Chapter 2

JOINT ALTERNATIVES

CHAPTER 2

JOINT ALTERNATIVES

2.1 Introduction

As discussed in chapter 1, this document combines a planning report and an environmental impact statement. It complies with both NEPA and SEPA requirements and has alternatives generated under two separate authorities. Reclamation's authorization to conduct a feasibility study of Black Rock reservoir and other storage options within the Yakima River basin results in a focused evaluation of potential storage solutions for the basin's water deficiency problems. Any alternative selected for implementation would be operated as part of the Yakima Project. Because Ecology is a partner in this feasibility study, the alternatives developed under this authorization are referred to as "Joint Alternatives" and are discussed in this chapter. Because this is a combined planning report and EIS, this chapter also includes the planning study criteria and evaluation of those alternatives. The following Joint Alternatives are considered:

- No Action Alternative
- Black Rock Alternative
- Wymer Dam and Reservoir Alternative
- Wymer Dam Plus Yakima River Pump Exchange Alternative

Ecology's authorization allows evaluation of both storage and nonstorage plans within the Yakima River basin and elsewhere in the Columbia Basin. These alternatives that fall outside Reclamation's Storage Study authority are referred to as "State Alternatives," and are described in chapter 3. Chapters 4 and 5 present discussions of the affected resources and environmental consequences of implementing each of the proposed Joint and State Alternatives, respectively.

2.2 Alternatives Formulation and Evaluation

The Joint Alternatives addressed in this chapter were developed via processes that conform to the *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies*. These criteria were addressed in the *Summary Report, Appraisal Assessment of the Black Rock Alternative* (Reclamation, 2004e) and the *Storage Study Team Technical Information and Hydrologic Analysis for Plan Formulation* (Reclamation, 2006c). The four criteria for evaluating a Federal water resource project are as follows:

Completeness – the extent to which the alternative provides and accounts for all necessary investments and actions to implement the plan.

Effectiveness – the extent to which the alternative alleviates the problems and accomplishes the objectives.

Efficiency – the extent to which the alternative is cost-effective in accomplishing the project objectives.

Acceptability – the workability and viability of the plan in terms of acceptance by Federal, State, and local governments and the public and compatibility with existing laws, regulations, and public policies.

The alternatives are then compared using four accounts to facilitate evaluation and to display effects of the alternatives. These accounts are as follows:

National Economic Development (NED) – The Federal objective is to contribute to national economic development consistent with protecting the Nation's environment. The NED account measures the beneficial and adverse monetary effects of each alternative in terms of changes in the value of the national output of goods and services.

Regional Economic Development (RED) – This account evaluates the beneficial and adverse impacts of each alternative on the economy of the affected region, with particular emphasis on income and employment measures. The affected region reflects the geographic area where significant impacts are expected to occur. Impacts can be measured in both monetary and nonmonetary terms.

Environmental Quality (EQ) – This account provides the mechanism for displaying information relative to the effects of proposed alternatives on significant resources. "Significant" in this context means resources that are likely to have bearing on the decisionmaking process.

Other Social Effects (OSE) – This account serves as a repository for alternative effects that are not reflected in the other three accounts. Examples may include safety and health issues, long-term productivity, energy consumption issues, and others.

Feasibility studies conducted by Reclamation are detailed investigations specifically authorized by law to determine the desirability of seeking congressional authorization for implementation of a preferred alternative, normally the NED Alternative, which reasonably maximizes net national economic development benefits. However, none of the alternatives developed in this feasibility study meet the requirements to be identified as the NED Alternative. The alternatives do, however, result in positive effects on regional income and regional employment, anadromous fish habitat, and urban

and community attributes as shown in the RED, EQ, and OSE accounts, respectively. Because of these positive effects (presented in tables 2.58 and 2.60), the alternatives are presented in this Draft PR/EIS.

2.2.1 Goal Setting

This section describes how Reclamation and Ecology quantified the three Storage Study goals listed in chapter 1, namely, improving instream flows and dry year irrigation water supply, and meeting future municipal water supply needs.

2.2.1.1 Instream Water Supply

A variety of legal requirements exist related to providing and/or maintaining instream flows in the Yakima River basin. Generally, these are based on court orders and Federal legislation related to the Yakima Project. The State of Washington has not established minimum instream flows for the Yakima River basin. The State and Federal courts have mandated that Reclamation operate the Yakima Project to reduce impacts to the fisheries resource, treaty-reserved rights for fish, and instream flows to support treaty fishing rights at "usual and accustomed places." The System Operation Advisory Committee advises Reclamation on an annual basis how to operate the project to meet these mandates.

Instream flows included in Title XII of the Act of October 31, 1994 (Public Law 103-464), are quantified "target flows" at two points in the Yakima River basin (Sunnyside and Prosser Diversion Dams). The legislation provides that the Yakima Project Superintendent (currently, the Yakima Field Office Manager) shall estimate the water supply which is anticipated to be available to meet water rights, and provide instream flows in accordance with the Title XII criteria shown in table 2.1. This operational regime was initiated by the Yakima Project Superintendent in 1995.

Table 2.1 Title XII target flows

TWSA estimate for period of April-September (maf)					Target flow from date of estimate through October downstream from:	
Scenario	**April through September**	**May through September**	**June through September**	**July through September**	**Sunnyside Diversion Dam (cfs)**	**Prosser Diversion Dam (cfs)**
1	3.20	2.90	2.40	1.90	600	600
2	2.90	2.65	2.20	1.70	500	500
3	2.65	2.40	2.00	1.50	400	400
Less than scenario 3 water supply					300	300

Title XII target flows do not necessarily provide for a natural (unregulated) ecosystem function. Title XII target flows at the two control points do not address fish habitat and food web needs at the basin level and thus, by themselves, cannot be expected to lead to restoration of anadromous fish runs (SOAC, 1999).

Reclamation met with the Storage Study Technical Work Group to establish informal flow objectives for fish habitat analyses. The SSTWG developed a consensus on desired flows for five Yakima River reaches for each life-cycle season—spring, summer, and winter. The SSTWG considered many factors in developing the flow objectives. These included the needs for spawning and incubation, rearing and migration. They also looked at estimated unregulated flow to help inform their decisions.

The 12 calendar months were grouped into spring, summer, and winter seasons consisting of four months, each based on the general life history pattern of steelhead and salmon in the Yakima River basin. The spring season is when juvenile steelhead and salmon migrate to the ocean as smolts. The summer season is the summer juvenile rearing period, and the juvenile over-winter rearing occurs during the winter.

- Spring—March through June
- Summer—July through October
- Winter—November through February

Table 2.2 presents the monthly flow objectives and volume for the Easton reach, the Cle Elum River, and the Ellensburg, Wapato, and lower Naches River reaches.

Table 2.2 Monthly flow objectives and volumes for an average water year for the Easton reach, Cle Elum River, and Ellensburg, Wapato, and lower Naches River reaches

Reach		Spring				Summer				Winter			
		Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
Easton	Flow objective (cfs)	722	1,166	1,400	787	450	375	375	375	425	450	450	450
	Volume (acre-feet)	42,943	69,406	83,300	46,856	26,775	22,313	22,313	22,313	25,288	26,775	26,775	26,775
Cle Elum River	Flow objective (cfs)	511	954	1,500	1,301	589	400	400	400	425	425	425	425
	Volume (acre-feet)	30,432	56,777	89,250	77,391	35,061	23,800	23,800	23,800	25,288	25,288	25,288	25,288
Ellens-burg	Flow objective (cfs)	1,982	2,424	3,700	2,586	2,000	1,000	1,000	1,000	980	1,016	1,257	1,459
	Volume (acre-feet)	117,938	144,238	220,150	153,849	119,000	59,500	59,500	59,500	58,311	60,446	74,807	86,821
Wapato	Flow objective (cfs)	3,109	2794	3,500	2655	1,300	1,300	1,300	1,300	1,758	1,854	2,163	2,460
	Volume (acre-feet)	184,978	166,261	208,250	157,958	77,350	77,350	77,350	77,350	104,616	110,295	128,712	146,389
Lower Naches River	Flow objective (cfs)	1,265	1,802	2,297	2,291	988	550	550	550	500	576	691	720
	Volume (acre-feet)	75,296	107,194	136,682	136,307	58,772	32,725	32,725	32,725	29,779	34,290	41,112	42,834

2.2.1.2 Irrigation Water Supply

The reliability of the surface-water supply for irrigation use is of concern because of droughts that periodically occur in the Yakima River basin. Current Yakima Project legal, contractual, and operational parameters provide that when there is a deficiency in the available water supply to meet recognized water rights, senior (nonproratable) water rights are served first, and shortages are assessed against junior (proratable) water rights. In recent years, the Yakima River basin has experienced water shortages in 1987, 1992, 1993, 1994, 2001, and 2005. The most severe years were 1994, 2001, and 2005, when proratable water entitlements received a 37-percent supply (1994 and 2001) and a 42-percent supply (2005).

As a part of the work conducted for the *Watershed Management Plan* (Yakima River Basin Watershed Planning Unit and Tri-County Water Resources Agency, 2003) during the early 2000s, the Yakima River Basin Watershed Planning Unit and the Tri-County Water Resources Agency examined criteria to evaluate water supply strategies and to estimate the volume of water needed to meet irrigation demands. This included work by Northwest Economic Associates conducted for the Tri-County Water Resources Agency in 1997 and by the Yakima River

Watershed Council in 1998. Information from both was circulated to irrigation entities and conservation districts in the Yakima River basin to solicit comments about establishing irrigation water supply reliability criteria. It was the opinion of those responding that, if a supply of not less than 70 percent of the proratable water rights could be provided in dry years, major economic losses could be averted.

Reclamation has adopted these criteria for the irrigation water supply goal for the Storage Study. Reclamation measured all alternatives by their ability to provide a dry year supply of not less than 70 percent of the proratable water entitlements. Table 2.3 presents the Yakima River basin annual water entitlements for the proratable water users upstream of the Parker gage (RM 103.7) for the period April through October (irrigation season).

2.2.1.3 Municipal Water Supply

Communities in the Yakima River basin presently rely primarily on groundwater (83 percent) and some surface water to meet current municipal and domestic water needs. These systems include large and small public water systems, individual household wells, and wells provided by self-supplied industrial users.

The year 2000 estimated municipal and domestic water use in the Yakima River basin from surface-water and groundwater resources was about 104,000 acre-feet.

The projected municipal and domestic water needs in year 2050 from Yakima River basin surface water and groundwater sources is about 186,000 acre-feet, an increase of 82,000 acre-feet from year 2000.

Table 2.3 Yakima River basin annual water entitlements

Irrigation entity	Annual water entitlements (maf)[1]		
	Proratable	Nonproratable	Total
Kittitas Division	.336		.336
Roza Division	.375		.375
Wapato Irrigation Project	.350	.306	.656
Sunnyside Division	.143	.316	.459
Tieton Division	.038	.076	.114
Other	.042	.519	.561
Total basin	1.284	1.217	2.501

[1] Entitlements used when prorationing of the water supply available for irrigation is required. Conditional Final Orders of the Adjudication Court and Water Right Settlement Agreements have in some cases established limitations on the volume that can be diverted in any year.

In preparing the *Watershed Management Plan*, the Yakima River Basin Watershed Planning Unit and Tri-County Water Resources Agency assumed the increased need would be met by surface water withdrawals. This assumption was made because of a potential for a connection between surface water and groundwater in the basin. An ongoing study is evaluating if this connection exists and the impacts of this connection on either water source by withdrawals from the other source. It is possible that if the connection is proven, the State may require mitigation for any withdrawals of surface or groundwater.

Assuming a 1-to-1 groundwater-to-surface-water mitigation, 82,000 acre-feet could be required for mitigation by the year 2050. On the other hand, assuming mitigation is not necessary, and only those presently using surface water as their municipal and domestic water supply (cities of Cle Elum and Yakima) would do so in the future, the additional surface-water needs are estimated at about 10,000 acre-feet. At the urging of the Roundtable participants, Reclamation agreed to use the assumption that mitigation for 82,000 acre-feet would be required and is using that volume as the future municipal demand. The 82,000-acre-foot estimate for future domestic, municipal, and industrial demand is based upon future population estimates and past water use. The estimate may be conservative as it did not account for future conservation actions, increased pricing, and other demand changes that occur when water is scarce as is the case in the Yakima River basin.

Table 2.4 presents municipal and domestic water needs for years 2000, 2010, 2020, and 2050.

Table 2.4 Municipal and domestic water needs for years 2000, 2010, 2020, and 2050

	Number of services (in 1999)	Needs (acre-feet)			
		[1]2000	[1]2010	[1]2020	2050
Yakima River basin total	**109,180**	**115,772**	**138,199**	**163,316**	**[2]215,000**
Upper Yakima subarea					
Ellensburg	3,230	4,820	6,053	7,062	
Cle Elum	1,000	897	1,009	1,121	
Other community and Class B PWS	3,111	3,139	3,845	4,551	
Noncommunity	881	988	1,210	1,432	
Yakima Training Center	4	90	90	90	
Households with own well	5,602	5,652	6,924	8,195	
Total Upper Yakima	13,828	15,585	19,130	22,451	29,000
Middle Yakima subarea					
City of Yakima (potable supply)	16,756	17,151	18,384	19,393	
City of Yakima (irrigation supply)		Not available	2,242	2,242	
Nob Hill Water Association	7,595	3,811	4,708	5,717	
Selah	1,682	2,915	3,363	3,699	
Union Gap	1,200	1,211	1,398	1,586	
Terrace Heights	1,104	673	1009	1,223	
Other community and Class B PWS	3,489	3,520	4,066	4,611	
Noncommunity	154	173	199	226	
Yakima Training Center	109	90	90	90	
Households with own well	18,720	18,887	21,814	24,741	
Total Middle Yakima	50,809	48,430	57,274	63,539	70,000
Naches subarea					
Other community and Class B PWS	1,474	1,487	1,755	2,022	
Noncommunity	607	680	803	925	
Households with own well	2,575	2,598	3,066	3,533	
Total Naches	4,656	4,565	5,623	6,481	18,000
Lower Yakima subarea					
Sunnyside	2,956	3,252	3,399	4,260	
Grandview	2,300	3,139	4,148	5,381	
Toppenish	2,000	2,018	2,331	2,643	
Wapato	1,104	1,345	2,803	3,139	
Benton City	729	224	785	1,345	
Prosser	1,600	3,139	3,587	3,924	
Richland	5,451	9,192	9,753	15,358	
West Richland	2,200	2,915	3,924	6,278	
Other community and Class B PWS	6,777	6,837	7,897	8,957	
Noncommunity	272	305	353	399	
Households with own well	14,498	14,627	16,894	19,161	

Table 2.4 Municipal and domestic water needs (years 2000, 2010, 2020, and 2050) (continued)

	Number of Services (in 1999)	Needs (acre-feet)			
		[1]2000	[1]2010	[1]2020	2050
Lower Yakima subarea (continued)					
Total Lower Yakima	39,887	46,992	56,172	70,844	[4]98,000
LESS: Richland and West Richland[3]	-7,561	-12,107	-13,677	-21,636	[5]-29,000
Adjusted lower basin	32,326	34,885	42,495	49,208	69,000
Yakima River basin groundwater and surface-water supply	101,619	103,465	124,522	141,679	186,000
Increase from year 2000			20,000	38,000	82,000

[1] From table 6 of the *Municipal, Domestic, and Industrial Water Needs and Supply Strategies,* January 2002, Technical Memorandum prepared by Economics and Engineering Services. This is consistent with table 2-1 of the January 6, 2003, *Watershed Management Plan.*

[2] From exhibit 2-2 of the W*ater Management Plan*.

[3] Water system plans provide for joint development of Columbia River surface supply.

[4] Page 3-6 of the January 6, 2003, *Water Management Plan* provides information on the extent of increased needs in the upper Yakima, middle Yakima, and Naches subareas from year 2000 to year 2050. These increased needs were added to the respective subareas' year 2000 use to provide a year 2050 total of 117,000 acre-feet for the three subareas. The 117,000 acre-feet was subtracted from the Yakima River basin total need of 215,000 acre-feet, providing a figure of 98,000 acre-feet for the lower Yakima subarea.

[5] The year 2020 need of the cities of Richland and West Richland is 30 percent of the lower Yakima subarea year 2020 estimated need. The 30-percent figure was applied to the lower Yakima subarea year 2050 need of 98,000 acre-feet, resulting in a year 2050 estimated need of 29,000 acre-feet for these two cities.

2.2.2 Geology

Several key geologic characteristics must be considered in the design of major embankment structures such as the Black Rock and Wymer dams. These characteristics are critical to the stability and feasibility of all embankment designs. The following briefly discusses these geologic characteristics of both the Black Rock and Wymer damsites and how these characteristics would be addressed in the final design process.

Typical geologic characteristics of embankment damsites are liquefaction (a loss of material strength that can result in large areas of slope failure), slope failures, and fault displacements. Seismic evaluation and geologic characteristics at Black Rock and Wymer damsites are discussed below.

In general, these geologic considerations are typical of many embankment damsites, and are not viewed as indicative of any "fatal flaws" that would indicate the site is not technically feasible. Rather, it is judged that safe embankments can be designed and constructed without any particularly unusual measures or features beyond what are typically considered for a major embankment dam (Reclamation, 2007a).

2.2.2.1 Black Rock Damsite Seismicity

Technical Memorandum No. D-8330-2004-14, *Probabilistic Seismic Hazard Assessment for Appraisal Studies of the Proposed Black Rock Dam* (Reclamation, 2004f) documents the preliminary characterization of the earthquake potential at Black Rock damsite. Probabilistic Seismic Hazard Assessment (PSHA) is a technique that provides an assessment of the annual levels of earthquake ground motions that the site might experience based on the rates of seismic activity and fault movements in the region surrounding the site. Peak Horizontal Acceleration (PHA), a measure of very high-frequency earthquake ground motions, can be estimated through PSHA and was used in the preliminary assessments of the potential Black Rock damsite.

Seismic hazard information is used to guide engineering decisions on the design and placement of the dam and related structures. High levels of earthquake ground motion can potentially lead to liquefaction of saturated, lower density soils. Other potential concerns include the stability of natural and engineered slopes and the effects of potential fault displacements on the dam and related structures. To mitigate this concern, it is critical that all potentially liquefiable foundation soils are removed and that all embankment materials are compacted to high densities, which can be routinely accomplished through the use of large rollers.

The initial assessment indicates that the Black Rock damsite lies in an area of relatively high earthquake potential. For example, at a return period of 10,000 years, the estimated mean PHA is about 0.95g (acceleration of gravity), a level of ground shaking that might be associated with the occurrence of magnitude 6 to 7+ earthquakes relatively near the site. Faults that are associated with the Yakima Fold Belt near the Black Rock damsite are the main sources of potential ground motion. These include the large fold on Horsethief Mountain, which is related to a low-angle thrust fault (a part of the Black Rock Valley fault, also known as Horsethief Mountain fault) that surfaces in the lower portion of the south dam abutment and dips to the south beneath Horsethief Mountain. Because of its proximity to the site, the Black Rock Valley fault is the largest contributor to the initial estimates of PHA for the site. The Cascadia Subduction Zone (a deep fault zone along the coast of Washington and Oregon that is capable of producing very large magnitude earthquakes) is not a major contributor to the PHA at the damsite.

While the Black Rock Valley fault has not been studied in sufficient detail to define its activity, it is assumed at this stage of study that the fault may be capable of a large-magnitude earthquake and that associated fault offsets within the dam footprint could range from a few centimeters to several meters. Given the orientation of the east-west folds comprising the Yakima Fold Belt, which includes Black Rock Valley, the orientation of the displacements would be in the north-south (cross-valley) direction reflecting compression of the folds. Several

secondary faults, scarps, and lineaments that appear to be related to the fold atop Horsethief Mountain are also potential sites of secondary faulting, fissuring, and landslides (Reclamation, 2004f). Existing landslides and potential for reactivation of landslides exists along Horsethief Mountain, the south abutment of the dam.

The earthquake shaking can be addressed by carefully analyzing the dam for potential deformations from the expected earthquake load and designing crest dimensions, zoning, and embankment slopes to ensure stability, as well as selecting appropriate materials and keeping the phreatic surface (water level) in the embankment as low as possible. Key features to include in an embankment would be filters and drains of sufficient dimension to ensure that cracking, offsets, or differential movements will not exceed the width of the filters. These filters and drains should be constructed of clean, cohesionless, and permeable sands and gravels, so that if the dam is cracked, these materials will collapse or rearrange so that a crack is not supported within these zones.

2.2.2.2 Wymer Damsite Seismicity

Although a site-specific seismotectonic evaluation has not been performed for the Wymer damsite, it is possible that the site may be subject to relatively high seismicity, or earthquake potential. Potential contributors to the seismic hazard are the Yakima Fold Belt, a prominent group of mostly east-west striking folds, and the deep zone of the Cascadia Subduction Zone, which is capable of producing very large magnitude earthquakes. Other local faults may be present in the vicinity which could have some contribution to the site seismicity. Given the lack of site-specific information, the Wymer damsite was assumed to have potentially high seismicity, with peak horizontal ground acceleration expected from a 10,000-year earthquake in the range of 1.0 acceleration of gravity (g). This assumed potentially high-level of shaking leads to the possibility that lower density embankment or foundation saturated soils may experience liquefaction, which is essentially a loss of strength that can result in large slope failures. To mitigate this concern, it is critical that all potentially liquefiable foundation soils are removed and that all embankment materials are compacted to high densities, which can be routinely accomplished through the use of large rollers.

Another potential concern is earthquake shaking. If shaking is severe and of sufficiently long duration, it could induce slope failures in an embankment. This concern can be addressed by carefully analyzing the dam for potential deformations from the expected earthquake load and designing crest dimensions, zoning, and embankment slopes to ensure stability, as well as selecting strong materials and keeping the phreatic surface in the embankment as low as possible.

One final concern in areas subject to earthquake loading is the possibility of fault displacements within the footprint of the embankments. Based on the limited preliminary geologic characterization of the site, there is no evidence to indicate that a potentially active fault exists within the dam, dike, or reservoir area.

However, it is important to note that relatively little exploration has been conducted to date, and further investigations could conceivably find evidence of foundation faulting. Fortunately, because an embankment dam is generally viewed as less stiff or rigid than a concrete dam, an embankment alternative may be best able to accommodate potential fault displacements. Key features to include in an embankment would be filters and drains of sufficient dimension to ensure that cracking, offsets, or differential movements would not exceed the width of the filters.

Another design feature frequently used when fault displacement is possible is the use of large rockfill shells. These rockfill shells, constructed of rock up to 3 feet in size, form an extremely stable downstream buttress for the earth core or concrete face. Of equal importance is the proven ability of rockfill to allow extensive reservoir leakage or flows to safely "flow through" the rockfill without causing dam failure. This is possible because of the high horizontal permeability of rockfill and the fact that extremely high seepage velocities are required to erode or move large-size rocks (boulders) (Reclamation, 2007a).

2.2.2.3 Wymer Dam Potential South Abutment Landslide

Previous studies of the Wymer damsite have indicated the possibility that part, and perhaps a large portion, of the south abutment for the main dam consists of an ancient landslide. However, the limited amount of geologic investigations at the appraisal stage found no evidence of a large landslide, although there are areas of minor slope instability and indications of poor rock quality in the south dam abutment. Should a slide exist, the impact to the dam (and appurtenant structure) stability would be carefully analyzed in future design studies. A proactive approach to the potential existence of a slide or presence of poor rock quality would be to assume additional excavation of the left dam abutment to remove unstable materials.

2.2.3 Cost Estimates

Reclamation *Directives and Standards* prescribe the following three general stages of project cost-estimate development during preparation of a planning report:

1. Preliminary Cost Estimate: Preliminary cost estimates are prepared for studies at the very early stages of the planning process. They are developed to document a very preliminary analysis of a given problem, need, or opportunity, utilizing readily available data.

2. Appraisal-Level Cost Estimate: Appraisal-level cost estimates are used in appraisal reports to determine whether more detailed investigations of a potential project are justified. These estimates may be prepared from cost graphs, simple sketches, or rough general designs using existing site-

specific data. These estimates are intended to be used as an aid in selecting the most economical plan by comparing alternative features such as dam types, damsites, canal or transmission line routes, and powerplant or pumping capacities. Appraisal-level cost estimates are not suitable for requesting project authorization or construction fund appropriations from Congress.

3. Feasibility-Level Cost Estimate: Feasibility-level cost estimates are based on information and data obtained during investigations for preauthorization activity. These investigations provide sufficient information to permit the preparation of preliminary layouts and designs from which approximate quantities for each kind, type, or class of material, equipment, or labor may be obtained. These estimates are used to assist in the selection of a preferred alternative, to determine the economic feasibility of a project, and to support seeking congressional authorization from Congress.

Once a project receives Congressional authorization, it generally enters the design phase. The first part of the design phase involves preparation of percent-design estimates. These estimates are used to refine the selected alternative or design, and to keep Congress apprised of the latest estimate for funding requirements prior to construction. Percent-design estimates are updated feasibility-level estimates.

Cost estimates contained in this planning report were developed by sizing the major features of the alternatives to accomplish the goals of the Storage Study. Major features include dams, pumping plants, tunnels, pipelines, powerplants, and other pertinent items. The major features were distilled to pay items, with approximate quantities developed for materials and activities required to construct those features such as excavation, embankment, concrete, and steel. Unit prices, adjusted for location and current construction cost trends, were applied to the quantities and mobilization costs; an allowance for unlisted items was added to determine the construction contract cost estimate. Contingencies were then added to the construction contract costs to determine the field cost estimates. Field costs were then added to noncontract costs to determine the total project cost. To summarize:

- Construction Contract Cost = Itemized Pay Items + Mobilization Costs + Unlisted Items
- Field Cost = Construction Contract Cost + Contingencies
- Total Project Cost = Field Cost + Noncontract Cost

At the current level of design, mobilization costs, allowances for unlisted items and contingencies, and noncontract costs are typically estimated as a percentage

They are rounded values based on Reclamation rounding criteria so the actual dollar value may deviate from the percentage shown below.

- Mobilization costs (5+/- percent of pay items) identify funds for mobilizing contractor personnel and equipment to the project site during initial project startup.

- Unlisted Items (10+/- percent of pay items plus mobilization) are a means to recognize the confidence level in the estimates and the level of detail and knowledge that was used to develop the estimated cost. This line item may be considered as a contingency for minor design changes and also as an allowance to cover minor pay items that have not been itemized.

- Contingencies (25+/- percent of construction contract cost) are considered funds to be used after construction starts for overruns on quantities, changed site conditions, change orders, etc. Contingencies are not used for design changes during project planning.

- Noncontract costs (35 +/- percent of field cost) include preparation of final engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, land acquisition, relocation, and right-of-way costs.

Reclamation considers the cost estimates provided for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives to be comparable to an Association for the Advancement of Cost Engineering (AACE) Class 4 cost estimate. While Reclamation has not run range-of-costs analyses for these cost estimates, AACE's guidance state that the accuracy range for Class 4 estimates typically run from 15 percent on the low side (i.e., the Class 4 estimate may overestimate the actual cost by 15 percent) to 30 percent on the high side (i.e., the Class 4 estimate may underestimate the actual costs by 30 percent). AACE recommends the use of a more refined (Class 3) estimate as the basis for project budget authorization.

Due to the need to efficiently evaluate the several very large potential project configurations identified in this planning report in a reasonable time period and at a reasonable cost, additional design data and design analysis will be required to produce a Reclamation feasibility-level estimate. The final planning report will identify the additional design data collection and analyses that would be required if an alternative were authorized for construction.

2.2.4 Operations

Operation studies were conducted to assess the effects of the No Action, Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump

Exchange Alternatives on water resources. Water resources include flows in the Yakima and Columbia Rivers, reservoir operations in the Yakima River basin, and water supply. The operation studies were also used to assess the economic justification and environmental consequences of the alternatives on many of the Yakima River basin's aquatic and terrestrial resources, as discussed in detail in chapter 4.

The No Action Alternative is comprised of water conservation measures that are being considered for implementation with funding from Title XII of the Act of October 31, 1994, and from other sources. Each Joint Alternative also incorporates these water conservation measures.

In addition, a natural (unregulated) flow regime for the Yakima, Naches, Cle Elum, Bumping, and Tieton Rivers was developed by modeling the river system without the existing Yakima Project storage reservoirs and diversions and associated return flows. This flow regime was used in developing instream flow water supply goals. The results of the operations analyses are shown in a monthly time step.

Results generated by the Yakima Project RiverWare (Yak-RW) model,[1] a daily time-step reservoir and river simulation computer model, were used to assess the effects of the alternatives on selected indicators of water resources. The Yak-RW model uses a 25-year hydrologic period of historical water years of 1981-2005 (November 1, 1981-October 31, 2005) and provides daily, monthly, and yearly output for this period. This 25-year hydrologic period includes 18 nonprorated water years (wet and average water supply conditions) and 7 proration water years (dry water supply conditions). It also includes the longest dry cycle of the Yakima River basin (1992-94). In the discussions of operations, 1994 is used as an illustration of dry year conditions, as it represents a water year when the proratable supply available was at its lowest. The proration levels generated by the Yak-RW model for the current operation are different than actually experienced in the prorated water years of the 25-year period of record (1981-2005). This is because the most current operating procedures for "flip-flop" and "mini-flip-flop," along with the "minimum" target flows immediately downstream from the dams and Title XII instream target flow, are included in the Yak-RW model for each of the 25 years. This provides consistency, even though some requirements such as the Title XII instream targets flows were not mandated until after water year 1994.

[1] The RiverWare software is a river basin simulation tool developed at the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado in cooperation with Reclamation and Tennessee Valley Authority. The center's Web site, http://cadswes.colorado.edu/riverware, provides supporting documents on the RiverWare software.

2.2.4.1 Water Supply and Water Distribution

The indicators used to assess effects on the Yakima Project water supply consist of the 25-year average for the following:

- April-September TWSA

  This estimate is an indicator of the water supply available to the Yakima Project upstream of the Parker gage to meet all water needs during the major demand season. (Note that during the months of November through March, all demands are a small portion of the unregulated supply available during these months.) The April-September TWSA is comprised of storage contents at the end of March plus runoff and return flows upstream of the Parker gage during this 6-month period.

- TWSA Distribution

  While the volume of the TWSA may be greater under a given alternative, in reality, there is not much room for improving the TWSA by more than a few percentage points. What is really required is a change in the distribution of TWSA.

  TWSA distribution consists of:

  (1) April-September flow volume downstream from the Parker gage. This flow volume is comprised of Title XII target flows and undiverted unregulated runoff and operational spills.

  (2) April-September total irrigation and municipal diversions upstream of the Parker gage. The volume of the water supply available for irrigation, which is the irrigation and municipal diversion portion of the TWSA, determines the need for proration. The irrigation proration level is expressed as the percent of the proratable water supply provided as of the end of September in relation to the September proratable entitlement. When comparing alternatives, an increase in the proration level is moving toward a full (100-percent) water supply.

  (3) September 30 reservoir contents, or carryover of stored water at the end of the irrigation season. The only way to increase TWSA is to increase the storage contents by March 31. However, there is little room for improving the stored water supply with new or existing Yakima River basin storage because of winter flow objectives and the limited runoff above new storage sites. Runoff is fixed by nature. Return flows are a function of irrigation efficiency, and, while system efficiency improvements do decrease irrigation diversions, they also reduce return flows, a component of the TWSA.

- April-September Flow Volume at the Mouth of the Yakima River

  The alternative with the greatest instream flow benefit would improve flows not only at the Parker gage but at the confluence. The flow volume at the Parker gage is a good indicator of the benefits to the Yakima River at the Parker gage, but does not fully reflect what is occurring at the Columbia River confluence. This criterion is best represented by differences in the flow volume at the mouth of the Yakima River.

2.2.4.2 Proratable Irrigation Supply

The indicators used to assess the proratable irrigation supply available in dry years are:

- Irrigation proration level for dry years when the proratable water supply available is less than 70 percent.

  The proration level is an indication of the volume of water that can be diverted from the river. However, this does not account for the increase in the volume of the diversion actually getting to the farm turnout (the farm delivery) as the result of improvements in canal efficiencies. Farm delivery is a better representation of the volume of water available to meet irrigation demands.

- Difference in the irrigation delivery shortage for water year 1994

  The delivery shortage represents the difference between a full water supply to the farm (represented by the median volume delivered for the period of record 1981-2005) and the volume delivered in a specific year. The difference in the delivery shortage is a better indication of the effectiveness of an alternative to ensure a full supply for irrigation. It also accounts for the new stored water supply from the Columbia River not captured by the TWSA, as the TWSA only accounts for Yakima River basin water supplies.

2.2.5 Water Rights and Water Contracts

2.2.5.1 Introduction

Yakima Project water users divert natural flows, releases of stored water, and return flows. Their diversions are governed by Federal contracts, a Federal consent decree, treaty rights, and State water rights and court decisions. Reclamation must consider the effect on existing water rights and contracts if Columbia River water is diverted to serve Yakima River diverters.

Reclamation currently delivers water to Yakima Project water users under the authority of Federal contracts, the *1945 Consent Decree* Judgment in *Kittitas*

Reclamation District v. Sunnyside Valley Irrigation District (Civil 21, Eastern District Washington, 1945), and Decisions and Orders of the Superior Court, *State of Washington Department of Ecology* v. *James J. Acquavella et al.* (*Acquavella).* The *1945 Consent Decree* established a unique water allocation scheme for the Yakima River basin. Water rights perfected prior to the Yakima Project authorization (May 10, 1905) are delivered, in full, according to priority date. (Historically, these senior rights have never been curtailed.) Project water rights with a priority date of May 10, 1905, are susceptible to a reduction in delivery, *pro rata*, in times of drought. Water rights perfected after May 10, 1905, can, potentially, be fully curtailed in drought years.

In 1977, Reclamation formalized operating procedures that had for many years tracked the parameters laid out in the *1945 Consent Decree* Judgment. Reclamation estimates the TWSA for Yakima Project purposes in March of every year and forecasts the amount of proration, if any, which will apply for the coming irrigation season. TWSA is recalculated on a regular basis during the irrigation season and the proration percentage updated. In this way, Reclamation has institutionalized the equitable sharing of the available water supply among irrigators in the basin as the *1945 Consent Decree* envisioned. Through a pending final decree, the Superior Court will confirm the surface water rights for the Yakima River basin.

After the severe drought year of 2001, a year of 37-percent proration, all water right holders looked to tighter regulation of unauthorized and out-of-priority use and more careful management of existing water. In March 2005, the Superior Court in *Acquavella* entered a permanent order that certain identified post-1905 water users are immediately curtailed when Reclamation imposes prorationing among May 10, 1905, rights. Mandatory water measurement, diversion reporting, and regulation also help stretch available supplies within the context of existing water rights.

2.2.5.2 Current Status

Participating Irrigation Entities

Two divisions of the Yakima Project—Roza and Sunnyside—have expressed an interest in water exchange possibilities.

