IN REPLY REFER TO:

# United States Department of the Interior

BUREAU OF RECLAMATION
Upper Columbia Area Office
1917 Marsh Road
Yakima, Washington 98901-2058

11/29/06

UCA-370
PRJ-3.00

Interested Parties (See Enclosed List)

Subject: Results of the Plan Formulation Phase of the Yakima River Basin Water Storage Feasibility Study (Storage Study)

Dear Ladies and Gentlemen:

In February 2003, Congress authorized the Secretary of the Interior, acting through the Bureau of Reclamation, to conduct the Storage Study. Reclamation is evaluating options to improve the reliability of Yakima Project water supply during dry years, improve anadromous fish habitat, and provide water to meet future municipal demands.

The purpose of this letter is to provide you with the results of the Plan Formulation Phase of the Storage Study and explain how Reclamation and the State of Washington, through the Department of Ecology (Ecology), intend to proceed.

Through appraisal assessments, Reclamation identified two alternatives—the Black Rock Dam and Reservoir Alternative and the Wymer Dam and Reservoir Alternative—which warranted further analyses in the Plan Formulation Phase. After further analysis, Ecology requested and Reclamation added a pump exchange option to the Wymer Dam and Reservoir Alternative to increase the flexibility of the water supply from the Wymer Dam and Reservoir. The exchange would take place by pumping water from the mouth of the Yakima River to the Roza/Sunnyside area.

The two alternatives meet the goals of the Storage Study in varying degrees. The Black Rock Alternative provides enough exchange water to meet all three goals of the Storage Study, while the Wymer Alternative with the pump exchange option meets the irrigation goal in every year of the 23-year period of record, except 1994, and provides winter and summer instream flow benefits for the Cle Elum River and the Yakima River from the mouth of the Cle Elum to where the Wymer Dam would be located on Lmuma Creek. The municipal water goal would be met by both

alternatives. However, both alternatives have high construction and annual operating costs and benefit/cost ratios considerably below 1. The benefit/cost ratio is one of the main factors used to determine the best alternative in the Federal feasibility analysis.

The Yakima Basin Storage Alliance, in cooperation with the Port of Sunnyside and Yakima and Benton Counties, is sponsoring an independent assessment of potential recreational benefits from the Black Rock Alternative. Information from that assessment will be considered when it is available.

Reclamation and the State have decided to proceed into the Feasibility Report/Environmental Impact Statement Phase (FR/EIS) (Phase 4) of the Storage Study. This Phase includes implementing the Federal National Environmental Policy Act (NEPA) process and the State of Washington's Environmental Policy Act (SEPA) process.

During this Phase, which will include public scoping activities, Reclamation and the State of Washington will explore any new, potentially viable alternatives which could benefit the Yakima River Basin, in addition to the already studied Black Rock and Wymer (with pump exchange) Alternatives. Also, further evaluation of the Black Rock and Wymer Dams and Reservoirs concepts, including options to the current alternatives, may show additional recreation, irrigation, fish, hydropower, or municipal benefits, and may, through downsizing of facilities or different operations scenarios, provide better benefit/cost ratios. When this phase is complete, the results of the analyses will be shown in a draft FR/EIS report.

Reclamation will continue analyzing the potential impacts of groundwater seepage from a Black Rock Reservoir on the Hanford Reservation. Since significant design and cost estimating analysis has recently been prepared for the Black Rock Alternative, Reclamation will not perform additional design or cost estimating for the structural features of this alternative unless indicated by new information. Cost estimates for the structural features of Wymer Dam and Reservoir were indexed from the mid-1980s and will require updating for a better comparison of prices with the Black Rock Dam and Reservoir Alternative.

We plan to hold meetings with certain stakeholder groups to brief them on the findings of the Plan Formulation analyses and explain the remainder of the Storage Study process. We will be contacting you to set up these meeting dates and times in the near future. In addition, meetings will be held after January 1, 2007, to explain Storage Study progress and to gather information for the NEPA/SEPA scoping process.

Enclosed is the *Technical Information and Hydrologic Analysis* for the two alternatives including preliminary benefit/cost analyses. For an additional copy of this information, or if you have general questions related to the *Technical Information and Hydrologic Analysis* of the Plan Formulation Phase or the Storage Study, please contact Mr. Kim McCartney at 509-575-5848, extension 370, or visit the following website:

http://www.usbr.gov/pn/programs/storage_study/index.html.

If you have any questions about this information, please contact Mr. Gerald Kelso at 509-575-5848, extension 202, or Mr. Derek Sandison at 509-457-7120.

Sincerely,

/s/ Gerald Kelso

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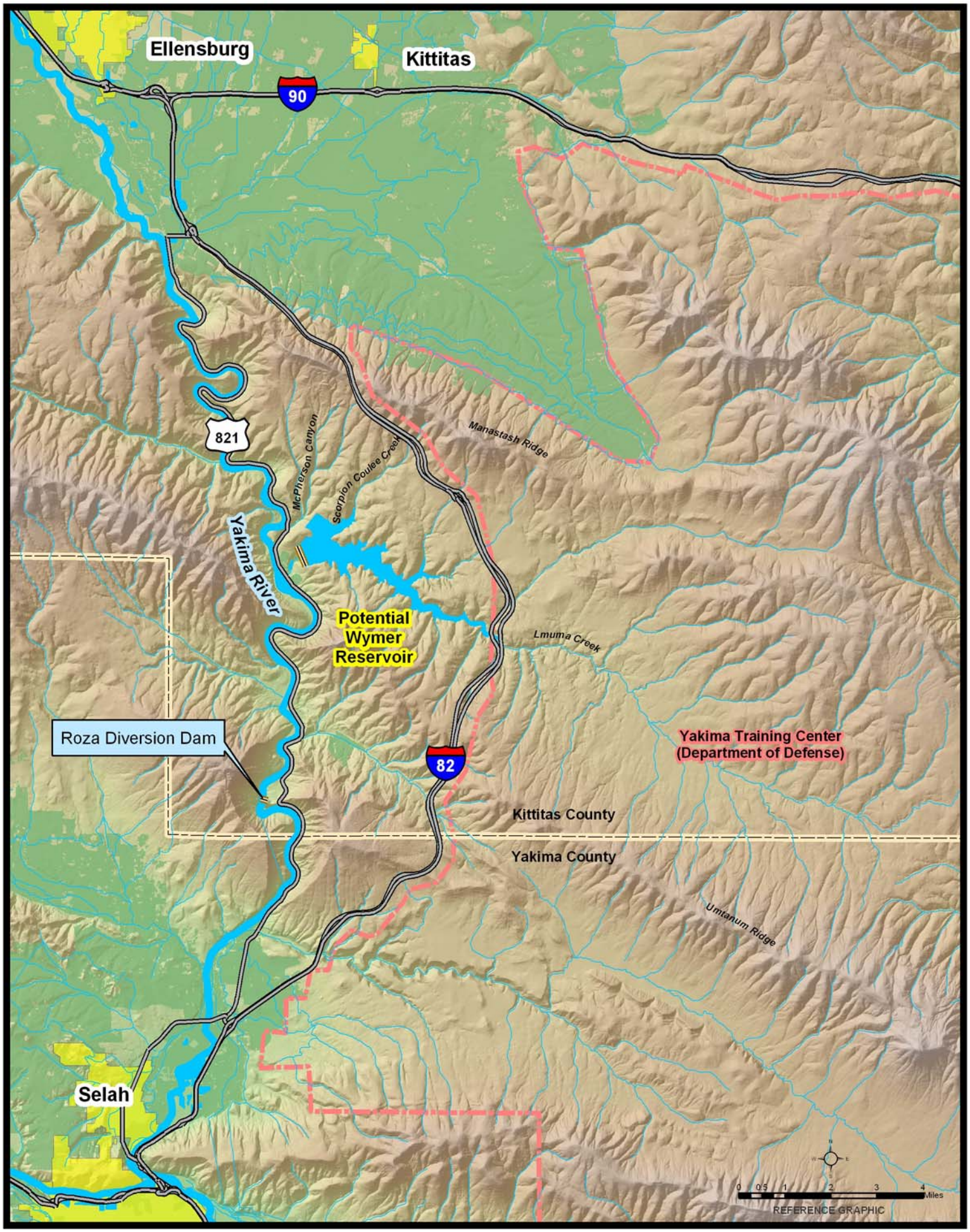
# Storage Study Team Technical Information and Hydrologic Analysis for Plan Formulation

**A component of**
**Yakima River Basin Water Storage Feasibility Study, Washington**

**November 2006**




***Potential Wymer Reservoir***

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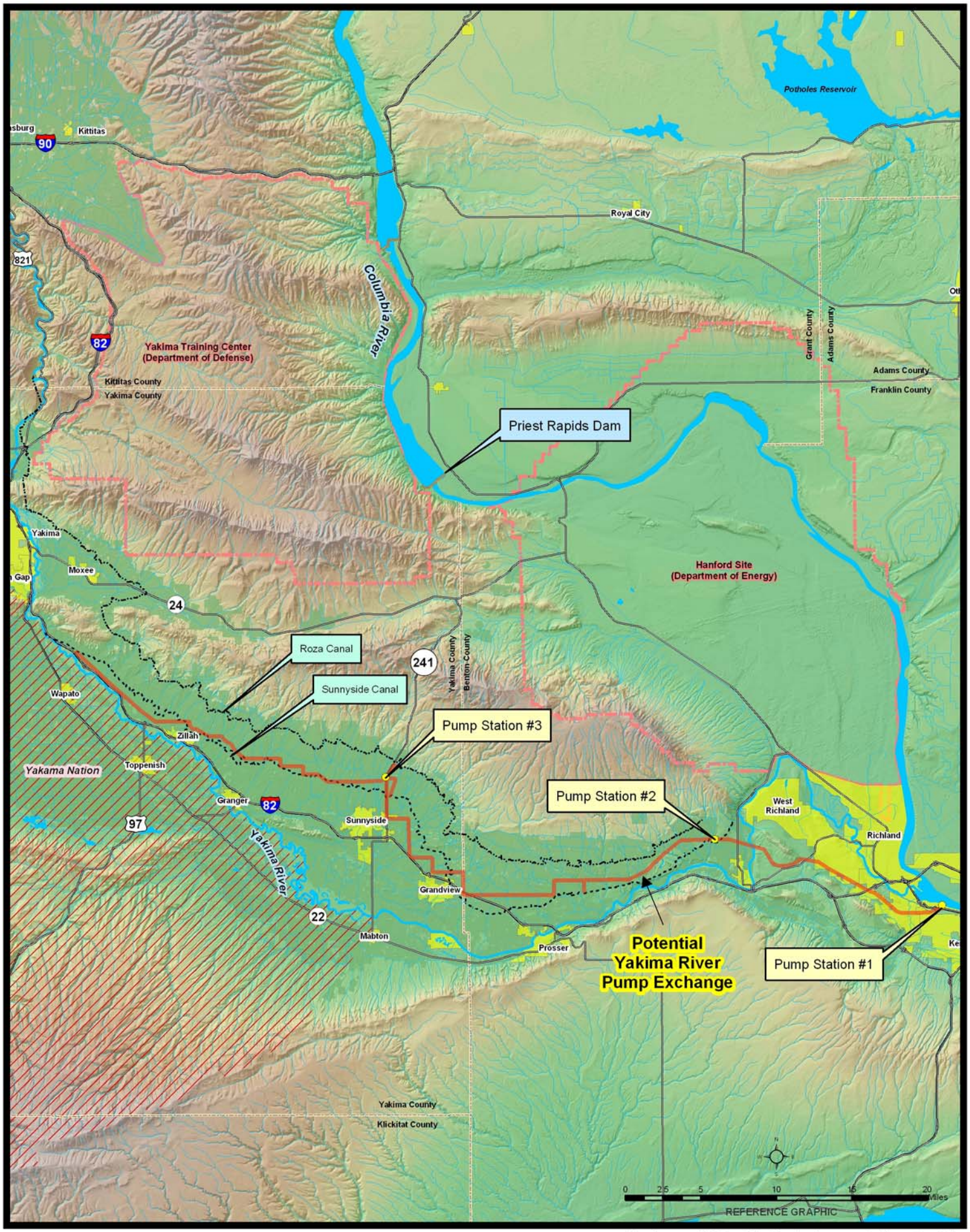


***Potential Yakima River Pump Exchange***

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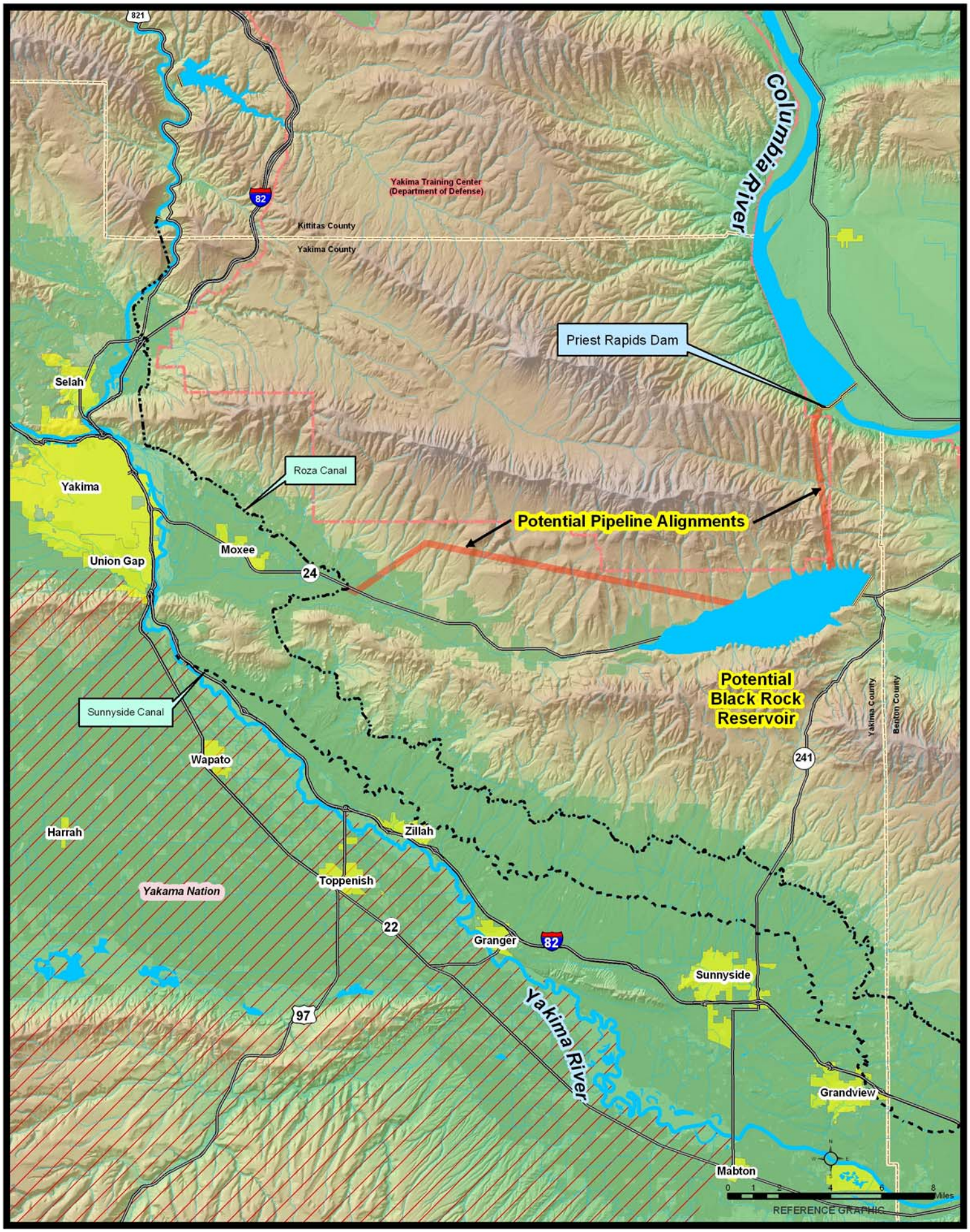


***Potential Black Rock Reservoir***

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# Chapter 1.0 INTRODUCTION

The Bureau of Reclamation's Yakima River Basin Water Storage Study Team has prepared this *Technical Information and Hydrologic Analysis* to document the studies conducted for the Plan Formulation Phase (Phase 3) of the Yakima River Basin Water Storage Feasibility Study (Storage Study). The objective of Phase 3 is to evaluate known alternatives and determine if those alternatives should be included for further refinement and consideration in the Feasibility Report/Environmental Impact Statement Phase (Phase 4), the last phase of the Storage Study.

Phase 4 will involve public scoping and more detailed evaluations in terms of the estimated costs, operations, economic and financial analyses, and environmental considerations. If the evaluations are favorable, Reclamation will identify a "preferred alternative" in Phase 4, which could be the basis for seeking congressional authorization for construction of a solution to the water supply needs of the Yakima Basin.

This *Technical Information and Hydrologic Analysis* identifies the:

- Purpose and need of the Storage Study
- Alternatives being considered
- Operation studies conducted to simulate operations of the existing Yakima Project with the addition of the alternatives
- Appraisal-level economic benefits and the allocation of costs to purposes or functions served by the alternatives.

Prior work reported in the December 2004 *Summary Report, Appraisal Assessment of the Black Rock Alternative* (*Black Rock Appraisal Assessment*) and the May 2006 *Yakima River Basin Storage Alternatives Appraisal Assessment* (*Yakima Basin Appraisal Assessment*) is the basis for evaluating the alternatives in the Plan Formulation Phase. The *Yakima Basin Appraisal Assessment* recommended that the Wymer Dam Alternative be moved forward into the Plan Formulation Phase of the Storage Study. That *Assessment* did not show if the Wymer Dam Alternative could provide the flexibility of water operations to achieve the goals of the Storage Study. The State of Washington suggested that a Yakima River water exchange be analyzed. To increase the flexibility of the water operations of the Wymer Dam Alternative, the suggested water exchange was added to that alternative. The results shown in this report are from this alternative, called the "Wymer Dam Plus Yakima River Pump Exchange Alternative."

## 1.1 Purpose and Need

The purpose of the Storage Study is to evaluate alternatives that would create additional water storage in the Yakima River basin and assess their potential to supply the water needed for ecosystem aquatic habitat, basinwide agriculture, and municipal demands.

The need for the Storage Study is based on the existing finite water supply and limited storage capability of the Yakima River basin in low-water years. This finite supply and limited storage capacity do not meet the water supply demands in all years and result in significant adverse impact to the Yakima River basin's agriculture-based economy and to the basin's aquatic habitat, specifically, anadromous fisheries. The Storage Study seeks to identify means of increasing water supplies available for purposes of improving anadromous fish habitat and meeting irrigation and municipal water supply needs.

## 1.2 Storage Study Goals

Reclamation has developed the following Storage Study goals based on the congressional authorization and the purpose and need of the Storage Study.

- Improve anadromous fish habitat by restoring the flow regimes of the Yakima and Naches Rivers to more closely resemble the natural (unregulated) hydrograph.

- Improve the water supply for proratable irrigation water rights in dry years by providing a not less than 70-percent irrigation water supply during dry years at diversions subject to proration.

- Meet future municipal water supply needs by maintaining a full municipal water supply for existing users and providing additional surface water supply for population growth to the year 2050.

This *Technical Information and Hydrologic Analysis* will address the first two bullets above by summarizing the results of the operation studies. The future municipal surface water supply needs are relatively small and were assumed met by all alternatives.

The operation models used to evaluate the alternatives are the same as those used in the previous two appraisal assessments. The criteria used to create the operational scenarios was changed based on professional judgment and the results and comments on the previous analyses.

# Chapter 2.0 DESCRIPTION OF THE ALTERNATIVES

Reclamation's Storage Study Team analyzed different configurations of each alternative during Plan Formulation. Brief descriptions of the alternatives the Storage Study Team considered during Plan Formulation follow.

## 2.1 No Action Alternative

The No Action Alternative is intended to represent the most likely future expected in the absence of constructing additional storage. This alternative is the baseline from which the action alternatives are measured for benefits. The analysis and operation studies performed for the No Action Alternative included future implementation of water conservation measures and water acquisitions; however, it did not include the emergency drought relief provisions allowed under state law. These provisions were not included because they can vary with each drought.

### 2.1.1 Water Conservation Measures

The No Action Alternative for the Storage Study includes future implementation of water conservation measures. Section 1203 of Title XII of the Act of October 31, 1994, authorized Phase II (the Basin Conservation Program) of the Yakima River Basin Water Enhancement Project (YRBWEP) for the purpose of evaluating and implementing measures to improve the availability of water supplies for irrigation and the protection and enhancement of fish and wildlife resources, including wetlands. Two-thirds of the conserved water resulting from a conservation measure is assigned to instream flows and is assumed to remain in the river from the implementing entity's point of diversion to the last point of operational discharge from its water system. One-third of the conserved water is retained by the implementing entity for irrigation use.

Section 1203 of Title XII provides that two-thirds of the implementation cost of the conservation measure(s) will be federally funded (Reclamation) and one-third will be nonfederally funded equally by Washington State Department of Ecology (Ecology) and the implementing entity. A "cost ceiling" was established for the Federal funds of $67.5 million (September 1990 prices) and is subject to increase by applicable cost indexes. (The January 2006 Federal cost ceiling is estimated at about $109 million.)

Yakima basin irrigation entities developed and submitted water conservation plans for evaluation and approval by Reclamation. The water conservation measures included in the No Action Alternative are those currently being constructed or considered for future implementation with funding from the Basin Conservation Program or from other sources. It should be noted that

implementation does not require additional congressional authorization but, rather, completion of the processes established for the Basin Conservation Program.

Table 2-1 summarizes the water conservation measures included in the No Action Alternative. The costs of the conservation measures are from the entity water conservation plans provided in the late 1990s to early 2000s and have not been indexed. The table displays the total conserved water, the two-thirds instream flow component, and the one-third irrigation component.

