by a percentage rate that compounds over time. The overall effect is that, all else equal, costs or benefits that occur in the present or near future are valued more than costs or benefits that will occur in the more distant future.

[2] Inclusion of additional benefits for the ecological restoration purpose would not change the outcome of the cost allocation. This is because the procedure requires that the lower of either the benefits or the single-purpose alternative cost be used in determining the justifiable expenditure. In this case the cost of the single-purpose alternative is lower. Increased benefits would still leave the single-purpose alternative cost as the lower value and therefore would not change the justifiable expenditure.

that would emerge as changes in climate reduce the supply and increase the demand for irrigation supplies in the basin. These benefits have not been quantified, so are not used in the cost allocation procedure.

3.3 Municipal and Domestic Water Supply Benefits

The economic analysis also examined the value of improved supply for municipal and domestic uses in the Yakima Basin. Municipal uses refer to all residential, commercial, industrial, and government uses of the public water systems in the Yakima River Basin that supply drinking water to consumers. Domestic uses refer to the household consumption of water supplies by the owners of domestic wells in the basin.

In 2010, municipal and domestic users in the Yakima River basin used approximately 91,000 acre-feet of water. Municipal users obtain water from surface and groundwater, while domestic wells rely exclusively on groundwater (Reclamation and Ecology, 2011b).

The current population served by municipal public water systems and domestic wells in the basin was estimated at 326,000 in the year 2010. By 2060, the population is projected to increase to 590,000 if no constraints on growth from water supplies occur. Modeling suggests that municipal/domestic use will rise 48,900 acre-feet above the 2010 level, to 140,000 acre-feet per year, by 2060 (Reclamation and Ecology, 2011b).

Municipal and domestic water supplies become restricted during dry years when low flows cannot meet all demands. Municipal and domestic uses are typically junior to irrigation water rights, so their supplies can be reduced when drought occurs. These circumstances have the potential to cause major disruption of service during severe drought years (Reclamation and Ecology, 2011c).

The Integrated Plan would yield economic benefits by providing water to satisfy demands that otherwise would remain unmet and by increasing the reliability of future water supplies. Increases in supply for municipal and domestic uses are expected to start materializing in 2020 and continue increasing with population growth through 2060, reaching 48,900 acre-feet annually. The value of this benefit was estimated based on market prices paid for municipal and domestic water supplies in the Columbia River Basin (the Yakima River Basin is part of the Columbia River Basin). The overall present value of the municipal and domestic supply benefits over a 100 year period is estimated to be $395 million in 2012 dollars (Reclamation and Ecology, 2012b).

4.0 Integrated Plan Costs

4.1 Construction Costs

Estimated construction costs for the projects and programs in the Integrated Plan were documented in a separate Technical Memorandum (Reclamation and Ecology 2011a). Costs at that time were estimated in third quarter 2010 dollars and are shown in Appendix A. While a range of costs from low to high was presented, only the middle of the range is considered here.

Costs have been modified since the Integrated Plan was issued in April 2011. First, the Thorp Conveyance System identified as an alternative means of filling Wymer Reservoir was removed from the list of projects, because its cost was deemed too high for the benefits it offered.

Second, a cost risk analysis was performed in Spring 2012 to more closely examine the costs of six large infrastructure projects within the Integrated Plan. Results of the cost risk analysis are documented in Reclamation and Ecology 2012a. For those six projects, the 50th percentile costs from the cost-risk analysis have been used in the cost allocation, replacing the original estimates[3]. Third, the cost of land acquisition was not identified in the Integrated Plan, because it is highly uncertain and can be determined only through negotiations with landowners. While this remains true, a preliminary value has been included here. The value used for land acquisition should be considered a gross estimate and would need to be refined once the actual costs are better understood. Finally, all costs from prior documents have been escalated to first quarter 2012 using Reclamation construction cost indices (Reclamation 2012).

Some of the projects and programs included in the Integrated Plan require capital investment but do not involve actual construction activity. For example, land acquisition does not, in itself, involve construction. Studies such as periodic updating of the water needs assessment do not involve construction. These cost items are included in the construction costs in order to provide a comprehensive accounting of costs to be allocated. However interest during construction is not calculated for those items (see Section 4.2).

Construction costs are displayed in Table 2. The table includes current year construction costs, representing costs in 2012 dollars without discounting. The table also includes the present value of construction costs. This is the discounted cost of projects after accounting for the various time periods that construction would occur. The present value is the value actually used in the cost allocation in Section 6. The total present value of construction cost is estimated to be $3.1 billion in 2012 dollars. (Section 6 of this technical memorandum also presents the construction cost as a future value[4] in year 2026.)

Table 2. Summary of Construction Costs

Project	Undiscounted Construction Cost ($M)	Completion Date[1]	Present Value ($M)
Fish Passage at Lake Cle Elum Dam	87.0	2018	71.5
Fish Passage at Bumping Lake Dam	28.4	2022	20.0
Fish Passage at Clear Creek Dam	3.2	2017	2.6
Fish Passage at Tieton Dam	105.2	2023	71.1
Fish Passage at Kachess Dam	105.2	2023	71.1
Fish Passage at Keechelus Dam	105.2	2023	71.1
Wymer Reservoir and Adjacent Intake	1,138.0	2019	918.1
Wymer Downstream Conveyance	289.0	2019	233.1
Conveyance from Lake Keechelus to Lake Kachess	197.0	2025	125.6
Lake Kachess Inactive Storage Alternative 1 - Tunnel	279.0	2025	177.9
Fish Passage at Box Canyon Creek	1.3	2023	0.8

[3] The six projects are: Wymer Reservoir, Wymer Downstream Conveyance, Bumping Lake Reservoir Enlargement, Kachess Inactive Storage, Keechelus-to-Kachess Conveyance and Cle Elum Dam Fish Passage.

[4] Future value is based on the same concept as present value. However it is calculated by compounding costs to a common future date, instead of discounting future costs to the present date. The percentage rate used is the same in both cases.

Project	Undiscounted Construction Cost ($M)	Completion Date[1]	Present Value ($M)
Bumping Lake Reservoir Enlargement	571.0	2022	409.5
Pool Level Increase at Cle Elum Dam	18.1	2017	15.5
KRD Main Canal and South Branch Modifications	38.3	2017	32.8
Wapatox Canal Conveyance - Alternative 2	87.7	2016	76.4
Mainstem Floodplain Restoration Program	288.3	2030	202.7
Tributaries Habitat Enhancement Program	192.2	2030	135.2
Enhanced Agricultural Conservation	427.1	2030	300.3
Municipal Conservation	0.0	N/A	0.0
Market Reallocation	2.1	2017	1.9
Groundwater Infiltration (Pilot Plus Full Scale)	111.5	2020	84.0
Municipal ASR Opportunities	5.3	2030	3.0
Columbia River Pumping & Storage Feasibility Study	4.3	2015	4.0
Land Acquisition Program	100.0	2015	88.9
Update Water Needs Assessment	0.3	2060	1.1
Periodic Review of Integrated Plan	0.2	2025	0.5
Roza Alternate Supply & Dam Removal Feasibility Study	1.1	2015	1.0
Other Mitigation (not broken out by individual project)[2]	2.5	2024	1.9
Total Construction Cost	4,188.2		3,121.7

Costs expressed in 2012 dollars.
[1] Completion date based on schedule from Integrated Plan (2011). Actual dates are subject to change.
[2] Mitigation costs are included in the six projects analyzed using cost risk assessment in 2012. This row represents additional mitigation not included in the individual projects.

For calculation of present value, a discount rate of 4.00% was used, as directed by the Federal Government (U.S. Department of the Treasury, 2012). The same rate was used to compound values in calculating future value (see Section 6). Construction schedules are based on the schedule included in the Integrated Plan document (see Appendix A, from Reclamation & Ecology 2011c). The scheduling of projects may change as the YRBWEP Workgroup works with state and Federal officials to determine how the plan would be implemented. The preliminary cost allocation may need to be updated periodically, as the implementation schedule is refined. However in broad terms, as long as implementation decisions maintain the balance among the different purposes of the Integrated Plan, changes in the implementation schedule are not expected to make a large difference in the percentages of costs allocated to the different purposes of the Integrated Plan.

4.2 Interest During Construction

The Federal procedure for cost allocation includes calculation of Interest During Construction (IDC). Interest is calculated only on costs of actually constructing the physical facilities, not design, planning, or permitting activities. Interest was calculated using the Federal rate for 2012 published by the Federal Government, which is 4.00 percent (U.S. Department of the Treasury, 2012). Interest was not calculated on costs of programmatic actions where it is assumed funds would be disbursed to various local project sponsors to reimburse their costs (e.g. agricultural conservation program, mainstem floodplain habitat program and tributaries habitat program).

Table 3 displays the present value of IDC by project, and for the Integrated Plan as a whole. Values are expressed in 2012 dollars. For more information, see Appendix B.

Table 3. Interest During Construction

Project	IDC (Present Value in $M)
Fish Passage at Lake Cle Elum Dam	3.3
Fish Passage at Bumping Lake Dam	0.9
Fish Passage at Clear Creek Dam	0.0
Fish Passage at Tieton, Kachess, and Keechelus Dams	9.9
Wymer Reservoir and Adjacent Intake	57.0
Wymer Downstream Conveyance (Roza Delivery)	14.5
Conveyance from Lake Keechelus to Lake Kachess	7.8
Lake Kachess Inactive Storage Alternative 1 – Tunnel	11.1
Fish Passage at Box Canyon Creek	0.0
Bumping Lake Reservoir Enlargement	25.4
Pool Level Increase at Cle Elum Dam	0.7
KRD Main Canal and South Branch Modifications	1.5
Wapatox Canal Conveyance – Alternative 2	2.4
Groundwater Infiltration (Pilot plus Full Scale)	4.3
Total	139

All values expressed in 2012 dollars.

4.3 Operation, Maintenance and Replacement Costs

Operations and maintenance (O&M) costs reflect activities occurring every year after a project has been constructed. These include operator wages, energy costs, spare parts, supplies, and routine repair work, among other things. O&M costs for projects in the Integrated Plan were estimated in Reclamation and Ecology 2011a. They are expressed as a constant annual value and have been escalated to first quarter 2012.

Replacement costs represent larger costs that occur occasionally as major components of a project wear out and need to be replaced. This includes, for example, costs of large pumps, valves, or other equipment. Generally these costs are estimated to recur at 25-year or 50-year intervals over the 100-year time period analyzed.

For purposes of cost allocation, O&M and replacement costs are combined into a single category called OM&R. OM&R costs are calculated on an annualized basis and a present value basis and are shown in Table 4. For more information, see Appendix B. As with construction and IDCs, Section 6 also presents these costs in terms of future value at year 2026.

Programmatic actions under the Integrated Plan include funding for agricultural conservation, mainstem floodplain habitat restoration and tributaries habitat restoration. It is assumed these programs would provide grants to project sponsors. With limited exceptions, OM&R costs were not calculated, because it is assumed either that facilities already exist and would incur OM&R

costs by local owners even without the Integrated Plan, or that OM&R costs would folded into grants issued to project sponsors and are therefore already counted in the capital cost for these programs used in this analysis.