Water Contracts

In general, Reclamation has executed two types of contracts in the Yakima River basin: repayment contracts and water supply contracts. Repayment contracts make up the majority of the contract-based commitments in the basin. Water supply contracts are typically Warren Act contracts, which supplement the supply of water users who depend on pre-Yakima Project natural flow water rights. In other instances (e.g., the Sunnyside Valley Irrigation District contract of 1945), the contract applies to conditions of both repayment and water supply.

Reclamation and irrigation entities executed repayment contracts for the lower basin in the early years of the Yakima Project. These early contracts are perpetual and not fixed-term arrangements. The contracts have subsequently been modified and expanded, but have not been amended or renegotiated since 1951. Limiting agreements executed in the early 1900s as a condition for Federal commitment to the Yakima Project set limits on these pre-project water rights.

Participation in the exchange would probably not require any modification to existing contracts. However, some form of new agreements will be necessary to implement the exchange of water from storage with Yakima River water in addition to contracts for any additional or supplementary water supply.

Reclamation Authority for Withdrawal and Appropriation of State Water - Chapter 90.40 Revised Codes of Washington State.—Reclamation is directed to acquire water rights under prevailing State water law under Section 8 of the 1902 Federal Reclamation Act. For projects proposed under the 1902 Act, the United States has a unique status under Washington State law. In 1905, the Washington Legislature enacted Chapter 90.40 RCW to facilitate construction of the Yakima Project and other Reclamation projects in Washington. The statute allows the withdrawal of public waters from appropriation upon request of the Secretary of the Interior. Upon notice to the State that the United States intends to make examinations or surveys for the use of certain specified waters, the State withdraws those waters from appropriation for a period of 1 year from the date of the notice. If the United States certifies in writing within the 1-year period that the project contemplated in the notice appears to be viable and investigations will be made in detail, the waters continue to be withdrawn from appropriation for 3 years and such further time as the State may grant by extension. During a withdrawal, State law prevents adverse claims to that water except where formally released in writing by the United States.

At such time as a construction contract is executed for storage of irrigation water, the United States may appropriate that volume of the withdrawn or reserved water as is necessary for the storage project ". . . in the same manner and to the same extent as though such appropriation had been made by a private person, corporation or association" (RCW 90.40.040). The priority date of such an appropriation relates back to the date of the withdrawal or reservation.

2.2.5.3 Water Appropriation from the Columbia River

Background

The exchange features of the Black Rock Alternative are based on diversion of Columbia River water. Authorization for such a diversion must comply with Washington State law. Washington instituted a moratorium on new water rights from the Columbia River in 1991, shortly after Snake River sockeye salmon were listed under ESA. In 1997, Washington lifted the moratorium with revisions to Chapter 173-563 WAC. The revisions mandated an evaluation of impacts on fish

and existing water rights in consultation with Federal agencies and Indian tribes. In 2006, Washington's Legislature enacted Chapter 90.90 RCW, which directed Ecology to aggressively pursue the development of water supplies to benefit both instream and out-of-stream use. Appropriations from the Columbia River are still regulated by Chapter 173-563 WAC.

Columbia Basin Project Withdrawal

The Columbia Basin Project (CBP) and the water withdrawn for CBP purposes is not the withdrawn water to be used for the alternatives being studied in this Draft PR/EIS. Water from the Columbia River will be applied for from the December 2004 withdrawal discussed below. Through a May 16, 1938, filing with the State pursuant to RCW 90.40.030, the United States gave notice of its intent to develop the CBP. Columbia River water sufficient for this purpose was withdrawn from appropriation. Water rights for existing power development and the first half of the irrigation project have been perfected. The withdrawal continues in effect for water to benefit the second half of the irrigation development.

December 2004 Notice of Withdrawal

On December 28, 2004, Reclamation filed the requisite notice under RCW 90.40 with the Washington Department of Ecology and Department of Natural Resources. Reclamation filed the notice for an exchange alternative as a preliminary measure to secure a 2004 priority date for any new water rights that the alternative might require. The withdrawal is not an application to appropriate water. At some point in the alternative development, if construction is authorized, funded, and certain, the United States would file an application to appropriate public water under the RCW 90.03 water code process, "such appropriation to be made, maintained, and perfected in the same manner and to the same extent as though such appropriation had been made by a private person, corporation, or association . . ." RCW 90.40.030. If an application is filed, it will have a priority date of December 28, 2004. The withdrawal remains in force through 2008.

Effect of Exchange on Yakima River Basin Water Rights

The exchange alternatives present some issues regarding State water right processes that have not been well exercised; thus, the discussion here represents possible, but not certain, processes for water right acquisition related to storage and the exchange alternatives.

Any storage alternative will require an application for storage pursuant to State procedures. The application for a storage permit will be based on the December 2004 withdrawal. Once stored, the water could be delivered from storage by contract.

The use of water to supplement Yakima River supplies when proration is declared is not an exchange of water and would be considered part of a new water right. That is, during drought, less water is present and available from the Yakima

Project supply and water originating for Columbia River diversion and storage would be considered a new supplemental supply, not an exchange. Therefore, that supplemental supply would have a priority date of December 28, 2004.

Water from any new storage supply that is used *instead of* available and entitled Yakima River water supply would be an exchange. This use of new storage supply will probably require an additional Reclamation contract for delivery and an exchange agreement that will describe terms regarding the details of the exchange, including any further requirements for water right permits and water right permit elements. The exchange agreement would not disturb the project water rights confirmed in the United States' 2007 CFO, but the agreement would be based on the exchange of a portion of those rights for rights from new storage.

2.3 No Action Alternative

2.3.1 Description

The No Action Alternative is intended to represent the most likely future expected in the absence of constructing additional storage. All the Joint Alternative are measured against the No Action Alternative for accomplishments with respect to the Storage Study goals and for benefits and impacts. The analysis and operation studies performed for the No Action Alternative included future implementation of water conservation measures and water acquisitions authorized under YRBWEP; however, it did not include the emergency drought relief provisions allowed under State law, although they are considered to be part of the No Action Alternative. These provisions were not included in the studies because they can vary with each drought.

2.3.1.1 Water Conservation Measures

The No Action Alternative for the Storage Study includes implementation of water conservation measures proposed under Title XII of the Act of October 31, 1994. Section 1203 of Title XII authorized Phase II (the Basin Conservation Program) of 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. Section 1204 of Title XII provides for water conservation on the Yakama Reservation.

Yakima River basin irrigation entities developed and submitted water conservation plans for evaluation and approval by Reclamation in the late 1990s to early 2000s. 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. The No Action Alternative includes

construction of new facilities such as reregulation reservoirs, pumping plants, pipelines, etc., along the alignment of the existing facilities. Site-specific NEPA would be completed as projects are identified.

Under section 1203 of Title XII, two-thirds of the conserved water resulting from a conservation measure is assigned to instream flows and is assumed to remain in the river downstream from the implementing entity's point of diversion. The conservation measure improves delivery efficiencies by reducing return flows and, thus, the diversion requirements, but consumptive use is not reduced. Consequently, the conservation measure only improves streamflows for the river downstream from the entity's point of diversion to the "last" point of operational discharge. One-third of the conserved water is retained by the implementing entity for irrigation use.

Title XII also sets instream target flows over Sunnyside Diversion Dam in wet and average water years at 400 to 600 cfs, depending on the estimated water supply, and in dry years, at 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.

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 and the implementing entity. A "cost ceiling" of $67.5 million (September 1990 prices) was established for the Federal funds and is subject to increase by applicable cost indexes. The April 2007 indexed Federal cost ceiling is estimated at about $115 million.

Table 2.5 presents a summary of the water conservation measures included in the No Action Alternative. The table displays the total conserved water, the two-thirds instream flow component, and the one-third irrigation component.

Table 2.6 presents a summary of the cumulative effects of water conservation measures from Roza Diversion Dam (RM 127.9) to Sunnyside Diversion Dam (RM 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.

Table 2.6 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, which results in an increase in target flows of 94 cfs in a repeat of a 1994 dry water supply year for the 25-year period of record (1981-2005).

Table 2.5 Conserved water resulting from water conservation measures for the No Action Alternative[1]

Entity	Action	Conserved water					
		Volume (acre-feet)			Flow (cfs)		
		Total	Instream	Irrigation	Total	Instream	Irrigation
Upper Yakima River area							
Kittitas Reclamation District	System improvements	47,800	31,700	16,100	132	88	44
Middle Yakima River area							
Roza Division	System improvements under Basin Conservation Program	13,700	9,200	4,500	37	26	11
	System improvements with "pay as you go approach"	30,000	N/A	30,000	82	N/A[2]	82
	Total	43,700	9,200	34,500	119	25	94
Union Gap Irrigation District	Change in diversion	13,000			36		
	System improvements	5,600	3,700	1,900	15	10	5
Wapato Irrigation Project[3]	Change in diversion				50	50	
Sunnyside Division	System improvements (1)	29,100	19,400	9,700	80	54	26
	System improvements (2)	24,700	16,500	8,200	68	46	22
	Total	53,800	35,900	17,900	148	100	48
Benton Irrigation District	Change in diversion	21,000			58		
	System improvements	6,300	4,200	2,100	17	11	6
Naches River area							
Naches-Selah Irrigation District	Change in diversion				100		
Total No Action Alternative		157,200	84,700	72,500			

[1] The change in diversion represents the amount the current diversion is reduced. This amount becomes an operational flow in the river reach between the current and new diversion points.

[2] Does not include diversion reduction.

[3] Proposed for implementation under section 1204 of Title XII.

Table 2.6 Middle Yakima River area instream flow associated with water conservation actions from river mile 127.9 to 103.7

			Instream flow (cfs)			Elements of instream flow (cumulative) (cfs)	
Entity	**Action**	**River Mile**	**Accre-tion**	**Deple-tion**	**Cumu-lative**	**Title XII**	**Opera-tional**
Roza Division	System improvements	127.9	+26		26	26	
Union Gap Irrigation District	Change in diversion	114.7	+36		62		36
Wapato Irrigation Project	Change in diversion	106.7	+50		112		86
Union Gap Irrigation District	New diversion	105.0		-36	76		50
	System improvements	105.0	+10		86	36	
Sunnyside Division	System improvements	103.8	+100		186	136	
Benton Irrigation District [1]	Change in diversion	103.8	+58		244		108
Flow at Parker gage		[2]103.7					
Title XII increase						+136	
Operational							+108

[1] The Benton Irrigation District instream flow portion (11 cfs) of the conserved water increases streamflows in the Yakima River from the new point of diversion (RM 32.1) to the last point of return flows (RM 23.8).

[2] RM 103.7 is the Parker gage, a short distance downstream from Sunnyside Diversion Dam.

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 Benton Irrigation District would 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, in table 2.6, the improvements in Roza increase the streamflow by 26 cfs (accretion) beginning at the point of diversion (RM 127.9). This is the instream flow portion of the conserved water, so the cumulative flow increases by 26 cfs. Another example is the Union Gap diversion—the current diversion is 36 cfs at RM 114.7. That diversion would change to a new diversion 9.7 miles downstream (RM 105.0), resulting in an operational flow of 36 cfs in this reach. Without system improvements, the depletion at the new diversion would be 36 cfs, as shown in table 2.6. However, Union Gap's new pressure pipeline

delivery system will result in conserved water of 15 cfs, of which 10 cfs is the instream flow portion and remains in the river, and 5 cfs is retained by the entity for dry year irrigation. The net depletion to the river is, thus, 26 cfs, and the cumulative flow downstream from mile post (MP) 105.0 is 86 cfs.

2.3.1.2 Water Acquisition

In 2003, Reclamation acquired the water rights associated with 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 results 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 more than 1,905 acres of lands and the associated water rights (263,370 acre-feet) in the tributaries and on the mainstem of the Yakima River (Isley, 2007). These actions secured senior water rights, increasing instream flows from (1) the point of diversion to the downstream return flow point by the amount previously diverted and (2) downstream from the return flow point throughout the river system by the amount of the retired consumptive use. This has resulted in an average cumulative instream target flow increase of about 4 cfs below Sunnyside Diversion Dam.

2.3.1.3 Emergency Drought Relief

While this was not included in the modeling analysis, an emergency drought relief provision has been 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 River basin would roughly translate into less than a 45- to 50-percent proration level for proratable water entitlements.[2] A drought condition was declared in the Yakima River basin in 1994, 2001, and 2005.

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; the water was 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.

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 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 in 1994 are identified as emergency drought wells, the use of which is contingent on a drought condition order and Ecology's approval to use the well. Ecology may also approve development of new emergency drought wells.

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.

2.3.2 Current Yakima Project Operations

The objectives of the current Yakima Project operation are to:

- Store as much as possible up to the reservoir system's full active capacity of about 1 million acre-feet following the end of the irrigation season through early spring.

[2] 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.

- Provide for target flows and diversion entitlements downstream from the dams, meeting Title XII flows at Sunnyside and Prosser Diversion Dams.
- Provide reservoir space for flood control operations.

The irrigation season starts about April 1. During the initial part of the irrigation season, unregulated runoff from tributaries downstream from the five reservoirs, incidental releases from the reservoirs (for target flows and flood control), and irrigation return flows are generally adequate to meet irrigation diversion demands and the Title XII target instream flows at Sunnyside Diversion Dam until about June 24. Once these flows fail to meet diversion demands and Title XII instream target flows, reservoir releases are made, resulting in depletions in the stored water supply (commonly referred to as the beginning of the storage control period).

From the beginning of the storage control period until early September, releases from Cle Elum Lake are used in coordination with releases from Keechelus and Kachess Lakes to meet mainstem Yakima River water entitlements from the Cle Elum River confluence (RM 179.6) to Sunnyside Diversion Dam (RM 103.8). These water entitlements amount to about 1.46 million acre-feet to supply diversions, mostly from Roza Diversion Dam downstream, including Roza Division, Wapato Irrigation Project, and Sunnyside Division. A peak of about 3,600 cfs for irrigation is moved through this area.

About September 1, Cle Elum Lake releases are substantially reduced over a 10-day period, and releases from Rimrock Lake are substantially increased to meet the September-through-October irrigation demands downstream from the confluence of the Naches and Yakima Rivers. This is referred to as the flip-flop operation. The flip-flop operation was instituted to encourage spring Chinook to spawn at a lower streamflow that requires less stored water to be released during the egg incubation period to protect spawning nests (redds). Affected spring Chinook spawning reaches are the Yakima River from Easton Dam to the city of Ellensburg and the Cle Elum River downstream from the dam.

A similar operation, referred to as “mini flip-flop,” is performed between Keechelus and Kachess Lakes in years of sufficient water supply and is performed for similar reasons as discussed for the flip-flop operation that occurs downstream from Easton and Cle Elum Dams. Irrigation releases from Keechelus Lake are higher than from Kachess Lake from June through August. Then, in September and October, irrigation releases from Keechelus Lake are decreased and correspondingly increased from Kachess Lake.

The “Yakima River Basin Schematic,” found in Reclamation’s *System Operations Technical Document* (Reclamation, 2008c) shows the Yakima River basin irrigation diversions and irrigation return flows.

2.3.3 No Action Alternative Operations

2.3.3.1 Operation Criteria

The No Action Alternative operation criteria are the same as the current Yakima Project operation with the following exceptions:

The irrigation diversions of entities included in the No Action Alternative water conservation measures are reduced in wet and average water years by the total volume of conserved water (157,200 acre-feet). In dry years, the diversion reduction reflects only the instream flow portion of the conserved water (84,700 acre-feet). The irrigation portion (72,500 acre-feet) is assumed to be diverted by the entity.

During the first part of the irrigation season, when diversions are being met from unregulated flows (generally April through June), all conserved water remains in the river. However, once the storage control period begins, the irrigation portion provided from storage is not released from Yakima Project reservoirs in wet and average water years. This volume is carried over at the end of the irrigation season and improves the stored water supply for subsequent years. However, once carried over, it loses its identity to a specific entity and becomes a part of the total water supply available for the Yakima River basin. During dry years, that irrigation portion in storage would be released to the specific entity responsible for its conservation.

2.3.3.2 Accomplishments

Water Provided by the No Action Alternative

Table 2.7 presents the differences in the hydrologic indicators between the No Action Alternative and the current operation. The differences outlined in the table show some improvement in the Yakima Project water supply over the 25-year period of record (1981-2005) with implementation of the No Action Alternative. These indicators are discussed in detail in section 2.2.4.

Instream Flows Provided

The Title XII target flows over Sunnyside Diversion Dam (at Parker gage) are 136 cfs greater as a result of conservation measures, resulting in the target flows shown in table 2.8. In addition, there are operational flows of 108 cfs as the result of changes in points of diversion from upstream to downstream from Sunnyside Diversion Dam by some entities under the No Action Alternative. The 108 cfs is not an additional target flow, but does go over the Sunnyside Diversion Dam.

Table 2.7 Changes in hydrologic indicators under the No Action Alternative compared to the current operation for the 25-year period of record (1981-2005) (changes shown in absolute value and percent of change)

	April 1 TWSA	TWSA distribution			Apr-Sep Yakima flow volume at mouth	Irrigation delivery volume shortage[1]	Irrigation proration level
		Apr-Sep Yakima flow volume at Parker gage	Apr-Sep diversion volume upstream of Parker gage	Sep 30 reservoir contents			
	(maf) and % change						Proration and % change
Average year 1981-2005 (results from Yak-RW model)							
Current operation	2.82	0.51	2.02	0.27	0.85	0.07	
No Action Alternative	2.84	0.62	1.91	0.30	0.86	0.05	
Change from current operation	0.02	0.11	-0.11	0.03	0.01	-0.02	
% change	1%	22%	-5%	11%	1%	-28%	
Dry year 1994 (results from Yak-RW model)							
Current operation	1.75	0.19	1.49	0.07	0.32	0.40	28%
No Action Alternative	1.75	0.25	1.42	0.07	0.31	0.38	27%
Change from current operation	0.00	0.06	-0.07	0.00	-0.01	0.02	[2]-1%
% change	0%	31%	-5%	0%	-3%	-5%	

[1] The irrigation delivery volume shortage is the difference between a full water supply to the farm (represented by the median volume delivered for the period of record 1981-2005) and the volume delivered in a specific year.

[2] The irrigation water supply benefits of the conservation actions are realized in 1992 and 1993 as shown by the improved irrigation proration levels of the No Action Alternative. By 1994, the third year of the dry cycle, the difference in the proration level of the No Action Alternative and the current operation is negligible and is due to the rounding of the Yak-RW model results.

Table 2.8 Differences in Title XII target flows downstream from Sunnyside Diversion Dam—current Yakima Project operation compared to No Action Alternative

Total water supply available estimate (maf)				Title XII target flow at Parker gage (cfs)	
April - September	May - September	June - September	July - September	Current operation	No Action Alternative
3.2	2.9	2.4	1.9	600	736
2.9	2.65	2.2	1.7	500	636
2.65	2.4	2.0	1.5	400	536
Less than above		300		300	varies[1]

[1] In dry water years, the target flow is 300 cfs and the 136-cfs increase is adjusted according to the water rights of the entities participating in the Basin Conservation Program. In a dry year such as 1994, the target flow would be 394 cfs.

Introduction to Hydrographs

Monthly instream flow objectives were established by the SSTWG for the Easton, Cle Elum River, Ellensburg, Wapato and lower Naches River reaches. (See table 2.2 as a means of evaluating the performance of each alternative. See table 2.9 and figure 2.1 for reach locations and descriptions.)

Table 2.9 Gages and stream reaches

Gage/ hydrograph	Reach name	Stream reach
Easton (RM 202.0)	Easton	Yakima River: Easton Diversion Dam (RM 202.5) to Cle Elum River confluence (RM 185.6)
Cle Elum Dam outlet (RM 7.9)	Cle Elum	Cle Elum River downstream from 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 103.7)	Wapato	Yakima River: Sunnyside Diversion Dam (RM 103.8) to Granger (RM 83.0)
Kiona (RM 29.9)	Not applicable	Not applicable

Table 2.2 presents these values for an average water year. For many of the reaches, but not all, the relationship between flow and habitat quantity for key salmon and steelhead species and life stages and the unregulated flow pattern were used to assist in establishing the monthly flow objectives. Spring flow objectives for the Wapato reach were based on flow-to-smolt survival studies conducted by the Yakima Klickitat Fisheries Project. Flow objectives were established for wet, average, and dry water years. For the sake of simplicity, the monthly flow objectives were grouped by season—spring (March-June); summer (July-October); and winter (November-February).

The seasonal flow objectives were expressed in terms of total acre-feet of water required to meet the combined monthly flow objective for each season and were calculated taking the average of the four median monthly flow objective volumes. Seasonal flow objectives were expressed in terms of volume, or acre-feet of water, instead of cubic feet per second of streamflow because of the need to account for a total basin water budget. These seasonal flow volume objectives (acre-feet) for the Ellensburg reach (Umtanum gage) and Wapato reach (Parker gage) are shown in table 2.10 for an average water year. The Ellensburg and Wapato reaches were selected to represent a general overview of how each alternative compared to the flow volume objectives. The Ellensburg and Wapato reaches represent the general flow conditions in the upper and middle-to-lower Yakima River, which are the reach areas most influenced by the Storage Study alternatives.

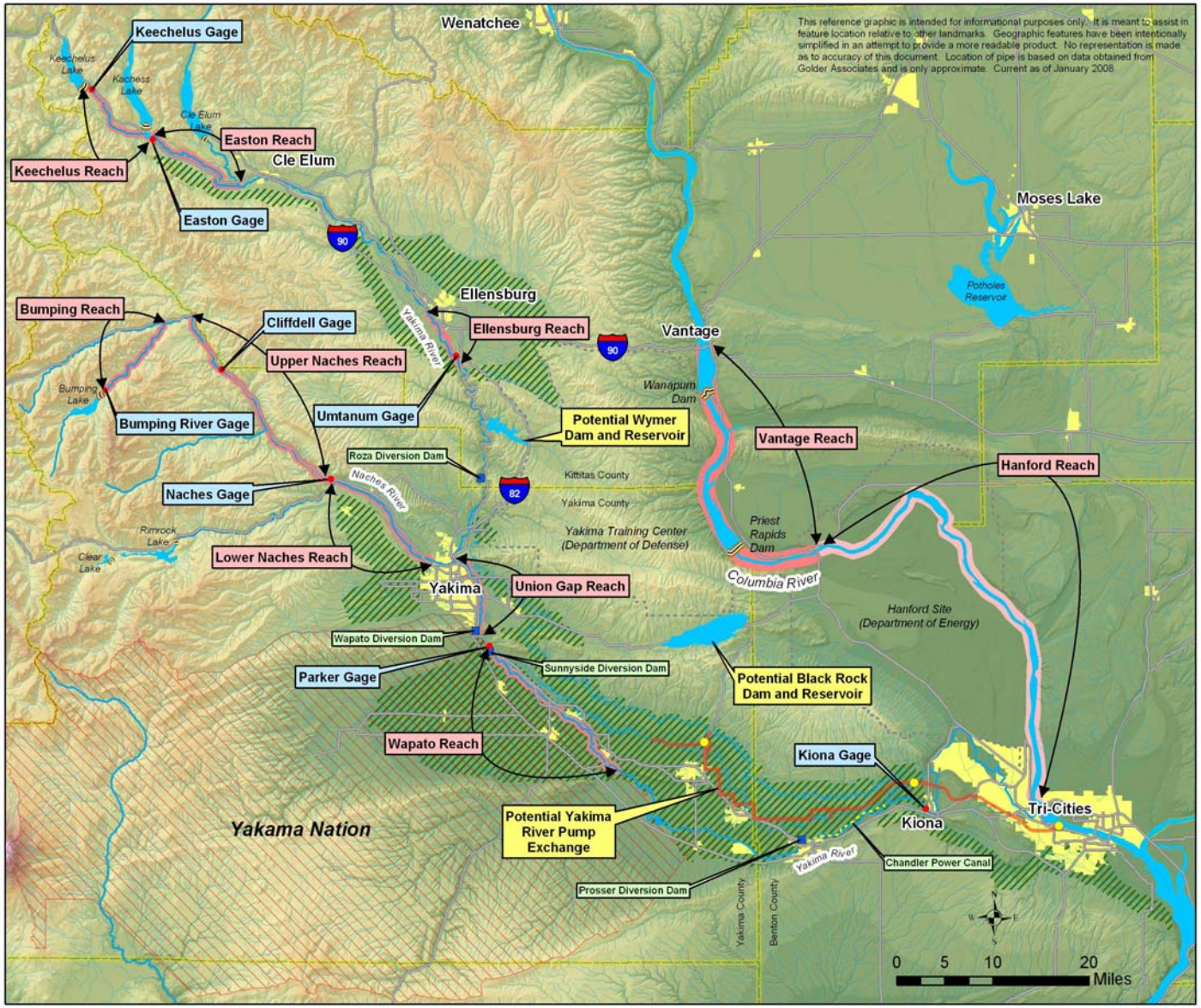


Figure 2.1 Reaches map.

Table 2.10 Seasonal flow volume objectives and model results for the Umtanum and Parker gages for an average water year (acre-feet)

Flows	Umtanum gage			Parker gage		
	Spring	Summer	Winter	Spring	Summer	Winter
Flow objective	741,915	304,920	380,010	780,410	316,602	898,766
No Action Alternative	685,946	614,456	380,010	725,734	190,155	698,766
Black Rock Alternative	751,152	476,734	434,527	1,007,651	313,234	758,113
Wymer Dam and Reservoir Alternative	701,927	550,763	418,356	700,894	187,865	689,855
Wymer Dam Plus Yakima River Pump Exchange Alternative	702,532	549,792	418,433	863,031	375,893	690,108
Enhanced water conservation	695,326	604,366	379,163	765,463	195,416	694,414

In addition, a natural (unregulated) flow regime for the Yakima, Naches, Cle Elum, Bumping, and Tieton Rivers was developed by modeling the river system without the existing Yakima Project storage reservoirs and diversions and associated return flows. This flow regime was used in developing instream flow objectives.

Exceeding the spring and winter seasonal flow volume objectives is acceptable. However, for the summer seasonal flow objective, the closer the alternative is to the flow objective the better, but falling below the flow objective is considered detrimental.

The No Action Alternative seasonal flow volumes for the Ellensburg (Umtanum gage) and Wapato (Parker gage) reaches were compared to the flow volume objectives for an average water year. Table 2.11 presents the differences in the volumes for the No Action Alternative compared to the flow objectives, with the difference reported as a percent of the flow objective. That is, if the No Action Alternative meets the flow objective, the percent difference is 0 percent; if it doubles the flow objective volume, the difference is 100 percent. Modeled flows in these two reaches are shown in figure 2.2 and figure 2.3. In both reaches, the No Action Alternative annual stream runoff pattern is essentially identical to current flow conditions for the spring, summer, and winter seasons.

Table 2.11 Differences between the No Action Alternative flows and flow volume objectives by season

Gage location	No Action Alternative Spring	No Action Alternative Summer	No Action Alternative Winter
Umtanum	-9%	+103%	0%
Parker	-7%	-40%	0%

Relative to the flow volume objective, No Action Alternative flows essentially meet the flow objectives in the Ellensburg reach (Umtanum gage) in the spring and winter, but they are double the flow objective in the summer. In the Wapato reach (Parker gage), No Action Alternative flows are about 40 percent below the flow objectives in the summer and meet the flow objectives in the winter. In both reaches, the No Action Alternative annual stream runoff pattern is essentially identical to current flow conditions for all seasons (figure 2.2 and figure 2.3). (Hydrographs for four other key reaches are shown in figures 2.4, 2.5, 2.6, and 2.7.)

The three Joint Alternatives were compared to the No Action Alternative for the Ellensburg (Umtanum gage) and Wapato (Parker gage) reaches. The differences between the Joint Alternative and the No Action Alternative are presented in table 2.12.

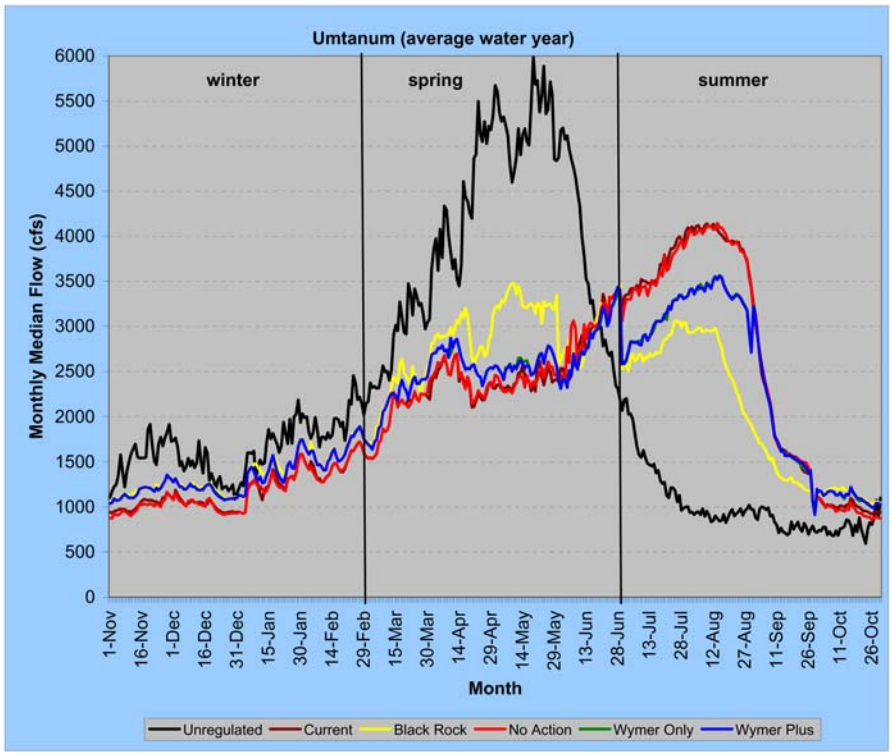


Figure 2.2 Median daily flow hydrograph for the Umtanum stream gage (RM 140) for the period of record 1981-2005.

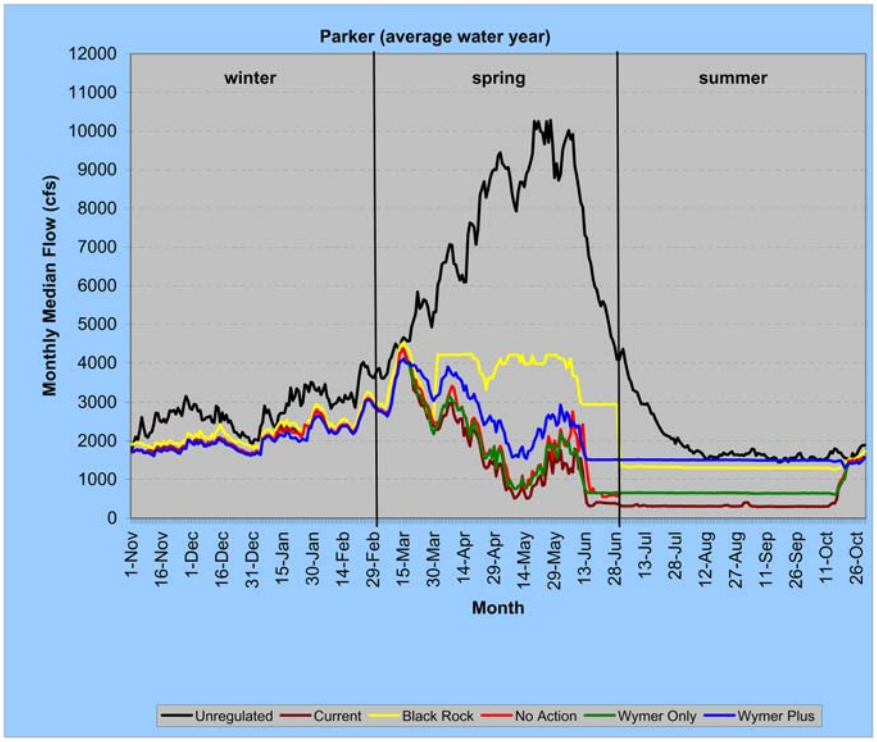


Figure 2.3 Median daily flow hydrograph for the Parker stream gage (RM 104) for the period of record 1981-2005.

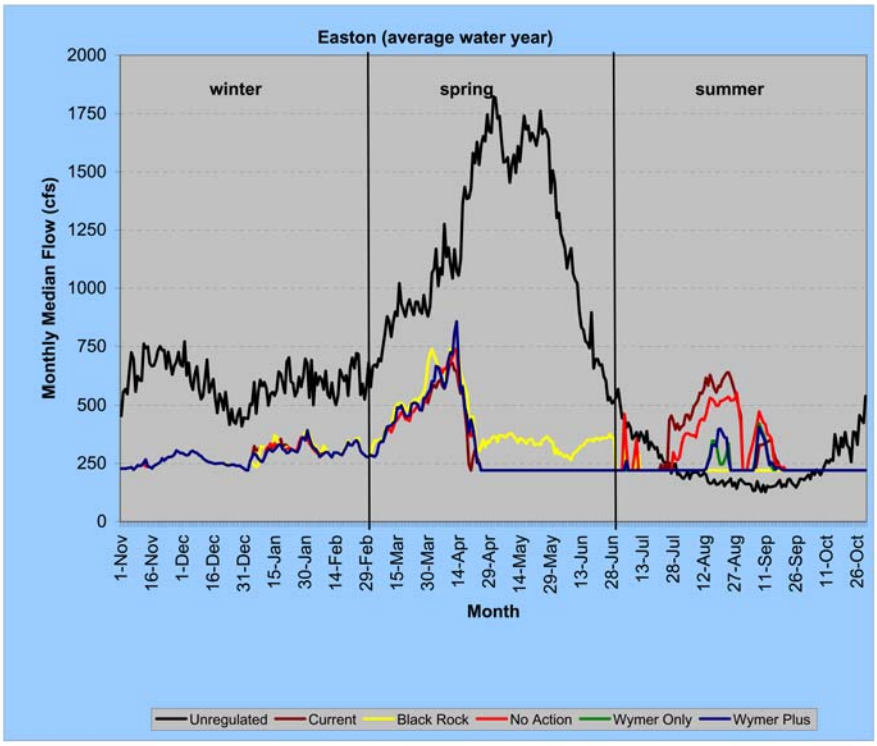


Figure 2.4 Median daily flow hydrograph for the Easton stream gage (RM 202) for the period of record 1981-2005.

