RECLAMATION
Managing Water in the West

Final Planning Report/Environmental Impact Statement

Volume 1

Yakima River Basin
Water Storage Feasibility Study

Yakima Project
Washington

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Upper Columbia Area Office
Yakima, Washington

December 2008

Mission Statements

The Mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Final Planning Report/Environmental Impact Statement
Yakima River Basin Water Storage Feasibility Study
Benton, Yakima, and Kittitas Counties, Washington

Lead Agency

U.S. Department of the Interior
Bureau of Reclamation

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State of Washington, Department of Ecology
Yakima County Public Services
U.S. Army Corps of Engineers – Seattle District
U.S. Department of the Army – Yakima Training Center
U.S. Department of Energy – Hanford Site, Office of River Protection

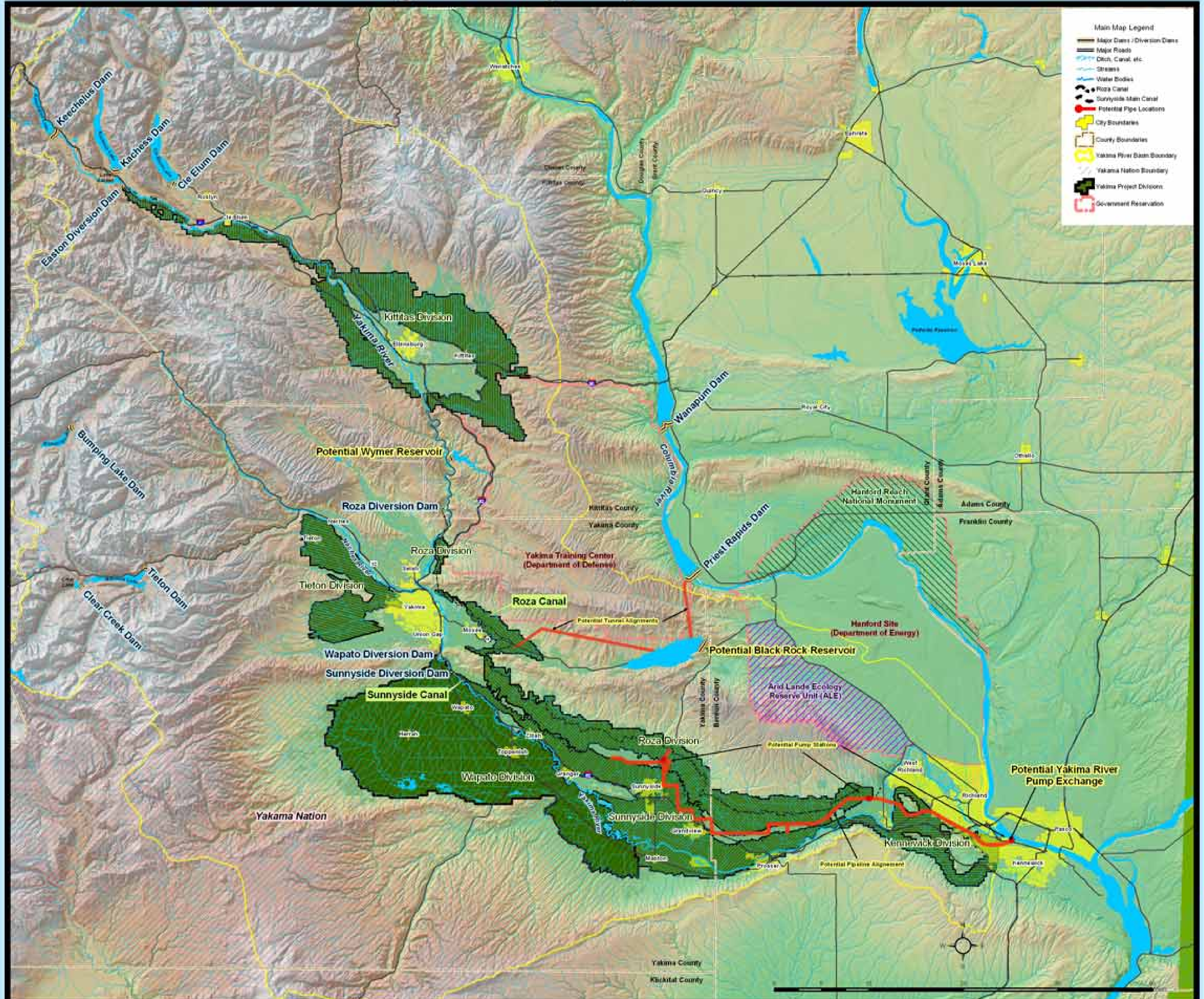
This final planning report/environmental impact statement (Final PR/EIS) examines the feasibility, acceptability, and environmental consequences of alternatives to create additional water storage for the Yakima River basin for the benefit of anadromous fish, irrigated agriculture, and future municipal water supply. A No Action Alternative and three Joint Alternatives were evaluated. The Joint Alternatives consider water storage options as directed under feasibility study authority (Public Law 108–7).

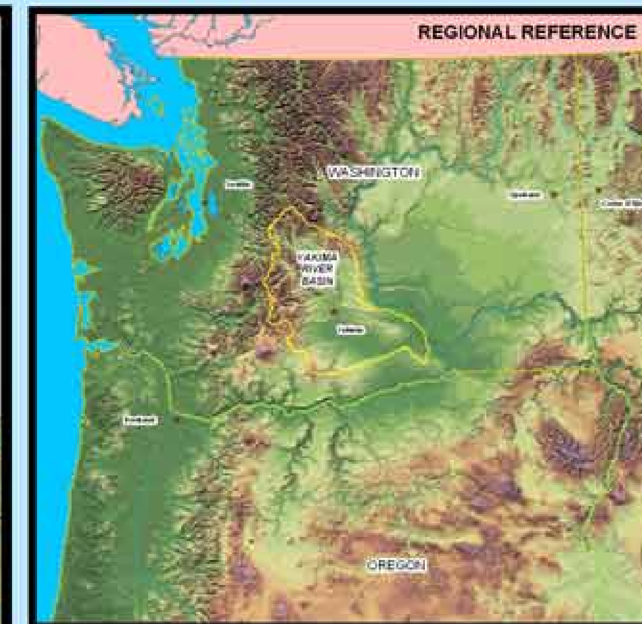
The Washington State Department of Ecology (Ecology) and the Bureau of Reclamation (Reclamation) prepared the draft planning report/environmental impact statement (Draft PR/EIS) (released in January 2008) as joint lead agencies. Some comments received on the Draft PR/EIS suggested that the water supply alternatives could not be evaluated adequately without considering fish habitat and fish passage needs as part of the alternatives analysis. Because the Reclamation could focus only on storage alternatives due to the Congressional authorization, Ecology has separated from the joint National Environmental Policy Act/State Environmental Policy Act (NEPA/SEPA) process and will proceed with a separate evaluation of water supply and management alternatives. Ecology continues to participate in this PR/EIS as a cooperating, rather than a joint lead, agency.

This Final PR/EIS was prepared in compliance with the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (*P&Gs*) and NEPA. It also provides the public review required under Executive Orders 11988 (Floodplain Management) and 11990 (Protection of Wetlands) and the National Historic Preservation Act. Results of compliance with the Fish and Wildlife Coordination Act are included in the evaluations contained in this Final PR/EIS.

Public comment will be accepted on the Final PR/EIS because it contains new information regarding seepage mitigation measures for the potential Black Rock reservoir that was not available for the Draft PR/EIS. Following a 45-day review period, Reclamation will complete its Record of Decision, which will respond to those comments and identify the alternative to be implemented. Comments are due to Reclamation by February 3, 2009.

Yakima River Basin Water Storage Feasibility Study





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 2006.

RECLAMATION
Managing Water in the West

REFERENCE GRAPHIC

ACRONYMS AND ABBREVIATIONS

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°C	degrees Celsius
°F	degrees Fahrenheit
μg/L	micrograms per liter
1-D	one-dimensional
ACHP	Advisory Council on Historic Preservation
Acquavella	*State of Washington Department of Ecology* v. *James J. Acquavella et al.*
AHA	All H: Habitat, Hatcheries, Harvest, and the Hydroelectric Analyzer
ALE Reserve	Arid Lands Ecology Reserve
APE	area of potential effect
ATV	all-terrain vehicle
BCA	benefit-cost analysis
BCAA	Benton County Air Authority
BIA	Bureau of Indian Affairs
Biology TWG	Biology Technical Work Group
BiOp	Biological Opinion
Black Rock Summary Report	*Summary Report, Appraisal Assessment of the Black Rock Alternative*
BLM	Bureau of Land Management
BMP	Best Management Practice
BOD	biochemical oxygen demand
BPA	Bonneville Power Administration
CBP	Columbia Basin Project
CCD	County Census Division
CDC	Centers for Disease Control
CDP	Census Designated Place
CFO	Conditional Final Order
CFR	Code of Federal Regulations
cfs	cubic feet per second
CLIVAR	Climate Variability and Predictability
cm	centimeters
CO	carbon monoxide
CPOM	coarse-particulate-organic-matter
CR	contingent ranking/conjoint analysis
CRBG	Columbia River Basalt Group
CRBWMP	Columbia River Basin Water Management Program
CRBWMP EIS	*Columbia River Basin Water Management Program, Final Programmatic Environmental Impact Statement*
CSRIA	Columbia Snake River Irrigator's Association

CV	contingent valuation
DAHP	Washington State Department of Archaeology and Historic Preservation
dB	decibels
dBA	A-weighted decibel
DDT	dichlorodiphenyltrichloroethane
DO	dissolved oxygen
DOE	U.S. Department of Energy
Draft PR/EIS	Draft Planning Report/Environmental Impact Statement, Yakima River Basin Water Storage Feasibility Study
DSS	decision support system
Ecology	Washington State Department of Ecology
EDT	Ecosystem Diagnostics and Treatment
EIS	environmental impact statement
EO	Executive order
EPA	U.S. Environmental Protection Agency
EPT	*Ephemeroptera Plecoptera* and *Trichoptera*
EQ	Environmental Quality
ESA	Endangered Species Act of 1973, as amended
ESU	evolutionarily significant unit
FAR	Fourth Assessment Report
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
Final PR/EIS	Final Planning Report/Environmental Impact Statement, Yakima River Basin Water Storage Feasibility Study
FLIR	forward-looking infrared
FWCA	Fish and Wildlife Coordination Act
g	acceleration of gravity
gpm	gallons per minute
Hanford Site	Hanford Nuclear Reservation
HC	Hadley-Carter
HEC-RAS	Hydraulic Engineering Center - River Analysis System
HEP	Habitat Evaluation Procedures
HSI	Habitat Suitability Index
HU	habitat units
HUD	Housing and Urban Development
I–	Interstate
ICC	Indian Claims Commission
IDC	interest during construction
IMPLAN	IMpact Analysis for PLANning
IOP	*Interim Comprehensive Basin Operating Plan for the Yakima Project*

IPCC	Intergovernmental Panel on Climate Change
ITA	Indian trust asset
k	hydraulic conductivity
Kh	horizontal hydraulic conductivity
KID	Kennewick Irrigation District
kV	kilovolts
kWh	kilowatthours
LWD	large woody debris
maf	million acre-feet
mg/L	milligrams per liter
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MP	mile post
mph	miles per hour
MPI	Max Planck Institute
MW	megawatts
MWa	megawatts (average)
MWh	megawatthours
N	nitrogen
NAAQS	National Ambient Air Quality Standards
NASS	National Agricultural Statistics Service
National Register	*National Register of Historic Places*
NED	National Economic Development
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act, as amended
NO_x	nitrogen oxide
NPPC	Northwest Power Planning and Conservation Council
NRC	National Research Council
NTU	nephelometric turbidity units
NWI	National Wetlands Inventory
NWR	National Wildlife Refuge
OHV	off-highway vehicle
OM&R	operation, maintenance, and replacement
Omnibus Act	Omnibus Appropriations Act of 2003
OMR&E	operations, maintenance, replacement, and energy
OSE	Other Social Effects
OSHA	Occupational Safety and Health Administration
P	precipitation
P	phosphorus

P&Gs	*Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*
PCB	polychlorinated bi-phenols
PCE	primary constituent elements
PEM	palustrine emergent wetlands
PFO	palustrine forested wetlands
PHA	Peak Horizontal Acceleration
PM10	particulate matter nominally 10 microns or less
PMOA	Programmatic Memorandum of Agreement
PNNL	Pacific Northwest National Laboratory
PSD	Prevention of Significant Deterioration
PSHA	Probabilistic Seismic Hazard Assessment
PSS	palustrine scrub-shrub wetlands
PUD	Public Utility District
QAPP	Quality Assurance Project Plan
RCW	Revised Code of Washington
Reclamation	Bureau of Reclamation
RED	Regional Economic Development
RM	river mile
RV	recreational vehicle
SD	standard deviation
SEPA	State Environmental Policy Act
Service	U.S. Fish and Wildlife Service
SHPO	State Historic Preservation Officer
SIAM	Sediment Impact Analysis Methods
SIP	State Implementation Plan
SMA	Washington State Shoreline Management Act of 1972
SNTEMP	Stream Network Temperature
SOAC	System Operation Advisory Committee
SPCC	Spill Prevention Control and Countermeasures
SR–	State Route
SSTEMP	Stream Segment Temperature
SSTWG	Storage Study Technical Work Group
Storage Study	Yakima River Basin Water Storage Feasibility Study
SWE	snow water equivalent
T	temperature
TMDL	total maximum daily load
TSS	total suspended solids
TVA	Tennessee Valley Authority
TWSA	total water supply available

UCAO	Upper Columbia Area Office
USGS	U.S. Geological Survey
VOC	volatile organic compounds
VRA	voluntary regional agreements
WAC	Washington Administrative Code
Watershed Council	Yakima River Watershed Council
WCRP CMIP3	World Climate Research Programme's Coupled Model Intercomparison Project – Phase 3
WDFW	Washington Department of Fish and Wildlife
WSDOT	Washington State Department of Transportation
WHO	World Health Organization
WIP	Wapato Irrigation Project
WSAI	water supply available for irrigation
WSU	Washington State University
WTWG	Water Transfer Working Group
YAI	Yakima Agricultural Impact
Yakima Appraisal Assessment	*Yakima River Basin Storage Alternatives Appraisal Assessment*
Yak-RW	Yakima Project RiverWare
YBSA	Yakima Basin Storage Alliance
YBFWRB	Yakima Basin Fish and Wildlife Recovery Board
YRBWEP	Yakima River Basin Water Enhancement Project
YTC	U.S. Department of the Army, Yakima Training Center

EXECUTIVE SUMMARY

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Introduction

The Yakima River Basin Water Storage Feasibility Study (Storage Study), as authorized by the Omnibus Appropriations Act of 2003, Public Law 108–7, examines the feasibility and acceptability of storage augmentation for the benefit of fish, irrigation, and future municipal water supply for the Yakima River basin.

The State of Washington, represented by the Department of Ecology (Ecology), and the Bureau of Reclamation (Reclamation), as joint lead agencies, prepared the Draft Planning Report/Environmental Impact Statement for the Storage Study (Draft PR/EIS), released in January 2008. The Draft PR/EIS contained Joint and State Alternatives. Because Public Law 108–7 only authorized storage as a means to augment the water supplies, Reclamation focused its analyses on storage alternatives only and did not address fish habitat restoration, fish passage, or other nonstorage water supply or management issues. The State Alternatives were nonstorage concepts that could be addressed by Ecology through its legislative authorization.

Based on comments received on the Draft PR/EIS, Ecology determined that it may not have fulfilled its requirements under Washington State law to identify and evaluate all reasonable water supply alternatives. Those comments suggested that all reasonable water supply alternatives could not be adequately evaluated without considering fish habitat and fish passage needs. Ecology has separated from the joint National Environmental Policy Act/State Environmental Policy Act (NEPA/SEPA) process and will proceed with a separate evaluation of water supply and management alternatives. That evaluation will culminate in a SEPA document. Ecology will respond to comments on the State Alternatives presented in the joint Draft PR/EIS in its Final SEPA EIS. Ecology continues to participate in this PR/EIS process as a cooperating, rather than a joint lead, agency. Reclamation finalized the PR/EIS as directed by the Congress, focusing on the water storage alternatives outlined in the Draft PR/EIS.

The purpose of the Storage Study is to evaluate plans that would create additional water storage for the Yakima River basin and assess each plan's potential to supply the water needed for fish and the aquatic resources that support them, basinwide irrigation, and future municipal demands.

The need for the study is based on the finite existing water supply and limited storage capability of the Yakima River basin. This finite supply and limited storage capability do not meet the water supply demands in all years and result in significant adverse impacts to the Yakima River basin's economy, which is agriculture-based, and to the basin's aquatic resources—specifically those resources supporting anadromous fish.

Through a process of meeting with stakeholders, Tribal, Federal, State, and local agencies and using previous investigations, Reclamation developed the goals for the Storage Study, which include:

- Improve anadromous fish habitat by restoring the flow regimes of the Yakima and Naches Rivers to resemble more closely the natural (unregulated) hydrograph. Through a collaborative process with the Storage Study Technical Work Group (SSTWG),[1] Reclamation developed nonbinding flow objectives to assist in measuring goal achievement (table ES.1).

- Improve the water supply for proratable (junior) irrigation entities by providing a not-less-than 70-percent irrigation water supply for irrigation districts during dry years, relying on diversions subject to proration. This 70-percent goal equates to 896,000 acre-feet of proratable entitlements.

- Meet future municipal water supply needs by maintaining a full municipal water supply for existing users and providing additional surface water supply of 82,000 acre-feet for population growth to the year 2050.

Table ES.1 presents the monthly flow objectives and flow volumes for the Easton reach; the Cle Elum River; and the Ellensburg, Wapato, and lower Naches River reaches.

Table ES.1 Monthly flow objectives (cubic feet per second [cfs]) and flow volumes (acre-feet) 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	2,794	3,500	2,655	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

[1] A biologist work group formed to assist on technical matters related to the Yakima River basin aquatic habitat aspects.

This Final PR/EIS combines a planning report and an environmental impact statement. The storage augmentation alternatives are referred to in this document as "Joint Alternatives." The following Joint Alternatives are considered:

- Black Rock Alternative
- Wymer Dam and Reservoir Alternative
- Wymer Dam Plus Yakima River Pump Exchange Alternative

Background

The Yakima Project's surface water supply comes from the unregulated runoff of the Yakima River and its tributaries, irrigation return flows, and releases of stored water from the five main reservoirs in the basin.[2] Only 30 percent of the average annual natural runoff can be stored in the storage system. The Yakima Project depends heavily on the timing of unregulated spring and summer runoff from snowmelt and rainfall. The spring and early summer natural runoff flows supply most river basin demands through June in an average year. The majority of spring and summer runoff is from snowmelt; as a result, the snowpack is often considered a "sixth reservoir." In most years, the five major reservoirs are operated to maximize storage in June, which typically coincides with the end of the major natural runoff. The reservoirs have a combined storage capacity of about 1.07 million acre-feet (maf).

Existing water rights, also known as entitlements, from the Yakima River cannot always be met in years with below-average runoff. Though all of the entitlement holders do not call on their full entitlement volume every year, the existing surface water supply does not presently meet all water needs in dry years. A poor water year results in prorationing[3] during the irrigation season. In addition, reduced summer and early fall streamflows inhibit migrating, spawning, and rearing conditions for anadromous fish.

Currently, only the cities of Cle Elum and Yakima obtain their municipal and domestic water from the surface waters of the Yakima River basin. Groundwater supplies the remainder of the municipal and domestic needs (83 percent) and is the preferred source for meeting future needs.

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[2] The five major reservoirs (and their acre-foot active capacities) are: Keechelus (157,800); Kachess (239,000); Cle Elum (436,900); Bumping (33,700); and Rimrock/Tieton Dam (198,000).

[3] Prorationing refers to the process of equally reducing the amount of water delivered to junior, i.e., "proratable," water right holders in water-deficient years.

Alternatives

Analytical Process

Operation studies were conducted and resource indicators were used 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 and resource indicators also were used to assess the economic justification and environmental consequences of the alternatives on many of the Yakima River basin's aquatic and terrestrial resources.

The operation studies include the use of several analytical models including Yakima Project RiverWare (Yak-RW), Sediment Impacts Analysis Methods (SIAM), Decision Support System (DSS), U.S. Geological Survey (USGS) temperature, and Ecosystem Diagnostic and Treatment (EDT) models, as well as groundwater seepage and seepage mitigation models.

The Yak-RW model is a river flow model used to assess the effectiveness 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). The SIAM model estimates bedload movement and bed scour for key stream reaches. The DSS model for the Easton, Ellensburg, Union Gap, Wapato, and lower Naches River reaches was used to estimate the amount (acres) and difference in summer rearing habitat for the spring Chinook and steelhead fry and yearling life stages under each Joint Alternative compared to the No Action Alternative. The USGS temperature model focuses on the Parker-to-Prosser Diversion Dam reach, comparing the relative change in water temperature between alternatives. The EDT model estimates the difference in salmon and steelhead abundance based on habitat quantity and quality.

In addition to analyzing how the alternatives meet the goals of the Storage Study, this PR/EIS also analyzes the impacts of the Black Rock Alternative on groundwater at the Hanford Nuclear Reservation (Hanford Site). The proposed Black Rock reservoir site is located approximately 5 miles west of the 586-square-mile Hanford Site. The Hanford Site is a former nuclear weapons production, research, and development facility owned and managed by the U.S. Department of Energy (DOE). The Hanford Site is undergoing extensive remediation and cleanup of multiple plumes of radioactive and chemical contamination in the soil and groundwater. DOE cleanup plans include treatment of approximately 53 million gallons of radioactive waste stored in 177 underground tanks for disposal in a Federal repository. Additional groundwater could make that cleanup effort more difficult. Reclamation developed the groundwater seepage model to determine seepage volume and direction from the proposed Black Rock reservoir. Reclamation then developed the seepage mitigation model to determine the effectiveness of proposed mitigation measures, such as geomembrane blankets, cutoff walls, and drain systems.

Reclamation considers the total project cost estimates provided for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives to be at an appraisal level. The cost estimate level is defined by the amount and detail of the design data collected for the designs, such as geologic, survey, and groundwater information. Current Reclamation standards require more information to confirm assumptions made about existing conditions and design parameters before Reclamation will label these cost estimates as feasibility-level estimates. Reclamation determined that time and resources were not available to gather the information needed to meet its feasibility-level design and cost estimate standards. To adequately define the costs required to construct the alternatives evaluated in this Final PR/EIS, Reclamation conducted a Monte Carlo cost-risk simulation to identify the cost-risk and critical cost drivers for the Black Rock and Wymer Dam and Reservoir Alternatives. Reclamation did not calculate a range of costs for the Wymer Dam Plus Yakima River Pump Exchange Alternative because, while it does provide some additional fish benefits when compared to the Wymer Dam and Reservoir Alternative, it does not provide more irrigation benefits than the Wymer Dam and Reservoir Alternative and it has a much higher construction cost. Additional studies and design work required to meet Reclamation standards for feasibility and final designs are outlined in this Final PR/EIS.

Through the Monte Carlo cost-risk analysis, Reclamation has determined the expected low and high total project cost estimates for the Black Rock and Wymer Dam and Reservoir Alternatives. This report displays the Monte Carlo 0%, most probable, and Monte Carlo 100% total project cost estimates and uses those estimates in the benefit-cost analysis. The total project cost is the amount required from Federal and non-Federal funding sources to construct the alternative.

Because resources in the Storage Study area are numerous and complex, potential effects on some resources were evaluated using representative indicators. Resource indicators are considered to be the key attributes (or measurements) specific to each resource. For example, rather than analyzing all fish populations, certain species were selected to provide a focused analysis of the effects of the alternatives.

Joint Alternatives

The Joint Alternatives addressed in this document were developed via processes that conform to the *Economic and Environmental Principles and Guidelines for Water and Related Land Resource Implementation Studies* (*P&G*s). The alternatives are then compared using the four accounts—National Economic Development, Regional Economic Development (RED), Environmental Quality (EQ), and Other Social Effects (OSE)—to facilitate evaluation and to display effects of the alternatives.

Feasibility studies conducted by Reclamation, such as the Storage Study, 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 in regional income and regional employment, anadromous fish habitat improvements, and improved urban and community attributes as shown in the RED, EQ, and OSE accounts, respectively.

No Action Alternative (Preferred Alternative)

The No Action Alternative is intended to represent the most likely future expected in the absence of constructing additional storage, against which all action alternatives are measured. The No Action Alternative includes future implementation of water conservation measures and water acquisitions as proposed under Title XII of the Act of October 31, 1994, which established the Yakima River Basin Water Enhancement Project. The water conservation measures included in the No Action Alternative are those plans submitted by irrigation entities under the Basin Conservation Program that are currently being constructed or considered for future implementation with funding from the Basin Conservation Program or from other sources.

The No Action Alternative includes construction of new facilities such as reregulation reservoirs, pumping plants, pipelines, etc., along the alignment of the existing facilities. The costs of the No Action Alternative would be the same under all alternatives; therefore, the costs of implementing the No Action Alternative do not affect the economic analysis.

Accomplishments

Instream Flows Provided.—The SSTWG established instream flow objectives for wet, average, and dry water years. For simplicity, the monthly flow objectives were grouped by season—spring (March–June); summer (July–October); and winter (November–February)—and were expressed in terms of total acre-feet of water required to meet the combined monthly flow objective for each season. The seasons are based on the general life history pattern of steelhead and salmon in the Yakima River basin. Table ES.2 presents these seasonal flow volume objectives (acre-feet) and modeled seasonal flow volumes (acre-feet) provided under the No Action Alternative at the Ellensburg reach (Umtanum gage) and Wapato reach (Parker gage) in an average water year. Flows at the Ellensburg and Wapato reaches represent general conditions in the upper and middle Yakima River, which are the reach areas most influenced by the Storage Study alternatives.

Table ES.2 Seasonal flow volume objectives (acre-feet) and modeled seasonal flow volumes (acre-feet) at the Umtanum and Parker gages in an average water year

Flows	Umtanum gage			Parker gage		
	Spring	Summer	Winter	Spring	Summer	Winter
Flow volume objective	636,175	297,500	280,385	717,448	309,400	490,012
No Action Alternative	585,335	601,322	280,385	445,928	159,919	490,012
Black Rock Alternative	675,962	460,431	322,529	881,588	311,415	526,985
Wymer Dam and Reservoir Alternative	610,142	540,142	318,324	434,352	160,178	478,654
Wymer Dam Plus Yakima River Pump Exchange Alternative	612,475	541,831	318,329	599,914	355,487	478,834

Exceeding the spring and winter seasonal flow volume objectives at the Umtanum and Parker gages is acceptable. However, at the Umtanum gage, maintaining flows at or close to the summer seasonal flow objective is considered ideal; while, at the Parker gage, falling below the flow objective is considered detrimental.

In addition, a natural (unregulated) flow regime for the Yakima, Naches, Cle Elum, Bumping, and Yakima-Tieton Rivers was developed by modeling the 25-year period of record (1981–2005) for the river system without the existing Yakima Project storage reservoirs, diversions, and associated return flows. This flow regime also was used in developing instream flow water supply goals.

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 6 years, the proration level is better under the No Action Alternative than under the current operation; however, in 1994, the third year of the 3-year dry cycle of 1992–94, it is not. Table ES.3 presents the proration level for the 6 dry years for the No Action Alternative as compared to the current operation.

Table ES.3 Irrigation proration level for the No Action Alternative compared to the current operation for the 25-year period of record (1981–2005)[1]

Water year	Proration level (percent)		
	Current operation	No Action Alternative	Difference under No Action Alternative
1987	64	69	+5
1992	68	70	+2
1993	56	57	+1
1994	28	27	-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 3-year dry cycle, the difference in the proration level between the No Action Alternative and the current operation is negligible and is due to rounding of the Yak-RW model results.

Municipal Water Supply Provided.—The municipal water supply need would be satisfied by the communities' acquisition of water rights from existing water right holders.

Black Rock Alternative

The Black Rock Alternative involves a diversion and partial exchange of Columbia River water for Yakima Project water currently diverted by 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. The Sunnyside Division Board and Yakima-Tieton Irrigation District have indicated they do not desire an additional dry-year proratable supply; however, Sunnyside is willing to participate in an exchange.

Water from the Columbia River would be pumped from Priest Rapids Lake any time that:

(1) Columbia River water is available in excess of the target flows contained in the National Marine Fisheries Service's Biological Opinion and pumping withdrawals are consistent with actual operating decisions during in-season management.

(2) Storage space is available in a Black Rock reservoir, except during July and August, when no Columbia River withdrawals would occur. In addition, the State of Washington, as 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).

The operation objective is to maintain Black Rock reservoir at full active capacity (1.3 million acre-feet) to ensure the water exchange can be effected. Stored water would be conveyed to the lower Yakima Valley and delivered to Roza and Sunnyside's existing canals. Yakima Project water, currently diverted from the Yakima River by these two water exchange participants, would not be diverted; the freed-up water instead would be used to meet the Storage Study goals. Reclamation has determined that the water exchange would meet the goals of the Storage Study.

Reclamation also has concluded that the Black Rock Alternative is technically viable, including the ability to withstand expected seismic activity. The dam design has been selected to withstand anticipated ground shaking and maintain the ability to contain the reservoir behind it. Although additional study of site seismicity is warranted to better understand the response of the damsite, Reclamation's preliminary seismic hazard analysis is conservative and is consistent with the present scientific understanding of earthquake activity associated with the Yakima Fold Belt.

Through the groundwater seepage and seepage mitigation modeling, Reclamation has determined that, while most of the seepage flows east toward the Hanford Site, the groundwater seepage from Black Rock reservoir could be intercepted before it reaches the western boundary of the Hanford Site. Reclamation also has prepared designs and cost estimates of features to intercept and convey the seepage away from the Hanford Site. Model results suggest these mitigation measures effectively would eliminate nearly all impacts to groundwater conditions at the Hanford Site and eliminate any impacts to the existing contaminants at the site.

The total project cost for the Black Rock Alternative ranges from $4.95–7.73 billion (Monte Carlo 0% cost estimate to Monte Carlo 100% cost estimate) with a most probable cost estimate of $5.69 billion (April 2007 prices). The total project cost is the estimate to construct the Black Rock Alternative features including the noncontract costs. The annual operation, maintenance, replacement, and energy costs are estimated at $60.2 million, including pumping energy costs of $50 million.

Accomplishments

Instream Flows Provided.—Table ES.2 presents seasonal flow volumes provided under the Black Rock Alternative.

Dry-Year Proratable Irrigation Water Provided.—Table ES.4 presents the irrigation proration level for the 6 dry years in the 25-year period of record (1981–2005). The irrigation water supply goal is met in all years, including 1994, the third year of the 3-year dry cycle.

Table ES.4 Irrigation proration level under the Black Rock Alternative compared to the No Action Alternative for the 25-year period of record (1981–2005)

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

Model results for 1994 show that the Black Rock Alternative would have provided approximately 400,000 acre-feet of additional proratable water compared to the No Action Alternative. Of the four largest divisions, the additional proratable water supply that would have been provided is approximately as follows: Wapato, 125,000 acre feet; Kittitas, 113,000 acre-feet;

Roza, 125,000 acre feet; and Sunnyside, 34,000 acre feet. The Black Rock Alternative would have provided an additional 280,000 acre-feet of flow in April–June downstream from the Parker gage and an additional 40,000 acre-feet in July–September when compared to the No Action Alternative.

Municipal Water Supply Provided.—The average annual municipal water supply provided under the Black Rock Alternative for the 25-year period of record (1981–2005) is 81,100 acre-feet. The municipal water supply available in 1994, the third year of the 3-year drought cycle, is 79,000 acre-feet.

Wymer Dam and Reservoir Alternative

The Wymer Dam and Reservoir Alternative involves construction of an off-channel storage facility on Lmuma Creek, approximately 8 miles upstream of Roza Diversion Dam. Wymer reservoir would have an 162,500-acre-foot active capacity filled by pumping water from the Yakima River and would release water back to the Yakima River by gravity. For operational purposes, Wymer reservoir storage space is divided into two components:

(1) 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 (withdrawn from the Yakima River October 1–May 31 from Cle Elum Lake releases).

(2) 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 (withdrawn January 1–March 31 when Yakima River flows at the pumping plant are in excess of 1,475 cfs).

The irrigation, instream flow, and municipal water supply goals are the same as for the Black Rock Alternative description.

The total project cost for the Wymer Dam and Reservoir Alternative ranges from $867 million–1.34 billion (Monte Carlo 0% cost estimate to Monte Carlo 100% cost estimate) with a most probable cost estimate of $1.02 billion (April 2007 prices). The total project cost is the estimate to construct the Wymer Dam Alternative features, including the noncontract costs. The annual operation, maintenance, replacement, and energy costs are estimated at $3 million, including pumping energy costs of $1.9 million.

Accomplishments

Instream Flows Provided.—Table ES.2 presents seasonal flow volumes provided under the Wymer Dam and Reservoir Alternative.

Dry-Year Proratable Irrigation Supply Provided.—Table ES.5 presents the proration level for the 6 dry years in the 25-year period of record (1981–2005).

The Wymer Dam and Reservoir Alternative proration level is better than under the No Action Alternative in all years, including 1994, the third year of the 3-year dry cycle. The proration level is better primarily because, 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 provides the opportunity for subsequent refill of some of the vacated Cle Elum Lake storage space and creates specific carryover storage in Wymer reservoir to improve the proratable water supply in dry years.

Table ES.5 Irrigation proration level for the Wymer Dam and Reservoir and Wymer Dam Plus Yakima River Pump Exchange Alternatives compared to the No Action Alternative for the 25-year period of record (1981-2005)

Water year	Proration level (percent)		
	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

Municipal Water Supply Provided.—The average annual municipal water supply provided under the Wymer Dam and Reservoir Alternative for the 25-year period of record (1981–2005) is 79,800 acre-feet. The municipal water supply available for the Wymer Dam and Reservoir Alternative in 1994, the third year of the 3-year drought cycle, is 68,000 acre-feet.

Wymer Dam Plus Yakima River Pump Exchange Alternative

The Wymer Dam Plus Yakima River Pump Exchange Alternative couples Wymer dam and reservoir with a pump exchange component. The pump exchange component involves a "bucket-for-bucket" exchange of up to 1,050 cfs that would not be diverted by Roza and Sunnyside but would remain in the Yakima 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, beginning in mid- to late March and continuing through the irrigation season of April–October. The water supply for the Wymer dam component of this alternative would be obtained from the Yakima River in the same manner and quantities described for the Wymer Dam and Reservoir Alternative.

The total project cost for the pump exchange component was estimated at $4.07 billion (April 2007 prices). The total project cost is the estimate to construct the Wymer Dam Plus Yakima Pump Exchange Alternative features, including the noncontract costs. The annual operation, maintenance, replacement, and energy costs are estimated at $38 million, including pumping energy costs of $20 million.

Accomplishments

Instream Flows Provided.—Table ES.2 presents seasonal flow volumes provided under the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Dry-Year Proratable Irrigation Supply Provided.—This is the same as for Wymer Dam and Reservoir Alternative.

Municipal Water Supply Provided.—This is the same as for Wymer Dam and Reservoir Alternative.

Resource Analysis

Following is a narrative summary of the effects of the Joint Alternatives on key resources that likely would be affected by the alternatives. Table ES.6, at the end of the Executive Summary, presents summaries of impacts on all resources evaluated in the Final PR/EIS.

Water Resources

No Action Alternative

Under the No Action Alternative, model results show the hydrograph is little changed from the current operation. Winter and spring flows throughout the systems are essentially unchanged as a result of water conservation, which allocates two-thirds of conserved irrigation water to instream flows and one-third to irrigation. Summer flows increase slightly in some reaches, mostly downstream from the Parker gage, as water that currently is released from storage and diverted downstream for irrigation remains instream to meet the higher target flows.

Because conservation is achieved by improving efficiency that reduces return flow, the effects are limited to the reaches where conservation occurs. Downstream from those reaches, there is no effect.

Black Rock Alternative

The Black Rock Alternative adds 1.3 million acre-feet of active storage capacity to the Yakima Project to bring the total storage capacity to 2.37 million acre feet. Model results also show an improvement in the Yakima Project water supply over the 25-year period of record (1981–2005) when compared to the No Action Alternative; the dry-year proratable irrigation water supply goal is met in all years. In general, the Black Rock Alternative also provides the greatest increase in spring flows at the Parker gage and the greatest reduction in summer flows in the upper Yakima River compared to the two Wymer Alternatives. Winter flows are generally higher under the Black Rock Alternative than under all the other alternatives.

Wymer Dam and Reservoir Alternative

The addition of the Wymer Dam and Reservoir Alternative would increase the Yakima Project total active storage capacity from 1,070,700 to 1,233,200 acre-feet, respectively. In general, spring flows at the Parker gage are similar to those under the No Action Alternative, while summer flows at the Parker gage are somewhat higher than under the No Action Alternative. Summer flows in the upper Yakima River are similar under the two Wymer Alternatives, with a reduction in summer flows that falls between the Black Rock and No Action Alternatives. Model results show an improvement in the Yakima Project water supply over the 25-year period of record (1981–2005) when compared to the No Action Alternative; the dry-year proratable irrigation and municipal water supply goals of 70 percent are met in 2 of the 6 years.

Wymer Dam Plus Yakima River Pump Exchange Alternative

This operation would improve the aquatic habitat of the Yakima River by leaving some of the water in the river that otherwise would have been diverted by Roza and Sunnyside. In general, the Wymer Dam Plus Yakima River Pump Exchange Alternative provides higher 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 highest summer flows of all the alternatives. Summer flows in the upper Yakima River are identical to those under the Wymer Dam and Reservoir Alternative, with a flow reduction that falls between that of the Black Rock and No Action Alternatives. Model results show improvement in the Yakima Project water supply over the 25-year period of record (1981–2005) when compared to the No Action Alternative; the dry-year proratable irrigation and municipal water supply goals of 70 percent are met in 2 of the 6 years.

Water Quality

No Action Alternative

The No Action Alternative would have no effect on water quality in Yakima River reaches.

Black Rock Alternative

Analysis shows no effect, either adverse or beneficial, on water quality in the Columbia River resulting from the withdrawal of water for pumping.

Seepage from Black Rock reservoir should not affect Columbia River water quality because mitigation measures would be constructed to intercept and convey most of the seepage away from the Hanford Site to the Yakima River. The seepage would be conveyed to the Yakima River via pipeline and would not adversely affect Yakima River water quality due to the relatively small percentage of seepage water compared to the Yakima River flows. Modeling results show that the only seepage from Black Rock reservoir that would reach the Hanford Site would be in deep basalt layers. Seepage in those layers could not mobilize contaminants in the vadose zone and carry them to the Columbia River.

In the Yakima River, higher flows in the lower river during the summer should provide improved water quality conditions relative to nutrients, dissolved oxygen, and dichlorodiphenyltrichloroethane (DDT).

Wymer Dam and Reservoir Alternative

In the Yakima River, in wet and average years, there likely would be beneficial cooling downstream from the Wymer reservoir discharge point during summer and fall. In dry years, there may be some slight warming of Yakima River temperatures during August. Mitigation measures are proposed to monitor water quality parameters to prevent releases of warm or otherwise low-quality water into the Yakima River from Wymer reservoir.

Wymer Dam Plus Yakima River Pump Exchange Alternative

Effects on water quality under the Wymer Dam Plus Yakima River Pump Exchange Alternative would be the same as under the Wymer Dam and Reservoir Alternative. In the middle and lower Yakima River, higher summer flows at the Parker gage would provide water quality improvements as a result of dilution.

Vegetation and Wildlife

No Action Alternative

The No Action Alternative would have no effect on shrub-steppe habitat, movement corridors, and black cottonwoods when compared to the current condition.

Black Rock Alternative

The Black Rock Alternative would impact, both directly and indirectly, approximately 3,850 acres of shrub-steppe habitat, which would affect the sage-grouse population by reducing available shrub-steppe habitat and disturb more than one-third of animal movement corridors. This alternative would increase black cottonwood regeneration.

Wymer Dam and Reservoir Alternative

The Washington Department of Fish and Wildlife has identified the area around the proposed Wymer dam and reservoir as core wintering habitat for bighorn sheep and core habitat for mule deer; therefore, this alternative would have an adverse effect on shrub-steppe habitat and movement of bighorn sheep and mule deer when compared to the No Action Alternative. This alternative would generally have a negligible or slight effect on black cottonwoods when compared to the No Action Alternative.

Wymer Dam Plus Yakima River Pump Exchange Alternative

Effects on vegetation and wildlife under the Wymer Dam Plus Yakima River Pump Exchange Alternative would be the same as under the Wymer Dam and Reservoir Alternative.

Anadromous Fish

No Action Alternative

Under the No Action Alternative, model results show that the average rate of change in daily flow and the summer rearing habitat in the upper Yakima River basin are essentially the same as under the current condition. Therefore, no effect is expected on upper Yakima River anadromous salmonid rearing under the No Action Alternative compared to the current condition. However, compared to the current condition, the somewhat greater spring flows downstream from the Parker gage could improve anadromous salmon smolt outmigration survival through the middle and lower Yakima River. The greater channel velocity during summer in the lower Yakima River would result in habitat losses in the main channel. The Wapato flood plain flow-to-habitat relationship for summer rearing coho suggests the increase in summer flow due to conservation may result in a slight decrease in overall habitat area because of an increase in mainstem channel water velocity. However, the net loss of coho rearing habitat attributed to the mainstem may be compensated by higher quality habitat gained in the side channels, even though the quantity gained would be less than what was lost in the mainstem.

Black Rock Alternative

Compared to the No Action Alternative, differences in flow in the Yakima River under the Black Rock Alternative are the greatest of the three Joint Alternatives. Spring flows are greater throughout the system, while summer flows in the middle and lower Yakima River are substantially greater as a result of being able to meet higher target flows at the Parker gage because of a greater available water supply for instream flow augmentation. These differences generally would benefit anadromous fish.

Of the Joint Alternatives, the Black Rock Alternative would provide the greatest increase in steelhead and spring Chinook summer rearing habitat in the Easton reach, which potentially would equate to an increase in juvenile survival and the ability to accommodate more summer rearing fish. For similar reasons, the Black Rock Alternative appears most beneficial to steelhead yearlings in the Ellensburg reach.

In the lower Yakima River, the stream runoff pattern is better under the Black Rock Alternative than under the No Action Alternative, as the high flows continue into April, May, and June when most smolt migration is occurring. These greater flows should increase overall smolt outmigration survival. However, the summer flows downstream from the Parker gage do not appear to result in a significant change in the amount of coho summer yearling habitat compared to the No Action Alternative. Summer flows in the upper Yakima and Cle Elum Rivers are 140,000 acre-feet less (23 percent) than under the No Action Alternative, the most of any of the three Joint Alternatives. The seepage mitigation flows added to the Yakima River at the Horn Rapids area consist of 2–3 percent of the total Yakima River flow and would not create a false attraction problem.

The fishery models estimated approximate increases of 20–60 percent in anadromous fish populations for the Black Rock Alternative compared to the No Action Alternative, which, of all the Joint Alternatives, affords the greatest modification of the current flow regime in the Yakima River basin. These population increases do not approach the numbers of fish that are estimated to have historically inhabited the basin. Possible reasons for this are as follows:

- The Joint Alternatives do not improve the habitat itself; they only change the amount of access to it.
- The Joint Alternatives only affect the stream reaches downstream from the five major storage reservoirs, not habitat conditions in the tributaries.
- Fisheries habitat conditions have significantly changed through decades of development, both within the Yakima River basin and downstream.
- Changes in habitat conditions (e.g., hydropower development and loss of estuary habitat) along the mainstem Columbia River have reduced smolt and adult migration survival.

Wymer Dam and Reservoir Alternative

Model results show that winter flows from Cle Elum Lake to the Wymer site are greater than under the No Action Alternative, resulting in more than doubling of flows in the Cle Elum River. Local fisheries biologists believe these flows would improve overwintering juvenile salmonid habitat conditions. During the summer months, flows in the upper Yakima River are lower, as some of the irrigation needs in the middle basin are met by releases from Wymer reservoir. Because the percent change in habitat values are all less than 10 percent compared to the No

Action Alternative, no effect on the biological response of steelhead or spring Chinook upper Yakima River population is expected, compared to the No Action Alternative.

Also, there is virtually no difference in the flow volumes or in the spring runoff pattern and no significant change in summer habitat downstream from the Parker gage. Therefore, no effect in the survival or rearing capacity for anadromous fish in the Wapato reach is expected compared to the No Action Alternative.

Wymer Dam Plus Yakima River Pump Exchange Alternative

There are no significant differences (i.e., greater than 10 percent) between this alternative and No Action Alternative for either of the species and life stages in the Easton or Ellensburg reaches. As under the Wymer Dam and Reservoir Alternative, habitat generally would be better for steelhead and spring Chinook in the Easton reach, while results are mixed in the Ellensburg reach.

Spring flows downstream from the Parker gage are substantially greater (79 percent) than under the No Action Alternative, which should increase overall smolt outmigration survival. In addition, a small potential exists to improve the survival or rearing capacity for anadromous fish in the Wapato reach compared to the No Action Alternative.

Land and Shoreline Use

No Action Alternative

The No Action Alternative includes conservation-oriented system improvements, including pumping stations and pipelines, at various locations in the Yakima Valley region. These improvements are associated with existing approved programs and orient predominantly to existing facilities; none are being or will be constructed under the auspices of the Storage Study. To the extent that NEPA analysis is required for these actions, appropriate documentation of the directly affected land/shoreline use environment would be prepared separately, apart from the Storage Study process.

Black Rock Alternative

Land acquisition requirements and associated land use impacts associated with Black Rock dam and reservoir would be long term and unavoidable. Mitigation would focus exclusively on:

(1) Compensating impacted landowners at fair market value according to established Federal regulations, guidelines, and procedures.

(2) Relocating/rerouting existing utility and transportation infrastructure.

In the latter regard, State Route (SR–) 24 is proposed to be rerouted along the south side of the reservoir. The impacted transmission lines and fiber optic cable would be relocated/reconstructed along the new SR–24 alignment.

Development of the seepage mitigation features (cutoff wall, embankment, wells, and pipelines) within the Fitzner-Eberhardt Arid Lands Ecology Reserve (ALE Reserve) could be considered inconsistent with the management and administration of the lands. Development of the cutoff wall/embankment and wells would alter habitat conditions in an area along the western boundary of the ALE Reserve. Reclamation proposes to revegetate and restore the habitat along the pipelines to reduce the long-term impact to affected lands. The owners of the land on which a powerline would be constructed for the wells would be compensated appropriately.

Wymer Dam and Reservoir Alternative

Land use impacts associated with Wymer dam and reservoir would be long term and unavoidable. Mitigation would focus exclusively on compensating impacted landowners at fair market value according to established Federal regulations, standards, and procedures.

Wymer Dam Plus Yakima River Pump Exchange Alternative

Land and easement/rights-of-way acquisition and associated short- and long-term land use impacts from pipeline, pumping plant, and transmission line facilities of this alternative would be largely unavoidable. However, more detailed studies of pipeline and transmission line routing options should explore opportunities for avoiding direct, dislocation impacts on existing residences and business to the maximum extent feasible. For example, in the rural/agricultural lands of Benton and Yakima Counties, routing of the pipeline on/near property lines or on quarter- or half-section lines (rather than immediately along roads) in some areas may offer the opportunity to avoid dislocation impacts to residences and minimize construction-phase access disruptions. Such detailed routing studies should also seek opportunities to minimize long-term impacts on existing developed uses in the urban environments of Richland, Kennewick, and West Richland.

Beyond such site/alignment adjustments during detailed planning, mitigation would focus primarily on compensating impacted landowners at fair market value according to established Federal guidelines, standards, and procedures.

National Economic Development (NED)

The NED benefit-cost analysis (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 benefits period or period of analysis across which benefits occur was assumed to be 100 years, as suggested by the *P&Gs* for this type of dam construction project. 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. The cost categories developed for the BCA include: (1) NED construction costs (i.e., field costs, noncontract costs, and interest during construction) and (2) NED annual operation, maintenance, replacement, and energy (OMR&E) costs. The Monte Carlo 0%, most probable, and Monte Carlo 100% construction cost estimates are presented. The benefit categories developed for the BCA include: (1) agriculture, (2) municipal, (3) recreation, (4) hydropower, and (5) fisheries. The fisheries benefits reflect harvest-based use values only and do not include controversial nonuse values related to the threatened and endangered fish. See table ES.7. None of the alternatives evaluated for the Storage Study proved economically justified based on the costs and benefits measured.

Regional Economic Development (RED)

The RED analysis focuses on economic impacts to the local region, whereas the NED analysis focuses on economic benefits to the entire Nation. 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. The RED evaluation recognizes the NED benefits accruing to the local region plus the transfers of income into the region. However, since 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. 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 inputs to the directly affected industries (referred to as the multiplier effect). This multiplier effect is not included in the NED analysis. See table ES.7 at the end of this Executive Summary for results of the RED analysis.

Environmental Quality (EQ)

The EQ account is used to describe beneficial and adverse effects of the alternatives on significant EQ resources. A multidisciplinary team identified the significant resources for comparing the alternatives. The team then used a nominal group technique to determine the EQ account "score" for each alternative. Because the seepage mitigation analysis was completed after the Draft PR/EIS was released, the EQ account was reevaluated by the team. The results of that evaluation are as follows:

	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Total score	0	0.86	0.25	0.50

Other Social Effects (OSE)

The OSE account is used to display effects of the alternatives on resources that are not shown in the other three accounts. A multidisciplinary team identified three resources to include in the OSE account. The team then used a nominal group technique to determine the alternative that has the most positive impacts on those resources. Because the seepage mitigation analysis was completed after the release of the Draft PR/EIS, a multidisciplinary team reevaluated the resources in the OSE account, as follows.

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

Environmental Commitments

Reclamation has the primary responsibility to ensure that environmental commitments are met if any action is implemented. The Final PR/EIS contains many commitments, such as implementing construction monitoring programs, ensuring all safety, water quality, and best management practices are followed, mitigating for those impacts that require mitigation, and implementing after-construction monitoring programs.

Public Involvement

Along with the technical analyses prepared for this Final PR/EIS, a public involvement process also was initiated. This process included release of a Notice of Intent to prepare an EIS on December 29, 2006; public scoping meetings held on January 23, 2007; and meetings with interested groups, individuals, agencies, stakeholders, and others. A Roundtable was set up to discuss the goals of the Storage Study and how the alternatives would be measured in meeting those goals. The Storage Study Technical Working Group was formed to discuss and resolve issues and concerns related to the Yakima River basin fisheries. Government-to-government consultation occurred between Reclamation and the Yakama Nation as well.

One important step in the public involvement process was the January 29, 2008, release of 750 copies of the Draft PR/EIS for review and comment. Public hearings were held in late February 2008; 80 people presented oral testimony and 17 entities provided written testimony. In addition, Reclamation received 163 unique letters and 183 form letters during the public comment period. From these letters, a total of 792 individual comments were identified and addressed. The comments and Reclamation's responses are included in Volume 2 of this Final PR/EIS.

Consultation and Coordination

Concurrent with preparation of this document, agency coordination and consultation have been conducted in accordance with the Fish and Wildlife Coordination Act, Endangered Species Act of 1973, as amended, and National Historic Preservation Act of 1966. Additionally, consultation with the Yakama Nation has occurred.

In coordination with Reclamation in its role as a cooperating agency, the U.S. Department of Energy provided a Responsible Opposing View regarding the Black Rock Alternative. See attachment A.

Selection of the Preferred Alternative

Reclamation has selected the No Action Alternative of the Yakima River Basin Water Storage Feasibility Study as the Preferred Alternative for this planning report/environmental impact statement. There are a number of factors that contribute to the choice of the No Action Alternative as the Preferred Alternative. Each of the Joint Alternatives would require a significant investment of Federal funds ($1 billion to $7.73 billion) and annual operating costs of millions of dollars. None of the Joint Alternatives provides a positive benefit-cost ratio (or net National Economic Development [NED] benefit), and none of them are considered to be economically justified under Federal water resource planning guidelines. The benefit-cost ratios for each Joint Alternative are Black Rock, 0.13; Wymer Dam and Reservoir, 0.31; and Wymer Dam Plus Yakima River Pump Exchange, 0.07. In addition, there is a lack of acceptability of any of the Joint Alternatives in the community at large as a stand-alone approach to meeting the Storage Study goals.

Natural resource benefits, primarily for anadromous fish, including the threatened Mid-Columbia River steelhead, would accrue under each of the Joint Alternatives.

Under the Black Rock Alternative, the four anadromous fish stocks would increase 21–61 percent; steelhead would increase 51 percent. Under the Wymer Dam and Reservoir Alternative, the four stocks would increase 1–3 percent; steelhead would increase 1 percent. Under the Wymer Dam Plus Yakima River Pump Exchange Alternative, the four stocks would increase 11–35 percent; steelhead would increase 24 percent.

Only the Black Rock Alternative consistently would meet the irrigation water supply goal.

Municipal water supply needs could be met under each of the Joint Alternatives.

Reclamation does not consider the benefits provided by each Joint Alternative, when weighed against the respective impacts and costs, to provide justification for moving forward with any of these three alternatives.

Summary of Impacts

Table ES.6 presents a summary of the impacts of the Joint Alternatives on resources. Table ES.7 presents the results of the NED and RED analyses.

Table ES.6 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Final PR/EIS

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
WATER RESOURCES				
	Average for water years 1981–2005 (maf) Actual change from No Action Alternative Percent change from No Action Alternative			
Water supply				
April 1 total water supply available (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 0.36 58%
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 45%	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 ES.6 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Final PR/EIS (continued)

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
1994 dry-year (maf) Actual change from No Action Alternative Percent change 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%
September 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 megawatt [MW])	None	- 9.2 MW	Not applicable (NA)	NA
Value of generation loss (average annual $ million)		- $4 million		
Additional generation capacity (average annual MW)	None	52.5 MW	NA	NA
Pumping power requirement (average annual MW)	None	132 MW	4.8 MW	61.6 MW
Cost of pumping (average annual $ million)	None	$50 million	$1.9 million	$19.8 million
GROUNDWATER				
Volume and direction of seepage, continuous annual flow (cfs)	No change	Mitigated to prevent impacts to Hanford Site	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
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	No change	No change	No change

Table ES.6 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Final PR/EIS (continued)

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
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 one-third of corridor	Impedes movement	Impedes movement
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 and percent change from No Action Alternative)				
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%
Summer flows downstream from the Parker gage (acres of available coho yearling habitat and percent change from No Action Alternative)				
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%
Rate of change in flow during flip-flop (average cfs/day August 16–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 ES.6 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Final PR/EIS (continued)

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Pre- (August 1-15) and post- (September 14-28) flip-flop flow and absolute change in flow				
Easton reach				
Pre-flip-flop flow (cfs)	572	352	518	508
Post-flip-flop flow (cfs)	328	220	309	319
Absolute change in flow (cfs)	-245	-132	-209	-189
Ellensburg reach				
Pre-flip-flop flow (cfs)	3,860	2,774	3,229	3,208
Post-flip-flop flow (cfs)	1,506	1,239	1,507	1,493
Absolute change in flow (cfs)	-2,354	-1,535	-1,722	-1,715
Lower Naches River reach				
Pre-flip-flop flow (cfs)	612	621	572	578
Post-flip-flop flow (cfs)	1,628	1,220	1,691	1,670
Absolute change in flow (cfs)	1,016	599	1,120	1,092
Reduced spring freshets downstream from the Parker gage (percent change in spring season flow between the alternative and flow objective; if positive, then target flow reached)				
Percent change	-7%	29%	-10%	11%
Stream runoff timing	No change	Improved	No change	No change
Average annual fish (natural and hatchery) escapement numbers (including harvest)				
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 percent change 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 ES.6 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Final PR/EIS (continued)

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Bull trout spawner upmigration at reservoirs (inseason days impeded and percent change from No Action Alternative)				
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 (feet) 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)	NA	13,000	4,000	110
Acquisition of public land (approximate acres)	NA	1,000	0	0
Easement/right-of-way acquisition across private land (approximate miles)	NA	18	6	61
Compatibility with existing uses	NA	Local incompatibilities	Local incompatibilities	Local incompatibilities
Consistency with relevant county land use plans and policies	NA	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

Table ES.6 Comparative analysis of Joint Alternatives by indicator: Yakima River Basin Water Storage Study Final PR/EIS (continued)

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
REGIONAL ECONOMY. See Regional Economic Development (RED) section of table ES.7				
PUBLIC SERVICES AND UTILITIES				
Exceedance of service or utility capacity (long-term impact)	NA	None	None	None
Disruption of services or utilities for existing residents and landowners (short-term, construction-phase impacts)	NA	High potential; mitigable	Minor potential; mitigable	Highest potential; mitigable
TRANSPORTATION				
Long-term: Road/highway relocations (miles)	NA	15	0	0
Short-term: Federal, State, or local arterial highway crossings (instances))	NA	1	1	9
Short-term: Local road crossings (instances)	NA	5-10	0	45–50
AIR QUALITY				
Emissions during construction	NA	Slight, short-term effect	Slight, short-term effect	Slight, short-term effect
Emissions during operation	NA	No effect	No effect	No effect
NOISE QUALITY				
Noise levels during construction	NA	Slight, short-term effect	Slight, short-term effect	Slight, short-term effect
Noise levels during operation	NA	No effect	No effect	No effect
VISUAL RESOURCES				
Large-scale changes in visual setting	NA	Visible to the public (significant)	Visible to the public (significant)	Visible to the public (significant)
Local-scale changes in visual setting	NA	Yes (significant)	Yes (significant)	Yes (significant)
HISTORIC PROPERTIES				
Number of affected properties	NA	Unknown	Unknown	Unknown
INDIAN SACRED SITES				
Number of affected sites	NA	Unknown	Unknown	Unknown
INDIAN TRUST ASSETS				
Number/type affected	None	None	None	No change
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

Table ES.7 Comparative display of the NED and RED accounts for the Final 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)								
		Monte Carlo 0%	Most probable	Monte Carlo 100%	Monte Carlo 0%	Most probable	Monte Carlo 100%	
Agriculture	NA	84.6	84.6	84.6	26.5	26.5	26.5	26.5
Municipal and industrial	NA	284.6	284.6	284.6	280.0	280.0	280.0	282.5
Hydropower	NA	62.5	62.5	62.5	0	0	0	0
Recreation	NA	615.4	615.4	615.4	103.9	103.9	103.9	118.9
Fisheries	NA	20.9	20.9	20.9	1.1	1.1	1.1	12.2
Total benefits	NA	1,068.0	1,068.0	1,068.0	411.5	411.5	411.5	440.0
Adverse effects – OMR&E costs reflect present value of 100-year annual cost stream ($ million)								
Total project costs	NA	4,950	5,690.9	7,730.0	867.0	1,024.0	1,340.0	4,023.0
Interest during construction	NA	1,216.6	1,394.8	1,954.2	220.8	255.9	351.0	1,130.6
OM&R costs (present value)	NA	206.8	206.8	206.8	22.0	22.0	22.0	370.1
Power costs (present value)	NA	1,016.9	1,016.9	1,016.9	38.6	38.6	38.6	403.1
Total NED costs	NA	7,390.2	8,308.4	10,907.8	1,148.4	1,340.6	1,751.6	5,926.8
Net benefits (total NED benefits – NED total costs)	NA	(6,322.3)	(7,240.5)	(9,839.9)	(737.0)	(929.1)	(1,340.2)	(5,486.8)
Benefit-cost ratio (total NED benefits ÷ total NED costs)	NA	.14	.13	.10	.36	.31	.23	0.07
RED account								
Construction period impacts								
Construction: Estimates reflect impacts summed over the entire 10-year construction period.								
Output/sales ($ million)	NA	3,380			617			1,732
Income ($ million)	NA	1,195			217			589
Employment (jobs)	NA	31,400			5,720			15,539

Table ES.7 Comparative display of the NED and RED accounts for the Final PR/EIS (continued)

	No Action Alternative[1]	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
RED account (continued)				
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	NA	$53.9	$16.8	$3.4
1993	NA	$66.4	$45.7	$38.0
1994	NA	$234.1	$14.5	$12.1
2001	NA	$126.9	$81.3	$70.8
2005	NA	$121.2	$22.8	$19.9
Labor income ($ million)				
1987	NA	$18.4	$5.7	$1.2
1993	NA	$22.7	$15.6	$13.2
1994	NA	$82.6	$5.3	$4.4
2001	NA	$44.2	$28.6	$25.3
2005	NA	$42.2	$8.0	$7.2
Employment				
1987	NA	580	179	37
1993	NA	716	493	407
1994	NA	2,608	169	140
2001	NA	1,394	902	786
2005	NA	1,330	254	222
Recreation (Recreation effects were converted to an average annual basis)				
Existing sites				
Output/sales ($ million)	NA	$0.12	$0.04	$0.1
Labor income ($ million)	NA	$0.06	$0.02	$0.05
Employment	NA	2	1	1
Proposed reservoirs (Black Rock and Wymer)				
Output/sales ($ million)	NA	$4.72	NA[2]	NA[2]
Labor income ($ million)	NA	$1.84	NA	NA
Employment	NA	72	NA	NA

[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.

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Chapter 1

PURPOSE AND NEED

CHAPTER 1
PURPOSE AND NEED

1.1 Introduction

The Yakima River Basin Water Storage Feasibility Study (Storage Study), as authorized by the Omnibus Appropriations Act of 2003 (Omnibus Act), Public Law 108–7, examines the feasibility and acceptability of storage augmentation for the benefit of fish, irrigation, and future municipal water supply for the Yakima River basin.

Storage augmentation, as defined within the Storage Study, includes two concepts:

- Diverting Columbia River water to a potential Black Rock reservoir for further water transfer to irrigation entities in the Yakima River basin as exchange supply, thereby reducing irrigation demand on Yakima River water and improving Yakima Project stored water supplies

- Creating additional water storage for the Yakima River basin to provide increased management flexibility of the existing water supply

The Storage Study is generally confined to resources within the Yakima River basin currently served by the Bureau of Reclamation's (Reclamation's) Yakima Project water storage and distribution features. However, because the feasibility of importing Columbia River water for delivery to the Yakima Project water users is a major component of the Storage Study, the effects of such an action on Columbia River water and on other resources (energy production and water quality) are also evaluated. Based on Public Law 108–7, which authorized only storage augmentation, Reclamation focused its analyses only on storage alternatives, also called Joint Alternatives, and did not address fish habitat restoration, fish passage, or other nonstorage water supply or management issues. The State Alternatives were nonstorage concepts that could be addressed by the Washington State Department of Ecology (Ecology) through its legislative authorization.

The State of Washington, represented by Ecology, and Reclamation, as joint lead agencies, prepared the Draft Planning Report/Environmental Impact Statement, Yakima River Basin Water Storage Feasibility Study (Draft PR/EIS), released in January 2008. That document combined a planning report and an environmental impact statement (EIS) that complied with both National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) requirements and followed the *Economic and Environmental Principles and Guidelines for Water* *and Related Land Resources Implementation Studies* (*P&Gs*) (U.S. Water Resources Council, 1983), for documenting benefits and costs of Joint Alternatives.

Following the release of the Draft PR/EIS to the public, Reclamation and Ecology received many comments from individuals; organizations; Federal, State, and local agencies; and other entities. Responses to comments are contained in Volume 2, "Comments and Responses." This report, the Final Planning Report/ Environmental Impact Statement, Yakima River Basin Water Storage Feasibility Study (Final PR/EIS), was developed using those comments and responses.

On the basis of comments received on the Draft PR/EIS, Ecology determined that it may not have fulfilled its requirements under Washington State law to identify and evaluate all reasonable water supply alternatives. Those comments suggested that all reasonable water supply alternatives could not be adequately evaluated without considering fish habitat and fish passage needs. Ecology has separated from the joint NEPA/SEPA process and will proceed with a separate evaluation of water supply and management alternatives. That evaluation will culminate in a SEPA document. Ecology will respond to comments on the State Alternatives presented in the joint Draft PR/EIS in its Final SEPA EIS. Ecology continues to participate in this PR/EIS process as a cooperating, rather than a joint lead, agency. Reclamation finalized the PR/EIS as directed by Congress, focusing on the water storage alternatives outlined in the Draft PR/EIS.

The State Alternatives described in chapter 3 and evaluated in chapter 5 of the Draft PR/EIS have been eliminated from this Final PR/EIS.

1.2 Purpose of and Need for Action

The purpose of the Storage Study is to evaluate plans that would create additional water storage for the Yakima River basin and assess each plan's potential to supply the water needed for fish and the aquatic resources that support them, basinwide irrigation, and future municipal demands.

The need for the study is based on the finite existing water supply and limited storage capability of the Yakima River basin. This finite supply and the limited storage capability do not meet the water supply demands in all years and result in significant adverse impacts to the Yakima River basin's economy, which is agriculture-based, and to the basin's aquatic resources—specifically those resources supporting anadromous fish. Reclamation seeks to identify means of increasing water supplies available for purposes of improving anadromous fish habitat and meeting irrigation and future municipal needs.

1.2.1 Study Authority

Benton County and the Yakima Basin Storage Alliance, a grassroots organization promoting the Black Rock Alternative, went to the Congress and the State of Washington to obtain the authorizations necessary for the Storage Study to be initiated and funded from the Congress.

Section 214 of the Act of February 20, 2003 (Public Law 108–7) states:

> *The Secretary of the Interior, acting through the Bureau of Reclamation, shall conduct a feasibility study of options for additional water storage in the Yakima River Basin, Washington, with emphasis on the feasibility of storage of Columbia River water in the potential Black Rock reservoir and the benefit of additional storage to endangered and threatened fish, irrigated agriculture, and municipal water supply.*

This Final PR/EIS was prepared to address the technical viability of Yakima River basin storage alternatives and the extent that additional stored water supply provided by these alternatives would assist in meeting the Storage Study goals. Storage Study goals include:

- Improve anadromous fish habitat by restoring the flow regimes of the Yakima and Naches Rivers to more closely resemble the natural (unregulated) hydrograph. Through a collaborative process with the Storage Study Technical Work Group (SSTWG),[1] Reclamation developed nonbinding flow objectives to assist in measuring goal achievement (table 1.1).

- Improve the water supply for proratable (junior) irrigation entities that rely on diversions subject to proration by providing a not-less-than-70-percent irrigation water supply for irrigation districts during dry years. This 70-percent goal equates to 896,000 acre-feet of proratable entitlements.

- Meet future municipal water supply needs by maintaining a full municipal water supply for existing users and providing an additional surface water supply of 82,000 acre-feet for population growth to the year 2050.

[1] A biologist work group formed to assist on technical matters related to the Yakima River basin aquatic habitat aspects.

Table 1.1 Monthly flow objectives (cubic feet per second [cfs]) 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	722	1,166	1,400	787	450	375	375	375	425	450	450	450
Cle Elum River	511	954	1,500	1,301	589	400	400	400	425	425	425	425
Ellensburg	1,982	2,424	3,700	2,586	2,000	1,000	1,000	1,000	980	1,016	1,257	1,459
Wapato	3,109	2,794	3,500	2,655	1,300	1,300	1,300	1,300	1,758	1,854	2,163	2,460
Lower Naches River	1,265	1,802	2,297	2,291	988	550	550	550	500	576	691	720

1.2.2 Physical Constraints on the Water Supply

1.2.2.1 Instream Flows/Habitat

Management of the current water supply in the Yakima River basin affects anadromous and resident salmonids in the following ways:

- In most years, spring flows in the middle and lower Yakima River are not sufficient to optimize smolt outmigrant survival. The inadequacy in flow is expressed in a decrease in the magnitude and frequency of peak flow events.
- In most years, summer flows in the Wapato reach and immediately downstream from Prosser Diversion Dam (river mile [RM] 48) to the Chandler Powerplant (RM 36) are less than ideal for salmonid habitat and for proper riparian function (e.g., cottonwood regeneration).
- Unnaturally high summer flows persist in the upper Yakima and Cle Elum Rivers that impact juvenile salmonid rearing habitat.
- The annual late summer "flip-flop"[2] operation disrupts salmonid habitat spatially and has impacts to the aquatic insect populations.
- Winter flows in upper Yakima and Cle Elum Rivers are low and controlled for water storage that potentially impacts winter survival of over-wintering juvenile salmonids.

1.2.2.2 Dry-Year Irrigation

The Yakima Project's surface water supply comes from the Yakima River and its tributaries, irrigation return flows, and releases of stored water from the five major reservoirs in the basin.[3] Only 30 percent of the average annual runoff can

[2] A detailed history and description of the flip-flop river operation, instituted in the early 1980s, can be found in the *Interim Comprehensive Basin Operating Plan* (Reclamation, 2002a).

[3] The five major reservoirs (and their acre-foot active capacities) are: Keechelus (157,800); Kachess (239,000); Cle Elum (436,900), Bumping Lake (33,700), and Rimrock/Tieton Dam (198,000).

be stored in the storage system. The Yakima Project depends heavily on the timing of spring and summer runoff from snowmelt and rainfall. The spring and early summer runoff flows supply most river basin demands through June in an average year. The majority of spring and summer runoff is from snowmelt; as a result, the snowpack is often considered a “sixth reservoir.” In most years, the five major reservoirs are operated to maximize storage in June, which typically coincides with the end of the major runoff. The reservoirs have a combined storage capacity of about 1.07 million acre-feet (maf).

Demand for water from the Yakima River cannot always be met in years with below-average runoff. Though all of the entitlement holders do not call on their full entitlement volume every year, the existing surface water supply does not presently meet all water needs in dry years. A dry year results in prorationing[4] during the irrigation season. In addition, reduced summer and early fall streamflows inhibit migrating, spawning, and rearing conditions for anadromous fish.

1.2.2.3 Municipal and Domestic Water Supply

Currently, only the cities of Cle Elum and Yakima obtain their municipal and domestic water from the surface waters of the Yakima River basin. Groundwater supplies the remainder of the municipal and domestic needs (83 percent) and is the preferred source by the cities for meeting future needs.

In the *Watershed Management Plan, Yakima River Basin* (2003), the Yakima River Basin Watershed Planning Unit and the Tri-County Water Resources Agency noted the importance of the relationship between surface water and groundwater in managing water resources in the Yakima River basin. They indicated pumping groundwater from some aquifers at some locations may reduce flows in surface waters, affecting fish and other aquatic resources, or may impair senior water rights. (This relationship is referred to as “connectivity.”) In other cases, pumping groundwater may have little effect on surface waters, or may have effects that are delayed in time or occur at distances far from the well.

Because groundwater is the preferred source for municipal and domestic water supply, and the extent of connectivity of surface and groundwater is unknown at this time, the *Watershed Management Plan, Yakima River Basin* took a conservative approach in its analysis by assuming that surface water withdrawals would meet the future municipal and domestic water supply needs. The U.S. Geological Survey (USGS) is currently investigating the groundwater aquifers in the Yakima River basin to clarify the surface water and groundwater relationship.

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[4] Prorationing refers to the process in the Yakima River basin of equally reducing the amount of water delivered to junior, i.e., “proratable,” water right holders in water-deficient years.

1.2.3 Statutory Constraints on the Water Supply

Reclamation operates the Yakima Project to achieve specific purposes: irrigation water supply; flood control; power generation; and instream flows for fish, wildlife, and recreation. Irrigation operations and flood control management have been historical priorities for reservoir operations. The Yakima Project's authorization and water rights, issued under Washington State water law, and the *1945 Consent Decree* (section 1.6.3.2) are statutory constraints for water resources. Reclamation must operate the Yakima Project divisions and storage facilities in a manner that avoids injury to water users within this framework.

Project operators use a number of control points to monitor the river system. The primary control point for operation of the upper Yakima Project is the Yakima River near the Parker stream gage. Legislation in 1994 provided that an additional purpose of the Yakima Project shall be for fish, wildlife, and recreation, but that this additional purpose "shall not impair the operation of the Yakima Project to provide water for irrigation purposes nor impact existing contracts." Since April 1995, the Yakima Project has been operated as required by the 1994 legislation to maintain target streamflows downstream from Sunnyside Diversion Dam, as measured at the Yakima River near the Parker stream gage. These flows, based on the estimated water available, range from 300–600 cfs between April 1 and October 31.

Reclamation's *Yakima River Basin Water Enhancement Project, Washington, Final Programmatic Environmental Impact Statement* (Reclamation, 1999) presents a more complete description of statutory constraints for managing water resources in the Yakima Project.

1.3 Background – Yakima Storage Study

In 2004, as part of the Storage Study, Reclamation asked the Washington Department of Fish and Wildlife (WDFW) to identify fish and wildlife issues that the Storage Study should address. WDFW prepared a list of 45 issues.

Reclamation then asked area fish and wildlife experts to form a Biology Technical Work Group (Biology TWG), consisting of technical representatives from the National Marine Fisheries Service, U.S. Fish and Wildlife Service (Service), WDFW, Ecology, the Yakama Nation, Yakima Basin Joint Board, Yakima Subbasin Fish and Wildlife Planning Board, and Reclamation's Upper Columbia Area Office (UCAO) and Technical Service Center. The Biology TWG refined the 45-item list down to 16 significant issues to serve as the foundation for fish and wildlife analyses and an environmental impact statement. A fish or wildlife issue was considered significant if the resource response was anticipated to be: (1) measurable (i.e., either a positive or negative change from existing conditions) and (2) linked more or less to water in the Columbia or Yakima River systems resulting from implementing an alternative of the Storage Study. The *Defining Fish and Wildlife Resource Issues for the Yakima River Basin*

Water Storage Feasibility Study (Biology Technical Work Group, 2004) describes these Storage Study activities in more detail.

In response to input received during stakeholder meetings and the Storage Study scoping meetings, Reclamation and Ecology formed a "Roundtable" group to participate in key aspects of the Storage Study. The Roundtable included representation from key interest groups/constituencies with a stake in the Storage Study and its outcome. It was intended to operate primarily at a policy/management level with support from technical specialists on an as-needed basis. While the Roundtable was not a formal advisory group or decisionmaking body, Reclamation and Ecology believed that it could play an important role in ensuring the completeness, effectiveness, efficiency, and acceptability of the Storage Study as the detailed phase of analysis and decisionmaking got underway. Chapter 6 provides more information on the meetings.

Reclamation initiated the Storage Study in May 2003. Funding has been provided to Reclamation for Storage Study activities under a Memorandum of Agreement for Cost Sharing entered into with the Washington State Department of Ecology on November 14, 2003, and by congressional appropriations. Initial Storage Study efforts were directed at the Black Rock Alternative to develop data comparable to the level of information existing for other potential alternatives (e.g., Bumping Lake Enlargement, Wymer Dam and Reservoir, and Keechelus-to-Kachess Pipeline).

In February 2005, Reclamation released the *Summary Report, Appraisal Assessment of the Black Rock Alternative* (*Black Rock Summary Report)* (Reclamation, 2004a). The *Black Rock Summary Report* includes the information from six technical reports addressing water supply, geology, groundwater, and designs and cost estimates. Reclamation based its initial analysis on a reconnaissance study commissioned by Benton County and partially funded by the Washington Department of Agriculture: the *Yakima Storage Enhancement Initiative—Black Rock Reservoir Study* (Benton County Sustainable Development, 2002). Benton County hired Washington Infrastructure Services to study the potential for diverting water from the Columbia River and delivering it to Yakima River basin irrigators who would be willing to exchange it for their present (entire or partial) diversions from the Yakima River. As a result of analyses prepared for the *Black Rock Summary Report*, a water reservation was requested from the State of Washington for the Black Rock Alternative. This request informed the State that Reclamation was working on a project that would require water from the Columbia River. If the project proved feasible, was authorized for construction, and required a water right, it would preserve the date of December 29, 2004, for the water right. Reclamation has requested that this reservation be extended through December 29, 2011.

In addition to the *Black Rock Summary Report,* Reclamation prepared a report on Yakima River basin water storage alternatives, the *Yakima River Basin Storage*

Alternatives Appraisal Assessment (*Yakima Appraisal Assessment*) (Reclamation, 2006a). This report displayed the extent a Bumping Lake Enlargement, a Wymer Dam and Reservoir, and a Keechelus-to-Kachess Pipeline Alternative would satisfy the goals of the Storage Study. The alternatives were investigated, and only the Wymer Dam and Reservoir Alternative was selected to be carried forward to the feasibility phase of the Storage Study.

Since issuing the *Yakima Appraisal Assessment*, Reclamation has been gathering and analyzing data and information to determine the effects and benefits of Storage Study alternatives. The benefits may come from protecting threatened and endangered steelhead, enhancing other fishery conditions, providing more recreation opportunities, producing power, mitigating the impacts of droughts on Yakima River basin agriculture, and providing a firm future municipal water supply. Analysis of effects included an investigation of seepage toward the Hanford Nuclear Reservation (Hanford Site) and mitigation of the impacts of the seepage. See *Modeling Groundwater Hydrologic Impacts of the Potential Black Rock Reservoir* (Reclamation, 2007a) and *Modeling Mitigation of Seepage from the Potential Black Rock Reservoir* (Reclamation, 2008a).

The *Storage Study Team Technical Information and Hydrologic Analysis for Plan Formulation* (Reclamation, 2006b) displayed the alternatives that would be carried forward into the PR/EIS phase of analysis. These alternatives were the Black Rock Alternative, the Wymer Dam and Reservoir Alternative, and another alternative, the Wymer Dam Plus Yakima River Pump Exchange Alternative. The last alternative was developed at the request of State and local entities to determine the effectiveness of pumping water from the mouth of the Yakima River rather than diverting at the current locations for the Roza and Sunnyside Irrigation Divisions. The plan formulation document also displayed a preliminary benefit-cost analysis. The analysis did not portray a positive benefit-cost ratio, but there were other positive parameters of the alternatives, so they were carried forward into the PR/EIS phase of analysis.

1.4 Related Permits, Actions, and Laws

To implement any alternative, Reclamation would need to apply for and receive various permits, take certain actions, and conform to various laws, regulations, and Executive orders. The following major permits, actions, and laws may apply to each alternative:

- National Environmental Policy Act
- Endangered Species Act (ESA)
- Secretary’s Native American Trust Responsibilities
- National Historic Preservation Act (NHPA)
- Executive Order 11988: Floodplain Management

- Executive Order 11990: Protection of Wetlands
- Executive Order 12898: Environmental Justice
- Executive Order 13007: Indian Sacred Sites
- Section 401 Certification, Clean Water Act
- Section 402 Permit, Clean Water Act
- Section 404 Permit, Clean Water Act
- State Environmental Policy Act
- Washington Department of Natural Resources Permit
- Additional Points of Diversion Authorization
- State Trust Water Rights Program Participation
- Water use permit/certificate of water right
- Reservoir permit/aquifer storage and recovery
- Dam safety permit
- Shoreline conditional use permit or variance
- Water system plan approval
- Hydraulic project approval
- Critical areas permit or approval
- Flood plain development permit

1.5 Public Involvement

Formulating water storage alternatives that are responsive to the needs and desires of the American public requires planning expertise and direct public participation. Several agencies, entities, organizations, and groups participated in the Storage Study. The degree of participation ranged from providing viewpoints and general observations to direct contributions in plan formulation. Chapter 6 summarizes public outreach efforts and public input. Volume 2 contains comments received on the Draft PR/EIS and Reclamation's responses to the comments.

1.6 Yakima River Basin Background and History

1.6.1 Location and Setting

The Yakima River basin is located in south-central Washington, bounded on the west by the Cascade Range, on the north by the Wenatchee Mountains, on the east by the Columbia River drainage, and on the south by the Horse Heaven Hills. The Yakima River originates in the Cascade Mountains near Snoqualmie Pass and flows southeasterly for about 215 miles to its confluence with the Columbia River near Richland, Washington. The Yakima River basin encompasses about 6,155 square miles and includes portions of Kittitas, Yakima, Benton, and Klickitat Counties. (See the frontispiece map.)

The basin varies considerably from the higher mountain altitudes (elevation 8,184 feet in the Cascades) to the semiarid lower Yakima Valley (elevation 340 feet at the Yakima River confluence with the Columbia River). The western and northern mountains annually receive about 140 inches of precipitation. The lower valley often receives less than 10 inches of precipitation per year. The higher elevation areas in the northern and western areas are mostly forested and used for timber harvest, cattle grazing, fish and wildlife habitat, and recreation. About one-fourth of this area is designated as wilderness. The middle elevations are primarily used for dry land and irrigated agriculture, cattle grazing, wildlife, and military training. The lower elevations in the eastern and southern portions of the basin, including the study area, are primarily used for irrigated agriculture. Agriculture is the main economy of the basin.

The Yakima River and its tributaries are the primary sources for surface water in the basin. Major tributaries include the Kachess, Cle Elum, Teanaway, and Naches Rivers. The Naches River, which joins the Yakima River at the city of Yakima, has several tributaries, including the American, Bumping, and Tieton Rivers. The Yakima River and its tributaries historically provided spawning and rearing habitat for anadromous fish. Natural streamflow conditions prevail only in the upper uncontrolled reaches of the Yakima River system because of storage development and use of water for irrigation.

Portions of some of the potential alternatives would be constructed on, or may affect, properties outside the current footprint of the Yakima Project. One of these properties is the Yakima Training Center (YTC), owned and managed by the U.S. Department of the Army primarily as a tank, artillery, and infantry gunnery range. YTC is located northeast of the city of Yakima and is bounded on the west (approximately) by Interstate (I–) 82, on the north by I–90, on the east by the Columbia River, and on the south by private lands north of State Route (SR–) 24. YTC encompasses more than 500 square miles (327,231 acres) of arid lands.

YTC supports one of the largest contiguous blocks of shrub-steppe vegetation remaining in Washington and one of three remaining greater sage-grouse populations in the State.

Other areas that could be affected by potential alternatives include certain sections of the Columbia River and adjacent lands. These sections include the Priest Rapids Dam and Lake, the river immediately downstream known as the Hanford reach of the Columbia River, and portions of the Hanford Site. The area is located in the center of Washington where the Columbia River forms partial boundaries for Franklin, Grant, Benton, Yakima, and Kittitas Counties. This area is east of the Cascade Mountain Range in a generally semiarid region, along the western edge of a vast basalt plateau that dominates the landscape of central Washington. Runoff related to historic glaciation carved numerous canyons—known as coulees—in the area. Many of the coulees are dry. In Grant County, the heaviest precipitation usually falls between November and March; the driest period occurs from July–September. Native vegetation is sparse and restricted to low-lying shrubs and grasses known as shrub-steppe. The average maximum temperature (87 degrees Fahrenheit [ºF]) occurs during July, and the coldest temperatures (average maximum of 33–35 ºF) occur in December and January.

Priest Rapids Dam is owned and operated by Grant County Public Utility District (PUD), which also owns and operates Wanapum Dam. Priest Rapids Dam is a hydroelectric facility located on the Columbia River at RM 397. The dam is located about 24 miles south of Vantage, Washington, and about 47 miles northeast of Richland, Washington, between YTC and the Hanford Site. The dam was completed in 1961. Priest Rapids Lake extends upstream 18 miles to the Wanapum Dam.

The Hanford Site was established in 1943 during World War II as part of the Manhattan Project to provide the plutonium needed for nuclear weapons and provide a site for nuclear defense research and development. The 586-square-mile site is currently undergoing extensive remediation and cleanup of multiple plumes of radioactive and chemical contamination in soil and groundwater from past operations. The U.S. Department of Energy (DOE) is responsible for management and cleanup of the site. Cleanup plans include the treatment of approximately 53 million gallons of radioactive waste stored in 177 underground tanks for disposal of the high-level radioactive waste in the Federal repository. The cleanup is being conducted under Federal and State requirements. The State of Washington participates with the U.S. Environmental Protection Agency (EPA) and DOE in a tri-party cleanup agreement.

Historically, the Hanford Site included some lands in Grant and Franklin Counties on the east side of the Columbia River, with the majority of the 586-square-mile site in Benton County, in south-central Washington. Portions of the original Hanford Site have been put to other uses over the years as the need for new nuclear weapons diminishes. The Arid Lands Ecology Reserve (ALE Reserve) was established in 1967 and subsequently renamed the Fitzner-Eberhardt Arid Lands Ecology Reserve in 1994. The unit occupies about 120 square miles (77,000 acres) southwest of the Columbia River and SR–240, between SR–24 and SR–225. The unit contains Rattlesnake Mountain and portions of the Rattlesnake Hills. In 1971, the unit was designated a Research Natural Area, and in 1975 became part of the Department of Energy's National Environmental Research Parks system. The Saddle Mountain Unit (about 50 square miles or 32,000 acres) of the Saddle Mountain National Wildlife Refuge (NWR)—located in the northwest corner of the original Hanford Site in Grant County—came under management of the U.S. Fish and Wildlife Service in 1971. The Wahluke Unit (about 89 square miles or 57,000 acres) is located adjacent to and northeast of the Saddle Mountain Unit. This unit was managed by the Washington Department of Fish and Wildlife from 1971–1999, and then became part of the Saddle Mountain NWR. The ALE Reserve, Saddle Mountain Unit, and Wahluke Unit, plus the McGee Ranch-Riverlands Unit (about 14 square miles or 9,100 acres), the Hanford reach, and other smaller land parcels became part of the 305-square-mile (195,000 acres) Hanford Reach National Monument in 2000. Portions of the remaining historic core area of the Hanford Site are undergoing cleanup.

The Hanford reach of the Columbia River includes the river and shoreline lands from Priest Rapids Dam downstream 51 miles to near Richland, Washington. The reach is free-flowing and supports a diverse mix of backwaters, islands, and other features used by area fish and wildlife. For example, the reach supports the largest spawning population (an estimated 80–90 percent) of fall Chinook salmon using the mainstem Columbia River. In addition, two federally threatened or endangered salmonid populations—Upper Columbia River steelhead and Upper Columbia River spring Chinook—migrate through the reach. Other important fish species and/or salmon runs using the reach include white sturgeon, coho, sockeye, and summer Chinook. The Hanford reach qualified for, and was proposed for, protection under Wild and Scenic River legislation in the mid-1990s; however, no action occurred until the reach became part of the Hanford Reach National Monument by Executive order in 2000.

1.6.2 Yakima Project Description

The Yakima Project is composed of seven divisions: six irrigation divisions (Kittitas, Roza, Tieton, Wapato, Sunnyside, and Kennewick), and a storage division. The six irrigation divisions provide water to about 465,400 irrigated acres of the Yakima Project and represent about 70 percent of the total diversions of major entities in the Yakima River basin. The remaining 30 percent are made up of other irrigation entities which are mainly senior water right holders. The storage division is comprised of the five major reservoirs with a total capacity of about 1,065,400 acre-feet. A sixth reservoir, Clear Lake, has a capacity of 5,300 acre-feet and is used primarily for recreational purposes.

The five major reservoirs—Bumping, Kachess, Keechelus, Rimrock (Tieton Dam), and Cle Elum Lakes—store and release water to meet irrigation demands, flood control needs, and instream flow requirements. Other project features include 5 diversion dams, 420 miles of canals, 1,697 miles of laterals, 30 pumping plants, 144 miles of drains, 2 federally owned powerplants, plus fish passage and protection facilities constructed throughout the project (Reclamation, 2002a). In addition to providing water for irrigation, the Yakima Project also provides hydroelectric power generation, flood control, fish and wildlife benefits, and recreation.

The Kittitas, Roza, Tieton, and Kennewick Divisions each contain a single irrigation district that is responsible for the operation and maintenance of the facilities within its division. The Wapato Division is located within the exterior boundary of the Yakama Nation Reservation and is operated by the Bureau of Indian Affairs (BIA) in consultation with the Yakama Nation and the Wapato Irrigation District. The Sunnyside Division contains four irrigation districts in addition to two ditch companies and three cities. The Sunnyside Division Board of Control has responsibility for operating and maintaining the joint facilities of the Sunnyside Division (primarily the Sunnyside Main Canal), with Sunnyside Valley Irrigation District operating these facilities on behalf of the Board of Control.

Reclamation operates the six dams and reservoirs of the storage division as well as the Roza Powerplant (part of the Roza Division) and the Chandler Pumping and Generating Plant (part of the Kennewick Division). The five major reservoirs are operated as a pooled system with no reservoir or storage space designated for a specific area, division, or entity. Stored water that is not used is carried over to the next year to the benefit of all water users.

Table 1.2 provides information on the six irrigation divisions and the physical sources of the stored water supply.

Table 1.2 Yakima Project irrigation divisions and stored water sources

Division	Location (subarea)	Diversion river mile	Stored water source	Operating entity
Kittitas	Upper Yakima	Yakima River RM 202.5	Keechelus and Kachess Lakes	Kittitas Reclamation District
Roza	Middle Yakima	Yakima River RM 127.9	Keechelus, Kachess, and Cle Elum Lake	Roza Irrigation District
Tieton	Naches	Naches River RM 14.2	Rimrock Lake	Yakima-Tieton Irrigation District
Wapato	Middle Yakima	Yakima River RM 106.7	All reservoirs	BIA and Wapato Irrigation District
Sunnyside	Middle Yakima	Yakima River RM 103.8	All reservoirs	Sunnyside Division Board of Control
Kennewick	Lower Yakima	Yakima River RM 47.1	Unregulated and return flows	Kennewick Irrigation District

The following sections provide background information of the Yakima River basin and an overview of several important studies and activities related to water management that have transpired or are ongoing within the basin.

1.6.3 History of Water Management in the Yakima River Basin

Development of irrigation in the Yakima River basin began as early as the 1850s. By 1902, an estimated 122,000 irrigated acres were served by natural flows in the rivers and tributaries. However, even at that time, the natural flow was inadequate to assure a dependable water supply. A petition dated January 28, 1903, from citizens of Yakima County to the Secretary of the Interior requested United States involvement in irrigation. Further irrigation development was not possible unless two things occurred: (1) existing water users had to agree to limit their water use during the low-flow periods of late summer and early fall and (2) water storage was necessary to capture early season runoff for supplying irrigation water throughout the growing season.

The limitation on water use was accomplished by "limiting agreements" with more than 50 appropriators on the Yakima and Naches Rivers.[5] The development of storage was made possible by the Washington Legislature in March 4, 1905, by granting to the United States the right to exercise eminent domain in acquiring lands, water and property for reservoirs, and other irrigation works. Under this law, a withdrawal of the unappropriated waters of the Yakima River and its principal tributaries was filed by the United States on May 10, 1905. These actions led to the authorization of the Yakima Project on December 12, 1905.

1.6.3.1 May 10, 1905, Withdrawal

Using the provisions of Chapter 90.40 Revised Code of Washington (RCW), the Secretary of the Interior withdrew all the unappropriated waters of the Yakima River and tributaries for benefit of the proposed Yakima Reclamation Project. The withdrawal was effective from its May 10, 1905, initiation to its December 31, 1951, expiration. In that span of 45 years, water rights were established under Washington law for the developed project facilities.

1.6.3.2 1945 Consent Decree

Disputes over water use from the Yakima River during years of low runoff resulted in litigation in the Federal court. In 1945, the District Court of Eastern Washington issued a decree under Civil Action No. 21 called the *1945 Consent Decree*. The *1945 Consent Decree* is a legal document pertaining to water distribution and water rights in the basin. It established the rules under which Reclamation should operate the Yakima Project system to meet the water needs of the irrigation districts that predated the Yakima Project, as well as the rights of divisions formed in association with the Yakima Project.

The *1945 Consent Decree* determined water delivery entitlements for all major irrigation systems in the Yakima River basin, except for lower reaches of the

[5] Not all appropriators signed "limiting agreements," and some appropriators' water claims were modified as "heretofore recognized rights."

Yakima River near the confluence with the Columbia River. The *1945 Consent Decree* states the quantities of water to which all water users are entitled (maximum monthly and annual diversion limits) and defines a method of prioritization to be placed in effect during water-deficient years. The water entitlements are divided into two classes—nonproratable and proratable. Nonproratable entitlements are generally held by preproject water users, and these entitlements are to be served first from the total water supply available (TWSA). The *1945 Consent Decree* also spelled out the concept of TWSA, which is defined as, "That amount of water available in any year from natural flow of the Yakima River, and its tributaries, from storage in the various Government reservoirs on the Yakima River watershed and from other sources, to supply the contract obligations of the United States to the Yakima River and its tributaries, heretofore recognized by the United States." The TWSA estimate has an important role in determining operations of the Yakima Project and is estimated using forecasted runoff, forecasted return flows, and storage contents. Additional discussion of the TWSA concept can be found in chapter 4.

All other Yakima Project water rights are proratable, which means they are of equal priority. Any shortages that may occur are shared equally by the proratable water users.

The Federal projects within the basin were constructed to manage water supplies to serve the proratable water users in the basin. The contractors for this water supply repay the Yakima Project storage construction costs and the annual operation and maintenance costs allocated to the irrigation purpose. However, nonproratable entitlements are met first from the TWSA, which includes stored water.

1.6.3.3 Water Right Adjudication

The *1945 Consent Decree* controlled distribution of Yakima Project water in the Yakima River basin between 1945 and 1977. In the spring of 1977, with a drought imminent, Reclamation predicted the proratable water users would receive only 15 percent of their normal water supply. Some proratable water users brought action in the U.S. District Court for the Eastern District of Washington to modify the *1945 Consent Decree* and make all right holders proratable. The Yakama Nation sought to intervene and also filed a separate action in U.S. District Court to have its treaty-reserved water rights determined. In light of this dilemma, United States District Judge Marshall Neill suggested a State court general adjudication to finally determine water rights in the Yakima River basin.

On October 12, 1977, the State of Washington Department of Ecology filed an adjudication of the Yakima River system in the Superior Court of Yakima County naming the United States and all persons claiming the right to use the surface waters of the Yakima River system as defendants. The purpose of this adjudication was to determine all existing surface water rights within the basin, and to correlate each right in terms of priority with all other rights. At about the same time, the Yakama Nation filed an action in U.S. District Court to determine the priority and water rights of the Yakama Nation under the treaty of 1855. The Federal case was remanded to the State case, and the filing by the Yakama Nation did not proceed.

An order of the Superior Court was entered on July 17, 1990, regarding the rights of the Yakama Nation. This Partial Summary Judgment defined the treaty-reserved rights of the Yakama Nation, and the rights to flow in the mainstem Yakima River were unanimously affirmed by the Washington Supreme Court on appeal. The treaty rights were divided into separate rights for fish and agriculture.

The Court determined that various acts of the Congress, agencies, and decisions of various tribunals had defined and limited the treaty irrigation of the Yakama Nation. This right translated into existing nonproratable irrigation rights with 1855 priority and proratable irrigation rights with a priority date of 1905.

The treaty right for fish had likewise been limited by various acts of the Congress and agency actions and had been compensated in the proceeding before the Indian Claims Commission (ICC), Docket No. 147. The flow right was held to be the "specific minimum instream flow necessary to maintain anadromous fish life in the river, according to the annual prevailing conditions as they occur and determined by the Yakima Field Office Manager in consultation with the Yakima River Basin System Operations Advisory Committee, Irrigation Districts and Company managers and others." This decision was later extended to include all tributaries that support fish at the Yakama Nation's usual and accustomed fishing locations. The priority date for the treaty fishing right is "time immemorial."

The relationship of the *1945 Consent Decree* to the State's adjudication proceeding was an issue addressed by the Superior Court in 1993 (Memorandum Opinion Re: Threshold Issues). The Court held that the *1945 Consent Decree*, in and of itself standing alone, did not establish any water rights. However, it did "memorialize the appropriations thereto made" (pre-1945). Water right claimants had the burden of addressing changes in the appropriations after 1945. The Court further stated, "Once this case is concluded . . . the final judgment herein would supersede that (1945) Decree."

The Superior Court has issued most of the Conditional Final Orders (CFO) which confirm the surface water rights for the Yakima River basin. The Court is proceeding to prepare the *Final Decree*. The United States has been issued its CFO, including the water rights for the Yakima Project. These are the surface water rights upon which the exchange will be based.

1.6.3.4 February 17, 1981, Withdrawal

In a February 13, 1981, letter to the State of Washington Department of Ecology, referenced *Withdrawal of Waters for Yakima River Basin Water Enhancement Study*, Reclamation filed notice that it ". . . intends to make examinations and surveys for the utilization of the unappropriated waters of the Yakima River and its tributaries for multipurpose use under the Federal Reclamation laws."

Reclamation certified on January 16, 1982, that the project was feasible and that investigations would be made in detail. Pursuant to RCW 90.40.030, this certification of feasibility continued the withdrawal until January 18, 1985. Reclamation has continuously renewed this withdrawal, and it remains active.

The current withdrawal of Yakima River basin unappropriated surface water is for benefit of the Yakima River Basin Water Enhancement Project (YRBWEP). While the current YRBWEP Act does not authorize new storage reservoirs, it does authorize investigations into storage as a way to augment project supply.[6] To build additional storage, Reclamation will require Federal authorization, either through a "Phase III" YRBWEP Act, or through another congressional authorization.

1.7 Prior Investigations and Activities in the Yakima River Basin

Since completion of the Yakima Project's last storage facility (Cle Elum Dam and Lake in 1933), numerous investigations and activities have addressed the need for additional storage to meet water supply deficiencies. The current water resources infrastructure of the Yakima River basin has not been capable of consistently meeting aquatic resource demands for fish and wildlife habitat, dry-year irrigation demands, and municipal water supply demands.

This section highlights the more recent prior investigations and activities to develop additional water supplies in the Yakima River basin, beginning with the 1966 *Bumping Lake Enlargement—Joint Feasibility Report* (Reclamation and Service, 1966).

1.7.1 Bumping Lake Enlargement

The *Bumping Lake Enlargement Joint Feasibility Report* was prepared in 1966 by Reclamation and the U.S. Fish and Wildlife Service. The purpose of this feasibility study, authorized by the Act of September 7, 1966 (Public Law 89–56)

[6] Title XII of the Act of October 31, 1994 (Public Law 103–434) authorized the *Basin Conservation Plan* and other measures. This Act is commonly referred to as Phase II of YRBWEP.

and the Fish and Wildlife Coordination Act (FWCA), was to address the water-related problems and needs of the Yakima River basin. A preliminary feasibility report was completed in March 1968 on construction of a new dam about 1 mile downstream from the existing Bumping Lake Dam on the Bumping River, a tributary in the Naches River drainage.[7] The report was forwarded to the Secretary of the Interior for consideration. During this process, recreation development in the recommended plan became a concern as to its compatibility with the Cougar Mountain (William O. Douglas) Wilderness Area then under consideration. It was determined that the recommended plan should be reevaluated and modified.

Following appropriations for the reevaluation work in 1974, the revised feasibility report was resubmitted to the Commissioner of Reclamation and the Director, U.S. Fish and Wildlife Service, in 1976. It was approved by the Secretary of the Interior in 1979. Reclamation filed the *Proposed Bumping Lake Enlargement, Final Environmental Impact Statement* with the Council of Environmental Quality August 23, 1979 (Reclamation, 1979). Bills were introduced in the Congress in 1979, 1981, and 1985 to authorize construction of the Bumping Lake enlargement, but the Congress did not take action.

1.7.2 Yakima River Basin Water Enhancement Project

The 1977 drought in the Yakima River basin prompted legislative action for additional water supply. In 1979, the Washington Legislature provided $500,000 for ". . . preparation of feasibility studies related to a comprehensive water supply project designed to alleviate water shortage in the Yakima River basin." Also in 1979, the Congress authorized, provided funds for, and directed the Department of the Interior to ". . . conduct a feasibility study of the Yakima River Basin Water Enhancement Project in cooperation with the State" (Act of December 28, 1979, Public Law 96–162).

The Yakima River Basin Water Enhancement Project included study activities both off and on the Yakama Nation Reservation. Some 35 potential storage sites off the Yakama Reservation were identified and evaluated. Two sites, Bumping Lake enlargement and Wymer dam and reservoir, emerged as the preferable storage sites.[8] The enlarged Bumping Lake reservoir had previously been studied at the feasibility level. Wymer reservoir was brought to a feasibility level of evaluation in 1985. Four alternative plans, including "core measures," reservoir storage, and establishment of a "Trust Fund" for implementation of nonstorage

[7] The capacity of the enlarged Bumping Lake was about 458,000 acre-feet, including the existing 33,700 acre-feet of the existing reservoir, which would be inundated.

[8] The Wymer Dam and Reservoir Alternative is an off-channel site adjacent to the Yakima River, about 6 miles upstream of Roza Diversion Dam.

elements, were developed.[9] Three areas for potential new on-reservation irrigation development, including storage, were identified (Satus Creek, Toppenish-Simcoe Creeks, and Ahtanum Creek), and preliminary plans were prepared for these potential developments.

As planning was underway for YRBWEP, some early implementation actions were identified. These actions resulted in a cooperative Federal, State, Tribal, and local undertaking to construct "state-of-the-art" fish ladders and fish screens at water diversion points throughout the Yakima River basin. This is commonly referred to as Phase I of the YRBWEP and was initiated in the early 1980s. Fish ladders and fish screens have been completed at diversions on the Yakima and Naches Rivers and at tributary diversions.

In 1987 and 1988, considerable effort was made by the Washington congressional delegation to structure a comprehensive solution to the water needs of the Yakima River basin in lieu of continuing with the adjudication. The impetus for this effort was the desire to reach a mutual water right settlement by means of Federal-State comprehensive legislation providing for further development of water resource facilities and stipulating the Yakima River basin's surface water rights among the parties. However, in the fall of 1988, this effort was abandoned with the decision of some of the off-reservation irrigators to pursue the adjudication process rather than a stipulated settlement.

Subsequently, in the spring of 1990, there was renewed interest in proceeding with legislation authorizing nonstorage elements. As a result, Title XII of the Act of October 31, 1994, Public Law 103–434 (commonly referred to as Phase II of the YRBWEP) was enacted. The actions that evolved from Title XII are discussed below.

1.7.2.1 Yakima River Basin Water Conservation Program

The Yakima River Basin Water Conservation Program (the centerpiece of the Title XII legislation), is a voluntary program structured to provide economic incentives with cooperative Federal, State, and local funding to stimulate the identification and implementation of structural and nonstructural water conservation measures in the Yakima River basin. Improvements in the efficiency of water delivery and use will result in improved, reach-specific streamflows for aquatic resources and improve the reliability of water supplies for irrigation.

The *Basin Conservation Plan*, prepared by the Yakima River Basin Conservation Advisory Group (1998) which was charted under the Federal Advisory

[9] Bumping Lake enlargement capacities considered were 250,000, 400,000, and 450,000 acre-feet (including the existing 33,700-acre-foot capacity); Wymer reservoir capacity was about 142,000 acre-feet.

Committee Act and appointed by the Secretary of the Interior, was submitted to the Secretary of the Interior in 1998 and published and distributed in October 1999. The *Basin Conservation Plan* sets forth the mechanism for implementing water conservation measures, including eligibility requirements for Federal- and State-sponsored grants, standards for the scope and content of water conservation plans, criteria for evaluating and prioritizing conservation measures for implementation, and administrative procedures.

1.7.2.2 Yakima River Basin Water Enhancement Project, Washington, Final Programmatic Environmental Impact Statement

In January 1999, Reclamation prepared the *Yakima River Basin Water Enhancement Project, Washington, Final Programmatic Environmental Impact Statement* (Reclamation, 1999). A Record of Decision was signed in 1999. As specific actions authorized by Title XII are pursued, NEPA compliance will be developed as appropriate and to a great extent will be "tiered" off this EIS.

1.7.2.3 Report on Biologically Based Flows

The System Operation Advisory Committee (SOAC) consists of Yakima River basin biologists representing Federal, State, Tribal, and irrigation agencies and entities. SOAC provides information, advice, and assistance to Reclamation on aquatic-related issues concerning operation of the Yakima Project. Pursuant to Title XII, SOAC was directed to assess the target flows included therein "for the purpose of making a report with recommendations to the Secretary and the Congress evaluating what is necessary to have biologically based flows." This report was provided to the Secretary of the Interior in May 1999.

The purpose of the SOAC report was to review the factors affecting anadromous fish resources in the Yakima River basin and to recommend processes and procedures required to determine biologically based flows for increasing the abundance of salmon and steelhead. SOAC suggested that river management should embrace the concept of a normative flow regime and that effects of flow management could be evaluated with such indicators as anadromous fish early life stage survival, smolt production, and habitat quality indices.[10] SOAC provided nine recommendations as a part of a comprehensive program designed to recover the aquatic ecosystem and the anadromous salmonid populations that depend on it.

[10] SOAC defined a normative flow regime as one that represents historic flow conditions to the greatest extent possible given the cultural, legal, and operational constraints associated with river basin development.

1.7.2.4 The Reaches Project: Ecological and Geomorphic Studies Supporting Normative Flows in the Yakima River Basin

One of the recommendations in the SOAC report was to describe the health of the Yakima River basin aquatic ecosystem through a comprehensive review and synthesis of available data on Yakima River flow management, water quality, habitat condition, land use activities, and biological communities. The purpose of this activity was to identify areas in the watershed where changes in water management or Yakima Project operations offer the greatest potential to recover the aquatic ecosystem. This activity was undertaken by Jack Stanford et al. of the University of Montana's Flathead Lake Biological Station in conjunction with Reclamation and the Yakama Nation. It is reported on in the October 2, 2002, document, *The Reaches Project: Ecological and Geomorphic Studies Supporting Normative Flows in the Yakima River Basin, Washington* (Stanford et al., 2002).

The report concludes that the distribution and concentration of algae, macro-invertebrates, and fish on the five major floodplain reaches of the Yakima River basin system clearly demonstrate the importance of off-channel habitat and indicates these floodplains have significant potential for restoration. It also suggests the Yakima River system can be restored to a normative condition and that the floodplain reaches retain some ecological integrity but are substantially degraded. Because of this degradation, these reaches cannot sustain enhanced runs of salmon and steelhead without restoration of more normative flows throughout the mainstem Yakima and Naches Rivers.

1.7.2.5 Interim Comprehensive Basin Operating Plan for the Yakima Project

The *Interim Comprehensive Basin Operating Plan for the Yakima Project* (*IOP*) was completed by Reclamation in 2002. The preparation of the *IOP* was mandated by Title XII to provide a general framework within which the Yakima Project is operated. The *IOP* presents a historical context of the Yakima Project and its current operation. It describes the Yakima Project's legal and institutional aspects, articulates the impacts of Yakima Project operation on the natural resources of the basin, analyzes various operational alternatives, and recommends strategies and operational changes that will address the goals of Title XII.

1.7.3 Yakima River Watershed Council

The Yakima River Watershed Council (Watershed Council) was formed in March 1994 as a nonprofit organization. Its membership included more than 800 individuals representing water-based interests in the Yakima River basin. A primary objective of the Watershed Council was to develop strategies and a plan(s) that could be implemented to provide consistent and adequate water to meet the economic, cultural, and natural environmental needs in the Yakima River basin.

The first activity of the Watershed Council toward developing a plan was to issue a report in July 1996, called the *State of the Water Resources of the Yakima River Basin.* This was an assessment of problems and needs from the perspective of water supply, water quality, and water management.

Following development of planning goals, the Yakima River Watershed Council prepared the draft plan, *A 20/20 Vision for a Viable Future of the Water Resource of the Yakima River Basin* (1997). A review and comment period followed, and the council issued a revised plan dated June 9, 1998. This included a critique of the storage sites considered in the YRBWEP investigations.

During this same timeframe, the Tri-County Water Resources Agency was formed (1995), and the Washington Legislature enacted the State of Washington Watershed Management Act (1997). Subsequently, the Tri-County Water Resources Agency received a Washington State planning grant for Yakima River basin watershed planning. Due to these actions, the Yakima River Watershed Council terminated its activities in July 1998 and did not finalize the draft report.

1.7.4 *Watershed Assessment*, *Yakima River Basin* and *Watershed Management Plan, Yakima River Basin*

The Yakima River Basin Watershed Planning Unit was formed in 1998 to develop a comprehensive watershed management plan for the Yakima River basin. The Yakima River Basin Watershed Planning Unit represented local governments, citizens and landowners, irrigation districts, conservation districts, State agencies, and others. With the assistance of the Tri-County Water Resources Agency (currently known as the Yakima Basin Water Resources Agency), a *Watershed Assessment, Yakima River Basin* (2001) and *Watershed Management Plan, Yakima River Basin* (2003) were completed. The *Watershed Management Plan, Yakima River Basin* covers the entire Yakima River basin with the exception of the Yakama Nation Reservation.

The *Watershed Management Plan, Yakima River Basin* provides a “road map” for maintaining and improving the Yakima River basin’s economic base, planning responsibility for expected growth in population, managing water resources for the long-term, and protecting the basin’s natural resources and fish runs. Seven goals for a balanced management of water resources were addressed. The following four goals are directly related to the management of surface water:

- Improve the reliability of surface water supply for irrigation use
- Provide for growth in municipal, rural, domestic, and industrial demand
- Improve instream flows for all uses with emphasis on improving fish habitat

- Maintain economic prosperity by providing an adequate water supply for all uses.

Extensive work was done with respect to water resource needs and supplies. Alternatives for improving water supplies for aquatic resources and future municipal needs and to meet dry-year irrigation deficiencies were identified and evaluated.

1.7.5 *Yakima Subbasin Plan*

The Yakima Subbasin Fish and Wildlife Planning Board (currently renamed the Yakima Basin Fish and Wildlife Recovery Board [http://www.YBFWRB.org]) completed a draft *Yakima Subbasin Plan* in May 2004 as a part of the Northwest Power Planning and Conservation Council's (NPPC) process to guide the selection of projects funded by the Bonneville Power Administration (BPA) for the protection, restoration, and enhancement of fish and wildlife affected by the Federal hydropower system. Further clarification of the draft *Yakima Subbasin Plan* was requested by NPPC before consideration for adoption into its Fish and Wildlife Program. The *Supplement*, dated November 26, 2004, was then prepared.

The *Supplement* identifies the key factors limiting the biological potential of representative ("focal") species, the biological objectives to address each limiting factor, and management strategies to achieve success for each objective. The *Yakima Subbasin Plan and Supplement* was adopted by NPPC into its Fish and Wildlife Program.

1.7.6 *Yakima Steelhead Recovery Plan*

In 1999, the National Marine Fisheries Service classified Middle Columbia River steelhead as a threatened species under the Endangered Species Act. In 2006, the National Marine Fisheries Service revised its listing to apply only to the anadromous (ocean-going) form of *Onchorynchus mykiss*, commonly known as steelhead. This listing applies to steelhead that spawn in a large portion of central and eastern Washington and Oregon. The Yakima Basin Fish and Wildlife Recovery Board, a locally based organization governed by representatives of Yakima, Benton, and Kittitas Counties, the Yakama Nation, and cities in the basin, prepared the 2007 *Yakima Steelhead Recovery Plan* for those listed Middle Columbia River steelhead that spawn in the Yakima River basin.

This 2007 *Yakima Steelhead Recovery Plan* was incorporated into the National Marine Fisheries Service's *Columbia Steelhead Recovery Plan*, which was released in draft form on September 24, 2008.

1.8 Relationship of Other Water Resource Activities to this Study

Several Federal and State agencies, the Yakama Nation, local entities, and public interest organizations are involved in water resource activities within the Yakima River basin. It is often informative to view these in the context of regional planning as represented by ongoing activities within the Columbia River Basin.

These activities are briefly discussed here because of the relevance to the Storage Study and this Final PR/EIS. The presentation is not exhaustive, but rather attempts to highlight activities that have generated information relevant to this Final PR/EIS.

1.8.1 Columbia River Basin Water Management Program

The Columbia River Basin Water Management Act was passed by the Washington Legislature in 2006. The Act directs Ecology to ". . . aggressively pursue the development of water supplies to benefit both instream and out-of-stream uses" (Ecology, 2007a). The major components of the Columbia River Basin Water Management Program (CRBWMP) include storage, conservation, voluntary regional agreements, and other measures intended to meet the above legislative mandate. The CRBWMP also includes administrative functions such as development of a project inventory, a water supply and demand forecast, and a data management system. Funding and management of a number of major projects—including the Yakima River Basin Water Storage Feasibility Study—are components of the CRBWMP.

The CRBWMP directs Ecology to focus efforts to develop water supplies for the Columbia River Basin to meet the following needs:

- Alternatives to groundwater for agricultural users in the Odessa Subarea aquifer
- Sources of water supply for pending water rights applications
- A new uninterruptible supply of water for the holders of interruptible (junior) water rights on the Columbia River mainstem that are subject to instream flows or other mitigation conditions to protect streamflows
- New municipal, domestic, industrial, and irrigation water needs within the Columbia River Basin.

The *Columbia River Basin Water Management Program, Final Programmatic Environmental Impact Statement* (CRBWMP EIS) (Ecology, 2007a) was developed by Ecology under SEPA as part of the Columbia River Basin Water Management Program development process. The CRBWMP EIS was prepared to assist in evaluating conceptual approaches to developing the CRBWMP and in describing the potential impacts that could be associated with components of the CRBWMP. Components evaluated included storage, conservation, voluntary regional agreements, instream resources, and policy alternatives for implementing requirements of the Columbia River Basin Water Management Act. The document also evaluated potential impacts associated with implementation of three actions: drawdowns of Lake Roosevelt, a supplemental feed route to supply Potholes Reservoir, and the proposed Columbia-Snake River Irrigators Association Voluntary Regional Agreement.

Components of the CRBWMP are briefly addressed below, with a more detailed treatment available in the CRBWMP EIS.

1.8.1.1 Storage

Potential storage projects that may be approved for study and funding include new large storage facilities (more than 1 million acre-feet), new small storage facilities (less than 1 million acre-feet), modification of existing storage facilities, and groundwater storage. Examples of potential storage projects include: Black Rock reservoir (new large facility), Wymer reservoir (new small facility), reoperation of Banks Lake (modification of existing facilities), and the City of Kennewick Groundwater Storage.

1.8.1.2 Conservation

Ecology has developed an inventory of more than 500 conservation projects and is currently developing, screening, and ranking criteria to determine which projects best meet the goals of the CRBWMP. Potential projects may address issues such as incentive payments to reduce water use and full or partial water banking, improvements to municipal water infrastructure, use of reclaimed water, improved water delivery efficiency at the irrigation district level and onfarm conservation, improved industrial infrastructure, and pump exchanges. Ecology would manage the use of conserved water.

1.8.1.3 Voluntary Regional Agreements

Under this component, groups would be able to enter voluntary regional agreements (VRA) with Ecology to exchange a package of water projects for new water rights. All existing legislation governing new water rights would remain in place, and VRAs must meet minimum requirements to be approved by Ecology. A request from the Columbia-Snake River Irrigators Association is an example of a VRA and is evaluated in the CRBWMP EIS.

1.8.1.4 Instream Water

Ecology is pursuing a full range of options for augmenting instream resources. The Columbia River Basin Water Management Act provides that one-third of the active storage in any new storage facility made possible with CRBWMP funding will be available for instream flows. Water for allocation to instream uses could be provided by a number of projects that Ecology is considering under the CRBWMP.

1.8.1.5 Inventory and Demand Forecasting

The Columbia River Basin Water Management Act directs Ecology to develop a water supply inventory and a long-term water supply and demand forecast that is updated every 5 years. The first inventory and long-term water supply and demand forecast was released in November 2006. The inventory and forecast include conservation and water storage projects, a water rights inventory, a water use inventory, a long-term water supply forecast, and a long-term demand forecast.

1.8.1.6 Early Actions

Ecology has begun to implement the three early actions included in the CRBWMP—incremental storage releases from Lake Roosevelt, a supplemental feed route for Potholes Reservoir, and the Columbia-Snake River Irrigator's Association (CSRIA) VRA. The Lake Roosevelt Incremental Storage Releases Project involves releasing flows from Lake Roosevelt to provide water to improve municipal and industrial water supply, provide water to replace some groundwater use in the Odessa Subarea, enhance streamflows in the Columbia River to benefit fish, and provide water to interruptible water rights holders in drought years. Ecology issued the *Final Supplemental Environmental Impact Statement for the Lake Roosevelt Incremental Storage Releases Program* in August 2008 and began implementing the flow releases September 2008. The selected route to improve the distribution of water to Potholes Reservoir is a combination of Crab Creek, a natural water body, and the existing Frenchman Hills Wasteway. To accommodate the additional flows in Frenchman Hills Wasteway, Reclamation expanded a culvert crossing at Road C Southeast. That work was completed in March 2008. Reclamation does not anticipate receiving the congressional funding for the Crab Creek portion of the supplemental feed route before 2010. Under the VRA provision of the CRBWMP, Ecology signed a permit agreement with the CSRIA in July 2008. Under the agreement, the State will issue drought permits to irrigators who face shutoff during dry years. In return, CSRIA will manage water savings and efficiency programs and develop pilot projects to create more efficient ways to use irrigation water.

1.8.2 Priest Rapids Hydroelectric Project Relicensing

Grant County PUD owns and operates Priest Rapids and Wanapum Dams on the Columbia River as the Priest Rapids Project. The Priest Rapids Project has operated under a 50-year license that expired in October 2005 and has operated on an annual license since that date. The Federal Energy Regulatory Commission

(FERC) recently completed the *Priest Rapids Hydroelectric Project, Washington, Final Environmental Impact Statement* (FERC, 2006) that outlines the requirements for relicensing. Requirements cover a range of resources, including aquatic resources such as resident and anadromous fish that inhabit Priest Rapids Lake or the Hanford reach or pass through the dam. Many of the requirements deal with the timing and magnitude of flows designed to protect anadromous fish.

FERC issued a new 44-year license on April 17, 2008, for the operation of Priest Rapids and Wanapum hydroelectric dams. The license outlines the requirements for Grant County PUD to operate Priest Rapids and Wanapum hydroelectric dams.

Priest Rapids Dam and Lake, located about 30 miles east of Yakima, would be the site of a water intake structure under the Black Rock Alternative evaluated in this Final PR/EIS. The potential effects of water withdrawal from Priest Rapids Lake require close coordination with Grant County PUD, FERC, BPA, and other agencies.

1.8.3 Yakima Dams Fish Passage

Reclamation is leading a cooperative investigation with the Yakama Nation, State and Federal agencies, and others to study the feasibility of providing fish passage at the five large storage dams of the Yakima Project. These dams—Bumping Lake, Kachess, Keechelus, Cle Elum, and Tieton—were never equipped with fish passage facilities. Four of the five reservoirs were originally natural lakes and historically supported Native American fisheries for sockeye salmon and other anadromous and resident fish (Reclamation, 2003a).

Implementation of passage features at the dams is an essential component of any potential plan to reintroduce sockeye salmon to the watershed. Passage at the dams would also likely benefit upper basin populations of steelhead, coho salmon, and Chinook salmon. Isolated populations of bull trout would potentially be reconnected by passage at the dams. Rainbow trout and other resident species would also be likely to benefit.

The scope of the fish passage planning study is currently limited to study of passage features at Bumping Lake and Cle Elum Dams. Successful implementation of fish passage at Cle Elum and Bumping Lake Dams could eventually lead to future detailed study of the other three dams (Kachess, Keechelus, and Tieton). The draft *Cle Elum and Bumping Lake Dams Fish Passage Facilities Planning Report* was released in September 2008.

1.8.4 Additional Projects

In addition to the projects mentioned above, the following projects are reasonably certain to occur:

Tank Farm Closure and Waste Management Environmental Impact Statement. The U.S. Department of Energy is preparing a new EIS to evaluate options for managing and disposing of waste, selecting supplemental treatments, closing tanks, and closing the Fast Flux Test Facility at the Hanford Site.

Bonneville Power Administration Fish and Wildlife Program Activities. BPA funds fisheries mitigation projects in the Columbia River Basin, including the Yakima River basin, to improve fish habitat. Projects in the Yakima River basin could act in concert with actions taken as part of the program activities to benefit anadromous fish.

Planned Growth in Yakima, Benton, and Kittitas Counties. Planned growth will continue in these counties. This growth currently involves expansion into underdeveloped areas potentially affecting fish and wildlife resources. Similar growth patterns will continue and could affect resources potentially affected by actions taken as a result of this Final PR/EIS. For example, the expanded growth could generate a need for additional water supplies.

1.9 How to Read This Document

This Final PR/EIS is organized into six chapters. Chapter 1 has provided a general overview of issues beginning with the purpose and need for action, followed by study authorities, a brief discussion of public involvement, and ending with relevant background information on the study area, history of water management within the basin, and prior studies and activities dealing with local water management issues. Chapter 2 presents a description of the Joint Alternatives and compares the Joint Alternatives via the *P&Gs* (U.S. Water Resources Council, 1983) and, essentially, provides the "planning report" technical data component of the Final PR/EIS. The alternatives are referred to as "Joint Alternatives" because they were originally developed by both Ecology and Reclamation. While Ecology is no longer a joint lead agency, the nomenclature of "Joint Alternatives" has been retained in this Final PR/EIS. Chapter 4 addresses the affected environment and environmental consequences to resources and provides the NEPA technical analyses component of the Final PR/EIS. Finally, chapter 6 describes consultation and coordination necessary for developing this Final PR/EIS. Descriptions of the State Alternatives and discussions of the affected environment and environmental consequences that were provided in chapters 3 and 5 of the Draft PR/EIS, respectively, have been eliminated from this Final PR/EIS.

Because this Final PR/EIS contains new information on seepage mitigation for the Black Rock Alternative, additions to, or revisions from, the Draft PR/EIS have been highlighted or shaded. Deletions are not indicated.

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. 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 supply deficiencies. Any alternative selected for implementation would be operated as part of the Yakima Project. The alternatives developed under this authorization are referred to as "Joint Alternatives" because they originally were developed by both Reclamation and Ecology. While Ecology is no longer a joint lead agency, the nomenclature of "Joint Alternatives" has been retained in this Final PR/EIS. The Joint Alternatives are discussed in this chapter. Because this is a combined planning report and EIS, this chapter also includes the planning study criteria (*P&Gs*) and evaluation of those alternatives (U.S. Water Resources Council, 1983). The following alternatives are considered:

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

Chapter 4 presents discussions of the affected resources and environmental consequences of implementing each of the proposed Joint Alternatives.

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* (U.S. Water Resources Council, 1983). These criteria were addressed in the *Summary Report, Appraisal Assessment of the Black Rock Alternative* (Reclamation, 2004a) and the *Storage Study Team Technical Information and Hydrologic Analysis for Plan Formulation* (Reclamation, 2006b). 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. Because none of the Joint Alternatives meets the requirements to be identified as the Preferred Alternative, the No Action Alternative is selected as the Preferred 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, shown later in this chapter), the alternatives are presented in this Final PR/EIS.

2.2.1 Goal Setting

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

2.2.1.1 Instream Water Supply

A variety of legal requirements exists related to providing and/or maintaining instream flows in the Yakima River basin. Generally, these requirements 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." SOAC advises Reclamation on an annual basis how to operate the Yakima 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	Apr–Sep	May–Sep	Jun–Sep	Jul–Sep	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. The SSTWG also looked at estimated unregulated flow to help inform its decisions.

The 12 calendar months were grouped into spring, summer, and winter seasons consisting of 4 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–June
- Summer—July–October
- Winter—November–February

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

Table 2.2 Monthly flow objectives (cfs) and volumes (acre-feet) 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	2,794	3,500	2,655	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* (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 April–October (irrigation season). During discussions with irrigation districts about the 70-percent goal, the Sunnyside Division Board indicated that it did not want to receive additional dry-year irrigation water if it meant it would incur additional repayment costs. The Yakima-Tieton Irrigation District also indicated it did not want to receive dry-year irrigation supply. The irrigation water supply analyses do include these districts in the 70-percent irrigation need to indicate how well the alternatives could meet the Yakima Project's needs. The Sunnyside Division Board did indicate it was willing to participate in a water exchange to provide more water for the Yakima River basin.

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. In some cases, Conditional Final Orders of the Adjudication Court and Water Right Settlement Agreements have established limitations on the volume that can be diverted in any year.

2.2.1.3 Municipal Water Supply

Currently, communities in the Yakima River basin 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.

Estimated municipal and domestic water use in the Yakima River basin from surface water and groundwater resources in year 2000 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.

In preparing the *Watershed Management Plan, Yakima River Basin*, 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 public water systems	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 subarea	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	1,009	1,223	
Other community and Class B public water systems	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 subarea	50,809	48,430	57,274	63,539	70,000
Naches subarea					
Other community and Class B public water systems	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 subarea	4,656	4,765	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	

Table 2.4 Municipal and domestic water needs for 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)					
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 public water systems	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	
Total Lower Yakima subarea	39,887	46,993	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	34,886	42,495	49,208	69,000
Yakima River basin groundwater and surface water supply	101,619	103,666	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, Yakima River Basin.*

[2] From exhibit 2-2 of the W*atershed Management Plan*, *Yakima River Basin.*

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

[4] Section 2.3 of the January 6, 2003, *Watershed Management Plan, Yakima River Basin* 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 were 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 the 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, 2007b).

2.2.2.1 Black Rock Damsite Seismicity

Reclamation's *Probabilistic Seismic Hazard Assessment for Appraisal Studies of the Proposed Black Rock Dam* (Reclamation, 2004b) 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 potentially can 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 using 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 0.95 acceleration of gravity (g), a level of ground shaking that might be associated with the occurrence of magnitude 6–7+ 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 also are potential sites of secondary faulting, fissuring, and landslides (Reclamation, 2004b). Existing landslides and potential for reactivation of landslides exist along Horsethief Mountain, the south abutment of the dam. Ground shaking from earthquakes on the Black Rock Valley fault could trigger movement in existing landslides or cause currently stable slide areas to become active again. In addition, presently stable slopes along Horsethief Mountain and further upstream along the reservoir rim would be saturated by the reservoir, potentially increasing the susceptibility of these slopes to sliding when subjected to large ground motions.

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.

A number of engineering methods could be employed to mitigate the effects of existing or potential landslide areas near the Black Rock damsite or along the reservoir rim. Smaller landslide areas close to the damsite could be excavated and used as borrow areas for construction of the dam embankment. Larger landslide areas could be stabilized through various methods including, but not limited to, reshaping and flattening of steep slopes; constructing rock buttresses to support the toe of the slope; reshaping the landslide surface to improve drainage of surface runoff and limit the amount of percolation of precipitation into the ground; and installing both horizontal and vertical drainage wells to lower the water table within the slide mass. Other nonstructural methods are also possible, such as limiting the rate at which the reservoir is filled or lowered to allow water pore pressures in the slide areas to stabilize over time. The actual methods used to stabilize a specific landslide area would depend, to a large extent, on the size and geometry of the slide mass and could consist of several different methods, involving both engineered features and nonstructural solutions, acting in combination with each other.

The U.S. Department of Energy submitted a Responsible Opposing View (attachment A) expressing concern about the lack of evaluation of failure modes for Black Rock dam and the associated impacts to the Hanford Site. Reclamation has the following response. Black Rock dam has been designed with state-of-the-practice defensive design features and would have an extremely remote probability of failure. For earthquake stability, a prime feature is the selection of a compacted rockfill dam, recognized as the safest type of dam under earthquake loading. This strong embankment dam has an extremely high resistance to all types of loadings. With an upstream sloping core, the bulk of the dam consists of unsaturated and strong rockfill that can withstand extreme shaking. The vast majority (if not all) of the foundation overburden would be removed so that the embankment dam is founded on bedrock, eliminating the potential for soil liquefaction to create strength loss and slope failure. An internal filter and drainage system is sized to adequately withstand many feet of movement and still safely filter and drain reservoir seepage and prevent an internal erosion failure.

If the decision were made to proceed with construction of Black Rock dam, additional geologic and geotechnical investigations (see section 2.2.3.1) would be required to determine the engineering properties of the dam foundation materials, including detailed analysis of the Horsethief Mountain/Black Rock Valley thrust fault in the right abutment of the damsite and other seismic sources. Final design (see section 2.2.3.2) of the dam would include analysis of all potential dam failure modes, including seismic, static, and hydrologic failures. Downstream inundation areas would be mapped to evaluate downstream risk, including the Hanford Site that potentially could be impacted in the unlikely event of a dam failure.

Once constructed, a Black Rock dam would fall under the purview of Reclamation’s Dam Safety Program, which performs periodic combined facility reviews of all high-hazard dams in its inventory to ensure continued safe operation of its facilities. This review would include an evaluation of the design and construction of the dam to account for possible changes in the state-of-the-art in both geotechnical engineering design and in Reclamation’s understanding of seismic hazards. The combined facility review would include updated risk analyses for all failure modes. Should a future combined facility review identify a deficiency due to a change in the state-of-the-art after completion of the project, Reclamation would be required by the Safety of Dams Act of 1978, as amended, to perform modifications to the structure to ensure continued safe operation of the facility.

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 that could contribute 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 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 using 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 generally is 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 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 that extremely high seepage velocities are required to erode or move large-size rocks (boulders) (Reclamation, 2007c).

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 structures) stability would be analyzed carefully 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.

The potential for landslides also exists in the reservoir area where rigid basalt lava flows overlie layers of sandstone and siltstone. These slopes currently are stable but would be saturated by a Wymer reservoir. These materials potentially could have increased susceptibility to sliding when experiencing ground shaking from large earthquakes.

A number of engineering methods could be employed to mitigate the effects of existing or potential landslide areas near the Wymer damsite or along the reservoir rim. Smaller landslide areas close to the damsite could be excavated and used as borrow areas for construction of the dam embankment. Larger landslide areas could be stabilized through various methods including, but not limited to, reshaping and flattening of steep slopes; constructing rock buttresses to support the toe of the slope; reshaping the landslide surface to improve drainage of surface runoff and limit the amount of percolation of precipitation into the ground; and installing both horizontal and vertical drainage wells to lower the water table within the slide mass. Other nonstructural methods also are possible, such as limiting the rate at which the reservoir is filled or lowered to allow water pore pressures in the slide areas to stabilize over time. The actual methods used to stabilize a specific landslide area would depend, to a large extent, on the size and geometry of the slide mass and could consist of several different methods, involving both engineered features and nonstructural solutions, acting in combination with each other.

2.2.3 Design Data Gathering

The following section describes future investigations that have been identified by Reclamation for each alternative in order to provide adequate data for final designs. Note that this is not to be considered an all-inclusive list.

2.2.3.1 Geology

Black Rock Alternative

Additional geologic study of the Black Rock reservoir area, damsite, plant sites, and water conveyance alignments would be required for final design and construction of these facilities, including the following: damsite, seepage mitigation features downstream from the dam, powerplants, tunnels, pumping plants, highway relocations, and borrow sites. In addition, investigations would be necessary to reduce uncertainty in the groundwater seepage model and confirm placement of the seepage mitigation features. These investigations would be used to add to the existing knowledge about geologic formations and groundwater movement (both vertical and horizontal) and identify the extent of the sediment layers at critical points for seepage mitigation. In addition, seismotectonic investigations would be performed to further refine the designs and estimates prepared for the Storage Study.

These geologic, groundwater, and seismotectonic investigations include about 60 drill holes, 112 test pits, and geologic mapping and are expected to cost about $9 million in 2008 prices.