**Table 2-1. Water Conservation Measures by Irrigation Entity for the No Action Alternative**

| Entity | Total Cost | Reclamation's share | Ecology's share | Entity's share | Conserved Water | Instream Flow | Irrigation |
|---|---|---|---|---|---|---|---|
| | (million dollars) | | | | (acre-feet) | | |
| **Funding from Basin Conservation Program (Section 1203 of Title XII)** | | | | | | | |
| **Upper Yakima River** | | | | | | | |
| Kittitas | 36.9 | 23.9 | 6.5 | 6.5 | 48,500 | 32,400 | 16,100 |
| **Middle Yakima River** | | | | | | | |
| Roza | 15.5 | 10.1 | 2.7 | 2.7 | 13,700 | 9,200 | 4,500 |
| Union Gap | 16.5 | 10.7 | 2.9 | 2.9 | 5,600 | 3,700 | 1,900 |
| Sunnyside | 32.6 | 21.2 | 5.7 | 5.7 | 29,100 | 19,400 | 9,700 |
| Benton | 16.4 | 10.6 | 2.9 | 2.9 | 6,900 | 4,600 | 2,300 |
| **Naches River** | | | | | | | |
| Naches | 8.0 | 5.2 | 1.4 | 1.4 | | | |
| **Subtotal** | 125.9 | 81.7 | 22.1 | 22.1 | 103,800 | 69,300 | 34,500 |
| **Funding from Other Sources[1]** | | | | | | | |
| **Middle Yakima River** | | | | | | | |
| Roza | | | | | 30,000 | -- | 30,000 |
| Sunnyside | | | | | 24,700 | 16,500 | 8,200 |
| **Total** | | | | | 158,500 | 85,800 | 72,700 |

[1] Costs of water conservation measures paid for by other sources is not available at this time.

As previously indicated, the January 2006 Federal cost ceiling is estimated at about $109 million, and the costs of the above-mentioned conservation measure(s) ($81.7 million) are from entity water conservation plans provided in the late 1990s to early 2000s. Therefore, these costs would need to be indexed to January 2006 prices to determine if these water conservation measures could be accomplished within the current Federal cost ceiling.

Table 2-2 displays the river reaches [by river mile (RM)] that would be affected when the water conservation measures are fully implemented. For example, the Union Gap Irrigation District

point of diversion changes from RM 114.7 to RM 105.0, which results in an additional 46 cfs instream flow in the Yakima River between RM 114.7 and 105.0 (approximately 9.7 river miles). The increase in the instream flow component resulting from system improvements at the point of the return flow (RM 41.8) is 10 cfs.

**Table 2-2. Entity System Improvements and Changes in Point of Diversion**

| Entity | Action | River Mile Affected | | | Increase in Instream Flow (cfs) |
|---|---|---|---|---|---|
| | | Diversion (RM) | | Return Flow (RM) | |
| | | Current Diversion Point | New Diversion Point | | |
| **Upper Yakima River** | | | | | |
| **Basin Conservation Program Funding (Section 1203 of Title XII)** | | | | | |
| Kittitas R.D. | System Improvements | 202.5 | | Creeks[1] | 90 |
| **Middle Yakima River** | | | | | |
| **Basin Conservation Program Funding (Section 1203 of Title XII)** | | | | | |
| Roza I.D. | System Improvements | 127.9 | | 34.3 | 26 |
| Union Gap I.D. | Change in Point of Diversion | 114.7 | 105.0 | | 46 |
| | System Improvements | | 105.0 | 41.8 | 10 |
| Sunnyside Division | System Improvements | 103.8 | | 41.8 | 54 |
| Benton I.D. | Change in Point of Diversion | 103.8 | 32.1 | | 58 |
| | System Improvements | | 32.1 | 23.8 | 13 |
| **Other Funding** | | | | | |
| Roza I.D. | System Improvements | 127.9 | | 34.3 | |
| Sunnyside Division | System Improvements | 103.8 | | 41.8 | 46 |
| **Yakama Nation (Section 1204)** | | | | | |
| Wapato Irrigation Project | Change in Point of Diversion | 106.7 | 66.7 | | 50 |

[1] Water will be released to Taneum Creek, Big Creek, and Little Creek for flow enhancement.

Table 2-3 summarizes the cumulative effects of water conservation measures from Roza Diversion Dam (RM 127.9) to Sunnyside Diversion Dam (103.8). The table shows the accretions and depletions in this 24.1-mile reach and the additional river flow associated with conserved water assigned to instream flows and operational flow resulting from changes in the points of diversion.

Title XII sets instream target flows over Sunnyside Diversion Dam in wet and average water years at 400 to 600 cfs, depending on the total water supply available (TWSA) estimates; in dry years, the flow is 300 cfs. Title XII also provides that these flows will be increased by the

instream flow component of the conserved water realized through the Basin Conservation Program.

Table 2-3 also indicates Title XII instream target flows should be increased by 136 cfs in wet and average water years. In dry years, the increased target flow would be adjusted according to the amount of proratable or nonproratable water rights of the implementing entities. This results in a flow of 97 cfs in a repeat of a 1994 water supply year.

In addition to the increased Title XII target flow, operational flows of 108 cfs from proposed changes in points of diversion by the Wapato Project and the Union Gap Irrigation District will pass over Sunnyside Diversion Dam in wet and average water years. Operational flows resulting from changes in points of diversion are not included in determining increased Title XII target flows. This operational flow would be reduced in dry years according to the entity's water rights.

For example, the improvements in the Roza Division increase the streamflow by 26 cfs (accretion) beginning at the point of diversion (RM 127.9). This is the increase in conserved water, so the cumulative flow increases by 26 cfs. Another example is the Union Gap diversion—the current diversion is 46 cfs at RM 114.7. That diversion will change to RM 105.0, which adds 46 cfs to the river from RM 114.7 to RM 105.0, increasing the total cumulative flow to 72 cfs. Union Gap's new pressure pipeline delivery system results in 10 cfs remaining in the river, and up to 36 cfs being diverted (depleted), making the total cumulative instream flow 86 cfs (122 cfs flow at Wapato, minus 46 cfs, plus 10 cfs = 86 cfs, or a net change in the cumulative flow at RM 105.0 of -36 cfs).

**Table 2-3. Middle Yakima River Instream Flow Cumulative Effects**

| Entity (Irrigation District) | Action | RM | Accretion (cfs) | Depletion (cfs) | Total Cumulative Instream Flow (cfs) | Elements of Instream Flow | |
|---|---|---|---|---|---|---|---|
| | | | | | | Conserved[1] | Operational Flow[2] |
| Roza | System Improvements | 127.9 | +26 | | 26 | 26 | |
| Union Gap | Change in Point of Diversion | 114.7 | +46 | | 72 | | 46 |
| Wapato | Change in Point of Diversion | 106.7 | +50 | | 122 | | 96 |
| Union Gap | System Improvements | 105.0 | +10 | | 86 | 10 | 50 |
| | New Diversion | 105.0 | | -46 | | | |
| Benton | Change in Point of Diversion | 103.8 | +58 | | 144 | | 108 |
| Sunnyside | System Improvements | 103.8 | +100 | | 244 | 136 | |
| Sunnyside Diversion Dam | | 103.8 | | | 244 | 136 | 108 |

[1] Conserved water applies to Title XII flows.
[2] Operational flows resulting from changes in points of diversion are not included in Title XII flow increases.

## 2.1.2 Water Acquisition

In 2003, Reclamation acquired the Naches River hydroelectric powerplants of the Pacific Power and Light Company. This water right acquisition and the proposed Naches-Selah Irrigation District change in point of diversion for joint use with the Wapatox Ditch Company of the Wapatox Canal will result in the following:

- An operational flow of 100 cfs in the Naches River from RM 18.4 (the present Naches-Selah Irrigation District diversion) to RM 17.1 (the Wapatox Canal diversion).

- An additional average flow of about 370 cfs in the Naches River from RM 17.1 to RM 9.7 (the point of prior discharge from the Wapatox Powerplant).

The Basin Conservation Program also provides for acquisition of land and water rights on a permanent and temporary basis. The acquisitions accomplished to date involve the purchase of irrigated lands and the associated water rights in the tributaries. These actions secured senior water rights increasing the tributary flow from (1) the point of diversion to the point of spill by the amount previously diverted and (2) downstream from the point of spill throughout the river

system by the amount of the consumptive use. This has resulted in an average cumulative flow of about 2 cfs at Sunnyside Diversion Dam.

### 2.1.3 Emergency Drought Relief

An emergency drought relief provision was established by Ecology and is described in RCW Chapter 173-166 WAC. Ecology can determine that water supply conditions are expected to cause undue hardship to water users in a geographical area or a significant part of a geographical area when less than 75 percent of normal water supply conditions exist. Following approval by the Governor, a drought condition order can then be issued by Ecology.

Issuance of a drought condition order allows water users to obtain water from alternate groundwater and surface water sources, allows temporary water transfers and transactions, and provides funding assistance to public bodies for projects and measures designed to help alleviate drought conditions relating to agriculture and fisheries.

In the Yakima Project, the drought condition criteria of 75 percent of normal water supply for the Yakima basin would roughly translate into less than a 45- to 50-percent proration level for proratable water entitlements.[1] A drought condition was declared in the Yakima River basin in 1994, 2001, and 2005.

#### 2.1.3.1 Dry-Year Surface Water Purchase

A team of agencies and water users has been established in the Yakima River basin to provide technical review of proposed water right transfers. This team, known as the Water Transfer Working Group (WTWG), is most active during drought years and operates according to a predetermined set of rules tailored to the basin to protect other water rights of the Yakima River and tributary streams. The WTWG is not a permitting agency, as jurisdiction for surface water rights rests with the Yakima County Superior Court (for temporary changes and transfers) or with Ecology (for permanent changes and transfers).

In the 2001 drought year, about 10,100 acres were taken out of agricultural production and fallowed, and the water transferred to irrigation, fishery, and other uses. The Roza Irrigation District (all proratable water entitlements) acquired and diverted about 16,000 acre-feet at a cost of about $125 per acre-foot. It is estimated this additional diversion is equivalent to an increase in the proration level of about 1.5 percent.

#### 2.1.3.2 Groundwater Pumping

Groundwater wells permitted by Ecology can be used during drought conditions by individuals situated both within and outside the service area of irrigation entities. Use of wells permitted

[1] This is because of the intermix of senior and junior water rights and the amount of irrigated acres in the Yakima Project in relation to irrigation in all of the Yakima River basin.

prior to 1994 (identified as permanent supplemental rights) are not dependent on a drought order and can be used anytime the permittee suffers a water supply shortfall. Existing drought wells permitted beginning with 1994, are identified as emergency drought wells whose use is contingent on a drought order and Ecology's approval to use the well. Development of new emergency drought wells can also be approved.

In the Yakima River basin, groundwater withdrawal of up to 24,000 acre-feet at a rate of 1 acre-foot per acre has been permitted. This volume includes both permanent supplemental right wells and emergency drought wells.

## 2.2 Black Rock Alternative

The Black Rock Alternative consists of pumping water from the Columbia River, when available in excess of current instream flow targets, for storage in a Black Rock reservoir. Stored water would then be released through an outflow conveyance system to the lower Yakima Valley and provided to some lower Yakima Valley irrigation entities situated to receive exchange water into their existing or modified distribution systems. The Yakima River water currently used by the potential participating exchange irrigation entities would not be diverted by those entities. The freed-up Yakima River water would instead be used to meet the Storage Study goals. Other Yakima Valley irrigators with junior proratable water rights, but not physically located to receive exchange water from the Black Rock Alternative, would receive a portion of the freed-up Yakima River water in dry years.

A basic requirement of the Black Rock Alternative is that a sufficient number of lower Yakima Valley irrigation entities are willing to participate in a water exchange. The following five entities (whose April-through-October senior [nonproratable] and junior [proratable] irrigation water rights total 869,000 acre-feet) are identified as potential water exchange participants: Roza and Sunnyside Divisions and Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts.

The Black Rock Alternative was analyzed with two different configurations in the *Black Rock Appraisal Assessment* in 2004. The configuration used in those operation studies and brought forward into Plan Formulation is:

- A large reservoir pump-only option including a fish-screened intake from Priest Rapids Lake, a 3,500-cfs pumping plant to lift water to Black Rock Valley, a dam to store 1,300,000 acre-feet of active storage in a Black Rock reservoir, a 2,500-cfs reservoir outflow conveyance system, and powerplants at the points of discharge to Roza and Sunnyside Canals.

Delivery system options were developed to convey exchange water upstream from Roza Canal MP 22.6 to Roza Division's service area and downstream from Roza Canal MP 22.6 to the Sunnyside Canal. Exchange water could be provided to Roza Division's service area downstream from Roza Canal MP 22.6 through the existing Roza Canal facilities.

Table 2-4 shows this configuration of the Black Rock Alternative. (For the Plan Formulation operation studies, 2,000 cfs was used for the outflow conveyance system.)

Reclamation's *Black Rock Appraisal Assessment* and subsequent geologic investigations in 2006 concluded that, based on current information, a potential Black Rock Alternative appears to be technically viable and that a potential water exchange could meet the goals of the Storage Study.

The total appraisal-level project cost for the Black Rock Alternative was estimated at $3.5 to $4 billion (April 2004 prices).

**Table 2-4. Summary of Major Facilities for the Black Rock Alternative**

| FACILITIES | | LARGE RESERVOIR, PUMP ONLY |
|---|---|---|
| Priest Rapids Lake intake and fish screen | | |
| | design flow capacity | 3,500 cfs |
| | intake location | on right bank of Priest Rapids Lake |
| Priest Rapids plant | | Pumping |
| | design flow capacity | 3,500 cfs – 172 MW (annual average) |
| | 500-cfs, two-stage spiral case pumps | Three |
| | 1,000-cfs, two-stage spiral case pumps | Two |
| | Pump lift | 1,400 feet |
| Inflow conveyance system | | |
| | design flow capacity | 3,500 cfs |
| | conveyance type | all tunnel |
| Black Rock dam | | |
| | Location | original Washington Infrastructure Services' damsite |
| | central core rockfill embankment dam | |
| | Crest elevation | 1785.0 feet |
| | structural height | 755 feet |
| | Crest width | 40 feet |
| | spillway | None |
| | low-level outlet works | upstream steel-lined concrete conduit, downstream buried steel pipe, and two jet-flow gates in left abutment |
| Black Rock reservoir | | |
| | maximum water surface elevation | 1778.0 feet |
| | active storage capacity | 1,300,000 acre-feet |
| | elevation top of active storage | 1775.0 feet |
| | Inactive storage capacity | 157,610 acre-feet |
| | elevation top of inactive storage | 1500.0 feet |
| State Highway 24 relocation | | south of Black Rock reservoir in Rattlesnake Hills |
| Outflow conveyance system | | |
| | design flow capacity | 2,500 cfs |
| | intake structure | single-level screened |
| | conveyance type | tunnel/pipeline |
| Black Rock outlet facility | | |
| | Location | adjacent to Roza Canal MP 22.6 |
| | pump delivery | all water through powerplant to Roza Canal |

| FACILITIES | | LARGE RESERVOIR, PUMP ONLY |
|---|---|---|
| | | 1,500-cfs Black Rock powerplant – 38 MW |
| | pressure delivery | upstream bifurcation to pressurized pipeline |
| | | 900-cfs Black Rock powerplant – 23 MW |
| Sunnyside Powerplant and bypass | | |
| | Powerplant capacity | 900 cfs – 15 to 29.5 MW |

# 2.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

The analysis done in the *Yakima Basin Appraisal Assessment* showed the Wymer Alternative meets the purpose and need of the Storage Study and is technically viable. However, because it did not show if the Wymer Alternative alone impacted the hydrograph positively, it was combined with a pump exchange option on the Yakima River. This section will describe the Wymer Dam Plus Yakima River Pump Exchange Alternative.

## 2.3.1 Wymer Dam and Reservoir

The potential Wymer dam would be a concrete rockfill structure across Lmuma Creek between Ellensburg and Yakima, Washington, approximately 415 feet high, creating a 174,000-acre-foot-capacity reservoir extending from about ¾-mile east of the Yakima River to Interstate 82. The proposal also includes construction of a 130-foot-high concrete rockfill dike in a saddle on the north side of the reservoir. The reservoir would be filled by pumping from the Yakima River, with reservoir releases being supplied back to the Yakima River by gravity. The possibility for hydroelectric generation when releasing from the reservoir back into the Yakima River would be a consideration in future work.

In the *Yakima Basin Appraisal Assessment*, the Wymer configuration and appraisal-level costs of $380 million (July 2004 price levels) were based on a 400-cfs pumping plant intake and a 400-cfs outflow. However, for this operation study, a 1,000-cfs pumping plant and a 1,400-cfs outflow was used to optimize benefits realized from Wymer. These additional costs were not computed for this analysis.

Table 2-5 shows the physical characteristics of Wymer dam, dike, pumping plant, and reservoir.

**Table 2-5. Wymer Dam, Dike, Pumping Plant, and Reservoir Characteristics**

| Item | Data | |
|---|---|---|
| **Dam and Dike (concrete-faced rockfill)** | **Dam** | **Dike** |
| Height | 415 feet | 130 feet |
| Crest elevation | 1745 feet | 1745 feet |
| Crest length | 2,855 feet | 2,310 feet |
| Crest width | 30 feet | 30 feet |
| **Pumping Plant** | 400 cfs[1] | |
| **Reservoir** | **Elevation (feet)** | **Volume (acre-feet)** |
| Surcharge | 1730 - 1740 | 14,400 |
| Active conservation | 1450 - 1730 | 174,000[2] |
| Inactive conservation | 1351 - 1450 | 7,090 |
| Dead storage | 1330 - 1351 | 210 |

[1] 1,000-cfs inflow and 1,400-cfs outflow was used for these operation studies.
[2] Rounded to 175,000 acre-feet for modeling purposes.

## 2.3.2 Yakima River Pump Exchange

In September 2006, an appraisal-level study was completed on behalf of Reclamation and Ecology by Golder Associates, Inc., in collaboration with MWH Americas, Inc., and Montgomery Water Group, to analyze a Yakima River pump exchange option. The Yakima River pump exchange option involves a pump and pipeline system to deliver up to 1,200 cfs from near the mouth of the Yakima River in Kennewick, Washington, to various points in the Sunnyside Valley and Roza Irrigation Divisions (SVID and RID) southeast of Yakima, Washington. The water that would be delivered to SVID and RID by this system would be exchanged for the water they would normally divert from the Yakima River. That water would remain in the Yakima River to improve fishery habitat and provide irrigation water to proratable irrigators during dry years. Water delivery from the pump and pipeline system would take place during the irrigation season of April through October.

### 2.3.2.1 Two Plans Developed

Two delivery system plans were developed, both with three pumping plants and buried pipelines. Following are brief descriptions of each plan:

Plan 1 would deliver 1,200 cfs to the Sunnyside Canal, completely replacing SVID's diversion from the Yakima River at Sunnyside Dam. A 750-cfs delivery would be made near the headworks at MP 2.35, and two other deliveries would be made lower on the canal—400 cfs at MP 37.0 and 50 cfs at MP 59.29 (at the reregulation reservoir at the end of Sunnyside Canal, prior to Benton Irrigation District). The intermediate deliveries are planned to achieve minimum operating flow requirements in the Sunnyside Canal.

Plan 2 would split the deliveries between SVID and RID, with 650 cfs delivered to Sunnyside Canal and 550 cfs to Roza Canal. In Plan 2, deliveries would not be made at the head of the Sunnyside Canal, which would save a substantial length of pipe. Deliveries would be made to the Sunnyside Canal at three locations—200 cfs at MP 30.0, 400 cfs at MP 37.0; and 50 cfs at MP 59.29. A delivery of 550 cfs will be made to the Roza Canal at one location, MP 59.0. The division of flow between SVID and RID could be adjustable.

Table 2-6 shows the components of each plan.

**Table 2-6. Configurations of Yakima River Pump Exchange**

| Item | Components of Both Plans 1 and 2 | | Plan 1 | Plan 2 |
|---|---|---|---|---|
| | Pump Station 1 | Pump Station 2 | Pump Station 3 | |
| Location | By Columbia River, in Kennewick WA | Near Benton City WA | Near Sunnyside Canal MP 37.0 | |
| Inflow | 1,200 cfs | 1,200 cfs | 1,150 cfs | 1,150 cfs |
| Outflow Capacity | 1,200 cfs | 1,200 cfs | 750 cfs | 550 cfs |
| Pumps and Capacity | 6 pumps @ 200 cfs each[1] | 6 pumps @ 200 cfs each[1] | 4 pumps @ 187.5 cfs[1] | 3 pumps @ 183 cfs[1] |
| Lift | 530 feet | 270 feet | 100 feet | 165 feet |
| Discharge to | Outflow pipeline | Outflow pipeline | (see below) | |
| **Outflow Pipeline (Pumped Water)** | | | | |
| Location | Station 1 to Station 2 | Station 2 to Station 3 with 50 cfs discharge to Sunnyside Canal MP 59.29 | Station 3 to Sunnyside Canal MP 2.35 | Station 3 to Roza Canal MP 59.0 |
| Capacity | 1,200 cfs | 1,200 cfs | 750 cfs | 550 cfs |
| Type | 2 steel pipelines | 2 steel pipelines | 1 steel pipeline | 1 steel pipeline |
| Diameter | 132-inch-diameter each | 132-inch-diameter each | 132-inch-diameter | 120-inch |
| Length | 17 miles | 31 miles | 25 miles | 1 mile |
| **Outflow Pipeline (Gravity Flow Water)** | | | | |
| Location | | | Station 3 to Sunnyside Canal MP 37.0 | Station 3 to Sunnyside Canal MP 37.0 |
| Capacity | | | 400 cfs | 400 cfs |
| Type | | | 1 steel pipeline | 1 steel pipeline |
| Diameter | | | 84-inch | 84-inch |
| Length | | | 2 miles | 2 miles |
| Location | | | | Station 3 to Sunnyside Canal MP 30.0 |
| Capacity | | | | 200 cfs |
| Type | | | | 1 steel pipeline |
| Diameter | | | | 72-inch |
| Length | | | | 5 miles |

[1] In addition, there is one standby pump at each Pump Station.