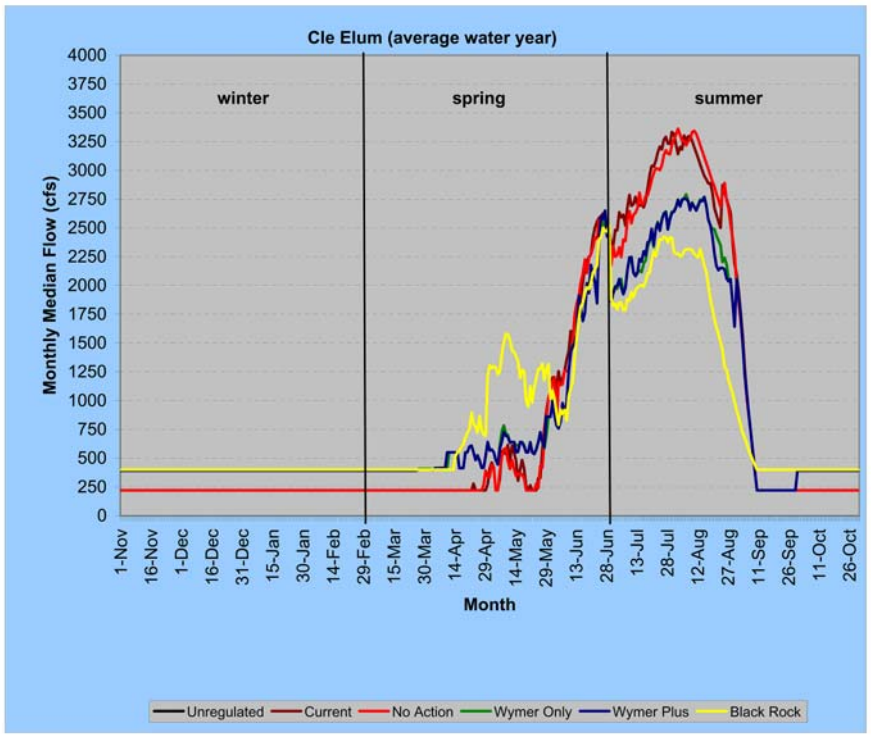


Figure 2.5. Median daily flow hydrograph for the Cle Elum stream gage on the Cle Elum River below dam (RM 7.9) for the period of record 1981-2005.

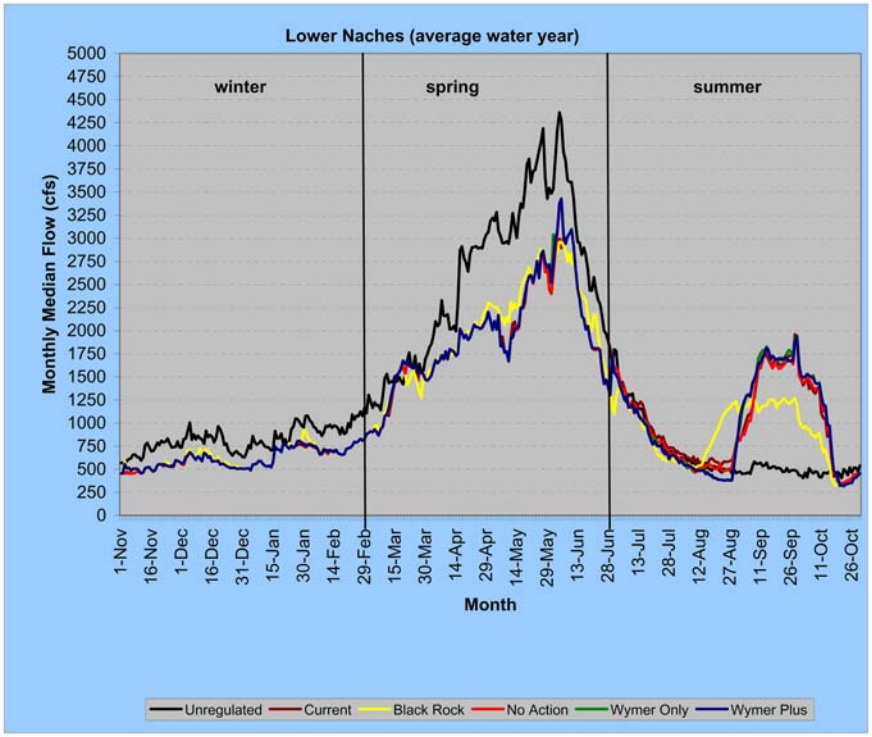


Figure 2.6. Median daily flow hydrograph for the Lower Naches stream gage near Yakima (RM 17) for the period of record 1981-2005.

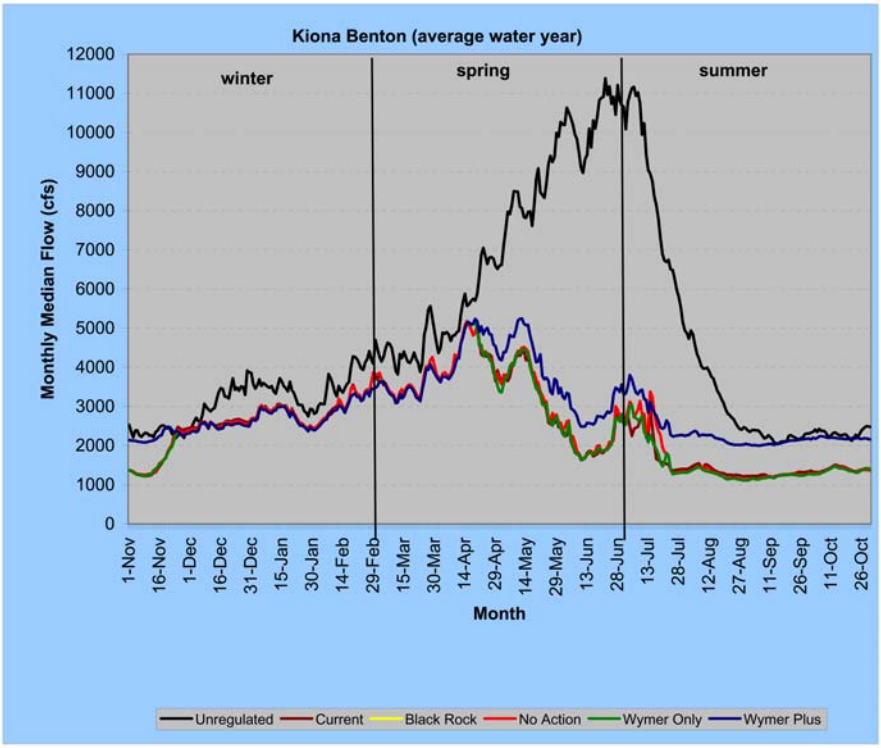


Figure 2.7 Median daily flow hydrograph for the Kiona gage (RM 29) for the period of record 1981-2005.

Table 2.12 Differences in flow between Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives and No Action Alternative

	Spring			Summer			Winter		
Gage location	**Black Rock Alternative**	**Wymer Dam and Reservoir Alternative**	**Wymer Dam Plus Yakima River Pump Exchange Alternative**	**Black Rock Alternative**	**Wymer Dam and Reservoir Alternative**	**Wymer Dam Plus Yakima River Pump Exchange Alternative**	**Black Rock Alternative**	**Wymer Dam and Reservoir Alternative**	**Wymer Dam Plus Yakima River Pump Exchange Alternative**
Umtanum	10%	2%	2%	-22%	-10%	-11%	14%	10%	10%
Parker	39%	-3%	19%	65%	-1%	98%	8%	-1%	-1%

Dry Year Proratable Irrigation Supply Provided

Under the current operation, there are 6 years in the 25-year period of record (1981-2005) when the proration level is less than 70 percent. In 5 of these years, the proration level is better under the No Action Alternative; however, in the third year (1994) of the 3-year dry cycle of 1992-94, it is not (table 2.13). Some improvement occurs in the irrigation delivery shortage indicating that, in a dry year, more water is delivered to the farm turnout as the result of the water conservation measures included in the No Action Alternative.

Table 2.13 shows the proration level for the 6 dry years for the 25-year period of record (1981-2005) under the No Action Alternative compared to the current operation.

Table 2.13 Irrigation proration level for the No Action Alternative compared to the current operation for the 25-year period of record (1981-2005)

Water year	Proration level (percent)		
	Current operation	No Action Alternative	Difference
1987	64	69	+5
1992	68	70	+2
1993	56	57	+1
1994	28	27	[1]-1
2001	40	44	+4
2005	38	45	+7

[1] The irrigation water supply benefits of the conservation actions are realized in 1992 and 1993 as shown by the improved irrigation proration levels of the No Action Alternative. By 1994, the third year of the dry cycle, the difference in the proration level of the No Action Alternative and the current operation is negligible and is due to rounding of the Yak-RW model results.

Municipal Supply Provided

Under the No Action Alternative, the municipal water supply need would be satisfied by the communities' acquisition of water rights from existing water right holders.

2.3.4 Economic and Financial Analysis

No economic and financial analysis was performed for the No Action Alternative because an incremental analysis was used. In an incremental analysis, economic effects of the proposed Joint Alternative are measured in terms of changes from the No Action Alternative. Any construction costs for water conservation measures included in the No Action Alternative would be provided by the YRBWEP program or other sources.

2.3.5 Actions and Permits

Reclamation would obtain all necessary permits to implement the No Action Alternative before any conservation plans are implemented, in accordance with local, State, Federal, and Tribal laws. See chapter 1, Section 1.4, "Related Permits, Actions, and Laws."

2.4 Black Rock Alternative

2.4.1 Description

2.4.1.1 Physical Features

The Black Rock Alternative involves a diversion and partial exchange of Columbia River water for Yakima Project water currently diverted by the Roza and Sunnyside Divisions (Roza and Sunnyside) of the Yakima Project for irrigation. Roza and Sunnyside have been identified as potential willing water exchange participants. See foldout map.

Columbia River water pumped from Priest Rapids Lake would be stored in a Black Rock reservoir to be constructed in the Black Rock Valley. Stored water would be conveyed by an outflow conveyance system extending from the reservoir to the lower Yakima Valley and delivered to Roza Canal at MP 22.6 for Roza's downstream users and to Sunnyside Canal at MP 3.83 for Sunnyside upstream and downstream users. Most of the Yakima Project water currently diverted from the Yakima River by these two water exchange participants would not be diverted, and the freed-up water would instead be used to meet the Storage Study goals.

A 2,400-foot intake channel on Priest Rapids Lake with fish screens that meet NOAA and Washington State criteria would carry water to the Priest Rapids pumping plant. The pumping plant would house three 500-cfs pump units and two 1,000-cfs pump units (total 3,500 cfs) that would withdraw water from Priest Rapids Lake at about elevation 488 feet and lift it to elevation 1,440 feet. Conveyance from the Priest Rapids pumping plant to the new Black Rock reservoir would be via a 6.5-mile, 17-foot-diameter tunnel with a capacity of 3,500 cfs. A 22-foot vertical surge shaft would be located about ¾-mile up the tunnel from the pumping plant. A 6-mile-long, 500-kV transmission line would be constructed from the Midway Substation to the Priest Rapids pumping plant. Black Rock reservoir would be impounded with a central core rockfill dam 525 feet high above original ground (structural height, 755 feet) and 6,695 feet long. The reservoir would have an active storage of 1,300,000 acre-feet. It would be 10 miles long at full pool (1,775 feet elevation) and a mile across at its widest point.

Pumping from Priest Rapids Lake would occur anytime Columbia River water is available in excess of current instream target flows and storage space is available

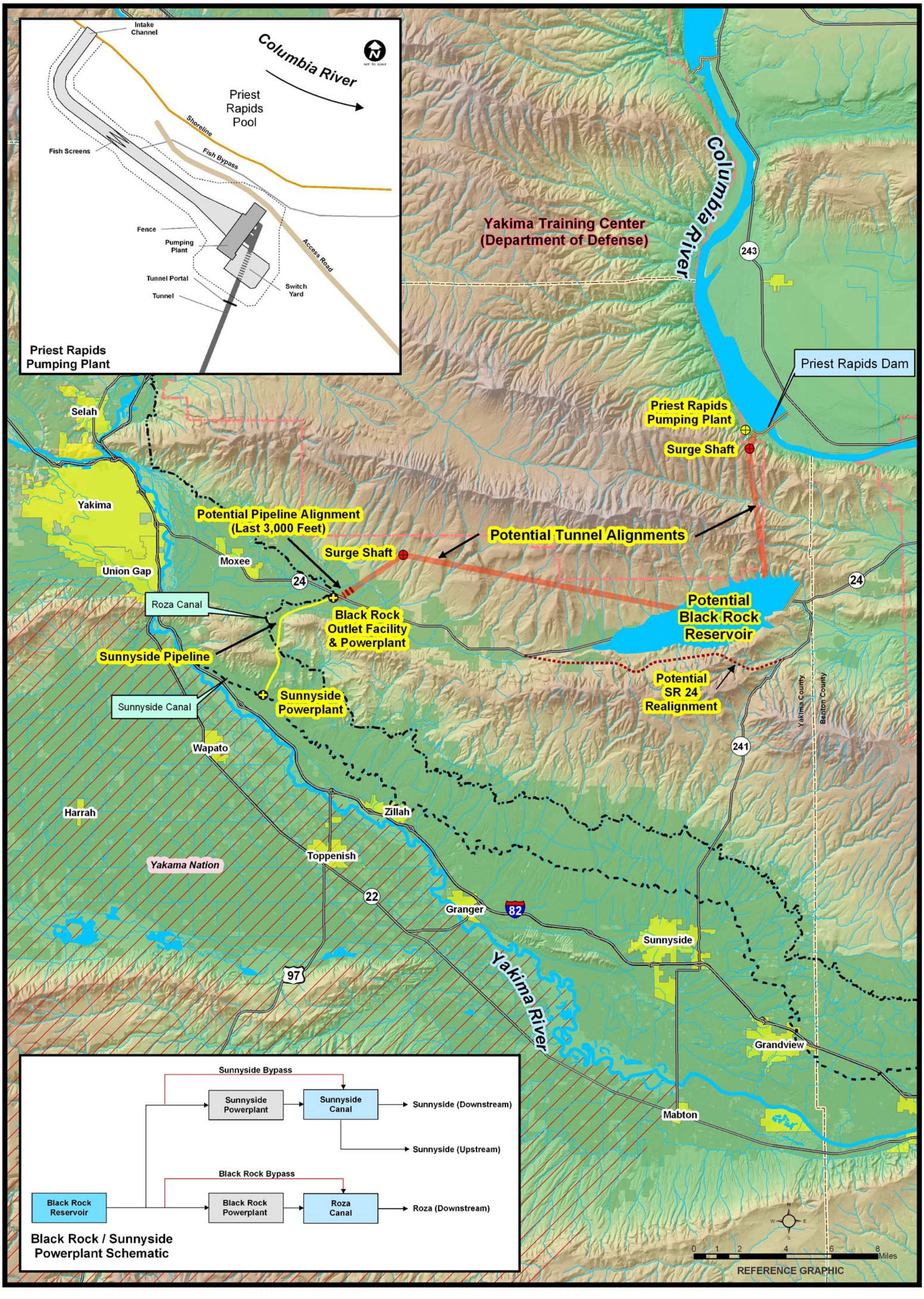
in Black Rock reservoir, with the exception of July and August, when no Columbia River withdrawals would occur. State law prohibits withdrawals from the Columbia River in July and August unless the withdrawals can be replaced by other water. The operation objective is to annually fill Black Rock reservoir to full capacity to assure the water exchange can be effected.

Throughout this document, the availability of water for pumping into Black Rock reservoir is characterized as a monthly average quantity because its measure is based on the BPA's HYDSIM simulation of current monthly operations. Within this monthly modeling capability, the available water for pumping is limited by the smallest of the excess of flows at Bonneville Dam, McNary Dam, and Priest Rapids above their respective ESA seasonal flow targets. These ESA targets are presented in Section 2.4.2, "Operations." However, in actual operations, the issue of availability of water for pumping is contemplated to be resolved on a daily or weekly basis with parties to ESA in-season forums.

Stored water would be released through the reservoir's single-level screen intake at elevation 1,500 feet to a 17-foot-diameter tunnel with a capacity of 2,500 cfs on the northern side of the reservoir. The tunnel would parallel Yakima Ridge for about 14 miles to a 40-foot-diameter surge shaft. At that point, the tunnel would turn to the southwest and extend about 3 miles to the north side of SR-24. From there, water would be conveyed in a 3,000-foot-long, 17-foot-diameter buried steel pipeline that would cross under SR-24 to MP 22.6 of the Roza Canal. At this point, the pipeline would split, with 885 cfs carried to the 23-MW Black Rock powerplant and into the Roza Canal and up to 1,200 cfs carried in a 12-foot-diameter buried steel pipeline to the Sunnyside Canal.

The Sunnyside pipeline would extend from the vicinity of MP 22.6 of the Roza Canal about 6.5 miles over Konnowac Pass to the Sunnyside Canal at MP 3.83. At this point, most of the water would be discharged through a new Sunnyside powerplant (29.5 megawatts) into the Sunnyside Canal for downstream delivery. However, a small number of Sunnyside water users upstream of this point would receive delivery of 17 to 20 cfs by a pumping plant and a buried PVC pipeline about 3.2 miles long, located on the right embankment of the Sunnyside Canal.

Roza would continue to obtain its water supply from the Yakima River by diverting at the Roza Diversion Dam (RM 127.9.) to MP 22.6. This diversion would continue to provide flows (up to 1,075 cfs) for the operation of the existing Roza Powerplant and the approximately 180-200 cfs required for irrigation by Roza of lands upstream of MP 22.6. Sunnyside would continue to receive some water from the Yakima River in wet water years, as discussed in the operations criteria. In addition, both Roza and Sunnyside would continue to divert mid-March to late-March "flood flow waters" for "priming" their canal systems prior to the beginning of the irrigation season.



Black Rock Alternative

This reference graphic is intended for informational purposes only. It is meant to assist in feature location relative to other landmarks. Geographic features have been intentionally simplified in an attempt to provide a more readable product. No representation is made as to accuracy of this document. Current as of January 2008.

In addition, Reclamation would provide minimum basic recreation facilities at the reservoir (such as day-use only), resource protection and public safety, parking lots, boat ramps (existing SR-24), vehicular access of drawdown shoreline, and portable utilities. Additional recreation facilities could be provided by others.

Features to Mitigate for Reservoir Seepage

Modeling Groundwater Hydrologic Impacts of the Black Rock Reservoir (Reclamation, 2007d) indicated seepage could occur, so the following features are being considered to mitigate reservoir seepage. For a more detailed discussion of mitigation for reservoir seepage, see the "Water Quality" section in chapter 4.

Features to mitigate seepage from the reservoir would likely include a vertical cutoff blanketing wall, drainage tunnel, and downstream well fields.

Blanketing would be located upstream of the dam on the south reservoir rim and would consist of an impervious layer (such as impervious soils, shotcrete, or geomembrane). Upstream blankets lengthen the seepage path by forcing seepage to enter the underlying formations further upstream of the dam.

The key portion of the cutoff wall/grout curtain would be located on the south abutment of the dam and would intercept seepage up to 400 feet deep. The structure would be underground.

The drainage tunnel collects seepage through the south dam abutment with a series of tunnels and drain holes to transport seepage away from the area. Structures would be underground.

The well fields would withdraw seepage water out of the ground. Numerous pumped wells would be installed in a grid in the downstream sediments, connected to a manifold system that would collect seepage and convey it from the site in a pipeline or lined canal. The wells would be several hundred feet deep. There would be a fenced area for the well field that could comprise several acres along downstream portions of the Dry Creek and Cold Creek drainages.

Construction Activities

A cellular cofferdam would be constructed on Priest Rapids Lake to allow for dewatering of the area around the gated intake structure.

An access road would be constructed on the right bank of the Columbia River off SR-24 approximately 10 miles to the Priest Rapids pumping plant location. It would be located along an abandoned railroad track.

Material from tunnel-boring operations would be hauled to the damsite to be used as necessary in the embankment. Other borrow and stockpile areas would be located in the reservoir area.

SR-24 would be relocated approximately 12 miles south of the Black Rock reservoir (frontispiece map). Relocating two transmission lines and replacing a buried fiber optic line along SR-24 would also be necessary.

Operation and Maintenance Activities

Routine maintenance at the intake for Priest Rapids pumping plant would include daily cleaning of debris off the trashrack and fish screens. At the pumping plant, minor painting, facility cleaning, and lubrication would be required on a monthly and annual basis. Major maintenance and disassembly of pumps would take place on a 5-year cycle. Replacement of pumps and associated equipment would be on a 20-year cycle.

The dam would require periodic maintenance, inspection, monitoring, and debris removal.

Powerplants would need routine maintenance. Replacement or winding of generators and turbine overhauls would be on a 20-year cycle.

Tunnels and surge shafts would require minor coating and concrete repair periodically.

Typical Annual Operation Scenario

Black Rock reservoir releases would begin in April with the start of the Yakima Project irrigation season and continue through late October. During the months of April through June, reservoir depletions could, to some extent, be replaced by pumping if Columbia River flows were available in excess of the instream target flows. As such, reservoir drawdown during this period would be relatively slow. However, during the peak demand months of July and August, when the release volume is generally about 110,000 acre-feet per month, pumping is not permitted from the Columbia River, and the reservoir contents would be depleted rapidly without subsequent refill. The maximum volume that can be pumped by the Priest Rapids pumping plant in any month is about 215,000 acre-feet, and maximum pumping would generally occur in September and October to refill this depleted storage space. Figure 2.8 shows daily reservoir elevations for the typical annual operation.

In years when the maximum water exchange occurs, Black Rock reservoir would release a total of about 600,000 acre-feet annually.[3] Reservoir contents would generally be at maximum pool prior to the beginning of the irrigation season and at minimum pool at the end of August.

[3] These are the water years when the April 1 TWSA is less than 3.2 maf.

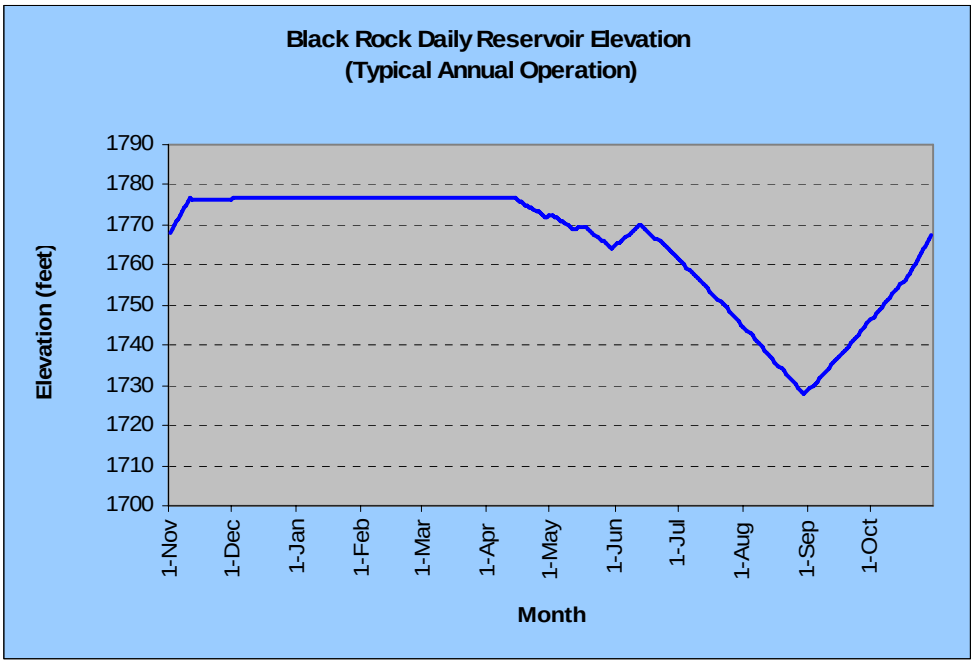


Figure 2.8 Black Rock daily reservoir elevations for the typical annual operation.

Table 2.14 presents this configuration of the Black Rock Alternative.

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

The total project cost for the Black Rock Alternative (table 2.15) was estimated at $4.5 billion (April 2007 prices).

Table 2.16 presents annual operation, maintenance, replacement, and pumping energy (OMR&E) costs.

2.4.2 Operations

2.4.2.1 Columbia River Water Supply for Black Rock Reservoir

The Federal Columbia River Power System (FCRPS) 2004 Biological Opinion (BIOP) prepared by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NOAA Fisheries) establishes seasonal flow targets downstream from Priest Rapids, McNary, and Bonneville Dams.[4] Target flows facilitate spawning and downstream passage of juveniles, and accommodate returning adult salmon and steelhead. Flow objectives to protect fall Chinook

[4] These targets are identical to those contained in the December 2000 BIOP.

Table 2.14 Summary of major facilities for the Black Rock Alternative

Facilities	Black Rock 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 pumping plant	
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 (17-foot-diameter, 6.2 miles long)
Black Rock dam	
Location	Black Rock Valley (see foldout map)
Central core rockfill embankment dam	
Crest elevation	1,785 feet
Structural height	755 feet
Crest width, length	40 feet, 6,695 feet
Spillway	None – low-level outlet only
Low-level outlet works through dam	Upstream steel-lined concrete conduit, downstream buried steel pipe, and two jet-flow gates in south dam abutment
Black Rock reservoir	
Maximum water surface elevation	1,778 feet
Active storage capacity	1,300,000 acre-feet
Elevation top of active storage, surface area	1,775 feet, 8,640 acres
Inactive storage capacity	157,610 acre-feet
Elevation top of inactive storage	1,500 feet
Length	10 miles long at 1,775 feet elevation
SR-24 relocation	12 miles 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 (17-foot-diameter)
Black Rock outlet facility/powerplant and bypass	
Location	Adjacent to Roza Canal MP 22.6
Powerplant capacity	900-cfs Black Rock powerplant – 23 MW
Sunnyside powerplant and bypass	
Location	Adjacent to Sunnyside Canal MP 3.83
Powerplant capacity	900 cfs – 15 to 29.5 MW

Table 2.15 Total project costs for Black Rock Alternative

Feature	Costs
Priest Rapids fish screen and intake, pumping plant, and inflow conveyance (all tunnel)	$504,865,800
Black Rock dam—central core rockfill embankment	$890,935,200
Highway and utility relocations	$71,881,100
Black Rock reservoir outlet works, outlet structure, and outflow conveyance to Roza Canal	$463,042,600
Black Rock outlet facility—1,500-cfs powerplant	$120,704,500
Sunnyside powerplant	$37,100,000
Delivery systems to Roza, Sunnyside, and modification to existing facilities	$164,880,000
Subtotal of pay items	$2,253,409,200
Total mobilization costs (5% +/-)	$115,000,000
Subtotal with mobilization	$2,368,409,200
Total unlisted items (10% +/-)	$231,590,800
Construction contract cost	$2,600,000,000
Total contingencies (25% +/-)	$700,000,000
Total field cost	$3,300,000,000
Noncontract costs (35% +/-)	$1,200,000,000
Total project cost[1]	$4,500,000,000

[1]Total project cost does not include interest during construction.

Table 2.16 Annual operation, maintenance, replacement, and pumping energy costs

Item	Black Rock reservoir pump only
Operation, maintenance, and replacement costs	$10,170,000
Energy costs for pumping	$50,000,000
Total	$60,170,000

spawning, incubation, and rearing downstream from Priest Rapids Dam at Vernita Bar are also in place. Table 2.17 and figure 2.9 show these seasonal targets.

The water supply for Black Rock reservoir is obtained by pumping from the Priest Rapids Lake when mainstem Columbia River flows are greater than the seasonal instream target flows. In addition, the State of Washington, as a part of its Columbia River Basin Water Management Program, has indicated that withdrawal of water from the Columbia River for out-of-stream uses in July and August is prohibited (unless appropriately mitigated).

Table 2.18 provides the average monthly volumes of water in the vicinity of Priest Rapids Dam after all the instream target flow assumptions have been met downstream. These volumes may be available for diversion to Black Rock reservoir under water supply conditions similar to those of water years 1981-2005.

Table 2.17 Seasonal flow targets and planning dates for the mainstem Columbia River

Columbia River location	Fall through spring targets		Summer targets	
	Dates	Flow (cfs)	Dates	Flow (cfs)
At Priest Rapids Dam - transport target[1]	4/10 – 6/30	135,000	NA	NA
At Priest Rapids Dam - spawning target[2]	10/10 – 6/30	55,000	NA	NA
At McNary Dam - transport target[1]	4/10 – 6/30	[3]220,000 – 260,000	7/01 – 8/31	200,000
At Bonneville Dam - spawning target[1]	11/1 – 4/30	[4]125,000 – 160,000	NA	NA

[1] As per NOAA – Fisheries, 2000 for listed species.

[2] Pertains to nonlisted species (Chinook salmon) as per Vernita Bar Agreement; would govern in October; after 4/10, the 135,000-cfs minimum governs.

[3] Objective varies according to water volume forecasts.

[4] Objective varies based on actual and forecasted water conditions.

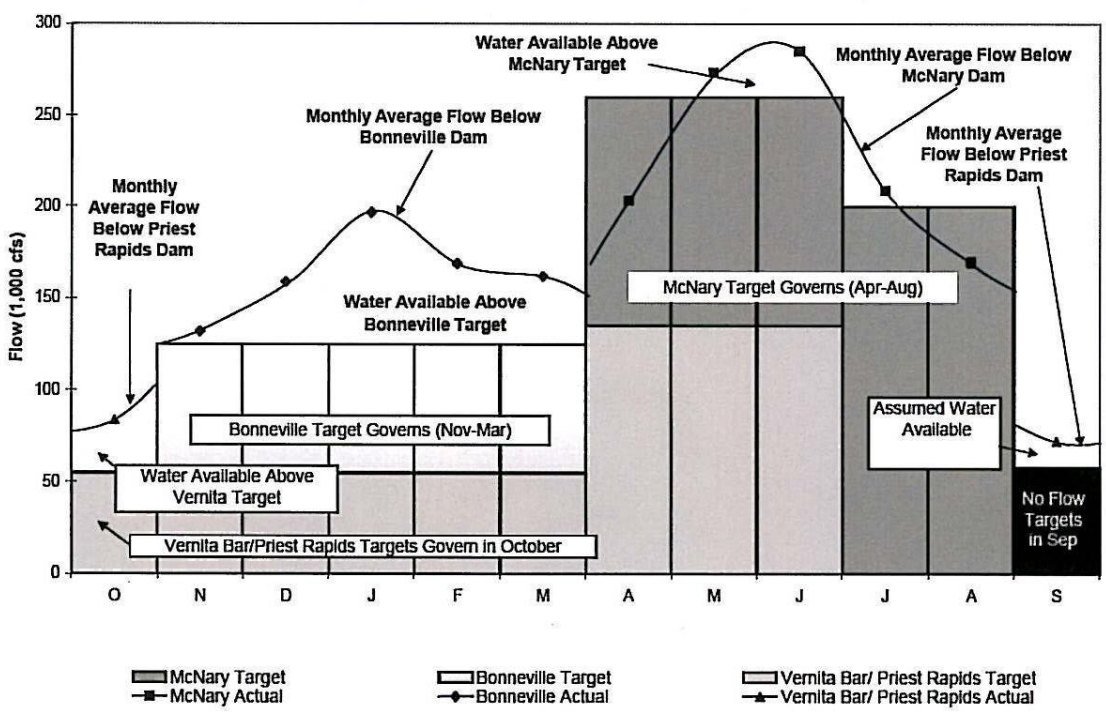


Figure 2.9 Flow targets on the Columbia River and water availability above flow targets.

Table 2.18 Columbia River volumes available for pumping (acre-feet) for the 25-year period of record (1981-2005)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	0	3,471,000	7,138,000	3,483,000	1,184,000	0	0	5,199,000	No pumping per Columbia River Water Basin Management Program	No pumping per Columbia River Water Basin Management Program	1,413,000	1,674,000	23,562,000
1982	0	1,354,000	5,289,000	3,658,000	4,584,000	311,000	3,983,000	9,600,990			2,625,000	1,886,000	33,290,990
1983	0	2,112,000	5,911,000	2,314,000	5,548,000	52,5000	2,567,000	207,000			1,346,000	1,016,000	21,546,000
1984	2,336,000	1,356,000	5,746,000	1,143,000	2,503,000	371,500	0	2,170,000			938,000	1,063,000	17,626,500
1985	268,000	1,057,000	4,440,000	117,000	914,000	290,500	1,395,000	0			332,000	1,40,8000	10,221,500
1986	190,000	0	4,585,000	1,467,000	4,553,000	1,048,500	0	666,000			330,000	911,000	13,750,500
1987	0	0	1,596,000	207,000	926,000	0	0	0			239,000	1,244,000	4,212,000
1988	0	0	0	0	0	0	0	0			1,067,000	1,400,000	2,467,000
1989	0	0	227,000	0	207,000	205,500	791,000	0			484,000	1,314,000	3,228,500
1990	0	599,000	5,324,000	2,772,000	1,647,000	749,000	0	2,261,000			939,000	1,329,000	15,620,000
1991	1,266,000	2,326,000	6,649,000	5,141,000	1,477,000	0	1,737,000	305,000			1,311,000	1,593,000	21,805,000
1992	0	0	0	1,618,000	46,000	0	0	0			481,000	1,649,000	3,794,000
1993	0	0	0	0	0	0	0	0			637,000	1,475,000	2,112,000
1994	0	0	399,000	0	0	0	0	0			578,000	1,481,000	2,458,000
1995	0	0	576,000	2,466,000	3,262,000	156,000	998,000	0			1,577,000	1,774,000	10,809,000
1996	2,275,000	6,778,000	6,023,000	7,962,000	6,077,000	1,583,500	4,843,000	3,723,000			1,233,000	1,500,000	41,997,500
1997	0	2,033,000	6,221,000	6,792,000	5,145,000	1,541,000	10,186,990	11,865,990			2,745,000	4,342,000	50,871,980
1998	1,277,000	1,039,000	5,063,000	1,574,000	1,415,000	0	131,000	4,259,000			442,000	4,113,000	19,313,000
1999	1,720,000	3,145,000	4,376,000	4,330,000	4,320,000	735,500	1,290,000	3,407,000			3,492,000	1,230,000	28,045,500
2000	4,000	2,659,000	4,896,000	3,763,000	3,084,000	1,042,000	0	0			1,938,000	2,469,000	19,855,000
2001	1,807,000	4,987,000	469,000	308,000	36,000	0	0	0			818,000	1,487,000	9,912,000
2002	403,000	1,241,000	1,133,000	1,319,000	444,000	436,000	0	3,839,000			1,282,000	562,000	10,659,000
2003	0	0	0	822,000	2,091,000	424,500	0	0			657,000	1,691,000	5,685,500
2004	110,000	0	1,081,000	789,000	449,000	0	0	0			1,359,000	1,620,000	5,408,000
2005	50,000	868,000	1,390,000	1,043,000	438,000	0	0	0			796,000	1,774,000	6,359,000
Avg	468,240	1,401,000	3,141,280	2,123,520	2,014,000	376,780	1,116,880	1,900,119			1,162,360	1,680,200	15,384,379
Min	0	0	0	0	0	0	0	0			239,000	562,000	2,112,000
Max	2,336,000	6,778,000	7,138,000	7,962,000	6,077,000	1,583,500	10,186,990	11,865,990			3,492,000	4,342,000	50,871,980

Pumping to Black Rock Reservoir

Table 2.19 shows the monthly pumping of the portion of the available Columbia River water needed to replenish Black Rock reservoir contents as the result of annual depletions associated with deliveries to the water exchange participants and reservoir evaporation and seepage losses. The operation objective is to maintain Black Rock reservoir contents at full capacity (1.3 million acre-feet) as much as possible by pumping when Columbia River water is available and there is space available in Black Rock reservoir to store the water.