Wymer Dam and Reservoir Alternative

Additional geologic study of the Wymer reservoir area, damsite, plant site, and water conveyance alignments would be required for final design and construction of these facilities, including the following: damsite, the dike site, pumping plant, pipeline, highway crossings, and borrow sites. These investigations would identify all relevant geologic, groundwater, and seismotectonic concerns for this alternative. The geologic and seismotectonic investigations include about 20 drill holes, 22 test pits, and geologic mapping and are expected to cost about $5 million in 2008 prices.

Wymer Dam Plus Yakima River Pump Exchange Alternative

In addition to the future geologic investigations described for the Wymer Dam and Reservoir Alternative, additional geologic and geotechnical investigations, including construction dewatering, would be necessary if the pump exchange component of this alternative were constructed. These additional investigations include 68 drill holes and 12 test pits and are expected to cost about $1.4 million in 2008 prices.

2.2.3.2 Design

Black Rock Alternative

Additional design investigations of the Black Rock Alternative features would have to be performed before final designs and construction could be initiated. These investigations would continue throughout the design process to ensure the most efficient design and the most economical construction methods and materials are used. Design investigations might include, but would not be limited to, considering alternative materials for the dam, foundation designs, and other features; refining drainage features in the dam and abutments; performing additional transient and hydraulic studies for the powerplants; initiating power operation studies; verifying the sizes of alternative features with detailed reservoir operation studies; developing an initial filling procedure for the reservoir; and performing value engineering analyses for specific features of the alternative.

Wymer Dam and Reservoir Alternative

Additional design investigations of the Wymer Dam and Reservoir Alternative features would have to be performed before final designs and construction could be initiated. These investigations would continue throughout the design process to ensure that the most efficient design and the most economical construction methods and materials are used. Design investigations might include, but would not be limited to, verifying reservoir design floods; conducting hydrologic studies to confirm the maximum water surface of the reservoir; conducting a comprehensive river study for the pumping plant; confirming the best type of pumps to use (i.e., variable-speed or fixed-speed units); considering alternative materials for the dam, foundation designs, and other features; conducting a reservoir sediment study, and confirming the location and design of the spillway.

Wymer Dam Plus Yakima River Pump Exchange Alternative

In addition to the design investigations described for the Wymer Dam and Reservoir Alternative, investigations might include, but would not be limited to, optimizing the pipeline routing, considering an energy recovery station at pumping plant #3, determining the potential to replace the overflow reservoirs with comparable features, investigating possible gravity delivery from the pipeline, and determining the best location of pumping plant #1.

2.2.4 Cost Estimates

Reclamation considers the total project cost estimates provided for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives to be at an appraisal level. The amount of data collected to define major cost drivers and technical adequacy is not considered to be at the level required for a feasibility-level assessment of project features.

To adequately define the costs required to construct the Black Rock and Wymer Dam and Reservoir Alternatives in this Final PR/EIS, Reclamation conducted a Monte Carlo cost-risk simulation to identify cost risk and critical cost drivers for those alternatives. Because of the very low benefit-cost ratio and minimal irrigation, fishery, and municipal benefits identified in the Draft PR/EIS, Reclamation decided not to calculate a range of costs for the Wymer Dam Plus Yakima River Pump Exchange Alternative. Additional studies and design work (including, but not limited to, optimization of conveyance facilities capacity, gathering more information on geotechnical, groundwater, and other resources) required to meet Reclamation standards for feasibility and final designs are outlined in section 2.2.3 of this Final PR/EIS.

To prepare the Monte Carlo cost-risk simulation, Reclamation developed the most probable low, most probable, and most probable high cost estimates for the Black Rock and Wymer Dam and Reservoir Alternatives. These three costs estimates, which include quantity and unit price ranges, helped define the potential cost risk associated with possible difficulties with construction due to uncertainty with local conditions. The most probable low field-cost estimate was generally calculated by multiplying the lowest quantity value by the lowest cost value for each identified pay item and adding the lowest estimates for allowances (design contingencies and construction contingencies). The most probable field cost estimate was calculated by multiplying the most-likely quantity value by the most-likely cost value for each identified pay item and adding the most-likely estimates for allowances (design contingencies and construction contingencies) given the current understanding of local conditions. Similarly, the most probable high field-cost estimate generally was calculated by multiplying the highest quantity value by the highest cost value for each identified pay item and adding the highest estimates for allowances (design contingencies and construction contingencies). Monte Carlo simulation techniques then were applied to the three cost estimates to evaluate the cost risk associated with each line item. The Monte Carlo cost-risk simulation is a statistical analysis randomly generating total costs based on the sum of the distributions of quantities and unit prices generated from the most probable low, most probable, and most probable high cost estimates. The Monte Carlo cost estimates provide a confidence level that a certain project cost estimate will cover the costs associated with construction.

This report displays the Monte Carlo 0%, most probable, and Monte Carlo 100% cost estimates that are used in the benefit-cost analyses. The Monte Carlo 0% cost estimate has a 0-percent probability of not being exceeded, and the Monte Carlo 100% cost estimate has a 100-percent probability of not being exceeded. These values are typically between the most probable low and most probable high values because the probability that all pay items and allowances will be at their minimums (or maximums) is highly unlikely. For a complete description and display of all the cost estimates, see *Cost-Risk Analysis for Black Rock and Wymer Alternatives* (Reclamation, 2008i).

Reclamation's *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 the 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 help select a preferred alternative, to determine the economic feasibility of a project, and to support seeking authorization from the Congress.

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 and design contingencies (formerly unlisted items) were added to determine the construction contract cost estimate. Construction 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. The total project cost is the amount required from Federal and non-Federal funding sources to construct the alternative. To summarize:

- Construction Contract Cost = Itemized Pay Items + Mobilization Costs + Design Contingencies

- Field Cost = Construction Contract Cost + Construction Contingencies

- Total Project Cost = Field Cost + Noncontract Cost

At the current level of design, mobilization costs, design contingencies, construction contingencies, and noncontract costs typically are estimated as a percentage of the pay items, construction contract cost, or field cost as discussed below. They are rounded values based on Reclamation rounding criteria, so the actual dollar value may deviate from the percentages shown below.

- Mobilization – Mobilization costs include mobilizing contractor personnel and equipment to the project site during initial project startup. The assumed 5 (+/-) percent of the subtotal cost used in the most probable low, most probable, and most probable high cost estimates is based on past experience.

- Design Contingencies (formerly unlisted items) – Design contingencies are a means to recognize the confidence level in the estimates and the level of detail and knowledge 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 but will have some influence on the total cost. The design contingency line item is a percentage of the subtotal cost plus mobilization. This percentage was varied between 10 and 20 percent across the most probable low, most probable, and most probable high cost estimates to account for the level of detail and anticipated cost risk.

- Construction Contingencies (formerly contingencies) – Construction contingencies are considered funds to be used after construction starts and not for design changes during project planning and design stage. The purpose of construction contingencies is to identify funds to pay contractors for overruns on quantities, changed site conditions, change orders, etc. Construction contingencies also account for a lack of specific geologic information that would have a greater impact on tunnel and dam construction than on pipeline and pumping plant construction. This percentage was varied between 15 and 30 percent across the most probable low, most probable, and most probable high cost estimates to account for the anticipated cost risk.

- Noncontract costs are funds for engineering designs and specifications, regulatory compliance and permitting activities, environmental mitigation and monitoring, construction contract administration and management, and costs associated with land acquisition and relocation or rights-of-way that may be required for construction of the project features. A percentage of the field cost, typically ranging from 25–35 percent, often is used to identify funds for noncontract items. Lower percentages were used for the Black Rock Alternative because not all contract costs vary linearly with the size of the features, e.g., design costs for a 500-foot dam would be similar to those for a 600-foot dam, even though the construction cost would be significantly greater. To develop the most probable low, most probable, and most probable high total project cost estimates for the Black Rock and Wymer Dam and Reservoir Alternatives, 20, 25, 30 and 25, 30, 35 percent were used to estimate noncontract costs, respectively.

Reclamation developed the major cost items for the Black Rock Alternative estimates using "Hard Dollar" commercial estimating software, produced by Hard Dollar Corporation of Scottsdale, Arizona. Current labor-equipment-materials resources were input, production rates were applied, and totals extended for each item within each feature to produce direct costs for each pay item. Additionally, project overhead costs were estimated and applied to each feature for this project, generating unit prices and construction cost totals for each feature. Similar methods were used to develop major cost items for the Wymer Dam and Reservoir Alternative; however, these cost estimates were not input directly into the Hard Dollar program. Minor cost items for both the Black Rock and Wymer Dam and Reservoir Alternatives were developed using historical unit prices, standard industry reference sources, and other methods.

Typical percentages for general and administrative costs, as well as profit for each feature, were applied. The final unit prices were then entered into the estimate worksheets, and totals were extrapolated. The costs and unit prices for these cost estimates were developed at an April 2007 price level. Labor rates were generated based on the historical Davis Bacon Wage Decision available in April 2007. The appraisal level cost estimates contained in this report do not include an adjustment for escalation. They were prepared and presented as cost estimates in present worth dollars with unit price levels set at April 2007 values.

The rights-of-way estimates for the Black Rock and Wymer Dam and Reservoir Alternatives were developed from USGS quadrangle maps and design drawings. Reservoir rights-of-way were estimated by determining the high-water contour on the quadrangle maps and then determining the parcels of land which contained that contour. The minimum land parcel was 40 acres; however, in some cases, where the terrain is steep or other issues were apparent, larger parcels were chosen. Pipeline and powerline rights-of-way were determined by estimating the width of land needed to construct, operate, and maintain the pipeline or powerline and multiplying that width by the length of pipeline or powerline.

Rights-of-way for specific facilities, such as powerplants, were estimated from the design drawings for that facility. Rights-of-way costs were determined by using Yakima and Kittitas County databases on land values and computing average price per acre from that information. Tax databases and geographic information system information were supplied by Yakima and Kittitas Counties. These average prices then were applied to the right-of-way required for that facility or feature. Noncontract costs include costs for land appraisals; environmental, cultural, and hazardous materials clearances; title fees; relocation expenses; and legal fees.

Recreation costs also were developed for this study; however, because of their relative low cost compared to the noncontract cost calculated as a percentage of field cost, these costs were assumed to be covered adequately by the noncontract cost estimates. Recreation cost estimates were developed for minimum basic recreation facilities such as pit toilets, picnic tables, parking lots, and boat ramps. The rights-of-way for the recreation facilities are included in the estimate for the dam and reservoir operations. Reclamation policy is to have a non-Federal entity or contractor fund recreation facilities that are beyond minimum, basic levels. That entity would enter into an agreement with Reclamation to construct, operate, and maintain the facilities and the minimum, basic facilities until the cost of the investment could be recouped by that entity.

2.2.5 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 also were 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 prorated 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 from 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.

The operation criteria selected for the Storage Study analyses of the three action alternatives are not intended to reflect the only way these alternatives could be operated in conjunction with the Yakima Project. Other operation scenarios would be possible except as may be constrained by "specific firm" criteria. For

[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 the Tennessee Valley Authority (TVA). The center's Web site, http://cadswes.colorado.edu/riverware, provides supporting documents on the RiverWare software.

instance, the Yakima River pump exchange component of the Wymer Dam Plus Yakima River Pump Exchange Alternative is constrained by the "bucket for bucket" exchange of flow at the mouth of the Yakima River. In other words, the pump exchange operation is predicated on the flow that is pumped back to the exchange participants being not greater than that discharged at the mouth. Therefore, when the Yakima Project is on storage control operation, stored water must be released to effect an exchange. Thus, for the most part, these criteria are flexible and could be assessed and revised on an annual basis, as is now done for the Yakima Project. The more stored water that is made available, the greater the flexibility in the operations and the greater the actual impacts that can be effected on an annual basis.

2.2.5.1 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–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 also 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 changes in the flow volume at the mouth of the Yakima River.

2.2.5.2 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 25-year 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.

The Kennewick Irrigation District (KID) was not included in the prorationing calculations or the water demand modeling for the Storage Study. KID has been prorated a few times in the past, however, not to the extent that users upstream of the Parker gage were prorated. KID has a water service contract that allows it to take any water above the Title XII target flow at Prosser Dam within the limits of its entitlement (most of this being return water from the other users). However, if at some point in any irrigation season KID were to call for storage water to meet demands, the TWSA would have to be recalculated to include the users downstream from the Parker gage. Also, KID was not included in calculations related to benefits received from prorationed water during dry years.

2.2.6 Water Rights and Water Contracts

2.2.6.1 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, 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 never have 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, potentially can 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.

2.2.6.2 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 subsequently have 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 preproject water rights.

Participation in the exchange probably would 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 at 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.

2.2.6.3 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 the Endangered Species Act. In 1997, Washington lifted the moratorium with revisions to Chapter 173-563 Washington Administrative Code (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 Final 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 State Departments of Ecology and 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 current withdrawal remains in force through 2008. Reclamation has requested that Ecology grant an extension of the withdrawal until December 2011 but has not received confirmation as of this printing.

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.

Using 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 probably will 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 Conditional Final Order, 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 (Preferred 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 Alternatives 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 evaluating and implementing measures to improve the availability of water supplies for irrigation and to protect and enhance 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 compliance 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 400–600 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 2.5 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	NA	30,000	82	NA[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 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 riverflow associated with conserved water assigned to instream flows and operational flow resulting from changes in the points of diversion.

Table 2.6 Middle Yakima River area instream flow associated with water conservation actions from RM 127.9–103.7

			Instream flow (cfs)			Elements of instream flow (cumulative) (cfs)	
Entity	Action	RM	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.

Table 2.6 also indicates that 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).

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, as shown 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 then can be issued by Ecology.

Issuing 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 translate roughly 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 that this additional diversion is equivalent to a 1.5-percent increase in the proration level.

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 also may approve development of new emergency drought wells.

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[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.

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 water 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.
- 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 reduced substantially over a 10-day period, and releases from Rimrock Lake are increased substantially to meet the September–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 greater than from Kachess Lake from June–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, 2008b), 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–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 changes in hydrologic indicators under the No Action Alternative compared to the current operation for the 25-year period of record (1981–2005). As shown in the table, with implementation of the No Action Alternative, model results show improvement in the Yakima Project water supply over the 25-year period when compared to the current operation. The hydrologic indicators are discussed in detail in section 2.2.4.

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 River flow volume at mouth (maf)	Irrigation delivery volume shortage (maf)[1]	Irrigation proration level and % change
		Apr–Sep Yakima River flow volume at Parker gage (maf)	Apr–Sep diversion volume upstream of the Parker gage (maf)	Sep 30 reservoir contents change (maf)			
Average 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 25-year 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 3-year 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.

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.

Introduction to Hydrographs

The SSTWG established monthly instream flow objectives 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 figure 2.1 and table 2.9 for reach locations and descriptions.)

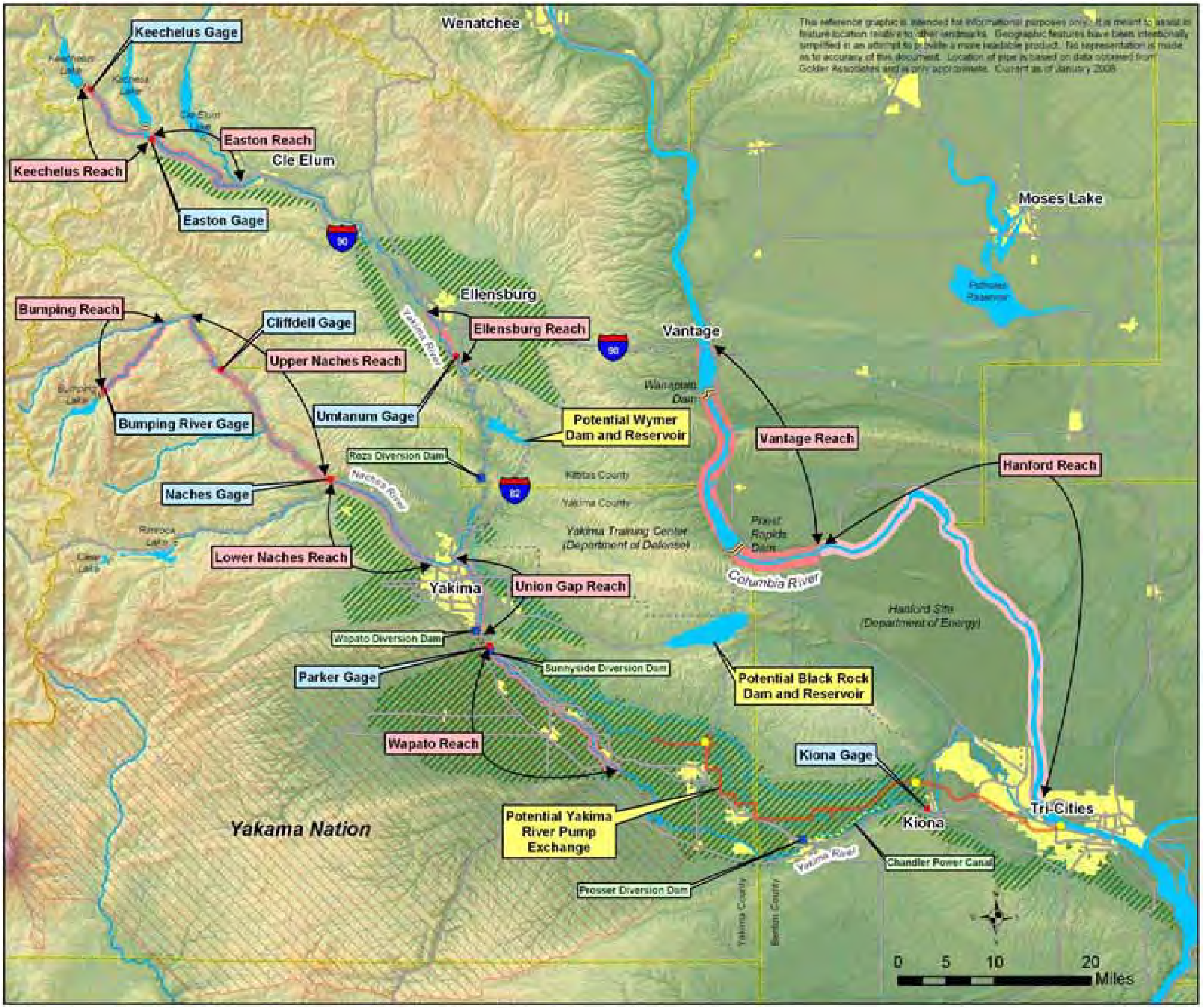


Figure 2.1 Reaches map.

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

Total water supply available estimate (maf)				Title XII target flow at Parker gage (cfs)	
Apr–Sep	May–Sep	Jun–Sep	Jul–Sep	Current operation	No Action Alternative
3.2	2.9	2.4	1.9	600	736
2.9	2.7	2.2	1.7	500	636
2.7	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.

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)	NA	NA

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. Table 2.10 presents these seasonal flow volume objectives (acre-feet) and modeled seasonal flow volumes (acre-feet) provided under the alternatives at the Ellensburg reach (Umtanum gage) and Wapato reach (Parker gage) in an average water year. Flows at the Ellensburg and Wapato reaches represent general conditions in the upper and middle Yakima River, which are the reach areas most influenced by the Storage Study alternatives.

Table 2.10 Seasonal flow volume objectives (acre-feet) and modeled seasonal flow volumes (acre-feet) at the Umtanum and Parker gages in an average water year

Flows	Umtanum gage			Parker gage		
	Spring	Summer	Winter	Spring	Summer	Winter
Flow volume objective	636,175	297,500	280,385	717,448	309,400	490,012
No Action Alternative	585,335	601,322	280,385	445,928	159,919	490,012
Black Rock Alternative	675,962	460,431	322,529	881,588	311,415	526,985
Wymer Dam and Reservoir Alternative	610,142	540,142	318,324	434,352	160,178	478,654
Wymer Dam Plus Yakima River Pump Exchange Alternative	612,475	541,831	318,329	599,914	355,487	478,834

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 at the Umtanum and Parker gages is acceptable. However, at the Umtanum gage, maintaining flows at or close to the summer seasonal flow objective is considered ideal; while, at the Parker gage, 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 between No Action Alternative seasonal flow volumes and season flow volumes 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.

Table 2.11 Differences between No Action Alternative seasonal flow volumes and seasonal flow volume objectives

Gage location	No Action Alternative Spring	No Action Alternative Summer	No Action Alternative Winter
Umtanum	-8%	+102%	0%
Parker	-38%	-48%	0%

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.

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 spring and 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 (figures 2.2 and 2.3). (Hydrographs for four other key reaches are shown in figures 2.4–2.7.)

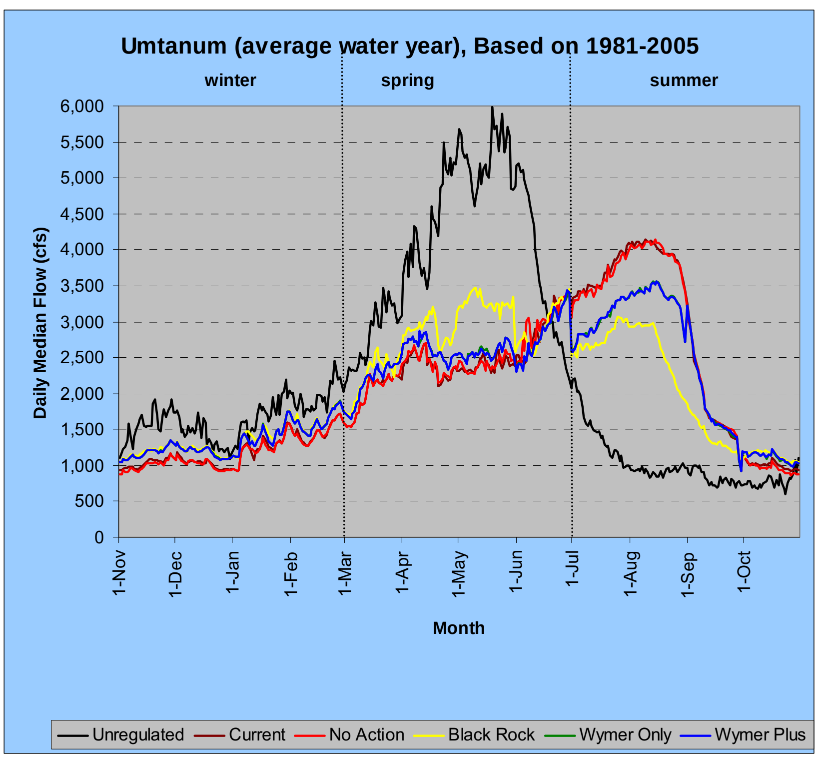


Figure 2.2 Median daily flow hydrograph for the Umtanum stream gage (RM 140) for the period of record (1981–2005).

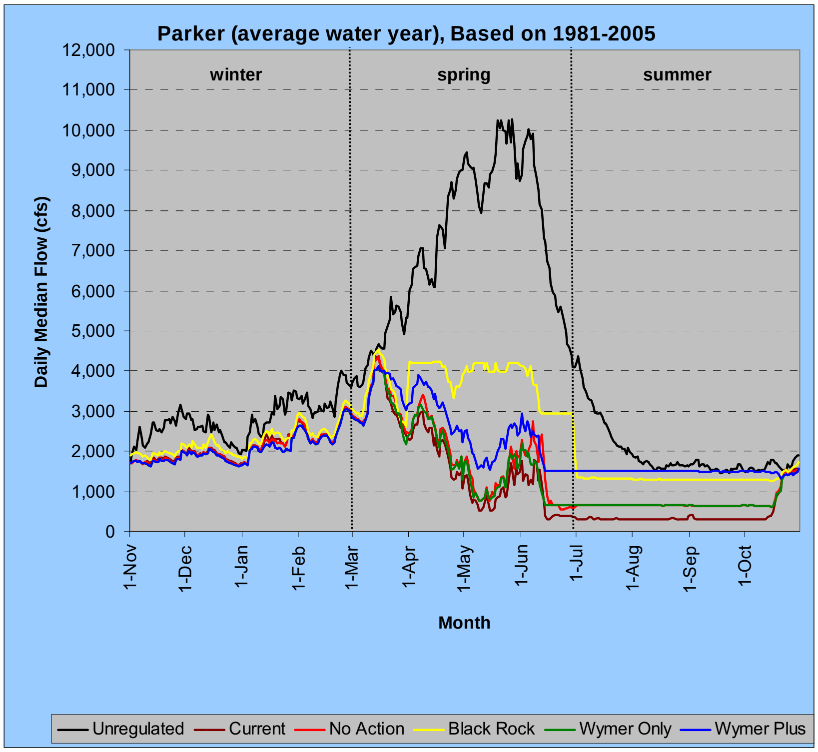


Figure 2.3 Median daily flow hydrograph for the Parker stream gage (RM 104) for the period of record (1981–2005).

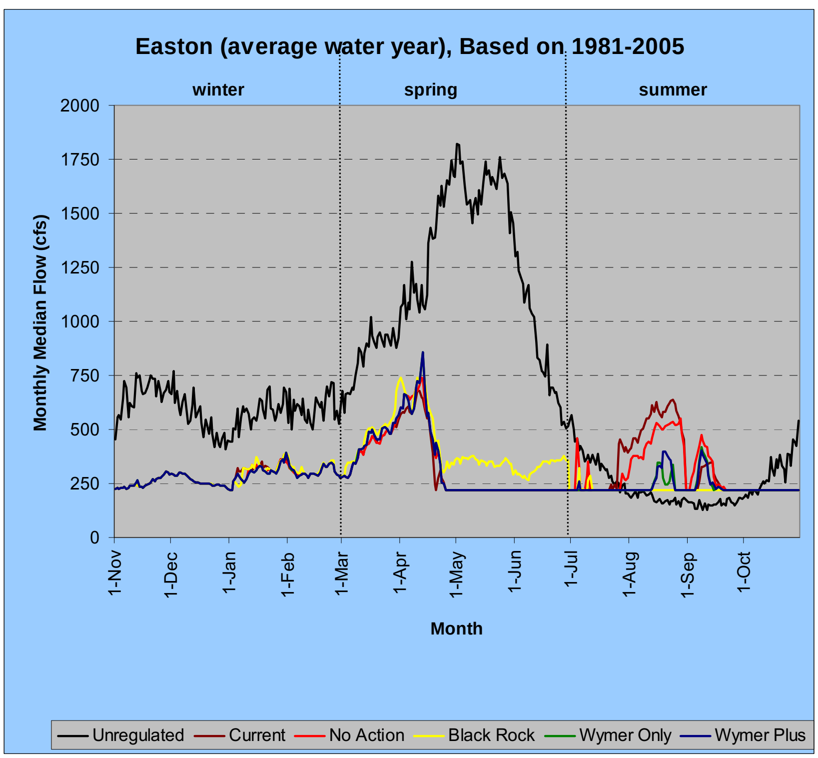


Figure 2.4 Median daily flow hydrograph for the Easton stream gage (RM 202) for the period of record (1981–2005).

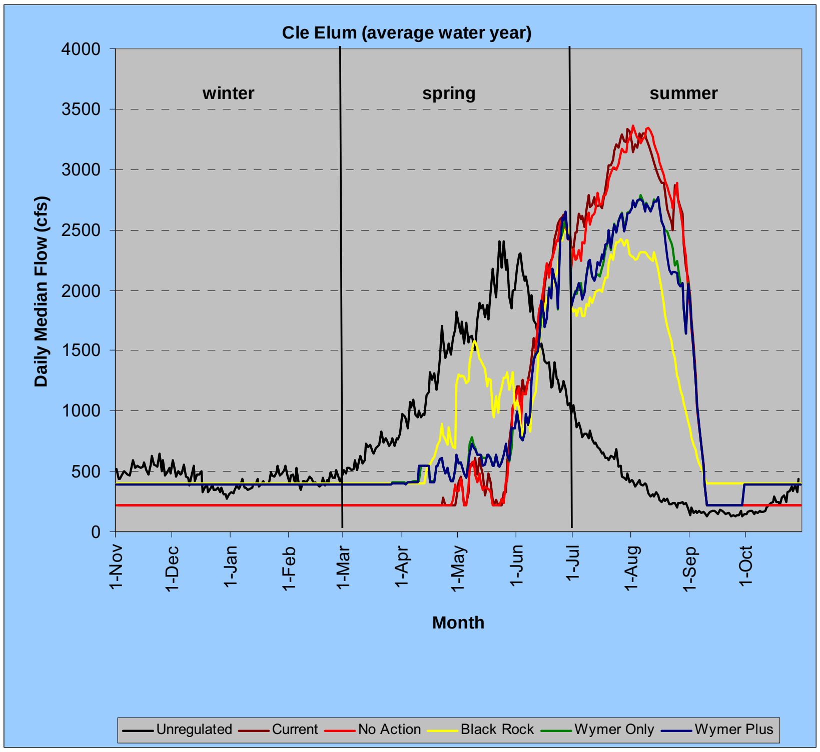


Figure 2.5 Median daily flow hydrograph for the Cle Elum stream gage on the Cle Elum River below dam (RM 7.9) for the period of record (1981–2005).

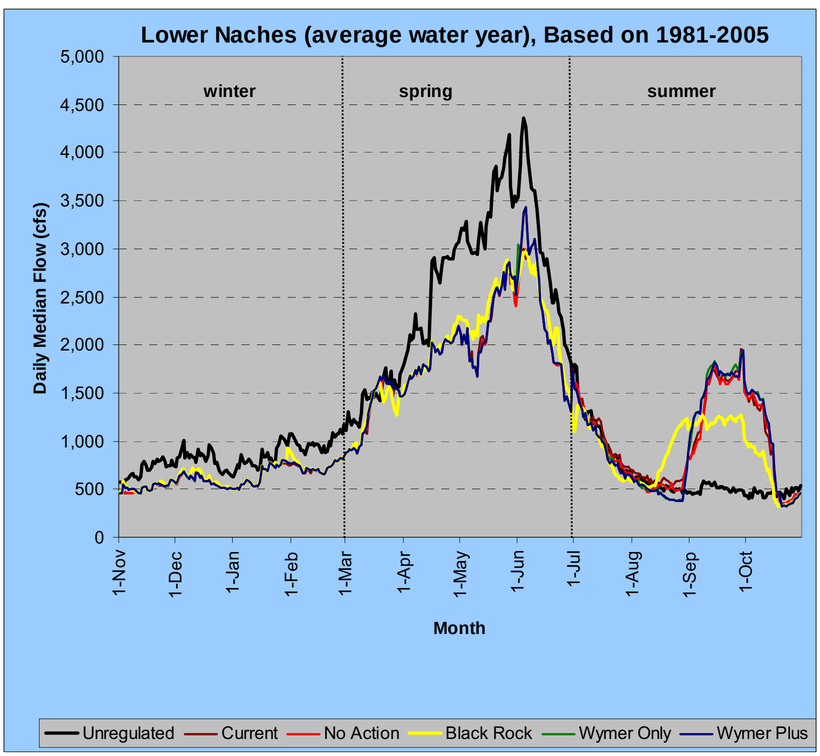


Figure 2.6 Median daily flow hydrograph for the lower Naches River stream gage near Yakima (RM 17) for the period of record (1981–2005).

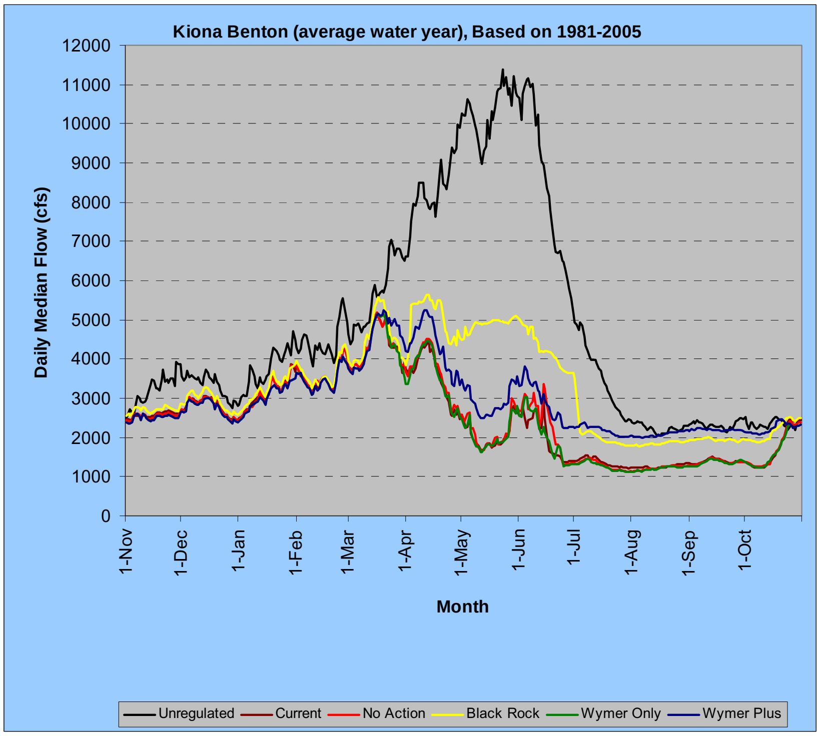


Figure 2.7 Median daily flow hydrograph for the Kiona gage (RM 29) for the period of record (1981–2005).

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

Table 2.12 Differences in seasonal flow volumes between Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives when compared to the No Action Alternative

Gage location	Spring			Summer			Winter		
	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	15%	4%	5%	-23%	-10%	-10%	14%	14%	14%
Parker	98%	-3%	35%	95%	0%	122%	8%	-2%	-2%

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 6 years, the proration level is better under the No Action Alternative; however, in 1994, the third year 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 under 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 3-year dry cycle, the difference in the proration level between the No Action Alternative and the current operation is negligible and is due to rounding of the Yak-RW model results.

Municipal Water 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

Economic or financial analyses were not performed for the No Action Alternative because it includes conservation measures that are authorized and will be funded under YRBWEP. In addition, 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 Most Probable Alternative Description

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 instead would be used to meet the Storage Study goals.

A 2,400-foot intake channel on Priest Rapids Lake with fish screens that meet National Marine Fisheries Service 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 (totaling 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 three-quarters of a mile up the tunnel from the pumping plant. A 6-mile-long, 500-kilovolt (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 1 mile across at its widest point.

Pumping from Priest Rapids Lake would occur when Columbia River water is available in excess of current instream target flows (section 2.4.2, "Operations") and storage space is available in Black Rock reservoir, with the exception of July and August. 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.

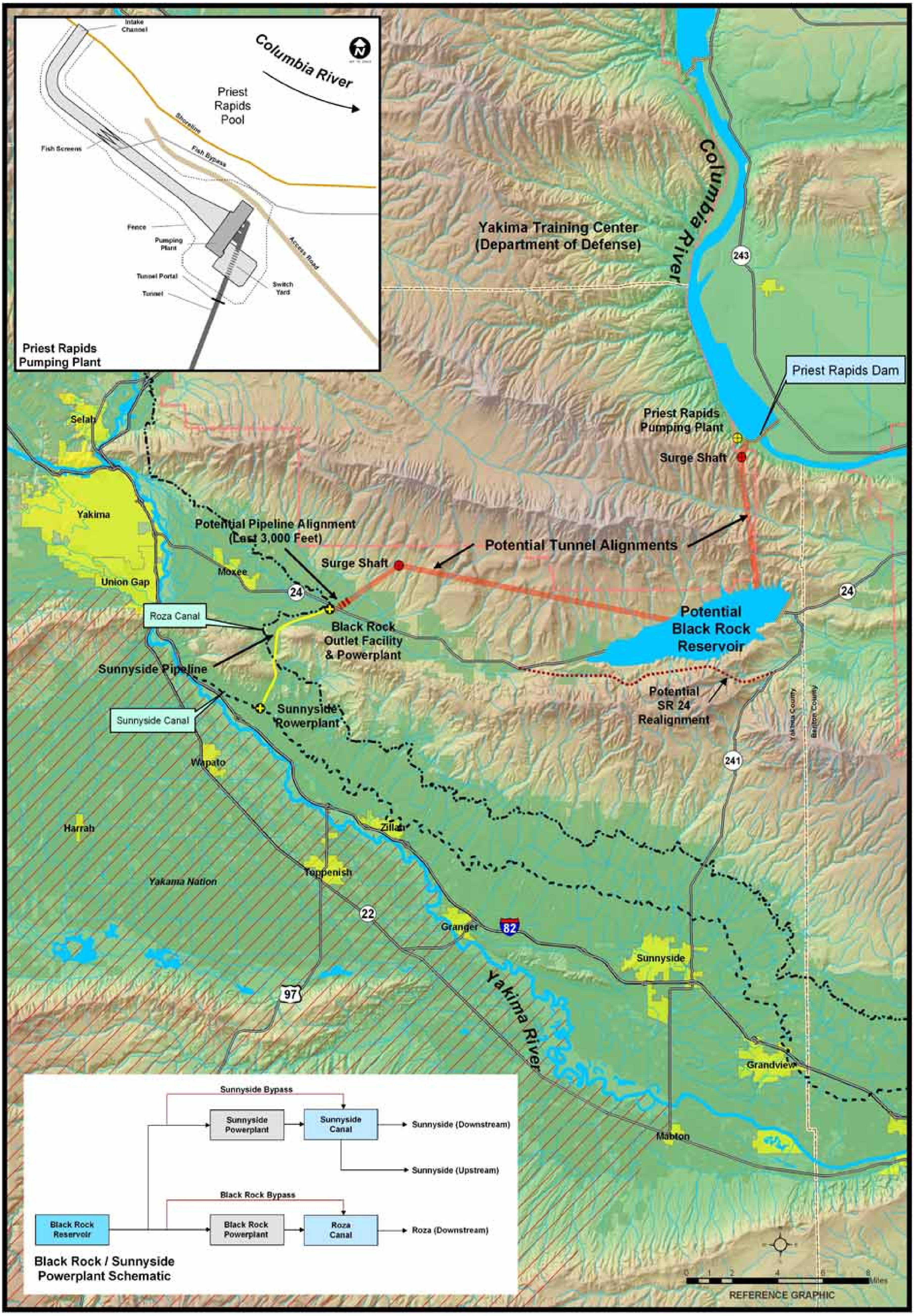
Throughout this document, the availability of water for pumping into Black Rock reservoir is characterized as a monthly average quantity because its measure is based on the BPA's HYDSIM simulation of current monthly operations. Within this monthly modeling capability, the available water for pumping is limited by the smallest of the excess of flows at Bonneville Dam, McNary Dam, and Priest Rapids above their respective seasonal target flows (section 2.4.2, "Operations"). However, in actual operations, the issue of availability of water for pumping would be resolved on a daily or weekly basis with appropriate parties.

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; 885 cfs would be carried to the 23-megawatt (MW) Black Rock powerplant and into the Roza Canal; and up to 1,200 cfs would be 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 MW) into the Sunnyside Canal for downstream delivery. However, a small number of Sunnyside water users upstream of this point would receive delivery of 17–20 cfs by a pumping plant and a buried polyvinyl chloride 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.

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 would be provided by others.



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.

2.4.1.1 Mitigation for Reservoir Seepage

Widespread concern exists about the possibility of higher groundwater levels and increased contaminant migration on the Hanford Site resulting from seepage from the proposed Black Rock dam and reservoir. This section describes the mitigation measures selected to reduce reservoir seepage and/or intercept seepage water before it reaches the Hanford Site and the effectiveness of those measures in minimizing impacts to the Hanford Site.

Key attributes considered when selecting the mitigation measures included preventing or intercepting reservoir seepage as close to the reservoir as possible and minimizing operational costs of mitigation (such as by pumping wells). Figure 2.8 provides an overview of the affected area. Reclamation developed two models to evaluate potential seepage and the effectiveness of proposed mitigation measures. First, Reclamation developed the groundwater seepage model to determine Black Rock reservoir seepage volume and direction (Reclamation, 2007a). Next, Reclamation developed the seepage mitigation model to determine the effectiveness of proposed seepage mitigation measures (Reclamation, 2008a).

Mitigation measures selected to reduce seepage at the reservoir include the following:

- Replacing sediments under the dam with zone 1 (impervious) core material.
- Installing a grout curtain under the dam.
- Constructing drainage tunnels in the right abutment.
- Constructing a cutoff wall in the right dam abutment.

Seepage mitigation model results show that the combination of these mitigation measures would reduce total *maximum* modeled reservoir seepage by approximately 30 percent (from 74.3 to 51.9 cfs). However, most of that seepage (46.5 cfs of the 51.9 cfs) would bypass these mitigation features and surface in the Dry Creek drainage downstream from the dam. The remaining total reservoir seepage (about 5.4 cfs) would continue deeper into the basalts. The minimal deep basalt flow is expected to have negligible effect on the Hanford Site contaminants.

Without further mitigation, the water that would surface in Dry Creek would flow downstream (with some loss to evaporation, assumed to be 25 percent) until it reached thick sediments near the intersection with Cold Creek. Then, it would re-infiltrate and continue flowing in the subsurface toward the Hanford Site.

Mitigation features to capture surface water and groundwater flows in Dry Creek would be constructed about 6.6 miles downstream from the dam in the Dry Creek drainage. These features include:

- Constructing a cutoff wall, approximately 200 feet deep[3] and 5,500 feet long across the valley.
- Constructing a 15-foot-high embankment on top of the cutoff wall to collect surface water in Dry Creek.
- Constructing a 48-inch-diameter pipeline to convey the surface water away from the site to the Yakima River.

The first two features would be located entirely within the ALE Reserve, while the pipeline would be located mostly in the ALE Reserve. Seepage mitigation model results show that the combination of these mitigation measures would capture the remaining seepage (46.5 cfs) and convey it to the Yakima River. Although seepage mitigation model results indicate the potential success of siting a cutoff wall in the Dry Creek Valley to capture the remaining seepage, a much more detailed assessment would be required to fully analyze the proposed mitigation measures to ensure their long-term effectiveness prior to actual application. Groundwater models are simplified representations of complex natural systems. They are helpful in understanding and comparing the effectiveness of proposed actions, but there are also uncertainties in the representation that must be recognized when evaluating the results.

The pipeline would extend 20.6 miles to the Yakima River along existing roadways, mostly within the ALE Reserve. A pipe inlet structure would be constructed through the 15-foot-high embankment wall to direct water to the pipeline. The inlet would have a trashrack to catch large debris, a trash rake for cleaning, and a steel slide gate to close off flow to the pipeline for maintenance (in the final design process, provisions would be made to accommodate the seepage flow during maintenance). A baffled outlet structure would transition water from the pipeline outlet to the Yakima River near Horn Rapids. A 150-foot-wide construction right-of-way along existing roadways would be needed for the pipeline construction, and a 100-foot right-of-way would be needed for permanent easement. Most of this right-of-way is on ALE Reserve property, except for the area where the pipeline discharges into the Yakima River, which is in Horn Rapids County Park. The outlet structure would be located on the north shore of the Yakima River, upstream of the boat ramp. The pipeline alignment in the park would be along existing roads.

Additionally, 10 wells (each about 300 feet deep) were included in the estimate for the mitigation features. The wells would be constructed, as needed, downstream from the cutoff wall to capture seepage in the deeper basalt layers, as well as any groundwater passing around or through the cutoff wall to prevent it from flowing east to the Hanford Site. The need for these wells would be

[3] In the seepage mitigation model, the cutoff wall was assumed to be constructed to the top of the basalt.

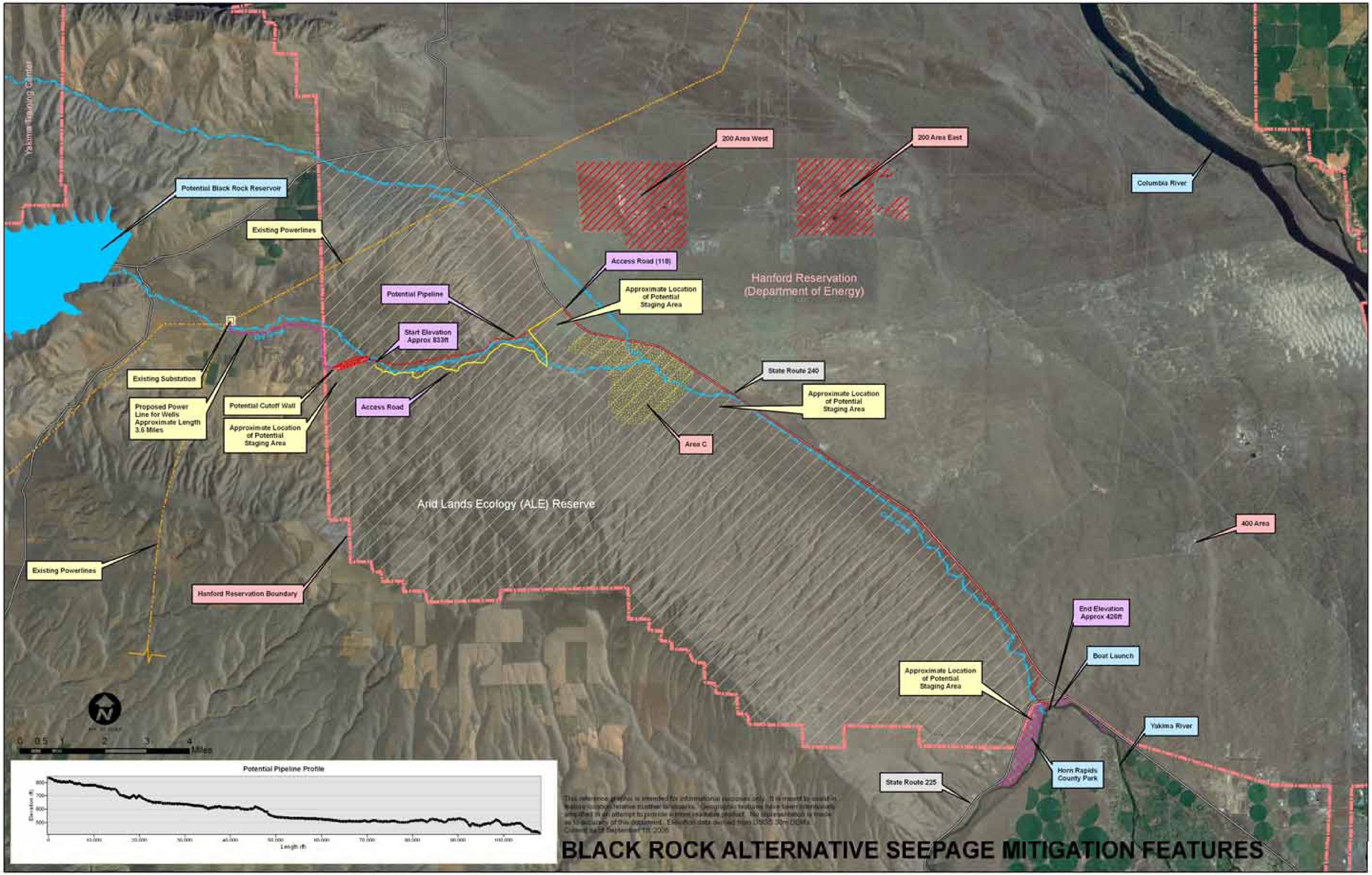


Figure 2.8 Area affected by seepage from Black Rock reservoir to Hanford Site.

indicated by groundwater monitoring wells that would be installed between the cutoff wall and SR–240. One or two of these wells could be placed upstream of the cutoff wall/embankment to pump groundwater into the pipeline upstream of the cutoff wall. These refinements would be made in the final design if construction were authorized. A 3.6-mile powerline would be constructed from an existing BPA substation located west of the ALE Reserve along Dry Creek to the embankment and wells in Dry Creek.

Surface water flow in Dry Creek, between the downstream side of Black Rock dam and the cutoff wall, should not affect the existing substation (shown on figure 2.8). An access road to the embankment, cutoff wall, and wells would be via a 12-foot-wide gravel-surfaced road along the existing road alignment. Figure 2.9 shows the modeled seepage mitigation features and provides a schematic cross-section of the flow paths of seepage.

DOE submitted a Responsible Opposing View (attachment A) expressing concern about potential failure of the seepage mitigation features and associated impacts to the Hanford Site. Reclamation has the following response. Black Rock dam is designed with multiple defensive design measures for reservoir seepage. This philosophy of including redundant design features is a hallmark of all well-designed dams and is important to ensure that there are multiple lines of defense in place to protect against unexpected performance. The design concept has been to include multiple seepage reduction and control features both at the dam and in downstream areas both to minimize the amount of reservoir seepage and also to intercept the seepage that does migrate downstream before it impacts any sensitive areas. At the dam, features to reduce seepage include excavation and cutoff of all alluvium beneath the dam core, careful foundation preparation, a multiple-row grout curtain through bedrock, a 400-foot-deep cutoff wall along the right abutment, and the possible use of an upstream blanket. Seepage collection features at the dam include the use of internal filters and drains, including drainage tunnels to intercept seepage flowing through the basalt bedrock. Downstream collection features include a deep cutoff wall to trap seepage with well fields to pump collected seepage and maintain existing groundwater levels. Seepage and groundwater models have been developed to identify the critical area(s) for the location of such features. However, during operation of Black Rock reservoir, all downstream groundwater levels would be monitored carefully to assess the level of reservoir-induced seepage. Should any areas experience unexpected high groundwater levels, additional wells could be located in those areas. While Reclamation projects typically do not include features to completely control seepage, the seepage mitigation features included in the Black Rock reservoir design are all industry-accepted measures that are effective in controlling and reducing seepage. The seepage mitigation measures are appropriate for this application and are not unique or unusual. There is no reason to expect failure of any components, particularly the internal dam features. Pumps and wells would be properly maintained and their performance monitored.

Should parts deteriorate or simply age, these components can be replaced. Given the multiple defenses and performance monitoring, the chance of the seepage mitigation measures suddenly failing is very remote.

2.4.1.2 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.

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

In order to construct the seepage mitigation features, a cofferdam would need to be constructed in Dry Creek upstream of the cutoff wall and embankment in case of runoff; a cofferdam also would need to be constructed in the Yakima River at Horn Rapids to allow for dewatering around the baffled outlet structure. Potential staging areas are shown on figure 2.8.

2.4.1.3 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 regular 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 periodic minor coating and concrete repair.

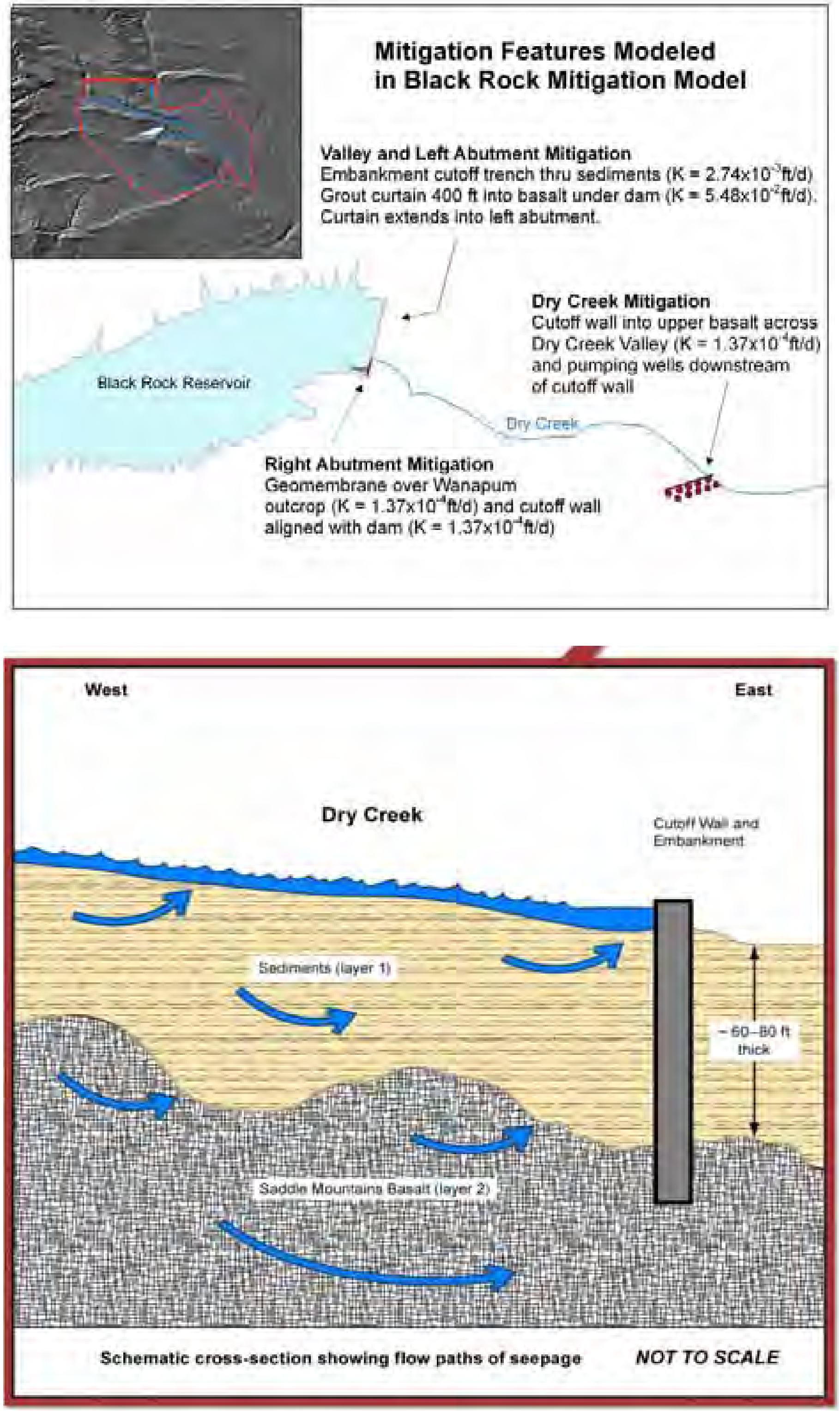


Figure 2.9 Black Rock reservoir seepage mitigation features.

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

Table 2.14 Summary of major facilities—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 requirement)
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, 6,590 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 capacity, production	
Location	Adjacent to Roza Canal MP 22.6
Powerplant capacity	900-cfs Black Rock powerplant – 23 MW
Sunnyside powerplant capacity, production	
Location	Adjacent to Sunnyside Canal MP 3.83
Powerplant capacity	900 cfs – 15–29.5 MW

Table 2.14 Summary of major facilities for the Black Rock Alternative (continued)

Facilities	Black Rock reservoir pump only
Rights-of-way for facilities	
Purchased land and easements	13,600 acres
Seepage mitigation features in Dry Creek	
Cutoff wall	200 feet deep and 5,500 feet long
Embankment	15 feet high and 5,500 feet long
Pipeline	20.6 miles long
Wells	10 wells below cutoff wall and embankment
Powerline	3.6 miles long

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 $5.7 billion (April 2007 prices).

Table 2.15 Total project costs—Black Rock Alternative[1]

Feature	Monte Carlo 0%	Most probable	Monte Carlo 100%
Priest Rapids fish screen and intake, pumping plant, and inflow conveyance (all tunnel)		$710,985,556	
Black Rock dam—central core rockfill embankment and outlet works		$1,319,362,715	
Downstream reservoir seepage mitigation (only)		$246,940,609	
Highway and utility relocations		$102,891,000	
Black Rock outlet structure and outflow conveyance to Roza Canal		$415,741,270	
Black Rock outlet facility—900-cfs powerplant		$126,833,699	
Sunnyside powerplant		$57,756,137	
Delivery systems to Roza, Sunnyside, and modification to existing facilities		$171,873,870	
Subtotal of pay items		$3,152,384,856	
Total mobilization costs (5% +/-)		$157,500,000	
Subtotal with mobilization		$3,309,884,856	
Total design contingencies		$367,115,144	
Construction contract cost		$3,677,000,000	
Total construction contingencies		$883,000,000	
Total field cost	$4,100,742,596	$4,560,000,000	$6,018,929,396
Noncontract costs	$853,319,620	$1,130,000,000	$1,713.635.756
Total project cost[2 3]	$4,954,062,216	$5,690,000,000	$7,732,565,152

[1] Results of the Monte Carlo cost-risk analyses are shown for the total field cost and total project cost for comparison purposes. More detail is in *Cost-Risk Analysis for Black Rock and Wymer Alternatives* (Reclamation, 2008j).

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

[3] Total project cost includes $6.6 million for right-of-way purchase and related activities.

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

Table 2.16 Annual OMR&E costs—Black Rock Alternative

Item	Black Rock reservoir pump only
Operation, maintenance, and replacement costs	$10,170,000
Pumping energy costs	$50,000,000
Total	$60,170,000

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 Marine Fisheries Service establishes seasonal target flows downstream from Priest Rapids, McNary, and Bonneville Dams.[5] Target flows facilitate spawning and downstream passage of juveniles and accommodate returning adult salmon and steelhead. Flow objectives are in place to protect fall Chinook spawning, incubation, and rearing downstream from Priest Rapids Dam at Vernita Bar. Table 2.17 and figure 2.11 show these seasonal target flows.

Table 2.17 Seasonal target flows 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[2]	NA
At Priest Rapids Dam – spawning target[3]	12/1–5/31	50,000–70,000	NA	NA
At McNary Dam – transport target[1]	4/10–6/30	[4]220,000–260,000	7/01–8/31	200,000
At Bonneville Dam – spawning target[1]	11/1–4/30	[5]125,000–160,000	NA	NA

[1] Per National Marine Fisheries Service BiOp.

[2] Not applicable.

[3] Minimum discharge required by Priest Rapids license is 36,000 cfs. Higher minimums at 50,000–70,000 cfs required for December 1–May 31. Monthly flow levels determined pursuant to Hanford Reach Fall Chinook Protection Program (Hanford Reach Agreement) signed in 2004. On April 10–June 30, the 135,000-cfs minimum would apply, subject to in-season decisions pursuant to the BiOp.

[4] Objective varies according to water volume forecasts.

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

The water supply for Black Rock reservoir is obtained by pumping from Priest Rapids Lake when mainstem Columbia River flows are greater than the seasonal instream target flows. Annual pumping includes replacement water for seepage and evaporation losses from Black Rock reservoir.

[5] The Columbia River water withdrawal schedule to fill Black Rock reservoir was based on the target flows established in the 2004 BiOp (National Marine Fisheries Service, 2004a). There was a remand of the 2004 BiOp in 2008; however, the Columbia River target flow remained the same as those in the 2004 BiOp (National Marine Fisheries Service, 2008).

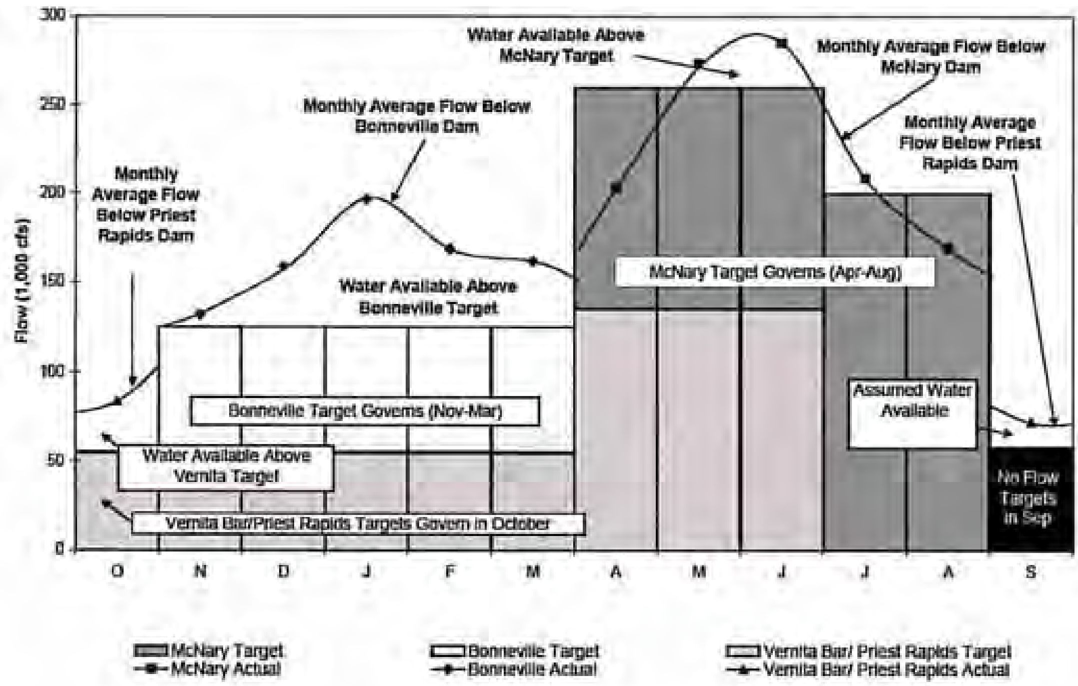


Figure 2.11 Target flows on the Columbia River and water availability above target flows.

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.

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:

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

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

- Up to 890 cfs to the Roza Canal primarily for delivery to downstream Roza lands[6]
- 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

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 on the Roza Irrigation District system.[7] Yakima River diversions also are 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 (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.

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

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

[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 1 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.

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.

Table 2.21 provides Black Rock reservoir storage contents (maximum, minimum, average, and average percent of full) for the 25-year period of record (1981–2005).

Table 2.21 Black Rock reservoir storage contents (thousand 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	Jun	Jul	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 1992–94 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 Black Rock reservoir end-of-month contents for the 3 dry years of 1992–94 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 1991–95)

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

Table 2.22 Columbia River water available, water pumped to Black Rock reservoir, and Black Rock reservoir end-of-month reservoir contents (water years 1991–95) (continued)

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–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 reaches of the Yakima River. 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 also would 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 improve flows considerably at the Parker gage beyond the unregulated flow of the No Action Alternative. (See figures 2.2–2.7.) 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–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.

- The water exchange with Roza and Sunnyside is limited by their irrigation diversion demands. The disposition of the exchange water is dependent on whether the Yakima Project is in the pre- or post-storage control operation. In the first part of the irrigation season prior to storage control (generally April–June), when the Black Rock Alternative operation criteria calls for significant flows downstream from Parker, the water acquired from the exchange operation, together with stored water releases (or bypass of reservoir inflow which would have been stored), is added to the unregulated flow to increase the flow at Parker. Once storage control begins, a portion of the water acquired from the exchange is used to meet the Black Rock Alternative operation criteria for the Parker flow objectives. This amount is determined by taking into account the monthly Title XII target flow requirements at the Parker gage as increased by the water conservation actions of the No Action Alternative. For instance, if the Black Rock Alternative operation criteria calls for a flow at the Parker gage of 1,300 cfs, the amount of this flow that is met from the water exchange is 1,300 cfs, less the Title XII target flows (as increased by the water conservation actions of the No Action Alternative). The residual amount accruing from the exchange remains in the Yakima Project storage system as potential carryover for the next year spring operation.

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 water 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–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 also is 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 water demands.

The municipal water 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 water supply 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.

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 supply diversions													

2.4.3 Accomplishments

2.4.3.1 Water Provided by the Black Rock Alternative

Table 2.26 presents changes in hydrologic indicators under the Black Rock Alternative compared to the No Action Alternative for the 25-year period of record (1981–2005). As shown in the table, with implementation of the Black Rock Alternative, model results show improvement in the Yakima Project water supply over the 25-year period when compared to the No Action 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.

In 1994, the most severe drought year in the 25-year period of record, model results show that the Black Rock Alternative would have provided approximately 400,000 acre-feet of additional proratable water compared to the No Action Alternative. Of the four large irrigation divisions, the additional proratable water supply that would have been provided is approximately as follows:
Wapato, 125,000 acre-feet; Kittitas, 113,000 acre-feet; Roza, 125,000 acre-feet; and Sunnyside, 34,000 acre-feet. The additional proratable water supply for the Roza and Sunnyside Divisions (the exchange participants) was from Black Rock reservoir.[8]

[8] In a November 7, 2007, letter to the Commissioner of Reclamation, the Sunnyside Division Board indicated that, while it would participate in a water exchange to facilitate a better water supply for the Yakima River basin, it did not want to receive water in a dry year if it would have to incur additional costs to its members. Storage Study analyses show the additional water that could be available to the division and also include the agricultural benefits from that water. The Yakima-Tieton Irrigation District also indicated its desire to not be included in receiving dry-year supplemental water from any alternative.

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)

		TWSA distribution					
	April 1 TWSA	Apr–Sep Yakima River flow volume at Parker gage (maf)	Apr–Sep diversion volume upstream of the Parker gage (maf)	Sep 30 reservoir contents change (maf)	Apr–Sep Yakima River flow volume at mouth (maf)	Irrigation delivery volume shortage (maf)[1]	Irrigation proration level 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 25-year period of record of 1981–2005) and the volume delivered in a specific year.

In 1994, compared to the No Action Alternative, the Black Rock Alternative would have provided an additional 280,000 acre-feet (additional mean daily flow of 1,575 cfs) of flow downstream from the Parker gage in April–June and an additional 40,000 acre-feet (additional mean daily flow of 220 cfs) in July–September.

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 greatest reduction in summer flows in the upper Yakima River compared to the two Wymer Alternatives. Winter flows are greater under the Black Rock Alternative than under the Wymer Dam and Reservoir and No Action Alternatives and similar to the Wymer Dam Plus Yakima River Pump Exchange Alternative. (See figures 2.2–2.7.)

Ellensburg Reach (Umtanum gage)

Compared to the No Action Alternative, seasonal flow volumes are 15 percent greater in spring; 23 percent less in summer; and 14 percent greater in winter (table 2.12).

The spring season stream runoff pattern under 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)

Compared to the No Action Alternative, seasonal flow volumes are 98 percent greater in spring; 95 percent greater in summer; and 8 percent less in winter, which is not considered detrimental (table 2.12).

The spring season stream runoff pattern under 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 1994, the third year of the 3-year dry cycle.

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.

Table 2.27 Irrigation proration level under the Black Rock Alternative compared to the No Action Alternative for the 25-year period of record (1981–2005)

	Irrigation proration level (percent)		
Water year	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

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 supply is prorated in the same manner as the irrigation water supply. This would result in the following municipal water 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 water supply available during prorated years under the Black Rock Alternative

Water year	Municipal water supply 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 three benefit-cost ratios for the Black Rock Alternative, as presented in table 2.29. These three benefit-cost ratios stem from the three cost estimates (i.e., Monte Carlo 0%, most probable, and Monte Carlo 100%) that were developed for this alternative. Because total costs exceeded total benefits under each scenario, this results in negative net benefits, or benefit-cost ratios less than one. On the basis of the results of this benefit-cost analysis, this alternative is not economically justified. The complete economic and financial analysis is in section 2.7.

Table 2.29 Black Rock Alternative benefit-cost ratio

		Monte Carlo 0%	Most probable	Monte Carlo 100%
Total NED costs ($ million)	Present value	7,390.2	8,308.4	10,907.8
	Annual	363.4	408.5	536.4
Total NED benefits ($ million)	Present value	1,068.0	1,068.0	1,068.0
	Annual	52.5	52.5	52.5
Net benefits ($ million)	Present value	-6,322.3	-7,240.5	-9,839.9
	Annual	-310.9	-356.0	-483.8
Benefit-cost ratios	Present value and annual	.14	.13	.10

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, "Related Permits, Actions, and Laws."

2.5 Wymer Dam and Reservoir Alternative

2.5.1 Most Probable Alternative Description

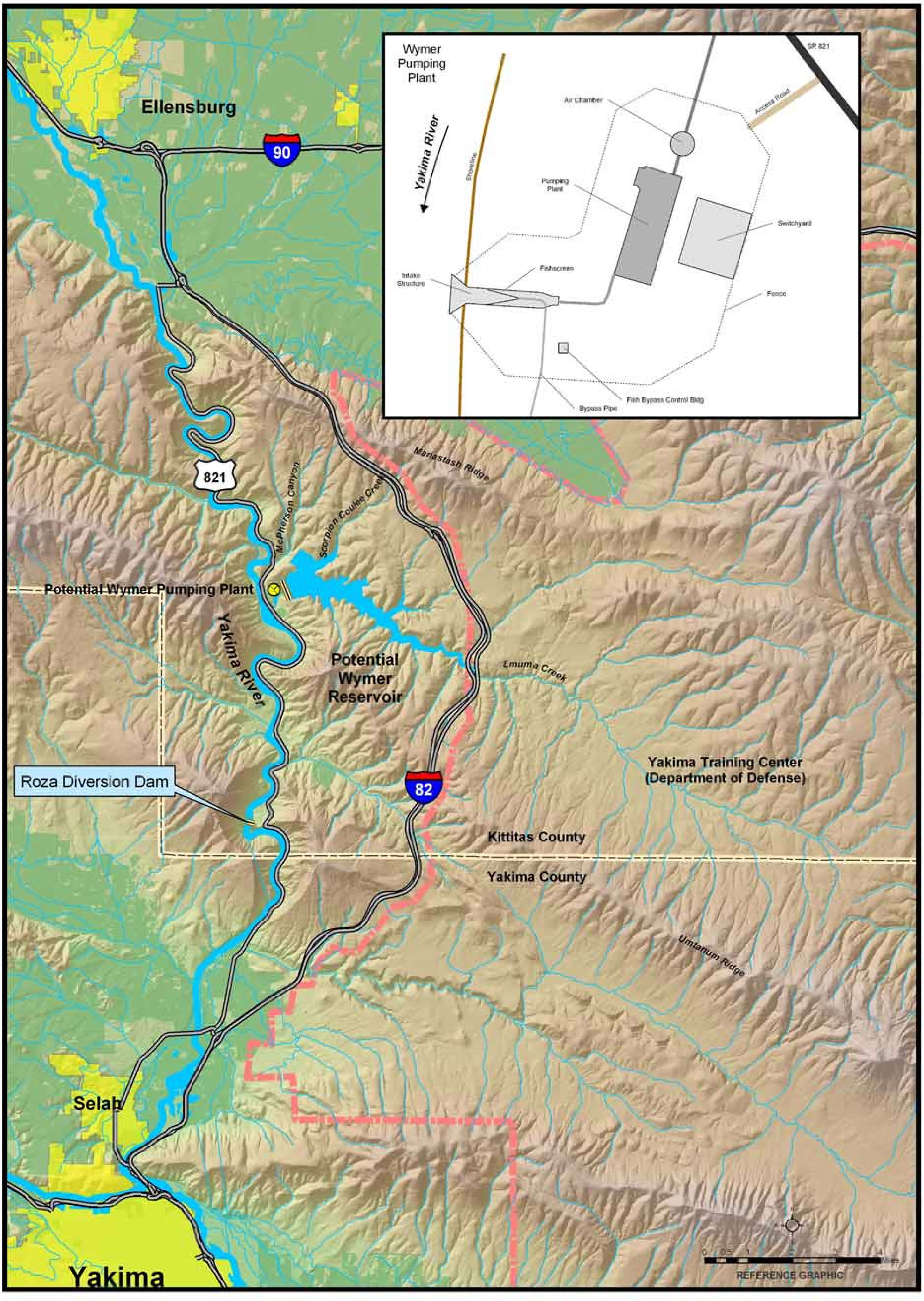
The Wymer Dam and Reservoir Alternative involves construction of an off-channel storage facility on Lmuma Creek (an intermittent stream), approximately 8 miles upstream of Roza Diversion Dam. See foldout map.

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 0–50 feet. The elevation of the bottom girder of the eastbound 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 National Marine Fisheries Service 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, 120-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-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 (structural height), 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 also would 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 single-level outlet works on the south dam abutment, sized for 1,600 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 to 1,233,200 acre-feet, respectively.

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



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 October 2008.

nontrailered boats, and portable utilities. Additional recreation facilities could be provided. Table 2.30 presents a summary of the most probable characteristics of this alternative.

Table 2.30 Summary of major facilities—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 (120-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	1,600 cfs
Intake structure	Single-level intake sized for reservoir evacuation
Conveyance type	Pipeline (102-inch diameter), Lmuma Creek
Rights-of-way facilities	
Purchased land and easements	4,040 acres

2.5.1.1 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-diameter 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 also may 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.

2.5.1.2 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 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.

2.5.1.3 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
- 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–May would be used to fill the 82,500 acre-feet of storage space each year. January–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 2.12 shows Wymer daily reservoir elevation for typical annual operation.

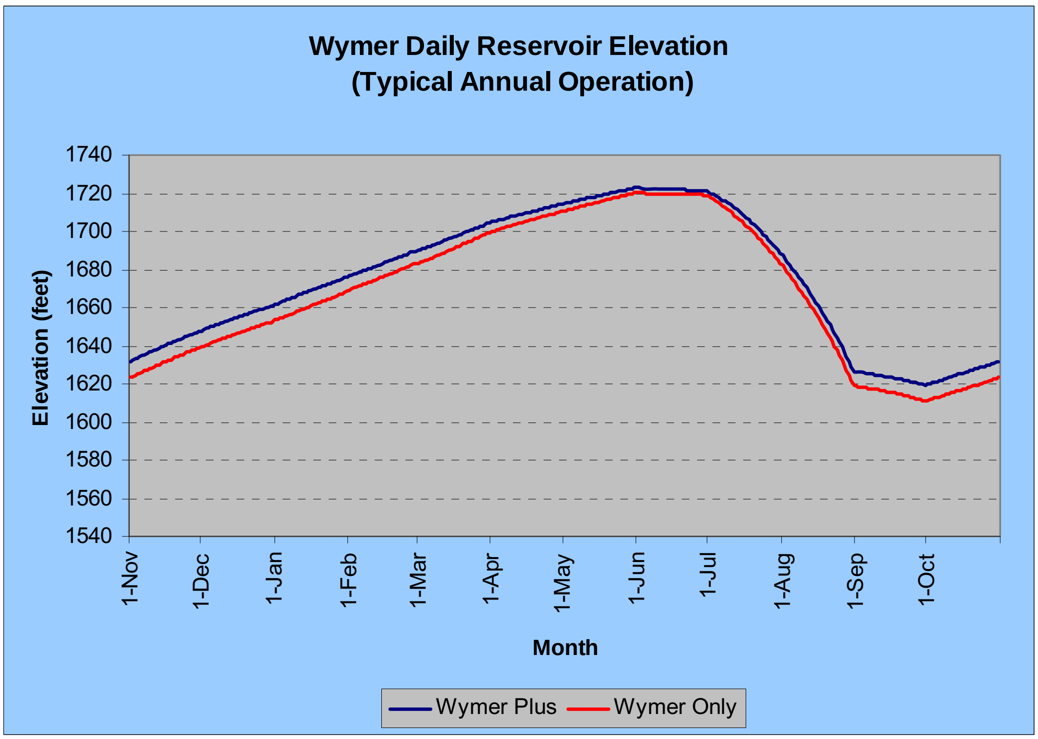


Figure 2.12 Wymer daily reservoir elevation for typical annual operation.

Total project cost for the Wymer Dam and Reservoir Alternative was estimated at $1.2 billion (table 2.31). Table 2.32 shows annual OMR&E costs.

Table 2.31 Total project costs—Wymer Dam and Reservoir Alternative[1]

Feature	Monte Carlo 0%	Most probable	Monte Carlo 100%
Wymer dam structure, 400 cfs pumping plant, and outlet		$544,730,818	
Subtotal of pay items		$544,730,818	
Total mobilization costs (5%+-)		$26,800,000	
Subtotal with mobilization		$571,530,818	
Total design contingencies		$56,469,182	
Construction contract cost		$628,000,000	
Total construction contingencies		$158,000,000	
Total field cost	$704,179,176	$786,000,000	$1,011,946,307
Noncontract costs	$163,620,755	$238,000,000	$325,461,024
Total project cost[2 3]	$867,799,931	$1,024,000,000	$1,337,407,331

[1] Results of the Monte Carlo cost-risk analyses are shown for the total field cost and total project cost for comparison purposes. More detail is in *Cost-Risk Analysis for Black Rock and Wymer Alternatives* (Reclamation, 2008j).

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

[3] Total project costs include $1.9 million for right-of-way purchase and related activities.

Table 2.32 Annual OMR&E costs—Wymer Dam and Reservoir Alternative

Item	Wymer Dam and Reservoir Alternative
Operation maintenance and replacement costs	$1,080,000
Pumping energy costs	$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 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 greater releases not to exceed the 420-cfs pump capacity of Wymer pumping plant. An illustration of this is water year 1988 when greater 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 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 of record (1981–2005).

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.[9] 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. Releases from Wymer reservoir of up to 1,000 cfs can be made as 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 show that 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 also is completed.

Table 2.35 provides Wymer reservoir storage contents (maximum, minimum, average, and average percent of full) for the 25-year period of record (1981–2005).

Table 2.35 Wymer reservoir storage contents (thousand acre-feet) 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

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:

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

- 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 that previously was 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 supply diversions													

2.5.3 Accomplishments

2.5.3.1 Water Provided by the Wymer Dam and Reservoir Alternative

Table 2.37 presents 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). As shown in the table, with implementation of the Wymer Dam and Reservoir Alternative, model results show improvement in the Yakima Project water supply over the 25-year period 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)

		TWSA distribution					
	April 1 TWSA	Apr–Sep Yakima River flow volume at Parker gage (maf)	Apr-Sep diversion volume upstream of the Parker gage (maf)	Sep 30 reservoir contents change (maf)	Apr–Sep Yakima River flow volume at mouth (maf)	Irrigation delivery volume shortage (maf)[1]	Irrigation proration level 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%	

[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 25-year period of record of 1981–2005) and the volume delivered in a specific year.

In 1994, the most severe drought year in the 25-year period of record, model results show that the Wymer Dam and Reservoir Alternative would have provided approximately 16,000 acre-feet of additional proratable water compared to No Action. Of the four large irrigation divisions, the additional proratable water supply that would have been provided is approximately as follows: Wapato, 4,800 acre-feet; Kittitas, 4,700 acre-feet; and Roza, 4,800 acre-feet; and Sunnyside, 1,600 acre-feet.

In 1994, compared to the No Action Alternative, the Wymer Dam and Reservoir Alternative would have provided slightly less flow (-2,000 acre-feet) in April–June, equating to an average daily flow reduction of approximately 10 cfs downstream from the Parker gage, and an additional 775 acre-feet (additional mean daily flow of 4 cfs) in July–September.

The irrigation operation for the Wymer Dam and Reservoir Alternative provides that water be replaced from the 80,000 acre-feet of Wymer reservoir capacity assigned to irrigation storage only when the irrigation proration level is less than 70 percent. This occurred in 1993; consequently, the irrigation storage contents were depleted, and there were not sufficient flows to replace these releases in year 1994.

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 greater than the No Action Alternative. Summer flows in the upper Yakima River (Umtanum gage) under the Wymer Dam and Reservoir Alternative are similar to those under the Wymer Dam Plus Yakima River Pump Exchange Alternative and are between summer flows for the Black Rock and No Action Alternatives. (See figures 2.2–2.7.)

Ellensburg Reach (Umtanum gage)

Compared to the No Action Alternative, seasonal flow volumes are 4 percent greater in spring; 10 percent less in summer; and 14 percent greater in winter, 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 2.2).

Wapato Reach (Parker gage)

Compared to the No Action Alternative, seasonal flow volumes are 3 percent less in spring, the same in summer; and 2 percent less in winter, 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; summer flows are the same as under the No Action Alternative, but better than under the current operation. (See figures 2.2–2.7.)

2.5.3.3 Dry-Year Proratable Irrigation Supply Provided

Table 2.38 presents 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 1994, the third year 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 under the Wymer Dam and Reservoir and Wymer Dam Plus Yakima River Pump Exchange Alternatives compared to the No Action Alternative for the 25-year period of record (1981–2005)

Water year	Proration level (percent)		
	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 Water 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 supply is prorated in the same manner as the irrigation water supply. This would result in the following municipal water 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 under the Wymer Dam and Reservoir Alternative

Water year	Municipal water supply 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 NED analysis provides three benefit-cost ratios for the Wymer Dam and Reservoir Alternative, as presented in table 2.40. These three benefit-cost ratios stem from the three cost estimates (i.e., Monte Carlo 0%, most probable, and Monte Carlo 100%) which were developed for this alternative. Because total costs exceeded total benefits under each scenario, this results in negative net benefits, or benefit-cost ratios of less than one. Based on the results of this benefit-cost analysis, this alternative is not economically justified. The complete economic and financial analysis is in section 2.7.

Table 2.40 Wymer Dam and Reservoir Alternative benefit-cost ratio

		Monte Carlo 0%	Most probable	Monte Carlo 100%
Total NED costs ($ million)	Present value	1,148.4	1,340.6	1,751.6
	Annual	56.5	65.9	86.1
Total NED benefits ($ million)	Present value	411.5	411.5	411.5
	Annual	20.2	20.2	20.2
Net benefits ($ million)	Present value	-737.0	-929.1	-1,340.2
	Annual	-36.2	-45.7	-65.9
Benefit-cost ratios	Present value and annual	.36	.31	.23

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

The Wymer Dam Plus Yakima River Pump Exchange Alternative couples 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 component of this alternative involves a "bucket-for bucket" exchange of up to 1,050 cfs that would not be diverted by Roza and Sunnyside but would remain in the Yakima 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 component 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.[10] 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–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. The intake to pumping plant #1 would have fish screens consisting of 22 stainless steel wedge wire fish screen panels, each measuring 11 feet wide and 14 feet high, and would comply with all National Marine Fisheries Service and Washington State criteria. 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, 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

[10] 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.

(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 event 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:

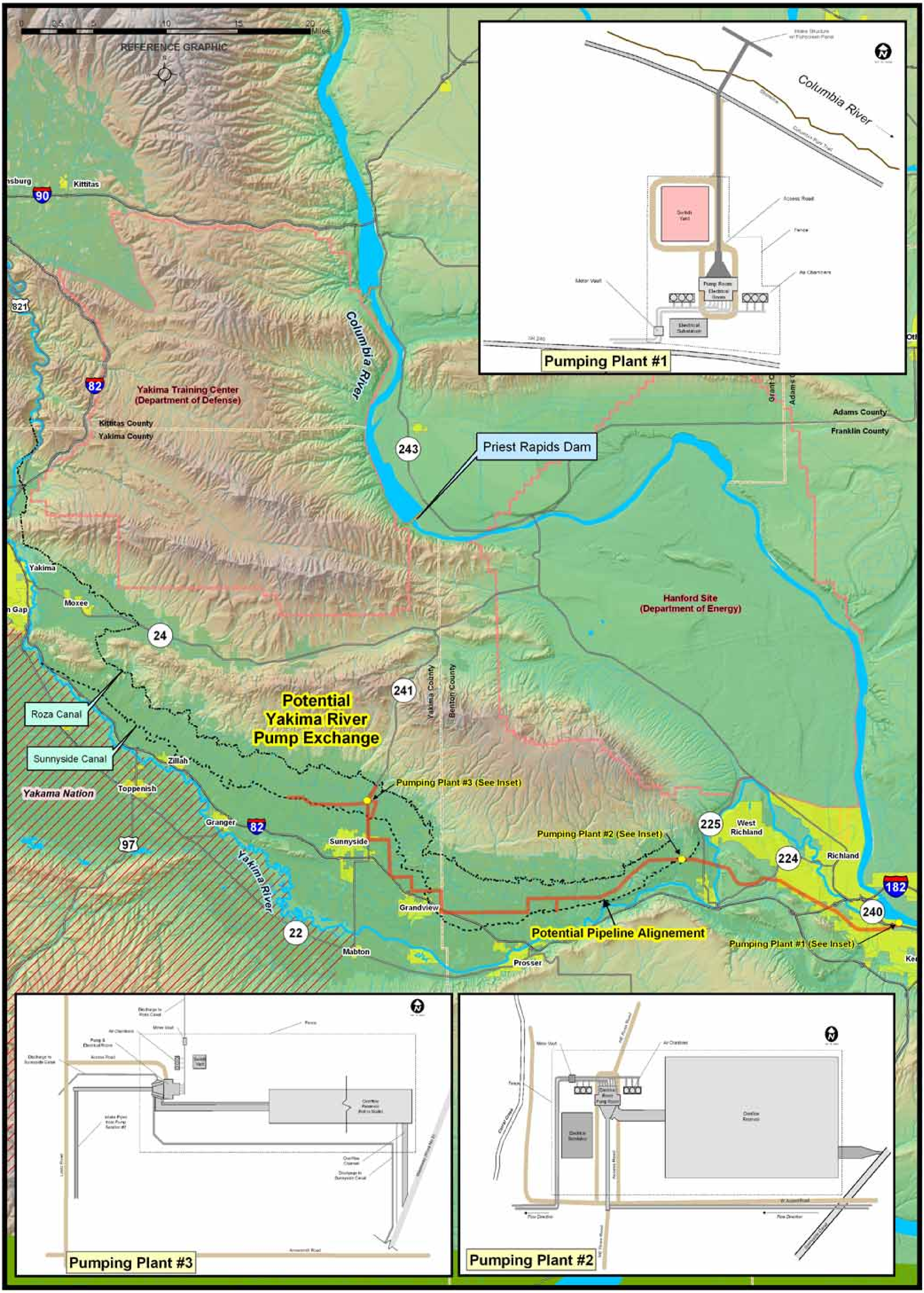
- A 500-kV, ½-mile-long, powerline from pumping plant #1 to the closest substation
- A 230-kV, 1½-mile-long powerline from an existing nearby substation to pumping plant #2
- A 115-kV, 3-mile-long powerline from the closest tap onto an existing powerline to pumping plant #3

The annual volume delivered during the irrigation season by the pump exchange in a nonprorated water year would range from about 263,000–382,000 acre-feet. The residual demand of about 278,000–382,000 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).

2.6.1.1 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, Washington**	**Near Benton City, Washington**	**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			Pumping plant #3 to Sunnyside Canal (MP 30.0)
Capacity			200 cfs
Type			1 steel pipeline
Diameter			72-inch
Length			5 miles
Total rights-of-way, pumping plants, and pipeline			1,600 acres

[1] In addition, there is one standby pump at each pumping plant.

2.6.1.2 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.

2.6.1.3 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.

2.6.1.4 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–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. Reclamation did not calculate a range of costs for the Wymer Dam Plus Yakima River Pump Exchange Alternative because, while it does provide some additional fish benefits when compared to the Wymer Dam and Reservoir Alternative, it does not provide more irrigation or municipal benefits and does have a much higher total project cost and a lower benefit-cost ratio.

Table 2.42 Total project costs—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	$544,731,000
Subtotal of pay items	$1,996,451,000
Total mobilization costs (5% +/-)	$99,823,000
Subtotal with mobilization	$2,096,274,000
Total design contingencies (15% +/-)	$314,441,000
Construction contract cost	$2,410,715,000
Total construction contingencies (25% +/-)	$602,685,000
Total field cost	$3,013,400,000
Noncontract costs (35% +/-)	$1,054,600,000
Total cost for pump exchange component	$3,044,000,000
Total project cost	$4,068,000,000

Table 2.43 Annual OMR&E costs—Wymer Dam Plus Yakima River Pump Exchange Alternative

Item	Costs
Operation, maintenance, and replacement costs	$18,198,000
Pumping energy costs	$19,815,000
Total	$38,013,000

2.6.2 Operations

2.6.2.1 Wymer Reservoir Component

The operational aspects of Wymer reservoir 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

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.

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.[11] 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 July 1), 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.

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.[12] 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.[13]

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

[12] 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.

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

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

2.6.2.3 Yakima Project

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.

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

<table>
<tr><th colspan="4">End of prior calendar year</th><th colspan="10">Current calendar year</th></tr>
<tr><th colspan="2">Prior irrigation season</th><th colspan="5"></th><th colspan="7">Irrigation season</th></tr>
<tr><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th></tr>
<tr><td></td><td colspan="8">Additional Cle Elum Lake releases of 185–200 cfs</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="8">Filling 82,500 acre-feet Wymer reservoir</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="3">Filling 80,000 acre-feet Wymer reservoir (following dry years)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="7">Yakima Project irrigation diversions</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="7">Yakima River pump exchange deliveries to Roza and Sunnyside</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="7">Enhanced Parker gage flows</td></tr>
<tr><td colspan="14">Municipal water supply diversions</td></tr>
</table>

2.6.3 Accomplishments

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

Table 2.46 presents changes in hydrologic indicators under the Wymer Dam Plus Yakima River Pump Exchange Alternative compared to the No Action Alternative for the 25-year period of record (1981–2005). As shown in the table, under the Wymer Dam Plus Yakima River Pump Exchange Alternative, model results show improvement in the Yakima Project water supply over the 25-year period when compared to the No Action Alternative. 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.

Table 2.46 Changes in hydrologic indicators under the 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 (maf)	Irrigation delivery volume shortage (maf)[1]	Irrigation proration level and % change
		Apr–Sep Yakima River flow volume at Parker gage (maf)	Apr–Sep diversion volume upstream of the Parker gage (maf)	Sep 30 reservoir contents change (maf)			
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	1.76	0.57	1.13	0.04	0.31	0.38	29%
Change from No Action Alternative	0.01	0.32	-0.29	-.03	0.00	0.00	2%
% change	1%	128%	-20%	-14%	0%	0%	

[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 25-year period of record of 1981–2005) and the volume delivered in a specific year.

In 1994, the most severe drought year in the 25-year period of record, model results show that the Wymer Dam Plus Yakima River Pump Exchange Alternative would have provided approximately 19,000 acre-feet of additional proratable water compared to the No Action Alternative. Of the four large irrigation divisions, the additional proratable water supply that would have been provided is approximately as follows: Wapato, 5,600 acre-feet; Kittitas, 5,600 acre-feet; Roza, 5,700 acre-feet; and Sunnyside, 1,900 acre-feet.

In 1994, compared to the No Action Alternative, the Wymer Dam Plus Yakima River Pump Exchange Alternative would have provided an additional 161,000 acre-feet (additional mean daily flow of 890 cfs) of flow downstream from the Parker gage in April–June and an additional 156,000 acre-feet (additional mean daily flow of 860 cfs) in July–September.

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. Summer flows in the upper Yakima River (Umtanum gage) are the same as under the Wymer Dam and Reservoir Alternative, with a flow reduction that falls between those of the Black Rock and No Action Alternatives. (See figures 2.2–2.7.)

Ellensburg Reach (Umtanum gage)

Compared to the No Action Alternative, the seasonal flow volumes are 5 percent greater in spring; 10 percent less in summer; and 14 percent greater in winter, 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 that under the Wymer Dam and Reservoir Alternative in the upper Yakima River and in between those under the Black Rock and No Action Alternatives.

Wapato Reach (Parker gage)

Compared to the No Action Alternative, the seasonal flow volumes are 35 percent greater in spring; 122 percent greater in summer; and 2 percent less in winter, 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 greater daily flows. Summer flows are the highest of all the alternatives. (See figures 2.2–2.7.)

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 Water Supply Provided

The municipal water 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 a 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 benefit-cost ratio

Construction period (noncontract cost percent)		10 years (35%)
Total NED costs ($ million)	Present value	5,926.8
	Annual	291.4
Total NED benefits ($ million)	Present value	440.0
	Annual	21.6
Net benefits ($ million)	Present value	-5,486.8
	Annual	-269.8
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. The economic and financial analysis has been updated from the Draft PR/EIS. This section presents this updated analysis.

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 period of analysis (also referred to as the study period), it is important to convert the benefits and costs to a common point in time. The period of analysis can be separated into the construction period (timeframe during which construction costs are incurred) and the benefits period (timeframe during which project benefits, as well as annual operating costs, are incurred). 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 length of 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.

Table 2.48 NED benefit-cost analysis summary

		Black Rock Alternative			Wymer Dam and Reservoir Alternative			Wymer Dam Plus Yakima River Pump Exchange Alternative
	Value Option	**Monte Carlo 0%**	**Most probable**	**Monte Carlo 100%**	**Monte Carlo 0%**	**Most probable**	**Monte Carlo 100%**	
Total NED costs ($ million)	Present value	7,390.2	8,308.4	10,907.8	1,148.4	1,340.6	1,751.6	5,926.8
	Annual	363.4	408.5	536.4	56.5	65.9	86.1	291.4
Total NED benefits ($ million)	Present value	1,068.0	1,068.0	1,068.0	411.5	411.5	411.5	440.0
	Annual	52.5	52.5	52.5	20.2	20.2	20.2	21.6
Net benefits ($ million)	Present value	-6,322.3	-7,240.5	-9,839.9	-737.0	-929.1	-1,340.2	-5,486.8
	Annual	-310.9	-356.0	-483.8	-36.2	-45.7	-65.9	269.8
Benefit-cost ratios	Present value and annual	.14	.13	.10	.36	.31	.23	.07

This table displays the total NED costs, total NED benefits, net benefits (i.e., total NED benefits minus total NED costs), and benefit-cost ratios (i.e., total NED benefits divided by total NED costs) for each alternative. As discussed in detail in section 2.2.4, a range of cost estimates (i.e., Monte Carlo 0%, most probable, and Monte Carlo 100%) are presented for the Black Rock and Wymer Dam and Reservoir Alternatives, which results in a range of net benefits and benefit-cost ratios for those alternatives. Because of the very low benefit-cost ratio identified in the Draft PR/EIS, Reclamation decided to not calculate a range of costs for the Wymer Dam Plus Yakima River Pump Exchange Alternative; the benefit-cost analysis was computed using the same costs that were presented in the Draft PR/EIS for the pipeline and pumping plants and the new costs for Wymer dam.

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 are provided in sections 2.7.1.1 and 2.7.1.2.

The cost categories aggregated into total NED costs include: (1) total project costs comprised of field costs and noncontract costs, (2) interest during construction, and (3) 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 into the total NED cost estimate.

The benefit categories aggregated into total NED 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., the powerplant at Priest Rapids Dam), and (5) fisheries use values (commercial, sport, Tribal subsistence). The 100-year stream of annual benefits also was discounted to a present value as of the start of the benefits period. While the benefit categories were included in the benefit-cost analysis, the valuation of threatened and endangered fish was not included in the analysis; as a result, the fishery benefits may be considered understated. For more discussion on this topic, see the fisheries nonuse value discussion in the fisheries benefit portion in section 2.7.1.2.

Black Rock Alternative. The benefit-cost results for the Black Rock Alternative are presented in table 2.48. The three NED cost estimates displayed for this alternative (i.e., Monte Carlo 0%, most probable, and Monte Carlo 100%), when combined with the NED benefit estimates, result in three net benefit estimates and benefit-cost ratios. The most probable estimate produces a negative net benefit of $7.24 billion and covers 13 percent of total NED costs. The Monte Carlo 0% and Monte Carlo 100% cost estimates cover 14 and 10 percent of total NED costs, respectively. Based on the results of this benefit-cost analysis, this alternative is not economically justified.

Wymer Dam and Reservoir Alternative. As shown in table 2.48, three NED cost estimates also were developed for the Wymer Dam and Reservoir Alternative. The most probable estimate produces a negative net benefit of $929.1 million and covers 31 percent of total NED costs. The Monte Carlo 0% and Monte Carlo 100% cost estimates cover 36 and 23 percent of total NED costs, respectively. Based on the results of this benefit-cost analysis, this alternative is not economically justified.

Wymer Dam Plus Yakima River Pump Exchange Alternative. As shown in table 2.48, only one NED cost estimate was developed for the Wymer Dam Plus Yakima River Pump Exchange Alternative. Estimated total NED benefits cover 7 percent of total NED costs, which 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 NED Cost Analysis

The cost of each alternative is broken down into two primary components: (1) NED construction costs and (2) NED OMR&E costs. NED construction costs, which occur during the construction period for each alternative, include total project costs (i.e., field costs and noncontract costs) and interest during construction (IDC). A 10-year construction period was assumed for each alternative. Noncontract costs were estimated as a percentage of field costs; the percentages ranged from 20 to 35 percent, depending on the alternative and scenario. The IDC calculation represents the opportunity cost of forgone interest earned on Federal funds during the construction period and is used to convert costs to a common dollar estimate. NED OMR&E costs, which occur annually across the 100-year benefits period, reflect the costs for operations, maintenance, replacements, and pumping energy.

For the Black Rock and Wymer Dam and Reservoir Alternatives, the total project costs range from low to high, based on a Monte Carlo cost-risk analysis (section 2.2.4). In addition to the Monte Carlo 0% and Monte Carlo 100% cost estimates, a most probable total project cost estimate also was developed for the Black Rock and Wymer Dam and Reservoir Alternatives. Only a single total project cost estimate was developed for the Wymer Dam Plus Yakima River Pump Exchange Alternative.

As suggested above, IDC provides the basis for converting/compounding costs incurred throughout the construction period into a future value as of the start of the benefits period (same as the end of the construction period). The annual NED OMR&E costs were converted/discounted into a present value as of the start of the benefits period. Combining the future value of the NED construction costs and the present value of the NED OMR&E costs provides an estimate of total NED cost by alternative as of the start of the benefits period.

The largest component of total NED cost is the field cost, reflecting more than half of the total NED cost, generally followed by IDC, noncontract costs, pumping costs, and, finally, operation, maintenance, and replacement (OM&R) costs.

Black Rock Alternative. As shown in table 2.49, NED construction costs were estimated to range from a Monte Carlo 0% cost estimate of $6.17 billion to a Monte Carlo 100% cost estimate of $9.68 billion, with a most probable cost estimate of $7.08 billion. Field costs reflect 62–66 percent of NED construction costs. Noncontract costs ranged from 20–30 percent of field costs (14–18 percent of NED construction costs). IDC represents the remaining 20 percent of NED construction costs.

Annual NED 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 NED OMR&E cost of $60.17 million ($1.224 billion in present value).

The total NED cost, representing the sum of the total NED construction costs plus the present value of the annual NED OMR&E cost, ranged from $7.39 billion to $10.9 billion, with a most probable estimate of $8.31 billion.

Wymer Dam and Reservoir Alternative. As shown in table 2.49, NED construction costs were estimated to range from a Monte Carlo 0% cost estimate of $1.09 billion to a Monte Carlo 100% cost estimate of $1.69 billion, with a most probable cost estimate of $1.28 billion. Field costs reflect 60–65 percent of NED construction costs. Noncontract costs ranged from 25–35 percent of field costs (15–20 percent of NED construction costs). IDC represents the remaining 20 percent of NED construction costs.

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

	Black Rock Alternative			Wymer Dam and Reservoir Alternative			Wymer Dam Plus Yakima River Pump Exchange Alternative
	Monte Carlo 0%	Most probable	Monte Carlo 100%	Monte Carlo 0%	Most probable	Monte Carlo 100%	
Construction period	10 years	10 years	10 years	10 years	10 years	10 years	10 years
Noncontract cost %	20	25	30	25	30	35	35
NED construction costs ($ million)							
Field	4,100.0	4,560.0	6,020.0	704.0	786.0	1,010.0	2,980.0
Noncontract	850.0	1,130.0	1,710.0	163.0	238.0	330.0	1,043.0
Subtotal: total project cost	4,950.0	5,690.0	7,730.0	867.0	1,024.0	1,340.0	4,023.0
IDC	1,216.6	1,394.8	1,954.2	220.8	255.9	351.0	1,130.6
Total NED construction cost	6,166.6	7,084.8	9,684.2	1,087.8	1,279.9	1,691.0	5,153.6
NED OMR&E costs ($ million)							
Annual OM&R	10.17	10.17	10.17	1.08	1.08	1.08	18.20
Annual Energy	50.0	50.0	50.0	1.9	1.9	1.9	19.82
Total annual NED OMR&E costs	60.17	60.17	60.17	2.98	2.98	2.98	38.01
Present value of 100 years of annual NED OMR&E costs:	1,223.7	1,223.7	1,223.7	60.6	60.6	60.6	773.1
Total NED cost ($ million)							
Total NED construction costs plus present value of NED OMR&E costs	7,390.2	8,308.4	10,907.8	1,148.4	1,340.6	1,751.6	5,926.8

The annual NED 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 NED OMR&E cost of $2.98 million ($60.6 million in present value).

The total NED cost, representing the sum of total NED construction costs plus the present value of the NED OMR&E cost, ranged from $1.148 billion to $1.752 billion, with a most probable estimate of $1.341 billion.

Wymer Dam Plus Yakima River Pump Exchange Alternative. 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. Adding these costs results in a total project cost of $4.023 billion. Based on the 10-year construction period and the annual project cost estimates, Reclamation calculated IDC at $1.131 billion for a total NED construction cost estimate of $5.154 billion.

The annual NED 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 NED OMR&E cost of $38.013 million ($773.1 million in present value).

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

2.7.1.2 NED Benefits Analysis

This section presents estimates of NED 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 annual water supply, (2) the cropping pattern for both with and without the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives, and (3) the benefit unit value per acre for each crop. The Yakima Agricultural Impact (YAI) model measures the cropping pattern for the alternatives, including the No Action Alternative, based on the proration levels. The benefit unit values, estimated using a farm budget methodology, are applied to the cropping patterns, incremental to the No Action Alternative, and averaged over the 25-year hydrologic period of record to estimate the average annual NED agricultural benefit for both the with and without alternatives. The YAI model and the benefit unit values are discussed below.

Reclamation's YAI model, developed by the Technical Service Center's 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 YAI model relies on the Yakima Project RiverWare model to estimate the water supply. This analysis assumes that future dry years will follow the same pattern as occurred over 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 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.

Note: While the Sunnyside Division Board and the Yakima-Tieton Irrigation District have indicated they did not want to receive additional water during dry years, the benefits attributed to those acreages are included in this table to indicate the total benefits possible with each alternative.

Irrigation diversions downstream from the Parker gage are included in the Yak-RW model. The major diverter is the Kennewick Division, which has a water service contract to divert flows in excess of the Title XII instream target flow at the Prosser Diversion Dam up to the limits of its entitlement. This water supply is all proratable and is provided from unregulated flows and from return flows of upstream irrigation diversions. While the water supply available to the Kennewick Division has been prorated a few times, it has not been prorated as much as diverters upstream of the Parker gage and does not require the release of stored water. The Yak-RW model and the operation studies conducted for the various alternatives indicate the Kennewick Division's water supply is greater than the 70-percent proratable irrigation goal in all years of the 25-year period of record. Thus, no additional proratable water supply was provided in dry years, and no irrigation benefits were included for the Kennewick Division.

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 U.S. Department of Agriculture's National Agricultural Statistics Service (NASS) and the availability of crop enterprise budgets published by Washington State University (WSU).

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.

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. Not all districts would benefit simply because they receive nonproratable water. The present value of the 100-year stream of agricultural benefits equals $84.6 million (the annual equivalent equals $4.16 million) for the Black Rock Alternative. The majority of the benefits are experienced by the Roza Irrigation District (74.5 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 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).

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 about 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 in year 2050 after taking into consideration municipal water supply dry-year proration levels associated with each alternative.

Methodology.—A $235.66-per-acre-foot wholesale price of municipal water supply (indexed to April 2007 dollars), as obtained from a recent Reclamation report, *2006 M&I Water Rate Survey Data* (Reclamation, 2006c), 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 wholesale municipal water supply prices for the Yakima Project.

The valuation of municipal water supply is based on an avoided cost concept. The basic assumption of the avoided cost method to valuation is that municipal water demand must be addressed. If municipal water supply needs are assumed to be met regardless of the selected alternative, then the benefits associated with the provision of municipal water supply 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 about 82,000 acre-feet of municipal water supply 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 supply was assumed to be a water market purchase. The costs of providing about 82,000 acre-feet of municipal water supply 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 the *Watershed Management Plan, Yakima River Basin* (Yakima River Basin Watershed Planning Unit and Tri-Counties Water Resources Agency, 2003). 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 then was assumed that the year 2050 municipal water supply for each alternative would be provided from year 2050 to the end of the 100-year benefit period. Proration percentages by alternative were applied to estimate yearly unmet prorated demand. 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 added 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 supply would be a market purchase.
- The assumption was made that municipalities in search of municipal water supply 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 million annually, or $284.6 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 $13.8 million annually, or $280 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 $13.9 million annually, or $282.5 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 potentially could 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 also could 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 also could 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 presents an analysis of the potential recreational effects at the proposed Black Rock and Wymer reservoirs. 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 section 4.12, "Recreational Resources," 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 section 4.12, "Recreational Resources," of chapter 4 (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 23–100 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.

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

Table 2.52 Black Rock reservoir visitation projections

Year (% of total =>)	Recreation activities									Total visits
	Boat fishing	Shore fishing	Swim-ming	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	100,94 0	168,250	20,180	20,180	13,460	13,460	672,960
22	173,300	69,320	103,970	103,97 0	173,300	20,790	20,790	13,860	13,860	693,160
23-100	175,000	70,000	105,000	105,00 0	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

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 42–100 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. Adding 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 adds to $97.7 million for Wymer reservoir.

Recreation Benefits at Existing Reservoirs and Rivers.—This section presents an analysis of 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 riverflows) 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 (measured in visitor days) as described and presented in section 4.12, "Recreational Resources," of chapter 4. 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, 2008c).

Table 2.53 Wymer reservoir visitation projections

Year (% of Total =>)	Recreation activities: Canoeing, kayaking, small sailboats	Boat fishing	Shoreline fishing	Swim-ming	Pic-nicking	Walking, hiking	Wildlife viewing	Total visits
	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 (April 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 an average year and 25 percent each for wet and dry years). This weighted average change in visitation at each site under each alternative reflects current conditions. The current conditions estimate was used as the starting point in a 100-year change in visitation projection similar to that developed for the proposed reservoirs. A 2-percent annual visitation growth rate was assumed for each site, with the resulting change in visitation constrained by the estimated visitation carrying capacity at each site (i.e., 82,500 for Kachess Lake, 67,000 for Cle Elum Lake, 44,900 for Yakima River, and 34,700 for Tieton River). Instead of displaying the visitation projections for each existing site and alternative, the range of visitation results across the 100-year projections are presented in terms of the average annual, high, and low.

Because the differences in visitation were not estimated by recreation activity, it was assumed that they 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 day by recreation activity (as obtained from Kaval and Loomis, 2003). The weighted average values per day 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. These weighted average values were applied to the annual change in visitation estimates obtained from the visitation projection to estimate changes in annual economic value. This 100-year stream of annual recreation economic values then was discounted to a present value estimate.

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 are expected for the Tieton River. The combined average annual difference in value across all four existing sites approaches $1.3 million. The discounted stream of benefits across the 100-year study period resulted in a present value of $37.3 million.

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 average annual difference in value across all four existing sites was estimated at $175,900. The discounted stream of benefits across the 100-year study period resulted in a present value of $6.2 million.

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

Expected annual visitation change based on current conditions										
Site	Water year type	Difference in recreation days compared to the No Action Alternative[1]							Probability	Difference in days (expected value)
		May	Jun	Jul	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**
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**
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**
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**
Combined total										**15,492**

Projected range in annual change in visitation and value					
Site	Projection range estimate	Change in visitor days from No Action Alternative	April 2007 weighted average value per day[2]	Value per year	Present value of 100-year benefit stream ($ million)
Kachess Lake	Average	10,971		990,462	
	High	26,786		2,418,240	
	Low	0	90.28	0	27.2
Cle Elum Lake	Average	3,916		270,204	
	High	8,801		607,269	
	Low	0	69.00	0	3.9
Yakima River	Average	2,532		136,551	
	High	11,562		623,539	
	Low	0	53.93	0	7.6
Tieton River	Average	-3,346		-104,429	
	High	-1,456		-45,442	
	Low	-4,244	31.21	-132,455	-1.4
Combined total	Average	14,073		1,292,788	
	High	45,693		3,603,606	
	Low	-4,244		-132,455	37.3

[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).

Table 2.55 Differences in recreation visitation and value at existing sites under Wymer Dam and Reservoir Alternative

Expected annual visitation change based on current conditions

Site	Water year type	Difference in recreation days compared to the No Action Alternative[1] May	Jun	Jul	Aug	Sep	Oct	Total	Probability	Difference in days (expected value)
Kachess Lake	None									
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**
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**
Tieton River	None									
Combined total										4,461

Projected range in annual change in visitation and value

Site	Projection range estimate	Change in visitor days from No Action Alternative	April 2007 weighted average value per day[2]	Value per year	Present value of 100-year benefit stream ($ million)
Kachess Lake	Average	0		0	
	High	0		0	
	Low	0	90.28	0	0
Cle Elum Lake	Average	1,147		79,143	
	High	2,674		184,506	
	Low	0	69.00	0	1.1
Yakima River	Average	1,795		96,804	
	High	7,853		423,512	
	Low	0	53.93	0	5.1
Tieton River	Average	0		0	
	High	0		0	
	Low	0	31.21	0	0
Combined total	Average	2,942		175,947	
	High	10,527		608,018	
	Low	0		0	6.2

[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).

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

Expected annual visitation change based on current conditions										
Site	Water year type	Difference in recreation days compared to the No Action Alternative[1] May	Jun	Jul	Aug	Sep	Oct	Total	Probability	Difference in days (expected value)
Kachess Lake	Wet							0	0.25	0
	Dry		8,610	8,610				17,220	0.25	4,305
	Average								0.5	0
									Total:	**4,305**
Cle Elum Lake	Wet				2,736			2,736	0.25	684
	Dry							0	0.25	0
	Average							0	0.5	0
									Total:	**684**
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**
Tieton River	None									
Combined total										**9,074**

Projected range in annual change in visitation and value					
Site	Projection range estimate	Change in visitor days from No Action Alternative	April 2007 weighted average value per day[2]	Value per year	Present value of 100-year benefit stream ($ million)
Kachess Lake	Average	6,302		568,945	
	High	15,917		1,436,987	
	Low	0	90.28	0	14.1
Cle Elum Lake	Average	2,043		140,967	
	High	4,673		322,437	
	Low	0	69.00	0	1.9
Yakima River	Average	1,795		96,804	
	High	7,853		423,512	
	Low	0	53.93	0	5.1
Tieton River	Average	0		0	
	High	0		0	
	Low	0	31.21	0	0
Combined total	Average	10,140		806,716	
	High	28,443		2,182,936	
	Low	0		0	21.2

[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).

No impacts were identified for the Tieton River under this alternative. The combined average annual difference in value across all four existing sites was estimated at $806,700. The discounted stream of benefits across the 100-year study period resulted in a present value of $21.2 million.

***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. This analysis does not take into account possible substitution from other recreation sites outside the region. As a result, this analysis may overstate recreation benefits.

Black Rock Alternative. The combined recreational benefit stream for both the proposed Black Rock reservoir and the existing reservoir and river sites results in a total present value of $615.4 million ($30.3-million average annual equivalent) for the Black Rock Alternative.

Wymer Dam and Reservoir Alternative. The combined recreational benefit stream for both the proposed Wymer reservoir and the existing reservoir and river sites results in a total present value of $103.9 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 Wymer reservoir and the existing reservoir and river sites results in a total present value of $118.9 million ($5.8-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 Dam 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 from the Yakima River. 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 monthly average unit power costs ($/MWh) to estimate the monthly hydropower values. The unit power costs, as used by the Bonneville Power Administration, were obtained from the *Summary Report, Appraisal Assessment of the Black Rock Alternative* (Reclamation, 2004a). 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, there is a net annual loss in Columbia River hydropower generation. This net annual loss would result from (1) pumping water from Priest Rapids Lake to Black Rock reservoir, (2) subsequent return of some of these flows into McNary forebay during latter periods, and (3) minor reoperation of Grand Coulee

In addition, there is a net annual loss in Columbia River hydropower generation. This net annual loss would result from (1) pumping water from Priest Rapids Lake to Black Rock reservoir, (2) subsequent return of some of these flows into McNary forebay during latter periods, and (3) minor reoperation of Grand Coulee and Libby Dams in reaction to such pumping operations and return flows. Water that is pumped to Black Rock reservoir would no longer be available to generate hydropower at Priest Rapids Dam and at downstream Federal Columbia River hydropower facilities at the time of pumping. But, in later months, the return flows into McNary Dam provide for increased generation at lower Columbia River projects. Also, in HYDSIM modeling, which is discussed in chapter 4 in section 4.4.2.1, “Methods and Assumptions,” minor reoperation of projects upstream of Priest Rapids Dam occurs. This reoperation is an incidental effect of the modeling method to confine the power impacts at Priest Rapids Dam and lower Columbia River projects.

While there are both positive and negative effects upstream of and downstream from Priest Rapids Dam due to hydropower system reoperation, the *Summary Report, Appraisal Assessment of the Black Rock Alternative,* estimated the net result as a loss in annual hydropower benefits of $4 million (Reclamation, 2004a). To calculate a present value, the annual costs were assumed to occur each year of the 100-year study period. This lost hydropower from Columbia River projects was deducted from the additional hydropower generated at the Black Rock and Sunnyside powerplants to estimate an overall net hydropower benefit.

Results.—
Black Rock Alternative. As presented in table 2.57, the hydropower generation at both powerplants 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	Generation (MWh)	Monthly average unit power cost ($/MWh)	Energy value ($ thousand)	Present value of 100-year benefit stream ($ thousand)
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	
Annual 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	
Annual totals	125,080.0		4,514.7	91,822.0
Black Rock and Sunnyside powerplants total				
April	19,620.0	$37.60	737.7	
May	30,251.9	$31.92	965.6	
June	33,384.0	$22.68	757.1	
July	35,637.6	$32.24	1,149.0	
August	35,637.6	$40.69	1,450.1	
September	27,712.0	$43.64	1,209.4	
October	14,508.0	$55.56	806.1	
Annual 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).

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 typically are based on the quantity of fish actually used (e.g., harvested/caught). Use values can be further categorized into consumptive and nonconsumptive. Consumptive use values derive from the consumption of the fish (i.e., harvested or kept fish) whereas nonconsumptive use values imply the fish are not consumed as with catch and release fishing. To clarify, the fisheries analysis focuses on consumptive use values; nonconsumptive use values are addressed under the recreation analysis. Finally, a relatively small amount of Tribal commercial and subsistence harvest occurs for steelhead in both the Columbia River and the Yakima River. However, given the Tribes do not target steelhead, but only catch them incidentally when targeting other species, no attempt was made to value the steelhead harvest.

It should be noted that consideration also was 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 (except for a small amount of Tribal subsistence harvest), 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 indeed may exist at least for the listed steelhead population. By excluding nonuse values for this threatened species, the overall fishery benefit estimate will be understated.

Another potential fish related "benefit" that was considered, but deemed inappropriate for the proposed alternatives, regards avoided costs to increase salmon and steelhead abundance. If it could be shown that a portion of the costs to increase salmon and steelhead abundance associated with the No Action Alternative no longer would be necessary under one or more of the Joint Alternatives, then those cost savings could be considered an avoided cost "benefit" for those proposed alternatives. The Yakima River Basin Water Enhancement Project, which provides additional water supply through agricultural conservation, and the Washington State Department of Ecology's Supplemental Draft EIS, which will consider potential habitat restoration actions, both were considered from the perspective of possible avoided costs. The currently active YRBWEP was included in all the alternatives and, therefore, generates no avoided costs. The habitat restoration actions associated with Ecology's Supplemental Draft EIS were not included in any of the Joint Alternatives and, therefore, also generate no avoided costs. Ecology's contemplated habitat restoration actions were excluded from all of the alternatives because they have not been finalized. Even if Ecology's actions were finalized, they likely would be included under all the alternatives, again resulting in no avoided costs. This is because the water-supply-oriented actions (e.g., storage and conservation) of the proposed alternatives do not offset the need for habitat restoration actions. As a result, the costs associated with potential habitat restoration actions will be incurred in addition to those costs associated with the water-supply-oriented actions of the proposed alternatives.

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 typically is 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 likely is 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 and harvest category, 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 Technical Report* (Reclamation, 2007d). 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.

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

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, it was assumed 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 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 four Hs toward 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 at http://www.fws.gov/pacific/Fisheries/Hatcheryreview/documents/All-HAnalyzerDraftUsersGuideAug05.pdf.

Differences in harvest by species were calculated for each of the Joint Alternatives 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 294–1,926 fish. These annual estimates of total additional harvest by alternative and fish species then were allocated across the eight harvest categories.

Table 2.59 Annual increment in fish harvest as compared to the 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	7,471	396	4,262
High	26,513	1,365	15,988
Low	3,619	195	1,964
Coho			
Average	623	41	323
High	1,875	123	947
Low	304	19	150

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 then were included in the BCA calculation. The total fisheries use value by alternative reflects the difference in value from the No Action Alternative.

Results.—

Black Rock Alternative. Table 2.60 presents the results of the fisheries use value analysis. The table reflects 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 $20.9 million. More than 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	11,400	0	25,300	386,900	16,600	83,000	437,800	114,100	1,075,100
Fall Chinook	107,500	426,900	186,000	3,884,200	742,700	48,800	13,141,300	0	18,537,400
Coho	23,700	521,400	7,300	568,400	4,000	300	136,500	0	1,261,600
Total	142,600	948,300	218,600	4,839,500	763,300	132,100	13,715,600	114,100	20,874,100
Wymer Dam and Reservoir									
Spring Chinook	700	0	1,500	22,300	1,000	4,800	25,200	6,600	62,100
Fall Chinook	5,600	22,300	9,700	202,800	38,800	2,500	686,100	0	967,800
Coho	1,600	34,400	500	37,500	300	0	9,000	0	83,300
Total	7,900	56,700	11,700	262,600	40,100	7,300	720,300	6,600	1,113,200
Wymer Dam Plus Yakima River Pump Exchange									
Spring Chinook	7,400	0	16,500	252,100	10,800	54,100	285,300	74,300	700,500
Fall Chinook	62,600	248,600	108,300	2,262,400	432,600	28,400	7,654,200	0	10,797,100
Coho	12,300	271,700	3,800	296,200	2,100	100	71,100	0	657,300
Total	82,300	520,300	128,600	2,810,700	445,500	82,600	8,010,600	74,300	12,154,900

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 $1.1 million.

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 $12.2 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 never actually will 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, or 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 also might 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 likely are 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 likely is 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 actually may 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.[14] 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

[14] 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.

fairly controversial in its own right, and the use of benefits transfer approaches for nonuse valuation has 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.

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 project's 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 or gross economic activity within a given region using such indicators as output (sales or gross receipts), income, and employment. Gross measures simply show the amount of money changing hands (e.g., sales reflect income to the business, but expenditures to the purchaser). Economic impacts stem from changes in expenditures/revenues 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 Final 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)								
		Monte Carlo 0%	Most probable	Monte Carlo 100%	Monte Carlo 0%	Most probable	Monte Carlo 100%	
Agriculture	NA	84.6	84.6	84.6	26.5	26.5	26.5	26.5
Municipal and industrial	NA	284.6	284.6	284.6	280.0	280.0	280.0	282.5
Hydropower	NA	62.5	62.5	62.5	0	0	0	0
Recreation	NA	615.4	615.4	615.4	103.9	103.9	103.9	118.9
Fisheries	NA	20.9	20.9	20.9	1.1	1.1	1.1	12.2
Total NED benefits	NA	1,068.0	1,068.0	1,068.0	411.5	411.5	411.5	440.0
Adverse effects – OMR&E costs reflect present value of 100-year annual cost stream ($ million)								
Total project costs	NA	4,950	5,690.9	7,730.0	867.0	1,024.0	1,340.0	4,023.0
Interest during construction	NA	1,216.6	1,394.8	1,954.2	220.8	255.9	351.0	1,130.6
OM&R costs (present value)	NA	206.8	206.8	206.8	22.0	22.0	22.0	370.1
Power costs (present value)	NA	1,016.9	1,016.9	1,016.9	38.6	38.6	38.6	403.1
Total NED costs	NA	7,390.2	8,308.4	10,907.8	1,148.4	1,340.6	1,751.6	5,926.8

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

	No Action Alternative[1]	Black Rock Alternative			Wymer Dam and Reservoir Alternative			Wymer Dam Plus Yakima River Pump Exchange Alternative
NED account (continued)								
Adverse effects – OMR&E costs reflect present value of 100-year annual cost stream ($ million) (continued)								
Net benefits (total NED benefits – NED total costs)	NA	(6,322.3)	(7,240.5)	(9,839.9)	(737.0)	(929.1)	(1,340.2)	(5,486.8)
Benefit-cost ratio (total NED benefits ÷ total NED costs)	NA	.14	.13	.10	.36	.31	.23	0.07
RED account								
Construction period impacts								
Construction: Estimates reflect impacts summed over the entire 10-year construction period.								
Output/sales ($ million)	NA	3,380			617			1,732
Income ($ million)	NA	1,195			217			589
Employment (jobs)	NA	31,400			5,720			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	NA	$53.9			$16.8			$3.4
1993	NA	$66.4			$45.7			$38.0
1994	NA	$234.1			$14.5			$12.1
2001	NA	$126.9			$81.3			$70.8
2005	NA	$121.2			$22.8			$19.9
Labor income ($ million)								
1987	NA	$18.4			$5.7			$1.2
1993	NA	$22.7			$15.6			$13.2
1994	NA	$82.6			$5.3			$4.4
2001	NA	$44.2			$28.6			$25.3
2005	NA	$42.2			$8.0			$7.2
Employment								
1987	NA	580			179			37
1993	NA	716			493			407
1994	NA	2,608			169			140
2001	NA	1,394			902			786
2005	NA	1,330			254			222

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

	No Action Alternative [1]	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Recreation (Recreation effects were converted to an average annual basis)				
Existing sites				
Output/sales ($ million)	NA	$0.12	$0.04	$0.1
Labor income ($ million)	NA	$0.06	$0.02	$0.05
Employment	NA	2	1	1
Proposed reservoirs (Black Rock and Wymer)				
Output/sales ($ million)	NA	$4.72	NA[2]	NA[2]
Labor income ($ million)	NA	$1.84	NA	NA
Employment	NA	72	NA	NA

[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

A team of Reclamation staff evaluated the EQ account using information from the analyses prepared for each of the three Joint Alternatives in the Draft PR/EIS. The team met again and evaluated the EQ account again using new information from the analysis of the seepage mitigation. The team represented four disciplines: 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 alternative with the most positive effects on the identified resources. 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	0.20	Prorationing	0.60	0.1200
		Municipal	0.13	0.0260
		Total water supply available	0.27	0.0540
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	0.08	Shrub-steppe	0.67	0.0536
		Black cottonwood	0.33	0.0264
Water quality	0.36	Temperature	0.27	0.0972
		Seepage	0.73	0.2628
Threatened and endangered species	0.04	Steelhead	0.60	0.0240
		Bull trout	0.40	0.0160
Land use	0.04	Overall impacts	1.00	0.0400
Totals	1.00			1.00

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

	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Total score	0	0.86	0.25	0.50

2.8.2 Preparing the OSE Evaluation

The *P&Gs* recommend that 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	1.00	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 Final PR/EIS

	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
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 Alternative		Wymer Dam and Reservoir Alternative		Wymer Dam Plus Yakima River Pump Exchange Alternative	
EQ resource categories		**Weight**	**Significance**	**Score**	**Significance**	**Score**	**Significance**	**Score**
Water resources	Prorationing	0.1200	3	0.360	1	0.120	1	0.120
	Municipal	0.0260	3	0.078	2	0.052	2	0.052
	TWSA	0.0540	1	0.054	1	0.054	1	0.054
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	0.0536	-2	-0.1072	-1	-0.0536	-1	-0.0536
	Black cottonwood	0.0264	1	0.0264	0	0	1	0.0264
Water quality	Temperature	0.0972	0	0	0	0	0	0
	Seepage	0.2628	-1	-0.2628	0	0	0	0
Threatened and endangered species	Steelhead	0.0240	1	0.0240	0	0	1	0.0240
	Bull trout	0.0160	0	0	0	0	0	0
Land use	Overall impacts	0.0400	1	0.0400	1	0.0400	-1	-0.0400
Totals		1		0.8648		0.2488		0.5020
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 Selection of the Preferred Alternative

Reclamation has selected the No Action Alternative of the Yakima River Basin Water Storage Feasibility Study as the Preferred Alternative for this planning report/environmental impact statement. As explained in section 2.2, "Alternatives Formulation," the Joint Alternatives were evaluated on the basis of the four criteria discussed in the *P&Gs*—completeness, effectiveness, efficiency, and acceptability.

Following is a brief discussion of how well the Joint Alternatives meet these criteria.

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

Cost estimates were developed for each Joint Alternative, including annual operation, maintenance, replacement, and pumping energy costs. For the Black Rock and Wymer Dam and Reservoir Alternatives, risk analyses also were conducted to account for some of the uncertainty in the cost estimates due to the current level of the design and design data. Similar estimates were not made for the Wymer Dam Plus Yakima River Pump Exchange Alternative, as discussed previously. The permits necessary to construct and operate each of the Joint Alternatives also were generically identified. All Joint Alternatives were developed to a similar level of completeness, and all investments and actions were accounted for.

- Black Rock Alternative – Total project cost: $5,690,000,000; annual OMR&E cost: $60,170,000.
- Wymer Dam and Reservoir Alternative – Total project cost: $1,024,000,000; annual OMR&E cost: $2,980,000.
- Wymer Dam Plus Yakima River Pump Exchange Alternative – Total project cost: $4,068,000,000; annual OMR&E cost: $38,013,000.

Effectiveness—*The extent to which the alternative alleviates the problems and accomplishes the objectives*.

As discussed in chapter 1, section 1.2.1, "Study Authority," Reclamation evaluated the extent that the additional stored water supply provided by the Joint Alternatives assisted in meeting the Storage Study goals for anadromous fish, irrigation water supply, and municipal water supply.

- Black Rock Alternative
  - The four anadromous fish stocks would increase 21–61 percent; steelhead would increase 51 percent.
  - The 70-percent proratable irrigation goal would be met or exceeded in all years of the 25-year period of record.
  - Future municipal water supply needs would be met.
- Wymer Dam and Reservoir Alternative
  - The four anadromous fish stocks would increase 1–3 percent; steelhead would increase 1 percent.
  - The 70-percent proratable irrigation goal would be met in 2 of the 6 proratable years (1987, 1992) in the 25-year period of record.
  - Future municipal water supply needs would be met.
- Wymer Dam Plus Yakima River Pump Exchange Alternative
  - The four anadromous fish stocks would increase 11–35 percent; steelhead would increase 24 percent.

- The 70-percent proratable irrigation goal would be met in 2 of the 6 proratable years (1987, 1992) in the 25-year period of record.
- Future municipal water supply needs would be met.

Efficiency—*The extent to which the alternative is cost effective in accomplishing the project objectives.*

In addition to the cost estimates, benefit-cost analyses were performed for each Joint Alternative using the No Action Alterative for the baseline.

- Black Rock Alternative – The benefit-cost ratio is 0.13.
- Wymer Dam and Reservoir Alternative – The benefit-cost ratio is 0.31.
- Wymer Dam Plus Yakima River Pump Exchange Alternative – The benefit-cost ratio is 0.07.

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.*

Generally, none of the Joint Alternatives was viewed acceptable as stand-alone approaches to meeting the three goals of the Storage Study. Many commenters on the Draft PR/EIS felt that an approach that combined other actions, e.g., enhanced water conservation,[15] habitat enhancement, and fish passage (with or without additional storage), should have been or should be investigated. Specific concerns were raised by individual parties regarding the acceptability of some of the Joint Alternatives. The U.S. Department of Energy provided a Responsible Opposing View (attachment A) indicating opposition to the selection of the Black Rock Alternative as the Preferred Alternative. Similarly, Benton County earlier had opposed the Wymer Dam Plus Yakima River Pump Exchange Alternative. The Yakama Nation and the Roza Irrigation District have sought a broadening of the alternatives and have not supported any of the Joint Alternatives as presented in the Final PR/EIS. The Yakima Basin Storage Alliance strongly supports the Black Rock Alternative as the solution to the water supply need in the Yakima River basin.

In summary, each of the Joint Alternatives provided some natural resource benefits, primarily for anadromous fish, including the threatened Middle Columbia River steelhead. Only the Black Rock Alternative consistently met the irrigation water supply goal. Each of the Joint Alternatives met the municipal water supply goal. However, there are a number of factors that contribute to the choice of the No Action Alternative as the Preferred Alternative. Each of the Joint Alternatives would require a significant investment of Federal funds

[15] Advanced beyond those included in the No Action Alternative.

($1 billion to $7.73 billion) and annual operating costs of millions of dollars. None of the Joint Alternatives provides a positive benefit-cost ratio (or net NED benefit), and none of them are considered to be economically justified under Federal water resource planning guidelines. In addition, there is a lack of acceptability in the community at large to consider water storage as a stand-alone approach to meeting the Storage Study goals. Therefore, when weighed against the respective impacts and costs, Reclamation does not consider the benefits provided by any of the Joint Alternative to provide justification for moving forward with any of these three alternatives.

2.10 Other Alternatives Considered but Eliminated from Further Study

2.10.1 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 400,000–458,000 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 also was 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 also was 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 primarily is 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 400,000–458,000 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 also would 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 also could 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 2.13 provides hydrographs of the estimated natural (unregulated) flow regime and the No Action Alternative 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.

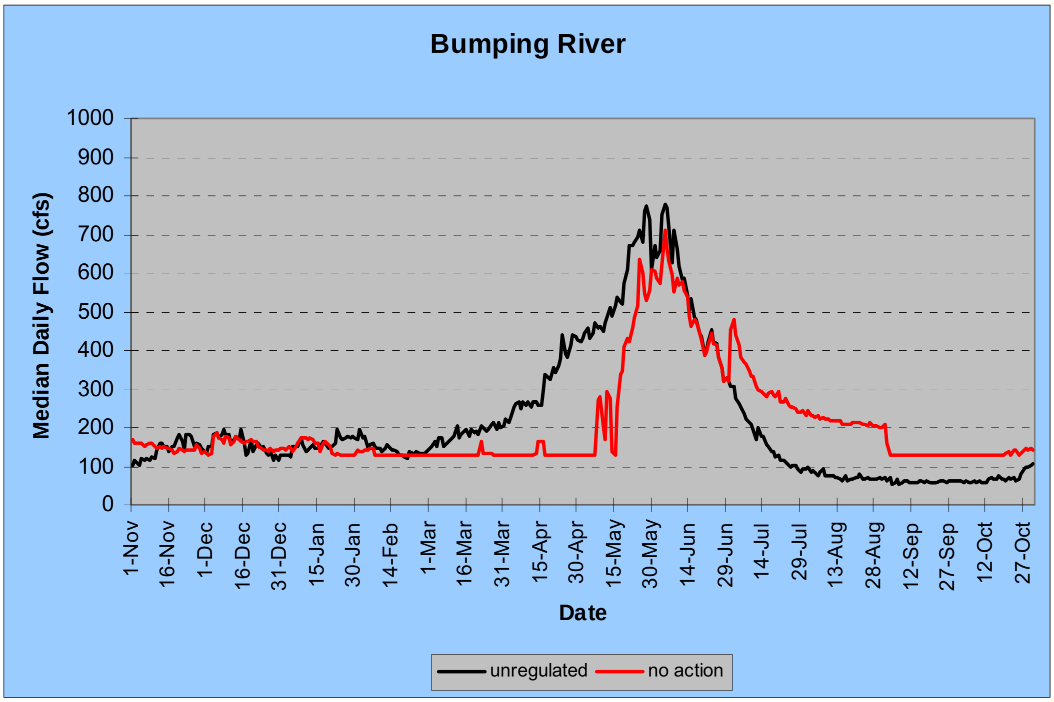


Figure 2.13 Median daily flow (cfs) in the Bumping River for unregulated and No Action Alternative flow scenarios for the period of record (1981–2005).