Appraisal-level cost estimates were developed for the two plans—Plan 1, $2.85 billion, and Plan 2, $2.58 billion (April 2004 prices).

## 2.4 Costs of Alternatives

Project costs for the two action alternatives are shown in Table 2-7. The costs for the Black Rock Alternative and the pump exchange portion of the Wymer Dam Plus Yakima River Pump Exchange Alternative are at the April 2004 price levels.

The costs for Wymer were indexed from July 1985 costs to July 2004 using the Bureau of Reclamation Construction Cost Trend indices (www.usbr.gov/pmts/estimate/cost_trend.html). These costs do not include costs to purchase rights-of-way.

Annual Operation, Maintenance, Replacement, and Pumping Energy Costs for the two action alternatives are shown in Table 2-8. These costs for Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives are also based on the April 2004 cost index.

**Table 2-7. Project Costs for Action Alternatives (April 2004)**

| Project Feature | Black Rock Alternative | Wymer Dam Plus Yakima River Pump Exchange Alternative | |
|---|---|---|---|
| | Large Reservoir, Pump Only Inflow = 3,500 cfs | Plan 1 – 1,200 cfs Sunnyside | Plan 2 – 650 cfs Sunnyside; 550 cfs Roza |
| Priest Rapids fish screen and intake, pumping plant, and inflow conveyance (all-tunnel option) | $427,426,690 | n/a | n/a |
| Black Rock dam: central core rockfill embankment | $733,280,000 | n/a | n/a |
| Highway and utility relocations | $57,320,000 | n/a | n/a |
| Black Rock reservoir—outlet works, outlet structure, and outflow conveyance to Roza Canal | $389,896,715 | n/a | n/a |
| Black Rock outlet facility—1,500 cfs powerplant | $104,010,535 | n/a | n/a |
| Sunnyside Powerplant | $32,302,450 | n/a | n/a |
| Delivery Systems to Roza, Sunnyside, and modification to existing facilities | $177,200,000 | | |
| Yakima River Pump Exchange intake structure and Pumping Plant #1 | | $102,000,000 | $102,000,000 |
| Yakima River Pump Exchange Pumping Plant #2 | | $98,300,000 | $98,300,000 |
| Yakima River Pump Exchange Pumping Plant #3 | | $41,700,000 | $43,900,000 |
| Delivery facilities | | $360,000 | $350,000 |
| Pipeline | | $1,156,500,000 | $1,022,800,000 |
| Wymer dam structure, 400-cfs pumping plant and outlet | | $187,524,675 | $187,524,675 |
| **Subtotal of pay items** | **$1,921,436,390** | **$1,586,384,675** | **$1,454,874,675** |
| Total mobilization costs (±5%) | $96,100,000 | $79,320,000 | $72,744,000 |
| Total unlisted items (±10% for Black Rock; ±15% for Yakima River Pump Exchange) | $192,463,610 | $250,295,325 | $229,381,325 |
| **Construction contract cost** | **$2,210,000,000** | **$1,916,000,000** | **$1,757,000,000** |
| Contingencies (±25%) | $567,000,000 | $479,000,000 | $436,000,000 |
| **Total field cost** | **$2,777,000,000** | **$2,395,000,000** | **$2,193,000,000** |
| Non-contract costs (±35%) | $972,000,000 | $839,000,000 | $767,000,000 |
| **Total Project Cost** | **$3,749,000,000** | **$3,235,000,000** (Pump Exchange, $2.855 billion + Wymer, $380 million) | **$2,960,000,000** (Pump Exchange, $2.580 billion + Wymer, $380 million) |

**Table 2-8. Annual Operation, Maintenance, Replacement, and Pumping Energy Costs (April 2004)**

| Item | Black Rock | Wymer Dam Plus Yakima River Pump Exchange[1] | |
|---|---|---|---|
| | Large Reservoir – Pump only | Plan 1 | Plan 2 |
| Operation, Maintenance, and Replacement Costs | $12,730,000 | $15,325,000 | $14,901,000 |
| Energy Costs | $62,000,000 | $18,629,700 | $18,521,700 |
| Total | $74,730,000 | $33,954,700 | $33,422,700 |

[1] These costs include $320,000 for Wymer OM&R and $607,000 for Wymer energy costs (400 cfs pumping plant).

# Chapter 3.0 OPERATION STUDIES

The effectiveness of the three alternatives (No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange) in meeting the Storage Study goals was evaluated by simulating the manner in which the existing Yakima Project could be operated as an integrated system with each alternative. As a point of comparison, a No Action Alternative was first developed by adding conservation to current facilities; then, individually adding the Black Rock Alternative and the Wymer Dam Plus Yakima River Pump Exchange Alternative.

In addition to these three operation studies, the Current Operation of the existing Yakima Project is provided to illustrate how the project is operated today. A natural (unregulated) flow shows how the Yakima, Naches, Bumping, Tieton, and Cle Elum Rivers may have looked in the past without the existing storage facilities, diversions, and surface and subsurface return flows from crop irrigation. The model does not exactly mimic historic operations, but provides a way to compare alternatives for decisionmaking purposes.

The Yakima Project RiverWare (Yak-RW) model was used in the operation studies. This model is a daily time-step reservoir and river operation simulation model of the Yakima Project, created with the RiverWare software. The model's network file consists of the five major project reservoirs (Keechelus, Kachess, Cle Elum, Bumping, and Rimrock), with a storage capacity of just over 1 million acre-feet and 56 major and minor river diversions and canal systems. The model includes the associated canal losses, on-farm losses, and return flows for the 56 river diversions.

The hydrologic base for the Yak-RW model reflects hydrologic conditions during the 23 water years of 1981 through 2003 (November 1, 1980, through October 31, 2003). This 23-year period includes 18 water years above 70-percent prorationing levels (wet and average water supply conditions) and 5 years under 70-percent prorationing levels (dry water supply conditions). A description of the input to the model and how it works is included in Appendix C of the *Yakima Basin Appraisal Assessment*. This report also contains a description of the Current Operation and the natural (Unregulated) hydrograph.

## 3.1 Criteria

Table 3-1 summarizes criteria used in the operation studies of the three alternatives in the Plan Formulation analyses. These criteria should be considered as an illustration of one approach to integrated project operations, but not the only one.

## Table 3-1. Criteria Used in the Operation Studies of the Three Alternatives

| | No Action Alternative | Black Rock Alternative | Wymer Dam Plus Yakima River Pump Exchange Alternative |
|---|---|---|---|
| **Water Exchange Operations** | | | |
| **Water Exchange Assumptions** | | | |
| Period | | The water exchange extends throughout the irrigation season of April through October. | The water exchange extends throughout the irrigation season of April through October. |
| Volume | | The rate of water to exchange shall not be greater than 2,000 cfs. | The rate of water to exchange shall not be greater than 1,200 cfs. |
| Participants | | The exchange participants being considered at this time are the Roza and Sunnyside Divisions. | The exchange participants being considered at this time are the Roza and Sunnyside Divisions. |
| Type of Exchange | | This is a full exchange of Yakima River diversions for water delivered from Black Rock. Black Rock reservoir is filled by pumping from the Columbia River when flows are greater than current instream target flows. | This is a partial instantaneous exchange of Yakima River diversions for water pumped from the mouth of the Yakima River. On any day, the water pumped cannot be more than the rate that would have been diverted by the participating entity(s), limited by the capacity of the exchange facilities. There is to be no depletion in the outflow at the mouth of the Yakima (no "net loss of water to the Columbia River"). |
| **April - June (Irrigation Season)** | | | |
| Exchange Participants' Irrigation Demands | Irrigation demands will be met by diversion of Yakima River basin unregulated flows. | Irrigation demands will be met entirely through an exchange of water delivered from Black Rock reservoir. | Irrigation demands will be met by a combination of Yakima River diversions of unregulated flows and a water exchange. |
| Instream Flow at Parker Gauge | The Parker flow will not be less than 644 cfs to 844 cfs. This consists of a combination of the current Title XII target flow (400 cfs to 600 cfs), the increased Title XII flow resulting from conservation measures (136 cfs), and operational flows from changes in points of diversion (108 cfs). | The Parker flow will be the unregulated flow, plus the water exchange, plus a stored water release of 1,500 cfs. | The Parker flow will not be less than 1,500 cfs. This flow will be met by a water exchange of up to 1,200 cfs with the residual provided from the No Action Alternative flows. |

## Table 3-1. Criteria Used in the Operation Studies of the Three Alternatives

| | No Action Alternative | Black Rock Alternative | Wymer Dam Plus Yakima River Pump Exchange Alternative |
|---|---|---|---|
| **July - October (Irrigation Season)** | | | |
| Exchange Participants' Irrigation Demands | Irrigation demands will be met by diversion of Yakima River basin unregulated flows plus stored water releases from Yakima Project reservoirs. | Irrigation demands will be met entirely through an exchange of water delivered from Black Rock reservoir. | Irrigation demands will be met by a combination of Yakima River diversions of unregulated flows and by a water exchange. |
| Instream Flow at Parker Gauge | The Parker flow will not be less than 644 cfs to 844 cfs. | The Parker flow will not be less than the No Action Alternative flow. | The Parker flow will not be less than 1,500 cfs. [2] |
| **October – May** | | | |
| | Cle Elum River flows are maintained at not less than 220 cfs by releases from Cle Elum Reservoir. | Cle Elum River flows are maintained at not less than 500 cfs[3] by releasing an additional 280 cfs from Cle Elum Reservoir. This 280-cfs flow increase continues downstream to the mouth of the Yakima River and is "lost from the Yakima basin." | Cle Elum River flows are maintained at about 400-410 cfs by releasing an additional 187 cfs from Cle Elum Reservoir. This 187-cfs flow increase is then diverted at the Wymer pumping plant and stored in Wymer reservoir. |
| **Wymer Reservoir Operations** | | | |
| **Wymer Reservoir Assumptions (90,000 acre-feet)** | | | |
| Volume (90,000 acre-feet) | | | The active capacity of Wymer reservoir is 175,000 acre-feet, of which 90,000 acre-feet is used to store water released from Cle Elum Reservoir during October through May. The pumping plant capacity is 1,000 cfs, and the reservoir outflow capacity is 1,400 cfs. |

[2] The basis for modeling a minimum summer (storage control) target flow of 1,500 cfs at Parker is because it approximates the unregulated median August and September flows (summer low-flow period) and results in increased summer juvenile salmonid rearing habitat.

[3] An increase in the Cle Elum River winter target flow from 220 to 500 cfs provides for increased winter habitat in the main channel for juvenile salmonids.

## Table 3-1. Criteria Used in the Operation Studies of the Three Alternatives

| | No Action Alternative | Black Rock Alternative | Wymer Dam Plus Yakima River Pump Exchange Alternative |
|---|---|---|---|
| **April - June (Irrigation Season)** | | | |
| Diversions to Wymer reservoir | | | The increased April and May release of 187 cfs from Cle Elum Reservoir to maintain a Cle Elum River flow of 400-410 cfs is pumped to Wymer reservoir for storage. |
| Releases from Wymer reservoir | | | There are no releases from the 90,000 acre-feet of storage space. |
| **July - October (Irrigation Season)** | | | |
| Diversions to Wymer reservoir | | | Water is not pumped to Wymer reservoir during July through September. The increased October Cle Elum flow release of 187 cfs is pumped for storage in Wymer reservoir. |
| Releases from Wymer reservoir | | | Releases from Wymer reservoir are made in July and August for instream flows and irrigation. |
| **November – March** | | | |
| Diversions to Wymer reservoir | | | The increased November-through-March release from Cle Elum Reservoir of 187 cfs to maintain a Cle Elum River flow of 400-410 cfs is pumped to Wymer reservoir for storage. |
| Releases from Wymer reservoir | | | Stored water is not released from Wymer reservoir. |
| **Wymer Reservoir Assumptions (85,000 acre-feet)** | | | |
| Volume (85,000 acre-feet) | | | The active capacity of Wymer reservoir is 175,000 acre-feet, of which 85,000 acre-feet is used exclusively for improving the irrigation proratable supply when the proration level is less than 70 percent. |

**Table 3-1. Criteria Used in the Operation Studies of the Three Alternatives**

| | No Action Alternative | Black Rock Alternative | Wymer Dam Plus Yakima River Pump Exchange Alternative |
|---|---|---|---|
| **January – March** | | | |
| Diversions to Wymer reservoir | | | Yakima River flows in excess of 1,475 cfs are pumped to Wymer reservoir. |
| **April - October (Irrigation Season)** | | | |
| Releases from Wymer reservoir | | | Releases are made only when the proration level is less than 70 percent. |

### 3.1.1 No Action Alternative

As described in Chapter 2, the No Action Alternative includes water conservation measures presently being constructed or considered for future implementation with funding from the Basin Conservation Program or from other sources. Operation studies for the *Black Rock Appraisal Assessment* and the *Yakima Basin Appraisal Assessment* did not include a No Action Alternative, only the natural (unregulated) operation.

The following primary assumptions were used for the No Action Alternative operation study:

- Diversions of the entities implementing water conservation measures are reduced in wet and average water supply years by the total amount of the conserved water. In dry years, diversions are reduced by only the instream flow component; it is assumed the irrigation component will be diverted by the entity (see Table 2-1).

- In all water years, the instream flow component remains in the river from the implementing entity's point of diversion to the return flow points used in the Yak-RW model. For the Roza and Sunnyside Divisions, there are three return flow points downstream of Sunnyside Diversion Dam and upstream of Prosser Diversion Dam. This results in an increase of 136 cfs in Title XII instream target flows passing over Sunnyside Diversion Dam in wet and average water years.

- In wet and average water years, the irrigation component of the conserved water remains a part of the irrigation TWSA. However, at the end of the irrigation season, it loses its identity as conserved water of a specific entity and, to the extent possible, is carried over in the project reservoirs and becomes a part of the TWSA for the next irrigation season.

- All conserved water and operational flows are prorated in dry years in accordance with the water rights of the implementing entities. For example, in 1994, proration would result in 97 cfs over Sunnyside Dam rather than 136 cfs.

- Operational flows resulting from potential changes in points of diversion are accounted for in the operation study but are not considered a part of the Title XII target flow. These operational flows amount to 108 cfs over Sunnyside Diversion Dam and 58 cfs over Prosser Diversion Dam.

Table 3-2 shows the primary operation criteria of the No Action Alternative in nonproration years.

**Table 3-2. No Action Alternative Primary Operation Criteria**

| | Water Year | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Irrigation Season | | | | | | |
| Aug | Sept | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct |
| | | | | | | | | Parker Flows Not Less Than 644 cfs-844 cfs[4] | | | | | | |

## 3.1.2 Black Rock Alternative

The operation studies for the combined Black Rock Alternative and No Action Alternative are characterized by the following:

- A potential water exchange of up to 2,000 cfs with the Roza and Sunnyside Divisions. The operation study is based on a maximum water exchange of 950 cfs with the Roza Division and 1,050 cfs with the Sunnyside Division.[5]

- Water delivered from Black Rock reservoir begins with the mid-March priming of the canals. During the pre-storage control period (generally April through June), the water not diverted remains in the Yakima River for instream flow purposes. Once the storage control period begins, and continuing through the remainder of the irrigation season, the stored water which would have been released to meet the irrigation demands of the exchange participants remains in the reservoirs as the result of the exchange.[6]

- The April-to-June release of 1,500 cfs[7] of stored water from Yakima Project reservoirs would assist in mimicking the natural (unregulated) flow regime of the Yakima and Naches Rivers.

- A July-to-October flow at the Parker gauge similar to the No Action Alternative.

- Cle Elum River flows increased from about 220 cfs to not less than 500 cfs from October 1 to May 31. These flows (an annual volume of about 135,000 acre-feet) continue downstream to the Yakima-Columbia River confluence and are "lost to the Yakima River system."

[4] These flows include the conserved (136 cfs) and operational flows (108 dfs) for wet and average water years.
[5] With implementation of the water conservation measures of the No Action Alternative, the diversions of the Roza and Sunnyside Divisions decrease from about 1,075 cfs and 1,275 cfs to 950 cfs and 1,050 cfs, respectively.
[6] In a dry year when the proration level is less than 70 percent, a portion of the stored water is provided to other proratable irrigation rights to bring their water supply up to 70 percent.
[7] To be consistent for comparative purposes with Wymer Dam Plus Yakima River Pump Exchange Alternative, the block of water used to maintain a minimum summer instream flow target of 1,500 cfs was fully allocated to the spring season for the Black Rock Alternative.

Table 3-3 shows the primary operation criteria of the integrated Black Rock Alternative in nonproration years.

**Table 3-3. Black Rock Alternative Primary Operation Criteria**

<table>
<tr><td></td><td colspan="12">Water Year</td><td></td></tr>
<tr><td colspan="8"></td><td colspan="6">Irrigation Season</td></tr>
<tr><td>Aug</td><td>Sept</td><td>Oct</td><td>Nov</td><td>Dec</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>June</td><td>July</td><td>Aug</td><td>Sept</td><td>Oct</td></tr>
<tr><td colspan="2"></td><td colspan="6">Cle Elum River Flows Not Less Than 500 cfs</td><td colspan="6"></td></tr>
<tr><td colspan="8"></td><td colspan="2">Parker Flows = unregulated flow + water exchange + 1,500 cfs</td><td colspan="5"></td></tr>
<tr><td colspan="10"></td><td colspan="5">Parker Flows Not Less Than 644 cfs-844 cfs</td></tr>
<tr><td colspan="7"></td><td colspan="8">Water Exchange</td></tr>
</table>

## 3.1.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

The Wymer Dam Plus Yakima River Pump Exchange Alternative is added to the No Action Alternative, resulting in a system operation with the following primary criteria:

- A potential water exchange with the Roza and Sunnyside Divisions of 1,200 cfs. The operation study is based on the following daily water exchanges:
  - **Roza Division** - The lesser of 550 cfs, or the Roza daily diversion demand minus 200 cfs.[8]
  - **Sunnyside Division** - The lesser of 750 cfs, or 1,200 cfs minus the Roza Division exchange, or Sunnyside Division daily diversion demand.
- An instantaneous "bucket-for-bucket" exchange at the mouth of the Yakima River for a portion of the water not diverted by the Roza and Sunnyside Divisions would begin when water is first diverted (about mid-March, for priming of the canals). This exchange continues throughout the April 1-to-late October irrigation season. The undiverted water remains in the Yakima River for instream flow purposes.
- An April-through-October flow at the Parker gauge during the irrigation season of not less than 1,500 cfs.[9]

[8] The 200 cfs amount is the minimum "canal carriage flow" required for operation of the Roza Canal upstream of the pump-back inflow point which is near MP 59.0.

[9] The basis for modeling a minimum summer (storage control) target flow of 1,500 cfs at Parker is because it approximates the unregulated median August and September flow (summer low-flow period) and results in increased summer juvenile salmonid rearing habitat.

- Storage in the 175,000-acre-foot active capacity[10] Wymer reservoir is segregated into the following volumes:

    - Ninety thousand acre-feet to be filled each year by moving about 187 cfs from Cle Elum Reservoir during October 1 to May 31 to Wymer. The purpose of this operation is to increase Cle Elum River flows from about 220 cfs to about 400 to 410 cfs.[11] This stored water is then released in July and August for irrigation and for instream flows as needed.
    - Eighty-five thousand acre-feet to improve the dry-year proratable water supply. This storage space is filled from January 1 to March 31 by pumping only when Yakima River flows at the Wymer pumping plant are greater than 1,475 cfs. The 85,000 acre-feet may not be available for pumping in each year. Stored water is carried over from year to year until needed when the proration level without the 85,000 acre-feet would be less than 70 percent.

Table 3-4 illustrates the primary operation criteria of the integrated Wymer Dam Plus Yakima River Pump Exchange Alternative in nonproration years.

**Table 3-4. Wymer Dam Plus Yakima River Pump Exchange Alternative Primary Operation Criteria**

<table>
<tr><td colspan="2"></td><td colspan="11">Water Year</td><td></td></tr>
<tr><td colspan="8"></td><td colspan="6">Irrigation Season</td></tr>
<tr><td>Aug</td><td>Sept</td><td>Oct</td><td>Nov</td><td>Dec</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>June</td><td>July</td><td>Aug</td><td>Sept</td><td>Oct</td></tr>
<tr><td colspan="2"></td><td colspan="7">Cle Elum River Flows Not Less Than 400 cfs</td><td colspan="6"></td></tr>
<tr><td colspan="2"></td><td colspan="7">Fill Wymer 90,000 af</td><td></td><td colspan="2">Wymer Rls. 90,000 af</td><td colspan="2"></td></tr>
<tr><td colspan="5"></td><td colspan="3">Fill Wymer 85,000 af</td><td colspan="6"></td></tr>
<tr><td colspan="8"></td><td colspan="6">Parker Flows Not Less Than 1,500 cfs</td></tr>
<tr><td colspan="8"></td><td colspan="6">Water Exchange</td></tr>
</table>

# 3.2 Results

## 3.2.1 Irrigation Supply

In dry years when the irrigation water supply available is less than the irrigation water rights, proration is necessary. Under the 1945 Consent Decree, nonproratable (senior)

[10] The Wymer reservoir was designed with a 174,000-acre-foot active capacity. For these operation studies, that number was rounded to 175,000 acre-feet.
[11] The increased instream flow of 187 cfs is based on filling the 90,000 acre-feet of Wymer reservoir storage space during the October-May period of 243 days.

water rights holders are to receive their full water supply and the water supply available to proratable (junior) rights is to be reduced. A goal of the Storage Study is to provide a not less than 70-percent proratable irrigation supply in dry years.