Water Releases

Water is released from Black Rock reservoir beginning with the irrigation season in April of each year. Water is transported by the Black Rock outflow conveyance system to a bifurcation at the Roza Canal MP 22.6 near the SR-24 crossing where the following deliveries are made:

- Up to 890 cfs to the Roza Canal primarily for delivery to downstream Roza lands[5]

- Up to 1,260 cfs to a new buried steel pipeline extending to MP 3.83 of the Sunnyside Canal primarily for delivery to downstream Sunnyside lands[6]

All of Roza's irrigation needs upstream of Roza Canal MP 22.6 continue to be supplied by Yakima River diversions at the Roza Diversion Dam, except for those at pumping plant #3 (footnote 6). Yakima River diversions are also made for the operation of the Roza powerplant.

In wet water years when the Yakima Project April 1 TWSA estimate is greater than 3.2 million acre-feet, Yakima River flows in excess of the Black Rock Alternative operation criteria for flow objectives at the Parker gage (see table 2.23 shown later in this chapter) can be diverted from the Yakima River at Sunnyside Diversion Dam. In such years, any residual water supply necessary to meet Sunnyside's irrigation demands is delivered from Black Rock reservoir. When the TWSA is less than 3.2 million acre-feet, all of Sunnyside's irrigation needs would be provided from Black Rock reservoir.[7]

Table 2.20 provides an example of the sources of water supply when the maximum and minimum Sunnyside water exchange occurs in nonprorated water years.

---

[5] About 35 cfs would be used upstream at Roza Pumping Plant #3 (MP 22.5).

[6] About 20 cfs would be delivered upstream by a new pumping plant and a buried PVC pipeline.

[7] Of the 25-year period of hydrologic record, excess flows were available in 10 years. In 9 years the excess flows were only adequate to meet some of the irrigation needs for one month or more. In 1997 when the April 1 TWSA was 4.5 million acre-feet these flows could fully meet Sunnyside's April and May irrigation needs.

Table 2.19 Black Rock pumping volumes (acre-feet) for the 25-year period of record (1981-2005) (results from the Yak-RW Model)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
1981	0	132,420	6,240	6,020	7,660	0	0	208,260	No pumping per Columbia River Basin Water Management Program	No pumping per Columbia River Basin Water Management Program	208,260	215,210	784,070
1982	0	21,310	6,240	6,020	7,660	30,520	88,760	68,390			208,260	148,130	585,290
1983	0	12,730	6,240	6,020	7,660	21,420	86,800	82,050			208,260	161,170	592,350
1984	6,480	6,250	6,240	6,250	7,720	56,320	0	178,250			208,260	149,160	624,930
1985	6,460	6,240	6,240	6,020	7,660	46,020	120,880	0			208,260	215,210	622,990
1986	81,950	0	12,490	6,020	7,660	69,100	0	207,460			208,260	182,150	775,090
1987	0	0	18,970	6,020	7,660	0	0	0			208,260	215,210	456,120
1988	0	0	0	0	0	0	0	0			208,260	215,210	423,470
1989	0	0	215,210	0	207,000	134,010	97,820	0			208,260	215,210	1,077,510
1990	0	88,180	6,240	6,020	7,660	39,840	0	207,460			208,260	177,300	740,960
1991	6,480	6,250	6,240	6,020	7,660	0	166,810	109,930			208,260	182,150	699,800
1992	0	0	0	25,220	7,720	0	0	0			208,260	215,210	456,410
1993	0	0	0	0	0	0	0	0			208,260	215,210	423,470
1994	0	0	215,210	0	0	0	0	0			208,260	215,210	638,680
1995	0	0	215,210	194,380	62,160	30,520	136,360	0			208,260	215,210	1,062,100
1996	81,960	6,250	6,240	6,250	7,720	33,320	93,500	108,280			208,260	179,120	730,900
1997	0	12,700	6,240	6,020	7,660	33,290	45,530	59,090			208,260	99,260	478,050
1998	6,480	6,250	6,240	6,020	7,660	0	110,950	87,380			208,260	179,370	618,610
1999	6,480	6,250	6,240	6,020	7,660	29,100	86,100	58,470			208,260	94,070	508,650
2000	4,000	8,730	6,240	6,250	7,720	15,120	0	0			208,260	215,210	471,530
2001	169,100	6,240	6,240	6,020	7,660	0	0	0			208,260	215,210	618,730
2002	189,620	6,250	6,240	6,020	7,660	21,500	0	184,050			208,260	149,860	779,460
2003	0	0	0	24,990	7,660	30,520	0	0			208,260	215,210	486,640
2004	110,000	0	118,520	6,250	7,720	0	0	0			208,260	215,210	665,960
2005	50,000	202,160	6,240	6,020	7,660	0	0	0			208,260	215,210	695,550
Avg	28,760	21,128	35,568	14,155	16,906	23,624	41,340	62,363			208,260	188,587	640,693
Min	0	0	0	0	0	0	0	0			208,260	94,070	423,470
Max	189,620	202,160	215,210	194,380	207,000	134,010	166,810	208,260			208,260	215,210	1,077,510

Table 2.20 Sources of water supply of exchange participants for the Black Rock Alternative for the 25-year period of record (1981-2005) (results from the Yak-RW Model using nonprorated water years 1997 and 2004 as illustrations)

	Yakima River	Black Rock reservoir	Total
	(acre-feet rounded for illustration)		
Water year 1997			
Roza Division	65,000	235,000	300,000
Sunnyside Division (with minimum from Black Rock)	222,000	138,000	360,000
Total	287,000	373,000	660,000
Water year 2004			
Roza Division	65,000	235,000	300,000
Sunnyside Division (with maximum from Black Rock)	0	360,000	360,000
Total	65,000	595,000	660,000

Reservoir Contents

Black Rock reservoir contents are at the maximum level not later than the end of March prior to the start of the Yakima Project irrigation season. Minimum reservoir contents occur at the end of August because of the restriction on July and August pumping from the Columbia River. Maximum pumping to refill Black Rock storage space generally occurs in September and October.

End-of-month Black Rock reservoir contents (maximum, minimum, average, and average percent of full) for the 25-year period of record are shown in table 2.21.

Table 2.21 Black Rock reservoir end-of-month contents (thousands acre-feet) for the 25-year period of record (1981-2005) based on the water delivery criteria (results from Yak-RW Model)

	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
Maximum	1,300	1,300	1,300	1,300	1,300	1,299	1,298	1,298	1,240	1,140	1,256	1,300
Minimum	838	832	1,041	1,035	1,045	974	879	772	659	541	662	845
Average	1,206	1,221	1,250	1,258	1,267	1,229	1,182	1,146	1,036	919	1,037	1,181
Average % full	93	94	96	97	97	95	91	88	80	71	80	91

Water years 1992-1994 are the lowest water supply years for both the Columbia River Basin and the Yakima River basin. Table 2.22 shows the monthly volumes of Columbia River water available for pumping, the volumes pumped, and the Black Rock reservoir end-of-month contents for the 3 dry years of 1992-1994, and the year preceding (1991) and following (1995) this period.

Table 2.22 Columbia River water available, water pumped to Black Rock reservoir, and Black Rock reservoir end-of-month reservoir contents (water years 1991-1995)

Water year	Monthly water volumes available for pumping from the Columbia River in the vicinity of Priest Rapids Dam (maf)											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1991	1.266	2.326	6.649	5.141	1.477	0	1.737	.305	0	0	1.311	1.593
1992	0	0	0	1.618	0.46	0	0	0	0	0	.481	1.649
1993	0	0	0	0	0	0	0	0	0	0	.637	1.475
1994	0	0	.399	0	0	0	0	0	0	0	.578	1.481
1995	0	0	.576	2.466	3.262	.156	.998	0	0	0	1.577	1.774

Water year	Monthly water volumes pumped to Black Rock reservoir from the Columbia River in the vicinity of Priest Rapids Dam (results from Yak-RW Model [maf])											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1991	.006	.006	.006	.006	.007	0	.167	.110	0	0	.208	.182
1992	0	0	0	.025	.007	0	0	0	0	0	.208	.215
1993	0	0	0	0	0	0	0	0	0	0	.208	.215
1994	0	0	.215	0	0	0	0	0	0	0	.208	.215
1995	0	0	.215	.194	.062	.030	.136	0	0	0	.208	.215

Water year	End-of-month reservoir contents (results from Yak-RW Model [maf])											
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1991	Full	Full	Full	Full	Full	1.228	1.297	1.296	1.175	1.055	1.171	Full
1992	1.293	1.287	1.281	Full	Full	1.228	1.131	1.022	.902	.785	.907	1.090
1993	1.083	1.077	1.071	1.065	1.057	.986	.889	.781	.667	.554	.679	.862
1994	.856	.850	1.059	1.053	1.045	.974	.879	.772	.661	.551	.677	.860
1995	.854	.848	1.057	1.245	Full	1.259	1.297	1.187	1.066	.946	1.062	1.224

2.4.2.2 Yakima Project Modifications to Operations

Under the Black Rock Alternative, filling of Yakima Project reservoirs is the same as under the current operation. However, in regard to reservoir releases, the changes discussed below would be made:

- From September through May, additional releases of about 185-200 cfs would be made from Cle Elum Reservoir to increase Cle Elum River flows from the current 200 cfs to about 400 cfs. The objective is to improve the aquatic habitat of the Cle Elum River and downstream. These additional flows will continue downstream to exit the Yakima River basin at the Columbia River confluence.

- To lessen the effect of the early September flip-flop operation, the transition period of decreasing Cle Elum Lake releases and increasing Rimrock Lake releases would be extended with the shift in releases from Cle Elum Lake to Rimrock Lake beginning on August 12 rather than

August 31. The completion of the reservoir release transition would remain at mid-September. Storage releases prior to August 12 and in the fall would also be modified to shift some of the release from the upper Yakima River reservoirs to the Naches River reservoirs.

- Enhanced instream flows at the Parker gage would occur. These enhanced flows are based on flow objectives suggested by the SSTWG shown in table 2.2. The criteria input into the Yak-RW model for operation of the Black Rock Alternative appears in table 2.23. The flow at the Parker gage when the April 1 TWSA estimate is 2.90 million acre-feet is similar to the flow objectives shown in table 2.2 for an average water supply year. These criteria require the release of stored water (or bypass of reservoir inflow that would have been stored) in the spring to considerably improve flows at the Parker gage beyond the unregulated flow of the No Action Alternative (figure 2.11 in section 2.9.1). This operation is made possible as the result of the summer exchange whereby a major portion of the stored water required is delivered to Roza and Sunnyside from Black Rock reservoir rather than from Yakima Project reservoirs.

Table 2.23 Operation criteria for flow objectives at the Parker gage

April 1 TWSA (maf)	Instream flow objectives (cfs)[1]						
	Apr	May	Jun	Jul	Aug	Sep	Oct
1.75 and less	300 all months						
1.80	1,500	2,000	1,000	700	300	300	300
2.00	2,000	3,000	1,700	1,000	500	500	500
2.65	2,400	3,000	1,900	1,200	1,100	1,100	1,100
2.90	2,700	3,500	2,700	1,300	1,300	1,300	1,300
3.20	4,200	4,200	4,100	1,400	1,300	1,300	1,300
5.00	4,200	4,200	4,100	1,400	1,300	1,300	1,300

[1] For the period of July through October, the flow at the Parker gage is the greater of the values shown or the Title XII target flow modified by the water conservation actions of the No Action Alternative.

2.4.2.3 Municipal Operations

Under all of the Joint Alternatives, the additional future municipal water supply of 82,000 acre-feet required by the year 2050 is modeled as a continuous flow withdrawal at selected diversion points in various reaches of the Yakima River. These reaches and the volumes of water required for municipal demand were determined by the projected population growth for those parts of the Yakima River basin. These volumes were distributed evenly throughout the year. From November through June, the demand was assumed to be met by natural flows or return flows and did not require releases from storage. However, beginning with the storage control period (generally July 1) and continuing through October 31, the demand upstream of the Parker gage was provided from storage releases (table 2.24).

Table 2.24 Reaches and volume of future municipal water supply

Subarea	Future additional municipal needs (acre-feet)	Water supply criteria
Upstream of the Parker gage		
Upper Yakima River	13,000	Storage releases during storage control and unregulated flows during the residual period
Middle Yakima and Naches Rivers	35,000	
Subtotal	48,000	
Downstream from the Parker gage		
Lower Yakima River	34,000	Unregulated flows
Subtotal	34,000	
Total	82,000	

The additional future municipal water demand (year 2050) is estimated at 82,000 acre-feet. Of this amount, 48,000 acre-feet is estimated to be required upstream of the Parker gage (RM 103.7) and 34,000 acre-feet downstream. The downstream volume of 34,000 acre-feet is provided from unregulated flows for the entire 12-month period. The upstream volume of 48,000 acre-feet is also provided from unregulated flows until such time as the Yakima Project operation is declared to be on storage control (generally about July 1). This means that, for approximately one-third of the year (July-October), about 16,000 acre-feet of stored water is being released to meet the future municipal demands.

The municipal demand was treated as being proratable and was subject to proration in dry years in the same manner as the proratable irrigation supply. It is assumed that 50 percent of this municipal withdrawal returns as surface and subsurface flows during the winter and 50 percent during the summer.

2.4.2.4 Summary

Table 2.25 illustrates the primary criteria for the integrated Black Rock Alternative, Yakima Project.

2.4.3 Accomplishments

2.4.3.1 Water Provided by the Black Rock Alternative

The changes in the hydrologic indicators which occur with the Black Rock Alternative are shown in table 2.26. The changes outlined in the table show an improvement in the Yakima Project water supply over the 25-year period of record with implementation of the Black Rock Alternative. This improvement is primarily the result of the redistribution of the TWSA achieved by delivering water to Roza and Sunnyside from Black Rock reservoir in lieu of their current Yakima River diversions.

Table 2.25 Integrated Black Rock Alternative - Yakima Project operation criteria

End of prior calendar year		Current calendar year											
Prior irrigation season							Irrigation season						
Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
		Filling Black Rock reservoir										Filling Black Rock reservoir	
Additional Cle Elum Lake releases of 185-200 cfs													
							Yakima Project irrigation diversions						
							Black Rock reservoir exchange deliveries to Roza and Sunnyside						
							Enhanced Parker gage flows based on TWSA estimates						
Municipal water diversions													

Table 2.26 Changes in hydrologic indicators under the Black Rock Alternative compared to the No Action Alternative for the 25-year period of record (1981-2005) (Changes shown in absolute value and percent of change)

	April 1 TWSA	TWSA distribution			Apr-Sep Yakima River flow volume at mouth	Irrigation delivery volume shortage[1]	Irrigation proration level
		Apr-Sep Yakima flow volume at Parker gage	Apr-Sep diversion volume upstream of the Parker gage	Sep 30 reservoir contents change			
	(maf) and % change						Proration and % change
Average 1981-2005 (results from Yak-RW model)							
No Action Alternative	2.84	0.62	1.91	0.30	0.86	0.05	
Black Rock Alternative	2.90	0.98	1.47	0.43	1.22	0.02	
Change from No Action Alternative	0.06	0.36	-.44	0.13	0.36	-0.03	
% change	2%	58%	-23%	43%	42%	-60%	
Dry year 1994 (results from Yak-RW model)							
No Action Alternative	1.75	0.25	1.42	0.07	0.31	0.38	27%
Black Rock Alternative	1.94	0.58	1.32	0.04	0.65	0.12	70%
Change from No Action Alternative	0.19	0.33	-.10	-.03	0.34	-0.26	43%
% change	11%	132%	-7%	-43%	110%	-68%	

[1] The irrigation delivery volume shortage is the difference between a full delivery supply to the farm (represented by the median volume delivered for the period of record of 1981-2005) and the volume delivered in a specific year.

2.4.3.2 Instream Flows Provided

In general, the Black Rock Alternative would provide the greatest increase in spring flows at the Parker gage and the most reduction in summer flows in the upper Yakima River compared to the two Wymer Alternatives. Winter flows are higher for the Black Rock Alternative than for the Wymer Dam and Reservoir and No Action Alternatives, and similar to the Wymer Dam Plus Yakima River Pump Exchange Alternative. (See hydrographs in section 2.3.3.)

Ellensburg Reach (Umtanum gage)

The seasonal flow volumes are spring, 10 percent above the No Action Alternative; summer, 22 percent below the No Action Alternative; and winter, 14 percent above the flow objective (table 2.12).

The spring season stream runoff pattern for the Black Rock Alternative is the best of all the alternatives. The Black Rock Alternative also provides the greatest reduction in summer flows in the upper Yakima River (figure 2.2).

Wapato Reach (Parker gage)

The seasonal flow volumes are spring, 39 percent above the No Action Alternative; summer, 65 percent above the No Action Alternative; and winter, 8 percent above the objective, which is not considered detrimental (table 2.12).

The spring season stream runoff pattern for the Black Rock Alternative is the best of all the alternatives. Summer flows are less than under the Wymer Dam Plus Yakima River Pump Exchange Alternative.

2.4.3.3 Dry Year Proratable Irrigation Supply Provided

Table 2.27 presents the proration level of the 6 dry years for the 25-year period of record (1981-2005). The Black Rock Alternative meets the irrigation water supply goal in all years, including the third year (1994) of the 3-year dry cycle.

Table 2.27 Irrigation proration level for the Black Rock Alternative compared to the No Action Alternative

Water year	Irrigation proration level (percent)		
	No Action Alternative	Black Rock Alternative	Difference
1987	69	82	+13
1992	70	80	+10
1993	57	73	+16
1994	27	70	+43
2001	44	70	+26
2005	45	70	+25

The irrigation delivery shortage in a dry year such as 1994 of 260,000 acre-feet is also better under the Black Rock Alternative, indicating more water is being

delivered to the farm turnout. This is the result of the significant improvement in meeting the dry year proratable irrigation water supply goal of 70 percent.

2.4.3.4 Municipal Water Supply Provided

The additional future (year 2050) municipal water demand is 82,000 acre-feet. In 6 years of the 25-year period of record, proration of the irrigation water supply of less than 70 percent occurs. The municipal water is prorated in the same manner as the irrigation water supply. This would result in the following municipal supply: 1987, 80,000 acre-feet; 1992, 80,000 acre-feet; 1993, 79,000 acre-feet; 1994, 79,000 acre-feet; 2001, 78,000 acre-feet; and 2005, 78,000 acre-feet. The average annual municipal water supply provided under the Black Rock Alternative over the 25-year period is 81,100 acre-feet.

The municipal water supply available for the Black Rock Alternative in the following 6 dry years when proration is necessary is presented in table 2.28.

Table 2.28 Municipal proration level under the Black Rock Alternative

Water year	Municipal water available (acre-feet)	Proration level (percent)
1987	80,000	82
1992	80,000	80
1993	79,000	73
1994	79,000	70
2001	78,000	70
2005	78,000	70

2.4.4 Economic and Financial Analysis

The NED analysis provides a benefit-cost ratio of 0.16 for the Black Rock Alternative, as presented in table 2.29. This benefit-cost ratio is based on a total project cost including interest during construction (IDC) of $6.7 billion and total benefits of $1.0 billion. This implies a negative net benefit or uncovered costs of $5.7 billion. Based on the results of this benefit-cost analysis (BCA), this alternative is not economically justified. The complete economic and financial analysis is in section 2.7.

2.4.5 Actions and Permits

Reclamation would obtain all necessary permits to implement the Black Rock Alternative before any construction is begun, in accordance with local, State, Federal, and Tribal laws. See chapter 1, Section 1.4, “Related Permits, Actions, and Laws.”

Table 2.29 Black Rock Alternative benefit-cost ratio

Construction period (noncontract cost percent)		10 years (35%)
Total costs ($ million)	Present value	6,739.5
	Annual	331.4
Total benefits ($ million)	Present value	1,045.1
	Annual	51.4
Net benefits ($ million)	Present value	-5,694.4
	Annual	-280.0
Benefit-cost ratios	Present value and annual	0.16

2.5 Wymer Dam and Reservoir Alternative

2.5.1 Description

2.5.1.1 Physical Features

The Wymer Dam and Reservoir Alternative involves construction of an off-channel storage facility on Lmuma Creek (an intermittent stream), approximately 8 miles upstream of Roza Diversion Dam. See foldout map.

Wymer reservoir would be filled by a 400-cfs-capacity pumping plant to withdraw water from the Yakima River and would release water back to the Yakima River by gravity. The dam would back water onto the Yakima Training Center for about 2,500 feet, varying in depth from 0 to 50 feet. The elevation of the bottom girder of the eastbound Interstate 82 (I-82) bridge is 1,743 feet. The water surface elevation of Wymer reservoir at full pool would be 1,730 feet.

A 200-foot-intake channel on the Yakima River with fish screens and a fish bypass system that meets NOAA and Washington State criteria would carry water to an intake manifold to the Wymer pumping plant. The pumping plant would house seven 60-cfs pump units (total 420 cfs [with wear factor]) that would withdraw water from the Yakima River at about elevation 1,275 feet and lift it to elevation 1,610 feet. Conveyance from the Wymer pumping plant to the new reservoir would be via a 4,700-foot-long, 96-inch-diameter steel pipeline with a 46-foot-diameter air chamber for surge protection. The pumping plant and air chamber would be located partially underground to minimize visual impacts. A switchyard and 115 kilovolt (kV) transmission line (5 miles long) would be required to supply power to the pumping plant. The Wymer dam would be a concrete-faced rockfill embankment across Lmuma Creek approximately 450 feet high, creating a 162,500-acre-foot active capacity reservoir extending 5 miles from about ¼ mile east of the Yakima River to I-82. A 180-foot-high central-core rockfill dike would also be constructed in a saddle on the north side of the reservoir. On the south abutment of Wymer dam, a reinforced concrete uncontrolled ogee crest spillway with slotted bucket stilling basin would be constructed to discharge water into Lmuma Creek. A two-level outlet works on

the south dam abutment, sized for 1,200 cfs, would return water to Lmuma Creek and the Yakima River. The Lmuma Creek channel would be modified with seven drop structures and then realigned (straightened) from after the SR-821 bridge to the Yakima River. Drainage through the dam would be collected and redirected to Lmuma Creek.

The addition of the Wymer Dam and Reservoir Alternative would increase the Yakima Project total active storage capacity from 1,070,700 acre-feet to 1,233,200 acre-feet.

In addition, Reclamation would provide minimum basic recreation facilities at the reservoir (such as day-use only), resource protection and public safety, a small parking lot, boat ramp (human-powered boats only), shoreline access for nontrailered boats and portable utilities. Additional recreation facilities could be provided.

Table 2.30 presents a summary of the characteristics of this alternative.

Construction Activities

Cofferdams on Yakima River would be installed and used to dewater the area around the intake structure and fish bypass outfall structure. Lmuma Creek bypass facilities would consist of a cofferdam located approximately 450 feet from the upstream toe of the dam. The cofferdam is to be a 57-foot-high embankment constructed of earth obtained from excavation from the dam foundation. A 60-inch pipe would convey floodflows impounded by the cofferdam downstream from the damsite and ultimately through the outlet works tunnel.

Wells to dewater Wymer pumping plant would need to be drilled.

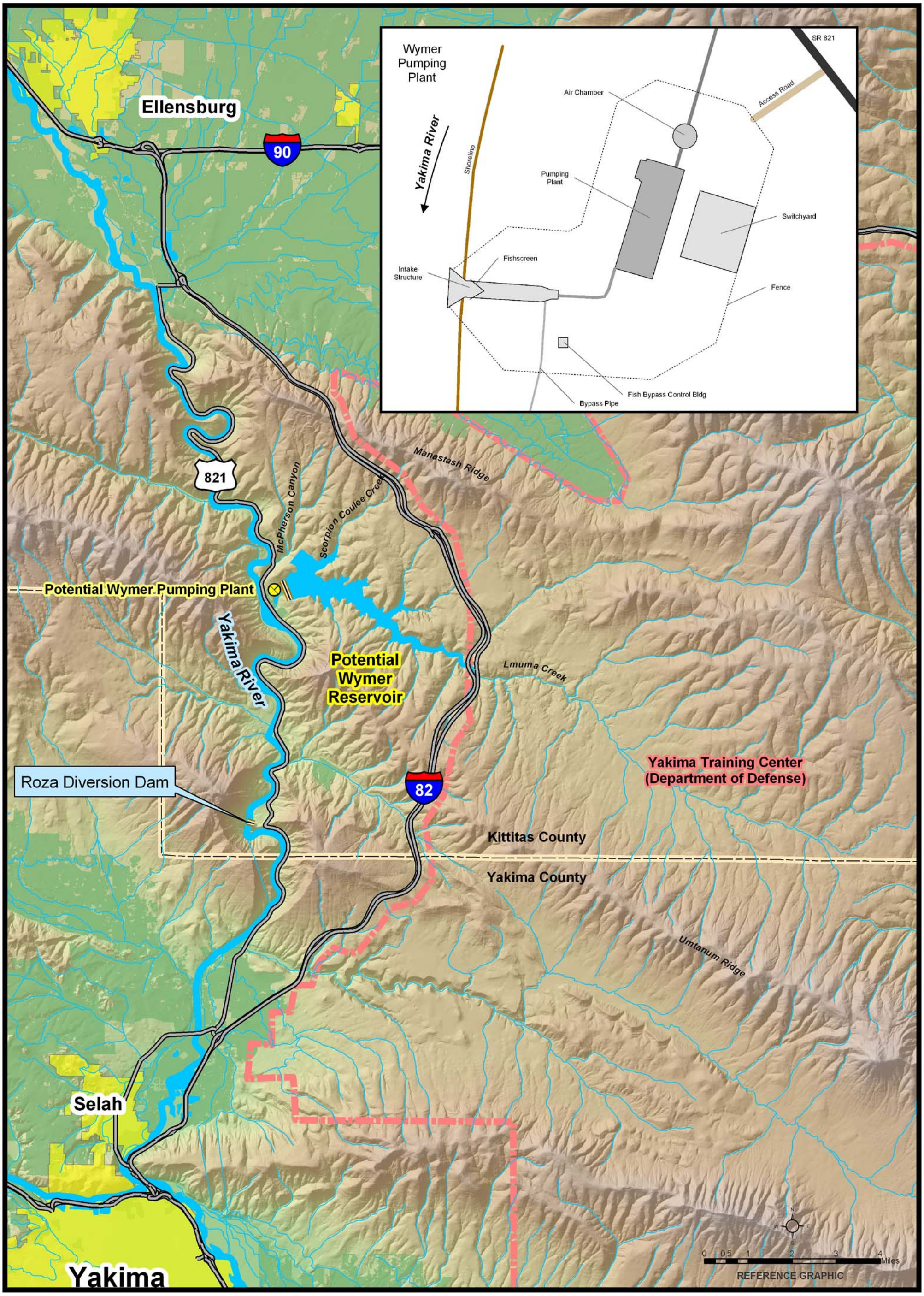
Cut-and-cover construction for the discharge line across SR-821 would require building a detour and rehabilitation of SR-821.

Embankment material would be excavated and hauled to the damsite and saddle dike site to be used as necessary in the embankment. Hauling embankment material from local sources may also be needed. Borrow and stockpile areas would be specified in the reservoir area.

Embankments of the eastbound I-82 bridge abutments would need to be riprapped, and bridge columns would need to be waterproofed.

Operation and Maintenance Activities

Routine maintenance at the intake for Yakima River pumping plant would include daily cleaning of debris off the trashrack, fish screens, and fish bypass outfall. At the pumping plant, minor painting, facility cleaning, and



Wymer Dam and Reservoir Alternative

This reference graphic is intended for informational purposes only. It is meant to assist in feature location relative to other landmarks. Geographic features have been intentionally simplified in an attempt to provide a more readable product. No representation is made as to accuracy of this document. Current as of January 2008.

Table 2.30 Summary of major facilities for the Wymer Dam and Reservoir Alternative

Facilities	Wymer Dam and Reservoir
Yakima River intake and fish screen	
Design flow capacity	480 cfs
Intake location	On left bank of Yakima River
Wymer pumping plant	
Design flow capacity	420 cfs – 4.8 MW (annual average)
60-cfs, horizontal centrifugal pumps	seven
Pump lift	475 feet
Inflow conveyance system	
Design flow capacity	400 cfs
Conveyance type	Steel pipe (96-inch diameter, 4,700 feet)
Wymer dam	
Location	Across Lmuma Creek
Concrete face rockfill embankment dam	
Crest elevation	1,750 feet
Structural height	450 feet
Crest width, length	35 feet, 3,200 feet
Spillway	Reinforced concrete uncontrolled ogee crest
Low-level outlet works through dam	
Saddle dike	
Central core rockfill embankment	
Crest elevation	1,750 feet
Structural height	180 feet
Crest width, length	30 feet, 2,700 feet
Wymer reservoir	
Maximum water surface elevation	1,741.7 feet
Active storage capacity	162,500 acre-feet
Elevation top of active storage, surface area	1,730 feet, 1,325 acres
Inactive storage capacity	7,115 acre-feet
Elevation top of inactive storage	1,456 feet
Length	5 miles long at 1,730 feet elevation
Outflow conveyance system	
Design flow capacity	1,200 cfs
Intake structure	two-level intake sized for reservoir evacuation and releases at elevation 1,375 feet and 1,456 feet
Conveyance type	pipeline (102-inch diameter), Lmuma Creek

lubrication would be required on a monthly and annual basis. Major maintenance and disassembly of pumps would take place on a 5-year cycle. Replacement of pumps and associated equipment would be on a 20-year cycle.

The dam would require periodic maintenance, inspection, monitoring, and debris removal. The concrete spillway would require routine inspection and maintenance of concrete.

Typical Annual Operation Scenario

For operational purposes, Wymer reservoir storage space is divided into two components:

- 82,500 acre-feet to be used annually to provide portions of the stored water for downstream irrigation demands and for instream flows each year during July and August, and
- 80,000 acre-feet to improve the proratable irrigation water supply in dry years when the proration level is determined to be less than 70 percent.

Releases from Cle Elum Lake of about 200 cfs from October through May would be used to fill the 82,500 acre-feet of storage space each year. January through March diversions would occur when Yakima River flows are in excess of 1,475 cfs, to fill the 80,000 acre-feet of Wymer reservoir storage space. About 3 years would be required to fill this storage space following depletion.

Water would be released from the 82,500-acre-foot reservoir storage space in Wymer in July and August only (approximately 41,250 acre-feet each month). Figure 2.10 shows Wymer daily reservoir elevation for typical annual operation.

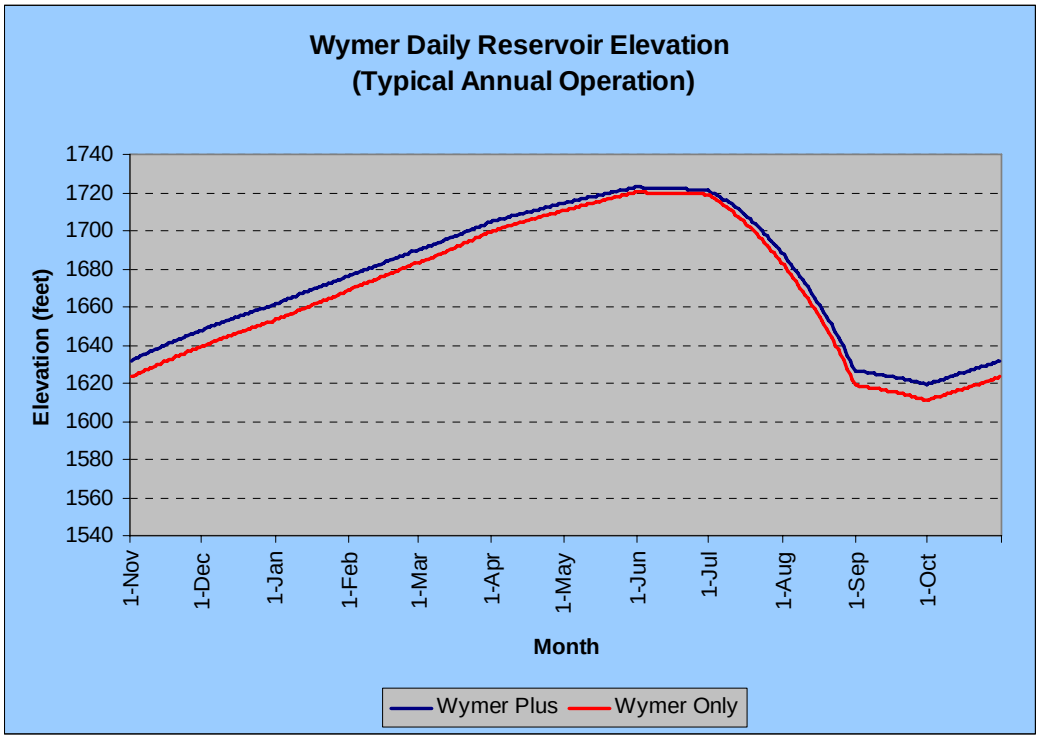


Figure 2.10 Wymer daily reservoir elevation for typical annual operation.

Total project cost for the Wymer Dam and Reservoir Alternative was estimated at $1.1 billion (table 2.31). Table 2.32 shows annual operation, maintenance, replacement, and pumping energy costs.

Table 2.31 Total project costs—Wymer Dam and Reservoir Alternative

Feature	Costs
Wymer dam structure, 400-cfs pumping plant, and outlet	$538,659,713
Subtotal of pay items	$538,659,713
Total mobilization costs (5% +/-)	$27,000,000
Subtotal with mobilization	565,659,713
Total unlisted items (10% +/-)	$54,340,287
Construction contract cost	$620,000,000
Total contingencies (25% +/-)	$160,000,000
Total field cost	$780,000,000
Noncontract costs (35% +/-)	$270,000,000
Total project cost[1]	$1,050,000,000

[1]Total project cost does not include interest during construction.

Table 2.32 Annual operation, maintenance, replacement, and pumping energy costs

Item	Wymer Dam and Reservoir Alternative
Operation maintenance and replacement costs	$1,080,000
Energy costs for pumping	$1,900,000
Total	$2,980,000

2.5.2 Operations

2.5.2.1 Wymer Reservoir

Yakima River Water Supply Available and Pumping to Wymer Dam

The water supply for storage in the 162,500-acre-foot active capacity Wymer reservoir would be obtained by withdrawing Yakima River flows at the Wymer pumping plant (RM 135.0). The water available for pumping is comprised of the following:

- October 1-May 31 releases from Cle Elum Lake to (1) improve the aquatic habitat of the Cle Elum River and downstream and (2) fill 82,500 acre-feet of the Wymer reservoir storage space. The instream flow objective from this operation is about 185-200 cfs in addition to the current instream flow release of about 200 cfs. Table 2.33 presents the monthly volume of water pumped to the 82,500 acre-feet of storage space.