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 also would 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 in excess of 400, 300, and 200 cfs are captured and stored and later used for an exchange in streamflow increments of 100–500 cfs.

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

cfs	Average water year		
	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.

2.10.2 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 also could 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).[16] 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 riverflow 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.

Through its hydrologic analysis, Reclamation 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 Final PR/EIS.

2.10.3 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, contain about 4.9 million cubic yards of embankment material, and require relocation of some county roads.

[16] Prior to 2007, Storage Study operation studies used a 23-year period of hydrologic record of 1981–2003. This subsequently was expanded to a 25-year period of record 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 also could 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.

2.10.4 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–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–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.

2.10.5 Groundwater Storage Alternative

The Groundwater Storage Alternative was considered as a State Alternative in the Draft PR/EIS. Under this alternative, aquifers would be recharged with either active or passive methods that would increase streamflow and improve water supply. Typically, aquifers would be recharged with surface water during high flow periods. The stored water would be used to supply out-of-stream uses, increase streamflows through increased groundwater discharge, and/or replenish depleted groundwater storage. The source water was expected to be surface water from the Yakima River or one of its tributaries. A water right would be required to divert water from the river or a tributary and to store the water in a reservoir, including an underground geological formation.

For this alternative, model results showed that, over a 22-year analysis period (1978–2000), streamflow (as measured at the Parker gage) from April–September would be an average of 22,800–25,800 acre-feet greater than under the current operation and 33,000 acre-feet greater than under the No Action Alternative. It was assumed that any increase in flow would be used to supply municipal demands, with the remainder benefiting TWSA for all other water users in the Yakima Project. In general, the increased flow volumes would be less in dry years and greater in wet years, and no additional diversion for groundwater storage would be available during drought months. The increase in flow volume at the Parker gage would be considerably short of providing 82,000 acre-feet of water for municipal water supply; and, because the benefits are less in low-flow years, the increase would have no effect on water supply for irrigation in proratable years. Because flows in the Yakima River would not be significantly greater than under the No Action Alternative, anadromous fish would not benefit under the Groundwater Storage Alternative.

Therefore, the Groundwater Storage Alternative was eliminated from consideration in the Final PR/EIS because, while model results showed somewhat greater flows, it did not sufficiently meet the Storage Study goals of (1) improving anadromous fish habitat by restoring the flow regimes of the Yakima and Naches Rivers to more closely resemble the natural (unregulated) hydrograph; (2) improving the water supply for proratable (junior) irrigation entities by providing a not less than 70-percent irrigation water supply for irrigation districts during dry years relying on diversions subject to proration or (3) meeting future municipal water supply needs by maintaining a full municipal water supply for existing users and providing additional surface water supply of 82,000 acre-feet for population growth to the year 2050. Ecology will respond to comments received on this alternative in its Final SEPA EIS.

2.11 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 Feasibility Study Final PR/EIS

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
WATER RESOURCES				
Average for water years 1981–2005 (maf) Actual change from No Action Alternative Percent change 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 0.36 58%
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 45%	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 Final PR/EIS (continued)

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
1994 dry-year (maf) Actual change from No Action Alternative Percent change 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%
September 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 megawatt [MW])	None	- 9.2 MW	NA	NA
Value of generation loss (average annual $ million)		- $4 million		
Additional generation capacity (average annual MW)	None	52.5 MW	NA	NA
Pumping power requirement (average annual MW)	None	132 MW	4.8 MW	61.6 MW
Cost of pumping (average annual $ million)	None	$50 million	$1.9 million	$19.8 million
GROUNDWATER				
Volume and direction of seepage, continuous annual flow (cfs)	No change	Mitigated to prevent impacts to Hanford Site	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 Final PR/EIS (continued)

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
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	No change	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 one-third of corridor	Impedes movement	Impedes movement
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 and percent change from No Action Alternative)				
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%
Summer flows downstream from the Parker gage (acres of available coho yearling habitat and percent change from No Action Alternative)				
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%

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

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
ANADROMOUS FISH (continued)				
Rate of change in flow during flip-flop (average cfs/day August 16–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
Pre- (August 1-15) and post- (September 14-28) flip-flop flow and absolute change in flow				
Easton reach				
Pre-flip-flop flow (cfs)	572	352	518	508
Post-flip-flop flow (cfs)	328	220	309	319
Absolute change in flow (cfs)	-245	-132	-209	-189
Ellensburg reach				
Pre-flip-flop flow (cfs)	3,860	2,774	3,229	3,208
Post-flip-flop flow (cfs)	1,506	1,239	1,507	1,493
Absolute change in flow (cfs)	-2,354	-1,535	-1,722	-1,715
Lower Naches River reach				
Pre-flip-flop flow (cfs)	612	621	572	578
Post-flip-flop flow (cfs)	1,628	1,220	1,691	1,670
Absolute change in flow (cfs)	1,016	599	1,120	1,092
Reduced spring freshets downstream from the Parker gage (percent change in spring season flow between the alternative and flow objective; if positive, then target flow reached)				
Percent change	-7%	29%	-10%	11%
Stream runoff timing	No change	Improved	No change	No change
Average annual fish (natural and hatchery) escapement numbers (including harvest)				
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 percent change 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%

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

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
RESIDENT FISH (continued)				
Summer flows in the upper Yakima and lower Naches Rivers (acres of available habitat and percent change from No Action Alternative) (continued)				
Easton reach (continued)				
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%
Bull trout spawner upmigration at reservoirs (in-season days impeded and percent change from No Action Alternative)				
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%
Summer flows in the upper Yakima and lower Naches Rivers (acres of available habitat and percent change from No Action Alternative)				
Average, minimum, and maximum reservoir elevation (feet) during bull trout spawning migration: July 15–September 15				
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

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

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
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)	NA	13,000	4,000	110
Acquisition of public land (approximate acres)	NA	1,000	0	0
Easement/right-of-way acquisition across private land (approximate miles)	NA	18	6	61
Compatibility with existing uses	NA	Local incompatibilities	Local incompatibilities	Local incompatibilities
Consistency with relevant county land use plans and policies	NA	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 SERVICES AND UTILITIES				
Exceedance of service or utility capacity (long-term impact)	NA	None	None	None
Disruption of services or utilities for existing residents and landowners (short-term, construction-phase impacts)	NA	High potential; mitigable	Minor potential; mitigable	Highest potential; mitigable
TRANSPORTATION				
Long-term: Road/highway relocations (miles)	NA	15	0	0
Short-term: Federal, State, or local arterial highway crossings (instances))	NA	1	1	9
Short-term: Local road crossings (instances)	NA	5-10	0	45-50
AIR QUALITY				
Emissions during construction	NA	Slight, short-term effect	Slight, short-term effect	Slight, short-term effect
Emissions during operation	NA	No effect	No effect	No effect
NOISE QUALITY				
Noise levels during construction	NA	Slight, short-term effect	Slight, short-term effect	Slight, short-term effect
Noise levels during operation	NA	No effect	No effect	No effect

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

Resource indicator (measurement)	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
VISUAL RESOURCES				
Large-scale changes in visual setting	NA	Visible to the public (significant)	Visible to the public (significant)	Visible to the public (significant)
Local-scale changes in visual setting	NA	Yes (significant)	Yes (significant)	Yes (significant)
HISTORIC PROPERTIES				
Number of affected properties	NA	Unknown	Unknown	Unknown
INDIAN SACRED SITES				
Number of affected sites	NA	Unknown	Unknown	Unknown
INDIAN TRUST ASSETS				
None	None	None	None	No change
INDIAN TRUST ASSETS				
Number/type affected	None	None	None	No change
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

Chapter 3

STATE ALTERNATIVES

CHAPTER 3
STATE ALTERNATIVES

On the basis of comments received on the Draft PR/EIS, the Washington State Department of Ecology determined that it may not have fulfilled its requirements under Chapter 197-11 of the Washington Administrative Code to identify and evaluate all reasonable water supply alternatives. Therefore, Ecology has separated from the joint NEPA/SEPA process and will evaluate additional water supply alternatives in a supplemental Draft EIS. Further, because a number of the comments made the point that it is not possible to adequately evaluate all reasonable water supply alternatives without considering habitat and fish passage needs, those needs will be addressed in the supplemental Draft EIS. The State Alternatives described in chapter 3 and evaluated in chapter 5 of the Draft PR/EIS have been eliminated from this Final PR/EIS. The State will respond to comments on the State Alternatives in its Final SEPA EIS.

Chapter 4

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES: JOINT ALTERNATIVES

CHAPTER 4

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES: JOINT ALTERNATIVES

4.1 Introduction

This chapter presents a description of the affected environment and an evaluation of the environmental consequences of implementing each of the proposed Joint Alternatives. Effects under the Joint Alternatives are compared to the No Action Alternative, and effects under the No Action Alternative are compared to the current condition, as appropriate. In cases in which alternatives would have the same effects on an environmental component, the analysis is presented once and summarized or referenced in subsequent analyses to eliminate redundancy. Environmental consequences, impacts, and effects are synonymous in this document. Additional information has been added to this Final PR/EIS regarding seepage and seepage mitigation measures associated with the Black Rock Alternative. Consequently, additional information about the effects of those features has been added for those resources that could be affected.

Some alternatives may cause effects outside the Yakima River basin in specific reaches of the Columbia River. Therefore, some discussions address Columbia River reaches, as appropriate, and then address the Yakima River basin.

Resources and/or resource issues identified during scoping activities are addressed in a hierarchical fashion. For example, water resources are presented first because changes in this resource resulting from the Joint Alternatives would likely affect other resources.

Finally, because resources in the Storage Study area are numerous and complex, potential effects on some resources were evaluated using representative indicators. Resource indicators are considered to be the key attributes (or measurements) specific to each resource. For example, rather than analyzing all fish populations, certain species were selected to provide a focused analysis of the effects of the alternatives.

4.2 Water Resources

4.2.1 Affected Environment

Water resources within both the Columbia River Basin and the Yakima River basin could be affected by the proposed Joint Alternatives. This section addresses river regulation and water supply available. The current operation is discussed in detail in chapter 2 in the description of the No Action Alternative.

4.2.1.1 River Regulation

The natural flow regime defines river ecosystems. The availability and diversity of habitats are determined by physical processes, especially the movement of water and sediment within the channel, and between the channel and flood plain. Different habitat features are created and maintained by a wide range of flows. For example, many channel and flood plain features, such as river bars and riffle-pool sequences, are formed and maintained by dominant or bank-full runoff that can move significant quantities of sediment. Occurring frequently enough, bank-full runoff can modify the channel, which, in turn, maintains a healthy river ecosystem. For many riverine species, including anadromous and resident salmonids, the complete life cycle requires an array of different habitat types, which are produced by the flow regime.

River basins such as the Yakima that are regulated for irrigation and flood control purposes exhibit a change from the natural flow. A portion of the natural flows produced from precipitation during the winter and snowmelt during the spring and early summer are captured for storage. Downstream from major reservoirs, flows are greatly altered from the major variations observed under natural hydrologic conditions. Peaking natural flows from rain and rain-on-snow events, causing "flood events," are captured in available storage and bypassed during a lower flow period. Consequently, the magnitude and frequency of ecologically significant discharges (overbank and channel-forming flows) are reduced.

Patterns of spring and summer flows are largely influenced by irrigation demands, with flows typically reaching peaks during July and August upstream of the major diversions. Downstream from these diversions, flows can be low, even to the point of being below natural flows. Unnatural flow patterns result from reservoir storage and releases intended to meet downstream irrigation demands.

Yakima Project irrigation diversions generally begin in mid-March when "flood flows" are diverted to "prime" (fill) the irrigation systems. These flows are returned to the rivers as operational spills. Irrigation deliveries generally begin in April and continue through mid- to late-October. In the initial part of the irrigation season, diversion demands are met by unregulated runoff accruing to the river system downstream from the reservoirs (or being spilled from the reservoirs) and irrigation return flows. On the average, this period has generally extended to June 24. When Yakima River flows at the Parker gage must be controlled to meet the Title XII target flows by using supplemental storage releases, the Yakima Project is deemed to be on “storage control,” and depletions of reservoir storage begin. Storage control has begun as early as April 1 and as late as August 17. The variability in the date of storage control depends on the extent of precipitation and snowpack and the timing of the snowmelt.

The cumulative impacts of the regulated Yakima River basin system result in major changes throughout the water year on the flow regime. These changes can best be illustrated by the hydrographs in chapter 2, which show flows at six Yakima River locations: Umtanum gage (RM 140), which is the upstream boundary of the middle Yakima River basin and near the point of diversion for the Roza Division (RM 127.9); Parker gage (RM 104), which is the downstream boundary of the middle Yakima River basin just downstream from Sunnyside Diversion Dam; Easton gage (RM 202); Cle Elum River (RM 7.9); lower Naches River gage (RM 17); and Kiona gage (RM 29). Water entitlements in this subarea account for about 60 percent of the total.[1]

The flow regimes depicted in these hydrographs are an approximation of natural flows that might have occurred under predevelopment runoff conditions without the influence of reservoir storage or diversions. The current condition hydrograph reflects current Yakima Project operations. As shown, there is a substantial “shift” in the timing and volume of peak spring flows and summer flows from the unregulated regime to the current condition.

4.2.1.2 Water Supply Available

The major control point for operating the Yakima Project is the Yakima River near the Parker gage. Yakima Project operations are keyed to meet the irrigation entitlements upstream of the Parker gage, maintain instream target flows for the fishery resources, and provide maximum flood control benefits for the Yakima River basin. Since April 1995, the Yakima Project has been operated to provide the target flows downstream from Sunnyside Diversion Dam as specified in the Title XII legislation (table 4.1). These flows are based on total water supply estimates and range from 300–600 cfs for April 1–October 31. Runoff and return flows downstream from the Parker gage in the lower Yakima River basin subarea exceed irrigation demands in that area and, therefore, do not influence storage releases.

[1] The major diverters are the Roza Division (RM 127.9), Wapato Irrigation Project (RM 106.7), and the Sunnyside Division (RM 103.8).

Table 4.1 Title XII target flows

TWSA estimate for period (maf)					Target flows from date of estimate through October downstream from:	
Scenario	Apr–Sep	May–Sep	Jun–Sep	Jul–Sep	Sunnyside Diversion Dam (cfs)	Prosser Diversion Dam (cfs)
1	3.2	2.9	2.4	1.9	600	600
2	2.9	2.7	2.2	1.7	500	500
3	2.7	2.4	2.0	1.5	400	400
Less than scenario 3 water supply					300	300

Total Water Supply Available Estimates

The TWSA estimate is a primary component of the *1945 Consent Decree* and Yakima Project operations. TWSA represents the combined quantity of forecasted runoff, return flows, and stored water available upstream of the Parker gage. Each year, Reclamation prepares TWSA forecasts for the Yakima River basin upstream of the Parker gage beginning in March for the April–September period. The estimate is updated each subsequent month through July, and, in dry years, forecasts may continue throughout the irrigation season. These forecasts are the basis for determining Title XII target flows and irrigation water entitlements and deciding the amount of proration, if any, which may be necessary.[2]

Simply put, TWSA is equal to the sum of the following:

- The natural runoff forecast for April 1–September 30
- The reservoir storage at the end of March 31
- The usable return flows upstream of the Parker gage

TWSA is used to determine the instream target flows for the year in accordance with Title XII operating criteria.

The water supply available for irrigation (WSAI) is equal to the TWSA minus the following:

- The estimated reservoir contents at the end of September 30 (desired carryover)

[2] In calculating TWSA, only the irrigation water entitlements in the *1945 Consent Decree* for the mainstem Yakima River basin are included; irrigation diversions on tributaries or other adjudicated streams are not included.

- The flows downstream from the Parker gage for April 1–September 30 (the combination of undiverted unregulated flows, operational spills, and Title XII quantified target flows).

Nonproratable irrigation entitlements are subtracted from the total water supply available for irrigation as these are the senior (pre-1905) entitlements. The remaining WSAI is the water supply available to meet proratable (post-1905) entitlements. If the remaining WSAI divided by the proratable entitlements is less than 100 percent, prorationing may be necessary.

Projected runoff forecasts are made for the five major reservoirs and at three key checkpoints on the Yakima River system.[3] While the runoff volume for a given period can be estimated with some degree of accuracy, the timing of how and when the runoff will occur is unknown, as it is affected by temperature variation, snowpack density, rainfall intensity, and subsequent snowfall. Warm temperature or precipitation, especially in combination, greatly affects the intensity of the runoff. Generally, runoff begins about mid-March and peaks about mid-June. As the season progresses, a portion of runoff becomes reservoir storage until the date of storage control or the storage is filled. Consequently, the TWSA estimate becomes more accurate as the runoff component declines and the reservoir storage component increases.

Return flows resulting from irrigation diversions upstream of Sunnyside Diversion Dam are an integral part of the TWSA estimate. The timing of return flows and the location where they enter the river system determines whether or not they can be reused. Return flows depend on the level of diversion, which is conditioned by the amount, time, and availability of runoff. The return flow volume varies from year to year, but the useable portion is fairly uniform.

Reservoir contents are the volume of water available in the total storage system. In most years, Yakima Project reservoirs are operated to peak storage contents in mid-June, about the same time the major natural runoff ends.

RiverWare Model

A reservoir and river simulation computer model known as the Yak-RW model is used to assess potential physical and operational changes to the Yakima Project. The Yak-RW model is a daily time-step reservoir and river operation simulation model of the Yakima Project that uses a 25-year Yakima River basin historical hydrologic period of water years 1981–2005 (November 1, 1980–October 31, 2005). Current-day operation criteria, such as the Title XII instream target flows (implemented in 1995), and current minimum streamflow maintenance releases from Yakima Project reservoirs were input to the model for the entire 25-year period. Further, actual day-to-day “hands-on” operation

[3] These three key checkpoints are the Yakima River at Cle Elum (RM 185.6), Naches River near Naches (RM 16.8), and Yakima River at Parker (RM 103.7).

decisions cannot be reflected in the Yak-RW model. Consequently, the proration levels generated by the Yak-RW model for the current operations are different than actually experienced in the prorated water years for the 25-year period of record (1981–2005). The Yak-RW model is used in the Storage Study to compare the operational effects and accomplishments of Joint Alternatives to the No Action Alternative.

Yak-RW model results show that the average April 1 TWSA estimate for the 25-year period of record is about 2.82 million acre-feet, ranging from a maximum (1997) of 4.54 million acre-feet to a minimum (1994) of 1.74 million acre-feet. The components and the distribution of this average TWSA are shown in figure 4.1.

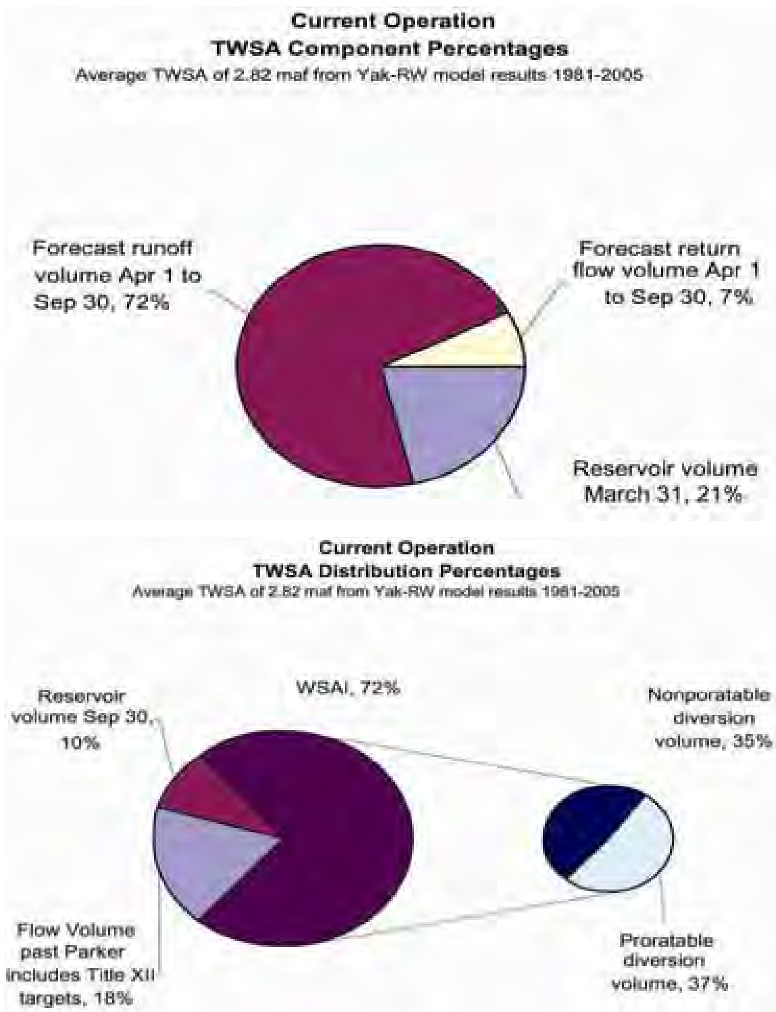

Figure 4.1 Components and distribution of average TWSA: (1) reservoir volumes (left) and (2) flow volumes compared to prorated and nonprorated diversion volumes (right).

Drought Operations

The years 2001 and 2005 were single dry years. The TWSA was 1.80 and 1.76 million acre-feet in 2001 and 2005, respectively, which resulted in major single-year irrigation proration levels of 40 and 38 percent, respectively. The 3-year dry cycle of water years 1992, 1993, and 1994 resulted in a downward trend in TWSA of 2.1 maf in 1992; 2.1 maf in 1993; and 1.75 maf in 1994; and irrigation proration levels of 68, 56, and 28 percent, respectively. Reservoir carryover was severely depleted at the end of October 1992 and 1993; in 1994, total system contents were 50,000 acre-feet, about 5 percent of the total reservoir capacity.

Irrigation entities with major proratable water entitlements are the ones most critically affected by dry water years—both from short- and long-term agricultural cropping and production and economic considerations. The Kittitas and Roza Divisions, with only proratable entitlements of 336,000 and 375,000 acre-feet, respectively, and the Wapato Irrigation Project, with 350,000 acre-feet (53 percent) of its water entitlements proratable, are significantly affected. Table 4.2 summarizes the distribution of water entitlements in the Yakima River basin.

Table 4.2 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 dry years, instream flows throughout the Yakima River basin are also substantially reduced. The Title XII target flows downstream from Sunnyside Diversion Dam can be 300 cfs less than (or half) the target flows in wet years and 100–200 cfs less than in average years; summer base flows are substantially less than the unregulated flow regime.

Future Municipal Water Supply

The Storage Study used the average municipal water supply provided over the 25-year period of record and the water supply provided in dry years to indicate future (year 2050) municipal water needs.

4.2.2 Environmental Consequences

Chapter 2 provides information on the hydrologic indicators used to evaluate the success in meeting the Storage Study goals of improving instream flows, dry-year irrigation proratable water supply, and future municipal water needs. This section discusses the environmental consequences to the Yakima River basin's water resources of the current Yakima Project operation and the operation of each Joint Alternative in comparison to the No Action Alternative as measured by the hydrologic indicators.

Table 4.3 presents a summary of the "absolute values" of the hydrologic indicators shown in chapter 2. An explanation of why these were selected as the hydrologic indicators for the system operations studies also is provided in chapter 2.

Table 4.3 Hydrologic indicators

Hydrologic indicator	Current operation	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Average for water years 1981–2005 (maf)					
April 1 TWSA	2.82	2.84	2.90	2.94	2.94
Apr–Sep flow volume at the Parker gage	0.51	0.62	0.98	0.59	0.90
Apr–Sep diversion volume upstream of the Parker gage	2.02	1.91	1.47	1.95	1.64
Sep 30 reservoir contents	0.27	0.30	0.43	0.40	0.40
Apr–Sep flow volume at the mouth of the Yakima River	0.85	0.86	1.22	0.83	0.83
Water year 1994 (maf)					
Irrigation delivery volume shortage	0.40	0.38	0.12	0.38	0.38
Irrigation proration level	28%	27%	70%	29%	29%

4.2.2.1 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

April 1 TWSA.—Model results show that the April 1 TWSA estimate is 20,000 acre-feet greater under the No Action Alternative than under the current operation. This difference is the result of greater September 30 carryover storage, which, in turn, is the result of implementing No Action Alternative water conservation measures and the ability to retain some of the irrigation portion of the conserved water as carryover storage in wet and average years.

Table 4.4 presents the environmental consequences on the Yakima River basin's reservoir resources. These consequences are represented by the average contents of the Yakima Project reservoir system for three dates: March 31 (prior to the beginning of the irrigation season and used in the April 1 TWSA estimate); June 30 (the target date for the reservoirs to reach full storage capacity); and September 30. Cle Elum Lake contents are shown for June 30.

Table 4.4 Yakima Project total reservoir contents and Cle Elum Lake contents (1981–2005) (maf)

Period	Current operation	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
March 31	0.60 (56% full)	0.62 (58% full)	0.68 (63% full)	0.72 (58% full)	0.73 (59% full)
June 30 Yakima Project total	0.91 (85% full)	0.92 (86% full)	0.91 (85% full)	1.05 (85% full)	1.05 (85% full)
June 30 Cle Elum Lake	0.35 (80% full)	0.36 (82% full)	0.34 (78% full)]	0.33 (75% full)	0.33 (75% full)
September 30	0.27 (25% full)	0.30 (28% full)	0.43 (40% full)	0.40 (37% full)	0.40 (32% full)

April–September Flow Volume Downstream from the Parker Gage.—The April–September flow volume is greater under the No Action Alternative than under the current operation because the Title XII flows are greater as a result of implementing water conservation measures and changes in points of diversions. Table 4.5 presents the April–September flow volumes and the July–September flow volumes downstream from the Parker gage under all the alternatives.

The greater July–September flow volume of 40,000 acre-feet under the No Action Alternative is about 36 percent of the total 6-month change of 110,000 acre-feet. The daily average flow for the July–September period is 470 cfs under the current operation compared to 720 cfs under the No Action Alternative.

Table 4.5 Flow volumes (maf) downstream from the Parker gage for April–September and July–September

Period	Current operation	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Apr–Sep	0.51	0.62	0.98	0.59	0.90
Jul–Sep	0.09	0.13	0.23	0.13	0.29

April–September Diversion Volume Upstream of the Parker Gage.—April–September diversions upstream of the Parker gage average 110,000 acre-feet less over the 25-year period of record under the No Action Alternative than under the current operation because the water conservation measures are implemented. Water conservation measures result in a total diversion reduction of about 157,200 acre-feet (conserved water), of which 84,700 acre-feet is the instream flow portion and 72,500 acre-feet is the irrigation portion retained by the conserving entities for use in dry years.

September 30 Reservoir Contents.—See "April 1 TWSA."

April–September Flow Volume at the Mouth of the Yakima River.—Under the No Action Alternative, the April–September flow volume at the mouth of the Yakima River provides an additional average of 10,000 acre-feet of water compared to the current condition. This increase is associated with YRBWEP conservation measures, which result in an increase in Title XII flows downstream from the Parker gage.

Irrigation Delivery Volume Shortage and Proration Level (1994 Dry Year).— The current operation does not include the water conservation measures of the No Action Alternative. Water conservation measures improve the irrigation delivery volume shortage; because these measures are included in the No Action Alternative, the irrigation delivery shortage volume is less (20,000 acre-feet) than under the current operation. These measures, however, do not improve the irrigation proratable level in the third year (1994) of the 3-year 1992–1994 dry cycle, and the current operation proration level of 28 percent is slightly better than the No Action Alternative proration level of 27 percent.[4]

[4] 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.

4.2.2.2 Black Rock Alternative

Construction Impacts

No construction-related impacts to the storage and delivery of water are anticipated under this alternative.

Long-Term Impacts

April 1 TWSA.—The April 1 TWSA estimate for the Black Rock Alternative is 60,000 acre-feet greater than under the No Action Alternative. This difference is the result of the water exchange whereby a sizeable irrigation demand of the Roza and Sunnyside Divisions is removed from the Yakima Project and met by the delivery of water stored in Black Rock reservoir. As a result, the September 30 reservoir carryover is greater, which increases the April 1 TWSA. It should be noted that the only storage included in the TWSA estimate is storage in the existing reservoirs filled from Yakima River basin runoff. The TWSA estimate does not include the volume of stored water in Black Rock reservoir. Further, the additional release of 185–200 cfs from Cle Elum Lake to improve the aquatic resources begins in September and continues through May. While some "backfilling" of the vacated storage space does occur, there is no Yakima Project storage downstream from Cle Elum Lake to capture these releases and they continue downstream to the Columbia River confluence. The impacts of this water exchange on the Yakima River basin's reservoir resources are presented in table 4.4.

April–September Flow Volume Downstream from the Parker Gage.—The April–September flow volume downstream from the Parker gage is 360,000 acre-feet greater than under the No Action Alternative, which is the result of the water exchange and the enhanced instream flows based on the April 1 TWSA estimate (chapter 2). Table 4.5 presents a summary of the April–September and July–September flow volumes downstream from the Parker gage.

The Black Rock Alternative flow volume downstream from the Parker gage during July–September of 230,000 acre-feet is equivalent to a daily average flow of about 1,260 cfs. A hydrograph showing median daily flows at Parker under the Black Rock Alternative and the No Action Alternative is shown in chapter 2.

April–September Diversion Volume Upstream of the Parker Gage.—An increase in the April–September diversion volume upstream of the Parker gage is associated with the future municipal water supply. Irrigation diversions are less than under the No Action Alternative, as a major portion of the Roza and Sunnyside Divisions' water needs are from Black Rock reservoir. The net effect is a decrease of 440,000 acre-feet.

September 30 Reservoir Contents.—See "April 1 TWSA."

April–September Flow Volume at the Mouth of the Yakima River.—With the integration of the Black Rock Alternative and Yakima Project operations, the April–September flow volume at the mouth of the Yakima River is 360,000 acre-feet greater under the Black Rock Alternative than under the No Action Alternative, which is the result of importing water into the basin.

Irrigation Delivery Volume Shortage and Proration Level (1994 Dry Year).— The irrigation delivery volume shortage is substantially less under the Black Rock Alternative, and the irrigation proration level is improved to the 70-percent goal in the third year of the 3-year dry cycle. These differences are the result of the greater proratable irrigation water supply that is available in dry years.

The environmental consequences of these actions include the following:

- Agricultural irrigated areas would receive an adequate water supply to sustain cropping through extreme dry cycles.
- In 1994, the most severe drought year in the 25-year period of record, the Black Rock Alternative would have provided approximately 400,000 acre-feet of additional proratable water compared to the No Action Alternative. Of the four large divisions, Wapato would have received approximately 125,000 acre-feet of additional proratable; Sunnyside approximately 34,000 acre-feet; Roza approximately 125,000 acre-feet; and Kittitas approximately 103,000 acre-feet.[5]
- In 1994, compared to the No Action Alternative, the Black Rock Alternative would have provided an additional 284,000 acre-feet (additional mean daily flow of 1,575 cfs) of flow downstream from the Parker gage in April–June and an additional 41,000 acre-feet (additional mean daily flow of 220 cfs) in July–September.

4.2.2.3 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction-related impacts to the storage and delivery of water are anticipated under this alternative.

[5] In a November 7, 2007, letter to the Commissioner of Reclamation, the Sunnyside Division Board indicated that, while it would participate in a water exchange to facilitate a better water supply for the Yakima River basin, it did not want to receive water in a dry year if it would have to incur additional costs to its members. Storage Study analyses show the additional water that could be available to the division and also include the agricultural benefits from that water. The Yakima-Tieton Irrigation District also indicated its desire to not be included in receiving dry-year supplemental water from any alternative.

Long-Term Impacts

April 1 TWSA.—With the addition of Wymer reservoir to the Yakima Project, several primary changes occur, increasing the April 1 TWSA estimate.

The contents in the 162,500 acre-feet of Wymer reservoir capacity is included in the TWSA estimate.

The additional October–May Cle Elum Lake releases to improve aquatic habitat conditions in the Cle Elum River and downstream to the Wymer pumping plant result in the capability to "backfill" vacated storage space in Cle Elum Lake. This, in turn, provides more stored water for the April 1 TWSA.

However, all of the Cle Elum Lake vacated space cannot be "backfilled." As a result, total Yakima Project reservoir contents would be greater, but the Cle Elum Lake contents would be less. The average contents of the Yakima Project reservoir system for the 25-year period of record are shown in table 4.4 for three dates: March 31 (prior to the beginning of the irrigation season and used in the April 1 TWSA estimate), June 30 (the target date for the reservoirs to full storage capacity), and September 30. Cle Elum Lake contents are also shown for June 30.

April–September Flow Volume Downstream from the Parker Gage.—The April–September volume of flows downstream from the Parker gage would be slightly reduced with implementation of the Wymer Dam and Reservoir Alternative. This reduction is due to (1) the "backfilling" of Cle Elum Lake vacated space, which results from the additional October–May releases and (2) future municipal water supply diversions upstream of Parker which are provided from unregulated flows prior to the storage control period (generally about April–June). Title XII target flows are the same as under No Action Alternative.

Table 4.5 presents flow volumes downstream from the Parker gage during the April–September and July–September periods for the Wymer Dam and Reservoir Alternative. The flow reduction occurs during April–June, which is normally prior to the storage control period. The average volume reduction of 30,000 acre-feet is about a 5-percent decrease from the No Action Alternative and is equivalent to a daily average flow of about 83 cfs. The July–September flow volume downstream from the Parker gage is the same under the No Action Alternative (130,000 acre-feet) and is equivalent to a daily average flow of about 720 cfs.

April–September Diversion Volume Upstream of the Parker Gage.—Diversions upstream of the Parker gage are an average of about 40,000 acre-feet greater for the 25-year period of record (1981–2005) under the Wymer Dam and Reservoir Alternative than under the No Action Alternative. This difference is the result of the following two actions: (1) diversions to meet future municipal water needs and (2) improvement in the dry-year water supply for proratable irrigation entitlements.

September 30 Reservoir Contents.—See "April 1 TWSA."

April–September Flow Volume at the Mouth of the Yakima River.—The April–September volume of water exiting the Yakima River basin at the Columbia River confluence with implementation of a Wymer Dam and Reservoir Alternative is an average of about 30,000 acre-feet (about 4 percent) less than under the No Action Alternative. This decrease in flow volume is associated with the added diversions to meet future municipal water supply needs. This average decrease takes into account the return flows that would accrue to the river from the additional future municipal water use.

Irrigation Delivery Volume Shortage and Proration Level (1994 Dry Year).— Model results show a slight improvement in the proration level under the Wymer Dam and Reservoir Alternative as the result of Wymer reservoir storage space of 80,000 acre-feet for dry-year proratable irrigation water supply. The shortage in the volume of water delivered to the farm turnout does not differ appreciably between the Wymer Dam and Reservoir Alternative and the No Action Alternative.

- In prorated water years (i.e., 1987, 1992, 1993, 1994, 2001, and 2005), the level of proration would have improved 2 percent (1994) to 15 percent (2001), depending on the water year.

- In 1994, the most severe drought year in the 25-year period of record, the Wymer Dam and Reservoir Alternative would have provided approximately 16,000 acre-feet of additional proratable water compared to the No Action Alternative. Of the four large divisions, Wapato, Roza, and Kittitas would have received approximately 5,000 acre-feet of additional proratable water, and Sunnyside would have received approximately 1,600 acre-feet.

- In 1994, compared to the No Action Alternative, implementation of the Wymer Dam and Reservoir Alternative would have resulted in a slight decrease (2,000 acre-feet; mean daily flow of 11 cfs) in water available for flows downstream from the Parker gage in April–June and a slight increase (775 acre-feet; mean daily flow of 4 cfs) in July–September.

4.2.2.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction-related impacts to the storage and delivery of water are anticipated under this alternative.

Long-Term Impacts

April 1 TWSA.—The greater April 1 TWSA estimate is the result of the same primary changes as noted for the Wymer Dam and Reservoir

Alternative. Table 4.4 presents the environmental consequences on the Yakima River basin's reservoir resources.

April–September Flow Volume Downstream from the Parker Gage.—Under the Wymer Dam Plus Yakima River Pump Exchange Alternative, the April–September flow volume downstream from the Parker gage is 280,000 acre-feet greater than under the No Action Alternative. This increase is the result of establishing instream flow objectives at Parker gage and implementing the Yakima River pump exchange whereby some of the water that would normally be diverted by the Roza and Sunnyside Divisions remains in the river. Flow volumes downstream from the Parker gage are presented in table 4.5.

The July–September daily average flow downstream from the Parker gage is equivalent to 1,580 cfs, or 860 cfs (121 percent) greater than under the No Action Alternative, as shown in the hydrographs in chapter 2.

April–September Diversion Volume Upstream of the Parker Gage.—April–September diversion volume upstream of the Parker gage is greater under this alternative than under the No Action Alternative as a result of the future municipal water supply. However, the net effect is a decrease of about 270,000 acre-feet in diversions because of the water exchange whereby water pumped from the mouth of the Yakima River is substituted for irrigation diversions that would have been made from the Yakima River by the Roza and Sunnyside Divisions.

September 30 Reservoir Contents.—See "April 1 TWSA."

April–September Flow Volume at the Mouth of the Yakima River.—
Average flows in the Columbia River at the mouth of the Yakima River are less than under the No Action Alternative. While the pump exchange is "bucket-for-bucket," the Columbia River flows at the mouth of the Yakima River are reduced because of the added diversions to meet future municipal water supply needs. The environmental consequences are a very slight reduction in Columbia River discharge.

Irrigation Delivery Volume Shortage and Proration Level (1994 Dry Year).—
Model results show a minor improvement in the shortage in the volume of water delivered to the farm turnout in 1994, the third year of the 3-year dry cycle. The improvement is because the irrigation proration level is 29 percent, slightly greater than the No Action Alternative proration level of 27 percent. The environmental consequences associated with these actions are that more water is provided to the agricultural lands and return flows to the river system are about 11 percent greater (10,000 acre-feet) than under the No Action Alternative.

- In prorated water years (i.e., 1987, 1992, 1993, 1994, 2001, and 2005), the level of proration would have improved 2 percent (1994) to 15 percent (2001), depending on the water year.

- In 1994, the most severe drought year in the 25-year period of record, the Wymer Dam Plus Yakima River Pump Exchange Alternative would have provided approximately 19,000 acre-feet of additional proratable water compared to the No Action Alternative. Of the four large divisions, Wapato, Roza, and Kittitas would have received approximately 5,600 acre-feet of additional proratable water, and Sunnyside would have received approximately 1,900 acre-feet.

- In 1994, compared to the No Action Alternative, the Wymer Dam Plus Yakima River Pump Exchange Alternative would have provided an additional 160,000 acre-feet (additional mean daily flow of 890 cfs) of flow downstream from the Parker gage in April–June and an additional 156,000 acre-feet (additional mean daily flow of 860 cfs) in July–September.

4.2.2.5 Mitigation

No mitigation would be required.

4.2.2.6 Cumulative Impacts

Columbia River Basin Water Management Program

The Columbia River Basin Water Management Program could affect water resources in both the Yakima and Columbia Rivers. The conservation provisions could improve irrigation deliveries and instream flows in both the Yakima and Columbia Rivers, but conservation actions under the program are not well enough defined to estimate what the changes might be. The same is true with respect to future storage. Options being considered might improve streamflows and irrigation deliveries in the Yakima River basin, but options are not sufficiently developed to determine the potential impacts, adverse or beneficial. Currently, three sites are under consideration for development of a large off-stream storage reservoir off the Columbia River. It would be difficult to develop both the Black Rock Alternative and a large mainstem off-stream storage option as both would depend upon flows in the Columbia River to fill the reservoirs.

Ecology issued the *Final Supplemental Environmental Impact Statement for the Lake Roosevelt Incremental Storage Releases Program* in August 2008 (Ecology, 2008). Section 4.2.2.3, “Surface Water,” states that no significant impacts are expected to the surface water flows downstream from Lake Roosevelt. Reductions in flows in the Columbia River would occur primarily in September, when water would be stored in Lake Roosevelt and Banks Lake. Under the preferred alternative for that project, flows would be reduced by about

1,400 cfs in most years and by about 2,200 cfs in extreme drought years. These reductions would be in addition to pumping under the Black Rock Alternative but would not prevent pumping to Black Rock reservoir in September, even in drought years. All existing target flows in the Columbia River still would be met. During September, the average monthly flow at The Dalles Dam is 94,600 cfs; the combined withdrawal for both projects would be about 5 percent of the total September flow. This impact would be reduced, however, because the Black Rock Alternative would increase discharges down the Yakima River during September by about 700-1,000 cfs, so the combined effect on the Columbia River downstream from the mouth of the Yakima River would be about 4 percent. Because of the relatively small volume of pumping required from Priest Rapids Lake, the withdrawal of water under the Black Rock Alternative is not expected to result in any adverse cumulative impacts.

The Joint Alternatives would have no significant adverse impacts on downstream or prospective users. Water would be diverted at times of the year when flows are available for diversion, and all available flow would not be diverted. The off-stream storage option actually would make additional water available for diversion by providing a means to divert water during low-flow periods by calling on storage.

Global Climate Change

Global climate change has the potential to impact water resources in the study region. Potential impacts relate to changes in future temperatures and precipitation patterns, and the resulting implications to stream runoff rate and timing, water temperatures, and reservoir operations.

Current Understanding of Global and Regional Climate Change.—Assessments on climate change science and contemporary projections have been periodically released by the Intergovernmental Panel on Climate Change (IPCC) since 1988. The IPCC was established by the World Meteorological Organization and the United Nations Environment Programme and has been coordinating the assessments of "*…climate change, its potential impacts and options for adaptation and mitigation*" (www.ipcc.ch). IPCC has recently released its Fourth Assessment Report (FAR) (IPCC, 2007). The IPPC report offers statements and associated uncertainties about recent trends, apparent human influence, and projections for various extreme weather events (e.g., table SPM.2; IPCC, 2007). Relatively more certain statements are offered about warming-related events. For example, table SPM.2 states that global trends of "*warmer and fewer cold days*" and "*warmer and more frequent hot days*" occurred with greater than 90-percent probability during the 20th century and that it is "*virtually certain*" that these trends will continue based on 21st century projections of climate response to future greenhouse gas emissions scenarios (IPCC, 2000). Relatively less certain statements are offered about precipitation-related events (e.g., phenomena like the areal extent of droughts, heavy precipitation event frequency).

Recent Studies of Climate Change Impacts to Pacific Northwest Water Resources.**—**Numerous studies have been conducted on the potential consequences of climate change for water resources in the Pacific Northwest. This section summarizes findings from recent studies demonstrating evidence of regional climate change during the 20th century and exploring water resources impacts associated with various climate change scenarios.

Recent Historical Trends in Pacific Northwest Climate and Snowpack.—It appears that the Pacific Northwest has became generally warmer and wetter during the 20th century. Based on results from Mote et al. (1999), the region experienced average temperature and precipitation trends of approximately +1.4 degrees °F (+0.8 degree Celsius [°C]) and +14 percent, respectively, during 1916–1997. Hamlet et al. (2007) showed similar findings in an annual sense; however, seasonal trends in precipitation were found to differ in sign from about the mid-20th century (table 4.6).

Table 4.6 Pacific Northwest Region meteorological trends: 1916–2003 and 1947–2003 (Hamlet et al., 2007)[1]

Season	Period	Precipitation	Temperature maximum	Temperature minimum
Cool (Oct–Mar)	1916–2003	0.79	0.181 (0.101)	0.301 (0.167)
	1947–2003	-1.11	0.347 (0.193)	0.409 (0.227)
Warm (Apr–Sep)	1916–2003	2.77	0.040 (0.022)	0.243 (0.135)
	1947–2003	1.62	0.268 (0.149)	0.347 (0.193)

[1] Precipitation units are percent change per decade. Temperatures units are °F (°C) per decade.

Coincident with these trends, the region also experienced a general decline in spring snowpack, as indicated by analysis of 20th century snow water equivalent (SWE) measurements dating back to at least 1950 (Mote, 2003). It appears that at most regional SWE measurement stations, particularly those located below about 5,900 feet above mean sea level (i.e., 1,800 meters), there has been a decline in SWE coincident with observed temperature increase and in spite of coincident precipitation increase (Mote, 2003). In the latter study, declines in SWE were found to be largest in the Cascade and Coast Ranges; and trend magnitudes were found to diminish at elevations above about 1,800 meters.

Mote (2006) explored the separate roles of temperature trend, precipitation trend, and climate variability in explaining observed SWE trends in the Pacific Northwest. Results showed that about half of the Pacific Northwest's SWE trend since the mid-20th century can be accounted for by an indicator of Pacific climate variability, the North Pacific Index on sea level pressure conditions, and the other half by the coincidental warming in the region. The significance of the results is that, even after accounting for the influence of climate variability, there still seems to be a substantial decreasing trend in Pacific Northwest snowpack conditions consistent with the observed warming.

These findings are significant for regional water resources management and reservoir operations because snowpack has traditionally played a central role in determining the seasonality of natural runoff. In many Pacific Northwest headwater basins, the precipitation stored as snow during winter accounts for a significant portion of spring and summer inflow to lower elevation reservoirs. The mechanism for how this occurs is that (with precipitation being equal) warmer temperatures in these watersheds cause reduced snowpack development during winter, more runoff during the winter season, earlier spring peak flows associated with an earlier snowmelt, and reduced warm season natural runoff (Hamlet et al., 2007).

Climate Change Studies in the Columbia River Basin.—A study conducted by Hamlet and Lettenmaier (1999) was framed by future climate scenarios derived from four state-of-the-art global climate models and focused on scenario changes in regional climate, Columbia River Basin runoff, and Columbia River reservoir system management. The relevance of Hamlet and Lettenmaier (1999) for this report is that their assumed climate scenarios span different increments of future warming and precipitation changes that remain within the range of changes surveyed among contemporary climate projections. (See the following section.)

Hamlet and Lettenmaier (1999) highlight water resource impacts associated with two of the scenarios analyzed (table 4.7). The impacts analysis starts from the treatment of each climate scenario, where change in long-term mean temperature and precipitation conditions is superimposed on observed climate variability. In other words, their study does not consider change in the spread or extremes of temperature or precipitation conditions about the mean.

Table 4.7 Scenario changes in climate analyzed by Hamlet and Lettenmaier, 1999[1 2]

	Change in…			Change in…		
Scenario	**Winter temperature**	**Summer temperature**	**Annual temperature**	**Winter precipitation**	**Summer precipitation**	**Annual precipitation**
HC	+3.6 (+2.0)	+2.7 (+1.5)	+3.2 (+1.8)	+20	+22	+21
MPI	+3.4 (+1.9)	+4.0 (+2.2)	+3.8 (+2.1)	+3	-9	-3

[1] Temperatures units are °F (°C). Precipitation units are percent change.

[2] Hadley Center (HC) and Max Planck Institute (MPI) scenarios were derived from climate simulations produced by the United Kingdom Hadley Centre and Deches Klimarechenzntrum at the Max Planck Institute as part of the IPCC's global climate change experiments conducted during 1998–1999.

Results showed that changes in Columbia River runoff at The Dalles varied significantly by scenario (table 4.8). The two scenarios were consistent in that increased winter runoff volumes would be expected as warmer temperatures cause a greater fraction of winter precipitation to fall as rain rather than snow. This, in turn, results in reduced snowpack accumulation during winter leading to less

Table 4.8 Scenario changes in natural runoff at The Dalles, simulated by Hamlet and Lettenmaier, 1999[1 2]

Scenario	Change in…		
	Winter mean	Summer mean	Annual mean
HC	162	107	123
MPI	121	88	98

[1] Change is expressed as percent of base runoff, as simulated using 20th century meteorology over the basin.

[2] Scenarios are the same as those listed in table 4.7.

snowmelt support of summer runoff. The results from these two scenarios suggest that, without an increment of precipitation increase to offset warming, dry season runoff in the region would decrease. Further, it highlights the importance of seasonally focused climate change on the regional water response.

Hamlet and Lettenmaier (1999) subsequently translated simulated changes in Columbia River runoff into reservoir operations response. Their results suggest that the scenario runoff changes presented in table 4.8, particularly for scenario MPI, could lead to increased competition for water during the spring, summer, and early fall between nonfirm energy production, irrigation, instream flow, and recreation. Other studies focused on Columbia River system response to scenario climate changes have produced similar findings (Mote et al., 1999; Mote et al., 2003; Payne et al., 2004).

Past Climate Change Studies in the Yakima River Basin.—Several recent investigations have explored scenario climate change impacts for runoff and water demand response in the Yakima River basin. Both of the two studies discussed in this section (Scott et al., 2006; Mastin and Sharp, 2006) were based on warming-only scenarios and did not include the influence of coincidental precipitation change.

Scott et al. (2006) focused on how scenario climate changes could translate into shifts in water shortages for irrigated agriculture and associated impacts on regional agribusiness. Their results showed that the "normal years" probability of needing more than 50-percent prorationing among basin junior water users increased from about 14 percent under current climate to about 54 percent with 3.6 ºF (2 °C) warming.

Mastin and Sharp (2006) used an application of the U.S. Geological Survey's Modular Modeling System and simulated runoff under historical meteorology (1950–2005) (i.e., base) and then again with the same historical meteorology warmed by a uniform 3.6 ºF (+2 °C) during the simulation period (i.e., climate change). Results showed that runoff was seasonally redistributed during the year and would seem to necessitate water management adjustments in the Yakima River basin to continue serving present operating objectives.

Table 4.9 presents “dry season” runoff responses to the scenario increment of warming (i.e., change in April–August natural runoff volume in the warmed climate scenario versus the base climate scenario) for five locations in the basin.

Table 4.9 Change in April–August natural runoff at various Yakima River basin locations based on a 3.6-ºF (2-°C) warming scenario (Mastin and Sharp, 2006)

Basin location	Difference (%) Exceedence percentile 10%	50%	90%
Bumping Lake	-27	-28	-37
Rimrock Lake	-25	-20	-16
Cle Elum Lake	-40	-49	-39
Kachess Lake	-47	-54	-55
Keechelus Lake	-45	-53	-53
Yakima River near Parker gage	-38	-41	-37

They show a median reduction of dry season runoff of -28 to -54 percent, varying by location. Mastin and Sharp (2006) attributed their simulated seasonal redistribution of runoff to reduction in snowpack.

Contemporary Climate Projection Information.—The preceding section highlighted earlier modeling efforts by Scott et al. (2006) and Mastin et al. (2006) reflecting future warming without precipitation change in the Pacific Northwest that could impact water resources in the Yakima River basin. The climate scenarios modeled by Scott and Mastin can be viewed as “what if” scenarios. It is of interest to understand how their scenarios compare to a survey of contemporary climate projection information, which this section introduces in some detail. In summary, the contemporary information reveals consensus among reputable climate models that future warming should occur. Further, there appears to be a split-majority among the models that, with this future warming, there will also be an increase in mean-annual precipitation over the region.

For this study, the survey was on projections contained within the World Climate Research Programme’s Coupled Model Intercomparison Project – Phase 3 multi-model dataset (WCRP CMIP3), http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php. These are the same projections referenced in the IPCC Fourth Assessment Report (IPCC, 2007). Specifically, the WCRP CMIP3 dataset was sampled to collect regional information from 112 contemporary climate projections (http://gdo-dcp.ucllnl.org/downscaled_ cmip3_projections) representing 16 different climate models. Each projection was spatially sampled over the Columbia River Basin and adjusted for climate model bias and downscaled to 1/8 -degree spatial resolution (Wood et al., 2002; Wood et al., 2004).

Results from the survey are summarized for two areas in this study: near Cle Elum Lake and Kachess Lake in the upper Yakima River watershed (figure 4.2) and over the greater Upper Columbia River Basin region (figure 4.3).

Figure 4.2 Projection survey area #1 near Cle Elum and Kachess Lakes, Washington.

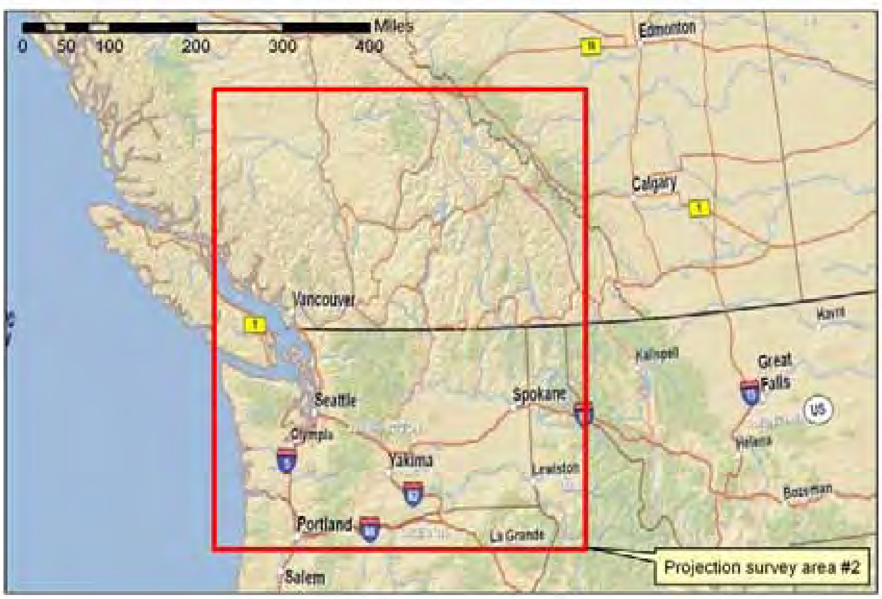

Figure 4.3 Projection survey area #2 over the Upper Columbia River Basin and surrounding region.

From the surveyed projections, there is consensus that Yakima-region warming should occur during the 21st century (figure 4.4), with median warming projections being about 1.8 ºF (+1.0 ºC) and 3.4 ºF (+1.9 ºC) by early- and mid-21st century, respectively. As for regional precipitation change, there is a split-majority, with more projections suggesting wetter rather than drier conditions. Roughly 75 percent of the projections suggest wetter conditions with median expected change being about +3.3 and +5.8 percent by early- to mid-21st century, respectively.

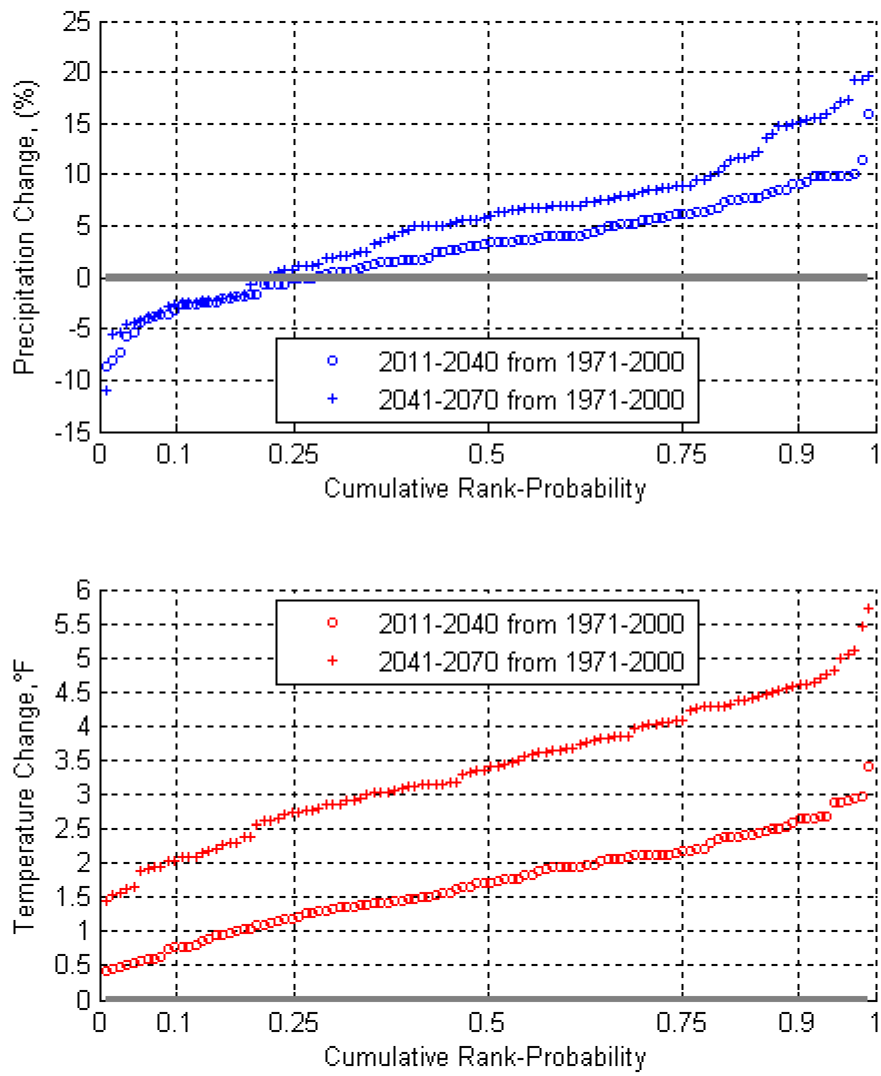

Figure 4.4 Variable-specific 21st century climate projections over Cle Elum and Kachess Lakes, Washington.

Plots show projection-specific changes in surface air temperature (ºF) and precipitation (percent) by 2011–2040 (top panel) and 2041–2070 (bottom panel) relative to 1971–2000 from 112 climate projections. The projections were collectively produced by 16 WCRP CMIP3 climate models offering one or more simulations of the IPCC Special Report on Emissions Scenarios pathways A2, A1b, and B1 (IPCC, 2000).

From the distribution of projected paired-changes in the Yakima region (figure 4.5), there does not appear to be a significant relationship between projected temperature (T) and precipitation (P) changes. For example, the correlation between projected T and P by period (n = 112) was -0.14 and -0.06, neither of which passes a test of statistical significance at the 90-percent confidence level given 112 paired observations. This suggests that contemporary projections of T and P change are somewhat independent and that the systematic drivers behind projected T change cannot be used to explain projected P changes. This raises questions about the spread and central tendency of projected P changes. In other words: What is the paradigm for Pacific Northwest precipitation response to global warming scenarios; and is this paradigm reflected on contemporary climate projections? These questions relate to more general questions of regional climate responses to anthropogenic warming in the context of natural climate variability, and remain a focus of ongoing research (e.g., WRCP Climate Variability and Predictability (CLIVAR) activities, www.clivar.org/science/components.php).

On the second survey area, figures 4.6 and 4.7 illustrate how projected T and P changes are spatially distributed throughout the region by early- and mid-21st century, respectively. At each 1/8-degree location in the projection datasets, all 112 projections were surveyed for mean-annual T and P change by early- and mid-21st century period. The 25-, 50- and 75-percent exceedence changes were then sampled and mapped as shown on the panels of figures 4.6 and 4.7. Similar to information on figure 4.4 and 4.5, it appears that there is consensus among the projections that warming is projected to occur throughout the basin; for roughly 75 percent of the projections, there is an expectation for wetter conditions throughout the basin.

The data shown on figures 4.4–4.7 do not imply regional "climate change probabilities." The data represent only the surveyed results from a heterogeneous mix of WCRP CMIP3 climate models, three IPCC FAR emissions pathways, and various states of climate modeling capability. Not represented among these projections are the uncertainties associated with the many factors still absent from current climate models or in the pathways included here (e.g., assumed global technological development, distributed energy-technology portfolios, resultant spatial distribution of greenhouse gas sources and sinks through time, and biogeochemical interaction with greenhouse gas sources and sinks through time, and many others). Further, these data do not fully represent how climate change impacts on large-scale weather patterns (e.g., Pacific storm tracks affecting the region) could interact with local-scale features relevant to Yakima River basin hydroclimate (e.g., Cascade orographic controls on Yakima River basin precipitation fed by storms tracking in from the Pacific Ocean, and how those controls vary with rainfall versus snowfall storms).

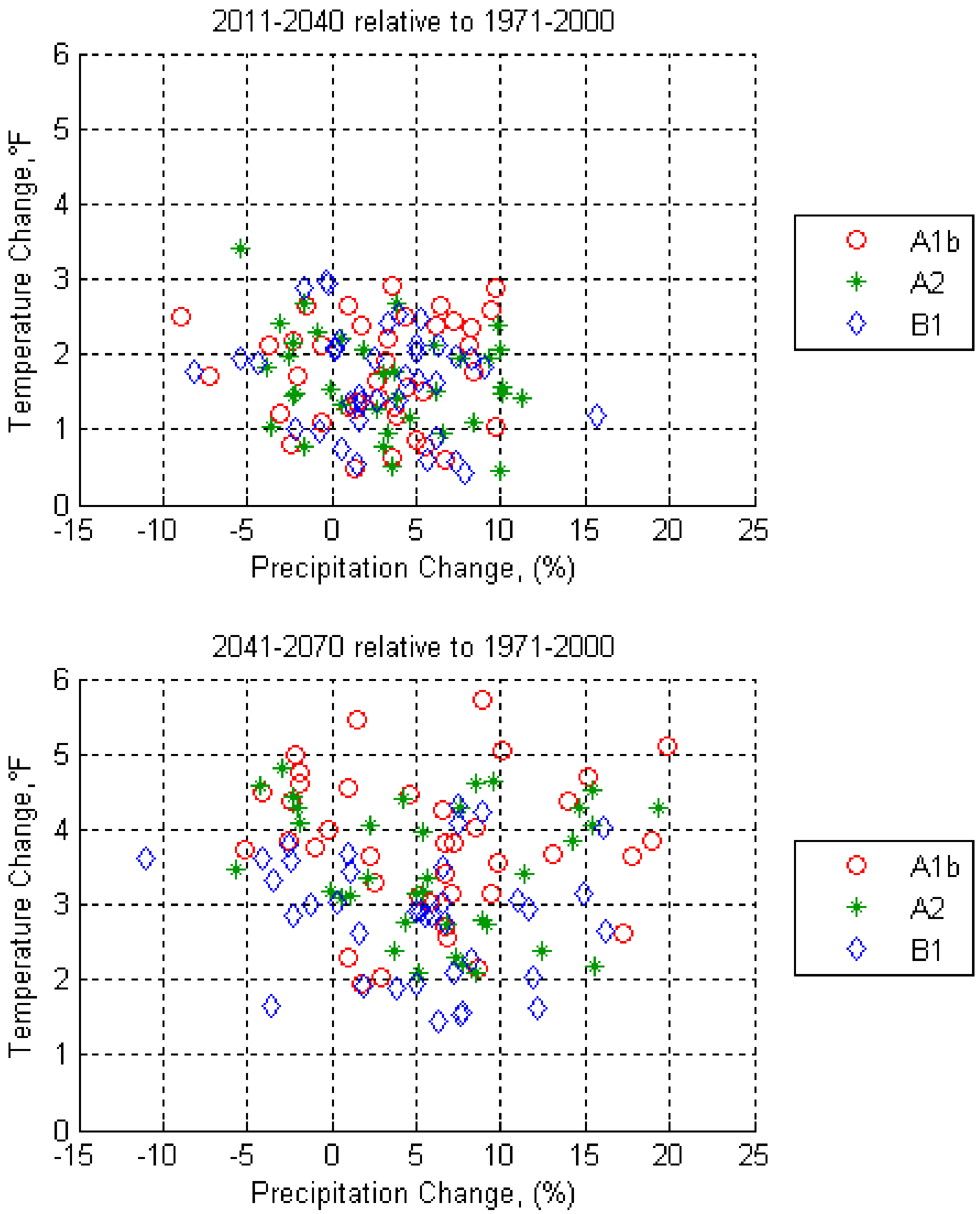

Figure 4.5 Paired 21st century climate projections over Cle Elum and Kachess Lakes, Washington.

Plots show paired projection-specific changes in surface air temperature (ºF) and precipitation (percent) by 2011–2040 (top panel) and 2041–2070 (bottom panel) relative to 1971–2000 for the same 112 climate projections summarized on figure 4.4.

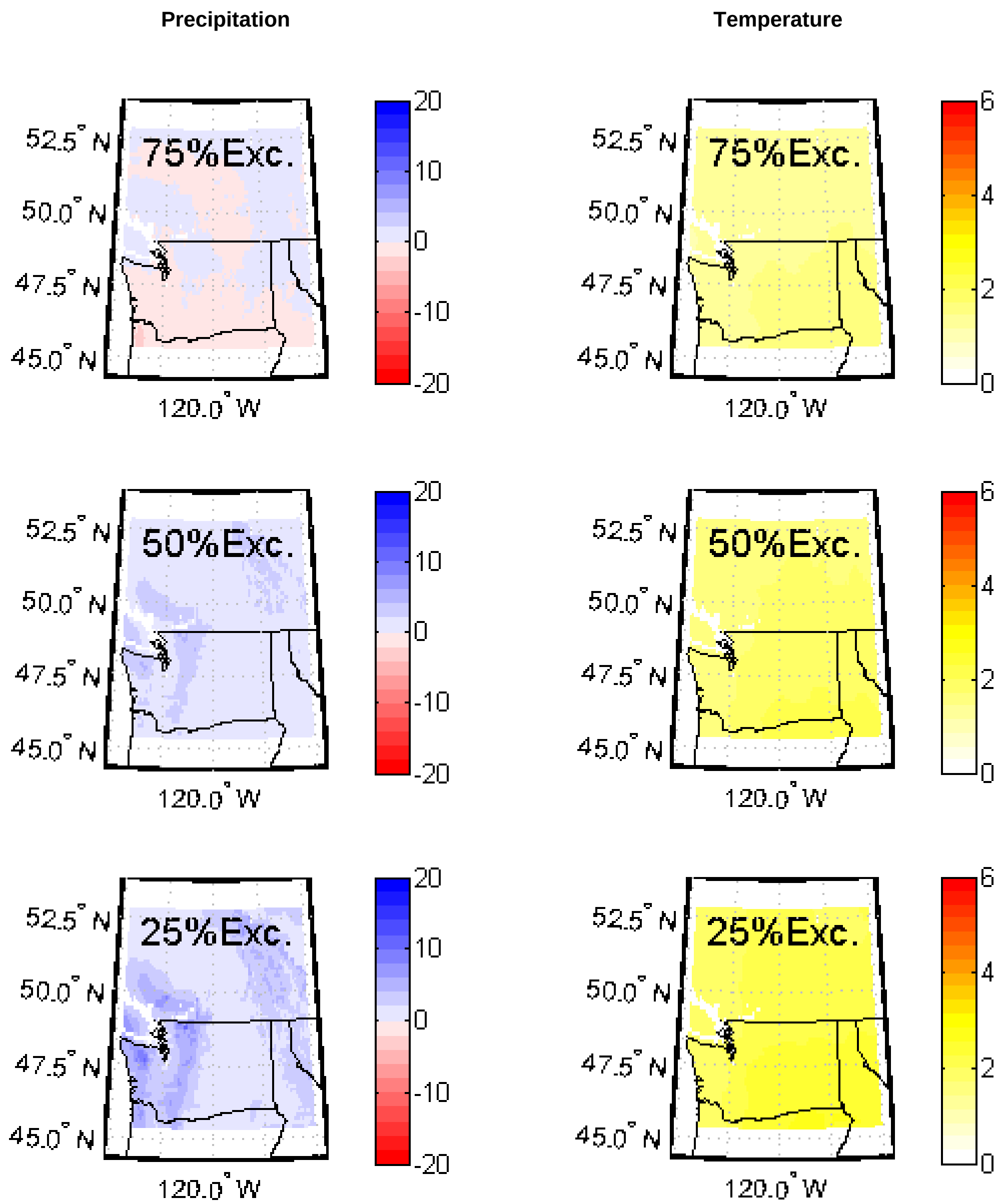

Figure 4.6 Early-21st century WCRP CMIP3 climate change projections over the Upper Columbia Region.

Maps show projected changes in surface air temperature (ºF) and precipitation (inches per year) by 2011–2040 relative to 1971–2000 from 112 climate projections, as described in the caption of figure 4.4. At each downscaled location (i.e., ⅛-degree spatial resolution), projections were sorted to identify 75-, 50-, and 25-percent exceedence projection values.

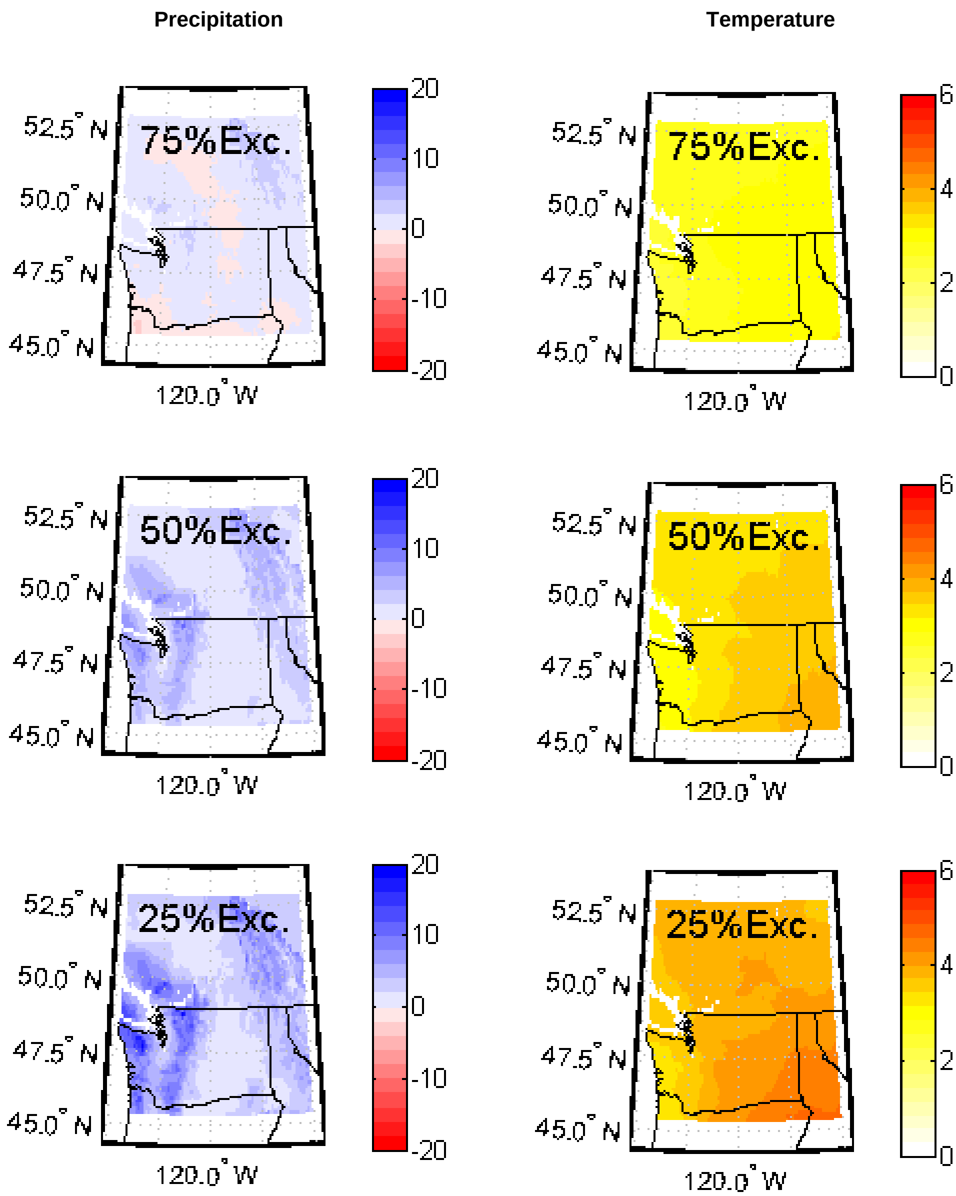

Figure 4.7 Mid-21st century WCRP CMIP3 climate change projections over the Upper Columbia Region.

Same as figure 4.6 but for projected changes in surface air temperature (ºF) and precipitation (inches per year) by 2041–2070 relative to 1971–2000.

***Treatment of Climate Change in the Storage Study.*—**Initial efforts for the Storage Study focused on two "what-if" climate scenarios and their associated impacts on Yakima River basin and Columbia River Basin water resources. Those two climate scenarios assumed amounts of mean-annual warming (i.e., +1 ºC and +2 ºC) with no change in precipitation. Reclamation proceeded to coordinate scenario analyses of runoff response in both the Yakima River basin and in the Columbia River basins, operations response in the Columbia River reservoir system, and related water supply available for diversion at Priest Rapids.

While that work was underway, the IPCC released its Fourth Assessment Report. As presented earlier, a survey of projections from the WCRP CMIP3 dataset suggests that the assumption of "no precipitation change" implicit in the scoped climate change scenarios may not be well representative of the future. However, this survey of contemporary precipitation projections is not accompanied by information on regional projection credibility. For example, the IPCC FAR (IPCC, 2007) did not offer information suggesting that global climate models can credibly translate global warming scenarios into regional precipitation response.

In contrast, the IPCC FAR offered information that suggested climate models can credibly simulate global- to continental-scaled temperature trends, which also suggests credibility on a regional scale as continental and regional temperature trends are similar.

Realistic projections of future runoff appear to be dependent upon our ability to predict future changes in both temperature and precipitation. As noted above, credible projections of temperature changes now can be made, but the credibility of contemporary regional precipitation projections remains questionable. The uncertainly associated with the regional precipitation projections is a significant concern when trying to develop quantitative results since scenario studies have shown that warming-induced decreases in Pacific Northwest runoff during spring and summer can be offset by some amount of precipitation increase (Hamlet and Lettenmaier, 1999). Given this uncertainty, the treatment of climate change for the Storage Study was modified to involve a qualitative discussion rather than a presentation of quantitative results from the originally scoped scenarios. Therefore, the remainder of this section provides a qualitative assessment of climate change impacts. Specifically, the remainder of this section summarizes potential climate change impacts related to runoff and surface water supplies, flood control, hydropower, fisheries, surface water quality, and groundwater.

- Runoff and Surface Water Supplies
    - Based on recent scenario studies of climate change impacts to Columbia River and Yakima River runoff, it appears that *warming without precipitation change* would trigger a seasonal shift toward increased runoff during winter and decreased runoff during

summer. It appears that such runoff shifts would lead to reduced scenario water supplies under the No Action Alternative.

- Based on contemporary climate projections, it appears plausible that precipitation increase could occur with regional warming and offset a significant portion of summer runoff decreases associated with warming alone. The resultant effect could be a minor change in dry-season water supply (albeit with significantly increased winter runoff to manage).

- Flood Control
  - With or without offsetting precipitation increases, it would appear that winter runoff increases under regional warming could motivate adjustments to Columbia River flood control strategies. If current flood protection values in the Columbia River reservoir system are to be preserved, it could become necessary to make flood control rule adjustments as climate evolves (e.g., deeper winter draft requirements) which may further affect dry-season water supply at Priest Rapids.
- Hydropower
  - Hydropower production is generally a function of reservoir storage while demand generally tracks with temperature (e.g., heating demand during cold days, air conditioning demand during warm days). Climate changes that decrease the quantity or alter the timing of reservoir inflows have the potential to adversely impact the productivity of hydroelectric facilities (Hamlet and Lettenmaier 1999). Alternatively, increases in average flows would increase hydropower production.
- Fisheries
  - The scenario studies on regional warming, which assumed no change in precipitation, would seem to indicate adverse effects on Pacific Northwest salmon due to increased winter flows, reduced summer and fall flows, and warmer stream and estuary temperatures (Mote et al., 2003). Assumptions about possible changes in precipitation, which could affect projected summer runoff, may alter these conclusions.
- Surface Water Quality
  - Water quality depends on several variables including water temperature, flow, runoff rate and timing, and the physical characteristics of the watershed. Climate change has the potential to alter all of these variables. Increased summer air temperatures could increase dry-season aquatic temperatures and affect fisheries habitat.

- Groundwater
  - Reduced mountain snowpack, earlier snowmelt, and reductions in spring and summer streamflow volumes originating from snowmelt would likely affect surface water supplies and could trigger heavier reliance on groundwater resources (Scott et al., 2006). However, warmer, wetter winters could increase the amount of water available for groundwater recharge.

Considering how climate change could influence each of these areas, it seems questionable whether contemporary water management objectives and operations would persist as climate evolves. Previous scenario studies on climate change impacts for regional water resources have typically assumed contemporary management paradigms and constraints while allowing climate change to modify surface water supplies. On the contrary, it seems possible that new water management paradigms could emerge in the region as an adaptation response, thereby affecting the assumptions framing these EIS analyses. Social systems could play a role, as they define values related to local and regional flood protection, environmental habitat support, energy management, recreational objectives, etc.

4.3 Groundwater Resources

4.3.1 Affected Environment

Groundwater is the principal source of drinking water in the Yakima River basin and supplies about 330,000 people, or about 80 percent of the population, in a three-county area. At least 45,000 wells withdraw water in the basin. Irrigation of cropland is the largest use of groundwater, pumped from about 2,300 irrigation wells (Vaccaro and Sumioka, 2006).

The headwaters of the Yakima River basin are on the forested east slope of the Cascade Range, where annual precipitation is more than 100 inches. However, the sedimentary and metamorphic rocks in the upper basin are generally poor aquifers; and groundwater recharge in the upper basin is not available to the majority of wells in the lower basin. The lower Yakima River basin is generally arid, with an annual precipitation of less than 10 inches. Mean annual recharge to the basin has increased about 31 percent since predevelopment conditions due to the application of irrigation water to croplands (Vaccaro and Olsen, 2007).

The addition of surface water storage and conveyance facilities could affect the groundwater resource by providing the opportunity for water to seep into the ground. This additional seepage could have either beneficial or detrimental effects, depending on the quantity and location.

4.3.1.1 Geology Overview

Basaltic rocks that underlie the majority of the Yakima River basin are part of the larger Columbia River Basalt Group (CRBG). The CRBG is comprised of more than 300 individual basalt flows that erupted from fissures in the eastern part of the Columbia Plateau during the Miocene Epoch (6–17 million years ago). Individual flows range from a few feet to more than 300 feet thick, with an average about 100 feet. The CRBG hosts multiple aquifers in various layers and formations that are collectively called the Columbia Plateau Aquifer System. The Columbia Plateau Aquifer System underlies about 63,000 square miles in central and eastern Washington, north-central and eastern Oregon, and a small portion of northwestern Idaho (figure 4.8).

The Columbia Plateau Aquifer System lies in the Columbia Intermontane physiographic province, which has been divided into three subprovinces: the Yakima Fold Belt, the Palouse, and the Blue Mountains. The three subprovinces are largely defined by structural differences. The Yakima River basin lies within the Yakima Fold Belt, which has experienced more tectonic folding and faulting than the other areas (figure 4.8). The topography of the Yakima Fold Belt consists of northwest-southeast-trending ridges (anticlines) separated by broad, flat valleys (synclines) that were folded and faulted under north-south compression.

The basalts have been divided into separate formations based on their physical, geochemical, and paleomagnetic polarity differences. From oldest to youngest the basaltic formations include the following:

- **Grande Ronde Basalt -** found mainly in the subsurface and only exposed at the surface where faulting or erosion has occurred. It is the thickest and most extensive of the basalt formations. The top of the Grande Ronde Basalt is generally defined by a zone of weathering or the presence of a sedimentary interbed (the Vantage sandstone).

- **Wanapum Basalt -** overlies the Grande Ronde Basalt and is found nearly everywhere in the Yakima River basin at depth. The Wanapum Basalt is a very productive aquifer throughout the Columbia Plateau and is widely used for irrigation and municipal wells.

- **Saddle Mountains Basalt -** is less than 1 percent of the total volume of the CRBG, yet is the most chemically diverse of any of the basaltic formations in the group (Swanson and Wright, 1978). The thickness and extent of the Saddle Mountains Basalt also varies more than other basalt formations.

Figure 4.8 Location of Yakima River basin and Columbia Plateau Aquifer System.

Interbedded sediments between some of the basalt flows are assigned to the Ellensburg Formation and are mainly found between flows of the Saddle Mountains Basalt. Toward the end of the volcanism period, there were longer intervals of time between subsequent basalt flows for deposition to occur. The interbed materials were derived chiefly from volcanic activity and erosion from the Cascade Range and from the anticlinal ridges. The interbeds are relatively thin, compared to the thick sequence of basalts, and are generally fine-grained, weakly consolidated, and have low permeability. However, in some areas, the interbeds are coarse-grained and serve as aquifers.

Folding, faulting, and other large-scale geologic deformation can affect regional groundwater flow direction, influence hydraulic gradients, and create flow conduits or barriers. At least some of the faults in the Yakima Fold Belt are proven hydraulic barriers. Others appear to be conductive and may connect deep basaltic formations with shallower formations and surface springs. Folding increases the occurrence of fractures on the anticlinal ridges and tends to enhance aquifer hydraulic conductivity.

4.3.1.2 Groundwater Occurrence

Groundwater within the basalts is controlled primarily by the physical characteristics of the rock units, the geometry and relationship between rock units, and the geologic structure. The physical characteristics of the basaltic flows (density and texture, fractures, and internal structures) are important in determining their hydraulic properties. Internal structures found in the flows may influence both the ease of water movement and direction of flow through the formation. Individual basalt flows typically exhibit features that are formed from the emplacement and cooling of the flow. These features may include a vesicular (having many small cavities) flow top, dense flow interior, and vesicular or brecciated (having many sharp angled fragments) flow bottom. If the basalt flowed into a body of water or encountered saturated sediments, a pillow-shaped structure is often formed, and the space between the pillows is usually composed of palagonite (hydrated basaltic glass). "Pillow basalts" generally exhibit high hydraulic conductivity values. Hydraulic conductivity (permeability) is a measure of the ease with which water flows through geologic layers. Below the basalt flow top, in the dense interior portion of the flow, the basalt has very low horizontal conductivity, and the flow interiors often serve as confining beds that separate adjacent aquifers. The flow bottom has hydraulic properties similar to the flow top, and the combination of flow top and adjacent flow bottom is called an "interflow." The interflow zone generally has high horizontal conductivity and is where most of the horizontal groundwater flow occurs within the basalt units. The basaltic flows and permeable interflow zones are often laterally continuous for tens of miles.

The thickness and extent of basalt flows and the occurrence or absence of fine-grained sedimentary interbeds also influence groundwater movement. At the distal ends of the basalt flows or where erosion has interrupted the continuity of flows, interbedded sediments are able to commingle and may serve as a vertical conduit between previously separated flow systems.

Groundwater flow is generally from the anticlinal ridges toward the streams and rivers in the synclinal valleys. Shallow groundwater flow is usually vertically downward from the surface to the underlying basalt units. However, because of the geologic structure of the synclinal basins, there are a number of areas that have upward flow and artesian wells in the lower valleys.

4.3.1.3 Aquifer Recharge and Discharge

Local-, intermediate-, and regional-scale groundwater flow systems within the Yakima River basin are recharged by various mechanisms. Local and intermediate flow systems are recharged through basalts that are exposed to precipitation at the ground surface on the anticlinal ridges and through groundwater exchange with other basins and formations. On a regional scale, basaltic units are recharged along the western margin of the Columbia Plateau where the basalts interfinger with prebasaltic rocks and sediments at higher elevations in the Cascade Range.

Much of the natural recharge (from precipitation) occurs in the upper basin and is not available to the bedrock aquifers where most pumping takes place (Vaccaro and Olsen, 2007). The lower, arid portion of the Yakima River basin generally receives about 6–10 inches of precipitation annually, and most groundwater recharge is from application and distribution of irrigation water (Vaccaro and Olsen, 2007).

About 45 percent of the water diverted for irrigation is eventually returned to the river system as surface water inflows and groundwater discharge (Reclamation, 1999). Irrigation return flows to the lower Yakima River account for about 75 percent of the streamflow downstream from the Parker gage (Vaccaro and Sumioka, 2006).

Aquifer discharge occurs principally to major surface drainage systems (i.e., Yakima and Columbia Rivers) and through irrigation well pumping. Annual pumping in the Yakima River basin increased almost 270 percent from 1960–2000 (Vaccaro and Sumioka, 2006). About 395,096 acre-feet were pumped in 2000; 60 percent of the pumping was for irrigation, and another 12 percent was for municipal water supply. The annual quantities appropriated in State water right certificates and permits are about 529,231 acre-feet (Vaccaro and Sumioka, 2006).

4.3.1.4 Hydraulic Properties

Physical variations within the basalt flows indicate that a wide range of hydraulic conductivity values exist within a single basalt flow. Hydraulic conductivities can be inferred from injection or pumping tests in drill holes and from water level measurements and trends. Aquifer testing at the Hanford Site and at other locations around the Columbia Plateau has provided a range of hydraulic conductivity values for various zones within the basalt units (Lindsey et al., 2003).

Hydraulic conductivity, along with gradient and other material properties, determines the likelihood and quantity of seepage from the proposed Black Rock and Wymer reservoir sites.

Hydrogeologic unit	Range of horizontal hydraulic conductivity (Kh)[1]
Basalt flow tops	$1x10^{-6}$ to $1x10^{3}$ feet per day
Basalt flow interiors	$1x10^{-9}$ to $1x10^{-3}$ feet per day (vertical k estimated about 1 to 3 times Kh or $3x10^{-9}$ to $3x10^{-3}$ feet per day)
Sedimentary interbeds	$1x10^{-6}$ to 1 feet per day

[1] Kh = horizontal hydraulic conductivity; k = hydraulic conductivity.

4.3.2 Environmental Consequences

4.3.2.1 Methods and Assumptions

Several methods were used to help evaluate the effects of the Joint Alternatives on groundwater, as described in the following sections.

The following indicators were selected to evaluate groundwater:

- Increased hydraulic head and pore pressures (resulting from the creation of surface storage reservoirs at the Black Rock or Wymer sites)
- Volume and direction of seepage flow
- Construction impacts – dewatering and water disposal

Black Rock Reservoir Modeling

Reclamation developed two models to help evaluate the effects of the proposed Black Rock reservoir on groundwater. First, Reclamation developed the groundwater seepage model to determine seepage from, and hydrologic effects of, the proposed Black Rock reservoir. The groundwater seepage model used the USGS MODFLOW software package (Harbaugh et al., 2000), a computer program that provides a mathematical representation of the groundwater flow system. MODFLOW is recognized as the industry standard for groundwater flow models, and it has been reviewed and used for more than 20 years. It numerically solves the three-dimensional groundwater flow equation for a porous medium by using a finite-difference method. The modeled area is represented by a three-dimensional grid of cells laid out in a series of rows, columns, and layers. The model layers simulate confined or unconfined aquifers. Each cell has a single point, called a node, where head is calculated. Hydraulic boundary conditions, hydraulic parameters, and stresses to the system (such as pumping wells, flow to riverbeds, aerial recharge) are defined as model input. Model output includes head and flow at each node within the model domain.

The groundwater seepage model relied heavily on previous hydrogeologic studies, including the USGS Columbia Plateau regional groundwater model (Hansen et al., 1994) and the Yakima River basin hydrogeologic framework study (Jones et al., 2006). Reclamation first used the groundwater seepage model to represent the current condition in the modeled area (called the base case in the seepage study and comparable to the No Action Alternative) and then to predict a range of expected impacts related to the presence of Black Rock reservoir. Data used in the groundwater seepage model were acquired through various literature reviews, field work, hydrological testing of wells, geological mapping, and from the model itself. The investigation also incorporated the results of recent geologic drilling and aquifer testing by Reclamation at the proposed Black Rock site (Reclamation, 2004g; Reclamation, 2007a; Reclamation, 2007j).

Reclamation subsequently modified the groundwater seepage model to determine the effectiveness of proposed seepage mitigation measures (Reclamation, 2008a). This modified model is called the seepage mitigation model. First, the horizontal grid spacing was reduced in the Dry Creek area to provide better resolution for comparatively small mitigation features that were to be represented in the model. The new grid mesh is 375-feet-square in the dam area and the Dry Creek drainage and gradually increases to 3,000-feet-square in the outlying areas. Second, the Saddle Mountain model layer (layer 2 in the groundwater seepage model) was split into two layers to provide greater vertical resolution in the layer most likely to be affected by mitigation measures. In the seepage mitigation model, six model layers were used to represent Black Rock Valley hydrogeologic units: layer 1 represents the overburden sediments of the alluvium, Ringold, and Ellensburg Formations; layers 2 and 3 represent the Saddle Mountains Basalt; layer 4 represents the Wanapum Basalt; and layers 5 and 6 represent the Grande Ronde Basalt.

After making these modifications, Reclamation calibrated the seepage mitigation model to existing conditions and ran a Monte Carlo simulation to determine statistically valid limits of the high and low values of seepage volumes. Then, Reclamation selected mitigation measures to (1) reduce seepage from the reservoir and (2) intercept seepage water in the Dry Creek drainage before it could reach the Hanford Site. These measures were assigned appropriate conductivity values in the model grid. Mitigation measures in the seepage mitigation model include:

- Replacement of overburden (sediment layer) under the dam with low-permeability zone 1 core material and installation of a grout curtain along the dam alignment, across the valley, and extending into the left (north) abutment.

- A geomembrane barrier on the right abutment blanketing an outcrop of Wanapum Basalt.

- Concrete cutoff walls in the right abutment and downstream from the reservoir in the Dry Creek Valley.

- An embankment at the cutoff wall downstream from the reservoir.

- A pipeline to convey the seepage water from the embankment to the Yakima River.

Wymer Reservoir Modeling

A comparable study has not been completed for the Wymer Dam and Reservoir Alternative, but head increases and seepage flows can be qualitatively described based on site investigations and available data. Field investigations and borehole testing were recently completed, and the results of these and previous studies were used to evaluate the likely effects under the Wymer Dam and Reservoir Alternative.

4.3.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

During dry water years, State law allows emergency pumping from numerous drought relief wells as a source of supplemental irrigation supply. Historical water level data indicate that pumping from these wells during droughts has caused long-term water level declines in the deep basalts. The potential use of these emergency wells is expected to be less under any of the Joint Alternatives than under the No Action Alternative.

4.3.2.3 Black Rock Alternative

Construction Impacts

During excavation of the pumping plants, tunnels, seepage mitigation features, and appurtenant structures associated with the Black Rock Alternative, dewatering may be necessary during construction in some areas. The Priest Rapids member of the Wanapum Basalt would be excavated for the intake pumping plant along the Columbia River. The amount of dewatering necessary would depend on the occurrence of rock fractures and interflow zones encountered in the excavation. Some provision for dewatering and disposal of pumped water would be necessary. The tunnels would be excavated above the regional water table and may not require substantial dewatering during construction (Reclamation, 2004a).

Long-Term Impacts

Table 4.10 presents total annual reservoir seepage (without any mitigation), annual rate of increase in aquifer storage, and annual rate of increase in discharge to creeks, drains, and springs, as estimated by the groundwater seepage model, with respect to time since reservoir filling begins. The table provides a range of seepage values resulting from a sensitivity analysis that was conducted to bracket most of the uncertainty in model input parameter values.

Table 4.10 Model-based estimates of total annual reservoir seepage rates (Reclamation, 2007a)

Time since reservoir filling begins	Total annual reservoir seepage (acre-feet)[1]			Annual rate of increase in aquifer storage (acre-feet)			Annual rate of increase in discharge to creeks, drains, and springs (acre-feet)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
13 months	72,900 101 cfs	121,000 168 cfs	96,950 135 cfs	49,900 69 cfs	80,000 111 cfs	64,950 90 cfs	22,400 31 cfs	40,400 56 cfs	31,400 44 cfs
5 years	32,100	54,300	44,900	2,400	14,700	8,600	25,600	51,100	36,300
25 years	30,700	53,400	42,200	1,000	6,100	3,400	27,600	51,400	38,800
100 years	29,900	53,200	41,300	200	2,900	1,300	28,500	51,500	40,000
300 years	29,800 41 cfs	52,300 73cfs	40,900 57 cfs	1 0 cfs	1,500 2 cfs	600 1 cfs	29,200 41 cfs	51,600 72 cfs	40,400 56 cfs

[1] Total annual reservoir seepage is generally not the exact sum of its two components in this table because the minimum, maximum, and mean values presented are from different model runs.

Groundwater seepage model results indicate that the effect of reservoir seepage on aquifer hydraulic head conditions is greatest in the immediate area of the proposed reservoir itself, but especially at the dam, where the reservoir would be deepest (Reclamation, 2007a). A full reservoir would ultimately increase head directly beneath the reservoir in the sediments and Saddle Mountains and Wanapum Basalts by 250–650 feet. Groundwater seepage model results show that the effect of seepage on head diminishes rapidly with distance from the reservoir. Five to ten miles from the reservoir, the head increase in the basalts to the south and northwest is generally less than 20 feet.

A minimal increase in head is expected in the sediments west of the reservoir because the west end is the upper, shallow, end and there would be a lower hydraulic gradient in that direction. In the Saddle Mountains Basalt, the head increase is mainly to the south since the unit is absent in the Yakima Ridge anticline, north of the reservoir. Likewise, the Wanapum Basalt thins slightly to the west of the reservoir, and the unit outcrops along the north and south anticlinal ridges. These conditions and variations in vertical conductivity influence the pattern of increased head in the basalts. The modeled head increase in the basalts is generally less than 10 feet in the lower Yakima Valley after 300 years (Reclamation, 2007a).

Most of the increase in aquifer discharge to creeks, drains, and springs occurs into the Dry Creek drainage. Seepage is expected to "daylight" at the upstream end of Dry Creek (to the east of Black Rock reservoir) then reinfiltrate into the sediments that overlie the basalts at the downstream end of Dry Creek and result in an increase in head of up to 250 feet. Along Cold Creek, at the western boundary of the Hanford Site, head increases can range up to 60 feet; the increased head continues, although diminished, into the Hanford Site.

Reclamation developed the seepage mitigation model to determine the effectiveness of proposed mitigation measures (Reclamation, 2008a) to reduce the head of the groundwater at the western boundary of the Hanford Site. These mitigation features would be constructed at the same time that Black Rock dam would be constructed. Seepage mitigation model results show that a combination of these mitigation measures would reduce total *maximum* modeled reservoir seepage by approximately 30 percent (from 74.3 to 51.9 cfs). However, most of the remaining water (46.5 cfs of the 51.9 cfs) would bypass these mitigation features and surface in the Dry Creek drainage downstream from the dam. The remaining total reservoir seepage (about 5.4 cfs) would continue deeper into the basalts. The minimal deep basalt flow is expected to have negligible effect on the Hanford Site.

To capture surface water and groundwater flows in Dry Creek, a cutoff wall, approximately 200 feet deep[6] and 5,500 feet long, would be constructed about 6.6 miles downstream from the dam in the Dry Creek drainage (figure 2.8). A 15-foot-high embankment on top of the cutoff wall would prevent surface water from flowing further down Dry Creek and would direct the surface flow into a 48-inch-diameter pipeline that would convey the water away from the site. Seepage mitigation model results indicate these measures could reduce total reservoir seepage across the Cold Creek boundary by 99 percent. The remaining seepage would be in the deeper basalt formations and would not affect the contaminants in the sediments at the Hanford Site.

Additionally, a series of pumping wells (each about 300 feet deep) would be constructed, as needed, downstream from the cutoff wall to capture seepage in the deeper basalt layers and intercept any groundwater that bypasses the cutoff wall. (See figure 2.9.)

[6] In the seepage mitigation model, the cutoff wall was assumed to be constructed to the top of the basalt.

Although seepage mitigation model results indicate the potential success of siting a cutoff wall in the Dry Creek Valley to capture the remaining seepage, a much more detailed assessment would be required to fully analyze the proposed mitigation measures to ensure their long-term effectiveness prior to actual application. Groundwater models are simplified representations of complex natural systems. They are helpful in understanding and comparing the effectiveness of proposed actions, but there are also uncertainties in the representation that must be recognized when evaluating the results.

As discussed in chapter 1 under "Additional Projects," the U.S. Department of Energy issued a Notice of Intent (*Federal Register* Vol. 71, No. 22, 5655, February 2, 2006) for the *Tank Farm Closure and Waste Management Environmental Impact Statement,* which is evaluating treatment, storage, and closure options for tanks and other units around the Hanford Site. Remediation technologies and programs either currently implemented or under development at the Hanford Site could be affected by seepage from the proposed Black Rock reservoir. DOE is using groundwater flow and transport models to evaluate multiple alternatives for the *Tank Farm Closure and Waste Management EIS*, and, in addition to other site analyses, DOE is analyzing the potential impact of the addition of seepage from the potential Black Rock reservoir on the Hanford Site.

Seepage from Black Rock reservoir, if unmitigated, could affect existing groundwater contamination at the Hanford Site in a number of ways. For example, seepage from the reservoir would increase the groundwater flow in the aquifer beneath the Hanford Site. Increased groundwater flow has the potential to increase the movement of contaminants from the central part of the site, referred to as the Central Plateau. Such an increase in groundwater flow has the potential to change containment plume shapes, travel times, and peak concentrations. The hydraulic conductivity distribution differs between the eastern and western portions of the Central Plateau, so an increase in groundwater flow also would likely have differing effects across the Hanford Site. Seepage from Black Rock reservoir, if unmitigated, also has the potential to raise the water table level beneath the Hanford Site. A higher water table has the potential to mobilize contaminants currently in the soil, as well as shorten the travel time of contaminants through the vadose (unsaturated) zone. DOE is investigating this contaminant mobilization at the Hanford Site, along with contaminant travel time toward the river.

However, as stated in chapter 2, Reclamation would construct the seepage mitigation features, along with Black Rock reservoir, to mitigate for seepage impacts to the Hanford Site and would operate and maintain the dam and the appurtenant works (including the mitigation features) for the life of the project.

Reclamation provided DOE the results of its modeling of seepage and seepage mitigation for Black Rock reservoir (Reclamation, 2007e; Reclamation, 2008h).

These results include the predicted minimum and maximum seepage rates that would cross the Cold Creek boundary onto the Hanford Site after steady-state conditions have been achieved, assuming that no mitigation features are in place. The results also include the modeled results assuming that mitigation features are in place. In its EIS, DOE has chosen to use Reclamation's Black Rock seepage modeling results that project seepage across the Cold Creek boundary with no mitigation measures in place to portray a worst-case scenario for its study.

The modeling that DOE is performing for contaminant fate and transport analysis on the Hanford Site has extended time scales and different modeling approaches than the models used by Reclamation. Therefore, the modeling results from the two agencies should not be compared to each other, but both are important analyses of possible impacts to the groundwater conditions from the proposed Black Rock reservoir to the Cold Creek boundary and onto the Hanford Site.

DOE submitted a Responsible Opposing View expressing concern (attachment A) about potential effects the cleanup of the seepage, if unmitigated, on the Hanford Site. Reclamation has the following response. A Black Rock seepage analysis was completed in 2007 (*Modeling Groundwater Hydrologic Impacts of the Potential Black Rock Reservoir* [Reclamation, 2007a]) to estimate the volume and direction of seepage from the potential reservoir. The groundwater flow model estimated a maximum rise of groundwater level in the sediment layer at Cold Creek[1] of up to 60 feet. (Cold Creek is considered the western hydrologic boundary of the Hanford Site.) Most of the head increase would result from reinfiltration of Dry Creek surface flow into a thick sequence of sediments near the confluence of Dry Creek and Cold Creek drainages. A head increase would increase groundwater flow across the Cold Creek boundary. The estimates of increased flow volumes, based on model results after reaching equilibrium conditions and without any mitigation to reduce or capture the seepage, were provided to DOE. DOE is modeling multiple alternatives and conditions to investigate potential impacts to contamination on the Hanford Site as part of the *Tank Farm Closure and Waste Management EIS*.

Subsequent groundwater flow modeling (*Modeling Mitigation of Seepage from the Potential Black Rock Reservoir* [Reclamation, 2008a]) estimated the effectiveness of various mitigation measures to reduce and capture the expected seepage from the reservoir. Based on the initial modeling results and current understanding of the groundwater flow system, the mitigation features were chosen and located in areas that would reduce total seepage and capture the seepage in the Dry Creek drainage before the water could reinfiltrate into the sediments near the Hanford Site boundary.

If the Black Rock Alternative were to move forward into the final design phase, additional hydrogeologic investigations would be required to verify the assumptions and information used in the groundwater flow models. Additional investigations also would provide information about the complex geologic structure that exists in the Dry Creek area that could significantly affect groundwater flow.

Landslides are common in the Yakima Fold Belt and generally form on the over-steepened south limbs of the anticlines. Several ancient landslides have been identified on the Horsethief Mountain anticline, which comprises the right abutment of the proposed Black Rock dam (Columbia Geotechnical Associates, 2004). The steeply dipping orientation and layering of the low-strength sediments and the presence of the Horsethief Mountain Thrust Fault along the southern edge of the reservoir valley present a potentially hazardous combination. Though the slide areas are currently stable, seepage from the reservoir into the presently unsaturated basalts and interbedded sediments would increase pore pressures within those materials and would likely reactivate some of those slides as well as initiate new landslides along the reservoir rim and dam abutments. Slope stability would also be an issue for the realignment of SR–24 along the south rim of the reservoir. Additional design data collection outlined in chapter 2, section 2.2.3, describes the possible landslide locations and potential mitigation measures.

4.3.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

The pumping plant to supply Wymer reservoir would be located along the Yakima River, and construction of the plant would require dewatering. Approximately 25 feet of alluvial material lies above the Grande Ronde Basalt in the pumping plant location, and the groundwater level would be expected to follow the river stage, which is about 10 feet below ground surface. The pumped water would need to be treated or allowed to settle to remove turbidity and suspended sediments prior to discharging the water back to the river. There are no private wells in the immediate area that would be affected by the dewatering.

Dewatering also would be required during construction of the dam foundation. Artesian conditions were encountered at a depth of about 55 feet (35 feet into the Grande Ronde Basalt) during the drilling of two wells in the river valley (Reclamation, 1988). About 20 gallons per minute (gpm) flowed at the ground surface under unknown pressure from each well. Additional water may be encountered with depth and excavation into additional water-bearing basalt flows.

Long-Term Impacts

The majority of groundwater seepage from the proposed Wymer reservoir would be west toward the Yakima River and could involve substantial volumes. Permeability testing in a drill hole on the left abutment indicates very high hydraulic conductivity values in the upper basaltic layers. The basalt was so pervious that no pressure could be established within the test zone while injecting water at the capacity of the pump (50–60 gpm). The upper dam abutments would be in the Frenchman Springs member of the

Wanapum Basalt. This basalt member is a widely used aquifer because of its high conductivity and water-bearing properties.

The Vantage interbed lies below the Frenchman Springs member. Results of hydraulic conductivity testing indicate moderate values in the sandstone and siltstone: $1x10^1$ to $2x10^3$ feet per day; similar values are indicated in the underlying Grande Ronde Basalt: $1x10^1$ to $2x10^2$ feet per day. The Vantage interbed is currently unsaturated. Reservoir seepage would cause a rise of pore pressures within the unit and could cause instability of the low-strength materials in the reservoir basin. There are seeps and springs along the lower contact of the Vantage interbed, indicating that the underlying Grande Ronde Basalt is a lower permeability unit and probable confining bed.

As under the Black Rock Alternative, hydraulic head increases would be greatest near the downstream end of the proposed reservoir and would decrease with distance away from the reservoir. Because the Yakima River Valley is less than a mile from the Wymer damsite, seepage would have a relatively short-flow path and would be under a high-flow gradient from the full reservoir to the river valley below. Mitigation would be required to control the seepage and potential for sediment transport through the abutments and reservoir rim.

4.3.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

The environmental consequences of this alternative would include all of the impacts for the Wymer Dam and Reservoir Alternative, plus the impacts from the pump exchange project in the lower Yakima River basin.

Construction Impacts

The Yakima River pump exchange component of this alternative includes construction of a pumping plant in Columbia Park that would require dewatering by wells. In addition, excavation of the pipeline delivery system to a depth of about 18 feet would require dewatering in areas where the water table is shallow and where the pipeline crosses the Yakima River and other minor creeks. The dewatering may lower water levels in nearby wells and temporarily affect the water supply to those wells.

Long-Term Impacts

Other groundwater impacts (decrease of recharge or return flows) due to decreasing the amount of irrigation water delivered and applied would be relatively small and would be spread out over a relatively large area, and so have not been quantified for this analysis.

4.3.2.6 Mitigation

For the Black Rock Alternative, facilities would be constructed to provide control and removal of the groundwater seepage if the dam were constructed. Also, a monitoring well program would be established to determine where the water flows and how much water could be expected. Additional facilities would be constructed as the monitoring program indicated was necessary. Measures to mitigate seepage from the reservoir have been incorporated into the alternative.

Mitigation for Wymer reservoir has not been identified. Chapter 2, section 2.2.3, "Design Data Gathering," identifies additional work that would help identify areas where seepage might be of concern for Wymer dam. Appropriate mitigation measures would be put in place to minimize the seepage or to control it so it would not cause stability or other problems at or downstream from the dam.

4.3.2.7 Cumulative Impacts

Currently, groundwater pumping occurs on the Hanford Site as part of cleanup operations. Additional pumping may occur in the future as cleanup options are selected. Pumping on the Hanford Site is not anticipated to affect conditions at Black Rock dam or reservoir or affect the quantity of seepage from the reservoir. However, depending on the quantity and location of pumping, the area of influence from Hanford Site pumping could extend to or beyond the western Hanford Site boundary and affect the hydraulic gradient across the boundary at Cold Creek. A steepening of the gradient could increase the amount of groundwater flow (including Black Rock seepage) entering the Hanford Site.

4.4 Hydropower Resources

This section describes the mid-Columbia River hydroelectric power generation system and the possible effects of the Joint Alternatives.

4.4.1 Affected Environment

The following discussion of the mid-Columbia River hydroelectric power generation system is from Grant County's PUD 2003 relicensing report (Grant County PUD, 2003).

The Priest Rapids Project is located on the mainstem Columbia River in central Washington and includes two hydroelectric developments—Wanapum and Priest Rapids—owned and operated by Grant County PUD. Each development consists of a dam, powerplant, fishways, reservoir, 230-kV transmission lines, and ancillary facilities. Wanapum and Priest Rapids powerplants each have 10 turbine-generators with capacities of 900 and 850 MW, respectively, for a presently authorized, installed capacity of 1,750 MW. The maximum hydraulic capacity of each powerplant is approximately 175,000 cfs, assuming all units are operating at full capacity.

The two developments produced a total of 9.65 billion kilowatthours (kWh) of electricity in 2002, which is equivalent to the energy consumed in a year by a city of approximately the size of Seattle. Under current power purchase agreements, Grant County PUD reserves 36.5 percent of the energy produced for its own use. The remaining 63.5 percent of the generation is provided under long-term contracts, at cost, to 12 Pacific Northwest utilities that collectively serve customers in Washington, Idaho, Oregon, Montana, and Utah.

Priest Rapids development is part of the much larger, seven-dam, mid-Columbia River hydroelectric system of about 14,000 MW, which extends from near the United States/Canada border to the beginning of the Hanford reach, for a total of 351 miles. This system includes two Federal facilities, Grand Coulee Dam (Reclamation) with an installed generation capacity of about 6,800 MW, and Chief Joseph Dam (U.S. Army Corps of Engineers) with an installed capacity of about 2,600 MW.

Three Washington PUDs own and operate the five hydroelectric projects downstream from Chief Joseph Dam, with a combined installed generation capacity of about 4,500 MW. Priest Rapids Dam is at the downstream end of this integrated system of hydropower facilities.

Table 4.11 presents information on the mid-Columbia River system. Figure 4.9 shows many of the important dams in the Federal Columbia River Power System. Downstream from the mouth of the Yakima River, Federal powerplants on the lower Columbia River are at McNary, John Day, The Dalles, and Bonneville Dams.

The seven-dam, mid-Columbia River system contains a substantial amount of active storage that enhances the reliability and flexibility of the Northwest's entire electric generation system. The usable storage in the mid-Columbia system is primarily at Grand Coulee Dam (Franklin D. Roosevelt Lake) with more than 5,200,000 acre-feet, while the six downstream projects account for about 440,000 acre-feet, or about 10 percent. Overall, 86 percent of the annual flow at Priest Rapids Dam is provided by controlled releases from Grand Coulee Dam.

Table 4.11 Summary of hydroelectric projects in the mid-Columbia River system

Project	Owner	Location (RM)	Drainage area (square miles)	Usable storage[1] (maf)	Maximum plant hydraulic activity (cfs)	Installed capacity (MW)
Grand Coulee	Reclamation	596.6	74,700	5.22	280,000	[2]6,809
Chief Joseph	U.S. Army Corps of Engineers	545.1	75,000	0.12	213,000	2,614
Wells[3]	Douglas PUD	515.8	86,100	0.10	220,000	840
Rocky Reach[3]	Chelan PUD	473.7	87,800	0.04	220,000	1,287
Rock Island[3]	Chelan PUD	453.4	89,400	0.01	220,000	660
Wanapum[3]	Grant PUD	415.8	90,900	0.16	180,000	900
Priest Rapids[3]	Grant PUD	397.1	96,000	0.04	175,000	855

[1] The volume of water contained within the normal reservoir operating range.

[2] Includes generating capacity of the pump/generator plant.

[3] Data for these private facilities obtained from Grant PUD's relicensing report of 2003.

Figure 4.9 Important dams in the Federal Columbia River Power System.

4.4.2 Environmental Consequences

4.4.2.1 Methods and Assumptions

Black Rock Alternative

The Black Rock Alternative would affect the mid-Columbia River hydroelectric power generation system by (1) adding an additional power demand associated with pumping water from Priest Rapids Lake to a Black Rock reservoir and (2) changing the mid-to-lower Columbia River flow regime available for hydropower generation at Federal and non-Federal powerplants by the depletion of water withdrawn at Priest Rapids Lake and the accretion of water from Yakima Project operations about 62 miles downstream at the confluence of the Yakima River. Monthly modeling methods to confine flow and power impacts to Priest Rapids and lower Columbia River projects resulted in minor alterations in draft-and-fill operations of Grand Coulee and Libby Dams.

These effects on power generation due to altered flows on the Columbia River were evaluated using the Bonneville Power Administration's HYDSIM computer model. The model simulated the current monthly operating requirements of the FCRPS based on the recurrence of flows and the alteration of such flows by Black Rock operations during the historical hydrologic period of record of 1929–98. This period provides an 18-year overlap with the Yak-RW model's hydrologic period of 1981–2005 and includes the high-flow years of 1996–97 and the low-flow years of 1992–94.

The value of net loss in power generation due to such alteration of flows, as well as the value of power to operate Black Rock pumps, was computed using the unit power cost estimates developed by BPA for the historical runoff years of 1929–78 for the *Summary Report, Appraisal Assessment of the Black Rock Alternative* (Reclamation, 2004a). These cost estimates reflected the same assumptions in BPA's August 2003 rate case. However, based on BPA cost estimates for similar runoff years during the period of 1929–78, Reclamation determined the monthly average unit power costs for each year from 1981–98.

The following indicators were selected to evaluate effects on hydropower for the Black Rock Alternative:

- Average monthly or annual pumping power requirement (MWa)
- FCRPS and non-Federal Columbia River generation losses (MWa)
- Value of Columbia River generation losses (average annual $ million)
- Additional generation capacity (average annual MW)

Wymer Dam and Reservoir Alternative

For the Wymer Dam and Reservoir Alternative, the indicator of average annual pumping power requirement was selected. The amount of power required to pump water from the Yakima River into Wymer reservoir was computed using daily flow data from the Yak-RW model. The difference in pumping head was computed from the daily elevation of the water in the reservoir and the average elevation of the Yakima River at the pumping plant. Because the elevation of the water of the Yakima River at the pumping plant ranges from 1,275–1,284 feet, the average elevation used in the daily computations was 1,279.5 feet. The daily energy used was totaled, and an average computed for each month. The average monthly megawatt hours of pumping was then determined. From this, the average monthly pumping cost was computed by applying monthly pumping energy cost estimates forecast by the BPA in its August 2003 rate case. These reflect an average hourly rate for the respective month. Finally, an average annual pumping power requirement was computed.

Wymer Dam Plus Yakima River Pump Exchange Alternative

Energy use and power costs were calculated for pumping into Wymer reservoir as outlined above. Energy use and power costs for the exchange portion of this alternative were also calculated. These costs were based on the energy required to pump the water at all three pumping plants plus the energy needed for plant service needs. Volume to be pumped was determined from a schedule of deliveries derived for the proposed project to the Sunnyside and Roza Canals (Sonnichsen, 2007). The needs were calculated from historic daily data of canal diversions from 1980–2003. These values were averaged for each month. The head loss and pumping head were calculated using these average flows. The pumps were assumed to have a water-to-wire efficiency of 80 percent. The deliveries from pumping plant #3 would be by gravity and pump. It was assumed that the deliveries by pump would be up to the pump capacity. The flows above this were assumed to be delivered by gravity, which provides a conservative estimate of the energy requirements.

Once energy needs were calculated, average monthly pumping cost was computed by applying monthly pumping energy cost estimates forecast by the BPA in its August 2003 rate case. These reflect an average hourly rate for the respective month. Finally, an average annual pumping power requirement was computed.

4.4.2.2 No Action Alternative

There would be no construction or long-term impacts on hydropower generation under the No Action Alternative.

4.4.2.3 Black Rock Alternative

Construction Impacts

No construction-related impacts to hydropower resources are anticipated under this alternative.

Long-Term Impacts

Pumping Energy Requirements and Costs.—Table 4.12 presents monthly pumping power required in average megawatts (MWa) and estimated pumping costs for the Black Rock Alternative. The average monthly or annual power required for pumping to Black Rock reservoir is estimated at 132 MWa.

Table 4.12 Black Rock Alternative: pumping power required and costs

Month	Pumping power required (MWa)[1]
November	27
December	40
January	98
February	43
March	50
April 1–15	74
April 16–30	64
May	128
June	184
July	No pumping[2]
August 1–15	No pumping[2]
August 16–31	No pumping[2]
September	511
October	430
Average megawatts (MWa)	[3]132
Range of costs	$33 to $93 million
Average annual costs	$50 million

[1] The monthly power required represents the 18-year (1981–98) average for the respective month.

[2] Pursuant to the Columbia River Basin Water Management Program authorized by the State of Washington in 2006, the policy is that no withdrawal of water from the Columbia River will occur in July and August (unless appropriate mitigation is provided).

[3] Represents the 18-year (1981–1998) average computed by adding the monthly averages (using 69 megawatt-months for the split month of April) and dividing this sum of 1,580 megawatt-months by 12.

To arrive at monthly or annual average megawatts, it is necessary to add the monthly pumping loads as total megawatt-months over a year period and apportion the loads uniformly into each month by dividing by 12. Megawatt is a rate of power, whereas megawatt-hour and megawatt-month are amounts of power over a period of time. For the Black Rock Alternative, an average megawatt of 132 MWa represents (1) 132 MW over each hour for all 8,760 hours per year for a total of 1,156,320 MWh in one year or (2) 132 MW over each of the 12 months for a total of 1,580 megawatt-months in 1 year.

This 132 MWa represents a "flat" round-the-clock energy capability of a Powerplant, such as a combustion turbine or of a power purchase contract. In actual operations, this might operate between 0 in July–August and up to its full load nameplate capacity of perhaps 600 megawatts during certain hours in September to run the pumps as needed. The costs of this assumed 600-MW capacity and energy shaping for 132 MWa are not separately quantified. Capacity and energy costs are assumed to be within (1) the $/MWh unit power costs that are used in this Final PR/EIS and (2) FCRPS shaping flexibility to deliver varying amounts of energy to run the pumps.

Current Hydropower Generation.—Hydropower generation effects associated with Black Rock Alternative would occur at both Federal and non-Federal projects wherever the flows are altered due to: (1) pumping withdrawals from Priest Rapids forebay into Black Rock reservoir and (2) altered operations of FCRPS reservoirs upstream of Priest Rapids in reaction to power loss on the coordinated system due to Black Rock pumping or power gain due to return flows from Yakima River into McNary forebay. In HYDSIM's monthly simulation, the alterations of the operations of Grand Coulee and Libby Dams are minor due to modeling limitations. Also, Hungry Horse Dam operations do not change because Hungry Horse Dam has been at its operating limits; hence, there are no power impacts on downstream projects on the Clark Fork River basin. However, in actual operations, all FCRPS reservoir draft or fill, as well as the availability of water for pumping into Black Rock reservoir, are contemplated to be coordinated on a weekly basis at in-season management forums under the BiOp.

Hydropower Generation at Non-Federal Hydropower Projects.—Diversion of 3,500 cfs from Priest Rapids Lake for pumping to Black Rock reservoir would reduce generation at Priest Rapids Powerplant, on the average, by about 4 MWa, which is less than 1 percent annually. Power generation impacts at other non-Federal projects on the mid-Columbia River are power gains or losses. These power gains or losses are the result of the reoperation of the FCRPS and flow impacts at non-Federal projects, as explained in the preceding paragraph, as well as in section 4.4.2.1, "Methods and Assumptions." Table 4.13 presents the monthly difference in generation at non-Federal Columbia River hydropower projects and the estimated value of the difference.

Hydropower Generation at Federal Hydropower Projects.—Hydropower generation would change at Federal facilities upstream of Priest Rapids Dam and downstream from the Yakima River confluence. With Black Rock reservoir in operation, diversions from Priest Rapids Lake would diminish streamflow in the

62-mile reach from Priest Rapids Dam to the Yakima River confluence, where there are no Federal hydropower facilities. Streamflow depletions from Black Rock pumping would be somewhat offset by greater flows entering the Columbia River from the Yakima River as the result of using exchange water. On average, the FCRPS would lose approximately 5.4 MWa of annual average generation, as shown on table 4.13, at an annual value of $3 million.

Table 4.13 Monthly difference in non-Federal, Federal, and regional combined non-Federal and Federal Columbia River hydropower generation related to operation of the Black Rock Alternative (average MW or MWa)

Month	Priest Rapids only (MWa)	Non-Federal hydropower without Priest Rapids (MWa)	Non-Federal hydropower including Priest Rapids (MWa)	FCRPS (MWa)	Combined Federal and Non-Federal (MWa)[1]
October	-14.8	0	-14.8	-53.4	-68.2
November	-1.7	-3.2	-4.9	-5.7	-10.6
December	-0.8	+1.7	+0.9	+7.6	+8.5
January	-2.7	+0.9	-1.8	-5.5	-7.3
February	-1.2	+0.5	-0.7	-0.1	-0.8
March	-1.5	-0.1	-1.6	-1.9	-3.5
April 1–15	-2.0	+0.2	-1.8	+10.8	+9.0
April 16–30	-0.4	0	-0.4	+14.3	+13.9
May	-1.1	0	-1.1	+17.7	+16.6
June	-1.9	0	-1.9	+9.1	+7.3
July	0	0	0	+7.1	+7.1
August 1–15	-0.1	-2.0	-2.1	+1.1	-1.0
August 16–31	+0.4	+2.3	+2.7	+16.3	+19.0
September	-18.2	0	-18.2	-61.8	-80.0
Average change in energy (MWa)	-3.7	0	-3.7	-5.4	-9.2
Range of value	-$3 million to $1 million	near $0	-$5 million to +$1 million	-$17 million to +$8 million	-$21 million to +$9 million
Average annual value	-$2 million	near $0	-$2 million	-$3 million	-$4 million

[1] Due to rounding, these values do not equal precisely the sum of the previous columns.

Changes in the drawdown pattern in Franklin D. Roosevelt Lake would occur primarily in the fall and winter months; the greatest average monthly change in drawdown of less than 0.1 foot would occur in November.

New Hydropower Generation.—Two new powerplants would be constructed as a part of the Black Rock Alternative at the point of discharge of water from the Black Rock outflow conveyance system to the Roza Canal at MP 22.6 (Black Rock powerplant) and to the Sunnyside Canal at MP 3.83 (Sunnyside powerplant).

Each powerplant would consist of one turbine generator; the Black Rock powerplant would have a generating capability of 23 MW, and the Sunnyside powerplant would have a generating capability of 29.5 MW. Generation would occur during the Yakima Project irrigation season of April–October when water would be released from Black Rock reservoir to the two exchange participants.

Annual generation is estimated to total about 197,000 MWh (72,000 MWh at the Black Rock powerplant and 125,000 MWh at the Sunnyside powerplant).

4.4.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction-related impacts to hydropower resources are anticipated under this alternative.

Long-Term Impacts

Pumping power required, costs, and energy rates (October–May) are presented in table 4.14. The average monthly pumping power required ranges from 0 MWa in June–September to 9.7 MWa in March. The average pumping power required for the 25-year period of record (1981–2005) is 4.8 MWa. Average monthly pumping costs range from $0 in June–September to about $300,000 in March. Total average annual pumping costs are estimated at about $1.9 million, but these costs could be higher or lower if a new rates analysis is performed due to changes in market conditions (Reclamation, 2006a).

Table 4.14 Wymer Dam and Reservoir Alternative: pumping power required and average monthly pumping costs and energy rates

Month	Pumping power required (MWa)[1]	Average monthly pumping cost ($)	Average monthly energy rate ($/MWh)
October	4.6	190,000	55.56
November	5.3	220,000	58.16
December	5.7	240,000	56.32
January	7.0	245,000	47.27
February	8.4	285,000	50.63
March	9.7	300,000	42.14
April	8.3	220,000	37.60
May	8.5	200,000	31.92
Average power (MWa)	[2]4.8		
Average annual pumping cost		$1,900,000	

[1] The monthly power required represents the 25-year (1981–2005) average for the respective month.

[2] Represents the 25-year (1981–2005) average computed by adding the monthly averages and dividing this sum of 57.5 megawatt-months by 12.

4.4.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction-related impacts to hydropower resources are anticipated under this alternative.

Long-Term Impacts

In addition to the Wymer pumping power required, costs, and energy rates presented in table 4.14, the pumping power requirements, costs, and energy rates (March–October) are presented in table 4.15 for the Yakima River pump exchange component of the Wymer Dam Plus Yakima River Pump Exchange Alternative. The average monthly pumping power required ranges from 0 MWa in November–February to 110.7 MWa in June. The average annual pumping power required for the 23-year period of record (1981–2003)[7] is 56.6 MWa. Average monthly pumping costs range from $0 in November–February to about $3.3 million in August. Total average annual pumping costs are estimated at about $17.9 million, but these costs could be higher or lower if a new rates analysis is performed due to changes in market conditions (Reclamation 2006e).

Table 4.15 Yakima River pump exchange component of Wymer Dam Plus Yakima River Pump Exchange Alternative: pumping power required amd average monthly pumping costs and energy rates[1]

Month	Pumping power required (MWa)[2]	Average monthly pumping cost ($)	Average monthly energy rate ($/MWh)
March	19.9	624,000	42.16
April	80.4	2,177,000	37.60
May	109.3	2,595,000	31.92
June	110.7	1,808,000	22.68
July	110.5	2,650,000	32.24
August	110.3	3,341,000	40.69
September	99.4	3,125,000	43.64
October	38.6	1,595,000	55.56
Average power (MWa)	[3]56.6		
Average annual pumping cost		$17,915,000	

[1] Information obtained from table 18, Reclamation 2006e. Estimates of pumping energy required were in megawatt hours for the respective month and were converted to MWa to be consistent with tables 4.12 and 4.14.
[2] The monthly power required represents the 23-year (1981–2003) average for the respective month. March and October pumping occurs for 15 days of each of those months.
[3] Represents the 23-year (1981–2003) average computed by adding the monthly averages and dividing this sum of 679.1 megawatt-months by 12.

[7] 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 work in Reclamation 2006e is based on the 23-year period of record.

Table 4.16 presents the average power required and energy costs at each pumping plant under the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Table 4.16 Wymer Dam Plus Yakima River Pump Exchange Alternative: average pumping power required and annual energy costs

	Wymer Dam Plus Yakima River Pump Exchange Alternative	
	Average pumping power required (MWa)	**Average annual energy cost ($)**
Wymer pumping plant	4.8	1,900,000
Pumping plant #1	35.1	11,118,000
Pumping plant #2	17.3	5,444,000
Pumping plant #3	4.4	1,353,000
Total	61.6	$19,815,000

Source: Reclamation, 2006e.

4.4.2.6 Mitigation

No mitigation would be required.

4.4.2.7 Cumulative Impacts

As the FCRPS mitigation projects on the mainstem Columbia River and Biological Opinion continue to be implemented, hydropower generation in the FCRPS will continue to be reduced. Coupled with the Black Rock Alternative, there could be additional loss of power generation in the FCRPS.

In the *Final Supplemental Environmental Impact Statement for the Lake Roosevelt Incremental Storage Releases Program,* section 4.2.2.12, "Public Services and Utilities," indicates that there would be a net reduction in total hydropower generation in April–October as a result of that project. The estimated reduction is less than 0.1 percent of the total estimated generation during that period. Consequently, this activity would have little cumulative effect on hydropower generation.

4.5 Sediment Resources

Sediment transport investigations in a river basin serve two purposes:

- To improve understanding of aquatic resources important in defining habitat suitability for fish
- To provide potential scenarios of future channel change

Changes in basin hydrology and the construction of roads, bridges, levees, and other structures within flood plains alter the transport of sediment within the basin. Future changes in hydrology likely would affect sediment transport and, therefore, aquatic habitat conditions, because of linkages and dependencies among system processes and components (figure 4.10).

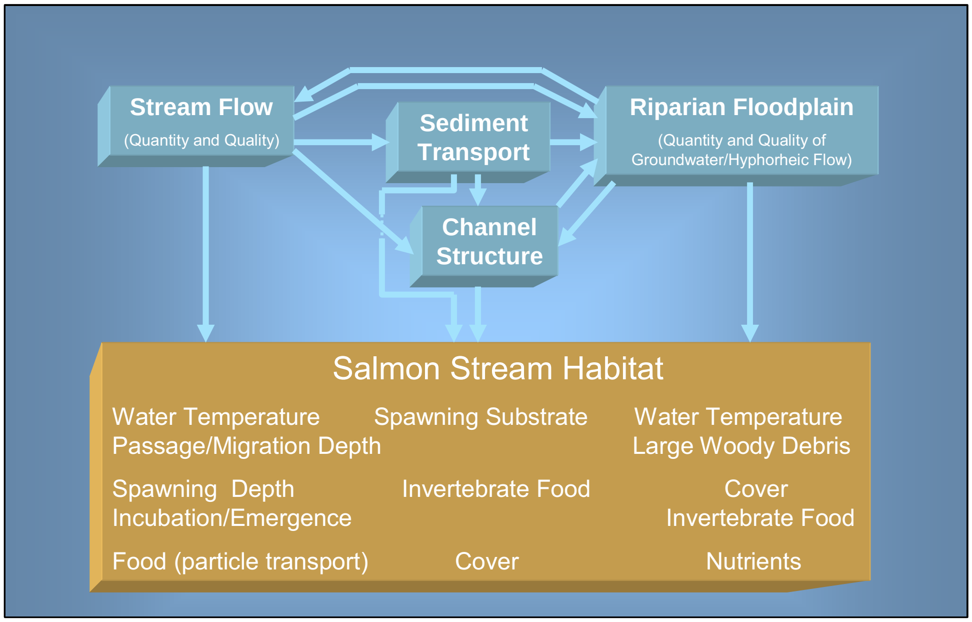

Figure 4.10 Streamflow and sediment transport attributes that define the quality of salmon stream habitat.

4.5.1 Affected Environment

It was assumed that any effects of the Joint Alternatives would occur within the Yakima River basin and that any potential effects to sediment from water withdrawal from the Columbia River would be nondetectable and/or nonmeasurable within the Columbia River due to the size of the withdrawal relative to riverflow; thus, sediment resources in the Columbia River were not evaluated.

The western part of the Yakima River basin is mountainous and formed by sedimentary, volcanic, and metamorphic rock; the eastern portion of the basin is comprised of a thick sequence of lava flows that have folded into ridges and troughs (Kinnison and Sceva, 1963). This type of geology has an important impact on sediment transport, as the river flows from alluvial valleys through bedrock canyons and gaps. It has been stated that the Yakima River has a low sediment discharge for a river of its size (Dunne and Leopold, 1978), which might be attributed to the lack of available sediment in the canyon reaches and bedrock control at many locations. More recently, intensive flow regulation and levee construction have affected the transport of sediment and channel morphology since the early part of the 20^{th} century.

Yakima River flood plains were also likely historically important in providing habitat resources for anadromous salmonids and resident fish (Snyder and Stanford, 2001), but are now degraded (Stanford et al., 2002). Key fluvial processes include erosion and deposition of sediments and channel movement. These processes shape the flood plain and result in a continual shifting mosaic of physical channel attributes that either provide habitat resources directly or support habitat resources for fish and other aquatic organisms (figure 4.10). Maintaining this shifting mosaic is dependent on the ability of the river to move freely about the historic flood plain and on the balance between channel movement and sediment erosion and deposition. Native aquatic species have evolved to these historical fluvial processes, and their alteration is likely to have adverse effects on one or more life stages of salmonids. Fluvial processes also are dependent on a sufficient sediment supply needed to build new bars and islands and to prevent channel incision that would disconnect important groundwater-surface water interactions (Stanford et al., 2002).

4.5.2 Environmental Consequences

Changes in sediment transport and bed scour are related to the changes in the flow regime. Those alternatives that would significantly increase flows in particular reaches could change the sediment transport locally. Because the most significant changes in flow occur downstream from the Parker gage, the reaches that would be most affected are in that area. Changes in operations would affect bed scour, particularly in the upper portions of the Yakima River; however, these changes generally are not biologically significant, even in years with the highest scour values.

4.5.2.1 Methods and Assumptions

Several methods were used to evaluate sediment resources, as discussed in the following sections. The indicators of sediment transport and bed scour were selected to evaluate sediment resources.

Sediment Transport

The analysis of sediment transport was performed using techniques from the model, Sediment Impact Analysis Methods (SIAM). SIAM simulates the movement of sediment through a drainage network to estimate the effect of sediment dynamics on channel morphology. Using principles of sediment continuity and channel response, SIAM links basinwide processes to perform a trend analysis on a river system identifying the current state as well as the direction of potential adjustments in both the short and long term. The model was developed to accommodate large basins, incorporate sediment sources, and prescribe rehabilitation alternatives using a system perspective. More information about SIAM can be found at http://www.usbr.gov/pmts/sediment/model/srhsiam/index.html. This analysis assumed equilibrium conditions where inflowing load restocked any transported material; therefore, long-term changes could not be detected. A lack of calibration and verification data for high-flow hydraulics and the reference shear stresses results in high levels of uncertainty for interpreting results quantitatively (i.e., actual tons in the river). However, the underlying assumptions are unlikely to change significantly between reaches or between alternatives for the same reach. The analysis can provide a relative sense of the impact from changes in discharge.

Results are only for those reaches modeled, not the entire basin. The reaches modeled for sediment are the same as those modeled for one-dimensional (1-D) hydraulics, as the 1-D hydraulic model provided the geometric input to the sediment model (Reclamation, 2007b).

Hydraulic Engineering Center-River Analysis System (HEC-RAS) is a 1-D hydraulic model intended for calculating water surface profiles for steady, gradually varied, and unsteady flow conditions. More information about HEC-RAS can be found at http://www.hec.usace.army.mil/software/hec-ras/hecras-document.html.