Table 4. Summary of OM&R Costs

Project	Undiscounted Annual O&M ($M)	Undiscounted 100-Year Replacement ($M)	100-Year OM&R (Undiscounted) ($M)	Undiscounted Average Annual OM&R ($M)	Present Value 100-Year OM&R ($M)
Fish Passage at Lake Cle Elum Dam	0.3	4.4	4.7	$0.345	$6.654
Fish Passage at Bumping Lake Dam	0.3	1.4	1.7	$0.302	$5.386
Fish Passage at Clear Creek Dam	0.1	0.2	0.2	$0.073	$1.517
Fish Passage at Tieton Dam	0.3	5.3	5.6	$0.338	$5.523
Fish Passage at Kachess Dam	0.3	5.3	5.6	$0.338	$5.523
Fish Passage at Keechelus Dam	0.3	5.3	5.6	$0.338	$5.523
Wymer Reservoir and Adjacent Intake	3.9	236.6	240.5	$6.029	$105.579
Wymer Downstream Conveyance	0.1	3.2	3.3	$0.156	$2.931
Conveyance from Lake Keechelus to Lake Kachess	0.1	41.0	41.1	$0.491	$4.821
Lake Kachess Inactive Storage Alternative 1 - Tunnel	0.3	23.6	23.9	$0.496	$6.812
Fish Passage at Box Canyon Creek	0.0	0.1	0.1	$0.029	$0.510
Bumping Lake Reservoir Enlargement	0.2	95.3	95.5	$1.156	$17.428
Pool Level Increase at Cle Elum Dam	0.0	0.9	0.9	$0.009	$0.105
KRD Main Canal and South Branch Modifications	0.2	1.9	2.1	$0.171	$3.433
Wapatox Canal Conveyance - Alternative 2	0.2	18.1	18.3	$0.396	$6.469
Mainstem Floodplain Restoration Program	0.5	0.0	0.5	$0.494	$9.731
Tributaries Habitat Enhancement Program	0.0	0.0	0.0	$0.000	$0.000
Enhanced Agricultural Conservation	0.0	0.0	0.0	$0.000	$0.000
Municipal Conservation	1.1	0.0	1.1	$0.365	$15.944
Market Reallocation	0.2	0.0	0.2	$0.006	$0.484
Groundwater Infiltration (Pilot Plus Full Scale)	2.3	5.6	7.9	$2.186	$43.033
Municipal ASR Opportunities	0.3	0.0	0.3	$0.227	$3.586
Columbia River Pumping & Storage Feasibility Study	0.0	0.0	0.0	$0.000	$0.000
Land Acquisition Program	0.5	0.0	0.5	$0.308	$8.985
Update Water Needs Assessment	0.0	0.0	0.0	$0.000	$0.000
Periodic Review of IP	0.0	0.0	0.0	$0.000	$0.000
Roza Alternate Supply & Dam Removal Feasibility Study	0.0	0.0	0.0	$0.000	$0.000
Other Mitigation (not broken out by individual project)[2]	0.0	0.0	0.0	$0.000	$0.000
Totals	11.7	447.8	459.5	14.3	260.0

Costs expressed in 2012 dollars (millions).

Totals may be different from the sum of parts, due to rounding.

5.0 Cost Allocation

The cost allocation procedure used by Reclamation is defined in the Reclamation Economics Guidebook (Reclamation, undated). Section 2.2 of this technical memorandum described the step-by-step procedure. This section provides additional information on how Specific Costs, Single-Purpose Alternative Costs, Remaining Justifiable Expenditures, and Joint Costs were determined. Section 6 provides the cost allocation results.

5.1 Specific Costs

The AJE Method of cost allocation requires identification of "specific costs" or those that can be attributed to just a single purpose. Costs of the following components of the Integrated Plan were identified as specific costs for the preliminary allocation.

- **Costs specific to the Ecological Restoration purpose:**
  - Fish Passage at Cle Elum Lake Dam
  - Fish Passage at Bumping Lake Dam
  - Fish Passage at Clear Creek Dam
  - Fish Passage at Tieton, Kachess and Keechelus Dams
  - KRD Canal modifications to improve flow in local creeks
  - Wapatox Canal improvements to improve flows in the Naches River
  - Mainstem Floodplain Restoration Program
  - Tributary Habitat Enhancement Program
  - Land Acquisition Program

  The total specific cost for this purpose is $920 million, including construction, IDC and OM&R.

  Fish passage at Box Canyon Creek provides ecological benefits but was not identified as a "specific" cost in this category. This is because it accompanies the Kachess Inactive Storage project which has benefits for irrigated agriculture.

- **Costs specific to the Agricultural Irrigation purpose:**
  - Kachess Inactive Storage.
  - Fish passage at Box Canyon Creek (this project would accompany the Kachess Inactive Storage project; and would not be necessary without it)

  The total specific cost for this purpose is $197 million, including construction, IDC and OM&R.

  The Wymer Downstream Conveyance system was also considered for possible designation as a cost specific to agriculture. However the project team concluded that the improved operational flexibility afforded by this conveyance system has benefits for management of fish flows and water temperature, and therefore this is considered to be a joint cost between agriculture and ecological restoration.

- **Costs specific to the Municipal and Domestic Uses purpose:**
    - Municipal water conservation

  The total specific cost for this purpose is $16 million. This cost consists solely of O&M costs, due to the programmatic nature of the municipal water conservation action.

Of the remaining components of the Integrated Plan not listed above (e.g. storage projects, groundwater infiltration, agricultural conservation, etc.), no sub-features have been identified that can clearly be identified as "specific costs." Therefore all of the remaining projects were treated in full as "joint cost" items.

5.2 Single Purpose Alternatives

The AJE Method requires that a "Single Purpose Alternative" (SPA) be defined for each of the three purposes discussed in Section 2.3: Ecological Restoration, Agricultural Irrigation, and Municipal and Domestic Supply. This is defined as the cost of a comparable alternative project that would provide equivalent benefits in the same geographic area as the proposed project would, for just one of the purposes of the multi-purpose project. An SPA must be a project that it would be reasonable for the Federal Government to plan and construct.

An SPA was defined for each of the three purposes discussed in Section 2.3. These include groups of select projects at full size as well as downsized projects from the Integrated Plan. Each of the three SPA's was identified solely to carry out the cost-allocation procedure. The SPA's are not proposed for implementation.

Additional information on specification of the Single Purpose Alternatives is presented in Appendix C. Costs for the projects included at full size were based on cost data in Reclamation and Ecology 2011a. Costs for downsized projects were evaluated based on an engineering analysis of reduced-size project requirements, using the cost-estimation framework from Reclamation and Ecology 2011a. The engineering analysis and costs of the downsized projects are described in Appendix D.

5.2.1 SPA for the Ecological Restoration Purpose

The SPA for the Ecological Restoration purpose was defined to include all of the specific costs identified for this purpose (see Section 4.5) plus down-sized versions of certain projects with joint purposes. The projects included in this SPA are listed in Table 5. The total cost determined for this SPA in first quarter 2012 dollars is $2.6 billion, including construction, IDC and OM&R. See Appendix B for more information.

Table 5. Projects Included in SPA for Ecological Restoration

Projects Specific to this Purpose and Included at Full Size • Fish Passage at Cle Elum Lake Dam • Fish Passage at Bumping Lake Reservoir Dam • Fish Passage at Clear Creek Dam • Fish Passage at Tieton, Kachess and Keechelus Dams • KRD Canal modifications to improve flow in local creeks • Wapatox Canal improvements to improve flows in the Naches River • Mainstem Floodplain Restoration Program • Tributary Habitat Enhancement Program • Land Acquisition Program
Other Projects Included at Full Size • Keechelus to Kachess Pipeline • Cle Elum Pool Raise • Groundwater Infiltration
Downsized Projects • Bumping Lake Reservoir Enlargement (enlarged to 87 KAF instead of 198 KAF) • Wymer Reservoir (80 KAF instead of 162.5 KAF) • Wymer Downstream Conveyance (500 cfs instead of 1,000 cfs) • Agricultural Conservation (50% of the program cost)

KAF = thousand acre-feet; cfs = cubic feet per second

5.2.2 SPA for the Agricultural Irrigation Purpose

The SPA for the Agricultural purpose was defined in the same way as for the Ecological Restoration SPA but with reference to agricultural needs instead of ecological needs. The projects included in this SPA are listed in Table 6. The total cost determined for this SPA in first quarter 2012 dollars is $1.2 billion, including construction, IDC and OM&R. See Appendix B for more information.

Table 6. Projects Included in SPA for Agricultural Irrigation

Projects Specific to this Purpose and Included at Full Size • Kachess Inactive Storage • Fish Passage at Box Canyon Creek
Other Projects Included at Full Size • Bumping Lake Reservoir Enlargement • Keechelus to Kachess Pipeline • Agricultural Conservation • Market Reallocation • Groundwater Infiltration
Downsized Projects • None

5.2.3 SPA for the Municipal and Domestic Supply Purpose

The SPA for the Municipal and Domestic Supply purpose was defined in the same way as for the other two SPAs. All of the projects included in this SPA are listed in Table 7. The total cost determined for this SPA in first quarter 2012 dollars is $406 million, including construction, IDC and OM&R. See Appendix B for more information.

Table 7. Projects Included in SPA for Municipal and Domestic Supply

Projects Specific to this Purpose and Included at Full Size • Municipal Conservation • Municipal Aquifer Storage and Recovery (ASR)
Other Projects Included at Full Size • Market Reallocation • Cle Elum Pool Raise
Downsized Projects • Bumping Lake Reservoir Enlargement (enlarged to 68 KAF instead of 198 KAF)

KAF = thousand acre-feet

5.3 Remaining Justifiable Expenditure

Remaining justifiable expenditures are the remainder of costs left after subtracting specific costs from the justifiable expenditure.[5] The remaining justifiable expenditures for each purpose are divided by the total remaining justifiable expenditure to obtain each purpose's percentage. This percentage is then used to distribute the total joint costs among the project purposes (including its components: construction cost; IDC and OM&R cost).

5.4 Joint Costs

Joint costs are the costs of facilities that generate benefits for multiple project purposes and cannot be distinguished as specific costs. In the AJE procedure, they are costs remaining after specific costs have been subtracted from total costs. Each purpose is assigned a share of the joint costs, using the procedure described above under Remaining Justifiable Expenditure.

6.0 Cost Allocation Results

Cost allocation results are presented in Tables 8 and 9, using 2012 present values and 2026 future values, respectively (see discussion of future value, below). Additional data on the cost allocation is included in Appendix B. Using results expressed in 2012 present value, the allocation indicates the following breakdown among the three project purposes:

Ecological Restoration:	$2,440 million (69.3%)
Agricultural Irrigation:	$729 million (20.7%)
Municipal and Domestic Water Supply:	$351 million (10.0%)

[5] The justifiable expenditure is the lesser of either the benefits for a given purpose or the cost of the SPA for that purpose.

Table 8. Preliminary Cost Allocation – 2012 (Present Value)

Item	Project Purposes			Total ($M)
	Ecological Restoration	Agriculture	Municipal & Domestic	
1 Costs to be Allocated	0	0	0	3,520
Construction Costs	0	0	0	3,121
IDC	0	0	0	139
Capitalized OM&R	0	0	0	260
Annual OM&R	0	0	0	14
2 Benefits[1]	6,200	800	395	7,395
Benefits (Present Value)	6,200	800	395	7,395
3 Single Purpose Alternative Cost[2]	2,642	1,222	406	0
Construction Costs	2,349	1,100	350	0
IDC	101	49	21	0
Capitalized OM&R	191	73	35	0
Average Annual OM&R	11	4	2	0
4 Justifiable Expenditure[3]	2,642	800	395	0
5 Specific Costs[4]	920	197	16	1,133
Construction Costs	843	179	0	1,022
IDC	18	11	0	29
Capitalized OM&R	59	7	16	82
Average Annual OM&R	3	1	0	4
6 Remaining Justifiable Expenditure[5]	1,722	603	379	2,704
7 Percent Distribution	63.7%	22.3%	14.0%	100.0%
8 Remaining Joint Cost[6]	1,520	532	335	2,387
Construction Costs	1,337	468	294	2,099
IDC	70	24	15	110
Capitalized OM&R	113	40	25	178
Average Annual OM&R	7	2	1	10
9 Total Allocation[7]	2,440	729	351	3,520
Construction Costs	2,180	647	294	3,121
IDC	88	36	15	139
Capitalized OM&R	172	47	41	260
Average Annual OM&R	10	3	2	14

All values are expressed in 2012 dollars.