In the analysis of any alternative being considered, it is important to address the computation of TWSA and proration level to be as consistent to the current process as possible. The current process is based on water supply estimates beginning April 1 of natural and return flows upstream of the Parker gauge plus Yakima Project reservoir contents. The amount of available irrigation water is the remainder after allowing for the Title XII flows and unusable flows at Parker. The adequacy of the remaining supply to meet the irrigation water entitlements (when necessary) is based on the nonproratable and proratable entitlements set forth in the 1945 Consent Decree. This current process is adhered to in the operation studies of the three alternatives with the allotments and timing of water to calculate proration levels. Once the current proration level is determined for an alternative, it is possible to improve the proratable irrigation supply in dry years and then determine further flow improvements for fishery habitat.

Table 3-5 shows the modeled April 1 TWSA and the end of the irrigation season proration level for the 23-year period used in the Yak-RW model. This information is used to simulate current Yakima Project operations and for the operations of the three alternatives.

#### 3.2.1.1 No Action Alternative

The implementation of water conservation measures throughout the Yakima basin included in the No Action Alternative results in improved system efficiencies of the canals and distribution works of the implementing entities. This is illustrated in Table 3-6.

**Table 3-5. TWSA and Proratable Supply**

| Water Year | April 1 – September 30 TWSA for Alternative Operation (million acre-feet) | | | | Proratable Water Supply Provided for Alternative Operation[1] (percent) | | | |
|---|---|---|---|---|---|---|---|---|
| | Current | No Action | Black Rock | Wymer + Pump Exchange | Current | No Action | Black Rock | Wymer + Pump Exchange |
| 1981 | 2.50 | 2.50 | * | 2.50 | 95 | 95 | * | 100 |
| 1982 | 3,42 | 3.44 | 3.41 | 3.49 | 100 | 100 | 100 | 100 |
| 1983 | 3.35 | 3.37 | 3.38 | 3.46 | 100 | 100 | 100 | 100 |
| 1984 | 3.26 | 3.27 | 3.26 | 3.34 | 100 | 100 | 100 | 100 |
| 1985 | 2.78 | 2.81 | 2.93 | 2.96 | 100 | 100 | 100 | 100 |
| 1986 | 2.52 | 2.55 | 2.65 | 2.70 | 92 | 99 | 90 | 100 |
| 1987 | 2.27 | 2.32 | 2.47 | 2.46 | 65 | 70 | 76 | 89 |
| 1988 | 2.34 | 2.34 | 2.54 | 2.44 | 73 | 73 | 92 | 86 |
| 1989 | 2.69 | 2.69 | 2.77 | 2.78 | 98 | 98 | 94 | 100 |
| 1990 | 3.13 | 3.15 | 3.08 | 3.19 | 100 | 100 | 100 | 100 |
| 1991 | 3.04 | 3.04 | 3.03 | 3.10 | 100 | 100 | 100 | 100 |
| 1992 | 2.13 | 2.17 | 2.25 | 2.33 | 69 | 72 | 80 | 90 |
| 1993 | 2.09 | 2.10 | 2.29 | 2.22 | 54 | 56 | 70 | 75 |
| 1994 | 1.75 | 1.74 | 1.82 | 1.79 | 26 | 26 | 70 | 40 |
| 1995 | 2.93 | 2.93 | 2.86 | 2.93 | 100 | 100 | 100 | 100 |
| 1996 | 3.23 | 3.23 | 3.23 | 3.30 | 100 | 100 | 100 | 100 |
| 1997 | 4.53 | 4.55 | 4.58 | 4.64 | 100 | 100 | 100 | 100 |
| 1998 | 3.17 | 3.17 | 3.14 | 3.19 | 100 | 100 | 100 | 100 |
| 1999 | 4.01 | 4.03 | 4.10 | 4.14 | 100 | 100 | 100 | 100 |
| 2000 | 3.28 | 3.28 | 3.24 | 3.35 | 100 | 100 | 100 | 100 |
| 2001 | 1.81 | 1.86 | 2.04 | 2.03 | 41 | 46 | 70 | 73 |
| 2002 | 3.26 | 3.26 | 3.36 | 3.25 | 100 | 100 | 100 | 100 |
| 2003 | 2.58 | 2.61 | 2.68 | 2.75 | 97 | 100 | 100 | 100 |

[1]As computed at the end of the irrigation season for the proration period.
*The Yak-RW model under-predicts the water supply for the Black Rock Alternative due to the starting storage of the model.

**Table 3-6. Illustration of Water Conservation Effects on Farm Delivery Water Supply**

| | Current | No Action Alternative | Difference |
|---|---|---|---|
| Efficiency | 62% | 71% | +11% |
| Nonprorated year diversion | 350,500 acre-feet | 306,800 acre-feet | - 43,700 acre-feet |
| Farm delivery (full supply) | 217,300 acre-feet | 217,300 acre-feet | -- |
| Canal loss | 133,200 acre-feet (38%) | 89,500 acre-feet (29%) | -43,700 acre-feet (-11%) |

Table 3-6 also shows the current nonprorated water year diversion of 350,500 acre-feet (with a conveyance-system efficiency of 62 percent) results in a full farm delivery supply of 217,300 acre-feet. Implementing these water conservation measures are estimated to result in about 43,700 acre-feet of conserved water and decrease the nonprorated year diversion to 306,800 acre-feet. This results in a conveyance-system efficiency of 71 percent.

The conserved water (43,700 acre-feet) is assigned two-thirds to instream flows (29,200 acre-feet) and one-third to irrigation (14,500 acre-feet). In all water years, the 29,200-acre-foot instream flow component remains in the river. In wet and average water supply years, the 14,500-acre-foot irrigation component is not diverted and remains in the Yakima Project system as part of the TWSA. However, in dry years—when prorationing of junior irrigation water rights occurs—this water, which may be adjusted by the entity's water rights, is diverted by the entity implementing the water conservation measures.

The increase in farm delivery described above is not accounted for by changes in the proration levels of the No Action Alternative operation. The differences in proration levels between the Current Operation and the No Action Alternative operation shown in Table 3-5 are those resulting from increased TWSA when it is possible to carry over the irrigation component of the conserved water not diverted in wet and average years and accumulate it in Yakima Project reservoirs. This increased the proratable water supply available in the prorated water years of 1986, 1987, 1988, 1992, 1993, and 2001 for the 23-year period of record. Figure 3-1 and Figure 3-2 illustrate the diversions and farm deliveries of two of the four major irrigation entities (Roza and Sunnyside Divisions) implementing water conservation in the No Action Alternative as compared to the Current Operation (shown in the first 4 bars). Average annual river diversion and average annual farm delivery are those over the 23-year period of hydrologic record; minimum annual river diversion and minimum annual farm delivery are that for the 1994 water year.

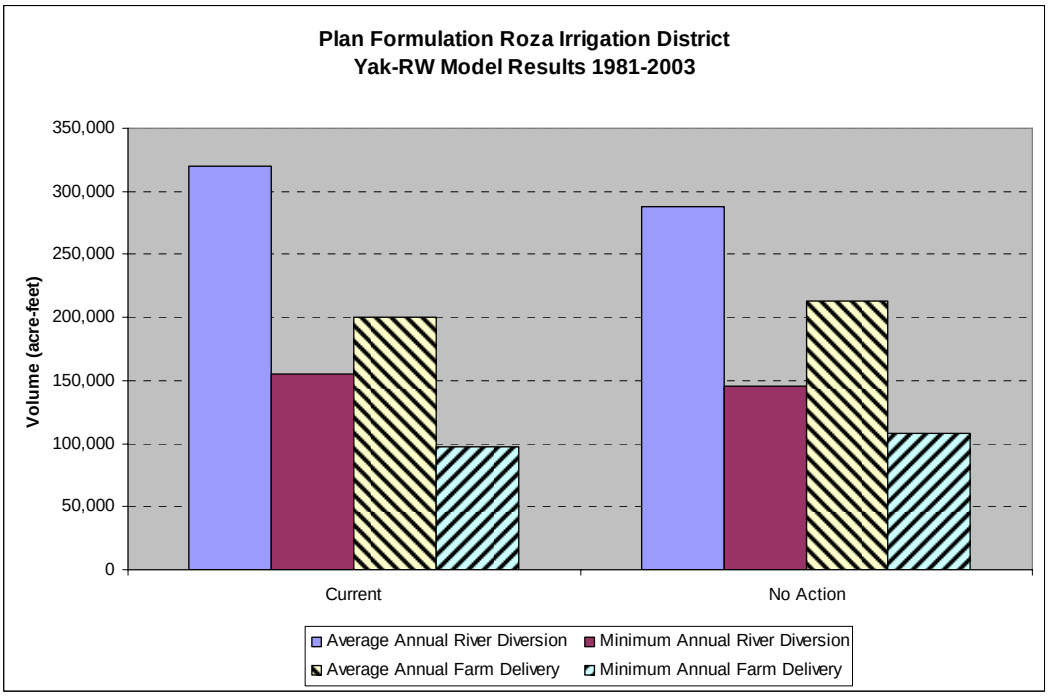


**Figure 3-1. Plan Formulation Roza Irrigation District Yak-RW Model Results 1981-2003**

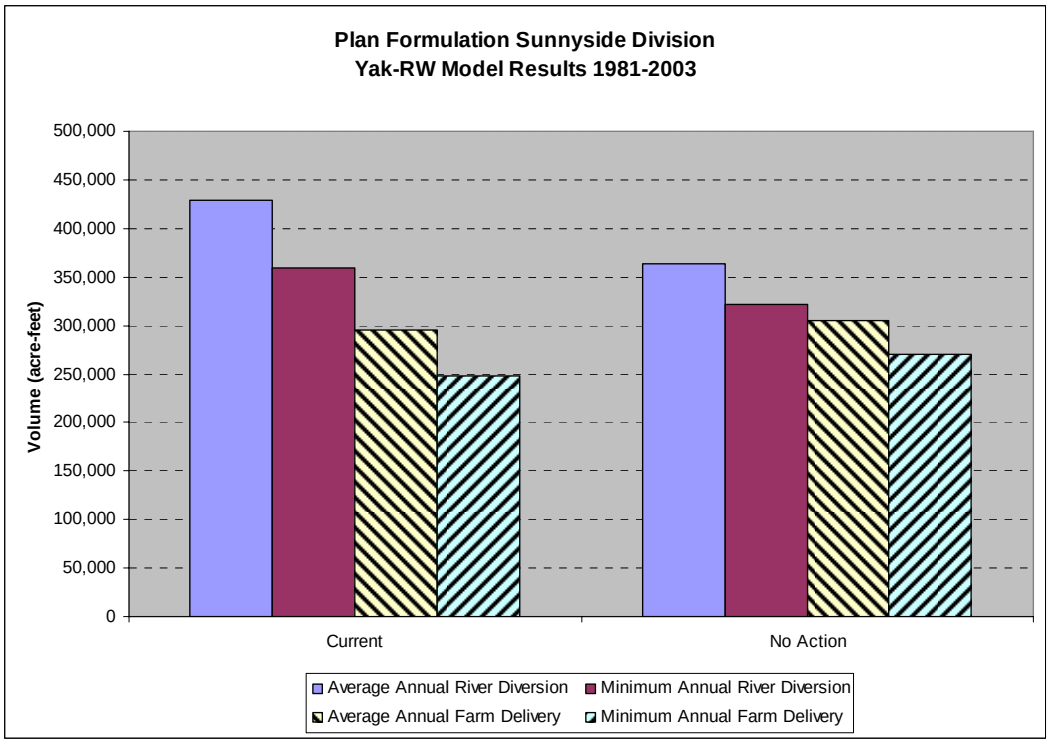


**Figure 3-2. Plan Formulation Sunnyside Division Yak-RW Model Results 1981-2003**

It should be recognized that water conservation will reduce return flows to the Yakima River basin system. Currently, an estimated 300,000 acre-feet of return flows comprise a portion of the TWSA estimate.[12] The irrigation component of the saved water that had previously been diverted and returned to the river as surface and subsurface return flows would not be diverted in wet and average water years. This reduces return flows for downstream diverters.

In the case of the water conservation measures included in the No Action operations study, all return flows accrue to the Yakima River below Sunnyside Diversion Dam. All of the water supply for diverters in this lower reach of the Yakima River is provided by return flows and continued water conservation activities could require stored water releases.

[12] This represents wet and average water years. In dry years, the return flow figure is reduced.

#### 3.2.1.2 Black Rock Alternative

The result of the Black Rock Alternative operation study is to make the TWSA (about 685,000 acre-feet associated with the Roza and Sunnyside Divisions) available for instream flows and improving the dry-year supply of all other proratable irrigation water rights to a not less than 70-percent supply. In nonprorated water years, this 685,000 acre-feet of natural flow, return flow, and stored water is used to:

- Increase October-through-May flows in the Cle Elum River downstream of Cle Elum Dam to not less than 500 cfs, an increase of about 280 cfs (135,000 acre-feet),

- Increase April-through-June unregulated flows downstream of the points of diversion of the Roza and Sunnyside Divisions by delivering water from Black Rock reservoir in exchange for that which would have been diverted and, in addition, 1,500 cfs (about 270,000 acre-feet) throughout the river reaches by releasing water from project reservoirs, and

- Retain some stored water in project reservoirs as carryover for the next year.

In an extreme dry year, it would be necessary to prorate the 1,500 cfs to meet the proratable irrigation goal of not less than 70 percent. For instance, in 1994, the 1,500-cfs flow is prorated by the percentage needed to bring the irrigation proration level to not less than 70 percent which, in this case, is an increase of 30 percent.

#### 3.2.1.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

The Wymer Dam Plus Yakima River Pump Exchange Alternative improves the proratable irrigation water supply in dry water years by:

- Assigning 85,000 acre-feet of Wymer reservoir storage capacity to be used for irrigation only when the proration level is less than 70 percent, and

- Retaining a portion of the Title XII instream target flows in the project reservoirs.

The 85,000 acre-feet of Wymer reservoir storage space is enough to improve the proration level by about 8.5 percent. Water is released from this storage space only in 1994 when proration is less than 70 percent. While it would be possible to use this water in other years, such use would not assure that 85,000 acre-feet of stored water would be available when needed in severe drought years.

Retention in storage of a portion of the Title XII instream target flows is possible during the storage control period because the major portion of the July-October flows at the Parker gauge (not less than 1,500 cfs) is provided through the water exchange, with the residual made up by Title XII releases. When the maximum exchange of 1,200 cfs

occurs, a Title XII release of 300 cfs is required. In the 17 nonprorated water years, an average volume of about 85,000 acre-feet of Title XII water is accumulated in storage which otherwise would have been released from July to October. This additional stored water results in an increase in the irrigation proratable water supply in 8 years of the 23-year period of record (1981, 1986, 1987, 1988, 1989, 1992, 1993, and 2001). In 1994, about 55,000 acre-feet of stored Title XII water creates about a 5.5-percent improvement in the proration level.

As indicated in Table 3-5, the Wymer Dam Plus Yakima River Pump Exchange Alternative can improve the proratable irrigation water supply to not less than the 70 percent goal in a single dry year and in back-to-back dry years. However, in the third year of the 3-year 1992-1994 dry period, this alternative falls 30 percent (or 300,000 acre-feet) short of the goal.

Figure 3-3 and Figure 3-4 compare the diversions and farm deliveries provided to the Roza and Sunnyside Divisions (two of the irrigation entities implementing water conservation in the No Action Alternative) for the Current Operation, No Action Alternative, Black Rock Alternative, and the Wymer Dam Plus Yakima River Pump Exchange Alternative operations.

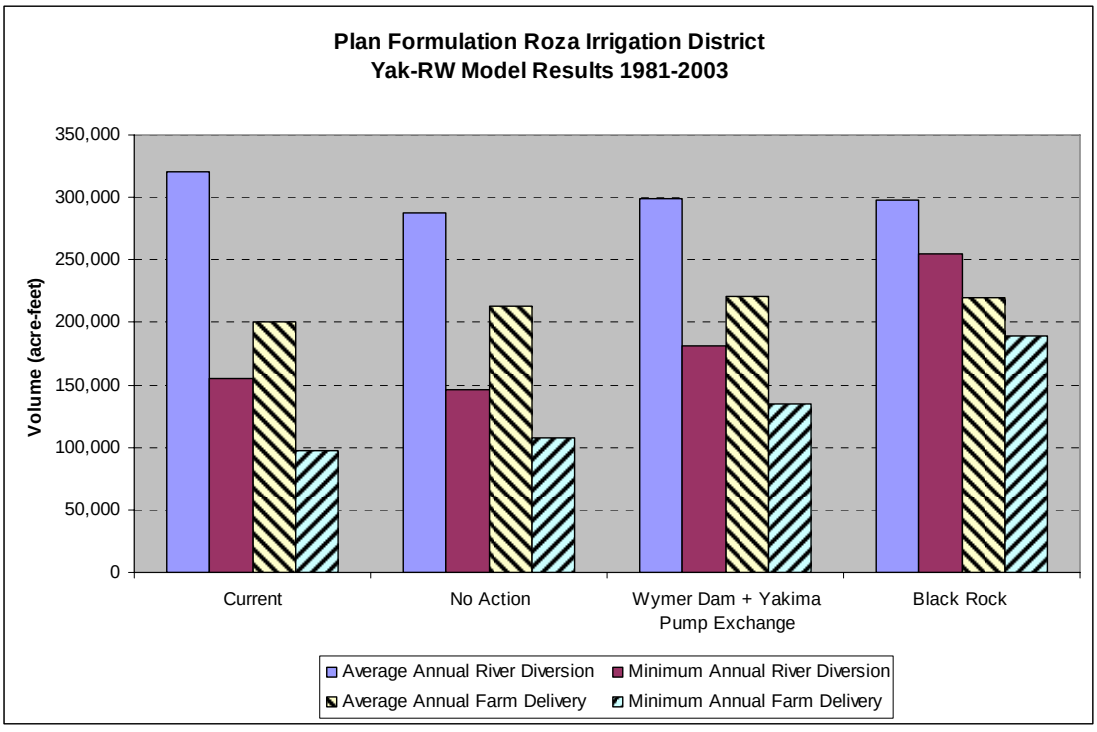


**Figure 3-3. Plan Formulation Roza Irrigation District Yak-RW Model Results 1981-2003**

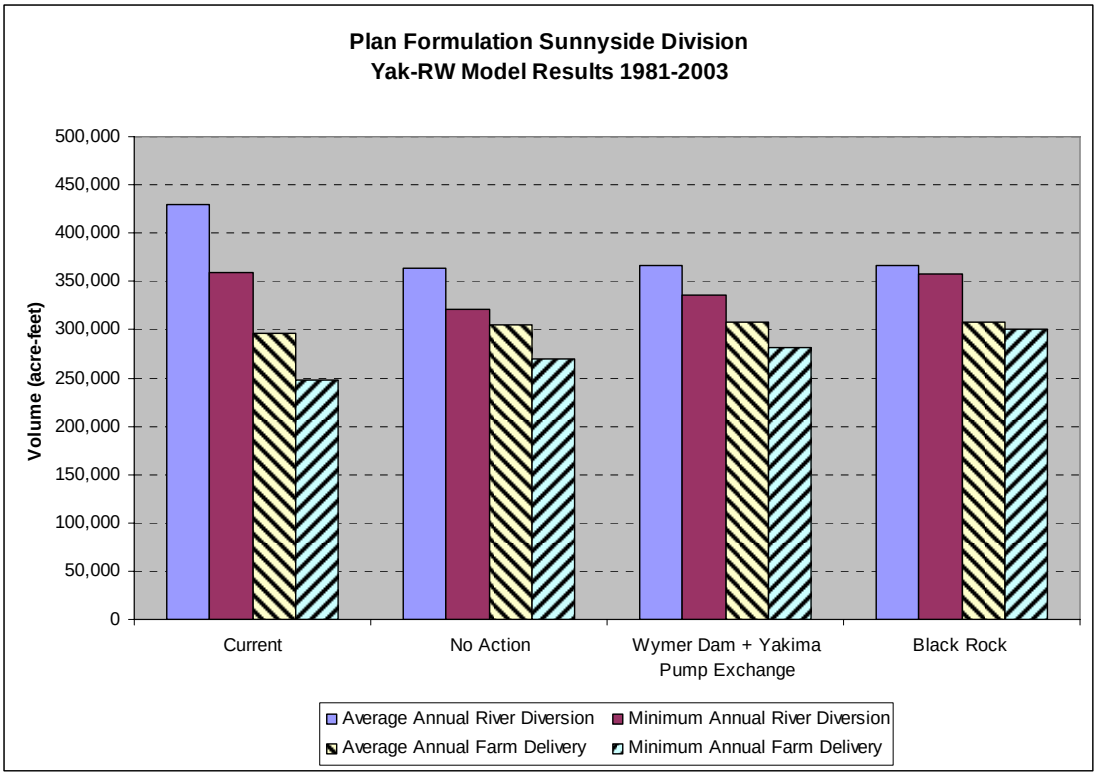


**Figure 3-4. Plan Formulation Sunnyside Division Model Results 1981-2003**

## 3.2.2 Instream Flows

The No Action Alternative and the two action alternatives (Black Rock and Wymer Dam Plus Yakima River Pump Exchange) were analyzed for similarities and differences in instream flow attributes. This analysis was based on the median monthly (shown on hydrographs) and seasonal flows, the seasonal Indicator of Hydrological Alterations (IHA) model critical scores, and the effects of the "flip-flop" operation.[13] A discussion of the data used in the analysis follows.

### 3.2.2.1 Median Monthly and Seasonal Flows

Median monthly and seasonal flows based on the Yak-RW model generated average daily flows at the seven gauging stations shown in Table 3-7. These average daily flow values were based on the 23 water years (October 1 through September 30) of 1981 through 2003.

[13] For a detailed discussion of the "flip-flop" operation, see the *Yakima River Basin Storage Alternatives Appraisal Assessment* (Reclamation, May 2006).