The modeling performed for this assessment used a steady flow analysis over a wide range of discharges to evaluate flow depth, top width, and cross-section averaged-values of velocity. The primary purpose of the HEC-RAS modeling effort was to provide input to the decision support system (DSS), SIAM, and temperature models. The HEC-RAS output was also used as input for some of the attributes for the Ecosystem Diagnosis and Treatment (EDT) biological model.

Bed Scour

Female anadromous salmonids generally bury their eggs beneath the channel bed to a depth of about 6–8 inches (15–20 centimeters [cm]); smaller resident and anadromous trout bury their eggs to a depth of 2–4 inches (5–10 cm) (DeVries, 1997; Montgomery et al., 1996). SIAM provides estimates of mean annual bed scour using the monthly time step provided by the Yak-RW model. While this value provides some information regarding bed scour, it is more critical to understand bed scour on a daily time step during periods of incubation. For this reason, bed scour as it relates to the disruption of redds was investigated using a decision support system model. The DSS model takes daily values of streamflow and sediment transport capacity for a given discharge, determined by SIAM, to arrive at a daily value of bed scour.

The DSS model estimates the amount of habitat available for various species and life stages. Habitat is measured for the various species and life stages. Flow depth, velocity, and substrate also factored into estimates of spawning habitat. For this study, it was used to estimate the quantity of habitat specific to spring and fall Chinook, coho, steelhead, bull trout, and resident rainbow trout for the adult holding, spawning/incubation, fry, summer rearing, and winter rearing lifestages in the Easton, Ellensburg, Union Gap, Wapato, and lower Naches River reaches. The following input was required for this component of the DSS model to function: (1) the estimated daily average streamflow for each alternative for each of the five reaches, (2) two-dimensional hydraulic flow models that "map" flow depth and velocity through each reach at each flow of interest, and (3) the relationship between flow depth and velocity and habitat for each species and lifestage.

4.5.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Because sand-sized and smaller particles can have an adverse effect on salmonid habitat, their widespread deposition in a river system is of concern. Model results indicate that the capacity of the Yakima River to transport sand would not change under the No Action Alternative and would not decrease under the other alternatives. Sand transport under this and the other Joint Alternatives would have no net negative effect on habitat or morphology, because significant deposition is not expected. Effects on channel morphology and, therefore, habitat are much more affected by gravel transport in the Yakima River. Morphologic activity of the recent past is expected to continue under the No Action Alternative. That is to say, significant morphologic change or change to habitat is only likely to occur during very large flood events and would be localized. No widespread effect on channel morphology or habitat is anticipated under the No Action Alternative.

Table 4.17 presents model results for percent differences in average gravel load, by Yakima River reach, between each Joint Alternative and the No Action Alternative.

The maximum bed scour estimated for the egg incubation period for steelhead, salmon, and rainbow trout in the Easton, Ellensburg, Wapato, and lower Naches River reaches of the Yakima River for all alternatives is shown in table 4.18.

These are the largest values for the 25-year period of record. Overall, there is little difference in potential maximum bed scour among the alternatives for all the species for the four reaches. With the exception of the lower Naches River reach, the risk of potential egg scour is minimal for salmonids (table 4.18).

Table 4.17 Percent differences in average annual gravel load, by Yakima River reach, between each Joint Alternative and No Action Alternative (negative values indicate a decrease in the modeled load) (modified from Mooney, 2007)

Yakima River reach	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Easton	10	2	-4.1
Upstream of Ellensburg	25	0	5
Ellensburg	4.1	-1.4	4.1
Lower Naches River	2	0	3
Union Gap	14	-7	6
Wapato Dam to Sunnyside Diversion Dam	6	-7	-2
Wapato	21	-6	18
Upstream of Prosser Diversion Dam	29	-6	24
Downstream from Prosser Diversion Dam	12	4	7

Table 4.18 Maximum annual bed scour in inches and centimeters during the egg incubation period for steelhead, salmon, and rainbow trout for the Easton, Ellensburg, Wapato, and lower Naches River reaches of the Yakima River

Species	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange
Easton				
Steelhead	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)	2.5 in (6.4 cm)
Spring Chinook	2.5 in (6.4 cm)	7.6 in (19.2 cm)	3.8 in (9.6 cm)	5.0 in (12.8 cm)
Coho	2.5 in (6.4 cm)	3.8 in (9.6 cm)	3.8 in (9.6 cm)	3.8 in (9.6 cm)
Rainbow trout	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)	2.5 in (6.4 cm)
Ellensburg				
Steelhead	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)
Spring Chinook	2.5 in (6.4 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)
Coho	2.5 in (6.4 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)
Rainbow trout	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)	1.3 in (3.2 cm)
Wapato				
Fall Chinook	2.5 in (6.4 cm)	1.3 in (3.2 cm)	2.5 in (6.4 cm)	2.5 in (6.4 cm)
Coho	1.3 in (3.2 cm)	1.3 in (3.2 cm)	2.5 in (6.4 cm)	1.3 in (3.2 cm)
Lower Naches River				
Steelhead	55.1 in (140 cm)	53.9 in (137 cm)	57.5 in (146 cm)	55.1 in (140 cm)
Coho	24.0 in (61 cm)	24.0 in (61 cm)	24.0 in (61 cm)	24.0 in (61 cm)
Rainbow trout	49.2 in (125 cm)	46.9 in (119 cm)	51.6 in (131 cm)	49.2 in (125 cm)

4.5.2.3 Black Rock Alternative

Construction Impacts

No construction-related impacts to sediment resources are anticipated under this alternative.

Long-Term Impacts

The Yakima River from Prosser Diversion Dam (RM 47) to approximately Toppenish Creek (RM 80) currently has the lowest sediment transport rate in the Yakima River (the reach upstream of Prosser Diversion Dam and portions of the Wapato reach in table 4.17), primarily because the Columbia River Basalt formation rises to the surface and exerts a control on the river, and to a lesser extent, Prosser Diversion Dam. These reaches of the Yakima River indicate the greatest likelihood of morphologic change under the Black Rock Alternative, as sediment transport would be greater under this alternative than under the No Action Alternative. Morphologic change is expected to improve habitat conditions, as there would be increased habitat diversity that may continue to change over time. Although morphologic change in this reach may benefit habitat, channel migration has the potential to affect properties adjacent to the river. A more detailed analysis would be required to understand the magnitude of channel change in this reach.

Model results for the Wapato reach also show greater gravel transport under the Black Rock Alternative than under the No Action Alternative (table 4.17). Anticipated effects on this reach may consist of greater split channel morphology throughout much of the reach, which would represent an improvement to habitat. Much of the flood plain in this reach is low relative to the main channel, indicating greater flood plain-channel interaction with increased discharges. Channel migration in this reach is of less concern, as much of the flood plain is not developed or under cultivation.

Model results for the Union Gap reach indicate slightly greater gravel loads (table 4.17) under the Black Rock Alternative than under the No Action Alternative. Greater gravel transport through this reach may provide some benefit to surrounding infrastructure near Union Gap, as recent aggradation (accumulation of sediment) has caused the channel to migrate in this location and threaten roadways. Greater gravel transport at Union Gap is dependent on the level of control exerted on the river by Wapato Dam and the gap itself. This level of analysis has not been performed.

Model results for the reach upstream of Ellensburg indicate a 25-percent greater average annual gravel load under this alternative (table 4.17) than under the No Action Alternative. Gravel transport in this reach is very low compared to other reaches and may be attributed to increased sediment sizes related to channel confinement throughout much of the reach. Additionally, irrigation diversions may limit the transport of sediment from upstream reaches to this reach. The greater sediment transport is not expected to affect morphology, as transport rates are expected to remain low in spite of the 25-percent increase. However, a more frequent disruption of the armor layer would be of some benefit to habitat.

Compared to the No Action Alternative, no consequential effects on maximum annual bed scour are expected under the Black Rock Alternative (table 4.18). Though model results show the bed scour value in the Easton reach for spring Chinook increases from 2.5–7.6 inches (6.4–19.2 cm), which is within the egg pocket depth for anadromous salmon, this level of bed scour only occurs once in the 25-year period of record. In all other years, the change in scour is not enough to reach the egg pocket depth.

4.5.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction-related impacts to sediment resources are anticipated under this alternative.

Long-Term Impacts

Model results indicate slightly less sand transport throughout most of the river under the Wymer Dam and Reservoir Alternative than under the No Action Alternative. The minor difference indicated (generally less than 5 percent) would have no effect on the habitat and morphology in the Yakima River basin with respect to aggradation of sand. Model results for gravel loads also indicate no significant change in gravel transport rates. Thus, this alternative is not expected to significantly affect the morphology or habitat with respect to sediment transport compared to the No Action Alternative.

Compared to the No Action Alternative, no consequential changes to maximum annual bed scour are expected under the Wymer Dam and Reservoir Alternative.

4.5.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction-related impacts to sediment resources are anticipated under this alternative.

Long-Term Impacts

This alternative would have similar effects on habitat and morphologic change as the Black Rock Alternative. For the Wapato reach and the reach upstream of Prosser Diversion Dam, the increase in gravel transport loads (table 4.17) under the Wymer Dam Plus Yakima River Pump Exchange Alternative is slightly less than under the Black Rock Alternative, indicating that similar changes are likely to occur, although they may progress more slowly. No significant changes are indicated in other reaches.

Compared to the No Action Alternative, no consequential changes to maximum annual bed scour are expected.

4.5.2.6 Mitigation

No mitigation would be required.

4.5.2.7 Cumulative Impacts

Other ongoing or proposed projects in the basin would have little significant effect on seasonal or annual discharge in the basin. None of the actions predicted to occur in the reasonably foreseeable future would involve reconnecting significant portions of the flood plain to the river channel where disconnection has occurred. As a result, there would be little additional effects on sediment transport or bed scour.

4.6 Water Quality

4.6.1 Affected Environment

Surface water quality could be affected in the Columbia and Yakima Rivers, where additional storage and changes in streamflow may occur. Under two of the proposed alternatives, Black Rock and Wymer Dam Plus Yakima River Pump Exchange, water would be withdrawn from the Columbia River. The surface water quality parameters discussed in this section are limited to those parameters that appear to be of most concern and potentially would be affected under the Joint Alternatives. These parameters are either physical or chemical in nature. Physical parameters of interest include: temperature, dissolved oxygen (DO), and turbidity. Chemical parameters of interest include nutrients (such as nitrates-nitrites and total phosphorus [P]), total suspended solids (TSS), and toxins such as pesticides or Hanford Site contaminants (Reclamation, 2007e). A brief discussion of each of these parameters and a summary of the general levels that exist for each of the reaches follows.

4.6.1.1 Columbia River

The area of interest is a portion of the mid-Columbia River extending from Vantage, Washington, to the confluence of the Columbia and Yakima Rivers near Pasco, Washington. Temperature was one of the water quality parameters of interest, because Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives would remove water from the Columbia River, which could affect temperatures. Other parameters of interest with respect to the Columbia River are the contaminants found in the surface water and groundwater at the Hanford Site. Because increased seepage from the Hanford Site to the Columbia River could occur under the Black Rock Alternative, these contaminants were considered.

Temperature

The Columbia River is on the Washington State list of impaired water bodies (i.e., "303(d) list") for temperature (Ecology, 2007b). Historical data retrieved from the Rock Island Dam for 1933–97 show that daily temperatures for August and September, the warmest months of the year, were above 64.4 °F (18 °C) 58 percent and 43 percent of the time, respectively. Monitoring for 1997–2000 at fixed monitoring sites shows that the State temperature numeric criteria standards were exceeded during the warm months of the year.

Ecology is planning to implement a temperature total maximum daily load (TMDL) for the Columbia River in the near future, which is anticipated to improve conditions.

Hanford Site Contaminants

Hanford Site pollutants, both radiological and chemical, enter the Columbia River along the Hanford reach. Effluent from each direct discharge point is monitored routinely (Pacific Northwest National Laboratory [PNNL], 2006). Potential sources of pollutants *not* associated with the Hanford Site include pollutants in irrigation return water and groundwater seepage associated with irrigation north and east of the Columbia River and industrial, agricultural, and mining effluent introduced upstream of the Hanford Site (PNNL, 2006).

Surface Water

In 2005, Columbia River water samples were collected from fixed-location monitoring stations at Priest Rapids Dam and Richland, Washington, and from cross-river transects and near-shore locations near the Vernita Bridge, 100-N Area, 100-F Area, Hanford town site, 300 Area, and the city of Richland, Washington (PNNL, 2006). (See figure 4.11.) A number of the parameters measured have no regulatory limits; however, they are useful as indicators of water quality and contaminants of Hanford Site origin. Results of the water samples collected at Priest Rapids Dam and Richland in 2005 show that radionuclide concentrations were low throughout the year. Tritium, strontium-90, iodine-129, uranium-234, uranium-238, plutonium-239/240, and naturally occurring beryllium-7 and potassium-40 were consistently measured at levels above the reported minimum detectable concentrations but below the Washington State ambient surface water quality criteria, EPA drinking water standards, or the Ecology-derived concentration guide (PNNL, 2006). Concentrations of all other radionuclides were typically below the minimum detectable concentrations. Tritium, strontium-90, iodine-129, and plutonium-239/240 exist in worldwide fallout from historical nuclear weapons testing, as well as in effluent from Hanford Site facilities. Tritium and uranium occur naturally in the environment, in addition to being present in Hanford Site effluent.

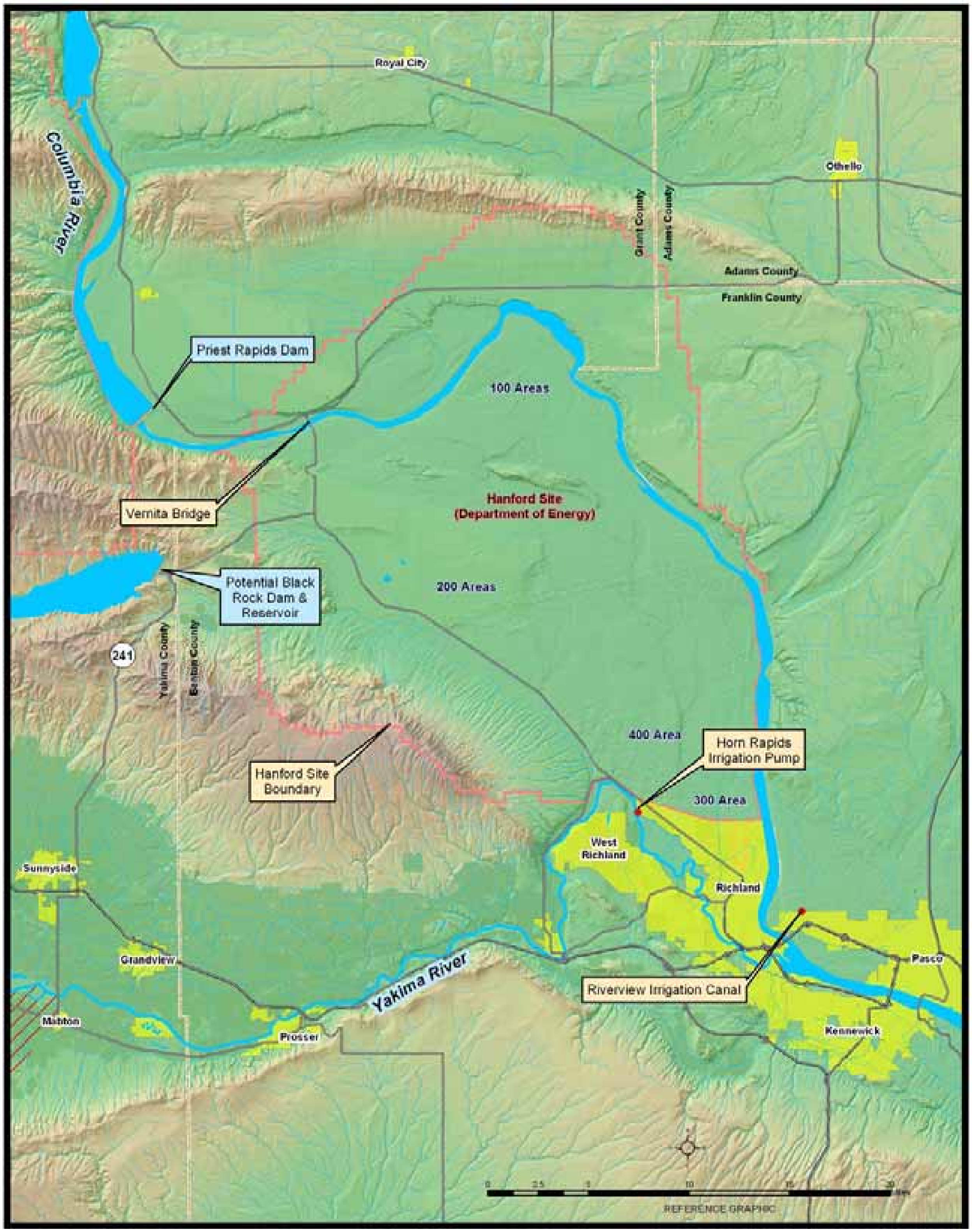

Figure 4.11 Locations of Columbia River water sampling.

Contaminants of Hanford Site origin continued to be detected in water from shoreline springs entering the Columbia River along the Hanford Site in 2005. Tritium, strontium-90, technetium-99, iodine-129 (2005 data pending), uranium-234, uranium-235, and uranium-238 were detected in spring water. All radiological contaminant concentrations measured in shoreline springs in 2005 were less than applicable DOE-derived concentration guides. Metals and anions (chloride, fluoride, nitrate, and sulfate) were detected in spring water. The concentrations of most metals measured in water collected from springs along the Hanford Site shoreline during 2003–05 were below Washington State ambient surface water chronic toxicity levels (Ecology, 2006a). Concentrations of volatile organic compounds were near or below their detection limits in all samples. Chemicals measured with detected concentrations were nitrate and dissolved chromium. Nitrate concentrations at all spring water locations were in compliance with the Federal drinking water standard. Concentrations of dissolved chromium at the shoreline springs were above the Washington State ambient surface water chronic toxicity level and above the acute toxicity level for the same area (PNNL, 2006).

Several metals and anions were detected in Columbia River transect samples both upstream of and downstream from the Hanford Site in the 2005 samples. The concentrations of metals and anions observed in river water in 2005 were similar to those observed in the past. Arsenic, antimony, cadmium, copper, lead, mercury, nickel, and zinc were detected in the majority of samples, with similar levels at most locations. Beryllium, cadmium, chromium, lead, selenium, silver, and thallium were detected occasionally. All metal and anion concentrations in river water were less than the Washington State ambient surface water quality criteria for the protection of aquatic life, with the exception of arsenic concentrations, which exceeded the EPA standard for the protection of human health for the consumption of water and organisms (PNNL, 2006).

Sediment

As a result of past operations at the Hanford Site, large amounts of radioactive and nonradioactive materials were discharged to the Columbia River. Upon release to the Columbia River, some of these materials were deposited on the riverbed as sediment, particularly in reservoir pools downstream from the Hanford Site. The concentrations of the radioactive materials decreased as they underwent radioactive decay. Fluctuations in the riverflow, as a result of the operation of upriver hydroelectric dams, annual spring high riverflows, and occasional floods have resulted in the resuspension, relocation, and subsequent redeposition of the sediment. Upper layer sediment in the Columbia River contains low concentrations of radionuclides and metals of Hanford Site origin, as well as radionuclides from nuclear weapons testing fallout, along with metals and other nonradioactive contaminants from mining and agricultural activities. Radionuclides consistently detected in river sediment adjacent to and downstream from the Hanford Site in 2005 included potassium-40, strontium-90, cesium-137, uranium-238, plutonium-238, and plutonium-239/240. The concentrations of all other radionuclides were below the reported minimum detectable concentrations for most samples (PNNL, 2006).

Detectable amounts of most metals were found in all river sediment samples. Maximum and median concentrations of most metals were higher for sediment collected in the reservoir upstream of Priest Rapids Dam compared to either the Hanford Site or McNary Dam sediment. The concentrations of cadmium, mercury, and zinc had the greatest differences between locations. Currently, there are no Washington State freshwater sediment quality criteria for comparison to the measured values (PNNL, 2006).

Groundwater

Current groundwater quality conditions on the Hanford Site are mainly the result of the production of plutonium. For this reason, groundwater is monitored throughout the entire Hanford Site, especially in areas where contaminants were stored. The 100, 200, and 300 Areas located on the Hanford Site have ongoing extensive monitoring of groundwater. These areas are contaminated with tritium, strontium-90, nitrate, chromium, trichloroethene, sulfate, technetium-99, uranium, and iodine-99. The 400 Area is the Hanford Site water supply and is contaminated with a tritium plume, although the supply is in compliance with drinking water standards (PNNL, 2006).

Contaminant plumes with concentrations above drinking water standards were present on about 12 percent of the Hanford Site in 2006 (PNNL, 2006). The tritium and iodine-129 plumes have the largest areas. The dominant plumes had sources in the 200-East Area and extend toward the east and southeast. Tritium and iodine-129 plumes are also present in the 200-West Area. Technetium-99 plumes are present in the 200-East and 200-West Areas. One technetium-99 plume has moved northward from the 200-East Area. Uranium plumes are found in the 100-H, 200-East, 200-West, and 300 Areas. Strontium-90 concentrations exceed the drinking water standard in the 100 Areas (except the 100-D Area), the 200-East Area, and beneath the former Gable Mountain Pond. Other radionuclides, including cesium-137, cobalt-60, and plutonium, exceed drinking water standards in a few wells.

Certain contaminants, which are found only in specific areas of the site, are hexavalent chromium, carbon-14, petroleum hydrocarbons, plutonium, carbon tetrachloride, ranium, chloroform, cis-1, 2 dichloroethene, tributyl phosphate, fluoride, cesium-137, cobalt-60, cyanide, calcium, sodium, chemical oxygen demand, chlorine, coliform bacteria, and low pH (PNNL, 2006). Many of these contaminants form plumes throughout the site, while many of the same contaminants exceed drinking water standards (PNNL, 2006).

Nitrate is a widespread chemical contaminant in Hanford Site groundwater. Plumes originated from the 100 and 200 Areas and from offsite industry and agriculture. Carbon tetrachloride forms a large plume beneath the 200-West Area. Trichloroethene plumes are found in the 100-F and 200-West Areas. New wells in the 300 Area detected trichloroethene at levels above the drinking water standard at depth in the aquifer. Chromium exceeds the 100-micrograms-per-liter (μg/L) drinking water standard in parts of the 100-K and 100-D Areas. Chromium exceeds the State's aquatic standard (10 μg/L) in these areas and parts of the 100-B/C, 100-H, and 100-F Areas. Local plumes of chromium are also present in the 200 Areas, particularly the north part of the 200-West Area.

Drinking water located on the Hanford Site has ongoing extensive monitoring similar to that done for groundwater. All 11 DOE-owned drinking water systems on the Hanford Site were in compliance with drinking water standards for radiological, chemical, and microbiological contaminant levels in 2005 (10 of the 11 systems use water from the Columbia River, and 1 system in the 400 Area uses groundwater from the unconfined aquifer beneath the site). Contaminant concentrations measured in 2005 were similar to those observed in recent years (PNNL, 2006).

The Columbia River is the primary source of the city of Richland's drinking water. The city of Richland also monitors its water for radiological and chemical contaminants, and for general water quality.

4.6.1.2 Yakima River

The Yakima River basin was separated into the upper and lower reaches to analyze water quality. The upper and lower Yakima River basins are separated by the Yakima River Canyon, approximately 20 miles of arid shrub-steppe and steep basalt canyon lying approximately north-south between the Kittitas and Yakima Valleys (Ecology, 2002a; Ecology 2006a). The upper reach extends from RM 214.5 at the Keechelus gage to RM 140.4 at the Umtanum gage. The lower reach extends from RM 140.4 at the Umtanum gage to the mouth of the Yakima River at RM 0.

Water quality in headwater streams and the upper Yakima River is good but degrades downstream to the mouth. This degradation is caused both by natural processes and by the impacts from human activities, including both point and nonpoint sources (Reclamation, 1999).

Water quality parameter values indicate that current surface water quality standards for water temperature, DO, pH, turbidity, ammonia, dichlorodiphenyl-trichloroethane (DDT), and other pesticides, as well as fecal coliform bacteria, are not met on the mainstem and some tributaries of the upper and lower Yakima River basin at various times. These contaminants are listed along with their impaired water body or water bodies on the 2002–2004 303(d) list (Johnson, 2007; Coffin et al., 2006). In addition, phosphorus concentrations have been detected on occasion at levels of concern relative to effects on aquatic life.

The highest concentrations of turbidity, nutrients, bacteria, and pesticides occur in agricultural drains rather than in the mainstem or natural tributaries and, therefore, cause degradation in the water quality of the Yakima River downstream from the drain discharge points (Reclamation, 1999).

The parameters analyzed for this study that may be affected are temperature, DO, turbidity/suspended sediments, and the nutrients phosphorus and nitrogen.

Temperature

The primary factors that control the mainstem water temperatures are streamflow (river morphology and slope); air temperature; rate of vertical mixing; time of travel; and the temperature of inflowing water from natural tributaries (including groundwater discharge), canals, wasteways, and agricultural drains. Water in the upper basin is cold but warms as the river flows to the lower basin. As water flows through the stream reaches with a high rate of vertical mixing, the water temperature quickly equilibrates near air temperature. The temperature of slow-moving water in shallow reaches increases because of the long exposure time to the sun, particularly where shading riparian vegetation is missing. Fast-flowing water in deep channels with minimal roughness, such as in canals, increases temperature the least. In the lower portion of the basin, the mainstem temperatures in the late summer tend to be similar to the temperatures of the agricultural return flows because a high percentage of riverflows in the late summer is return flows from agriculture (Reclamation, 1999).

Many of the tributaries and the mainstem Yakima River are currently listed on the 2002–04 Washington State 303(d) list for temperature impairment (Ecology, 2007c). Temperature concerns in the Yakima River basin focus on the protection of aquatic life; Ecology has implemented TMDLs for the mainstem of the river as well as for some of its tributaries.

Dissolved Oxygen

In the lower Yakima River, few locations downstream from Prosser Diversion Dam failed to meet the DO criteria of 8 milligrams per liter (mg/L) during USGS's July 1987 synoptic sampling. A value of 7.5 mg/L was measured at the Yakima River near Van Geisen Bridge (Richland, Washington) near sunrise, when DO levels are usually at their minimum. Review of 1986–91 data showed the mainstem Yakima River at Kiona also did not meet the DO criteria. USGS noted that the effects of agricultural return flow, urban runoff, and point source discharges are noticeable in the lower Yakima Valley, where most of the low DO levels were measured (Morace et al., 1999).

Turbidity/Suspended Sediment

Comprehensive water quality monitoring studies of the Yakima River basin were conducted in the mid- to late-1970s (Ecology, 1979) with several studies evaluating sediment loading in various parts of the basin (CH2M Hill, 1975;

Boucher, 1975; Soil Conservation Service, 1978; U.S. Army Corps of Engineers, 1978; Nelson, 1979; Boucher and Fretwell, 1982). Much of the work indicated that irrigation practices directly affected suspended sediment concentrations and turbidity in the lower Yakima River and return drains from March–October (Coffin et al., 2006). The 2003 TMDL targets called for a 90th-percentile turbidity limit of 25 nephelometric turbidity units (NTU) at the mouths of all irrigation drains within the Storage Study area. The turbidity limit was set to correspondingly limit the suspended sediment concentration to 56 mg/L, as based on the prior TSS/turbidity correlation. Both values were considered moderately protective of aquatic communities according to literature at the time (Joy and Patterson, 1997). Of the nine monitoring sites for turbidity, five are on the mainstem Yakima River and four are major irrigation return flows; only one (Granger Drain) did not meet the fifth-year (2003) goal of a 90th-percentile turbidity of 25 NTU or less during the entire sampling period (April–October). Two of the four major tributaries, Moxee Drain and Granger Drain, did not meet the TSS concentration goal of 56 mg/L; however, sediment loads still have been reduced in each of these tributaries by approximately 60 and 85 percent, respectively (Coffin et al., 2006). Although turbidity levels are decreasing, values still remain above State standard criteria.

Implementation of Best Management Practices by the irrigation districts and on-farm practices, as well as the TMDL process initiated by Ecology have resulted in significant improvements to the turbidity and suspended sediment/solid concentrations throughout the basin. With continued efforts to keep improving water quality in the drains and wasteways, the Yakima River should experience even further improvements.

Toxins

Pesticides (DDT and its metabolites, endosulphan, dieldrin, and others, as well as polychlorinated bi-phenols [PCB] 1260) are widespread low-level contaminants that have been observed in water and sediment samples in the Yakima River system. The concentrations of dieldrin and DDT compounds apparently have been decreasing (USGS, 1991) since the early 1970s because of the EPA ban on using DDT in 1972 and the ban on producing dieldrin in 1974. However, these pesticides still show up in the drains and, subsequently, in the Yakima River because of the residuals that exist in the irrigated soils in the basin. These compounds tend to adsorb to soils; subsequently, the sediment that is eroded from the agricultural fields is carried by the irrigation return flow water to the Yakima River. DDT originally was deposited in the irrigated soils decades ago when it was commonly used in agriculture. Recent water quality data have shown that the greatest concentrations of DDT and dieldrin have occurred at sites that also have the largest suspended sediment concentrations. This relation suggests that reducing suspended sediment concentrations in the drains would result in reduced concentrations of DDT and other pesticides in the Yakima River (Reclamation, 1999). TMDL effectiveness monitoring conducted by Ecology in

2003 showed that turbidity has been reduced dramatically (Johnson, 2007). USGS has reported a corresponding decrease in total DDT levels in water samples from 1992 compared to 2000 (Fuhrer et al., 2004; Johnson, 2007). For example, in the Moxee Drain, maximum concentrations of suspended sediment decreased sharply from more than 600 mg/L in 1988–89 to about 200 mg/L in 1999–2000. The Granger Drain had similar results; the total DDT concentration for a given concentration of suspended sediment decreased by a factor of 3 or more from 1988–89 to 1999–2000 (Fuhrer et al., 2004).

Phosphorus and Nitrogen

Nutrient (phosphorus and nitrogen) concentrations are conducive to eutrophication in the lower Yakima River. Eutrophication is the process by which a body of water becomes enriched in dissolved nutrients that stimulate the growth of aquatic plant life, usually resulting in the depletion of DO. Activities upstream of Prosser Diversion Dam, municipal effluent, runoff from agriculture and urban sources, and storm runoff affect nutrient loading. Although these concentrations are adequate to support aquatic growth, turbidity may inhibit the sunlight penetration necessary for that growth. If the turbidity were to decrease, eutrophication of the lower Yakima River would occur and result in unacceptable levels of DO, pH, and aquatic growth (Morace et al., 1999).

Washington State has not established criteria for phosphorus or nitrates within river systems; however, literature values for the prevention of eutrophication indicate total phosphates as phosphorus should not exceed 100 µg/L in any river system; 50 µg/L in any stream at the point where it enters any lake, reservoir, or other standing water body; or 25 µg/L within the lake, reservoir, or other standing water body. EPA water quality criteria for 1986 concur with literature values. EPA has established a maximum contaminant level of 10,000 µg/L for nitrates in drinking water (EPA, 1986a).

During irrigation season, most of the water in the lower Yakima River is agricultural return flow. Concentrations of nutrients (phosphorus and nitrogen) in the river reflect the influx of agricultural chemicals. In August 1999, concentrations of total phosphorus in the Yakima River increased from 10 µg/L in the headwaters near Cle Elum to 140 µg/L near the mouth at Kiona. The concentrations of phosphorus in 71 percent of the irrigation-season samples and 80 percent of the nonirrigation-season samples exceeded the EPA desired goal of 100 µg/L to prevent nuisance growth of plants in aquatic systems. Also, 13 percent of the nonirrigation-season concentrations of nitrate exceeded 10,000 µg/L, which is the EPA drinking water standard (Fuhrer et al., 2004).

4.6.2 Environmental Consequences

4.6.2.1 Methods and Assumptions

Washington State-approved water quality standards were used to assess the status of the Columbia and Yakima Rivers and the effects each alternative would have on the water quality.

Effects of the Joint Alternatives were analyzed using data obtained through literature reviews, professional judgment, ongoing monitoring, and models created by Ecology, USGS, and Reclamation, as discussed below. The indicators of temperature, DO, nutrients, total suspended solids, and toxins were selected to evaluate water quality.

Reclamation conducted an assessment of the potential effects the Black Rock pumping plant at Priest Rapids Dam would have on water temperature using the U.S. Army Corps of Engineer's CE-QUAL-W2 model and the Stream Segment Temperature (SSTEMP) model. Both models have substantial limitations with respect to their use for the Storage Study, but no other models were available. The results from both were similar with respect to temperature and suggested that building a separate model for this study was not warranted (USGS, 2008).

CE-QUAL-W2 is a water quality and hydrodynamic model that models in two dimensions, longitudinally and vertically. It can be used for rivers, estuaries, lakes, reservoirs, and river basin systems. It can be used in both stratified and nonstratified systems, and it can model a variety of water quality parameters including temperature. Its primary limitation with respect to its use for the Storage Study is its inability to model lateral reservoir variations. The laterally averaged (bank-to-bank average) assumption may be inappropriate for large waterbodies exhibiting significant lateral variations in water quality. Because the Columbia River likely is well mixed, this is not a critical limitation. Also, dynamic branches can be included for large embayments in a CE-QUAL-W2 model to minimize the limitations of the laterally averaged assumption. Input data is most often the most limiting factor in the application or misapplication of any model.

SSTEMP may be used to evaluate alternative reservoir release proposals, analyze the effects of changing riparian shade or the physical features of a stream, and examine the effects of different stream withdrawals and returns on instream temperature. It can model only single stream segments for a single time period (e.g., month, week, day) for any given "run." Initially designed as a training tool, SSTEMP may be used satisfactorily for a variety of simple cases that might be faced on a day-to-day basis. It is especially useful for performing sensitivity and uncertainty analyses (Bartholomew, 2002). However, it cannot model flows of more than 100,000 cfs, which are routinely exceeded on the Columbia River. As such, the modeling had to be performed for flows of less than 100,000 cfs and then "scaled up" to greater flows.

The Department of Ecology developed a model using the QUAL2E software to address water quality issues associated with a proposal to increase flows in the lower Yakima River by foregoing diversions at Prosser Diversion Dam and, instead, diverting from the Columbia River near the mouth of the Yakima River (Carroll and Joy, 2001). The model looked at the lower Yakima River between RM 47.2 (upstream of Prosser Diversion Dam) and RM 5.6 (the backwater of the McNary pool). Model input was provided to simulate water temperature; DO; biochemical oxygen demand (BOD); chloride; TSS; nitrogen (N) in the forms of organic-N, ammonia-N, nitrate-N; phosphorus in the forms of organic-P and dissolved P; and chlorophyll-a at steady-state conditions. Turbidity could not be directly modeled, so a regression relationship between TSS (a model parameter) and turbidity for the lower Yakima River was used (Joy and Patterson, 1997). Carroll and Joy (2001) have summarized and drawn conclusions from the information collected about water quality in the lower Yakima River. The results from these earlier model runs were examined in light of the changes in projected flows to help estimate water quality under the Wymer Dam Plus Yakima River Pump Exchange Alternative, which is on a larger scale than the original model.

USGS developed a temperature model for the Storage Study using the Stream Network Temperature (SNTEMP) model, which was developed to help predict the consequences of stream manipulation on water temperatures. Manipulations may include reservoir discharge and release temperatures, irrigation diversion, riparian shading, channel alteration, or thermal loading. The SNTEMP model has been used to help formulate instream flow recommendations, assess the effects of altered streamflow regimes, assess the effects of habitat improvement projects, and assist in negotiating releases from existing storage projects (USGS, 2008).

Input values correlated air and water temperature for the period 1984–2003 for the Yakima River from Roza Diversion Dam to Prosser Diversion Dam and at the mouth of the Naches River. The time period used for data collection of water temperatures was April–October, which corresponds to irrigation season (Voss, et al., 2008).

CE-QUAL-W2 modeling of Wymer reservoir was also performed. Wet (1997), average (1991), and dry (1994) years were evaluated to determine the effects of Wymer dam releases on Yakima River temperatures just downstream from Wymer reservoir releases and upstream of the Roza Diversion Dam pool.

4.6.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Under the No Action Alternative, there would be no effect, either adverse or beneficial, on Columbia River water quality. No diversions would be made from the Columbia River, and there would be no additional influx of contaminants.

Based on the modeling done by Carroll and Joy (2001) for the lower Yakima River, the relatively modest, reach-specific differences in flows are not expected to affect water quality in the Yakima River. Carroll and Joy looked at changes in flows downstream from Prosser Diversion Dam of about 628–980 cfs in the Prosser Diversion Dam to Chandler reach and 1,344–2,010 cfs from Chandler to the mouth of the Yakima. They noted virtually no change in the water quality parameters modeled when flows were increased. The water conservation projects included in this alternative would create flow improvements of not more than a few hundred cfs, so similar effects to water quality would be anticipated.

Nutrient concentrations in the drains and wasteways likely would be greater under this alternative. The amount of nutrients that enter the drains and wasteways as a result of surface and subsurface runoff is a function of the amount of water applied for irrigation. Conservation measures would not reduce the amount of water applied but, instead, would reduce the amount that seeps or is discharged from the canals and laterals. Nutrient concentrations would increase as the amount of nutrients discharged to the drains and wasteways stays constant, but the amount of the total discharge in the drain or wasteway, which can dilute their concentrations, would decline.

4.6.2.3 Black Rock Alternative

Construction Impacts

There would be short-term impacts to water quality from instream and near-stream construction activities for the Black Rock pumping plant on the Columbia River. The required instream work may cause local, temporary increases in turbidity during installation and removal of coffer dams. These increases likely would be most intense near the construction activity itself and would decrease over time and distance. Given the slow-moving nature of the river at this location, turbidity would be expected to be confined near the site of the construction.

Construction of the Black Rock reservoir seepage pipeline would affect Yakima River water quality in the short term. The required instream work may cause local, temporary increases in turbidity during the installation and removal of coffer dams. These increases in turbidity likely would be most intense near the construction activity itself and would decrease over time and distance.

Long-Term Impacts

Under the Black Rock Alternative, there would be no effect, either adverse or beneficial, on the water quality in the Columbia River. The water quality modeling performed for the pumping station just upstream of Priest Rapids Dam that would lift water into Black Rock reservoir indicates no measurable difference in the water temperature prediction with or without withdrawal. This appears to be a reasonable conclusion given the size of the withdrawal relative to flows in the Columbia River. See chapter 2, section 2.4.2, for a discussion of Columbia River flows. At the time of modeling, the withdrawal by the Black Rock pumping plant was assumed to be 6,000 cfs. That amount has since been reduced to 3,500 cfs. Also note that water would be pumped from the Columbia River for Black Rock reservoir primarily during fall and winter, when the flows are low and the temperatures are declining. See chapter 2, section 2.4.2, "Operations," for a discussion of Columbia River flows. For these reasons, a new model was not constructed for the study; the results of the two models available were determined to be adequate to address this issue.

USGS model results (Voss et al., 2008) indicate that there would be modest changes (up to 1°C) in water temperatures in the Yakima River, depending on the reach, under this alternative compared to the No Action Alternative (figure 4.12), which is consistent with previous temperature modeling conducted for the Yakima River (Varccaro, 1986).

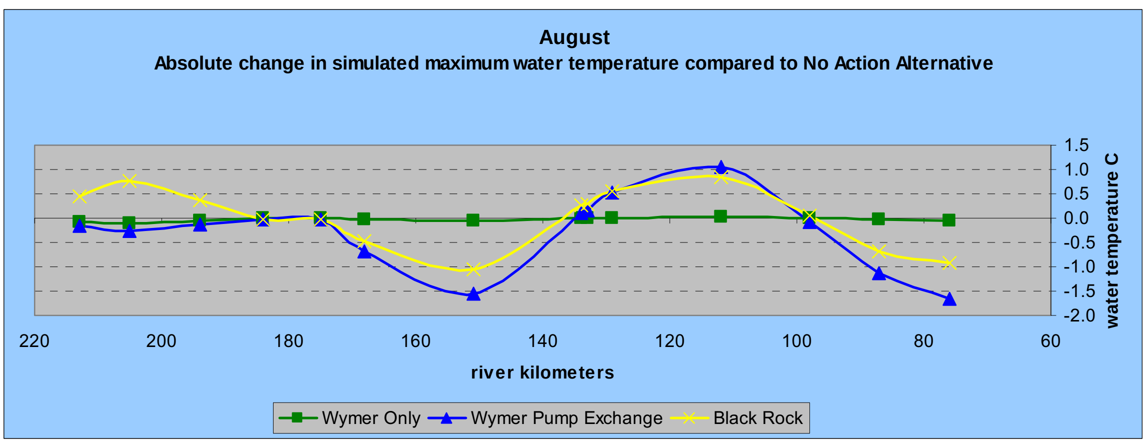

Figure 4.12 Modeled August absolute change in maximum water temperatures for Wymer Dam and Reservoir, Wymer Dam Plus Yakima River Pump Exchange, and Black Rock Alternatives compared to the No Action Alternative.

Notes: 1 °C = 1.8 °F; 1 km = 0.62 miles; No Action Alternative is represented by the x-axis (0.0.).

Greater flows during summer in the lower river should provide improved water quality conditions relative to nutrients, DO, and DDT. The water used to augment flows would come from reservoir releases higher in the valley where water quality is better. At the Parker gage, flows would be 3–4 times greater, so a water quality improvement would be expected. Lower in the river, the flows also would be increased; therefore, concentrations of nutrients could possibly be reduced.

The central portion of the Hanford Site is approximately 11 miles from the proposed Black Rock reservoir. From 1943–89, Hanford's principal mission was to produce weapons-grade plutonium. To produce this material, uranium metal was irradiated in production reactors. The uranium metal was cooled, and then treated through chemical separations in a reprocessing plant.

From this process, a large amount of waste was produced and stored in tanks or disposed of in cribs and trenches. In some cases, chemicals and radionuclides from this material have leaked or were discharged to the ground. The cleanup of the contamination present at the site is being done under the Resource Conservation and Recovery Act or Comprehensive Environmental Response Compensation and Liability Act, depending on the particular process or unit being addressed. See *Modeling Mitigation of Seepage from the Potential Black Rock Reservoir* (Reclamation, 2008a).

The mitigation measures to control/manage seepage from Black Rock reservoir could slightly affect Yakima River water temperatures downstream from the outlet structure. Because the water to be discharged could be conveyed underground for about 20 miles, cooler water should be discharged from the pipeline into the Yakima River, at least during the summer months when water temperatures in the Yakima River are a concern. The amount of water to be discharged, though, is minimal when compared to the discharge of the Yakima River at Horn Rapids; any effect would likely be unmeasurable, except at the immediate discharge point.

Seepage from Black Rock reservoir should not affect Columbia River water quality because the only seepage that would reach the Hanford Site would be in deep basalt layers. Seepage in those layers could not mobilize contaminants in the unconfined aquifer or the vadose zone and carry them to the Columbia River.

4.6.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

There would be short-term impacts to water quality from instream and near-stream construction activities for the Wymer pumping plant on the Yakima River. The required instream work may cause local, temporary increases in turbidity during installation and removal of coffer dams. These increases likely would be most intense near the construction activity itself and would decrease over time and distance.

Care also would have to be taken with flows in Lumuma Creek during dam construction. A coffer dam and one or more temporary bypass channels would have to be constructed to route the flowing water away from any construction activity. Rerouting the stream to the bypass may create a minor amount of sediment that would settle out before it reaches the Yakima River.

Long-Term Impacts

Under the Wymer Dam and Reservoir Alternative, there would be no effect, either adverse or beneficial, on water quality in the Columbia River.

USGS model results (Voss et al., 2008) indicate that there would be no changes in water temperatures in the Yakima River under this alternative compared to the No Action Alternative (figure 4.12) because the flow regime would differ only slightly compared to the No Action Alternative.

For the proposed Wymer reservoir, CE-QUAL-W2 temperature model results indicated that during June and July in wet, average, and dry years, Wymer dam release temperatures would be cooler than those of the Yakima River. During late August in wet and average years, Wymer reservoir releases would approach Yakima River temperatures. During late August in dry years, Wymer reservoir releases would be warmer than those of the Yakima River. At low Wymer reservoir elevations during September, warm surface waters could be discharged to the Yakima River. Therefore, minimal discharges are anticipated during September in dry years.

Little change would be expected in other Yakima River water quality parameters as a result of releases from Wymer reservoir. During dry years, using bottom releases from Wymer reservoir potentially could affect only Yakima River water quality. Therefore, stagnant water quality conditions, such as low DO, in the lower layers of Wymer reservoir could be minimized by mixing water quality releases from upper outlets with potentially poor water quality from the lower outlet.

4.6.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction impacts for Wymer reservoir would be the same as for the Wymer Dam and Reservoir Alternative. Additionally, there would be short-term impacts to water quality from instream and near-stream construction activities for the Yakima River pump exchange (pumping plant #1) on the Columbia River. The required instream work may cause local, temporary increases in turbidity during installation and removal of coffer dams. These increases likely would be most intense near the construction activity itself and would decrease over time and distance. Given the slow-moving nature of the river at this location, turbidity would be expected to be confined near the site of the construction.

Long-Term Impacts

Under the Wymer Dam Plus Yakima River Pump Exchange Alternative, there would be no effect, either adverse or beneficial, on Columbia River water quality.

USGS model results (Voss et al., 2008) indicate that water temperatures in the Yakima River could vary up to 1.5 °C, depending on the reach, under this alternative compared to the No Action Alternative (figure 4.12), which is somewhat greater than under the Black Rock Alternative.

In the middle and lower Yakima River, the greater summer flows at Parker would provide water quality improvements as a result of dilution. The flow increase is only about two-thirds of that expected under the Black Rock Alternative; while water quality benefits are anticipated, they are not expected to be as prevalent as under the Black Rock Alternative.

4.6.2.6 Mitigation

Contributing sediment from construction activities (such as staging areas and temporary access roads) would need to be prevented. The contractor would be required to use silt curtains, settling ponds, and other measures to prevent construction site runoff. Waste water associated with construction activities, such as dewatering excavations, washing equipment or wet sawing, would be kept from directly discharging into surface waterways. Complying with Federal, State, and local permits would provide the necessary water quality protection.

A water quality monitoring plan would be established if an action alternative is selected. Quality assurances and controls would be developed along with proper standard operating procedures. A Quality Assurance Project Plan (QAPP) would be written using the Washington State Department of Ecology Guidelines. The QAPP would include a list of priority parameters, a schedule of events, sampling sites with coordinates, data verification and validation, and any other pertinent information. These documents would be in place prior to any monitoring and shall be strictly followed throughout the duration of the project. Modifications would need to be made to the documents yearly to address any operational or environmental changes.

As mitigation for warmwater releases from Wymer reservoir, releases would be maximized and made as early as possible in a dry water year to minimize the potential for warm water releases later in the summer when the Yakima River and Wymer reservoir would be warmer.

4.6.2.7 Cumulative Impacts

Planned development in the basin, independent of project-related activities, could have an adverse effect on water quality. The additional development would result in more water use, and the returns of more used water could impact the area’s streams and river. While some of the return flows would come through municipal water treatments facilities, they would add pollutants to the system. This increase in wastewater from residential and other developments could offset some of the benefits expected under the Black Rock and Wymer Dam Plus Yakima River Pump Exchange Alternatives. Because there are no expected water quality impacts associated with the No Action or Wymer Dam and Reservoir Alternatives, there would be no cumulative impacts for these alternatives.

In the *Final Supplemental Environmental Impact Statement for the Lake Roosevelt Incremental Storage Releases Program,* section 4.2.2.3, "Surface Water," states that the Columbia River flows will increase during most months, except September and October when water is being stored in Lake Roosevelt and Banks Lake. Discharges from the Yakima River are expected to increase under the Black Rock Alternative. In most months, then, the two projects would act together to increase flows in the Columbia River downstream from the confluence with the Yakima River, although this increase would be relatively small relative to the discharge in the Columbia River (less than 5 percent). These increases would have no significant impacts on water quality in the Columbia River. In September, when impacts from storing water in Lake Roosevelt and Banks Lake and pumping at the Black Rock pumping plant would be greatest, flows in the lower Columbia River would be reduced by about by about 4,000 cfs, or about 4 percent, of the average September flow at The Dalles. As suggested by the SSTEMP and CE-QUAL model results, which were based on a 6,000-cfs withdrawal, the combined effects on these two actions on water temperature in the Columbia River would not be measurable.

4.7 Vegetation and Wildlife

4.7.1 Affected Environment

Vegetation issues of concern involve the loss of shrub-steppe associated with the development of facilities under some of the alternatives and effects to riparian and wetland habitat along the river corridor as a result of changes in flows. The loss of shrub-steppe is also an issue for wildlife, as it could be affected by its loss. Movement corridors for some species may also be affected with the development of some of the facilities.

Shrub-steppe communities were historically a dominant vegetation type in eastern Washington, and have been extensively studied (Yakima Subbasin Fish and Wildlife Planning Board, 2004). The shrub-steppe vegetation type is a mixture of woody shrubs, grasses, and forbs generally dominated by Wyoming big sagebrush and bluebunch wheatgrass in east-central Washington (Daubenmire, 1970). Environmental factors such as elevation, aspect, soil type, proximity to water, and others contribute to an individual site's vegetation diversity potential. For example, at higher elevations and on north-facing slopes, three-tip sagebrush and Idaho fescue may dominate; on ridge tops with shallow soils, rigid sage-brush and Sandberg's bluegrass and/or bluebunch wheatgrass may dominate (Yakima Subbasin Fish and Wildlife Planning Board, 2004). Rabbitbrush may be common on recently burned sites. Other grasses and shrubs that may be scattered throughout dominant stands of Wyoming big sagebrush and bluebunch wheatgrass include needle and thread, Thurber's needle grass, Indian rice grass, squirreltail, Cusick's bluegrass, short-spine horsebrush, antelope bitterbrush, spiny hopsage, and basin sagebrush (Crawford and Kagan, 2001). More alkaline sites may support black greasewood, basin wild rye, and inland saltgrass (Daubenmire, 1970). Estimates of historic vegetation cover on undisturbed sites range from 5- to 30-percent shrub cover and from 69- to 100-percent bunchgrass cover.

Agricultural, residential, and urban development over the past century have changed the landscape drastically, resulting in large losses of shrub-steppe habitat. Approximately 40 percent of the estimated 10.4 million acres of the shrub-steppe vegetation type that existed in Washington before the 1800s remains today (Dobler et al., 1996). This residual habitat continues to be threatened by continued loss/conversion of habitat; declines in vegetative diversity; reduction of microbiotic crusts, which are an indicator of undisturbed habitat and prevent the influx of exotic species (e.g., cheatgrass); and isolation of habitat (Service, 2007b). The further loss of habitat and the degradation of remaining shrub-steppe can be attributed to increased fragmentation, varying fire management practices, competition with exotic and invasive species, overgrazing from livestock, off-road vehicle use, and overall conversion and development (Crawford and Kagan, 2001). In the Yakima River basin, three large properties remain that continue to support large blocks of shrub-steppe: the YTC; a portion of the Yakama Reservation; and the ALE Reserve, located on Hanford Reach National Monument and managed by the U.S. Fish and Wildlife Service (Yakima Subbasin Fish and Wildlife Planning Board, 2004). Table 4.19 presents the shrub-steppe acreage at major facility sites for each alternative area (Service, 2007b). More detailed treatment of this vegetation type is found in the *Yakima Subbasin Plan* (Yakima Subbasin Fish and Wildlife Planning Board, 2004) and the numerous references cited within that report.

Table 4.19 Shrub-steppe habitat at major facility sites (acres)

Location	Shrub-steppe habitat
Black Rock site	3,539
Wymer site	1,055
Other facilities: SR–24 Road relocation and access road to Priest Rapids to pumping plant	330
Total affected area	4,924

4.7.1.1 Wildlife

Several wildlife species utilize and exist within the remaining shrub-steppe habitats. The affected areas for these species and their habitat includes not only the footprint of the proposed Black Rock and Wymer dams and reservoirs but also the ancillary facilities, such as pipeline construction and alignment; pumping plants; access roads; staging areas; realignment of SR–24 and utilities; and potential recreational development in adjacent areas where they occur in shrub-steppe (Reclamation, 2004a).

The following section provides a general analysis of wildlife known to occur or have the potential to occur within the affected areas of both Black Rock and Wymer dam and reservoir sites.

An abundance of diverse wildlife inhabits and utilizes shrub-steppe communities in the region. Table 4.20 presents a list of the known wildlife species within the affected areas (both Black Rock and Wymer dam and reservoir sites), as well as a partial list of potential wildlife species that may occur.

Both habitat generalists and shrub-steppe obligates occupy the Black Rock and Wymer dam and reservoir sites. The U.S. Fish and Wildlife Service lists core habitat for the following species within the Black Rock site: short-eared owls (*Asio flammeus)*, burrowing owl (*Athene cunicularia)*, long-billed curlew *(Numenius americanus)*, ferruginous hawk (*Buteo regalis*), loggerhead shrike (*Lanius ludovicianus*), sage thrasher (*Oreoscoptes montanus*), greater sage-grouse (*Centrocerus urophasianus*), Townsend ground squirrel (*Citellus townsendi*), black-tailed jackrabbit (*Lepus californicus*), Merriam's shrew (*Sorex merriami*), mule deer (*Odocoileus hemionus*), pallid bat (*Antrozous pallidus*) and small-footed myotis (*Myotis subulatus*) (Reclamation, 2007f). Peripheral habitat exists for the white-tailed jackrabbit (*Lepus townsendii*) and Rocky Mountain elk (*Cervus canadensis*).

The Wymer site provides core habitat for bighorn sheep (*Ovis canadensis*), Townsend ground squirrel, golden eagle (*Aquila chrysaetos*), ferruginous hawk, short-eared owl, long-billed curlew, loggerhead shrike, sage sparrow (*Amphispiza belli*), Brewer's sparrow (*Spizella breweri*), sage thrasher, greater sage-grouse, black-tailed jackrabbit, Merriam's shrew, mule deer, pallid bat, and small-footed myotis. Peripheral habitat exists for the white-tailed jackrabbit. Other species that may live in the diverse habitats within the affected areas include the coyote (*Canus latrans*), badger (*Taxidea taxus*), western kingbird (*Tyrannus verticalis*), western meadowlark (*Sturnella neglecta*), mourning dove (*Zenaida macroura*), western rattlesnake (*Crotalus virdis*), Great Basin spadefoot toad (*Spea intermontana*), and northern sagebrush lizard (*Sceloporus graciosus*) (Service, 2007b).

4.7.1.2 Movement Corridors

Valleys are often used as movement corridors by numerous land animals. This is especially true for species with relatively large home ranges such as deer and elk. This section addresses the issue of movement corridors in the area.

Table 4.20 Known and potential wildlife species within affected shrub-steppe habitats

	Federal ESA Candidate Species, State-listed (Threatened)	"Species of Concern" by Washington State	Known to exist/utilize shrub-steppe: Black Rock site	Have potential to exist/utilize shrub-steppe: Black Rock site	Known to exist/utilize shrub-steppe: Wymer site	Have potential to exist/utilize shrub-steppe: Wymer site
Birds						
Greater sage-grouse	x	x	x		x	
Brewer's sparrow			x		x	
Ferruginous hawk	State-listed only	x	x		x	
Burrowing owl		x	x			x
Prairie falcon				x		x
Golden eagle		Candidate		x	x	
Short-eared owl				x		x
Long-billed curlew			x		x	
Red-tailed hawk				x		x
Sage sparrow		x		x	x	
Chukar				x		x
Loggerhead shrike		x	x		x	
Northern shrike				x		x
Sharp-tailed grouse		x		x		x
Western kingbird				x	x	
Grasshopper sparrow				x		x
Sage thrasher		x	x		x	
Northern harrier				x		x
Swainson hawk				x		x
Rough-legged hawk				x		x
American kestrel				x		x
Common nighthawk				x		x
Common poorwill						x
Western meadowlark			x		x	
Vesper sparrow				x		x
Lark sparrow				x		x
Mourning dove				x		x
Mammals						
Townsend's ground squirrel		x	x		x	
Black-tailed jackrabbit		x	x		x	
White-tailed jackrabbit		x	x		x	
Mule deer			x		x	
Bighorn sheep			NA		x	
Coyote			x		x	
Merriam's shrew		x	x		x	
American badger			x		x	
Rocky Mountain elk			x	x	NA	
Pallid bat			x		x	
Small-footed myotis			x		x	
Reptiles and amphibians						
Northern sagebrush lizard		x		x		x
Western rattlesnake				x		x
Great Basin spadefoot toad				x		x

Movement corridors are crucial to wildlife and may be seasonal, depending on the species. The primary function of a corridor is to connect two areas of habitat and encourage migration and dispersal into these areas. Wildlife movement is essential to healthy wildlife populations because it does the following: provides connectivity and, thereby, genetic variation and biodiversity between differing populations and habitats; connects isolated habitats and may allow recolonization of extirpated species; provides varying habitats for migration patterns, e.g., foraging, nesting, brood-rearing, wintering, and mating; encourages plant propagation; allows populations to move in response to habitat changes, e.g., fires; and can provide habitat for "corridor dwellers," species that live within corridors for extended periods (Beier and Loe, 1992).

The loss of movement corridors would further isolate and fragment vegetative and wildlife species' populations, as well as substantially decrease and/or eliminate suitable habitats. A large reservoir can be a major barrier for some species including elk, deer, and greater sage-grouse in the Yakima River basin.

Evidence has shown that elk historically have occupied the shrub-steppe habitats of the Columbia River Basin (McCorquodale, 1985). In recent times, elk first were observed in the Rattlesnake Hills in 1972 and are believed to come from the Yakima elk herd west of the Hanford Reach National Monument (McCorquodale et al., 1988; Eberhardt et al., 1996). The Rattlesnake Hills elk herd utilizes the ALE Reserve (located within the Hanford Site) and has grown considerably throughout its history.

The ALE Reserve encompasses more than 127 square miles and is designated a Research Natural Area and a National Environmental Research Park. The majority of the Rattlesnake Hills elk are found within the ALE Reserve year-round, but some have moved to adjacent areas as the population has grown and disturbance to habitat from fire has pushed them westward. Most of the land surrounding the ALE Reserve is privately owned but also includes the Saddle Mountain Wildlife Refuge, Wahluke Wildlife Area, and the YTC. The population has grown extensively over the years. Presently, the Washington Department of Fish and Wildlife is managing elk through hunting, trapping, and relocations because of crop damage complaints from private landowners (Tsukamoto, 2000).

The Rattlesnake Hills elk herd demonstrates distinct seasonal migration patterns and is concentrated within two areas, the ALE Reserve and the YTC. The elk usually winter in the ALE Reserve and then move out into adjacent lands in the spring and summer. The Cold Creek Valley within the ALE Reserve is the main area of distribution and runs along SR–240. Elk frequently are observed next to the western and southern boundaries of the ALE Reserve, on the Rattlesnake Hills and Yakima Ridge, and onto the southeastern portion of the YTC (Tsukamoto, 2000). They also move across the Columbia River toward the Saddle Mountain Wildlife Refuge and Wahluke Wildlife Area.

The YTC supports a small population of elk that migrate northwest from the ALE Reserve and south from the Colockum and Quilomene Wildlife Areas. The geography indicates that the Rattlesnake Hills elk probably cross the Black Rock Valley or move along the Yakima Ridge into the YTC (Tsukamoto, 2000). Neither the Yakima nor the Colockum herds have been observed within the Wymer area or in the areas directly east of the Yakima River (Stephenson, 2007).

4.7.1.3 Black Cottonwoods

Cottonwood reproduction has been identified as a key issue for the Yakima River basin by many recent studies and documents, mainly because black cottonwoods (*Populus balsamifera ssp. trichocaepa*) are the dominant plant species in lowland riparian forests of the Yakima River basin and are considered essential to the integrity of Yakima River riparian systems (Biology Technical Work Group, 2004; Braatne et al., 2007; Reclamation, 2002a; Yakima Subbasin Fish and Wildlife Board, 2004). As a dominant riparian plant species, black cottonwoods interact with other river system components, both physical and biological (Fierke and Kauffman, 2005). While hydrologic and sedimentary processes drive the creation and destruction of cottonwood habitat, the trees, in turn, modify physical river processes through increased channel and flood plain roughness, increased bank stability, and inputs of large woody debris (LWD) (Montgomery et al., 2003). Black cottonwoods also influence aquatic ecosystems through exchanges of nutrients, species, and energy. Because dominant riparian species such as black cottonwoods can be seen as integral components of the river system, it follows that changes in cottonwood recruitment can affect salmonid species both directly and indirectly in both the short and long terms (Naiman and Latterell, 2005).

Black cottonwoods range from northern California to the timberline in Alaska and grow mostly in riparian zones (DeBell, 1990). Their reproduction, growth, and mortality are closely linked to river processes (Auble and Scott, 1998). Other processes, such as grazing by native ungulates and cattle, fire, insect predation, and disease, also have been linked to black cottonwood ecology.

Seedling reproduction in black cottonwoods is thought to be the usual means of new stand establishment and occurs in periodic pulses on many Western rivers. Black cottonwoods can also reproduce extensively by root sprouting and other clonal means; however, the relationship between riverflows and asexual reproduction is not well understood. Therefore, only sexual reproduction is considered here.

Mortality appears to be driven by floods, which undercut trees by sediment scour during channel avulsions and migration (Lytle and Merritt, 2004). Rapid declines in water table levels also have been shown to cause early mortality in cottonwoods (Rood, et al., 1995).

Riverflows and Cottonwood Seedling Reproduction

The life history of riparian cottonwoods is bound tightly to riverflow dynamics. Much research has been conducted on the relationship between riverflow and cottonwood seedling reproduction, and several models have been published that describe this relationship for the semiarid Western United States (Lytle and Merritt, 2004; Mahoney and Rood, 1998). In general, a sequence of events spanning several years is thought to be necessary for abundant seedling production, beginning with a flood of at least a 5-year recurrence interval that scours or deposits sediments to produce bare, open sites. Also required is a 1.5- to -2-year recurrence (bank-full flow) spring snowmelt flood that coincides with the June seed release period of cottonwoods on the Yakima River. This flow level moistens the surface of bare nursery sites and recharges shallow groundwater. Wind- and water-borne seeds, produced in vast quantities, then land on these sites and germinate. A gradual recession of the snowmelt flood, at a rate not more than about 1 inch of river stage per day, allows growing seedling roots to keep in contact with the capillary fringe of the groundwater. Survival after recession is favored by adequate summer base flows. Finally, a period of 2–5 years with low to moderate flows enables seedlings and juveniles to avoid being scoured or buried as would happen in large floods. These particular flow sequences occur episodically and result in a punctuated, rather than continuous, cohort recruitment process for cottonwoods. See figure 4.13.

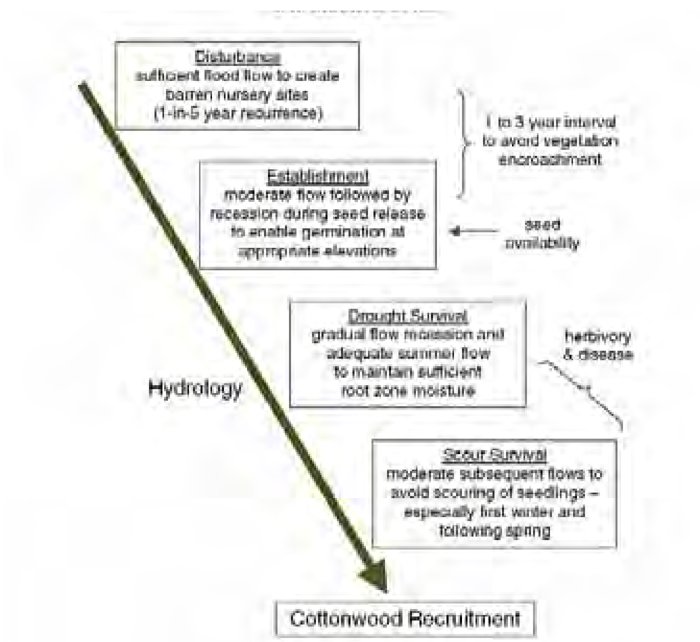

Figure 4.13 Conceptual model of flows for successful black cottonwood reproduction by seed (Braatne et al., 2007).

Current Conditions

Large areas of cottonwood forest are found on alluvial segments of the Yakima River and the Naches River. These include the Easton, Cle Elum, Kittitas, Union Gap, Lower Naches, and Wapato flood plains. For the sake of brevity, the Easton, Cle Elum, and Umtanum flood plains are considered as a group and termed the upper reaches or flood plains, while the Union Gap, Lower Naches, and Wapato flood plains are considered individually. Several observations apply to all flood plains. The most general effect of current river operations is to reduce the volume of total annual discharge; simply put, the Yakima River has become a smaller stream. On average, smaller flows would reduce the potential size of riparian forests. Current Yakima Project operations also affect cottonwood reproduction most directly through the attenuation of fall and spring floods, which reduces the potential spatial extent of cohort recruitment. Indeed, several studies have documented a river-wide paucity of young cottonwood stands on the Yakima River. The identified causes of the poor reproduction are altered riverflows in addition to physical changes to flood plains such as levees, channelization, and gravel mining. These physical impediments to cottonwood reproduction would have to be addressed to realize the full potential of any benefits associated with the Joint Alternatives. The Wapato and Union Gap flood plains have been identified as having greater restoration potential because of greater flood plain connectivity and complexity; hydrologic improvement might be expected to show relatively better results in these areas (Stanford et al., 2002).

Upper Flood Plains (Easton, Cle Elum, and Kittitas).—River operations for the Yakima Project create reduced spring flows and very high summer base flows. As a result, cottonwood seedlings of the year are probably scoured each summer, and relatively few young cottonwoods occur. However, some forest stands remain, most likely because of periodic large spring floods that provide recruitment sites beyond the reach of summer flow levels.

Lower Naches.—This flood plain has a flow pattern that is fairly close to natural flow, with the exception of fall high water caused by the flip-flop operation. Spring flows average substantially greater than the flip-flop surge, meaning that some seedlings most likely establish at high enough elevations to avoid being scoured in the fall. In general, seedling reproduction probably is occurring at higher rates on this reach than on mainstem Yakima River flood plains.

Union Gap.—Spring flows are reduced, and summer flows are somewhat elevated in this reach. These flow alterations are not nearly as dramatic as those in the upper flood plains, however, and periodic spring floods still generate pulses of cottonwood reproduction. High summer flows may raise the lower elevational limit of establishment, but they most likely do not scour the bulk of seedlings of the year.

Wapato.—Cottonwood reproduction on this flood plain is limited by flow regulation. Spring flows are reduced substantially, spring recession rates are extremely rapid, and summer base flows average less than half of estimated natural flow. The combined effect of these conditions is limited opportunities for germination and high mortality of seedlings that do establish.

4.7.1.4 Wetlands

The single feature that most wetlands share is soil or substrate that is saturated at least periodically or covered with water. The National Wetlands Inventory (NWI) classification system (Cowardin et al., 1979) identifies wetlands and deepwater habitats. The NWI had identified 43,695 acres of wetlands within the Yakima River basin, including 20,040 acres of herbaceous wetlands; 20,044 acres of scrub-shrub and forested wetlands; and 3,611 acres of unvegetated wetlands.

Because of the affected area's semiarid environment, wetlands are extremely important to many species of wildlife as they provide some of the best vegetative growth for food and cover, invertebrate production, and water. Recognition of the value of wetlands historically has focused on waterfowl populations. The Service (2007b) estimated that up to 300,000 ducks wintered on the Yakama Reservation in the 1960s. Tens of thousands of waterfowl can still be found in the lower basin in winter and during migration. Several species of waterfowl also use these wetlands for nesting and brood rearing. Sandhill cranes (*Grus canadensis*) and swans (*Cygnus* species) historically nested in the basin and could return if wetland restoration and enhancement efforts were to continue (Service, 2007b).

Wetlands in the affected area provide functions beyond fish and wildlife habitat. They provide both consumptive and nonconsumptive recreational uses, groundwater recharge, flood control (i.e., floodwater storage), and improvement of water quality as important functions. Wetlands in Washington have declined 30 percent, with the loss of freshwater wetlands estimated at 25 percent (Service, 2007b). Losses have been attributed to agriculture conversion; filling for solid waste disposal; road construction and commercial, residential, and urban development; construction of dikes, levees, and dams for flood control, water supply, and irrigation; discharges of materials; hydrologic alteration by canals, drains, spoil banks, roads, and other structures; and groundwater withdrawal. Aside from direct loss of wetland, many wetlands have been reduced in quality from the above factors.

Black Rock Reservoir Site

Analysis of wetlands at the Black Rock site was confined to that area found within the footprint of the proposed dam, impounded reservoir (at maximum pool elevation) site, and the indirect impact area around the perimeter of the dam and reservoir (0.31 mile [one-half kilometer] wide). The Black Rock Valley is located in a semiarid environment; the primary drainage in the affected area is considered an intermittent/ephemeral watercourse tributary to the lower Yakima River subbasin. Although the plant community has been altered for agricultural purposes, it is unlikely that there were any wetlands historically found in the affected area. In fact, the only wetlands identified through analysis are relatively small in area (0.9 acre) and created by an impounded pond. They are not considered a natural occurrence (Reclamation, 2007f).

Wymer Reservoir Site

Wetlands in the Wymer reservoir site are found exclusively in the riparian zone in both Lmuma Creek and an unnamed tributary in the proposed impoundment area. Seeps were observed in the riparian corridor of Lmuma Creek. The riparian/ wetland plant community has been degraded significantly due to extensive past and ongoing livestock grazing; as such, these provide minimal value functioning habitat for wildlife. Remnant vegetation in the riparian/wetlands area included some cottonwood, willow, and black hawthorn. Some emergent vegetation was also observed. Even though the flow of Lmuma Creek is not regulated, there was no evidence of cottonwood recruitment, apparently a result of livestock grazing (Service, 2007b).

Wymer Reservoir Site Plus Yakima River Pump Exchange

Wetland and riverine habitats at the reservoir site are described above. Wetlands that may be present along the alignment for the pump exchange/pipeline were not included in this analysis due to lack of spatial data. They may be present at the site of the Yakima River siphon and at crossings of any irrigation delivery or drainage features along the pipeline through the irrigated portions of the valley.

4.7.2 Environmental Consequences

4.7.2.1 Methods and Assumptions

Shrub-Steppe Habitat

Many wildlife species dependent on shrub-steppe habitat potentially would be affected by the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives. This assessment is limited to the footprint and directly adjacent areas of the proposed reservoirs and ancillary facilities.

Shrub-steppe vegetation and wildlife impacts, species identification, and habitat requirements were based upon and evaluated using available literature and personal communication.

An assessment of the quality of the shrub-steppe habitat at the Black Rock and Wymer dam and reservoir sites also was performed using the U.S. Fish and Wildlife Service's Habitat Evaluation Procedures (HEP). HEP uses habitat units (HU) as the currency for addressing ecological losses or gains associated with any project development and implementation. HUs for a given species are the product of habitat quantity (acres) and habitat quality estimates. Habitat quality estimates are provided by a Habitat Suitability Index (HSI). HSI values range from 0.0–1.0 and are a projection of a given habitat parcel's ability to provide the life requisites of a given species. An HSI of 1.0 indicates an essentially optimum habitat condition for the species in question. HSI values for a given species are determined on the basis of quantifiable habitat features (e.g., vegetation height, tree canopy cover, distance to water), which are known to be required for the success of that species. For this study, the Brewer's sparrow was used to estimate the quality of the habitat for shrub-steppe species.

Habitat and associated wildlife were first evaluated by identifying the areas that would be directly and indirectly affected by each storage alternative. Wildlife impacts are based on documented utilization by wildlife and estimated changes in their habitats.

Shrub-steppe habitat and wildlife assessments were based on the following premise:

- Impacts related to any loss of shrub-steppe habitat and subsequent habitat fragmentation would adversely affect shrub-steppe wildlife species and vegetation.

Habitat fragmentation can be defined as "the discontinuity, resulting from a given set of mechanisms, in the spatial distribution of resources and conditions present in an area at a given scale that affects occupancy, reproduction, or survival in a particular species" (Franklin et al., 2002). In this analysis, the fragmentation of habitat for elk and deer is measured by reduced habitat area and presence of barriers for migration/dispersal. This, in turn, may lead to habitat isolation (Davidson, 1998).

Movement Corridors

Movement corridors are important aspects of resident and migratory wildlife and vegetation (Beier and Loe, 1992). This analysis specifically evaluated the Rocky Mountain elk as species that could be affected by the construction of the proposed dams and reservoirs.

Movement corridor delineation for Rocky Mountain elk is based upon the information provided in The *Rattlesnake Hills (Hanford) Elk Strategic Management Plan* (Tsukamoto, 2000); telemetry data and observations from the Hanford ALE Reserve regarding movement off the reserve; personal communication with elk biologist Jim Stephenson of the Yakama Nation; occurrence of shrub-steppe vegetation from aerial photographs; and topography of ridgelines and valleys where elk have been observed to frequent and move through.

Black Cottonwoods

Riverflows in the semiarid Western United States tend to follow strong seasonal patterns, and their hydrographs can be dissected into yearly repeating elements known as hydrograph components (Trush et al., 2000). For example, the Yakima River reliably experiences a small-to-moderate spring flood caused by melting snow in April–June, which gradually recedes to a stable summer base flow from July–September. Large floods may happen in the spring because of high snowmelt volume but more often occur following fall or winter storms (Reclamation, 2000). In turn, cottonwoods have evolved life history adaptations that are tightly linked to these recurring patterns, collectively termed the natural flow regime (Karrenberg et al., 2002; Lytle and Poff, 2004). Those hydrograph components important to cottonwood reproduction are the spring snowmelt flood, snowmelt recession, summer base flow, and fall/winter floods. They can be analyzed to assess the effects of the proposed alternatives on cottonwood recruitment, a procedure termed hydrograph components analysis (RMC Water and Environment and McBain & Trush, 2007). See table 4.21 for the biological relevance of each selected hydrograph component.

In addition to focusing on individual components of hydrographs, a key aspect of the hydrograph components analysis is that different classes of water years have different functions. Thus, the same hydrograph component in a wet versus a dry year might provide a different function for cottonwood seed reproduction. Hydrograph components used were fall/winter flood peaks, spring snowmelt flood peaks and timing, and summer base flow average stage. Snowmelt flood recession, while important to cottonwood seed reproduction, was not used because of limitations in the modeled flow data.

After hydrograph components were defined and extracted from Yak-RW model output, the data were summarized for each alternative at each flood plain. For example, the median value for the fall/winter flood peak during the period of record (water years 1981–2005) was calculated for each alternative. The absolute value of the difference between these median values and the median value for the modeled unregulated flow then was calculated, giving the percent difference from estimated unimpaired riverflow conditions. This process was repeated for each hydrograph component for each flood plain under each alternative. Because of model errors and errors in the underlying streamflow measurements, this method only can provide a rough estimate of the differences between alternatives in relation to cottonwood seedling reproduction success. See table 4.21.

Wetlands

Wetlands were evaluated using the wetland delineations that were available for the construction and impoundment sites. Where wetlands existed within the construction or impoundment footprint, they were presumed to be lost with implementation of the alternative.

Table 4.21 Significance of hydrograph components for cottonwood reproduction for water year types

Hydrograph component	Timing	Water year type	Biological function for cottonwood recruitment
Fall/winter flood	November–March	Wet	Creates large bare nursery sites for seedlings by major scouring or deposition; causes channel avulsion. Woody debris recruited from flood plains provides sheltered nursery sites on bars.
		Average	Minor scour and deposition create small nursery sites.
		Dry	No scour of seedlings allows for survival of seedlings from previous years.
Spring snowmelt peak flow	April–June	Wet	Scour and deposition; broad wetted band on bare sites allows for potentially large numbers of cottonwood seedlings to germinate.
		Average	Some bare sites wetted; moderate to small numbers of seedlings germinate.
		Dry	No scour of seedlings allows for survival of seedlings from previous years. No recruitment of seedlings of the year.
Spring snowmelt recession	June–August	Wet	Gradual recession far into summer allows growing seedling roots to maintain contact with receding capillary fringe; large numbers survive the first summer.
		Average	Gradual recession ends mid-summer; some seedlings of the year survive.
		Dry	Recession ends early in the summer; no same year seedling survival. Seedlings from previous years survive.
Spring snowmelt timing	June	Wet	Needs to be synchronized with seed release in order for seeds to land on moist nursery sites.
		Average	Needs to be synchronized with seed release in order for seeds to land on moist nursery sites.
		Dry	Not important since no seedling of the year survival is expected.
Summer base flow	August–October	Wet	High base flow promotes high survival of seedlings of year; growing season may be prolonged.
		Average	Moderate base flow allows some survival of seedlings of year; prevents stress to existing seedlings and juveniles.
		Dry	Low base flow prevents survival of seedlings of the year; causes drought stress and mortality for established seedlings and juveniles.

Adapted from RMC Water and Environment and McBain & Trush, 2007.

Flows were also evaluated to determine if wetlands associated with the river corridor would be affected by the flow changes. If spring or summer flows were to decline, it was assumed that wetlands associated with the river would be adversely impacted. If those flows were to increase, benefits were assumed.

Impacts to black cottonwoods were also examined to determine if the effects were negative or positive. Impacts to wetlands were assumed to have the same trend.

4.7.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Shrub-Steppe Habitat.—Under the No Action Alternative, existing management and recovery efforts for shrub-steppe habitat and existing wildlife would continue. Some shrub-steppe habitat would continue to suffer degradation from grazing, conversion to agriculture, or development. The susceptibility for fire and subsequent invasion of exotic species (e.g., cheatgrass) also would be a major concern.

A Memorandum of Understanding (MOU) was signed in 2006 among Federal, Tribal, State, and private agencies within Yakima, Benton, Grant, and Kittitas Counties to establish a partnership dedicated to conserve shrub-steppe and rangelands surrounding and connecting the YTC, Hanford Reach National Monument, the Yakama Reservation, and the Washington Department of Fish and Wildlife's wildlife areas. To date, the partnership, named the South-Central Washington Shrub Steppe/Rangeland Conservation Partnership, has acquired a conservation easement for a property located within the Rattlesnake Hills, south of Moxee (Burkepile, 2007). This partnership would have the ability to work with landowners to protect shrub-steppe habitat and potentially restore these areas. The U.S. Fish and Wildlife Service estimates there are 6,591 acres of shrub-steppe and 5,059 acres of grassland (including Conservation Reserve Program lands) within the Black Rock footprint and .31-mile (0.5-kilometer) buffer that have the potential to be protected from future degradation and development. The Wymer footprint and buffer consists of 3,634 acres of shrub-steppe and 996 acres of grassland that have the potential for restoration and protection.

Movement Corridors.—Existing movement corridors and habitat would continue to be used by shrub-steppe wildlife. This alternative would coincide with the South-Central Washington Shrub Steppe/Rangeland Conservation Partnership objectives and recovery efforts for the greater sage-grouse, to decrease fragmentation of populations and habitat. It would also allow for potential reintroductions and larger species dispersal into surrounding shrub-steppe habitat. Other wildlife, such as the Rattlesnake Hills elk herd, also would be able to utilize existing corridors along the Black Rock Valley and Yakima Ridge to reach the YTC from the ALE Reserve.

Black Cottonwoods.—Under the No Action Alternative, negligible changes in cottonwood reproduction would occur in comparison to the current condition. Flows in the upper reaches and the Union Gap reach would remain lower in the spring and greater in the summer than estimated unregulated conditions. In the lower Naches River, the flip-flop surge would remain; in the Wapato flood plain, spring floods are truncated and summer base flow, while marginally greater, would not be expected to increase seedling survival.

Wetlands.—If this alternative were selected, water conservation measures would continue to be researched and implemented as part of the Yakima River Basin Water Enhancement Project authorized by the Congress with Public Law 96–162 on December 28, 1979 (Reclamation, 1996). Water conservation measures may have an adverse impact on existing wetlands in the area because, as water delivery systems are made to be more efficient, wetlands that have been created by seepage from existing delivery systems likely would be reduced or dry up all together. However, YRBWEP provides for mitigation of conservation-related wetland losses.

4.7.2.3 Black Rock Alternative

Construction Impacts

Wildlife would be affected most by noise and increased traffic caused by construction and maintenance concentrated primarily at the damsite.

Many species of migratory and resident birds would be affected during construction. Nests and eggs on the ground and in shrubs would be destroyed.

Regarding Black Rock reservoir seepage mitigation features, impacts to wildlife from construction of the cutoff wall and pipeline would be from the construction equipment. Noise and human presence most likely would force wildlife using that area as a migration corridor to move farther east to migrate from the Hanford Site to the YTC and vice versa. Removal of vegetation at the cutoff wall site, pipeline, staging areas, and any spoil piles would affect wildlife termporarily until the native vegetation can be restored.

Currently there is some riparian vegetation along Dry Creek that most likely is used by wildlife. The riparian area downstream from the cutoff wall would not be disturbed. The 6.6 miles between the dam and the cutoff wall could be disturbed during construction, adversely affecting wildlife. If this vegetation is removed to enable work in the streambed, it would be replanted with native vegetation. Short-term impacts resulting from placement of power poles and construction of a powerline maintenance road would be loss of shrub-steppe habitat and a temporary disturbance to wildlife.

No impacts to wetlands would occur during construction of the seepage mitigation features.

Long-Term Impacts

Shrub-Steppe Habitat.**—**The Black Rock Alternative would affect, both directly and indirectly, shrub-steppe habitat within the Black Rock Valley and adjacent lands. These impacts would result from the construction and use of the dam, reservoir, access roads, SR–24 realignment, and recreational development. The proposed reservoir includes the following approximate habitat acreage: 3,539 acres of shrub-steppe, 113 acres of grassland, 3,771 acres of Conservation Reserve Program lands, 1,126 acres of agricultural croplands, 113 acres of developed land (i.e., residential), and some acreage of other habitat types (Service, 2007a).

After conducting a HEP analysis using the Brewer's sparrow as a model, it was determined that 1,692 HUs for the sparrow would be lost completely in the footprint of the reservoir and dam. The total area to be lost to reservoir inundation and the dam is about 8,700 acres. The relatively low number of HUs for Brewer's sparrow at the site, relative to the number of acres, suggests it provides marginal habitat for the sparrow and other shrub-steppe species that it was intended to represent. If the entire site is used to estimate the number of HUs, then the average value of the habitat, on a scale from 0.0–1.0, is about 0.2. If the agricultural and developed lands are omitted, then the value is slightly higher, at about 0.5. This value indicates that the lands within the reservoir and dam footprint are of relatively average value for shrub-steppe species. This may be due largely to the fact that less than half of the site is actually in shrub-steppe.

Indirect impacts could also occur at the site as a result of some increase in activity associated with operations and maintenance and recreation. Indirect adverse effects could include degradation of habitat adjacent to the site through introduction of nonnative invasive plants, increased development in the areas adjacent to the proposed reservoir, and increased fire danger. Given the modest level of recreational enhancement proposed and the disturbed nature of much of the site today, these indirect impacts are not expected to be significant.

Construction of the powerline maintenance road would result in the permanent loss of 5 acres of shrub-steppe habitat. Loss of vegetation along the pipeline, staging areas, spoils area, and the cutoff wall would be minimal because those areas would be replanted.

Vegetation along the 6.6 miles of Dry Creek from the dam to the cutoff wall would change from dryland/bare channel to riparian/wetland/aquatic because water would be in the creek bed continuously.

Movement Corridors.—This alternative would not significantly affect migration of the Rattlesnake Hills elk herd because they still have the potential to move from the ALE Reserve into the YTC along the Yakima Ridge, northeast of the reservoir. Elk have been observed within the Rattlesnake Hills and may be most affected by the southern realignment of the highway and utilities, as well as the associated recreational development.

Black Cottonwoods.—This alternative would improve cottonwood reproduction by seed in several, but not all, reaches as compared to the No Action Alternative. In the upper reaches, few changes would occur because summer flow remains high; thus, recruitment would continue at current low levels. In the Union Gap reach, spring flows would be greater, which would spur increased germination; late summer flows, however, are not reduced much, so the risk of scour remains. Thus, reproduction would increase moderately. The Wapato reach hydrograph shows both greater spring flows and much greater summer base flows, however, moving it closer to estimated natural conditions. These changes would be expected to lead to more frequent and larger (more seedlings) recruitment events. For the Naches River reach, a small reduction in the September flow surge caused by the flip-flop operation may spare some newly established seedlings from scouring but most likely would not change reproduction dynamics. Even though cottonwood reproduction would be improved noticeably on only the Wapato and Union Gap flood plains, this would be a large overall improvement in cottonwood forest trends because these two river segments currently support the largest stands of cottonwood forest in the Yakima River basin.

Wetlands.—During an average water year, water releases associated with the Black Rock Alternative would increase flow and availability of water in the Yakima River (Wapato reach) during the mid-summer growing season. In some cases, this would double or triple the flows available under the No Action Alternative but not reaching the peak flows that occur under the natural flow regime. These flows would probably result in the redistribution and a slight or moderate increase in area of palustrine emergent (PEM) and palustrine scrub-shrub (PSS) wetlands in the Wapato reach. Higher up in the basin in the Cle Elum reach, releases from Cle Elum Lake would be less under this alternative, reducing scour of wetlands during the mid-summer growing season. PSS and PEM class wetlands probably would benefit under this alternative (Reclamation, 2007f).

The 0.9 acre of palustrine wetlands would be inundated by the proposed reservoir and permanently lost as habitat (Service, 2007b). Seepage from Black Rock reservoir and dam would provide subsurface and possibly surface flows that likely would create a wetland plant community in the presently intermittent Dry Creek downstream from the dam. This would create several miles of riparian and wetland habitat along the creek. If not managed specifically for wildlife habitat (i.e., to provide a plant community with native plant species), this area likely would attract invasive plant species such as Russian olive and other nonnative wetland vegetation with minimal habitat value. Fluctuations in the water level in Black Rock reservoir would not be conducive to growth of water-dependent shoreline plant community. The reservoir generally would be full or nearly so through the early part or the growing season, but the water surface elevation would decline rapidly in July and August. The west end of the reservoir pool has a very shallow slope, and a portion of this slope likely would become vegetated with some kind of wetland or riparian vegetation. In the upper end of Potholes Reservoir near Moses Lake, which also has an extensive summer drawdown, an extensive area of shrub-scrub and forested wetlands exists. It is difficult to predict how much of the upper end of Black Rock reservoir would be vegetated.

Wetlands would increase downstream from Black Rock dam and upstream of the cutoff wall.

4.7.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Similar to the Black Rock Alternative, wildlife would be most affected by noise and increased traffic caused by construction and maintenance of the reservoir and dam. However, the dam would be located near SR–821, which already creates some disturbance related to traffic in the area. Bighorn sheep may also avoid the area during the winter if construction occurs at that time. Many species of migratory and resident birds would be affected during construction. Nests and eggs on the ground and in shrubs would be destroyed.

Long-Term Impacts

***Shrub-Steppe Habitat.*—**The Wymer Dam and Reservoir Alternative would have direct and indirect impacts on shrub-steppe vegetation and wildlife within the Lmuma Creek drainage. Many of the impacts would be similar to those described for the Black Rock Alternative and include: inundation of shrub-steppe habitat, impacts to movement corridors, possible exotic plant species invasion, possible increase in fire susceptibility, and indirect impacts associated with the construction of facilities.

Habitat acreage within the footprint includes the following: 1,055 acres shrub-steppe habitat; 167 acres grassland; 62 acres barren land; 50 acres riparian area; 30 acres of cliff/canyon; 11 acres of agricultural cropland; 7 acres developed land; 6 acres forest habitat; 4 acres wetlands (Service, 2007b). Wildlife species known to, or that have the potential to, use this area are included in table 4.20.

The HEP conducted at this site using Brewer's sparrow as the indicator species found that the 378 HUs existing within the footprint of the reservoir and dam would be lost. The total area to be lost to reservoir inundation and the dam is about 1,400 acres. Of this total, about 1,200 provide habitat suitable for Brewer's sparrow. The relatively low number of HUs for Brewer's sparrow at the site, relative to the number of acres, suggests it provides marginal habitat for the sparrow and other shrub-steppe species that it was intended to represent. If the entire site is used to estimate the number of HUs, then the average value of the habitat, on a scale from 0.0–1.0, is about 0.87. This value indicates that the lands within the reservoir and dam footprint are of relatively high value for shrub-steppe species.

Indirect impacts also could occur at the site as a result of some increase in activity associated with operations and maintenance and recreation. Indirect adverse effects could include degradation of habitat adjacent to the site through introduction of nonnative invasive plants, increased development in the areas adjacent to the proposed reservoir, and increased fire danger. Currently, there is a fairly high level of recreational use occurring in the Yakima River Canyon just downstream from the damsite. Given the modest level of recreational enhancement proposed, the disturbed nature of much of the reservoir area today, and the existing level of recreational use in the area, these indirect impacts are not expected to be significant.

Movement Corridors.—Elk movements within the Wymer reservoir vicinity would not be affected. Elk that are west of the Yakima River usually do not cross over, and the Rattlesnake Hills elk herd tends to stay in the YTC's southeastern portion or move north on the eastern side. There is migration southward from the Colockum and Quilomene elk herds, but there is little evidence that these herds move into the Wymer area. WDFW has identified the Wymer reservoir site as core wintering habitat for bighorn sheep and core habitat for mule deer. Based on this, Wymer dam and reservoir could have an effect on movement for these species of wildlife.

Black Cottonwoods.—The Wymer Dam and Reservoir Alternative would result in only negligible changes in the flood plain flow patterns and would not have an adverse effect on cottonwood reproduction when compared to the No Action Alternative.

Wetlands.—Under the Wymer Dam and Reservoir Alternative, flows in the Wapato reach would continue as under existing conditions. PEM and PSS class wetlands would not be affected; however, the degradation of palustrine forested (PFO) wetlands would continue due to the continuing lack of cottonwood recruitment. Eighty-three acres of palustrine (unclassified) wetlands would be inundated by the reservoir and permanently lost as habitat (Service, 2007b). Seepage from Wymer reservoir and dam would provide subsurface and possible surface flows that likely would expand the riparian and wetland plant community in Lmuma Creek downstream from the dam. Fluctuation in the water level in Wymer reservoir would not be conducive to the growth of water-dependent shoreline plant community. Thus, no viable lakeshore fringe habitat value can be expected around the perimeter of the reservoir.

4.7.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction impacts for Wymer reservoir would be the same as for the Wymer Dam and Reservoir Alternative. In addition, there would be effects associated with the construction of the pump exchange system and location of the pipeline and pumping plants.

Long-Term Impacts

Shrub-Steppe Habitat.—The direct and indirect impacts regarding this alternative generally would be similar to those described for the Wymer Dam and Reservoir Alternative. Some additional losses of shrub-steppe habitat may occur if the buried steel pipeline and two of the pumping stations are located in such habitat. Based on the location described for the pipeline at this time, the losses would be very minor.

Movement Corridors.—Elk movement corridors would not be affected beyond the impacts discussed for the Wymer Dam and Reservoir Alternative.

Black Cottonwoods.—The pump exchange component of this alternative would have very similar effects on flood plain hydrographs and, thus, similar effects on cottonwood reproduction as the Black Rock Alternative. Recruitment would be expected to increase moderately in the Union Gap reach and substantially on the Wapato flood plain, while no large changes would occur in other flood plains. This would be an overall improvement for cottonwood forests on the Yakima River because of the large spatial extent of cottonwood stands on the Union Gap and Wapato flood plains.

Wetlands.—Under the Wymer Dam Plus Yakima River Pump Exchange Alternative, summer flows downstream from Parker would be significantly greater than under the No Action Alternative. This flow scenario would probably result in the redistribution and a slight increase in area of PEM and PSS wetlands in the Wapato reach. Similar to the Wymer Dam and Reservoir Alternative, 83 acres of palustrine (unclassified) wetlands would be inundated by the reservoir and lost (Service, 2007b). Seepage from Wymer reservoir and dam would provide subsurface, and possibly surface, flows that would likely expand the riparian and wetland plant community in Lmuma Creek downstream from the dam. At present, overgrazing by livestock is the most detrimental effect to the riparian plant community. Fluctuation in the water level in Wymer reservoir would not be conducive to the growth of water dependent shoreline plant community. Thus, no viable fringe habitat value can be expected around the perimeter of the reservoir.

4.7.2.6 Mitigation

Potential mitigation measures for either the Black Rock or Wymer Dam and Reservoir Alternative include the following:

- Create wetland and riparian habitats. This would entail constructing dikes in shallow water areas within the reservoir and maintaining adequate water levels for the production of wetland/riparian vegetation.
- Establish a wildlife management area adjacent to the reservoir in areas that would be able to provide suitable wildlife habitat.
- Install artificial perches on selected areas adjacent to the new reservoir to provide perches for raptors.
- Create, restore, and/or protect the amount of shrub-steppe habitat that would lead to production of a similar number of HUs elsewhere within the Yakima River basin.
- Conduct plant surveys for threatened and endangered species and protect any species discovered.

In addition to these mitigation measures, potential mitigation measures for the Wymer Dam Plus Yakima River Pump Exchange Alternative could include the following:

- Bury pipelines underground and restore native vegetation along the pipeline corridor. Develop a vegetation maintenance and monitoring plan.
- Locate any aboveground structures in areas that would cause minimal disturbance to wildlife and associated habitats.

4.7.2.7 Cumulative Impacts

Shrub-Steppe Habitat and Wildlife Movement Corridors

Shrub-steppe habitat in eastern Washington has been altered significantly by agricultural, residential, and urban development over the past century. There are three large areas of shrub-steppe remaining in the Yakima River basin; two are on public lands (the YTC and the Hanford Reach National Monument); the third is on the Yakama Reservation. These large blocks are protected from future residential and urban development. Management efforts are occurring or in the process of being implemented at these three remaining sites to preserve, restore, and increase shrub-steppe habitat and connectivity. Both the South-Central Washington Shrub Steppe/Rangeland Conservation Partnership and Washington's Greater Sage-Grouse Recovery Plan seek to implement these objectives for the remaining tracts of shrub-steppe (Stinson et al., 2004). The partnership has acquired a conservation easement for a private property located within the Rattlesnake Hills, south of Moxee (Burkepile, 2007).

Outside of these areas, the residual habitat and the wildlife that subsists within it continue to be threatened by urban and residential development and habitat fragmentation where shrub-steppe occurs on private land. While development to date has been primarily in the valley bottom where irrigated agriculture is dominant, shrub-steppe habitat is being lost to development in some places such as the north slope of the Moxee Valley, the north end of the Yakima River canyon south of Ellensburg, and near Richland and Kennewick. Losses of shrub-steppe habitat at either the Black Rock or Wymer sites would exacerbate these ongoing losses.

Black Cottonwoods

Riparian vegetation in alluvial basins in the Storage Study area has been changed significantly by human actions since at least the mid-19th century. Both upland and lowland watersheds have been altered dramatically by logging, infrastructure development, land clearance for agriculture, urban development, changing fire regimes, and beaver trapping (Eitemiller et al., 2000; McIntosh et al., 2000; Ring and Watson, 1999; Wissmar et al., 1994). Furthermore, direct changes to flood plains and channels have been dramatic since the early 1900s. Irrigation diversions, storage dams, and channel confinement have altered inter-annual and seasonal flow patterns, reduced total annual discharge, severed the connections between channel and flood plain, and changed geomorphic processes (Snyder et al., 2002). These direct changes have had negative consequences for cottonwood seed reproduction (Braatne et al., 2007). Overall, cottonwood forests have a diminished extent, older age structure, reduced diversity, less frequent stand recruitment, and altered species composition as compared to pre-European conditions.

Future actions that have the potential to affect black cottonwood recruitment include the Wapato Irrigation Project (WIP) conservation measures, planned growth in the Yakima River basin, and some Washington State Department of Transportation (WSDOT) projects.

The WIP conservation measures will add to instream flow levels in the Wapato reach of the Yakima River during summer months (irrigation season). Increased summer base flows would benefit cottonwood reproduction as already explained. The volume to be added by the WIP conservation measures is likely to be small, perhaps 50–100 cfs during an average irrigation season (Crane, 2007). Such a small change would not significantly affect reproduction dynamics from the effects already described for each alternative. Growth in population and water demand has been forecast and incorporated in the modeled flow data; therefore, it already has been accounted for in the analysis. WSDOT projects may have localized affects on flow but are not expected to affect flow or cottonwood reproduction dynamics over a river reach or valley segment scale. In summary, none of the reasonably foreseeable future actions likely would have any significant effect on cottonwood forest dynamics.

Wetlands

Cumulative impacts from other projects most likely would be beneficial or insignificant. The water conservation projects that increase flows in the rivers would benefit vegetative growth in the wetlands. Any projects that would have an impact to wetlands would be mitigated to minimize impacts by State and Federal agencies.

4.8 Anadromous Fish

4.8.1 Affected Environment

4.8.1.1 Columbia River

Extent of Affected Area

The areas of interest include the lower Priest Rapids Lake and the downstream segment of the Columbia River, including the Hanford reach, and extending to include the confluence of the Yakima River with the Columbia River (figure 2.1 in chapter 2).

Priest Rapids Dam is located at RM 397 on the Columbia River. The lake behind the dam is approximately 18 river miles long. The 7 river miles immediately upstream of the dam is like a lake, with slower currents and deeper water depths; the uppermost 11 river miles of the pool is more like a river, with a faster current and shallower water depths.

The Hanford reach of the Columbia River extends approximately 62 river miles from the mouth of the Yakima River (RM 335) to Priest Rapids Dam (RM 397). The Hanford reach is the last remaining free-flowing portion of the Columbia River within the United States; however, flows are subject to daily fluctuations resulting from hydroelectric power generation at Priest Rapids Dam.

A more indepth description of the Hanford reach and Priest Rapids Lake can be found in the *Priest Rapids Hydroelectric Project, Washington Final Environmental Impact Statement* (FERC, 2006).

Status and Distribution

Spring, summer, and fall Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), steelhead (*O. mykiss*), and sockeye salmon (*O. nerka*) migrate through the Hanford reach and downstream from Priest Rapids Dam, destined for upriver subbasins (i.e., Wenatchee, Entiat, Methow, and Okanogan). Fall Chinook spawn, rear, and begin their seaward migration within the Hanford reach and, to some extent, in Priest Rapids Lake (FERC, 2006).

Anadromous Salmonids Status

Table 4.22 shows the 10-year average (1997–2006) of anadromous salmonid adult counts downstream from Priest Rapids Dam.

Peak migration for adult anadromous salmonids through the Hanford reach and Priest Rapids Dam is April–November. Juveniles migrate downstream April–August; peak migration occurs April–June (table 4.23) (FERC, 2006).

Table 4.22 10-year anadromous salmonid adult counts downstream from Priest Rapids Dam (1997–2006)

Species	10-year average fish count	10-year range in fish counts
Spring Chinook	17,852	4,186–52,120
Summer Chinook	50,400	13,922–96,167
Fall Chinook	33,702	11,266–54,453
Coho	2,896	19–11,186
Sockeye	55,683	10,769–124,943
Steelhead	12,838	5,837–29,963

Table 4.23 Summary of the upstream (adults) and downstream (juveniles) migration timing for anadromous salmonids in the Hanford reach and at Priest Rapids Dam (based on information contained in FERC, 2006)

Species/run	Upstream migration timing	Downstream migration timing
Spring Chinook	Upstream migration timing	April–June
Summer Chinook	Mid-May–mid-August	June–August
Fall Chinook	Mid-June–mid-August	June–August
Coho	Mid-August–November	April–June
Sockeye	July–November	April–June
Steelhead	September–November	April–June

4.8.1.2 Yakima River

Extent of Affected Area

The areas of interest include the existing and proposed reservoirs within the basin and the mainstem of the Yakima, Naches, and Tieton Rivers from headwater reservoirs to the confluence of the Yakima River with the Columbia River (figure 2.1 in chapter 2).

Distribution of Steelhead and Salmon

Spring and fall Chinook, coho, and steelhead currently reside in the Yakima River basin, while summer Chinook and sockeye have been extirpated. Coho were extirpated in the 1970s but were reintroduced in the mid-1980s. Spring Chinook spawn and rear as juveniles in the Bumping, American, Little Naches, upper Yakima, and Naches Rivers. Fall Chinook generally spawn and rear as juveniles in the Yakima River downstream from the Naches River to the mouth of the

Yakima River. Steelhead spawn and rear as juveniles in many of the tributaries to the Yakima and Naches Rivers, including the mainstem of the Naches and upper Yakima (upstream of Roza Diversion Dam) Rivers. Coho (reintroduced) spawn and rear primarily in the Wapato and Ellensburg reaches of the Yakima River and in the lower Naches River downstream from the Tieton River. Some coho spawning and rearing is known to occur in Ahtanum, Cowiche, Taneum, Wilson, Reecer, and Big Creeks in the Yakima River basin. Coho spawning and rearing also occur in the Nile and Pileup Creeks and the North Fork of the Little Naches River in the Naches River subbasin.

Anadromous Fish Status

The discussion of anadromous salmonid life histories is limited to spring Chinook and steelhead in this section. See an indepth discussion of spring and fall Chinook, coho and steelhead, their life history, and demographics in *Habitat Limiting Factors, Yakima River Watershed Final Report* (Haring, 2001).
Table 4.24 provides annual Yakima salmon and steelhead adult counts at Prosser Diversion Dam.

Table 4.24 Annual Yakima salmon and steelhead adult counts at Prosser Diversion Dam (RM 47)

Year	Spring Chinook	Fall Chinook	Coho	Year	Steelhead
1997	3,173	1,120	1,312	1997–98	1,113
1998	1,903	1,148	4,679	1998–99	1,070
1999	2,781	1,896	3,943	1999–00	1,611
2000	19,101	2,293	6,216	2000–01	3,089
2001	23,265	4,311	5,046	2001–02	4,525
2002	15,099	6,241	818	2002–03	2,235
2003	6,957	4,875	2,354	2003–04	2,755
2004	15,289	2,947	2,389	2004–05	3,451
2005	8,758	1,942	3,115	2005–06	2,005
2006	6,314	1,528	4,510	2006–07	1,537
10-year average	10,264	2,830	3,438	10-year average	2,339

Salmon and steelhead were once abundant in the Yakima River basin, but native populations of sockeye, coho, and summer Chinook have been extirpated. Historically, sockeye were present in many natural lakes within the basin, including Keechelus, Kachess, Cle Elum, and the smaller lakes upstream of Cle Elum and Bumping Lakes (Reclamation, 1999). Sockeye disappeared from the Yakima River basin with the construction of dams for storage reservoirs. Anadromous fish currently using the basin include steelhead, spring and fall Chinook, and coho (reintroduced). Anadromous fish spawn and the resulting young fish rear in the basin; juvenile fish migrate to the ocean to become adults, and adults return to spawn. While there are differences in the resource requirements for various species and life stages, there are also similarities; the summer steelhead is used to represent the general habitat requirements of anadromous fish in the Yakima River basin. Spring Chinook, because of the interest in the flip-flop operation, also is addressed.

***Steelhead.*—**The greatest abundance of steelhead is found in the Satus, Toppenish, Naches, upper Yakima, and Ahtanum River watersheds. Steelhead enter the Yakima River in greatest numbers September–November and then again in February–April (Haring, 2001). The majority of adults spend the winter months holding in deep, slow pools in the Yakima River in the vicinity of Satus Creek, though some move into the Naches and upper Yakima Rivers. Adults spawn March–June, with early spawning occurring in Satus and Toppenish River watersheds and late spawning occurring in the Naches and upper Yakima River watersheds. The majority of spawning occurs in tributaries rather than the mainstem of the Naches and upper Yakima Rivers. Similar to other salmon species, steelhead require small gravels free of fine sediment for successful egg incubation and hatching. Fry emerge from the gravel from May into July. Satus and Toppenish River fry emerge beginning in May, and Naches and upper Yakima River fry emerge in June and July. Like all salmon species, emergent steelhead fry require shallow and very slow-velocity water, preferably with associated cover to avoid predators. As young steelhead grow in size, they seek deeper and faster water with associated cover that provides both protection from predators and resting areas. Yakima River basin steelhead spend from 1–3 years living in freshwater before they begin their seaward migration. April is the peak outmigration month at the Chandler Juvenile Monitoring Facility located at Prosser Diversion Dam (RM 47). As with other salmon species, steelhead rely on spring freshets to move them successfully downriver through the Yakima River into the Columbia River.

***Spring Chinook.*—**The upper Yakima, Naches River subbasin, and American River spawning groups comprise the Yakima River basin spring Chinook population. About 60–70 percent of the population returns to the upper Yakima (Keechelus Dam to Ellensburg) and Cle Elum Rivers annually. Adult spring Chinook return to the Yakima River beginning in late April–June and swim upstream to their spawning areas. However, spawning does not occur until August (American River) and September (Naches and upper Yakima). Prespawning adults require deep holding pools with adequate overhead cover and water that is cool and well oxygenated. Females typically build their spawning nests near the streambank, close to cover, in water 12–30 inches deep with moderate velocities. Successful egg incubation and fry emergence requires spawning gravels that are relatively free from fine sediments which can impede water percolation through the spawning nest and entomb emergent fry. Emergent spring Chinook fry seek out quiet, shallow waters with instream cover near the shoreline, which afford a hospitable rearing environment. As the juveniles increase in size, they move into deeper, faster water—preferably with instream cover such as a log jam or overhanging vegetation along the bank margin. The combination of faster water with resting areas created by the instream cover allows juveniles to dart into the current to capture drifting insects and then return to the area of low velocity. A portion of the juveniles will move slowly downstream from the time of emergence throughout the summer. With onset of cooler water temperatures in the fall, a more pronounced downstream movement of juveniles begins in late September and can extend through the winter. It is thought that most of these fall-winter moving juveniles spend the winter in deep, quiet water with overhead cover in the lower Naches and Yakima (upstream of Prosser Diversion Dam) Rivers. After spending 1 year in fresh water, spring Chinook begin their seaward migration, with the majority passing Prosser Diversion Dam (RM 47) in April. Returning adults can spend from 1–3 years in the ocean before returning as a spawning adult to the Yakima River basin.

4.8.1.3 Habitat Conditions

Habitat is defined as ". . . the combination of resources (like food, cover, water) and the environmental conditions (temperature, precipitation, presence or absence of predators and competitors) that promotes occupancy by individuals of a given species (or population) and allows those individuals to survive and reproduce. . ." (Morrison et al., 1978).

Numerous instream and flood plain elements of habitat (e.g., substrate, LWD, pool frequency and quality, off-channel areas, and refugia) combine to produce habitat heterogeneity and are vital to the production and maintenance of native fish assemblages (Everest et al., 1985; Bjornn and Reiser, 1991; Karr, 1991; Spence et al., 1996; National Research Council [NRC], 1996; National Marine Fisheries Service, 1996). The interaction of these habitat elements, combined with streamflow and other physicochemical determinants, produces a complex mosaic under which native aquatic species assemblages evolved and live.

Flow/Hydrology

The results of other studies suggest that the natural, unregulated flow regime of the Yakima River and its tributaries was the master variable that nourished the distribution and abundance of riverine species and sustained the ecological integrity of the ecosystem via physicochemical processes that provide riverine structure and function (Leopold et al., 1964; Schlosser, 1985; Resh et al., 1988; Allan, 1995; Power et al., 1995; Stanford et al., 1996; Poff et al., 1997).

Flow variability provides ecological benefits to flood plain ecosystems and the terrestrial and aquatic organisms that depend upon them (Williams and Hynes, 1977; Chapman et al., 1982; Poff and Ward, 1989; Closs and Lake, 1996). The natural timing of variable flows provides numerous environmental cues for fish to spawn, hatch eggs, rear, move to off-channel flood plain habitats for feeding or reproduction, and migrate upstream or downstream, etc. (Seegrist and Gard, 1972;

Montgomery et al., 1983; Nesler et al., 1988; Junk et al., 1989; Welcomme, 1992; Naesje et al., 1995; Sparks, 1995; Trepanier et al., 1996, Poff et al., 1997).

Under the current condition, riverflows are altered substantially as a result of storing water in the reservoirs in the winter and diverting water in the spring, summer, and fall to meet entitlements, primarily for irrigation. Flow regimes that deviate substantially from the natural condition, as is currently the case in the Yakima River basin, are well understood to produce a diverse array of ecological consequences (Hill et al., 1991; Ligon et al., 1995; Richter et al., 1996; Stanford et al., 1996). While a range of flows is vital to the structure and function of aquatic ecosystems, stable base flows are important in supporting high growth rates for fish that are timed with periods of high ecosystem production (i.e., late spring through early fall) (Binns and Eiserman, 1979; Poff and Ward, 1989; Stanford et al., 1996).

Thus, natural streamflow variability has a controlling effect on the biology of native aquatic species assemblages and the physical and chemical ecosystem attributes upon which they depend for survival. Current conditions have inverted and truncated the natural flow regime, producing river systems that are out of phase with their natural runoff regimes.

Temperature

Perhaps no other environmental factor has a more pervasive influence on salmonids and other aquatic biota than temperature (Brett, 1956; Hynes, 1970; Spence et al., 1996). Temperature influences all aspects of fish life, as well as those of the macroinvertebrates (Sweeney and Vannote, 1986; Bjornn and Reiser, 1991) and primary producers (algae, bacteria, etc.) that dwell within the stream and serve as food for fish (Hynes, 1970). The majority of aquatic organisms are coldblooded, meaning that their body temperatures and metabolic demands are determined by the temperature of the environment in which they live.

Slight changes in stream temperatures that differ from the natural condition can alter the processes listed above and most often adversely affect native aquatic species assemblages (Groot et al., 1995; Spence et al., 1996; McCullough, 1999). Quantitatively defining the effects of temperature on key biological functions is essential for understanding how temperature contributes to fish success, how it places species at risk, and how moderating and controlling the thermal regime can contribute to recovering impaired populations (McCullough, 1999; Sullivan et al., 2000). However, it is a widely held view that high water temperatures are one of the most harmful environmental variables affecting salmonid extent, biomass, and survival (Spence et al., 1996).

Dams, riparian vegetation removal, water withdrawal and regulation, irrigated agriculture, channel engineering (e.g., straightening, channelization, diking, revetments, etc.), urbanization, increasing impervious surfaces, and flood plain development alter the factors that drive stream temperature (Poole and Berman, 2001). All of these factors occur in the Yakima River basin to some extent and have altered the temperature regime from the predevelopment, natural condition. Water temperature, especially in the lower Yakima River, has consistently been acknowledged as a factor affecting salmonids, especially during some life stages. High temperatures at the mouth of the Yakima River may affect anadromous fish, including migrating smolts and adults. In the upper parts of the basin, bottom draw release structures, like those used at Keechelus, Kachess, Cle Elum, Rimrock, and Bumping Dams, provide thermally homogeneous, cold discharge to the Yakima, Kachess, Cle Elum, Tieton, and Bumping Rivers, which may interfere with certain aspects of salmonid ecology in the Yakima River basin (e.g., migration cues, spawn timing, and growth).

Sediment

Suspended sediment is a naturally variable phenomenon in riverine ecosystems, and increased concentrations above background levels are most strongly correlated with erosional processes and elevated discharge observed during spring runoff, or discrete precipitation events. Heavy loads of suspended sediments directly impact salmonids through their avoidance of impacted habitats, mortality (in extreme cases), a skewed distribution of prey species within the habitat, reduced feeding and growth, and reduced tolerance to disease (Waters, 1995). Sediment and bedload movement occur naturally. It is acknowledged that sediment (fine sediments to cobble) transport is beneficial to the ecological health of a river system (Poff et al., 1997). However, irrigated agricultural activities have altered the timing, volume, and magnitude of sediment movement in the river by modifying the magnitude and timing of riverflows.

Large Woody Debris

In recent years, the relationship between LWD (loosely defined as trees greater than 4 inches in diameter, greater than 6 feet long, with or without the root wad attached), riparian vegetation, and fish habitat has received much emphasis in the Pacific Northwest. Flow regime alteration by impoundment and diversion can affect the cycling of organic and inorganic materials, including LWD. Numerous authors have described the interactions between LWD and stream ecosystems (Bisson et al., 1987; Sedell et al., 1988; Bilby and Bisson, 1998). Additionally, the influence of LWD on channel morphology (Keller and Swanson, 1979; Lisle, 1986; Bilby and Ward, 1991; Montgomery et al., 1996) and its importance to the ecology of native aquatic species assemblages in the Pacific Northwest (Abbe and Montgomery, 1996; Naiman et al., 1992; Naiman et al., 1998; McIntosh et al., 1994; Naiman and Décamps, 1997) also has been documented and analyzed. LWD is an important element in the creation of complex habitats and pools.

Recruitment of LWD likely has been affected by many human activities in the Yakima River basin. First, headwater source areas were removed from the river continuum by construction of the storage dam embankments on the Yakima, Kachess, Cle Elum, Tieton, and Bumping Rivers. Natural lakes on all these streams, except the Tieton, may have acted to some extent as LWD "traps" before the dams were built. Farther down the system, diversion structures may impede the transport of LWD. To large extent, however, LWD is simply passed over these structures as part of operations. Secondly, flow regulation and extraction has contributed to impaired flood plain function along alluvial reaches of the river (Snyder and Stanford, 2001). Cottonwoods (*Populus spp.*) are a primary species along the alluvial flood plain reaches of the Yakima River basin. Their growth and survival are important to the aquatic ecosystem. The status of cottonwoods in the Yakima River basin is discussed further in section 4.7, "Vegetation and Wildlife."

Channel Condition and Dynamics

Truncation of flood peaks by capturing them in reservoirs reduces the duration, magnitude, and spatial extent of flood plain inundation. This not only alters the quantity, quality, and timing of groundwater discharge to the river but also diminishes the availability, extent, and temporal duration of off-channel habitats for anadromous and resident fish. Among the myriad habitat attributes of these flood plain ecosystems, off-channel areas provide complex, diverse habitats for cold water fishes. Flood flows form and maintain the channel network including side channels. In turn, side channels and sloughs provide a large area of edge habitat and slower water velocities favored by early salmonid life stages (Pringle et al., 1988; Naiman et al., 1988; Stanford and Ward, 1993; Arscott et al., 2001). Spring brooks receiving discharging groundwater provide low-velocity, thermally moderate, food-rich habitat for juvenile fish. For salmonids in the Yakima River basin, these side-channel complexes likely help to increase productivity, carrying capacity, and life history diversity by providing suitable habitat for all life stages in close physical proximity (Ring and Watson, 1999; Snyder and Stanford, 2001).

Flood plain disconnection combined with flow regulation has reduced river flood plain interactions in the Yakima River basin. Of particular importance has been the loss of habitat complexity, including connectivity between off-channel and mainstream habitats, which directly relates to the ability of the ecosystem to support salmonid populations, including steelhead and bull trout. Flood control dikes and levees and railroad and highway construction have disrupted the lateral connectivity between wetted areas that occurred historically (Eitemiller et al., 2002). This deprivation of lateral connectivity has resulted in loss of habitat, reduced vertical connectivity, loss of or changes in nutrient flux, and reduction in the tempering affect of groundwater on stream temperature. The result has been a significant loss, compared to pristine conditions, of horizontal and vertical connectivity, diminished habitat heterogeneity through the loss of off-channel habitat, and a general loss of ecosystem function.

Habitat Alterations

Alterations in the aquatic ecosystem have affected the habitat of anadromous fish in the Yakima River basin. In its most basic form, regulation alters streamflow volume, sediment transport, flood plain connectivity, and water temperature.

The Yakima River basin has experienced well over 100 years of Euro-American development, with a marked increase seen after the advent of storage reservoirs and watercourse (e.g., canals, drains, ditches, laterals) development in the early 20th century. Consequently, there is a long history of forest practices and flood plain development for irrigated agriculture, urban centers, roadways, railways, and housing (McIntosh et al., 1994; Reclamation, 2000). As development progressed, so did the magnitude and extent of flood plain revetments (e.g., levees, road and railway prisms, riprap, etc.) intended to protect local infrastructure. However, flood plain activities and revetments have armored, shortened, realigned, and simplified many miles of mainstem and tributary habitat in the Yakima River basin (Dunne and Leopold, 1978; Snyder and Stanford, 2001; Braatne and Jamieson, 2001). Consequently, channel form and processes have been altered (Leopold et al., 1964), and the potential for normal riparian processes (e.g., shading, bank stabilization, and LWD recruitment) to occur is diminished (Ralph et al., 1994; Young et al., 1994; Fausch et al., 1994; Dykaar and Wigington, 2000). Ultimately, the once diverse and extensive assemblage of riparian and aquatic habitats in the Yakima River and its tributaries has become simplified (Stanford et al., 1996; Ring and Watson, 1999).

As a result of irrigation development in the Yakima River basin, including development of the Yakima Project, runoff in the system has become highly regulated for multiple purposes. Regulation of streamflow—whether that regulation is for flood control, irrigation, or for some other purpose—alters the physical environment of the system (Collier et al., 1996; Stanford et al., 1996; Poff et al., 1997; Friedman et al., 1998).

4.8.2 Environmental Consequences

As discussed, flow is an important variable affecting many aspects of habitat suitability for anadromous fish. Consequently, the various alternatives being considered could affect anadromous fish primarily by altering habitat quantity and quality as a consequence of changing the flow regime in various parts of the basin and at various times. These flow changes drive most of the following anadromous fish effects analysis.

Two of the alternatives also change the source of the water for some of the basin's irrigation. This potentially affects the homing of anadromous fish into the Yakima River basin and is also an important part of this analysis.

4.8.2.1 Methods and Assumptions

Columbia River

An issue identified by the Biology Technical Work Group (2004) was the potential effects of water withdrawal from Priest Rapids Lake to fill Black Rock reservoir on anadromous fish spawning and rearing habitat, fry and juvenile stranding, and passage and migration.

The report by Anglin et al. (2006) discussing the effects of hydropower operations on the Hanford reach fall Chinook population was used to assess the potential effects of water withdrawal from Priest Rapids Lake on anadromous fish spawning, rearing, and stranding. Specifically, Anglin et al. (2006) provide information on changes in fall Chinook spawning and rearing habitat and in juvenile stranding as a function of river discharge.

The *Assessment of the Effects of the Yakima Basin Storage Study on Columbia River Fish Proximate to the Proposed Intake Locations* (Reclamation, 2008d) examined the effects of the Black Rock pumping station located at Priest Rapids Lake on anadromous and resident fishes residing in or migrating through the pool. The report also provides a list of fish species documented to reside in or migrate through Priest Rapids Lake.

Yakima River

RiverWare and Flow Data—Most of the indicators for anadromous fish link at some point to the flow data generated from the Yak-RW model. Results at critical locations in the river system are discussed in section 4.2, "Water Resources." The Yak-RW model is a riverflow model used to estimate daily average streamflow at several locations throughout the Yakima River basin, daily irrigation diversions, and daily reservoir storage volume by reservoir for each alternative. A detailed description of the Yak-RW model is found in the *System Operations Technical Document* (Reclamation, 2008b).

Temperature.—There were no substantial differences in water temperature between the Joint Alternatives and the No Action Alternative for the Yakima River stream reaches between Roza and Prosser Diversion Dams, which was the modeled reach, as shown in section 4.6, "Water Quality." Because there were no substantive differences in water temperature between alternatives, this topic is not discussed further for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives.

A description of the Stream Network Temperature model is presented in section 2.2.6 of *Aquatic Ecosystem Evaluation for the Yakima River Basin* (Reclamation, 2008e). In addition, the USGS technical report on the Yakima temperature model (Voss et al., 2008) can be downloaded from the following Web address: http://pubs.usgs.gov/sir/2008/5070/.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—

Description.—Typically, in unregulated streams, low streamflows occur in the summer after the spring snowmelt, resulting in the creation of more pool habitat preferred by juvenile salmonids. In the upper Yakima River, storage releases for irrigation delivery result in high flow levels and associated water velocities which reduce the amount of suitable rearing habitat. This results in fish occupying unfavorable habitats that decrease juvenile survival. Consequently, the river environment is not capable of supporting a larger fish population.

This indicator quantifies the difference in the amount (acres) and percent in juvenile spring Chinook and steelhead summer rearing habitat relative to the No Action Alternative for the Easton and Ellensburg reaches, which represent the upper Yakima River where high summer flows occur in important salmonid rearing areas. Of the five reaches that were modeled to describe the flow-to-fish habitat relationship, these two reaches were selected for this indicator because they are located in the upper Yakima River where high summer flows occur.

Method.—The DSS model for the Easton and Ellensburg reaches was used to estimate the amount (acres) and difference in summer rearing habitat for the spring Chinook and steelhead fry and yearling life stages for each of the three alternatives compared to the No Action Alternative.

Estimated daily average streamflows for each alternative are supplied as output from the Yak-RW model. The relationship between habitat quantity and streamflow for each species and lifestage requires output from the two-dimensional hydraulic flow models that were developed for the Easton, Ellensburg, Union Gap, Wapato, and lower Naches River reaches.

A detailed description of the DSS model and its development for the Yakima River basin is found in the USGS draft Open File Report 2008-1251 (Bovee et al., 2008).

Two-Dimensional Hydraulic Model Description.—This study used the two-dimensional hydraulic models, SRH-W (formerly GSTAR-W) and the River2D, to characterize the riverflow conditions over a range of streamflows in the Easton, Ellensburg, Union Gap, Wapato, and lower Naches River reaches. A description of the SRH-W model is found on Reclamation's Web site at: http://www.usbr.gov/pmts/sediment/model/srh2d/index.html, and a description of the University of Alberta's River2D model is found at: http://www.river2d.ualberta.ca/description.htm.

Hydraulic models are physical models that describe how flow moves through a channel based on its configuration, slope, and the amount of discharge. For this analysis, the river channel bathymetry (the three-dimensional contour of the wetted river channel) was measured primarily using an aerial topography mapping system (LIDAR) supplemented in some locations with traditional surveys and hydroacoustic mapping. Using the channel shape data, the two-dimensional hydraulic model estimates channel width, water depth and velocity, and water surface elevation at points throughout the modeled reach arranged in a grid pattern. These physical parameters were later used to characterize fishery habitat (e.g., pool, riffle, glide).

Development of the two-dimensional hydraulic model for the Easton, Ellensburg, and lower Naches River reaches is discussed in *Identifying Stream Habitat Features with a Two-Dimensional Hydraulic Model* (Reclamation, 2007h). Development of the two-dimensional hydraulic model for the Union Gap and Wapato reaches is discussed in appendix 1 of Bovee et al. (2008).

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.—

Description.—Unnatural and relatively sudden changes in streamflow and elevation can disrupt the habitats of both fishes and aquatic insects. The first measurement for this indicator is the average rate of change in daily streamflow during the flip-flop operation for the Easton, Ellensburg, and lower Naches River reaches. This measurement shows how significant the average rate of change in daily streamflow might be in terms of spatial change in habitats for juvenile salmonids. The greater the rate of change in average daily streamflow, the greater the potential for habitat disruption.

The second measurement for this indicator is the average daily flow before and after the flip-flop operation and the absolute difference in flow for the Easton, Ellensburg, and lower Naches River reaches. This measurement provides some context for the magnitude of change in streamflow and its potential effect on fish habitat.

Method.—The Yak-RW model was used to estimate the daily average streamflow for the Easton, Ellensburg, and lower Naches River reaches for each alternative. These flows were used to calculate the average rate of change in streamflow during the flip-flop operation and the median flows and change in magnitude of flows before and after the flip-flop operation. The average rate of change in daily streamflow during the flip-flop operation was calculated by taking the difference in the average median flow before and after flip-flop and dividing it by 30 days, the number of days from the start to the completion of the flip-flop operation. The before flip-flop period was August 1–15, and the after flip-flop period was September 14–28. The calculated flow values used to determine the average rate of change in daily streamflow during the flip-flop operation were also used to determine the median flows and change in magnitude of flows before and after the flip-flop operation.

Indicator 3: Spring Flow Downstream from the Parker Gage.—

Description.—The reduction in the magnitude, frequency, and runoff pattern of spring freshets that smolts rely on for their seaward migration causes increased migration time and exposure to predators, an environment more conducive to predators, and body chemistry issues related to delayed migration into saltwater. This decreases survival rates for the Columbia River.

Method.—This indicator measures the volume (acre-feet) of water that flows downstream from the Parker gage during the spring season of March–June based on average daily flows generated by the Yak-RW model. For the No Action Alternative, the spring season water volume is compared to the desired target volume and is expressed as a percentage of how much it is above or below the target volume. The three Joint Alternatives are compared to the No Action Alternative in a similar fashion.

The spring freshet runoff pattern, as opposed to the runoff quantity, for the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives is qualitatively compared to the No Action Alternative and is ranked as “no change” or “improved.”

This indicator provides a way to gauge what the potential change in smolt survival might be by comparing the percent change in spring flows under an alternative to the No Action Alternative.

Indicator 4: July–September Flow Downstream from the Parker Gage.—

Description.—Reduced summer flows in the Wapato flood plain, considered some of the best salmonid habitat that remains in the basin, is an issue because of reduced availability of summer rearing habitat. Of concern is the loss of off-channel and side-channel habitat.

Method.—The indicator is the amount of coho summer yearling habitat (acres) in the Wapato reach. The DSS model was used to estimate the average amount of habitat in the Wapato reach for the summer period of July–September. Total habitat quantity and how it compares to the No Action Alternative were recorded. The coho summer yearling life stage was selected because juvenile coho are present in the Wapato reach during the summer and readily use pool and side-channel habitat for summer rearing.

Indicator 5: Estimated Anadromous Fish Population Size.—

Description.—The projected numerical response of the anadromous fish populations under the Joint Alternatives compared to the No Action Alternative provides a way to estimate the anadromous fishery benefits.

Method.—The EDT model provides estimates of population size and productivity for salmon and steelhead based on the quantity and quality of habitat within a watershed. On the basis of the quantity and quality of habitat, the EDT model tracks population survival by life stage. Survival rates remain static under all alternatives for all lifestages that occur outside of the Yakima River basin (e.g., lower Columbia River, Columbia River estuary, and ocean). Therefore, any observed differences in population size between alternatives are due to differences in habitat quantity and quality within the Yakima River basin specific to each alternative.

Output from the Yak-RW (daily flow) and the two-dimensional hydraulic habitat models provided input for the EDT flow and habitat attributes for each alternative. Information pertaining to the relative change in daily maximum water temperature between alternatives generated by the USGS-Tacoma's water temperature model was used for stream reaches from Roza to Prosser Diversion Dams. (See section 4.6, "Water Quality," for a model description.)

This analysis used the EDT model in conjunction with the AHA model to compare change in average annual escapement of steelhead and spring Chinook between alternatives based on a 100-year simulation which takes into account fluctuations in ocean survival. Fish escapement numbers are inclusive of both natural and hatchery fish populations.

A disparity occurs in the escapement numbers for coho between observed and those estimated by the EDT and AHA models. This disparity occurs because the EDT model estimates population equilibrium abundance—meaning the population is approaching full capacity for current habitat conditions. The Yakima coho population is relatively new, having been reintroduced in the mid-1980s, and has not expanded fully into all potential reaches in the basin.

Indicator 6: False Attraction.—

Description.—Because the Storage Study is currently in a planning feasibility phase, it was deemed prudent to initially address the issue of false attraction through a literature review and expert opinion. Reclamation's Technical Service Center secured the expertise of Dr. Andrew Dittman with National Marine Fisheries Service, Northwest Fisheries Science Center, and Dr. Thomas Quinn, University of Washington, School of Aquatic and Fishery Sciences, to assist in assessing the possible outcomes of false attraction associated with the Storage Study. A complete discussion of their work can be found in *Assessment of the Effects of the Yakima Basin Storage Study on Columbia River Fish Proximate to the Proposed Intake Locations* (Reclamation, 2008d).

Method.—Dittman and Quinn identified four primary questions to be evaluated regarding the issue of false attraction for the Storage Study. For both the Yakima and Columbia Rivers, how does the infusion of Columbia River water into the Yakima River affect the homing/straying patterns of:

- Salmon that migrated to sea before the diversion was completed and, thus, were not exposed to an admixture of Yakima-Columbia River water prior to returning as adults?

- Salmon that migrated to sea after the diversion was completed and, thus, were exposed to an admixture of Yakima-Columbia river water prior to returning as adults?

They identified two issues that could influence the effect of Columbia River water entering the Yakima River on Yakima returning adult salmon. These issues were: what was the proportion of Columbia River water entering the Yakima River through the irrigation system; and the extent that the chemical signature of the Columbia River water is lessened as it is exchanged through seepage through the soil. Dittman and Quinn had no way to quantify this influence. In general, it is assumed that both a smaller proportion of Columbia River water and/or increased exposure of this water to Yakima River basin soils will decrease the risk of false attraction for Yakima returning adult salmon.

They suggest there likely is a decreased risk of false attraction for Yakima returning adult salmon that, as juveniles, were incubated, hatched, and reared on Yakima River water after the diversion of Columbia River water commenced (termed second-generation fish), as opposed to returning adults that, as juveniles, incubated, hatched, and reared on Yakima River water prior to the influence of Columbia River water (termed first-generation fish) but return after the diversion of Columbia River water commenced.

For salmon returning to rivers upstream of the Yakima River confluence (i.e., Wenatchee and Methow) for both before and after the release of Columbia River water into the Yakima River basin, Dittman and Quinn suggest that the risk of false attraction by these salmon populations would be less than compared to the false attraction risk for Yakima returning adults to the Yakima River described above. Their rationale was that Columbia River water entering the Columbia River at the Yakima River confluence would be sufficiently modified in terms of the chemical signature that returning adults would be seeking as a homing queue. They suggest the greatest risk would be to the first-generation fish compared to the second-generation fish.

4.8.2.2 Summary of Impacts

Columbia River

The maximum amount of water that is pumped from Priest Rapids Lake is 3,500 cfs. The greatest percent of Columbia River water pumped occurs in September at 4 percent, followed by 3.4 percent in October. For the remaining months, with the exception of July and August when no pumping occurs, the amount of Columbia River water pumped is less than 1 percent.

The amount of change in fall Chinook spawning habitat in the Hanford reach due to power generation is expected to be much greater than that which may result from the maximum withdrawal of 3,500 cfs from Priest Rapids Lake to fill Black Rock reservoir. For example, riverflows on the Hanford reach in 2004 measured at White Bluffs (RM 370) during the peak fall Chinook spawning period (November 4–14) fluctuated from a low of approximately 50,000 cfs to a high of 160,000 cfs (Anglin et al., 2006), which is several times greater than the water withdrawal associated with the filling of Black Rock reservoir. In addition, the water withdrawal pumping schedule adheres to the spawning flow requirements dictated by the Vernita Bar Agreement approved by FERC in 1980.