IDC = Interest During Construction; OM&R = Operations, Maintenance and Replacement

1. Benefits from National Economic Development (NED) analysis (2012).
2. Construction Cost from Reduced Size Projects technical memorandum (HDR 2012).
3. Lesser of values from Row 2 and Row 3.
4. Total costs of all project elements that are unique to just one purpose.
5. Values from Row 4 minus values from Row 5.
6. Using total column at far right, subtract value in Row 5 from value in Row 1. Then allocate the resulting value to the purposes, using percentages from Row 7.
7. Total allocation is the sum of Specific Costs from Row 5 and Remaining Joint Costs from Row 8.

Table 9. Preliminary Cost Allocation – 2026 (Future Value)

Item	Project Purposes			Total ($M)
	Ecological Restoration	Agriculture	Municipal & Domestic	
1 Costs to be Allocated	0	0	0	6,096
Construction Costs	0	0	0	5,405
IDC	0	0	0	241
Capitalized OM&R	0	0	0	450
Average Annual OM&R	0	0	0	25
2 Benefits[1]	10,736	1,385	684	12,806
Benefits (Present Value)	10,736	1,385	684	12,806
3 Single Purpose Alternative Cost[2]	4,575	2,116	703	0
Construction Costs	4,068	1,905	606	0
IDC	175	84	37	0
Capitalized OM&R	331	127	60	0
Average Annual OM&R	19	8	3	0
4 Justifiable Expenditure[3]	4,575	1,385	684	0
5 Specific Costs[4]	1,593	341	28	1,962
Construction Costs	1,460	310	0.0	1,770
IDC	31	19	0.0	50
Capitalized OM&R	102	13	28	142
Average Annual OM&R	5	0.9	0.6	7
6 Remaining Justifiable Expenditure[5]	2,981	1,044	656	4,682
7 Percent Distribution	63.7%	22.3%	14.0%	100.0%
8 Remaining Joint Cost[6]	2,632	922	580	4,133
Construction Costs	2,315	811	510	3,635
IDC	121	42	27	190
Capitalized OM&R	196	69	43	308
Average Annual OM&R	11	4	2.5	18
9 Total Allocation[7]	4,225	1,263	607	6,096
Construction Costs	3,775	1,120	510	5,405
IDC	152	62	27	241
Capitalized OM&R	298	81	71	450
Average Annual OM&R	17	5	3.1	25

All values are expressed in 2012 dollars.
IDC = Interest During Construction; OM&R = Operations, Maintenance and Replacement

1. Benefits from National Economic Development (NED) analysis (2012).
2. Based on Single Purpose Alternatives (SPA) analysis technical memorandum (June 2012).
3. Lesser of values from Row 2 and Row 3.
4. Total costs of all project elements that are unique to just one purpose.
5. Values from Row 4 minus values from Row 5.
6. Using total column at far right, subtract value in Row 5 from value in Row 1. Then allocate the resulting value to the purposes, using percentages from Row 7.
7. Total allocation is the sum of Specific Costs from Row 5 and Remaining Joint Costs from Row 8.

In many projects, a single facility or group of facilities is completed at the same time, and benefits begin to accrue in that year. Cost allocation then values all costs and benefits to that same year. The Integrated Plan is different, in that it contains a suite of many projects which are scheduled to be completed at different times. For consistency with Reclamation procedures, the year 2026 was selected as a common year for computation of the future value of all costs and benefits. This is the year when all of the discrete capital projects are scheduled to be operational based on the implementation schedule contained in the Integrated Plan. Results of the cost allocation are therefore provided for both 2012 and 2026.

This cost allocation is based on programmatic level analysis of project features and benefits. Implementation of the Integrated Plan would provide more accurate information on plan benefits and costs. Further, additional information may be developed as the plan elements are refined, such as allocation of water from reservoirs to meet the multipurpose aspects of the plan and benefits for a more reliable water supply for all post 1905 water users. The cost allocation would be expected to be adjusted accordingly when sufficient additional information is available to support the analysis.

7.0 Repayment

Reimbursable project functions included in the Integrated Plan are agricultural irrigation and municipal and domestic water supply. Construction costs allocated to agricultural irrigation are generally reimbursable without interest, while those allocated to municipal and domestic supply are reimbursable with interest. For the Integrated Plan, cost-share partners such as the State of Washington, local governments or other parties, may participate in reimbursement.

Ecological restoration is generally a non-reimbursable function that is typically expected to be borne by the U.S. Treasury in combination with the state and other cost-share partners.

It is anticipated that the State of Washington would be a partner in funding many of the elements of the Integrated Plan. At this time specific cost-sharing provisions between the State and Federal Government have not been determined.

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9.0 List of Preparers

NAME	BACKGROUND	RESPONSIBILITY
HDR ENGINEERING, INC.		
Andrew Graham	Public policy; water resource planning	Task Lead; Technical Memorandum Author
Keith Goss	Engineering	Cost Estimation, Cost Allocation Calculations
Richard Glassen	Cost Estimator	Construction Cost Estimation
Birol Shaha	Engineering	Engineering of Single Purpose Alternatives
Jim Peterson	Engineering	Review of Single Purpose Alternatives
ANCHOR QEA.		
Bob Montgomery	Engineering	Definition of Single Purpose Alternatives
RECLAMATION		
Randy Christopherson	Public policy and economics	Review of technical memorandum

Appendix A

Cost Summary and Schedule from the Integrated Plan

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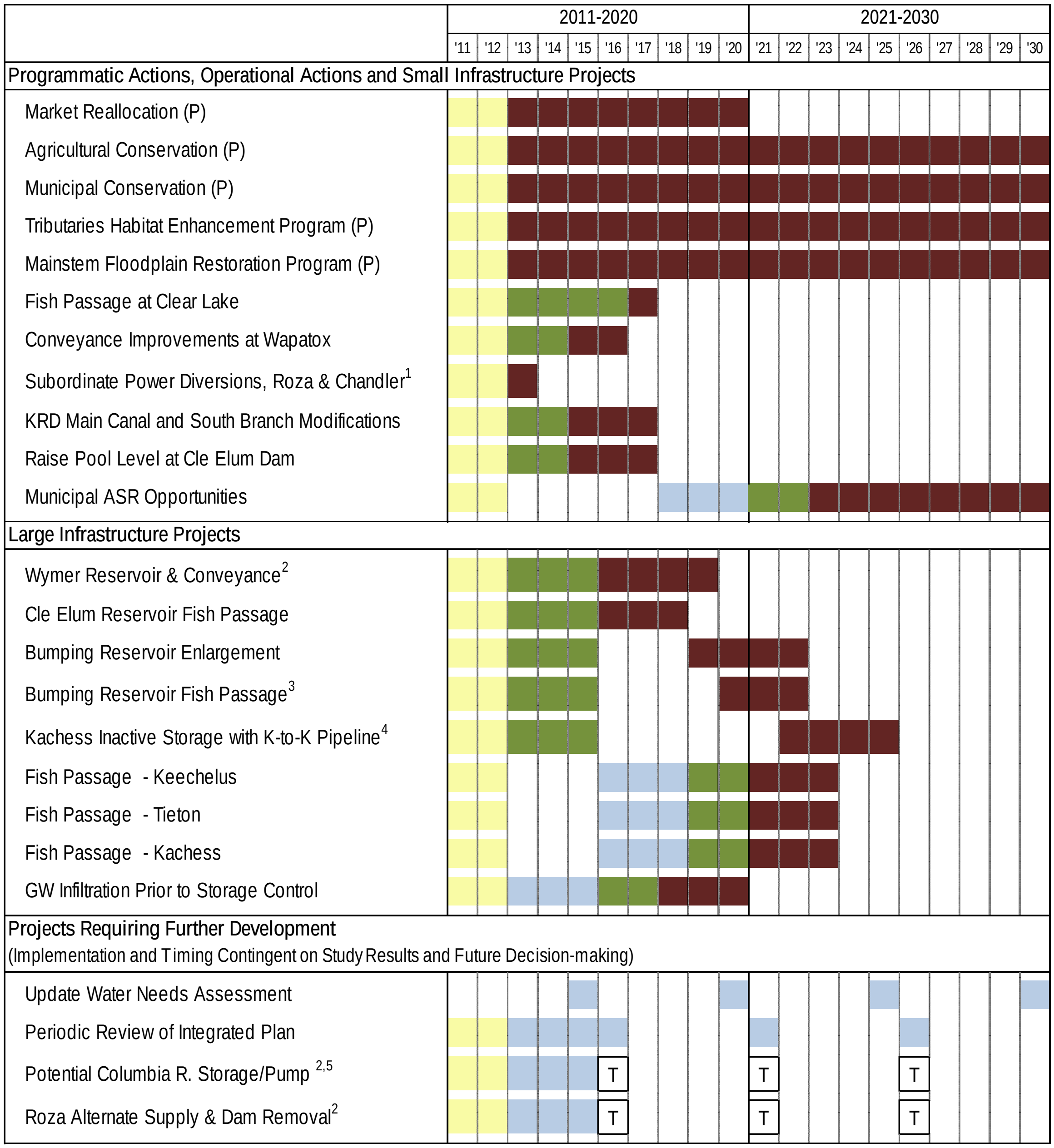
Estimated Costs from the Integrated Plan

	Construction Plus Non Contract Costs ($Million)[1]			Annual O & M ($Million)[1]
	Base Cost	Range		
		Lower	Upper	
Fish Passage at Cle Elum Lake Dam	$87.6	$70.0	$122.6	$0.30
Fish Passage at Bumping Lake Dam	$26.6	$21.3	$37.3	$0.30
Fish Passage at Clear Creek Dam	$3.0	$2.4	$4.2	$0.07
Fish Passage at Tieton, Kachess, and Keechelus Dams	$292.5	$234.0	$409.5	$0.90
Wymer Reservoir with Thorp Intake and Roza Delivery	$1,638.8	$1,311.1	$2,294.4	$4.05
Pipeline from Lake Keechelus to Lake Kachess	$190.7	$152.5	$266.9	$0.09
Lake Kachess Inactive Storage Alternative 1 – Tunnel	$253.8	$203.1	$355.3	$0.28
Fish Passage at Box Canyon Creek	$1.2	$0.9	$1.6	$0.03
Bumping Lake Enlargement	$402.5	$322.0	$563.5	$0.21
Pool Level Increase at Cle Elum Dam	$16.8	$13.5	$23.6	$0.00
KRD Main Canal and South Branch Modifications	$35.9	$28.7	$50.3	$0.15
Wapatox Canal Conveyance – Alternative 2	$82.1	$65.7	$115.0	$0.21
Mainstem Floodplain Restoration Program	$270.0	$216.0	$378.0	$0.50
Tributary Habitat Enhancement Program	$180.0	$144.0	$252.0	$0.00
Enhanced Agricultural Conservation	$400.0	$320.0	$560.0	$0.00
Municipal Conservation	N/A	N/A	N/A	$1.00
Market Reallocation	$2.0	$1.6	$2.8	$0.20
Groundwater Infiltration (Pilot study)	$4.7	$3.7	$6.5	$0.00
Groundwater Infiltration (Full Scale)	$98.2	$54.3	$163.6	$2.15
Columbia River Pump Exchange Study	$4.1	$3.3	$5.7	$0.00
Total	*$3,990*	*$3,168*	*$5,613*	*$10*

Source: Reclamation and Ecology, 2011c.
N/A = Not Applicable
Note: Cost of land acquisition for targeted watershed protections and enhancements have not been estimated and are not included in this table.
[1] Values are in 3rd Quarter 2010 dollars. Operation and maintenance (O&M) includes traditional O&M costs for projects and programmatic costs for nonproject actions.