Table 2.33 Additional Cle Elum Lake releases pumped to the 82,500 acre-feet of Wymer reservoir active capacity for the 25-year period of record (1981-2005) (results from Yak-RW Model)[1]

Year	Nov	Dec	Jan	Feb	Mar	Apr	May		Oct	Total
	(acre-feet)									
1981	11,670	12,060	12,060	10,900	12,060	11,670	12,060		10,520	93,000
1982	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1983	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,480	82,450
1984	10,140	10,480	10,480	9,510	10,480	10,140	10,480		10,520	82,530
1985	10,190	10,320	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1986	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1987	10,190	10,520	10,520	9,510	10,520	10,190	10,520		0	71,970
1988	0	1,710	20	3,150	17,030	24,990	25,820		7,420	80,140
1989	10,620	10,980	10,980	9,920	10,980	10,620	10,980		6,940	82.020
1990	8,600	11,400	11,400	10,300	11,400	11,040	11,400		10,520	85.060
1991	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,480	82,400
1992	10,190	10,480	10,480	9,810	10,480	10,140	10,480		3,040	75,050
1993	7,030	6,510	4,660	10,320	10,910	19,690	20,350		0	79,470
1994	0	0	3,280	4,910	19,320	24,990	25,820		740	79,060
1995	11,230	12,010	12,010	10,850	12,010	11,630	12,010		10,480	92,230
1996	10,140	10,480	10,480	9,810	10,480	10,140	10,480		10,520	82,530
1997	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1998	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,520	82,490
1999	10,190	10,520	10,520	9,510	10,520	10,190	10,520		5,810	77,780
2000	5,620	5,810	5,810	5,430	5,810	5,620	5,810		10,520	50,430
2001	10,190	10,520	10,520	9,510	10,520	10,190	10,520		1,200	73,170
2002	11,350	11,910	11,910	9,810	11,910	11,530	11,910		10,520	91,800
2003	10,190	10,520	10,520	9,510	10,520	10,190	10,520		10,480	82,450
2004	10,140	10,480	10,480	9,810	10,480	10,140	10,480		10,520	82,530
2005	10,190	10,520	10,520	9,810	10,520	10,190	10,520		3,200	75,170
Maximum	11,670	12,060	12,080	10,900	19,320	24,990	25,820		10,520	93,000
Minimum	0	0	20	3,150	5,810	5,620	5,810		0	50,430
Average	9,158	9,622	9,612	9,196	11,184	11,785	12,173		7,860	80,590

[1] At times, due to unavailable inflow to Cle Elum Lake, the release of this additional instream flow may be delayed, resulting in shorter periods of higher releases not to exceed the 420-cfs pump capacity of Wymer pumping plant. An illustration of this is water year 1988 when higher releases occur in March, April, and May to make up for deficits in the prior months.

- The residual 80,000 acre-feet of Wymer reservoir storage space would be filled by "skimming" Yakima River flows during January 1-March 31 when the flows at the Wymer pumping plant are in excess of 1,475 cfs. Wymer pumping plant has a maximum capacity of 420 cfs, of which 200 cfs is used to "capture" the additional water released from Cle Elum Lake leaving a residual pumping capacity of 220 cfs to fill the 80,000 acre-feet. Table 2.34 presents the monthly volume of Yakima River water available in excess of 1,475 cfs and the volume pumped during the 25-year period (1981-2005) of the operation study.

Table 2.34 Yakima River volume available in excess of 1,475 cfs and volume pumped to the 80,000 acre-feet of Wymer Reservoir active capacity for the 25-year period of record (1981-2005) (results from Yak-RW Model)

Year	Volume available				Volume pumped			
	Jan	Feb	Mar	Total	Jan	Feb	Mar	Total
	(acre-feet)							
1981	33,730	84,290	24,040	142,060	6,230	66,660	10,630	83,520
1982	29,480	103,980	65,860	199,320	5,430	11,150	15,300	31,880
1983	60,140	25,760	115,070	200,970	7,720	5,780	11,090	24,590
1984	116,320	32,170	87,210	235,700	Full	Full	Full	0
1985	0	0	1,300	1,300	0	0	0	0
1986	0	39,290	127,670	166,960	0	0	0	0
1987	0	0	36,520	36,520	0	0	0	0
1988	0	900	3,140	4,040	0	0	0	0
1989	2,700	3,550	7,830	14,080	0	0	0	0
1990	13,400	19,630	33,310	66,340	0	0	0	0
1991	97,320	82,660	56,600	236,580	0	0	0	0
1992	8,600	15,470	34,180	58,250	0	0	0	0
1993	0	0	12,610	12,610	0	0	0	0
1994	0	0	2,150	2,150	Full	Full	Full	0
1995	10,840	133,830	77,700	222,370	2,640	12,470	13,810	28,920
1996	218,810	330,810	212,480	762,100	13,340	14,350	15,340	43,030
1997	39,150	77,650	302,320	419,120	1,730	2,000	2,310	6,040
1998	3,370	19,350	72,660	95,380	Full	Full	Full	0
1999	52,470	5,260	57,330	115,060	0	0	0	0
2000	2,920	0	21,520	24,440	0	0	0	0
2001	0	0	810	810	Full	Full	Full	0
2002	9,550	7,020	6,820	23,390	4,320	3,220	5,140	12,680
2003	19.290	45,580	65,740	111,339	3,120	11,360	11,770	26,250
2004	950	2,250	52,550	55,750	890	1,800	12,550	15,240
2005	24,950	60	0	25,010	5,120	60	0	5,180
Maximum	218,810	330,810	302,320	762,100	13,340	66,660	15,340	83,520
Minimum	0	0	0	810	0	0	0	0
Average	28,989	41,180	59,097	129,266	2,407	6,136	4,664	11,093

Water Releases

The 82,500 acre-feet of Wymer reservoir stored water would be released every year in July and August to meet downstream irrigation demands and Title XII target flows downstream from Sunnyside Diversion Dam.8 This operation would subsequently decrease summer demands on Cle Elum Lake releases, reducing flows in the Yakima River at the Umtanum gage by an average of about 600 cfs compared to the No Action Alternative. This operation also would diminish, to some extent, the flip-flop operation effects.

[8] These are the Title XII flows downstream from Sunnyside Diversion Dam as increased by the water conservation measures of the No Action Alternative.

Releases from Wymer reservoir of up to 1,000 cfs can be made as may be necessary within the limit of stored water available.

Water stored in the remaining 80,000 acre-feet of the active reservoir capacity would be released only in dry years when the irrigation proration level is less than 70 percent. Wymer reservoir contents in the 80,000 acre-feet of active capacity are included in the TWSA. This 80,000-acre-foot pool of water is considered as carryover unless proration without this volume of water drops below 70 percent: then it is a considered part of the water supply available for irrigation.

Reservoir Contents

Operations for the 25-year period of record shows the average Wymer reservoir end-of-month contents are at their maximum by the end of May. At this time, the additional Cle Elum Lake releases above current releases and the subsequent pumping to refill the 82,500 acre-feet of Wymer reservoir active capacity are completed. In addition, the January 1-March 31 "skimming" operation to replenish, to the extent possible, any prior year releases from the 80,000 acre-feet of Wymer reservoir capacity is also completed.

Table 2.35 provides Wymer reservoir end-of-month storage contents for the 25-year period of record.

Table 2.35 Wymer reservoir storage contents for the 25-year period of record (1981-2005) (results from Yak-RW Model)

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	(162,500 acre-feet active reservoir capacity—1,000 acre-feet)											
Maximum	128	143	140	145	151	157	163	163	162	117	117	123
Minimum	0	0	3	8	28	52	78	78	39	0	0	0
Average	75	85	96	108	123	134	145	144	107	60	58	66
Average % full	46	52	59	66	76	82	89	89	66	37	36	40

2.5.2.2 Yakima Project

Modifications to Operations

With the integration of the Wymer Dam and Reservoir Alternative into the Yakima Project, modifications to the current Yakima Project operations would be as follows:

- October 1-May 31 additional releases from Cle Elum Lake for improved aquatic habitat and for filling 82,500 acre-feet of Wymer reservoir storage capacity. These releases permit, to some extent, the subsequent "backfilling" of vacated Cle Elum Lake storage space.

- The capability to meet some of the irrigation demands and Title XII flows downstream from Wymer dam and reservoir by releasing the stored water which is pumped to the 82,500 acre-feet of Wymer reservoir storage space.

- The January 1-March 31 "skimming operation" of Yakima River flows in excess of 1,475 cfs for storage in the 80,000 acre-feet of Wymer reservoir storage space for use in dry years to improve the proratable irrigation water supply when it is less than 70 percent.

- Flows downstream from Sunnyside Diversion Dam would be those associated with the Title XII target flows and conservation action flows of the No Action Alternative.

2.5.2.3 Municipal Operations

Municipal water supply operations would be the same as described for the Black Rock Alternative.

2.5.2.4 Summary

Table 2.36 illustrates the primary criteria of an integrated Wymer Dam and Reservoir Alternative-Yakima Project operation.

Table 2.36 Integrated Wymer Dam and Reservoir Alternative – Yakima Project operation criteria

End of prior calendar year				Current calendar year									
Prior irrigation season							Irrigation season						
Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Additional Cle Elum Lake releases of 185-200 cfs												
	Filling 82,500 acre-feet Wymer reservoir												
				Filling 80,000 acre-feet Wymer reservoir (following dry years)									
							Yakima Project irrigation diversions						
							Title XII instream flows with water conservation measures						
Municipal water diversions													

2.5.3 Accomplishments

2.5.3.1 Water Provided by the Wymer Dam and Reservoir Alternative

Table 2.37 shows the hydrologic indicators comparing the Wymer Dam and Reservoir Alternative to the No Action Alternative. The changes in the table show some improvement in the Yakima Project water supply over the 25-year period of record with the integration of the Wymer Dam and Reservoir Alternative when compared to the No Action Alternative.

Table 2.37 Changes in hydrologic indicators under the Wymer Dam and Reservoir Alternative compared to the No Action Alternative for the 25-year period of record (1981-2005) (Changes shown in absolute value and percent of change)

	April 1 TWSA	TWSA Distribution			Apr-Sep Yakima River flow volume at mouth	Irrigation delivery volume shortage[1]	Irrigation proration level
		Apr-Sep Yakima flow volume at Parker gage	Apr-Sep diversion volume upstream of Parker gage	Sep 30 reservoir contents change			
	(maf) and % change						Proration and % change
Average 1981-2005 (results from Yak-RW Model)							
No Action Alternative	2.84	0.62	1.91	0.30	0.86	0.05	
Wymer Dam and Reservoir Alternative	2.94	0.59	1.95	0.40	0.83	0.05	
Change from No Action Alternative	0.10	-0.03	0.04	0.10	-0.03	0.00	
%change	4%	-5%	2%	33%	-4%	0%	
Dry year 1994 (results from Yak-RW Model)							
No Action Alternative	1.75	0.25	1.42	0.07	0.31	0.38	27%
Wymer Dam and Reservoir Alternative	1.76	0.25	1.44	0.06	0.31	0.38	29%
Change from No Action Alternative	0.01	0.00	0.02	-0.01	0.00	0.00	2%
% change	1%	0%	1%	-14%	0%	0%	

The irrigation delivery volume shortage is the difference between a full water supply to the farm (represented by the median volume delivered for the period of record of 1981-2005) and the volume delivered in a specific year.

2.5.3.2 Instream Flows Provided

In general, spring flows at the Parker gage under the Wymer Dam and Reservoir Alternative are similar to those under the No Action Alternative, and summer flows are somewhat higher than the No Action Alternative (figure 2.11 in section 2.9.1). Summer flows in the upper Yakima River (Umtanum gage) are similar between the Wymer Dam and Reservoir Alternative and the Wymer Dam Plus Yakima River Pump Exchange Alternative; summer flows are between those under the Black Rock and No Action Alternatives (figure 2.10).

Ellensburg Reach (Umtanum gage)

The seasonal flow volumes are spring, 2 percent above the No Action Alternative; summer, 10 percent below the No Action Alternative; and winter, 10 percent above the No Action Alternative, which is not considered detrimental (table 2.12).

The spring flow objective is nearly satisfied; however, the spring season stream runoff pattern is the same as under No Action and the Wymer Dam Plus Yakima

River Pump Exchange Alternatives. Compared to the No Action Alternative, the Wymer Dam and Reservoir Alternative reduces summer flows in the upper Yakima River, but not as much as under the Black Rock Alternative, and about the same as under the Wymer Dam Plus Yakima River Pump Exchange Alternative (figure 2.10).

Wapato Reach (Parker gage)

The seasonal flow volumes are spring, 3 percent below the No Action Alternative; summer, 1 percent below the No Action Alternative; and winter, 1 percent below the No Action Alternative, which is not considered detrimental (table 2.12).

The spring season stream runoff pattern for the Wymer Dam and Reservoir Alternative is not better than under the No Action Alternative, and summer flows are the same as under the No Action Alternative, but better than under the current operation (figure 2.11 in section 2.9.1).

2.5.3.3 Dry Year Proratable Irrigation Supply Provided

Table 2.38 shows the proration level of the 6 dry years for the 25-year period of record (1981-2005). The Wymer Dam and Reservoir Alternative shows some improvement in the third year (1994) of the 3-year dry cycle. The primary reasons for this are that, while moving 185-200 cfs from Cle Elum Lake during October 1-May 31 (for aquatic habitat improvements) to Wymer reservoir is primarily a shift in reservoir contents, it does (1) provide the opportunity for subsequent refill of some of the vacated Cle Elum Lake storage space and (2) create specific carryover storage in Wymer reservoir to improve the proratable water supply in dry years.

Table 2.38 Irrigation proration level for the Wymer Dam and Reservoir Alternative compared to the No Action Alternative

	Proration level (percent)		
Water year	No Action Alternative	Wymer Dam and Reservoir Alternative	Difference
1987	69	73	+4
1992	70	76	+6
1993	57	68	+11
1994	27	29	+2
2001	44	59	+15
2005	45	49	+4

The irrigation delivery shortage is slightly better under the Wymer Dam and Reservoir Alternative than under the No Action Alternative. This minor improvement is a result of Wymer reservoir's 80,000 acre-feet of irrigation storage, which increases the dry year irrigation proratable water supply in a dry year such as 1994 from a proration level of 27 percent under the No Action Alternative to 29 percent under the Wymer Dam and Reservoir Alternative.

2.5.3.4 Municipal Supply Provided

The additional future (year 2050) municipal water demand is 82,000 acre-feet. In 6 years of the 25-year period, proration of the irrigation water supply of less than 70 percent occurs. The municipal water is prorated in the same manner the irrigation water supply. This would result in the following municipal supply: 1987, 78,000 acre-feet; 1992, 78,000 acre-feet; 1993, 77,000 acre-feet; 1994, 68,000 acre-feet; 2001, 75,000 acre-feet; and 2005, 71,000 acre-feet. The average annual municipal water supply provided from the Wymer Dam and Reservoir Alternative over the 25-year period is 79,800 acre-feet.

The municipal water supply available for the Wymer Dam and Reservoir Alternative in the following 6 dry years when proration is necessary is presented in table 2.39.

Table 2.39 Municipal water supply available during prorated years with the Wymer Dam and Reservoir Alternative

Water year	Municipal water available (acre-feet)	Proration level (percent)
1987	78,000	73
1992	78,000	76
1993	77,000	68
1994	68,000	29
2001	75,000	59
2005	71,000	49

2.5.4 Economic and Financial Analysis

The total project costs were estimated using 35 percent noncontract cost component. For the Wymer Dam and Reservoir Alternative, estimated benefits cover 29 percent of total project costs. This implies negative net benefits or uncovered costs of $1,002.9 million. Based on the results of this BCA, this alternative is not economically justified. See table 2.40. See section 2.7 for a complete economic and financial analysis.

Table 2.40 Wymer Dam and Reservoir Alternative benefit-cost ratio

Construction period (noncontract cost percent)		10 years (35%)
Total costs ($ million)	Present value	1,417.7
	Annual	69.7
Total benefits ($ million)	Present value	414.8
	Annual	20.4
Net benefits ($ million)	Present value	-1,002.9
	Annual	-49.3
Benefit-cost ratios	Present value and annual	0.29

2.5.5 Actions and Permits

Reclamation would obtain all necessary permits to implement the Wymer Dam and Reservoir Alternative before any construction is begun, in accordance with local, State, Federal, and Tribal laws. See chapter 1, Section 1.4, "Related Permits, Actions, and Laws."

2.6 Wymer Dam Plus Yakima River Pump Exchange Alternative

2.6.1 Description

2.6.1.1 Physical Features

The Wymer Dam Plus Yakima River Pump Exchange Alternative couples the Wymer dam and reservoir with a pump exchange component. This alternative includes the same Wymer dam, reservoir, and pumping plant facilities described in section 2.5. The pump exchange option of this alternative involves a "bucket-for bucket" exchange of up to 1,050 cfs that would not be diverted by Roza and Sunnnyside, but would remain in the river to enhance instream flows. In return, water would be pumped from the mouth of the Yakima River upstream for delivery to these two divisions. See foldout map.

The Yakima River pump exchange option involves a pump and pipeline system designed to have the capability to deliver up to 1,200 cfs from near the mouth of the Yakima River in Kennewick, Washington, to various points in the Sunnyside and Roza Irrigation Divisions southeast of Yakima, Washington.[9] Water delivery from the pump and pipeline system would begin mid-to-late March when the irrigation systems are "primed" and continue through the irrigation season of April through October.

Pumping plant #1 would be constructed on the Columbia River near Kennewick, Washington, for conveying water through two 132-inch buried steel pipelines extending northwest approximately 17 miles upstream to pumping plant #2 north of Benton City. Pumping plant #1 would be at elevation 350 feet, and pumping plant #2 would be at elevation 800 feet, both consisting of six pump units of 200-cfs capacity each with six 40-foot-diameter spherical air chambers for surge suppression. The two 132-inch buried steel pipelines then would continue another 31 miles to their terminus at pumping plant #3 northwest of the city of Sunnyside at an elevation of about 960 feet. About 50 cfs would be delivered to the Sunnyside Canal (MP 59.29) enroute.

Pumping plant #3 would have three pump units of 183 cfs each with three 25-foot-diameter spherical air chambers for surge suppression. From this point,

[9] The design is for an exchange of up to 1,200 cfs. However, subsequent operation studies indicate an exchange of up to 1,050 cfs not to exceed the "bucket-for-bucket" exchange objective.

one 120-inch-diameter buried steel pipeline (550-cfs capacity) would extend 1 mile to the Roza Canal (MP 59.0); one 84-inch buried steel pipeline (400-cfs capacity) would extend about 2 miles to discharge into the Sunnyside Canal (MP 37.0); and one 72-inch-diameter buried steel pipeline (200-cfs capacity) would continue farther upstream to the Sunnyside Canal (MP 30.0). The pipelines to the Sunnyside Canal would provide water by gravity flow, while the pipeline to the Roza Canal would require pumping the water. Most of the buried pipeline system would be located on the east side of the Yakima River. The pipeline would cross the Yakima River downstream from Benton City, Washington, at Songbird Island. Pumping plants #2 and #3 would have emergency overflow reservoirs that would be used in the case of pumping plant shutdown. Additional facilities would include minimum basic recreation facilities as described under the Wymer Dam and Reservoir Alternative.

The power for the pumping plants would be supplied by the construction of the new powerlines as follows:

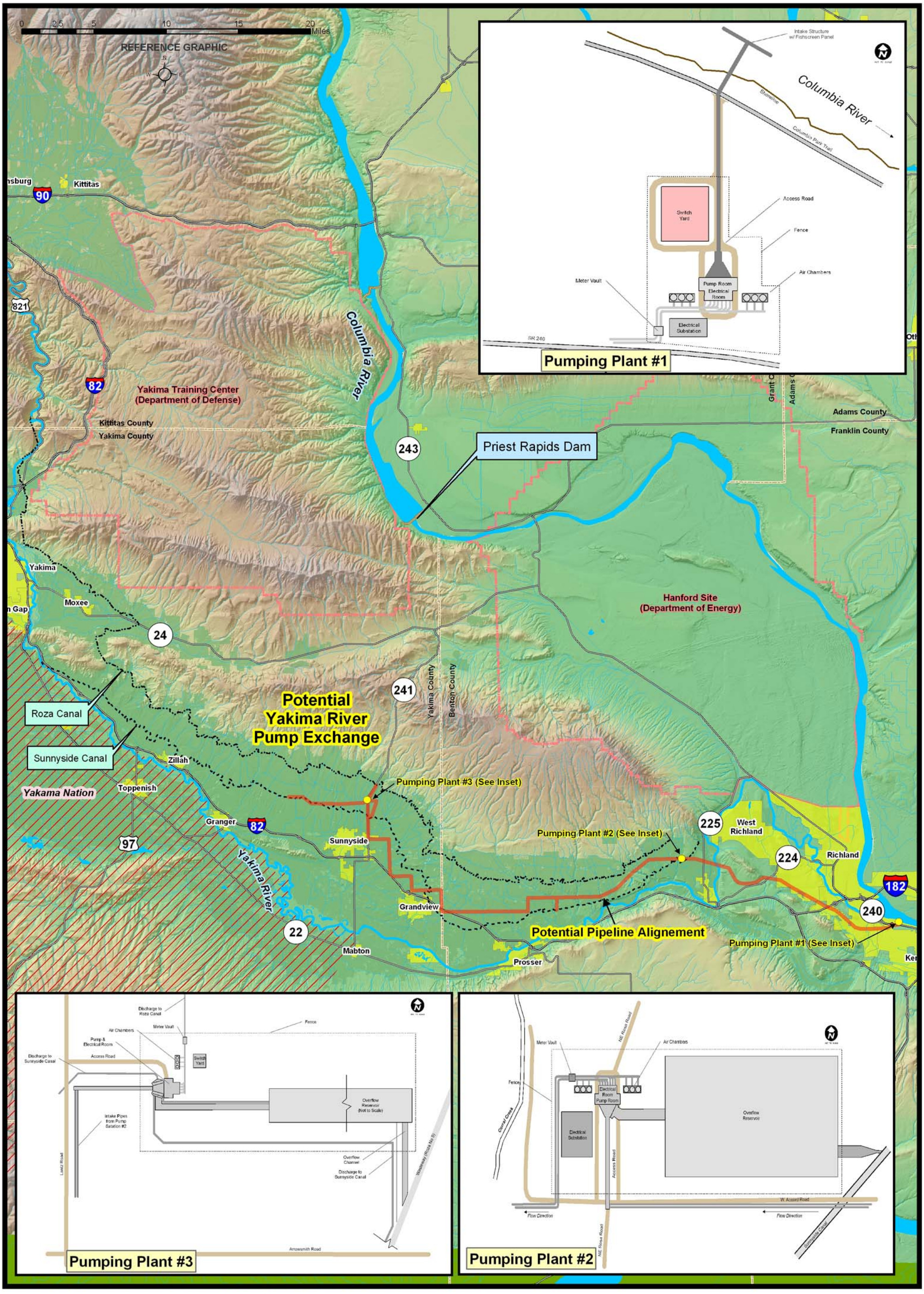
- A 500-kV, ½-mile-long, powerline from pumping plant #1 to the closest substation,
- A 230-kV, 1½-mile-long powerline from an existing nearby substation to pumping plant #2, and
- A 115-kV, 3-mile-long powerline from the closest tap onto an existing powerline to pumping plant #3.

The annual volume delivered during the irrigation season by the pump exchange in a nonprorated water year would range from about 263,000 to 382,000 acre-feet. The residual demand of about 278,000 to 382,000 acre-feet would continue to be diverted from the Yakima River at the Roza Diversion Dam (RM 127.9) and the Sunnyside Diversion Dam (RM 103.8).

Pipeline Delivery System

The pipeline delivery system would split the deliveries between Sunnyside and Roza, with the capability to deliver 650 cfs to Sunnyside Canal and 550 cfs to Roza Canal. The points of delivery and the delivery capabilities are the Sunnyside Canal at three locations: 200 cfs at MP 30.0; 400 cfs at MP 37.0; 50 cfs at MP 59.29; and the Roza Canal at one location, MP 59.0, with a delivery capability of 550 cfs. The division of flow between Sunnyside and Roza could be adjustable.

Table 2.41 presents the design components of the pump exchange portion of the Wymer Dam Plus Yakima River Pump Exchange Alternative.



Yakima River Pump Exchange Component

This reference graphic is intended for informational purposes only. It is meant to assist in feature location relative to other landmarks. Geographic features have been intentionally simplified in an attempt to provide a more readable product. No representation is made as to accuracy of this document. Location of pipe is based on data obtained from Golder Associates and is only approximate. Current as of January 2008.

Table 2.41 Design components of the Yakima River pump exchange

Item	Pumping plant #1	Pumping plant #2	Pumping plant #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
Outflow capacity	1,200 cfs	1,200 cfs	550 cfs
Pumps and capacity	6 pumps at 200 cfs each[1]	6 pumps at 200 cfs each[1]	3 pumps at 183 cfs[1]
Lift	530 feet	270 feet	165 feet
Discharge to	Outflow pipeline	Outflow pipeline	(see below)
Outflow pipeline (pumped water)			
Location	**Pumping plant #1 to pumping plant #2**	**Pumping plant #2 to pumping plant #3 with 50 cfs discharge to Sunnyside Canal (MP 59.29)**	**Pumping plant #3 to Roza Canal (MP 59.0)**
Capacity	1,200 cfs	1,200 cfs	550 cfs
Type	2 steel pipelines	2 steel pipelines	1 steel pipeline
Diameter	132-inch-diameter each	132-inch-diameter each	120-inch
Length	17 miles	31 miles	1 mile
Outflow pipeline (gravity-flow water)			
Location			Pumping plant #3 to Sunnyside Canal (MP 37.0)
Capacity			400 cfs
Type			1 steel pipeline
Diameter			84-inch
Length			2 miles
Location			Plant #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 pumping plant.

The capacities represent the design capacities from the October 2006 report (Golder and Associates, 2006). Since that time, it has been concluded that the maximum pump exchange would have to be no more than about 1,050 cfs to have "no net loss" in flow in the Columbia River at the mouth of the Yakima River.

Construction Activities

A cofferdam on Columbia River would be installed for intake and fish screen construction for pumping plant #1.

Pumping plant #1 would require wells for dewatering the pumping plant site.

Major crossings for the discharge pipelines at SR-240, I-182, and Yakima River at Songbird Island would be by bored tunnel. The Yakima River crossing would require dewatering and excavation on Songbird Island.

Minor crossing for the pipelines at SR-224, SR-225, Sunnyside Canal, Corral Creek, Snipes Creek, and Spring Creek would be cut-and-cover construction.

Operation and Maintenance Activities

Routine maintenance at the intake for pumping plant #1 would include daily cleaning of debris off the trashrack and fish screens. At the pumping plants, minor painting, facility cleaning and lubrication would be required on a monthly and annual basis. Major maintenance and disassembly of pumps would take place on a 5-year cycle. Replacement of pumps and associated equipment would be on a 20-year cycle.

Typical Annual Operation Scenario

The pump exchange would operate every year beginning in mid-to-late March with the priming of the irrigation systems and continuing through the April through October irrigation season. This operation would improve the aquatic habitat of the Yakima River by leaving up to approximately 1,000 cfs of water in the river that otherwise would have been diverted by Roza and Sunnyside.

Total project cost estimate for the pump exchange (table 2.42) was estimated at $4 billion (April 2007 prices). Table 2.43 presents annual operation, maintenance, replacement, and pumping energy costs.

2.6.2 Operations

2.6.2.1 Wymer Reservoir Component

The operational aspects of Wymer reservoir in are the same as described in section 2.5.2.1 for the Wymer Dam and Reservoir Alternative.

2.6.2.2 Yakima River Pump Exchange Component

Exchange Participants Water Supply

A “bucket-for-bucket” exchange of flow at the mouth of the Yakima River for a portion of the flow that would have been diverted by Roza and Sunnyside begins when water is first required for priming of the canal systems (usually about mid-March). The Yakima River pump exchange would continue throughout the April-October irrigation season. The water that Roza and Sunnyside would have diverted remains in the Yakima River from the current points of diversion, increasing the volume of water passing the Parker gage and continuing downstream to its confluence with the Columbia River.

Table 2.42 Total project costs for Wymer Dam Plus Yakima River Pump Exchange Alternative

Feature	Costs
Yakima River pump exchange intake structure and pumping plant #1	$120,210,000
Yakima River pump exchange pumping plant #2	$115,400,000
Yakima River pump exchange pumping plant #3	$51,530,000
Delivery facilities	$450,000
Pipeline	$1,164,130,000
Wymer dam structure, 400-cfs pumping plant and outlet	$538,659,713
Subtotal of pay items	$1,990,379,713
Total mobilization costs (5% +/-)	$100,000,000
Subtotal with mobilization	2,090,379,713
Total unlisted items (15% +/-)	$313,556,957
Construction contract cost	$2,400,000,000
Total contingencies (25% +/-)	$600,000,000
Total field cost	$3,000,000,000
Noncontract costs (35% +/-)	$1,100,000,000
Total project cost[1]	$4,100,000,000

[1] Total project cost does not include interest during construction

Table 2.43 Annual operation, maintenance, replacement, and pumping energy costs for Wymer Dam Plus Yakima River Pump Exchange Alternative

Item	Costs
Operation, maintenance, and replacement costs	$18,198,000
Energy costs for pumping	$19,815,000
Total	$38,013,000

The flow objective (and the equivalent volume of water) in the Yakima River at the Parker gage (Wapato reach) is shown in table 2.2. The operation criteria for the Wymer Dam Plus Yakima River Pump Exchange Alternative is to provide 1,500 cfs during the irrigation season, in conjunction with the Title XII target flow requirements downstream from Sunnyside Diversion Dam, to assist in meeting these instream target flows.[10] In the first part of the irrigation season (April-June), a combination of unregulated flows (natural and return flows) supplemented from the pump exchange are used. Once storage control begins (generally about the first of July), stored water releases are made to meet the Title XII instream target flows similar to the No Action Alternative operation and these are supplemented to the extent necessary by the pump exchange to maintain a July-October target objective of 1,500 cfs.

[10] These are the Title XII target flows as increased by the water conservation measures of the No Action Alternative.

The maximum pump exchange is about 1,050 cfs which results from 1,500 cfs, less the dry year Title XII target flows and conservation action flows downstream from Sunnyside Diversion Dam. In wetter years when the Parker Title XII target flows are greater, the pump exchange is at the minimum of about 650 cfs.[11] The first priority of the exchange is the 550 cfs to be delivered at Roza Canal MP 59.0. This is because Roza's current point of diversion is higher in the Yakima River system (RM 127.9) than Sunnyside's (RM 103.8), thus providing the maximum extent of improved streamflows. The exchange with Sunnyside is contingent on the residual flow needed to meet the 1,500-cfs operation criteria. However, the exchange is limited by the pump exchange delivery capacity to the Sunnyside Canal, which is 650 cfs and cannot result in a flow in the Columbia River at the mouth of the Yakima River that would be less than that which would have occurred in the absence of the pump exchange. When Roza is exchanging its maximum, Sunnyside's maximum exchange capability is 500 cfs. However, Sunnyside's pump exchange may be as low as 100 cfs in wet years when maximizing Roza's exchange.[12]

The volume of water delivered to Roza and Sunnyside by means of the pump exchange and the residual volume diverted from the Yakima River is illustrated in table 2.44 by two nonprorated water years: 1997 (with a TWSA estimate of about 4.63 million acre-feet) and 2004 (with a TWSA estimate of 2.64 million acre-feet). As shown in the table, the water exchange to Roza in a nonprorated water year remains the same and the variance occurs in the pump exchange deliveries to Sunnyside.

Table 2.44 Source of water supply for exchange participants (using nonprorated years)

	Yakima River pump exchange	Yakima River	Total
	(acre-feet rounded for illustration)		
Water year 1997 (results from Yak-RW model)			
Roza Division	188,000	112,000	300,000
Sunnyside Division (with minimum from pump exchange)	75,000	285,000	360,000
Total	263,000	397,000	660,000
Water year 2004 (results from Yak-RW model)			
Roza Division	188,000	112,000	300,000
Sunnyside Division (with maximum from pump exchange)	194,000	166,000	360,000
Total	382,000	278,000	660,000

[11] It was assumed in the operation modeling that the maximum delivery to Sunnyside was 750 cfs. However, the current plan has a maximum delivery capacity of 650 cfs to Sunnyside.

[12] The 500 cfs is computed as 1,050 cfs less Roza's 550 cfs.

2.6.2.3 Yakima Project

Modifications to Operations

The addition of the Wymer Dam Plus Yakima River Pump Exchange Alternative results in the following operational modifications to the Yakima Project:

- October 1-May 31 additional releases from Cle Elum Lake for improved aquatic habitat and for filling 82,500 acre-feet of Wymer reservoir storage capacity. This permits, to some extent, the subsequent "backfilling" of the vacated Cle Elum Lake storage space.

- The capability to meet some of the irrigation demands and Title XII target flows downstream from Wymer dam and reservoir by releasing the stored water, which is pumped to the 82,500 acre-feet of Wymer reservoir storage space.

- The January 1-March 31 "skimming operation" of Yakima River flows in excess of 1,475 cfs for storage in the 80,000 acre-feet of Wymer reservoir storage space for use in dry years to improve the proratable water supply when it is less than 70 percent.

- Flows downstream from Sunnyside Diversion Dam would be the enhanced flows during the April-October irrigation season with the capability to deliver up to 1,050 cfs to Roza and Sunnyside by means of the Yakima River pump exchange.

2.6.2.4 Municipal Operations

Municipal water supply operations would be the same as described for the Black Rock Alternative.

2.6.2.5 Summary

The primary operation criteria of an integrated Wymer Dam Plus Yakima River Pump Exchange Alternative are shown in table 2.45.

2.6.3 Accomplishments

2.6.3.1 Water Provided by the Wymer Dam Plus Yakima River Pump Exchange Alternative

Table 2.46 shows the hydrologic indicator changes which occur when comparing the Wymer Dam Plus Yakima River Pump Exchange Alternative to the No Action Alternative.