Nugent et al. (2002a; 2002b; 2002c) report that, during the period of fall Chinook emergence and rearing, the Priest Rapids Dam tailrace can fluctuate up to 6.9 feet (2.1 meters) per hour and 13.1 feet (4 meters) per day in a 24-hour period. Fluctuations in river stage occur in the Hanford reach year-round as a result of power generation, which affects the habitat for juvenile anadromous salmonids and increases the risk of stranding. These effects overshadow the small decrease in the amount of available habitat in the Hanford reach, as a consequence of withdrawing, through pumping, 3,500 cfs from Priest Rapids Lake based on the juvenile fall Chinook habitat to river discharge relationship defined by Anglin et al. (2006). Furthermore, pumping from Priest Rapids Lake occurs only when water is available above the established 2004 BiOp target flows downstream from Priest Rapids Dam. In conclusion, water withdrawal from Priest Rapids Lake is not expected to have a substantive effect on existing habitat availability or on the risk for stranding of juvenile anadromous salmonids residing in the Hanford reach.

In all likelihood, the elevation of Priest Rapids Lake would remain unchanged to maintain optimal pool elevation for power generation. Therefore, there are no anticipated impacts to anadromous fish residing in the lake.

If river outflow at Priest Rapids Dam is reduced by the amount of water withdrawn by pumping into Black Rock reservoir (maximum 3,500 cfs) to maintain pool elevation, it is not expected to affect anadromous adult fish migrating downstream from Priest Rapids Dam.

It is not likely that many anadromous salmonid smolts would become entrained into the pump intake channel because their outmigration behavior is to follow the thalwag where the river current is the fastest. Typically, smolts do not outmigrate near shore where the current is slow (and where the entrance to the pump intake channel is located). Additionally, the approximate average monthly percent of water being pumped from the Columbia River is April, 0.3 percent; May, 0.4 percent; and June, 0.5 percent.

Similarly, entrainment of juvenile salmonids rearing in the lake is expected to be minimal because of their preference for habitat that consists of a shear zone (slow moving water that transitions to faster moving water that provides both resting and drift insect feeding habitat) that would be nonexistent in the pump intake channel in July and August when no pumping occurs. Greatest risk to entrainment of juvenile salmonids into the pump intake channel would occur in September, which has the highest average monthly pumping rate and associated channel velocity.

No significant mortality is expected of juvenile anadromous salmonids in association with the fish screens because the State's fish screening criteria are designed to safely pass juvenile salmonids. However, the potential exists for increased predation of juvenile salmonids that are entrained into the pump intake channel and use the fish bypass system back into the Columbia River where predators typically congregate. Because Washington State fish screening criteria focus on protecting juvenile salmonid species, the potential exists for smaller, nonsalmonid eggs and larvae/fry to pass through the mesh openings (maximum allowable diameter is 2.38 mm) and to become entrained in the pump intake system.

Yakima River

Table 4.25 summarizes the effects of the alternatives on the selected indicators for spring Chinook and steelhead.

Table 4.25 Summary of impacts on the selected indicators for spring Chinook and steelhead

Resource indicator	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
High summer flows in the upper Yakima and Cle Elum Rivers (acres of available habitat and percent change from the No Action Alternative)				
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%

Table 4.25 Summary of impacts on the selected indicators for spring Chinook and steelhead (continued)

Resource indicator	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Summer flows downstream from the Parker gage (acres of available coho yearling habitat and percent change from the No Action Alternative)				
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%
Rate of change in flow during flip-flop (average cfs/day August 16–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
Pre- (August 1–15) and post- (September 14–28) flip-flop flow and absolute change in flow				
Easton reach				
Pre-flip-flop flow (cfs)	572	352	518	508
Post-flip-flop flow (cfs)	328	220	309	319
Absolute change in flow (cfs)	-245	-132	-209	-189
Ellensburg reach				
Pre-flip-flop flow (cfs)	3,860	2,774	3,229	3,208
Post-flip-flop flow (cfs)	1,506	1,239	1,507	1,493
Absolute change in flow (cfs)	-2,354	-1,535	-1,722	-1,715
Lower Naches River reach				
Pre-flip-flop flow (cfs)	612	621	572	578
Post-flip-flop flow (cfs)	1,628	1,220	1,691	1,670
Absolute change in flow (cfs)	1,016	599	1,120	1,092
Reduced spring freshets downstream from the Parker gage (percent change in spring season flow between the alternative and flow objective; if positive, then target flow reached)				
Percent change	-7%	29%	-10%	11%
Stream runoff timing	No change	Improved	No change	No change
Average annual fish (natural and hatchery) escapement numbers (including harvest)				
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

4.8.2.3 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Under the No Action Alternative, the flow regime is about the same as under the current condition. Winter and spring flows throughout the systems are essentially unchanged as a result of water conservation. Summer flows increase slightly in some reaches, mostly downstream from Parker, as water that currently is released from storage and diverted downstream for irrigation remains instream to meet the greater flow objectives. Because the conservation is achieved by improving efficiency, which reduces return flow, the effects are limited to the reaches where conservation occurs. Downstream from those reaches, there is no effect. The magnitude of the streamflow changes varies by reach. At the Parker gage, the increase is estimated at 136 cfs in average or wet years and about 90 cfs in dry years. Because the flow regimes under this alternative are essentially the same as under the current condition, the indicators linked to flows generally reflect conditions that currently exist.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—The habitat quantity amounts for each reach and species/life stage are presented in table 4.25. These values are essentially the same as under the current condition. Only habitat changes near or greater than 10 percent are discussed in the text, but all values are presented in table 4.25.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.—For a more detailed description of each parameter, see section 4.8.2.1, "Methods and Assumptions," for indicator 2.

Easton reach

- Average rate of change in daily flow during the flip-flop operation is -8 cfs.
- Average daily flow before flip-flop is 572 cfs.
- Average daily flow after flip-flop is 328 cfs.
- Magnitude of change in flow before to after flip-flop is -245 cfs.

Ellensburg reach

- Average rate of change in daily flow is -78 cfs.
- Average flow before flip-flop is 3,860 cfs.
- Average flow after flip-flop is 1,506 cfs.

- Magnitude of change in flow is -2,354 cfs

Lower Naches River reach

- Average rate of change in daily flow is 34 cfs.
- Average flow before flip-flop is 612 cfs.
- Average flow after flip-flop is 1,628 cfs.
- Magnitude of change in flow is 1,016 cfs.

Indicator 3: Spring Flow Downstream from the Parker Gage.—Median spring season (March–June) flow downstream from the Parker gage under the No Action Alternative is 2,274 cfs, or 291 cfs greater than under the current condition (1,983 cfs). This greater spring flow downstream from the Parker gage is considered beneficial because it could improve anadromous salmon smolt outmigration survival through the middle and lower Yakima River.

The spring seasonal flow volume is 7 percent below the flow volume objective (chapter 2), and the stream runoff pattern is the same as under the current condition.

Indicator 4: July–September Flow Downstream from the Parker Gage.— The median July–September flow downstream from the Parker gage under the No Action Alternative is 642 cfs, or 333 cfs greater than under the current condition (309 cfs). However, based on the flow-to-habitat relationship for coho yearlings, the result is a net decrease of approximately 4.8 acres in the amount of available summer rearing habitat (figure 4.14). This decrease is the result of habitat loss in the main channel (7.9 acres) as channel velocity increases and as a result of increased flow that is not compensated for by an equal increase in side-channel habitat (3.1 acres) because the flow threshold that results in the watering-up of side channels has not been realized.

Overall, the amount of habitat begins to increase again at 750 cfs; and the amount of habitat (73 acres) at 300 cfs is nearly the same as at 2,000 cfs (72.5 acres). However, the percent of side-channel habitat increases from approximately 4 percent at 300 cfs to 44 percent at 2,000 cfs. This may suggest that overall habitat quality is improved since presumably side-channel habitat is of greater quality than mainstem habitat for juvenile rearing salmonids.

Indicator 5: Estimated Anadromous Fish Population Size.—A summary of the average annual escapement for spring and fall Chinook, coho, and steelhead under the No Action Alternative is presented in table 4.26. These escapement estimates include the contribution of hatchery-produced fish. The EDT and AHA models estimated average annual escapement under the No Action Alternative as follows:

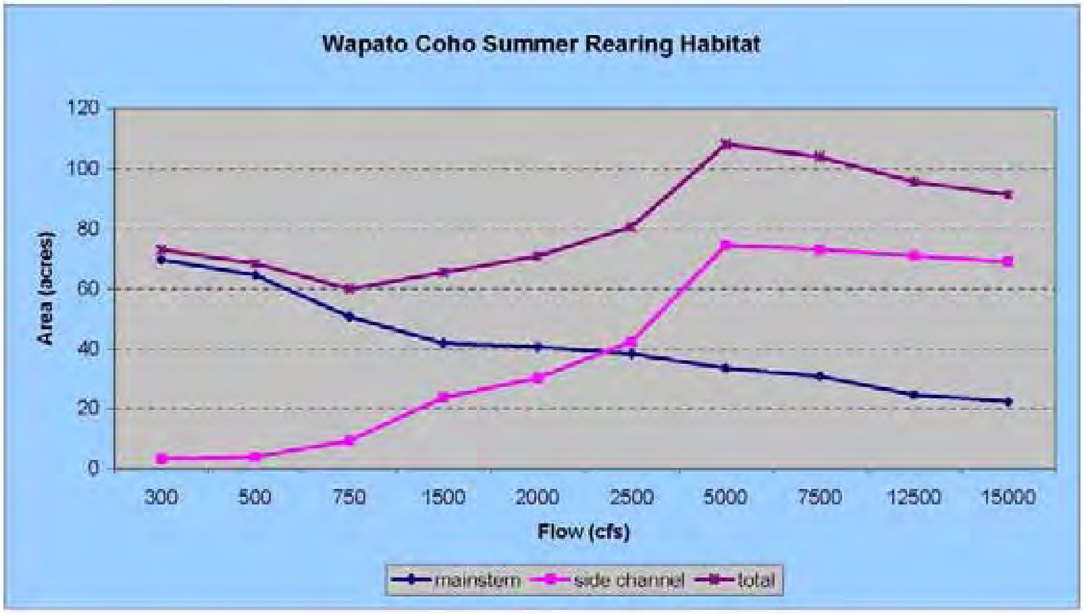

Figure 4.14 Relationship of coho summer yearling habitat amount to flow for the Wapato reach.

Table 4.26 Estimates of average annual spring Chinook, fall Chinook, coho, and steelhead total recruitment, harvest, escapement, and percent increase in total escapement under the Joint Alternatives compared to the No Action Alternative based on results from the AHA model; estimates include both natural and hatchery-produced fish based on a 100-year model simulation

Resource indicator	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
		Spring Chinook		
Total recruitment				
Absolute estimate	9,591	12,048	9,729	11,209
Change compared to the No Action Alternative		2,457	138	1,618
Harvest				
Absolute estimate	2,402	2,982	2,435	2,781
Change compared to the No Action Alternative		580	33	379
Escapement				
Absolute estimate	7,189	9,066	7,294	8,428
Change compared to the No Action Alternative		1,877	105	1,239
Percent increase in total escapement compared to the No Action Alternative		26	2	17
		Fall Chinook		
Total recruitment				
Absolute estimate	19,254	30,957	19,870	25,941
Change compared to the No Action Alternative		11,703	615	6,687

Table 4.26 Estimates of average annual spring Chinook, fall Chinook, coho, and steelhead total recruitment, harvest, escapement, and percent increase in total escapement under the Joint Alternatives compared to the No Action Alternative based on results from the AHA model; estimates include both natural and hatchery-produced fish based on a 100-year model simulation (continued)

Resource indicator	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Fall Chinook (continued)				
Harvest				
Absolute estimate	12,366	19,837	12,762	16,628
Change compared to the No Action Alternative		7,471	396	4,262
Escapement				
Absolute estimate	6,141	10,123	6,343	8,446
Change compared to the No Action Alternative		3,982	202	2,305
Percent increase in total escapement compared to the No Action Alternative		61	3	35
Coho				
Total recruitment				
Absolute estimate	11,461	13,850	11,618	12,702
Change compared to the No Action Alternative		2,389	157	1,241
Harvest				
Absolute estimate	2,986	3,608	3,027	3,309
Change compared to the No Action Alternative		623	41	323
Escapement				
Absolute estimate	8,475	10,242	8,591	9,392
Change compared to the No Action Alternative		1,767	116	918
Percent increase in total escapement compared to the No Action Alternative		21	1	21
Steelhead				
Total recruitment				
Absolute estimate	3,096	4,663	3,124	3,827
Change compared to the No Action Alternative		1,567	28	731
Harvest				
Absolute estimate	396	596	399	489
Change compared to the No Action Alternative		200	4	94
Escapement				
Absolute estimate	2,700	4,067	2,724	3,338
Change compared to the No Action Alternative		1,367	24	638
Percent increase in total escapement compared to the No Action Alternative		51	1	24

- Spring Chinook: 7,189
- Fall Chinook: 6,893
- Coho: 8,475
- Steelhead: 2,700

Indicator 6: False Attraction.—The existing Yakima River water supply would be used under the No Action Alternative; therefore, no false attraction issue is associated with an out-of-basin water supply mixing with Yakima River water.

4.8.2.4 Black Rock Alternative

Construction Impacts

Construction of the intake to Priest Rapids pumping plant and the fish bypass pipe outlet would affect fishery resources, but the overall effect is anticipated to be minor relative to the quality and amount of aquatic habitat found within the Columbia River. Impacts resulting from construction activities (installation and removal of coffer dams and dewatering the coffer dams) may also alter aquatic conditions by temporarily increasing sedimentation (turbidity), but these impacts are anticipated to be temporary.

Construction of the Black Rock reservoir seepage pipeline outfall structure would affect Yakima River water quality in the short term. The required instream work would likely cause local, temporary increases in turbidity during the installation and removal of the coffer dam along the left bank in the vicinity of Horn Rapids County Park (approximately RM 18.2). These increases in turbidity would likely be most intense near the construction activity itself and would decrease over time and distance. A July–August work window would have the least effect on anadromous salmonid species.

Long-Term Impacts

Differences in flow in the Yakima River under the Black Rock Alternative (compared to the No Action Alternative) are the greatest of any Joint Alternative. Spring flows are greater throughout the system, while summer flows in the middle and lower Yakima River are significantly greater as a result of being able to meet greater flow objectives at the Parker gage because of an increase in available water supply for instream flow augmentation. Summer and early fall flows in the upper Yakima River basin are less, as water previously released for diversion by Roza and Sunnyside Valley Irrigation Districts is now provided from Black Rock reservoir. Winter flows are also greater throughout the basin as a result of improved carryover and a reduced volume that needs to be stored each winter. These changes in the flow regime generally would benefit anadromous fish.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—In the Easton reach, steelhead and spring Chinook yearling habitat are 10.4 and 9.8 percent greater, respectively, than under the No Action Alternative (table 4.25). In the Ellensburg reach, the amount of steelhead yearling habitat is 29.2 percent greater than under the No Action Alternative.

Of the Joint Alternatives, the Black Rock Alternative provides the greatest amount of steelhead and spring Chinook summer rearing habitat in the Easton reach, which would potentially equate to an improvement in juvenile survival and the ability to accommodate more summer rearing fish. For similar reasons, of the three Joint Alternatives, the Black Rock Alternative appears most beneficial to steelhead yearlings in the Ellensburg reach.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.—For a more detailed description of each parameter, see section 4.8.2.1, "Methods and Assumptions," for indicator 2.

Easton reach

- Average rate of change in daily flow during the flip-flop operation is -4 cfs.
- Average daily flow before flip-flop is 352 cfs.
- Average daily flow after flip-flop is 220 cfs.
- Magnitude of change in flow before to after flip-flop is -132 cfs.

Ellensburg reach

- Average rate of change in daily flow is -51 cfs.
- Average flow before flip-flop is 2,774 cfs.
- Average flow after flip-flop is 1,239 cfs.
- Magnitude of change in flow is -1,535 cfs.

Lower Naches River reach

- Average rate of change in daily flow is 20 cfs.
- Average flow before flip-flop is 621 cfs.
- Average flow after flip-flop is 1,220 cfs.
- Magnitude of change in flow is 599 cfs.

The following summarizes effects under the Black Rock Alternative compared to the No Action Alternative:

- Compared to the No Action Alternative, a decrease in the average rate of change in daily flow during the flip-flop operation is greatest in the

Ellensburg and lower Naches River reaches. The Easton reach has the highest percent change relative to the No Action Alternative (-50 percent); however, the absolute change is only 4 cfs.

- Compared to the No Action Alternative, the magnitude of change in flow is decreased in the Easton reach, -46%; Ellensburg reach, -35%; and lower Naches River reach, -41%.

- Compared to the No Action Alternative, the average flows before and after flip-flop are lower, except for the lower Naches River reach before flip-flop.

- Compared to the No Action Alternative, the Black Rock Alternative provides the greatest improvement to the flip-flop operation of the Joint Alternatives.

These differences represent an improvement in all three reaches for fish and aquatic insects compared to the No Action Alternative. While the specific biological implications are difficult to measure, these differences should provide a more stable rearing habitat by less disruption to desired habitat (i.e., the change in location of desired habitat in a relatively short period of time) that should translate into less stranding of both fish and aquatic invertebrates.

The average flow and change in magnitude of flow before and after flip-flop in the three reaches are as follows:

- Easton: before, 352 cfs; after, 220 cfs; change, -132 cfs
- Umtanum: before, 2,774 cfs; after, 1,239 cfs; change, -1,535 cfs
- Lower Naches: before, 621 cfs; after, 1,220 cfs; change, +599 cfs

Thus, for the Easton reach, there is essentially no change in the average rate of change in daily flow during the flip-flop operation compared to the No Action Alternative. However, the change in magnitude of flows before and after flip-flop is 46 percent less than for the No Action Alternative. For the Ellensburg reach, the average rate of change in daily flow and the change in magnitude of flow before and after flip-flop are 35 percent less compared to the No Action Alternative. For the lower Naches River reach, the rate of increase in flow and the change in magnitude of flow before and after flip-flop are 41 percent less compared to the No Action Alternative.

These differences represent an improvement for fish in both the Ellensburg and lower Naches River reaches compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change should translate into less stranding of both fish and aquatic invertebrates in the Ellensburg reach that need to move to adjust to the change and less spatial disruption to desired habitat (i.e., the change in location of desired habitat in a relatively short period of time) in the lower Naches River reach.

Indicator 3: Spring Flow Downstream from the Parker Gage.—The spring seasonal flow is 29 percent above the flow volume objective, while the No Action Alternative is 7 percent below the flow volume objective (table 4.25). These results represent a more than 500-percent improvement in the spring seasonal flow compared to the No Action Alternative. There is also an improvement in the stream runoff pattern compared to the No Action Alternative, as the high flows continue into April, May, and June when most smolt migration is occurring, which should increase overall smolt outmigration survival.

Indicator 4: July–September Flow Downstream from the Parker Gage.—The median July–September flow downstream from the Parker gage for Black Rock is 1,301 cfs compared to 642 cfs under the No Action Alternative. These greater flows would result in 1.5 percent more total coho summer yearling habitat (64.7 acres under the Black Rock Alternative compared to 63.7 acres under the No Action Alternative) (figure 4.14). The reduction in mainstem habitat is nearly equal to the increase in side-channel habitat.

Indicator 5: Estimated Anadromous Fish Population Size.—The EDT and AHA models estimated average annual escapement under the Black Rock Alternative as follows:

- Spring Chinook: 9,066
- Fall Chinook: 11,128
- Coho: 10,242
- Steelhead: 4,067

Rationale for Flow Versus Fish Abundance

The fishery models (EDT and AHA) estimated increases of approximately 20–60 percent in anadromous fish population sizes under the Black Rock Alternative compared to the No Action Alternative. Of all the Joint Alternatives, the Black Rock Alternative results in the greatest modification of the current flow regime in the Yakima River basin. One finding suggests that, in many cases, there was not a significant change (increase or decrease) in the amount of fishery habitat even when flow differences were fairly substantial. For example, in the Ellensburg flood plain, there is generally not a substantial change in the amount of spring Chinook and steelhead fry and summer rearing habitat between the Black Rock Alternative and the No Action Alternative (table 4.27).

Table 4.27 Summary of spring Chinook and steelhead fry and summer rearing habitat area (acres) in the Ellensburg flood plain and the July and August median flow for the No Action and Black Rock Alternatives

Species/Lifestage	No Action Alternative	Black Rock Alternative
Spring Chinook fry habitat (acres)	1.7	1.8 (5.9% increase)
Spring Chinook summer rearing habitat (acres)	14.9	14.6 (2.0% decrease)
Steelhead fry habitat (acres)	2.2	2.1 (4.5% decrease)
Steelhead summer rearing habitat (acres)	20.2	26.1 (29.2% increase)
July median flow (cfs)	3,500	2,700 (23% decrease)
August median flow (cfs)	3,960	2,500 (37% decrease)

It is important to recognize that the Joint Alternatives do not increase or improve the existing habitat conditions in the basin but only modify how the existing habitat is utilized by changes to the flow regime. Furthermore, the effects of the Joint Alternatives are limited to the stream reaches downstream from the five major storage reservoirs and would not affect habitat conditions in the tributaries.

On a much larger geographic scale, fisheries habitat conditions have significantly changed through decades of development, both within the Yakima basin and downstream, that preclude achieving near-historic anadromous fish populations through actions provided by the Joint Alternatives or any other suite of realistic actions. For example, Eitemiller et al. (2002) investigated the historic size (includes both wetted and nonwetted areas) of the seven largest flood plains in the Yakima River basin (i.e., Easton, Cle Elum of the Yakima River, Kittitas, Selah, lower Naches, Union Gap, and Wapato) and concluded that they have been reduced to approximately 15–43 percent of their historic size, depending on the flood plain. Changes in habitat conditions (e.g., hydropower development and loss of estuary habitat) in the Columbia River have reduced smolt and adult migration survival from historic levels which further reduce the potential to achieve near-historic anadromous fish run sizes in the Yakima River basin.

Indicator 6: False Attraction.**—**Under the Black Rock Alternative, Columbia River water would be pumped from Priest Rapids Lake into Black Rock reservoir and released into Roza and Sunnyside Canals during the irrigation season. In wet years, the amount of water put into Sunnyside Canal is less (median = 847 cfs) than in average and dry water years (median = 928 cfs). The monthly median amount of operational spill of Black Rock reservoir water from Roza and Sunnyside Canals ranges from 2.2 cfs in March to 30.4 cfs in August. The percent of Black Rock reservoir water mixed with the Yakima River water at the Kiona-Benton gage (RM 29.9) ranges from 0.05–1.65 percent (table 4.28).

Table 4.28 Percent of Black Rock reservoir water mixed with Yakima River water at the Kiona-Benton gage (RM 29.9) by month during the irrigation season as a result of direct operational spill from Roza and Sunnyside Canals

Month	Kiona-Benton gage monthly median flow (cfs)	Total monthly median Roza and Sunnyside Canals operational spill of Black Rock reservoir water (cfs)	Percent of Black Rock reservoir water mixed with Yakima River water at Kiona-Benton gage (cfs)
March	4,507	2.2	0.05
April	5,162	17.5	0.34
May	4,933	24.4	0.49
June	4,428	29.0	0.65
July	1,932	30.1	1.56
August	1,845	30.4	1.65
September	1,939	24.5	1.26
October	2,206	20.9	0.95

Under laboratory conditions, Fretwell (1989) investigated the behavioral response of sockeye salmon to their home water source in comparison to their home water source mixed with an increasing percent of a nonhome water source. He found that if the home water source were made up of more than 10 percent of a nonhome water source, fish began to discriminate between the two water sources and selected their home water source more frequently than the water source comprised of both water sources. This study suggests that sockeye salmon begin to discriminate between the home and home-nonhome mixed water sources once the nonhome level of the mixed water source exceeds 10 percent.

Most adult anadromous fish migration into the Yakima River basin occurs outside of the summer months (September–June) when the amount of Black Rock reservoir water mixed in the Yakima River water is generally 1 percent or less. Based on these findings, the potential for false attraction resulting from direct operational spill of mixed Yakima and Black Rock reservoir water appears to be minimal.

Seepage Mitigation Features.—Black Rock reservoir seepage mitigation measures, as proposed, would result in a constant year-round inflow of approximately 50 cfs to the Yakima River at the Benton County Horn Rapids Park. The monthly percent of Black Rock reservoir seepage mitigation inflows comprising 25th-, 50th-, and 75th-percentile Yakima River flows are presented in table 4.29. The highest percentages occur in the July–September period (50th percentile, 2.5–2.6 percent), followed by the October–December, January–March, and April–June periods, which coincide with increasing riverflows. Fall Chinook, coho, and steelhead begin to enter the Yakima River in September, when Black Rock reservoir seepage mitigation inflows range from 2.2–3.2 percent.

Table 4.29 Monthly Black Rock seepage mitigation inflows as a percent of total Yakima River flow (based on the Kiona-Benton gage), monthly rank, and the key months for salmon and steelhead adult upmigration in the lower Yakima River

Percentile flow	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
25th	1.4%	1.3%	1.0%	0.9%	0.7%	0.8%	0.9%	0.9%	2.1%	2.4%	2.2%	2.0%
50th	1.8%	1.7%	1.5%	1.4%	1.1%	1.0%	1.0%	1.1%	2.5%	2.6%	2.5%	2.2%
75th	2.1%	2.0%	2.1%	1.8%	1.5%	1.4%	1.3%	1.9%	2.9%	3.5%	3.2%	2.6%
Monthly rank	5	6	7	8	9	10	11	12	3	1	2	4
Species	**Key months of anadromous salmonid adult upmigration in the lower Yakima River**											
Spring Chinook					x	x	x					
Fall Chinook	x										x	x
Coho	x	x										x
Steelhead	x	x			x	x	x				x	x

Because combining the seepage mitigation flows with the operational spills from Roza and Sunnyside does not exceed 5.2 percent of Columbia River water in the Yakima River, the potential for false attraction appears low. Reclamation (2008d) indicates the greatest potential for false attraction would occur for first-generation returning adults that had not imprinted as juveniles or smolts on an admixture of Black Rock reservoir seepage water and Yakima River water.

An inflow of 50 cfs into the Horn Rapids Dam forebay area is likely to create a small, localized cooling in the summer and warming in the winter of the Yakima River water temperature. As a result, this may attract both salmonid and nonsalmonid species, depending on the time of year. This relatively small (3.5-percent maximum) quantity of cooler inflow in the summer is not expected to alter the existing Yakima River water temperature beyond a small localized effect.

4.8.2.5 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction impacts to fishery resources would occur during the construction of the intake to Wymer pumping plant and fish bypass pipe outlet (installation and removal of coffer dams and dewatering the coffer dams), but the overall impact is anticipated to be minor relative to the quality and amount of aquatic habitat found within the Yakima River system. Impacts resulting from construction activities (installation and removal of coffer dam and dewatering the coffer dam) in and around Lmuma Creek may also alter aquatic conditions in Lmuma Creek and the Yakima River by temporarily increasing sedimentation (turbidity), but these impacts are anticipated to be temporary.

Long-Term Impacts

Winter flows from Cle Elum Lake to the Wymer site are greater under this alternative as winter flows are "bypassed" through Cle Elum Lake to be stored in Wymer reservoir. This "bypass" more than doubles flows in the Cle Elum River. During the summer months, flows in the upper Yakima River are lower, as some of the irrigation needs in the middle basin are met by releases from Wymer reservoir. Summer flows are about 600 cfs less.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—Less summer flows in the upper Yakima River basin result in slightly more fry and yearling habitat for both steelhead and spring Chinook than under the No Action Alternative in the Easton reach. However, the increases do not exceed 10 percent for either species or life stage. In the Ellensburg reach, habitat for steelhead yearlings and spring Chinook fry is greater; steelhead fry and spring Chinook yearling habitat is less than under the No Action Alternative. Again, all differences are less than 10 percent (table 4.25).

Because the percent change in habitat values are all less than 10 percent compared to the No Action Alternative, no effect on the biological response of steelhead or spring Chinook upper Yakima River population is expected compared to the No Action Alternative.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.—For a more detailed description of each parameter, see section 4.8.2.1, "Methods and Assumptions," for indicator 2.

Easton reach

- Average rate of change in daily flow during the flip-flop operation is -7 cfs.
- Average daily flow before flip-flop is 518 cfs.
- Average daily flow after flip-flop is 309 cfs.
- Magnitude of change in flow before to after flip-flop is -209 cfs.

Ellensburg reach

- Average rate of change in daily flow is -58 cfs.
- Average flow before flip-flop is 3,229 cfs.
- Average flow after flip-flop is 1,507 cfs.
- Magnitude of change in flow is -1,722 cfs.

Lower Naches River reach

- Average rate of change in daily flow is 37 cfs.
- Average flow before flip-flop is 572 cfs.

- Average flow after flip-flop is 1,691 cfs.
- Magnitude of change in flow is 1,120 cfs.

The following summarizes effects under the Wymer Dam and Reservoir Alternative compared to the No Action Alternative:

- Compared to the No Action Alternative, the average rate of change in daily flow during the flip-flop operation decreased in the Ellensburg reach and remained similar in the Easton and lower Naches River reaches.
- Compared to the No Action Alternative, a reduction in the magnitude of change in flow is greatest (-27 percent) in the Ellensburg reach, followed by the Easton reach, -15%; and lower Naches River reach, -7%.
- Compared to the No Action Alternative, there are modest differences in the average flows before and after flip-flop, except for a 27-percent reduction in the average before flip-flop flow in the Ellensburg reach.
- Compared to the No Action Alternative, the Wymer Dam and Reservoir Alternative provides improvement to the flip-flop operation, but this improvement is less than that provided by the Black Rock Alternative.

These results represent an improvement in the Ellensburg reach and comparable conditions in the Easton and lower Naches River reaches for fish and aquatic insects compared to the No Action Alternative. While the specific biological implications are difficult to measure, a reduction in the average rate of change in daily flow during the flip-flop operation, a decrease in peak summer flows, and a decrease in the magnitude of change in flow (-27 percent) that results in the Ellensburg reach should translate into less stranding of both fish and aquatic invertebrates for reasons similar to those stated for the Black Rock Alternative.

Indicator 3: Spring Flow Downstream from the Parker Gage.—The spring seasonal flow is 10 percent below the flow volume objective, or about the same as under the No Action Alternative. The stream runoff pattern is the same as under the No Action Alternative. No effect on steelhead or spring Chinook smolt survival is expected because there is virtually no difference in the flow volume objective or in the spring runoff pattern.

Indicator 4: July–September Flow Downstream from the Parker Gage.—The median July–September flow downstream from the Parker gage under the Wymer Dam and Reservoir Alternative is 644 cfs, compared to 642 cfs under the No Action Alternative. This difference in flow does not result in a significant change in the total amount of coho summer yearling habitat compared to the No Action Alternative; therefore, no effect on the survival or rearing capacity for anadromous fish in the Wapato reach is expected compared to the No Action Alternative.

***Indicator 5: Estimated Anadromous Fish Population Size.*—**The EDT and AHA models estimated average annual escapement under the Wymer Dam and Reservoir Alternative as follows:

- Spring Chinook: 7,294
- Fall Chinook: 7,112
- Coho: 8,591
- Steelhead: 2,724

***Indicator 6: False Attraction.*—**A minimal potential exists for false attraction to occur at the confluence of Lmuma Creek, which would receive the outflow from Wymer reservoir. The water supply for the reservoir is both skimmed Yakima River water, along with Cle Elum Lake water released during the winter months, and should have a similar chemical signature as the river water steelhead and salmon have imprinted to. In most years (except in prorated water years), reservoir releases would occur in July and August; the number of adult steelhead and salmon migrating through this reach of the river would be minimal at that time. Some late arriving spring Chinook could be affected.

4.8.2.6 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

In addition to the construction impacts for Wymer reservoir discussed for the Wymer Dam and Reservoir Alternative, construction impacts to fishery resources would occur during construction of the intake to pumping plant #1 and the pipeline crossings under the Yakima River and various roads and waterways. The impacts of crossing the Yakima River and roads and waterways (installation and removal of coffer dams and dewatering the coffer dams) are anticipated to be minor relative to the quality and amount of aquatic habitat found within the Yakima River system. Impacts resulting from construction activities may also alter aquatic conditions by temporarily increasing sedimentation (turbidity), but these impacts are anticipated to be temporary.

Long-Term Impacts

Winter flows from Cle Elum Lake to Wymer reservoir are greater under this alternative as winter flows are “bypassed” through Cle Elum Lake to be stored in Wymer reservoir. This “bypass” more than doubles flows in the Cle Elum River. In the spring and summer, flows are greater in the middle and lower basin as water available for diversion at Roza and Parker is left in the river because some of the irrigation demand is met by the exchange. The flow objective at Parker increases from about 640–1,500 cfs. During the summer months, flows in the upper Yakima River are less, because some of the irrigation needs in the middle basin are met by releases from Wymer reservoir. Summer flows are about 600 cfs less than under the No Action Alternative.

Indicator 1: Summer Rearing Habitat in the Easton and Ellensburg Reaches for Spring Chinook and Steelhead Fry and Yearlings.—There are no significant differences (greater than10-percent change) between this alternative and the No Action Alternative for either of the species and life stages for the Easton or Ellensburg reaches. As under the Wymer Dam and Reservoir Alternative, habitat is generally better for steelhead and spring Chinook in the Easton reach, while results are mixed for the Ellensburg reach (table 4.25).

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers for Yearling Steelhead and Spring Chinook.—For a more detailed description of each parameter, see section 4.8.2.1, "Methods and Assumptions," for indicator 2.

Easton reach

- Average rate of change in daily flow during the flip-flop operation is -6 cfs.
- Average daily flow before flip-flop is 508 cfs.
- Average daily flow after flip-flop is 319 cfs.
- Magnitude of change in flow before to after flip-flop is -189 cfs.

Ellensburg reach

- Average rate of change in daily flow is -57 cfs.
- Average flow before flip-flop is 3,208 cfs.
- Average flow after flip-flop is 1,493 cfs.
- Magnitude of change in flow is -1,715 cfs.

Lower Naches River reach

- Average rate of change in daily flow is 36 cfs.
- Average flow before flip-flop is 578 cfs.
- Average flow after flip-flop is 1,670 cfs.
- Magnitude of change in flow is 1,092 cfs.

See the summary statements for the Wymer Dam and Reservoir Alternative in section 4.8.2.5 for indicator 2. Because river operations were very similar upstream of Roza Dam under the two Wymer alternatives, the effect on flows in Easton, Ellensburg, and lower Naches River reaches are comparable.

Indicator 3: Spring Flow Downstream from the Parker Gage.—The spring seasonal flow is 11 percent above the flow volume objective, an improvement (19 percent) compared the No Action Alternative, which is 7 percent below the objective. The stream runoff pattern is the same as under the No Action Alternative. Overall smolt outmigration survival should be better under this alternative.

Indicator 4: July–September Flow Downstream from the Parker Gage.— The median July–September flow downstream from the Parker gage under the Wymer Dam Plus Yakima River Pump Exchange Alternative is 1,505 cfs, compared to 642 cfs under the No Action Alternative. These greater flows result in a 4.1-percent increase in the amount of coho summer yearling habitat compared to the No Action Alternative. The reduction in mainstem habitat (14.8 acres) is offset by an increase of 16.7 acres of side-channel habitat. Though the overall increase in the amount of habitat is small compared to the No Action Alternative, the shift towards a greater percentage in the side channels may be of greater habitat quality compared to mainstem habitat.

Indicator 5: Estimated Anadromous Fish Population Size.—The EDT and AHA models estimated average annual escapement under the Wymer Dam Plus Yakima River Pump Exchange Alternative as follows:

- Spring Chinook: 8,428
- Fall Chinook: 9,321
- Coho: 9,392
- Steelhead: 3,338

Indicator 6: False Attraction.—The Wymer Dam Plus Yakima River Pump Exchange Alternative would use Columbia River water pumped in the vicinity of the Yakima River confluence, which would occur during the irrigation season and would be pumped into the Roza and Sunnyside Canals. A maximum of 1,040 cfs of Columbia River water would be exchanged between Roza and Sunnyside during the irrigation season. Potential false attraction issues on the Yakima and Middle Columbia River (upstream of the Yakima River) salmon populations discussed in “Methods and Assumptions” would be further reduced because the pumping plant would be located immediately downstream from the Yakima River confluence; thus, the pumped water would be an admixture of Yakima and Columbia River water.

The monthly median operational spill of Columbia River water from Roza and Sunnyside canals ranges between 10.5 cfs in June–August to 13.7 cfs in April. The mixture of Columbia River water to Yakima River water at the Kiona-Benton gage ranges from about 0.3–0.7 percent (table 4.30). As discussed for the Black Rock Alternative, most adult anadromous fish migration into the Yakima River basin occurs outside of the summer months—September–June—when the amount of Columbia River water mixed in the Yakima River water is generally 1 percent or less.

Based on these findings, the potential for false attraction resulting from direct operational spill of mixed Yakima and Columbia River water appears to be minimal.

Table 4.30 Percent of Columbia River water mixed with Yakima River water at the Kiona-Benton gage (RM 29.9) by month during the irrigation season as a result of direct operational spill from Roza and Sunnyside Canals

Month	Kiona-Benton gage monthly median flow (cfs)	Total monthly median Roza and Sunnyside Canals operational spill of Black Rock reservoir water (cfs)	Percent of Black Rock reservoir water mixed with Yakima River water at Kiona-Benton gage (cfs)
March	4,541	12.2	0.27
April	4,439	13.7	0.31
May	2,842	12.2	0.43
June	2,739	10.5	0.38
July	2,114	10.5	0.49
August	2,064	10.5	0.51
September	2,189	13.9	0.64
October	2,260	14.6	0.65

4.8.2.7 Mitigation

The following measures will be implemented to reduce short-term impacts of construction activities to anadromous fish:

- Implement construction Best Management Practices (BMPs) to avoid and minimize potential construction impacts, including erosion and sedimentation, accidental and incidental discharge of pollutants (Spill Prevention, Containment, and Control Plan), and dewatering and discharge of dewatering water.

- Prior to complete dewatering of coffer dams, fishery personnel will salvage all fishes using the most appropriate capture gear and methods.

- Provide treatment of construction dewatering discharges, such as sediment removal or filtration, as necessary, before the release of such water to wetlands or streams.

4.8.2.8 Cumulative Impacts

While there are some short-term, minor adverse impacts to anadromous fish from construction activities under the Joint Alternatives, for the most part, the impacts are, in the long term, beneficial. Those benefits could be diminished by some of the other actions that are reasonably likely to occur. In particular, the future growth in the area may affect anadromous fish both directly and indirectly. Future population growth in the Pacific Northwest and the development and use of scarce natural resources that accompanies it will diminish populations of wild salmonids. While laws and regulations, like the Shorelines Management Act, the Hydraulic Project Approval Act, and the Endangered Species Act, are in place to try to minimize, or at least manage, some of the direct impacts of development on salmonids and their habitat, continued development in the Yakima River basin would likely erode some of the benefits of the alternatives considered here.

Cumulative impacts could also occur from the implementation of fish enhancement projects as part of the BPA Fish and Wildlife Program or through other fish enhancement programs such as the State of Washington's Salmon Recovery Funding Board. Funds from both of these programs have been used in the Yakima River basin to restore and enhance anadromous fish habitat,, and this is expected to continue in the future. In the *Yakima Subbasin Plan* (Yakima Subbasin Fish and Wildlife Planning Board, 2004), estimates of potential anadromous fish populations were made using EDT, assuming improvements in habitat were made under the *Yakima Subbasin Plan*. The estimates were made looking forward 30 years with the assumption that funding was not limited but that the actions contemplated met some test of reasonableness given the current condition. This exercise also took into account future development and actually decreased habitat values in areas where development was likely to be focused. Spring Chinook abundance estimates increased by about 60 percent over estimates under the current condition, while fall Chinook and coho abundance estimates increased by about 35 percent. The flow improvements contemplated under the Joint Alternatives would enhance these projected increases; in some cases, in an additive fashion but, in other cases, by multiplying the benefits to be achieved by the habitat enhancement projects. For example, by improving flow conditions in the basin under the Joint Alternatives, they work in concert with the habitat enhancements to grow more smolts in the basin and then improve their survival out of the basin, magnifying the benefit of the habitat enhancement.

In the *Final Supplemental Environmental Impact Statement for the Lake Roosevelt Incremental Storage Releases Program,* section 4.2.2.6, "Fish," (under "Mid-Columbia River" and "Hanford Reach" subsections) states that releases would be made to enhance the fish habitat in those reaches. Because those releases likely would be made during drought conditions and the Black Rock Alternative pumping criteria call for all downstream target flows to be met before any withdrawals can be made from the Columbia River, no adverse cumulative impacts to anadromous fish resources are expected in the Columbia or Yakima Rivers.

4.9 Resident Fish

4.9.1 Affected Environment

4.9.1.1 Columbia River

The extent of the affected area in the Columbia River for the Storage Study is described in section 4.8, "Anadromous Fish." A total of 38 resident species are known to reside in the Hanford reach and/or Priest Rapids Lake (Pfeifer et al., 2001) and are grouped as native game fish, native nongame fish, introduced (nonnative) game fish, and introduced nongame fish. They are listed, along with their type and relative abundance, in table 4.31.

Important resident fish that prey on juvenile salmonids are northern pikeminnow, walleye, and small mouth bass. Walleye and small mouth bass are also important to recreational fisheries.

The capture of one juvenile bull trout in November was documented during an intensive fishery survey in 1999 (FERC, 2006).

White sturgeons are known to spawn in July in the tailrace of Wanapum and Priest Rapids Dams and farther downstream in the Hanford reach. A total of 230 fish were sampled between the three locations in a census study conducted in 2000 (FERC, 2006).

4.9.1.2 Yakima River

The areas of interest include the existing and proposed reservoirs within the basin and the Yakima, Cle Elum, Naches, Tieton, and Bumping Rivers from headwater reservoirs to the confluence of the Yakima River with the Columbia River. (See the frontispiece map.)

Description and Distribution

Resident native salmonids that currently exist in streams and lakes of the upper Yakima River basin include bull trout (*Salvelinus confluentus*), westslope cutthroat trout (*Oncorhynchus clarki*), rainbow trout (*Oncorhynchus mykiss*), kokanee (*Oncorhynchus nerka*), mountain whitefish (*Prosopium williamsoni*), and pygmy whitefish (*Prosopium coulteri*) (Pearsons et al., 1998; WDFW, 1998). Eastern brook trout (*Salvelinus fontinalis*), a nonnative (introduced) salmonid, is also present. Of these species, those of special concern include bull trout (federally threatened), westslope cutthroat trout, and pygmy whitefish (State sensitive). Although bull trout tend to exhibit several different life history strategies, they are included in the resident fish analysis.

Table 4.31 Resident fishes sampled in the Priest Rapids Project area during multiple year surveys

Common name	Scientific name	Species category	General abundance
White sturgeon	*Acipenser transmontanus*	Native game fish	Common
Bull trout native	*Salvelinus confluentus*	Game fish	ESA threatened, rare
Rainbow trout	*Oncorhynchus mykiss*	Native game fish	Common
Cutthroat trout	*Oncorhynchus clarki*	Native game fish	Uncommon
Brown trout	*Salmo trutta*	Introduced game fish	Uncommon
Mountain whitefish	*Prosopium williamsoni*	Native game fish	Common
Lake whitefish	*Coregonus clupeaformis*	Native game fish	Rare
Northern pikeminnow	*Ptychocheilus oregonensis*	Native nongame fish	Abundant
Peamouth	*Mylocheilus caurinus*	Native nongame fish	Abundant
Chiselmouth	*Acrocheilus alutaceus*	Native nongame fish	Abundant
Redside shiner	*Richardsonius balteatus*	Native nongame fish	Abundant
Longnose dace	*Rhinichthys cataractae*	Native nongame fish	Common
Speckled dace	*Rhinichthys osculus*	Native nongame fish	Common
Leopard dace	*Rhinichthys falcatus*	Native nongame fish	Rare
Carp	*Cyprinus carpio*	Introduced nongame fish	Common
Tench	*Tinca tinca*	Introduced nongame fish	Uncommon
Bridgelip sucker	*Catostomus columbianus*	Native nongame fish	Abundant
Largescale sucker	*Catostomus macrocheilus*	Native nongame fish	Abundant
Longnose sucker	*Catostomus catostomus*	Native nongame fish	Common
Channel catfish	*Ictalurus punctatus*	Introduced game fish	Common
Black bullhead	*Amiurus melas*	Introduced game fish	Uncommon
Burbot	*Lota lota*	Native game fish	Rare
Three-spined stickleback	*Gasterosteus aculeatus*	Native nongame fish	Abundant
Sandroller	*Percopsis transmontana*	Native nongame fish	Rare
Largemouth bass	*Micropterus salmoides*	Introduced game fish	Common
Smallmouth bass	*Micropterus dolomieu*	Introduced game fish	Common
Black crappie	*Pomoxis nigromaculatus*	Introduced game fish	Common
White crappie	*Pomoxis annularis*	Introduced game fish	Common
Bluegill	*Lepomis macrochirus*	Introduced game fish	Uncommon
Pumpkinseed	*Lepomis gibbosus*	Introduced game fish	Uncommon
Torrent sculpin	*Cottus rhotheus*	Native nongame fish	Common
Prickly sculpin	*Cottus asper*	Native nongame fish	Common
Walleye	*Stizostedion vitreum*	Introduced game fish	Common
Yellow perch	*Perca flavescens*	Introduced game fish	Common

Source: Pfeifer et al., 2001.

At least in the Yakima River basin, westslope cutthroat appear to be fairly abundant and widely distributed, particularly in the upper reaches (higher elevations) of tributaries to Keechelus Lake and the Yakima River. Cutthroat, as well as other resident salmonid species, provide recreational angling opportunities throughout the upper basin. Resident rainbow trout and mountain whitefish angling in the upper Yakima River and in the lower reaches of tributary streams is extremely popular. In fact, the trout fishery in the upper Yakima River is considered one of the best "blue ribbon" catch-and-release fisheries in Washington State.

Thirty-seven resident nonsalmonid species are present in the Yakima River basin (Pearsons et al., 1998). The most abundant nonsalmonids in the upper Yakima River basin are speckled dace *(Rhinichthys osculus*), longnose dace (*Rhinichthys cataractae*), redside shiners (*Richardsonius balteaus*), northern pikeminnow (*Ptychocheilus oregonensis*), largescale suckers (*Catostomus macrocheilus*), bridgelip suckers (*Catostomus columbianus*), and several sculpin species, including mottled, torrent, piute, and shorthead sculpins (*Cottus sp*.). Although these nonsalmonid species do not receive the notoriety of salmonids (trout, salmon, and steelhead) or other lower river nonsalmonid game fish (such as bass and catfish), they are, nevertheless, an important component of the aquatic environment. Most serve as forage for other game and food fish. Burbot (*Lota lota*) is an important game fish present in Keechelus Lake.

Two other species, although not as abundant as those listed above but important due to their status, are the mountain sucker (*Catostomus platyrhynchus*) (a State candidate species) and the Pacific lamprey (*Lampetra tridentata*) (a Federal species of concern). Mountain suckers occur within the basin, and it is possible that lamprey do as well, although few have been observed in the Yakima River. Although not listed, numerous fish species inhabiting the middle to lower zones of the Yakima River potentially may be impacted by the proposed Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives. For a complete fish species list for the Yakima River basin, refer to Pearsons et al. (1998).

Habitat Conditions

Habitat conditions for native resident fish in the river segments downstream from the storage dams are identical to those discussed in section 4.8, "Anadromous Fish." Unlike anadromous fish, resident fish are also present in the storage reservoirs, which are part of the area affected by the alternatives. Reservoir operations may affect resident fish by affecting the productivity of the reservoirs for fish and their food base and by affecting access from the reservoir to tributary spawning streams.

Annual drawdown of the basin reservoirs, which is part of the routine operation and maintenance of the Yakima Project, could affect reservoir aquatic productivity. Existing data suggest that the Yakima River basin reservoirs have limited nutrients, especially phosphorus and trace elements (Flagg et al., 2000; Hiebert, 1999; Mongillo and Faulconer, 1982). Based on the information available, all of the reservoirs are oligotrophic (lacking plant nutrients and usually containing plentiful amounts of DO without stratification). Studies by Mongillo and Faulconer integrated many limnological factors to determine the fish-producing potential of the reservoirs. The studies were conducted in the presence of what would have been routine operations at the time. Their analysis suggested that flushing rates may be removing phosphorus from the reservoirs (Mongillo and Faulconer, 1982), that there was a significant relationship between zooplankton production and fish catch per unit effort, and that lake levels, if held higher, might enhance benthic invertebrate production.

Generally, time is an important factor for the effectiveness of lake processes (stratification, sedimentation, population growth, etc.); adequate time under relatively stable conditions is required for the ecosystem to function adequately (Wetzel, 1990). One common effect of an annual drawdown is to reduce the time available to complete population growth (e.g., phytoplankton, zooplankton), and this can result in reduced diversity of biota and the favoring of biota with broad physiological tolerances (Wetzel, 1990).

Drawdown also impacts the littoral zone, the area between the high and low water marks, which is often important to several aspects of fish production. In 1981, Washington State Department of Game wrote a report to Reclamation for the Yakima River Basin Water Enhancement Project (Washington State Department of Game, 1981). The biologists reported:

> *All reservoirs in the basin are seasonally drafted to meet irrigation needs. The decrease in reservoir surface area has an adverse impact on primary productivity reducing the food supply for fish. The major source of productivity in most reservoirs is phytoplankton, which thrive in the upper photic zone of the pool. As reservoir levels decrease through the summer, primary production and resultant food supplies decline. Because of inadequate food supplies, fish populations in reservoirs are maintained at artificially low levels. In addition, a low water level in fall limits the habitat available for shoal spawning species.*

Reservoir elevations may affect the ability of species which rear in the reservoir but spawn in the tributaries to move from one to the other. The access problem is a function of both tributary streamflow and reservoir elevation and occurs mainly in the fall and early winter when reservoirs are low, as are flows in the tributaries. As the reservoirs are drawn down, the exposed stream channels on the reservoir bottoms may be ill-defined as they flow across the exposed sediments. Much of what little water is present may seep into the ground because the sediments are permeable; consequently, the stream may become too shallow for passage. In some years (e.g., 1996) when the reservoir and streamflows were low, some streams became disconnected completely from the reservoirs. Years when flows and reservoir elevations are higher present less of a problem.

4.9.2 Environmental Consequences

4.9.2.1 Methods and Assumptions

Columbia River

The Biology Technical Work Group (2004) identified two issues that pertain to resident fish in the affected area of the Columbia River. The first issue is the potential effects of water withdrawal from Priest Rapids Lake to fill Black Rock reservoir on the spawning and rearing habitat of resident fish.

The relationship between the Hanford reach juvenile fall Chinook habitat area to river discharge (Anglin et al., 2006) was used as an indicator to evaluate the potential affects of pumping Columbia River water from Priest Rapids Lake on resident fish residing in the Hanford reach. Because of the large number of resident fish that reside in the affected area and lack information pertaining to the relationship of habitat area to river discharge specific to these resident species, the habitat-area-to-river-discharge relationship for juvenile fall Chinook was used as a surrogate.

The second issue was to evaluate the potential effects on resident fish mortality at the pump intake site of pumping Columbia River water from Priest Rapids Lake to fill Black Rock reservoir.

This issue was evaluated in qualitative terms, factoring in the pump intake location, screen design, pumping schedule, and quantity of water pumped, as was discussed for anadromous fish.

Yakima River

There was no appreciable change in water temperature in the modeled reach (Roza Diversion Dam to Prosser Diversion Dam) during the irrigation season between the Joint Alternatives and the No Action Alternative (section 4.8, “Anadromous Fish”). Thus, no change is expected in the biological consequence of water temperatures to resident fishes for the Joint Alternatives compared to the No Action Alternative.

Indicator 1: Summer Rearing Habitat in the Easton, Ellensburg, and Lower Naches River Reaches for Rainbow Trout and Bull Trout

See section 4.8, “Anadromous Fish,” for a complete description of this indicator. The methods and assumptions are the same, except that the fry and subyearling life stage time periods for rainbow trout and bull trout differ from the steelhead and spring Chinook because of differences in their life cycles. Few records exist of bull trout spawning or fry/juvenile rearing in the three reaches evaluated for this indicator. The lifestage time periods used to estimate the amount of fry and subyearling habitat in the Easton, Ellensburg, and lower Naches River reaches were as follows:

- Rainbow trout fry: July 1–August 30
- Rainbow trout subyearling: September 1–September 30
- Bull trout subyearling: June 1–September 30

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers

This indicator applies similarly to anadromous and resident fishes. A complete description of this indicator is discussed in section 4.8, "Anadromous Fish."

Indicator 3: Reservoir Operations

The reservoir operations indicator applies to bull trout spawners in Kachess, Keechelus, and Rimrock Lakes. This indicator has two components. The first component counts the average annual number of days access from the reservoir to spawning tributary is impeded for bull trout spawners due to low reservoir volume. Critical passage due to reservoir volume is influenced by the amount (cfs) of tributary inflow. For the same reservoir volume, bull trout passage generally improves as tributary inflow increases. To account for this tributary influence on passage (Thomas and Bovee, 2007), lookup tables were developed for each of the three reservoirs that were used in the DSS model to track this indicator. These lookup tables are based on multiple field observations by Thomas and Bovee (2007) spanning several years, where the number of spawning nests (redds) in the reservoir tributaries were counted and loosely correlated to reservoir volume and the amount of tributary inflow.

The critical bull trout spawner migration time period was defined as July 15–September 15 (Thomas and Bovee, 2007).

The second component is a measure of the median Kachess, Keechelus, and Rimrock Lake elevation during the bull trout spawning migration period of July 15–September 15 when they migrate from the reservoirs into the tributaries.

The first component of the reservoir operations indicator is calculated by the DSS model with input of daily reservoir elevation from the Yak-RW model for the hydrologic period of 1981–2005. The DSS model counts the number of days for each year in the hydrologic period that reservoir elevation is below the critical threshold volume for each of the three reservoirs from July 15–September 15 and is recorded as the average number of days annually that the critical threshold volume is not exceeded. This indicator was calculated for all four alternatives; the percent change between each Joint Alternative and the No Action Alternative was also calculated.

The second component of the reservoir operations indicator calculates the median reservoir elevation for Kachess, Keechelus, and Rimrock Lakes based on estimated daily reservoir elevations for the 1981–2005 hydrologic period provided as output from the Yak-RW model.

4.9.2.2 Summary of Impacts

Columbia River

Much of the discussion for anadromous fish in section 4.8 applies to resident fish and is not discussed further here. The only difference identified was the potential for entrainment of newly emergent resident fry through the fish screens; this potential does not exist for anadromous salmonids. The State's criterion is a 3/32-inch mesh size opening for all screens designed to preclude entrainment of juvenile salmonids. Many of the resident warm water species have fry that hatch at approximately 15 millimeters or less long (salmon and steelhead fry are approximately 20–25 millimeters long at emergence), which would result in entrainment into the intake pipe to Black Rock reservoir until they grow to a size comparable to anadromous salmonids. While some fish would be actively drawn into the Priest Rapids pumping plant, intake screening would restrict entrainment.

Yakima River

Table 4.32 summarizes the effects of the alternatives on the selected indicators for rainbow trout and bull trout.

4.9.2.3 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Indicator 1: Resident Fish Impacts.—The habitat quantity amounts for each reach and species/life stage are presented in table 4.32. These values are essentially the same as under the current condition.[8] Only habitat changes near or greater than 10 percent are discussed in the text, but all values are reported in table 4.32.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers.—The results are the same as discussed for anadromous fish, and results are shown in table 4.25.

[8] The DSS model was not run for the Yak-RW current flows; therefore, the only way to compare and, thus, make this statement is by comparing flows between the current condition and No Action Alternative.

Table 4.32 Summary of impacts on the selected indicators for rainbow trout and bull trout

Resource Indicator	No Action Alternative	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Summer flows in the upper Yakima and lower Naches Rivers (acres of available habitat and percent change 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%
Bull trout spawner upmigration at reservoirs (inseason days impeded and percent change from No Action Alternative)				
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 (feet) 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

No change is expected in the biological consequence to resident rainbow trout and bull trout under the No Action Alternative compared to the current condition.

***Indicator 3: Reservoir Operations.*—**The average annual number of days with a critical threshold reservoir volume for bull trout spawners under the No Action Alternative is Kachess Lake, 18 days; Keechelus Lake, 37 days; and Rimrock Lake, 3 days (table 4.32).

The average reservoir elevations for the period coinciding with bull trout spawner migration for all the alternatives are presented in table 4.32. The average reservoir elevation for the No Action Alternative are Kachess Lake, 2,248.4 feet; Keechelus Lake, 2,467.3 feet; and Rimrock Lake 2,909.9 feet.

4.9.2.4 Black Rock Alternative

Construction Impacts

Construction impacts would be the same as discussed in section 4.8, "Anadromous Fish."

Long-Term Impacts

Indicator 1: Resident Fish Impacts.—Compared to the No Action Alternative, flows changes in the Yakima River are the greatest under this alternative. Spring flows are greater throughout the system, while summer flows in the middle and lower Yakima River are significantly greater as a result of a greater flow objective at the Parker gage. Summer and early fall flows in the upper Yakima River basin are less, as water previously released for diversion by Roza and Sunnyside Valley Irrigation Districts is now provided from Black Rock reservoir. Winter flows are also greater throughout the basin as a result of improved carryover and a reduced volume that needs to be stored each winter.

Generally, there is no substantive difference in the amount of fry and yearling habitat between the Black Rock and the No Action Alternatives in the Easton reach (table 4.32). The only exception is a 10.5-percent increase in the amount of rainbow trout yearling habitat. In the Ellensburg reach, the only substantive change in habitat quantity is the nearly 30-percent increase in rainbow trout yearling habitat compared to the No Action Alternative. There are no changes 10 percent or greater in the lower Naches River reach.

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers.—The results are the same as discussed for anadromous fish, and results are shown in table 4.25.

The results represent an improvement in both the Ellensburg and lower Naches River reaches for fish compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change should translate into less stranding of both fish and aquatic invertebrates in the Ellensburg reach that need to move to adjust to the change, and less spatial disruption to desired habitat (i.e., the change in location of desired habitat in a relatively short period of time) in the lower Naches River reach.

Indicator 3: Reservoir Operations.—The average annual number of days with a critical threshold reservoir volume for bull trout spawners under the Black Rock Alternative is Kachess Lake, 15 days; Keechelus Lake, 38 days; and

Rimrock Lake, 3 days; compared to 18, 37, and 3 days, respectively, under the No Action Alternative (table 4.32).

The average reservoir elevations under the Black Rock Alternative are Kachess Lake, 2,255.3 feet; Keechelus Lake, 2,466.6 feet; and Rimrock Lake, 2,906.2 feet (table 4.32). Average reservoir elevation is higher in Kachess Lake (+4.7 feet) and lower in Keechelus Lake (-0.7 feet) and Rimrock Lake (-3.7 feet) than under the No Action Alternative. No effects on bull trout spawner migration are expected as a result of these differences in average reservoir elevations compared to the No Action Alternative.

Seepage Mitigation Features.—Black Rock reservoir seepage mitigation measures, as proposed, would result in a constant year-round inflow of approximately 50 cfs to the Yakima River at the Benton County Horn Rapids Park. No negative impacts to resident fishes are anticipated. The majority of resident fishes (e.g., smallmouth bass, catfish, carp, chiselmouth, suckers, and speckled dace) that inhabit the lower Yakima River prefer warmer water but can tolerate a wide temperature range. It is possible that the warmwater plume resulting from the seepage inflow during the late fall to early spring, when the Yakima River water temperature is cooler (less than the seepage inflow), may attract some resident fishes.

4.9.2.5 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction impacts would be the same as discussed in section 4.8, “Anadromous Fish.”

Long-Term Impacts

Indicator 1: Resident Fish Impacts.—Winter flows from Cle Elum Lake down to the Wymer site are greater under this alternative as winter flows are “bypassed” through Cle Elum Lake to be stored in Wymer reservoir. This “bypass” more than doubles flows in the Cle Elum River. During the summer months, flows in the upper Yakima River are lower as some of the irrigation needs in the middle basin are met by releases from Wymer reservoir. Summer flows are about 500–600 cfs less.

There are no substantive differences of 10 percent or greater in the amount of rainbow trout and bull trout habitat between the Wymer Dam and Reservoir and the No Action Alternatives in the Easton reach (table 4.32).

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers.— The results are the same as discussed for anadromous fish, and the results are presented in table 4.25.

The results represent an improvement in the Ellensburg reach (third best) and a slight worsening condition in the lower Naches River reach (third best) for fish compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change in flow in the Ellensburg reach should translate into less stranding of both fish and aquatic invertebrates for reasons similar to those presented for the Black Rock Alternative. Even though the rate of change in flow is somewhat greater in the lower Naches River reach, it is anticipated this would not result in any biological change compared to the No Action Alternative for rainbow trout and bull trout in the Naches River basin.

Indicator 3: Reservoir Operations.—The average annual number of days with a critical threshold reservoir volume for bull trout spawners is Kachess Lake, 18 days; Keechelus Lake, 37 days; and Rimrock Lake, 1 day (table 4.32). Under this alternative, the number of critical passage days is the same for Kachess and Keechelus Lakes and 2 days fewer for Rimrock Lake than under the No Action Alternative.

The average reservoir elevation is Kachess Lake, 2,249.3 feet; Keechelus Lake, 2,467.6 feet; and Rimrock Lake, 2,912.3 feet (table 4.32). Average reservoir elevation is higher in Kachess Lake (+0.9 feet), Keechelus Lake (+0.3 feet), and Rimrock Lake (+1.8 feet) than under the No Action Alternative. No effects on bull trout spawner migration are expected as a result of these differences in average reservoir elevations compared to the No Action Alternative.

4.9.2.6 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction impacts would be the same as discussed in section 4.8, "Anadromous Fish."

Long-Term Impacts

Indicator 1: Resident Fish Impacts.—Winter flows from Cle Elum Lake to the Wymer site improve under this alternative as winter flows are "bypassed" through Cle Elum Lake to be stored in Wymer reservoir. This "bypass" more than doubles flows in the Cle Elum River. In the spring and summer, flows are greater in the middle and lower basin as water available for diversion at Roza and Parker is left in the river as some of the irrigation demand is met by the exchange. The flow objective at the Parker gage increases from about 640–1,500 cfs.

During the summer months, flows in the upper Yakima River are lower as some of the irrigation needs in the middle basin are met by releases from Wymer reservoir. Summer flows are about 1,000 cfs less.

There are no substantive changes of 10 percent or greater in the amount of rainbow trout and bull trout habitat between this alternative and the No Action Alternative in the Easton reach (table 4.32).

Indicator 2: Flip-Flop in Both the Upper Yakima and Naches Rivers.—The results are the same as discussed for anadromous fish, and the results are shown in table 4.25.

For the three Joint Alternatives, these results represent the third best improvement in the Ellensburg reach (and comparable to the Wymer Dam and Reservoir Alternative) and the second best improvement in the lower Naches River reach (and comparable to the Wymer Dam and Reservoir Alternative) compared to the No Action Alternative. While the specific biological implications are difficult to measure, the reduction in the rates of change in flow in the Ellensburg reaches should translate into less stranding of both fish and aquatic invertebrates for reasons similar to those presented for the Black Rock Alternative. A reduction in the rate of increase in flow in the lower Naches River reach may decrease the potential for juvenile rainbow trout and bull trout to be displaced from their rearing habitats.

Indicator 3: Reservoir Operations.—The average annual number of days with a critical threshold reservoir volume for bull trout spawners is nearly the same as under the Wymer Dam and Reservoir Alternative.

The average reservoir elevation for Wymer Dam and Reservoir Alternative is Kachess Lake, 2,249.7 feet; Keechelus Lake, 2,468.0 feet; and Rimrock Lake, 2,911.7 feet (table 4.32). Average reservoir elevation is higher in Kachess Lake (+1.3 feet), Keechelus Lake (+0.7 feet), and Rimrock Lake (+1.8 feet) than under the No Action Alternative. No effects on bull trout spawner migration are expected as a result of these differences in average reservoir elevations compared to the No Action Alternative.

4.9.2.7 Mitigation

Mitigation would be the same as discussed in section 4.8, "Anadromous Fish."

4.9.2.8 Cumulative Impacts

Cumulative impacts on resident fish would be similar to those described for anadromous fish. Future growth and development in the basin will likely diminish the benefits of the Joint Alternatives for resident fish in the affected stream reaches. The benefits foreseen at the reservoirs as a result of higher reservoir elevations would not likely be diminished by growth. Most of the land surrounding the reservoirs is public land and not subject to the same development pressures as private lands located elsewhere in the basin.

Implementation of habitat enhancement projects for anadromous fish would also benefit native resident fish. The EDT modeling done for anadromous fish as part of the subbasin planning process (Yakima Subbasin Fish and Wildlife Planning Board, 2004) also included steelhead. Because of difficulties using the EDT model to evaluate only steelhead, the modeling was done for both steelhead and rainbow trout (the nonanadromous form of steelhead) combined. This analysis indicated a better then four-fold increase in abundance for steelhead/rainbow over the current condition. As with anadromous fish, the improvements under the Joint Alternatives would work in concert with these habitat improvements to further boost resident fish numbers.

4.10 Aquatic Invertebrates

4.10.1 Affected Environment

Invertebrate responses to regulated river systems are often complex and variable. Invertebrates are a major part of the food resource for fishes, and changes in invertebrate communities may result in changes in condition of fish communities (Waters, 1982; Bowlby and Roff, 1986; Wilzbach et al., 1986). Invertebrates, like other aquatic organisms, respond to changes in water quality, food abundance, and other habitat parameters (Ward, 1976; Armitage, 1984; Armitage et al., 1987). Many habitat parameters affecting the distribution and/or abundance of aquatic invertebrates are affected by flow regime (Statzner et al., 1988), and the effects of change in flow are, thus, the focus of this resources assessment.

This analysis of aquatic invertebrate communities is based on studies from other river systems and site-specific sampling within the Yakima River basin. Sites sampled in 2002–04 include areas downstream from storage reservoirs: Keechelus, Kachess, Cle Elum, Bumping, Clear, and Rimrock (Tieton) Lakes; downstream from diversion dams (Easton and Roza); and in unregulated tributaries (Bumping, Cle Elum, Cooper, Gold Creek, Deep Creek, Indian Creek, South Fork Tieton Creek, and Waptus) (Nelson, 2004; Nelson, 2005). Sampling in the lower portion of the Yakima River was conducted in 2006 in the Union Gap/Wapato reach. Study results are summarized in the following sections, and additional details are in Nelson (2004).

4.10.1.1 Flow Magnitude and Timing

Aquatic invertebrates appear to be adapted to flow fluctuations within a range of what can be considered normal conditions. For example, Morgan et al. (1991) found that invertebrate density doubled if flows were generally held within a range of about one to three times the base flow. However, under extreme flood conditions (28–60 times the base flows), benthic biomass can be reduced 75–95 percent within the first few miles downstream; a reduction of 40–60 percent (compared to undisturbed areas) can be detected 12–25 miles downstream (Moog, 1993). In general, flood flows need to exceed about 20 times the median flow to have significant effects on invertebrate abundance and taxonomic richness 3–4 weeks after a flood event (Quinn and Hickey, 1994).

However, artificially high flows at unseasonable times may have a major effect on benthic composition. The length of time that biota are exposed to high flows also likely plays a role in the amount of community resiliency that is exhibited, with short-term (pulse) alterations less damaging than long-term (press) alterations. This may explain some of the variance in invertebrate assemblages downstream from Yakima Project reservoirs and may play a role in the low richness values relative to other Reclamation reservoirs (Nelson, 2004). Macroinvertebrate communities downstream from Cle Elum Lake and Bumping Lake appeared, however, to recover relatively quickly, with distance and time, from dam-induced impacts (Nelson, 2004).

Arango (2001) determined that the flip-flop operation affected the insect community in an upper Yakima River riffle near the town of Ellensburg. It appeared that some insects were stranded as the water level was lowered in the Yakima River, while other insects entered the drift. Standing crop, however, doubled in samples collected in the river. The study suggested that a major portion of the invertebrate community is successful in moving down the drying bank and back into the wetted area.

4.10.1.2 Recovery from Regulation

The benthic communities downstream from Cle Elum Lake and Bumping Lake appeared to recover from dam-induced impacts within a relatively short distance (1.5–5.9 miles) downstream from dams (Nelson, 2004). However, the hyporheic invertebrate community may be more impacted by river regulation than macroinvertebrates associated with surface substrates (Nelson and Bowen, 2004); the recovery distances downstream from dams for this portion of the macroinvertebrate community remains unstudied.

4.10.1.3 Lateral Connectivity/Backwater Effects

Backwaters in natural systems often function as macroinvertebrate refugia from extreme flows. Backwaters accumulate macroinvertebrates during spates, and lateral heterogeneity of stream channels is an important element of stream restoration (Negishi et al., 2002). Flood plain production of invertebrates can be orders of magnitude greater than that produced in the river channel (Gladden and Smock, 1990) and result in enhanced growth and survival of salmonids (Sommer et al., 2001). However, this may not always be the case; Naches River invertebrate drift biomass and the abundance of benthos preferred by salmonids decreased in a season with greater flows, suggesting that invertebrates may have been flushed out of backwaters (Reclamation, unpublished data). Differences between studies may be the result of variable responses to differences in flow duration (e.g., pulse versus press disturbances).

Stanford et al. (2002) emphasized the importance of flow for maintaining off-channel environments in the Yakima River system, and it was suggested that these areas are often dewatered because of reduced base flows. Productivity decreases in benthic invertebrates caused by flow alterations likely to impact the quality of salmonid food resources. Presence of coarse-particulate-organic-matter (CPOM) has been found to be positively correlated with aquatic invertebrate biomass in upstream portions of the Yakima River basin (Nelson, 2005); CPOM is associated, to a large degree, with riparian trees. Leaf fall in the autumn provides a large input of CPOM, with much of this linked to black cottonwoods, which then enter the main channel directly through leaf fall and via connection with side channels and flood plain inundation.

4.10.1.4 Relationship to Discharge and Project Facilities

It is likely that aquatic invertebrate distribution in the Yakima Project area is related to discharge; therefore, the potential for community changes resulting from altered flows is high. Alternatives that shift flows from what were the historic normative flows should have the greatest adverse effect on macroinvertebrate communities. However, despite some of the extreme alterations already present in the system, there is a great diversity and abundance of macroinvertebrates at some sites downstream from dams in the Yakima Project area.

Yakima Project facilities and their operations have variable effects on aquatic invertebrates, with variability likely related to the degree of resulting flow alteration as compared to the natural flow regime. For example, taxa richness values downstream from diversion dams were similar to those obtained from unregulated tributaries and much greater than those obtained below storage reservoirs (Nelson, 2004). Macroinvertebrate communities downstream from Cle Elum Lake and Bumping Lake appear to recover from dam-induced effects with distance downstream and season.

4.10.2 Environmental Consequences

As discussed in detail in this section, the analysis of alternatives based on hydrology suggests that the Black Rock Alternative would result in major positive changes in macroinvertebrate assemblages in the Wapato reach of the Yakima River and major changes of an indeterminate nature in the Cle Elum River. It appears that the Wymer Dam and Reservoir Alternative would have few effects, and that the Wymer Dam Plus Yakima River Pump Exchange Alternative may result in only minor to moderate positive changes in the Wapato reach.

4.10.2.1 Methods and Assumptions

Impact assessment for aquatic invertebrate communities that may be affected by the alternatives was based on studies from other river systems and site-specific sampling within the Yakima River basin. Study results are summarized in the following sections; additional details can be found in Nelson (2004) and in the *Aquatic Ecosystem Evaluation* report developed for the Storage Study (Reclamation, 2008e).

Reclamation scientists have been sampling aquatic invertebrates at Yakima River basin sites for several years, but this has occurred mostly in the upper part of the basin. Sites sampled in 2002–04 include areas downstream from storage reservoirs (Keechelus, Kachess, Cle Elum, Bumping, Clear, and Rimrock [Tieton] Lakes); downstream from diversion dams (Easton and Roza); and in unregulated tributaries (Bumping, Cle Elum, Cooper, Gold Creek, Deep Creek, Indian Creek, South Fork Tieton Creek, and Waptus) (Nelson, 2004; Nelson, 2005). Sampling was conducted in 2006 at six sites in the Union Gap and Wapato reaches using the same methods as presented in Nelson (2004). These data indicated that Ephemeroptera Plecoptera and Trichoptera (EPT) and taxa richness were similar between the Union Gap/Wapato sites (EPT = 12.5 plus or minus 1.5 [95-percent confidence interval]), taxa richness = 23.3 plus or minus 6.0 (95-percent confidence interval) and unregulated tributaries (n = 30) (EPT = 15.3 plus or minus 1.8 (95-percent confidence interval), taxa richness = 22.7 plus or minus 2.4 (95-percent confidence interval). Abundance values were greater at sites in the lower reaches (lower reach abundance = 504 plus or minus 315 [95-percent confidence interval]) individuals/sample, unregulated tributaries abundance = 252 plus or minus 90 (95-percent confidence interval) individuals/sample but had overlapping confidence intervals. Taxa richness refers to the total number of taxa sampled at sites, while EPT richness depends on the number of taxa within the disturbance sensitive insect orders of EPT.

Yakima River basin reservoirs/diversions were compared to 15 other Reclamation reservoirs with similar water quality parameters through a percentile ranking mechanism based on taxa (same classification level) and EPT richness (Nelson, 2004). Richness scores from the 15 Reclamation reservoirs are categorized from low to high values, and Yakima sites are compared based on percentiles: greater than or equal to 75 percent is high; greater than 50–75 percent is moderately high; greater than 25–50 percent is moderately low; and less than or equal to 25 percent is low.

The focus in this analysis is largely on three reaches and includes the Cle Elum River and the Kittitas (Ellensburg) and Wapato (Parker) reaches of the Yakima River. Hydrographs for these reaches are presented in chapter 2 (figures 2.2–2.7). Changes in macroinvertebrate assemblages likely are to occur under conditions that alter the timing and/or magnitude of flows, and these alterations may vary in different reaches of the same river. Macroinvertebrate data are relatively common for the Cle Elum River, largely absent for the Kittitas reach, and limited for the Wapato reach. A variety of metrics, including EPT and taxa richness along with macroinvertebrate functional feeding groups, was used to estimate effects related to hydrographs for these three reaches. It should be recognized that hydrological responses and macroinvertebrates in a river section may be variable under similar flows, and the conclusions are not intended to be very specific.

4.10.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Under the No Action Alternative, flows are little changed from the current condition. Yakima Project facilities and their operations have variable effects on aquatic invertebrates under the No Action Alternative, with variability likely related to the degree of resulting flow alteration as compared to the natural flow regime. For example, taxa richness values downstream from diversion dams were similar to those obtained from unregulated tributaries and much greater than those obtained downstream from storage reservoirs (Nelson, 2004). Flows from diversions typically resemble run-of-the-river flows and may, thus, be more similar to historic hydrology. Clear Lake and Rimrock Lake differed from other reservoirs by exhibiting high taxa richness values. Clear Lake flows are similar to natural flows and are typically surface withdrawals, while large substrate downstream from Rimrock Lake may provide a more stable habitat for invertebrates. It should also be noted that sampling at Rimrock Lake occurred in August, almost a year after—and before—the initiation of annual high flows associated with flip-flop operations. Macroinvertebrate communities downstream from Cle Elum Lake and Bumping Lake appear to recover from dam-induced effects with distance downstream and season.

When compared among themselves based on aquatic invertebrate richness, Yakima River basin reservoirs and diversions can be ranked from highest to lowest as: Rimrock = Roza = Clear Lake = Easton > Kachess = Bumping > Cle Elum = Keechelus (Nelson, 2004). The high late-summer flows from Cle Elum Lake (chapter 2) likely are responsible for the low macroinvertebrate rankings downstream from this reservoir in August/September.

Despite alterations in the basin, there is a great diversity and abundance of macroinvertebrates at some sites downstream from dams in the Yakima Project area. For example, high-quality resilient invertebrate communities exist in the upper Yakima River basin under the altered flow regimes associated with flip-flop operations (Cuffney et al., 1997; Stanford et al., 2002; Nelson, 2004; Reclamation, unpublished data). Limited data appear to indicate some impairment to aquatic invertebrates in downstream sites. Cuffney et al. (1997) describe sites along the mainstem Yakima River between Umtanum and Parker as containing moderately impaired communities. Conditions that may have influenced the macroinvertebrate communities included municipal wastewater discharges, irrigation return flows, and hydrological alterations caused by water diversions. Water diversions in conjunction with enrichment from wastewater discharges may result in major alterations of invertebrate communities (Suren et al., 2003). It is possible that, in the lower portion of the Yakima Project area, water diversions result in more easily detected consequences on the invertebrate community than the alterations in flow timing that presently occur in the upper part of the project under flip-flop operations. However, recent data collection indicates that metrics from macroinvertebrate samples collected from the Union Gap and Wapato reaches have values similar to those from unregulated tributaries. It should be noted that some investigators (Paller et al., 2006) have found that macroinvertebrate taxa richness increases with growing stream width. This appears not to be the case at Union Gap and Wapato, and taxa richness equivalent to upstream sites may be indicative of impacts.

Model results suggest that spring flows in the Ellensburg reach, which are decreased by 8 percent, are less altered than those in the Wapato reach, which are decreased by 38 percent. This alteration from unregulated flow would be expected to affect in-channel invertebrates but would also affect flood plain aquatic invertebrates and CPOM production from black cottonwoods. The No Action Alternative would likely result in diminished production of CPOM over time because of the low cottonwood seedling recruitment that presently occurs on some of the reaches.

4.10.2.3 Black Rock Alternative

Construction Impacts

Construction-related impacts are anticipated to be minimal and isolated to areas adjacent to or immediately downstream from any new intake or outlet structures.

Long-Term Impacts

The Black Rock Alternative appears to result in the most normative/unregulated flow regime (chapter 2) at the three reaches. In the Cle Elum River, the Black Rock Alternative would shift high flows from summer to early spring (chapter 2). These high flows, however, would be much lower than unregulated flows (chapter 2) and even lower than the current high flows (around 13 times lower in some cases). At present, the macroinvertebrate community recovers from the impacts of regulation at about 6 miles downstream from the dam; in the absence of large flows in July–September, this recovery distance may decrease and result in community assemblages found immediately downstream from the dam becoming more like those found at downstream stations (Nelson, 2004), at least in the short term. Because of the presence of Cle Elum Lake, communities would still be altered with a larger presence of collector-filterers closer to the reservoir. Collector-filterers are animals with anatomical structures (setae or fans) or secretions that sieve particulate matter from suspension. In the absence of near normative high flows at any time of the year, there is a concern that finer substrates may become more common in the Cle Elum River downstream from the dam. This could have a large impact on the macroinvertebrate community because fine sediment deposition has been correlated with lower benthos abundance and changes in composition from EPT to burrowing midges and oligochaetes (Waters, 1995). The overall lower flows that would occur under the Black Rock Alternative would also likely result in the retention of more CPOM in the Cle Elum River. This could result in an abundance of shredders (organisms that process large pieces of decomposing plant matter) and collector-gatherers (organisms that feed primarily on deposited fine particulate organic matter) in what would become a largely low-flow environment with larger amounts of CPOM.

In the Ellensburg reach of the Yakima River, summer flows would still be relatively high under the Black Rock Alternative, but would become more like unregulated conditions during spring runoff. Because of the high summer flows, it is likely that the macroinvertebrate community would be mostly unchanged in this reach under the Black Rock Alternative.

The Wapato reach shows greater spring and summer flows (around 4–5 times greater than under the No Action Alternative) under the Black Rock Alternative, which results in a flow regime more similar to unregulated conditions. Despite these current alterations, the macroinvertebrate community in this reach and the Union Gap reach just upstream contain assemblages that have richness and abundance values similar to those in upstream unregulated tributaries (“Methods and Assumptions”). The greater summer base flows may expand the river channel area and increase channel production for a given reach. The Black Rock Alternative, because of greater spring flows, may result in more flood plain inundation for a longer period of time. This could have a large impact on invertebrate production in these areas. It has also been suggested that there would be an improvement in cottonwood forest trends in this reach of the Yakima River (section 4.7, “Vegetation and Wildlife”) which could maintain or increase CPOM production. It is unclear whether the increased (relative to the No Action Alternative) wintertime flows under this alternative would flush CPOM from this reach.

Abundance of hyporheic invertebrates in sample wells in the Wapato reach was low relative to other sites in the Yakima River basin (Stanford et al., 2002). It is possible that the greater base flow under the Black Rock Alternative could increase the interaction between surface water and groundwater in this reach, resulting in increased invertebrate production in the hyporheic. Much of this invertebrate biomass would eventually make its way back to the main channel, resulting in increased productivity under the Black Rock Alternative.

4.10.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction-related impacts are anticipated to be minimal and isolated to areas adjacent to or immediately downstream from any new intake or outlet structures.

Long-Term Impacts

Hydrology under the Wymer Dam and Reservoir Alternative is very similar to the No Action Alternative for the Cle Elum River (chapter 2), with the exception of slightly greater (less than 2 times) winter flows. Thus, major effects on macroinvertebrate assemblages are unlikely. The major impact from the high late-season flows would be the likely driver under this alternative.

Changes in hydrology in the Ellensburg reach under the Wymer Dam and Reservoir Alternative would also be limited and would still retain the flattened spring runoff peak and summertime maximum flows. It would be expected that macroinvertebrate assemblages would be similar to those under the No Action Alternative.

The Wymer Dam and Reservoir Alternative hydrology in the Wapato reach appears to be similar to the No Action Alternative; therefore, it is not expected that there would be any observable effects on the macroinvertebrate community.

4.10.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction-related impacts are anticipated to be minimal and isolated to areas adjacent to or immediately downstream from any new intake or outlet structures.

Long-Term Impacts

Hydrology under the Wymer Dam Plus Yakima River Pump Exchange Alternative is very similar to the No Action Alternative for the Cle Elum River (chapter 2) and, thus, would be unlikely to result in major effects on the macroinvertebrate assemblages. The timing of flows late in the season would be largely unchanged lfrom the No Action Alternative.

Changes in hydrology in the Ellensburg reach under this alternative would also be limited and would still retain the flattened/depressed spring runoff peak and summertime maximum flows. It would be expected that macroinvertebrate assemblages would be similar to those under the No Action Alternative.

The Wymer Dam Plus Yakima River Pump Exchange Alternative would result in greater base flows in the late summer and early fall in the Wapato reach. Spring flows are approximately two times greater, which may result in some increased flooding of the riparian area. Effects on the macroinvertebrate community under this alternative would be less than those expected under the Black Rock

Alternative. This would include changes caused by increased channels width, hyporheic exchange, and CPOM introduction to the reach from black cottonwoods.

4.10.2.6 Mitigation

No mitigation would be required because impacts to aquatic invertebrate populations are anticipated to be minor or, in the long term, potentially beneficial.

4.10.2.7 Cumulative Impacts

Impacts to aquatic invertebrates under the Joint Alternatives are largely beneficial, except for potential minor impacts associated with short-term construction activities. To a large extent, the beneficial impacts associated with the Joint Alternatives stem from changes in the flow regime, modifying it to resemble more closely the natural flow regime. None of the actions that are reasonably foreseeable would significantly alter the flow regime, so they should not offset the benefits to aquatic invertebrates that are projected under the Joint Alternatives. Some of the fisheries enhancement projects to be carried out under the BPA Fish and Wildlife Program or through other fish enhancement programs such as the State of Washington's Salmon Recovery Funding Board could provide very localized improvements in aquatic invertebrate populations; from a basinwide perspective, they would not be significant.

4.11 Threatened and Endangered Species

4.11.1 Affected Environment

Reclamation evaluated special status species potentially occupying or using the Storage Study area. Columbia River species selection was confined to the river channel only within Priest Rapids Lake and the Hanford reach downstream. In the Yakima River basin, only Benton, Kittitas, and Yakima Counties were addressed. Although the basin includes a narrow strip of northern Klickitat County (including the headwaters of Status Creek), no facilities would be constructed and/or operated that would affect resources in Klickitat County.

As in other sections addressing both Columbia River and Yakima River basin locations, the Columbia River is addressed first followed by the Yakima River species. Anadromous fish are treated first followed by other species.

4.11.1.1 Columbia River

There are four anadromous salmonids that inhabit or migrate through the Columbia River reaches that may be affected by the Joint Alternatives. These species include: spring, summer, and fall Chinook; summer steelhead; coho; and sockeye. Only fall Chinook are known to spawn in the Columbia River reaches within the study area (FERC, 2006). Upper Columbia River steelhead and Upper Columbia River spring Chinook migrate through this area and are a federally listed species under ESA.

Upper Columbia River Steelhead (*O. mykiss*)

The Upper Columbia River steelhead was listed as endangered under ESA on June 13, 2007, by court decision. Critical habitat for the Upper Columbia River steelhead was designated on September 2, 2005 (*Federal Register*, 2005). Upper Columbia River steelhead include fish from the mainstem Columbia River and its tributaries upstream of the confluence of the Columbia and Yakima Rivers.

Steelhead life history and ecological considerations are discussed under Middle Columbia River steelhead and are not repeated here. Steelhead do not spawn in the Columbia River reaches potentially affected by the alternatives, but they do migrate through the reaches as adults on their way to spawning streams and as juveniles on their way to the Pacific Ocean (FERC, 2006). Most steelhead adults pass Priest Rapids Dam during August and September, while most smolts migrate downstream from Priest Rapids Dam in May (range is late April–early June).

The average number of adult steelhead passing Priest Rapids Dam from 1960–2004 was 11,379 fish (ranging from 2,462 in 1975 to 34,589 in 1985) (FERC, 2006). Prior to 1960, steelhead were counted upstream at Rock Island Dam. Counts from 1933–59 ranged from 2,600–3,700 fish. Hatchery production in the 1960s increased run size to about 6,700 fish. Adult steelhead counts at Priest Rapids for the years 2003, 2004, and 2005 were 17,652; 18,727; and 13,449, respectively (FERC, 2006).

Upper Columbia River Spring Run Chinook Salmon

Three different runs of adult Chinook salmon pass Priest Rapids Dam. Adult Chinook returning from April 17–June 13 are "spring" Chinook, adults returning from June 14–August 13 are "summer" Chinook, and adults returning from August 14–November 15 are "fall" Chinook (FERC, 2006). Only spring Chinook are federally listed under ESA. The Upper Columbia River spring Chinook salmon, a State candidate species, was federally listed as endangered June 28, 2005 (*Federal Register*, 2005). Critical habitat for this species was designated on September 2, 2005 (*Federal Register*, 2005).

Spring Chinook life history and ecological considerations are discussed in section 4.8, "Anadromous Fish," and are not repeated here. Spring Chinook do not spawn in the Columbia River reaches potentially affected by the alternatives, but they do migrate through the reaches as adults on their way to spawning streams and as juveniles on their way to the Pacific Ocean (FERC, 2006).

The average annual return of spring Chinook for the period 1960–2004 is 13,067 fish (ranging from 1,130 fish in 1995 to 1,133 in 2001) (FERC, 2006). Adult spring Chinook counts at Priest Rapids in 2004 and 2005 were 14,541 and 14,663, respectively.

Spring Chinook juveniles outmigrate through the Middle Columbia River in April–June, with peak numbers passing Wanapum and Priest Rapids Dams in mid- to late-May (FERC, 2006).

Additional detail on the affected environment of anadromous fish is found in section 4.8, "Anadromous Fish."

Bull Trout

The bull trout, a State candidate species, was federally listed as threatened in the Columbia and Klamath River basins in 1998.

Bull trout exhibit four life history types in Washington: anadromous, adfluvial (downstream migration to lakes), fluvial (downstream migration to larger rivers), and resident (Wydoski and Whitney, 2003). The resident, fluvial, and adfluvial forms occur in the study area. Resident fish complete their entire life cycle in the streams (or nearby) in which they spawn and rear, while fluvial forms mature in their natal streams but then move to large streams and rivers after maturation. Adfluvial bull trout rear from 1–4 years in their natal stream, then migrate to lakes, but return to natal streams to spawn.

Bull trout are native to the Pacific Northwest and are found from the California-Oregon border east to Nevada, north through western Montana and western Alberta, westward through British Columbia, and north to at least 60 degrees north latitude in Alaska (Wydoski and Whitney, 2003). Bull trout occur in the Yukon River drainage and may occur further north. In the mid-Columbia River region of Washington, some 16 subpopulations of bull trout occur in the Yakima, Wenatchee, Entiat, and Methow River basins (FERC, 2006). Historically, subpopulations were more numerous; distribution covered a larger area and included the Columbia River mainstem. Information for the mainstem is limited. However, bull trout are believed to be extirpated from the Hanford reach and are exceedingly rare in the Priest Rapids and Wanapum Lakes.

4.11.1.2 Yakima River Basin

The initial group of federally threatened or endangered species from the three-county Yakima River basin and State-listed threatened or endangered species identified as being potentially affected by the proposed project include the gray wolf, Canada lynx, grizzly bear, marbled murrelet, and northern spotted owl. These species are associated with forest resources high in the basin on lands that may be in proximity to Reclamation's storage reservoirs or other Yakima Project facilities. In 2000, Reclamation concluded—in another study—that operations of project facilities would not result in alterations to habitat resources important to these species (Reclamation, 2000). Reclamation believes that similar circumstances exist with this study (i.e., habitat resources potentially used by these species would not be affected, and these species are not considered further). Four additional species—the pygmy rabbit, the greater sandhill crane, the mardon skipper, and the basalt daisy—have occurred historically, or currently occur, within the three-county study area but are unlikely to be affected by the alternatives. These four species are briefly addressed but are not considered further. In addition, the bald eagle, although removed from listing, is briefly addressed but also is not considered further.

Middle Columbia River Steelhead (*O. mykiss*)

Spawning Habitat.**—**Within the Yakima River basin, wild adult steelhead returns have averaged 1,818 fish (range of 505–4,491) over brood years 1985–2006 as monitored at Prosser Diversion Dam (RM 47.1; brood year 2006 data from Yakima-Klickitat Fisheries Program (Yakama Nation, 2006). The relative number and timing of wild adult steelhead returning during the fall and winter-spring migration periods vary from year to year (Reclamation, 2000; Northwest Power Planning and Conservation Council, 2001).

Minimal numbers of adult steelhead pass Prosser Diversion Dam during July and August, with numbers beginning to increase in September. Peak passage timing upstream of Prosser Diversion Dam occurs in October and November when a combined 50 percent of the steelhead run occurs at this location. Steelhead abundance over Prosser Diversion Dam declines slightly in December and early January due to the onset of cold water temperatures. However, adult migration resumes in February–April, coincident with the spawning run. Adult steelhead migration is essentially completed at Prosser Diversion Dam by early April.

Most adult steelhead overwinter in the Yakima River between Prosser (RM 47.1) and Sunnyside Diversion Dams (RM 103.8) before moving upstream into tributary or mainstem spawning areas (Hockersmith et al., 1995). The Yakima River upstream of Prosser Diversion Dam is known to be occupied by steelhead as well as resident rainbow trout and provides important habitat for adult steelhead migration and holding, as well as for juvenile rearing for this species. In addition, the upper sections of the Yakima River and the entire Naches River basin contains important spawning habitat for steelhead and rainbow trout (Campton and Johnson, 1985).

Hockersmith et al. (1995) identified the following spawning populations within the Yakima River basin: upper Yakima River upstream of Ellensburg, Teanaway River, Swauk Creek, Taneum Creek, Roza Canyon, mainstem Yakima River between the Naches River and Roza Diversion Dam, Little Naches River, Bumping River, Naches River, Rattlesnake Creek, Toppenish Creek, Marion Drain, and Satus Creek. Of 105 radio-tagged fish observed from 1990–92, Hockersmith et al. (1995) found that well over half of the spawning occurred in Satus and Toppenish Creeks (59 percent), with a smaller proportion in the Naches River drainage (32 percent), and the remainder in the mainstem Yakima River downstream from Wapato Dam (4 percent), mainstem Yakima River upstream of Roza Diversion Dam (3 percent), and Marion Drain (2 percent), a Wapato Irrigation Project drain tributary to the Yakima River. Yakima River basin steelhead spawn in intermittent streams, mainstem and side-channel areas of larger rivers, and in perennial streams up to relatively steep gradients (Hockersmith et al., 1995; Pearsons et al., 1996). Within the Naches River basin, most steelhead spawning (85 percent) occurred in the Naches River mainstem, primarily from RM 2.7 (Cowiche Creek confluence) to the Little Naches River, with the remainder distributed in lower reaches of the Bumping River, Little Naches River, and Rattlesnake Creek (Cramer et al., 2003). Electrophoretic analyses have identified four genetically distinct spawning populations of wild steelhead in the Yakima River basin: the Naches, Satus, Toppenish, and upper Yakima stocks (Phelps et al., 2000).

Typically, steelhead spawn earlier at lower, warmer elevations than higher, colder waters. Overall, most spawning is completed from January–May (Hockersmith et al., 1995), although steelhead have been observed spawning in the Teanaway River (RM 176.1), a tributary to the upper Yakima River, into July (Pearsons, 2007). From radio tagging data and records of the first observations of steelhead fry, steelhead spawn in the lower Naches (below Tieton) and its tributaries from early March–mid-May. In the upper Naches River, the spawning period is from late March–late May. In the higher elevation tributaries of the upper Naches (the Little Naches River, Bumping River, Rattlesnake Creek), spawning occurs from late April–late May, peaking in early May.

Hatching and Rearing Habitat.—Steelhead eggs take about 30 days to hatch at 50 °F and another 2–3 weeks before fry emerge from the gravel. However, time required for incubation varies significantly with water temperature. Fry emergence typically occurs between mid- to late May and early July, depending on time of spawning and water temperature during incubation.

Juvenile steelhead use tributary and mainstem reaches throughout the Yakima and Naches River basins as rearing habitat until they begin to smolt and emigrate from the basin. Smolt emigration begins in November and peaks from mid-April–May. Busack et al. (1991) analyzed scale samples from smolts and adult steelhead and found that the smolt transformation typically occurs after 2 years in the Yakima system, with a few fish maturing after 3 years and an even smaller proportion reaching the smolt stage after 1 year.

Steelhead Distribution.—The Yakima River upstream of Roza Diversion Dam is known to be occupied by steelhead as well as resident rainbow trout and provides important habitat for migration and spawning, as well as for juvenile rearing for this species. Although adult run sizes upstream of Roza Diversion Dam are not large, they constitute an important part of the overall Middle Columbia River steelhead evolutionarily significant units. Since 1985, steelhead abundance in the upper Yakima River upstream of Roza Diversion Dam has averaged about 85–108 returning adults, depending on the data source and period of record analyzed (Yakama Nation, 2006; University of Washington, 2006; Haring, 2001). Figure 4.15 shows the total steelhead run size for the upper Yakima River stock and the number of adults passing Roza Diversion Dam for the years 1985–2007 from these various data sources.

Data provided in figure 4.15 indicates some level of inconsistency in data records for the upper Yakima River stock abundance and fish ladder counts at Roza Diversion Dam. Most of these inconsistencies occurred as a result of inadequate monitoring of fish passage at the dam or because of lack of record keeping related to steelhead passage. However, the data from 2001 to the present are considered to be the most accurate because of more detailed record keeping and specific monitoring activities for anadromous steelhead passage at Roza Diversion Dam.

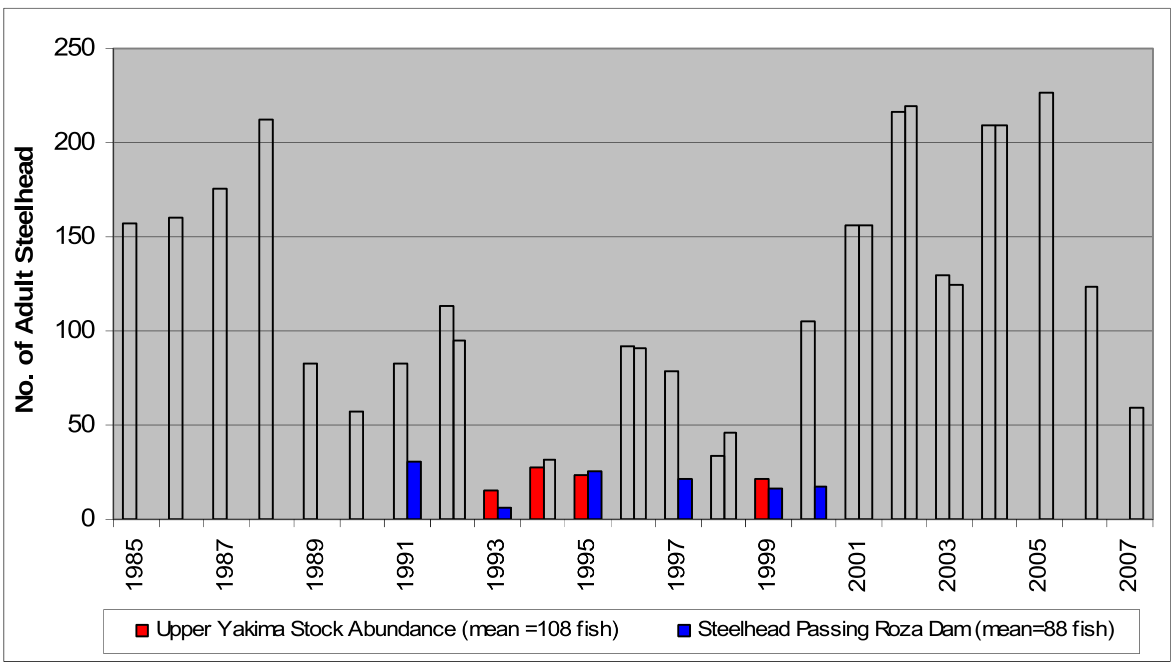

Figure 4.15 Abundance of the Upper Yakima River stock and total number of steelhead passing Roza Diversion Dam (1985–2007).

Sources: University of Washington (2006) and Haring (2001).

Specific information regarding steelhead distribution within the upper Yakima River has not been well understood in this area, despite the early radio-tracking work of Hockersmith et al. (1995). However, recent steelhead radio-tracking studies in the upper Yakima River basin (upstream of Roza Diversion Dam), conducted by Reclamation and the Yakama Nation, have provided detailed information on the distribution patterns of adult steelhead (Reclamation, 2003b).

These recently completed studies show that tagged steelhead are migrating to and spawning in the Yakima River mainstem as well as major tributary systems of the upper Yakima River (Reclamation, 2003b; Reclamation, 2005).

In 2002–03, approximately 34 of 75 (45 percent of the total) radio-tagged wild steelhead remained in the mainstem Yakima River between Roza Diversion Dam and Easton, while 24 (32 percent) migrated into the Teanaway River, 9 (12 percent) were tracked into Swauk Creek, and 1 (2 percent) moved about 2.5 miles up Taneum Creek. The remaining seven fish (9 percent) tagged in 2002–03 were tracked to other Yakima River tributaries (Reclamation, 2003b). Results of steelhead radio tracking in 2003–04 indicate that 51 percent of tagged steelhead remained in the mainstem river between Roza Diversion Dam and Easton, while 38 (32 percent), 9 (7 percent), and 7 (6 percent) used the Teanaway River, Swauk Creek, and Taneum Creek, respectively (Reclamation, 2005).

***Critical Habitat.*—**The final rule designating critical habitat for 12 evolutionarily significant units of west coast salmon and steelhead in Washington, Oregon, and Idaho was published in the *Federal Register* on September 2, 2005, and became effective on January 2, 2006 (*Federal Register*, 2006). Critical habitat designated for Middle Columbia River steelhead in the Yakima River basin included the entire mainstem Yakima River from the confluence with the Columbia River to the upstream limits of migration at storage dams or tributary headwater streams.

Critical habitat for steelhead in the Yakima River and tributaries consists of primary constituent elements (PCE) that support steelhead spawning, freshwater rearing, and migration habitat (National Marine Fisheries Service, 2004a; *Federal Register*, 2005). National Marine Fisheries Service has determined that critical habitat PCEs for steelhead spawning, rearing, and migration exist in the upper Yakima and Naches Rivers as well as several tributaries, and that these PCEs are currently providing an acceptable level of protection that will contribute to the conservation of steelhead populations in this area (National Marine Fisheries Service, 2004a).

Bull Trout

The U.S. Fish and Wildlife Service identified 22 recovery units within the Columbia River Distinct Population Segment (Service, 2002). The Yakima River basin was designated as the Middle Columbia River recovery unit. For recovery purposes, the Service has identified a single core area (Yakima River basin) within the Middle Columbia River recovery unit encompassing a majority of the basin and its tributaries.

Bull trout have some of the most demanding habitat requirements of any native trout species mainly because they require water that is especially cold and clean.

As a result, water temperature is a critical habitat characteristic for bull trout. Bull trout have demonstrated a unique adaptation for spawning, incubating, and rearing in colder water than salmon and steelhead. This adaptation has allowed this species to survive in habitat areas that may be unsuitable for most other species of fish. Ratliff and Howell (1992) note that, in many of the cold streams where bull trout spawn, they are the only fish present. McPhail and Murray (1979) demonstrated that survival of bull trout eggs was 80–95 percent to hatching at temperatures of 36–40 °F (2–4 ºC) and dropped to 0–20 percent at temperatures of 46–50 °F (8–10 ºC). Buchanan et al. (1997) report observations from throughout Oregon and the published literature and conclude that, while optimum temperatures for juvenile growth are 40–50 °F (4–10 ºC), the optimum temperature for adult bull trout is about 54–59 °F (12–15 ºC). Temperatures above 59 °F (15 ºC) exceed bull trout physiological preferences and are, therefore, thought to limit their distribution (Fraley and Shepard, 1989).

Bull trout reach sexual maturity after 4 or more years and live up to 10–12 years. They typically spawn from September–November in relatively cold streams that are clean and free of sediment. The incubation period for bull trout is extremely long, and young fry may take up to 225 days to emerge from the gravel (Craig, 1997; Service, 1998; *Federal Register*, 1998). Because of this long incubation period, eggs are particularly vulnerable to siltation problems and bed load movement in rivers and streams where spawning occurs. Any activity that causes erosion, increases siltation, removes stream cover, or affects water flow or temperature affects the number of bull trout that hatch and their ability to survive to maturity (Knowles and Gumtow, 1996).

Bull trout exhibit both migrant and resident life history strategies. After rearing as juveniles for 2–4 years in their natal streams (Meehan and Bjornn, 1991), migrant bull trout emigrate to larger rivers or lakes, whereas resident fish complete their entire life cycle within their natal stream. Migrant forms, both fluvial and adfluvial, grow rapidly, often reaching over 20 inches in length and 2 pounds by the time they are 5–6 years old. Migratory bull trout live several years in larger rivers or lakes, where they grow to a much larger size than resident forms before returning to tributaries to spawn. Growth differs little between forms during their first years of life in headwater streams but diverges as migratory fish move into larger and more productive waters (Rieman and McIntyre, 1993).

Yakima River basin studies indicate that bull trout typically occur in the upper reaches of several tributaries in small populations that are mostly isolated from each other (Goetz, 1994; Wissmar and Craig, 1998; WDFW, 1998). Studies have indicated that bull trout are most likely to occur, and to be strong in cold, high elevation, low- to mid-order watersheds with low road density (Rieman et al., 1997; Goetz, 1994; MacDonald et al., 1996).

In the 1998 final listing rule (*Federal Register*, 1998), the Service identified eight bull trout subpopulations in the Yakima River basin: (1) Ahtanum Creek, (2) Naches River, (3) Rimrock Lake, (4) Bumping Lake, (5) North Fork Teanaway River, (6) Cle Elum Lake, (7) Kachess Lake, and (8) Keechelus Lake. At the time of listing, only the Rimrock Lake subpopulation was considered stable. The remaining subpopulations were classified as depressed and declining. The population status for the Naches River subpopulation was classified as unknown. With the exceptions of Rimrock Lake and the Naches River, the remaining subpopulations were considered to be at risk of extirpation.

WDFW recognizes nine bull trout stocks in the Yakima River basin. Eight of these stocks are consistent with the subpopulations identified by the Service in the final listing rule. However, they also include one (Yakima River) that was not recognized by the Service at the time of listing. The Service now concurs with the presence of nine populations. Redd counts for some of these stocks have been conducted annually since 1984 (table 4.33).

Table 4.33 Annual redd counts since 1993 for eight local bull trout populations in the Yakima River basin (data from WDFW). The average number of redds counted in the index areas along with the standard deviation (SD) is given at the bottom.

Survey year	Ahtanum Creek	Rattle-snake Creek	American River	South Fork Tieton River	Indian Creek	Deep Creek	Box Canyon Creek	Gold Creek
1993	9			38	140	45	4	11
1994	14	4		167	179	12	11	16
1995	6	26		95	201	101	4	13
1996	5	38	25	233	193	46	8	51
1997	7	46	24	177	193	126	10	31
1998	5	53	31	142	212	98	16	36
1999	7	44	30	161	205	107	17	40
2000	11	45	44	144	226	147	10	19
2001	20	57	36	158	117	51	14	15
2002	17	69	27	141	100	120	15	31
2003	12	54	30	190	101	57	8	9
2004	8	32	40	180	50	97	19	20
2005	6	15	35	205	91	73	8	7
2006	7	40	55	189	106	95	8	8
Average	9.6	40.2	34.3	158.6	151.0	83.9	10.8	21.9
SD	4.7	17.7	9.2	47.9	56.3	37.6	4.7	13.6

One or more local populations may exist within each stock (WDFW, 1998). A local population represents a group of bull trout that spawn within a particular stream or portion of a stream system. Thus, a local population is considered the smallest group of fish that represent an interacting reproductive unit. Gene flow may occur between local populations but is assumed to be infrequent compared to that among individuals within a local population. There are presently 13 local populations that have been identified in the Yakama River basin (WDFW, 1998; Service, 2002). Other local populations may exist that are as yet unrecognized.

For example, as recently as 2002, a juvenile bull trout was captured by Yakama Nation fisheries personnel in a tributary to Cowiche Creek (Anderson, 2002); 13 bull trout were observed in the North Fork Tieton River during a comprehensive snorkel census in 2004.

The main migration period for fluvial adult bull trout in the Naches River occurs from May–October. Peak upstream movement occurs in July, and peak downstream movement occurs from September–October (Mizell, 2006).

The early part of this time period is coincident with both water temperature and day-length increases and with the early onset and preparation for spawning by adult fish. The later part of this active migration period relates to the downstream movement of post-spawn adults as they return to winter and spring holding habitats in the mainstem of the Naches River. Subadult bull trout also are known to have increased migration activity during this late-spring to early-summer period; however, this behavior is not related to spawning. Adult bull trout that have been radio-tagged as part of the WDFW bull trout telemetry study in the Yakima River basin have been tracked throughout the Naches River mainstem during the active migration period. However, the majority of radio-tagged bull trout has remained near the city of Naches and only occasionally have migrated as far as the city of Yakima. A few fish have migrated into the Yakima River where they have held in suitable habitat for a short time (a few days to weeks) before migrating back to the mainstem Naches River. Prior to the onset of spawning, adult bull trout in the mainstem Naches migrate upstream to spawning areas in several tributaries of the upper Naches River basin.

During the winter and spring periods (approximately November–May), adult and subadult bull trout hold or overwinter in the mainstem Naches River. The winter and spring is characterized by a period of relative inactivity by bull trout. Overwintering adults and subadults tend to congregate in highly selective pool habitats that may be used year after year by the same fish (Mizell, 2006). Preferred pool overwintering habitats that are used by radio-tagged bull trout occur in the mainstem Naches River from the Wapatox Diversion Dam (RM 17) to the town of Cliffdell (RM 36) (Mizell, 2006).

Greater Sage-Grouse

The greater sage-grouse is State-listed as threatened and is a Federal candidate for listing under the ESA. The current range of the greater sage-grouse includes portions of eastern Montana, Wyoming, northwestern Colorado, Utah, southern Idaho, northeastern California, southeastern Oregon, and central Washington. In Washington, sage-grouse formerly ranged from the Columbia River north to Oroville, west to the foothills of the Cascade Range, and east to the Spokane River. Sage-grouse in Washington currently are restricted to three isolated populations. The largest population (estimated at about 600 birds) is located on mostly private land in Douglas and Grant Counties. A second population of 300–400 birds occurs on the YTC in Kittitas and Yakima Counties (Schroeder and

Vander Haegen, 2006), and a third population of 25–30 birds occurs within the Yakama Reservation (Schroeder et al., 2000; Burkepile, 2007). Data from radio-tagged sage-grouse show that they use habitat in the Black Rock and Wymer reservoir sites (Livingston, 2007). See figures 4.16 and 4.17. Habitat fragmentation in the area has adversely impacted the species as have loss of shrub-steppe habitat from fires, overgrazing, military practices in the YTC, conversion to cropland, invasion of exotic species, and additional development (Stinson, et al., 2004).

The Washington Sage-Grouse working group, an interagency technical group, has developed recovery objectives and delineated management units for the sage-grouse. The Black Rock site lies within the Rattlesnake Hills Management Unit, and the Wymer site lies within the Umtanum Ridge Management Unit. Telemetry data indicates these units are utilized by greater sage-grouse from the YTC. The Rattlesnake Hills Unit is designated as both a potential corridor and habitat for future reintroductions. The northeastern section may allow greater sage-grouse movement between the YTC and the ALE Reserve). Sage-grouse were probably extirpated from the Hanford Management Unit due to catastrophic fires in 1981 and 1984, although there has been telemetry data of individual birds since 1998 indicating movement out of the YTC (Stinson et al., 2004). The possible use area and movement corridor for greater sage-grouse extends from shrub-steppe lands east of the Columbia River, along Priest Rapids Lake and the Hanford reach, west across the Hanford Site, ALE Reserve, and the YTC, to the upper end of the Moxee Valley and the shrub-steppe-covered hills west of the Yakima River in the Wenas, Umtanum, and Manastash Creek drainages. To the north, it extends up to the irrigated lands in the Ellensburg Valley. Along the southern edge, it extends from the Rattlesnake Hills west along Ahtanum Ridge, across the Yakima River, and along the ridge to shrub-steppe lands on the Yakama Reservation.

Ferruginous Hawk

The ferruginous hawk is a State-threatened species and a species of concern under ESA. This species breeds from southeastern Alberta, southern Saskatchewan, and southwestern Manitoba south through eastern Washington, eastern Oregon, and Nevada to Arizona and New Mexico. The range also extends eastward into Utah, Colorado, Wyoming, Idaho, Montana, the Dakotas, and western Nebraska, Oklahoma, and Texas.

In Washington, the range of the ferruginous hawk coincides with the remaining shrub-steppe communities in the eastern part of the State. This species is believed to depend on native prairie systems of the Great Plains and Great Basin. The decline of shrub-steppe prey, such as black-tailed jackrabbits and Washington ground squirrels, has likely contributed to the listing of the ferruginous hawk as threatened in Washington (Watson and Pierce, 2000).

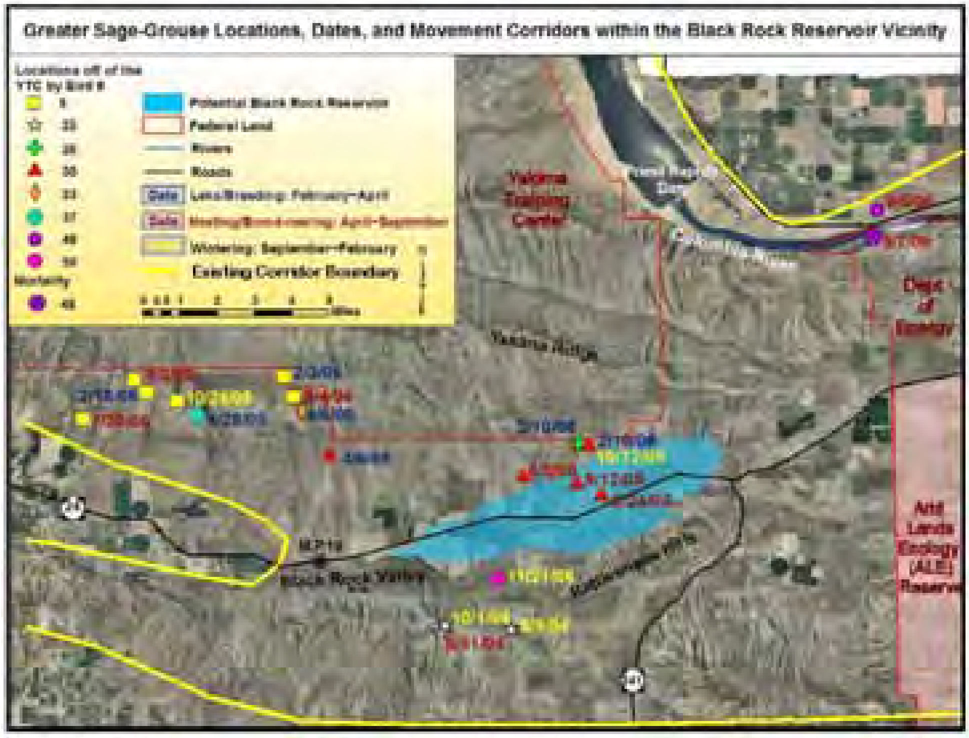

Figure 4.16 Greater sage-grouse locations, dates, and movement corridors within the Black Rock reservoir vicinity.

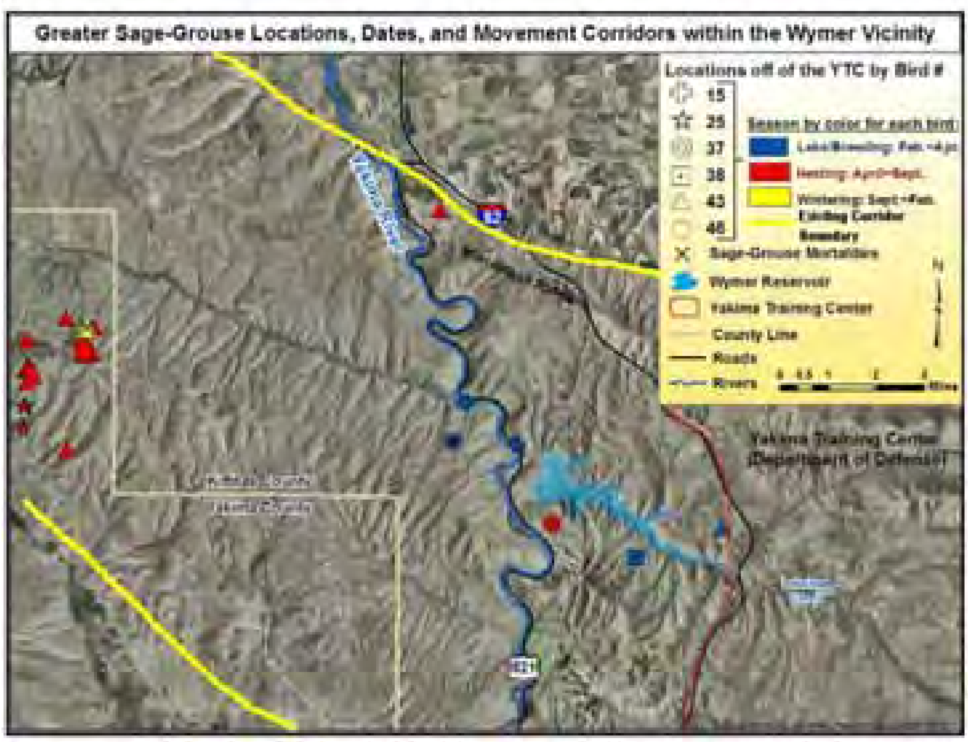

Figure 4.17 Greater sage-grouse locations, dates, and movement corridors within the Wymer site vicinity.

Ferruginous hawks use open grasslands for both nesting and hunting prey. In winter (September–February), this species leaves Washington and generally moves east in search of more abundant prey (Watson and Pierce, 2000). Small- to medium-sized mammals comprise 80–90 percent of their prey. The YTC, Hanford Reach National Monument, and sage-brush-dominated areas on the Yakama Nation lands provide potential habitat resources for this species.

Ute Ladies'-tresses

Ute ladies'-tresses (*Spiranthes diluvialis*), a perennial orchid, was federally listed as threatened in 1992 (Service, 1992). It is also a State-threatened species. In 1996, a population was found along the upper Snake River in southeastern Idaho. In 1997, another population was found in Okanogan County, the only known population in Washington (Service, 2007c). Prior to these discoveries, it was known only from a few locations in Montana, Colorado, Wyoming, and Nebraska. Ute ladies'-tresses is a wetland and riparian species found in springs, wet meadows, river meanders, and flood plains at 1,500- to 7,000-foot elevations (Service, 1995).

This species has not been found in the Yakima Project, though no formal surveys have been conducted with the exception of a wetland site downstream from Keechelus Reservoir in the upper river (Reclamation, 1999).

This species occurs in full sunlight to partially shaded sites in early- to mid-seral communities subject to flooding or periodic inundation. Beaked spikerush (*Eleocharis rostellata*) appears to be the dominant species in habitat occupied by Ute ladies'-tresses and is a good indicator throughout its range. Other species commonly associated with the orchid include creeping bentgrass (*Agrostis stolonifera*), Baltic rush (*Juncus balticus*), long-styled rush (*Juncus longistylis*), and scouring rush (*Equisetum laevigatus*). Other common associates include rushes (*Juncus spp.*), paint-brushes (*Castilleja spp.*), thinleaf alder saplings (*Alnus incana*), narrowleaf cottonwood saplings (*Populus angustifolia*), sweet clover (*Melilotus spp)*, willow saplings *(Salix spp.*), sedges (*Carex spp.*), red clover (*Trifolium praetense*), and western goldenrod (*Solidago spp*).

Umtanum Wild Buckwheat

Umtanum wild buckwheat is a State-endangered species and a Federal candidate species. This species is endemic to a very narrow range in Benton County. It currently is known only from one ridgeline in the Columbia Basin physiographic province, most of which recently burned in a wildfire (Washington State Department of Natural Resources et al., 1997). The only known population occurs at elevations ranging from 1,100–1,320 feet on flat to gently sloping microsites near the top of the steep, north-facing basalt cliffs overlooking the Columbia River. It apparently is restricted to the exposed top of one particular basalt flow (the Lolo Flow). Approximately 5,000 plants grow interruptedly in a narrow band 1.6 miles long and less than 98 feet wide in the Hanford Site. This species' restriction to exposures of one particular basalt flow may suggest a dependent relationship with the chemical composition of that flow. The relatively high water-holding capacity of the substrate has also been suggested as an important factor. The overall vegetation cover is quite low.

The area occupied is being considered for a change in ownership or management responsibility. Public access could accompany such a change. Off-road vehicle use, livestock grazing, and increased risk of wildfire are potentially significant threats (Reveal et al., 1995).

Pygmy Rabbit, Greater Sandhill Crane, Mardon Skipper, Basalt Daisy, and Bald Eagle

The pygmy rabbit, the greater sandhill crane, the mardon skipper, and the basalt daisy historically have occurred, or currently occur, within the three-county study area but are unlikely to be affected by the alternatives. These four species, along with the bald eagle, are addressed briefly but are not considered further.

Pygmy Rabbit.—The pygmy rabbit is a species with endangered status in the State of Washington and under ESA and was initially evaluated for potential effects from the proposed action. The pygmy rabbit was thought to have been extirpated from Washington in the mid-1900s, but some small populations were relocated in 1979. Extensive surveys in 1987 and 1988 located five small populations in southern Douglas County (WDFW, 1995). A sixth population was located in 1997; however, between 1997 and 2000, five of the six populations disappeared (Hays, 2001). The Washington Department of Fish and Wildlife initiated a pygmy rabbit captive breeding program in 2001 and released captive-bred rabbits at a Douglas County site in the spring of 2007. No animals have been detected since 2004, indicating that the pygmy rabbit in Washington may be extirpated from the wild (Service, 2007a). This species is not considered further.

Greater Sandhill Crane.—The sandhill crane has been listed as endangered in Washington since 1981 (Littlefield and Ivey, 2001), but there is no listing status for sandhill cranes under ESA. This species was also initially evaluated for potential effects from the proposed project. A small number of greater sandhill cranes nest in Klickitat and Yakima Counties, and 20,000 plus lesser sandhill cranes stop in eastern Washington during migration. Sandhill cranes that breed in the study area (Yakima County) are part of the Central Valley population that winters in California's Central Valley and nests in California, Nevada, Oregon, Washington, and British Columbia (Littlefield and Ivey, 2001). The lesser sandhill cranes that stop in eastern Washington during migration belong to the Pacific Flyway population. Cranes that breed in Yakima County use an area some distance from project facilities and would not be affected by any proposed operation changes. Therefore, habitat resources potentially used by this species would not be affected, and greater sandhill cranes are not considered further.

Mardon Skipper.—The mardon skipper is a small northwestern butterfly currently found at only four small geographically distinct areas in Washington, Oregon, and California. This species is federally listed as endangered and is a State candidate for listing. In Washington, the mardon skipper occurs in a small number of sites in the Puget Prairie and South Cascades (Potter et al., 1999). Active sites within the South Cascades are known from southwestern Yakima and northwestern Klickitat Counties. In the South Cascades, mardon skippers are found in open grassland sites within the Ponderosa pine savanna woodland at elevations ranging from 1,900–5,100 feet. All known occupied sites are on U.S. Forest Service or Yakama Nation lands. Mardon skippers are closely associated with sites supporting native bunch grass such as Idaho fescue. Skippers that occur in Yakima County use areas some distance from project facilities and would not be affected by any proposed operation changes. Therefore, habitat resources potentially used by this species would not be affected, and mardon skippers are not considered further.

Basalt Daisy.—The basalt daisy is State-listed as threatened and is a candidate for Federal listing under the ESA. The basalt daisy, a small daisy, is found in the steep cliffs above Selah Creek and within the Yakima River Canyon. It is unlikely that habitat resources potentially used by this species would be affected by the alternatives, and the basalt daisy is not considered further.

Bald Eagle.—The bald eagle was removed from Federal Endangered Species protection on June 28, 2007, but the species remains protected under the Bald and Golden Eagle Protection Act, the Migratory Bird Treaty Act, and remains State-listed as threatened. Bald eagles occur in the Yakima River basin along the shores of lakes, reservoirs, and streams. Suitable habitat includes areas that are close to water and provide a suitable food resource such as anadromous or resident fish, waterfowl, or carrion. Three nests have been reported in the Yakima River basin that are at, or near, Reclamation facilities. One nest has been reported at Cle Elum Lake; one at Rimrock Lake; and one in the Yakima River Canyon near Roza Diversion Dam (Reclamation, 2000).

Bald eagle wintering sites typically occur in the vicinity of concentrated food resources such as anadromous fish spawning areas, waterfowl concentration areas, or sources of mammalian carrion such as ungulate winter ranges. Other important wintering habitat features include perch sites and communal roost sites. The birds do not arrive until late December or, more typically, early January. Mid-winter bald eagle surveys were conducted in Washington, including the Yakima River area, from the winter of 1981–82 to the winter of 1988–89 (Stinson et al., 2001). During this period, the Yakima River counts varied from a high of 39 to a low of 3 with a mean of 23.9 (Stinson et al., 2001). The 2002 Christmas Bird Count for the Tri-Cities tallied 16 bald eagles, compared to 34 in 2001. The overall trend for these counts is quite erratic from year to year (National Audubon Society, 2002).

The Hanford reach of the Columbia River has been monitored for wintering bald eagles since 1960 (Caldwell et al., 2000). Wintering bald eagles generally have increased during the early study period, reaching a high in 1989 of 58. The number of eagles declined through the 1990s. In 2000, 26 eagles were counted wintering along the Hanford reach. Caldwell et al. (2000) indicate that the bald eagle numbers generally track changes in the number of returning fall Chinook salmon, a major fall and winter food source. Fall Chinook redds counted in the Hanford reach increased during the 1960s–1980s until reaching a high of about 9,000 in 1989. Redd counts dropped during the early 1990s to about one-third of the 1989 peak. In 2000, about 5,507 redds were counted. It is likely that bald eagle use in the nearby lower Yakima River would follow a similar trend. Due to its removal from Federal Endangered Species protection, the bald eagle is not discussed further. The remaining seven threatened or endangered species (table 4.34) are addressed below or in other sections of this Final PR/EIS.

Table 4.34 State and federally listed endangered or threatened species that may occur within the Yakima River basin and may be affected by the project

Species	State of Washington status	Federal ESA status
Upper Columbia River steelhead	Species of Concern	Endangered
Upper Columbia River spring Chinook	Species of Concern	Endangered
Middle Columbia River steelhead	Candidate for Listing	Threatened
Bull trout	Candidate for Listing	Threatened
Greater sage-grouse	Threatened	Candidate for Listing
Ferruginous hawk	Threatened	Species of Concern
Ute Ladies'-tresses	Not Listed	Threatened
Umtanum wild buckwheat	Candidate for Listing	Endangered

4.11.2 Environmental Consequences

4.11.2.1 Methods and Assumptions

The issues, indicators, methods, and assumptions previously described in section 4.8, "Anadromous Fish," and section 4.9, "Resident Fish," are the same for the threatened and endangered salmonids: threatened and endangered stocks of steelhead and Chinook salmon and bull trout. The following is a summary of the indicators and methods used in the analysis of impacts.

- Early life-stage survival as measured by a difference (acres and percent) in steelhead summer rearing habitat compared to the No Action Alternative for the Easton and Ellensburg reaches. The DSS, SRH-W, and River2D models were used to quantify these changes.

- Restoration of more natural flows as measured by a comparison of the average median streamflows and rate of change in daily flow in the

Easton, Ellensburg, and the lower Naches River reaches for before and after flip-flop operations. The Yak-RW model was used to estimate the daily median streamflows for the Easton, Ellensburg, and lower Naches River reaches.

- Success of seaward migration as measured by the volume of water (March–June) measured at the Parker gage. The spring runoff volume (acre-feet) for the Joint Alternatives was qualitatively compared to the flow volume objectives and expressed as percent toward meeting the objective. The spring runoff time was qualitatively compared to the current condition and categorized as "no change" or "improved."

- Fish population: The EDT, Yak-RW, and USGS temperature models were used to estimate limiting factors and fish population numbers by species.

- False attraction of spawning runs caused by the diversion of Columbia River water to the Yakima River. The methods were derived from *Assessment of the Effects of the Yakima Basin Storage Study on Columbia River Fish Proximate to the Proposed Intake Locations* (Reclamation, 2008d). The analysis is based on the timing of the fishes' interaction prior to or post diversion, the percentage of native versus diverted flows, and the chemical signature of the diverted flows after seepage through Yakima River basin soils.

- The ability of bull trout, residing in reservoirs, to access spawning streams. The first component of this indicator is the average annual number of days access from the reservoir to spawning tributary is impeded by low reservoir volume and tributary inflows. The second component is the average pool elevation in Kachess, Keechelus, and Rimrock Lakes during bull trout spawning migration (July 15–September 15). This indicator is described in detail in section 4.9, "Resident Fish."

The greater sage-grouse analysis focuses on changes in acres of shrub-steppe habitat, movement corridors, and exposure to West Nile virus. Movement corridor delineation for the greater sage-grouse was evaluated based on the following: telemetry data of collared birds off of the YTC; topography of area dependent on ridgelines and valleys where greater sage-grouse are most likely to occur or travel through; and occurrence of shrub-steppe vegetation based upon aerial photographs, which excludes agricultural and residential lands. Sage-grouse do not usually occur within or along riparian zones. The methodology for evaluating the risk of West Nile virus is described in detail in section 4.23, "Public Health." The analysis of movement corridors is described in section 4.7, "Vegetation and Wildlife."

The Ute Ladies'-tresses analysis is based on instream flows and riparian flooding discussed in the black cottonwood reproduction section. Both black cottonwood and Ute Ladies'- tresses reproduction are assumed to benefit from the early succession conditions created by riparian flooding.

The ferruginous hawk and Umtanum wild buckwheat analysis is based on changes in acreage to shrub-steppe habitat.

4.11.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

Middle Columbia River Steelhead and Bull Trout in the Yakima River.—The flow regime under the No Action Alternative is about the same as under the current condition, suggesting the indicators linked to flow generally reflect conditions that currently exist. The EDT and AHA models estimated average annual escapement of 2,362 for steelhead under the No Action Alternative.

The average annual number of days with a critical threshold reservoir volume for bull trout spawners under the No Action Alternative is Kachess Lake, 18 days; Keechelus Lake, 37 days; and Rimrock Lake, 3 days.

Median reservoir elevations under the No Action Alternative are Kachess Lake, 2,248.4 feet; Keechelus Lake, 2,467.3 feet; and Rimrock Lake, 2,909.9 feet. Additional detail is provided in section 4.8, "Anadromous Fish," and section 4.9, "Resident Fish."

Greater Sage-Grouse, Ferruginous Hawk, and Umtanum Wild Buckwheat.— These protected species have been combined in the analysis because they would be impacted by the same habitat and disturbance issues associated with the Joint Alternatives. The No Action Alternative would have no impact on greater sage-grouse, ferruginous hawk, and Umtanum wild buckwheat because the quality and quantity of their primary habitat would be unaltered. Existing management and recovery efforts for shrub-steppe habitat and existing wildlife would continue, including the *Washington State Recovery Plan for the Greater Sage-Grouse* (Stinson, et al., 2004), the Conservation Reserve Program conservation of habitat (Vander Haegen et al., 2004), and possible reintroductions.

Ute Ladies'-tresses.—Greater instream flows would improve riparian habitat associated with Ute Ladies'-tresses. However, the unknown presence of the plant in the study area and the small increase in overbank flooding associated with greater instream flows suggest a negligible improvement for the species.

4.11.2.3 Black Rock Alternative

Construction Impacts

The greatest construction impacts would be for greater sage-grouse because they tend to be in the Black Rock Valley area for foraging from July–September, although most of the grouse located by radio telemetry were not near the damsite. Relocating SR–24 could result in sage-grouse leaving the site during construction (Burkepile, 2007.)

Construction of the Black Rock pumping plant on Priest Rapids Lake would have minor effects to Upper Columbia River steelhead and spring Chinook. A small area of the pool would be isolated during construction, and migrating smolts or returning adults would not have access to that area.

Regarding Black Rock reservoir seepage mitigation features, no impacts to threatened and endangered species would occur, except for greater sage-grouse. Noise from construction of the seepage mitigation most likely would force the sage-grouse using that area as a migration corridor to move farther east or west.

Long-Term Impacts

Regarding Black Rock reservoir seepage mitigation features, no long-term impacts to threatened and endangered species would occur. The migration corridor for greater sage-grouse would be restored after construction.

Middle Columbia River Steelhead and Bull Trout in the Yakima River.—Flow changes in the Yakima River (compared to the No Action Alternative) are the greatest of any Joint Alternative. These changes in the flow regime are generally beneficial to anadromous fish.

Early Life-Stage Survival.—In the Easton reach, habitat for steelhead is 10.4 percent greater than under the No Action Alternative. In the Ellensburg reach, the amount of steelhead yearling habitat is 29.2 percent greater than under the No Action Alternative.