(P) = Programmatic Actions

T = Assessment of triggers for possible implementation.

[1] Further power subordination subject to approval by Reclamation, BPA, and either Roza or Kennewick Irrigation District, as applicable.

[2] Roza alternate supply to be considered as part of Wymer Project or storage/pump exchange projects such as Columbia River supply.

[3] Timing of fish passage at Bumping Lake could be advanced to an earlier date if an enlarged reservoir is not authorized.

[4] I-90 crossing of K-to-K Pipeline to be constructed early (2012), in conjunction with Wash. Dept. of Transportation construction project.

[5] Step 1 in feasibility study of potential future storage/pump exchange projects.

Color Codes:

- PR / EIS and Authorization (for "trigger" projects, authorize studies)
- Studies
- Project environmental review, permitting & design
- Project Construction or Program Activation

Preliminary Implementation Schedule from the Integrated Plan

Appendix B

Cost Allocation Data

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Appendix B-1

Construction and OM & R Costs for Integrated Plan and Single-Purpose Alternatives

Construction Cost Summary (Present Value at Year 2012)

Project	2012 PV Full IP Costs	Specific Costs: Ecological Restoration	Specific Costs: Agricultural Irrigation	Specific Costs: Municipal/ Domestic Uses	SPA Costs: Ecological Restoration	SPA Costs: Agricultural Irrigation	SPA Costs: Municipal/ Domestic Uses
Fish Passage at Lake Cle Elum Dam	71,544,329	71,544,329			71,544,329		
Fish Passage at Bumping Lake Dam	19,963,282	19,963,282			19,963,282		
Fish Passage at Clear Creek Dam	2,632,584	2,632,584			2,632,584		
Fish Passage at Tieton, Kachess, and Keechelus Dams	213,242,840	213,242,840			213,242,840		
Wymer Reservoir and Adjacent Intake	918,071,155				606,023,771		
Wymer Downstream Conveyance (Roza Delivery)	233,148,123				168,447,502		
Conveyance from Lake Keechelus to Lake Kachess	125,603,075				125,603,075	125,603,075	
Lake Kachess Inactive Storage Alternative 1 – Tunnel	177,884,557		177,884,557			177,884,557	
Fish Passage at Box Canyon Creek	848,872		848,872			848,872	
Bumping Lake Enlargement	409,515,336				356,228,139	409,515,336	329,620,400
Pool Level Increase at Cle Elum Dam	15,458,721				15,458,721		15,458,721
KRD Main Canal and South Branch Modifications	32,780,189	32,780,189			32,780,189		
Wapatox Canal Conveyance – Alternative 2	76,425,393	76,425,393			76,425,393		
Mainstem Floodplain Restoration Program	202,734,918	202,734,918			202,734,918		
Tributaries Habitat Enhancement Program	135,156,612	135,156,612			135,156,612		
Enhanced Agricultural Conservation	300,348,026				150,174,013	300,348,026	
Municipal Conservation	-			-			-
Market Reallocation	1,889,175					1,889,175	1,889,175
Groundwater Infiltration (Pilot Study plus Full Scale)	83,960,681				83,960,681	83,960,681	
Municipal ASR Opportunities	3,035,054						3,035,054
Columbia River Pump Exchange Study	4,023,595						
Land Acquisition Program (assumed cost)	88,899,636	88,899,636			88,899,636		
Update Water Needs Assessment	265,225						
Periodic Review of Integrated Plan	159,135						
Roza Alternate Supply & Dam Removal Study	1,060,900						
Other Mitigation (not broken out by project)	2,500,000						
Column Total	**3,121,151,414**	**843,379,783**	**178,733,430**	**-**	**2,349,275,684**	**1,100,049,723**	**350,003,351**

Shading indicates down-sized projects for SPA.

Capitalized OM&R Summary (Present Value at Year 2012)

Project	2012 PV Full IP Costs	Specific Costs: Ecological Restoration	Specific Costs: Agricultural Irrigation	Specific Costs: Municipal/ Domestic Uses	SPA Costs: Ecological Restoration	SPA Costs: Agricultural Irrigation	SPA Costs: Municipal/ Domestic Uses
Fish Passage at Lake Cle Elum Dam	6,653,533	6,653,533			6,653,533		
Fish Passage at Bumping Lake Dam	5,385,918	5,385,918			5,385,918		
Fish Passage at Clear Creek Dam	1,517,202	1,517,202			1,517,202		
Fish Passage at Tieton, Kachess, and Keechelus Dams	16,570,488	16,570,488			16,570,488		
Wymer Reservoir and Adjacent Intake	105,579,148				66,206,101		
Wymer Downstream Conveyance (Roza Delivery)	2,930,656				2,802,633		
Conveyance from Lake Keechelus to Lake Kachess	4,820,651				4,820,651	4,820,651	
Lake Kachess Inactive Storage Alternative 1 – Tunnel	6,812,483		6,812,483			6,812,483	
Fish Passage at Box Canyon Creek	510,143		510,143			510,143	
Bumping Lake Enlargement	17,428,084				15,642,282	17,428,084	14,750,584
Pool Level Increase at Cle Elum Dam	104,525				104,525		104,525
KRD Main Canal and South Branch Modifications	3,433,103	3,433,103			3,433,103		
Wapatox Canal Conveyance – Alternative 2	6,469,462	6,469,462			6,469,462		
Mainstem Floodplain Restoration Program	9,730,763	9,730,763			9,730,763		
Tributaries Habitat Enhancement Program	-	-			-		
Enhanced Agricultural Conservation	-				-	-	
Municipal Conservation	15,943,669			15,943,669			15,943,669
Market Reallocation	483,966					483,966	483,966
Groundwater Infiltration (Pilot Study plus Full Scale)	43,033,232				43,033,232	43,033,232	
Municipal ASR Opportunities	3,585,878						3,585,878
Columbia River Pump Exchange Study - not allocated	-						
Land Acquisition Program (assumed cost)	8,984,633	8,984,633			8,984,633		
Update Water Needs Assessment							
Periodic Review of Integrated Plan							
Roza Alternate Supply & Dam Removal Study							
Other Mitigation (not broken out by project)							
Column Total	**259,977,536**	**58,745,101**	**7,322,626**	**15,943,669**	**191,354,525**	**73,088,558**	**34,868,622**

Shading indicates down-sized projects for SPA.

Average Annual OM&R Summary (Simple Average, not Present Value)

Project	Full IP Costs	Specific Costs: Ecological Restoration	Specific Costs: Agricultural Irrigation	Specific Costs: Municipal/ Domestic Uses	SPA Costs: Ecological Restoration	SPA Costs: Agricultural Irrigation	SPA Costs: Municipal/ Domestic Uses
Fish Passage at Lake Cle Elum Dam	344,576	344,576			344,576		
Fish Passage at Bumping Lake Dam	302,464	302,464			302,464		
Fish Passage at Clear Creek Dam	72,600	72,600			72,600		
Fish Passage at Tieton, Kachess, and Keechelus Dams	1,012,930	1,012,930			1,012,930		
Wymer Reservoir and Adjacent Intake	6,028,732				3,804,320		
Wymer Downstream Conveyance (Roza Delivery)	156,143				147,255		
Conveyance from Lake Keechelus to Lake Kachess	491,113				491,113	491,113	
Lake Kachess Inactive Storage Alternative 1 – Tunnel	495,654		495,654			495,654	
Fish Passage at Box Canyon Creek	29,147		29,147			29,147	
Bumping Lake Enlargement	1,156,183				1,032,197	1,156,183	970,288
Pool Level Increase at Cle Elum Dam	9,038				9,038		9,038
KRD Main Canal and South Branch Modifications	171,304	171,304			171,304		
Wapatox Canal Conveyance – Alternative 2	396,210	396,210			396,210		
Mainstem Floodplain Restoration Program	493,787	493,787			493,787		
Tributaries Habitat Enhancement Program	-	-			-		
Enhanced Agricultural Conservation	-				-	-	
Municipal Conservation	364,950			364,950			364,950
Market Reallocation	6,365					6,365	6,365
Groundwater Infiltration (Pilot Study plus Full Scale)	2,185,537				2,185,537	2,185,537	
Municipal ASR Opportunities	226,795						226,795
Columbia River Pump Exchange Study	-						
Land Acquisition Program (assumed cost)	307,500	307,500			307,500		
Update Water Needs Assessment							
Periodic Review of Integrated Plan							
Roza Alternate Supply & Dam Removal Study							
Other Mitigation (not broken out by project)							
Column Total	**14,251,027**	**3,101,371**	**524,801**	**364,950**	**10,770,831**	**4,363,999**	**1,577,435**

Shading indicates down-sized projects for SPA.

Appendix B-2

Replacement Costs of Major Project Features

Yakima Basin Study
Economic Effects Analysis - All costs escalated to First Quarter 2012
Extension of Costs to Year 100
Replacement Costs of Major Project Elements (Infrastructure Elements $1M and greater listed individually)

Project	Cost	Interval (yrs)	Last Year of Const.	Year Repair Work Occurs		
Cle Elum Improvements - 3' Pool Raise						
N/A	5%	50	2017	2067		
Keechelus to Kachess Pipeline						
Fish Screen Replacement	1,484,029	50				
Pipeline Repair	39,490,196	50	2025	2075		
Subtotal	40,974,225					
Kachess Inactive Storage Alt 1 - Tunnel						
Intake Tunnel Repair	2,135,294	25	2025	2050	2075	
Pump Replacement for 20 cfs Pump Station	1,200,000	25	2025	2050	2075	
Main Tunnel Repair	2,135,294	25	2025	2050	2075	
Subtotal	5,470,588					
Fish Screen Replacement	3,942,821	50	2025	2075		
Gates (two main gates, one needs plug below)	2,135,294	50	2025	2075		
Plug inlet for main gate replacement	1,067,647	50	2025	2075		
Subtotal	7,145,762					
Wymer Reservoir and Pump Station						
Spillway and Pipe Repair	1,067,647	25	2019	2044	2069	2094
Equipment Replacement	4,270,588	25	2019	2044	2069	2094
Dam Repairs at 5% every 25 years	56,900,000	25	2019	2044	2069	2094
Pipe Repair	0	0	0	0	0	0
Equipment Replacement	4,270,588	25	2019	2044	2069	2094
Subtotal	66,508,824					
Surge Tank Replacement	12,145,553	50	2019	2069		
Large Butterfly Valves	3,689,788	50	2019	2069		
Large Pump Replacement	19,348,968	50	2019	2069		
Large Isolation Valve Replacement	1,844,894	50	2019	2069		
Subtotal	37,029,203					
Wymer Downstream Conveyance (no powerhouse)						
Pipe Repair	1,067,647	25	2019	2044	2069	2094
Subtotal	1,067,647					
Bumping Lake Dam Enlargement						
Equipment Replacement - dam/reservoir	1,075,908	25	2019	2044	2069	
Dam Repairs at 5% every 25 years	28,550,000	25	2019	2044	2069	
Equipment Replacement - power plant	2,135,294	25	2019	2044	2069	
Subtotal	31,761,202					
KRD Canal South Branch Modifications						
N/A	5%	50	2017	2067		
Wapatox Canal Option 2						
Main Pipeline Repair/Replacement	15,588,235	50	2022	2072		
Pipe Repair and Replacement (Dist. Pipelines)	2,508,971	50	2022	2072		
Subtotal	18,097,206					
Fish Passage - Cle Elum						
N/A	5%	50	2018	2068		
Fish Passage - Bumping						
N/A	5%	50	2022	2072		
Fish Passage - Clear Lake						
N/A	5%	50	2017	2067		
Fish Passage - Box Canyon			2023	2073		
N/A	5%	50				
Fish Passage - (Tieton, Kachess, Keechelus)						
N/A	5%	50	2023	2073		
Enhanced Agriculture Conservation						
N/A	N/A	N/A				
Groundwater Infiltration (Pilot study : 2 areas)						
N/A	N/A	N/A				
Groundwater Infiltration (Full scale :160-500 acres)						
N/A	5%	50	2020	2070		
Columbia River Pump Station Study						
N/A	N/A	N/A				
Municipal Conservation						
N/A	N/A	N/A				
Tributary Habitat						
N/A	N/A	N/A				
Mainstem Habitat						
N/A	N/A	N/A				

Source: HDR analysis (K. Goss) performed Spring 2011 and Updated Spring 2012.