Table 2.45 Integrated Wymer Dam Plus Yakima River Pump Exchange Alternative – Yakima Project operation criteria

End of prior calendar year				Current calendar year									
Prior irrigation season							Irrigation season						
Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Additional Cle Elum Lake releases of 185-200 cfs												
	Filling 82,500 acre-feet Wymer reservoir												
				Filling 80,000 acre-feet Wymer reservoir (following dry years)									
							Yakima Project irrigation diversions						
							Yakima River pump exchange deliveries to Roza and Sunnyside						
							Enhanced Parker gage flows						
Municipal water diversions													

Table 2.46 Changes in hydrologic indicators under Wymer Dam Plus Yakima River Pump Exchange Alternative compared to the No Action Alternative for the 25-year period of record (1981-2005) (changes shown in absolute value and percent of change)

	April 1 TWSA	TWSA distribution			Apr-Sep Yakima River flow volume at mouth	Irrigation delivery volume shortage[1]	Irrigation proration level
		Apr-Sep Yakima River flow volume at Parker gage	Apr-Sep Diversion volume upstream of Parker gage	Sep 30 reservoir contents change			
	(maf) and % change						Proration and % change
Average 1981-2005 (results from Yak-RW Model)							
No Action Alternative	2.84	0.62	1.91	0.30	0.86	0.05	
Wymer Dam Plus Yakima River Pump Exchange Alternative	2.94	0.90	1.64	0.40	0.83	0.05	
Change from No Action Alternative	0.10	0.28	-0.27	0.10	-0.03	0.00	
% change	4%	45%	-14%	33%	-3%	0%	
Dry year 1994 (results from Yak-RW Model)							
No Action Alternative	1.75	0.25	1.42	0.07	0.31	0.38	27%
Wymer Dam Plus Yakima River Pump Exchange Alternative	1.77	0.57	1.13	0.06	0.31	0.38	29%
Change from No Action Alternative	0.02	0.32	-0.29	-0.01	0.00	0.00	2%
% change	1%	128%	-20%	-14%	0%	0%	

[1]The irrigation delivery volume shortage is the difference between a full water supply to the farm (represented by the median volume delivered for the period of record of 1981-2005) and the volume delivered in a specific year.

The changes outlined in the table show an improvement in the Yakima Project water supply over the 25-year period of record. The primary reason for this improvement is the water exchange whereby some of the current Yakima River irrigation diversions are now provided by pumping water from near the mouth of the Yakima River upstream for delivery to Sunnyside and Roza.

2.6.3.2 Instream Flows Provided

In general, the Wymer Dam Plus Yakima River Pump Exchange Alternative would provide greater spring flows than the No Action Alternative at the Parker gage, but with the same stream runoff pattern as the No Action Alternative and the greatest summer flows of all the alternatives (figure 2.3). Summer flows in the upper Yakima River (Umtanum gage) are identical to those under the Wymer Dam and Reservoir Alternative, with a flow reduction that falls between those of the Black Rock and No Action Alternatives (figure 2.10.)

Ellensburg Reach (Umtanum gage)

The seasonal flow volumes are spring, 2 percent above No Action; summer, 11 percent below the No Action Alternative; and winter, 10 percent above the No Action Alternative, which is not considered detrimental (table 2.12).

The spring season stream runoff pattern for the Wymer Dam Plus Yakima River Pump Exchange Alternative is similar to the other alternatives. The Wymer Dam Plus Yakima River Pump Exchange Alternative provides a reduction in summer flows similar to the Wymer Dam and Reservoir Alternative in the upper Yakima River and in between those of the Black Rock and No Action Alternatives.

Wapato Reach (Parker gage)

The seasonal flow volumes are spring, 19 percent above No Action; summer, 98 percent above the No Action Alternative; and winter, 1 percent below the No Action Alternative, which is not considered detrimental (table 2.12).

The spring season stream runoff pattern for the Wymer Dam Plus Yakima River Pump Exchange Alternative is not improved, as it mimics that of the No Action Alternative only at higher daily flows. Summer flows are the highest of all the alternatives (figure 2.11 in section 2.9.1).

2.6.3.3 Dry Year Proratable Irrigation Supply Provided

Dry year proratable irrigation supply provided is the same as under the Wymer Dam and Reservoir Alternative.

2.6.3.4 Municipal Supply Provided

Municipal supply provided is the same as under the Wymer Dam and Reservoir Alternative.

2.6.4 Economic and Financial Analysis

The total project costs were estimated using 35 percent noncontract cost component (table 2.47). For the Wymer Dam Plus Yakima River Pump Exchange Alternative, estimated benefits cover 7 percent of total project costs. This implies negative net benefits or uncovered costs of $5.5 billion. Based on the results of this BCA, this alternative is not economically justified. See section 2.7 for a complete economic and financial analysis.

Table 2.47 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction period (noncontract cost percent)		10 years (35%)
Total costs ($ million)	Present value	5,926.8
	Annual	291.4
Total benefits ($ million)	Present value	428.7
	Annual	21.1
Net benefits ($ million)	Present value	-5,498.1
	Annual	-270.4
Benefit-cost ratios	Present value and annual	.07

2.6.5 Actions and Permits

Reclamation would obtain all necessary permits to implement the Wymer Dam Plus Yakima River Pump Exchange Alternative before any construction is begun, in accordance with local, State, Federal, and Tribal laws. See chapter 1, Section 1.4, “Related Permits, Actions, and Laws.”

2.7 Economic and Financial Analysis

This section describes the results of a NED-oriented BCA, presenting information as to the economic feasibility of the proposed alternatives. See section 2.2 in this chapter for a discussion of national versus regional economic analyses. In addition, a short discussion of financial feasibility (i.e., cost allocation/repayment) is presented at the end of this section.

2.7.1 NED Benefit-Cost Analysis

The NED BCA compares the present value of a proposed project’s benefits to the present value of its costs. If benefits exceed costs, the project is considered economically justified. Because both benefits and costs can occur at various points throughout the study period, it is important to convert them to a common point in time. For this analysis, the costs and benefits were measured as of the start of the benefits period (which is equivalent to the end of the construction period). The study period or period of analysis for the benefits period was

assumed to be 100 years, as suggested by the *P&Gs*. The interest rate used to convert costs and benefits to a common year was Reclamation's fiscal year 2007 planning rate of 4.875 percent.

Table 2.48 presents the results of the NED BCA for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives. This table displays the total costs, total benefits, net benefits (i.e., total benefits minus total costs), and benefit-cost ratios (i.e., total benefits divided by total costs) for each alternative. Each piece of information is shown in both present value and annual equivalent terms. The annual equivalent estimate converts the present value figure to an average annual value over the 100-year study period. Details on the individual cost and benefit estimates associated with each alternative can be found below.

Table 2.48 Benefit-cost analysis summary

	Value option	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Construction period		10 years	10 years	10 years
Noncontract cost %		35	35	35
Total costs ($ million)	Present value	6,739.5	1,417.7	5,926.8
	Annual	331.4	69.7	291.4
Total benefits ($ million)	Present value	1,045.1	414.8	428.7
	Annual	51.4	20.4	21.1
Net benefits ($ million)	Present value	-5,694.4	-1,002.9	-5,498.1
	Annual	-280.0	-49.3	-270.4
Benefit-cost ratios	Present value and annual	0.16	0.29	0.07

The cost categories aggregated into total costs include: (1) upfront total construction costs including field costs, noncontract costs, and interest during construction and (2) annual operation, maintenance, replacement, and pumping energy costs. The 100-year stream of annual OMR&E costs was discounted to a present value as of the start of the benefits period before being combined with the total construction costs.

The benefit categories aggregated into total benefits include: (1) agriculture, (2) municipal, (3) recreation (both at the proposed reservoirs and at existing reservoirs and rivers), (4) hydropower (Black Rock and Sunnyside plants plus lost hydropower benefits from Federal and non-Federal facilities, e.g., Priest Rapids powerplant), and (5) fisheries use values (commercial, sport, Tribal subsistence). The 100-year stream of annual benefits was also discounted to a present value as of the start of the benefits period.

Black Rock Alternative. The benefit-cost results for the Black Rock Alternative are presented in table 2.48. The costs were developed using a 10-year construction period and noncontract costs estimated at 35 percent of total field costs. The estimated benefits for the Black Rock Alternative cover 16 percent of total project costs. This implies negative net benefits or uncovered costs of nearly $5.7 billion. Based on the results of this benefit-cost analysis, this alternative is not economically justified.

Wymer Dam and Reservoir Alternative. As presented in table 2.48, the Wymer Dam and Reservoir Alternative costs were estimated using a 10-year construction period with noncontract costs at 35 percent of total field costs. Estimated total benefits cover 29 percent of total project costs. This implies negative net benefits or uncovered costs of about $1.0 billion. Based on the results of this benefit-cost analysis, this alternative is not economically justified.

Wymer Dam Plus Yakima River Pump Exchange Alternative. As presented in table 2.48, the Wymer Dam Plus Yakima River Pump Exchange Alternative costs were estimated using a 10-year construction period with noncontract costs at 35 percent of total field costs. Estimated total benefits cover 7 percent of total project costs. This implies negative net benefits or uncovered costs of nearly $5.5 billion. Based on the results of this benefit-cost analysis, this alternative is not economically justified.

2.7.1.1 Cost Analysis

The cost analysis for each alternative is broken down into two subsections: (1) upfront construction costs, including IDC and (2) annual OMR&E costs. The IDC calculation represents the cost of Federal borrowing during the construction period.

Black Rock Alternative. The appraisal-level construction costs for the Black Rock Alternative, as obtained from the *Black Rock Summary Report* (Reclamation, 2004e), were indexed to April 2007 dollars via Reclamation cost engineers. As presented in table 2.49, total field costs were estimated at $3.274 billion. Noncontract costs were estimated at 35 percent of the total field costs or $1.146 billion. Adding these two cost items together results in a total construction cost (before IDC) of $4.420 billion. Using a 10-year construction period along with the annual construction cost estimates, Reclamation calculated IDC at $1.096 billion for a total construction cost of $5.516 billion.

The OMR&E costs occur on an annual basis. To calculate a present value, these annual costs were assumed to occur each year of the 100-year study period. The annual OM&R costs were estimated at $10.17 million ($206.8 million in present value) and the annual energy costs at $50 million ($1.017 billion in present value) for a total annual OMR&E cost of $60.17 million ($1.224 billion in present value).

Table 2.49 Upfront construction costs and annual OMR&E costs by alternative

	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Construction period	10 years	10 years	10 years
Noncontract cost %	35	35	35
Upfront construction costs ($ million)			
Field	3,274.0	780.0	2,980.0
Noncontract:	1,145.9	273.0	1,043.0
IDC	1,095.9	304.1	1,130.6
Total	5,515.8	1,357.1	5,153.6
OMR&E costs ($ million)			
Operation, maintenance, and replacement (OM&R)	10.17	1.08	18.20
Energy	50.0	1.90	19.82
Total	60.17	2.98	38.02
Present value of 100 years of OMR&E costs	1,223.7	60.6	773.1
Total cost ($ million)			
Total construction cost plus present value of OMR&E	6,739.5	1,417.7	5,926.8

The total project cost, representing the sum of the total construction cost plus the present value of the annual OMR&E cost, equals $6.740 billion.

Wymer Dam and Reservoir Alternative. The appraisal-level construction costs for the Wymer Dam and Reservoir Alternative, as obtained from the *Wymer Dam and Reservoir Appraisal Assessment* (Reclamation, 2007a), were indexed to April 2007 dollars by Reclamation cost engineers. As shown in table 2.49, total field costs were estimated at $780 million. Noncontract costs were estimated at 35 percent of the total field costs or $273.0 million. Summing these two cost items results in a total construction cost (before IDC) of $1.053 billion. Based on the 10-year construction period and the annual construction cost estimates, Reclamation calculated IDC at $304.1 million for a total construction cost estimate of $1.357 billion.

The OMR&E costs occur on an annual basis. To calculate a present value, the annual costs were assumed to occur each year of the 100-year study period. The annual OM&R costs were estimated at $1.08 million ($21.96 million in present value) and the annual energy costs at $1.9 million ($38.64 million in present value) for a total annual OMR&E cost of $2.98 million ($60.6 million in present value).

The total project cost, representing the sum of total construction cost plus the present value of the OMR&E cost, equals $1.418 billion.

Wymer Dam Plus Yakima River Pump Exchange Alternative. The appraisal-level construction costs for the Wymer Dam Plus Yakima River Pump Exchange Alternative, as obtained from the *Wymer Dam and Reservoir Appraisal Assessment* (Reclamation, 2007a), were indexed to April 2007 dollars by Reclamation cost engineers.

Total field costs were estimated at $2.98 billion. Noncontract costs were estimated at 35 percent of the total field cost or $1.043 billion. Summing these results in a total construction cost (before IDC) of $4.023 billion. Based on the 10-year construction period and the annual construction cost estimates, Reclamation calculated IDC at $1.131 billion for a total construction cost estimate of $5.154 billion.

The OMR&E costs occur on an annual basis. To calculate a present value, the annual costs were assumed to occur each year of the 100-year study period. The annual OM&R costs were estimated at $18.198 million ($370.1 million in present value) and the annual energy costs at $19.815 million ($403.1 million in present value) for a total annual OMR&E cost of $38.013 million ($773.1 million in present value).

The total project cost, representing the sum of total construction cost plus the present value of the OMR&E cost, equals $5.927 billion.

2.7.1.2 Benefits Analysis

This section estimates economic benefits for the following areas: (1) agriculture, (2) municipal, (3) recreation, (4) hydropower, and (5) fisheries.

As noted previously, to the extent possible, these analyses follow the criteria for measuring NED benefits defined in the *P&Gs*. A *P&G* analysis of NED benefits is a “with versus without” project comparison. Comparisons were, therefore, made between the “with project” Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives and the “without project” No Action Alternative.

Agricultural Benefits

Agricultural benefits for each alternative are realized only in drought years when the proration level is less than 70 percent. The Black Rock Alternative replaces some annual Yakima River water deliveries used for irrigated agriculture with Columbia River water. This Columbia River water exchange provides enough water so that all Yakima River basin entities with proratable irrigation entitlements will receive a proratable water supply of not less than 70 percent of their entitlements in dry years.

Methodology.—The agricultural benefits are based on (1) the cropping pattern for both with and without the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives, (2) the benefit unit value per acre for each crop, and (3) the probability of occurrence of dry years (below a 70-percent proration). Each of these is discussed below.

Reclamation's Yakima Agricultural Impact (YAI) model, developed by the Technical Service Center Economics Group, estimates the crop acreages for (1) the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives and (2) the dry years without the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives. The model relies on the Yakima RiverWare model to estimate the water supply. This analysis assumes that future dry years will follow the same pattern as those experienced in the 25-year period of record (1981-2005).

The cropping acreages estimated by the YAI model are based on the following water data supplied by the Yak-RW model. Yak-RW model results show that the water supply falls under the 70 percent threshold in 5 years out of the 25-year period of record (table 2.13) under the No Action Alternative.

The YAI model estimates the changes in cropping acreages for seven irrigation districts based on the available water supply. The decision to include these districts in the YAI model is based on the availability of Reclamation Crop Reports. The districts included in the YAI are shown in table 2.50, along with their water entitlements.

Table 2.50 Water entitlements by district

Entity	Proratable water entitlement (acre-feet)	Nonproratable water entitlement (acre-feet)
Kittitas Reclamation District	336,000	0
Roza Irrigation District	375,000	0
Subtotal	711,000	0
Sunnyside Division	142,684	315,836
Wapato Irrigation Project	350,000	305,613
Union Gap Irrigation District	4,642	20,697
Yakima Valley Canal Company	4,305	23,720
Yakima-Tieton Irrigation District	38,181	75,868
Subtotal	1,961,812	741,734
Other proratable water entitlements	29,062	
Total all proratable water entitlements	1,279,874	

Source: Reclamation (2002a).

Benefit Values.—A *P&G* analysis of NED agricultural benefits is a "with and without" project comparison that identifies the change in net farm income related to a change in crop acreage while maintaining the same cropping pattern. The YAI model aggregates the crops grown in the Yakima Project districts into representative crops and their acreages. This aggregation is based on the percent of total harvested acres that each crop represents and the availability of supporting data including yields, production costs, and prices.

Crop benefit unit values, based on net farm income (gross income minus production costs), were estimated using a farm budget methodology for the crops grown within the study area. The crops selected are based on production records collected by Reclamation and USDA's National Agricultural Statistics Service (NASS) and the availability of crop enterprise budgets published by Washington State University (WSU). Information on juice grapes was not available when the benefit unit values were estimated, but will be included in the final benefit analysis. This analysis assumes that juice grapes have the same benefit as wine grapes.

Crop benefit unit values, calculated in a previous study, are applied to the cropping acreages estimated by the YAI model to estimate the NED agricultural benefits.

Probability of Dry Years.—Because benefits only accrue in dry years below the 70-percent threshold, the probability of a dry year below the 70-percent level was applied to the total benefit value for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives. The probability used in this analysis assumes that, under the No Action Alternative, dry years occur 5 years out of the 25 years included in the period of record (1981-2005). Because the benefits in each of the 5 dry years vary depending on the proration percentage, an annual probability of .04 (1 out of 25 years) was applied to each annual benefit estimate.

Results.—

Black Rock Alternative. Table 2.51 presents the results of the agricultural benefits analysis by alternative for those districts that would benefit from the alternatives. It should be noted that not all the districts would benefit because they receive nonproratable water. The present value of the 100-year stream of agricultural benefits equals $84.6 million (the annual equivalent is equal to $4.16 million) for the Black Rock Alternative. The majority of the benefits are experienced by the Roza Irrigation District (74.5 percent).

Wymer Dam and Reservoir Alternative. As shown in table 2.51, the present value of the 100-year stream of agricultural benefits equals $26.51 million (the annual equivalent equals $1.3 million) for the Wymer Dam and Reservoir Alternative. The majority of the benefits are experienced by the Roza Irrigation District (74.6 percent).

Table 2.51 Agricultural benefits analysis by alternative

Irrigation district	Black Rock Alternative benefits ($ million)		Wymer Dam and Reservoir Alternative benefits ($ million)		Wymer Dam Plus Yakima River Pump Exchange Alternative benefits ($ million)	
	Annual	Present value	Annual	Present value	Annual	Present value
Roza	3.10	62.97	0.97	19.78	0.97	19.78
Kittitas	0.30	6.00	0.09	1.81	0.09	1.81
Tieton	0.09	1.84	0.03	0.56	0.03	0.56
Wapato	0.45	9.07	0.14	2.86	0.14	2.86
Sunnyside	0.22	4.44	0.07	1.40	0.07	1.40
Union Gap	0.01	0.29	0.00	0	0.00	0
Total	4.16	84.60	1.30	26.51	1.30	26.51

Wymer Dam Plus Yakima River Pump Exchange Alternative. As shown in table 2.51, the benefits associated with the Wymer Dam Plus Yakima River Pump Exchange Alternative are the same as for the Wymer Dam and Reservoir Alternative. The present value of the 100-year stream of agricultural benefits equals $26.51 million (the annual equivalent equals $1.3 million). The majority of the benefits are experienced by the Roza Irrigation District (74.6 percent).

Municipal Benefits

Providing a portion of future municipal water demand is a component of the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives. The goal of each alternative is to supply 82,000 acre-feet of future municipal water demand annually to the communities in the Yakima River basin by the year 2050. Specifically, the Black Rock Alternative is expected to supply 81,100 acre-feet; the Wymer Dam and Reservoir Alternative, 79,800 acre-feet; and Wymer Dam Plus Yakima River Pump Exchange Alternative, 80,500 acre-feet. The three Joint Alternatives were designed in part to try to meet year 2050 projections of unmet municipal demand. Subtle differences between the alternatives led to the minor differences in year 2050 municipal water supply for each alternative.

Methodology.—A $235.66-per-acre-foot wholesale price of municipal water (indexed to April 2007 dollars), as obtained from a recent Reclamation report, *2006 M&I Water Rate Survey Data* (Reclamation, 2006d), was used to value the annual supply of municipal water associated with each alternative. The $235.66-value reflects the average of Pacific Northwest Region municipal water prices for the Yakima Project.

The basic assumption of this alternative cost method to valuation is that municipal water demand must be addressed. If municipal water needs are assumed to be met regardless of the selected alternative, then the benefits associated with the provision of municipal water in essence become irrelevant and the analysis can focus on the cost differentials between the various water supply provision options inherent within each alternative. In this case, it was assumed that 82,000 acre-feet

of municipal water would be provided by each of the Joint Alternatives (i.e., Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange). The No Action Alternative source of municipal water would be a water market purchase. The costs of providing 82,000 acre-feet of municipal water are reflected in the construction and annual operating costs for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives, whereas the avoided cost-benefits (i.e., avoided market purchases associated with the No Action Alternative) are presented in this section.

Because the municipal water supply target for each Joint Alternative was identified for year 2050, it was necessary to project a growth in municipal water supply for each alternative from the start of the benefit period to year 2050. Assuming each alternative would involve a 10-year construction period, and it would take some additional time to complete the planning process, the assumption was made that the benefit period would not start until the year 2020. Therefore, a projection needed to be developed from year 2020 to year 2050 for each alternative.

The 82,000 acre-feet of unmet municipal water demand in year 2050 was obtained from a report entitled *Watershed Management Plan*. This report also provided a graphic (exhibit 2-2) which depicted estimates of future total municipal water demand in years 2010, 2020, 2030, 2040, and 2050. Deducting current groundwater and surface water supply sources of 104,000 acre-feet allowed for the estimation of unmet demand in each of these years. The difference in unmet demand between each 10-year period (e.g., 2030 minus 2020) was spread equally across each year of the 10-year period (2021, 2022, . . . 2030) to develop the projection for each alternative. It was then assumed that the year 2050 municipal supply for each alternative would be provided from year 2050 to the end of the 100-year benefit period. Finally, the $235.66 value per-acre-foot estimate was applied to each annual municipal water supply estimate associated with each alternative. The resulting annual municipal values by alternative were discounted to the start of the benefit period (i.e., year 2020) and summed into a present value estimate by alternative.

Assumptions.—

- Current groundwater and surface water supply sources are sustainable at 104,000 acre-feet.

- Assuming a 10-year construction period for each Joint Alternative, municipal water supply from each Joint Alternative would not begin until year 2020.

- Municipal water supplied by each alternative would reach its maximum in year 2050 and continue at that level to the end of the period of analysis.

- Unmet municipal water demands must be provided for regardless of the selected alternative.
- For each Joint Alternative, the next best option for obtaining the needed municipal water would be a market purchase.
- The assumption was made that municipalities in search of municipal water could obtain the water at wholesale rates.

Results.—
Black Rock Alternative. The value of the growth in annual municipal water supply to 81,100 acre-feet in year 2050 and beyond was estimated to average $14.1 million annually or $286.8 million in present value over the 100-year study period for the Black Rock Alternative.

Wymer Dam and Reservoir Alternative. The value of the growth in annual municipal water supply to 79,800 acre-feet in year 2050 and beyond was estimated to average $14.0 million annually or $285.2 million in present value over the 100-year study period for the Wymer Dam and Reservoir Alternative.

Wymer Dam Plus Yakima River Pump Exchange Alternative. The value of the growth in annual municipal water supply to 80,500 acre-feet in year 2050 and beyond was estimated to average $14.1 million annually or $286.1 million in present value over the 100-year study period for the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Recreation Benefits

Impacts to recreation could potentially be quite diverse with the construction of either Black Rock or Wymer reservoirs. Including the most obvious, and possibly most significant recreation benefit occurring at the new reservoirs themselves, recreation effects could also be seen at other existing regional reservoirs and river segments due to reductions in irrigation diversions or increases of instream flows for fish habitat from the Yakima River.

Adverse recreational effects could also be experienced outside the Yakima River basin due to site substitution. In this case, site substitution refers to reductions in recreation use of sites outside the Yakima River basin as a result of the construction of new sites or quality improvements at existing sites within the basin. Given the difficulty and speculative nature of attempts to quantitatively measure the degree of possible site substitution, site substitution effects have not been included in the recreation analysis. As a result, the estimated recreation benefits may be overstated.

Recreation Benefits at Proposed Black Rock and Wymer Reservoirs.—This section analyzes the potential recreational effects at the proposed Black Rock and Wymer reservoirs. Note that both the Wymer Dam and Reservoir and Wymer

Dam Plus Yakima River Pump Exchange Alternatives would produce the same recreational effects at the proposed Wymer reservoir, but different recreational effects at the existing reservoirs and rivers within the region. (See subsequent sections for an analysis of the effects at existing reservoir and rivers.) Reclamation recreation development at new reservoirs would remain at the minimum level to maintain safety and protect resources for the first 5 years.

The proposed reservoir recreation economic methodology used estimates of recreation visitation by activity as described and presented in the "Recreational Resources" section of chapter 4. The annual visitation by activity estimates were projected over the 100-year study period based on annual growth rate assumptions, as also noted in the "Recreational Resources" section (i.e., Black Rock reservoir, 5 percent for the first 10 years and 3 percent thereafter; Wymer reservoir, 3 percent for entire study period). Recreation specialists also provided carrying capacity estimates of 700,000 for Black Rock reservoir and 200,000 for Wymer reservoir based on reservoir surface acreage at high pool, boating acreage requirements, nonboating visitation estimates, associated parking lot size and turnover, and the length of the high- and low-use recreation seasons. The carrying capacity estimates were assumed to reflect an upper bound on annual visitation and were, therefore, used to constrain the visitation growth projection.

To estimate annual recreation economic benefits by alternative, per-visit economic benefits were applied to the estimated annual visitation levels. Because economic benefits or values per visit vary by recreation activity, it was important that the visitation estimates were broken down by recreation activity. Values per visit for the activities identified in the recreation visitation analysis were obtained from a nationwide recreation valuation study (Kaval and Loomis, 2003). The Kaval and Loomis study gathered information from hundreds of recreation economic studies throughout the United States. Values per visit by activity from the Pacific Coast region were used in the analysis. Because the values were in 1996 dollars, they were updated to April 2007 dollars using consumer price indexes to be consistent with the cost estimates. The annual values were then converted to a present value before incorporating them into the BCA.

Black Rock Alternative. Table 2.52 presents the results of the visitation projection by recreation activity for the proposed Black Rock reservoir. Note that the visitation projection is constrained by the estimated carrying capacity of the reservoir (700,000 visits) in year 23 such that years 23 through 100 are assumed to be at the 700,000-visit carrying capacity. The economic valuation results are presented at the end of table 2.52. The economic values per visit by recreation activity, ranging from $20.32 for horseback riding to $81.26 for wildlife viewing, are presented, as well as the present value of the 100-year stream of recreation benefits for each activity. The economic values per visit by activity were multiplied by the estimated annual visits by activity to estimate the annual economic benefit by activity (result not shown). The annual recreation benefit by activity was then discounted to the beginning of the 100-year benefit period.

Table 2.52 Black Rock reservoir visitation projections

Year (% of total =>)	Recreation activities									Total Visits
	Boat fishing	Shore fishing	Swimming	Pic-nicking	Water skiing, jet skiing	Walking, hiking	Wildlife viewing	Horse-back riding	Off-highway vehicle riding	
	0.25	0.1	0.15	0.15	0.25	0.03	0.03	0.02	0.02	
1	62,500	25,000	37,500	37,500	62,500	7,500	7,500	5,000	5,000	250,000
2	65,630	26,250	39,380	39,380	65,630	7,880	7,880	5,250	5,250	262,530
3	68,910	27,560	41,350	41,350	68,910	8,270	8,270	5,510	5,510	275,640
4	72,360	28,940	43,420	43,420	72,360	8,680	8,680	5,790	5,790	289,440
5	75,980	30,390	45,590	45,590	75,980	9,110	9,110	6,080	6,080	303,910
6	100,000	40,000	60,000	60,000	100,000	12,000	12,000	8,000	8,000	400,000
7	105,000	42,000	63,000	63,000	105,000	12,600	12,600	8,400	8,400	420,000
8	110,250	44,100	66,150	66,150	110,250	13,230	13,230	8,820	8,820	441,000
9	115,760	46,310	69,460	69,460	115,760	13,890	13,890	9,260	9,260	463,050
10	121,550	48,630	72,930	72,930	121,550	14,580	14,580	9,720	9,720	486,190
11	125,200	50,090	75,120	75,120	125,200	15,020	15,020	10,010	10,010	500,790
12	128,960	51,590	77,370	77,370	128,960	15,470	15,470	10,310	10,310	515,810
13	132,830	53,140	79,690	79,690	132,830	15,930	15,930	10,620	10,620	531,280
14	136,810	54,730	82,080	82,080	136,810	16,410	16,410	10,940	10,940	547,210
15	140,910	56,370	84,540	84,540	140,910	16,900	16,900	11,270	11,270	563,610
16	145,140	58,060	87,080	87,080	145,140	17,410	17,410	11,610	11,610	580,540
17	149,490	59,800	89,690	89,690	149,490	17,930	17,930	11,960	11,960	597,940
18	153,970	61,590	92,380	92,380	153,970	18,470	18,470	12,320	12,320	615,870
19	158,590	63,440	95,150	95,150	158,590	19,020	19,020	12,690	12,690	634,340
20	163,350	65,340	98,000	98,000	163,350	19,590	19,590	13,070	13,070	653,360
21	168,250	67,300	100,940	100,940	168,250	20,180	20,180	13,460	13,460	672,960
22	173,300	69,320	103,970	103,970	173,300	20,790	20,790	13,860	13,860	693,160
23-100	175,000	70,000	105,000	105,000	175,000	21,000	21,000	14,000	14,000	700,000
Economic value per visit by activity (4/2007$)	49.74	49.74	30.59	72.01	63.87	26.06	81.26	20.32	45.26	
Present value of 100-year stream of benefits ($ million)	134.9	54.0	49.8	117.2	173.2	8.5	26.4	4.4	9.8	578.1

Summing the present value estimates across the various recreation activities provides the $578.1 million total discounted recreation benefit estimate for Black Rock reservoir.

Wymer Dam and Reservoir Alternative. Table 2.53 presents the results of the visitation projection by recreation activity for the proposed Wymer reservoir included within both the Wymer Dam and Reservoir and Wymer Dam Plus Yakima River Pump Exchange Alternatives. The visitation projection is constrained by the estimated carrying capacity of the reservoir (200,000 visits) in year 42 such that years 42 through 100 are assumed to be at the 200,000-visit carrying capacity. The economic valuation results are presented at the end of table 2.53. The economic values per visit by recreation activity, ranging from $26.06 for walking/hiking to $81.26 for wildlife viewing, are presented, as well as the present value of the 100-year stream of recreation benefits for each activity. Summing the present value estimates across the various recreation activities provides the $97.7 million total discounted recreation benefit estimate for Wymer reservoir.

Wymer Dam Plus Yakima River Pump Exchange Alternative. Table 2.53 presents the results of the visitation projection by recreation activity for the proposed Wymer reservoir included within both the Wymer Dam and Reservoir and Wymer Dam Plus Yakima River Pump Exchange Alternatives. As noted previously for the Wymer Dam and Reservoir Alternative, the present value of the 100-year stream of annual recreation benefit estimates across the various recreation activities sums to $97.7 million for Wymer reservoir.

Recreation Benefits at Existing Reservoirs and Rivers.—This section analyzes the potential recreational effects of each alternative at existing reservoirs and river reaches within the Yakima River basin. The following reservoirs and rivers were included in the analysis: Kachess Lake, Cle Elum Lake, Clear Lake, Bumping Lake, Rimrock Lake, Keechelus Lake, Lake Easton, Yakima River, Tieton River, Cle Elum River, Naches River, and Bumping River. Of these sites, only four showed differences in hydrologic measures (e.g., reservoir water levels and river flows) resulting in visitation impacts as compared to the No Action Alternative: Kachess Lake, Cle Elum Lake, Yakima River, and Tieton River. This section presents the results of the recreation visitation and economic valuation analysis for these four sites.

As with the proposed reservoir recreation analysis, the existing site recreation economic methodology used estimates of recreation visitation as described and presented in the “Recreation” section of “Chapter 4, Environmental Consequences.” For the existing sites, changes in recreation visitation as compared to the No Action Alternative were estimated based on differences in the number of months in which reservoir water levels or river instream flows fell within acceptable ranges. The acceptable reservoir water levels and river instream flows were obtained from a recreation survey *Yakima River Basin Reservoir and River Recreation Survey Report of Findings* (Reclamation, 2008d).

Table 2.53 Wymer reservoir visitation projections

Year (% of Total =>)	Recreation activities							Total Visits
	Canoeing, kayaking, small sailboats	Boat fishing	Shoreline fishing	Swimming	Picnicking	Walking, hiking	Wildlife viewing	
	0.2	0.1	0.25	0.15	0.15	0.1	0.05	
1	8,000	4,000	10,000	6,000	6,000	4,000	2,000	40,000
2	8,240	4,120	10,300	6,180	6,180	4,120	2,060	41,200
3	8,490	4,240	10,610	6,370	6,370	4,240	2,120	42,440
4	8,740	4,370	10,930	6,560	6,560	4,370	2,180	43,710
5	9,000	4,500	11,260	6,760	6,760	4,500	2,250	45,030
6	14,000	7,000	17,500	10,500	10,500	7,000	3,500	70,000
7	14,420	7,210	18,030	10,820	10,820	7,210	3,610	72,120
8	14,850	7,430	18,570	11,140	11,140	7,430	3,720	74,280
9	15,300	7,650	19,130	11,470	11,470	7,650	3,830	76,500
10	15,760	7,880	19,700	11,810	11,810	7,880	3,940	78,780
11	16,230	8,120	20,290	12,160	12,160	8,120	4,060	81,140
12	16,720	8,360	20,900	12,520	12,520	8,360	4,180	83,560
13	17,220	8,610	21,530	12,900	12,900	8,610	4,310	86,080
14	17,740	8,870	22,180	13,290	13,290	8,870	4,440	88,680
15	18,270	9,140	22,850	13,690	13,690	9,140	4,570	91,350
16	18,820	9,410	23,540	14,100	14,100	9,410	4,710	94,090
17	19,380	9,690	24,250	14,520	14,520	9,690	4,850	96,900
18	19,960	9,980	24,980	14,960	14,960	9,980	5,000	99,820
19	20,560	10,280	25,730	15,410	15,410	10,280	5,150	102,820
20	21,180	10,590	26,500	15,870	15,870	10,590	5,300	105,900
21	21,820	10,910	27,300	16,350	16,350	10,910	5,460	109,100
22	22,470	11,240	28,120	16,840	16,840	11,240	5,620	112,370
23	23,140	11,580	28,960	17,350	17,350	11,580	5,790	115,750
24	23,830	11,930	29,830	17,870	17,870	11,930	5,960	119,220
25	24,540	12,290	30,720	18,410	18,410	12,290	6,140	122,800
26	25,280	12,660	31,640	18,960	18,960	12,660	6,320	126,480
27	26,040	13,040	32,590	19,530	19,530	13,040	6,510	130,280
28	26,820	13,430	33,570	20,120	20,120	13,430	6,710	134,200
29	27,620	13,830	34,580	20,720	20,720	13,830	6,910	138,210
30	28,450	14,240	35,620	21,340	21,340	14,240	7,120	142,350
31	29,300	14,670	36,690	21,980	21,980	14,670	7,330	146,620
32	30,180	15,110	37,790	22,640	22,640	15,110	7,550	151,020
33	31,090	15,560	38,920	23,320	23,320	15,560	7,780	155,550
34	32,020	16,030	40,090	24,020	24,020	16,030	8,010	160,220
35	32,980	16,510	41,290	24,740	24,740	16,510	8,250	165,020
36	33,970	17,010	42,530	25,480	25,480	17,010	8,500	169,980
37	34,990	17,520	43,810	26,240	26,240	17,520	8,760	175,080
38	36,040	18,050	45,120	27,030	27,030	18,050	9,020	180,340
39	37,120	18,590	46,470	27,840	27,840	18,590	9,290	185,740
40	38,230	19,150	47,860	28,680	28,680	19,150	9,570	191,320
41	39,380	19,720	49,300	29,540	29,540	19,720	9,860	197,060
42-100	40,000	20,000	50,000	30,000	30,000	20,000	10,000	200,000
Economic value per visit by activity (4/2007 $)	31.21	49.74	49.74	30.59	72.01	26.06	81.26	
Present value of 100-year stream of benefits ($ million)	13.3	10.6	26.6	9.8	23.1	5.6	8.7	97.7

The difference in visitation estimates varied with the water year type—wet, average, or dry. To calculate an average annual difference in visitation estimate, the differences in visitation by water year type were multiplied by the probability of occurrence of each water year type (i.e., 50 percent for average year and 25 percent each for wet and dry years). Because the differences in visitation were not estimated by recreation activity, the general assumption was made that the differences in visitation would follow the current distribution of recreation by activity seen at each impacted site. Instead of estimating the difference in visitation for each site by recreation activity as was done for the proposed reservoir analysis, a weighted average economic value for each site was developed by multiplying the percent of visitation by primary recreation activity at each site (as obtained from the recreation survey) by the indexed economic values per visit by recreation activity (as obtained from the Kaval and Loomis, 2003 study). The weighted average values per visit at each site were estimated as follows: Kachess Lake, $90.28; Cle Elum Lake, $69.00; Yakima River, $53.93; and Tieton River, $31.21. The annual difference in recreation economic value by site and alternative was assumed to occur each year over the 100-year study period. This 100-year stream of annual recreation economic values was then discounted to a present value estimate. These annual values were not projected to increase over the 100-year study period because no carrying capacity estimate was available to constrain the growth in visitation. As a result, the discounted present value may be an underestimate. Accounting for the potential growth in visitation as compared to the No Action Alternative over time is an issue which may need to be addressed in subsequent analyses.