Restoration of More Natural Flows.—The Black Rock Alternative provides greater natural flows and better habitat than the No Action Alternative. The lower average rates of change in daily flow would result in less fish and aquatic invertebrate stranding and more stable desired habitat.

Success of Seaward Migration.—Spring seasonal flows are 29 percent above the target flows, compared to 7 percent below the target flows under the No Action Alternative (table 4.25), which represents a more than 500-percent improvement in the spring seasonal flow compared to the No Action Alternative. The stream runoff pattern also is better than under the No Action Alternative, as the high flows continue into April, May, and June when most smolt migration is occurring. These greater flows should increase overall smolt outmigration survival.

Fish Population.—The EDT and AHA models estimated average annual escapement of 4,067 for steelhead under the Black Rock Alternative, compared to 2,700 under the No Action Alternative, or a 50.6-percent increase.

False Attraction.—Under the Black Rock Alternative, Columbia River water would be pumped from Priest Rapids Lake into Black Rock reservoir and released into Roza and Sunnyside Canals during the irrigation season. The percent of Roza and Sunnyside Canal operational spills is presented in table 4.28 and is discussed in section 4.8.2.4 under "Indicator 6: False Attraction."

The portion of the adult steelhead migration period that coincides with the latter part of the irrigation season is September–mid-October. Roza and Sunnyside operational spill of Black Rock reservoir water is approximately 1 percent. With implementation of Black Rock reservoir seepage mitigation measures as proposed, approximately 50 cfs of Black Rock reservoir seepage water would be released year-round into the Yakima River near RM 18.2. In September–October, at the onset of adult steelhead migration, approximately 2.3 percent of the Yakima River would be made up of Black Rock reservoir seepage water (table 4.28). When combined, both sources of Black Rock reservoir seepage water would make up approximately 3.5 percent of the total flow in the lower Yakima River downstream from RM 18.2 during adult steelhead migration. This is below the 10-percent laboratory threshold observed by Fretwell (1989), at which sockeye salmon began to discriminate between home and nonhome water sources.

Bull Trout Spawning.—The stream access thresholds and reservoir elevations associated with the Black Rock Alternative are about the same as those for the No Action Alternative. There is no biologically distinguishable difference in bull trout access to streams during the spawning migration between the No Action Alternative and the Black Rock Alternative.

Upper Columbia River Steelhead and Spring Chinook.—Impacts to fish in the Columbia River would occur from the pumping plant in Priest Rapids Lake. There should be no impacts to these species from pumping water out of the Columbia River as the pump intake would be screened to State specifications to prevent entrainment of fish.

Greater Sage-Grouse.—The issues associated with the Black Rock Alternative as they may affect greater sage-grouse include the following:

- Loss of habitat that would adversely impact movement, dispersal, reintroduction, and feeding.
- Exposure to West Nile virus resulting in direct and indirect mortality.

- Construction disturbance.
- Loss of nests and eggs from construction and reservoir inundation.

The proposed reservoir includes 3,539 acres of shrub-steppe, 113 acres of grassland, and 3,771 acres of Conservation Reserve Program lands, considered important for the continued survival of greater sage-grouse in central Washington (Service, 2007b). The Black Rock Alternative would inundate about 13.5 square miles of the Black Rock Valley, which would be no longer available as habitat. The highway and utilities relocation south of the proposed reservoir would impact a movement and potential dispersal corridor considered important for sage-grouse recovery (Livingston, 2007). Impacts would include loss of shrub-steppe habitat and the potential for greater mortality from vehicles. The location of the reservoir in the middle of three localized populations and the small, fragmented nature of the central Washington population suggest that the habitat losses from the alternative would have an adverse impact on greater sage-grouse.

Inundation by the reservoir would impact the greater sage-grouse population in the YTC by reducing available shrub-steppe habitat and placing an impediment to their dispersal and movement in the Black Rock Valley. Currently, greater sage-grouse can move through a “corridor” that stretches in an arc about 27 miles from the head of the Moxee Valley through the Black Rock Valley to the Columbia River near the SR–24 Vernita Bridge. This area provides a potentially important corridor between the Hanford Site, the YTC, and Rattlesnake Hills, which are the largest remaining shrub-steppe habitats left in Washington (figure 4.16). The existing corridor extends in a general east-west direction, and the long axis of the approximately 9-mile-long Black Rock reservoir would be oriented the same way. Presuming that greater sage-grouse could not fly over the reservoir, which would be more than a mile wide in places, it would block about one-third of the existing corridor. There would still be a corridor about 2½–3 miles wide at the west end of the reservoir, and one about 14 miles wide at the east end where habitat suitable for movement would exist. For comparison purposes, the identified corridor connecting the Rattlesnake Hills to Ahtanum Ridge is less than 1 mile wide in some spots and, for several miles, only about 2 miles wide. Therefore, Black Rock reservoir and dam would not prevent greater sage-grouse from moving from the YTC to the ALE Reserve and Rattlesnake Hills, but it would be a significant impediment. Birds approaching the reservoir from the YTC would have to move east or west to get around it.

Greater sage-grouse are susceptible to mortality from West Nile virus (Walker et al., 2007; Naugle et al., 2004). Research has shown West Nile virus reduced survival by an average of 25 percent and put small fragmented populations, like those in the study area, at risk of extinction (Naugle et al., 2004). Black Rock reservoir’s proximity to the YTC, Yakama Reservation, and Hanford greater sage-grouse populations increases their risk of exposure to West Nile virus. The effect of this exposure risk is unknown because of the climate, water management, and epidemiology variables that affect mosquito vector introduction, reproduction, and dispersion. These factors are discussed in detail in section 4.23, "Public Health." Research recommends "…eliminating mosquito breeding habitat in anthropogenic water sources …" (Walker et al., 2007). This alternative would not increase the sage-grouse's susceptibility to West Nile virus more than the current condition because the population of the mosquitos carrying the virus would not increase. The direct and indirect loss and disturbance of habitat and mortality resulting from exposure to West Nile virus suggest that the impact of the Black Rock Alternative would be moderate.

Ferruginous Hawk and Umtanum Wild Buckwheat.—The issues associated with the Black Rock Alternative as they may affect ferruginous hawk and Umtanum wild buckwheat include the following:

- Loss of shrub-steppe habitat
- Construction disturbance

The proposed reservoir includes 3,539 acres of shrub-steppe (Service, 2007b), inundating about 13.5 square miles of the Black Rock Valley. The highway and utilities relocation south of the proposed reservoir and land use changes associated with development surrounding the reservoir would also reduce available habitat and make the remaining habitat more susceptible to potential invasion of exotic species and fire. The unlikely occurrence of buckwheat in the area and the ranging ability of the ferruginous hawk would suggest insignificant impacts. Construction noise, increased traffic, and ground disturbance would have a short-term adverse impact on the ferruginous hawk. The risk to Umtanum wild buckwheat is low because it is unlikely to occur in the study area because of its specialized basalt flow and ridge-top habitat.

The direct and indirect loss of habitat and construction disturbance on ferruginous hawk and Umtanum wild buckwheat would be low.

Ute Ladies'-tresses.—Impacts under this alternative would be largely confined to those associated with changes in Yakima River flows. The Black Rock site is currently shrub-steppe and does not provide suitable habitat for this species.

The change in riverflows to a more unregulated-like pattern would generally be beneficial to this species. As discussed in section 4.7, "Vegetation and Wildlife," relative to black cottonwood reproduction, the greater spring flows on flood plains in the middle reaches of the river would create more seasonally flooded habitat where Ute Ladies'-tresses might survive. As with black cottonwoods, the potential increase in habitat would be confined to the Wapatox, Union Gap, and lower Naches River reaches. This possible benefit is tempered by the fact that the known populations of Ute-Ladies'-tresses have been found at elevations several hundred feet higher than elevations in the middle reaches of the Yakima River.

4.11.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction activities would disturb sensitive fauna and potentially alter sage-grouse movement corridors. Construction noise and increased traffic would have short-term adverse impacts on sage-grouse foraging from July–September (Burkepile, 2007).

Long-Term Impacts

Middle Columbia River Steelhead and Bull Trout in the Yakima River.—

Early Life-Stage Survival.—The Wymer Dam and Reservoir Alternative would increase fry and yearling habitat in the upper Yakima River basin compared to the No Action Alternative (table 4.32). However, these increases in habitat would not be significant.

Restoration of More Natural Flows.—The average rate of change in daily flows is better in the Ellensburg reach and slightly worse in the lower Naches River reach under this alternative than under the No Action Alternative. As a result, fish and aquatic invertebrate stranding would be reduced in the Ellensburg reach. Changes in the lower Naches River would not result in any adverse effects compared to the No Action Alternative.

Success of Seaward Migration.—Spring seasonal flows under this alternative are essentially the same as under No Action Alternative (table 4.25). No effect on steelhead smolt survival is expected because there is virtually no difference in target flows or in the spring runoff pattern.

Fish Population.—The EDT and AHA models estimated average annual escapement of 2,724 for steelhead under the Wymer Dam and Reservoir Alternative, compared to 2,700 under the No Action Alternative, or a 0.9-percent increase.

False Attraction.—The potential for false attraction at the confluence of Lmuma Creek is minimal, because in most years (except in prorated water years) July and August reservoir releases would occur when the number of migrating adult steelhead in this reach is minimal.

Bull Trout Spawning.—The stream access thresholds and reservoir elevations associated with the Wymer Dam and Reservoir Alternative are about the same as under the No Action Alternative. There is no biologically distinguishable difference in bull trout access to streams during the spawning migration under the Wymer Dam and Reservoir Alternative and the No Action Alternative.

Greater Sage-Grouse.**—**The issues associated with the Wymer Dam and Reservoir Alternative as they may affect greater sage-grouse include the following:

- Loss of habitat that would adversely impact movement, dispersal, reintroduction, and feeding
- Exposure to West Nile virus resulting in direct and indirect mortality

The proposed reservoir includes 1,055 acres of shrub-steppe habitat; 167 acres of grassland; 62 acres of barren land; 50 acres of riparian area; 30 acres of cliff/ canyon; 11 acres of agricultural cropland; 7 acres of developed land; 6 acres of forest habitat; 4 acres of wetlands (Service, 2007b). The location of the reservoir in the movement corridor of the local populations and the small, fragmented nature of the central Washington population suggest that the habitat losses from the alternative would have an adverse impact on the greater sage-grouse.

Movement corridors and habitat for the greater sage-grouse would be affected directly by the Wymer Dam and Reservoir Alternative (figure 4.17). The corridor through the Yakima River Canyon is about 14 miles wide, north to south. The long axis of the reservoir is oriented east and west so it obstructs very little of the corridor. Greater sage-grouse moving from the YTC to the west or back could easily circumvent the reservoir by moving either north or south.

As discussed for the environmental consequences of the Black Rock Alternative, greater sage-grouse are susceptible to mortality from West Nile virus (Walker et al., 2007; Naugle et al., 2004). The construction of Wymer reservoir in proximity to the YTC, Yakama Reservation, and Hanford greater sage-grouse populations would increase their risk of exposure to West Nile virus. The impact of this increased exposure risk is unknown because of the climate, water management, and epidemiology variables that affect mosquito vector introduction, reproduction, and dispersion. These factors are discussed in detail in section 4.23, "Public Health."

Ferruginous Hawk and Umtanum Wild Buckwheat.**—**These two protected species have been combined in the analysis because they are impacted by the same habitat and disturbance issues associated with the Joint Alternatives. Neither species is likely to occur in the study area because of its steep slopes and canyon habitats. The Wymer Dam and Reservoir Alternative is unlikely to affect either the ferruginous hawk or Umtanum wild buckwheat.

Ute Ladies'-tresses.**—**This alternative would not significantly affect the frequency or extent of riparian flooding in the study area. Lmuma Creek generally is incised, and the area is grazed. There is little riparian zone and few, if any, seasonally flooded areas that might provide habitat for this species.

Therefore, the Wymer Dam and Reservoir Alternative is unlikely to impact Ute Ladies'-tresses.

4.11.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Construction impacts to fish in the Columbia River would be the same as for the Black Rock Alternative, except the area disturbed by pumping plant construction would be in the McNary pool near the mouth of the Yakima River. Impacts to greater sage-grouse would be the same as for the Wymer Dam and Reservoir Alternative.

Long-Term Impacts

Upper Columbia River Steelhead, Upper Columbia River Spring Run Chinook Salmon, and Bull Trout in the Columbia River.—Impacts to fish in the Columbia River would occur from the pumping plant on the river. There should be no impacts to these species from pumping water out of the Columbia River as the pump intake would be screened to State specifications to prevent entrainment of fish.

Middle Columbia River Steelhead and Bull Trout in the Yakima River.—There are no substantive differences (10 percent or greater) between this alternative and the No Action Alternative for either species. As under the Wymer Dam and Reservoir Alternative, habitat for steelhead in the Easton reach is generally better, while results are mixed in the Ellensburg reach.

Restoration of More Natural Flows.—The Wymer Dam Plus Yakima River Pump Exchange Alternative represents the best improvement in the Ellensburg reach of the Joint Alternatives and the second best improvement in the lower Naches River reach compared to the No Action Alternative. This is expected to reduce fish and aquatic invertebrate stranding in the Ellensburg reach and improve juvenile steelhead rearing habitats.

Success of Seaward Migration.—Spring seasonal flows are 11 percent above the flow objectives, compared to 7 percent below the flow objectives under the No Action Alternative (table 4.25), which represents a more than 250-percent improvement in the spring seasonal flow compared to the No Action Alternative. The stream runoff pattern is similar to the No Action Alternative. Though the stream runoff pattern remains unchanged, the increase in spring flows should increase overall smolt outmigration survival.

Fish Population.—The EDT and AHA models estimated average annual escapement of 3,338 for steelhead under the Wymer Dam Plus Yakima River Pump Exchange Alternative compared to 2,700 under the No Action Alternative, or a 23.6-percent increase.

False Attraction.—The portion of the adult steelhead migration period that coincides with the irrigation season is September–mid-October, and the percent of operational spill is approximately 0.7 percent. Based on these findings, the potential for false attraction resulting from direct operational spill of mixed Yakima River and Columbia River water appears minimal, since it is below the 10-percent experimental threshold (Fretwell, 1989).

Bull Trout Spawning.—The stream access thresholds and reservoir elevations associated with the Wymer Dam Plus Yakima River Pump Exchange Alternative are about the same as under the No Action Alternative. There is no biologically distinguishable difference in bull trout access to streams during the spawning migration between the Wymer Dam Plus Yakima River Pump Exchange Alternative and the No Action Alternative.

Greater Sage-Grouse.—The type, magnitude, and duration of the impacts associated with this alternative are the same as under the Wymer Dam and Reservoir Alternative. The steep topography of Wymer reservoir suggests that mosquito populations carrying the West Nile virus would not become established and become a risk to greater sage-grouse. Habitat loss, disturbance of movement, and risk of exposure to the West Nile virus suggest that the impact of the Wymer Dam Plus Yakima River Pump Exchange Alternative would be slight.

Ferruginous Hawk and Umtanum Wild Buckwheat.—These two protected species have been combined in the analysis because they are impacted by the same habitat and disturbance issues associated with the Joint Alternatives. Neither species is likely to occur in the study area because of its steep slopes and canyon habitats. The Wymer Dam Plus Yakima River Pump Exchange Alternative is unlikely to affect either the ferruginous hawk or Umtanum wild buckwheat.

Ute Ladies'-tresses.—The Wymer Dam Plus Yakima River Pump Exchange Alternative would not significantly change the frequency or extent of riparian flooding in the study area. Therefore, the alternative is unlikely to affect Ute Ladies'-tresses.

4.11.2.6 Mitigation

Black Rock Alternative

Mitigation measures under the Black Rock Alternative could include the following:

- Perform botanical surveys in areas proposed for disturbance and relocation of sensitive species.
- Establish a wildlife management area adjacent to the reservoir.

- Bury pipelines underground and restore native vegetation along the corridor.
- Compensate for shrub-steppe losses by converting agricultural lands to shrub-steppe or enhancing degraded shrub-steppe habitat adjacent to the study area or at an offsite location where it would be more beneficial.
- Control nonnative invasive plant species.

Wymer Dam and Reservoir Alternative

Mitigation measures under the Wymer Dam and Reservoir Alternative would be the same as under the Black Rock Alternative.

Wymer Dam Plus Yakima River Pump Exchange Alternative

Mitigation measures under the Wymer Dam Plus Yakima River Pump Exchange Alternative would be the same as under the Black Rock Alternative.

4.11.2.7 Cumulative Impacts

Cumulative impacts with respect to bull trout and steelhead would be similar to those described in section 4.8, "Anadromous Fish." Cumulative impacts for terrestrial species would be similar to those discussed in section 4.7, "Vegetation and Wildlife."

4.12 Recreational Resources

4.12.1 Affected Environment

4.12.1.1 Recreation Setting

Washington provides a diverse array of recreation settings from designated wilderness areas to urban greenways. Within the Yakima River basin, the recreation opportunities are largely found in developed and rural natural settings.

Recreationists are attracted to the basin by the quality of the scenery, water, and recreation opportunities. Primary recreation activities include fishing the reservoirs and rivers for cold-water species; whitewater boating and kayaking; motorized boating; and other related activities such as camping, hiking, picnicking, and wildlife viewing.

All six reservoirs within the study area—Bumping, Rimrock, Cle Elum, Kachess, Keechelus, and Clear Lakes—are located on the eastern slopes of the Cascade Range (figure 4.18). The rugged mountain terrain and coniferous forests create magnificent scenic settings. Camping, swimming, boating, picnicking, and fishing are available at all reservoirs. Picnic sites and campgrounds are close to, or exceed, capacity on summer weekends and exceed capacity on holiday weekends (Novitsky, 2005).

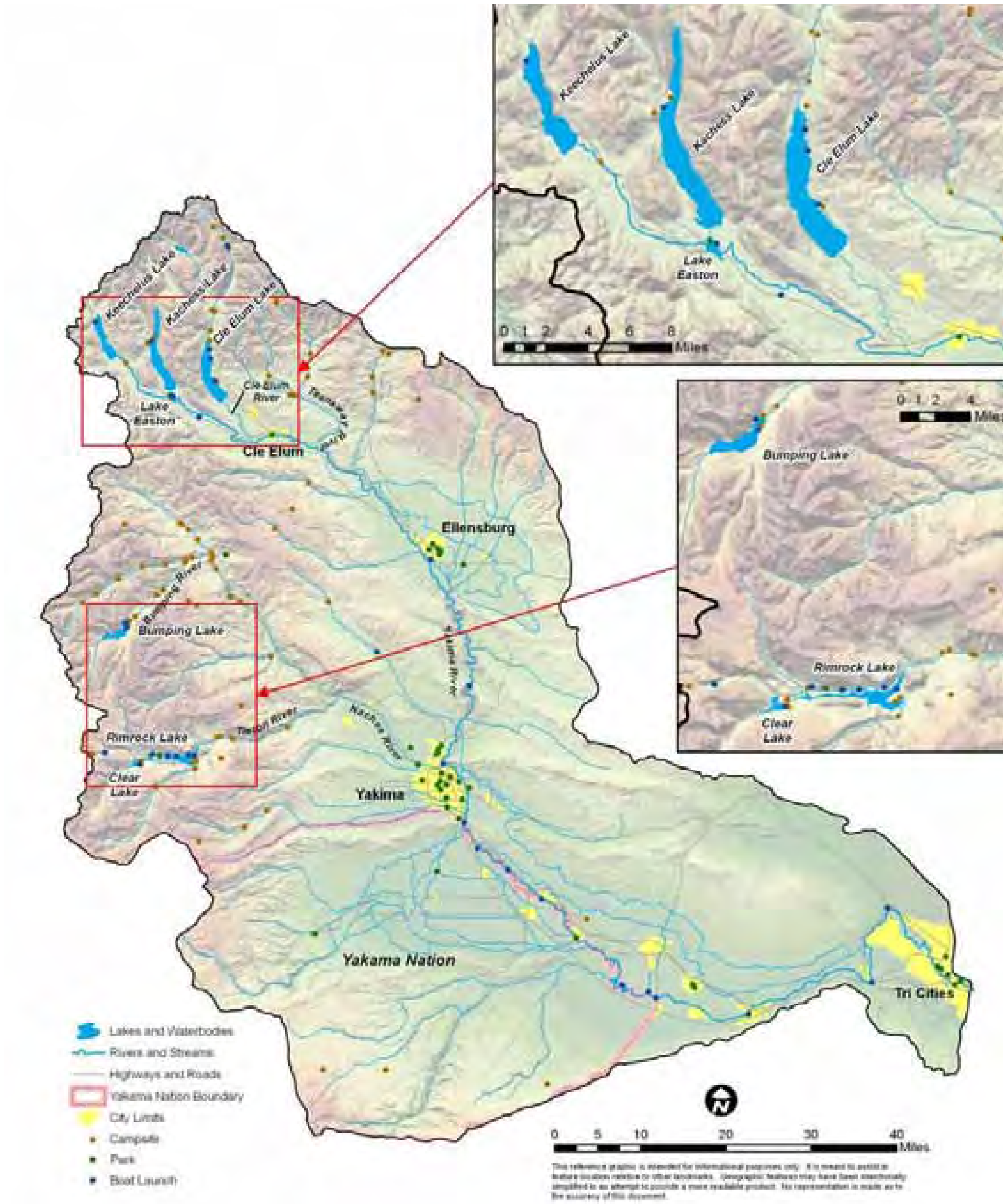

Figure 4.18 Yakima River basin recreation access points and recreation areas.

The Easton Diversion Dam area has a State park with facilities for camping, swimming, and boat launching and mooring. Recreational use is heavy. The reservoir also has a good fishery.

The five primary rivers within the basin that supply recreation opportunities are the Tieton, Naches, Cle Elum, Bumping, and Yakima Rivers. Although there are other smaller flat-water lakes and rivers in the basin that offer similar types of water-based recreation activities, the only water bodies discussed in this section and this report are the ones specifically mentioned above.

The Yakima River has a national reputation for its high-quality fly fishing, one of the fastest growing activities on the river. The Yakima River is also considered a "blue ribbon" trout stream (Yakima Valley Visitors and Convention Bureau, 2005). The prime periods for fishing the river are February–May and September–October, although fishing occurs on the river throughout the year.

The Naches and Tieton Rivers do not provide the quality of fishing found in the Yakima River. The Naches River does not provide quality fishing because of limited access, and the Tieton River does not because of its small size, swift water, woody debris, and cloudy water. The Tieton River has regionally acclaimed whitewater rafting during a 3-week period (flip-flop) in September. The rapids during that time are rated as Class III (Fairfield, 2005). There is very little rafting on the Naches River because of limited access due to private land ownership on adjacent lands.

The Yakima River basin also has a Pacific Northwest regional reputation for motorized recreation opportunities associated with trail bikes, all-terrain vehicles (ATV), jeeps, and snowmobiles, primarily on U.S. Forest Service lands on the west side of the basin.

4.12.1.2 Current Recreation Visitation

Tables 4.35 and 4.36 present the estimated annual visitation to the key reservoirs and rivers in the Yakima River basin.

Table 4.35 Estimated annual visitation to key reservoirs in the Yakima River basin (2006)

Reservoir	Number of annual visitors
Keechelus Lake	660
Kachess Lake	17,292
Cle Elum Lake	6,996
Rimrock Lake	10,824
Clear Lake	4,620
Bumping Lake	7,524
Lake Easton	19,260

Table 4.36 Estimated annual visitation to key rivers in the Yakima River basin (2006)

River	Number of annual visitors
Yakima River	18,000
Tieton River	8,844
Naches River	3,696
Bumping River	5,016
Cle Elum River	5,280

4.12.2 Environmental Consequences

This section describes the effects of implementation of the Joint Alternatives on recreation, including drawdown and recreation use at proposed reservoirs. This section also describes effects on recreation at existing reservoirs and on rivers. See chapter 2 for details of estimated changes in recreation under the Joint Alternatives.

4.12.2.1 Methods and Assumptions

The following assumptions were used in assessing the effects of all Joint Alternatives on recreation.

- The likely future recreation situation for the Wymer Dam and Reservoir Alternative and Wymer Dam Plus Yakima River Pump Exchange Alternative would be the same.

- Recreation visitation was estimated on the basis of (1) current visitation at the existing reservoirs in the basin, (2) current visitation to three State parks in comparable settings near Yakima, and (3) the findings reported in the *Recreation Demand and User Preference Analysis* (Reclamation, 2007g) which includes projected changes in population and demographics.

- A recreation managing partner would enter into a cooperative agreement with Reclamation for the design, development, and management of recreation facilities. It is expected that these managing partners would add facilities, programs, and services, which would meet the demand of the recreating public and attract more visitation.

- Likely managing partners include the Washington State Parks Commission or counties where the reservoirs would be located.

- State, county, and local tourism organizations are expected to promote and market the availability of any new reservoir site as a new recreation opportunity.

- The recreation situation described is confined to Reclamation's geographical boundaries and does not describe nearby future land use changes or residential and commercial development that may occur.
- A fish-stocking program (for the new reservoirs) would be prepared and implemented by the Washington Department of Fish and Wildlife.
- Drawdown can change the type, amount, and quality of recreation opportunities. It is recognized that as one type of recreation opportunity may be displaced by a certain water level, another opportunity may be afforded or enhanced.
- At the existing reservoirs, changes that could affect recreation were only projected to occur at Cle Elum and Kachess Lakes.

4.12.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

Effects on recreation at Cle Elum, Bumping, Rimrock, Keechelus, Kachess, Easton, and Clear Lakes and on riverine recreation would be the same as under the current condition.

4.12.2.3 Black Rock Alternative

Construction Impacts

There would be no construction impacts to existing recreation resources under the Black Rock Alternative.

Long-Term Impacts

Black Rock reservoir would be approximately 8,720 water surface acres at full pool (13.6 square miles), about 10 miles long, and more than 1 mile wide at its widest point. The west end of Black Rock reservoir would be within 20 miles of Yakima, while the east end would almost reach the Benton County line. Access would be from State Routes 24 and 241. Ten miles of SR–24 would be submerged and, thus, provide boat ramp access from the west.

The reservoir would be elongated, open, and have few coves or arms. The south and southeast side of Black Rock reservoir would be steep with tall hillsides, providing good vistas of the lake and surrounding landscape but with limited or no safe access. The north and west sides of the reservoir would be a rolling, flat terrain of dryland grasses and few trees.

The open exposure of the reservoir along with westerly winds coming down the valley would make for cool breezes for some recreationists but dangerous winds and wave-action for others.

Table 4.37 presents the recreation setting for Black Rock reservoir, including the startup years and the long-term operation. It is assumed that a managing partner would assume recreation management from Reclamation and provide the recreation facilities, programs, and services to meet the public demand. Table 4.38 presents projected recreation use at Black Rock reservoir by activity.

Effects on Reservoir Recreation.—

Drawdown of Black Rock Reservoir.—Black Rock reservoir would reach full pool in February–March and low pool in August. This August drawdown would result in about a 20-percent reduction in the available water surface acres for recreationists. Conversely, it would provide considerable shoreline acreage for associated land-based activities later in the summer months, such as off-highway vehicle (OHV) and ATV use on the north and west shores. See figures 4.19a–e.

Table 4.37 Recreation setting at Black Rock reservoir

Recreation setting	Initial startup (5 years) following reservoir completion	Post-initial startup years (beyond first 5 years) following reservoir completion
Management	Reclamation	Primary recreation manager (e.g., Yakima County Parks, Washington State Parks)
Facilities	Day use Minimal facilities for resource protection and public safety No fees or entrance station Minimal security Parking lot 1 boat ramp (old SR-24) Regulatory and directional signage Vehicular access of drawdown shoreline Portable toilets No utilities	Day and overnight facilities Boat marina (rentals and short-term slips) Concessioned services Developed campground, picnic area, trails, and toilets 2 boat ramps Fee-based Entrance station Security Utilities Interpretive signage Controlled shoreline access and boating capacity Wakeless zones
Projected annual visitation	250,000–304,000	400,000–700,000
Projected annual change in visitation	5-percent increase due to new location, marketing and media attention, improving fishery	5-percent increase in early facility buildout, similar to population growth in subsequent years

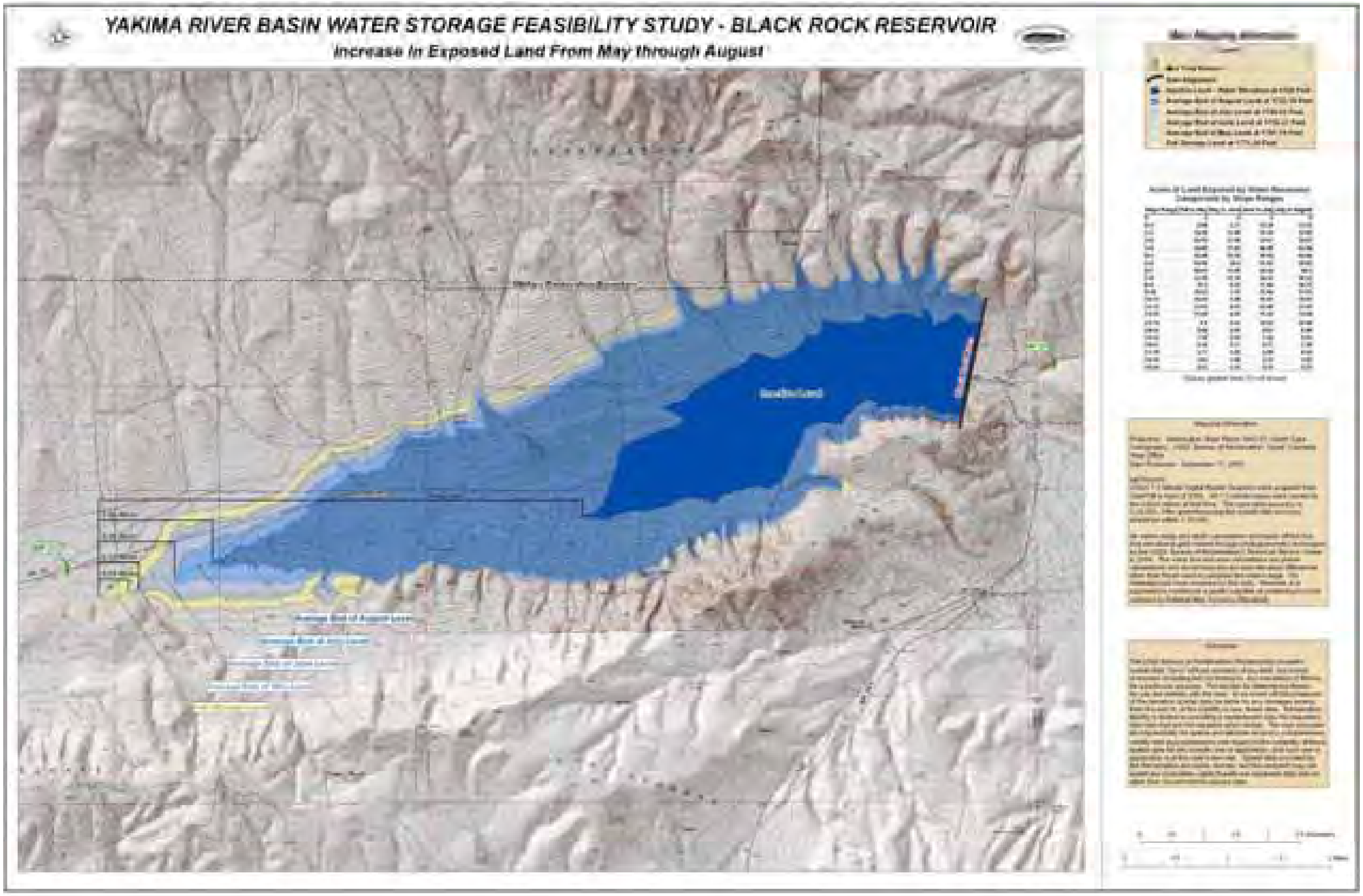

Figure 4.19 Black Rock Reservoir increase in exposed land from May through August.

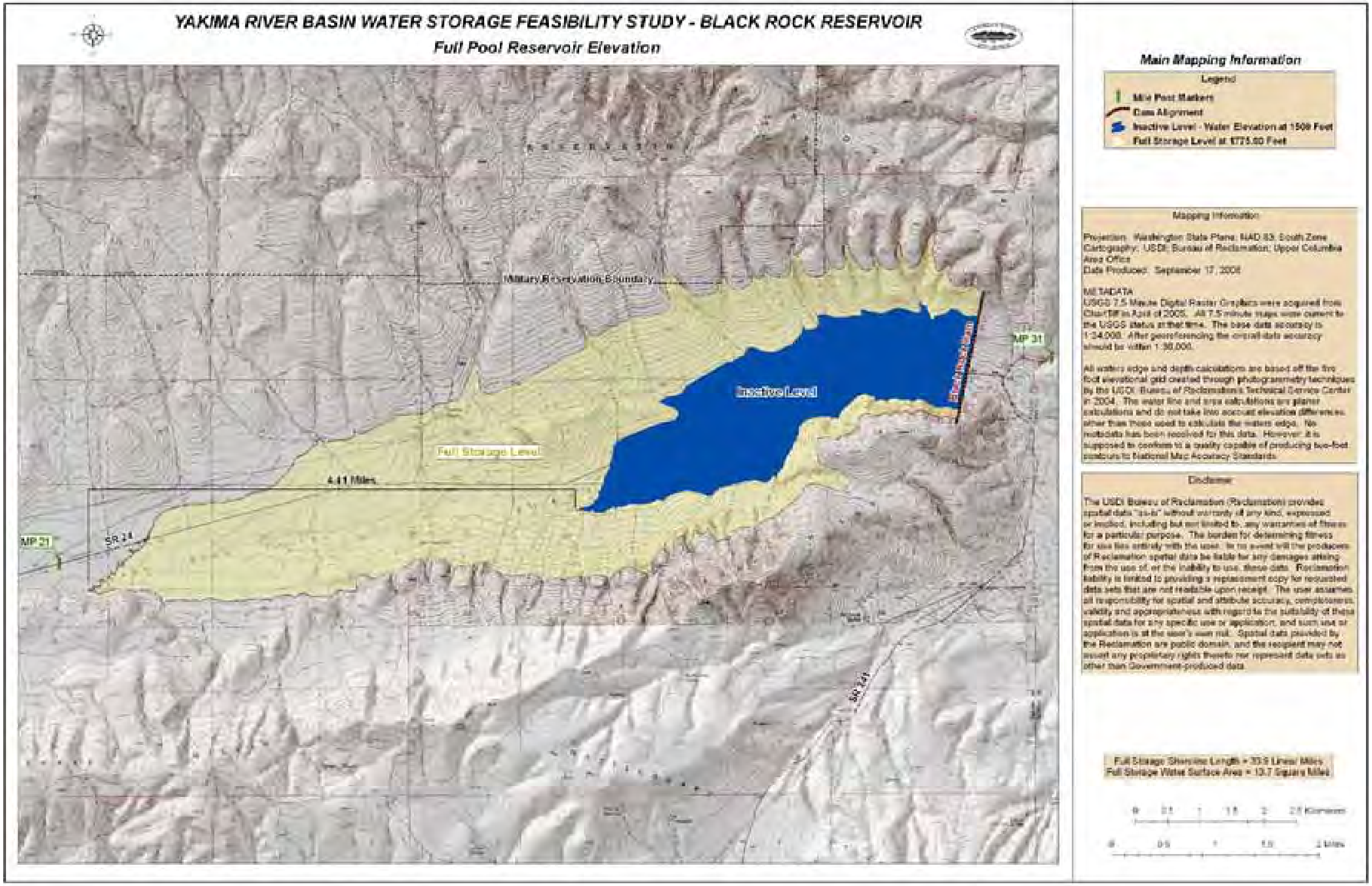
YAKIMA RIVER BASIN WATER STORAGE FEASIBILITY STUDY - BLACK ROCK RESERVOIR
Full Pool Reservoir Elevation
Military Reservation Boundary
Inactive Level
Full Storage Level
4.41 Miles
MP 21
MP 31
SR 24
SR 241
Main Mapping Information
Legend
Mile Post Markers
Dam Alignment
Inactive Level - Water Elevation at 1500 Feet
Full Storage Level at 1775.00 Feet
Mapping Information
METADATA
Disclaimer
Full Storage Shoreline Length = 33.9 Linear Miles
Full Storage Water Surface Area = 13.7 Square Miles

Figure 4.19a

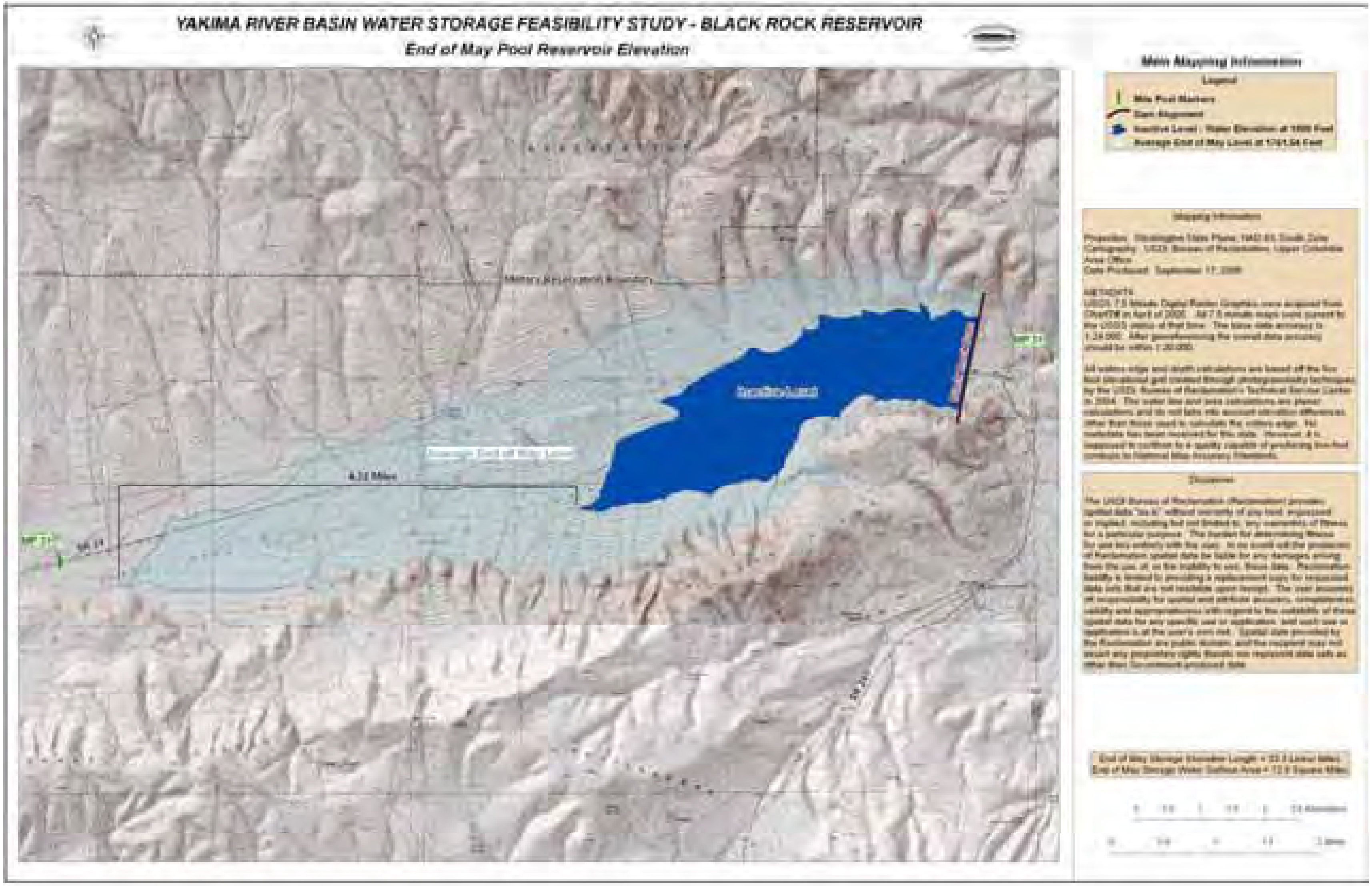
YAKIMA RIVER BASIN WATER STORAGE FEASIBILITY STUDY - BLACK ROCK RESERVOIR
End of May Pool Reservoir Elevation

Figure 4.19b

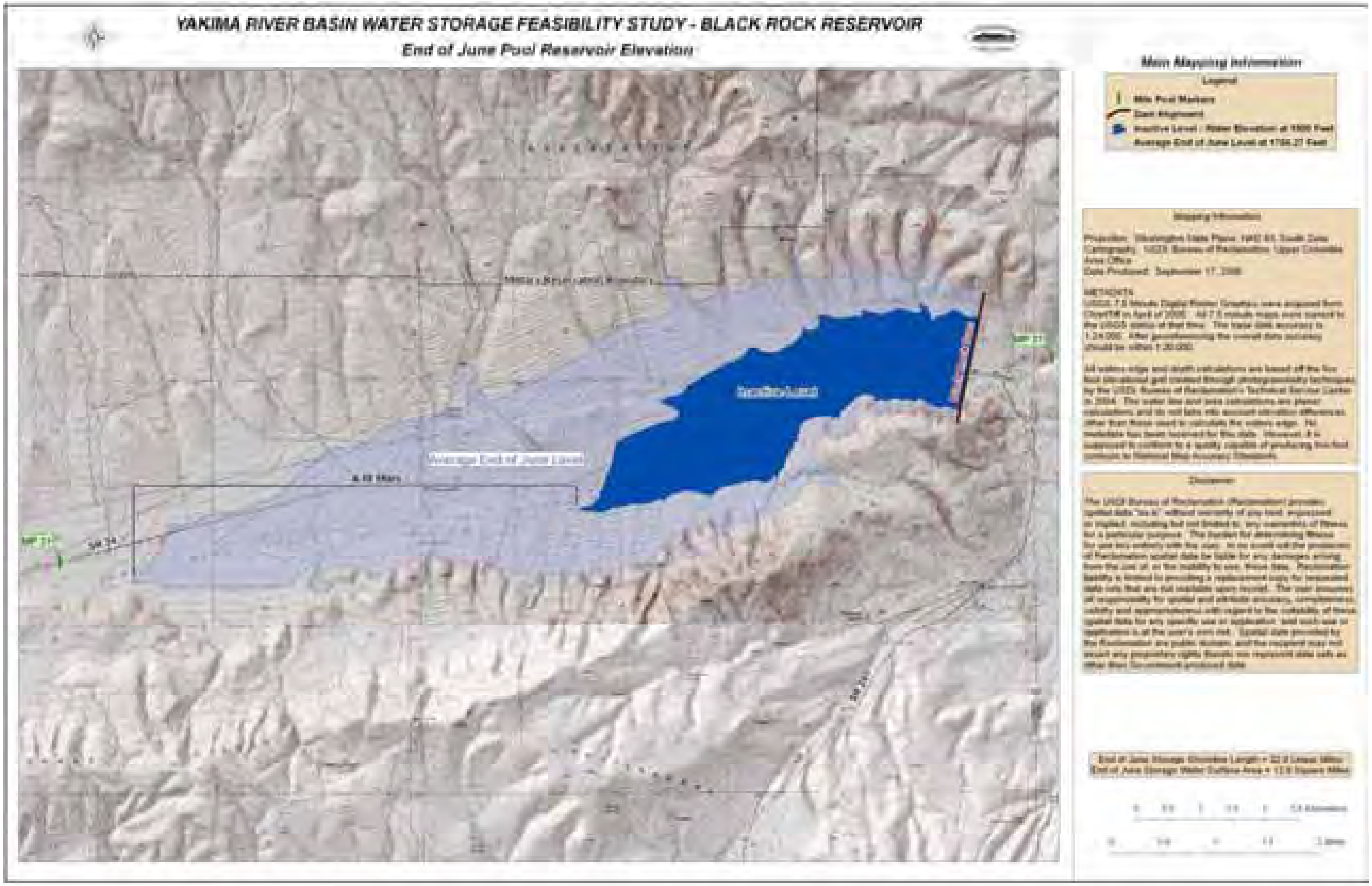
YAKIMA RIVER BASIN WATER STORAGE FEASIBILITY STUDY - BLACK ROCK RESERVOIR
End of June Pool Reservoir Elevation

Figure 4.19c

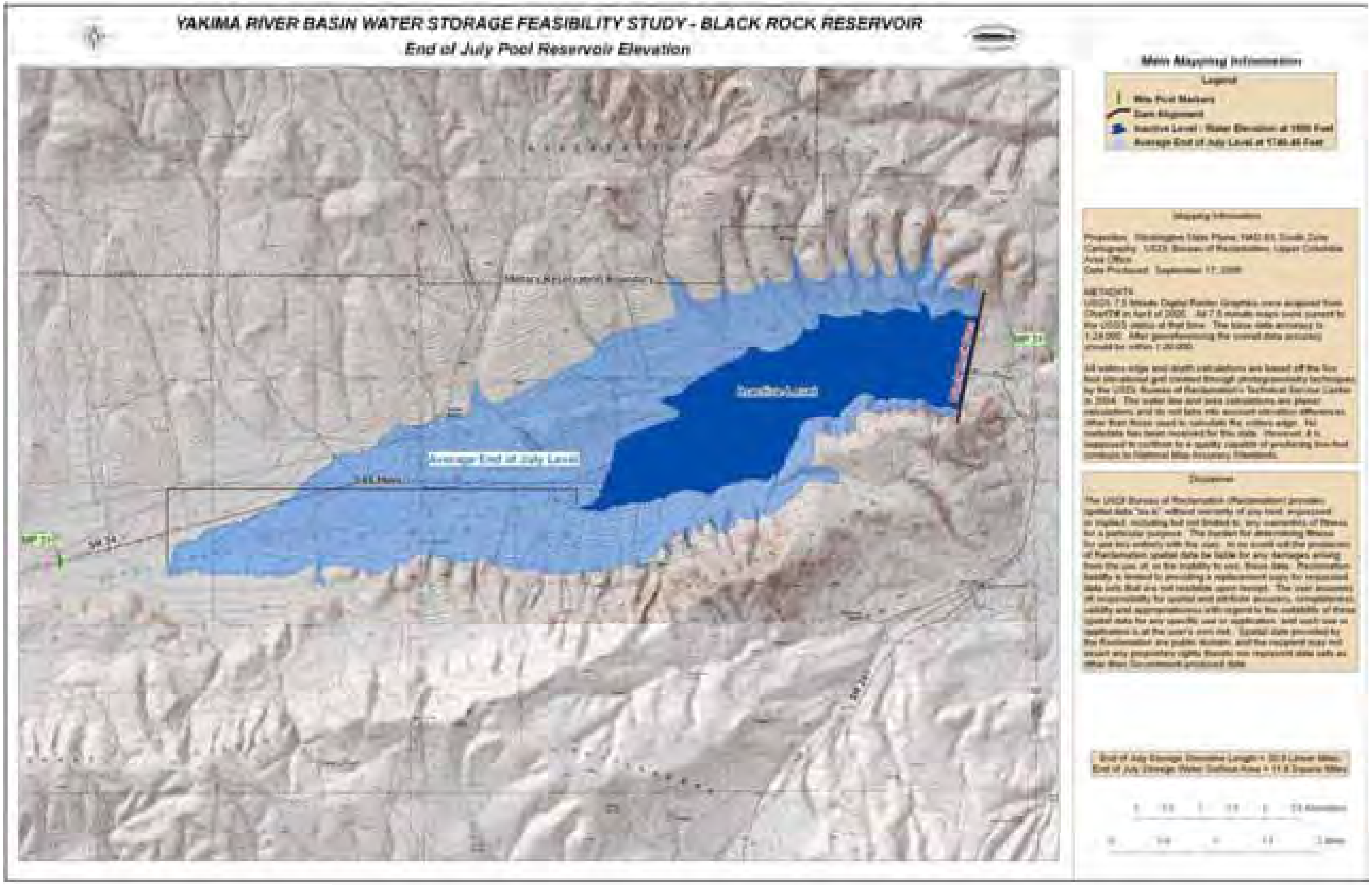
YAKIMA RIVER BASIN WATER STORAGE FEASIBILITY STUDY - BLACK ROCK RESERVOIR
End of July Pool Reservoir Elevation

Figure 4.19d

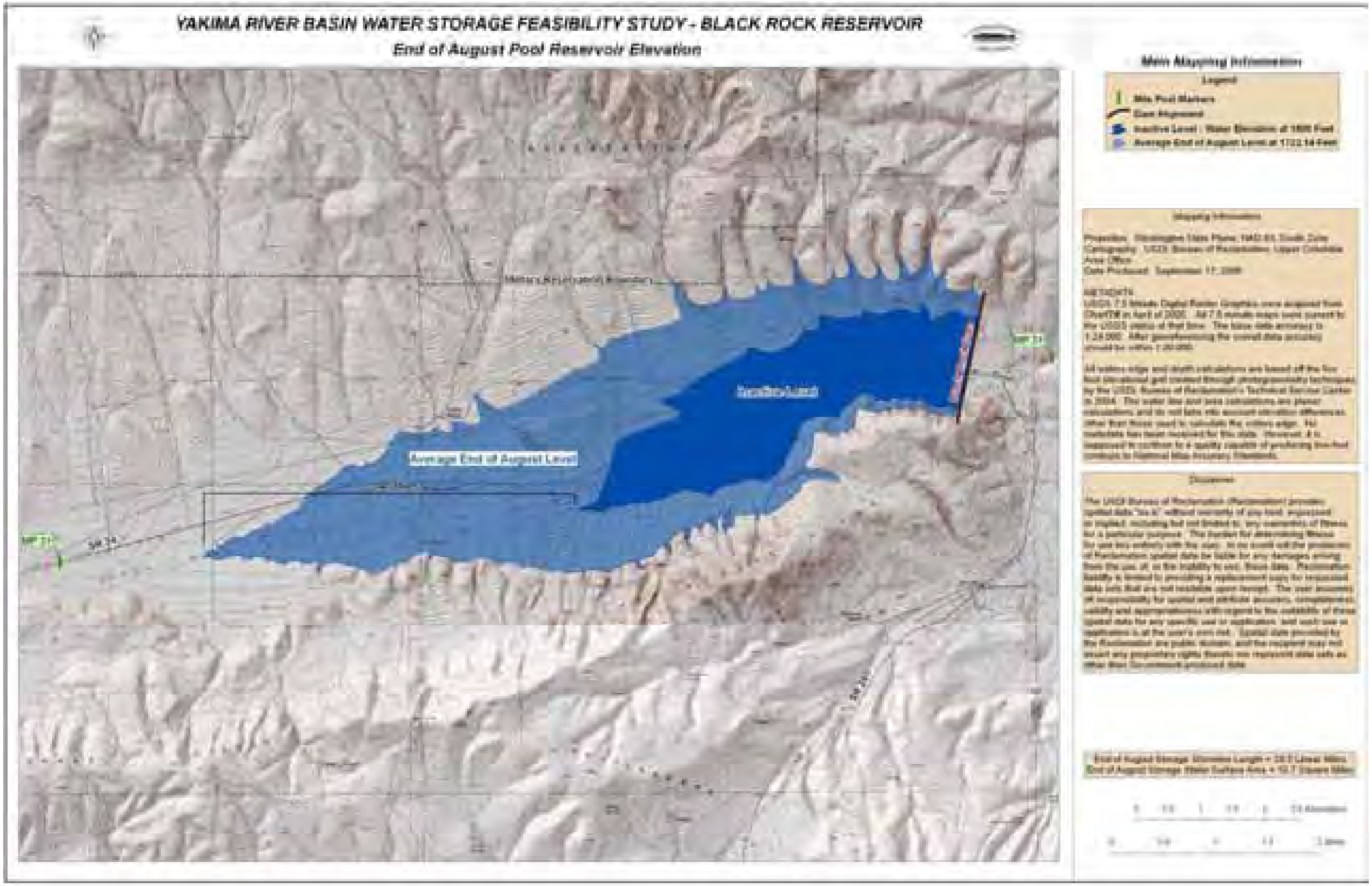
YAKIMA RIVER BASIN WATER STORAGE FEASIBILITY STUDY - BLACK ROCK RESERVOIR
End of August Pool Reservoir Elevation
Main Mapping Information
Legend
Average End of August Level
Inactive Level

Figure 4.19e

Table 4.38 Projected recreation use at Black Rock reservoir by activity

Primary activities	Primary visitation period	Percent of total annual visitation	Annual visitation estimate in initial startup years	Annual visitation estimate after initial startup years	Additional descriptors of visitation
Boat fishing	Spring and fall	25%	62,500–76,000	100,000–175,000	50% of boat fishers are local; 50% are nonlocal
Shoreline fishing	May–July	10%	25,000–30,400	40,000–70,000	Predominantly local residents; popular activities among the increasing senior and Hispanic population in basin.
Swimming	June–August	15%	37,500–45,600	60,000–105,000	
Picnicking	June–August	15%	37,500–45,600	60,000–105,000	
Water skiing, wakeboarding, jet skiing	June–August	25%	62,500–76,000	100,000–175,000	70% local; 30% from out of the basin
Walking	Spring and fall	3%	7,500–9,100	12,000–21,000	Local residents
Wildlife viewing	Spring and fall	3%	7,500–9,100	12,000–21,000	Local residents
Horseback riding	Spring and fall	2%	5,000–6,100	8,000–14,000	Local residents
Off-highway vehicle (OHV) riding	July–August	2%	5,000–6,100	8,000–14,000	Local residents
			250,000–304,000 annual visitors	400,000–700,000 annual visitors	Visitation would increase approximately 5% per year for the first 10 years and then stabilize similar to the rate of population growth in the Yakima area.

[1] Annual visitation numbers assume a fish-stocking program for the reservoir. Visitation could be substantially lower if no fish-stocking program were implemented.
[2] A comparison of the recreation setting in the initial years of reservoir completion versus later years is provided in table 4.36.

Kachess Lake.—At Kachess Lake, a water level below 2,256 feet could affect recreation. In wet years, the Black Rock Alternative would have little effect compared to the No Action Alternative; in average water years, the only effect occurs in August when the elevation of Kachess Lake remains at or above 2,256 feet, improving recreation in that month. The greatest effect occurs early in the recreation season (June and July) in dry years when Kachess water levels are higher than under the No Action Alternative. Under these conditions, recreation needs would be better met and would result in 17,220 more visitor days in dry years. Also in dry years, the Black Rock Alternative would allow boat launching for approximately 2.5 months or approximately 75 days from mid-May–July, whereas the No Action Alternative would allow boat launching for only a few days in mid-June.

Cle Elum Lake.—Cle Elum Lake recreation visitors, on average, prefer medium to high water levels, somewhere between an elevation of 2,200 and 2,237 feet. Water levels generally fall within the range under both the Black Rock and No Action Alternatives. In dry years, however, July and May water levels fall below that range under the Black Rock Alternative.

Effects on Riverine Recreation.—

Yakima River.—Under this alternative, Yakima River flows are within or close to the preferred medium flow range for recreation. In average water years, these flows would result in about 7,260 more visitor days from July–mid-August and October than under the No Action Alternative. These estimates are based on the average monthly visitation and visitor projections of increased visits if users' preferred flows were met.

Tieton River.—For the Tieton River, flows under the Black Rock Alternative range from about 1,000–1,250 cfs, which are at the lower end of, but still within, visitors' preferred flows for this river. The effect on recreation would occur during flip-flop, when flows would be about 350 cfs less in a wet year, 550 cfs less in an average year, and 250 cfs less in a dry year. These lower flows would occur at a crucial time for rafters and rafting companies and would affect rafting companies and rafters and kayakers seeking whitewater. More importantly from a visitor-day measurement standpoint, flows for all recreationists, including rafters, would be below their desired levels a week earlier in late September and early October than under the No Action Alternative. This week could represent a potential loss of about 1,000 visitors.

4.12.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

There would be no impacts to existing recreation resources during construction of Wymer dam and reservoir.

Long-Term Impacts

Wymer reservoir would be approximately 1,390 water surface acres at full pool (2+ square miles), about 4 miles long, and ½ mile wide in the dam area. The west end of Wymer reservoir would almost abut SR–821, while the east end would reach I–82. Access would be from SR–821. There would be no interstate access or anticipated signage.

While Wymer reservoir would be relatively small, the topography of rolling, steep hillsides with canyons would provide numerous coves and arms for recreationists to enjoy. The topography and lake configuration would provide water recreationists protection from winds, but shoreline use would be limited by the steep terrain and large projected drawdown.

Table 4.39 provides a description of the recreation setting that is projected at Wymer reservoir. It is assumed that a managing partner would take over the development and management of recreation facilities, programs, and services.

Table 4.40 presents the projected primary recreation activities and visitation periods and annual estimated visitation.

Effects on Reservoir Recreation.—

Drawdown of Wymer Reservoir.—Wymer reservoir would reach a full pool of some 1,300 water surface acres in May–June and a low pool of 600+ water surface acres in August–September. There would be about a 50-percent reduction in the available water surface acres for recreationists. Conversely, this drawdown would provide more shoreline acreage for associated land-based activities later in the summer months, such as OHV and ATV use.

Table 4.39 Recreation setting at Wymer reservoir

Recreation setting	Initial startup (5 years) following reservoir completion	Post-initial startup years (beyond first 5 years) following reservoir completion
Management	Reclamation	Primary recreation manager (e.g., Yakima County Parks, city of Yakima's Parks and Recreation Department, and Washington Parks Commission)
Facilities	Day use only Human-powered boating only Minimal facilities for resource protection and public safety No fees or entrance station Minimal security Small parking lot 1 boat ramp Shoreline access for nontrailered boats Regulatory and directional signage Portable toilets No utilities	Day use only Human-powered boating only Developed picnic and toilet facilities Designated trails Fee-based Entrance station Security Utilities (water and lighting) Small parking lot 1 boat ramp Shoreline access for nontrailered boats Interpretive signage Designated trail
Projected annual visitation	40,000–45,300	70,000–200,000
Projected annual change in visitation	Annual increase in visitation would approximate the rate of population growth in the Yakima area (i.e., at estimated 3 percent)	

Table 4.40 Projected recreation use at Wymer reservoir by activity

Primary activities	Primary visitation period	Percent of total annual visitation	Annual visitation estimate in initial startup years	Annual visitation estimate after initial startup years	Additional descriptors of visitation
Canoe, kayak, and small sailboats	May–July	20%	8,000–9,000	14,000–40,000	Wymer reservoir would be a small reservoir with consider-able water level fluctua-tion. It would be popular as a summer reservoir for locals to enjoy human-powered recreation activities.
Boat fishing	Spring and fall	10%	4,000–4,500	7,000–20,000	
Shoreline fishing	May–July	25%	10,000–11,300	17,500–50,000	
Swimming	June–August	15%	6,000–6,800	10,500–30,000	
Picnicking	June–August	15%	6,000–6,800	10,500–30,000	
Walking	Spring and fall	10%	4,000–4,500	7,000–20,000	
Wildlife viewing	Spring and fall	5%	2,000–2,300	3,500–10,000	
			40,000–45,200 annual visitors	70,000–200,000 annual visitors	Visitation would increase similar to the rate of popu-lation growth in the Yakima area.

Kachess Lake.—No impacts to recreation would occur under this alternative at Kachess Lake in wet, average, or dry conditions.

Cle Elum Lake.—Effects on recreation use at Cle Elum Lake would be relatively slight under this alternative. In wet years, the boat launches at the lake would still be useable in August, in contrast to the No Action Alternative. Conversely, under the Wymer Dam and Reservoir Alternative in a dry year, the elevation of the lake would fall below the preferred elevation range of 2,200–2,237 feet in June. Under the No Action Alternative, the elevation would be within the preferred range.

Effects on Riverine Recreation.—

Yakima River.—Under this alternative, Yakima River flows during the recreation season are about the same as under the No Action Alternative, except from the end of June to the end of August, when they are about 500–1,000 cfs less than under the No Action Alternative. As a result, flows are within or close to the preferred medium flow range for recreation and, thus, are better for recreation than under the No Action Alternative. These flows would result in about 3,631 more visitor days from July–mid-August and October (average water years) than under the No Action Alternative. These estimates are based on the average monthly visitation and visitor projections of increased visits if users' preferred flows were met.

Tieton River.—Under this alternative, Tieton River flows are virtually the same as under the No Action Alternative; thus, no effect on recreation is expected.

4.12.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

There would be no impacts to existing recreation resources during construction of Wymer dam and reservoir.

Long-Term Impacts

Impacts would be the same as for the Wymer Dam and Reservoir Alternative. Opportunities for new recreation would be the same as under the Wymer Dam and Reservoir Alternative.

Effects on Reservoir Recreation.—

Drawdown of Wymer Reservoir.—Effects on Wymer reservoir drawdown would be the same as under the Wymer Dam and Reservoir Alternative.

Kachess Lake.—There would be no effects on recreation at Kachess Lake under this alternative compared to the No Action Alternative, except in dry years. Reservoir elevations are higher in dry years, which would provide a better recreation experience in May, June, and July. As a result of these higher elevations, the boat launch would be useable for about 50 days in June and July in dry years compared to only a few days under the No Action Alternative. The only other impact would occur in average years in June, when reservoir elevations are higher than under the No Action Alternative, decreasing the quality of the recreation experience as less "beach" would be exposed.

Cle Elum Lake.—As discussed previously, Cle Elum Lake users prefer water surface elevations in the range of 2,200–2,237 feet. In wet years, elevations are within this range in June under this alternative, whereas they are below the range under the No Action Alternative. Elevations remain high in wet years into August, which would allow boat launching. Under the No Action Alternative, elevations are too low in August for launching in wet years. No other impacts to recreation were identified at Cle Elum Lake under other water year types in any part of the recreation season.

Effects on Riverine Recreation.—Effects on riverine recreation would be the same as under the Wymer Dam and Reservoir Alternative.

4.12.2.6 Mitigation

No mitigation would be required.

4.12.2.7 Cumulative Impacts

Regional, State, and local area population will continue to grow by approximately 1.5–2.5 percent annually. The increase in population within the prime recreation market area of the Yakima River basin (i.e., Washington, Oregon, Idaho, British Columbia, and California) will be greater than national averages and ensure continued increases in outdoor recreation participation on public lands and waters. National, State, regional, and local participation rates in outdoor recreation will continue to increase among all ages, income, and ethnic groups. On average, State park visitation in eastern Washington increased 2 percent annually from 2000–05. Water resources will continue to be a prime attraction for day use and overnight outdoor recreation participants. People will continue to seek opportunities to enjoy the outdoors and to experience a natural setting in contrast to their daily work and living environments. It is reasonable to project a 2- to 3-percent average annual increase in outdoor recreation demand for the Yakima River basin over the next 20 years.

4.13 Land Use and Shoreline Resources

This section addresses the following aspects of land use and shoreline resources in the study area:

- Land ownership/land status
- Existing land or shoreline uses
- Relevant city, county, State, or Federal land use and shoreline management plans, programs, and policies

These aspects are addressed relative to the direct physical development and operation of facilities associated with the Joint Alternatives, for which specific land areas and/or requirements have been identified.

4.13.1 Affected Environment

4.13.1.1 No Action Alternative

The No Action Alternative includes conservation-oriented system improvements, including pumping plants and pipelines, at various locations in the Yakima Valley region. These improvements are associated with existing approved programs and orient predominantly to existing facilities; none are being or would be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of the directly affected land/shoreline use environment will be prepared separately, apart from the Storage Study process.

4.13.1.2 Black Rock Alternative

Dam and Reservoir

The site of the proposed Black Rock dam and reservoir is the Black Rock Valley, located in eastern Yakima County, Washington. Land in the valley is predominantly privately owned. Federal landholdings in the area include scattered Bureau of Land Management (BLM) tracts, concentrated in the eastern half of the valley, and the YTC, which borders the valley on the north. No substantial State landholdings exist in the area. The general setting and proposed location of the reservoir (as well as appurtenant facilities) are detailed in chapter 2.

The land area that would be directly affected by the proposed dam and reservoir is held, for the most part, by relatively few (approximately 20) private landowners and BLM. Private holdings range in size from 120 to several thousand acres; BLM holdings range in size from 40–640 acres.

Land use in the Black Rock Valley is primarily open habitat and rangeland, with limited areas of irrigated pasture and other crops in the western end of the valley. BLM lands that would be affected by the project are leased for grazing, within two grazing allotments. The only developed land uses within the potential area of influence of the reservoir are three residences and a hunting club in the valley itself and a roadside café and one residence approximately 1 mile east of the damsite.

Land use planning in the Black Rock Valley is generally under the jurisdiction of Yakima County. All private land in and around the proposed the Black Rock dam and reservoir site is designated “agriculture” in the county’s comprehensive plan and zoning. The county’s “Plan 2015” (Yakima County, 1998a) describes the agriculture designation as:

> *Lands primarily devoted to or important for the long-term commercial production of horticultural, viticultural, floricultural, dairy, apiary, vegetable, or animal products…Generally lands in Yakima County zoned Exclusive or General Ag can be considered resource lands of long-term commercial significance.*

Seepage Mitigation Features

Seepage from Black Rock dam and the mitigation features proposed to manage this seepage would affect approximately 27.2 miles of stream channel and roadway corridors extending from the dam to Horn Rapids on the Yakima River in Benton County, Washington.

For the first 6.6 miles downstream from the dam, the channel of Dry Creek would be involved, conveying surface flow from the seepage. This distance of stream corridor passes through private land in Yakima and Benton Counties (all of which is designated “agriculture” in the respective county plans and zoning) and represents the only private land involved with the seepage or associated mitigation measures. Existing uses along the creek corridor in this area are primarily agriculture, grazing, and open habitat; developed land uses are limited to (1) a BPA substation, located along Dry Creek on the north side of the channel approximately 3 miles downstream (east) from the damsite and (2) an active irrigated farm operation to the south, with the associated residence approximately 1 mile from the creek channel. The only seepage mitigation program feature to be located along/near the Dry Creek corridor in this area is a power transmission line from the BPA substation eastward, approximately 3.6 miles to the proposed dewatering wells.

The main constructed elements of the seepage mitigation program (including cutoff wall/embankment/pipeline inlet structure, wells, 20.6-mile pipeline, and outlet structure) would begin on Dry Creek 6.6 miles downstream from the dam. With the exception of the powerline, all constructed features would occur exclusively on publicly owned land. The cutoff wall/embankment/inlet, wells, and most of the pipeline would be located within the ALE Reserve, a part of the Hanford Reach National Monument. These lands are managed by the U.S. Fish and Wildlife Service for the U.S. Department of Energy. The final (southerly) ½ mile or less of the pipeline and the outlet structure on the Yakima River would be located within Benton County’s Horn Rapids Park, north of the city of West Richland. Perspectives on existing and planned land use within each of these areas are provided below.

ALE Reserve.—Existing and planned land use within the ALE Reserve focuses on preservation, management, and enhancement of the natural and cultural resources identified as the basis for establishment of the ALE Reserve and the overall Hanford Reach National Monument (Clinton, 2000):

> *Bisected by the stunning Hanford Reach of the Columbia River, the monument contains the largest remnant of the shrub-steppe ecosystem that once blanketed the Columbia River Basin. The monument is also one of the few remaining archaeologically rich areas in the western Columbia Plateau...[and]...rich in geologic history... .*

Developed uses within the ALE Reserve are minimal and oriented exclusively to reserve management; primary examples include a network of unimproved access roads, a small educational facility along Dry Creek, and installations of soil stabilization/erosion control equipment. SR–240 borders the ALE Reserve along its entire northeast boundary. General public access to the ALE Reserve is not allowed; access is restricted to Service management personnel and limited educational purposes under Service supervision.

Only one developed use not strictly oriented to ALE Reserve management is planned. An approximately 2,287-acre site along SR–240 within the ALE Reserve, known as "Area C," is designated for extraction of soil materials needed in the remediation program for the adjacent Hanford Site, managed by the U.S. Department of Energy. Beyond this, the ALE Reserve is intended to remain free of development and general access to the maximum extent feasible. The following provision in the Presidential Proclamation establishing the National Monument (Clinton, 2000) is relevant: "All Federal lands and interests in lands within the boundaries of this monument are ... appropriated and withdrawn from all forms of entry, location, selection, sale, or leasing or other disposition under the public land laws... ." In addition, "all motorized and mechanized vehicle use off road, except for emergency or other federally authorized purposes, including remediation purposes" is prohibited.

Horn Rapids Park.—This Benton County park is located approximately 6 miles downstream from Benton City, on the north shore of the Yakima River. The park is 784 acres in size, of which most is natural open space and used primarily as horse/hiking trails and wildlife habitat. At the downstream (easterly) end of the park, east/southeast of Horn Road (which marks the boundary between the ALE Reserve and the park), 20+ acres is developed with a campground, paved boat launch, paved trails, picnic/lawn area, and other facilities. The county's 1984 master plan for the park envisions approximately 55 acres of developed facilities, focused also in the downstream portion of the park along the river.

Appurtenant Facilities

Intake/Inflow System.—The only substantial surface land area associated with the Black Rock intake/inflow system would be the site of the intake and fish screen facility. An access road (approximately 10 miles) and a new transmission line (approximately 6 miles to intake and fish screen facility site) would also be necessary.

The intake and fish screen facility itself would be located on the southwest shore of Priest Rapids Lake, approximately 3,600 feet upstream of Priest Rapids Dam. The facility would be on land owned by the Grant County PUD as part of the Priest Rapids hydroelectric project. The site and surrounding land is currently undeveloped except for a small marina facility used by PUD personnel.

The only developed use in the vicinity of the intake and fish screen site, other than the industrial facilities of the hydroelectric project, is a small Wanapum Village approximately 1 mile to the southeast, immediately downstream from Priest Rapids Dam, on the south side of the Columbia River.

The access road to the intake and fish screen facility site would be developed on an abandoned railroad right-of-way along the south side of the Columbia River from SR–24 to the southeast. The transmission line also would be constructed on the south side of the river, from the Bonneville Power Administration's Midway Substation located 4 miles west of SR–24. Both the access road and transmission line routes pass through predominantly undeveloped private land with isolated instances of irrigated agriculture; involved lands are within Yakima and Benton Counties and are designated/zoned by the counties as "agriculture." Both the access road and the transmission line would also pass adjacent to (south of) the Wanapum Village noted above.

Inflow conveyance from the intake and fish screen facility to Black Rock reservoir would be a tunnel under land within the YTC. The only surface facility associated with this tunnel would be a 22-foot-diameter surge/vent shaft connecting the tunnel with the ground surface approximately three-quarters of a mile south-southwest of the intake facility. This vent would be on steep terrain within the YTC, near the YTC's easternmost boundary.

From the standpoint of land use planning and shoreline resources management, the site of the intake and fish screen facility is (1) addressed in Grant County PUD's *Priest Rapids/Wanapum Land Use Plan*, which designates the site as wildlife area (Grant County PUD, 1992), and (2) subject to review and permitting pursuant to the State Shoreline Management Act (SMA). In the latter regard, all lakes and reservoirs in the State over 20 acres in surface area are formally designated as "shorelines of the State." Implementation of the Black Rock intake and fish screen facilities would be considered "substantial development" under the SMA, and a Substantial Development Permit would be required. SMA consistency review and issuance (if appropriate) of a Substantial Development Permit would be accomplished by Yakima County.[9] Relevant policies/provisions of the SMA governing this review and issuance of the required permit include (Ecology, 2007d):

- **Encourage water-dependent uses**: "uses shall be preferred which are consistent with control of pollution and prevention of damage to the natural environment, or are unique to or dependent upon use of the states' shorelines..." (generally, nonwater/shoreline-dependent uses are to be avoided unless there is no feasible alternative).

- **Protect shoreline natural resources**, **including:** "...the land and its vegetation and wildlife, and the waters of the state and their aquatic life..." (with an emphasis on restoring priority habitats and species, and specific policy of no net loss of ecological functions necessary to sustain shoreline natural resources).

[9] In partnership with the Washington State Department of Ecology, local counties and cities implement the SMA through required Shoreline Master Programs.

- **Promote public access**: "the public's opportunity to enjoy the physical and aesthetic qualities of natural shorelines of the state shall be preserved to the greatest extent feasible consistent with the overall best interest of the state and the people generally."

Outflow/Delivery System.—All outflow and delivery facilities would be located west of the Black Rock reservoir site on private lands within Yakima County. In all cases, except where noted, surface facilities (sites and conveyance routes) would involve land currently characterized as large lot ownership, used for agricultural production, and designated/zoned "agriculture" by Yakima County. (See the previous discussion in section 4.13.1.2 under "Dam and Reservoir.")

The following overviews of the land use setting for elements in the outflow/delivery system use the proposed location of the Black Rock outlet facility as a reference point. This facility would be located on the south side of SR–24, east of Moxee, approximately 3,000 feet east of Beane Road, and immediately east of the Roza Canal.

Outflow Conveyance.—From the proposed Black Rock reservoir to a point approximately 3,000 feet northeast of the Black Rock outlet facility (the first distribution element in the delivery system), the outflow conveyance from Black Rock reservoir would be via a tunnel. With the exception of a 40-foot-diameter surge/vent shaft, this tunnel would not involve surface land use/disturbance. The surge/vent shaft would be located approximately 3.4 miles northeast of the Black Rock outlet facility on land currently in open habitat/rangeland use. The final 3,000 feet of the conveyance would involve a buried pipeline passing through agricultural lands.

Black Rock Outlet Facility and Powerplant (and Point of Delivery for the Roza Division).[10]—At present, the site of this facility is in irrigated agriculture. All surrounding use is agricultural.

Sunnyside Powerplant and Bypass.—This facility would be located on land currently in orchard use on the north side of the Sunnyside Canal, immediately east of its Konnowac Pass Road crossing, approximately ¾ mile north of Yakima Valley Highway. All surrounding use is also agricultural.

Delivery System for Sunnyside Division.—The delivery of water to the Sunnyside Division would be via a new pipeline, approximately 6.4 miles long, connecting the Black Rock outlet facility with the Sunnyside powerplant and bypass facility. The conceptual alignment of this pipeline passes through a combination of large-lot agricultural and currently undeveloped land.

[10] Delivery of water to the Roza Division would be accomplished at the site of the Black Rock outlet facility via connection with the adjacent Roza Canal.

4.13.1.3 Wymer Dam and Reservoir Alternative

Dam and Reservoir

The location of the proposed Wymer dam and reservoir is the Lmuma Creek watershed/basin, tributary to the Yakima River, located in southern Kittitas County, Washington. The site spans the basin from the Yakima River and SR–821 on the west to I–82 on the east. The general setting and proposed location of the reservoir (as well as appurtenant facilities) are shown in chapter 2.

Land in the Lmuma Creek basin is primarily privately owned by one family. Approximately 320 acres of State ownership (Departments of Natural Resources and Transportation) are located in the northern part of the basin, and Federal ownership (YTC) begins in the extreme eastern part of the basin, immediately east of I–82.

Land use in the Lmuma Creek basin is open habitat and rangeland. There are no developed uses.

Land use planning in the area is under the jurisdiction of Kittitas County. All land in and around the dam and reservoir site is designated "rural" in the *County Comprehensive Plan*, with a zoning designation of "forest and range." The forest and range zone is intended "to provide for areas of Kittitas County wherein natural resource management is the highest priority and where subdivision and development of lands for uses and activities incompatible with resource management are discouraged" (Kittitas County, 1992).

Appurtenant Facilities

The import and export conveyances (pipelines, tunnels, and modified Lmuma Creek channel) for the Wymer Dam and Reservoir Alternative follow the Lmuma Creek corridor approximately 4,700 feet from the proposed damsite, southwest to the site of the pumping plant, air chamber, and switchyard along the Yakima River. Land crossed by these conveyances, as well as the land on which the pumping plant, air chamber, and switchyard would be located next to the river, is all privately owned and involves the same family who holds most of the Lmuma Creek basin in which the dam and reservoir would be located. Outside of privately held land in this area are State (Departments of Natural Resources and Fish and Wildlife) and Federal (BLM) holdings.

Current use of the land on which the Wymer facilities would be located (conveyances east of SR–821 and the pumping plant west of the highway) is primarily irrigated agriculture, with a family residence present in the area east of the highway. Surrounding State and Federal lands are primarily open space and habitat; BLM's Lmuma Creek recreation site is located along the river immediately to the southeast.

Land use planning jurisdiction, as well as assigned use designations, for involved private land are the same as described for the dam and reservoir (Kittitas County; "forest and range"). State and Federal lands are managed as open space, habitat, and recreation as part of the BLM-administered Yakima River Canyon Scenic and Recreation Highway.

In addition to the above land-use planning context, the Yakima River in this area is formally designated a "shoreline of the State" pursuant to the State's Shoreline Management Act. Similar to the Black Rock intake and fish screen facility discussed previously, the Wymer facilities along the river would be considered "substantial development"; an SMA Substantial Development Permit would be required. SMA consistency review and issuance (if appropriate) of a Substantial Development Permit would be accomplished by Kittitas County.[11] (See the discussion in section 4.13.1.2 under Black Rock appurtenant facilities for further perspective.)

4.13.1.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

The affected environment of the Wymer dam component of this alternative is presented in section 4.13.1.3, "Wymer Dam and Reservoir Alternative." The following discussion focuses on the land and shoreline use setting for the Yakima River pump exchange component of this alternative.

The 56 miles of underground pipeline comprising the Yakima River pump exchange component of this alternative would span portions of five local Washington jurisdictions: city of Richland (7 miles), city of Kennewick (1 mile), city of West Richland (4 miles), Benton County (24 miles), and Yakima County (20 miles). The three pumping plants that are the only major surface facilities associated with the alternative would be located in Richland (pumping plant #1), Benton County (pumping plant #2), and Yakima County (pumping plant #3). Chapter 2 maps illustrate the general locations of pump exchange facilities, including the conceptual pipeline alignment and pumping plant sites.[12]

With the exception of crossings at State and interstate highways, the Yakima River, and elements of the Roza and Sunnyside Valley Irrigation District systems, all land in the corridor through which the pump exchange would pass is privately owned with land use planning and shoreline management jurisdiction held by the local cities and counties.

[11] In partnership with Ecology, local counties and cities implement the SMA through required Shoreline Master Programs.

[12] More detailed mapping of the conceptual pipeline route and the location of the pumping plants is available for review in Reclamation's *Appraisal Assessment of the Yakima River Pump Exchange Alternative Delivery System for Roza and Sunnyside Valley Irrigation Districts* (Reclamation, 2006e).

Land use character along the proposed pipeline corridor is urban in the cities of Kennewick, Richland, and West Richland and rural/agricultural in both Benton and Yakima Counties.

Additional perspectives on existing and planned land use along the corridor are presented in the following text, by local jurisdiction.

City of Richland.—The Columbia River intake and pumping plant #1 facilities of the Yakima River pump exchange component of this alternative would be located in the southwesternmost portion of the city's Richland Wye Master Plan area. The proposed site and immediate surroundings of the intake and pumping plant are currently undeveloped but are designated "commercial recreation" in the Wye Master Plan, with a designation of "waterfront" on the overlying Comprehensive Plan. In addition, the Columbia River in this area is a designated water of the State, pursuant to the SMA. The intake and pumping plant #1 facilities would be considered "substantial development" under the SMA, and, thus, would be subject to obtaining a Substantial Development Permit. (See the discussion in section 4.13.1.2 under Black Rock appurtenant facilities for further perspective.)

Outside the Wye area, the proposed pump exchange corridor follows existing linear facilities, primarily a railroad right-of-way and Keene Road. A substantial proportion of the land along this corridor is currently undeveloped. However, urban development is present on one or both sides of the pipeline corridor. Developed uses along the corridor are generally consistent with the city's Comprehensive Plan and include high- and low-density residential, commercial, and limited examples of industrial. In terms of relative proportion (both existing and planned), low-density residential uses predominate.

City of Kennewick.—One mile of the pump exchange pipeline, approximately 1 mile west of pumping plant #1, would pass through land under city of Kennewick jurisdiction. This area of Kennewick is predominantly developed in a combination of residential and commercial uses. Also relevant is that the city's Columbia Park planning area is immediately southeast of and adjacent to Richland's Wye planning area along the Columbia River shore. Columbia Park lands, adjacent to the site of the proposed intake and pumping plant #1 facilities, are currently used as a campground but are designated for future resort hotel, public park, and habitat/buffer uses.

City of West Richland.—The pipeline corridor, centered on Keene Road, would pass through the southwest portion of West Richland. Land in the corridor is approximately 50-percent developed in a combination of residential and commercial uses. The city's Comprehensive Plan designates lands in the area as low-, medium-, and high-density residential; commercial; and light industrial. Low- and medium-density residential predominates.

Benton and Yakima Counties.—Beyond the city of West Richland, the pump exchange corridor would predominantly pass through existing irrigated agricultural lands with associated residences and appurtenant structures in Benton and Yakima Counties. The primary exception to this is approximately 10 miles of open, undeveloped land in Benton County. No substantial instances of residential or other urban development are present in the corridor. Both counties designate all land in the corridor as "agriculture."

Regarding shoreline management, the pipeline would cross the Yakima River in Benton County, north of Benton City. The Yakima River in the affected area is a designated "water of the State" under the SMA, and the pipeline crossing would be considered "substantial development." Thus, a Substantial Development Permit would be required. (See the discussion in section 4.13.1.2 under Black Rock appurtenant facilities for further perspective.)

4.13.2 Environmental Consequences

4.13.2.1 Methods and Assumptions

The land use and shoreline resources impact analysis was conducted using existing published information, supplemented by limited field reconnaissance. Primary sources of information for existing land ownership and use included mapping available at the respective county and city Web sites and available aerial photography.

As discussed previously, the following indicators were selected to evaluate land use and shoreline resources impacts:

- Changes in land ownership/land status
- Changes in land or shoreline uses and compatibility with surrounding uses
- Consistency with relevant city, county, State, or Federal land use/management plans and policies

In reviewing the analysis, the following points are of particular relevance:

- The proposed locations of and plans for facilities associated with the alternatives, including appurtenant facility development sites and conveyance alignments, are derived from Reclamation's appraisal-level assessments. Some facility locations (especially siting of structures) and substantial distances of the conveyance alignments are preliminary and subject to adjustment based on further study. Thus, the impacts reported herein for these facilities should be viewed as illustrative or prototypical, with site or alignment adjustments considered an important source of mitigation action. Further insight from this perspective is provided where relevant on a facility-specific basis.

- No construction plans have been prepared for facilities associated with the Joint Alternatives. Given this, potential short-term construction-phase impacts on existing land uses during construction (for example, road detours, extent of construction ongoing at any given time, or construction traffic patterns) cannot be specifically addressed.

4.13.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation as discussed in chapter 2.

Long-Term Impacts

As noted previously, conservation-related system improvements associated with the No Action Alternative are part of other approved programs and orient predominantly to existing facilities; none are being or will be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of land ownership changes, impacts on existing land use, or conflicts/inconsistencies with relevant land use plans or programs will be prepared separately, apart from the Storage Study process.

4.13.2.3 Black Rock Alternative

Construction Impacts

Construction impacts would include temporary impacts to existing land uses (for example, to agricultural production, habitat management, and/or access).

Long-Term Impacts

Dam and Reservoir.—Direct impacts resulting from development of the proposed Black Rock dam and reservoir (including necessary borrow and stockpile areas) would include Federal acquisition of approximately 13,000 acres of private land in the Black Rock Valley and withdrawal of approximately 1,000 acres of BLM land from the public land inventory. A small, northern tributary arm of the reservoir pool also may extend into the YTC, requiring either transfer of jurisdiction from the Department of Defense to Reclamation or an appropriate encroachment agreement between the two entities. In addition, the proposed relocation of SR–24 (section 4.16, “Transportation”) would transect a BLM tract in the hills south of the reservoir. The preliminary boundary of the acquisition area is shown on figure 4.20.

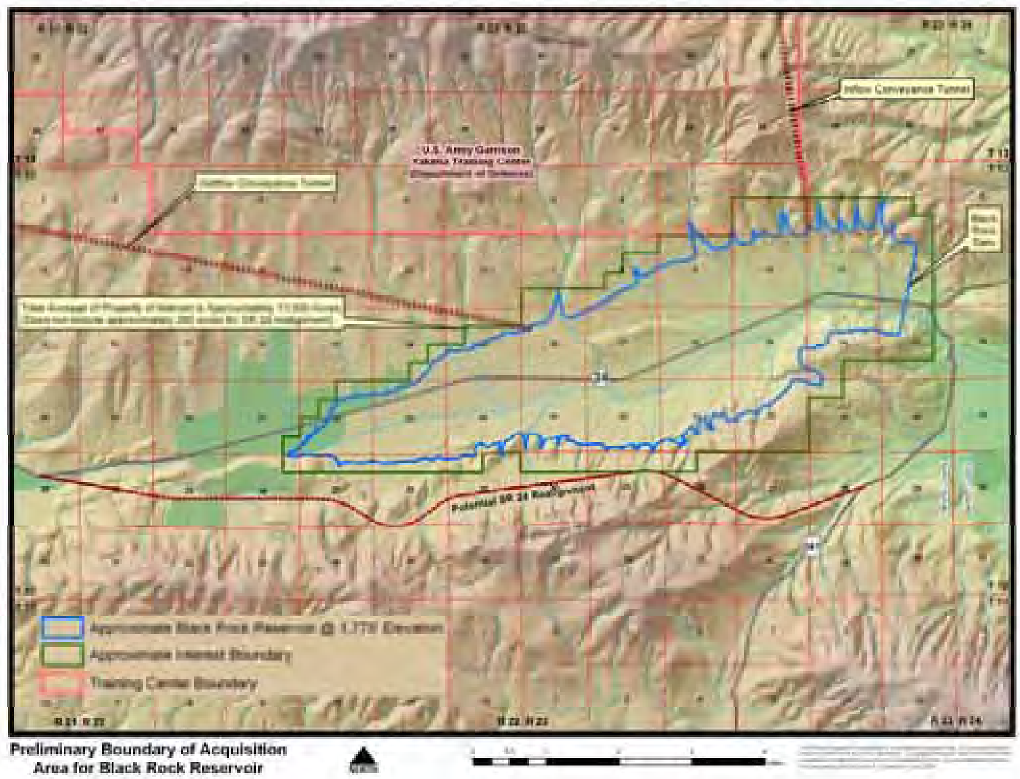

Figure 4.20 Preliminary boundary of acquisition area for the Black Rock Alternative (in green).

Private land acquisition would involve all or a portion of the holdings of approximately 20 landowners. Withdrawal of BLM land would involve four non-contiguous tracts (within secs. 2, 10, 12 and 14 of T. 12 N, R. 23 E); of these four tracts, one would be fully inundated; the remaining three tracts would be partially inundated. The extension of the reservoir pool into the YTC would occur across the southern boundary of sec. 4, T. 12 N., R. 23 E. The relocated SR–24 would cross a 440-acre BLM tract in sec. 28, T. 12 N., R. 23 E.

The acquired private land and withdrawn BLM land would be converted from predominantly open habitat and rangeland/grazing uses to dam and outlet works, reservoir pool, and shoreline management uses. Grazing leases on withdrawn BLM land necessarily would be terminated, and grazing use of the BLM tract transected by the new SR–24 likely would be disrupted. The extension of the reservoir pool into the YTC would be relatively minor and likely would not result in a significant direct disruption of the YTC mission.

Shoreline management at the proposed reservoir is expected to center on (1) long-term protection of water quality in the reservoir (e.g., restrictions on uses that could impact water quality), (2) provision of shorezone wildlife habitat, and (3) development of reservoir-oriented recreation facilities (e.g., day and overnight use sites, boat ramp(s)). In the last regard, recreation facilities, to the extent that these are developed, are expected to be located along the southern shore of the reservoir (section 4.12, “Recreational Resources”).

In terms of direct impacts on existing developed uses:

- One existing residence and a hunting club location would be displaced (inundated by the reservoir).
- Two other residences, associated with agricultural use in the western end of the reservoir area, would not be inundated, but a substantial portion of the associated landholding would need to be acquired, thus making uncertain the viability of continued agricultural operations.
- Two electric transmission lines and one buried fiber optic cable which traverse the valley in an east-west direction would require relocation.
- SR–24 would need to be rerouted. (See section 4.16, “Transportation.”)
- The roadside café and nearby residence located east of the damsite would likely be indirectly impacted by this alternative because of incompatibility between these uses and the development and operation of Black Rock dam.

Without mitigation, indirect land use impacts may also occur from development, operation, and use of the reservoir. These impacts would center on (1) disruption of access to private, BLM or YTC lands adjacent to the dam/reservoir acquisition/withdrawal area (particularly north of the reservoir) and/or (2) potential for trespass by reservoir recreation users onto these adjacent lands. In the latter regard, conflict with the YTC mission and concerns for public safety could occur.

From the standpoint of land use planning, the dam and reservoir are not anticipated by or consistent with the current Yakima County comprehensive plan or zoning. However, development of Black Rock dam and reservoir would involve removing associated land from Yakima County jurisdiction; thus, county plans and designations for the land would no longer be relevant.

Seepage Mitigation Features.—Assessment of land use and shoreline resources impacts related to Black Rock reservoir seepage mitigation features is organized according to the three land status categories involved: (1) private land along the Dry Creek channel immediately downstream from the damsite, (2) the ALE Reserve, where most facilities would be developed, and (3) Horn Rapids Park along the Yakima River in Benton County.

Private Land.—The only seepage mitigation facility proposed near/along the 6.6-mile reach of Dry Creek from the damsite to the border of the ALE Reserve is the approximately 3.6-mile powerline (a relatively low-voltage pole line) necessary for the dewatering wells. The exact route for this line (from the BPA station to the well installations in the ALE Reserve) has not been determined; however, a route generally along the stream corridor and avoiding existing agricultural operations is expected. Development of the line will require acquisition of a 100-foot easement or right-of-way from private landowners, within which the line and an associated access road would be located.

Except for installation and operation of the powerline, the only changes to existing land uses or shoreline conditions along this reach would be introduction of year-round (versus seasonal) flow in Dry Creek and any necessary stream channel stabilization at/near the BPA substation (i.e., to protect the substation from impacts due to erosion). The introduction of year-round streamflow would not alter existing land use and could have a positive local effect in terms of private recreation opportunities. The extent to which protective measures would be needed for the substation site has not been defined to date; any such measures would not represent substantial development and would be designed and implemented in coordination with BPA, the involved county, and any other responsible agencies.

ALE Reserve.—The proposed cutoff wall/embankment and pipeline inlet structure would be built on Dry Creek immediately within the western boundary of the ALE Reserve. Proposed wells would be concentrated primarily downstream from the embankment, but one or more wells also may be sited upstream. Beyond this concentration of facilities, the proposed pipeline (requiring a 150-foot construction right-of-way and a 100-foot permanent right-of-way) would be routed along existing roads, with approximately 6.6 miles along unpaved roads within the ALE Reserve and the remainder adjacent to SR–240 along the ALE Reserve's east/northeast boundary. The approximately 7 miles of existing roads within the ALE Reserve would be widened/improved to 12 feet to support construction and long-term operation and maintenance access. Access to the pipeline right-of-way along SR–240 would be directly from the existing highway; no alteration of the highway and no new roads would be required.

Overall, development of the seepage mitigation features within the ALE Reserve could be considered inconsistent with the intent of the Presidential Proclamation establishing the overlying national monument and associated provisions for management and administration of the lands. The relative severity or significance of this inconsistency must be judged by the extent to which the proposed project features cause long-term disruption or removal of habitat or other resources intended for permanent protection within the ALE Reserve:

- Development of the cutoff wall/embankment, inlet structure, and wells will alter habitat conditions on approximately 10 acres along the western boundary of the reserve; this impact on land/resources in the ALE Reserve is considered significant by the Service (Hughes, 2008).

- For the approximately 7 miles of pipeline within the ALE Reserve interior, habitat removal associated with widening the access road would be long term and unavoidable; the extent of this impact is expected to be no more than 10–15 acres. Beyond this, the long-term significance of impact depends on the success of revegetation/restoration of habitat disturbed during pipeline construction. To address this concern, Reclamation proposes (as part of the project) to (1) avoid vegetation impacts to the extent practicable during construction and (2) reestablish shrub-steppe vegetation on disturbed areas along the pipeline right-of-way. In the latter regard, aggressive management of invasive species would be carried out during habitat recovery to prevent long-term degradation of the restored habitat. Overall, impacts to land use objectives in the ALE Reserve would be significant in the short term but would be reduced to nonsignificance over the long term as restored habitat matures.

- For the approximately 15 miles of pipeline along SR–240, the facility would be installed as much as possible within the existing disturbed corridor associated with the highway. To the extent that construction would require disturbance of valuable habitat further into the ALE Reserve, restoration efforts (as described above) would prevent significant long-term impacts to land use. Long-term access along the pipeline also would be necessary; however, this access would be via SR–240 and would not represent an impact to ALE Reserve resources or uses.

Horn Rapids Park.—The approximately 0.5 mile of pipeline and the outlet structure to the Yakima River would be located east (downstream) from the main developed portion of the park. Neither the pipeline nor the outlet structure would significantly interfere with existing or planned uses of the park. Any public safety concern related to the outlet facility would be addressed by appropriate fencing or other access restrictions.

From the standpoint of the SMA, installation of the outlet facility is undoubtedly “water dependent.” Beyond this, the conceptual nature of facility plans and designs at this point in the planning process precludes a detailed assessment of response to SMA policies and provisions. (See section 4.13.2.6, “Mitigation.”)

Appurtenant Facilities.—

Intake/Import System.—Development of the Priest Rapids intake and fish screen facility would require Federal control (fee title or other appropriate land interest) of approximately 24 acres of Grant County PUD land on the southwest shore of Priest Rapids Lake. Structures above ground surface would include a pumping plant 56 feet high and an electrical switchyard with towers up to 104 feet high. The facility site would involve approximately

2,400 feet of shoreline near the dam. Use of this shoreline land would change from general wildlife area to developed project facilities.

This change in use would not be significant. No existing PUD facilities would be displaced. The 24 acres withdrawn from wildlife use would be minor in context with the overall lake environment, and all new facilities would be compatible in character with existing hydroelectric project infrastructure.

From the standpoint of shoreline management pursuant to the SMA, the intake and fish screen facilities are undoubtedly “water dependent.” Beyond this, the conceptual nature of facility plans and designs at this point in the planning process precludes a detailed assessment of response to SMA policies and provisions. (See section 4.13.2.6, “Mitigation.”)

Development of the access road and transmission line to the intake and fish screen facility would require acquisition of associated easements/rights-of-way but would not involve (1) direct impact to or displacement of any developed land uses[13] or (2) inconsistencies with existing county plans or zoning.

With one exception, development (boring) of the inflow tunnel from the intake facility to the reservoir would not involve changes in land use along the tunnel route. Material excavated for the tunnel would be used in the dam embankment. The exception to this is the surge/vent shaft, which would require dedication of an 80- by 80-foot fenced site where the shaft reaches the land surface in the YTC; this requirement is not expected to have a significant impact on YTC uses or activities.

Outflow/Delivery System.—The following discussions focus on potential long-term impacts from facility development on land ownership and existing land use. Also, project facilities generally would be consistent with the intent of the Yakima County’s agriculture land use designation, given that the facilities are similar to other local and regional irrigation infrastructure on which the region depends.

*Outflow Conveyance.—*Development and operation of a buried pipeline for the westernmost 3,000 feet of the conveyance would involve long-term use impacts to a 150-foot-wide corridor of predominantly agricultural land. Reclamation would acquire a right-of-way or easement along this corridor, and future use within it would be restricted. It is likely that agricultural uses could continue after construction is completed. However, no permanent structures would be permitted, and any permitted use would be subject to disruption in the event of a pipeline repair or replacement requirement.

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[13] See section 4.16, “Transportation,” and section 4.19, “Visual Resources,” for discussions of adjacency impacts of the road and transmission line on the existing Wanapum Village.

The preliminary alignment shown in the appraisal assessment report for Black Rock would cross several parcels of land at an angle and not along property lines, essentially dividing the parcels into two parts. It would also come in close proximity to, if not displace, at least one existing residence. These impacts would be locally significant (to individual landowners).

With one exception, construction (boring) of the outflow tunnel from the reservoir to the tunnel portal (at the beginning of the pipeline described above) would not involve land use impacts or changes along the tunnel route. All material excavated for the tunnel would be used in construction of the dam. The exception to this is the surge/vent shaft. Where this shaft reaches the land surface, Reclamation would need to acquire and fence an 80- by 80-foot site, as well as access to the site for construction, operation, and maintenance. Given that the land on which the shaft site would be located and through which the access road would be routed is currently undeveloped, open habitat/rangeland, no significant impact on existing uses occur.

*Black Rock Outlet Facility and Powerplant (and Point of Delivery to Roza Canal for the Roza Division).—*This facility would require Federal acquisition of approximately 5.7 acres of private agricultural land; no existing residences would be affected. The facility would include a 45-foot-high structure, a service yard, and an electrical switchyard with towers up to 104 feet high. The overall site would be fenced (7-foot chain link). Power to the facility is expected to be provided via a new wood pole transmission line from the existing Roza pumping plant #3 switchyard; this line could require acquisition of an easement or right-of-way along existing roads/property lines on private land. (No specific alignment studies for this line have been done to date.)

Overall, the facility would involve introducing an industrial use in a predominantly agricultural area. However, such facilities are not uncommon in the area given current irrigation infrastructure.

*Sunnyside Powerplant and Bypass.—*This facility would require Federal acquisition of approximately 2 acres of private agricultural land. No existing residences would be affected. The facility would include powerplant and bypass structures (35 and 18 feet high, respectively), a service yard, and an electrical switchyard with towers up to 104 feet high. The overall site would be fenced (7-foot chain link). Power to the facility is expected to be provided via a new wood pole line from the BPA line about 1 mile to the southwest. This line could require acquisition of an easement or right-of-way along existing roads/property lines on private land. (No specific alignment studies for this line have been done to date.)

The general impacts of the facility would be the same as that described for the Black Rock outlet facility.

*Delivery System for Sunnyside Division.—*Development and operation of 6.4 miles of buried pipeline connecting the Black Rock outlet facility with the Sunnyside powerplant and bypass facility would involve long-term use impacts to a 120-foot-wide corridor of predominantly agricultural land. Reclamation would acquire a right-of-way or easement along this corridor, and future use within it would be restricted. It is likely that agricultural uses could continue after construction is completed. However, no permanent structures would be permitted, and any permitted use would be subject to disruption in the event of a pipeline repair or replacement requirement.

Preliminary alignment studies show the pipeline facility would cross several agricultural parcels at an angle and/or not along property lines, thus dividing the parcels into two parts, and come close to, if not displacing, at least one residence. These impacts would be locally significant (to individual landowners).

4.13.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Construction impacts would include temporary impacts to existing land uses (e.g., to agricultural production and/or access).

Long-Term Impacts

Dam and Reservoir.—Direct impacts from development of Wymer dam and reservoir would involve Federal acquisition of approximately 4,000 acres of private land in the Lmuma Creek basin. The preliminary boundary of the acquisition area is shown on figure 4.21. This acquisition would involve two members of the same family. The land would be converted from open habitat and rangeland uses to dam and outlet works, reservoir pool, and shoreline management uses. Shoreline management is expected to include water quality protection, wildlife habitat, and reservoir-oriented recreation facilities (e.g., day use sites, boat ramp(s), etc.) (See section 4.12, “Recreational Resources.”)

At the easternmost extent of the reservoir, the high water line would extend approximately 2,500 feet into the YTC. This extension of the reservoir pool into the YTC would be relatively minor and should not result in a significant direct disruption of the YTC mission. However, either a transfer of jurisdiction from the Department of Defense to Reclamation or an appropriate encroachment agreement between the two entities would be required.

No other landowners (private or public) or developed uses would be directly affected.

Figure 4.21 Preliminary boundary of acquisition area for Wymer Dam and Reservoir Alternative (in green).

Without mitigation, indirect land use impacts may also occur from development, operation, and use of the reservoir. These impacts would center on (1) disruption of access to private or public lands adjacent to the reservoir acquisition area, and/or (2) potential for trespass by reservoir recreation users onto these adjacent lands. In the latter regard, conflict with the YTC mission and concerns for public safety could occur.

From the standpoint of land use planning, it is uncertain whether Kittitas County would consider the dam and reservoir consistent with the intent of the “forest and range” zoning designation. However, development of Wymer dam and reservoir would involve removing associated land from Kittitas County jurisdiction, thus making county plans and designations for the land no longer relevant.

Appurtenant Facilities.**—**Development of appurtenant facilities would require the following:

- **Pumping plant, air chamber, and switchyard:** Federal acquisition of approximately 6.8 acres of private, agricultural land along the Yakima River, including approximately 100 feet of shoreline.

- **Import conveyance (pipeline):** Federal control of (via acquisition, easement, or right-of-way) and construction within a 100-foot-wide corridor of agricultural land approximately 4,700 feet long from the dam to the pumping plant and crossing SR–821.
- **Outlet conveyance:** Federal control and modification of the Lmuma Creek channel from the dam to the Yakima River.
- **Electric transmission line:** Federal control of (via acquisition, easement, or right-of-way) and construction of a transmission line within a 100-foot-wide corridor of land approximately 5 miles long from the pumping plant to an existing Bonneville Power Administration transmission line located to the west. No routing studies for this line have been conducted to date.

With the exception of the SR–821 right-of-way (WSDOT) and transmission line right-of-way (route and associated land ownership not determined), all land on which appurtenant facilities would be located is owned by one family. The import conveyances would be underground, and the transmission line would be above ground; thus, long-term use of associated land could include continued agriculture with appropriate restrictions and conditions related to the potential for repair/replacement access. Whether the landowner's residence in the area immediately east of SR–821 would need to be relocated has not been determined. Use of the land on which the pumping plant, air chamber, and switchyard would be constructed would be changed from irrigated agriculture to project facilities.

These changes in use could be locally significant. This would be especially true (1) if the landowner's residence would be displaced and (2) related to incompatibility with the BLM Lmuma Creek recreation site (i.e., conversion of adjacent lands from agriculture to industrial uses). However, the changes would not be significant in the broader context of the Yakima River Canyon; in this regard, the commercial/industrial nature of the pumping plant, air chamber, and switchyard facilities would be similar to those associated with Roza Diversion Dam approximately 5 miles to the south and private commercial uses 1 mile to the north.

From the standpoint of land use planning, it is uncertain whether Kittitas County would consider project facilities consistent with the intent of the "forest and range" zoning designation in the area or if the BLM would consider these facilities compatible with the Scenic and Recreational Highway. However, as noted above, the Wymer facilities would be similar in nature to existing development upstream and downstream along the river.

From the standpoint of shoreline management (pursuant to the SMA), the Yakima River intake, pumping plant, and outlet facilities are undoubtedly "water dependent." Beyond this, the conceptual nature of facility plans and designs at this point in the planning process precludes a meaningful assessment of response to SMA policies and provisions. (See section 4.13.2.6, "Mitigation.")

4.13.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

In addition to the construction impacts described for the Wymer Dam and Reservoir Alternative, impacts would occur all along the pipeline route, impacting existing land uses and requiring significant undercrossings of waterways and roads.

Long-Term Impacts

The environmental consequences of the Wymer dam component of this alternative are the same as for the Wymer Dam and Reservoir Alternative. This section discusses the Yakima River pump exchange component of this alternative.

Development of the pump exchange component of this alternative would require Reclamation to acquire the following land interests from private owners:

- **Pipeline:** Approximately 56 miles of easement or right-of-way would need to be acquired. This easement or right-of-way would typically be 200 feet wide. Land use within the easement/right-of-way would be restricted for the life of the project. It is likely that agricultural, recreational, or other nonstructural uses could continue after construction is completed. However, existing structures would be removed, no new permanent structures would be permitted, and any permitted use would be subject to disruption in the event of a pipeline repair or replacement requirement.

- **Pumping plants:** Fee title to required lands for development of project surface facilities would need to be acquired. Approximate land area requirements are:
    - **Intake and pumping plant #1:** 16 acres
    - **Pumping plant #2:** 53 acres (16 for structures and yard; 37 for overflow reservoir)
    - **Pumping plant #3:** 40 acres (12 for structures and yard; 28 for overflow reservoir)
- **Transmission lines to pumping plants:** Easements or rights-of-way (width not specified to date) for new transmission lines to supply power to the pumping plants. Land use within this easement/ right-of-way would be restricted for the life of the project (in similar fashion to that described above for the pipeline). Preliminary studies specify the following requirements:

- **Intake and pumping plant #1:** One-half mile of 500-kV line
- **Pumping plant #2:** 1.5 miles of 230-kV line
- **Pumping plant #3:** 3 miles of 115-kV line

Also, the pipeline would require numerous crossings of other infrastructure facilities and waterways, necessitating coordination and permitting from involved State and/or Federal agencies. Required crossings include, but are not limited to, those presented in tables 4.41 and 4.42 (based on preliminary inventory of major facilities and not including utility lines, other pipelines, minor waterways/ drainages, etc.).

Table 4.41 Pump exchange pipeline crossings of rivers and waterways

Feature	Crossings
Yakima River	1
Roza ID wasteway	1
Sunnyside Canal	3
Other waterways	6

Table 4.42 Pump exchange pipeline crossings of highways and roads

Feature	Crossings
Interstate highways (I–182 in Richland)	1
State Routes (240, 224, 225 and 241)	4
Arterial highways (in Richland)	4
Local roads	45–50

Overall, this alternative would have significant impacts on land use within the required easements/rights-of-way and on surface facility sites. Long-term impacts would include restriction of allowable uses within the pipeline easements/rights-of-way and changes in land use at the pumping plant sites.

From the standpoint of shoreline management (pursuant to the SMA), both the intake and pumping plant #1 facilities on the Columbia River and the Yakima River pipeline crossing can certainly by considered “water dependent” given the purpose of the project/alternative. Beyond this, the conceptual nature of facility plans and designs at this point in the planning process precludes a meaningful assessment of response to SMA policies and provisions. (See section 4.13.2.6, “Mitigation.”)

Overviews of potentially significant long-term impacts on land use within affected jurisdictions are provided below.

City of Richland.—Approximately 16 acres (including approximately 200 feet of Columbia River/McNary pool shoreline) designated “commercial recreation” in the city’s Wye Master Plan would be used instead for the industrial facilities associated with intake and pumping plant #1. Project facilities may also have a wider impact because of incompatibilities with planned commercial recreation uses in the surrounding area; this is especially the case with the transmission line necessary to supply the pumping plant.

Beyond the Wye area, after the I–182 crossing near Columbia Center Boulevard, a substantial proportion of the land along the proposed pipeline corridor currently is undeveloped, especially on the north side of Keene Road (where the preliminary alignment of the pipeline has been shown). However, there are several instances of residential subdivisions abutting the pipeline route. There is at least one instance of high-density development built across the preliminary pipeline route. There are several crossings through commercial development, especially near roadway intersections. It is likely that at least some residential and/or commercial land uses would be displaced by pipeline construction.

City of Kennewick.—Most land along the proposed pipeline route through Kennewick (1 mile long) is developed with residential uses on the north and commercial uses on the south. Construction here likely would result in displacement of structures.

Another potential impact on Kennewick is incompatibility between the intake and pumping plant #1 facilities and both existing campground and park/resort hotel (planned) uses in the city's Columbia Park, immediately to the southeast.

City of West Richland.—Land along the proposed pipeline route within West Richland is more than 50 percent developed, primarily in low-density residential uses. It is unlikely that the pipeline could be implemented without some displacement of existing residences.

Benton and Yakima Counties.—The preliminary route shown for the pipeline primarily follows existing roads through irrigated agricultural areas in these two counties. As such, there are many instances of existing residences within 200 feet of the roads. These residences would be displaced if the pipeline were developed according to the preliminary alignment.

Land on which pumping plant #2 and pumping plant #3 and their associated overflow reservoirs and transmission lines would be located is currently in agricultural use. This use would be displaced by project facilities.

4.13.2.6 Mitigation

Black Rock Alternative

Dam and Reservoir.—Land acquisition requirements and associated direct land use impacts associated with Black Rock dam and reservoir would be long term and unavoidable. Mitigation would focus exclusively on (1) compensating impacted private landowners at fair market value according to established Federal regulations, guidelines, and procedures; (2) formally withdrawing impacted BLM lands for project purposes; (3) executing appropriate agreements with the Department of Defense related to the reservoir extension into the YTC; (4) notifying impacted BLM grazing lessees according to 43 Code of Federal Regulations (CFR) 4110.4-2 requirements (i.e., 2 years notice prior to loss of grazing use); and (5) relocating/ rerouting existing utility and transportation infrastructure. In the last regard, as shown conceptually in chapter 2 and described further in section 4.16,"Transportation," SR–24 is proposed to be rerouted along the south side of the reservoir. The impacted transmission lines and fiber optic cable would be relocated/reconstructed along the new SR–24 alignment. WSDOT requirements will need to be met regarding both the highway relocation and parallel relocation of transmission and cable lines (i.e., highway alignment and design standards, franchise agreements for location of utilities within State rights-of-way, utility crossing construction restrictions, etc.).

Mitigation of potential indirect access and trespass impacts on surrounding lands will need to be discussed and negotiated with affected landowners and agencies. New (replaced) access routes will need to be provided to lands that otherwise would be isolated by reservoir developments, and restrictions on public access to private or public lands surrounding the reservoir will need to be imposed if trespass or use conflicts are a concern. In the latter regard, appropriate measures may range from signage to physical barriers.

Seepage Mitigation Features.—Private and public land requirements (i.e., acquisitions, easements, and/or rights-of-way) associated with seepage mitigation features would be largely unavoidable. Efforts to mitigate land use impacts would include generally minimizing the extent of land disturbance (i.e., facility "footprint") as much as possible and:

- Coordinating with potentially impacted private landowners to define the most acceptable route for the powerline and associated access road.

- Ensuring effective habitat restoration (i.e., to a predisturbance condition), especially within the ALE Reserve and Horn Rapids Park. In the case of the embankment within the ALE Reserve, the potential to create valuable wetland or riparian habitat in the wetted upstream area also should be explored.

- Ensuring public safety related to the outlet structure in Horn Rapids Park.

- Obtaining a necessary Substantial Development Permit pursuant to the SMA. The SMA permit process would focus on (1) protection of shoreline natural resources (including response to the no net loss policy) and (2) promoting public access to the maximum extent feasible.

***Appurtentant Facilities.*—**Land and easement/right-of-way acquisition, as well as short- and long-term land use impacts associated with appurtenant facilities of the Black Rock Alternative, would be largely unavoidable. Mitigation would focus primarily on compensating impacted landowners at fair market value according to established Federal guidelines, standards, and procedures. Additional mitigation potential, to be explored during more detailed studies (especially for conveyance routes), would include the following:

- Minimize construction-phase disruption to existing land uses (especially related to construction duration and access/circulation).

- Avoid dislocation of or significant proximity impacts on existing residences or other major structures to the maximum extent feasible.

- Align conveyances along existing roads and/or property lines to the maximum extent feasible.

- In response to SMA policies and as part of obtaining the required Substantial Development Permit, design shoreline facilities at Priest Rapid Lake to (1) protect shoreline natural resources (including response to the no net loss policy) and (2) promote public access to the maximum extent feasible.

Wymer Dam and Reservoir Alternative

Land use impacts associated with Wymer dam and reservoir would be long term and unavoidable. Mitigation would focus exclusively on compensating impacted landowners at fair market value according to established Federal regulations, standards, and procedures and on executing appropriate agreements with the Department of Defense related to the reservoir extension into the YTC.

Mitigation of potential indirect access and trespass impacts on surrounding lands will need to be discussed and negotiated with affected landowners and agencies. New (replaced) access routes will need to be provided to lands that otherwise would be isolated by reservoir developments, and restrictions on public access to private or public lands surrounding the reservoir will need to be imposed if trespass or use conflicts are a concern. In the latter regard, appropriate measures may range from signage to physical barriers.

Land and easements/rights-of-way acquisition and use impacts associated with appurtenant facilities of the Wymer Dam and Reservoir Alternative would be largely unavoidable. Mitigation would focus primarily on compensating the impacted private landowners at fair market value according to established Federal guidelines, standards, and procedures. Additional mitigation potential, to be explored during more detailed studies, would include the following:

- Avoid dislocation of the existing residence east of the State route, if feasible.
- Work with the landowner to accommodate agriculture in conveyance and transmission corridors, if desired.
- In response to SMA policies and as part of obtaining the required Substantial Development Permit, design shoreline facilities to (1) protect shoreline natural resources (including response to the no net loss policy) and (2) promote public access to the maximum extent feasible.
- Use architectural treatments and landscape screening to blend facilities with the surrounding landscape. (See section 4.19, "Visual Resources.")

Wymer Dam Plus Yakima River Pump Exchange Alternative

Land and easement/right-of-way acquisition, and associated short- and long-term land use impacts from pipeline, pumping plant, and transmission line facilities of the Yakima River pump exchange component would be largely unavoidable. However, more detailed studies of pipeline and transmission line routing options should explore opportunities for avoiding direct, dislocation impacts on existing residences and businesses to the maximum extent feasible. For example, in the rural/agricultural lands of Benton and Yakima Counties, routing of the pipeline on/near property lines or on quarter- or half-section lines (rather than immediately along roads) in some areas may offer the opportunity to avoid dislocation impacts to residences and minimize construction-phase access disruptions. Such detailed routing studies also should seek opportunities to minimize long-term impacts on existing developed uses in the urban environments of Richland, Kennewick, and West Richland.

Beyond such site/alignment adjustments during detailed planning, mitigation for land use, and ownership impacts would focus primarily on (1) compensating impacted landowners at fair market value according to established Federal guidelines, standards, and procedures and (2) coordinating with involved owners and entities regarding design and implementation of required infrastructure crossings or other interactions.

Regarding shoreline resources, siting and design of the intake and pumping plant #1 facilities and the Yakima River pipeline crossing should seek to (1) protect shoreline natural resources (including response to the no net loss policy) and (2) promote public access to the maximum extent feasible. Consideration and adoption of potential responses in these regards would be part of the Substantial Development Permit process.

4.13.2.7 Cumulative Impacts

The Black Rock Alternative would have only minor cumulative impacts relative to local- or county-scale land ownership, existing land uses, or applicable land use plans and policies. Cumulative impacts would be associated predominantly with appurtenant facilities and would take the form of an incremental addition in the number of industrial/infrastructure facilities present in the context of rural environments. In the area of the intake facilities near Priest Rapids Dam, this change would primarily be an addition to already existing facilities and uses (i.e., no other similar facilities are planned). In the area of the outlet and distribution facilities (rural Yakima County), it can be expected that continuing urban development will also bring instances of this type of development over time.

The appurtenant facilities (pumping plant, switchyard, etc.) of the Wymer Dam and Reservoir Alternative would add cumulatively to the number of locations within the Yakima River Canyon where developed industrial/commercial land uses occur in the context of a primarily undeveloped river canyon, a canyon environment designated as “rural” by Kittitas County. This cumulative “land use compatibility” impact will be in relation to existing developed facilities such as Roza Diversion Dam; no additional, similar types of development are known to be planned within the canyon.

The Wymer Dam Plus Yakima River Pump Exchange Alternative would have only minor cumulative impacts relative to local- or county-scale land ownership, existing land uses, or applicable land-use plans and policies. Cumulative impacts would be associated predominantly with pumping plant #2 and pumping plant #3 and would take the form of an incremental addition to the number of industrial/ infrastructure facilities present in the context of rural environments in Benton and Yakima Counties. This change would primarily be an addition to already existing facilities and uses (i.e., no other similar facilities are known to be planned in the locally affected environment).

4.14 Socioeconomics (Regional Economy)

This section presents estimates of the regional economic impacts resulting from changes in construction expenditures, gross farm income, and recreational expenditures for each Joint Alternative as compared to the No Action Alternative. The regional economic impact analysis comprises the RED account. The

NED account compares the alternatives from a national perspective, while the RED account measures the effect of the alternatives on the region's local economy.

The RED analysis includes not only the initial or direct impact on the primary affected industries, but also the secondary impacts resulting from those industries providing inputs to the directly affected industries as well. This analysis also includes the changes in economic activity stemming from household spending of income earned by those employed in the sectors of the economy impacted either directly or indirectly. These secondary impacts are often referred to as "multiplier effects."

The NED economic benefits are not used directly in the RED analysis; only the physical changes are carried over from the NED analysis. For example, changes in agricultural water supply may result in a change in crop acreages, which subsequently results in a change in gross farm income. The change in gross farm income reflects the direct economic impact in the RED analysis, which after being run through the regional economic model, generates the secondary or multiplier effects. The NED benefits analysis uses net farm income as defined by the *P&Gs* as the estimate of agricultural benefits.

See chapter 2 for further explanation on the difference between the NED and RED accounts.

4.14.1 Affected Environment

The study area encompasses Kittitas, Yakima, Benton, and Franklin Counties. Ellensburg, Yakima, and the Tri-Cities (Richland, Pasco, and Kennewick) are the largest cities located within the study area. The Yakima River basin includes all of these counties except for Franklin County. Franklin County is included because the Tri-Cities are located in both Benton and Franklin Counties.

The common measures of regional economic impacts are employment, output, and labor income. Table 4.43 presents these measures for the four-county area for the year 2004. These measures are discussed in the following sections.

4.14.1.1 Employment

Employment measures the number of jobs related to the sector of the economy. In the study area, activities related to agricultural production generate the largest number of jobs (15.8 percent of total regional employment) in the study area. Government-related jobs rank second in terms of overall number of jobs in the study area (14.9 percent of total regional employment).

Table 4.43 Regional employment, output, and labor income, Kittitas, Yakima, Benton, and Franklin Counties (2004)

Sector category	Employment		Output		Labor income	
	Number of jobs	% Total	$ million	% Total	$ million	% Total
Agriculture, forestry, fish and hunting	39,059	15.8%	$2,944	11.1%	$1,023	10.7%
Mining	51	Less than 1	$7	Less than 1	$2	Less than 1
Utilities	357	0.1%	$173	0.7%	$32	0.3%
Construction	13,439	5.4%	$1,486	5.6%	$607	6.4%
Manufacturing	15,457	6.2%	$4,803	18.1%	$766	8.0%
Wholesale trade	7,745	3.1%	$877	3.3%	$330	3.5%
Transportation and warehousing	6,891	2.8%	$655	2.5%	$283	3.0%
Retail trade	23,485	9.5%	$1,481	5.6%	$602	6.3%
Information	2,839	1.1%	$535	2.0%	$127	1.3%
Finance and insurance	4,831	2.0%	$736	2.8%	$212	2.2%
Real estate and rental	5,623	2.3%	$789	3.0%	$157	1.6%
Professional: scientific and technical services	15,832	6.4%	$1,791	6.8%	$1,062	11.1%
Management of companies	918	0.4%	$141	0.5%	$61	0.6%
Administrative and waste services	13,958	5.6%	$2,181	8.2%	$832	8.7%
Educational services	2,653	1.1%	$108	0.4%	$49	0.5%
Health and social services	24,411	9.9%	$1,772	6.7%	$928	9.7%
Arts: entertainment and recreation	4,028	1.6%	$184	0.7%	$65	0.7%
Accommodation and food services	14,835	6.0%	$697	2.6%	$231	2.4%
Other services	14,252	5.8%	$879	3.3%	$298	3.1%
Government	37,020	14.9%	$4,29	16.2%	$1,874	19.6%
Total	247,684	100.0%	$26,532	100.0%	$9,541	100.0%

Source: 2004 IMPLAN data files, including U.S. Bureau of Economic Analysis, U.S. Bureau of Labor, and U.S. Bureau of the Census.

4.14.1.2 Output

Output, or industry output, represents the value of production of goods and services produced by business within a sector of the economy. The manufacturing sectors produce the highest level of output in the study area (18.1 percent of the total regional output). The vast majority of the manufacturing output stems from activities in the food-processing-related industries. The government sectors generate the second highest level of output within the study area (16.2 percent of total regional output). The agricultural production sectors rank third in level output (11.1 percent of the total regional output).

4.14.1.3 Labor Income

Labor income is the sum of Employee Compensation and Proprietor Income. The government sectors generate the largest portion of labor income in the region (19.6 percent of the total regional labor income). The sectors related to providing professional services rank second (11.1 percent of the total regional labor income). Ranking third, closely behind professional services, are the sectors related to agricultural production (10.7 percent of the total labor income).

4.14.1.4 Irrigated Agriculture

As discussed previously, activities related to agricultural production contribute the largest number of jobs to the region. The agricultural sector ranks third in terms of labor income and industry output. These jobs are primarily related to irrigated agricultural production, including livestock and food processing. Production agriculture is widely diversified in the region. The area is well known for tree fruit (apples, pears, and cherries), vegetable (sweet corn, potatoes, and asparagus), grape (wine and juice), and hay and grain (timothy hay, alfalfa hay, pasture, and wheat) production.

Table 4.44 presents gross onfarm income for each crop grown on Yakima Project lands. Gross onfarm income is calculated by multiplying together acres, yields, and prices for each crop. These data are taken from the Yakima Agricultural Impact model discussed in chapter 2.

Table 4.44 Gross onfarm income by crop

Crops	Output ($ million)
Vegetables	
Asparagus	17
Sweet corn	10
Potato	3
Fruits	
Cherries	68
Pears	28
Apples	342
Other	
Mint	8
Hops	86
Concord grapes	36
Wine grapes	41
Timothy hay	13
Alfalfa	32
Silage	9
Grains	
Wheat	7
Total	700

Source: Reclamation's YAI model.

The gross onfarm income from crops grown on Yakima Project lands generates 12,321 total jobs, $391.4 million in labor income, and $1,097.3 million in output in the study area. These data are estimated using the IMPLAN modeling package discussed in section 4.14.2.1.

4.14.1.5 Recreation

Recreation expenditures generate employment, output, and labor income in the study area. A recreation survey was conducted to gather information at existing reservoir and river sites within the region. Estimates of visitation, days per visit, nonlocal recreator visitation percentages (see section 4.14.2.1, "Methods and Assumptions," for a discussion of the logic for focusing on nonlocal recreation expenditures), and expenditures per visit were obtained from the survey. Because changes in recreation activity related to the proposed alternatives were estimated to occur at only four sites (i.e., Kachess Lake, Cle Elum Lake, Yakima River, and Tieton River), the description of current regional recreation expenditures also focuses on those sites. Obviously, the proposed Black Rock and Wymer reservoirs are not part of the current condition.

Table 4.45 presents information on current in-region recreational expenditures by nonlocal recreators by site. Adding across all four sites, nearly 70 percent of the visitation reflects nonlocal recreators. Average in-region expenditures per visit by nonlocal recreators range from a low of $49.02 at Kachess Lake to a high of $133.09 at Cle Elum Lake. The current total in-region expenditures by nonlocals at these sites were estimated at nearly $700,000.

Table 4.45 Current (2007) in-region recreation expenditures by nonlocal recreators by site

Site	Visitation (days)	Nonlocal percentage	Nonlocal visitation (days)	Days per visit	Nonlocal visits	Average in-region expenditures per visit	Current total in-region expenditures ($ thousand)
Kachess Lake	17,668	.86	15,194	5.3	2,867	$49.02	$140.5
Cle Elum Lake	8,976	.663	5,951	5.0	1,190	$133.09	$158.4
Yakima River	18,900	.5	9,450	3.7	2,554	$88.47	$226.0
Tieton River	9,108	.78	7,104	3.58	1,984	$85.24	$169.1
Combined	54,652		37,699		8,595		$694.0

4.14.2 Environmental Consequences

At the regional level, all of the alternatives would result in positive economic output as compared to the No Action Alternative. The most significant effect would result from construction activities. However, expenditures related to OM&R, recreation expenditures, and agricultural production also would affect the regional economy.

4.14.2.1 Methods and Assumptions

The modeling package used to assess the regional economic effects stemming from construction, irrigated agriculture, and recreation for each alternative is

IMpact Analysis for PLANning (IMPLAN). IMPLAN is an economic input-output modeling system that estimates the effects of economic changes in an economic region.

Input-output models measure commodity flows from producers to intermediate and final consumers. Purchases for final use (final demand) drive the model. Industries produce goods and services for final demand and purchase goods and services from other producers. These other producers, in turn, purchase goods and services. This buying of goods and services (indirect purchases) continues until leakages from the region (imports and value added) stop the cycle.

These indirect and induced effects (the effects of household spending) can be derived mathematically using a set of multipliers. The multipliers describe the change of output for each and every regional industry caused by a $1 change in final demand for any given industry.

IMPLAN data files are compiled from a variety of sources for the study area, including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor, and the U.S. Bureau of the Census. This analysis uses 2004 IMPLAN data for Washington's Benton, Yakima, Kittitas, and Franklin Counties, which comprise the study area for the RED analysis.

Construction

The construction-related expenditures associated with each of the alternatives were placed into categories that represent different sectors of production in the economy. The construction expenditures that are made inside the study region were considered in the regional impact analysis. Construction expenditures made outside the four-county area were considered "leakages" and would have no impact on the local economy.

The RED study assumed that the workforce would move to the region and spend their wages inside the area during the construction period. This analysis also assumed that the vast majority of the construction expenditures will be funded from sources outside the four-county study area. Money from outside the region that is spent on goods and services within the region would contribute to regional economic impacts, while money that originates from within the study region is much less likely to generate regional economic impacts. Spending from sources within the region represents a redistribution of income and output rather than an increase in economic activity.

For the purpose of the Storage Study, the total construction costs were used to measure the overall regional impacts. These overall impacts would be spread over the construction period and would vary year-by-year proportionate to actual expenditures.

Operation, Maintenance, and Replacement

Expenditures that are made inside the study region related to OM&R will also generate a positive economic output to the regional economy. Estimating regional impacts resulting from OM&R expenditures is difficult because they occur during different periods of time. For example, expenditures related to operations and maintenance occur annually, whereas replacement expenditures occur periodically based on the replacement schedule.

This analysis quantifies annual impacts resulting from annual costs related to operation and maintenance. The analysis does not quantify the positive impacts resulting from replacement costs given they are spread out over the entire study period. Like the construction-related expenditures, O&M expenditures made inside the study area associated with each alternative were placed into categories related to each sector of the economy and run through IMPLAN to estimate impacts to the regional economy.

Irrigated Agriculture

Regional economic impacts are realized in drought years when proration levels drop below 70 percent. To estimate the regional impacts in each of these years, the YAI model was used to estimate the changes in gross onfarm income between the No Action Alternative proration level and the proration level achieved by each alternative. No regional economic impacts accrue when the proration levels are above 70 percent for a given alternative. Table 4.46 presents the gross onfarm income by IMPLAN sector (incremental to the No Action Alternative) for each year of the 25-year period of record (1981–2005) that the proration levels drop below 70 percent.

The changes in gross onfarm income summarized in table 4.46 were used in the IMPLAN model to estimate total employment, output, and labor income associated with the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives.

This analysis measures regional economic impacts stemming from production agriculture. Industries related to production agriculture are not the only industries dependent on irrigation in a regional economy. Other industries depend on inputs of irrigated crops in their production process, e.g., the livestock and food processing industries.

Table 4.46 Gross onfarm income (incremental to the No Action Alternative) by IMPLAN sector for each year of the 25-year period of record (1981–2005) that the proration level falls below 70 percent

Year	Grains	Other	Fruits	Vegetables
Black Rock Alternative				
1987	556,579	17,232,110	16,043,770	1,129,626
1992	428,138	13,255,040	12,347,810	868,943
1993	685,021	21,206,100	19,804,730	1,393,283
1994	1,840,993	55,196,340	88,008,910	4,932,981
2001	1,113,159	34,101,480	43,542,390	2,964,663
2005	1,070,345	32,796,050	41,392,080	2,821,306
Wymer Dam and Reservoir Alternative				
1987	171,255	5,302,016	4,939,123	347,577
1992	256,883	7,953,024	7,408,685	521,366
1993	470,952	14,578,580	13,630,830	958,812
1994	85,628	2,086,366	6,944,756	32,920
2001	642,207	19,520,940	29,959,800	2,008,826
2005	171,255	5,221,744	8,601,246	573,428
Wymer Dam Plus Yakima River Pump Exchange Alternative				
1987	171,255	5,302,016	4,939,123	347,577
1992	256,883	7,953,024	7,408,685	521,366
1993	470,952	14,578,580	13,630,830	958,812
1994	85,627	2,086,367	6,944,756	32,920
2001	642,208	19,520,940	29,959,800	2,008,828
2005	171,255	5,221,744	8,601,246	573,428

Recreation

Regional economic impacts associated with changes in recreation activity within the region were estimated for both the proposed reservoirs and existing reservoirs and rivers. Estimates of changes in visitation by site were obtained from the recreation analysis. Given that the proposed Black Rock and Wymer reservoirs are obviously not a part of the No Action Alternative, the estimates of visitation for these proposed reservoirs reflect the full change in visitation as compared to the No Action Alternative.

In regional economic impact analyses of recreation, the assumption typically is made that the majority of impacts are generated by expenditures made inside the region by nonlocal recreators. Local recreators are generally assumed to spend the majority of their money within the region, regardless of the alternatives under consideration, implying they would generate little by way of additional regional economic activity. As a result, the analysis focuses on in-region expenditures by nonlocal recreators.

Given that in-region nonlocal recreator expenditures per visit vary by site, the survey was conducted across all the existing reservoirs and rivers within the region. Survey questions asked recreators to estimate their total expenditures for the current visit, the portion of those expenditures incurred within the local region, and the breakdown of expenditures into various expenditure categories (e.g., lodging, food, gas, etc.). This later piece of information was necessary to help subdivide the expenditures across the economic sectors included in the IMPLAN model. These data were used by IMPLAN to estimate output, labor income, and employment relative to the No Action Alternative and stemming from recreational expenditures for each alternative.

Potential Economic Development Around Black Rock Reservoir

If Black Rock reservoir were constructed, certain local interests plan on pursuing the idea of a recreational resort as well as residential and commercial developments around the reservoir. While no developers have come forward thus far, some basic conceptual plans have been proposed (Yakima Basin Storage Alliance [YBSA], 2007). The plans call for significant levels of resort, residential, and commercial development, resulting in sizable increases in property values compared to current conditions. Conversely, other local interests see the proposed development concepts as pure speculation. They claim that such proposed developments are unlikely given the significant degree of annual reservoir drawdown expected at Black Rock reservoir, the less-than-pristine natural setting compared to mountain reservoirs in the region, and that development around other reservoirs in similar settings in the general vicinity of the proposed Black Rock reservoir have not materialized (e.g., Desert Aire at Priest Rapids Lake).

The assumption was made in the economic benefit-cost analysis that if Black Rock reservoir is not constructed, potential developers would invest in developments elsewhere in the Nation, resulting in a "wash" from a national perspective. As a result, any potential development would not constitute a benefit to the Nation because the investment could be considered part of the No Action Alternative and, therefore, would be made regardless of the alternative selected in this study. Despite failing to reflect a national benefit, any development around Black Rock reservoir would represent a positive economic impact to the region's local economy.

4.14.2.2 No Action Alternative

The No Action Alternative provides the basis of comparison for changes in employment, output, and labor income under the Black Rock, Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternatives.