Appendix B-3

Interest During Construction for Integrated Plan and Single-Purpose Alternatives

IDCs - FULL Iintegrated Plan

IDC PER YEAR and 2012 PRESENT VALUE

	2012 Present Value	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Fish Passage at Lake Cle Elum Dam	3,316,150	0	0	0	446,154	1,356,308	2,302,868	0	$0	0	0	0	0	0
Fish Passage at Bumping Lake Dam	925,318	0	0	0	0	0	0	0	145,638	442,740	751,725	0	0	0
Fish Passage at Clear Creek Dam	40,501	0	0	0	0	49,276	0	0	0	0	0	0	0	0
Fish Passage at Tieton, Kachess, and Keechelus Dams	9,884,015	0	0	0	0	0	0	0	0	1,617,896	4,918,404	8,350,932	0	0
Full Size Wymer Reservoir and Adjacent Intake	57,039,506	0	0	0	4,376,923	13,305,846	22,591,926	32,249,449	0	0	0	0	0	0
Full Size Wymer Downstream Conveyance (Roza Delivery)	14,485,428	0	0	0	1,111,538	3,379,077	5,737,317	8,189,887	0	0	0	0	0	0
Pipeline from Lake Keechelus to Lake Kachess	7,803,684	0	0	0	0	0	0	0	0	0	757,692	2,303,385	3,910,905	5,582,725
Lake Kachess Inactive Storage Alternative 1 – Tunnel	11,051,918	0	0	0	0	0	0	0	0	0	1,073,077	3,262,154	5,538,794	7,906,499
Fish Passage at Box Canyon Creek	26,119	0	0	0	0	0	0	0	0	0	9,855	29,960	0	0
Bumping Lake Reservoir Enlargement	25,443,074	0	0	0	0	0	0	2,196,154	6,676,308	11,335,668	16,181,402	0	0	0
Pool Level Increase at Cle Elum Dam	716,527	0	0	92,694	281,788	478,447	0	0	0	0	0	0	0	0
KRD Main Canal and South Branch Modifications	1,519,394	0	0	196,557	597,532	1,014,546	0	0	0	0	0	0	0	0
Wapatox Canal Conveyance – Alternative 2	2,351,551	0	0	674,260	2,049,751	0	0	0	0	0	0	0	0	0
Groundwater Infiltration (Pilot Study plus Full Scale)	4,347,224	44,615	131,517	0	0	0	724,778	1,848,767	3,017,717	0	0	0	0	0
Columns Total	**138,950,410**	44,615	131,517	963,510	8,863,687	19,583,500	31,356,889	44,484,257	9,839,662	13,396,303	23,692,155	13,946,430	9,449,698	13,489,225

Downsized Projects - IDCs

Wymer Reservoir and Adjacent Intake (Downsized to 80 KAF)	37,652,089	0	0	0	2,889,231	8,783,262	14,913,054	21,288,037	0	0	0	0	0	0
Wymer Downstream Conveyance (Downsized to 500 cfs)	10,465,597	0	0	0	803,077	2,441,354	4,145,162	5,917,122	0	0	0	0	0	0
Bumping Lake Enlargement (Downsized to 87 KAF)	22,132,356	0	0	0	0	0	0	1,910,385	5,807,569	9,860,641	14,075,836	0	0	0
Bumping Lake Enlargement (Downsized to 68 KAF)	20,479,224	0	0	0	0	0	0	1,767,692	5,373,785	9,124,121	13,024,470	0	0	0

IDCs - Full Integrated Plan, Specific Costs, & SPAs
INTEREST DURING CONSTRUCTION

Project	2012 Present Value Full IP Costs	Specific Costs			SPA Costs		
		Ecological Restoration	Agricultural Irrigation	Municipal/ Domestic Uses	Ecological Restoration	Agricultural Irrigation	Municipal/ Domestic Uses
Fish Passage at Lake Cle Elum Dam	3,316,150	3,316,150	n/a	n/a	3,316,150	n/a	n/a
Fish Passage at Bumping Lake Dam	925,318	925,318	n/a	n/a	925,318	n/a	n/a
Fish Passage at Clear Creek Dam	40,501	40,501	n/a	n/a	40,501	n/a	n/a
Fish Passage at Tieton, Kachess, and Keechelus Dams	9,884,015	9,884,015	n/a	n/a	9,884,015	n/a	n/a
Wymer Reservoir and Adjacent Intake	57,039,506	n/a	n/a	n/a	37,652,089	n/a	n/a
Wymer Downstream Conveyance (Roza Delivery)	14,485,428	n/a	n/a	n/a	10,465,597	n/a	n/a
Conveyance from Lake Keechelus to Lake Kachess	7,803,684	n/a	n/a	n/a	7,803,684	7,803,684	n/a
Lake Kachess Inactive Storage Alternative 1 – Tunnel	11,051,918	n/a	11,051,918	n/a	n/a	11,051,918	n/a
Fish Passage at Box Canyon Creek	26,119	n/a	26,119	n/a	n/a	26,119	n/a
Bumping Lake Reservoir Enlargement	25,443,074	n/a	n/a	n/a	22,132,356	25,443,074	20,479,224
Pool Level Increase at Cle Elum Dam	716,527	n/a	n/a	n/a	716,527	n/a	716,527
KRD Main Canal and South Branch Modifications	1,519,394	1,519,394	n/a	n/a	1,519,394	n/a	n/a
Wapatox Canal Conveyance – Alternative 2	2,351,551	2,351,551	n/a	n/a	2,351,551	n/a	n/a
Groundwater Infiltration (Pilot plus Full Scale)	4,347,224	n/a	n/a	n/a	4,347,224	4,347,224	n/a
Column Total	**138,950,410**	**18,036,929**	**11,078,037**	-	**101,154,405**	**48,672,020**	**21,195,751**

Appendix C

Specification of Single Purpose Alternatives

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Table C-1: SPA for Ecological Restoration Purpose

Project	Volume of Water Needed or Provided	Cost Allocation	Notes
Bumping Lake Reservoir enlargement	42.5 kaf in drought years for late winter flow and spring flow. Release additional 11 kaf from Rimrock for winter flows.	Cost of expanded reservoir with 87 kaf total storage (53.5 kaf + existing 33.7 kaf)	This flow would be conveyed through lower Yakima River also helping satisfy need for spring pulses in drought years.
Wymer Reservoir	80 kaf. To enable additional flow releases from Cle Elum and Keechelus during winter (50 kaf) plus a 30 kaf pulse flow in drought years for upper Yakima River.	Cost of an 80 kaf reservoir	The fish storage portion of the full size reservoir from the Integrated Plan is 82.5 kaf.
Wymer Pump Station	200 cfs (one-half of the capacity in the Integrated Plan.)	Cost of a 200 cfs pump station and conveyance to reservoir	It could be argued that the entire 400 cfs capacity is needed to fill Wymer reservoir when flows in Yakima River are available.
Wymer downstream conveyance system (assumed required)	Assume 500 cfs, one-half of capacity in Integrated Plan.	Cost of 500 cfs conveyance system to Roza headworks.	
Lake Kachess Inactive Storage	None.	Not included.	Not needed for fish benefits as a single purpose
K-to-K pipeline project	400 cfs	Full cost of the project.	Needed to reduce flow in Upper Yakima River
Cle Elum Pool Raise	14.6 kaf	Full cost of the project.	Water will benefit fish in most years.
Agricultural conservation program	Good instream flow benefit for lower Yakima River. Assume one-half of program is implemented.	50% of the cost of the project in the Integrated Plan	One half the cost can yield a higher percentage of the benefits due to diminishing returns.
Groundwater Infiltration	To be determined.	Full cost of project.	

Kaf = thousand acre-feet; cfs = cubic feet per second

Table C-2: SPA for Agricultural Irrigation Purpose

Project	Volume of Water Needed or Provided	Cost Allocation	Notes
Bumping Reservoir enlargement	Assumed entire volume of Bumping and Kachess reservoirs from I.P. will be provided with remainder from Wymer since it is most expensive project.	Full cost of the project.	Estimated need for storage in multi-year drought (1994) is 412 kaf. Assume 200 from Kachess, 156 from Bumping (190 total volume – 33.7 existing storage) and 56 from Wymer. The need for 412 kaf comes from the RiverWare modeling (increase in supply of 386 kaf with the Integrated Plan under 2005 conditions). 26 kaf was added (water conservation).
Wymer Reservoir	Assume 200 kaf from Kachess, 156 kaf from Bumping Reservoir (190 kaf total volume – 33.7 kaf existing storage), 26 kaf from conservation and 30 kaf from water reallocation.	Not included.	Included Water Conservation and Water Reallocation in lieu of a smaller Wymer Reservoir as it is believed that even a smaller Wymer would be more expensive than those actions.
Wymer Pump Station	None.	Not included.	
Wymer downstream conveyance system	None.	Not included.	
Lake Kachess Inactive Storage	200 kaf of storage withdrawn during drought	Full cost of the project	Provides additional agricultural supply during a dry year.
Fish Passage at Box Canyon Creek	Not applicable.	Full cost of the project	Needed when Lake Kachess Inactive Storage is used.
K-to-K pipeline project	400 cfs	Full cost of the project	The reservoir will need to be refilled as quickly as possible after its use in drought years. The K-K pipeline serves this purpose.
Cle Elum Pool Raise	This project would not likely provide a reliable source of water during a drought year or extended drought	Not included.	
Agricultural conservation program	May provide 52 kaf during single year droughts (2005) and 26 kaf in the last year of a multi-year drought (1994).	Full cost of the program	This program does not provide a large benefit during extended drought periods, but it is less expensive than a reservoir project.
Groundwater Infiltr.	To be determined.	Full cost	
Market Reallocation	30 kaf	Full cost	Cost of leasing water are not included.