Black Rock Alternative. As shown in table 2.54, positive recreation effects are expected at Kachess Lake, Cle Elum Lake, and the Yakima River under the Black Rock Alternative. Negative effects were estimated for the Tieton River. The combined annual difference in value across all four existing sites approached $1.2 million, which converts to a discounted present value of $24.3 million. These estimates may be understated given that the visitation estimates could not be projected over time due to lack of carrying capacity information.

Wymer Dam and Reservoir Alternative. As shown in table 2.55, positive recreation effects are expected at Cle Elum Lake and the Yakima River under the Wymer Dam and Reservoir Alternative. No impacts were estimated at Kachess Lake and the Tieton River. The combined difference in value across all four existing sites was estimated at $246,200 annually, which converts to a discounted present value of $5.0 million. Again, these estimates may be understated.

Wymer Dam Plus Yakima River Pump Exchange Alternative. As shown in table 2.56, positive recreation effects are expected at Kachess Lake, Cle Elum Lake, and the Yakima River under the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Table 2.54 Differences in recreation visitation and value at existing sites under Black Rock Alternative

Site	Water year type	Difference in recreation days compared to No Action Alternative[1]							Probability	Difference in days (expected value)	Apr-07 weighted average value per day[2]	Average annual difference in value[3]	Present value of 100-year benefit stream ($ million)
		May	June	July	Aug	Sep	Oct	Total					
Kachess Lake	Wet							0	0.25	0			
	Dry		8,610	8,610				17,220	0.25	4,305			
	Average				8,610			8,610	0.5	4,305			
									Total:	8,610	90.28	777,269	15.8
Cle Elum Lake	Wet		2,736		2,736			5,472	0.25	1,368			
	Dry							0	0.25	0			
	Average							0	0.5	0			
									Total:	1,368	69.00	94,390	1.9
Yakima River	Wet			3,630	1,815		1,815	7,260	0.25	1,815			
	Dry	-667		3,630	1,815			4,778	0.25	1,195			
	Average			3,630	1,815		1,815	7,260	0.5	3,630			
									Total:	6,640	53.93	358,063	7.3
Tieton River	Wet						-2,250	-2,250	0.25	-563			
	Dry							0	0.25	0			
	Average					-1,125		-1,125	0.5	-563			
									Total:	-1,126	31.21	-35,146	-.7
Combined total										15,522		1,194,576	24.3

[1] From recreation analysis presented in chapter 4.
[2] Weighted value per visit based on current visitation by recreation activity percentages (as obtained from the recreation survey) combined with values per visit by activity (from Kaval and Loomis, 2003).
[3] Does not take into account projected population growth over the 100-year study period.

Table 2.55 Changes in recreation visitation and value at existing sites for Wymer Dam and Reservoir Alternative

Site	Water year type	Difference in recreation days compared to No Action Alternative[1]							Probability	Difference in days (expected value)	Apr-07 weighted average value per day[2]	Average annual difference in value[3]	Present value of 100-year benefit stream ($ million)
		May	June	July	Aug	Sep	Oct	Total					
Kachess Lake	None							0					0
Cle Elum Lake	Wet				2,736			2,736	0.25	684			
	Dry		-1,231					-1,231	0.25	-308			
	Average							0	0.5	0			
									Total:	376	69.00	25,943	.5
Yakima River	Wet			1,815	908		908	3,631	0.25	908			
	Dry			3,630	1,815			5,445	0.25	1,361			
	Average			1,815	908		908	3,631	0.5	1,816			
									Total:	4,085	53.93	220,284	4.5
Tieton River	None							0				0	0
Combined total										4,461		246,227	5.0

[1] From recreation analysis presented in chapter 4.
[2] Weighted value per visit based on current visitation by recreation activity percentages (as obtained from the recreation survey) combined with values per visit by activity (from Kaval and Loomis, 2003).
[3] Does not take into account projected population growth over the 100-year study period.

Table 2.56 Differences in recreation visitation and value at existing sites under Wymer Dam Plus Yakima River Pump Exchange Alternative

Site	Water year type	Difference in recreation days compared to No Action Alternative[1]							Probability	Difference in days (expected value)	Apr-07 weighted average value per day[2]	Average annual difference in value[3]	Present value of 100-year benefit stream ($ million)
		May	June	July	Aug	Sep	Oct	Total					
Kachess Lake	Wet							0	0.25	0			
	Dry		8,610	8,610				17,220	0.25	4,305			
	Average							0	0.5	0			
									Total:	4,305	90.28	388,635	7.9
Cle Elum Lake	Wet				2,736			2,736	0.25	684			
	Dry							0	0.25	0			
	Average							0	0.5	0			
									Total:	684	69.00	47,195	1.0
Yakima River	Wet			1,815	908		908	3,631	0.25	908			
	Dry			3,630	1,815			5,445	0.25	1,361			
	Average			1,815	908		908	3,631	0.5	1,816			
									Total:	4,085	53.93	220,284	4.5
Tieton River	None							0				0	0
Combined total										13,394		656,114	13.3

[1] From recreation analysis presented in chapter 4.
[2] Weighted value per visit based on current visitation by recreation activity percentages (as obtained from the recreation survey) combined with values per visit by activity (from Kaval and Loomis, 2003).
[3] Does not take into account projected population growth over the 100-year study period.

No impacts were identified for the Tieton River under this alternative. The combined difference in value across all four existing sites exceeds $655,000 annually, which converts to a discounted present value of $13.3 million. Again, recall that these estimates may be understated given that the visitation estimates could not be projected over time due to lack of carrying capacity information.

Combined Recreation Results.—This section combines the present value of the 100-year recreational benefit estimate stream at both the proposed reservoirs and the existing reservoir and river sites for each alternative.

On the one hand, this analysis fails to take into consideration population growth within the existing reservoir and river analysis (understates benefits), but on the other hand, the analysis does not take into account possible substitution from other recreation sites outside the region (overstates benefits). It is not possible to suggest whether the combined results are likely to be understated or overstated.

Black Rock Alternative. The combined recreational benefit stream for both the proposed reservoirs and the existing reservoir and river sites results in a total present value of $602.4 million ($29.6 million average annual equivalent) for the Black Rock Alternative.

Wymer Dam and Reservoir Alternative. The combined recreational benefit stream for both the proposed reservoirs and the existing reservoir and river sites

results in a total present value of $102.7 million ($5.1 million average annual equivalent) for the Wymer Dam and Reservoir Alternative.

Wymer Dam Plus Yakima River Pump Exchange Alternative. The combined recreational benefit stream for both the proposed reservoirs and the existing reservoir and river sites results in a total present value of $111.1 million ($5.5 million average annual equivalent) for the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Hydropower Benefits

The Black Rock Alternative includes the construction of two new hydropower facilities—the Black Rock powerplant and the Sunnyside powerplant. Because both the Wymer Dam and Reservoir Alternative and the Wymer Dam Plus Yakima River Pump Exchange Alternative have no hydropower generation component, the Black Rock Alternative is the only alternative that provides hydropower benefits. In addition, by pumping water up to the proposed Black Rock reservoir from the Columbia River at Priest Rapids Dam, a certain amount of power generation at Priest Rapids Dam and facilities both upstream of and downstream from Priest Rapids would be forgone. Some of the diverted water would be replaced by increased flows at the mouth of the Yakima River due to decreased irrigation diversions. This water replacement does not occur on an instantaneous basis but is accomplished on an annual basis.

Methodology.—Average annual power generation at the Black Rock and Sunnyside powerplants was estimated at about 71,671 and 125,080 megawatthours (MWh), respectively. These annual generation estimates were distributed by month based on monthly water delivery percentages and the resultant monthly generation multiplied by average monthly energy values to estimate total annual hydropower value. The average monthly energy values, as used by Bonneville Power Administration, were obtained from the *Black Rock Summary Report* (Reclamation, 2004e). The annual hydropower values were discounted to a present value based on the assumption that they would occur each year over the 100-year study period.

In addition, annual lost hydropower benefits result from the pumping of water from Priest Rapids Lake to the new Black Rock reservoir. The water which is pumped to Black Rock reservoir is no longer available to generate hydropower at Priest Rapids Dam and at downstream Federal Columbia River hydropower facilities. While there are both positive and negative effects upstream of and downstream from Priest Rapids Dam due to hydropower system reoperation, the December 2004 *Black Rock Summary Report* estimated the net result as a loss in annual hydropower benefits of $4 million. To calculate a present value, the annual costs were assumed to occur each year of the 100-year study period. This lost hydropower was deducted from the additional hydropower generated at the Black Rock and Sunnyside powerplants to estimate a net hydropower benefit.

Results.—

Black Rock Alternative. As presented in table 2.57, the hydropower generation at both plants is expected to average about 196,751 MWh annually, with a combined monthly generation ranging from a low of about 14,508 MWh in October to a high of 35,637.6 MWh in July and August. Total generation was valued at about $7.1 million annually. The present value of the 100-year stream of annual hydropower benefits was estimated at $143.9 million. The lost hydropower generation at Priest Rapids Dam and other upstream and downstream dams was estimated at $4 million annually, or $81.3 million in present value. Combining the gains and losses in hydropower value results in a positive hydropower benefit of approximately $3.1 million annually, or $62.5 million in present value. This combined hydropower benefit accrues only to the Black Rock Alternative.

Table 2.57 Hydropower benefits for the Black Rock Alternative

Month	Monthly generation (MWh)	Average energy value per month ($/MWh)	Total annual value ($ thousands)	Present value of 100-year benefit stream ($ thousands)
Black Rock powerplant				
April	7,820.0	$37.60	294.0	
May	10,742.5	$31.92	342.9	
June	12,144.0	$22.68	275.4	
July	13,689.6	$32.24	441.4	
August	13,689.6	$40.69	557.0	
September	8,832.0	$43.64	385.4	
October	4,753.3	$55.56	264.1	
Totals	71,671.1		2,560.2	52,063.0
Sunnyside powerplant				
April	11,800.0	$37.60	443.7	
May	19,509.3	$31.92	622.7	
June	21,240.0	$22.68	481.7	
July	21,948.0	$32.24	707.6	
August	21,948.0	$40.69	893.1	
September	18,880.0	$43.64	823.9	
October	9,754.7	$55.56	542.0	
Totals	125,080.0		4,514.7	91,822.0
Black Rock and Sunnyside powerplants total				
April	19,620.0		737.7	
May	30,251.9		965.6	
June	33,384.0		757.1	
July	35,637.6		1,149.0	
August	35,637.6		1,450.1	
September	27,712.0		1,209.4	
October	14,508.0		806.1	
Totals	196,751.1		7,075.0	143,885.0
Value of lost generation at Priest Rapids and other Columbia River dams			-4,000.0	-81,348.4
Net hydropower benefit			3,075.0	62,536.6

Wymer Dam and Reservoir Alternative. The Wymer Dam and Reservoir Alternative has no hydropower generation effects.

Wymer Dam Plus Yakima River Pump Exchange Alternative. The Wymer Dam Plus Yakima River Pump Exchange Alternative has no hydropower generation effects.

Fisheries Benefits

This section presents the results of the anadromous fisheries benefits analysis for salmon (i.e., spring Chinook, fall Chinook, coho) and steelhead.

The anadromous fisheries analysis focuses primarily on use values. Use values refer to values individuals obtain by using the fishery resource. In the case of anadromous fisheries, use values accrue to individuals that use/consume the fish (e.g., commercial, sport, or Tribal fishermen) and are typically based on the quantity of fish actually used (e.g., harvested/caught).

It should be noted that consideration was also given to the estimation of nonuse values. Nonuse values reflect values individuals hold for a resource even if they will never actually use it (e.g., threatened and endangered species). Yakima River steelhead are a federally listed (i.e., threatened) species and generally speaking cannot be harvested, implying little to no fishery use value. However, given steelhead were expected to be impacted by the alternatives under consideration, it was speculated the nonuse values (but not use values) may be applicable to this species. As will be discussed in a subsequent section, for various reasons mostly related to measurement, nonuse values were not included within the benefit-cost analysis. However, this does not diminish the possibility that nonuse values may indeed exist at least for the listed steelhead population. By excluding nonuse values for this threatened species, the overall fishery benefit estimate will be understated.

Fisheries Use Value.—The use value analysis represents the traditional commercial and recreational fisheries analysis found in many Reclamation benefit-cost analyses, with the added dimension of attempting to value Tribal subsistence harvest.

Methodology.—For this analysis, fish harvests were valued for the following harvest categories:

- Pacific Ocean commercial
- Pacific Ocean sport
- Lower Columbia River zones 1-5 non-Indian commercial
- Lower Columbia River zones 1-5 sport
- Columbia River zone 6 Tribal commercial

- Columbia River zone 6 Tribal ceremonial and subsistence
- Yakima River sport
- Yakima River Tribal ceremonial and subsistence

These harvest categories reflect the migratory path of Yakima River salmon. Note that the harvest category "Tribal ceremonial and subsistence," found in the Columbia River (zone 6) and the Yakima River, includes ceremonial harvest which is typically not included in BCAs because that would be akin to economically valuing Tribal spiritual beliefs. Because Storage Study biologists had no data to exclusively separate subsistence harvest from ceremonial harvest, the decision was made to value the total ceremonial and subsistence harvest using the subsistence harvest value under the assumption that the ceremonial harvest is likely to be a fairly minor portion of the total. As a result, total fishery use value benefits representing commercial, sport, and subsistence harvests may be overstated to some extent by the inclusion of ceremonial harvest.

Economic values per fish by species (e.g., coho salmon, spring Chinook salmon, fall Chinook salmon) and harvest category (listed above), as presented in table 2.58, were obtained from a detailed analysis of existing economic fishery value information as described in the *Yakima River Fishery Economics Draft Technical Report* (Reclamation, 2007g). These values were measured in April 2007 dollars to be consistent with the cost estimates. The following briefly summarizes the basis for the values: (1) commercial values were based on estimates of profitability per fish as obtained from the most recent 5 years of catch and price data; (2) sport values were obtained from a literature search; and (3) subsistence values were based on the market price per fish under the assumption that subsistence harvest could have been sold in the marketplace. While the subsistence value is considered a lower bound, the decision was made to value the harvest using a defendable lower bound rather than ignore valuing subsistence harvest altogether. As with other Columbia River Basin studies (e.g., U.S. Army Corps of Engineers, 2002), the per-fish salmon sport fishing values proved significantly higher than the other per fish values because these sport-fishing values are related to the per-trip values. The very low catch rates per trip (less than one) imply a single fish equates to the sport fishing value of several trips combined, hence the large value per sport caught fish. Note that Storage Study biologists also evaluated impacts to Yakima River steelhead populations, but given their Federal listed (threatened) status, the assumption was made that harvest of those species would be precluded.

Harvest estimates by fish species, type of harvest, and alternative were provided by Storage Study biologists. The harvest estimates were developed by applying harvest rates by species to annual estimates of returning adults by species. The harvest rates, as provided by Yakama Nation biologists, reflect current fishery management compacts and ESA restrictions for salmon and steelhead returning to the Yakima River basin. The All H Analyzer (AHA) model was used to calculate

Table 2.58 Economic values per fish by species and harvest category ($)

Harvest category	Coho salmon	Spring Chinook salmon	Fall Chinook salmon
Ocean commercial	8.07	25.57	25.57
Ocean sport	118.54	101.49	101.49
Lower Columbia River (zones 1-5) commercial	5.82	45.53	14.56
Lower Columbia River (zones 1-5) sport	304.02	304.02	304.02
Columbia River (zone 6) Tribal commercial	3.11	22.56	8.78
Columbia River (zone 6) Tribal ceremonial and subsistence	3.89	28.2	10.97
Yakima River sport	368.00	461.52	368.00
Yakima River Tribal ceremonial and subsistence	3.89	28.20	10.97

the annual number of returning adults for a 100-year period for spring Chinook, fall Chinook, coho, and steelhead, which accounts for fish produced both by the natural environment and those released from Yakima River basin hatcheries. The AHA model was developed by Washington State fishery managers as a tool to facilitate analysis of anadromous salmonid recovery strategies in the Pacific Northwest. The "H" stands for Habitat, Hatcheries, Harvest and the Hydroelectric system (of the Columbia River). The model allows the user to better understand the relationship between the 4-Hs towards developing viable salmon recovery and enhancement strategies. A more comprehensive discussion of the AHA model can be found on the U.S. Fish and Wildlife Service Web site http://www.fws.gov/pacific/Fisheries/Hatcheryreview/documents/All-HAnalyzerDraftUsersGuideAug05.pdf.

Differences in harvest by species were calculated for each of the Joint Alternative by subtracting No Action Alternative harvest levels from Joint Alternative harvest levels. Population and harvest estimates were developed on an annual basis for each year of the 100-year study period. Instead of presenting the 100-year harvest projections for each species and alternative, table 2.59 presents summary information on the range (i.e., average, high, and low) of annual incremental total harvest by species and alternative for the 100-year study period. For example, for the Black Rock Alternative, the average annual increase in total spring Chinook harvest over the No Action Alternative was estimated at 580 fish, with a range of 294 to 1,926 fish. These annual estimates of total additional harvest by alternative and fish species were then allocated across the eight harvest categories.

The economic values per fish by harvest category presented in table 2.58 were applied to the annual estimates of harvest difference by species, harvest category, and alternative to obtain annual values by species and alternative. The annual values were then discounted to a present value based on Reclamation's 2007 planning rate (4.875 percent). Finally, the discounted values by species, type of harvest, and alternative were aggregated to estimate the total fisheries use value by alternative. These fisheries use values were then included in the BCA calculation. The total fisheries use value by alternative reflects the difference in value from the No Action Alternative.

Table 2.59 Annual increment in fish harvest as compared to No Action Alternative

Salmon	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Spring Chinook			
Average	580	33	379
High	1,926	106	1,273
Low	294	17	191
Fall Chinook			
Average	2,580	133	1,479
High	9,121	460	5,519
Low	1,251	66	682
Coho			
Average	623	41	323
High	1,875	123	947
Low	304	19	150

Results.—

Black Rock Alternative. Table 2.60 presents the results of the fisheries use value analysis. The values presented in table 2.60 reflect the present value of the 100-year stream of fishery use values by alternative, fish species, and harvest category. The total present value for the Black Rock Alternative was estimated at $8.7 million. Over 90 percent of that additional fishery use value stemmed from the ocean, lower Columbia River (zones 1-5), and Yakima River sport fisheries.

Table 2.60 Discounted 100-year stream of fisheries use values by alternative ($)

Alternative	Ocean		Columbia River zones 1-5		Columbia River zone 6		Yakima River		Total
	Com-mercial	Sport	Com-mercial	Sport	Com-mercial	Ceremonial and Subsistence	Sport	Ceremonial and Subsistence	
Black Rock									
Spring Chinook	11,411	0	25,268	386,930	16,609	83,045	437,833	114,051	1,075,145
Fall Chinook	37,075	147,153	64,129	1,339,055	256,024	16,836	4,530,341	0	6,390,614
Coho	23,666	521,448	7,254	568,378	3,974	262	136,472	0	1,261,454
Total	72,152	668,601	96,651	2,294,364	276,607	100,142	5,104,645	114,051	8,727,213
Wymer Dam and Reservoir									
Spring Chinook	658	0	1,457	22,309	958	4,788	25,243	6,576	61,988
Fall Chinook	1,893	7,513	3,274	68,369	13,072	860	231,309	0	326,291
Coho	1,562	34,423	479	37,521	262	17	9,009	0	83,273
Total	4,113	41,936	5,210	128,198	14,292	5,665	265,562	6,576	471,552
Wymer Dam Plus Yakima River Pump Exchange									
Spring Chinook	7,436	0	16,466	252,147	10,823	54,117	285,318	74,322	700,631
Fall Chinook	21,703	86,143	37,541	783,882	149,877	9,856	2,652,058	0	3,741,061
Coho	12,333	271,740	3,780	296,196	2,071	136	71,119	0	657,375
Total	41,472	357,883	57,787	1,332,226	162,771	64,109	3,008,496	74,322	5,099,067

Wymer Dam and Reservoir Alternative. The total present value of the 100-year stream of fishery use values for the Wymer Dam and Reservoir Alternative was estimated at $471.6 thousand.

Wymer Dam Plus Yakima River Pump Exchange Alternative. The total present value of the 100-year stream of fishery use values for the Wymer Dam Plus Yakima River Pump Exchange Alternative was estimated at $5.1 million. As under the Black Rock Alternative, over 90 percent of that additional fishery use value stemmed from the ocean, lower Columbia River (zones 1-5), and Yakima River sport fisheries.

Fisheries Nonuse Value.—As mentioned in the introduction to this fisheries benefits section, consideration was given to the estimation of nonuse values. In their purest form, nonuse values suggest that individuals may value a resource despite the fact that they know they will never actually use the resource. For example, nonusers may be willing to pay to preserve a unique resource of national significance—a threatened and endangered species, a pristine free flowing river, a unique natural setting. Since Yakima River steelhead are currently a federally listed (i.e., threatened) species, it was deemed possible that nonuse values could be relevant to the study. From a fisheries perspective, pure nonuse values accrue only to nonharvested fish populations (e.g., threatened and endangered species).

A less strict interpretation of nonuse values suggests nonlisted harvested fish species of regional significance might also generate nonuse values, but likely to a much lesser extent. The economics literature indicates that nonuse values may be greatest when the resource is scarce or unique, when the magnitude of the resource difference is relatively large, when the resource is of national significance, and when adverse impacts are likely to be irreversible or of long duration. By diluting the idea of uniqueness (by focusing on nonlisted species) and relaxing the national significance requirement (by focusing on species of regional significance), this interpretation is likely to be met with much more resistance from the economic community. This less strict interpretation also suggests that resource users, as well as nonusers, may hold nonuse values for nonharvested nonlisted fish (e.g., spawners of a harvested population). However, for resource users, it may be difficult to separate nonuse values from future use values (i.e., users' willingness to pay to preserve the resource for future use).

Nonuse valuation is a very controversial topic. Most economists probably agree in theory with the concept of nonuse values; but, based on the previous discussion, interpretation questions exist as to which resources may actually generate nonuse values. The idea of nonuse values for less unique species of regional significance is more likely to be disputed as compared to unique species of national significance. In addition, the issue of nonuse value measurement may be even more pressing and problematic than the issue of which species generate nonuse values. Generally speaking, the most acceptable approach for estimating nonuse values would involve the use of stated preference contingent valuation

(CV) or contingent ranking/conjoint analysis (CR) surveys designed to address study-specific nonuse value questions.[13] Both of these survey-oriented approaches, especially the early CV approaches, have been severely criticized from a number of perspectives. Despite improvements in the application of these survey approaches over time, nonuse value measurement remains extremely controversial.

For various reasons (e.g., the considerable time and budget required to pursue such surveys, the lack of fish population estimates necessary to construct the willingness-to-pay questions), the nonuse value analysis attempted for the Storage Study instead investigated the use of benefits transfer techniques for nonuse value estimation. Benefits transfer attempts to make use of existing research conducted at other sites to value conditions at the study site. Initially, attempts were made to estimate a meta analysis model in which the willingness-to-pay results from previous salmon nonuse value surveys were statistically regressed on the fish population changes associated with each underlying study. The results of that modeling effort, while initially promising, ultimately proved unsatisfactory. Another effort involved the direct application of an existing salmon nonuse value model from what was considered the most applicable of the studies included within the meta analysis dataset. After investigating the details of the model, enough problems with interpretation surfaced as to make the application of the model to the Storage Study highly questionable. Because benefits transfer is fairly controversial in its own right, and the use of benefits transfer approaches for nonuse valuation have seldom been attempted, chances are that benefits transfer-based nonuse value estimates may not have been fully defensible even had they proved successful. This situation, along with the degree of controversy associated with even the preferred nonuse value survey approaches, led to the decision to leave measurement of nonuse values out of the BCA. While Reclamation currently has no binding policy with regard to the incorporation of nonuse values within a BCA, the decision to leave nonuse values out of the BCA in this case is consistent with other Reclamation studies to date which have attempted to consider nonuse values. In conclusion, Reclamation has yet to include nonuse values within a benefit-cost calculation.

Despite the fact that attempts at nonuse value estimation proved unsuccessful for this study and, therefore, the decision was made to exclude them from the BCA calculation, that does not diminish the possibility that nonuse values may indeed exist (especially for the listed steelhead populations) as well as vary with the alternatives under consideration in this study.

[13] Both approaches evaluate survey respondent willingness-to-pay for described changes in resource conditions (e.g., threatened and endangered fish populations). The CV approach directly asks valuation questions whereas the CR approach has respondents rank alternatives; both approaches provide respondents with information on before- and after-resource conditions, costs, etc., for each of the alternatives.

It should be noted that suggestions have been made in the past to use certain costs (e.g., the application of past, present, and likely future private and public expenditures of funds to preserve and recover listed species) as a proxy measure for nonuse value benefits under the assumption that those costs would not have been incurred had the benefits not at least equaled them. However, unless previous expenditures of funds had actually been made based on some sort of benefit-cost comparison, this claim of benefits at least equaling costs could not be made. In summary, costs reflect costs and do not provide an adequate measure of economic benefits.

2.7.2 Financial Feasibility

After a project is found to be economically justified, analyses are undertaken to determine if the Federal project cost outlays are recoverable from the project beneficiaries. Financial feasibility is the process of analyses identifying reimbursable and nonreimbursable financial costs and the ability to recover reimbursable costs from project beneficiaries. The analyses consist of a cost allocation and subsequent repayment analyses.

2.7.2.1 Cost Allocation

Cost allocation is used as a transitional step leading from economic evaluation to repayment analysis. Allocation is not a means of justifying an alternative or project but follows the determination of economically feasible project alternatives.

The objective of cost allocation is to equitably distribute economically justified project costs of feasible alternatives among the purposes served. The purposes allocated to can be either reimbursable or nonreimbursable based on existing legislative authority. Formulation of plans by incremental analysis normally assures that the cost of the plan increments is justifiable for each project purpose. Based on the assumptions that project formulation principles have been applied, equitable cost distribution may be obtained by preventing costs allocated to any purpose from exceeding corresponding benefits. This establishes, for reimbursable project functions, the cost base from which repayment schedules are developed.

Following are the principles of cost allocation:

- Each purpose is allocated directly, as a minimum, the identifiable separable cost (costs omitted from total project costs if one purpose is excluded) of that purpose.

- Project purposes should not be assigned costs in excess of benefits or the assigned costs should not be greater than the cost of a single purpose alternative that could likely be built as a Federal project. Thus, the lesser

of either benefits or the most likely Federal alternative costs is the justifiable expenditure or maximum allocation for a purpose.

- The costs remaining, after separable costs are identified and deducted from the justifiable expenditure, are allocated to each purpose in the same ratio as the remaining benefits.
- All costs necessary to achieve benefits claimed are included.

Based on the benefit-cost results of this analysis, benefits do not equal or exceed the costs under each of the conditions for the three alternatives; therefore, the alternatives are not economically justified. Because none of the alternatives are economically justified, a cost allocation to reimbursable and nonreimbursable purposes pursuant to acceptable methods cannot be made, and repayment requirements cannot be determined. If benefits were used in an attempt to allocate annual operating costs to determine repayment requirements, a dysfunctional allocation would result because there are insufficient benefits to justify the annual operating costs, and the entire project construction cost would remain unallocated as a non-Federal investment.

2.7.2.2 Project Repayment

A project repayment analysis usually follows the cost allocation but, in this case, because a Federal alternative has not been justified and an equitable cost allocation was not achievable, repayment of project costs was not considered.

The cost allocation equitably distributes project costs between reimbursable and nonreimbursable purposes as identified by Reclamation law and a projects authorizing legislation. Unless specifically identified in the authorizing legislation, costs allocated to irrigation water supply, municipal water supply, and power are reimbursable. A repayment study for those receiving an irrigation water supply determines their ability to pay for their allocated costs. The Reclamation Project Act of 1939 requires that water users, at a minimum, be able to pay for their allocated project's operation and maintenance costs.

2.8 Comparative Evaluation of Alternatives

The *P&Gs* outline the procedures Federal water resource agencies should use to identify, evaluate, and compare alternatives. The *P&Gs* present four accounts for the evaluation and display of that comparison. These accounts, listed at the beginning of chapter 2, are the NED, RED, EQ, and OSE. The NED account provides an evaluation of the economic justification of each alternative based on net benefits, as presented earlier in chapter 2. The *P&Gs* suggest that the study agency develop the methods to be used for the other three accounts.

The RED analysis examines how the regional and local economies are affected by each alternative. The RED analysis measures employment, industry output, and income resulting from construction expenditures, gross farm income, and recreational spending. The RED analysis is included in chapter 4. The remaining two accounts, EQ and OSE, are discussed in the following section.

A primary distinction between a NED BCA and a RED analysis is geographic. The RED analysis focuses on economic impacts to the local region, whereas NED analysis focuses on economic benefits to the entire Nation. The RED evaluation recognizes the NED benefits accruing to the local region plus the transfers of income into the region. However, because the RED analysis focuses purely on the local region, it does not take into account potential offsetting effects occurring outside the region as does the NED analysis. As a Federal agency, Reclamation must analyze the NED effects so as not to favor one area of the country over another. Reclamation also analyzes the RED effects to the local economy to provide specific information on the primary impact area. However, economic justification is determined for each Joint Alternative solely by the benefit-cost analysis and must be demonstrated on the basis of NED benefits exceeding NED costs.

In addition to the geographic differences between the analyses, the RED analysis includes not only the initial or direct impact on the primary affected industries (as does the NED analysis), but also the secondary or indirect effects on those industries providing input to the directly affected industries (referred to as the multiplier effect). This multiplier effect is not included in the NED analysis.

Finally, yet another difference between the NED and RED analyses relates to the distinction between economic impacts and economic benefits. Economic impacts measure total economic activity within a given region using such indicators as output (sales or gross receipts), income, and employment. Economic impacts stem from changes in expenditures within the region. Conversely, benefits measure economic welfare based on a net value concept. For consumers, economic welfare reflects the value of goods and services consumed above what is actually paid for them (willingness-to-pay in excess of cost—also referred to as consumer surplus). For producers or businesses, economic welfare can be estimated by gross revenues minus operating costs (profit).

While benefits and economic impacts often move in unison because they typically rise or fall with levels of production, there are many situations in which changes in benefits and economic impacts diverge. This potential for divergence, combined with the need to consider both national and regional perspectives, and the fact that different user groups are often interested in different economic measures, creates a need for both NED and RED analyses. Table 2.61 presents a summary of the results of the NED and RED analyses.

Table 2.61 Comparative display of the NED and RED accounts for the Draft PR/EIS

	No Action Alternative[1]	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
NED account				
Beneficial effects – Present value of 100-year annual benefit stream in excess of No Action Alternative ($ million)				
Agriculture	Not applicable	84.6	26.5	26.5
Municipal and industrial	Not applicable	286.8	285.2	286.1
Hydropower	Not applicable	62.5	0	0
Recreation	Not applicable	602.4	102.7	111.1
Fisheries	Not applicable	8.7	0.5	5.1
Total benefits	Not applicable	1,045.1	414.8	428.7
Adverse effects – OMR&E costs reflect present value of 100-year annual cost stream ($ million)				
Construction costs	Not applicable	4,419.9	1,053.0	4,023.0
Interest during construction	Not applicable	1,095.9	304.1	1,130.6
OM&R costs (present value)	Not applicable	206.8	22.0	370.1
Power costs (present value)	Not applicable	1,016.9	38.6	403.1
Total costs	Not applicable	6,739.5	1,417.7	5,926.8
Net benefits (total benefits – total costs)	Not applicable	(5,694.4)	(1,002.9)	(5,498.1)
Benefit-cost ratio (total benefits ÷ total costs)	Not applicable	0.16	0.29	0.07
RED account				
Construction period impacts				
Construction: Estimates reflect impacts summed over the entire 10-year construction period.				
Output/sales ($ million)	Not applicable	$2,100	$613	$1,732
Income ($ million)	Not applicable	$710	$216	$589
Employment (jobs)	Not applicable	18,667	5,677	15,539
Annual benefit period impacts				
Irrigated agriculture: Agricultural impacts only occur in years when the proration percentage falls below 70%. As a result, impacts occur periodically and not every year. Agricultural impacts occurred in 5 of the 25 years of the hydrologic record (i.e., 1987, 1993, 1994, 2001, and 2005).				
Output/sales ($ million)				
1987	Not applicable	$53.9	$16.8	$3.4
1993	Not applicable	$66.4	$45.7	$38.0
1994	Not applicable	$234.1	$14.5	$12.1
2001	Not applicable	$126.9	$81.3	$70.8
2005	Not applicable	$121.2	$22.8	$19.9
Labor income ($ million)				
1987	Not applicable	$18.4	$5.7	$1.2
1993	Not applicable	$22.7	$15.6	$13.2
1994	Not applicable	$82.6	$5.3	$4.4
2001	Not applicable	$44.2	$28.6	$25.3
2005	Not applicable	$42.2	$8.0	$7.2

Table 2.61 Comparative display of the NED and RED accounts for the Draft PR/EIS (continued)

	No Action Alternative[1]	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Employment				
1987	Not applicable	580	179	37
1993	Not applicable	716	493	407
1994	Not applicable	2,608	169	140
2001	Not applicable	1,394	902	786
2005	Not applicable	1,330	254	222
Recreation (Recreation effects were converted to an average annual basis)				
Existing sites				
Output/sales ($ million)	Not applicable	$ 0.14	$ 0.05	$ 0.09
Labor income ($ million)	Not applicable	$ 0.07	$ 0.02	$ 0.04
Employment	Not applicable	2	1	1
Black Rock reservoir				
Output/sales ($ million)	Not applicable	$ 23.6	Not applicable[2]	Not applicable[2]
Labor income ($ million)	Not applicable	$ 9.2	Not applicable	Not applicable
Employment	Not applicable	360	Not applicable	Not applicable

[1] All the economic effects were measured as a change from the No Action Alternative; as a result, No Action Alternative effects were not analyzed.