4.14.2.3 Black Rock Alternative

Construction Impacts

Regional economic impacts stemming from construction expenditures, incremental to the No Action Alternative, for each Joint Alternative, are presented in table 4.47. The employment, output, and income generated from each alternative's expenditures are compared to the overall regional economy. The estimated impacts are representative of the entire construction period. These impacts would not occur each year; they vary year by year proportionate to annual expenditures. The majority of the employment, output, and income impacts is due to the expenditures of the wages earned by the workforce involved in the construction project and the construction activities.

The total number of jobs during the approximate 10-year construction period, 31,414, includes 14,145 direct construction jobs. Thus, assuming a 10-year construction period, an average of about 1,415 of the 3,140 average annual jobs would be directly related to construction and include onsite and offsite labor. The 14,145 direct construction jobs would be about 6 percent of the regional 2004 employment, while the total number of jobs, 31,414, would be about 8 percent. The average annual direct and average annual total number of jobs, 1,415 and 14,145, respectively, would be about 1 percent of the regional 2004 employment.

Table 4.47 Total regional economic impacts stemming from construction activities

	Employment[1]		Output ($ million)[2]		Income ($ million)[3]	
	Total	Percent of the total regional economy	Total	Percent of the total regional economy	Total	Percent of the total regional economy
Regional economy	247,684		$26,532		$9,540	
Black Rock Alternative	31,400	12.7%	$3,380	7.9%	$1,195	12.7%
Wymer Dam and Reservoir Alternative	5,720	2.3%	$617	2.3%	$217	2.3%
Wymer Dam Plus Yakima River Pump Exchange Alternative	15,539	6.3%	$1,732	6.5%	$589	6.2%

[1] Employment is measured in number of jobs.
[2] Output represents the dollar value of industry production.
[3] Income is the dollar value of total payroll (including benefits) for each industry in the region plus income received by self-employed individuals located within the region.

The 2004 population of the four-county region was estimated to be 475,400. The total number of jobs associated with this alternative would be an increase of about 7 percent, while the direct construction jobs would be an increase of about 2 percent. The average annual direct and average annual total number of jobs would be less than one-half of 1 percent of the regional population.

In 2000, the region had a total of 167,696 housing units, of which 7.5 percent or 12,615 were vacant. The number of housing units in 2006 was estimated to be about 185,000, an increase of 17,300 units, with about 14,000 vacant units. The housing unit estimates include mobile homes but do not include the numerous motels, recreational vehicle (RV) parks, and similar facilities located within the four-county region.

The specific skills and numbers of the construction workforce would change during the construction period. It is likely some jobs may last for a few weeks or months, while others could last for 1 or more years. A few workers may elect to commute to the worksites associated with this alternative from outside the four-county region. Others may choose to stay in the region in temporary quarters (e.g., motels, RV parks) during the work week and return to their permanent residence on weekends. Some may relocate alone or with family to the region, renting or purchasing housing. Regardless, adequate housing likely would be available within the four-county area. With the construction workforce dispersed throughout the four-county area, it is unlikely any community would be overwhelmed with an influx of workers.

Long-Term Impacts

O&M Activities.—Regional economic impacts stemming from O&M activities, incremental to the No Action Alternative for each alternative, are presented in table 4.48. The employment, output, and income generated from each alternative's O&M activities are compared to the overall economy. These impacts are assumed to occur on an annual basis. Like the construction impacts, the majority of the O&M impacts are due to the expenditures of the wages earned by the workforce involved in O&M-related activities.

Table 4.48 Annual regional economic impacts stemming from O&M activities

	Employment (number of jobs)		Output ($ million)		Income ($ million)	
	Total	% of total regional economy	Total	% of total regional economy	Total	% of total regional economy
Regional economy	247,684		26,532		9,540	
Black Rock Alternative	33	Less than 1	4	Less than 1	1.1	Less than 1
Wymer Dam and Reservoir Alternative	9	Less than 1	1.1	Less than 1	0.314	Less than 1
Wymer Dam Plus Yakima River Pump Exchange Alternative	119	Less than 1	11.8	Less than 1	4.8	Less than 1

Irrigated Agriculture.—Table 4.49 presents the regional economic impacts for the Black Rock Alternative for each year of the 25-year period of record (1981–2005) that the proration level falls below 70 percent. Also presented in the table is a comparison to the total regional impacts stemming from the gross onfarm income generated on the Yakima Project lands.

Table 4.49 Regional economic inputs stemming from irrigated agriculture

Year	Output ($ million)	Percent of Yakima Project	Labor income ($ million)	Percent of Yakima Project	Employ-ment	Percent of Yakima Project
Black Rock Alternative						
2005	$121.2	11.1%	$42.2	10.8%	1,330	10.8%
2001	$126.9	11.6%	$44.2	11.3%	1,394	11.3%
1994	$234.1	21.3%	$82.6	21.1%	2,608	21.2%
1993	$66.4	6.1%	$22.7	5.8%	716	5.8%
1992	$41.4	3.8%	$14.1	3.6	447	3.6%
1987	$53.9	4.9%	$18.4	4.7	580	4.7%
Wymer Dam and Reservoir and Wymer Dam Plus Yakima River Pump Exchange Alternatives						
2005	$22.8	2.1%	$8.0	2.0%	254	2.1%
2001	$81.3	7.4%	$28.6	7.3%	902	7.3%
1994	$14.5	1.3%	$5.3	1.4%	169	1.4%
1993	$45.7	4.2%	$15.6	4.0%	493	4.0%
1992	$24.9	2.3%	$8.5	2.2%	268	2.2%
1987	$16.8	1.5%	$5.7	1.5%	179	1.5%

Recreation.—Recreation expenditures (the expenditures used in IMPLAN were incremental to the No Action Alternative) related to the proposed Black Rock reservoir stimulate $4.72 million of output, $1.84 million in labor income, and 72 jobs annually. Recreation expenditures at existing recreation sites generate a small amount of regional economic impacts ($0.66 million of output, $0.33 million of labor income, and 9.38 jobs). The majority of the regional impacts stemming from expenditures at the proposed reservoir and existing sites occur in the Accommodation and Food Service and the Retail Trade sectors. Table 4.50 presents regional economic impacts stemming from recreation expenditures at existing and proposed sites.

Table 4.50 Regional economic impacts stemming from recreation expenditures

Recreation	Black Rock Alternative	Percent of the current condition	Wymer Dam and Reservoir Alternative	Percent of the current condition	Wymer Dam Plus Yakima River Pump Exchange Alternative	Percent of the current condition
Existing sites						
Output/sales ($ million)	$0.12	18.2%	$0.04	5.9%	$0.1	16
Labor income ($ million)	$0.06	20.1%	$0.02	5.2%	$0.05	15.8
Employment	2	16.4%	1	7.5%	1	11.3
Proposed sites						
Output/sales ($ million)	$4.72	NA[1]	NA[2]	NA	NA	NA
Labor income ($ million)	$1.84	NA	NA	NA	NA	NA
Employment	72	NA	NA	NA	NA	NA

[1] The proposed Black Rock reservoir is not included in the current condition; therefore, no comparisons were made.
[2] Recreators at Wymer reservoir are assumed to be from the local area; therefore, no regional impacts were generated.

4.14.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Regional economic impacts related to construction expenditures for the Wymer Dam and Reservoir Alternative are presented in table 4.47.

The total number of jobs during the approximate 10-year construction period, 5,700, includes 2,535 direct construction jobs. Thus, assuming a 10-year construction period, an average of about 255 of the 570 average annual jobs would be directly related to construction and include onsite and offsite labor. The 2,535 direct construction jobs would be about 1 percent of the regional 2004 employment, while the total number of jobs, 5,700, would be about 2 percent. The average annual direct and average annual total number of jobs, 255 and 570, respectively, would be less than three-tenths of 1 percent of the regional 2004 employment.

The total number of jobs associated with this alternative would be an increase in regional population of less than 2 percent, while the direct construction jobs would be an increase of about one-half of 1 percent. The average annual direct and average annual total number of jobs would be about one-tenth of 1 percent of the regional population. Other effects would be as described for the Black Rock Alternative.

Long-Term Impacts

O&M Activities.—Table 4.48 presents the regional economic impacts stemming from O&M activities for the Wymer Dam and Reservoir Alternative.

Irrigated Agriculture.—Table 4.49 presents the regional economic impacts for the Wymer Dam and Reservoir Alternative and the Wymer Dam Plus Yakima River Pump Exchange Alternative for each year of the 25-year period of record (1981–2005) that the proration level falls below 70 percent.

Recreation.—It was assumed that recreators at the proposed Wymer reservoir are residents of the regional study area; thus, their recreational expenditures would not create regional economic impacts to the region. The Wymer Dam and Reservoir Alternative would generate a small amount of recreation expenditures at existing sites, as presented in table 4.50. Regional economic impacts stemming from recreational expenditures at existing sites stimulate $0.17 million in output, $0.07 million in labor income, and 3.38 jobs. As under the Black Rock Alternative, most of the regional impacts occur in the Accommodation and Food Services and Retail Trade sectors of the economy.

4.14.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Regional economic impacts stemming from construction expenditures for the Wymer Dam Plus Yakima River Pump Exchange Alternative are presented in table 4.47.

The total number of jobs during the approximate 10-year construction period, 15,539, includes 6,776 direct construction jobs. Thus, assuming a 10-year construction period, an average of about 680 of the 1,550 average annual jobs, would be directly related to construction and include onsite and offsite labor. The 6,776 direct construction jobs would be slightly less than 3 percent of the regional 2004 employment, while the total jobs, 15,539, would be about 6 percent. The average annual direct and average annual total number of jobs, 680 and 1,550, respectively, would be less than 1 percent of the regional 2004 employment.

The total number of jobs associated with this alternative would be an increase in regional population of about 3 percent, while the direct construction jobs would be an increase of about 1 percent. The average annual direct and average annual total number of jobs would be less than one-half of 1 percent of the regional population. Other effects would be as described for the Black Rock Alternative.

Long-Term Impacts

O&M Activities.—Table 4.48 presents the regional economic impacts stemming from O&M activities for the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Irrigated Agriculture.**—**The regional economic impacts are the same as for the Wymer Dam and Reservoir Alternative (table 4.49).

Recreation.**—**Like the Wymer Dam and Reservoir Alternative, regional economic impacts related to the Wymer Dam Plus Yakima River Pump Exchange Alternative are related to recreational expenditures at existing recreational sites. Regional economic impacts related to recreational expenditures are small ($0.49 million output, $0.22 million in labor income, and 5.46 jobs). Like both the Black Rock and Wymer Dam and Reservoir Alternatives, most of the regional impacts occur in the Accommodation and Food Services and Retail Trade sectors. These results are summarized in table 4.50.

4.14.2.6 Mitigation

Mitigation measures may have impacts to the regional economy due to activities related to construction.

4.14.2.7 Cumulative Impacts

No cumulative impacts are expected.

4.15 Public Services and Utilities

This analysis of public services and utilities addresses the affected environment and environmental consequences of the Joint Alternatives from the perspectives of the following:

- Public services
    - Law enforcement
    - Fire protection
    - Emergency medical/transportation
- Utilities
    - Electricity
    - Natural gas
    - Telecommunications
    - Water supply (domestic and irrigation)
    - Wastewater management

These are addressed from the standpoint of potential for short- or long-term impact on local systems (levels of service, response time, access, etc.) and/or infrastructure serving populated areas in/near which facilities would be developed. For analysis of potential impact to major/regional utility infrastructure (such as high voltage transmission lines, pipelines, and/or cable installations), see section 4.13, "Land Use and Shoreline Resources."

4.15.1 Affected Environment

4.15.1.1 No Action Alternative

The No Action Alternative includes conservation-oriented water supply system improvements, including pumping plants and pipelines, at various locations in the Yakima Valley region (Kittitas, Yakima, and Benton Counties). These improvements are associated with existing approved programs and orient predominantly to existing facilities; none are being or would be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of the directly affected public services and/or utilities environment would be prepared separately, apart from the Storage Study process.

4.15.1.2 Black Rock Alternative

The water storage and conveyance facilities associated with the Black Rock Alternative would be located in Yakima County. Public services and utilities in the affected areas of Yakima County are provided by the following:

- **Law enforcement**: Yakima County Sheriff
- **Fire protection**: Local Yakima County Fire Protection Districts (multiple)
- **Emergency medical/transportation**: Primarily local Yakima County Fire Protection Districts
- **Electrical power**: Pacific Power & Light Company and Benton County Rural Electric Association
- **Natural gas**: Cascade Natural Gas Corporation
- **Telecommunications**: Several companies, including Qwest
- **Water supply**: Domestic supply—predominantly from individual wells; irrigation supply—individual wells and local irrigation district surface deliveries
- **Wastewater management**: Individual septic tank and leach field installations

The seepage mitigation facilities associated with the Black Rock Alternative would be located in Benton County and the ALE Reserve, east of Black Rock damsite. Public service providers in Benton County are listed under the Wymer Dam Plus Yakima River Pump Exchange Alternative. Within the ALE Reserve, services and utilities are provided by a combination of Federal and local entities under agreements with the U.S. Fish and Wildlife Service.

4.15.1.3 Wymer Dam and Reservoir Alternative

All facilities associated with the Wymer Dam and Reservoir Alternative would be located in southern Kittitas County, Washington. Public services and utilities in the general area of the county where Wymer facilities would be developed are provided by the following:

- **Law enforcement:** Kittitas County Sheriff
- **Fire protection:** Kittitas County Fire Department
- **Emergency medical/transportation:** Kittitas County Fire Department
- **Electrical power:** Kittitas County Public Utility District
- **Natural gas:** No developed system in the study area
- **Telecommunications:** Several companies, including Qwest
- **Water supply:** Domestic supply—individual wells; irrigation supply—individual wells and Yakima River
- **Wastewater management:** Individual septic tank and leach field installations

4.15.1.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

The affected environment of the Wymer dam component of this alternative is presented in section 4.15.1.3, "Wymer Dam and Reservoir Alternative." The following presents the public services and utilities setting for the Yakima River pump exchange component of this alternative.

Facilities associated with the Yakima River pump exchange would be located in Yakima County, Benton County, and the cities of Richland and West Richland, Washington. The general public services and utilities setting for Yakima County are presented under the Black Rock Alternative. Comparable services and utilities in Benton County and incorporated Richland and West Richland are provided by the following.

- **Law enforcement:** Benton County Sheriff, Richland Police Department, and West Richland Police Department
- **Fire protection:** Benton County Fire Protection Districts (multiple) and Richland Fire Department
- **Emergency medical/transportation:** Primarily Benton County Fire Protection Districts (multiple) and Richland Fire Department
- **Electrical power:** Benton County Public Utility District, Benton Rural Electric Association, and City of Richland
- **Natural gas:** Cascade Natural Gas Corporation (Richland/West Richland area; no service in rural Benton County)

- **Telecommunications:** Several companies, including Qwest
- **Water supply:** Rural Benton County—domestic supply—primarily individual wells, with irrigation supply from individual wells and local irrigation district surface deliveries; cities of Richland and West Richland—all service through city-owned systems
- **Wastewater management:** Rural Benton County—individual septic tank and leach field installations; cities of Richland and West Richland—city-owned systems

4.15.2 Environmental Consequences

4.15.2.1 Methods and Assumptions

Potential for adverse effects to public services and utilities is based on analysis of the following indicators:

- **Short-term** (construction-phase) disruption of services or utilities to an extent that would impose unacceptable health and safety risk or additional cost on affected residents/landowners. This indicator is expressed in such terms as:
    - Blocking/disruption of efficient access by police, fire, or emergency service personnel.
    - Disruption of electrical, telecommunications, water, or sewer service.
    - Requirements for relocation of local electrical, telecommunications, water, or sewer service facilities.
- **Long-term** increases in demand for services or utilities to a point where existing capacity (ability to serve) would be exceeded, thus causing service shortfalls unless capacity is expanded. This indicator is expressed in one or more of the following terms:
    - Exceeding established local standards for police, fire, or emergency service personnel-to-population ratio (e.g., personnel per 1,000 population). This measure also sometimes can be expressed in terms of vehicles or equipment.
    - Exceeding established local standards for police, fire, or emergency medical service response time.
    - Inability of local utilities/utility systems to provide adequate service to proposed facilities (electric power, telecommunications, water supply, or wastewater management).

For this Final PR/EIS, analysis and discussion of potential for public service and utility impacts are generalized and qualitative. Direct consultation with potentially affected service/utility providers has not been conducted; instead, such consultation is included as a primary mitigation action should any of the alternatives be selected for development. This approach is considered appropriate for the following reasons:

- Potential for short-term impacts can only be addressed generally because:
    - The proposed locations, plans, and designs for facilities associated with the alternatives, especially appurtenant facility development sites and conveyance alignments, are derived from Reclamation's appraisal-level assessments. Some facility locations and substantial distances of the conveyance alignments are preliminary and subject to adjustment based on further study. Thus, site or alignment adjustments are considered an important source of mitigation action during more detailed planning.
    - No detailed construction plans have been prepared for facilities associated with the alternatives. Thus, detailed analysis of potential for short-term impacts (as described above) is not possible. Instead, as with actual facility location/alignment, avoidance or mitigation of potential for short-term service/utility disruptions would be an important concern during detailed planning.
- With the exception of electrical power, none of the Joint Alternatives would introduce a substantial new long-term demand for public service or utilities. This is because the Joint Alternatives do not involve increases in local population (i.e., the primary source of demand for most services and utilities).

4.15.2.2 No Action Alternative

As noted previously, conservation-related system improvements associated with the No Action Alternative are part of other approved programs and orient predominantly to existing facilities; none are being or will be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of potential for public service and/or utility impacts would be prepared separately, apart from the Storage Study process.

4.15.2.3 Black Rock Alternative

Construction Impacts

Public Services.—Short-term impacts to these services can be expected in all areas involved with facility construction (i.e., intake/inflow facilities, dam and reservoir, outflow and distribution facilities); such impacts would be primarily in the form of access disruptions. With proper construction-phase planning, these impacts are not expected to be significant. (See section 4.15.2.6, "Mitigation.")

Utilities.—Short-term impacts to local utility services can be expected on adjacent/surrounding lands in all areas involved with facility construction, especially related to the outlet and distribution facilities located in rural residential and agricultural areas. Such impacts would be primarily in the form of temporary service interruptions and requirements for infrastructure relocations (e.g., power, telecommunications or water supply lines, septic tanks or leach fields). Until more detailed construction-phase planning occurs, it is not possible to determine if potential for such impacts would be significant.

Long-Term Impacts

Public Services.—Development of the Black Rock Alternative would not result in a significant long-term increase in demand for police, fire protection, or emergency medical/transportation services.

Utilities.—Development of the Black Rock Alternative would result in a long-term increase in demand for electrical power, specifically associated with intake/import facilities at Priest Rapids Lake, the Black Rock outlet facility/ pumping plant and Sunnyside pumping plant/bypass in eastern Yakima County, and seepage mitigation pumps, etc. In each case, as noted in section 4.13, "Land Use and Shoreline Resources," power supply to these facilities is expected to be drawn directly from existing BPA transmission lines, and no constraint on the availability of necessary power has been recognized to date.

Two existing overhead 115-kilovolt powerlines on H frame-type wood pole supports and a buried fiber optic line along existing SR–24 would need to be relocated along new the SR–24 alignment.

Other perspectives on long-term utility service demand at/from Black Rock facilities include:

- Telecommunication system connections would be required at all major facility sites. Where land-line connections are not readily available, wireless systems could be used.
- Water supply and wastewater management would be provided via independent, onsite systems (e.g., water supply wells, septic tank/leach field, or other independent wastewater management system).
- No connections to natural gas distribution systems would be required. If gas energy is needed, onsite systems (i.e., propane) would be used.

4.15.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Public Services.—Minor, short-term access disruptions may occur during construction (i.e., along SR–821). However, with proper construction-phase planning, such impacts likely can be avoided. (See section 4.15.2.6, "Mitigation.")

Utilities.—Short-term impacts to utility services (e.g., temporary service interruptions and requirements for infrastructure relocation) may occur for the one local resident in the immediate study area. However, with proper construction-phase planning, such impacts likely can be avoided. (See section 4.15.2.6, "Mitigation.")

Long-Term Impacts

Public Services.—Development of the Wymer Dam and Reservoir Alternative would not result in a significant long-term increase in demand for police, fire protection, or emergency medical/transportation services.

Utilities.—Development of the Wymer Dam and Reservoir Alternative would result in a long-term increase in demand for electrical power, associated with the pumping plant and other intake/outlet facilities along the Yakima River. As noted in section 4.13, "Land Use and Shoreline Resources," power supply to these facilities is expected to be drawn directly from an existing BPA transmission line; no constraint on the availability of necessary power has been recognized to date.

Other perspectives on long-term utility service demand at/from Wymer facilities include:

- Telecommunication system connections would be required at facility sites. Where land-line connections are not readily available, wireless systems could be used.
- Water supply and wastewater management would be via independent, onsite systems (e.g., water supply wells, septic tank/leach field, or other independent wastewater management system).
- If gas energy is needed, onsite systems (i.e., propane) would be used.

4.15.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

The environmental consequences of the Wymer dam component of this alternative are the same as for the Wymer Dam and Reservoir Alternative. This section discusses the Yakima River pump exchange component of this alternative.

Construction Impacts

Public Services.—Short-term impacts to these services can be expected in all areas involved with facility construction (i.e., pumping plant sites and pipeline alignments); such impacts would be primarily in the form of access disruptions. With proper construction-phase planning, these impacts are not expected to be significant. (See section 4.15.2.6, "Mitigation.")

Utilities.—Short-term impacts to local utility services can be expected on adjacent/surrounding lands in all areas involved with facility construction (i.e., pumping plant sites and pipeline alignments). Such impacts would be primarily in the form of temporary service interruptions and requirements for infrastructure relocations (e.g., power, telecommunications or water supply lines, sewer lines, septic tanks, or leach fields). Until more detailed construction-phase planning occurs, it is not possible to determine if potential for such impacts would be significant.

Long-Term Impacts

Public Services.—Development of the Yakima River pump exchange would not result in a significant long-term increase in demand for police, fire protection, or emergency medical/transportation services.

Utilities.—Development of the Yakima River pump exchange would result in a long-term increase in demand for electrical power, associated with pumping plants. Power supply to these plants is expected to be drawn from existing transmission lines near the facility sites, and no constraint on the availability of necessary power has been recognized to date.

Other perspectives on long-term utility service demand at/from the Yakima River pump exchange facilities include:

- Telecommunication system connections would be required at each pumping plant site. Where land-line connections are not readily available, wireless systems could be used.
- Water supply and wastewater management would be provided (1) at pumping plant #1 by the city of Richland and (2) at pumping plants #2 and #3 via independent, onsite systems (e.g., water supply wells, septic tank/leach field, or other independent wastewater management system).
- If gas energy is needed, pumping plant #1 may be serviced via the local Cascade Natural Gas Corporation system. Onsite systems (i.e., propane) are an option at all three plant sites.

4.15.2.6 Mitigation

Long-term provision of all necessary public services and utilities for project facilities can be ensured by proper coordination and planning with involved service/utility providers. No significant, residual long-term impacts are expected.

Mitigation planning related to potential for short-term, construction-phase impacts on public services and utilities should also be rooted in close coordination with involved service providers, as well as with potentially impacted local residents/landowners. In this regard, the following objectives should be met during detailed implementation planning (resulting in no significant residual impacts):

- Retain appropriate access throughout construction zones and throughout the construction period for law enforcement, fire protection, and emergency medical/transportation service providers.
- Where local utility system connections/installations would be impacted by construction activities, plan for and implement alternative/relocated connections and facilities prior to construction (i.e., avoid service disruptions).
- Either accomplish the above two measures at no cost to affected service providers and/or residents and landowners or provide compensation to offset additional costs incurred.

4.15.2.7 Cumulative Impacts

There would be no significant cumulative impacts on public services or utilities.

4.16 Transportation

The transportation analysis addresses the affected environment and environmental consequences of the alternatives from the perspectives of road/highway and railroad transportation facilities in and serving the areas where alternative project facilities would be located. No air or navigable waterway transportation systems or facilities would be involved or impacted by any of the alternatives.

4.16.1 Affected Environment

4.16.1.1 No Action Alternative

The No Action Alternative includes conservation-oriented system improvements, including pumping plants and pipelines, at various locations in the Yakima Valley region. These improvements are associated with existing approved programs and orient predominantly to existing facilities; none are being or will be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of the directly affected transportation environment will be prepared separately, apart from the Storage Study process.

4.16.1.2 Black Rock Alternative

Dam and Reservoir

The site of the proposed Black Rock dam and reservoir is the Black Rock Valley, located in eastern Yakima County. SR–24 crosses this valley in an east-west direction and is the only paved roadway present. There are no rail facilities in the valley.

SR–24, a two-lane roadway, is a major transportation and shipping link between the Yakima Valley (city of Yakima and Moxee City) to the west and the Hanford Site to the east, the Tri-Cities area to the southeast, and central Columbia Basin towns and cities to the northeast.

Major SR–24 connections are I–82 in the Yakima Valley to the west of the Black Rock Valley and SR–240 and SR–241 east of the valley.

Within the Black Rock Valley, SR–24 provides access, via unpaved roads, to private landholdings north and south of the highway.

Seepage Mitigation Features

Seepage mitigation features would be constructed in Benton County downstream from Black Rock dam on the ALE Reserve portion of the Hanford Reach National Monument and Benton County’s Horn Rapids Park, which borders the ALE Reserve on the south. Access to the facility sites for construction, operation, and maintenance would be via the following:

- SR–241, a two-lane highway, and an existing unpaved road that provides access to the BPA substation (i.e., for construction, operation, and maintenance of the proposed powerline).
- SR–240, a two-lane highway that forms the east/northeast boundary of the ALE Reserve and along which approximately 15 miles of pipeline would be constructed.
- Existing unpaved roads that leads from SR–240 to the central ALE Reserve interior and provide access to the site of the cutoff wall/embankment, pipeline intake facility, and groundwater dewatering wells (approximately 7 miles of pipeline would also be constructed along these roads).

- Horn Road, a two-lane local road that intersects SR–240 and forms the boundary between the southern ALE Reserve and Horn Rapids Park. This road would provide necessary access to the southernmost portion of the pipeline and the outlet facility along the Yakima River.

Aside from the minor access road needed for the proposed powerline, no new access roads would be required for development, operation, or maintenance of the facilities.

Appurtenant Facilities

Intake/Inflow Conveyance System.—The Priest Rapids intake and fish screen facility and the northern portal for the flow conveyance tunnel to Black Rock reservoir would be located on Grant County PUD lands along the southwest shore of Priest Rapids Lake approximately 0.7 mile northwest of Priest Rapids Dam. Current access to the facility site is via Dam Road (across Priest Rapids Dam) from SR–243 east of the lake. On and around the site itself, the only access route is an unpaved road used by the PUD.

New access to the intake and fish screen facility site would be developed as part of the Black Rock Alternative. The new access route would be approximately 10 miles long, from SR–24 to the southeast, along the south side of the Columbia River, and connect with existing access roads southwest of the existing Wanapum Village and Priest Rapid Dam and leading to the facility site on the southwest shore of Priest Rapids Lake. Most of the new route would be built within an existing, abandoned railroad right-of-way through predominantly undeveloped land along Midway Substation and Priest Rapids Roads.

For the inflow conveyance tunnel connecting the Priest Rapids intake facility with the reservoir, surface access would be required only to the vent shaft site, located in the YTC approximately 0.75 mile south/southwest of the intake facility. No routing studies for this access have been conducted to date; however, it is likely that existing unpaved roads within the YTC can be used for most of the required distance.

Outflow Conveyance/Delivery System.—All transportation facilities within the settings of the Black Rock outflow/delivery system are roads and highways. No railroads or railroad rights-of-way would be affected.

Outflow Conveyance.—The eastern portal of the Black Rock outflow conveyance would be located in the Black Rock Valley. Access for construction of this portal would be from SR–24. (See section 4.16.2.3, “Dam and Reservoir.”) The western tunnel portal, vent shaft, and 3,000-foot pipeline components of the conveyance would be accessed regionally from SR–24 approximately 3 miles east of Moxee City; several two-lane local roads would also likely be used for access to various parts of these western outflow facilities (e.g., Smith, Deeringhoff, and Den Beste Roads).

Black Rock Outlet Facility and Powerplant.—The site of this facility is immediately adjacent to (and access to the site would be from) SR–24 east of Moxee City, roughly 3,000 feet east of Beane Road.

Sunnyside Powerplant and Bypass.—This facility would be located adjacent to and east of Konnowac Pass Road in Yakima County, approximately 1 mile north of Yakima Valley Highway. Access to the facility would be via Konnowac Pass Road, a two-lane road that connects with SR–24 on the north and the Yakima Valley Highway and I–82 on the south.

Delivery System for Sunnyside Division.—The 6.4 miles of pipeline comprising this conveyance would be routed from the Black Rock outlet facility to the Sunnyside powerplant and bypass facility generally paralleling (but not adjacent to) (1) the Roza Canal for the northern two-thirds of the route and (2) Konnowac Pass Road for the southern one-third. Access for construction, operation, and maintenance would be primarily from two-lane local roads (e.g., Beane, Desmarais) in the north and Konnowac Pass Road in the central and southern portions of the route.

4.16.1.3 Wymer Dam and Reservoir Alternative

Regional and local access to the proposed Wymer dam and reservoir site, as well as sites and alignments of all appurtenant facilities, would be exclusively via SR–821, a two-lane roadway in the Yakima River Canyon, southern Kittitas County. The easternmost extent of the reservoir pool at high water would pass under I–82, but no access to project facilities is proposed from this location, either for construction or long-term operation. There are no public roads or rail facilities in the Lmuma Creek basin where Wymer dam and reservoir would be built. The only access present is an unpaved, private ranch road. In terms of appurtenant facilities, the pumping plant would be built west of and adjacent to SR–821; the subsurface discharge pipelines would cross under SR–821 heading eastward to the damsite.

4.16.1.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

The affected transportation environment for the Wymer dam component of this alternative is presented in section 4.16.1.3, "Wymer Dam and Reservoir Alternative." The following discussion focuses on transportation setting for the Yakima River pump exchange component of this alternative.

The transportation environment, through which the 56 miles of underground pipeline comprising the Yakima River pump exchange component of this alternative would pass, includes (1) the regional highway and local road systems in the urban environments of southern Richland and West Richland and (2) the main regional highway and the rural road systems of the Yakima Valley in Benton and Yakima Counties. An active Union Pacific rail line in southern Richland also would be affected (Trumbull, 2007).

Perspectives on the transportation environment for individual local jurisdictions along the project corridor are provided in the following sections.

City of Richland

Major highway access routes to and around project facilities in Richland include (from east to west): SR–240, Columbia Center Boulevard, Leslie Road, Keene Road, I–182, and Bombing Range Road. Neighborhood- or development-specific local road systems are also present within the general pipeline corridor.

In terms of specific facility siting and pipeline routing, the intake and pumping plant #1 site would likely be accessed via Columbia Center Boulevard, north of SR–240. The pipeline from that site would be (1) within or immediately adjacent to the right-of-way of a Union Pacific Railroad line north of Gage Boulevard, from Columbia Center Boulevard to Leslie Road and (2) immediately adjacent to (conceptually shown on the north side of) Keene Road from Leslie Road to the city limits northwest of I–182, near the intersection of Bombing Range Road. In the latter regard, access roads to several developed areas connect with Keene Road.

City of Kennewick

The 1 mile of pipeline through north Kennewick would be within or immediately adjacent to the railroad right-of-way noted above for Richland. No major transportation facilities in Kennewick would be affected beyond the facilities noted above for areas adjacent to Richland (e.g., SR–240).

City of West Richland

Regional access to the pipeline route in West Richland would be from I–182 in Richland to the south and SR–224 from Benton City to the west. Within West Richland, the corridor would follow (pipeline conceptually shown on the north side of) Keene Road, from the southeast city limits near Kennedy Road to the northwest city limits near West Van Giesen Street (SR–224). At present, very few local and no major roads intersect Keene Road along this corridor.

Benton and Yakima Counties

Through affected portions of Benton and Yakima Counties, from West Richland to the pipeline terminus near Sunnyside, regional access is provided by I–82 connecting the Tri-Cities area with Yakima. All pipeline and pumping plant facilities in the two counties would be through the corridor of agricultural land north of I–82 and would be accessed primarily by the rural, local road system throughout the area. Three State routes intersect the pipeline alignment: SR–224 and SR–225 near Benton City and SR–241 near Sunnyside.

4.16.2 Environmental Consequences

4.16.2.1 Methods and Assumptions

The transportation impact analysis was conducted using existing published information (city and county maps and aerial photography) and supplemented by limited field reconnaissance.

The following indicators were selected to evaluate transportation impacts:

- Short-term (construction-phase):
  - Route crossings (i.e., traffic disruptions and detours)
  - Disruptions to rail traffic during construction within the right-of-way
  - Land parcel access disruption (i.e., where construction parallels existing public roads)
  - Increased traffic (construction workers and material/equipment hauling)
  - Increased road repair/maintenance requirements due to increased heavy load movements
- Long-term: Route (road or railroad) closures and/or relocations

Of particular relevance in reviewing the analysis are the following points:

- Given the nature of the facilities associated with the Joint Alternatives, the highest potential for significant transportation-related impacts would occur during the construction phase (i.e., traffic and transportation requirements/impacts would be relatively minor during project operations and maintenance).

- No construction plans have been prepared for facilities associated with the alternatives. Consequently, no detailed analysis is possible of construction-phase impacts such as material haul routes, construction traffic volumes, increased road repair and maintenance requirements, frequency and length of detours, etc. Impact analysis is, therefore, general and programmatic.

- The locations of and plans for facilities associated with the alternatives are derived from Reclamation's appraisal-level assessments. Many appurtenant facility locations (especially siting of structures) and substantial distances of the conveyance alignments are preliminary and subject to adjustment based on further study. Thus, the transportation impacts reported herein should be viewed as illustrative or prototypical, with site or alignment adjustments considered an important source of mitigation action. Further insight from this perspective is provided where relevant on a facility-specific basis.

4.16.2.2 No Action Alternative

As noted previously, conservation-related system improvements associated with the No Action Alternative are part of other approved programs and orient predominantly to existing facilities; none are being or will be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis is required for these actions, appropriate documentation of impacts on transportation systems and facilities will be prepared separately, apart from the Storage Study process.

4.16.2.3 Black Rock Alternative

Construction Impacts

Dam and Reservoir.—Construction of Black Rock dam would have significant construction-phase impacts on the regional highway system. All materials and personnel necessary for construction would use the State routes within and surrounding the Black Rock Valley (i.e., SR–24, SR–240, and SR–241). Traffic, especially heavy vehicle use, would increase significantly, with corresponding increases in highway maintenance requirements. On a localized basis, these impacts would be the greatest for the Black Rock Alternative.

Seepage Mitigation Features.—Construction impacts would be short term and would involve increases in material/equipment hauling and construction personnel-related traffic and localized detours or temporary lane closures. Impacts related to the specific access routes/facilities involved include the following:

- No significant impact would occur to SR–241 or the access road to the BPA substation. Construction of the powerline from the BPA substation to the ALE Reserve would involve minor, short-term increases in traffic along these roads. Access along the powerline route would be restricted to authorized personnel both during construction and throughout long-term operation.

- Within the central ALE Reserve, transportation of construction equipment, material, and personnel would result in a significant short-term introduction of traffic to the otherwise closed road system. Widening/improvement of the unpaved roads used for access to construction sites and along the pipeline corridor also would be necessary. Public access would continue to be restricted during both short-term construction and long-term operation.

- Construction of the pipeline parallel with SR–240 for a distance of approximately 15 miles likely would involve localized need for lower speed limits as a cautionary measure in the immediate construction zone as it proceeds along the highway. Brief, localized lane closures (perhaps controlled by flag personnel) also would be needed in the immediate construction zone to accommodate material delivery and movement of construction equipment.

- The primary impacts to Horn Road would be (1) increases in traffic from construction equipment, material delivery, and constructions personnel and (2) a crossing of the road by the pipeline. The pipeline would be constructed using a "cut and cover" method, which would require a temporary local detour of the road around the construction site as the road crossing excavation and installation proceeds.

Appurtenant Facilities.—Construction impacts would be short term and would involve (in some cases, significant) increases in material/equipment hauling and construction personnel-related traffic, road maintenance and repair requirements, and localized detours.

Related to the intake/inflow system:

- Construction-phase impacts would center on the Priest Rapids intake and fish screen facility and northern portal of the inflow tunnel. Regionally, SR–24, SR–240, and SR–243 would be most impacted, with the highest increases in traffic and heavy load movement likely to occur on SR–240 and SR–24 from the Tri-Cities area to the south. Locally, construction traffic would use the new access road to the facility site from SR–24; this traffic may temporarily disrupt circulation in/around the Wanapum Village immediately southwest of Priest Rapids Dam but otherwise would not substantially affect local routes or facilities.

- Access to the vent shaft site on the YTC would require coordination between agencies but should not result in any significant disruption of existing YTC access or circulation patterns.

For the outflow/delivery system, the focus of construction-phase traffic would be on (1) SR–24 from Yakima through Moxee City and (2) Konnowac Pass Road from SR–24 on the north and Sunnyside (via Yakima Valley Highway) on the south. Facility-specific perspectives include:

- Construction traffic impacts would focus on SR–24 from Yakima related to the western end of the outflow conveyance (including the vent shaft and the 3,000-foot pipeline), the Black Rock outlet facility, and the northern half of the Sunnyside delivery pipeline. The outflow pipeline would require temporary detour/reroute of SR–24 while the line is installed under the highway. Construction traffic impacts and temporary disruptions of access routes would also occur on the local road systems adjacent to SR–24.

- Construction traffic impacts associated with much of the Sunnyside Division pipeline and the Sunnyside powerplant and bypass facility will focus on Konnowac Pass Road, which would be crossed twice by the pipeline. Local disruption of access to properties and local road detours would also occur on both sides of Konnowac Pass Road.

Long-Term Impacts

Dam and Reservoir.—Construction of Black Rock dam would involve rerouting of an approximately 15-mile stretch of SR–24 in the Black Rock Valley, from a point approximately 10 miles east of Moxee City to the current interconnection with SR–241 east of the damsite. As shown conceptually in section 4.13, "Land Use and Shoreline Resources," the new alignment is proposed to be on higher-elevation terrain on the south side of the valley and would connect with SR–241 approximately 4 miles south of the existing SR–24/241 intersection (thus, making an approximately 4-mile portion of SR–241 also part of SR–24).

Overall, the new SR–24 route would be approximately 2.5 miles longer than the current alignment. It also would involve steeper grades/lower speeds in the eastern portion of the route. Preliminary alignment studies for the new route indicate that design speed would be 70 miles per hour (mph) for much of the route (like the existing highway); along the easterly 3 miles before the new SR–241 connection, design speed would be 50 mph with 7-percent grades. In addition to these slower speeds and higher gradients, WSDOT has noted that the southern alignment for a SR–24 reroute would involve slope aspects disadvantageous to winter travel (i.e., reduced exposure to the sun and consequent slower snowmelt) when compared with a route along the northern part of the valley. For these reasons, WSDOT has expressed a preference for rerouting SR–24 along the north side of the proposed reservoir (McCartney, 2007). Current residents in the Black Rock Valley have also indicated this northerly route preference (Reclamation, 2004c). However, the southerly route is proposed by Reclamation primarily due to (1) cost concerns (i.e., a northern route would involve bridging several tributary canyons), (2) potential recreation facilities requiring access at the reservoir being sited primarily on the southeast shore, and (3) a northerly alignment would cross lands within the YTC and conflict with the YTC mission (Kruger, 2008).

Seepage Mitigation Features.—No long-term road closures, realignments, or increases in traffic loads or maintenance/repair needs would result from development of the seepage mitigation features. A construction, operation, and maintenance road will be constructed along the powerline route, which is not expected to interfere with existing transportation flow. There would be no long-term impacts.

Appurtenant Facilities.—No long-term road closures or realignments would be required as a result of building Black Rock appurtenant facilities.

4.16.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Significant construction-phase traffic and repair/maintenance impacts would occur along SR–821, which would be the only available route for import of materials and equipment and access by construction personnel. It is uncertain what proportion of these impacts would occur north of the project site (i.e., to/from Ellensburg) compared to south of the site (i.e., to/from the Selah and Yakima areas).

SR–821 also would be affected directly by construction of the discharge pipeline for this alternative, which would pass directly under the highway. Short-term reroute/detour around a local portion of the highway likely would be required while the conveyance under-crossings are constructed. It is unlikely that any temporary closures of the highway would be required as this work is accomplished.

As noted in section 4.16.1.3, the easternmost extent of the reservoir at high water in this alternative would pass under the I–82 bridges at Lmuma Creek, inundating the bridge piers. Preliminary plans for the Wymer Dam and Reservoir Alternative include provision for reinforcement and protection of the bridge piers to avoid any significant impact from reservoir inundation. These measures could be accomplished without significant disruption to traffic on the highway.

Long-Term Impacts

Development of the Wymer Dam and Reservoir Alternative would not involve long-term relocation or closure of any roadways.

4.16.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

The environmental consequences of the Wymer dam component of this alternative are the same as for the Wymer Dam and Reservoir Alternative. This section discusses the Yakima River pump exchange component of this alternative.

Construction Impacts

Overall, construction-phase impacts would be greater for this alternative than for any other alternative being considered; this conclusion relates specifically to the following parameters:

- Level of urban and rural development present within or adjacent to the construction corridor (i.e., related to impacts from increased traffic and disruptions to circulation and access). See section 4.13, "Land Use and Shoreline Resources," for an overview of land and development conditions along the pipeline route.

- Number and length of highways and other roads impacted.

- Length of rail line disruption (i.e., this is the only alternative that would impact rail infrastructure).

- Geographic extent of impact (i.e., 56 miles of construction, overall, in four local jurisdictions).

A preliminary inventory of road crossings necessary in this alternative includes the following:

- I–182 in Richland
- SR–240 in Richland
- SR–224 west of West Richland
- SR–225 north of Benton City
- SR–241 northwest of Sunnyside
- Several arterial roads in Richland, including Columbia Center Boulevard, Leslie Road, Queensgate Drive, and Bombing Range Road
- 45–50 local roads in Benton and Yakima Counties

Approximately 2 miles of active rail line would also be disrupted during construction within the Union Pacific Railroad right-of-way.

In addition, the preliminary alignment for the exchange pipeline shows many miles of construction parallel with, and adjacent to, existing roadways, including Keene Road in Richland, and many local collector and rural roads in Benton and Yakima Counties. While direct impact on existing roads in these "parallel" situations likely would be minimal (i.e., construction limited to the construction pipeline right-of-way), temporary disruption of access (e.g., driveways) to adjacent land parcels may be widespread.

As noted previously, no construction phasing plans or specification of construction traffic routes have been prepared; specific construction methods and techniques also have not been selected for the pipeline.

For road crossings, boring methods would be used under major highways, such as I–182 and SR–240 in Richland; in such cases, significant facility closures or detours would not be necessary. However, most crossings would be constructed using cut-and-cover methods, necessitating temporary closures and/or detours.

Where roads are paralleled, preliminary planning indicates that access would be along the construction route, rather than using/impacting the adjacent roadway.

In all cases, as construction proceeds, increased local traffic would occur and road maintenance and repair requirements would increase (especially along equipment and material haul routes).

Long-Term Impacts

Development of the Yakima River pump exchange component of this alternative would not require any long-term relocations or closures of roadways or rail lines. All impacts would be during the construction phase.

4.16.2.6 Mitigation

Black Rock Alternative

Long-term impacts associated with relocation of SR–24 and significant construction-phase traffic and road impacts are largely unavoidable under this alternative. Efforts to mitigate impacts should focus on the following:

- Further discussion with WSDOT and local residents to explore the feasibility of relocating SR–24 to the north versus south side of the Black Rock Valley as a means of mitigating design speed, gradient, winter travel, and local parcel access concerns associated with proposed route.

- Working directly with WSDOT to assure compliance with applicable design standards and obtain all necessary permits and approvals related to relocation of SR–24 and any proposed utility/infrastructure facility installations within or crossing the highway right-of-way.

- Obtaining all necessary permits and approvals from WSDOT regarding other State highway access needs, (e.g., the role of SR–240 in development and operation of the seepage mitigation features). Issues to be addressed include direct highway access, utility installations or crossings, traffic control, construction route planning and construction impact mitigation, stormwater/surface runoff management, and/or signage.

- Potential adjustment of new conveyance pipeline routes to minimize necessary road crossings and other disruptions to local traffic patterns and access routes.

- Coordination with State and local transportation agencies and potentially impacted neighborhoods and landowners, as appropriate, in preparing construction transportation management plans. Objectives would include:
  - Specifying material haul routes and construction traffic patterns which minimize local traffic impacts.
  - Phasing construction to minimize the duration of necessary temporary road closures and detours.

Wymer Dam and Reservoir Alternative

Significant construction-phase traffic and road impacts to SR–821 are largely unavoidable with development of this alternative. More detailed planning should address questions of haul route and overall traffic direction and magnitude (i.e., east versus west) and, thus, potential traffic and road impacts in Ellensburg, Selah, or Yakima. Coordination with, and permits from, WSDOT would be required to plan for construction on, facility crossings of, and any potential traffic flow disruptions along SR–821, along with stormwater/surface flow management and signage, if applicable.

Wymer Dam Plus Yakima River Pump Exchange Alternative

Significant construction-phase traffic and road impacts are largely unavoidable with development of this alternative. Efforts to mitigate impacts should focus on the following:

- Close coordination with involved transportation agencies in obtaining necessary permits and preparing plans and schedules for crossings of highways and roads. This coordination would include obtaining all necessary permits and approvals from WSDOT regarding State highway access needs, utility installations or crossings, traffic control, construction route planning and construction impact mitigation, stormwater/surface runoff management, and/or signage.
- Close coordination and cooperation with involved railroad companies related to construction with the rail right-of-way.
- Potential adjustment of pipeline route to minimize necessary road crossings and other disruptions to local traffic patterns and access routes.
- Coordination with involved transportation agencies and potentially impacted neighborhoods and landowners, as appropriate, in preparing construction transportation management plans. Objectives would include the following:

- Specifying material haul routes and construction traffic patterns which minimize local traffic impacts.
- Phasing construction to minimize the duration of necessary temporary road closures and detours.

4.16.2.7 Cumulative Impacts

Short-term cumulative impacts could occur during construction with any of the Joint Alternatives. Specifically, it is possible that construction of proposed facilities could occur coincident with other development activities in local areas, thus cumulatively increasing the number or intensity of traffic impacts, road detours, etc. The potential for this type of short-term cumulative impact would be highest (by a wide margin) with the Wymer Dam Plus Yakima River Pump Exchange Alternative, given the length of required pipelines through urban, suburban, and rural development areas (particularly in the urban environments of Richland and West Richland). Such impacts could be avoided or mitigated by proper coordination among involved government entities.

None of the alternatives would result in significant long-term cumulative transportation impacts.

4.17 Air Quality

4.17.1 Affected Environment

This section describes the area studied for the air quality analysis as well as the regulatory and environmental setting. The regulatory setting is described in terms of Federal, State, and local requirements. The environmental setting is described in terms of air pollutant sources and existing concentrations. The air quality impact analysis evaluates existing conditions and impacts to Kittitas, Benton, and Yakima Counties, where the Joint Alternatives would generate emissions.

The Federal Clean Air Act has set National Ambient Air Quality Standards (NAAQS) that define levels of air quality necessary to protect the public health (primary standards) and the public welfare (secondary standards). Areas where the measured concentrations of a pollutant are above the primary and secondary NAAQS are identified as nonattainment areas. The Clean Air Act requires that Federal activities may not cause or contribute to new violations of air quality standards, exacerbate existing violations, or interfere with timely attainment or required emission reductions towards attainment (40 CFR 93.150).

In addition to ambient air quality standards, EPA has established standards for the Prevention of Significant Deterioration (PSD) of air quality. PSD standards provide maximum allowable increases in concentrations of pollutants for areas already in compliance with NAAQS. Regulated pollutants that most commonly lead to source-wide PSD applicability include particulate matter, sulfur dioxide, and nitrogen oxides. The PSD standards are expressed in allowable increments in atmospheric concentrations of these specific pollutants (40 CFR 52). EPA has established NAAQS for ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, inhalable particulate matter, fine particulate matter, and lead. The Federal Clean Air Act requires States to classify air basins as either attainment or nonattainment with respect to these air pollutants. Counties or regions designated as nonattainment areas for one or more pollutants must prepare a State Implementation Plan (SIP) that demonstrates how the area will achieve attainment by federally mandated deadlines. Section 176(c) of the Clean Air Act requires any entity of the Federal Government that engages in, supports, or in any way provides financial support for, licenses, or permits or approves any activity to demonstrate that the action conforms to the applicable SIP required under section 110(a). According to EPA guidance, before any approval is given for a proposed action, the regulating Federal agency must determine the regional significance of the action and its general conformity on a pollutant-by-pollutant basis. If the emissions are determined to be *de minimis*, no further analysis is required. However, if the conformity regulations apply, then an evaluation must be conducted.

Ecology (2002a) identified ambient air quality standards for total suspended particulates, lead, particulate matter, sulfur dioxide, carbon monoxide, ozone, and nitrogen dioxide. In 1994, EPA, Ecology, Benton County, and Franklin County signed a Memorandum of Agreement to study the area's air quality problems and develop controls over urban fugitive dust sources (fugitive dust is generally defined as particulate matter nominally 10 microns or less" [PM10]). The Washington Administrative Code regulates fugitive dust sources. According to this regulation, "the owner or operator of a source of fugitive dust shall take reasonable precautions to prevent fugitive dust from becoming airborne and shall maintain and operate the source to minimize emissions" (Ecology, 2000c). Typical construction or water delivery projects are regulated if they emit or have the potential to emit at least 250 tons per year of any regulated pollutant (Ecology, 2003a). Internal combustion engines that propel or power vehicles are exempt from PSD emissions regulations (Ecology, 2002a).

Air quality in Yakima, Kittitas, and Benton Counties in south-central Washington is well within most of these standards for pollutants. Air quality in the study area occasionally exceeds the 24-hour PM10 standard (Mann, 2003). Most exceedances are from windblown dust from area agricultural fields (Benton County Air Authority [BCAA], 1996) followed by windblown dust from open lands, outdoor and agricultural burning, woodburning stoves and fireplaces, wildfires, industrial sources, and motor vehicles (BCAA, 2003). Local air pollutant emissions are limited to windblown dust from agricultural operations and tailpipe emissions from vehicular traffic along State highways and local roads. From 1993–2002, the PM10 standard was exceeded in the Tri-Cities area 11 times, or about an average of once a year (Mann, 2003). In the eight occurrences since 1998, five were agricultural dust, two were wildfire smoke and ash, and one was construction dust. The Washington State Department of Ecology has identified the study area as having attainment status.

Dust originating from the Black Rock and Wymer reservoir drawdown zones is a concern for air quality and public health. Dispersion of dust into the atmosphere is a function of wind speed, duration, and direction of wind; intensity of atmospheric turbulence; and mixing depth. Conditions likely to increase dispersion are most common in the summer when the reservoir pool is declining and an unstable atmosphere exists, about 56 percent of the time. Atmospheric conditions in summer are favorable to dispersion. Less-favorable conditions occur in all seasons from about sunset to about an hour after sunrise as a result of temperature inversions and shallow mixing layers. Occasionally in winter months, poor dispersion conditions are associated with stagnant air in stationary high-pressure systems. The prevailing surface winds in the area are from the northwest and occur most frequently during the winter and summer. Winds from the southwest also occur frequently. During the spring and fall, there is an increase in winds from the southwest and a corresponding decrease in winds from the northwest. Though data for the presence of fine-grain sediments in the Black Rock and Wymer reservoir drawdown zone and site-specific wind data are lacking, the Hanford data (Neitzel, 2005) suggests that the conditions (wind speed, duration, direction, and atmospheric turbulence) favor dust dispersion that would be problematic for public health and air quality.

4.17.2 Environmental Consequences

4.17.2.1 Methods and Assumptions

This section describes the methodology used to develop the emission inventories and comparison of the analysis results to the significance and conformity thresholds. Construction emissions are not available for the Final PR/EIS. In general, they are estimated from emission models and spreadsheet calculations, depending on the source type and data availability. Dispersion models are also used to estimate the dissipation and movement of emissions. The following sources and activities typically are analyzed for emissions, demolition, drilling and blasting; grading; onsite and offsite construction equipment and haul truck emissions; onsite processing and concrete batch plants; asphalt paving; and offsite worker vehicle trips to and from the site.

Long-term air quality impacts associated with emissions known to contribute to global warming are evaluated qualitatively.

4.17.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

Population growth in the Tri-Cities and Yakima areas would increase air pollution associated with tailpipe emissions, but these emissions likely would not endanger Benton, Yakima, Kittitas, and Franklin Counties' attainment status. Overall, there likely would be little or no effect on air quality in the study area. Area agricultural activities and natural events such as wildfires would continue to cause occasional exceedances in fugitive dust ambient air quality standards at a rate of about one per year.

4.17.2.3 Joint Alternatives

Construction Impacts

Vehicle emissions and dust associated with either Black Rock or Wymer reservoir construction would result in short-term impacts ranging from moderate to severe.

A comparison of alternatives would need to consider the amount of material moved and the number of pieces of equipment used in the peak day and peak year of construction activity. The major sources of volatile organic compounds (VOC), carbon monoxide (CO), and nitrogen oxide (NO_x) emissions are expected to be the onsite construction equipment and haul trucks with nonroad equipment engines, which are not subject to stationary source permitting requirements. The various Joint Alternatives would require varying levels of construction with heavy machinery and equipment. Typical construction activities would include excavation, earthwork, trenching, tunneling, boring, and jacking. Most trenching work would involve very little stationary equipment and would be complete at any one location within a few weeks. Some trenching activities would occur very near residential areas.

Air quality impacts associated with constructing the proposed pumping facilities, pipelines, and reservoir would vary. The primary type of air pollution during construction would be combustible pollutants from equipment exhaust and fugitive dust particles from disturbed soils becoming airborne. Any adverse impacts from combustible pollutants and fugitive dust (PM10) would be temporary in nature and minor. The construction activity best management practices would help maintain PM10 emissions compliance with the 24-hour average criterion.

Regarding Black Rock reservoir seepage mitigation features, impacts to air quality would be the same as for construction of the damsite. Mitigation features would be similar to those at the dam, except for paving of roads within the work area because these roads would be graveled.

Long-Term Impacts

Dust and other airborne particulates originating from the drawdown zone of the reservoirs may be a chronic contribution to PM10 levels, particularly at the Black Rock site which is expected to be more susceptible to wind.

Regarding Black Rock reservoir seepage mitigation features, no long-term impacts to air quality are anticipated.

4.17.2.4 Mitigation

Emissions from offroad construction equipment and particulate concentrations are expected to exceed the general conformity *de minimis* thresholds for each year of construction. Therefore, additional mitigation would need to be applied to the emission sources. Such mitigation would include:

- Use of emulsified or aqueous diesel fuel.
- Use of equipment with engines that incorporate exhaust gas recirculation systems.
- Installation of a lean NO_x catalyst in the engine exhaust system.
- Wet suppression and soil stabilization.
- Wind fencing around the active area.
- Paving onsite roadways.
- Truck wheel washing facilities at site exits on public roadways.
- Maintaining minimal truck bed freeboard or covering haul truck beds.
- Compliance with all local, State, and Federal air quality regulations.

4.17.2.5 Cumulative Impacts

All the reasonably foreseeable projects could affect air quality. Each project would be expected to incorporate all feasible mitigation measures recommended by local regulatory agencies in proportion to the severity of the impact to reduce project-specific construction or operation effects.

4.18 Noise

4.18.1 Affected Environment

Noise has long been accepted as a byproduct of urbanization, but only recently has it received much social attention as a potential environmental hazard. Noise generally is defined as unwanted or objectionable sound. Excessive or sustained noise can contribute to both temporary and permanent physical impairments, such as hearing loss and increased fatigue as well as stress, annoyance, anxiety, and other psychological reactions in humans.

4.18.1.1 Noise Measurement Scales

Noise levels are measured on a logarithmic scale because of physical characteristics of sound transmission and reception. Noise energy typically is reported in units of decibels (dB). Noise levels diminish, or attenuate, as distance to the source increases.

Community noise levels typically are measured in terms of the A-weighted decibel (dBA), which measures the noise energy emitted from a noise source. The A-weighted frequency scale correlates noise or sound to the hearing range of the human ear and ranges from 1.0 dBA at the threshold of hearing to 140 dBA at the threshold of pain. Table 4.51 provides examples of common noise levels and their effects on the human ear. Table 4.52 provides the recommended noise levels of various land use types.

Table 4.51 Common noise levels and their effects on the human ear (EPA, 1986)

Source	Decibel level (dBA)	Exposure concern
Soft whisper	30	Normal safe levels.
Quiet office	40	
Average home	50	
Conversational speech	66	
Busy traffic	75	May affect hearing in some individuals depending on sensitivity, exposure length, etc.
Noisy restaurant	80	
Average factory	80–90	
Pneumatic drill	100	Continued exposure to noise over 90 dB eventually may cause hearing impairment.
Automobile horn	120	
Jet plane or gunshot blast	140	Noises at or over 140 dB may cause pain.

Table 4.52 Recommended land use noise levels (Housing and Urban Development [HUD], 1991)

Land use category	Noise Levels (dBA)			
	Clearly acceptable	Normally acceptable	Normally unacceptable	Clearly unacceptable
Residential	< 60	60–65	65–75	> 75
Commercial, retail	< 65	65–75	75–80	> 85
Commercial, wholesale	< 70	70–80	80–85	> 85
Manufacturing	< 55	55–70	70–80	> 80
Agricultural, farming	< 75	> 75	NA	NA
Natural recreation areas	< 60	60–75	75–85	> 85
Schools	< 60	60–65	65–75	> 75
Playgrounds	< 55	55–65	65–75	> 75

4.18.1.2 Current Noise Environment

The study area for noise is defined as the immediate vicinity of the proposed pumping plant locations, the proposed pipeline alignment, and the proposed reservoir locations. These areas include the project construction area as well as nearby agricultural, commercial, industrial, recreational, and residential areas. Currently, existing noise levels are attributable to motor vehicles, industrial and commercial operations, railroad transportation, and agricultural operations.

4.18.1.3 Applicable Laws, Ordinances, Regulations, and Standards

The construction and operation of new facilities under the Joint Alternatives are outside the city limits and their jurisdiction. The sites are not regulated by any county ordinances, regulations or standards. Further, construction activities are excluded from Washington State Department of Ecology noise ordinances (Ecology, 2000).

4.18.1.4 Ambient Noise Levels

Vehicular Noise

The primary noise source in the study area is motor vehicle traffic on highways and major arterials. The interstate highway produces the loudest noise in the area. Other arteries that pass through and adjacent to some of the pipeline alignment also generate moderate noise levels during daytime hours.

Railroad Traffic Noise

Railroad traffic constitutes an occasional but less intrusive element to the noise environment.

Stationary Source Noise

Stationary noise sources in the area include grading and construction activity, power tools, and mechanical equipment, such as heating and air conditioning units, fans, and compressors. Industrial noise in the area includes loading and transfer noise, outdoor warehousing operations, and unscreened commercial and industrial activities.

4.18.2 Environmental Consequences

Noise impacts were derived by identifying features of the various alternatives that would create noise at each of the project sites and by evaluating the sites' proximity to and effect on identified sensitive receptors. Noise impacts from construction, operation, and maintenance of the Joint Alternatives would be localized, most often in remote areas, and temporary in nature. During reservoir construction, use of the area by wildlife would be disrupted.

4.18.2.1 Methods and Assumptions

The degree to which noise affects the human environment depends on the affected area's land use category, the A-weighted decibel of the noise, and the corresponding recommended land use noise levels. This study used the categories, assignments, and acceptability ratings to determine potential impacts in the study area.

4.18.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

The cities of Richland and Kennewick likely would continue to experience population growth and urbanization. Traffic on major highways and arterials would continue to increase and produce additional noise. The current commercial and industrial growth in and around the cities of Kennewick and Richland would also increase localized noise levels.

4.18.2.3 Black Rock Alternative

Construction Impacts

There would be noise during construction; however, the construction areas are localized in remote areas. Wildlife use of the area would be disrupted.

Regarding Black Rock reservoir seepage mitigation features, noise impacts from construction of the cutoff wall would be minimal because it would be located in a remote area.

Long-Term Impacts

The Black Rock pumping plant at Priest Rapids Dam would be located in an unpopulated area with few receptors and an existing background noise level.

Regarding Black Rock reservoir seepage mitigation features, long-term noise impacts would be nonexistent because the pumps at the cutoff wall would be virtually silent and because of the remote location. Animals would become habituated to the noise very quickly and would not be affected.

4.18.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

There would be noise during construction; however, the construction areas are localized in remote areas. Wildlife use of the area would be disrupted.

Long-Term Impacts

The Wymer pumping plant would be located in an area with minimal background noise and frequented by summer recreators. The pumping plant has been designed below ground with low-profile pumps in order to minimize disturbance.

4.18.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

There would be noise during construction, and the construction areas are located in both developed and remote areas. Wildlife use of the area would be disrupted.

Long-Term Impacts

The pumping plants for the Wymer Dam Plus Yakima River Pump Exchange Alternative would be located in an area with existing background noise from highways, railroads, and urban development.

4.18.2.6 Mitigation

The project would comply with all local, State, and Federal noise regulations, and no mitigation would be necessary.

4.18.2.7 Cumulative Impacts

All the reasonably foreseeable projects could affect noise quality. However, all noise impacts are expected to be short term and in compliance with all county noise abatement regulations.

4.19 Visual Resources

4.19.1 Affected Environment

4.19.1.1 No Action Alternative

The No Action Alternative includes conservation-oriented system improvements, including pumping plants and pipelines, at various locations in the Yakima Valley region. These improvements are associated with existing approved programs and oriented predominantly to existing facilities; none are being or would be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis would be required for these actions, appropriate documentation of the directly affected visual environment would be prepared separately, apart from the Storage Study process.

4.19.1.2 Black Rock Alternative

The visual setting for the Black Rock Alternative is characterized by four geographically distinct areas, associated with the major elements of the alternative:

- Priest Rapids Lake and Dam area and downstream Columbia River corridor (proposed location of the intake, fish screen and inflow tunnel portal, and vent facilities and the access road and transmission line serving these facilities)

- The Black Rock Valley and the surrounding area (proposed location of the dam and reservoir)

- Dry Creek Valley, ALE Reserve, and Horn Rapids Park (proposed locations of the reservoir seepage mitigation features)

- Rural/agricultural Yakima County, generally north, east, and south of Moxee City (proposed location of the project outflow and distribution facilities)

Priest Rapids Lake and Dam Area and Downstream Columbia River

The proposed site of the Black Rock intake and fish screen facility and northern inflow tunnel portal is on the southwest shore of Priest Rapids Lake, approximately 0.7 mile upstream and northwest of Priest Rapids Dam. Public views of the site are generally from (1) from SR–243, Orchard Drive, and the small community of Desert Aire to the northeast, at a distance of approximately 2 miles, (2) Dam Road on the approach to Priest Rapids Dam from SR–243, and (3) the lake surface (i.e., while boating on the lake).

From these viewpoints, the visual setting of the facility site is characterized as a narrow, gently sloping, and sparsely vegetated bench of open land along the southwest lakeshore with steeply rising mountains as a backdrop. The site is part of a broad vista, undeveloped except for the Priest Rapids hydroelectric project facilities to the south. Within this vista, with the exception of the more proximate views available to boaters and those approaching the dam, the site is seen from across the lake and at a distance with desert scrubland or agricultural fields along the northeast shore of the lake in the foreground.

The vent shaft site required along the inflow tunnel alignment would be located approximately ¾ mile beyond, and in the mountains that represent the backdrop to, the intake and fish screen facility. If this site is visible to the public (uncertain given the small size and low height of the facility, the absence of specific site location data, and the steep/rough nature of the terrain), the viewpoints would be the same as those described above for the intake and fish screen facility.

The access road and transmission line serving the intake and fish screen facility would be sited on the south side of the Columbia River west of SR–24. The primary views of the corridor through which these facilities would be routed are (1) from SR–243, at distances ranging from 0.8–2 miles and (2) the Wanapum Village south of Priest Rapids Dam with the corridor immediately adjacent. The visual setting of the corridor from SR–243 viewpoints consists of a steep mountain backdrop with a combination of river shore, river channel, and open desert scrubland in fore- and middle-ground. Several instances of irrigated agriculture and existing power system facilities (e.g., transmission lines and the BPA Midway Substations) also are present in middle-ground views. The setting from viewpoints in the Wanapum Village includes the proposed road and transmission line corridor in the immediate foreground with a steep mountain backdrop rising from as close as 1,000 feet beyond.

Black Rock Valley

The Black Rock Valley, where Black Rock dam, reservoir, and associated facilities (including recreation) would be located, is a broad, east-west oriented desert valley. It is characterized predominantly by an open scrubland/grassland valley floor flanked by basalt mountains and hills along the northern and southern margins. With the exception of SR–24, which traverses the center of the valley, and a few farms/ranches in the west, the setting provides a perceived “natural” landscape with a relatively limited-built environment.

Public views of the Black Rock Valley are predominantly from SR–24. All other access within the valley is via unpaved roads, typically used by the few residents and other landowners.

Externally, the eastern end of the valley (proposed location of Black Rock dam) is visible from farms and ranches in the Dry Creek Valley to the southeast and from a roadside café and residence immediately to the east.

Dry Creek Valley, ALE Reserve, and Horn Rapids Park

The Dry Creek Valley, downstream from the proposed Black Rock dam, would be the site of the pole-mounted powerline connecting the BPA substation with the proposed dewatering wells in the ALE Reserve. The area in which the powerline would be located is private land, generally not accessible or visible to the public. Only one private residence, associated with a farming operation in this otherwise undeveloped desert valley, is located near (i.e., within 1–2 miles of) potential powerline routes.

The ALE Reserve would be the site of most above-ground (i.e., visible) elements of the seepage mitigation features, including the embankment, pipeline intake structure, and dewatering wells. Most of the buried pipeline associated with seepage mitigation also would be located within the ALE Reserve.

The ALE Reserve is visible to the public primarily from SR–240, which forms its east/northeast boundary, and from Horn Road along its southern boundary (the ALE Reserve itself is closed to public access). No significant residential, recreational, or other developed land uses are present in the area surrounding the ALE Reserve. From the SR–240 and Horn Road corridors, the visual setting of the ALE Reserve is characterized by wide vistas comprised of native shrub-steppe habitat along stream valleys and on hillsides, rising to a dramatic mountain backdrop. Most of the ALE Reserve is undisturbed with little or no sign of human activity beyond isolated unpaved roads. However, due to conditions resulting from a major wildfire, the managing agency (U.S. Fish and Wildlife Service) has installed erosion control/soil stabilization fences in some areas; these fences, many of which are orange in color, are highly visible and inconsistent with the generally natural character of the ALE Reserve landscape.

Horn Rapids Park would be the site of the southernmost half-mile of the buried pipeline and the outlet facility to the Yakima River. These facilities would be located downstream (east) from the developed facilities within the park with the outlet sited along a steeply sloping (near vertical) stretch of the Yakima River's north bank. Neither the exact alignment of the pipeline nor the site of the outlet facility has been determined. However, in general, public views of the pipeline route are only from Horn Road. Views of the river bank along which the outlet would be constructed are limited to large-acreage residential properties across the river to the south, the surface of the river itself in the immediate vicinity, vegetation along the river bank, and potentially the developed area of the park (although much of the northern river shore in question is not visible from the developed facilities within the park due to undulations in the river's course).

Overall, the visual character of pipeline route in the park is undeveloped, open land. The character of the area in which the outlet would be located is dominated by the river and adjacent river shore environments, which range from undeveloped to sparsely developed in residential and recreational uses with views limited in extent due to the incised and undulating nature of the river corridor.

Rural/Agricultural Yakima County

The setting of the proposed outlet and distribution facilities/systems of the Black Rock Alternative is characterized largely by irrigated agriculture and other large lot rural development (e.g., rural residential). Local agriculture includes a mixture of orchards, vineyards, and row/field crops. Agricultural infrastructure (canals and appurtenant facilities) is strongly in evidence. Structures are generally residential and farm-oriented.

Public viewpoints from which the locations of Black Rock facilities would be visible are generally along the local road system, especially SR–24 and Konnowac Pass Road. Facility sites and alignments would also be visible from numerous private residences in the area.

4.19.1.3 Wymer Dam and Reservoir Alternative

From a visual resources standpoint, the affected environment for the Wymer Dam and Reservoir Alternative is primarily the Yakima River Canyon, along SR–821, north of Selah and south of Ellensburg. It is only within the Yakima River Canyon where facilities associated with this alternative would be visible to the public. While the dam and reservoir would be located in the Lmuma Creek basin (tributary to the Yakima River Canyon to the east), that entire basin is privately owned with no public access, no existing residents, and very limited public viewpoints from surrounding areas. The only other location from which portions of this alternative would be seen is I–82, where the narrow, easternmost arm of the reservoir pool would be crossed by the highway and would be visible to motorists.

The Yakima River Canyon is generally narrow and meandering with the Yakima River corridor dominating the canyon bottom and steep-to-gently-rolling basalt hills rising high on both sides. Much of the canyon is undeveloped, presenting a natural desert canyon landscape with riparian vegetation along the river and low-growing scrubland/grassland on the hillsides. Evidence of human development is present, however, including Roza Diversion Dam and associated infrastructure, instances of irrigated agriculture (with associated residences and other buildings), and canyon-oriented recreational sites and businesses (for example, a river rafting company) where the canyon widens. SR–821 through the canyon is designated a State Scenic Byway and BLM Scenic and Recreational Highway.

Public viewpoints in the canyon are from the highway and the river (i.e., rafters and kayakers).

4.19.1.4 Wymer Dam Plus Yakima River Pump Exchange Alternative

The affected environment of the Wymer dam component of this alternative is presented in section 4.19.1.3, "Wymer Dam and Reservoir Alternative." The following discussion focuses on the visual setting for the Yakima River pump exchange component of this alternative.

The visual setting of the 56 miles of underground pipeline and three pumping plants comprising the Yakima River pump exchange component of this alternative is characterized by two broad landscape categories:

- Urban/suburban environments of Richland and West Richland
- Open and agricultural landscapes in rural Benton and Yakima Counties, north of I–82, between West Richland and Sunnyside

Urban/Suburban Richland and West Richland

The visual setting in Richland and West Richland is typical of small- to moderate-sized cities. The "cityscapes" where pump exchange facilities would be located include residential developments of varying densities, commercial sites and complexes, limited industrial development, and associated infrastructure (e.g., road systems, utility lines). Where the pipeline would be routed through this setting, public views of the facility corridor are generally short-range from adjacent roadways, residences, and businesses.

The intake and pumping plant #1 facilities of this alternative would be located along the Columbia River shore in a partially developed, flatland linear park between the river to the north and SR–240 to the south. The area immediately west of the facility site is undeveloped with commercial development occurring ¼ to ½ mile further west. The area east of the facility site is currently developed park with a campground. Public views of the facility site are from SR–240 along the southern site boundary from the river and West Pasco to the north and from within the shoreline park.

Rural Benton and Yakima Counties

West of the Richland/West Richland, the landscape through which the pump exchange pipeline would be routed and within which pumping plants #2 and #3 would be sited is characterized largely by irrigated agriculture and other large lot rural development (e.g., rural residential). The agriculture is a mixture of orchards, vineyards, and row/field crops. Agricultural infrastructure (canals and appurtenant facilities) is strongly in evidence. Structures are generally residential and farm-oriented. Limited instances of open desert hillsides also occur along the pipeline route in Benton County.

Public viewpoints from which the pipeline route and the sites of the pumping plants would be seen are the local roads, residences, and farms along the facility corridor. Relevant views in this setting generally are dominated by surrounding agriculture, often with open hillsides as a backdrop.

4.19.2 Environmental Consequences

4.19.2.1 Methods and Assumptions

Visual resources impact analysis focuses on (1) the extent to which facilities and actions of the alternatives would result in a long-term change in the visual character of landscapes/locations in which they would be located (e.g., landscape form, line, color, and/or texture) and (2) the extent to which these changes would be visible to/experienced by the general public or existing residents.

For the purpose of this Final PR/EIS, the primary visual resources indicator is a distinct, fundamental, and/or widespread change in the visual character of the subject landscape with this change visible to the general public or local residents. Significant visual quality effects can be either positive (e.g., restoration of a damaged natural landscape) or adverse (e.g., major introduction of contrasting, developed facilities in an otherwise natural landscape). This analysis focuses on identifying the potential for significant adverse visual resources impacts.

4.19.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

As noted previously, conservation-related system improvements associated with the No Action Alternative are part of other approved programs and orient predominantly to existing facilities; none are being or would be constructed under the auspices of the Storage Study. To the extent that NEPA or SEPA analysis would be required for these actions, appropriate documentation of visual impacts would be prepared separately, apart from the Storage Study process.

4.19.2.3 Black Rock Alternative

Construction Impacts

No construction-related impacts to visual resources are anticipated under this alternative.

Long-Term Impacts

Priest Rapids Lake and Dam Area and Downstream Columbia River.—
Development of the intake and fish screen facility and northern inflow tunnel

portal along the southwest shore of Priest Rapids Lake would introduce a substantial new industrial facility in the context of the existing Priest Rapids Dam hydroelectric project. Development would include a large pumping plant structure 56 feet high and an electric switchyard complex with towers up to 104 feet high. Although these facilities would be visibly separate from the existing Priest Rapids hydroelectric facilities, they would be consistent in character with the existing development. Considering this similarity in appearance with existing structures and the fact that the overall complex of facilities would be viewed predominantly from 2 miles or more away (e.g., the SR–243 corridor), the overall long-term visual resources impact is not expected to be significant.

Substantial amounts of waste may be left after construction of the tunnel and pumping plant. Depending on the economics of hauling this waste and the construction methods used, there may be a need to deposit the tunnel material along the hillside above the pumping plant. If the tunnel construction is started from the reservoir side, the waste could be used in construction of the dam. Any waste would be blended into the topography as much as possible and vegetation planted to blend in with the existing vegetation. There should be very little visual impact from this waste material.

As noted in discussion of the affected environment, it is uncertain whether the vent shaft along the inflow tunnel alignment beyond the intake and fish screen facility would be visible from public viewpoints. Thus, the potential for visual impact from this facility cannot be determined.

With one exception, development of the access road and transmission line serving the intake and fish screen facility would not represent a significant visual impact. For the most part (i.e., from SR–243 viewpoints), the new facilities would be introduced into a visual environment already containing several similar facilities. The exception to this would be at the location of the Wanapum Village. While this village is located in a setting containing hydroelectric facilities, including existing roads and transmission lines, the new, large transmission line (500 kV) would be placed immediately adjacent to the village and would intervene between village residences and the nearby mountain face. This impact would be locally significant.

Black Rock Valley.—Introduction of Black Rock dam and reservoir would affect significantly and irrevocably the visual character of the Black Rock Valley. Within the valley itself and along the rerouted SR–24 in the hills south of the valley floor ("Transportation"), the landscape would change from one dominated by open desert scrub/range land to one dominated by a working reservoir. This change would be perceived as either neutral or positive by some and as adverse by others. The degree of positive versus negative viewer reaction likely would vary by perceived opportunity (e.g., access for various types of recreation and similar pursuits), as well as by season, as the reservoir is drawn down (revealing large expanses of barren mudflats) and refilled.

External to the Black Rock Valley, construction of Black Rock dam would have a significant adverse impact on the visual environment from viewpoints immediately east of the dam (i.e., the café and residence); the view westward from these viewpoints would change from an open valley landscape to the face of the dam and associated outlet works. A limited number of existing farm residents in the Dry Creek Valley to the southeast would also see the dam as a significant new feature in the local visual environment.

Dry Creek Valley, ALE Reserve, and Horn Rapids Park.—The proposed powerline from the BPA substation to the dewatering wells in the ALE Reserve would not be visible to the public; the private owner of the farming operation 1–2 miles south/southwest of the substation may or may not have a view of this line, depending on the route selected. In any case, the proposed line would be a pole-mounted facility, small, and relatively inconspicuous in comparison with the high-voltage transmission line structures associated with the existing substation.

Within the ALE Reserve, most, if not all, above-ground seepage mitigation features would not be visible from any public viewpoint due to topography and, thus, would not result in adverse visual impacts. The site of the embankment, intake facility, and dewatering wells is not visible from SR–240 or from any surrounding private lands.

Much of the approximately 20.6 miles of pipeline route within the ALE Reserve and Horn Rapids Park would be visible from SR–240 and/or Horn Road. Ground disturbance along the pipeline corridor is expected to be approximately 150 feet wide. However, restoration of native vegetation is proposed along this corridor, thus eliminating any significant long-term visual impact.

At Horn Rapids Park, the outlet facility would represent an industrial installation introduced in an otherwise sparsely developed (undeveloped in some locations) river corridor. The visual impact of the new facility generally would be perceived as adverse to the three to four residences along the south shore across from the facility site, boaters on the river, and potential recreation users in the developed area of the park.

Rural/Agricultural Yakima County.—Most of the outlet and distribution facilities of the Black Rock Alternative would be underground pipelines with the only surface manifestation being management of land use and land cover within the associated easement or right-of-way. Management of the easement/right-of-way corridor would include prohibition of permanent structures, but landscape plantings, agriculture in some form, and/or restored natural vegetation (as appropriate to the environment along the route) would characterize the corridor after construction. Given the open, agricultural and otherwise sparsely developed character of the landscape through which these pipelines would be routed, their long-term visual impact would be minimal.

Exceptions to the above are the Black Rock outlet and powerplant and the Sunnyside powerplant and bypass facilities. Both of these facilities would be industrial in character, involving relatively large structures, an electrical switchyard, other work yards, and a new electric transmission line serving the facility site.

Structures at the Black Rock outlet and powerplant facility would include a building up to 45 feet high and switchyard towers up to 104 feet high. The overall site would be fenced (7-foot chain link). Power to the facility is expected to be provided via a new wood pole transmission line from the existing Roza powerplant switchyard.

At the Sunnyside powerplant and bypass site, structures would include buildings 18 and 35 feet high and switchyard towers up to 104 feet high. The overall site would be fenced (7-foot chain link). Power to the facility is expected to be provided via a new wood pole transmission line from an existing BPA line 1 mile to the southwest.

The visual impact of these facilities may be significant on a local scale (i.e., to existing residents in the immediate vicinity of the sites and along the transmission line routes). At this scale, the facilities would be generally out of character with the rural, agricultural, residential nature of the local areas and could interfere with view corridors or vistas from local residences.

Outside of this local perspective, however, major structures/facility sites would all be located along existing major roads in a broader environment containing numerous other examples of similar infrastructure associated with irrigated agriculture and power transmission; in this context, the long-term visual impact would not be significant.

4.19.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction-related impacts to visual resources are anticipated under this alternative.

Long-Term Impacts

Construction of the pumping plant, power system (switchyard and transmission line), air chamber, and other facilities, as well as the outlet channel, would introduce substantial new manmade facilities/features in the predominantly undeveloped Yakima River Canyon. The most prominent of the facilities would include the pumping plant (39 feet high) and the switchyard (which would include 80-foot-high towers). These facilities would be on a site currently in irrigated (center-pivot system) agriculture between SR–821 and the river. The outlet channel from the dam would be a constructed/engineered conveyance with several drop structures, replacing the existing Lmuma Creek channel and crossing under SR–821 to the Yakima River.

These facilities, at least prior to mitigation, would represent a significant visual impact in the context of the largely undeveloped, scenic Yakima River Canyon corridor. While the new facilities may be somewhat similar in character to those at Roza Diversion Dam (located 5 miles to the south) and not unlike the buildings and outdoor equipment storage of the river boating business 1 mile to the north, they would be more prominent, visible, and concentrated.

Related to the dam and reservoir, the top of Wymer Dam would be visible to motorists along an approximately ½-mile-stretch of SR–821; the saddle dikes north of the dam would not be visible from the highway. The view of the dam would be fleeting (available for less than a minute) and only would be noticed if motorists look eastward up Lmuma Creek immediately opposite the site of the pumping plant complex. Nonetheless, this visibility of the dam would add to the significance of impact from this alternative on the Yakima River Canyon corridor.

Other relevant perspectives on potential visual impacts of this alternative include the following:

- The import conveyance of the Wymer Dam and Reservoir Alternative would be underground between the dam and pumping plant and, thus, would not affect the visual environment.

- Where I–82 crosses the easternmost arm of the reservoir, motorists would see the reservoir at high water for a matter of seconds. When reservoir storage is being used, this view would be of the drawdown zone. Overall, this change from an intermittent drainage channel to the narrow upper arm of an active reservoir would not be significant.

4.19.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction-related impacts to visual resources are anticipated under this alternative.

Long-Term Impacts

Environmental consequences of the Wymer dam component of this alternative are the same as for the Wymer Dam and Reservoir Alternative. The following discussion focuses on the Yakima River pump exchange component of this alternative.

With the exception of the three pumping plant sites and the transmission lines associated with them, this alternative is comprised of underground pipelines; the only surface manifestation would be a managed corridor of land along the easement or right-of-way. Management of the easement/right-of-way corridor would include prohibition of permanent structures, but landscape plantings, agriculture in some form, and/or restored natural vegetation (as appropriate to the environment along the route) would characterize the corridor after construction. Given the open, agricultural, and otherwise sparsely developed character of the landscape through which these pipelines would be routed, their long-term visual impact would be minimal.

At the sites of each of the three pumping plants, a new industrial facility would be introduced. In the generally urban environment of Richland where pumping plant #1 would be located, this addition to the visual environment would not be significant, except for users of the shoreline park immediate adjacent (both existing and planned). See section 4.13, "Land Use and Shoreline Resources."

Pumping plants #2 and #3, however, would be located in agricultural settings and, without mitigation, would represent significant visual impact to their local surroundings. The facilities each would involve relatively large structures, an electrical switchyard, air chambers, an overflow reservoir, and a new electric transmission line.

At pumping plant #2, facilities would include 20- and 40-foot-high buildings, 80-foot-high switchyard towers, and six 40-foot-high air chambers. Overall site size would be 53 acres, with 16 acres used for the facilities and 37 acres used for the overflow reservoir. A new 1.5-mile, 230-kV transmission line also would be needed.

At pumping plant #3, facilities would be somewhat smaller, with 20- and 40-foot-high buildings, 50-foot-high towers in the switchyard, and 25-foot-high air chambers. Site size would be 40 acres, with 12 acres used for the above facilities and 28 acres used for the overflow reservoir. Three miles of new 115-kV transmission line would be needed.

4.19.2.6 Mitigation

Black Rock Alternative

Available mitigation for visual impacts of Black Rock facilities focuses on (1) architectural treatments and landscape screening at the intake and fish screen, Yakima River outlet of the seepage mitigation features, Black Rock outlet/powerplant and Sunnyside powerplant/bypass facilities, (2) sensitive routing of necessary transmission lines, and (3) vegetation restoration and management in the pipeline and transmission line easements/right-of-way.

Selection of structural materials with colors that blend with the surrounding environment and planting of appropriate landscape screening could reduce substantially the contrast of the facilities with the surrounding landscape. Such measures, in some cases, could reduce long-term visual impacts to an insignificant level. The same mitigation measures also may be applicable to outlet works and other appurtenant facilities at Black Rock dam.

In some cases (e.g., the powerline necessary as part of the seepage mitigation program), there may be considerable flexibility in selection of the most appropriate routes. Reduction or elimination of visual impacts (i.e., avoiding introduction of the facilities into areas where comparable facilities do not yet exist and/or minimizing visibility from public viewpoints) should be a factor in selecting these routes.

In the pipeline and transmission line easements/right-of-way, restoration and long-term maintenance of vegetation consistent with the surrounding environment would serve to minimize adverse visual impact.

However, some visual impacts associated with this alternative are not subject to mitigation. Most significantly, the impact of Black Rock dam and reservoir on the Black Rock Valley and the impact of Black Rock dam on viewpoints from the east and southeast are not mitigable. It is also unlikely that any meaningful mitigation is available for the visual impact of the required 500-kV transmission line on the Wanapum Village near Priest Rapids Dam.

Wymer Dam and Reservoir Alternative

Available mitigation for visual impacts of the Wymer Dam and Reservoir Alternative focuses on architectural treatment and landscape screening at the pumping plant facility complex and potential for landscape screening along the outlet channel. Selection of building/structure exterior color(s) that blend with the surrounding environment and planting of appropriate landscape screening could reduce substantially the contrast of the facility with the surrounding landscape. It is uncertain whether such measures could reduce the level of visual impact overall to an insignificant level.

Wymer Dam Plus Yakima River Pump Exchange Alternative

As with similar facilities associated with the Black Rock and Wymer Dam and Reservoir Alternatives, available mitigation would focus on architectural treatments and landscape screening at the pumping plant facility sites. Dependent of the proximity of proposed facilities to existing residences and the effectiveness of mitigation measures, impacts could be reduced to insignificant levels (i.e., if new facilities are not close to existing residences and do not block important vistas or sight lines and if screening is implemented that provides sufficient height and density).

In the pipeline and transmission line easements/right-of-way, restoration and long-term maintenance of vegetation consistent with the surrounding environment would serve to minimize adverse visual impact.

4.19.2.7 Cumulative Impacts

Appurtenant facilities of the Black Rock Alternative would add cumulatively to the number of industrial/infrastructure facilities present in the context of rural environments. In the area of the intake facilities near Priest Rapids Dam, this change primarily would be an addition to already existing facilities and uses (i.e., no other, similar facilities are planned). In the area of the outlet and distribution facilities (rural Yakima County), it can be expected that continuing urban development would also bring instances of this type of development over time.

For the Wymer Dam and Reservoir Alternative, the appurtenant facilities (pumping plant, switchyard, etc.) would add cumulatively to the number of industrial/commercial elements present in the primarily natural, undeveloped visual context of the Yakima River Canyon. This cumulative visual impact would be in relation to existing developed facilities such as Roza Diversion Dam and commercial recreation businesses; no additional, similar types of development are known to be planned within the Yakima River Canyon.

For the Wymer Dam Plus Yakima River Pump Exchange Alternative, pumping plants #2 and #3 would represent incremental/cumulative additions to the number of industrial/infrastructure facilities present in the context of rural environments in Benton and Yakima Counties. This change primarily would be an addition to already existing facilities and uses (i.e., no other similar facilities are known to be planned in the locally affected environment).

4.20 Historic Properties

The legislative and regulatory basis for the identification, evaluation, protection, and management of historic resources in Federal undertakings is based on the National Historic Preservation Act of 1966, as amended, and its implementing regulations at 36 CFR 800. Historic resources—also known as cultural resources—include districts, buildings, sites, structures, or objects possessing historical, architectural, archeological, cultural, traditional, or scientific significance to broad themes in American history and culture. American Indian Tribal and cultural history is an important component of historic resources.

NHPA requires that Federal agencies complete field inventories and evaluations to identify sites or properties that may be eligible for listing in the *National Register of Historic Places* (*National Register*) and then ensure that those resources “are not inadvertently transferred, sold, demolished, substantially altered, or allowed to deteriorate significantly.” Historic resources that meet

National Register criteria are referred to as "Historic Properties." Further, the regulations at 36 CFR 800 define a consultation process for ensuring compliance with NHPA. The consultative parties include the State Historic Preservation Officer (SHPO), the President's Advisory Council on Historic Preservation (ACHP), and Tribal governments with cultural and legal interests in the area of the undertaking.

4.20.1 Affected Environment

The following discussion pertains to all of the Joint Alternatives.

Relevant to understanding the human history and land use in the Yakima River basin is the federally recognized Yakama Nation, which consists of 14 Tribes and Bands that were combined socially and politically following the Walla Walla Treaty of June 9, 1855. The areas covered by all Joint Alternatives are in the territory ceded in the 1855 Treaty. The Yakama Nation governing Tribal Council, located at the Yakama Nation Reservation headquarters at Toppenish, speaks for and manages the interests of the constituent 14 Tribes and Bands.

At least as early as 8,000 years ago, the ancestral inhabitants of today's Yakama Nation, Confederated Tribes of the Colville Reservation, Confederated Tribes of the Umatilla Reservation, and the Wanapum Band developed a thriving native economy based on the natural richness and bounty of the Columbia Plateau. In precontact times, the Yakama and neighboring groups consisted of small, politically autonomous, yet closely related, bands, which lived in permanent winter villages located on major watercourses. The villages were essentially autonomous, although each group as a whole shared a common culture, maintained intervillage kinship ties, shared subsistence resources, and were engaged in frequent social interaction with one another.

Historians and anthropologists suggest that the traditional arrangement of autonomous villages was altered to a certain degree with the introduction of the horse in the 1700s (possibly earlier), which gave the people greater ability to access more distant resources and interact with more distant groups. These more distant contacts included encounters with people living in the Plains region. As a result of this interaction with Plains groups, some anthropologists believe the Yakama and related peoples adapted tipis, Plains clothing styles, and a Plains-like pattern of social organization by establishing a war chief and an incipient Tribal framework in which villages became more closely aligned. However, that view is not widely shared on the Yakama Reservation. It is nevertheless clear that the introduction of the horse created greater opportunities for cultural change and adaptations thoughout the range in which it was adopted.

Settlement centered on winter villages located in sheltered areas along the shores of rivers. The largest of these villages among the Kittitas and Yakama could have as many as 500 residents housed in circular-shaped houses with conical roofs.

About 2,000 people typically inhabited one village of the Lower Yakima, known as tsíkik 'spring.' From these villages, subsistence forays extended into the surrounding areas to fish, gather, and hunt. The foods processed from these subsistence activities were stored at the villages for the winter. In addition to residential structures, villages also contained menstrual huts, sweat huts, food caches, and burial grounds.

The proposed locations of the Joint Alternatives are situated in areas where there is a high potential for both historic and prehistoric resources. A records and literature review was conducted for lands associated with each of the Joint Alternatives. A 1-mile radius study area around both the proposed Black Rock and Wymer reservoirs and along the alignments for the tunnels and pipelines associated with them and a ½-mile corridor study area along the pipeline route for the Wymer Dam Plus Yakima River Pump Exchange Alternative were used for this review. As a result of this review, a total of 102 cultural resources have been identified and recorded, of which 76 are prehistoric, 26 are historic, and 1 is a site with both prehistoric and historic components. Among these, only five resources have been determined eligible for NRHP listing: a historic structure known as the Mattoon Cabin (45YA360) and a historic structure known as the Sawyer Mansion (45YA361), both located within the ½-mile study corridor for the Yakima River pump exchange pipeline boundaries; two precontact lithic material sites (45YA91 and 45YA94) located within the study area along the Black Rock reservoir outflow tunnel; and one precontact feature (45YA96), also located in the study area along the Black Rock reservoir outflow tunnel. In addition to the previously recorded archaeological sites, one archaeological district (Tri-Cities Archaeological District) transects the ½-mile study area along the Yakima River pump exchange pipeline corridor. This district is National and State Register listed and contains a combined 30 historic and prehistoric sites. One of these sites, 45BN52, is located within the ½-mile study area used for the Yakima River pump exchange pipeline corridor.

While there are only five resources that have been determined eligible for listing in the NRHP, the eligibility status of the majority of cultural resources (97 totals) has not been determined. These sites include 11 precontact camp sites, 37 precontact lithic material sites, 2 precontact burial sites, 10 precontact isolates, 1 precontact feature site, 3 precontact cairn sites, 6 precontact talus pit sites, 1 precontact house pit/depression site, 2 precontact petroglyph sites, 7 historic objects sites, 2 historic hydroelectric sites, 1 historic agriculture site, 8 historic refuse scatter/dump sites, 1 historic bridge site, 2 historic structure sites, 1 historic homestead site, 1 historic isolate, and 1 historic agriculture/lithic material site.

Given the abundance of previously recorded resources within the area, the construction of the proposed reservoirs and pipelines potentially could affect significant archaeological sites. This is most apparent in the study area along the Black Rock reservoir inflow tunnel alignment, where there are 42 previously recorded historic and prehistoric resources within an area of 11,345.75 acres.

This is in sharp contrast to the study area along the Yakima River pump exchange pipeline corridor, which encompasses a total area of 24,335.46 acres and contains a combined seven prehistoric and historic resources in addition to an archaeological district.

The limited records and known historic resources inventory for the Joint Alternatives indicate that there is a high potential for historic resources. The individual size of each of the Joint Alternatives and associated impacts, the relationship of these alternatives to the Columbia and Yakima Rivers and Indian ceded lands, the Holocene geomorphology, and the high site density in nearby locales are indicators of a high level of complexity in the cultural and historic resources. In addition, these factors predispose either alternative to a high level of interest and scrutiny from Indian Tribes, State, and Federal partners and reviewers, the professional historic preservation community, and the public.

4.20.2 Environmental Consequences

4.20.2.1 Methods and Assumptions

Methods to identify and evaluate historic resources include Class I inventories and Class III field surveys. The Class I inventory is a planning tool that involves a literature review and development of a low-level probability model for the occurrence of different kinds of sites and resources. The Class III survey is a complete field survey of project lands to identify unrecorded sites and resources.

The Class I inventory suggests that there are varieties of such resources in lands that would be affected under the Joint Alternatives; these resources span the long time depth of human occupation in the Columbia Plateau.

The Class III survey, which identifies historic resources and related discoveries, will occur after an alternative is selected and an area of potential effect (APE) can be defined. Class III surveys must await identification of a preferred alternative because Class III survey is predicated on the premise that a range of historic resources will be encountered, some of which will require additional investigations to evaluate their significance. Of those evaluated, a subset will be determined significant and eligible for the *National Register*. These eligible sites will require mitigation, which will be determined through consultation with Washington State Department of Archaeology and Historic Preservation (DAHP) and American Indian Tribes.

4.20.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

There would be no long-term impacts on historic properties under the No Action Alternative.

4.20.2.3 Joint Alternatives

Construction Impacts

Impacts to historic resources are, by their nature, not short-term or transitory. Once adversely impacted by construction activities, an historic resource cannot be returned to its preconstruction condition. As a result, all potential impacts to historic resources are long-term in nature and are discussed in the following section.

Long-Term Impacts

A Class III survey to identify historic resources in lands involved in any of the Joint Alternatives would occur only if one of them were selected; therefore, the numbers and kinds of historic resources are not yet known. At the current stage of project development, the assumption is that historic resources would be identified through a Class III survey, and some would require additional investigations to determine eligibility to the *National Register*. Further, some of these investigated resources would be determined eligible, and a round of consultations would proceed to develop mitigation measures.

4.20.2.4 Mitigation

Mitigation of historic resources is data recovery or archeological excavation, preservation, conservation, and interpretation of significant historic properties from direct and indirect impacts from a construction project. Specific mitigation measures cannot be developed and implemented until after a preferred alternative has been selected, and a Class III field survey has been conducted and reported; the Class III survey for any of the Joint Alternatives reasonably can be estimated to take at least 1 year.

A typical scenario for mitigation of a group of historic resources would be as follows:

- Identify the significant historic properties that cannot be avoided during project construction and development.
- Consult with the SHPO, ACHP, American Indian Tribes, other Federal agencies, and public entities on historic properties that are eligible for the NRHP.
- Depending on the number and range of historic properties to be treated through mitigation, develop either a Programmatic Memorandum of Agreement (PMOA) or Memorandum of Agreement (MOA) among

Reclamation, SHPO, and ACHP over mitigation measures. PMOA or MOA signatories may also include Tribes, other Federal agencies, and public entities.

- The MOA will include a research and data recovery plan, stipulations for permanent storage and curation of recovered material, and provisions for sharing the results of the data recovery phase with the public (e.g., interpretive facilities). The goal is to identify and implement a range of measures to record and preserve, in some manner, the record of historic resources affected by the project. Mitigation of historic properties can involve data recovery, large-scale archeological excavations, a program of monitoring of project effects, development of interpretive facilities and public educational opportunities, or a mix of those measures.

- The MOA may also include development of treatment plans in which goals for long-term historic properties management and monitoring are identified.

- The period for developing, implementing, and completing mitigation measures could take an estimated 2 years for any of the Joint Alternatives. However, certain activities could last for many years, if not decades, beyond completion of the alternative. Museum storage and curation costs, monitoring activities, and management of historic resources in the development footprint not impacted directly by project construction are examples of some common, long-term activities which have attendant costs.

4.20.2.5 Cumulative Impacts

The assumption is that historic resources would experience unavoidable physical effects under implementation of any of the Joint Alternatives. These effects cannot be quantified until a Class III survey is conducted. Nevertheless, some general statements can be made that suggest cumulative effects to historic resources could be severe, particularly with respect to the Black Rock and Wymer Dam and Reservoir Alternatives, and less so in the case of the Yakima River pump exchange component of the Wymer Dam Plus Yakima River Pump Exchange Alternative.

Historic resources, as records of an array of human culture and knowledge at different points in time, are nonrenewable. Consequently, it is axiomatic that once a historic property is gone, another one cannot be grown to take its place. Even though the aim of archeological investigations is to be able to re-create a site or historic property in the laboratory, it is also desirable to preserve a portion of the site for the future when advances in analytical methods and techniques may yield additional significant knowledge. For example, archeological sites contain evidence of environmental and climatic change, some of which is at a molecular level, the understanding of which depends on analytical tools that are not widely available or adapted to archeological applications yet.

4.21 Indian Sacred Sites

4.21.1 Affected Environment

See section 4.20, "Historic Properties," for a discussion of the affected environment of Indian sacred sites.

4.21.2 Environmental Consequences

4.21.2.1 Methods and Assumptions

Executive Order (EO) 13007, signed by President Clinton on May 24, 1996, instructs Federal land managers to accommodate access to, and protect the physical integrity of, sites of religious and spiritual significance to American Indians. The intent of EO 13007 is to memorialize the protection of the religious freedom of all American citizens. The sites subject to EO 13007 are those that are recognized by an American Indian Tribe through its government as a religious site, in contrast to sites significant to an individual. EO 13007 leaves open the method to learn if access to sacred sites will be impaired, except that knowledge of such sites should come from authoritative sources, such as from, or on behalf of, a Tribal Government. The Storage Study team chose to ask the Yakama Nation through stipulations in an interagency agreement for a spectrum of resource information bearing on the lands affected by the Storage Study, including cultural, traditional, and sacred sites.

Because the Joint Alternatives all lie in Yakama-ceded lands, the Storage Study team assumed sacred sites exist because of the land use history. The Storage Study team has been informed by the Yakama Nation Cultural Resources Program that sacred sites are known; however, identification and location are, at present, knowledge reserved by the Tribe. Whether access to, or physical integrity of, sacred sites would be affected by development of any Joint Alternatives is not known. EO 13007 directs Federal agencies to accommodate access to sacred sites in project planning through a good faith effort to learn of sites locations.

4.21.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

Official Tribal sources advise that sacred sites exist, although their locations and numbers have not been disclosed. If the No Action Alternative is selected, access to, and physical integrity of, sacred sites could, in the abstract, be adversely affected. However, the lands in question would remain privately owned; therefore, EO 13007, which applies to Federal land, would afford no protection.

4.21.2.3 Black Rock Alternative

The presence of sacred sites in the Black Rock reservoir site has not been disclosed at this time.

4.21.2.4 Wymer Dam and Reservoir Alternative

The presence of sacred sites in the Wymer reservoir site has not been disclosed at this time.

4.21.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

The presence of sacred sites in lands affected by this alternative has not been disclosed at this time.

4.21.2.6 Mitigation

Mitigation to offset project impacts to access to sacred sites has few precedents or standard treatments. Any focus on American Indian sacred sites is complicated by the very nature of the discussion, which is perceived by some, if not most, American Indian Tribes as outside the greater public sphere. EO 13007 allows Government-to-Government consultation between a Federal agency and the affected Tribes, which will occur if mitigation in this particular category is at issue if one of the Joint Alternatives is selected.

4.21.2.7 Cumulative Impacts

The cumulative impacts depend on knowledge of Indian sacred sites within the footprints of the Joint Alternatives, and if access would also be affected. Preliminary information confirms sites exist, particularly in the Black Rock and Wymer Dam and Reservoir Alternatives. However, affected Tribal Governments have chosen not to disclose site-specific information.

Assuming that sacred sites are identified, addressing cumulative effects also depends on an understanding of each site in relationship to its religious and cultural context. For example, loss of access to a site significant to Tribal members would obviously evoke a sense of loss. In the case where a sacred site is involved which obtains significance as a member of a network of sacred sites, loss of access conceivably has an even greater effect.

In some circumstances, access to sacred sites may not be impeded by development of one of the Joint Alternatives; however, the altered landscape can conceivably diminish the "sacredness" of the site in question.

4.22 Indian Trust Assets

Indian trust assets (ITA) are legal interests in property held in trust by the United States for Indian Tribes or individuals. Examples of trust assets are lands, minerals, hunting and fishing rights, and water rights. The United States has a trust responsibility to protect and maintain rights reserved by or granted to Indian Tribes or Indian individuals by treaties, statutes, and Executive orders, which sometimes are further interpreted through court decisions and regulations. This trust responsibility requires Reclamation to take all actions reasonably necessary to protect trust assets.

4.22.1 Affected Environment

As discussed earlier, several Tribes have interests in the areas associated with the potential Black Rock Alternative, Wymer Dam and Reservoir Alternative, and the Wymer Dam Plus Yakima River Pump Exchange Alternative. The dams, reservoirs, and other facilities are within lands ceded by the Yakama under the June 9, 1855, Treaty with the Yakama. This treaty reserved the Yakama Reservation and reserved to the Yakama the exclusive right of taking fish in the streams running through and bordering the reservation and at all other usual and accustomed stations in common with citizens of the United States and the privilege of hunting, gathering roots, and pasturing their stock on open and unclaimed lands in common with citizens. Most of the lands to be acquired for the Joint Alternatives are in private ownership.

Under their 1855 Treaties, the Confederated Tribes and Bands of the Yakama Reservation, Washington, the Confederated Tribes of the Umatilla Indian Reservation, Oregon, the Confederated Tribes of the Warm Springs Reservation of Oregon and the Nez Perce Tribe of Idaho have exclusive fishing rights. Court decisions and cases have confirmed Tribal treaty fishing rights and the extent of those rights.

Potential Indian trust assets of concern for this action include water rights, fishing rights, and hunting and gathering privileges.

4.22.2 Environmental Consequences

This section identifies potential impacts to potential ITAs under the Joint Alternatives.

4.22.2.1 Methods and Assumptions

The resources sections of this document were reviewed to identify impacts potentially affecting ITAs.

4.22.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

The water rights of the Yakama Nation would continue as affirmed by the Washington State Superior Court handling the Yakima River basin adjudication. The numbers of anadromous fish in the Yakima and Columbia River systems would not increase. Terrestrial resource trends would continue.

4.22.2.3 Black Rock Alternative

Construction Impacts

No construction impacts to ITAs have been identified.

Long-Term Impacts

No adverse impacts to water rights, fishing rights, or hunting and gathering privileges, or the ITAs of concern for this action have been identified.

The increases in harvestable anadromous fish identified in chapter 2, section 2.7, "Economic and Financial Analysis," would facilitate the exercising of Tribal fishing rights by members of area Tribes. It also would contribute to maintaining or increasing subsistence fishing.

4.22.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

No construction impacts to ITAs have been identified.

Long-Term Impacts

No adverse impacts to water rights, fishing rights, or hunting and gathering privileges, the ITAs of concern for this action, have been identified.

The increases in harvestable anadromous fish identified in chapter 2, section 2.7, "Economic and Financial Analysis," would facilitate the exercise of Tribal fishing rights by members of area Tribes. The increases would also contribute to maintaining or increasing subsistence fishing.

4.22.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

No construction impacts to ITAs have been identified.

Long-Term Impacts

No adverse impacts to water rights, fishing rights, or hunting and gathering privileges, the ITAs of concern for this action, have been identified.

The increases in harvestable anadromous fish identified in chapter 2, section 2.7, "Economic and Financial Analysis," would facilitate the exercising of Tribal fishing rights by members of area Tribes. It would also contribute to maintaining or increasing subsistence fishing.

4.22.2.6 Mitigation

No mitigation would be required.

4.22.2.7 Cumulative Impacts

No cumulative impacts have been identified.

4.23 Public Health

4.23.1 Affected Environment

4.23.1.1 Hazardous and Toxic Materials

The acquisition of residential, agricultural, or industrial property has inherent risks of the property containing solid wastes and hazardous and toxic materials. In order to avoid acquiring real property that is contaminated, it is required under *Reclamation Manual*, *Directives and Standards*, that an Environmental Site Survey be completed prior to any acquisition.

Septic Systems

Larger cities and towns in the Storage Study area have sanitary wastewater treatment plants. In areas outside town or city limits, most homes are on septic systems. When properly operating, septic systems treat bacteria and filter nutrients from the water within the confines of the treatment system. Under certain conditions, such as high water table and poor soil conditions, septic systems do not operate properly and could result in sanitary wastes being discharged into groundwater or, more commonly, into surface water. These conditions may require the closure or relocation of these systems to protect both groundwater and surface water.

Building Materials

Buildings, such as residences and outbuildings located on properties to be acquired, may require removal or demolition. Buildings older then 20 years have the potential of containing hazardous materials such as lead-based paint, asbestos-containing materials, PCBs, and mercury. These materials are known to be hazardous to human health and the environment. When used for the intended purpose, sll of these materials are considered safe if they are not disturbed or damaged. If a structure is to be removed or demolished, testing will be completed to determine the presence any of these hazards. Based on the test results, the appropriate method of disposal then will be determined.

4.23.1.2 Public Health (West Nile Virus) and Mosquitoes

Mosquitoes belong to the insect order *Diptera*. Mosquito mouthparts form a long, piercing-sucking proboscis with which females obtain a blood meal needed for egg production. Nectar is the main food source for male mosquitoes. Four distinct stages make up the life cycle of the mosquito: egg, larva, pupa, and adult. Larval and pupal stages are typically aquatic. Biting mosquitoes can become a serious nuisance to people recreating in areas with nearby mosquito populations. They also may be a health concern where transmission of disease agents, which often are maintained in bird populations, from mosquitoes to humans occurs.

Successful disease transmission requires several generations to increase the size of the adult mosquito population and amplify the virus within the bird population (e.g., Madder et al., 1983), which then will increase the likelihood of transmission to humans. Optimal conditions for development of high densities of adult mosquitoes are large water surfaces and long periods of time (Tadzhieva et al., 1979). Timing of availability of breeding areas likely is important, and Madder et al. (1983) found that *Culex pipiens* and *Cx. restuans* egg production declined in late summer. Length of time that mosquito production areas are available is also critical. Minimum mean time for embryonic, larval, plus pupal development time (*Culex* species) was about 8 days at a high temperature of 86 °F (30 °C) (Madder et al., 1983). The Washington State Department of Health (2002) suggests that water that stands for greater than 10 days is needed for production of *Culex tarsalis*. In a study by Williams et al. (1993), it took about 2 days for first instar larvae to appear in newly filled pool areas.

The association of dams with mosquito and human health problems has long been documented (World Health Organization [WHO], 2000), and the Tennessee Valley Authority made recommendations for limiting mosquito production in impoundments (Cooney, 1976). Cooney (1976) listed a number of measures to help control mosquitoes in TVA facilities: (1) monitoring of mosquito populations, (2) the application of approved insecticides when levels reach a nuisance threshold, (3) implementation of an effective water-level management scheme, (4) maintenance of effective internal drainage, (5) control of marginal vegetation; and (6) operation of dewatering projects for mosquito control.

Gartrell et al. (1972) suggested that dewatering areas controls mosquito production in the spring and summer. Water-level management destroys mosquito eggs and larvae by stranding them onshore or drawing them into open water where they are exposed to predators (Snow, 1956). Reservoir drawdowns during the summer and fall of at least 20 feet were effective in providing mosquito control in TVA reservoirs (Hess and Kiker, 1943) by decreasing marginal vegetation. Mosquito production is often highest in shallow, stagnant waters with dense, emergent vegetation. Wind-swept shorelines lacking vegetation and pools containing fish and other mosquito larvivores are not conducive to mosquito production (e.g., Pratt and Moore, 1993).

Mosquito-Borne Disease

Several arthropod-borne viruses associated with mosquitoes are found in Washington State. The Washington State Department of Health (2002) lists western equine encephalitis and St. Louis encephalitis as being diseases relevant to Washington State. Both of these viruses are maintained in a mosquito-bird-mosquito cycle and *Culex tarsalis* is a principal vector. To a great degree, these traits are shared with the newly emergent (in the Western hemisphere) West Nile virus.

History, Origin, and Status of West Nile Virus

West Nile virus is a typically mosquito-borne virus indigenous to Africa, Asia, Europe, and Australia (Campbell et al., 2002). West Nile virus recently was introduced to North America and first detected in 1999 in New York City. The virus spread across the United States by 2002 (Centers for Disease Control [CDC], 2002). The virus is maintained in nature in a mosquito-bird-mosquito transmission cycle primarily involving *Culex* spp. mosquitoes (CDC, 2002). A large number of bird species can become infected with West Nile virus. Many groups of birds, such as doves (columbiform) and quails (galliform), become infected but do not die (Reisen, 2004); highest mortality rates were found in passerines in a laboratory study (Komar et al., 2003). Members of the crow family (*Corvideae*) are the most susceptible to death from West Nile virus (Crane, 2003). Susceptibility to West Nile virus is variable, and groups that are reported to be resistant to mortality, such as the galliforms, may contain members that are highly susceptible to mortality following infection, such as the greater sage-grouse (*Centrocercus urophasianus*) (Naugle et al., 2004).

In the United States, most human infections with West Nile virus occur in summer or early fall (Campbell et al., 2002) and coincide with high abundance of adult *Culex* mosquitoes (Kulasekera et al., 2001). Mosquito feeding preferences can increase or decrease the potential of mosquitoes for transmitting the virus to humans. Opportunistic feeders that feed on both mammals and birds are best for bridging West Nile virus from birds to humans and other mammals. Goddard et al. (2002) suggested that a suite of *Culex* species is important for maintaining and bridging West Nile virus in wetland ecosystems in California. While mosquito genera other than *Culex* may be susceptible to West Nile virus infection, they often are found to be uninfected in nature (Reisen, 2004). Transmission of West Nile virus is most intense when initially arriving in a geographic area. West Nile virus will decline to a lower level after susceptible wild birds either have died or recovered and developed immunity to reinfection. Transmission of West Nile virus to humans requires a reservoir of infected, viremic animals (mostly birds) from which mosquitoes carry the virus to people (Crane, 2003).

To prevent West Nile virus infection in humans, extensive early season larval control has been recommended because it prevents the buildup of mosquito populations (CDC, 2001).

4.23.2 Environmental Consequences

4.23.2.1 Methods and Assumptions

Hazardous and Toxic Materials

As property is identified for acquisition, an Environmental Site Survey will be conducted.

Mosquitoes

The key to estimating impacts to human health from mosquitoes is related to understanding the relationship between mosquito life history characteristics and the physical and biological environment. Conditions that create shallow, warm, stagnant water in conjunction with emergent vegetation should be avoided to prevent public health concerns. Biological needs for virus transmission also include resident birds in high densities (typically found at roosting sites) for virus amplification.

This analysis focused on the mosquito vector *Culex tarsalis* and the disease agent West Nile virus. Other disease agents of public health concern are maintained in a similar *Culex tarsalis*-bird-*Culex tarsalis* cycle, and responses to alternatives would be grossly similar. Water-level management conditions which potentially would create mosquito habitat were examined, with slopes from 0–3 percent (obtained via geographic information system) considered as areas conducive to shallow water pooling and mosquito habitat. Other considerations were proximity of roosting sites for birds, potential for shoreline vegetation, and water surface disturbance from wind. This assessment is limited spatially to areas associated with the proposed reservoirs.

4.23.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

Hazardous and Toxic Materials.—There would be no impacts because no property would be acquired.

Mosquitoes.—West Nile virus presently is expanding in the United States and likely will increase. Climatic conditions may be associated with the spread of West Nile virus; in California, West Nile virus introduction coincided with above-average temperatures and anomalous rainfall events (Reisen, 2004) that apparently benefited *Culex* populations. Similar conditions may allow for expansion in Washington State independent of any of the alternatives. Other disease agents of concern in Washington State likely would maintain infection cycles similar to past conditions.

4.23.2.3 Black Rock Alternative

Construction Impacts

Hazardous and Toxic Materials.—For all construction activities associated with the Joint Alternatives, the contractor(s) must comply with Reclamation Safety and Health Standards. In doing so, the contractor(s) will be responsible for ensuring that all work under contract meets or exceeds Occupational Safety and Health Administration (OSHA) standards. These standards outline the requirements for proper handling, storage, and disposal of hazardous materials and wastes.

Mosquitoes.—Construction activities often alter drainage patterns and can leave tire ruts in the soil which may fill with water from rainfall or seepage in wet areas, creating mosquito breeding sites. In some cases, equipment that is left at constructions sites or tarpaulins used to cover equipment may retain water that also could be used by mosquitoes for rearing.

Water should be removed from depressions, and abatement strategies should be implemented during and after construction to minimize the creation of areas where water pools for extended periods of time (greater than 7 days).

Long-Term Impacts

Hazardous and Toxic Materials.—As property is identified for acquisition, an Environmental Site Survey would be conducted. Any materials or potential effects of hazardous substances that could be exposed to higher levels of surface water or groundwater would be removed prior to final implementation. This may include the removal of solid wastes, underground storage tanks, septic systems, any building structures, and/or other appropriate remedial action. The closer to human habitation or developed areas, the greater the possibility in finding hazardous wastes and/or contaminants. The Black Rock study area mostly contains undeveloped land or farmland, which minimizes the potential for hazardous findings.

All operational facilities associated with the Black Rock Alternative would comply with all environmental regulations pertaining to hazardous waste management issues such as storage, disposal, inspection, recordkeeping, and reporting associated with operating the facilities. Each facility, such as the powerplants, the pumping plant, and the dam would have a Spill Prevention Control and Countermeasure (SPCC) plan. The SPCC plan would detail measures to be in place to prevent spills of hazardous or dangerous materials and petroleum products and measures to control a spill should one occur.

Any hazardous materials and wastes associated with acquiring property would be remediated, and any related-to-construction activities would cease upon completion of the project; therefore, there would be no long-term impacts on public health.

Mosquitoes.—Operation of Black Rock reservoir would result in a drawdown beginning in April and refilling in September. It is estimated that, from about March to the beginning of June, 30 acres of previously inundated land would be exposed. This would increase to approximately 100 acres for the months of June to the beginning of August. The majority of this potential mosquito habitat would likely drain into the reservoir or dry quickly; however, any pool areas that remain could produce *Culex* mosquitoes. Arguments against increased mosquito production under this scenario include the historic use of dewatering reservoirs in the spring and summer for mosquito control (Gartrell et al., 1972). Snow (1956) noted that drawdown water-level management destroys mosquito eggs and larvae by stranding them onshore or drawing them into open water where they are exposed to predators. Reservoir drawdowns during the summer and fall of at least 20 feet were effective in providing mosquito control in TVA reservoirs (Hess and Kiker, 1943) by decreasing marginal vegetation. A temporary water-level drawdown in Minnesota wetlands also reduced densities of mosquito larvae (*Coquillettidia perturbans*) which did not recover until 4 years later (Batzer and Resh, 1992). The timing of the drawdown at Black Rock may also disrupt mosquito production. Drawdown during the spring likely would destroy egg rafts and early stages of larval mosquitoes. Inundation in the late summer may not allow enough time for populations of *Culex* mosquitoes to recover to levels needed for disease transmission. Mosquitoes that would be produced likely would be flood-water mosquitoes (e.g., *Aedes*) and not the *Culex* species typically associated with West Nile virus.

Terrestrial vegetation could create variance in landscape topography and impact drainage in the drawdown area. Vegetation also would provide structure and an organic food base for mosquito larvae when water levels increase at other times of the year. While some perennial marginal vegetation may be decreased under these conditions, annual weedy vegetation or exotic grasses could invade exposed mud flats and result in favorable conditions for larval mosquitoes upon refilling, at least until drawdown once again occurs. If drawdown levels vary between years, vegetation that is produced in 1 year could remain partially inundated in the next year and provide high-quality mosquito habitat. While many fluctuating reservoirs have shorelines that are devoid of vegetation, others may contain large stands of exotics such as reed canary grass (McKay and Renk, 2002). Responses of vegetation to drawdown areas likely depend upon drawdown timing (which seeds are present in the environment), the drawdown rate and its influence on soil moisture, and the type of substrate (whether it is rocky or fine substrate) (e.g., Auble et al., 2007).

Domestic livestock and wild ungulates also should be kept away from the drawdown area because of enrichment of the area with animal manure and the creation of hoof prints that retain water, both factors that would favor mosquito production.

Black Rock reservoir both would be filled and drained via pipeline and would be isolated in shrub-steppe habitat away from other riparian areas (nearest riparian area is the Columbia River approximately 5 miles away). Riparian corridors are important for dispersion of *Cx. tarsalis*, probably because of the presence of prey and higher humidity that is important for avoiding desiccation. The shrub-steppe habitat associated with Black Rock reservoir also lacks the elevated vegetation commonly used by West Nile virus-susceptible birds for roosting and nesting and which *Cx. tarsalis* has been found to be attracted to in California (Reisen, 2004). However, other birds associated with shrub-steppe habitat, such as sage-grouse, may be atypical but competent amplifying agents for West Nile virus (Walker et al., 2007).

Data from the Hanford Meteorology Station east of the Black Rock site capture the general climatic conditions for the region (Neitzel, 2005). Prevailing surface winds are from the northwest and are most frequent in the winter and summer. Monthly average wind speed at 50 feet above the ground averages 6–7 mph in the winter and 8–9 mph during the spring and summer. Summertime drainage winds from the northwest frequently exceed speeds of 30 mph. Wind gusts greater than or equal to 25 mph occur on an average 20 days per year in June and July.

Wind speed slows near the ground surface, and average wind speed of 9 mph at 50 feet during the summer was used to calculate the approximate wind speed at a 5-foot elevation from the following equation: $v_2 = v_1 \times (h_2/h_1)^n$ where v_1 is the known (reference) wind speed at height h_1 above ground, v_2 is the speed at a second height h_2, and n is the exponent determining the wind change caused by surface roughness (www.energy.iastate.edu). The exponent used (0.10) was the one pertaining to a smooth surface. Calculations suggest that spring/summer wind speed over the Black Rock site might be in the range of 7 mph and would be approximately 5 on the Beaufort wind scale, resulting in moderate wave action (www.spc.noaa.gov/faq/tornado/beaufort.html).

It should be recognized that this is a rough estimate of possible conditions on the ground at the Black Rock site, but it does suggest that there is a possibility for wave action on the reservoir during mosquito production periods. Pratt and Moore (1993) indicate that wind-swept shorelines are not conducive to production of mosquito larvae. Turbidity associated with windy shorelines and fine sediments may also create difficulties for mosquito survival because of the ingestion of large volumes of nonnutritive soil particles (Ye-Ebiyo et al., 2003). Wind would also increase the drying rate of exposed mudflats, decreasing the lifespan of potential isolated pool areas.

Operation and the physical placement of Black Rock reservoir indicates that relatively few mosquitoes would be produced, and limited transmission of West Nile virus would result from this facility, especially if vegetation does not invade the drawdown area. The low amount of emergent vegetation, limited roosting sites for bird congregations, timing of the drawdown, and winds associated with the area all argue against increases in *Culex* mosquito populations.

Following completion of project construction, to ensure there are no long-term adverse impacts from mosquitoes, Reclamation would:

- Perform management and maintenance activities necessary to control mosquito populations.
- Regularly consult with local health departments and mosquito abatement districts to identify mosquito management problems, mosquito monitoring and abatement procedures, and opportunities to adjust water management practices to reduce mosquito production during problem periods.

4.23.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Hazardous and Toxic Materials.—Construction impacts would be the same as under the Black Rock Alternative.

Mosquitoes.—Construction impacts would be the same as under the Black Rock Alternative.

Long-Term Impacts

Hazardous and Toxic Materials.—Impacts would be similar to those described for the Black Rock Alternative.

Mosquitoes.—Releases from Cle Elum Lake and flows in the Yakima River would be used to fill Wymer reservoir from November 1–May 31. Water would be released from Wymer reservoir only in July and August, and the drawdown would expose approximately 35 acres of potential pool area. This area would remain exposed through October. Drawdown elevations are presented in figure 4.19a-e.

Reservoir drawdowns that occur in late summer likely have negative impacts to mosquito production. Withdrawal of water from potentially vegetated shorelines would decrease mosquito populations and mitigate against any potential production from drawdown pools. Colonization of isolated pools in late July and August occurs at a time when egg production by females is beginning to decrease and the time needed to achieve multiple generations, which would lead to high adult densities, is unavailable. August is also the time of year when rapid evaporation of pools would take place because of high air temperatures.

Refill of the reservoir beginning in November gradually would fill the reservoir through the end of May. It seems likely that this pattern of filling and drawdown would decrease drastically the likelihood of vegetation being present along the shoreline of the reservoir and would diminish problems with mosquitoes.

4.23.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Hazardous and Toxic Materials.—Construction impacts would be the same as under the Black Rock Alternative.

Mosquitoes.—Construction impacts would be the same as under the Black Rock Alternative.

Long-Term Impacts

Hazardous and Toxic Materials.—Impacts would be similar to those described for the Black Rock Alternative.

Mosquitoes.—Impacts would be the same as under the Wymer Dam and Reservoir Alternative.

The Yakima River pump exchange component of this alternative would not result in any areas conducive to shallow water pooling and mosquito habitat and, therefore, would not result in any increase in *Culex* mosquito populations.

4.23.2.6 Mitigation

Hazardous and Toxic Materials

As property is identified for acquisition, Reclamation would conduct an Environmental Site Survey. Remediation for any materials or potential effects of hazardous substances will be conducted prior to final implementation. For all constructed facilities, Reclamation would comply with environmental regulations pertaining to hazardous waste management and develop a SPCC plan where required.

Mosquitoes

Reclamation would:

- Conduct baseline mosquito surveillance and control program, including a monitoring program for mosquito larvae.
- Ensure final design of project facilities are designed in consultation with experts in mosquito biology and control to prevent as much mosquito production as possible and to facilitate proper functioning and maintenance in the future. Appropriate operations and maintenance provisions will include considerations for routine monitoring and control of mosquito populations.
- Consult and coordinate with local health departments and mosquito abatement districts about mosquito control measures during design, implementation, and operations phases of the project.
- Prepare a mitigation monitoring plan to ensure that the proposed mitigation measures are implemented.

The construction contractors would be required to:

- Develop and implement mosquito abatement measures including stormwater management, reducing opportunities for mosquito breeding habitats in construction materials and facilities, management of vegetation that may be conducive to mosquito habitat, site maintenance to prevent topographical depressions and ponding, monitoring, and adult mosquito control.
- Consult with local health departments and mosquito and abatement districts to discuss design or control measures to inhibit mosquito breeding and stormwater practices.
- Monitor access routes to detect formation of undrained depressions in tire ruts. Backfill access-related shallow depressions or incise narrow drainages so they do not impound small, sheltered areas of standing water.
- Ensure any artificial depressions capable of holding water for a period greater than 7 days are rectified by filling, draining, or other treatment to prevent the creation of mosquito breeding sites.
- Optimize drainage.
- Keep discharge of test water to a practical minimum and prevent long-term pooling.

- Avoid water storage open to ingress of insects wherever possible. When open storage is necessary, the duration will be kept to a minimum and assure proper mosquito control treatment.

- Inform workers during the worker education program of the potential for increases in mosquito breeding populations and of the appropriate precautions to take to protect their health including requiring personnel to wear long sleeve shirts and long trousers and use insect repellent. Provide insect repellent.

4.23.2.7 Cumulative Impacts

Cumulative impacts are those environmental consequences that result from the incremental effects of an activity when added to other projects. Although it is unlikely that large increases in mosquito populations will occur with individual project reservoirs, the underlying result of these projects would be the ability to irrigate crops even during dry years. Mosquitoes often are associated with agriculture and irrigation (Lawler and Lanzaro, 2005); therefore, the increased ability to irrigate would increase cumulative mosquito numbers over periods that include both wet and dry years.

4.24 Environmental Justice

Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations," dated February 11, 1994, requires agencies to identify and address disproportionately high and adverse human health or environmental effects of their actions on minorities and low-income populations and communities as well as the equity of the distribution of the benefits and risks. Environmental justice addresses the fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that no group should bear a disproportionate share of negative impacts.

4.24.1 Affected Environment

4.24.1.1 Black Rock Alternative

Yakima County Census Tract 17, which includes the area around the Black Rock dam and reservoir site, and the Grant County Census Designated Place (CDP) of Desert Aire, which is immediately across Priest Rapids Lake from the Black Rock pumping plant, were selected for the immediate study area. Table 4.53 provides the numbers and percentages of population for the total racial minority population which includes six minority racial categories: Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, and Two or More Races and the Hispanic or Latino population, a minority ethnic group for the Black Rock study area, Yakima

County, and the State of Washington. Table 4.54 provides income, poverty, unemployment, and housing information for the same geographic areas.

In comparison to Yakima County, the study area has a smaller percentage of total racial minority and ethnic (Hispanic or Latino) populations. The percentages of racial minorities and ethnic populations for the study area and the county are greater than for the State.

Table 4.53 Race and ethnicity for study area, Yakima County, and State of Washington

Subject	Study area		Yakima County		State of Washington	
	Number	Percent	Number	Percent	Number	Percent
Total population	7,668	100.0	222,581	100.0	5,894,121	100.0
Racial minorities	1,768	23.1	76,576	34.4	1,072,298	18.2
Hispanic or Latino (of any race)	1,976	25.8	79,905	35.9	441,509	7.5

Table 4.54 Income, poverty, unemployment, and housing for study area, Yakima County, and State of Washington

Subject	Study area		Yakima County	State of Washington
	Yakima County Census Tract 17	Desert Aire CDP		
Income				
Median family income	$45,015	$36,971	$39,746	$53,760
Per capita income	$16,441	$18,719	$15,606	$22,973
Percent below poverty level				
Families	6.6	4.9	14.8	7.3
Individuals	11.7	6.5	19.7	10.6
Percent unemployed	11.3	13.8	11.1	6.2
Percent of housing				
Occupants per room – 1.01 or more	8.0	17.2	14.2	2.7
Lacking complete plumbing facilities	0.4	3.2	1.4	0.5

Additional potentially affected minority populations include members of the Yakama Nation and downstream Indian Tribes. While census data are available for recognized Indian reservations, specific data for Tribal members are not. Tribal members may be affected regardless of whether or not they reside on their reservations.

Low-income populations are identified by several socioeconomic characteristics. As categorized by the 2000 census, specific characteristics include income (median family and per capita), percentage of the population below poverty (families and individuals), unemployment rates, and substandard housing.

Median family income for Census Tract 17 is greater than Desert Aire and the County but less than for the State. Desert Aire has per capita income higher than Census Tract 17 and the county but less than for the State. Compared to Yakima County, the study areas have lower percentages of families and individuals below the poverty level.

Other measures of low income, such as unemployment and substandard housing, also characterize demographic data in relation to environmental justice. The 2000 unemployment rates for the study area and Yakima County were higher than the State's 6.2-percent rate. Substandard housing units are overcrowded and lack complete plumbing facilities. The percentage of occupied housing units with 1.01 or more occupants per room in the study area and county was greater than the percentage for the State. The percentage of housing units lacking complete plumbing facilities in Census Tract 17 was lower than Desert Aire, the county, and the State, while the percentages for Desert Aire and Yakima County were greater than for the State.

4.24.1.2 Wymer Dam and Reservoir Alternative

Kittitas County Census Tract 9757, which includes the area around the proposed Wymer dam and reservoir site, was selected for the immediate study area. Table 4.55 provides the numbers and percentages of population for the total racial minority population, which includes six minority racial categories: Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, and Two or More Races and the Hispanic or Latino population, a minority ethnic group for the Wymer study area, Kittitas County, and the State of Washington. Table 4.56 provides income, poverty, unemployment, and housing information for the same geographic areas.

In comparison to the State of Washington and Kittitas County, the local study area has a smaller percentage of racial minorities and a greater ethnic population percentage.

Additional potentially affected minority populations include members of the Yakama Nation and downstream Indian Tribes. While census data are available for recognized Indian reservations, specific data for Tribal members are not. Tribal members may be affected regardless of whether or not they reside on their reservations.

Table 4.55 Race and ethnicity for study area, Kittitas County, and State of Washington

Subject	Study area		Kittitas County		State of Washington	
	Number	Percent	Number	Percent	Number	Percent
Total population	3,361	100.0	33,362	100.0	5,894,121	100.0
Racial minorities	268	8.0	2,745	8.2	1,072,298	18.2
Hispanic or Latino (of any race)	301	9.0	1,668	5.0	441,509	7.5

Table 4.56 Income, poverty, unemployment, and housing for study area, Kittitas County, and State of Washington

Subject	Study area Kittitas County Census Tract 9757	Kittitas County	State of Washington
Income			
Median family income	$40,357	$46,057	$53,760
Per capita income	$20,399	$18,928	$22,973
Percent below poverty level			
Families	10.4	10.5	7.3
Individuals	13.3	19.6	10.6
Percent unemployed	7.1	9.1	6.2
Percent of housing			
Occupants per room – 1.01 or more	1.7	1.6	2.7
Lacking complete plumbing facilities	1.0	0.8	0.5

Median family income for Census Tract 9757 is less than for the County and the State. The study area's per capita income is higher than for Kittitas County but less than for the State. Compared to Kittitas County, the study area has lower percentages of families and individuals below the poverty level.

The 2000 unemployment rates for the study area and Kittitas County were higher than the State's 6.2-percent rate. The percentage of occupied housing units with 1.01 or more occupants per room in the study area and County was less than the percentage for the State. The percentage of housing units lacking complete plumbing facilities in Census Tract 9757 was greater than for the County and the State.

4.24.1.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

The pipeline associated with this alternative crosses Benton County and part of Yakima County. The Benton County Census County Divisions (CCD) of Benton City, Northwest Benton, and Richland-Kennewick and the Yakima County CCD of Sunnyside approximate the area to be traversed. Table 4.57 provides the numbers and percentages of population for the total racial minority population which includes six minority racial categories: Black or African American, American Indian and Alaska Native, Asian, Native Hawaiian and Other Pacific Islander, Some Other Race, and Two or More Races and the Hispanic or Latino population, a minority ethnic group for the Wymer pipeline area, county, and the State of Washington. Table 4.58 provides income, poverty, unemployment, and housing information for the same geographic areas.