Table C-3: SPA for Municipal and Domestic Supply Purpose

Project	Volume of Water Needed or Provided	Cost Allocation	Notes
Bumping Lake Reservoir enlargement	Future increased municipal and domestic demand = 49 kaf. Assume 14.6 kaf provided by Cle Elum pool raise offsetting Kittitas Valley growth. Remainder (34 kaf) will be stored in Bumping Reservoir and used for the middle/lower Yakima River basin.	Provide cost for 34 kaf of additional storage in Bumping Reservoir	See Water Needs Assessment technical memorandum (2011) for basis of municipal and domestic needs.
Wymer Reservoir	None.	Not included.	
Wymer Pump Station	None.	Not included.	
Wymer downstream conveyance system (assumed required)	None.	Not included.	
Lake Kachess Inactive Storage	None.	Not included.	
K-to-K pipeline project	None.	Not included.	
Cle Elum Pool Raise	Assume the 14.6 kaf provided in most years will be used to satisfy upper Yakima River basin water needs for municipal and domestic demand	Full cost of the project	
Municipal conservation program	Very little in drought years	Full cost of the project	Conservation program was included as part of the water need estimates (see 2011 technical memorandum)
Market Reallocation	Mainly needed in drought years	Full cost of the project	
Municipal ASR	To be determined.	Full cost of the project.	

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Appendix D

Reduced-Size Projects for Single-Purpose Alternatives

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Technical Memorandum
Yakima River Basin Integrated Water Resource Management Plan – Preliminary Cost Allocation

To: Andrew Graham (HDR)

From: Birol Shaha (HDR)

Reviewed: Jim Peterson (HDR)

Date: July 6, 2012

Title: Reduced-Size Projects for Single Purpose Alternative (SPA) Preliminary Cost Allocation

CC: Keith Goss (HDR)

1.0 Introduction

As part of Preliminary Cost Allocation (Sub-task 11.7), several Single Purpose Alternative (SPA) Projects were identified as "reduced-size" projects of the full scale projects discussed in the Integrated Water Resource Management Plan (Integrated Plan). The purpose of this memorandum is to document the assumptions, revised design parameters, changes in quantities and unit costs for revised capital cost estimates for the reduced-size projects. The reduced-size projects are intended solely to carry out the federal cost-allocation protocol, and do not reflect any change in the planned capacity of projects described in the Integrated Plan.

Table 1-1 shows the original and "reduced-size" versions of four selected projects:

Table 1-1. Project Design Parameters for Reduced-Size Version

Project Name	Full Size Project	Reduced-Size Project
Wymer Dam and Reservoir (Incld. Diversion during construction, Road and Creek Improvements)	• 169 KAF storage capacity	• 80 KAF storage capacity Wymer Dam and Reservoir
Wymer Pump Station, Intake and Discharge Pipeline	• 400 cfs design flow for pumping station and associated discharge pipeline • 480 cfs design flow for Yakima River Intake	• 200 cfs design flow for pumping station and associated discharge pipeline • 270 cfs design flow for Yakima River Intake
Wymer Downstream Conveyance System	• 1000 cfs design flow capacity	• 500 cfs design flow capacity
Bumping Lake Reservoir Enlargement	• 198 KAF storage capacity	• Two Reduced-Size versions: (a) 87 KAF total storage capacity (b) 68 KAF total storage capacity

2.0 Wymer Dam, Reservoir & Pumping Plant

2.1 Overview of Full Size Project

Wymer Dam and Reservoir would be constructed to create a new off-channel storage facility in the intermittent stream channel of Lmuma Creek, which enters the Yakima River approximately eight miles upstream of the Roza Diversion Dam.

The dam would be a concrete-faced rock fill embankment approximately 450 feet high with a full-pool elevation of approximately 1,730 feet. The storage capacity of the reservoir would be approximately 169,000 acre-feet. A spillway and stilling basin would be located on the south abutment of the dam to discharge water into Lmuma Creek. Outlet works on the south dam abutment, sized for approximately 1,600 cfs, would return flow to Lmuma Creek and the Yakima River.

An approximately 180-foot-high central core rock fill dike would also be constructed in a saddle on the north side of the reservoir. The reservoir would be filled by a pumping plant with a capacity of approximately 400 cfs that would withdraw water from the Yakima River. A screened intake channel, approximately 200 feet long, on the Yakima River would carry water to the pumping plant.

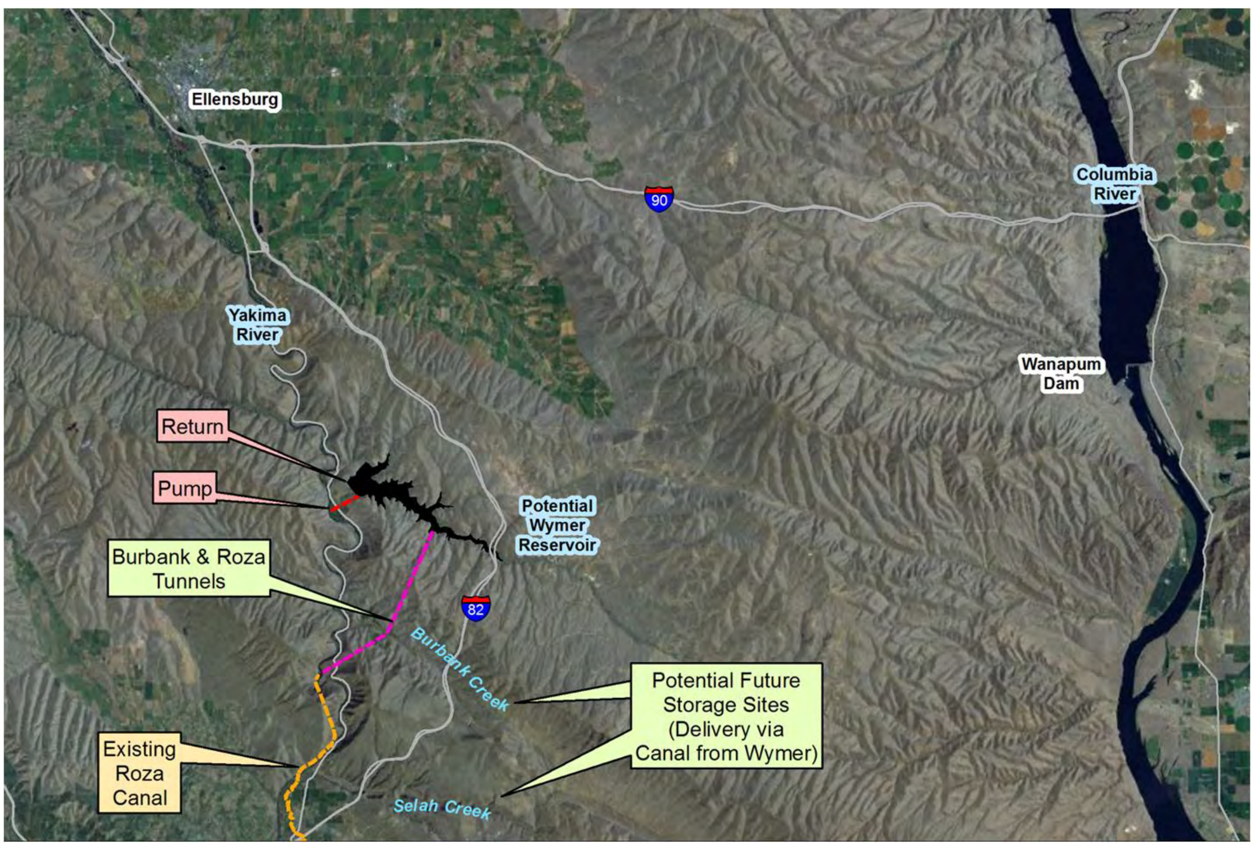

Figure 1. Wymer Dam and Reservoir

2.2 Reduced-Size Wymer Dam, Reservoir & Pumping Plant

The reduced-size Wymer Dam and Reservoir is designed for 80,000 acre-feet storage capacity. Based on the Wymer Reservoir capacity chart, the corresponding maximum water surface elevation is 1,645 feet. Attachment A1 shows the capacity chart for Wymer Reservoir.

The resulting concrete-faced rock fill embankment dam would be approximately 350 feet high with a full-pool elevation of approximately 1,645 feet, and a crest at EL1665 feet. The bottom of the active storage would remain the same at EL 1375 feet.

The spillway and stilling basin would at the same location, however, adjusted for the lower elevation. The outlet works on the south dam abutment would remain the same (sized for approximately 1,600 cfs).

The saddle dike on the north side of the reservoir would be approximately 100-feet-high with a crest at EL 1665 feet.

The new capacity of the pumping plant to withdraw water from the Yakima River would be approximately 200 cfs. The pumping equipment, building, intake and discharge piping would be sized for the lower flow rates.

Table 2-1 summarizes the major features of the reduced-size projects. Attachment A2 includes figures and concept designs of the full size projects that have been marked up for the reduced-size versions.

Table 2-1. Major Features of the "Reduced-Size" Wymer Dam and Reservoir

Project Components	Full Scale Project	Reduced-Size Project
Yakima River Intake:	• Design Flow Capacity: 480 cfs (includes 5% increase for pump wear factor and 60 cfs for fish bypass flows) • Min. Operating River WS= EL 1275.0 • Max. River WS = EL 1284 (1985 Planning Study) • Criteria for fish screens - Juvenile Fish Screen Criteria For Pump Intakes (NMFS-Northwest Region-1996): Approach velocity= 0.4 fps	• Design Flow Capacity: **270 cfs** (includes 5% increase for pump wear factor and 60 cfs for fish bypass flows) • Min. Operating River WS= EL 1275.0 • Max. River WS = EL 1284 (1985 Planning Study) • Criteria for fish screens - Juvenile Fish Screen Criteria For Pump Intakes (NMFS-Northwest Region-1996): Approach velocity= 0.4 fps • **Half size fish screen**
Pumping Plant:	• Design pumped flow capacity at TDH max of 475 feet: 400 cfs (w/o wear factor) • Head Range: 365 ft to 475 ft • Centerline units: EL 1256.67 • 7 equal-sized, fixed-speed, horizontal centrifugal pumps; • Each pump 60 cfs capacity; 4,000 HP	• Design pumped flow capacity at TDH max of 400 feet: **200 cfs** (w/o wear factor) • Head Range: **365 ft to 400 ft** • Centerline units: EL 1256.67 • **5 equal-sized**, fixed-speed, horizontal centrifugal pumps; • **Each pump 40 cfs capacity, 2500 HP**

Project Components	Full Scale Project	Reduced-Size Project
	• 48" inlet and 42" discharge piping and valves on each pumps; • Indoor plant with overhead crane; Building Size 250 feet x 100 feet	• **42" inlet and 36" discharge** piping and valves on each pumps; • Indoor plant with overhead crane; Building Size **200 feet x 100 feet;** • Same pumps configuration.
Discharge Pipe to Reservoir:	• 120-inch diameter intake manifold piping • 96-inch-diameter steel pipe • Pipe length= 4,700 feet • 46-foot-diameter steel air chamber • Outlet elevation in reservoir: EL 1610	• **96-inch** diameter intake manifold piping • **78-inch**-diameter steel pipe • Pipe length= 4,700 feet • 46-foot-diameter steel air chamber • Outlet elevation in reservoir: EL 1610
Reservoir:	• Normal WS (Top of Active Storage)= EL 1730 • Bottom of Active Storage= EL 1375 • Active Storage between EL 1375 and EL 1730: 169,076 A-F	• Normal WS (Top of Active Storage)= EL **1645** • Bottom of Active Storage= EL 1375 • Active Storage between EL 1375 and EL 1645: **80,000 A-F**
Main Dam:	• Type: Concrete face rock fill embankment • Top of Dam: EL 1750 • Crest Length= 3,200 feet • Maximum Structural Height= 450 feet	• Type: Concrete face rock fill embankment • Top of Dam**: EL 1665** • Crest Length= **2,500 feet** • Maximum Structural Height= **350 feet**
Saddle Dike:	• Type: Central core rock fill embankment • Top of Dike: EL 1750 • Crest Length= 2,700 feet • Maximum Structural Height= 180 feet	• Type: Central core rock fill embankment • Top of Dike: **EL 1665** • Crest Length= **1,800 feet** • Maximum Structural Height= **100 feet**
Spillway:	• Type: Reinforced concrete uncontrolled ogee crest • Top of Crest= EL 1730 • Crest Length= 60 feet • Total Length of spillway chute = 3200 feet • Rectangular chute on left abutment with air slots • Stilling Basin: Type II with slotted flip bucket • Discharge into Lmuma Creek	• Type: Reinforced concrete uncontrolled ogee crest • Top of Crest= **EL 1645** • Crest Length= 60 feet • Total Length of spillway chute = **2400 feet (Reduction of 20%)** • Rectangular chute on left abutment with air slots • Stilling Basin: Type II with slotted flip bucket • Discharge into Lmuma Creek
Outlet Works:	• Two-level intake at reservoir Bottom Intake Invert Elevation= EL 1375 Upper Intake Invert Elevation= EL 1456 • Sized for reservoir evacuation and	• No Change

Project Components	Full Scale Project	Reduced-Size Project
	releases. • 9.5-foot ID upstream tunnel • 15-foot ID downstream tunnel with 102-inch-diameter pipe. • Discharge into Lmuma Creek.	
Lmuma Creek:	• Channel modified for 100-year flood (1,600 cfs)	• No Change
I-82 Bridge Protection:	• Lowest elevation of eastbound bridge girders: EL 1741.7 • Coat piers with waterproofing membrane • Riprap embankments	• **NOT** required.