**Table 3-7. Gauging Stations and Stream Reaches**

| Gauge Station/ Hydrograph | Reach Name | Stream Reach |
|---|---|---|
| Easton (RM 202.0) | Easton | Yakima River: Easton Dam (RM 202.5) to Cle Elum River confluence (RM 185.6) |
| Cle Elum Dam Outlet (RM 7.9) | Cle Elum | Cle Elum River below Cle Elum Dam. |
| Umtanum (RM 140.4) | Ellensburg | Yakima River: Cle Elum River confluence (RM 185.6) to Roza Diversion Dam (RM 127.9). |
| Bumping Dam Outlet (RM 17.0) | Bumping | Bumping River: Bumping Dam (RM 17.0) to American River confluence (RM 0.0) |
| Cliffdell (RM 37.9) | Upper Naches | Naches River: Little Naches confluence (RM 44.6) to Tieton River confluence (RM 17.5) |
| Naches at Naches River (RM 16.8) | Lower Naches | Naches River: Tieton River confluence (RM 44.6) to the Naches River confluence (RM 0.0) |
| Parker (RM 108.7) | Wapato | Yakima River: Sunnyside Diversion Dam (RM 103.8) to Granger (RM 83.0) |

The seasonal flow values were calculated by taking the average of the three median monthly flow values. The seasons were defined as follows:

- Spring: April through June
- Summer: July through September
- Fall: October through December
- Winter: January through March.

Hydrographs were prepared for each of the seven gauging stations. These hydrographs show median monthly flows over the hydrologic period for the natural (Unregulated) condition, the Current Operation, the No Action Alternative, the Black Rock Alternative, and the Wymer Dam Plus Yakima River Pump Exchange Alternative. The median monthly flow is the flow that ranks 12$^{th}$ in the 23-year period (there are 11 months higher and 11 months lower than the median flow). The vertical lines on the hydrographs represent variations of the median monthly flow from the 75$^{th}$ percentile (top of the line) to the 25$^{th}$ percentile (bottom of the line). In other words, 75 percent of the flows recorded in a specific month were less than the flow at the top of the line, and 25 percent were less than the flow at the bottom of the line.

### 3.2.2.2 Indicator of Hydrologic Alterations Model

The IHA model has been used throughout the United States to evaluate river operations and impacts on the riverine ecosystem. The IHA model is a diagnostic tool that analyzes which flow parameters are within, or out of, the criteria as compared to the natural (unregulated) condition.

For this analysis, the Group 1 parameter (seasonal magnitude) of the IHA model was used. Three flow ranges (low, medium, and high) were evaluated for each month, totaling 36 monthly parameters that were organized by season. From this process, IHA critical values were developed for each season. An IHA critical value is defined by the System Operational Advisory Committee as any value less than or equal to -1.0 and greater than or equal to +2.0 when compared to the natural (Unregulated) condition. The greater the number of IHA critical value, the more it deviates from the desirable natural (unregulated) flow regime. The natural (Unregulated) flow regime does not have any critical values.

#### 3.2.2.3 Flip-Flop Effects

Flip-flop effects are those resulting from river operations employed during specific times of the irrigation season to improve spawning conditions by shifting the primary source of irrigation releases from one reservoir to another. An example is the September 1-10 operation, which decreases Cle Elum Reservoir releases and increases Rimrock Reservoir releases, thus shifting the primary source of water for mid-basin Yakima River irrigation diversions from the Yakima River to the Naches River. This operation significantly lowers flows in some river reaches of the Yakima River and, conversely, increases flows in reaches of the Naches River. This operation is commonly referred to as flip-flop and is not viewed as conducive to maintaining desirable fishery habitat.

The effect of the flip-flop operation was evaluated as a ratio of the difference in the median daily flow of the alternative compared to the natural (Unregulated) flow condition on August 15 and September 15. A lower flow ratio is considered more advantageous, equating to a lesser flow impact from the flip-flop operation.

#### 3.2.2.4 Results of Instream Flow Analysis

Table 3-8 and Figure 3-5 through Figure 3-11 show the results of the analysis of the Current Operation, the No Action Alternative, the Black Rock Alternative, and the Wymer Dam Plus Yakima River Pump Exchange Alternative.

In general, there are minimal differences in flows between the Current Operation and the No Action Alternative when these two are compared to the natural (Unregulated) condition. The most notable difference occurs at the Parker gauge during the spring and summer seasons resulting from the increased Title XII target flows, additional operational flows associated with water conservation measures, and changes in points of diversion included in the No Action Alternative (Table 3-8 and Figure 3-10).

The Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives both move the flow regime of all the gauging stations toward the natural (Unregulated) hydrograph. The Black Rock Alternative does more to move the flow regimes of the

Yakima River gauging stations than the other alternatives because it has a larger volume of water exchange.

**Table 3-8. Results of Flow Analysis for Current Operation, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Alternative**

| Gauge/ Season | Current Operation | | | No Action Alternative | | | Black Rock Alternative | | | Wymer Dam Plus Yakima River Pump Exchange Alternative | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flows | IHA | Flip-Flop | Flows | IHA | Flip-Flop | Flows (cfs) | IHA Values | Flip-Flop | Flows (cfs) | IHA Values | Flip-Flop |
| | Median | Number of Critical Values | Flow Ratio | Median | Number of Critical Values | Flow Ratio | Median | Number of Critical Values | Flow Ratio | Median | Number of Critical Values | Flow Ratio |
| **Easton Gauging Station** | | | | | | | | | | | | |
| Spring | 308 | 7 of 36 | | 339 | 7 of 36 | | 503 | 5 of 36 | | 339 | 7 of 36 | |
| Summer | 297 | 7 of 36 | | 289 | 8 of 36 | | 220 | 8 of 36 | | 220 | 7 of 36 | |
| Fall | 235 | 4 of 36 | 20.5 | 235 | 4 of 36 | 20.1 | 235 | 4 of 36 | 0 | 235 | 3 of 36 | 0 |
| Winter | 349 | 1 of 36 | | 347 | 1 of 36 | | 389 | 1 of 36 | | 341 | 1 of 36 | |
| Total | | 19 of 36 | | | 20 of 36 | | | 18 of 36 | | | 18 of 36 | |
| **Cle Elum Dam Outlet Gauging Station** | | | | | | | | | | | | |
| Spring | 838 | 4 of 36 | | 814 | 4 of 36 | | 1,400 | 4 of 36 | | 854 | 3 of 36 | |
| Summer | 2,062 | 7 of 36 | | 2,048 | 8 of 36 | | 1,043 | 6 of 36 | | 1,481 | 7 of 36 | |
| Fall | 220 | 5 of 36 | 26.6 | 220 | 5 of 36 | 25.8 | 500 | 3 of 36 | 7.0 | 407 | 1 of 36 | 17.8 |
| Winter | 220 | 5 of 36 | | 220 | 5 of 36 | | 500 | 2 of 36 | | 407 | 2 of 36 | |
| Total | | 21 of 36 | | | 22 of 36 | | | 15 of 36 | | | 13 of 36 | |
| **Umtanum Gauging Station** | | | | | | | | | | | | |
| Spring | 2,648 | 4 of 36 | | 2,713 | 3 of 36 | | 3,340 | 2 of 36 | | 2,749 | 3 of 36 | |
| Summer | 3,117 | 8 of 36 | | 3,046 | 8 of 36 | | 1,805 | 6 of 36 | | 2,443 | 8 of 36 | |
| Fall | 1,091 | 1 of 36 | 37.4 | 1,085 | 1 of 36 | 36.2 | 1,290 | 2 of 36 | 9.2 | 1,267 | 2 of 36 | 21.0 |
| Winter | 1,643 | 0 of 36 | | 1,664 | 0 of 36 | | 1,987 | 0 of 36 | | 1,831 | 0 of 36 | |
| Total | | 13 of 36 | | | 12 of 36 | | | 10 of 36 | | | 13 of 36 | |
| **Bumping Dam Outlet Gauging Station** | | | | | | | | | | | | |
| Spring | 312 | 1 of 36 | | 312 | 1 of 36 | | 312 | 1 of 36 | | 312 | 1 of 36 | |
| Summer | 220 | 7 of 36 | | 217 | 7 of 36 | | 211 | 7 of 36 | | 212 | 7 of 36 | |
| Fall | 144 | 3 of 36 | 24.3 | 145 | 3 of 36 | 22.7 | 143 | 3 of 36 | 19.0 | 146 | 3 of 36 | 17.6 |
| Winter | 152 | 0 of 36 | | 152 | 0 of 36 | | 148 | 0 of 36 | | 152 | 0 of 36 | |
| Total | | 11 of 36 | | | 11 of 36 | | | 11 of 36 | | | 11 of 36 | |
| **Cliffdell Gauging Station** | | | | | | | | | | | | |
| Spring | 1,565 | 0 of 36 | | 1,565 | 0 of 36 | | 1,565 | 0 of 36 | | 1,565 | 0 of 36 | |
| Summer | 426 | 6 of 36 | | 426 | 6 of 36 | | 410 | 1 of 36 | | 414 | 4 of 36 | |
| Fall | 347 | 1 of 36 | 2.5 | 348 | 1 of 36 | 2.5 | 350 | 1 of 36 | 2.0 | 350 | 1 of 36 | 2.0 |
| Winter | 586 | 0 of 36 | | 586 | 0 of 36 | | 586 | 0 of 36 | | 586 | 0 of 36 | |
| Total | | 7 of 36 | | | 7 of 36 | | | 2 of 36 | | | 5 of 36 | |
| **Naches at Naches Gauging Station** | | | | | | | | | | | | |
| Spring | 2,202 | 1 of 36 | | 2,179 | 1 of 36 | | 2,403 | 0 of 36 | | 2,207 | 1 of 36 | |
| Summer | 1,136 | 3 of 36 | | 1,104 | 3 of 36 | | 665 | 0 of 36 | | 947 | 4 of 36 | |
| Fall | 562 | 1 of 36 | 14.6 | 591 | 2 of 36 | 15.1 | 669 | 0 of 36 | 0 | 581 | 0 of 36 | 13.3 |
| Winter | 1,013 | 0 of 36 | | 1,013 | 0 of 36 | | 1,037 | 0 of 36 | | 1,013 | 0 of 36 | |
| Total | | 5 of 36 | | | 6 of 36 | | | 0 of 36 | | | 5 of 36 | |
| **Parker Gauging Station** | | | | | | | | | | | | |
| Spring | 1,513 | 6 of 36 | | 1,895 | 6 of 36 | | 4,349 | 3 of 36 | | 3,040 | 5 of 36 | |
| Summer | 313 | 8 of 36 | | 658 | 8 of 36 | | 658 | 5 of 36 | | 1,155 | 5 of 36 | |
| Fall | 1,439 | 2 of 36 | -0.2 | 1,506 | 2 of 36 | -0.5 | 2,008 | 0 of 36 | 2.9 | 1,771 | 1 of 36 | -0.3 |
| Winter | 2,843 | 0 of 36 | | 2,866 | 0 of 36 | | 3,404 | 0 of 36 | | 2,940 | 0 of 36 | |
| Total | | 16 of 36 | | | 16 of 36 | | | 8 of 36 | | | 11 of 36 | |

**Flows** = Median seasonal flows for the 1981-2003 hydrologic period.

**IHA** = Indicators of Hydrologic Alteration seasonal critical values for the 1981-2003 hydrologic period.

The natural (unregulated) flow regime has no critical values--the greater the number of IHA critical values, the greater the deviation from the desirable natural flow regime.

**Flip-Flop** = Effects of flip-flop operation expressed as the difference in flows on August 15 and September 15 of the alternative divided by the difference in flows on August 15 and September 15 of the natural (Unregulated) condition.

A lower flow ratio is considered more advantageous--the smaller the flow ratio, the lesser the impact from the flip-flop operation.

*Easton, Yakima River* (RM 202.0)

The Easton reach is the least affected of all the reaches. This is because only a small percentage of the Keechelus and Kachess Reservoirs' storage is used in meeting the irrigation demands of the exchange participants—the Roza and Sunnyside Divisions.

The Black Rock Alternative improved spring peak flow conditions more than the Wymer Dam Plus Yakima River Pump Exchange Alternative and resulted in a more gradual downward transition into the summer flow period (Figure 3-5). Both action alternatives had a lower number of critical IHA values (18 for the Wymer Dam Plus Yakima River Pump Exchange and 17 for Black Rock) than for the No Action Alternative (20 critical scores) (Table 3-8). The decrease in IHA critical scores occurred in the fall for the Wymer Dam Plus Yakima River Pump Exchange Alternative and in the spring for the Black Rock Alternative. This indicates very little change from the Current Operation. Both action alternatives eliminate the flip-flop operation in this reach.

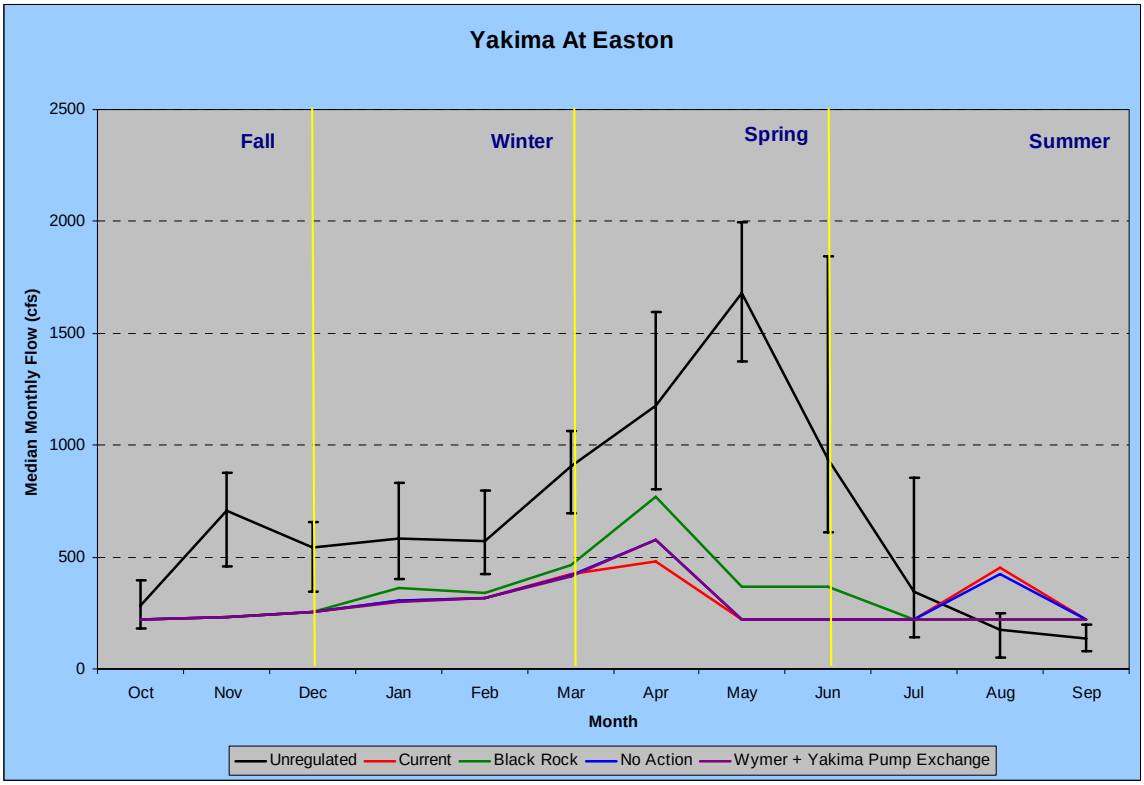


**Figure 3-5. Easton Gauge Monthly Median Flows for 1981-2003 Comparing the Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Annual Hydrographs.**

*Cle Elum Dam Outlet, Cle Elum River (RM 7.9)*

The Black Rock Alternative provided better spring flows when compared to the Wymer Dam Plus Yakima River Pump Exchange Alternative (median 1400 cfs vs. 854 cfs) (Figure 3-6). Both alternatives reduce flip-flop; however, the Black Rock Alternative resulted in a greater reduction. The flip-flop flow differential for the Black Rock Alternative was 829 cfs, with a flow ratio of 7.0, compared to a flow differential of 2,117 cfs and a flow ratio of 17.8 for the Wymer Dam Plus Yakima River Pump Exchange Alternative (Table 3-8). Winter flows were increased for both alternatives. The Black Rock Alternative increased winter flows from a median of 220 cfs to 500 cfs; while the Wymer Dam Plus Yakima River Pump Exchange Alternative increased winter flows to a median flow of 407 cfs. The No Action Alternative had a total of 22 critical IHA scores. The Black Rock Alternative had a total of 15 IHA critical scores compared to 12 for the Wymer Dam Plus Yakima River Pump Exchange Alternative.[14] The spring and fall seasons for the Black Rock Alternative had higher (two more for each season) IHA critical scores than for the Wymer Dam Plus Yakima River Pump Exchange Alternative.

[14] The reason the number of IHA critical scores is higher for the Black Rock Alternative compared to the Wymer Dam Plus Yakima River Pump Exchange Alternative is a consequence of generally constant flow releases that were outside of the defined 25$^{th}$ to 75$^{th}$ percentile range for the spring and fall periods.

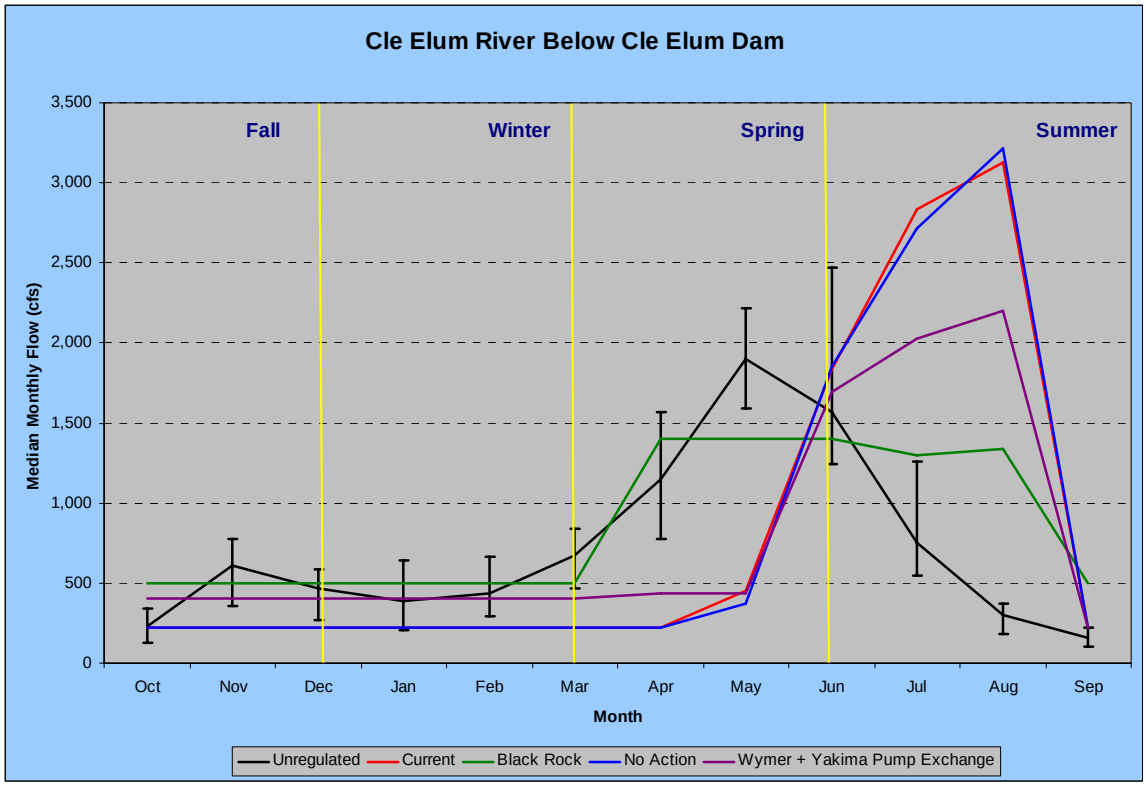


**Figure 3-6. Cle Elum Dam Outlet Gauge Monthly Median Flows for 1981-2003 Comparing the Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Annual Hydrographs.**

*Umtanum Gauging Station, Yakima River* (RM 140.4)

The Black Rock Alternative resulted in a higher spring median flow (3,340 cfs vs. 2,749 cfs) compared to the Wymer Dam Plus Yakima River Pump Exchange Alternative (Figure 3-7). Summer flows were reduced most by the Black Rock Alternative (1,805 cfs), while the Wymer Dam Plus Yakima River Pump Exchange Alternative reduced summer flows to a median flow of 2,443 cfs. Flip-flop was reduced most by the Black Rock Alternative. The August 15-to- September 15 median flow differential was 683 cfs for the Black Rock Alternative; 1,552 cfs for the Wymer Dam Plus Yakima River Pump Exchange Alternative; and 2,680 cfs for the No Action Alternative. The flip-flop flow ratios were 9.2, 21.0, and 36.2, respectively.

The winter median flow was slightly higher for the Black Rock Alternative (1,987 cfs) compared to the Wymer Dam Plus Yakima River Pump Exchange Alternatives (1,831 cfs). For the No Action Alternative there were a total of 12 IHA critical scores; while the Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives had 10 and 13 critical IHA scores, respectively (Table 3-8). The greatest seasonal

difference between the Black Rock Alternative and the Wymer Dam Plus Yakima River Pump Exchange Alternative occurred in the summer. The Black Rock Alternative had six critical IHA scores, and the Wymer Dam Plus Yakima River Pump Exchange Alternative had eight critical scores.