[2] Recreators at Wymer reservoir are assumed to be from the local area; therefore, no regional impacts were generated.

2.8.1 Preparing the EQ Evaluation

The EQ account was evaluated by a team of Reclamation staff using information from the analyses prepared for each of the three Joint Alternatives. Disciplines represented on the team are as follows: activity management, engineering, wildlife biology, and fishery biology. The team identified six resource categories considered to be the most important in comparing the alternatives. The team subdivided some of these resource categories and proceeded with a nominal group technique to prioritize and weight the subcategories and categories. The weights, combined with the determination of effects under each category within each alternative, provide the framework for determining the environmentally preferred alternative. Table 2.62 presents the categories, subcategories, and weights. Table 2.63 presents a summary of the results of the EQ analyses.

Table 2.62 Environmental quality resource categories and weights

Category	Weight	Subcategories	Weight	Final weight
Water resources	0.28	Prorationing	0.60	0.168
		Municipal	0.13	0.0364
		Total water supply available	0.27	0.0756
Fish	0.28	Base summer flow	0.07	0.0196
		Spring flows	0.33	0.0924
		Fish numbers	0.47	0.1316
		Flip-flop	0.13	0.0364
Vegetation	0.04	Shrub-steppe	0.67	0.0268
		Black cottonwood	0.33	0.0132
Water quality	0.32	Temperature	0.27	0.0864
		Seepage	0.73	0.2336
Threatened and endangered species	0.04	Steelhead	0.60	0.024
		Bull trout	0.40	0.016
Land use	0.04	Overall impacts	1.00	0.04
Totals	1.00			1.00

Table 2.63 Comparative display of the EQ account for the Draft PR/EIS

	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
EQ account				
Total score	0	0.66	0.37	0.61

2.8.2 Preparing the OSE Evaluation

The *P&Gs* recommend the Other Social Effects account should display and integrate information on effects from perspectives that are not reflected in the other three accounts. The study team identified three resource categories to include in the OSE account. The team subdivided two categories and used a nominal group technique to prioritize and weigh the subcategories and categories. The weights, combined with the determination of effects under each category within each alternative, provide the framework for determining the environmentally preferred alternative. Table 2.64 presents the identified categories, subcategories, and weights. Table 2.65 presents a summary of the results of the OSE analyses.

Table 2.64 OSE resource categories and weights

Category	Weight	Subcategories	Weight	Final weight
Environmental justice	0.12	Overall impacts	1.0	0.12
Recreation	0.44	Reservoir recreation	0.65	0.286
		Rafting	0.35	0.154
Public health	0.44	Mosquitoes	0.65	0.286
		Hazardous and toxic materials	0.35	0.154
Totals	1.00			1.00

Table 2.65 Comparative display of the OSE account for the Draft PR/EIS

	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
OSE Account				
Total score	0	0.57	0.44	0.17

2.8.3 Displaying the EQ and OSE Impacts from Alternatives

During the effects analysis, each team member used the degree of impact as measured by the preset indicators and off-setting factors to determine how significant each impact would be. To help compare the effects of each alternative, the team used the scale below.

0 (zero)	=	No effect
-1 or +1	=	Minor effect
-2 of +2	=	Significant effect
-3 or +3	=	Highly significant effect

To determine the final score, the team multiplied each alternative's resource category or subcategory effects score (between -3 and +3) with the category or subcategory weight. The resulting numbers reflect both the significance of the effect and the relative importance of the resource category or subcategory. The final scores indicate the relative beneficial or adverse affect on the environment or other social category. The Comparative Display of Alternatives (table 2.66) displays the final results of the EQ and OSE analyses.

Table 2.69 (at the end of this chapter) presents a summary of the effects of the Joint Alternatives on the selected resource indicators.

Table 2.66 Comparative display of alternatives

Category			Black Rock		Wymer Dam and Reservoir		Wymer Dam Plus Yakima River Pump Exchange	
EQ resource categories		**Weight**	**Significance**	**Score**	**Significance**	**Score**	**Significance**	**Score**
Water resources	Prorationing	0.168	3	0.504	1	0.168	1	0.168
	Municipal	0.0364	3	0.1092	2	0.0728	2	0.0728
	Total Water Supply Available	0.0756	1	0.0756	1	0.0756	1	0.0756
Fish	Base summer flow	0.0196	2	0.0392	0	0	3	0.0588
	Spring flows	0.0924	3	0.2772	0	0	1	0.0924
	Fish numbers	0.1316	2	0.2632	0	0	1	0.1316
	Flip-flop	0.0364	2	0.0728	1	0.0364	1	0.0364
Vegetation	Shrub-steppe	0.0268	-2	-0.0536	-1	-0.0268	-1	-0.0268
	Black cottonwood	0.0132	1	0.0132	0	0	1	0.0132
Water quality	Temperature	0.0864	0	0	0	0	0	0
	Seepage	0.2336	-3	-0.7008	0	0	0	0
Threatened and endangered species	Steelhead	0.024	1	0.024	0	0	1	0.024
	Bull trout	0.016	0	0	0	0	0	0
Land use	Overall impacts	0.04	1	0.04	1	0.04	-1	-0.04
Totals		1		0.664		0.366		0.606
OSE resource categories		**Weight**	**Significance**	**Score**	**Significance**	**Score**	**Significance**	**Score**
Environmental justice	Overall impacts	0.12	0	0	0	0	-1	-0.12
Recreation	Reservoir recreation	0.286	2	0.572	1	0.286	1	0.286
	Rafting	0.154	1	0.154	1	0.154	1	0.154
Public health	Mosquitoes	0.286	0	0	0	0	0	0
	Hazardous and Toxic Materials	0.154	-1	-0.154	0	0	-1	-0.154
Totals		1		0.572		0.440		0.166

2.9 Other Alternatives Considered but Eliminated from Further Study

2.9.1 Bumping Lake Enlargement Alternative

Enlarging Bumping Lake has been proposed at various times by Reclamation and others in the Yakima River basin since the 1950s. The proposal for Bumping Lake Enlargement consists of a new dam approximately 4,500 feet downstream from the existing dam, with an enlarged reservoir capacity of approximately 400,000 to 458,000 acre-feet. The zoned rockfill dam would be approximately 233 feet high, with a crest length of about 3,300 feet. The surface area of the enlarged reservoir would be about 4,100 acres. The existing Bumping Lake Dam would be breached. The Bumping Lake enlargement area lies at the end of a two-lane paved road some 12 miles off the Chinook Pass Highway. Goose Prairie is a small community a short distance downstream from the new damsite and would not be inundated.

In 1979, Reclamation and the U.S. Fish and Wildlife Service prepared a joint feasibility report which was approved by the Secretary of the Interior, and a *Proposed Bumping Lake Enlargement, Final Environmental Impact Statement*, was filed by Reclamation with the Council of Environmental Quality on August 23, 1979 (Reclamation, 1979). Bumping Lake enlargement was also considered as a part of the Yakima River Basin Water Enhancement Project conducted in the 1980s and early 1990s. In the mid-1980s, a 250,000-acre-foot enlargement was also considered.

Over the years, several bills have been introduced in the Congress to authorize the construction and operation of the Bumping Lake Enlargement Alternative. However, no action has been taken. This is primarily due to the concerns expressed by the environmental community through local, State, and national organizations opposed to such action.

The following environmental and social issues were raised in previous studies and are still of concern today.

The William O. Douglas Wilderness Area, approximately 170,000 acres, is adjacent to the existing Bumping Lake. None of the reservoir enlargement options that have been considered were within the Wilderness Area boundary. However, a common concern voiced was that the enlarged reservoir would be visible from various vantage points and detract from the scenic vistas and aesthetic value of the Wilderness Area through reservoir drawdown and exposure of the reservoir bottom area.

About 2,800 acres of terrestrial habitat, including approximately 1,900 acres of old-growth timber, would be inundated if Bumping Lake were enlarged to

a capacity of 400,000 to 458,000 acre-feet. Old-growth timber serves as habitat for the spotted owl, an ESA-listed endangered species.

Enlarging Bumping Lake would inundate approximately 10 miles of perennial and intermittent stream habitat downstream from the existing dam and upstream of the existing reservoir, affecting the aquatic ecosystem and fishery resources. This is compounded by the recent designation of Deep Creek and Bumping River as critical habitat for bull trout.

The larger capacity reservoir would not fill on a regular basis and would not be a reliable source of water.

Previous studies identified approximately 14 summer homes within the impact area of the enlarged reservoir. It was proposed that these summer homes would need to be relocated downstream from the new dam. A number of the owners opposed downstream relocation.

The enlarged reservoir would also inundate existing recreational facilities and approximately 9 miles of U.S. Forest Service road, plus approximately 17 miles of road that would be closed, terminating all vehicle traffic above the damsite and road access to campgrounds above the existing reservoir. In addition to the roads, about 4 miles of trails would be inundated. These actions would hamper accessibility to areas above the reservoir.

Increased traffic associated with construction activities at the new dam, including logging of the enlarged reservoir area, would have an adverse impact on the community of Goose Prairie. Further, increased recreation use at an enlarged reservoir could also adversely affect the community.

While the concept of a natural (unregulated) hydrograph was not a primary issue in the past, it has become a significant concern in recent years. Representatives of the Washington Department of Fish and Wildlife and others expressed considerable reluctance at the spring 2007 Storage Study Roundtable discussions to include an enlarged Bumping Lake as a storage alternative to be carried into the planning report and environmental impact statement phase of the Storage Study.

Figure 2.11 provides hydrographs of the estimated natural (unregulated) flow regime and the No Action flow regime of the Bumping River at RM 17.0. Currently, peak spring flows downstream from Bumping Dam parallel the natural (unregulated) flow with a “lag time” of about 20-30 days. With current capacity, Bumping Lake would fill and spill on the average about three times a year.

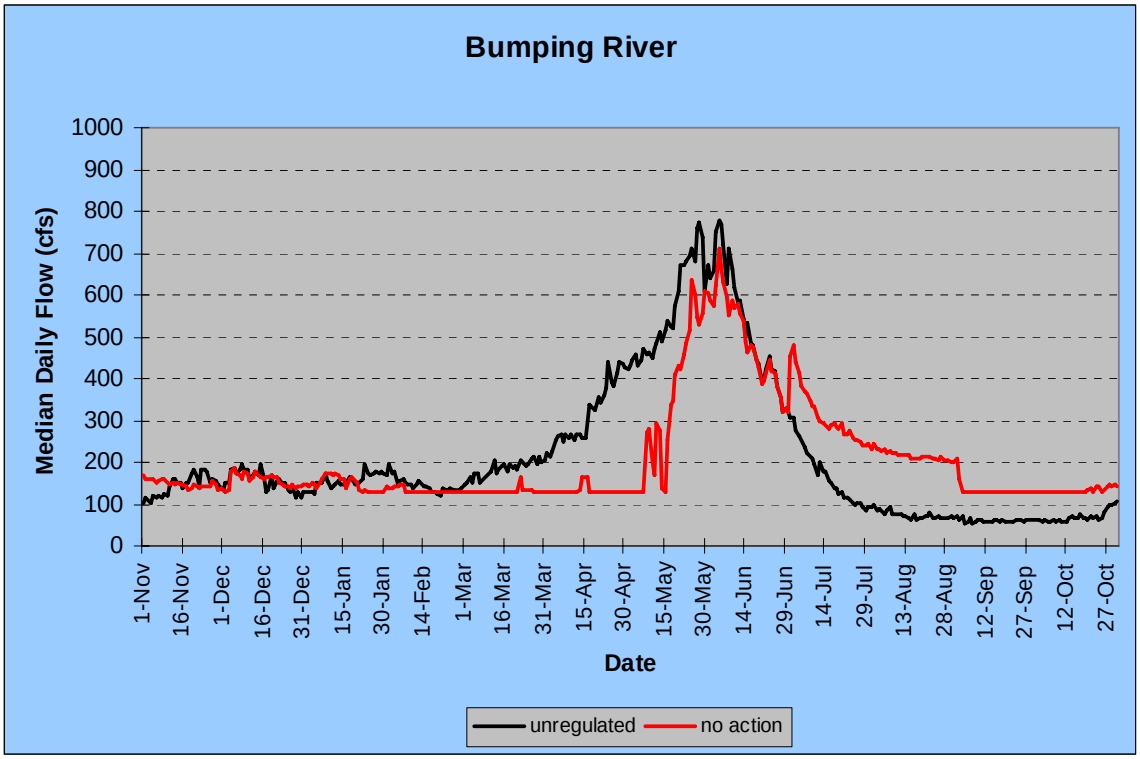


Figure 2.11 Median daily flow (cfs) in the Bumping River for unregulated and No Action Alternative flow scenarios, 1981-2005.

Spring flows in excess of those required to fill the 33,700-acre-foot Bumping Lake are currently passed downstream and diverted for irrigation purposes or flow downstream from the Sunnyside Diversion Dam. Increased Bumping Lake storage would require regulation of spring flows, thus altering the current flow regime of the Bumping and Naches Rivers to the confluence of the Tieton River. The extent of change would depend on how much of the spring peak flow is captured and stored.

An enlarged Bumping Lake could be used to help meet irrigation demands in the middle Yakima River basin subarea downstream from the confluence of the Yakima and Naches Rivers during the “storage control” period of Yakima Project operation. This could lessen the effect of the current early September “flip-flop” operation but it would require retention of some of the spring runoff from the Bumping Lake watershed in an enlarged Bumping Lake. This would also alter the current Bumping River flow regime.

For comparison, approximately 82,500 acre-feet of stored irrigation water is released from Cle Elum Lake and pumped into Wymer reservoir during the winter season under the Wymer Dam and Reservoir Alternative. This stored winter water would be released in July and August for irrigation, thus reducing

streamflows in the Cle Elum River and in the upper Yakima River to Lmuma Creek by approximately 700 cfs compared to the current operation.

The amount of Bumping Lake water available in an average water year to exchange with the upper Yakima River subbasin when flows greater than 400 cfs are captured and stored is 9,530 acre-feet; for 300 cfs, 19,200 acre-feet; and for 200 cfs, 35,300 cfs (table 2.67).

Table 2.67 Water available for an enlarged Bumping Lake and exchanged with the upper Yakima River reservoirs in an average water year

Water Year Type	Acre-feet potentially stored when flows >400 cfs	Acre-feet potentially stored when flows >300 cfs	Acre-feet potentially stored when flows >200 cfs
Average	9,530	19,200	35,300

If the maximum amount of additional Bumping Lake storage of 35,300 acre-feet is applied to the operation of Cle Elum Lake and Wymer reservoirs, it would provide a flow reduction in July and August of 295 cfs or a comparable reduction of 750 cfs for 24 days (table 2.68). Table 2.68 presents the number of flow days available for exchange between Bumping Lake and the upper Yakima River basin reservoirs for an average water year when Bumping River flows are in excess of 400, 300, and 200 cfs are captured and stored and later used for an exchange in streamflow increments of 100 to 500 cfs.

Table 2.68 Number of days available for exchange between Bumping Lake and the upper Yakima River basin

	Average water year		
cfs	Number of days riverflow >400 cfs	Number of days riverflow >300 cfs	Number of days riverflow >200 cfs
100	48	97	178
200	24	48	89
300	16	32	59
400	12	24	45
500	10	19	36

The amount of additional stored water available in average water years does not represent a meaningful amount to exchange with the three reservoirs in the upper Yakima River basin to warrant further consideration of this alternative.

Because of the reasons stated above, Reclamation has concluded that the proposal for Bumping Lake Enlargement Alternative will be eliminated from further consideration in the Storage Study.

2.9.2 Keechelus-to-Kachess to Pipeline Alternative

A pipeline extending from Keechelus Dam to Kachess Dam has been considered for the primary purpose of improving water storage in Kachess Lake. A secondary purpose is streamflow management in the upper Yakima River from Keechelus Dam to Easton Diversion Dam. The concept is to transfer water from Keechelus Lake to Kachess Lake to increase the volume of total stored water. The pipeline could also be used to bypass some of the releases from Keechelus Dam during the irrigation season in the 11-mile Yakima River reach upstream of the Kachess confluence for anadromous fishery management, primarily during September spawning.

The Keechelus-to-Kachess pipeline improves Kachess Lake storage contents in only 1 year of the 23-year period of record (1981-2003).[14] This additional stored supply amounts to only about 400 acre-feet. The capability to bypass up to a maximum of 210 cfs of summer releases from Keechelus Lake could provide a benefit to the fishery in the reach of the Yakima River from Keechelus Dam to Easton Dam. RiverWare modeling indicated all the integrated operation scenarios do not appear to move the river flow regime toward a more normative regime because of the need to transport a high volume of water from the upper Yakima River reservoirs (primarily Cle Elum Lake) to irrigation users in the middle Yakima River basin area. Moving this high volume of water during the summer and fall seasons results in high flows, which is contrary to the natural (unregulated) hydrograph. Also, the modeled integrated 70-percent operation scenario does not eliminate or significantly diminish the current flip-flop reservoir operation.

Reclamation, through its hydrologic analysis, has determined that the Keechelus-to-Kachess pipeline provides neither irrigation nor fish habitat benefits, as it only provides extra storage in 1 year out of the 23-year period of record (1981-2003) and does not move the flow regime toward the more normative regime. Also, this alternative would not contribute to achieving the municipal water supply goal. Because of its failure to adequately meet the purpose and need of the project, Reclamation will not further analyze the Keechelus-to-Kachess Pipeline Alternative in this Draft PR/EIS.

2.9.3 Rattlesnake Creek

A proposed damsite called “Devil’s Table” would be located on Rattlesnake Creek in central Washington about 6½ miles upstream of the Naches River. Reservoir size would be 43,000-58,000 acre-feet. The dam would inundate about 580 acres of land and contain about 4.9 million cubic yards of embankment material, and require relocation of some county roads.

[14] Prior to 2007, Storage Study operation studies used a 23-year period of hydrologic record of 1981-2003. This has subsequently been expanded to a 25-year period of 1981-2005.

The size of the reservoir is small, and the location within the basin is poor. This site cannot help meet the needs of the upper Naches River because it is not low enough on the Naches River system to achieve any significant benefits for reregulation of streamflows. Anadromous fish enhancement potential is only fair because of the limited amount of new storage possible and poor location on the Naches River system. Some potential anadromous fish spawning and rearing habitat would be inundated. Devil's Table would offer some cooler water temperatures for instream flows, but it would be a small amount.

Rattlesnake Creek sustains natural populations of cutthroat, rainbow, and bull trout. The remoteness of the area and presence of naturally produced fish results in a highly valued fishery because of the scarcity of such fisheries in the Yakima River basin. Impacts of a reservoir on this fishery would be highly significant, and elk and deer use of this area is substantial. Therefore, wildlife impacts and mitigation would be highly significant.

A geotechnical study was conducted in 1987 and identified serious geotechnical problems with the potential Devil's Table damsite, as well as with an alternative damsite identified at MP 4. Both locations are underlain by massive landslide deposits which could be reactivated by reservoir impoundment at these sites, causing instability of the right abutment and southern reservoir rim. Seepage through the right abutment areas at both sites could also be difficult to control. Remedial measures to reduce the seepage and the risk of slope failure are not technically practical or economically feasible.

This alternative is eliminated from further analysis due to the geologic instability of the dam and reservoir, lack of fishery benefits to the basin, and lack of benefit to the instream reregulation benefits.

2.9.4 Klickitat Diversion Project

Two slightly different storage projects have been proposed on the Klickitat River.

Project #1 was to build a "Mount Adams Dam" on the Klickitat River, including an 8-mile-long tunnel to divert the Klickitat River into the Yakima Valley near White Swan, west of Toppenish. Two aqueducts into the Yakima Valley would be included. One would run 25 miles from White Swan to Roza Canal, carrying 400,000 acre-feet from April through October; the other would carry 100,000 acre-feet of drinking water year-round to cities in the valley from White Swan to West Pasco, a distance of approximately 95 miles.

Project #2 involved building a "Wakkiacus Dam" on the Klickitat River, including a 15-mile-long tunnel to divert the Klickitat River into the Yakima Valley near the town of Klickitat, to the Hanford "300 Area" at North Richland. A 110-mile-long aqueduct would deliver 500,000 acre-feet from April through October.

This alternative is eliminated from further analysis due to the controversies associated with it. The Klickitat River is one of the few remaining free-flowing rivers in the Pacific Northwest, and construction of a mainstem dam would eliminate this. The lowermost reach of the Klickitat River (Wheeler Creek to the confluence) is designated as Wild and Scenic (1986); though this reach is downstream from the proposed damsite, disruption of sediment transport and a change in the temperature and flow regime would most likely have adverse consequences to this Wild and Scenic River reach. A dam of this size would decrease both juvenile and adult migrant survival rates, which is contrary to the fishery enhancement goals of the Yakama Nation and WDFW.

2.10 Summary Comparison of Environmental Impacts of Alternatives

Table 2.69 presents a summary of the effects of the Joint Alternatives on resources, by indicator.

Table 2.69 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Draft PR/EIS

Resource indicator measurement	Alternative			
	No Action	Black Rock	Wymer Dam and Reservoir	Wymer Dam Plus Yakima River Pump Exchange
WATER RESOURCES				
Average for water years 1981-2005 (million acre-feet) Actual difference from No Action Alternative Percentage difference from No Action Alternative				
Water supply				
April 1 TWSA	2.84	2.90 0.06 2%	2.94 0.10 4%	2.94 0.10 4%
Water distribution				
April-September Parker flow volume	0.62	0.98 0.36 58%	0.59 -0.03 -5%	0.90 0.28 45%
April-September diversion	1.91	1.47 -0.44 -23%	1.95 0.04 2%	1.64 -0.27 -14%
September 30 reservoir contents	0.30	0.43 0.13 43%	0.40 0.10 33%	0.40 0.10 33%
April-September flow volume at mouth of Yakima River	0.86	1.22 0.36 42%	0.83 -0.03 -4%	0.83 -0.03 -3%
Irrigation delivery volume shortage	-0.05	0.02 -0.03 -60%	0.05 0.00 0%	0.05 0.0 0%

Table 2.69 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Draft PR/EIS (continued)

Resource indicator measurement	Alternative			
	No Action	Black Rock	Wymer Dam and Reservoir	Wymer Dam Plus Yakima River Pump Exchange
WATER RESOURCES (continued)				
1994 dry year (million acre-feet) Actual difference from No Action Alternative Percentage difference from No Action Alternative				
Water supply				
April 1 TWSA	1.75	1.94 0.19 11%	1.76 0.01 1%	1.77 0.02 1%
Water distribution				
April-September Parker flow volume	0.25	.58 0.33 132%	0.25 0.00 0%	0.57 0.32 128%
April-September diversion	1.42	1.32 -0.10 -7%	1.44 0.02 1%	1.13 -0.29 -20%
Sep 30 reservoir contents	0.07	0.04 -0.03 -43%	0.06 -0.01 -14%	0.06 -0.01 -14%
April-September flow volume at mouth of Yakima River	0.31	0.65 0.34 110%	0.31 0.00 0%	0.31 0.00 0%
Irrigation delivery volume shortage	0.38	0.12 -0.26 -68%	0.38 0.00 0%	0.38 0.00 0%
Irrigation proration level	27%	70% 43%	29% 2%	29% 2%
NON-FEDERAL AND FEDERAL COLUMBIA RIVER HYDROPOWER				
Generation loss (average annual MW)	None	- 9.2 MW	Not applicable	Not applicable
Value of generation loss (average annual $ millions)		- $4 million		
Additional generation capacity (average annual MW)	None	52.5 MW	Not applicable	Not applicable
Pumping power requirement (average annual MW)	None	132 MW	4.8 MW	61.7 MW
Cost of pumping (average annual $ millions)	None	$50 million	$1.9 million	$19.8 million
GROUNDWATER				
Volume and direction of seepage, continuous annual flow (cfs)	No change	57 cfs – toward Columbia River	Unknown - toward Yakima River	Unknown - toward Yakima River
SEDIMENT				
Sand transport	No change	Increased	No change	Increased
Bed scour	No change	No change	No change	No change

Table 2.69 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Draft PR/EIS (continued)

Resource Indicator measurement	Alternative			
	No Action	**Black Rock**	**Wymer Dam and Reservoir**	**Wymer Dam Plus Yakima River Pump Exchange**
WATER QUALITY				
Temperature	No change	No change	No change	No change
Nutrients	No change	Decreased concentrations	No change	Decreased concentrations
Pollutants – Yakima River	No change	Decreased concentrations	No change	Decreased concentrations
Pollutants – Hanford reach	No change	Potential increase	No change	No change
VEGETATION AND WILDLIFE				
Shrub-Steppe				
Disturbance (number of acres)	None	3,850	1,055	1,055
Movement Corridors				
Disturbance (number of places animal corridors are disturbed)	None	Impedes passage over 1/3 of corridor	Negligible	Negligible
Black Cottonwood				
Regeneration	None	Increase	No change	Slight increase
Wetland Abundance and Distribution				
Number of acres disturbed	None	9	83	83
ANADROMOUS FISH				
High summer flows in the upper Yakima and Cle Elum Rivers (acres of available habitat)				
Easton reach				
Steelhead fry habitat	4.1	4.4 7.3%	4.4 7.3%	4.3 5.5%
Steelhead yearling habitat	57.9	63.9 10.4%	58.6 1.7%	58.7 1.3%
Spring Chinook fry habitat	2.5	2.4 -4.0%	2.5 0.0%	2.5 0.0%
Spring Chinook yearling habitat	47.9	52.6 9.8%	49.3 2.9%	49.0 2.3%
Ellensburg reach				
Steelhead fry habitat	2.2	2.1 -4.5%	2.1 -4.5%	2.1 -4.5%
Steelhead yearling habitat	20.2	26.1 29.2%	20.5 1.5	20.6 2.3%
Spring Chinook fry habitat	1.7	1.8 5.9%	1.8 5.9%	1.8 4.5%
Spring Chinook yearling habitat	14.9	14.6 -2.0%	13.8 -7.4%	14.5 -2.4%
Rate of change flip-flop (average cfs per day August 15 to September 14)				
Easton reach	-8 cfs	-4 cfs	-7 cfs	-6 cfs
Ellensburg reach	-78 cfs	-51 cfs	-58 cfs	-57 cfs
Lower Naches River reach	34 cfs	20 cfs	37 cfs	36 cfs

Table 2.69 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Draft PR/EIS (continued)

Resource indicator measurement	Alternative			
	No Action	Black Rock	Wymer Dam and Reservoir	Wymer Dam Plus Yakima River Pump Exchange
ANADROMOUS FISH (continued)				
Reduced spring freshets downstream from the Parker gage (percentage difference in spring season flow between the alternative and flow objective; if >=0 then target flow reached)				
Stream runoff timing	-7% Not applicable	29% Improved	-10% No change	-11% No change
Summer flows downstream from the Parker gage (acres of available habitat)				
Coho yearling habitat				
Total	63.7	64.7 1.5%	63.7 -0.1%	66.4 4.1%
Mainstem	56.7	44.2 -22.0%	56.7 -0.2%	41.8 -26.2%
Side channel	7.0	19.8 184.9%	7.0 0.6%	23.6 239.7%
Average annual fish escapement (includes harvest) numbers (natural + hatchery)				
Spring Chinook	7,189	9,066	7,294	8,428
Fall Chinook	6,893	11,128	7,112	9,321
Coho	8,475	10,242	8,591	9,392
Steelhead	2,700	4,067	2,724	3,338
RESIDENT FISH				
Summer flows in the upper Yakima and lower Naches Rivers (acres of available habitat and difference from No Action Alternative)				
Easton reach				
Rainbow trout fry habitat	5.2	5.5 5.8%	5.4 3.8%	5.5 5.8%
Rainbow trout yearling habitat	57.2	63.2 10.5%	57.9 -3.8%	54.6 -4.5%
Bull trout yearling habitat	61.9	66.1 6.8%	62.9 1.6%	62.8 1.5%
Ellensburg reach				
Rainbow trout fry habitat	2.5	2.4 -4.0%	2.4 -4.0%	2.4 -4.0%
Rainbow trout yearling habitat	19.9	25.7 28.9%	20.3 -20.1%	17.0 -9.5%
Bull trout yearling habitat	20.5	20.3 -1.0%	20.3 -1.0%	2.3 -1.0%
Lower Naches River reach				
Rainbow trout fry habitat	4.3	4.2 -0.8%	4.3 0.0%	4.3 0.0%
Rainbow trout yearling habitat	45.9	47.2 2.9%	48.1 0.2%	46.0 0.1%
Bull trout yearling habitat	64.8	65.0 0.3%	64.8 0.0%	64.6 -0.3%

Table 2.69 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Draft PR/EIS (continued)

Resource indicator measurement	Alternative			
	No Action	Black Rock	Wymer Dam and Reservoir	Wymer Dam Plus Yakima River Pump Exchange
RESIDENT FISH (continued)				
Bull trout spawner upmigration at reservoirs (inseason days impeded)				
Kachess Lake	18	15 -16.7%	18 0.0%	17 -5.5%
Keechelus Lake	37	38 2.7%	37 0.0%	37 2.7%
Rimrock Lake	3	3 0.0%	1 -66.6%	1 -66.6%
Average minimum and maximum reservoir elevation during bull trout spawning migration: July 15 – September 15 (feet)				
Kachess Lake	2,248.4 2,202.4 - 2,262.0	2,253.1 2,206.0 - 2,262.0	2,249.3 2,201.0 - 2,262.0	2,249.7 2,202.4 - 2,262.0
Keechelus Lake	2,467.3 2,427.5 - 2,513.3	2,466.6 2,427.6 - 2,514.4	2,467.6 2,427.5 - 2,514.9	2,468.0 2,427.5 - 2,514.9
Rimrock Lake	2,909.9 2,869.8 - 2,927.8	2,906.2 2,839.8 - 2,927.7	2,912.3 2,872.4 - 2,927.8	2,911.7 2,868.0 - 2,927.8
AQUATIC INVERTEBRATES				
Community changes	No change	Positive	No change	Slight benefit
THREATENED AND ENDANGERED SPECIES				
Middle Columbia River steelhead – false attraction	No effect	No effect	No effect	No effect
Bull trout – false attraction	No effect	No effect	No effect	No effect
Bald eagle	No effect	No effect	No effect	No effect
Greater sage-grouse	No effect	Moderate adverse effect	Moderate adverse effect	Moderate adverse effect
Ferruginous hawk	No effect	Low effect	No effect	No effect
Ute Ladies'-tresses	No effect	Low to moderate beneficial effects	No effect	No effect
Umtanum wild buckwheat	No effect	Low effect	No effect	No effect
RECREATIONAL RESOURCES				
Annual visitation for new facilities	No effect	400,000 - 700,000	70,000 - 200,000	70,000 - 200,000
Additional annual visitation at existing facilities (average year)	No effect	14,745	3,631	3,631
LAND USE AND SHORELINE RESOURCES				
Acquisition of private land (approximate acres)	Not applicable	13,000	4,000	110
Acquisition of public lands (approximate acres)	Not applicable	0	0	0
Easement/ROW acquisition across private land (approximate miles)	Not applicable	18	6	61

Table 2.69 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Draft PR/EIS (continued)

Resource indicator measurement	Alternative			
	No Action	**Black Rock**	**Wymer Dam and Reservoir**	**Wymer Dam Plus Yakima River Pump Exchange**
LAND USE AND SHORELINE RESOURCES (continued)				
Compatibility with existing uses	Not applicable	Local incompatibilities	Local incompatibilities	Local incompatibilities
Consistency with relevant county land use plans and policies	Not applicable	Reservoir: consistency uncertain. Other facilities: likely consistent as conditional use	Reservoir: consistency uncertain. Other facilities: likely consistent as conditional use	Reservoir: consistency uncertain. Pump exchange: locally significant inconsistencies
REGIONAL ECONOMY. See Regional Economic Development (RED) section of table 2.61				
PUBLIC SERVICE AND UTILITIES				
Exceedance of service or utility capacity (long-term impact)	Not applicable	None	None	None
Disruption of services or utilities for existing residents and landowners (short-term, construction-phase impacts)	Not applicable	High potential but mitigable	Minor potential; mitigable	Highest potential but mitigable
TRANSPORTATION				
Long term: Road/highway relocations (miles)	Not applicable	15	0	0
Short term: Road/highway crossing (instances)	Not applicable	1	1	9
AIR QUALITY				
Emissions during construction	Not applicable	Slight, short-term effect	Slight, short-term effect	Slight, short-term effect
Emissions during operation	Not applicable	No effect	No effect	No effect
NOISE QUALITY				
Noise levels during construction	Not applicable	Slight, short-term effect	Slight, short-term effect	Slight, short-term effect
Noise levels during operation	Not applicable	No effect	No effect	No effect
VISUAL RESOURCES				
Large-scale changes in visual setting	Not applicable	Visible to the public (significant)	Visible to the public (significant)	Visible to the public (significant)
Local-scale changes in visual setting	Not applicable	Yes – significant	Yes – significant	Yes – significant
HISTORIC PROPERTIES				
Number of affected properties	Not applicable	Unknown	Unknown	Unknown

Table 2.69 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Draft PR/EIS (continued)

Resource indicator measurement	Alternative			
	No Action	**Black Rock**	**Wymer Dam and Reservoir**	**Wymer Dam Plus Yakima River Pump Exchange**
HISTORIC PROPERTIES				
Number of affected properties	Not applicable	Unknown	Unknown	Unknown
INDIAN SACRED SITES				
Number of affected sites	Not applicable	Unknown	Unknown	Unknown
INDIAN TRUST ASSETS				
Number/type affected	None	None	None	None
PUBLIC HEALTH				
Hazardous and toxic materials	No change	No change	No change	No change
Mosquitoes	No change	No change	No change	No change
ENVIRONMENTAL JUSTICE				
Impact to minority and low-income populations	None	Negligible	None	Unknown