* All elevations are based on NGVD29 datum.

2.3 Cost Adjustments

The design and planning level costs for Wymer Dam, Reservoir and Pumping projects were originally prepared by Bureau of Reclamation in 1985. These estimates were initially indexed to the third quarter of 2010 from an estimate previously prepared by Reclamation in April 2007 (see HDR's 2011 Cost Technical Memorandum for further details).

The quantities and unit costs are adjusted for the reduced-size project as applicable. The adjustments/revisions to the cost estimates for the reduced-size project are noted as markup edits on Appendix D OPCC Wymer Reservoir with Adjacent Yakima River Intake for full scale project. These markup edits are included in this report as Attachment A3.

The unit costs and quantities are revised in following three ways:

- Items identified for quantities to be revised proportionally (i.e. reduced by X%)
- Revised quantity/unit cost for specific items due to change is size and number of equipment
- Items identified as "No Change"

All costs are to be adjusted to the 1st quarter of 2012 using appropriate indices.

Table 2-2. Cost Summary for Full Size Wymer Dam and Reservoir and Adjustments for Reduced-Size Projects

Component Amount	Full Size Project Costs, 3rd Qtr 2010 $	Revisions for Reduced-Size Wymer Dam Projects	Reduced-Size Project Costs, 1st Qtr 2012 $
1. Materials and Labor			
Yakima River Intake	$20,844,000	Revised per reduced flow rates	$17,095,997
Pumping Station	60,809,000	Revised per reduced flow rates (facility will be 20% smaller with fewer lower capacity pumps)	44,989,629
Switchyard and Transmission Line	6,545,000	No Changes	6,875,605
Discharge Line	27,724,000	Revised per reduced flow rates	25,767,326
Dam and Dike	399,921,000	Revised for lower capacity Dam/Dike	245,114,782
Spillway and Outlet Works	63,578,000	Spillway revised for shorter length due to elevation adjustment; No Change for Outlet Works	62,025,003
Diversion During Construction	4,769,000	No Changes	5,034,680
Road and Creek Improvements	6,610,000	No Changes	5,332,365
Materials and Labor	$ 590,800,000		$ 412,235,387
2. Field Overhead and Mobilization	17,724,000	Assume same percentage	12,367,062
3. Other Contractor Costs	56,730,000	Assume same percentage	37,672,821
Contract Cost	665,254,000		$462,275,270
4. Contingencies	166,313,000	Assume same percentage	115,568,818
Field Cost	831,567,000		577,844,088
5. Sales Tax		Assume included in the price	
Construction Cost	$831,652,000		$577,844,088
Non-Contract Cost	$249,500,000	Assume same percentage	$173,353,226
Project Total	$1,081,152,000		$751,197,314

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights of way. Non-contract costs are to be calculated using same percentage as used for the full size project.

3.0 Wymer Downstream Conveyance System

3.1 Overview of Full Size Project

The proposed Wymer Downstream Conveyance System would include a 6-mile long tunnel and pipeline to convey 1,000 cfs water from Wymer Reservoir to Roza Irrigation District headworks, at Roza Dam on the Yakima River. The proposed design includes a series of two tunnels, a siphon across the Burbank Creek drainage to connect the two tunnels, and a penstock. At the downstream end of the Roza Tunnel the installation of a hydroelectric power plant to dissipate the energy of the water prior to discharge into the Roza Tunnel was included in the 2011 estimate. The development of power is no longer included so the power plant has been removed from the project. However an energy dissipation structure has been substituted at the downstream end of the penstocks.

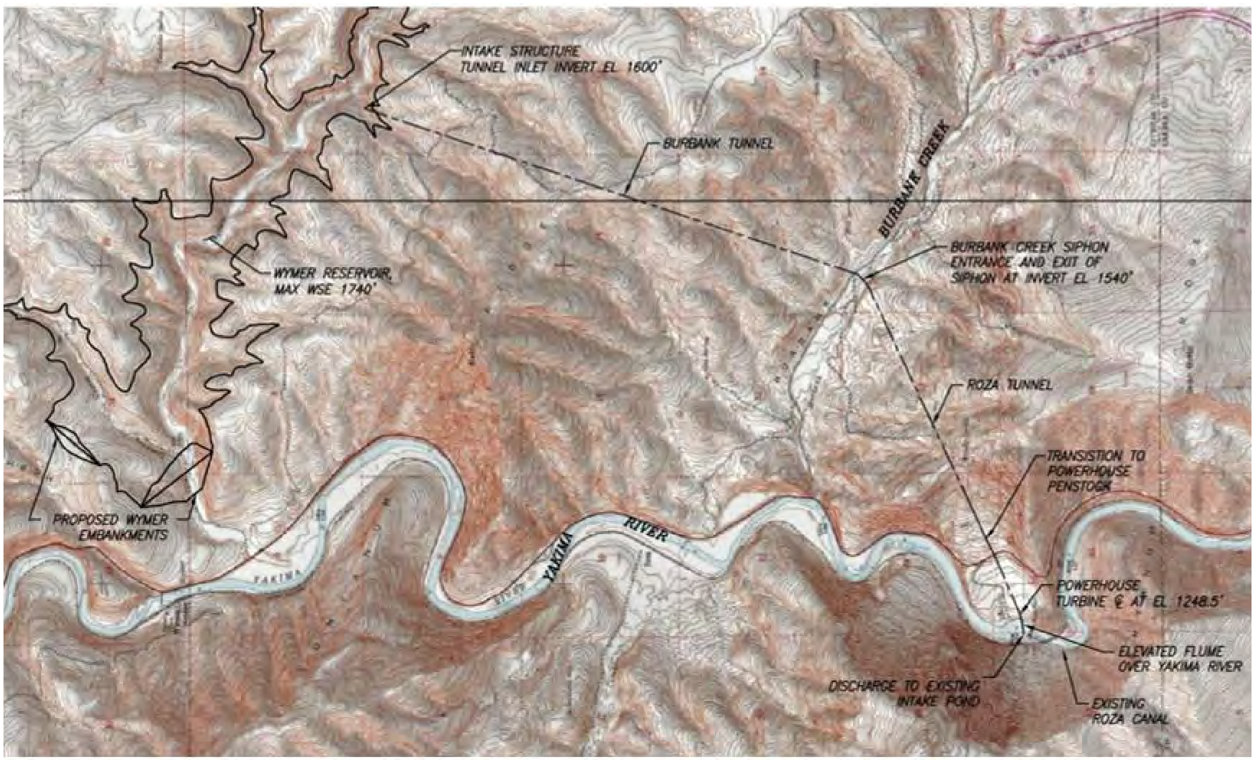

Figure 2. Wymer Downstream Conveyance System - Tunnel Alignments

3.2 Reduced-Size Wymer Conveyance Project

The reduced-size Wymer Conveyance System is designed for 500 cfs, one-half of capacity of the full size project. The top water surface elevation in the reduced-size Wymer Reservoir would be at EL 1645 feet corresponding to 80 KAF water storage. The required size of the tunnel to convey 500 cfs is estimated to be 10-feet diameter. It is assumed that the conveyance pipeline/tunnel designed for reduced-size project will follow same horizontal and vertical alignment as the full scale project.

The reduced-size Wymer Conveyance System will have ability to divert up to 30 KAF water from Wymer Reservoir to Roza headworks.

Table 3-1 below summarizes the major features of the reduced-size Wymer Downstream Conveyance Project. Attachment B2 includes figures and concept design of full size project that has been marked up for reduced-size project.

Table 3-1. Major Features of the "Reduced-Size" Wymer Downstream Conveyance System

Project Components	Full Scale Project	Reduced-Size Project
Wymer Reservoir Conveyance Intake:	• Design Flow Capacity: 1,000 cfs • Min. Operating WS= EL 1600 • Max. WS = EL 1740	• Design Flow Capacity: **500 cfs** • Min. Operating WS= EL 1600 • Max. WS = EL 1645
Burbank and Roza Tunnels:	• Design Flow Capacity: 1,000 cfs • 14' diameter modified horseshoe tunnel • 6.2 fps • 16,750 feet Burbank Tunnel and 8,750 feet Roza Tunnel • Tunnel excavated using TBM	• Design Flow Capacity: **500 cfs** • **10' diameter** modified horseshoe tunnel **(The tunnel size is selected to meet hydraulic requirements. Further review is required to verify if 10' diameter tunnel is adequate for tunnel working room and muck car)** • **6.3 fps** • Assume same horizontal and vertical alignment • 16,750 feet Burbank Tunnel and 8,750 feet Roza Tunnel • Tunnel excavated using TBM
Burbank Creek Siphon :	• Design Flow Capacity: 1,000 cfs • 10' diameter steel pipe • 930 feet long • Pipe wall thickness designed for 250 feet of head (110 psi)	• Design Flow Capacity: **500 cfs** • **8' diameter** steel pipe • Assume same horizontal and vertical alignment • 930 feet long • Pipe wall thickness designed for 145 feet of head (63 psi)
Penstock:	• Design Flow Capacity: 1,000 cfs • 9.5' diameter steel pipe • Velocity 14 fps	• Design Flow Capacity: 500 cfs • 8' diameter steel pipe • Velocity 10 fps
Powerhouse:	• Located on east side of River • 46 feet x 65 feet metal building structure	• Not Required. (Excluded from project);
Energy Dissipation Baffled Flume	• Not required due to inclusion of Powerhouse (energy recovery)	• Concrete flume with blocks for energy dissipation; • 32' wide Baffle Structure followed by flume with baffle blocks and riprap lined stilling basin (Similar design as for Thorp to Wymer Conveyance

Project Components	Full Scale Project	Reduced-Size Project
		Project)
Tailrace:	• Design Flow Capacity: 1,000 cfs • 20-feet wide, 8-feet high rectangular concrete flume; 6 feet water depth; • To be constructed on an elevated structure crossing the Yakima River	• Design Flow Capacity: 500 cfs • 14-feet wide, 6.5-feet high rectangular concrete flume; 4.5 feet water depth; • To be constructed on an elevated structure crossing the Yakima River

3.3 Cost Adjustments

The design and planning level costs for Wymer Conveyance System was prepared by HDR using a deterministic method based on appraisal-level design information. These estimates were initially indexed to the third quarter of 2010. The details of the cost estimate are included as Appendix F in the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology).