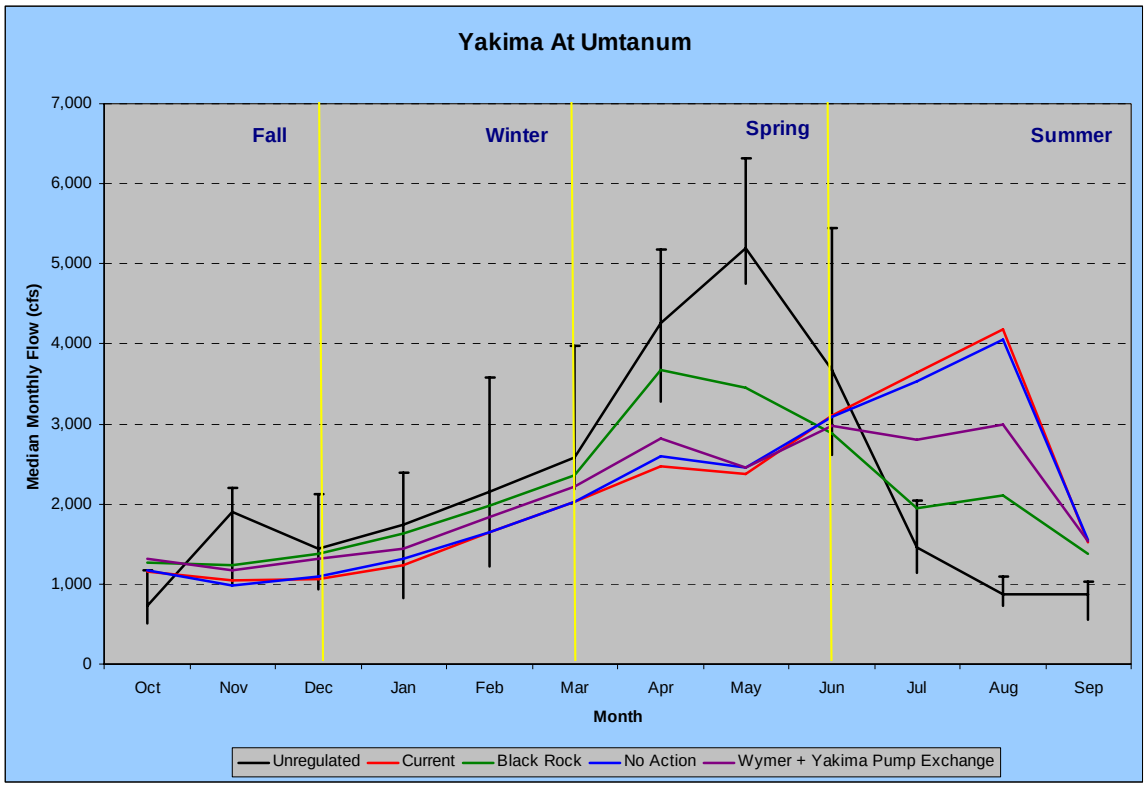


**Figure 3-7. Umtanum Gauge Monthly Median Flows for 1981-2003 Comparing the Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Annual Hydrographs.**

*Bumping Dam Outlet Gauging Station, Bumping River* (RM 17.0) and *Naches at Cliffdell Gauging Station, Naches River* (RM 37.9)

There were no appreciable differences in the annual hydrographs between the Bumping Dam outlet and Cliffdell gauges for the Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives (Table 3-8, Figure 3-8, and

Figure 3-9).

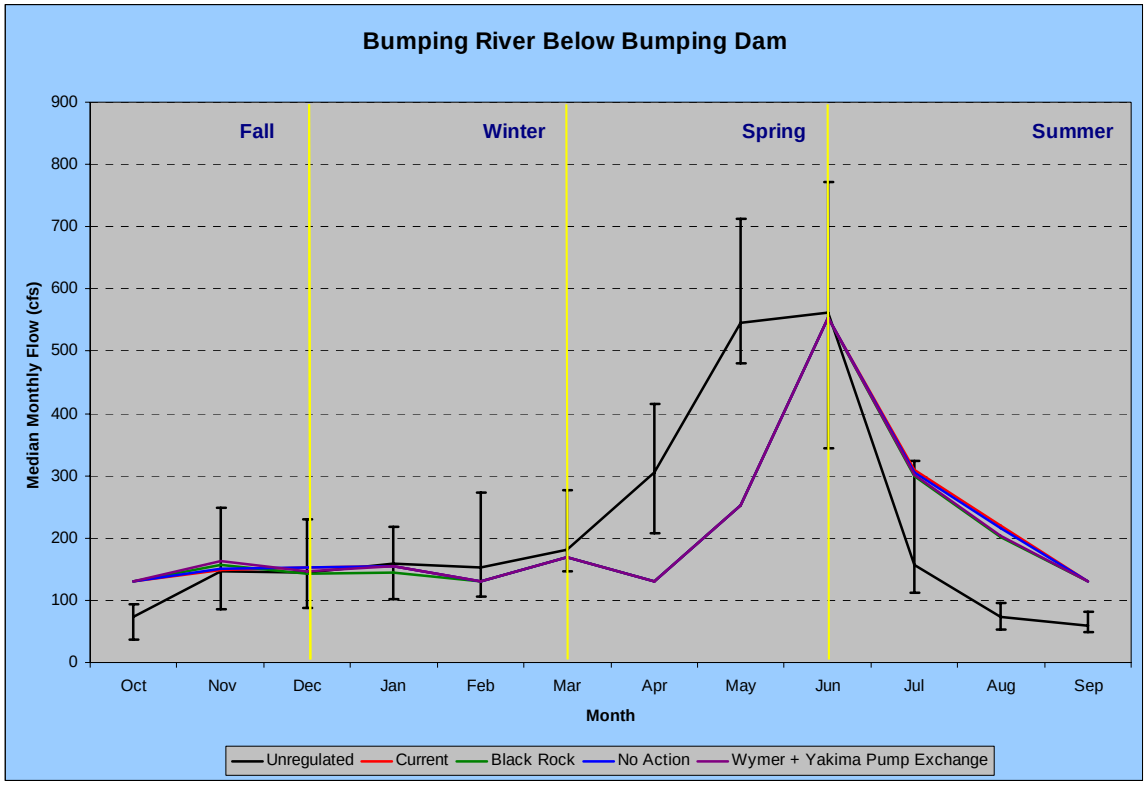


**Figure 3-8. Bumping Dam Outlet Gauge Monthly Median Flows for 1981-2003 Comparing the Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Annual Hydrographs.**

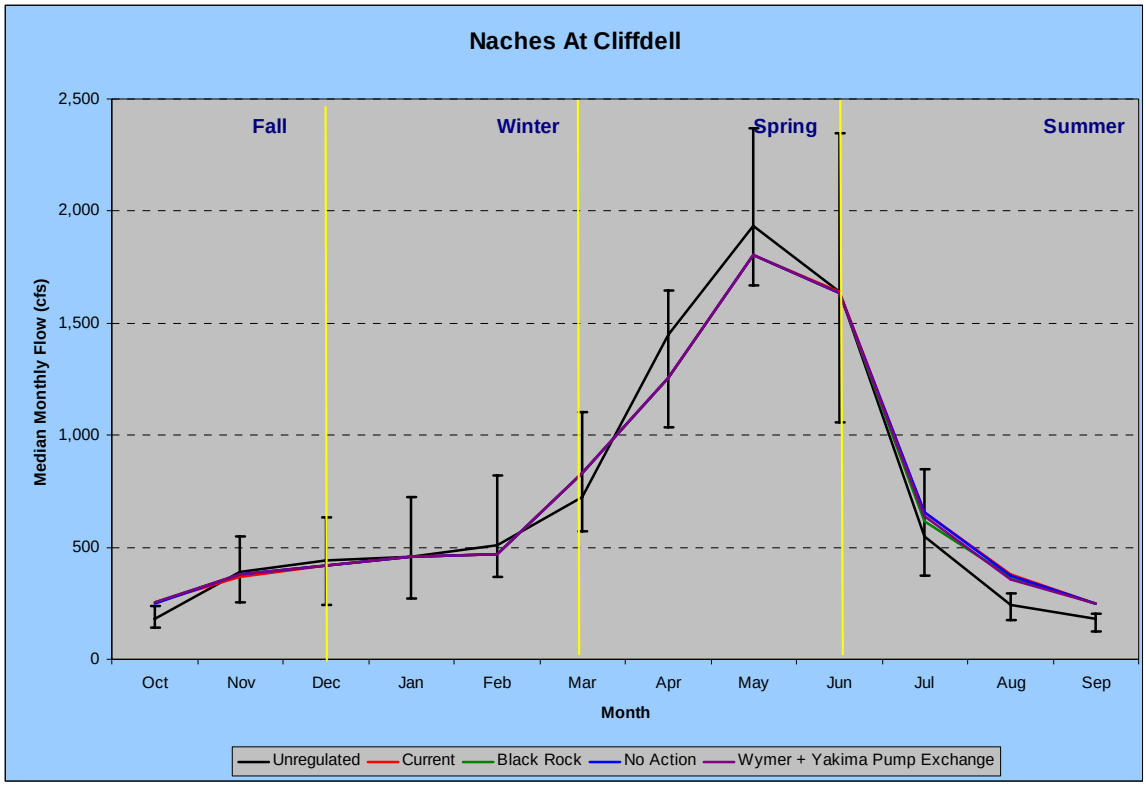


**Figure 3-9. Cliffdell Gauge Using the Monthly Median Flows for the 1981-2003 Period of Record Comparing the Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Annual Hydrographs**

*Naches at Naches Gauging Station, Naches River* (RM 16.8)

The spring median flows were somewhat better for the Black Rock Alternative (2,403 cfs) than for the Wymer Dam Plus Yakima River Pump Exchange Alternative (2,207 cfs) (Table 3-8 and Figure 3-10). The Black Rock Alternative resulted in a decreased summer median flow of 665 cfs, compared to the Wymer Dam Plus Yakima River Pump Exchange Alternative with a summer median flow of 947.

The flip-flop operation was essentially eliminated by the Black Rock Alternative (Table 3-8). The August 15-to-September 15 median flow differential was 2 cfs with a flow ratio of 0.2, meaning the change in flow was less than would normally occur on average for the unregulated flow. The Wymer Dam Plus Yakima River Pump Exchange Alternative slightly improved (decreased flows) flip-flop conditions compared to the Current Operation. The flow differential decreased to 1,588 cfs with a flow ratio of 13.3, compared to the No Action operation with a flow differential of 1,388 cfs and a flow ratio

of 18.8. The number of critical IHA scores for the No Action Alternative was six, for the Black Rock Alternative, zero, and for the Wymer Dam Plus Yakima River Pump Exchange Alternative, five. Most of the difference in IHA scores between the Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives occurred for the summer season (zero vs. four).

It should be mentioned that additional analysis of the Wymer Dam Plus Yakima River Pump Exchange Alternative suggests that it may be possible to reduce the magnitude of flip-flop in the lower Naches by reoperating how the instream flow and irrigation water held in Wymer reservoir is used. For example, if the amount of water released from Wymer reservoir in the summer was reduced and saved for release during the flip-flop period, this would allow for reduced releases from Rimrock (primarily) and Bumping Reservoirs, thus decreasing instream flows in the lower Naches. The tradeoff is increased flows in the upper Yakima downstream of Cle Elum Dam in July and August in order to meet downriver irrigation. This operation scenario merits further consideration.

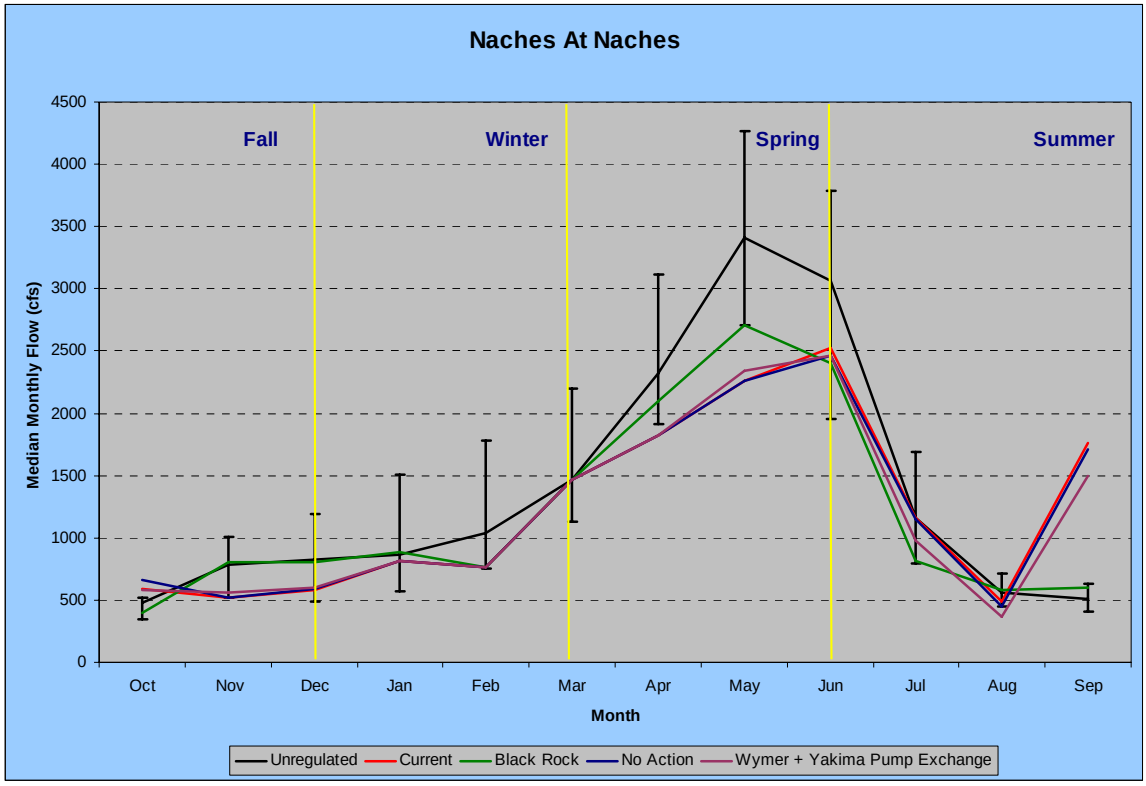


**Figure 3-10. Naches at Naches Gauge Monthly Median Flows for 1981-2003 Comparing the Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Annual Hydrographs.**

*Parker Gauging Station, Yakima River* (RM 108.7)

The Black Rock Alternative provided a better spring median flow (4,349 cfs) than did the Wymer Dam Plus Yakima River Pump Exchange Alternative (3,040 cfs) (Table 3-8 and Figure 3-11). The Wymer Dam Plus Yakima River Pump Exchange Alternative resulted in a better summer median flow (1,155 cfs) compared to the Black Rock Alternative (658 cfs) (Figure 3-14). Winter median flows were somewhat better for the Black Rock Alternative (3,404 cfs) compared to the Wymer Dam Plus Yakima River Pump Exchange Alternative (2,940 cfs). There were 16 critical IHA scores for the No Action Alternative, 8 for the Black Rock Alternative, and 11 for the Wymer Dam Plus Yakima River Pump Exchange Alternative. Between the Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives, the greatest seasonal difference occurred in the spring. The Black Rock Alternative had three critical IHA scores and the Wymer Dam Plus Yakima River Pump Exchange Alternative had five critical IHA scores.

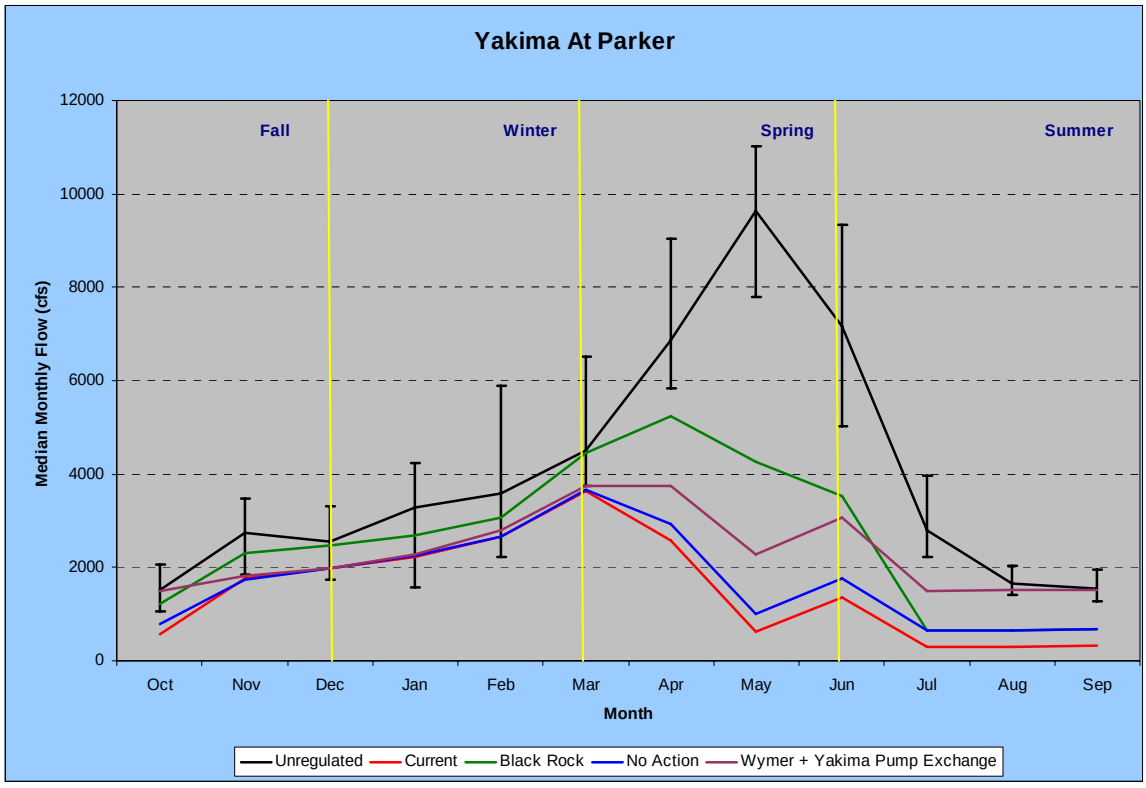


**Figure 3-11. Parker Gauge Monthly Median Flows for 1981-2003 Comparing the Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Annual Hydrographs.**

For comparative purposes, Figure 3-12 and Figure 3-13 present the daily mean flow at Parker gauge for the spring season (April 1-June 30). For water year 1994, which was the third consecutive year of the 3-year drought, monthly median flows ranged from 1,447 cfs (May) to 2,457 cfs (April) for the Wymer Dam Plus Yakima River Pump Exchange Alternative and from 936 cfs (June) to 3,571 cfs (April) for Black Rock Alternative. For water year 1996, which was an extremely wet year, monthly median flows ranged for 3,074 cfs (June) to 7,464 cfs (April) for the Wymer Dam Plus Yakima River Pump Exchange Alternative and from 3,228 cfs (June) to 8,426 cfs (April) for Black Rock. For comparison, the Current Operation median monthly flows range from 462 cfs (June) to 1,472 cfs (April).

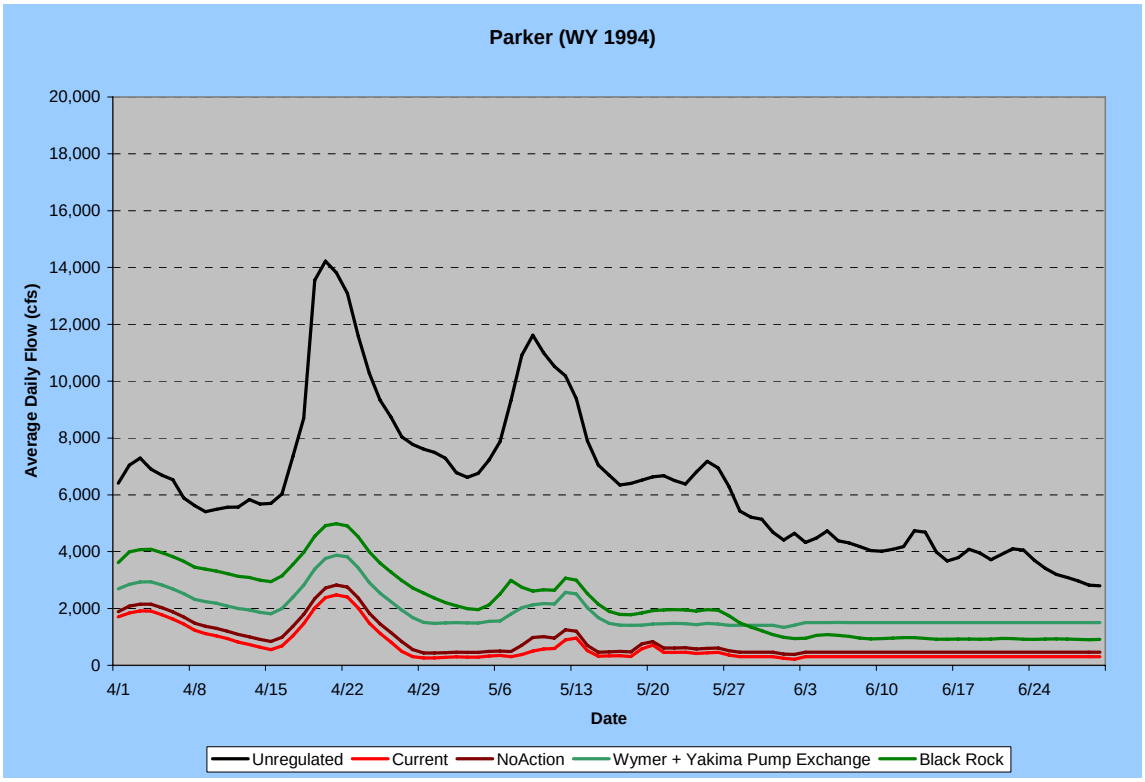


**Figure 3-12. Average Daily Flow at Parker from April 1 through June 30 for Wet Year 1994 for Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Alternatives**

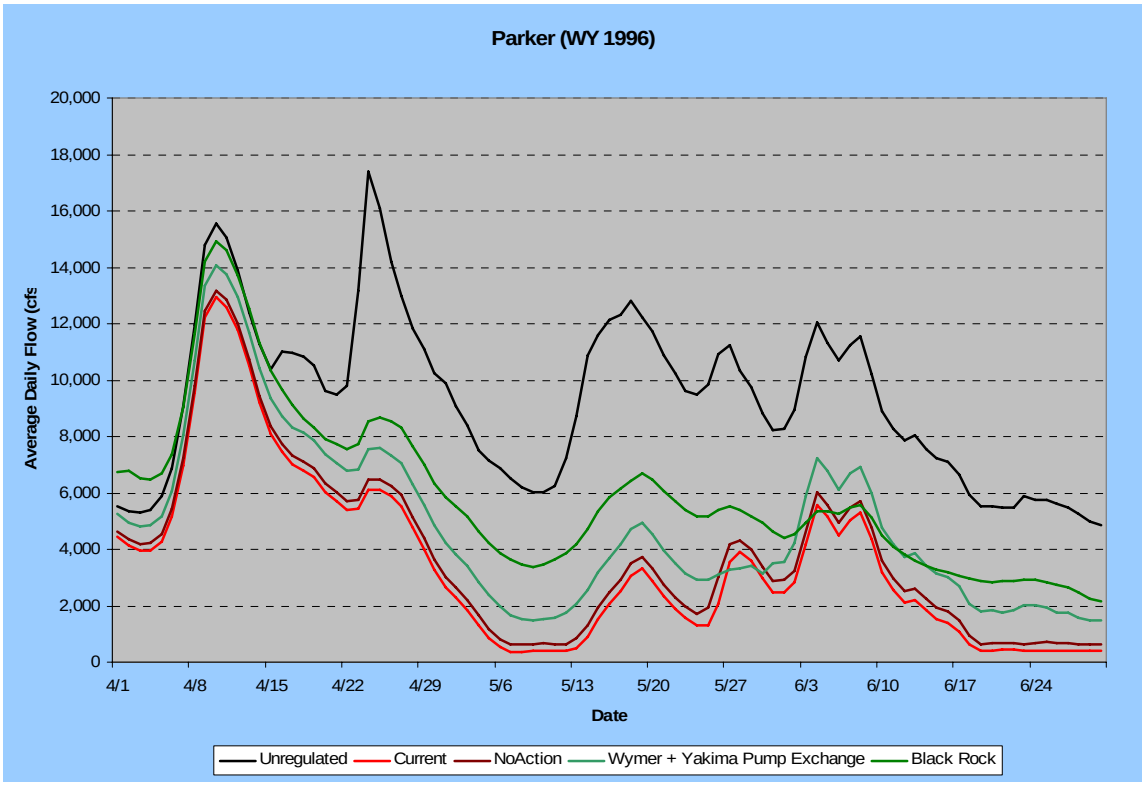


**Figure 3-13. Average Daily Flow at Parker from April 1 through June 30 for Wet Year 1996 for Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Alternatives**

### 3.2.3 Municipal Water Supply

In the *Yakima Basin Appraisal Assessment*, Reclamation assumed the future surface water need of 10,000 acre-feet for the cities of Cle Elum and Yakima (the only current municipal surface water users) could be met with new storage facilities. For this analysis, and pending the groundwater investigation, Reclamation will assume the surface water component for future municipal demand to be 10,000 acre-feet, and that amount could be met with either action alternative.

However, after reviewing the water supply estimates in the *Watershed Management Plan* (2003), Reclamation concluded the future total surface municipal water needs could be as high as 82,000 acre-feet by the year 2050. If an ongoing groundwater investigation (scheduled for completion in 2008) shows there is connectivity between surface- and groundwater, any future water use by municipalities and domestic users would require mitigation.

## 3.3 Assessment of Action Alternatives

This section provides an assessment of the major differences in the operation of the two action alternatives (Black Rock and Wymer Dam Plus Yakima River Pump Exchange) from the perspective of achieving flexibility in operations or, in other words, the capability of the alternative to react to various operation scenarios which may be desirable for an adaptive style of reservoir and river management.

### 3.3.1 Black Rock Alternative

The Black Rock Alternative water exchange relies on stored water in Black Rock reservoir pumped from the Columbia River at Priest Rapids Dam. This is not an instantaneous exchange, as pumping can occur throughout the year when Columbia River flows are in excess of instream target flows, except during July and August. Ultimately, the same volume of water returns to the Columbia River at the Yakima River confluence as surface and subsurface return flows from crop irrigation and increased Yakima River instream flows.

When a water exchange is being made during the storage control period, stored water which had previously been diverted by the exchange participants is now retained in the Yakima Project reservoirs. This additional stored water is carried over in the reservoirs at the end of the irrigation season.

The water exchange can reasonably be activated, deactivated, and modified at any time during the irrigation season. However, if an exchange is not in effect, the flows at the Parker gauge revert to the No Action Alternative level of 644 cfs to 844 cfs.

With the Black Rock Alternative, there is a “block of water” available to facilitate spring migration pulse flows throughout the main stem Yakima River, whether or not a water exchange is in effect. This “block of stored water” can be shaped to create pulse flows or other flow sequence as desired. Such flows would be realized from the reservoirs to the confluence of the Columbia River.

The release of an additional 280 cfs (to 500 cfs) from Cle Elum Reservoir during October through May to improve streamflows in the Cle Elum River would continue downstream to the Columbia River confluence and be lost to the Yakima basin, because a Wymer reservoir is not included in this alternative. This loss of stored water amounts to approximately 135,000 acre-feet.

The Black Rock Alternative water exchange operation during the storage control period results in a flow reduction of about 2,000 cfs in the Cle Elum River. Flows at the Umtanum gauge in mid-July and mid-August would be approximately 1,800 cfs to 2,100 cfs, similar to before 1980, when the flip-flop operation was initiated.

Mid-September flows in the Naches River would be reduced by approximately 650 cfs. Thus, the Black Rock Alternative essentially eliminates the flip-flop operation.

The Black Rock Alternative offers considerable flexibility in the future operations of the Yakima Project. The operation studies conducted for this analysis should be considered as an illustration of one of many approaches to integrated project operations.

The Black Rock Alternative, due to its large volume of water exchange that frees up Yakima River water, provides for a variety of operation scenarios. The Black Rock Alternative operation criteria in this Plan Formulation analysis was to use the freed-up water as spring flows to help flush fish through the Yakima River to the Columbia River and the ocean. In the *Black Rock Appraisal Assessment*, the operation criteria was to let the inflows to the reservoirs run through the reservoirs to simulate the natural (Unregulated) hydrograph as close as possible. In another scenario in the Plan Formulation analyses, the freed-up water was used to increase summer flows in the Yakima River. Figure 3-14 shows these two operation scenarios as well as all the other operations scenarios from this Plan Formulation analysis.

While the Wymer Dam Plus Yakima River Pump Exchange Alternative could be operated differently, there is not a large supply of water to provide many different operation scenarios. The scenario provided in the Plan Formulation analysis was selected to provide some instream flow benefit while not losing any water needed for irrigation. The size and location of the Wymer reservoir also limits the flexibility of the stored water.

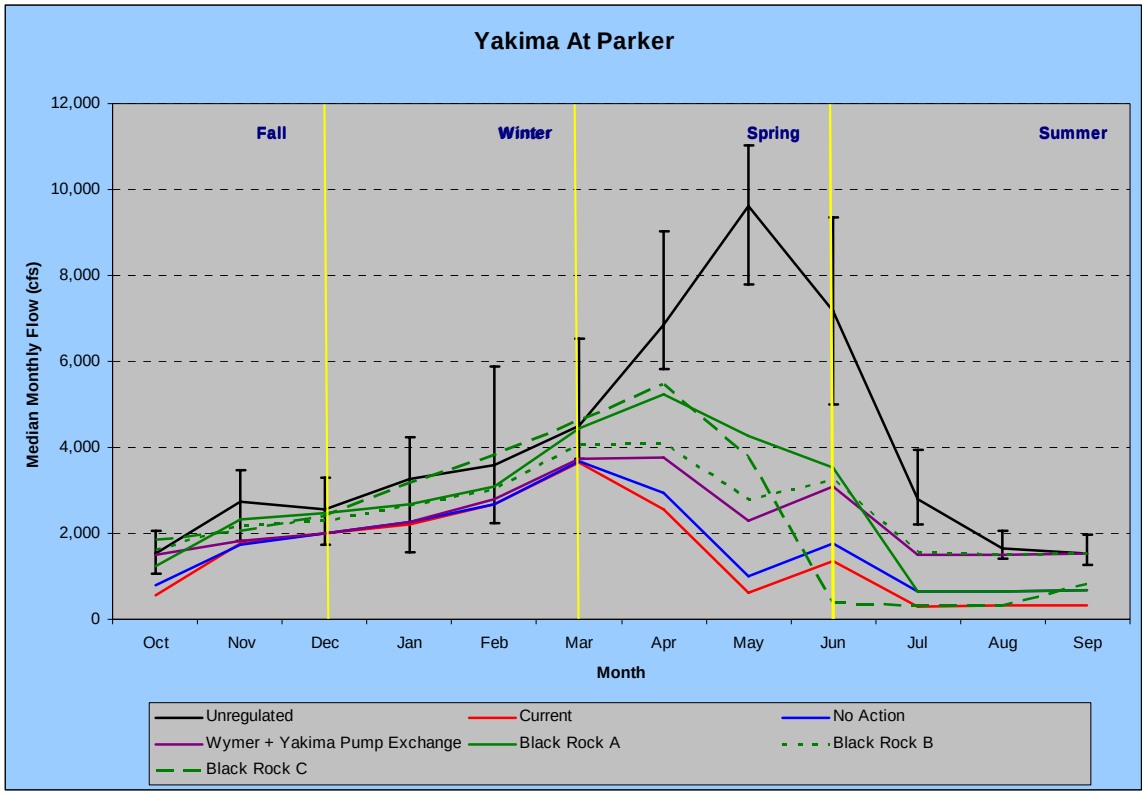


**Figure 3-14. Parker Gauge Median Monthly Flows from April 1 through June 30 for Unregulated, Current, No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Alternatives**

### 3.3.2 Wymer Dam Plus Yakima River Pump Exchange Alternative

The Wymer Dam Plus Yakima River Pump Exchange Alternative consists of two components—the Wymer dam, reservoir, and pumping plant, and the Yakima River Pump Exchange facilities. These components were combined into one alternative to maximize the water operations flexibility in the Yakima River. The Wymer Dam component provides instream flow benefits to the Cle Elum River and the upper portion of the Yakima River, while the Yakima River Pump Exchange facilities provide instream flow benefits to the Yakima River from Roza Diversion dam to the mouth of the Yakima River.

The water exchange aspect of this alternative is dependent on the corresponding outflow at the mouth of the Yakima River to achieve the "bucket for bucket" instantaneous exchange. During the storage control period, this exchange requires the continued release of water from Yakima Project reservoirs that would normally be diverted by the Roza and Sunnyside Divisions. With the instantaneous exchange, this stored water would pass

over Sunnyside Diversion Dam and continue downstream to the Columbia River confluence. Consequently, the water exchange does not create a block of water to be shaped for instream use.

The water exchange can be activated and deactivated at any time during the irrigation season. However, if an exchange is not in effect, the 1,500-cfs Parker target flow would revert to the No Action Alternative level of 644 cfs to 844 cfs. With this water exchange, there is no "block of stored water" available to facilitate spring migration pulse flows throughout the main stem Yakima River.

The 187-cfs release from Cle Elum Reservoir to improve streamflows to about 400 to 410 cfs in the Cle Elum River from October 1 to May 31 could be diverted and stored in the 90,000 acre-feet of Wymer reservoir space allotted for this purpose. This operation results in "no loss" in irrigation water supply to the Yakima basin; there could be, however, some "gain" in stored water if the Cle Elum Reservoir space refills.

Release of this stored water from Wymer reservoir in July and August for downstream irrigation demands reduces Yakima River flows by about 1,000 cfs as measured at the Umtanum gauge. Current average July and August flows at this gauge range from 3,600 cfs to 4,000 cfs, which places a heavy demand on Cle Elum Reservoir storage prior to the September flip-flop operation. Streamflows downstream of the Wymer reservoir would not be much different than under the Current Operation. This operation does not alleviate the need for increased releases from Rimrock Reservoir beginning about mid-August and extending to the end of the irrigation season. The Wymer Dam Plus Yakima River Pump Exchange Alternative makes some improvement in the current flip-flop operation, but does not eliminate it.

The 85,000 acre-feet of Wymer reservoir storage assigned for irrigation dry-year supply when the proratable level (without the inclusion of this storage) is less than 70 percent is used in only one year—1994, the third-year of the 3-year dry period. While it would be possible to use this water in other years, such use would not assure that 85,000 acre-feet of stored water would be available when needed.

The Wymer Dam Plus Yakima River Pump Exchange Alternative would not be very flexible in adapting to future operational changes due to its relatively small water supply and instantaneous water exchange criteria.

### 3.3.3 Comparison of Action Alternatives

In conclusion, a comparison of the two action alternatives indicates a major advantage of the Black Rock Alternative is the opportunity for greater operational flexibility. This is expressed by the ability of the Black Rock Alternative to meet desired flow outcomes under varying water supply conditions. For instance, it allows some Yakima Project

water to remain in storage and be used to shape the annual flow regime in wet, average, and dry years when desired, rather than releasing a constant flow of 1,500 cfs as illustrated in this operation study. It may be preferable to provide periodic spring flushing flows in dry years and in wet years (where typically spring flushing flows are not an issue) to improve the summer rearing flows for juvenile salmonids. The October-through-May Cle Elum Reservoir release of an additional 280 cfs to improve fishery flows in the Cle Elum River results in the loss of about 135,000 acre-feet of potential stored water from the Yakima River basin. However, this flow could be adjusted as needed to optimize operations.

In contrast, the Wymer Dam Plus Yakima River Pump Exchange Alternative has limited opportunity to shape the flow regime. The pump exchange portion of this alternative has limited operational flexibility because of the instantaneous exchange requirement. The Wymer reservoir portion provides limited operational flexibility because of the way the 90,000 acre-feet of instream flow and irrigation water will be used, and the 85,000 acre-feet of storage capacity is restricted to a carryover operation if the objective is to improve the dry-year proratable irrigation supply in the third year of the 3-year 1992-1994 dry cycle. Wymer reservoir does, however, allow recovery of the October-through-May Cle Elum Reservoir releases.

# Chapter 4.0 BENEFIT/COST ANALYSIS AND COST ALLOCATIONS

## 4.1 Benefits

This appraisal-level benefit analysis follows the criteria for measuring National Economic Development (NED) benefits defined in *The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, March 10, 1983* (commonly referred to as the "P&Gs"). The P&Gs were established by the U.S. Water Resources Council and approved by President Ronald Reagan February 3, 1983.

NED benefits show the effect on the national economy associated with a possible Federal water resource development action. These benefits reflect increases in the economic value of the national output of goods and services and are measured by a "with and without" comparison of benefits estimated to be realized from proposed alternative actions. Changes in regional income and employment that result from the alternative(s) are not included in the NED benefit analysis used for determining the economic justification of a possible Federal action.

In this appraisal-level analysis, benefits are estimated by individually comparing the benefits associated with the two action alternatives (Black Rock and Wymer Dam Plus Yakima River Pump Exchange) with those of the No Action Alternative. Benefits are assumed to accrue over a 100-year period. The present worth value of the "stream of benefits" is computed by using Reclamation's fiscal year 2006 planning interest rate of 5.125 percent.

### 4.1.1 Irrigation Benefits

The P&G analysis of NED agricultural benefits identifies the change in net farm income associated with the irrigation water supply available related to a change in crop acreage while maintaining the same cropping patterns. Reclamation's Yakima Agricultural Impact (YAI) Model is used to aggregate the crops grown in the Yakima Project into representative crops and acreages to estimate changes in the cropped acreage which occur during the 23-year period of hydrologic record (1981-2003) used in the alternative operation studies as the result of variances in the available project water supply. Crop benefit values, based on net farm income, were estimated using a farm budget approach. These benefit values are then applied to the annual cropped acreages to estimate the NED irrigation benefits.

In this analysis, irrigation benefits are accounted for in drought years when the proration level is less than 70 percent. For the 23-year hydrologic period, this occurs with the No Action Alternative in 3 years (1993, 1994, and 2001). Because benefits only accrue in years below the 70-percent threshold, the annual benefits for these 3 years are adjusted to take into account the number of occurrences in the 23-year period.

Table 4-1 shows the annual equivalent and present worth values of irrigation benefits over the 100-year period of analysis.

**Table 4-1. Irrigation Benefits**

| | Black Rock Alternative | Wymer Dam Plus Yakima River Pump Exchange Alternative |
|---|---|---|
| Annual Equivalent | $4,500,000 | $2,900,000 |
| Present Worth | $86,600,000 | $56,600,000 |

### 4.1.2 Fishery Benefits

Fishery benefits are associated with anadromous salmon (Spring Chinook, Coho, and Fall Chinook) and steelhead fisheries. The benefit analysis includes estimates of anadromous fishery use values and nonuse values. Use values are intended to represent the individual's harvest and consumption of the fishery resource through commercial, sport, and tribal subsistence activities. Use values are typically based on the quantity of fish actually used (harvested). Nonuse values are what individuals may be willing to pay for a scarce resource even though they may never use the resource. Nonuse values are based on nonharvested fish (spawners).

At this time, some work activities associated with the models to evaluate fishery habitat and populations have yet to be completed. It is anticipated these models will be available by summer 2007. In estimating anadromous fishery production, low, middle, and high ocean productivity conditions were assumed as well as a range of increases in adult fish populations due to improved Yakima River basin habitat conditions. While these estimates are preliminary, we believe they provide a valid range of what might be expected.

It should be noted that, while the economics community may, in theory, agree with the concept of nonuse fishery benefits, there is considerable controversy over how to measure these values. Generally speaking, the most acceptable approach involves a survey designed to answer study-specific questions regarding the resource in the study area.

While a study-specific survey was not conducted, information was obtained by using a relatively recent existing fisheries nonuse value model developed from survey information designed to address a wide range of fish population improvement scenarios in the State of Washington. This survey was not specific to the action alternatives being considered here, but it allows for the estimation of alternative-specific increases in nonuse values for the same migratory species in the same overall geographic area. For this reason, benefit/cost ratios are shown both with and without nonuse fishery benefits.

Use values per harvested fish were obtained from a 2002 U.S. Army Corps of Engineers environmental impact statement and from other studies. Nonuse values were estimated using the above-mentioned fisheries economic model developed for the Washington Department of Ecology in 1999, based on responses to a 1988 survey conducted in the State of Washington.

Table 4-2 shows the use and nonuse fishery benefits developed for the middle and high ocean productivity conditions and the high-end estimate of adult populations assumed for each action alternative. The estimates therefore reflect the most optimistic values.

**Table 4-2. Anadromous Fishery Benefits**

| | Fishery at Middle Ocean Productivity Conditions – High-End Estimate | | Fishery at High Ocean Productivity Conditions – High-End Estimate | |
|---|---|---|---|---|
| | ***Annual Equivalent ($)*** | ***Present Worth ($)*** | ***Annual Equivalent ($)*** | ***Present Worth ($)*** |
| **Black Rock Alternative** | | | | |
| Use Benefits | 900,000 | 17,000,000 | 1,700,000 | 33,800,000 |
| Nonuse Benefits | 28,300,000 | 548,200,000 | 45,500,000 | 881,600,000 |
| **Wymer Dam Plus Yakima River Pump Exchange Alternative** | | | | |
| Use Benefits | 400,000 | 6,800,000 | 700,000 | 13,500,000 |
| Nonuse Benefits | 12,300,000 | 239,000,000 | 20,900,000 | 404,900,000 |

### 4.1.3 Recreation Benefits

For this appraisal-level analysis, recreation benefits were estimated for the proposed Black Rock and Wymer reservoirs only, not for impacts to existing Yakima River basin reservoirs or rivers. Reservoir recreation benefits are based on estimated annual visitation by recreation activity (boating, fishing, picnicking, swimming/beach use, and camping) and monetary values for each activity.

Annual visitation at Black Rock and Wymer reservoirs was based on visitation estimates for similar reservoirs in the Columbia Basin Project area (Potholes Reservoir and Banks Lake), adjusted on (1) a per capita basis for the larger populations in the Black Rock reservoir and Wymer reservoir areas; and (2) differences in the surface areas between the two existing Columbia Basin Project reservoirs and the proposed action alternative reservoirs. This resulted in annual low and high estimates for Black Rock and Wymer reservoirs; the low estimate reflects Potholes Reservoir visitation and surface acres, and the high estimate reflects Banks Lake visitation and surface acres. Visitation was then distributed equally between the five reservoir recreation activities.[15]

Recreation activity monetary values were obtained from a nationwide analysis of hundreds of recreation economic studies throughout the United States. Visitation monetary values by activity for the Pacific Coast region of the nationwide analysis were indexed to current dollars. The indexed monetary activity values per visit are: boating ($28), fishing ($46), picnicking ($67), swimming/beach use ($28), and camping ($109).

Table 4-3 shows the low and high recreation benefit estimates for the two action alternative reservoirs.

**Table 4-3. Recreation Benefits**

| Item | Low Estimate | | High Estimate | |
|---|---|---|---|---|
| | Black Rock | Wymer | Black Rock | Wymer |
| **Annual Visitation** | | | | |
| Initial | 272,000 visits | 44,000 visits | 448,000 visits | 73,000 visits |
| Ultimate | 347,000 visits | 57,000 visits | 571,000 visits | 93,000 visits |
| **Benefits** | | | | |
| Annual Equivalent | $17,500,000 | $2,900,000 | $28,800,000 | $4,700,000 |
| Present Worth | $338,700,000 | $55,200,000 | $558,100,000 | $91,000,000 |

It should be noted the recreation benefit analysis does not attempt to estimate effects of potential site substitution. Site substitution refers to the extent visitation at a new reservoir may pull visitation from existing reservoirs in the area. This could negatively impact recreation visitation at the existing reservoirs.

[15] Annual reservoir visitation was based on regional population projections to year 2025 and, because of the lack of population projections beyond this time, visitation was assumed to remain at 2025 levels for the remainder of the 100-year period.