The quantities and unit costs are adjusted for the reduced-size project as applicable. The adjustments/revisions to the cost estimates for the reduced-size project are noted as markup edits on Appendix F OPCC Wymer Power Recovery and Conveyance to Roza Dam for the full scale project. These markup edits are included in this report as Attachment B3.

The unit costs and quantities are revised in the following ways:

- Items identified for quantities to be revised proportionally (i.e. reduced by X%) due to change is size
- Items identified as “No Change”

All costs are to be adjusted to the 1st quarter of 2012 using appropriate indices.

Costs for a concrete flume with block energy dissipation stilling basin was added. Comparable design and costs were obtained from “Thorp to Wymer” Project. Since the design flow rate for this reduced-size Wymer Conveyance project is one half of the design flow rate for “Thorp to Wymer” project, the total costs was adjusted with a 40% reduction factor. The markup edits for these costs are included as Attachment B4 in this report.

Table 3-2. Cost Summary for Full Size Wymer Downstream Conveyance System and Adjustments for Reduced-Size Project

Component Amount	Full Size Project Costs, 3rd Qtr 2010 $	Revisions for Reduced-Size Wymer Conveyance Projects	Reduced-Size Project Costs, 1st Qtr 2012 $
1. Materials and Labor			
Tunnels, Siphon and Penstock	$112,382,000	Revised per reduced flow rates & smaller size	$80,562,430
Tailrace Flume	3,067,000	Revised per reduced flow rates & smaller size	2,136,787
Concrete Flume for Energy Dissipation	0	Add relevant cost from "Thorp to Wymer Conveyance Project"	358,390
Powerhouse	45,679,000	Deleted (ie Excluded from Project)	0
Materials and Labor	$ 161,128,000		$ 83,057,607
2. Field Overhead and Mobilization	17,281,000	Assume same percentage	8,880,242
3. Other Contractor Cost	16,804,000	Assume same percentage	8,660,970
Contract Cost	$ 195,213,000		$ 100,598,819
4. Contingencies	48,803,000	Assume same percentage	25,149,705
Field Cost	244,016,000		125,748,524
5. Sales Tax	930,000	Assume same percentage	10,311,379
Construction Cost	$244,946,000		$ 136,059,903
Non-Contract Cost	$73,500,000	Assume same percentage	40,817,971
Project Total	$ 318,446,000		$ 176,877,874

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights of way. Non-contract costs are to be adjusted using the same percentage as used for the full size project.

4.0 Bumping Lake Reservoir Enlargement

4.1 Overview of Full Size Project

Bumping Lake Dam is located on the Bumping River, a tributary of the Naches River, approximately 40 miles northwest of Yakima. Bumping Lake Dam (blue line on Figure 3) was constructed in 1910 and created a reservoir with a capacity of 33,700 acre-feet at EL 3425 feet.

Enlargement of Bumping Lake Reservoir includes construction of a new dam and fish passage facilities about 4,500 feet downstream (purple line on Figure 3) from the existing Bumping Lake Dam (Reclamation and Ecology 2011b). The reservoir would be enlarged to a total active capacity of approximately 190,000 acre-feet at approximate EL 3490 feet (orange line on Figure 3). The existing dam would be breached following construction to allow full use of the existing pool.

The enlarged reservoir would inundate an additional 1,900 acres for a total inundation area of 3,200 acres. The reservoir would extend approximately five miles upstream from the dam and create approximately three more miles of shoreline, for a total of 15 miles.

The site of the proposed new dam and the lands that would be inundated by the expanded reservoir are contained entirely within the area reserved by Reclamation for the purposes of the Yakima project.

Figure 3. Aerial View of Bumping Lake

4.2 Reduced-Size Bumping Lake Reservoir Enlargement

Two different versions are considered for the reduced-size Bumping Lake Reservoir. These reduced-size projects are (a) 87 KAF Storage Capacity and (b) 68 KAF Storage Capacity Reservoir. Based on the reservoir capacity chart, the corresponding maximum water surface elevations are 3450 feet and 3430 feet respectively. Attachment C1 and C2 include the capacity charts indicating storage capacity and corresponding elevation respectively.

The sand-gravel-cobbles embankment dam would be approximately 123 feet and 103 feet high respectively with a full-pool elevation of approximately 3,450 feet and 3430 feet respectively. The stream bed elevation would remain the same at EL 3327 feet.

The spillway and stilling basin would remain at the same location, however, adjusted for the lower elevation. The outlet works would also remain the same. The existing dam would be breached following construction to allow full use of the existing pool.

Table 4-1 below summarizes the major features of the two reduced-size projects. Attachment C1 and C2 includes figures and concept design of the full size project that has been marked up for the two reduced-size projects respectively.

Table 4-1. Major Features of the "Reduced-Size" Bumping Lake Reservoir

Project Components	Full Scale Project	Reduced-Size Project 87 KAF Capacity	Reduced-Size Project 68 KAF Capacity
Reservoir:	• Storage: 190 KAF • Normal WS (Top of Active Storage)= EL 3490 • Stream Bed or Bottom of Storage = EL 3327	• Storage: **87 KAF** • Normal WS (Top of Active Storage)= EL **3450** • Stream Bed or Bottom of Storage = EL 3327	• Storage: **68 KAF** • Normal WS (Top of Active Storage)= EL **3430** • Stream Bed or Bottom of Storage = EL 3327
Main Dam:	• Type: 3' riprap face sand-gravel filled embankment • Top of Dam (Crest Elevation): EL 3510; 30-feet wide crest • Crest Length= 3,200 feet • Maximum Structural Height= 185 feet	• Type: 3' riprap face sand-gravel filled embankment • Top of Dam (Crest Elevation): EL **3470;** 30 feet wide crest • Crest Length= **2,900 feet** • Maximum Structural Height= **145 feet**	• Type: 3' riprap face sand-gravel filled embankment • Top of Dam (Crest Elevation): EL **3450;** 30 feet wide crest • Crest Length= **2,800 feet** • Maximum Structural Height= **125 feet**
Spillway:	• Type: Reinforced concrete overflow crest, open chute, and stilling basin • Design capacity – 17,562 cfs • Top of Crest= EL 3490 • Crest Length= 60 feet • Total Length of spillway chute = 900 feet	• Type: Reinforced concrete overflow crest, open chute, and stilling basin • Design capacity – 17,562 cfs • Top of Crest= **EL 3450** • Crest Length= 60 feet • Total Length of spillway chute = 900 feet (No	• Type: Reinforced concrete overflow crest, open chute, and stilling basin • Design capacity – 17,562 cfs • Top of Crest= **EL 3430** • Crest Length= 60 feet • Total Length of spillway chute = 900 feet (No

Project Components	Full Scale Project	Reduced-Size Project 87 KAF Capacity	Reduced-Size Project 68 KAF Capacity
	• Vertical drop – 177 feet	Change) • Vertical drop – 137 feet	Change) • Vertical drop – 117 feet
Outlet Works:	• Sized for reservoir evacuation and releases. • 11-foot diameter circular tunnel • 14-foot diameter circular tunnel • 10-dia shaft with gate chamber	• No Change	• No Change
Removal of Existing Dam	• The existing dam would be breached following construction to allow full use of the existing pool	• No Change	• No Change

* All elevations are based on NGVD29 datum.

4.3 Cost Adjustments

The design and planning level costs for Bumping Lake Reservoir were prepared by HDR using deterministic method using appraisal-level design information and sub-contractor quotes. These estimates were initially indexed to the third quarter of 2010. Details of the cost estimates are included in the Bumping Lake Reservoir Enlargement project from the Yakima River Basin Study *Costs of the Integrated Water Resource Management Plan Technical Memorandum* (Reclamation and Ecology).

The quantities and unit costs are adjusted for the reduced-size project as applicable. The unit costs and quantities are revised in following ways:

- Items identified for quantities to be revised proportionally (i.e. reduced by X%) due to change is size
- Items identified as "No Change"

The adjustments/revisions to the cost estimates for the reduced-size project are noted as markup edits on Appendix J OPCC Bumping Lake Reservoir Enlargement for the full scale project. These markup edits are included in this report as Attachment C3.

All costs are to be adjusted to the 1st quarter of 2012 using appropriate indices.

Table 4-2. Cost Summary for Full Size Bumping Lake Reservoir Enlargement and Adjustments for Reduced-Size Projects

Component Amount	Full Size Project Costs, 3rd Qtr 2010 $	Revisions for Reduced-Size Bumping Lake Reservoir Projects	Reduced-Size Project Costs, 1st Qtr 2012 $ (A) 87 KAF	Reduced-Size Project Costs, 1st Qtr 2012 $ (B) 68 KAF
1. Materials and Labor				
Land Rights	$712,621	No Changes	$712,407	$712,407
Relocation of Property of Others	3,488,426	No Changes	3,403,968	3,403,968
Clearing Lands	11,266,426	No Changes	14,503,169	14,503,169
Roads and Road Structures	4,019,000	No Changes	3,928,963	3,945,675
Dams	180,717,000	Revised for lower capacity Dam	154,010,350	140,771,913
Materials and Labor	$ 200,203,525		$ 176,558,857	$ 163.337,132
2. Field Overhead and Mobilization	6,006,106	Assume same percentage	5,296,766	4,900,114
3. Other Contractor Costs	36,465,473	Assume same percentage	32,188,877	29,803,125
Contract Cost	$ 242,675,104		$ 214,004,500	$ 198,040,371
4. Contingencies	60,668,776	Assume same percentage	53,511,125	49,510,093
Field Cost	303,343,880		267,555,625	247,550464
5. Sales Tax	6,270,002	Assume same percentage	21,939,561	20,299,138
Construction Cost	$309,613,882		$ 289,495,186	$267,849,602
Non-Contract Cost	$92,884,164	Assume same percentage	86,848,556	80,354,881
Project Total	$ 402,498,046		$ 376,343,741	$ 348,204,483

Non-contract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights of way. Non-contract costs are to be adjusted using the same percentage as used for the full size project.

5.0 Cost Summary

Detail costs estimated for the "Reduced-Size" projects are included in Attachment D.

Table 5-1 summarizes costs developed for the reduced size projects discussed in this report. In order to make costs consistent with the costs of the full-sized projects used in the cost allocation, the reduced-size project costs have been adjusted by a factor representing results from the Cost-Risk Analysis (CRA) performed by HDR in Spring 2012. This factor is the ratio of post-CRA costs to pre-CRA costs (with all costs escalated to first quarter 2012 values).

Table 5-1. Costs of Proposed Reduced Size Project to be used for Preliminary Cost Allocation

Projects	Construction Cost [1] ($M) (Base Cost)	Construction Plus Non-Contract Costs [2] ($M)	CRA Adjustment Factor	CRA Adjusted Costs [3] ($ M)
Wymer Dam, Reservoir & Pumping Plant	$577.8	$751.2	0.98	$736.1
Wymer Downstream Conveyance	$136.1	$176.9	1.18	$208.8
Bumping Lake Reservoir Enlargement (87 KAF)	$289.5	$376.3	1.32	$496.7
Bumping Lake Reservoir Enlargement (68 KAF)	$267.8	$348.2	1.32	$459.6

Note:

1. Construction Base costs are listed as 1st Qtr 2012 dollar. Costs are estimated by HDR Cost Estimators.
2. Non-contract costs are 30-percent of construction cost. This covers design, permitting, environmental compliance, and land or easement acquisition.
3. CRA Adjusted Costs are estimated by multiplying Construction Plus Non-Contract Costs with a Cost Risk Analysis (CRA) factors.