### 4.1.4 Hydropower Generation Benefits

The Black Rock Alternative includes two potential hydropower generation facilities—the Black Rock powerplant at the Black Rock outlet facility at Roza Canal MP 22.6 and the Sunnyside powerplant near Sunnyside Canal MP 3.83 at the terminus of the delivery system from the Black Rock outlet facility. Average annual generation is estimated at about 109 million kilowatt hours at the Black Rock powerplant and 140 million kilowatt hours at the Sunnyside plant.

Average monthly pumping energy cost forecasts of the Bonneville Power Administration in its August 2003 rate case were used to represent the monetary value of the annual generation. These were applied to the average annual generation which was distributed by month for the April-to-October irrigation season when exchange water from Black Rock reservoir is being delivered to the Roza and Sunnyside Divisions.

Table 4-4 summarizes the monthly average annual generation at the two powerplants and the monthly energy values used in estimating hydropower generation benefits.

**Table 4-4. Hydropower Generation Values**

| Month | Combined Monthly Generation (MWH) | Energy Values ($/MWH) | Annual Value ($) |
|---|---|---|---|
| April | 27,000 | 37.60 | 1,042,000 |
| May | 38,750 | 31.92 | 1,237,00 |
| June | 44,510 | 22.68 | 1,009,000 |
| July | 45,910 | 32.24 | 1,480,000 |
| August | 45,910 | 40.69 | 1,868,000 |
| September | 31,280 | 43.64 | 1,365,000 |
| October | 14,940 | 55.56 | 830,000 |
| **Total** | | | 8,831,000 |
| Present Worth 100 years | | | 171,200,000 |

### 4.1.5 Municipal Benefits

Future municipal and domestic surface water needs in the Yakima River basin area are yet to be resolved for the Storage Study. The *Yakima River Appraisal Assessment* indicated a potential increase in municipal needs of about 82,000 acre-feet by year 2050.

This 82,000-acre-foot estimate was from the *Watershed Management Plan* prepared by the Yakima River Basin Planning Unit and the Tri-County Water Resources Agency in

2003. This quantity was estimated due to potential connectivity between surface and groundwater which would require any groundwater withdrawals to be mitigated, potentially by surface water. If that is the case, then 82,000 acre-feet of surface water could be needed for the mitigation. It is possible that this need could be obtained by purchasing existing irrigation water rights.

However, if it is determined there is no connectivity or if mitigation of future groundwater withdrawals is not required, the increase in surface water municipal and domestic needs for the entities currently using surface water is estimated between 5,000 to 10,000 acre-feet. A year 2050 increased need of 10,000 acre-feet was used in this analysis.

Municipal benefits were based on a wholesale price of about $240 per acre-foot (obtained from the *2006 M&I Water Rate Survey Data*, Reclamation, 2006). This $240 per acre-foot value applied to a future surface water need of 10,000 acre-feet results in an annual benefit in year 2050 of $2,400,000.

Table 4-5 shows municipal water benefits. These benefits were assumed to accrue every year of the 100-year period regardless of the 50-year "buildup" to this amount.

**Table 4-5. Municipal Water Benefits**

| Annual Equivalent | Present Worth |
|---|---|
| $2,400,000 | $47,000,000 |

## 4.2 Costs

Costs for the benefit/cost analysis include the following (see Table 4-6 and Table 4-7):

- Total project costs for constructing the action alternatives, including the field cost plus noncontract costs estimated at both 20 percent and 35 percent of the field cost.
- Interest during construction computed for the 10-year construction period at simple interest 5.125 percent.
- Operation, maintenance, and replacement costs.
- Pumping energy.

- Hydropower generation effects occurring at both Federal and non-Federal hydropower projects of the mid- to lower Columbia River, including both positive and negative monetary changes.

Table 4-6 summarizes the information for the Black Rock Alternative benefit/cost analysis. Table 4-7 provides similar information for the Wymer Dam Plus Yakima River Pump Exchange Alternative.

**Table 4-6. Summary of Information for Black Rock Alternative Benefit/Cost Analysis**

| **Benefits and Costs (Annual Equivalent and Present Worth, 100 years @ 5.125 Discount Rate)** | | | | |
|---|---|---|---|---|
| **Benefits** | | | | |
| **Purpose** | **Fishery at Middle Ocean Productivity Condition – High-End Estimate** | | **Fishery at High Ocean Productivity Condition – High-End Estimate** | |
| | ***Annual Equivalent ($)*** | ***Present Worth ($)*** | ***Annual Equivalent ($)*** | ***Present Worth ($)*** |
| Irrigation | 4,500,000 | 86,600.000 | 4,500,000 | 86,600.000 |
| Fishery Use Values | 900,000 | 17,000,000 | 1,700,000 | 33,800,000 |
| Reservoir Recreation | 28,800,000 | 558,100,000 | 28,800,000 | 558,100,000 |
| Hydropower | 8,800,000 | 171,200,000 | 8,800,000 | 171,200,000 |
| Municipal | 2,400,000 | 46,500,000 | 2,400,000 | 46,500,000 |
| Subtotal | 45,400,000 | 879,400,000 | 46,200,000 | 895,600,000 |
| Fishery Nonuse Values | 28,300,000 | 548,200,000 | 45,500,000 | 881,600,000 |
| **Total** | 73,700,000 | 1,427,600,000 | 91,700,000 | 1,777,200,000 |
| **Costs (April 2004)** | | | | |
| | **Noncontract 20%, 10-yr Construction** | | **Noncontract 35% 10-yr Construction** | |
| | ***Annual Equivalent ($)*** | ***Present Worth ($)*** | ***Annual Equivalent ($)*** | ***Present Worth ($)*** |
| Total Field Cost | | 2,777,000,000 | | 2,777,000,000 |
| Noncontract Cost | | 555,400,000 | | 972,000,000 |
| Total Project Costs | | 3,332,400,000 | | 3,749,000,000 |
| Interest During Construction (IDC) | | 868,900,000 | | 986,400,000 |
| Total Project Costs with IDC | 216,800,000 | 4,201,300,000 | 244,300,000 | 4,735,400,000 |
| **OMR+E Costs** | | | | |
| OM&R | 12,700,000 | 246,700,000 | 12,700,000 | 246,700,000 |
| Pumping Energy | 62,000,000 | 1,201,600,000 | 62,000,000 | 1,201,600,000 |
| Lost Hydropower | 4,000,000 | 77,500,000 | 4,000,000 | 77,500,000 |
| Total OMR&E | 78,700,000 | 1,525,800,000 | 78,700,000 | 1,525,800,000 |
| **Total Costs** | 295,500,000 | 5,727,100,000 | 323,000,000 | 6,261,200,000 |

**Table 4-7. Summary of Information for Wymer Dam Plus Yakima River Pump Exchange Alternative Benefit/Cost Analysis**

| Benefits and Costs (Annual Equivalent and Present Worth, 100 years @ 5.125 Discount Rate) | | | | |
|---|---|---|---|---|
| **Benefits** | | | | |
| **Purpose** | **Fishery at Middle Ocean Productivity Condition – High-End Estimate** | | **Fishery at High Ocean Productivity Condition – High-End Estimate** | |
| | ***Annual Equivalent ($)*** | ***Present Worth ($)*** | ***Annual Equivalent ($)*** | ***Present Worth ($)*** |
| Irrigation | 2,900,000 | 56,600,000 | 2,900,000 | 56,600,000 |
| Fishery Use Values | 400,000 | 6,800,000 | 700,000 | 13,500,000 |
| Reservoir Recreation | 4,700,000 | 91,000,000 | 4,700,000 | 91,000,000 |
| Hydropower | - - - | - - - | - - - | - - - |
| Municipal | 2,400,000 | 46,500,000 | 2,400,000 | 46,500,000 |
| Subtotal | 10,400,000 | 200,900,000 | 10,700,000 | 207,600,000 |
| Fishery Nonuse Values | 12,300,000 | 239,000,000 | 20,900,000 | 404,900,000 |
| **Total** | 22,700,000 | 439,900,000 | 31,600,000 | 612,500,000 |
| **Costs (April 2004) – Plan 2** | | | | |
| | **Noncontract 20 %, 10-yr Construction** | | **Noncontract 35 %, 10-yr Construction** | |
| | ***Annual Equivalent ($)*** | ***Present Worth ($)*** | ***Annual Equivalent ($)*** | ***Present Worth ($)*** |
| Total Field Cost | | 2,192,900,000 | | 2,192,900,000 |
| Noncontract Cost | | 438,600,000 | | 767,500,000 |
| Total Project Costs | | 2,631,500,000 | | 2,960,400,000 |
| Interest During Construction | | 773,300,000 | | 893,600,000 |
| Total Construction | 175,700,000 | 3,404,800,000 | 198,900,000 | 3,854,000,000 |
| **OMR+E Costs** | | | | |
| O, M & R | 14,900,000 | 288,800,000 | 14,900,000 | 288,800,000 |
| Pumping Energy | 18,500,000 | 359,000,000 | 18,500,000 | 359,000,000 |
| Lost Hydropower | Not Evaluated | Not Evaluated | Not Evaluated | Not Evaluated |
| Total OMR&E | 33,400,000 | 647,800,000 | 33,400,000 | 647,800,000 |
| **Total Costs** | 209,100,000 | 4,052,600,000 | 232,300,000 | 4,501,800,000 |

## 4.2.1 Benefit/Cost Ratio

Several benefit/cost ratios were developed to show different assumptions. On the benefit side, the middle ocean productivity, high-end estimate and the high ocean productivity condition, high-end estimate were used for the fishery use and nonuse benefits. On the cost side, a 10-year construction period was used in computing the interest during construction, and noncontract costs were computed at both 20 percent and 35 percent.

Benefit/cost ratios and net benefits for the Black Rock Alternative and the Wymer Dam Plus Yakima River Pump Exchange Alternative are shown in Table 4-8.

**Table 4-8. Benefit/Cost Ratios and Net Benefits**

| | Fishery at Middle Ocean Productivity Condition – High-End Estimate | Fishery at High Ocean Productivity Condition – High-End Estimate |
|---|---|---|
| **Black Rock Alternative – Benefit/Cost Ratio** | | |
| **Noncontract Cost of 20%** | | |
| Without Nonuse | 0.15 | 0.16 |
| With Nonuse | 0.25 | 0.31 |
| **Noncontract Cost of 35%** | | |
| Without Nonuse | 0.14 | 0.14 |
| With Nonuse | 0.23 | 0.28 |
| **Wymer Dam Plus Yakima River Pump Exchange Alternative – Benefit/Cost Ratio** | | |
| **Noncontract Cost of 20%** | | |
| Without Nonuse | 0.05 | 0.05 |
| With Nonuse | 0.11 | 0.15 |
| **Noncontract Cost of 35%** | | |
| Without Nonuse | 0.04 | 0.05 |
| With Nonuse | 0.10 | 0.14 |
| **Black Rock Alternative – Net Benefits** | | |
| **Noncontract Cost of 20%** | | |
| Without Nonuse | -4,847,700,000 | -4,831,500,000 |
| With Nonuse | -4,299,500,000 | -3,949,900,000 |
| **Noncontract Cost of 35%** | | |
| Without Nonuse | -5,381,800,000 | -5,365,600,000 |
| With Nonuse | -4,833,600,000 | -4,484,000,000 |
| **Wymer Dam Plus Yakima River Pump Exchange Alternative – Net Benefits** | | |
| **Noncontract Cost of 20%** | | |
| Without Nonuse | -3,851,700,000 | -3,845,000,000 |
| With Nonuse | -3,612,700,000 | -3,440,100,000 |
| **Noncontract Cost of 35%** | | |
| Without Nonuse | -4,300,900,000 | -4,294,200,000 |
| With Nonuse | -4,061,900,000 | -3,889,300,000 |

## 4.3 Cost Allocation

The objective of cost allocation is to equitably distribute project costs of alternative projects among the purposes served. The purposes allocated to can be either reimbursable or nonreimbursable, based on existing Federal legislative authority. Repayment schedules can be developed from the cost base established by cost allocation for reimbursable purposes. This includes both the annual operating cost and the construction cost of the action alternatives.

The amount that can be allocated to a purpose is the lesser of the benefits attributed to the purpose, or the costs of a single-purpose alternative that could be federally developed to provide comparable benefits of the purpose. That is to say, the basic underlying assumption of performing a cost allocation is that the project alternative is economically justified. In this instance, based on the preliminary benefit/cost analysis, benefits do not exceed the costs; therefore, the alternatives are not economically justified. Consequently, an equitable cost allocation is not possible. In addition, Reclamation policy has been that nonuse fishery benefits will not be used in cost allocations.[16]

For example, the maximum costs that could be allocated for the Black Rock Alternative are $895,600,000 (all benefits except nonuse fish benefits). This reflects fishery use benefits for the high ocean productivity condition, high-end estimate. This indicates that, using the lower total cost estimate with 20 percent noncontract costs and a 10-year construction period, about $4.8 billion of the Black Rock Alternative costs could not be allocated ($5.7 billion - $0.9 billion). Similarly, there is about $3.8 billion of the Wymer Dam Plus Yakima River Pump Exchange Alternative costs that could not be allocated.

[16] Reclamation policy memorandum of October 1, 1993, explicitly states that nonuse benefits will not be used in cost allocations.

# Chapter 5.0 FINDINGS AND CONCLUSIONS

This chapter displays the findings and conclusions of the appraisal-level analyses that Reclamation has performed on the No Action, Black Rock, and Wymer Dam Plus Yakima River Pump Exchange Alternatives. The benefits and impacts attributed to the Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives are based on the No Action Alternative. Operation studies and an appraisal-level benefit/cost analysis were performed for each action alternative. These findings do not consider financial, environmental, cultural, or social aspects of any of the alternatives.

## 5.1 Study Team Findings

### 5.1.1 Technical Viability

Based on information available at this time, the two action alternatives (Black Rock and Yakima River Pump Exchange Plus Wymer) appear to be technically viable. This means that they may be constructible and may provide the means to at least partially meet the goals established for the Storage Study.

### 5.1.2 Storage Study Goals

The extent to which the alternatives meet the Storage Study goals is analyzed by operation studies using a 23-year period of hydrologic record of water years 1981-2003. These operation studies should be considered as an illustration of one approach to integrated project operations, but not the only one.

#### 5.1.2.1 Fish Habitat

The Yakima River basin reaches downstream of Parker (RM 103.8) are most affected by the No Action Alternative. This is the result of increased Title XII flows realized from implementation of water conservation measures. The Title XII target flows are increased in nonproration years to 644-844 cfs, compared to 400-600 cfs for the Current Operation.

The Black Rock Alternative affects all reaches of the Yakima and Naches Rivers, with minor effects occurring in the Easton reach of the Yakima River. Parker spring flows (April-June) are improved by the water exchange plus release of 1,500 cfs from the Yakima Project reservoirs. The median spring flow increases from 1,895 cfs to 4,349 cfs. Summer flows remain at the same level as the No Action Alternative.

The pump exchange portion of the Wymer Dam Plus Yakima River Pump Exchange Alternative influences streamflows as far upstream as Roza Dam (RM 127.9), but has the greatest influence downstream of Parker Dam. Parker flows are affected by the water exchange during the entire irrigation season. Median spring and summer flows are increased an additional 1,145 cfs and 2,454 cfs, respectively, above the Current Operation.

Both action alternatives improve habitat conditions in the Cle Elum River by increasing releases from Cle Elum Dam during October-May. The Black Rock Alternative could increase the flow to 500 cfs (an increase of about 280 cfs from the No Action Alternative), which would then flow to the Yakima River confluence. The Wymer Dam Plus Yakima River Pump Exchange Alternative provides a flow of 400 cfs. This approximately 180-cfs flow increase would be captured by the Wymer facilities and stored in a portion (90,000 acre-feet) of the 175,000-acre-foot active capacity Wymer reservoir for release in July and August to meet instream flow and irrigation needs downstream.

The Black Rock Alternative was the only alternative to virtually eliminate the Cle Elum Reservoir-to-Rimrock Reservoir September flip-flop operation. The Wymer Dam Plus Yakima River Pump Exchange Alternative reduces flip-flop moderately in the upper Yakima River and slightly in the lower Naches.

Overall, the Black Rock Alternative more closely mimics the natural (Unregulated) flow regime.

#### 5.1.2.2 Dry-Year Proratable Water Supply

Applying current operating criteria to the 23-year hydrologic period results in the proratable irrigation water supply being less than 70 percent in 5 years (1987, 1992, 1993, 1994, and 2001). The Black Rock Alternative would provide a 70-percent supply in these 5 years, including the third year of the 1992-1994 dry cycle.

The Wymer Dam Plus Yakima River Pump Exchange Alternative meets the 70-percent goal in 4 years, but is short by about 30 percent (about 300,000 acre-feet) in the third year of the dry cycle. The Wymer reservoir capacity devoted exclusively to dry-year irrigation water supply (85,000 acre-feet) is used only in 1994, which results in no carryover at the end of the irrigation season.

While the No Action Alternative provides some improvement in the proratable water supply, there are still 3 years when the supply is less than 70 percent. There is no change in the proratable water supply from the Current Operation in the third year of the 3-year dry cycle.

#### 5.1.2.3 Municipal Water Supply

In the *Yakima Basin Appraisal Assessment*, Reclamation assumed the future surface water need of 10,000 acre-feet for the cities of Cle Elum and Yakima (the only current municipal surface water users) could be met with new storage facilities. For this analysis, Reclamation assumed the surface water component for future municipal demand to be 10,000 acre-feet and that amount could be met with either action alternative.

After reviewing the water supply estimates in the *Watershed Management Plan* (2003), Reclamation has concluded the future total surface municipal water needs could be as much as 82,000 acre-feet by the year 2050. If an ongoing groundwater investigation (scheduled for completion in 2007) shows there is connectivity between surface- and groundwater, any future water use by municipalities and domestic users would require mitigation.

### 5.1.3 Economic Analysis

This *Technical Information and Hydrologic Analysis* includes an appraisal-level benefit/cost analysis and addresses cost allocation. Benefits were shown for agriculture, fish (use and nonuse benefits), recreation, hydropower, and municipal water. The benefits were determined by comparing results of the analyses for the Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives against the No Action Alternative. A 100-year period is used in the economic analysis.

#### 5.1.3.1 Benefit/Cost Analysis

The benefit/cost ratios that follow are for the most optimistic conditions of the economic analysis. The Black Rock benefit/cost ratio is 0.31. The Wymer Dam Plus Yakima River Pump Exchange benefit/cost ratio is 0.15. These ratios show that, using the criteria for measuring National Economic Development (NED) benefits defined in the P&Gs, neither action alternative is economically justified at the appraisal level of analysis.

In accordance with the P&Gs, changes in regional income and employment that may result from an alternative are not included as part of the NED benefits. Rather, these benefits would come under the Regional Economic Development (RED) benefits. Recreation benefits attributed to the Yakima River and existing Yakima Project reservoirs have not been estimated.

#### 5.1.3.2 Cost Allocation

The amount that can be allocated to a purpose such as irrigation, fish and wildlife, or recreation is the lesser of the benefits attributed to the purpose, or the costs of a single-purpose alternative that could be federally developed to provide comparable benefits of

the purpose. In this analysis, benefits do not exceed costs. Consequently, an allocation of all costs is not possible for either of these alternatives.

## 5.2 Conclusions

Both action alternatives meet the 70-percent irrigation goal, with the exception of the Wymer Dam Plus Yakima River Pump Exchange Alternative, which does not meet the goal in the third year of the 1992-1994 dry cycle.

The Black Rock Alternative provides a larger water exchange, backed by significant additional water storage. This allows greater flexibility and opportunities for adaptive management in project operations for fish habitat improvement.

The instantaneous exchange part of the Wymer Dam Plus Yakima River Pump Exchange Alternative does not provide the ability to use the exchange water when it might be needed, but can only be used when water is being pumped. This does not provide the flexibility required to make the Yakima River flow regime more closely mimic the natural (unregulated) flow regime. There is the potential to affect flows in the lower Naches River if the 90,000 acre-feet of water in Wymer reservoir is operated with different instream flow objectives and not solely for irrigation demands.

The Black Rock Alternative has the potential to influence the flow regime of all river reaches downstream of the five major Yakima Project reservoirs. The extent to which each river reach is affected will depend on the emphasis of the instream flow objectives, which could be dependent upon specific water year conditions.

### 5.2.1 Further Technical Investigations

The design of the Black Rock Alternative in the *Black Rock Appraisal Assessment* is adequate for feasibility-level cost estimates. Additional groundwater investigations should be performed in the Feasibility Phase of the Storage Study. If the alternative is selected for construction, additional geologic investigation would also have to be completed before final designs could be prepared, and new cost estimates would need to be prepared. An analysis of the impacts of potential seepage from the reservoir will be completed during the spring of 2007. The conveyance and storage capacity of all facilities should be reassessed before the environmental impact statement (EIS) is completed.

Future investigations of the Wymer Dam Plus Yakima River Pump Exchange Alternative should include a review of the design and the preparation of a new cost estimate. Additional geologic, seismic, and groundwater data should be obtained to confirm the design of Wymer dam, pumping plant and outlet facility. An analysis of the benefits of a

power-plant at the outlet of the dam would also be needed. Additional information is needed to assure adequate freeboard at the Lmuma Creek Interstate Highway 82 bridge and an updated estimate of the probable maximum flood would need to be prepared.

Many assumptions were made in the appraisal-level design and siting of the pipeline and pumping plants for the pump exchange facilities. Further investigations should include geologic exploration of pumping plant sites and pipeline alignments, optimizing the pipeline alignment through urban areas, diverting water to Sunnyside Canal via supply pipeline, energy recovery at Pumping Plant #3, eliminating overflow reservoirs, and locating pipeline alignment from Pumping Plant #2 to a lower elevation.

The Storage Study also has several ongoing investigations which are desirable to continue regardless of which alternative(s) are selected for the Feasibility and EIS Phase. These include hydrologic and biologic evaluation modeling (flow regimes, sediment, and temperature) to determine how the flow regime can be changed and the impacts any changes would have on the fish habitat. These investigations are expected to be completed in the summer of 2007.