Table 4.57 Race and ethnicity for Benton City CCD, Northwest Benton CCD, Richland-Kennewick CCD, Benton County, Sunnyside CCD, Yakima County, and State of Washington

Subject	Benton City CCD		Northwest Benton CCD		Richland-Kennewick CCD		Benton County	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total population	5,494	100.0	11,877	100.0	124,238	100.0	142,475	100.0
Racial minorities	731	13.3	2,915	24.5	15,716	12.6	19,596	13.8
Hispanic or Latino (of any race)	960	17.5	4,116	34.7	12,400	10.0	17,806	12.5

Subject	Sunnyside CCD		Yakima County		State of Washington	
	Number	Percent	Number	Percent	Number	Percent
Total population	45,291	100.0	222,581	100.0	5,894,121	100.0
Racial minorities	21,484	47.4	76,576	34.4	1,072,298	18.2
Hispanic or Latino (of any race)	27,054	59.7	79,905	35.9	441,509	7.5

Table 4.58 Income, poverty, unemployment, and housing for Benton City CCD, Northwest Benton CCD, Richland-Kennewick CCD, Benton County, Sunnyside CCD, Yakima County, and State of Washington

Subject	Benton City CCD	Northwest Benton CCD	Richland-Kennewick CCD	Benton County
Income				
Median family income	$45,872	$43,225	$55,954	$54,146
Per capita income	$16,971	$15,073	$22,149	$21,301
Percent below poverty level				
Families	9.6	13.5	7.1	7.8
Individuals	12.7	15.9	9.6	10.3
Percent unemployed	6.7	5	3.9	4.1
Percent of housing				
Occupants per room – 1.01 or more	5.0	4.4	2.8	3.0
Lacking complete plumbing facilities	1.3	0.8	0.3	0.4

Table 4.58 Income, poverty, unemployment, and housing for Benton City CCD, Northwest Benton CCD, Richland-Kennewick CCD, Benton County, Sunnyside CCD, Yakima County, and State of Washington (continued)

Subject	Sunnyside CCD	Yakima County	State of Washington	
Income				
Median family income	$35,086	$39,746	$53,760	
Per capita income	$12,375	$15,606	$22,973	
Percent below poverty level				
Families	19.5	14.8	7.3	
Individuals	25.7	19.7	10.6	
Percent unemployed	9.0	6.9	6.2	
Percent of housing				
Occupants per room – 1.01 or more	7.9	14.2	2.7	
Lacking complete plumbing facilities	0.8	1.4	0.5	

In Benton County, the Northwest Benton CCD has the highest percentage of racial minorities. The percentages of racial minorities in the CCDs and in Benton County are lower than for Yakima County and the State. The percentage of racial minorities in the Sunnyside CCD is higher than for Yakima County and more than twice the State percentage. The percentages of the Hispanic or Latino populations in the Benton City CCD and Northwest Benton CCD—17.5 and 34.7, respectively—are greater than the percentages for Benton County and the State, which are 12.5 and 7.5 percent, respectively. The percentage of the Hispanic or Latino populations in the Sunnyside CCD, 59.7, is greater than for the County, 35.9 percent, and the State, 7.5 percent.

Additional potentially affected minority populations include members of the Yakama Nation and downstream Indian Tribes. While census data are available for recognized Indian reservations, specific data for Tribal members are not. Tribal members may be affected regardless of whether or not they reside on their reservations.

Median family and per capita incomes in Benton City CCD and Northwest Benton CCD are less than for Benton County and the State. Richland-Kennewick CCD's median family income is greater than for the County and the State. Its per capita income is greater than for the County but less than for the State. Median family income and per capita income in the Sunnyside CCD are less than in Yakima County and the State.

The percentages of families and individuals below poverty are higher in Benton CCD and Northwest Benton CCD than for Benton County and the State. The percentages of families and individuals in the Richland-Kennewick CCD are lower than for Benton County and the State. The percentages of families and individuals below poverty in the Sunnyside CCD and Yakima County are more than twice the State percentages of families and individuals below poverty.

The 2000 unemployment rates for the Benton City CCD, Northwest Benton CCD, Benton County, Sunnyside CCD, and Yakima County were higher than the State's 6.2-percent rate.

The percentages of occupied housing units with 1.01 or more occupants per room in the Benton City CCD, Northwest Benton CCD, Benton County, Sunnyside CCD, and Yakima County are greater than for the State. Percentages of housing lacking complete plumbing facilities in Benton City CCD, Northwest Benton CCD, Sunnyside CCD, and Yakima County are greater than for the State.

4.24.2 Environmental Consequences

4.24.2.1 Methods and Assumptions

Construction of the alternatives would most directly impact those living, recreating, or pursuing other activities in the immediate areas. To the extent these are minority and/or low-income populations, there is potential for disproportionate adverse impacts.

Environmental justice issues are focused on environmental impacts on natural resources (and associated human health impacts) and potential socioeconomic impacts. In addition to the identification of minority and/or low-income populations in the study areas, the following issues were evaluated to determine potential impacts:

- Are affected resources used by minority or low-income populations?
- Are minority or low-income populations disproportionately subject to adverse environmental, human health, or economic impacts?
- Do the resources affected by the project support subsistence living?

Environmental resources potentially used by minority groups in the study area are terrestrial- and aquatic-related resources. Members of the Yakama Nation and other Tribes outside the immediate area currently may use these resources and would be expected to do so in the future. They may use these resources disproportionately to the total population. The subsistence level of use of renewable natural resources (such as fish, wildlife, and vegetation) by the Yakama Nation or other Tribes in the construction areas and downstream has not been quantified.

4.24.2.2 No Action Alternative

Construction Impacts

Construction impacts under the No Action Alternative would be considered under separate NEPA evaluation, as discussed in chapter 2.

Long-Term Impacts

No adverse impacts would occur under this alternative.

4.24.2.3 Black Rock Alternative

Construction Impacts

Minor, temporary construction-related impacts to aquatic-related resources have been identified.

Long-Term Impacts

The immediate study area potentially affected by implementation of this alternative has lower percentages of minority and low-income populations than Yakima County. There would be no disproportionate adverse impact to those populations; everyone in the area, especially nearest the construction areas, would be affected equally.

No adverse human health impacts to any human population have been identified.

Other than minor, temporary construction impacts, no adverse impacts to aquatic-related resources have been identified.

While permanent adverse impacts to terrestrial resources have been identified, and wildlife would be affected, there are only limited hunting opportunities in the area for game species (e.g., elk or deer). Thus, the potential impact to subsistence would be negligible. Overall, potential adverse impacts to minority and low-income populations would be negligible.

4.24.2.4 Wymer Dam and Reservoir Alternative

Construction Impacts

Minor, temporary construction-related impacts to terrestrial- and aquatic-related resources potentially used for subsistence have been identified.

Long-Term Impacts

The immediate area potentially affected by implementation of the alternative has lower percentages of minority and low-income populations than Kittitas County. There would be no disproportionate adverse impact to those populations; everyone in the area, especially nearest the construction areas, would be affected equally.

No adverse human health impacts to any human population have been identified.

Other than minor, temporary construction impacts, no adverse impacts to terrestrial- and aquatic-related resources have been identified.

This alternative would not have potential adverse impacts to minority and/or low-income populations.

4.24.2.5 Wymer Dam Plus Yakima River Pump Exchange Alternative

Construction Impacts

Minor, temporary construction-related impacts to terrestrial- and aquatic-related resources potentially used for subsistence have been identified. This alternative potentially could have disproportionately adverse construction impacts to minority and/or low-income populations.

Long-Term Impacts

Much of the pipeline corridor has high percentages of minority and low-income populations. The actual alignment of the pipeline could affect minority and low-income populations disproportionately.

No adverse human health impacts to any human population have been identified.

Other than minor, temporary construction impacts, no adverse impacts to terrestrial- and aquatic-related resources potentially used for subsistence have been identified.

4.24.2.6 Mitigation

No mitigation would be required for either the Black Rock or Wymer Dam and Reservoir Alternative because no adverse impacts to minority and/or low-income populations have been identified.

The pipeline associated with the Wymer Dam Plus Yakima River Pump Exchange Alternative should be aligned to avoid areas of minority and/or low-income populations.

4.24.2.7 Cumulative Impacts

No cumulative impacts have been identified.

4.25 Unavoidable Adverse Impacts

Unavoidable significant adverse impacts are defined as those that meet the following two criteria:

- There are no reasonably practicable mitigation measures to eliminate the impacts.
- There are no reasonable alternatives to the proposed project that would meet the purpose and need of the action, eliminate the impact, and not cause other or similar significant adverse impacts.

All the Joint Alternatives involve some in-water construction work at the associated pumping plants. The Wymer Dam and Reservoir Alternative has one pumping plant on the Yakima River. The Wymer Dam Plus Yakima River Pump Exchange Alternative has three pumping plants: one on the Columbia River and two booster pumping stations north and west of Benton City, Washington. The Black Rock Alternative has one pumping plant on the Columbia River. Construction of all of these pumping plants involves the installation and removal of coffer dams and dewatering of a small area of the riverbed. These actions would have minor, short-term impacts on aquatic resources at the sites.

Pumping operations at Black Rock dam and reservoir would result in a net consumption of electricity because the amount of energy required to pump water to storage would exceed the amount of energy produced when water is released from storage. In the event that the net energy requirements for the pumping operations of the three alternatives (i.e., total energy required to pump water to storage minus energy produced upon release) are served by electricity demand from fossil fuel rather than renewable energy sources, there would be an adverse impact associated with an incremental increase of emissions associated with the production of fossil fuels (i.e., associated atmospheric pollutants and greenhouse gases contributing to global climate change). However, the additional energy demand from Black Rock and Wymer reservoirs could be met by fossil-fuel-based energy production, renewable energy production, nuclear energy, or conservation. Consequently, the potential increase in greenhouse gases is not considered an unavoidable impact. In all likelihood, new demands would be met by a combination of these approaches such that the increase in demand would not necessarily result in an increase in emissions.

Construction of facilities under any of the Joint Alternatives would result in unavoidable impacts associated with the land committed to those facilities. The most significant impacts would be associated with the construction of the dam and reservoir, which are features of all three Joint Alternatives. At Black Rock reservoir, about 8,700 acres of existing vegetation would be lost to dam and reservoir construction, including more than 3,600 acres of shrub-steppe and grassland and several other nonnative cover types. These losses are unavoidable. Nearly 350 acres of other land would be occupied by other project facilities, with the biggest loss of about 280 acres associated with the relocation of SR–24. At the Wymer dam and reservoir site, the losses would total about 1,400 acres, with about 1,200 acres of shrub-steppe and grassland, 54 acres of riparian/wetland habitat, and a variety of other cover types. The same losses would occur under the Wymer Dam Plus Yakima River Pump Exchange Alternative, along with additional losses associated with the pump exchange pumping plants and pipeline. The pipeline would be buried, but installation of it would result in the disturbance of nearly 1,400 acres. The final route has not been determined in detail, but it would extend through urban and rural setting, likely affecting a variety of cover types, including agriculture and developed land.

Construction of the dams and reservoirs also may lead to unavoidable impacts to historic resources. The historic resources present at the damsites would need to be recorded and placed in a repository, if warranted. The Black Rock dam and Wymer dam and saddle dike sites unavoidably would destroy any historic resources present in those areas.

The Joint Alternatives all involve the impoundment of water. Seepage would occur in the vicinity of the dams and reservoirs. Design features would be included in the dams and saddle dikes to minimize or control and collect the seepage, but local groundwater tables would be affected, and there is no way to absolutely prevent the seepage from occurring.

With respect to land use and shoreline resources, adverse unavoidable impacts would occur with the Wymer Dam Plus Yakima River Pump Exchange Alternative. It would adversely affect ongoing land uses along the pipeline corridor while it is under construction. These impacts could include the need to relocate residences or other facilities depending upon the final route selected. Uses on the corridor also would be limited to accommodate the need for operation and maintenance access once the pipeline is in place.

The Black Rock Alternative would affect transportation by requiring the need to relocate SR–24. Transportation also would be temporarily affected under all the Joint Alternatives, as some of the proposed pipelines involve construction under existing roads. The Black Rock Alternative would involve two significant crossings, one of a State route. Minimal impacts would occur with the Wymer Dam and Reservoir Alternative, which involves a single road crossing; more significant temporary impacts would occur with the Wymer Dam Plus Yakima River Pump Exchange Alternative, which involves multiple road crossings, including a crossing of I–182 and several State routes.

Because all of the Joint Alternatives involve significant amounts of construction activity, they all would result in some short-term increase in construction-related noise and some effects to air quality. Since the sites are, for the most part, in either remote or rural areas, the impacts associated with these increases are not expected to be significant.

The construction of the dams and reservoirs under the Joint Alternatives would alter the visual landscape, and these changes are unavoidable. Black Rock dam and reservoir would be visible from SR–24 and SR–241, and Wymer reservoir would be visible from SR–821 and I–90. For Black Rock dam and reservoir, the changes would dominate the viewscape from vantage points to the east and southeast of the dam and reservoir. For Wymer dam and reservoir, the change in the visual environment will be less striking because the dam and reservoir would be visible from relatively short stretches of SR–821 and I–90, respectively.

4.26 Relationship Between Short-Term and Long-Term Productivity

NEPA requires considering “the relationship between short-term uses of man’s environment and the maintenance and enhancement of long-term productivity”(40 CFR 1502.16). Long-term productivity refers to the capability of the land to provide market outputs and amenity values for future decades. The quality of life for future generations is linked to the capability of the land to maintain its productivity.

All Joint Alternatives would implement ground-disturbing activities that would produce short-term effects to soil, water quality, and habitat while providing the long-term benefits in terms of greater instream flows in the Yakima River, improved irrigation and municipal water supply, recreation, and hydropower.

4.27 Irreversible and Irretrievable Commitments of Resources

An irreversible commitment is a permanent resource loss, including the loss of future options. These commitments are removed by an alternative without the option to renew these resources (such as spent time and money). These commitments usually apply to nonrenewable resources, such as minerals, or to factors that are renewable only over long periods, such as soil productivity. Table 4.59 presents a summary of these irreversible commitments.

An irretrievable commitment is the loss of use or production of a natural resource for some time. These commitments are used by an alternative. For example, if suitable wildlife habitat is being used for a reservoir, habitat growth or productivity is lost while the land is a reservoir but, at some point in time, could be revegetated. These commitments would include any constructed feature of an alternative for the life of that constructed feature. Table 4.60 presents a summary of irretrievable commitments.

Table 4.59 Irreversible commitments

Commitment	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Materials, labor, and energy needed to construct the project represented by total project cost	5,690,000,000	1,024,000,000	4,068,000,000
Materials, labor, and energy consumed in maintenance and operation of the project annually represented by total annual O&M	60,170,000	2,980,00	38,013,000
Flow uses during construction	Coffer dams and other temporary disturbances	Coffer dams and other temporary disturbances	Coffer dams and other temporary disturbances

Table 4.60 Irretrievable commitments

Commitment	Black Rock Alternative	Wymer Dam and Reservoir Alternative	Wymer Dam Plus Yakima River Pump Exchange Alternative
Direct land uses (total acreages for reservoirs, canals, pumping plants, switchyards, and other above-ground features)	13,600 acres	4,040 acres	1,600 acres
Indirect land uses (total acreages for borrow pits, fill disposal sites, excavation sites and other temporary construction features)	Undetermined at this time	Undetermined at this time	Undetermined at this time
Flow uses during operation	Flows would be diverted from the Columbia River	Flows would be diverted from the Yakima River	Flows would be diverted from the mouth of the Yakima River rather than from upstream of the Yakima River

4.28 Environmental Commitments

This list includes the environmental commitments made in the project plan and Final PR/EIS. Reclamation has the primary responsibility to ensure these commitments are met if an action is implemented.

4.28.1 General

Application would be made to the U.S. Army Corps of Engineers for a permit or an exemption under Section 404 of the Clean Water Act before commencing any work at the damsites, pumping plant intakes, fish bypass outlets, and contractor use areas, as necessary. If necessary, Reclamation also would obtain a Section 401 water quality certification from the Washington State Department of Ecology. A hydraulic project approval permit would be obtained from the Washington State Department of Fish and Wildlife, and any necessary stormwater discharge permits would be acquired. The contractor would be supplied copies of the permits and the associated conditions they would be required to adhere to throughout construction.

All construction activities would comply with applicable EPA, OSHA, and State requirements on quality and control of runoff from the construction site, sediment control, noise control, and safety.

4.28.2 Groundwater Resources

If the Black Rock Alternative were selected, groundwater seepage from the reservoir would be intercepted and prevented from impacting the contaminants at the Hanford Site. This would be accomplished by the seepage mitigation measures outlined in section 4.3.2.1. A groundwater monitoring program would measure the effectiveness of these seepage mitigation measures and, if necessary, groundwater wells could be installed to intercept other reservoir seepage.

If either the Wymer Dam and Reservoir or Wymer Dam Plus Yakima River Pump Exchange Alternative were selected, groundwater seepage issues would be defined by additional geological investigations outlined in chapter 2, and the appropriate measures would be implemented to reduce the impacts of the seepage.

4.28.3 Water Quality

Construction activities (such as staging areas and temporary access roads) would be performed in manners that would prevent sedimentation. The contractor would be required to use silt curtains, settling ponds, and other measures to prevent construction site runoff. Wastewater associated with construction activities, such as dewatering excavations, washing equipment, or wet sawing, would be kept from directly discharging into surface waterways. Complying with Federal, State, and local permits would provide the necessary water quality protection.

A water quality monitoring plan would be established if a Joint Alternative were selected. Quality assurances and controls would be developed along with proper standard operating procedures. A Quality Assurance Project Plan would be written using the Washington State Department of Ecology Guidelines. The QAPP would include a list of priority parameters, a schedule of events, sampling sites with coordinates, data verification and validation, and any other pertinent information. These documents would be in place prior to any monitoring and shall be strictly followed throughout the duration of the project. Modifications would need to be made to the documents yearly to address any operational or environmental changes.

4.28.4 Vegetation and Wildlife

4.28.4.1 Black Rock Alternative and Wymer Dam and Reservoir Alternative

Wetland and riparian habitats would be created. This would entail constructing dikes in shallow water areas within the reservoir and maintaining adequate water levels for the production of wetland/riparian vegetation.

Wildlife management areas would be established adjacent to the reservoir in areas that would be able to provide suitable wildlife habitat.

Artificial perches would be installed on selected areas adjacent to the new reservoir to provide perches for raptors.

Shrub-steppe habitat would be created, restored, and/or protected such that the amount of shrub-steppe habitat would lead to production of a similar number of HUs elsewhere within the Yakima River basin.

Plant surveys for threatened and endangered species would be conducted, and any species discovered would be protected.

Areas disturbed by construction activities would be revegetated.

4.28.4.2 Wymer Dam Plus Yakima River Pump Exchange Alternative

Pipelines would be buried underground, and native vegetation along the pipeline corridor would be restored. Vegetation maintenance and monitoring plans would be developed.

Any above-ground structures would be located in areas that would cause minimal disturbance to wildlife and associated habitats.

Areas disturbed by construction activities would be revegetated.

4.28.5 Anadromous and Resident Fish

The following measures would be implemented to reduce short-term impacts of construction activities to fishery resources:

- Implement construction BMPs to avoid and minimize potential construction impacts, including erosion and sedimentation, accidental and incidental discharge of pollutants (Spill Prevention, Containment, and Control Plan), and dewatering and discharge of dewatering water.
- Prior to complete dewatering of coffer dams, fishery personnel would salvage all fishes using the most appropriate capture gear and methods.
- Provide treatment of construction dewatering discharges, such as sediment removal or filtration, as necessary, before the release of such water to wetlands or streams.
- Comply with applicable Federal, State, and local environmental regulations to mitigate potential impacts to sensitive areas, including streams, buffers, and wetlands.
- Restore disturbed areas to the maximum extent possible.

- Construction work windows for special-status fish would be followed as required by State and Federal agencies such as Washington Department of Fish and Wildlife, National Marine Fisheries Service, and/or the U.S. Fish and Wildlife Service to avoid critical periods (i.e., breeding/spawning, migration).

4.28.6 Threatened and Endangered Species

4.28.6.1 Black Rock Alternative

Mitigation measures under the Black Rock Alternative could include the following:

- Perform botanical surveys in areas proposed for disturbance and relocate sensitive species.
- Establish a wildlife management area adjacent to the reservoir.
- Bury pipelines underground and restore native vegetation along the corridor.
- Compensate for shrub-steppe losses by converting agricultural lands to shrub-steppe or enhancing degraded shrub-steppe habitat adjacent to the study area or at an offsite location where it would be more beneficial.
- Control nonnative invasive plant species.

4.28.6.2 Wymer Dam and Reservoir Alternative

Mitigation measures under the Wymer Dam and Reservoir Alternative would be the same as under the Black Rock Alternative.

4.28.6.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

Mitigation measures under the Wymer Dam Plus Yakima River Pump Exchange Alternative would be the same as under the Black Rock Alternative.

4.28.7 Land Use and Shoreline Resources

4.28.7.1 Black Rock Alternative

Impacted landowners would be compensated at fair market value according to established Federal regulations, guidelines, and procedures.

Additional mitigation potential, to be explored during more detailed studies (especially for conveyance routes), would include the following:

- Avoid dislocation of, or significant proximity impacts on, existing residences or other major structures to the maximum extent feasible.
- Align conveyances along existing roads and/or property lines to the maximum extent feasible.
- Minimize construction-phase disruption to existing land uses (especially related to construction duration and access/circulation).

4.28.7.2 Wymer Dam and Reservoir Alternative

Impacted private landowners would be compensated at fair market value according to established Federal guidelines, standards, and procedures. Additional mitigation potential, to be explored during more detailed studies (especially for conveyance routes), would include the following:

- Avoid dislocation of the existing residence east of the State route, if feasible.
- Work with the landowner to accommodate agriculture in conveyance and transmission corridors, if desired.
- Use architectural treatments and landscape screening to blend facilities with the surrounding landscape. (See section 4.19, "Visual Resources.")

4.28.7.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

More detailed studies would be conducted of pipeline and transmission line routing options exploring opportunities for avoiding direct or dislocation impacts on existing residences and businesses to the maximum extent feasible. Such detailed routing studies also would seek opportunities to minimize long-term impacts on existing developed uses in the urban environments of Richland, Kennewick, and West Richland. Beyond such site/alignment adjustments during detailed planning, mitigation would focus primarily on compensating impacted landowners at fair market value according to established Federal guidelines, standards, and procedures.

4.28.8 Public Services and Utilities

Mitigation for short-term, construction-phase impacts on public services and utilities would involve close coordination with involved service providers, as well as with potentially impacted local residents/landowners. In this regard, the following objectives would be met during detailed implementation planning (resulting in no significant residual impacts):

- Retain appropriate access throughout construction zones and throughout the construction period for law enforcement, fire protection, and emergency medical/transportation service providers.
- Where local utility system connections/installations would be impacted by construction activities, plan for and implement alternative/relocated connections and facilities prior to construction (i.e., avoid service disruptions).
- Either accomplish the above two measures at no cost to affected service providers and/or residents and landowners or provide compensation to offset additional costs incurred.

4.28.9 Transportation

4.28.9.1 Black Rock Alternative

Further discussion with WSDOT and local residents would be conducted to explore the feasibility of relocating SR–24 to the north versus south side of the Black Rock Valley, as a means of mitigating design speed, gradient, winter travel, and local parcel access concerns associated with proposed route.

Potential adjustment of new conveyance pipeline routes to minimize necessary road crossings and other disruptions to local traffic patterns and access routes would be considered.

Coordination with State and local transportation agencies and potentially impacted neighborhoods and landowners would be done in preparing construction transportation management plans. Objectives would include:

- Specifying material haul routes and construction traffic patterns which minimize local traffic impacts.
- Phasing construction to minimize the duration of necessary temporary road closures and detours.

4.28.9.2 Wymer Dam and Reservoir Alternative

More detailed planning would be done to address questions of haul route and overall traffic direction and magnitude (e.g., east versus west) and, thus, potential traffic and road impacts in Ellensburg, Selah, or Yakima. Coordination with municipal water supply would be required to properly plan for construction on, and any potential traffic flow disruptions along, SR–821.

4.28.9.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

Efforts to mitigate impacts would focus on the following:

- Close coordination with involved transportation agencies in obtaining necessary permits and preparing plans and schedules for crossings of highways and roads.

- Close coordination and cooperation with involved railroad companies related to construction within the railroad right-of-way.

- Potential adjustment of pipeline route to minimize necessary road crossings and other disruptions to local traffic patterns and access routes.

- Coordination with involved transportation agencies and potentially impacted neighborhoods and landowners, as appropriate, in preparing construction transportation management plans. Objectives would include the following:

  - Specifying material haul routes and construction traffic patterns which minimize local traffic impacts.
  - Phasing construction to minimize the duration of necessary temporary road closures and detours.

4.28.10 Air Quality

Emissions from off-road construction equipment and particulate concentrations are expected to exceed the General Conformity *de minimis* thresholds for each year of construction. Therefore, additional mitigation would be applied to the emission sources. Such mitigation would include:

- Use of emulsified or aqueous diesel fuel.

- Use of equipment with engines that incorporate exhaust gas recirculation systems.

- Installation of a lean NO_x catalyst in the engine exhaust system.

- Wet suppression and soil stabilization.

- Wind fencing around the active area.

- Paving onsite roadways.

- Truck wheel washing facilities at site exits on public roadways.

- Maintaining minimal truck bed freeboard or covering haul truck beds.

- Compliance with all local, State, and Federal air quality regulations.

4.28.11 Visual Resources

4.28.11.1 Black Rock Alternative

Available mitigation for visual impacts of Black Rock facilities would focus on (1) architectural treatments and landscape screening at the intake and fish screen, Black Rock outlet/powerplant, and Sunnyside powerplant/bypass facilities and (2) vegetation restoration and management in the pipeline and transmission line easements/right-of-way.

In the first regard, building exterior colors that blend with the surrounding environment and planting of appropriate landscape screening would be done. The same mitigation measures also would be applicable to outlet works and other appurtenant facilities at Black Rock dam.

In the pipeline and transmission line easements/rights-of-way, vegetation consistent with the surrounding environment would be used and maintained.

4.28.11.2 Wymer Dam and Reservoir Alternative

Treatments similar to those for the Black Rock facilities in terms of building colors and landscaping would be used.

In the pipeline and transmission line easements/rights-of-way, vegetation consistent with the surrounding environment would be used and maintained.

4.28.11.3 Wymer Dam Plus Yakima River Pump Exchange Alternative

Treatments similar to those for the Black Rock facilities in terms of building colors and landscaping would be used.

In the pipeline and transmission line easements/rights-of-way, vegetation consistent with the surrounding environment would be used and maintained.

4.28.12 Historic Properties

Mitigation of historic resources is data recovery or archeological excavation, preservation, conservation, and interpretation of significant historic properties from direct and indirect impacts from a construction project. The Class III survey for any of the Joint Alternatives can be estimated reasonably to take at least 1 year.

A typical scenario for mitigation of a group of historic resources would be as follows:

- Identify the significant historic properties that cannot be avoided during project construction and development.

- Consult with the SHPO and ACHP that historic properties are eligible for the NRHP. Consultation may also occur with American Indian Tribes, other Federal agencies, and public entities.
- Develop a PMOA among Reclamation, SHPO, and ACHP over mitigation measures. MOA signatories may also include Tribes, other Federal agencies, and public entities.
- The MOA would include a research and data recovery plan, stipulations for permanent storage and curation of recovered material, and provisions for sharing the results of the data recovery phase with the public; for example, interpretive facilities. The goal is to identify and implement a range of measures to record and preserve, in some manner, the record of historic resources affected by the project. Mitigation of historic properties can involve data recovery or large-scale archeological excavations, a program of monitoring of project effects, development of interpretive facilities and public educational opportunities, or a mix of those measures.
- The MOA could also include goals for long-term historic properties management and monitoring.

The period for developing, implementing, and completing mitigation measures could take an estimated 2 years for any of the Joint Alternatives. However, certain activities may last for many years, if not decades, beyond completion of the alternative. Museum storage and curation costs, monitoring activities, and management of historic resources in the development footprint not impacted directly by project construction are examples of some common long-term activities that have attendant costs.

4.28.13 Indian Sacred Sites

Mitigation to offset project impacts to access to sacred sites has few precedents or standard treatments. Any focus on American Indian sacred sites is complicated by the very nature of the discussion, which is perceived by some—if not most—American Indian Tribes as outside the greater public sphere. EO 13007 allows Government-to-Government consultation between a Federal agency and the affected Tribe(s); such consultation would occur if mitigation in this particular category is at issue if one of the Joint Alternatives were selected.

4.28.14 Public Health

4.28.14.1 Hazardous and Toxic Materials

As property is identified for acquisition, Reclamation would conduct an Environmental Site Survey. Remediation for any materials or potential effects of hazardous substances would be conducted prior to final implementation. For all constructed facilities, Reclamation would comply with environmental regulations pertaining to hazardous waste management and develop a SPCC where required.

4.28.14.2 Mosquitoes

Reclamation would:

- Conduct baseline mosquito surveillance and control program, including a monitoring program for mosquito larvae.
- Ensure final design of project facilities are designed in consultation with experts in mosquito biology and control to prevent as much mosquito production as possible and to facilitate proper functioning and maintenance in the future. Appropriate operations and maintenance provisions would include considerations for routine monitoring and control of mosquito populations.
- Consult and coordinate with local health departments and mosquito and abatement districts about mosquito control measures during the design, implementation, and operations phases of the project.
- Prepare a mitigation monitoring plan to ensure that the proposed mitigation measures are implemented.

The construction contractors would be required to:

- Develop and implement mosquito abatement measures for control, including stormwater management, reducing opportunities for mosquito-breeding habitats in construction materials and facilities, management of vegetation that may be conducive to mosquito habitat, site maintenance to prevent topographical depressions and ponding, monitoring, and adult mosquito control.
- Consult with local health departments and mosquito and abatement districts to discuss design or control measures to inhibit mosquito-breeding and stormwater practices.
- Monitor access routes to detect formation of undrained depressions in tire ruts. Backfill access-related shallow depressions or incise narrow drainages so they do not impound small, sheltered areas of standing water.
- Ensure any artificial depressions capable of holding water for a period greater than 7 days are rectified by filling, draining, or other treatment to prevent the creation of mosquito-breeding sites.

- Optimize drainage.
- Keep discharge of test water to a practical minimum and prevent long-term pooling.
- Avoid water storage open to ingress of insects wherever possible. When open storage is necessary, the duration would be kept to a minimum and ensure proper mosquito-control treatment.
- Inform workers during the worker education program of the potential for increases in mosquito breeding populations and of the appropriate precautions to take to protect their health, including requiring personnel to wear long-sleeve shirts and long trousers and use insect repellent. Provide insect repellent.

Chapter 5

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES: STATE ALTERNATIVES

CHAPTER 5

AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES: STATE ALTERNATIVES

On the basis of comments received on the Draft PR/EIS, the Washington State Department of Ecology determined that it may not have fulfilled its requirements under Chapter 197-11 of the Washington Administrative Code to identify and evaluate all reasonable water supply alternatives. Therefore, Ecology has separated from the joint NEPA/SEPA process and will evaluate additional water supply alternatives in a supplemental Draft EIS. Further, because a number of the comments made the point that it is not possible to adequately evaluate all reasonable water supply alternatives without considering habitat and fish passage needs, those needs will be addressed in the supplemental Draft EIS. The State Alternatives described in chapter 3 and evaluated in chapter 5 of the Draft PR/EIS have been eliminated from this Final PR/EIS. The State will respond to comments on the State Alternatives in its Final SEPA EIS.

Chapter 6

CONSULTATION AND COORDINATION

CHAPTER 6

CONSULTATION AND COORDINATION

This chapter describes Reclamation's and Ecology's public involvement, consultation, and coordination activities to date, including future actions that will occur during the processing of this document. Public information activities would continue through the future developments of this project.

6.1 Public Involvement

Public involvement is a process where interested and affected individuals, organizations, agencies, and governmental entities are consulted and included in Reclamation's decisionmaking process. In addition to providing information to the public regarding the PR/EIS, Reclamation also solicited responses regarding the public's needs, values, and evaluations of the proposed alternatives. Reclamation encouraged and used both formal and informal input.

6.1.1 Scoping Process

The PR/EIS scoping process was initiated in December 2006 to receive public input on the scope of the Yakima River Basin Water Storage Feasibility Study, consistent with the requirements of NEPA and its implementing regulations and SEPA. The *Federal Register* Notice of Intent to prepare an EIS and a schedule for the scoping meetings were published December 29, 2006. On the same day, Ecology published the Determination of Significance as a public notice in area newspapers consistent with the requirements of SEPA.

Reclamation also issued a news release to local media. Meeting notices describing the project, requesting comments, and announcing the dates, times, and location of the public scoping meetings were mailed to interested individuals, Tribes, groups, and government agencies. A total of 331 meeting notices were distributed. The Notice of Intent, Determination of Significance, news release, and meeting notice are attached to the *Scoping Summary Report* (Reclamation and Ecology, 2007a). The *Scoping Summary Report* is available upon request or can be accessed from the Yakima River Basin Water Storage Feasibility Storage Study Web site: http://www.usbr.gov/pn/programs/storage_study/index.html.

The purposes of scoping were to:

- Inform the public about the background, purpose, and alternatives being considered as part of the Storage Study.
- Solicit opinions regarding issues and concerns associated with the current alternatives.
- Identify other alternatives for the Storage Study.

6.1.1.1 Public Scoping Meetings

On January 23, 2007, two scoping meetings were held at the Yakima Convention Center in Yakima, Washington. Both meetings were preceded by a 1-hour open house and included a question-and-answer period at the end of the meetings. The first meeting was held from 2 to 4 p.m., and the second meeting was held from 7 to 9 p.m. These were joint meetings with Ecology and complied with both NEPA and SEPA scoping requirements.

Approximately 70 people attended the afternoon session, and approximately 30 people attended the evening session.

6.1.1.2 Comments and Other Information Received from the Public

The official public scoping comment period began December 29, 2006, and concluded January 31, 2007.

Including those received during the scoping meetings, 130 written comment documents were received during this period. The documents included 1 request to be added to the mailing list with no comments, 6 identical form letters received by e-mail, 74 identical postcards received by U.S. mail, and 49 unique documents received by one or more of the following methods—hand delivery, e-mail, U.S. mail, or fax. Some documents were submitted by more than one method. Some ranged from brief comments or questions to detailed statements. The comments included suggestions that the Storage Study should investigate nonstorage alternatives such as aquifer storage and recovery for instream and out-of-stream uses, more water conservation measures, and reallocation of water resources for instream and out-of-stream uses. In addition, there were comments about how each of the resources should be analyzed, which led to the development of the indicators used to evaluate the effects of the alternatives on the resources.

Additionally, Reclamation received two analyses from the Yakima Basin Storage Alliance: Recreation and Economic Development Analyses of Lands Around Black Rock Reservoir (YBSA, 2007) and Evaluation of the Black Rock Project's Pumped Storage Power Costs and Benefits (Energy Northwest, 2007). A summary of these analyses follows.

During the course of the development of the Storage Study, YBSA suggested that the economic evaluations conducted by Reclamation, as directed by the *P&Gs*, do not capture the full extent of the economic benefits that could accrue from potential water-resource-related actions. Economic studies prepared by others have indicated greater monetary value arising from irrigated agriculture and water-related recreation development.

For example, YBSA, in cooperation with the Port of Sunnyside and Benton and Yakima Counties, commissioned a study in 2006 to address economic benefits which could be derived from construction and operation of a Black Rock reservoir. This study focused on the potential of residential, resort, and commercial development at Black Rock reservoir which could create significant increased revenue flows within the four-county area over a 20-year timeframe. The foregoing study reflected considerable development (outside the boundary of the land required for the reservoir operation) beyond the recreation facilities contemplated by Reclamation. These potential revenue flows would be regional in scope and not the national economic benefits that Reclamation and other Federal studies are mandated to address for the economic justification of Federal water resource projects.

The 2007 YBSA study is more representative of an economic impact analysis than a benefits analysis and relies on extensive private residential, resort, and commercial development. Federal legislation does provide for non-Federal development and operation and maintenance of recreation facilities at such potential reservoirs beyond minimum basic facilities, including residential, resort, and commercial development. However, such development must be consistent with the authorized purposes of the project and must not compromise project operations to achieve these purposes.

In addition to the two powerplants at the delivery points to the Roza and Sunnyside Canals, YBSA suggested that a pump-generation facility be considered for Black Rock reservoir. Pump generation is the concept of pumping water into a reservoir while power is relatively inexpensive and then, when power demand increases and is likely to be more expensive, releasing the water to generate power. Reclamation analyzed a pump-generation option at Black Rock reservoir during the appraisal phase of the Storage Study and determined that it was not economically or financially feasible to pursue.

YBSA commissioned a study to review those conclusions and provide recommendations on how pump generation could be made more financially attractive at Black Rock reservoir. Reclamation reviewed the recommendations and, using additional information from outside Reclamation, concluded that it is still appropriate to move forward with a pump-only Black Rock Alternative.

6.1.2 Public Hearings and Review of Draft PR/EIS

The Draft PR/DEIS was filed with EPA and the *Washington State Environmental Policy Act Register* on January 29, 2008. A Notice of Availability and Public Hearings appeared in the *Federal Register* February 1, 2008. Reclamation sent a news release announcing availability of the Draft PR/EIS and dates, times, and locations of the public hearings to area media. Ecology published a Notice of Availability in area newspapers. The comment period extended until March 31, 2008.

Approximately 750 copies of the Draft PR/EIS were distributed to Federal, State, and local agencies; Native American Tribes; irrigation districts; interested members of organizations and entities; and the general public. The Draft PR/EIS and supporting technical reports were also available online at Federal and State Web sites.

A total of 163 unique letters and 183 form letters were received during the public comment period. From these letters, a total of 792 individual comments were identified and addressed.

On Wednesday, February 27, 2008, an open house and a formal public hearing were held in the afternoon, and a second open house and formal public hearing were held in the evening in Yakima, Washington. On Thursday, February 28, 2008, an open house and formal public hearing were held in the afternoon and a second open house and formal hearing were held in the evening in Kennewick, Washington. In Yakima, 31 speakers gave oral testimony at the afternoon hearing, and 15 speakers gave oral testimony at the evening hearing. In Kennewick, 17 speakers gave oral testimony at the afternoon hearing, and 17 speakers gave oral testimony at the evening hearing. Combined, a total of 17 entities provided *written* testimony. The public hearing record is available for review at Reclamation's Upper Columbia Area Office in Yakima, Washington, and in the Pacific Northwest Regional Office in Boise, Idaho.

The comment letters and a summary of the public hearing testimony are reproduced in Volume 2, "Comments and Responses." Responses to the individual comments follow the comment documents.

Public comment will be accepted on the Final PR/EIS because it contains new information regarding seepage mitigation measures for the potential Black Rock reservoir that was not available for the Draft PR/EIS. Following a 45-day review period, Reclamation will complete its Record of Decision, which will respond to those comments and identify the alternative to be implemented.

6.1.3 Other Meetings Held with Interested Parties

Following are other meetings that have been held with interested parties in regard to the Storage Study, both during and prior to initiation of the NEPA/SEPA process.

6.1.3.1 Public Meetings

- April 27, 28, 29, 2004 – Public meetings/open houses were held for the public to provide information on the Storage Study process. The meetings were held in Ellensburg, Pasco, and Yakima, Washington, respectively.
- March 29, 2005 – An information meeting was held for the public to discuss findings reported in the *Summary Report, Appraisal Assessment of the Black Rock Alternative* (Reclamation, 2004a) and answer questions. The meeting was held at the Yakima Convention Center, Yakima, Washington.
- September 21, 2005 – A public meeting/open house was held at the Yakima Convention Center, Yakima, Washington, to provide updates and answer questions about the current alternatives being studied.
- June 20, 2006 – A public meeting/open house was held at the Yakima Convention Center, Yakima, Washington, to discuss and answer questions regarding the *Yakima River Basin Storage Alternatives Appraisal Assessment* (Reclamation, 2006a).
- September 18, 2007 – A press conference was held at Reclamation's Pacific Northwest Construction Office in Yakima, Washington, to announce the release of Reclamation's report, *Modeling Groundwater Hydrologic Impacts of the Potential Black Rock Reservoir* (Reclamation, 2007a).

6.1.3.2 Meetings with the Yakama Nation

- June 30, 2005 – Reclamation and Ecology management met with Yakama Nation staff in Toppenish, Washington, to discuss critical issues and concerns of the Nation regarding the Storage Study.

- November 10, 2005 – A presentation/update to Yakama Nation staff by Reclamation's Storage Study manager regarding the Storage Study process, results of the *Summary Report, Appraisal Assessment of the Black Rock Alternative*, and the Yakima River basin alternatives to be studied, Toppenish, Washington.

- November 15, 2006 – Presentation to Yakama Nation staff by Storage Study manager regarding the *Yakima River Basin Storage Alternatives Appraisal Assessment* and upcoming plan formulation document, Toppenish, Washington.

- December 15, 2006 – Reclamation and Ecology management met with Yakama Nation staff to review and discuss the results of the plan formulation phase and the joint Reclamation/Ecology decision on how to proceed with the Storage Study based on the results presented in the plan formulation document, Yakima, Washington.

- December 2006 – Storage Study biologist met with the Yakama Nation and Washington Department of Fish and Wildlife to discuss stream reach prioritization with regard to flow and biological significance.

6.1.3.3 Stakeholder Meetings

Storage Study staff have participated in many informal meetings with stakeholders in the Yakima River basin, including: the Yakama Nation, Kittitas Reclamation District, Roza Irrigation District, Wapato Irrigation District, Sunnyside Valley Irrigation District, Yakima Basin Storage Alliance, and others, on a variety of topics. In addition, the following formal meetings were held in connection with the Storage Study:

- February 19, 2004 – Reclamation and Ecology staff led an information meeting with Yakima River basin stakeholders to discuss the planning process and the Black Rock Alternative design process and schedule. The meeting was held at the Yakima Arboretum, Yakima, Washington.

- March 29, 2005 – Reclamation staff led an information meeting with Yakima River basin stakeholders to discuss findings reported in the *Black Rock Summary Report* and answer questions. The meeting was held at the Yakima Convention Center, Yakima, Washington.

- August 12, 2005 – Reclamation staff led an information meeting to discuss the *Yakima River Basin Storage Alternatives Appraisal Assessment,* the Storage Study process, and the fisheries modeling being done. The meeting was held at the Yakima Arboretum, Yakima, Washington.

- September 1, 2005 – Storage Study staff and technical team members met with stakeholders regarding the economic analysis of the Storage Study. The meeting was held at the Clarion Hotel, Yakima, Washington.

- December 7, 2006 – Storage Study staff met with YBSA to review and discuss the results of the plan formulation phase and the joint Reclamation/Ecology decision on how to proceed with the Storage Study based on the results presented in the plan formulation document. The meeting was held in Yakima, Washington.

- December 8, 2006 – Storage Study staff met with the Yakima Basin Joint Board to review and discuss the results of the plan formulation phase and the joint Reclamation/Ecology decision on how to proceed with the

Storage Study based on the results presented in the plan formulation document. The meeting was held in Yakima, Washington.

- December 14, 2006 – Storage Study staff met with the Yakima Basin Fish and Wildlife Recovery Board to review and discuss the results of the plan formulation phase and the joint Reclamation/Ecology decision on how to proceed with the Storage Study based on the results presented in the plan formulation document. The meeting was held in Yakima, Washington.

6.1.3.4 Roundtable Meetings

In response to input received during stakeholder meetings in December 2006 and the January 2007 scoping period for the Storage Study's NEPA/SEPA process, Reclamation and Ecology formed a Roundtable group to participate in the following key aspects of the Storage Study:

- Reviewing/revisiting Storage Study goals and focusing on identifying and confirming measures of success in meeting these goals.
- Critically reviewing the suggested alternatives with potential for meeting Storage Study goals (based on Storage Study results to date, input received through recent stakeholder and public scoping activities, and additional operation studies during the Roundtable process).
- Refining the methods, tools, and criteria to be used in comparing alternatives.

The Roundtable included representation from key interest groups/constituencies at a policy/management level with a stake in the Storage Study and its outcome, with support from technical specialists on an as-needed basis. The Roundtable played an important role in ensuring the completeness, effectiveness, efficiency, and acceptability of the Storage Study as the detailed phase of analysis and decisionmaking got underway. Notes and summaries were prepared for each meeting and posted on the Storage Study Web site.

The Roundtable process was conducted over a sequence of four meetings, each from 1 to 4 p.m. in Yakima, Washington, according to the following schedule:

- Meeting 1: Thursday, March 8, 2007, Yakima Arboretum
- Meeting 2: Thursday, March 29, 2007, Yakima Arboretum
- Meeting 3: Thursday, April 19, 2007, Yakima Arboretum
- Meeting 4: Thursday, November 1, 2007, Yakima Convention Center

6.1.3.5 Technical Work Group Meetings

From 2004–2007, the SSTWG, comprised of biologists from several agencies and organizations throughout the Yakima River basin, was formed to discuss/resolve issues and concerns related to the Yakima River basin fisheries. Meetings were held on an as-needed basis in Yakima, Washington.

As part of the Roundtable process, the SSTWG, involving the Yakama Nation, National Marine Fisheries Service, WDFW, YBSA, Yakima Basin Fish and Wildlife Recovery Board, Yakima Basin Water Resource Agency, and Yakima County, was convened on March 19, 2007, to establish nonbinding flow objectives upon which to base instream flow criteria for the Storage Study.

6.1.3.6 Other Meetings/Presentations

Other meetings and briefings attended by Reclamation staff included the following:

- June 2004, 2005, 2006, 2007, 2008 – Presentation to annual Aquatic Science Conference by Storage Study biologist, Central Washington University, Ellensburg, Washington.
- March 21, 2005 – A Joint Board Working Group (Roza and Sunnyside) meeting at Sunnyside, Washington, with representatives from Confederated Tribes of the Umatilla Indian Reservation, YRBWEP manager, and Storage Study manager, arranged by YBSA.
- September 29, 2005 – Presentation to American Water Resources Agency Conference by Storage Study manager, Richland, Washington.
- October 13, 2005 – Presentation to American Rivers, et al., by Storage Study manager and biologist, Seattle, Washington.
- November 3, 2005 – Presentation to Yakama Nation by Storage Study manager, Toppenish, Washington.
- November 30, 2005 – Presentation to Oregon State University by Storage Study manager, Corvallis, Oregon.
- February 16, 2006 – Presentation to Northwest Irrigation Operators, Inc., by assistant Storage Study manager, at the Doubletree-Riverside Hotel, Boise, Idaho.
- February 23, 2006 – Presentation to Confederated Tribes of the Umatilla Indian Reservation by Storage Study manager and UCAO Native American affairs coordinator, Pendleton, Oregon.

- July 2006 – Meeting with Storage Study biologist, Yakama Nation staff, and WDFW to discuss the Wymer Dam and Reservoir Alternative and the Wymer Dam Plus Yakima River Pump Exchange Alternative.
- August 16, 2006 – Presentation to YBSA Salmon Summit by UCAO manager, Yakima, Washington.
- October 3, 2006 – Presentation to 2007 Climate and Water Resource Forecast Meeting by UCAO manager, Washington.
- January 2007 – Meeting with Storage Study biologist, Yakama Nation staff, and WDFW to discuss the flow objective concept.
- February 3, 2007 – Meeting with the Storage Study manager and landowners in the Black Rock Valley. This meeting was held at the Silver Dollar Café; 12 people attended.

In addition to these meetings, each final report has been published on the Storage Study Web site with the appropriate notices to the public, stakeholders, and interested parties using the regional media, e-mail lists, and Ecology's mailing list server for the Storage Study.

6.2 Agency Coordination and Consultation

6.2.1 Cooperating Agencies

Reclamation and Ecology were responsible as joint lead agencies for developing the joint Draft PR/EIS, but Ecology has decided to not proceed further with a joint NEPA/SEPA process. For this Final PR/EIS, Ecology has assumed the role of a cooperating agency. Other cooperating agencies/entities include Yakima County; Yakima Training Center; Seattle District of the U.S. Corps of Engineers; and the U.S. Department of Energy, Office of River Protection. In assuming this responsibility, these agencies agreed to perform one or more of the following duties:

- Participate in the NEPA process
- At the request of Reclamation, develop information and prepare environmental analyses, including portions of the PR/EIS on which the cooperator has specific expertise. For example, the U.S. Department of Energy ensured that the PR/EIS reasonably and accurately describes the potential impacts to the Hanford Site and is consistent with analyses to be presented in the Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site (*Federal Register*, 2006).
- Review the Draft and Final PR/EIS.

6.2.2 U.S. Fish and Wildlife Service

6.2.2.1 Endangered Species Act

The Endangered Species Act of 1973, as amended (Section 7(a) (2)), requires Federal agencies to consult with the U.S. Fish and Wildlife Service when a Federal action may affect a listed endangered or threatened species or its critical habitat. This is to ensure that any action authorized, funded, or carried out by a Federal agency is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of its critical habitat. Reclamation obtained a list of the threatened and endangered species that reside within the study areas from the U.S. Fish and Wildlife Service Web site. If an alternative is selected for implementation, appropriate consultation will be completed prior to seeking construction authorization.

6.2.2.2 Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (16 United States Code 661-667e, as amended) requires Federal agencies to coordinate with the Service when planning a new project or modifying existing projects so that wildlife resources receive equal consideration and are coordinated with other project objectives and features. The recommendations (section IV) contained in the Fish and Wildlife Coordination Act Report are attached to this Final PR/EIS, along with Reclamation's responses to the recommendations (attachment B).

6.2.3 National Marine Fisheries Service

Section 7(a)(2) of the Endangered Species Act of 1973 requires Federal agencies to consult with National Marine Fisheries Service when a Federal action may affect a listed endangered or threatened species or its critical habitat. This is to ensure that any action authorized, funded, or carried out by a Federal agency is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of its critical habitat.

Reclamation obtained a listing of the threatened and endangered species that reside within the study areas from the National Marine Fisheries Service Web site. The National Marine Fisheries Service has participated in SSTWG and Roundtable meetings. If an alternative is selected for implementation, appropriate consultation will be completed prior to seeking construction authorization.

6.2.4 U.S. Army Corps of Engineers

Reclamation has ongoing coordination activities with the U.S. Army Corps of Engineers in conjunction with their interests and responsibilities for wetlands. Reclamation will make application to the U.S. Army Corps of Engineers or petition them for an exemption under Section 404 of the Clean Water Act as stated in the "Environmental Commitments."

6.2.5 State Historic Preservation Officer

The National Historic Preservation Act of 1966, as amended in 1992, requires that Federal agencies consider the effects that their projects have on historic properties. Section 106 of this act and its implementing regulations (36 CFR Part 800) provide procedures that Federal agencies must follow to comply with NHPA on specific undertakings.

To comply with Section 106 of NHPA, Federal agencies must consult with the State Historic Preservation Officer; any cultural group, including Native American Tribes with a traditional or religious interest in the study area; and the interested public. Federal agencies must show that a good faith effort has been made to identify historic properties in the area of potential effect for a project. The significance of historic properties must be evaluated, the effect of the project on the historic properties must be determined, and the Federal agency must mitigate adverse effects the projects may cause on significant resources.

6.2.6 U.S. Department of Energy

In coordination with Reclamation in its role as a cooperating agency, DOE provided a Responsible Opposing View regarding the Black Rock Alternative. See attachment A.

6.3 Tribal Consultation and Coordination

6.3.1 Government-to-Government Consultation

Executive Order 13175 establishes "regular and meaningful consultation and collaboration with Tribal officials in the development of Federal policies that have Tribal implications, to strengthen the United States Government-to-Government relationships with Indian Tribes, and to reduce the imposition of unfunded mandates upon Indian Tribes."

Government-to-Government consultation between Reclamation and the Yakama Nation has occurred at the following meetings:

- October 5, 2004 – Yakama Tribal Council and director of Reclamation's Pacific Northwest Region.
- April 5, 2005 – Yakama Tribal Council and director of Reclamation's Pacific Northwest Region.

See section 6.1.3.2 for a list of other meetings with the Tribe.

6.3.2 National Historic Preservation Act

As described in section 6.2.5, the NHPA requires Federal agencies to consult with the SHPO and Native American Tribes with a traditional or religious interest in the study area and the interested public.

6.3.3 Executive Order 13007: Indian Sacred Sites

Executive Order 13007, 1996, instructs Federal agencies to promote accommodation of access and protect the physical integrity of American Indian sacred sites. A sacred site is defined as any specific, discrete, narrowly delineated location on Federal land that is identified by an Indian tribe (or Indian individual determined to be an appropriately authoritative representative of an Indian religion) as sacred by virtue of its established religious significance to or ceremonial use by an Indian religion. A sacred site can only be identified if the Tribe or appropriately authoritative representative of an Indian religion has informed the agency of the existence of a site. In a letter dated November 13, 2007, the Yakama Nation Cultural Resources Program Manager informed Reclamation that sacred sites are present in the study area but does not wish to provide specific information.

6.3.4 Indian Trust Assets

Indian trust assets are legal interests in property held in trust by the United States for Indian Tribes, Nations, or individuals. The Secretary of the Interior is the trustee for the United States on behalf of Indian Tribes. All U.S. Department of the Interior agencies share the Secretary's duty to act responsibly to protect and maintain ITAs reserved by or granted to Indian Tribes, Nations, or individuals by treaties, statutes, and Executive orders. Reclamation's Indian policy is based on Secretarial Order 3175, U.S. Department of the Interior Responsibilities for Indian Trust Resources, November 8, 1993; reissued as U.S. Department of the Interior Manual (DM) Part 303: Indian Trust Responsibilities, Chapter 2: Principles for Managing Indian Trust Assets (303 DM 2), and most recently issued by Reclamation's Commissioner in his memorandum of February 25, 1998. This policy states Reclamation will carry out its activities in a manner that protects trust assets and avoids adverse impacts when possible. This Final PR/EIS addresses ITA effects of the Joint Alternatives in chapter 4. No adverse impacts to ITA are identified.

6.4 Native American Graves Protection and Repatriation Act

Reclamation will include in construction contracts a stipulation and protocol in the event of inadvertent discovery of human remains that are determined to be American Indian.

6.5 Compliance with Other Federal Laws

In addition to the laws, Executive orders, and regulations described above, Reclamation has complied and will continue to comply with these other laws and Executive orders.

6.5.1 Executive Order 11988: Floodplain Management

Reclamation will comply with Executive Order 11988 to reduce the risk of flood loss to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains.

6.5.2 Executive Order 11990: Protection of Wetlands

Reclamation will comply with Executive Order 11990 to minimize distribution, loss, or degradation of wetlands.

6.5.3 Executive Order 12898: Environmental Justice

Executive Order 12898 established environmental justice as a Federal agency priority to ensure that minority and low-income groups are not disproportionately affected by Federal actions. As discussed in chapter 4, section 4.24, only the Wymer Dam Plus Yakima River Pump Exchange Alternative might have disproportionate adverse impacts to minority or low-income populations because of pipeline routing.

DISTRIBUTION LIST

DISTRIBUTION LIST

This Final PR/EIS is available for information and review on Reclamation's Pacific Northwest Region Web site at www.usbr.gov and at the Yakima River Basin Water Storage Feasibility Storage Study Web site at http://www.usbr.gov/pn/programs/storage_study/index.html. In addition, copies for information and review were sent to those who requested a copy. An asterisk indicates those who commented on the Draft PR/EIS.

All locations are in the State of Washington, unless otherwise noted.

U.S. Congressional Delegation

United States Senate

Honorable Maria Cantwell, Richland, Seattle; Washington, DC
Honorable Patty Murray, Seattle, Tacoma, Yakima; Washington, DC

House of Representatives

Honorable Doc Hastings, Pasco, Yakima; Washington, DC
Honorable Cathy McMorris Rodgers, Spokane, Walla Walla; Washington, DC

Governor of Washington

Honorable Christine Gregoire, Olympia

Indian Tribes

Confederated Tribes of the Colville Reservation, Nespelem
Confederated Tribes and Bands of the Yakama Nation, Toppenish*, Yakima
Confederated Tribes of the Umatilla Indian Reservation, Pendleton, Oregon
Confederated Tribes of Warm Springs, Warm Springs, Oregon
Nez Perce Tribe, Lapwai, Idaho
Wanapum Tribe, Beverly

Washington State Legislature

7th Legislative District

Senator Bob Morton, Olympia
Representative Joel Kretz, Colville, Olympia
Representative Bob Sump, Olympia

8th Legislative District

Senator Jerome Delvin, Olympia, Richland
Representative Larry Haler, Olympia, Richland
Representative Shirley Hankins, Olympia, Richland

13th Legislative District

Senator Janéa Holmquist, Moses Lake, Olympia
Representative Bill Hinkle, Ellensburg, Olympia
Representative Judy Warnick, Moses Lake, Olympia

14th Legislative District

Senator Curtis King, Olympia
Representative Charles Ross, Olympia
Representative Mary Skinner, Olympia, Yakima

15th Legislative District

Senator Jim Honeyford, Olympia, Sunnyside
Representative Bruce Chandler, Olympia, Zillah
Representative Daniel Newhouse, Olympia, Sunnyside

16th Legislative District

Senator Mike Hewitt, Olympia, Walla Walla
Representative Bill Grant, Olympia, Walla Walla
Representative Maureen Walsh, Olympia, Walla Walla

Federal Agencies

Department of Agriculture
- Forest Service, Cle Elum, Leavenworth, Naches,

Department of Defense
- Department of the Army
  - Corps of Engineers, Seattle*; Portland, Oregon
  - Yakima Training Center, Yakima*

Department of Energy
- Bonneville Power Administration, Portland, Oregon
- Hanford Site
  - Office of River Protection, Richland*
  - Richland Operations Office, Richland
- Office of NEPA Policy and Assistance, Washington, DC
- Pacific Northwest National Laboratory, Richland*

Department of Commerce
- National Oceanic and Atmospheric Administration
  - National Marine Fisheries Service, Ellensburg, Seattle

Department of the Interior
- Bureau of Indian Affairs, Toppenish, Wapato; Portland, Oregon
- Bureau of Land Management, Spokane Valley
- Fish and Wildlife Service, Burbank, Lacey, Spokane*, Wenatchee, Yakima; Arlington, Virginia
- Geological Survey, Tacoma; Fort Collins, Colorado

Minerals Management Service, Herndon, Virginia
National Park Service, Seattle; Washington, DC
Natural Resources Library, Washington, DC
Office of Environmental Policy and Compliance, Portland, Oregon; Washington, DC
Office of Surface Mining, Washington, DC
Department of Transportation
Federal Highway Administration, Olympia
Environmental Protection Agency, Seattle*; Washington, DC

State and Local Government Agencies

State of Oregon

Department of Energy, Salem, Oregon

State of Washington

Department of Ecology, Olympia, Richland, Yakima
Department of Fish and Wildlife, Olympia, Yakima*
Department of Natural Resources, Olympia*
Department of Transportation, Yakima*
Department of Archaeology and Historic Preservation, Olympia*
Hop Growers of Washington, Moxee
Recreation and Conservation Office, Olympia
North Yakima Conservation District, Yakima
State Parks, Olympia
State Parks and Recreation Commission, Olympia
Washington House Republicans – Policy Development Department, Olympia

Local Agencies

Benton County
Commissioners, Prosser*
City of Ellensburg
City of Kennewick
City of Pasco
City of Richland
City of Sunnyside
City of West Richland
City of Yakima
Douglas County
Public Utility District No. 1, East Wenatchee
Grant County
Public Utility District, Ephrata
Kittitas County
Commissioners, Ellensburg

Yakima County
Commissioners, Yakima*
Planning Department, Yakima
Yakima Regional Clean Air Agency, Yakima*

Yakima River Basin Water Storage Feasibility Study Roundtable Membership

American Rivers (Michael Garrity), Seattle
Benton County Commissioners (Max Benitz), Prosser
City Of Yakima (Dave Brown), Yakima
Kittitas County Board Of Commissioners (David Bowen), Ellensburg
Kittitas Reclamation District (Urban Eberhart), Ellensburg
National Marine Fisheries Service (Dale Bambrick), Ellensburg
Roza Irrigation District (Ron Van Gundy), Sunnyside
Sunnyside Valley Irrigation District (James Trull), Sunnyside
Washington Department of Fish and Wildlife (Jeff Tayer), Yakima
Yakama Nation (Phil Rigdon), Toppenish
Yakima Basin Fish and Wildlife Recovery Board (Alex Conley), Yakima
Yakima Basin Storage Alliance (Sid Morrison), Zillah
Yakima Basin Water Resource Agency (Jim Milton), Yakima
Yakima County Commissioners (Mike Leita), Yakima

Irrigation Districts

Cascade Irrigation District, Ellensburg
Columbia Irrigation District, Kennewick
East Columbia Irrigation District, Othello
Kennewick Irrigation District, Kennewick
Kittitas Reclamation District, Ellensburg
Naches-Selah Irrigation District, Selah
Roza Irrigation District, Outlook, Prosser, Sunnyside, Yakima
Selah-Moxee Irrigation District, Moxee
Sunnyside Valley Irrigation District, Sunnyside
Union Gap Irrigation District, Wapato
Wapato Irrigation Project, Wapato

Libraries

Bellevue Regional Library, Bellevue
Benton City Library, Benton City
Carpenter Memorial Library, Cle Elum
Colorado State University Library, Fort Collins, Colorado
Columbia Basin College Library, Pasco
Donald K C North Library, Heritage University, Toppenish
Ellensburg Public Library, Ellensburg
Holland and Terrell Libraries, Washington State University, Pullman

Central Washington University Library Documents, Ellensburg
John A Brown Library Media Center, Wenatchee Valley College, Wenatchee
John F. Kennedy Library, Eastern Washington University Library, Cheney
Kennewick Library, Kennewick
Kittitas Public Library, Kittitas
Max E. Benitz Memorial Library, WSU Tri-Cities, Richland
Mid-Columbia Library, Kennewick
North Campus Library, Wenatchee Valley College at Omak, Omak
Pasco Library, Pasco
Peterson Memorial Library, Walla Walla University, College Place
Prosser Library, Prosser
Raymond Library and Media Center, Yakima Valley Community College, Yakima
Richland Public Library, Richland
Roslyn Public Library, Roslyn
Seattle Public Library, Seattle
Sunnyside Public Library, Sunnyside
Toppenish Library, Toppenish
Wapato Library, Wapato
Washington State Library, Olympia
West Richland Library, Richland
Yakama Nation Library, Toppenish
Yakima Valley Regional Library, Yakima

Organizations

American Rivers, Seattle*
Center for Environmental Law and Policy, Spokane*
Columbia River Intertribal Fish Commission, Portland, Oregon
Desert Aire Owners Association, Mattawa
Lower Columbia Basin Audubon Society, Pasco*
Northwest Power and Conservation Council, Portland, Oregon
Pacific Northwest Council of Carpenters, Yakima
Port Of Benton, Richland
Port Of Sunnyside, Sunnyside
Sierra Club, Seattle
Tri-County Water Resource Agency, Prosser
Trout Unlimited, Seattle
Washington Environmental Council, Seattle
Yakima Basin Fish and Wildlife Recovery Board, Yakima*
Yakima Basin Joint Board, Sunnyside, Yakima
Yakima Basin Storage Alliance, Granger, Yakima*, Zillah
Yakima Basin Water Resource Agency, Yakima*

Individuals

Bob Anderson, Seattle
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Duane and Dixie Baker, Chelan
Nathan Ballou, West Richland*
Ray Benish, Bothell
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Mickie Chamness, Richland*
Douglas Chapin, Yakima
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Thomas Clarke, Benton City*
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Bonnie Dunham, Kennewick*
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Robert A. Eaton, Ellensburg
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Duane Faletti, Richland*
Glen Fiedler, Puyallup
Scott Filkins, Yakima
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Herbert Gamer, Richland
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Business Entities

Allison Farms, Zillah
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Anchor Environmental LLC, Kirkland
Carpenter Farms, Granger*
ESA Adolfson, Seattle
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HDR Engineering, Bellevue
James R. Dillman, Architect, Richland*
John Latta Associates, Kennewick
K&L Gates LLP, Seattle
Krueger Farms, Toppenish*
Lyon, Weigand and Gustafson, Yakima
Northwest Farm Credit, Pasco
Rose and Associates Real Estate Office, Yakima
Schwisow and Associates, Olympia
Science Applications International Corp, Richland; Germantown, Maryland
Simon Martinez Livestock, Inc., Mabton
Taylor Angus Ranch, Moxee
TRIDEC, Kennewick
Velikanje Halverson, Yakima
Wautoma Valley LLC, Yakima
Whalen’s Accounting Service, Grandview*

Media

Ellensburg Daily Record, Ellensburg
Tri-City Herald, Tri-Cities
Yakima Herald Republic, Yakima

LIST OF PREPARERS

List of Preparers

Name and Title	Education and Professional Experience	Affiliation	Contribution
Lola M. Abshire, Regional NEPA Coordinator	B.S., Natural Resources Management, University of Arizona 28 years of experience in resource management and environmental compliance	Bureau of Reclamation	NEPA guidance, document review, and filing
Patty Alexander, Technical Editor	A.A., English, Red Rocks Community College (in progress) Diploma of Theology, Golden Gate Theological Seminary, (in progress) 24 years of experience editing and desktop publishing environ-mental compliance documents	Bureau of Reclamation	Technical editing, design, and desktop publishing
Robert Aukerman, Contractor	B.S., Parks and Recreation Administration and Planning, Pennsylvania State University M.S., Ph.D., Recreation and Parks Administration and Planning 40 years of experience in recreation and tourism planning and management	Bureau of Reclamation contractor	Recreational resources analysis
Susan Black, Social Science Analyst	B.A., Economics, St. Martin's University 23 years of experience in water resources planning, environ-mental compliance, social analysis, and public involvement	Bureau of Reclamation	Public health analysis (hazardous and toxic materials) Indian trust assets analysis Environmental justice analysis

Name and Title	Education and Professional Experience	Affiliation	Contribution
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Wendy Christensen, Civil Engineer/ Assistant Storage Study Manager	B.S., Civil Engineering, Colorado State University M.S., Engineering Management, Washington State University 17 years of experience in civil engineering	Bureau of Reclamation	Storage Study coordination and document review Joint Alternatives analysis
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Aja K. DeCoteau, GIS Specialist and Field Wildlife Biologist II	B.A., Environmental Studies/Native American Studies, Dartmouth College M.S., Environmental Management, Yale University, School of Forestry and Environmental Studies	Yakama Nation	Shrub-steppe and movement corridor analysis

Name and Title	Education and Professional Experience	Affiliation	Contribution
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Kayti Didricksen, Hydrogeologist	B.S., Geology, Western Washington University M.S., Hydrogeology, Eastern Washington University 29 years of experience in engineering geology and hydrogeology	Bureau of Reclamation	Groundwater analysis
Tom Elliott, Resources Manager	B.A., Virginia Commonwealth University 13 years of experience as a vegetation resources manager	Yakama Nation	Black cottonwood reproduction analysis
Paula Engel, Economist	B.S., Animal Science, University of Idaho M.S., Agricultural Economics, University of Idaho 16 years of experience in resource economics	Bureau of Reclamation	Regional economic development analysis
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Name and Title	Education and Professional Experience	Affiliation	Contribution
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Steve Hiebert, Fisheries Biologist	B.S., Fisheries, College of Agriculture, New Mexico State University 27 years of experience in fishery science	Bureau of Reclamation	Fisheries, false attraction, temperature, and fish screening analyses
Rob Hilldale, Civil Engineer, PE	B.S. and M.S., Civil Engineering, specializing in sediment transport and river mechanics, Washington State University 7 years of experience	Bureau of Reclamation	Sediment resource analysis
Gina Hoff, Water Quality Specialist/ Physical Scientist	B.S., Microbiology, Central Washington University 5 years of experience	Bureau of Reclamation	Water quality analysis
Lynn Holt, Technical Writer	15 years of experience in public affairs and writing	Bureau of Reclamation	Technical report management and editing Public involvement
Joel Hubble, Fisheries Biologist	B.S., Fisheries, University of Washington, College of Fisheries M.S., Biology-Fisheries, Central Washington University 27 years of experience in fishery science	Bureau of Reclamation	Anadromous fish analysis Resident fish analysis

Name and Title	Education and Professional Experience	Affiliation	Contribution
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David Kaumheimer, Environmental Programs Manager	B.S., Wildlife Ecology, University of Wisconsin M.S., Wildlife Management, University of Idaho 25 years of experience	Bureau of Reclamation	Storage Study oversight
Dave King, Hydraulic Engineer	B.S., Agricultural Engineering, The Ohio State University M.S., Agricultural Engineering, University of Idaho 31 years of experience in operation and maintenance of water systems	Bureau of Reclamation	Data management system development
Patrick Mangan, Technical Service Center Team Leader	B.S., Forestry and Soil Science, University of Wisconsin M.S., Water Resources, University of Wisconsin 25 years of experience as fisheries biologist	Bureau of Reclamation	Threatened and endangered species analysis Air quality analysis Noise analysis Relationship between short-term and long-term productivity analysis Irreversible and irretrievable commitments of resources analysis

Name and Title	Education and Professional Experience	Affiliation	Contribution
Teri Manross, Technical Editor	A.A., English/Psychology (in progress), Red Rocks Community College 17 years of experience editing and desktop publishing environmental compliance documents	Bureau of Reclamation	Technical editing and desktop publishing
Kim McCartney, Storage Study Manager	B.S., Agricultural Engineering, South Dakota State University 30 years of experience in civil engineering and water resource development	Bureau of Reclamation	Storage Study coordination
Mary Mellema, Hydrologist	B.S., Soil Science, University of Minnesota M.S., Soil Science, University of Minnesota 20 years of experience in hydrology	Bureau of Reclamation	Hydropower resources analysis
S. Mark Nelson, Research Aquatic Biologist	B.S., Biology, Metropolitan State College of Denver M.S., Fisheries, Colorado State University 20 years of experience in the areas of water quality and riparian ecology	Bureau of Reclamation	Aquatic resources analysis Public health analysis (mosquitoes)
John Petrovsky, Contractor	B.A., Psychology, University of California, Los Angeles M.L.A., Landscape Architecture, California Polytechnic University 30 years of experience as landscape architect and environmental planner	Bureau of Reclamation contractor	Land and shoreline use analysis Public services analysis Transportation analysis Visual resources analysis

Name and Title	Education and Professional Experience	Affiliation	Contribution
Jonathan Platt, Resource Economist	B.S., Business Administration, Bryant College M.S., Agricultural and Resource Economics, Colorado State University 20 years of experience in resource economics	Bureau of Reclamation	National economic development analysis
Roger Sonnichsen, Agricultural Engineer	B.S., Agricultural Engineering, Washington State University M.S., Engineering Sciences, Washington State University 15 years of experience in water resources engineering	Bureau of Reclamation	Hydropower resources analysis
Larry Vinsonhaler, Contractor	B.A, Economics, University of Pacific 48 years of experience in water resource planning, repayment contracts, and management and administration	Bureau of Reclamation Contractor	Background and history analysis Prior investigations analysis Joint Alternatives analysis Water resources analysis Hydropower resources analysis
Romeo Wisco, Electrical Engineer	B.S., Electrical Engineering, University of the Philippines Master's Program, Electrical Engineering, University of the Philippines 20 years of experience in electric utility system engineering; 15 years of experience in hydrology systems modeling	Bureau of Reclamation	Hydropower resources analysis

REFERENCES

REFERENCES

Abbe, T.E., and D.R. Montgomery, 1996. "Large Woody Debris Jams, Channel Hydraulics, and Habitat Formation in Large Rivers," *Regulated Rivers,* 12:201–21.

Adams, E.B., 1992. *Clean Water for Washington*. Washington State University Cooperative Extension, Washington Department of Ecology, Spokane, Washington.

Allan, J.D., 1995. *Stream Ecology: Structure and Function of Running Waters*. Chapman and Hall, Inc., New York, New York.

American Water Resources Association, 2000. *Summer International Specialty Conference on Riparian Ecology and Management in Multi-Land Use Watersheds*, R. Wigington, R.L. Beschta, and W.J. Ripple, editors. Central Washington University, Ellensburg, Washington; American Water Resources Association, Portland, Oregon, pp. 239–244.

Anderson, E., 2002. Personal communication. E-mail from Eric Anderson, Washington Department of Fish and Wildlife, May 7, 2002. Subject: Juvenile Bull Trout Found in Steelhead Survey on Cowiche Creek.

Anglin, D.R., S.L. Haeseker, J.J. Skalicky, and H. Schaller, U.S Fish and Wildlife Service, Columbia River Fisheries Program Office; K.F. Tiffan and J.R. Hatten, USGS, Biological Resources Division, Columbia River Research Laboratory; Washington Department of Fish and Wildlife; J. Nugent, Nugent GIS and Environmental Services; D. Benner, Fish Passage Center; M. Yoshinaka, Cexec, Incorporated; Alaska Department of Fish and Game; Yakama Nation; Columbia River Inter-Tribal Fish Commission, 2006. *Effects of Hydropower Operations on Spawning Habitat, Rearing Habitat, and Stranding/Entrapment Mortality of Fall Chinook Salmon in the Hanford Reach of the Columbia River: Final Report*.

Arango, C.P., 2001. "The Effect of a Sudden Flow Reduction on Aquatic Insects of the Upper Yakima River, Washington, USA," Master's thesis, Central Washington University, Ellensburg, Washington.

Armitage, P.D., 1984. "Environmental Changes Induced by Stream Regulation and their Effect on Lotic Macroinvertebrate Communities," *Regulated Rivers,* A. Lillehammer and S.J. Salveit, editors. University Press, Oslo, Norway, pp. 139–165.

Armitage, P.D., R.J.M. Gunn, M.T. Furse, J.F. Wright, and D. Moss, 1987. "The Use of Prediction to Assess Macroinvertebrate Response to River Regulation," *Hydrobiologia*, 144:25–32.

Arscott, D.B., K. Tockner, and J.V. Ward, 2001. "Thermal Heterogeneity Along a Braided Floodplain River" (Tagliamento River, northeastern Italy), *Canadian Journal of Fisheries and Aquatic Sciences,* 58(12):2359–2373.

Auble, G.T., and M.L. Scott, 1998. "Fluvial Disturbance Patches and Cottonwood Recruitment Along the Upper Missouri River, Montana," *Wetlands,* 18:546–556.

Auble, G.T., P.B. Shafroth, M.L. Scott, and J.E. Roelle, 2007. "Early Vegetation Development on an Exposed Reservoir: Implications for Dam Removal," *Environmental Management,* 39:806–818.

Ayers, R.S., and D.W. Westcot, 1985. *Water Quality for Agriculture*. Food and Agriculture Organization of the United Nations, FAO Irrigation and Drainage Paper 29, Rev. 1.

Bartholomew, J.M., 2002. *SSTEMP for Windows: The Stream Segment Temperature Model (Version 2.0)*, USGS computer model and documentation. <http://www.fort.usgs.gov/products/publications/ 10016/10016.pdf>. Accessed September 9, 2008.

Batzer, D.P., and V.H. Resh, 1992. "Wetland Management Strategies that Enhance Waterfowl Habitats Can Also Control Mosquitoes," *Journal of the American Mosquito Control Association,* 8(2):117–125.

Bauer, H.H., and A.J. Hansen, Jr., 2000. *Hydrology of the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho*, USGS Water Resources Investigations Report 96–4106.

BCAA, 1996. *Urban Fugitive Dust Policy*. Benton County Air Authority. <http://www.bcaa.net/Files/PubInfo/BCAAFDP.pdf>. Accessed September 9, 2008.

BCAA, 2003. *Other Air Quality Issues*. Benton County Air Authority. <http://www.bcaa.net/LAQ000.htm>. Accessed September 9, 2008.

Beier P., and S. Loe, 1992. *Wildlife Society Bulletin,* 20(4):434–440.

Benton County, 1997. *Benton County Comprehensive Plan*. <http://www.co.benton.wa.us/comp_plan.htm#Ch4Maps>. Accessed September 9, 2008.

Benton County Sustainable Development, 2002. *Yakima River Storage Enhancement Initiative: Black Rock Reservoir Study*. May 2002. Prepared by Washington Infrastructure Services, Inc.

Bilby, R.E., and J.W. Ward, 1991. "Characteristics and Function of Large Woody Debris in Streams Draining Old-Growth, Clear-Cut, and Second-Growth Forests in Southwestern Washington," *Canadian Journal of Fisheries and Aquatic Sciences* 48:24–2058.

Bilby, R.E., and P.A. Bisson, 1998. "Function and Distribution of Large Woody Debris," *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion*, R.J. Naiman and R.E. Bilby, editors. Springer-Verlag, New York, New York, pp. 324–346.

Binns, N.A., and F.M. Eiserman, 1979. "Quantification of Fluvial Trout Habitat in Wyoming," *Transactions of the American Fisheries Society,* 108:215–228.

Biology Technical Work Group, 2004. *Defining Fish and Wildlife Resource Issues for the Yakima River Basin Water Storage Feasibility Study*. Bureau of Reclamation, Yakima, Washington.

Bison, P.S., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Kolski, and J.R. Sedell, 1987. "Large Woody Debris in Forested Streams in the Pacific Northwest: Past, Present, and Future," *Streamside Management: Forestry and Fisheries Interactions*. University of Washington, Institute of Forest Resources, Contribution No. 57, Seattle, Washington.

Bisson, P.A., and R.E. Bilby, 1998. "Organic Matter and Trophic Dynamics," *River Ecology and Management: Lessons from the Pacific Coastal Ecoregion*, R.J. Naiman and R.E. Bilby, editors. Springer-Verlag, New York, New York, pp. 373–398.

Bjornn, T.C., and D.W. Reiser, 1991. "Habitat Requirements of Salmonids in Streams," *Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats,* W.R. Meeham, editor. Special Publication 19, American Fisheries Society, Bethesda, Maryland, pp. 83–138.

Bogatov, V.V., 1978. "Effects of Floods on the Drift of Benthos in the Bomnak River (Basin of Zeya River)," *Soviet Journal of Ecology*, 9:520–523.

Boucher, P.R., 1975. *Sediment Transport by Irrigation Return Flows in Four Small Drains Within the DID-18 Drainage of the Sulphur Creek Basin, Yakima County, Washington, April 1979 to October 1981*, USGS Water Resources Investigations Report 83–4167, Tacoma, Washington, 149 pp.

Boucher, P.R., and M.O. Fretwell, 1982. *Irrigation-Water Quality in the Sulphur Creek Basin, Yakima and Benton Counties, Washington, April 1976 through March 1977*, USGS Open File Report 81–1008, Tacoma, Washington, 68 pp.

Bovee, K.D., T.J. Waddle, C. Talbert, J.R. Hatten, and T.R. Batt, 2008. *Development and Application of a Decision Support System for Water Management Investigations in the Upper Yakima River, Washington*, USGS Open File Report 2008–1251, 289 pp. <http://www.fort.usgs.gov/Products/Publications/pub_abstract.asp?PubID=22263>. Accessed September 9, 2008.

Bowlby, J.N., and J.C. Roff, 1986. "Trout Biomass and Habitat Relationships in Southern Ontario Streams," *Transactions of the American Fisheries Society*, 115(4):503–514.

Braatne, J.H., and B. Jamieson, 2001. *The Impacts of Flow Regulation on Riparian Cottonwood Forests of the Yakima River*, Report to Bonneville Power Administration, Portland, Oregon. Contract No. 00000005, Project No. 200006800 (BPA Report DOE/BP-00000005-3), 69 pp.

Braatne, J.H., R. Jamieson, S.B. Rood, and K.M. Gill, 2007. "Instream Flows and the Decline of Riparian Cottonwoods Along the Yakima River, Washington, USA," *River Research and Applications*, 23:247–267. Available for order at <http://www3.interscience.wiley.com/journal/114126220/abstract?CRETRY=1&SRETRY=0>. Accessed September 9, 2008.

Braatne, J.H., S.B. Rood, and P.E. Heilman, 1996. "Life History, Ecology, and Conservation of Riparian Cottonwoods in North America," *Biology of Populus and its Implications for Management and Conservation*, Stettler, Bradshaw, Heilman, and Hinckley, editors. NRC Research Press, Ottawa, Canada.

Brett, J.R., 1956. "Some Principles in the Thermal Requirement of Fishes," *The Quarterly Review of Biology,* 31(2):75–87.

Brittain, J.E., and T.J. Eikeland, 1988. "Invertebrate Drift: A Review," *Hydrobiologia*, 166:77–93.

Brown, R.A., and Pasternack, G.B., 2008. "Engineered Channel Controls Limiting Spawning Habitat Rehabilitation Success on Regulated Gravel-Bed Rivers," *Gemorphology* 97:631–654. Available upon request at <http://shira.lawr.ucdavis.edu/publications.htm>. Accessed September 9, 2008.

Brown, T.C., 2004. *The Marginal Economic Value of Streamflow from National Forests*. U.S. Forest Service, Rocky Mountain Research Station, Discussion Paper DP-04-1, RMRS-4851, December 28, 2004.

Buchanan D.V., M.L. Hanson, and R.M. Hooton, 1997. *Status of Oregon's Bull Trout.* Oregon Department of Fish and Wildlife, Fish Division, Portland, Oregon, 24 pp.

Bureau of Reclamation, see Reclamation.

Burkepile, N., 2007, 2008. Personal communication. Yakama Nation Wildlife, Vegetation, and Range Programs.

Busack, C., C. Knudsen, A. Marshall, S. Phelps, and D. Seiler, 1991. *Yakima Hatchery Experimental Design*, Annual Progress Report DOE/BP.

Cade, T.J., and C.P. Woods, 1997. "Changes in the Distribution and Abundance of the Loggerhead Shrike," *Conservation Biology,* 11(1):21–31.

Cadwell, L.L., M.A. Simmons, J.L. Downs, and C.M. Sveum, 1994. *Sage-Grouse on the Yakima Training Center: A Summary of Studies Conducted During 1991 and 1992.* Pacific Northwest Laboratory, Richmond, Washington.

Caldwell, L.L., J.L. Downs, R.P. Mueller, M.R. Sackschewsky, M.A. Simmons, B.L. Tiller, and K.A. Gano, 2000. Chapter 8.2, "Ecosystem Monitoring and Ecological Compliance," *Hanford Site Environmental Report, Calendar Year 2000*. Prepared for U.S. Department of Energy by Pacific Northwest National Laboratories under contract DE-AC0-6-67RLO1830.

Camargo, J.A., and D.G. De Jalon, 1990. "The Downstream Impacts of the Burgomillodo Reservoir, Spain," *Regulated Rivers: Research and Management*, 5:305–317.

Campbell, G.L., A.A. Marfin, R.S. Lanciotti, and D.J. Gubler, 2002. "West Nile Virus," *The Lancet Infectious Diseases,* 2:519–529.

Campton, D.E., and J.M. Johnston, 1985. "Electrophoretic Evidence for a Genetic Admixture of Native and Nonnative Rainbow Trout in the Yakima River, Washington," *Trans. Am. Fish. Soc.,* 114:782–793.

Canessa, P., and R.E. Hermanson, 1994. *EM4885 Irrigation Management Practices to Protect Ground Water and Surface Water Quality: State of Washington*. Washington State Department of Ecology, Washington State University Cooperative Extension, and U.S. Department of Agriculture.

Carroll, J., and J. Joy, 2000. *Quality Assurance Project Plan: Lower Yakima River Water Quality Model and Evaluation of the USBR Columbia River Pump Exchange Project*. Environmental Assessment Program, Washington State Department of Ecology, Olympia, Washington.

Carroll, J., and J. Joy, 2001. *USBR Columbia River Pump Exchange Project Potential Water Quality Impacts on the Lower Yakima River,* Publication No. 01-03-000. Environmental Assessment Program, Washington State Department of Ecology, Olympia, Washington.

CDC, 2001. *Epidemic/Epizootic West Nile Virus in the United States: Revised Guidelines for Surveillance, Prevention and Control*. Centers for Disease Control. <http://www.cdc.gov/ncidod/dvbid/westnile/publications.htm>. Accessed September 9, 2008.

CDC, 2002. "Provisional Surveillance Summary of the West Nile Virus Epidemic: United States, January-November 2002," *MMWR,* 2002, 51:1129–1133. Centers for Disease Control. <http://www.cdc.gov/MMWR/ PREVIEW/MMWRHTML/ mm5150a1.htm>. Accessed September 9, 2008.

CH2M Hill, 1975. *Characterization of Present Water-Quality Conditions in the Yakima Basin*, Report to the Washington State Department of Ecology, Olympia, Washington, Technical Bulletin 10.

Chapman, R.J., T.M. Hinckley, L.C. Lee, and R.O. Teskey, 1982. *Impact of Water Level Changes on Woody Riparian and Wetland Communities,* vol. 10. U.S. Fish and Wildlife Service, Publication No. OBS-82/83, Kearneysville, West Virginia.

City of Kennewick, 2000. *Columbia Park Master Development Plan,* February 2000, Kennewick, Washington.

City of Richland, 1999. *Rivershore Master Plan,* October 1999, Richland, Washington.

City of Richland, 2004. *Richland Wye Master Plan.*

City of Richland, 2006. *Comprehensive Plan.*

Clinton, W.J., 2000. *President William Clinton; Presidential Documents, Proclamation 7319 of June 9, 2000; "Establishment of the Hanford Reach National Monument."* <http://www.fws.gov/hanfordreach/documents/ proclamation.pdf>. Accessed September 9, 2008.

Closs, G.P., and P.S. Lake, 1996. "Drought, Differential Mortality and the Coexistence of a Native and an Introduced Fish Species in a Southeast Australian Intermittent Stream," *Environmental Biology of Fishes,* 47:17–26.

Coffin, C., 2003. *Quality Assurance Project Plan for TMDL Effectiveness Monitoring and Water Quality Evaluation in the Lower Yakima River*, Publication No. 04-03-203, Washington State Department of Ecology, Central Regional Office, Yakima, Washington. <http://www.ecy.wa.gov/ pubs/0403203.pdf>. Accessed September 9, 2008.

Coffin, C., R. Plotnikoff, and R. Anderson, 2006. *Lower Yakima River Suspended Sediment Total Maximum Daily Load Study Water Quality Effectiveness Monitoring Report*, Publication No. 06-03-014. Washington State Department of Ecology, Central Regional Office, Yakima, Washington.

Cole, T., and S. Wells, 2002. *CE-QUAL-W2 V3 Hydrodynamic and Water Quality Model, General Model Description.* <http://eco.wiz.uni-kassel.de/model_db/mdb/ce-qual-w2.html>. Accessed September 9, 2008.

Columbia Geotechnical Associates, 2004. *Geologic Investigation, Black Rock Dam, Alternate Damsite, Yakima County, Washington*. Prepared for the Bureau of Reclamation by Columbia Geotechnical Associates, Inc., 66 pp.

Collier, M., R.H. Webb, and J.C. Schmidt, 1996. *A Primer on the Downstream Effects of Dams,* USGS Circular 1126, 94 pp.

Cooney, J.C., 1976. "Impoundments," *Mosquito News,* 36(4):413–414.

Cooper, R., 2005. Personal communication.

Corps. See U.S. Army Corps of Engineers.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe, 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. National Wetlands Inventory Center, FWS/OBS-79/31, December 1979.

Craig, S.E., 1997. "Habitat Conditions Affecting Bull Trout *(Salvelinus confluentus)* Spawning Areas within the Yakima River Basin, Washington," Master's thesis, Central Washington University, Ellensburg,Washington. 74 pp.

Cramer, S.O., D.B. Lester, P.A. Monk, and K.L. Witty, 2003. *A Review of Abundance Trends, Hatchery and Wild Fish Interactions, and Habitat Features of the Middle Columbia Steelhead ESU.* Prepared for Mid-Columbia Stakeholders by S.P. Cramer and Associates, Sandy, Oregon.

Crane, J.K., 2003. "Here Comes West Nile Virus: Again," *The Clinical Advisor*, July 2003:11–12.

Crane, S., 2007. Personal communication. Yakama Nation.

Crawford, R.C., and J. Kagan, 2001. "Wildlife Habitats: Descriptions, Status, Trends, and System Dynamics, Chapter 2.16: Shrub-Steppe," *Wildlife-Habitat Relationships in Oregon and Washington*, D. Johnson and T. O'Neil, editors. Oregon State University Press, Corvallis, Oregon, pp. 50–51.

Creech, J., and G. Bohn, 2005. *Wilson Creek Sub-Basin Bacteria Total Maximum Daily Load (Water Cleanup Plan)*, June 2005, Publication No. 05-10-041. Washington State Department of Ecology, Central Regional Office, Yakima, Washington. <http://www.ecy.wa.gov/pubs/0510041.pdf>. Accessed September 9, 2008.

Creech, J., and J. Joy, 2002. *Upper Yakima Basin Suspended Sediment, Turbidity and Organochlorine Pesticide Total Maximum Daily Load, Submittal Report*, Publication No. 02-10-047-WQ. Washington State Department of Ecology, Olympia, Washington. <http://www.ecy.wa.gov/pubs/0210047.pdf>. Accessed September 9, 2008.

Cuffney, T.F., M.R. Meador, S.D. Porter, and M.E. Gurtz, 1997. *Distribution of Fish, Benthic Invertebrate, and Algal Communities in Relation to Physical and Chemical Conditions, Yakima River Basin, Washington, 1990*, USGS Water Resources Investigations Report 96-4280, Raleigh, North Carolina.

Daily, G.C., 1997. *Nature's Services: Societal Dependence on Natural Ecosystem*. Island Press, Washington, DC.

Daubenmire, R., 1970. *Steppe Vegetation of Washington*. Washington Agricultural Experiment Station, Tech. Bulletin 62, 131 pp.

Davidson, C., 1998. "Issues in Measuring Landscape Fragmentation," *Wildlife Society Bulletin,* 26:32–37.

DeBell, D.S., 1990. "*Populus Trichocarpa*: Black Cottonwood," Silvics of North America: Hardwoods, vol. 2, *U.S. Department of Agriculture Handbook*, R.M. Burns and B.H. Honkala, editors, 645:570–576.

Degani, G., G.N. Herbst, R. Ortal, H.J. Bromley, D. Levanon, Y. Netzer, N. Harari, and H. Glazman, 1993. "Relationship Between Current Velocity, Depth, and the Invertebrate Community in a Stable River System," *Hydrobiologia*, 263:163–172.

DeVries, P.E., 1997. "Riverine Salmon Egg Burial Depths: Review of Published Data and Implications for Scour Studies," *Canadian Journal of Fisheries and Aquatic Science,* 54:1685–1698.

DeVries, P.E., 2000. *Scour in Low Gradient Gravel Bed Streams: Patterns, Processes, and Implications for the Survival of Salmonid Embryos,* Ph.D. dissertation, University of Washington, Seattle, Washington.

Dobler, F.C., J. Eby, C. Perry, S. Richardson, and M. VanderHaegen, 1996. *Status of Washington's Shrub-Steppe Ecosystem: Extent, Ownership, and Wildlife/Vegetation Relationships*. Wildlife Management Division, Washington Department of Fish and Wildlife, Olympia, Washington.

Draper, J.A., 1992. "The 1992 Options Analysis Study: Cultural Resources," *Contributions in Cultural Resource Management No. 38.* Center for Northwest Anthropology, Washington State University, Pullman, Washington.

Dunne T., and L.B. Leopold, 1978. *Water in Environmental Planning*. W.H. Freeman and Company, New York, NewYork.

Dykaar, B.D., and P.J. Wigington, Jr., 2000. "Floodplain Formation and Cottonwood Colonization Patterns on the Willamette River, Oregon," *Environmental Management,* 25:87–104.

Ebbert, J.C., and S.S. Embrey, 2002. *Pesticides in Surface Water of the Yakima River Basin, Washington, 1999–2000; Their Occurrence and an Assessment of Factors Affecting Concentrations and Loads*, USGS Water Resources Investigations Report No. 01-4211. USGS National Water-Quality Assessment Program, Tacoma, Washington.

Ebbert, J.C., S.S. Embrey, and J.A. Kelley, 2003. *Concentrations and Loads of Suspended Sediments and Nutrients in Surface Water of the Yakima River Basin, Washington, 1999–2000: With an Analysis of Trends in Concentrations*, USGS Water Resources Investigations Report 03-4026. USGS National Water-Quality Assessment Program, Tacoma, Washington.

Eberhardt, L.E., and L.A. Hoffman, 1991. *Sage-Grouse on the Yakima Training Center: A Summary of Studies Conducted During 1989 and 1990*, PNL-7647. Pacific Northwest Laboratory, Richland, Washington.

Eberhardt, L.E., L.L. Eberhardt, B.L. Tiller, and L.L. Cadwell, 1996. "Growth of an Isolated Elk Population," *Journal of Wildlife Management,* (60)2:369–373.

Ecology, 1979. *Irrigated Agriculture Water Quality Management Plan, Section 208, Public Law 95–217*. Washington State Department of Ecology, Water Quality Program, Olympia, Washington, Report 79-5b.

Ecology, 1990. Washington Administrative Code Chapter 173-200, *Water Quality Standards for Ground Waters of the State of Washington.* Washington State Department of Ecology Water Quality Program, Olympia, Washington.

Ecology, 1997. Washington Administrative Code, Chapter 173-201A, *Water Quality Standards for Surface Waters of the State of Washington*. Washington State Department of Ecology, Olympia, Washington.

Ecology, 1999. *Focus Sheet: Ground Water/Surface Water Interactions to Be Studied in Yakima River Basin*, Focus No. 99-1817.

Ecology, 2000. Washington Administrative Code, Chapter 173-060, *Maximum Environmental Noise Levels*. Washington State Department of Ecology. <http://www.ecy.wa.gov/pubs/wac17360.pdf>. Accessed September 9, 2008.

Ecology, 2002a. Washington Administrative Code, Chapter 173-401-532, *Categorically Exempt Insignificant Emission Units*. Washington State Department of Ecology. <http://www.ecy.wa.gov/pubs/ wac173401.pdf>. Accessed September 9, 2008.

Ecology, 2002b. *Lower Yakima River Water Quality Project Update*. Washington State Department of Ecology.

Ecology, 2003a. *Prevention of Significant Deterioration: Getting a Permit*. Washington State Department of Ecology.

Ecology, 2003b. "*Mitigation Measures Used in Water Rights Permitting*." Washington State Department of Ecology. <http://www.ecy.wa.gov/programs/ WR/instream-flows/Images/pdfs/mitmeas.pdf>. Accessed September 9, 2008.

Ecology, 2003c. *Ground Water Quality in the Central Ahtanum Valley, Yakima County, March 2001–December 2002*. Washington State Department of Ecology, Publication No. 03-03-040. <http://www.ecy.wa.gov/pubs/0303040.pdf>. Accessed September 9, 2008.

Ecology, 2004. *An Evaluation of Probable Benefits and Costs for the Proposed Rule to Establish the Columbia River Water Resources Management Program*. Washington State Department of Ecology, Publication No. 04-11-032.

Ecology and West Water Research, 2004. *Analysis of Water Banks in the Western States*, Publication No. 04-11-011. Washington State Department of Ecology. <http://www.ecy.wa.gov/pubs/0411011.pdf>. Accessed September 9, 2008.

Ecology, 2005a. *Determining Irrigation Efficiency and Consumptive Use*, Water Resources Program Guidance, Guide 1210. Washington State Department of Ecology. <http://www.ecy.wa.gov/programs/wr/rules/images/pdf/guid1210.pdf>. Accessed September 9, 2008.

Ecology, 2005b. *Ahtanum Creek Watershed Restoration Program Final Programmatic Environmental Impact Statement*, Publication No. 05-06-016. Washington State Department of Ecology. <http://www.ecy.wa.gov/ pubs/0506016.pdf>. Accessed September 9, 2008.

Ecology, 2005c. *Focus on Upper Yakima Basin*, Publication No. 01-10-003. Washington State Department of Ecology.

Ecology, 2005d. *Focus on Wilson Creek Sub-Basin Bacteria TMDL Approved - Detailed Planning Underway*, Publication No. 03-10-022. Washington State Department of Ecology, Yakima, Washington.

Ecology, 2006a. Washington Administrative Code, Chapter 173-201A, *Water Quality Standards for Surface Waters of the State of Washington*, Publication No. 06-10-091. Washington State Department of Ecology, Water Quality Program, Olympia, Washington. <http://www.ecy.wa.gov/pubs/wac173201a.pdf>. Accessed September 9, 2008.

Ecology, 2006b. *2006 Report to the Legislature: Water Banking in Washington State*, Publication No. 06-11-048. Washington State Department of Ecology. <http://www.ecy.wa.gov/pubs/0611048.pdf/>. Accessed September 9, 2008.

Ecology, 2007a. *Columbia River Water Management Program: Final Programmatic Environmental Impact Statement*. Washington State Department of Ecology. <http://www.ecy.wa.gov/PROGRAMS/wr/cwp/eis.html>. Accessed September 9, 2008.

Ecology, 2007b. *Washington State's Water Quality Assessment [303(d) and 305(b)] Report*. Washington State Department of Ecology, Water Quality Program.

Ecology, 2007c. *Washington State's Water Quality Assessment for 2004. Water Quality Listings by Category*. Washington State Department of Ecology. <http://www.ecy.wa.gov/Programs/wq/303d/2002/2002-index.html>. Accessed September 9, 2008.

Ecology, 2007d. *Ambient Groundwater Quality in the Moxee Valley Surficial Aquifer, Yakima County, January–June 2006,* Publication No. 07-03-023. Washington State Department of Ecology. <http://www.ecy.wa.gov/biblio/0703023.html>. Accessed September 9, 2008.

Ecology, 2007e. *Technical Report on Cultural Resources for the Yakima River Basin Water Storage Feasibility Study*. Prepared by Paragon Research Associates, LLC.

Ecology, 2007f. *Technical Report on the Enhanced Water Conservation Alternative for the Yakima River Basin Water Storage Feasibility Study*. Prepared by Anchor Environmental.

Ecology, 2007g. *Technical Report on the Groundwater Storage Alternative for the Yakima River Basin Water Storage Feasibility Study*. Prepared by Golder Associates.

Ecology, 2007h. *Technical Report on the Market-Based Reallocation of Water Resources Alternative: Water Markets-Water Banks for the Yakima River Basin Water Storage Feasibility Study*. Prepared by Cascadia Law Group and ECONorthwest.

Ecology, 2007i. *Technical Report on Socioeconomic Impacts of the State Alternatives for the Yakima River Basin Water Storage Feasibility Study*. Prepared by ECONorthwest.

Ecology, 2008. *Lake Roosevelt Incremental Storage Releases Program Draft Supplemental Environmental Impact Statement*, Publication No. 08-11-015. Washington State Department of Ecology, Yakima, Washington. <http://www.ecy.wa.gov/pubs/0811012.pdf>. Accessed September 9, 2008.

Ecology, no date. *Focus on Teanaway Basin Temperature TMDL: A Plan to Improve Stream Temperatures*, Publication No. 01-10-020. Washington State Department of Ecology, Yakima, Washington. <http://www.ecy.wa.gov/pubs/0110020.pdf>. Accessed September 9, 2008.

Eitemiller, D.J., C.P. Arango, K.L. Clark, and M.L. Uebelacker, 2002. *The Effects of Anthropogenic Alterations to Lateral Connectivity on Seven Select Alluvial Floodplains Within the Yakima River Basin*. Department of Geography and Land Studies, Central Washington University, Ellensburg, Washington.

Eitemiller, D.J., M.L. Uebelacker, D.A. Plume, C.P. Arango, and K.L. Clark, 2000. *The Effects of Anthropogenic Alterations to Lateral Connectivity on Seven Select Alluvial Floodplains Within the Yakima River Basin*. Department of Geography and Land Studies, Central Washington University, Ellensburg, Washington.

Energy Northwest, 2007. *Evaluation of the Black Rock Project's Pumped Storage Power Costs and Benefits*. <http://www.ybsa.org/generator/assets/Energy%20Study.pdf>. Accessed September 9, 2008.

EPA, 1986a. *Quality Criteria for Water 1986*. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, DC.

EPA, 1986b. *Noise and Your Hearing*. U.S. Environmental Protection Agency, Office of Noise Abatement and Control.

ESRI, 2005. *U.S. Major Roads*. Tele Atlas North America, Inc./Geographic Data Technology, Inc., ESRI, Redlands, California.

Everest, F.H., N.B. Armentrout, S.M. Keller, W.D. Parante, J.R. Sedell, T.E. Nickelson, J.M. Johnston, and G.N. Haugen, 1985. "Salmonids," *Management of Wildlife and Fish Habitats in Forests of Western Oregon and Washington*, Publication R6-F&WL-192-1985, E.R. Brown, editor. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Portland, Oregon, pp. 199-230.

Fairfield, G., 2005. Personal communication.

Fausch, K.D., C. Gowan, A.D. Richmond, and S.C. Riley, 1994. "The Role of Dispersal in Trout Population Response to Habitat Formed by Large Woody Debris in Colorado Mountain Streams," *Bulletin Français de la Pêche et de la Pisciculture,* 337/338/339, pp. 179–190.

Federal Register, 1998. 50 CFR Part 17, "Listing of Bull Trout in the Columbia and Klamath River Distinct Population Segment, Final Rule," *Rules and Regulations*, 63(111):31647–31674.

Federal Register, 2005. 50 CFR Part 226, "Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho, Final Rule," *Rules and Regulations*, 70(170):52630–52858.

Federal Register, 2006. "Notice of Intent to Prepare the Tank Closure and Waste Management Environmental Impact Statement for the Hanford Site, Richland, Washington," 71(22):5655.

FERC, 2006. *Priest Rapids Hydroelectric Project, Washington, Final Environmental Impact Statement*, FERC Project No. 2114. Federal Energy Regulatory Commission, Office of Energy Projects, Washington, DC.

Fierke, M.K., and J.B. Kauffman, 2005. "Structural Dynamics of Riparian Forests Along a Black Cottonwood Successional Gradient," *Forest Ecology and Management,* 215:149–162.

Flagg, T.A., T.E. Ruehle, L.W. Harrell, J.L. Mighell, C.R. Pasley, A.J. Novotny, E. Statick, C.W. Sims, D.B. Dey, and V.W. Mahnken, 2000. *Cle Elum Lake Anadromous Salmon Restoration Feasibility Study: Summary of Research, 2000*, Final Report to Bonneville Power Administration, Portland, Oregon, Contract No. 86AI6480, Project No. 86-045. National Marine Fisheries Service, Seattle, Washington, 118 pp.

Fluharty, D.L., 2000. *Characterization and Assessment of Economic Systems in the Interior Columbia Basin: Fisheries,* Gen. Tech. Rep. PNW-GTR-451. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Fraley, J.J., and B.B. Shepard, 1989. "Life History, Ecology and Population Status of Migratory Bull Trout *(Salvelinus confluentus)* in the Flathead Lake and River System, Montana," *Northwest Science,* 63(4):133–143.

Franklin, A.B., B.R. Noon, and T.L. George, 2002. "What is Habitat Fragmentation?" *Studies in Avian Biology*, 25:20–29, 10 pp.

Fretwell, M.R., 1989. *Homing Behavior of Adult Sockeye Salmon in Response to a Hydroelectric Diversion of Homestream Waters at Seton Creek.* International Pacific Salmon Commission, Vancouver, British Columbia, Canada, 38 pp.

Friedman, J.M., 1993. *Vegetation Establishment and Channel Narrowing Along a Great-Plains Stream Following a Catastrophic Flood,* Ph.D. dissertation, University of Colorado, Boulder, Colorado, 156 pp.

Friedman, J.M., W.R. Osterkamp, M.L. Scott, and G.T. Auble, 1998. "Downstream Effects of Dams on Channel Geometry and Bottomland Vegetation: Regional Patterns in the Great Plains," *Wetlands,* 18:619–633.

Fuhrer, G.J., S.L. Fluter, S.W. McKenzie, J.F. Rinella, J.K. Crawford, D.J. Cain, M.I. Hornberger, J.L. Bridges, and K.A. Skach, 1994. *Surface-Water-Quality Assessment of the Yakima River Basin in Washington; Major- and Minor-Element Data for Sediment, Water, and Aquatic Biota, 1987–91*, USGS Water Resources Investigations Report No. 94-308, Portland, Oregon.

Fuhrer, G.J., D.Q. Tanner, J.L. Morace, S.W. McKenzie, and K.A. Skach, 1996. *Water Quality of the Lower Columbia River Basin; Analysis of Current and Historical Water-Quality Data through 1994*, USGS Water Resources Investigations Report No. 95-4294, Portland, Oregon.

Fuhrer, G.J., J.L. Morace, J.F. Rinella, J.C. Ebbert, S.S. Embrey, I.R. Waite, K.D. Carpenter, D.R. Wise, and C.A. Hughes, 2004. *Water Quality in the Yakima River Basin, Washington, 1999–2000*, USGS Circular 1237, Portland, Oregon, 34 pp.

Gartrell, F.E., W.W. Barnes, and G.S. Christopher, 1972. "Environmental Impact and Mosquito Control Water Resource Management Projects," *Mosquito News,* 32(3):337–343.

Gladden, J.E., and L.A. Smock, 1990. "Macroinvertebrate Distribution and Production on the Floodplains of Two Lowland Headwater Streams," *Freshwater Biology,* 24:533–545.

Gleick, P., D. Haasz, C. Henges-Jeck, V. Srinivasan, G. Wolff, K.K. Cushing, and A. Mann, 2003. *Waste Not, Want Not: The Potential for Urban Water Conservation in California.* Pacific Institute, November 2003. <http://www.pacinst.org/reports/rban_usage/waste_not_want_not_full_report.pdf>. Accessed September 9, 2008.

Goddard, L.B., A.E. Roth, W.K. Reisen, and T.W. Scott, 2002. "Vector Competence of California Mosquitoes for West Nile Virus," *Emerging Infectious Diseases*, 8(12):1385–1391.

Goetz, F.A., 1994. "Distribution and Juvenile Ecology of Bull Trout *(Salvelinus confluentus)* in the Cascade Mountains," Master's thesis, Oregon State University, Corvallis, Oregon, 173 pp.

Gore, J.A., and R.D. Judy, 1981. "Predictive Models of Benthic Macroinvertebrate Density for Use in Instream Flow Studies and Regulated Flow Management," *Canadian Journal of Fisheries and Aquatic Science*, 38:1363–1370.

Gore, J.A.,1978. "A Technique for Predicting In-Stream Flow Requirements of Benthic Macroinvertebrates," *Freshwater Biology*, 8:141–151.

Grant County PUD, 1991. *Priest Rapids/Wanapum Land Use Plan*. Grant County Public Utility District, Ephrata, Washington.

Grant County PUD, 1992. *Priest Rapids/Wanapum Land Use Plan*. Grant County Public Utility District, Ephrata, Washington.

Grant County PUD, 2003. *Priest Rapids Hydroelectric Project No. 2114, Relicensing Report.* Grant County Public Utility District, Ephrata, Washington.

Greene, K.E., J.C. Ebbert, and M.D. Munn, 1996. *Nutrients, Suspended Sediment, and Pesticides in Streams and Irrigation Systems in the Central Columbia Plateau in Washington and Idaho, 1959–1991,* USGS Water Resources Investigations Report No. 94-4215, Tacoma, Washington.

Griffith, M.B., and S.A. Perry, 1993. "The Distribution of Macroinvertebrates in the Hyporheic Zone of Two Small Appalachian Headwater Streams," *Archiv fuer Hydrobiologie*, 126(3):373–384.

Groot, C., L. Margolis, and W.C. Clarke (editors), 1995. *Physiological Ecology of Pacific Salmon*. University of British Columbia Press, Vancouver, Canada.

Haas, G.E., R. Aukerman, V. Lovejoy, and D. Welch, 2004. *Water Recreation Opportunity Spectrum System (WROS) Users' Guidebook*. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado. < http://www.usbr.gov/pmts/planning/wros/>. Accessed September 9, 2008.

Hall, L.S., P.R. Krausman, and M.L. Morrison, 1997. "The Habitat Concept and a Plea for Standard Terminology," *Wildlife Society Bulletin*, 25(1):173–182.

Hallock, D., 2006. *Washington State Water Quality Conditions in 2005 Based on Data from Freshwater Monitoring Unit*, Publication No. 06-03-030, November 2006. Washington State Department of Ecology, Environmental Assessment Program, Olympia, Washington. <http://www.ecy.wa.gov/biblio/0603030.html>. Accessed September 9, 2008.

Hamlet, A.F., and D.P. Lettenmaier, 1999. "Effects of Climate Change on Hydrology and Water Resources in the Columbia River Basin," *Am. Water Res. Assoc*., 35(6):1597–1623.

Hamlet A.F., P.W. Mote, M.P. Clark, and D.P. Lettenmaier, 2007. "20th Century Trends in Runoff, Evapotranspiration, and Soil Moisture in the Western U.S.," *J. Climate*, 20 (8): 1468–1486.

Hansen, A.J., Jr., J.J. Vaccaro, and H.H. Bauer, 1994. *Ground-Water Flow Simulation of the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho*, USGS Water Resources Investigations Report 91-4187, Tacoma, Washington.

Harbaugh, A.W., E.R. Banta, M.C. Hill, and M.G McDonald, 2000. *MODFLOW-2000: The U.S. Geological Survey Modular Ground-Water Model: User Guide to Modularization Concepts and the Ground-Water Flow Process*, USGS Open File Report 2000-92, 121 pp.

Haring, D., 2001. *Habitat Limiting Factors, Yakima River Watershed, Water Resource Inventory Areas 37–39: Final Report*. Washington State Conservation Commission, 364 pp.

Hays, D.W., 2001. *Washington Pygmy Rabbit Emergency Action Plan for Species Survival-Addendum to Washington State Recovery Plan for the Pygmy Rabbit (1995)*. Washington Department of Fish and Wildlife, Wildlife Program, Olympia, Washington.

Hess, A.D., and C.C. Kiker, 1943. "Water Level Management for Malaria Control on Impounded Waters," *Journal of the National Malaria Society*, 3:181–196.

Hicks, M., 2002. *Establishing Surface Water Quality Criteria for the Protection of Agricultural Water Supplies*. Washington State Department of Ecology, Water Quality Program, Department of Ecology Publications Distributions Office, Olympia, Washington.

Hiebert, S., 1999. *Limnological Surveys of Five Reservoirs in the Upper Yakima River Basin, Washington, August 3–7, 1998: Progress Report*. Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Hill, M.T., W.S. Platts, and R.L. Bescha, 1991. "Ecological and Geomorphological Concepts for Instream and Out-of-Channel Flow Requirements," *Rivers,* 2(3):198–210.

Hilldale, R.C., and D. Raff, 2008. "Assessing the Ability of Airborne LiDAR to Map River Bathymetry," *Earth Surf. Process. Landforms*, 33:773–783.

Hockersmith, E., J. Vella, and L. Stuehrenberg, 1995. *Yakima River Radio-Telemetry Study: Steelhead, 1989–1993*, Annual Report Submitted to Bonneville Power Administration, DOE/BP-00276-3, Portland, Oregon.

Hopkins, B.S., D.K. Clark, M. Schlender, and Stinson, 1985. *Basic Water Monitoring Program Fish Tissue and Sediment Sampling for 1984*, Publication No. 85-7. Washington State Department of Ecology, Olympia, Washington. <http://www.ecy.wa.gov/biblio/857.html>. Accessed September 9, 2008.

Hughes, G., 2008. Personal communication. Manager, Arid Land Ecology Reserve, U.S. Fish and Wildlife Service, June 10, 2008.

Huppert, D., G. Green, W. Beyers, A. Subkoviak, and A. Wenzl, 2004. *Economics of Columbia River Initiative: Final Report to the Washington Department of Ecology and CRI Economics Advisory Committee*. University of Washington and Seattle University. <http://www.ecy.wa.gov/programs/WR/cri/Images/PDF/crieconrept_es_final.pdf>. Accessed September 9, 2008.

Hynes, H.B.N., 1970. *The Ecology of Running Waters*. University of Toronto Press, Waterloo, Ontario, Canada, 555 pp.

Hynes, H.B.N., 1975. "The Stream and its Valley," *Verhandlung Internationale Vereingung de Limnologie,* 19:1–15.

Independent Economic Analysis Board, 2005. *Economic Effects from Columbia River Basin Anadromous Salmonid Fish Production.* Northwest Power and Conservation Council, IEAB 2005-1, December 2005.

IPCC, 2000. *Special Report on Emission Scenarios.* N. Nakicenovic and R. Swart, editors. Cambridge University Press, 570 pp. <http://www.grida.no/climate/ipcc/emission/>. Accessed September 9, 2008.

IPCC, 2001. *Climate Change 2001: The Scientific Basis,* Contribution of Working Group I to the Third Assessment Report of the IPCC, J.T. Houghton, Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, and C.A. Johnson, editors. Intergovernmental Panel on Climate Change, Cambridge University Press, 881 pp. <http://www.grida.no/CLIMATE/IPCC_TAR/WG1/index.htm>. Accessed September 9, 2008.

IPCC, 2007. *Climate Change 2007: The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the IPCC, S. Soloman, D. Qin, M. Manning, M. Marquis, K. Averyt, M.M.B. Tignor, H.L. Miller, and Z. Chen, editors. Intergovernmental Panel on Climate Change, Cambridge University Press, 996 pp. <http://news.bbc.co.uk/2/shared/bsp/hi/pdfs/02_02_07_climatereport.pdf>. Accessed September 9, 2008.

Irvine, J.R., 1985. "Effects of Successive Flow Perturbations on Stream Invertebrates," *Canadian Journal of Fisheries and Aquatic Science*, 42:1922–1927.

Isley, S., 2007. Personal communication. Washington State Department of Ecology, November 30, 2007.

Jenkins, C.T., 1968. *Computation of Rate and Volume of Stream Depletion by Wells.* USGS Techniques of Water Resources Investigations, D1-4. <http://pubs.usgs.gov/twri/twri4d1/>. Accessed September 9, 2008.

Johnson, A., D. Norton, and B. Yake, 1986. *Occurrence and Significance of DDT Compounds and Other Contaminants in Fish, Water, and Sediment from the Yakima River Basin*, Publication No. 86-5. Washington State Department of Ecology, Olympia, Washington. <http://www.ecy.wa.gov/biblio/865.html>. Accessed September 9, 2008.

Johnson, A., 2006. *Quality Assurance Project Plan: Chlorinated Pesticides, PCBs, and Dioxins in Yakima River Fish - 2006: Assessing Progress Toward TMDL Targets and Updating the Fish Consumption Advisory*, Publication No. 06-03-111. Washington State Department of Ecology, Olympia, Washington. <http://www.ecy.wa.gov/biblio/0603111.html>. Accessed September 9, 2008.

Johnson, A., 2007. *Quality Assurance Project Plan: Yakima River Chlorinated Pesticides, PCBs, Suspended Sediment, and Turbidity Total Maximum Daily Load Study,* Publication No. 07-03-107, July 2007. Washington State Department of Ecology, Environmental Assessment Program, Olympia, Washington. <http://www.ecy.wa.gov/biblio/0703107.html>. Accessed September 9, 2008.

Johnson, K.P., and J.R. Kort, 2004. "2004 Redefinition of the BEA Economic Areas," *Survey of Current Business*, November, 68–75.

Jones, M.A., J.J. Vaccaro, and A.M. Watkins, 2006. *Hydrogeologic Framework of Sedimentary Deposits in Six Structural Basins, Yakima River Basin, Washington,* USGS Scientific Investigations Report 2006-5116, 24 pp. <http://pubs.usgs.gov/sir/2006/5116/section6.html>. Accessed September 9, 2008.

Joy, J., 2002. *Upper Yakima River Basin Suspended Sediment and Organochlorine Pesticide Total Maximum Daily Load,* Publication No. 02-03-012. Washington State Department of Ecology, Olympia, Washington. <http://www.ecy.wa.gov/biblio/0203012.html>. Accessed September 9, 2008.

Joy, J., and B. Patterson, 1997. *A Suspended Sediment and DDT Total Maximum Daily Load Evaluation Report for the Yakima River,* Publication No. 97-321. Washington State Department of Ecology, Olympia, Washington. <http://www.ecy.wa.gov/biblio/97321.html>. Accessed September 9, 2008.

Junk, W.J., P.B. Bayley, and R.E. Sparks, 1989. "The Flood Pulse Concept in River-Floodplain Systems," Proceedings of the International Large River Symposium, D.P. Dodge, editor, *Canadian Journal of Fisheries and Aquatic Sciences.,* 106, pp. 110–127.

Kardouni, J., and A. Stohr, 2005. *Quality Assurance Project Plan: Upper Yakima Basin Temperature Total Maximum Daily Load Study,* Publication No. 05-03-111, June 2005. Washington State Department of Ecology, Environmental Assessment Program, Olympia, Washington. <http://www.ecy.wa.gov/biblio/0503111.html>. Accessed September 9, 2008.

Karr, J.R., 1991. "Biological Integrity: A Long-Neglected Aspect of Water Resource Management," *Ecological Applications,* 1:66–84.

Karrenberg, S., P.J. Edwards, and J. Kollmann, 2002. "The Life History of Salicaceae Living in the Active Zone of Floodplains," *Freshwater Biology*, 47:733–748.

Kaval, P., and J. Loomis, 2003. *Updated Outdoor Recreation Use Values with Emphasis on National Park Recreation*, Final Report to NPS, Fort Collins, Colorado, Cooperative Agreement No. CA 1200-99-009.

Keller, E.A., and F.J. Swanson, 1979. "Effects of Large Organic Material on Channel Form and Fluvial Processes," *Earth Surface Processes and Landforms,* 4:361–380.

Kinnison H.B., and J.E. Sceva, 1963. *Effects of Hydraulic and Geologic Factors on Streamflow of the Yakima River Basin Washington*, USGS Water Supply Paper 1595.

Kirk, T., and T. Mackie, 1993. *Black Rock-Moxee Valley Groundwater Study*, Report No. OFTR 93-1. Washington Department of Ecology, 79 pp. <http://www.ecy.wa.gov/biblio/oftr9301.html>. Accessed September 9, 2008.

Kittitas County, 1992. Zoning Ordinance: Forest and Range, Ordinance 92-6 (part), 1992. Unofficial version is at: <http://www.co.kittitas.wa.us/boc/countycode/title17.asp#Chapter_17.56>. Accessed September 9, 2008.

Kittitas County, 2006. *Comprehensive Plan*. <http://www.co.kittitas.wa.us/cds/compplan.asp#2006>. Accessed September 9, 2008.

Knowles, C.J., and R.G. Gumtow, 1996. *Saving the Bull Trout.* The Thoreau Institute, Oak Grove, Oregon, 21 pp.

Komar, N., S. Langevin, S. Hinten, N. Nemeth, E. Edwards, D. Hettler, B. Davis, R. Bowen, and M. Bunning, 2003. "Experimental Infection of North American Birds with the New York 1999 Strain of West Nile Virus," *Emerging Infectious Diseases,* 9(3):311–322.

Kulasekera, V.L., L. Kramer, R.S. Nasci, F. Mostashari, B. Cherry, S.C. Trock, C. Glaser, and J.R. Miller, 2001. "West Nile Virus Infection in Mosquitoes, Birds, Horses, and Humans, Staten Island, New York, 2000," *Emerging Infectious Diseases*, 7(4).

Lai, Y.G., 2006. *Theory and User Manual for SRH-W. Version 1.1*. Sedimentation and River Hydraulics Group, Bureau of Reclamation, Denver, Colorado. <http://www.usbr.gov/pmts/sediment/model/srh2d/Downloads/SRH-W%20v1.1%20User%20Manual%20June2007.pdf>. Accessed September 9, 2008.

Lancaster, J., and A.G. Hildrew, 1993. "Characterizing In-Stream Flow Refugia," *Canadian Journal of Fisheries and Aquatic Science*, 50:1663–1675.

Lawler, S.P., and G.C. Lanzaro, 2005. *Managing Mosquitoes on the Farm,* Publication 8158. University of California, Division of Agriculture and Natural Resources. <http://www.ucmrp.ucdavis.edu/publications/managingmosquitoesonthefarm.html>. Accessed September 9, 2008.

Lenihan, D.J., T.L. Carrell, S. Fosberg, S.L. Ray, and J.A. Ware, 1981. *The Final Report of the National Reservoir Inundation Study,* vols. 1 and 2. National Park Service, Southwest Regional Office, Santa Fe, New Mexico.

Leopold, L.B., M.G. Wolman, and J.P. Miller, 1964. *Fluvial Processes in Geomorphology*. W.H. Freeman and Company, San Francisco, California.

Liang, X., D.P. Lettenmaier, E.F. Wood, and S.J. Burges, 1994. "A Simple Hydrologically Based Model of Land Surface Water and Energy Fluxes for General Circulation Models," *Journal of Geophysical Research,* 99, (D7):14415–14428.

Ligon, F.K., W.E. Dietrich, and W.J. Trush, 1995. "Downstream Ecological Effects of Dams," *Bioscience,* 45(3):183–192.

Lilga, M.C., 1998. "Effects of Flow Variation on Stream Temperatures in the Lower Yakima River," Master's thesis, Washington State University.

Lindsey, K.A., T.L. Tolan, and M. Nielson, 2003. *Hydrogeology of the Columbia Basin Groundwater Management Area, Adams, Grant and Franklin Counties, Washington*,4th Symposium on the Geology of Washington State Conference, April 6–10, 2003, Tacoma, Washington, 81 pp.

Lisle, T.E., 1986. "Effect of Woody Debris on Anadromous Salmonid Habitat, Prince of Wales Island, Southeast Alaska," *North American Journal of Fisheries Management*, 6:538–550.

Littlefield, C.D., and G.L. Ivey, 2001. *Washington State Recovery Plan for the Sandhill Crane*. Washington Department of Fish and Wildlife, Olympia, Washington.

Livingston, M., 2007. Personal communication. Washington Department of Fish and Wildlife.

Lytle, D.A., and D.M. Merritt, 2004. "Hydrologic Regimes and Riparian Forests: A Structured Population Model For Cottonwood," *Ecology*, 85:2493–2503.

Lytle, D.A., and N.L. Poff, 2004. "Adaptation to Natural Flow Regimes," *Trends in Ecology and Evolution,* 19:94–100.

MacDonald, K., S. Noble, and J. Haskins, 1996. *An Assessment of the Status of Aquatic Resources Within Subbasins on the Wenatchee National Forest*. U.S. Forest Service.

MacDonnell, L.J., 1995. *Water Banks: Untangling the Gordian Knot of Western Water.* Rocky Mountain Mineral Law Institute, University of Colorado.

Madder, D.J., G.A. Surgeoner, and B.V. Helson, 1983. "Number of Generations, Egg Production, and Developmental Time of *Culex pipiens* and *Culex restuans* (Diptera: Culicidae) in Southern Ontario," *Journal of Medical Entomology,* 20(3):275–287.

Mahoney, J.M., and S.B. Rood, 1998. "Streamflow Requirements for Cottonwood Seedling Recruitment – an Integrative Model," *Wetlands,* 18:634–645.

Mann, C., 2003. Personal communication. Air quality specialist, Benton County Air Authority, Kennewick, Washington.

Mastin, M.C., and W. Sharp, 2006. *Comparison of Simulated Runoff in the Yakima River Basin, Washington, for Present and Global Climate-Change Conditions*, Proceedings: Third Federal Interagency Hydrologic Modeling Conference. Subcommittee on Hydrology, a Subcommittee of the Advisory Committee on Water Information, Reno Nevada. <http://wa.water.usgs.gov/ projects/yakimawarsmp/data/9EKT2_03_approved.pdf>. Accessed September 9, 2008.

McCartney, K., 2007. Personal communication. Yakima Basin Storage Study Manager, September 2007. U.S. Department of the Interior, Bureau of Reclamation, Upper Columbia Area Office, Yakima, Washington.

McCorquodale, S.M., 1985. "Archaeological Evidence of Elk in the Columbia Basin," *Northwest Science*, 59(3):192–197.

McCorquodale, S.M., I.I. Eberhardt, and L.E. Eberhardt, 1988. "Dynamics of a Colonizing Elk Population," *Journal of Wildlife Management*, 52:309–313.

McCullough, D.A., 1999. *A Review and Synthesis of Effects of Alterations to the Water Temperature Regime on Freshwater Life Stages of Salmonids, with Special Reference to Chinook Salmon.* Columbia Intertribal Fisheries Commission, Portland, Oregon. Prepared for U.S. Environmental Protection Agency, Region 10. Published as EPA 910-R-99-010, 279 pp. <http://www.critfc.org/ tech/ EPAreport.htm>. Accessed September 9, 2008.

McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wissmar, S.E. Clarke, G.H. Reeves, and L.A. Brown, 1994. "Historical Changes in Fish Habitat for Selected River Basins of Eastern Oregon and Washington," *Northwest Science,* 68:36–53.

McIntosh, B.A., J.R. Sedell, R.F. Thurow, S.E. Clarke, and G.L. Chandler, 2000. "Historical Changes in Pool Habitats in the Columbia River Basin," *Ecological Applications*, 10:1478–1496.

McKay, K.L., and N.F. Renk, 2002. *Currents and Undercurrents: An Administrative History of Lake Roosevelt National Recreation Area.* U.S. Department of the Interior, National Park Service. <http://eric.ed.gov/ ERICWebPortal/custom/portlets/recordDetails/detailmini.jsp?_nfpb=true&_&ERICExtSearch_SearchValue_0=ED476001&ERICExtSearch_SearchType_0=no&accno=ED476001>. Accessed September 9, 2008.

McPhail, J.D., and C.B. Murray, 1979. *The Early Life-History and Ecology of Dolly Varden (Salvelinus malma) in the Upper Arrow Lakes*. Department of Zoology and Institute of Animal Resources, University of British Columbia, Vancouver, British Columbia, Canada.

Medina, V.F., and S. Vedula, 2002. *Kennewick Irrigation District Water Quality Project: Data From Years 2000 and 2001*. Washington State University Tri-Cities, Richland, Washington.

Meehan, W.R., and T.C. Bjornn, 1991. "Salmonid Distributions and Life Histories," *Influences of Forest and Rangeland Management on Salmonid Fishes and their Habitats*, Special Publication No. 19. American Fisheries Society Bethesda, Maryland, pp. 47–82.

Mentor, J., and J. Morin, 2007. "Water Banking: Mirage or Delusion?" *Washington-American Water Resources Association (WA-AWRA) Section Newsletter*. July-August 2007.

Mizell, M., 2006. Personal communication. Discussions about migration and holding areas for radio-tagged bull trout in the Naches River between 2004 and 2006. Washington Department of Fish and Wildlife.

Mongillo, P., and L. Faulconer, 1982. *Yakima Fisheries Enhancement Study Phase II Final Report.* Washington Department of Game, pp. 120.

Montgomery, D.R., J.M. Buffington, N.P. Peterson, D. Scheutt-Hames, and T.P. Quinn, 1996. "Streambed Scour, Egg Burial Depths and the Influence of Salmonid Spawning on Bed Surface Mobility and Embryo Survival," *Canadian Journal of Fisheries and Aquatic Science,* 53:1061–1070.

Montgomery, D.R., and H. Piegay, 2003. "Wood in Rivers: Interactions with Channel Morphology and Processes," *Geomorphology*, 51:1–5.

Montgomery, D.R., and E.E. Wohl, 2003. "Rivers and Riverine Landscapes," *Development in Quaternary Science,* 1:221–246.

Montgomery, D.R., B.D. Collins, J.M. Buffington, and T.B. Abbe, 2003. "Geomorphic Effects of Wood in Rivers," *American Fisheries Society*.

Montgomery, W.L., S.D. McCormick, R.J. Naiman, F.G. Whoriskey, and G.A. Black, 1983. "Spring Migratory Synchrony of Salmonid, Catastomid, and Cyprinid Fishes in Riviere je la Truite, Quebec," *Canadian Journal of Zoology*, 61:2495.

Moog, O., 1993. "Quantification of Daily Peak Hydropower Effects on Aquatic Fauna and Management to Minimize Environmental Impacts," *Regulated Rivers: Research and Management*, 8:5–14.

Morace, J.L., and S.W. McKenzie, 2002. *Fecal-Indicator Bacteria in the Yakima River Basin, Washington: An Examination of 1999 and 2000 Synoptic-Sampling Data and Their Relation to Historical Data*, USGS Water Resources Investigations Report No. 02-4054, Portland, Oregon.

Morace, J.L., G.J. Fuhrer, J.F. Rinella, and S.W. McKenzie et al., 1999. *Surface-Water-Quality Assessment of the Yakima River Basin in Washington: Overview of Major Findings, 1987–91*, USGS Water Resources Investigations Report No. 98-4113, Portland, Oregon. <http://or.water.usgs.gov/pubs_dir/Abstracts/98-4113.html>. Accessed September 9, 2008.

Morgan, R.P., R.E. Jacobson, S.B. Weisberg, L.A. McDowell, and H.T. Wilson, 1991. "Effects of Flow Alteration to Benthic Macroinvertebrate Communities Below the Brighton Hydroelectric Dam," *Journal of Freshwater Ecology*, 6(4):419–429.

Morrison, M.L., B.G. Marcot, and R.W. Manan, 1978. *Wildlife-Habitat Relationships: Concepts and Applications.* University of Wisconsin Press, Madison, Wisconsin.

Mote, P.W., 2003. "Trends in Snow Water Equivalent in the Pacific Northwest and their Climatic Causes," *Geophysical Research Letters* 30 (12):1601, doi:10.1029/2003GL017258.

Mote, P.W., D.J. Canning, D.L. Fluharty, R.C. Francis, J.F. Franklin, A.F. Hamlet, M. Hershman, M. Holmberg, K.N. Ideker, W.S. Keeton, D.P. Lettenmaier, L.R. Leung, N.J. Mantua, E.L. Miles, B. Noble, H. Parandvash, D.W. Peterson, A.K. Snover, and S.R. Willard, 1999. *Impacts of Climate Variability and Change, Pacific Northwest.* National Atmospheric and Oceanic Administration, Office of Global Programs, and JISAO/SMA Climate Impacts Group, Seattle, Washington, 110 pp.

Mote, P.W., E.A. Parson, A.F. Hamlet, K.G. Ideker, W.S. Keeton, D.P. Lettenmaier, N.J. Mantua, E.L. Miles, D.W. Peterson, D.L. Peterson, R. Slaughter, and A.K. Snover, 2003. "Preparing for Climatic Change: the Water, Salmon, and Forests of the Pacific Northwest," *Climatic Change*, 61 (12):45–88.

Mote, P.W., 2006. "Climate-Driven Variability and Trends in Mountain Snowpack in Western North America," *Journal of Climate,* 19 (23):6209–6220.

Naesje, T., B. Jonsson, and J. Skurdal, 1995. "Spring Floods: A Primary Cue of Hatching of River Spawning Coregoninae," *Canadian Journal of Fisheries and Aquatic Sciences*, 52:2190–2196.

Naiman, R.J., T.J. Beechie, L.E. Benda, D.R. Berg, P.A. Bisson, and L.H. MacDonald, 1992. "Fundamental Elements of Ecologically Healthy Watersheds in the Pacific Northwest Coastal Ecoregion," *Watershed Management*, R.J. Naiman, editor. Springer-Verlag, New York, New York, pp. 127–188.

Naiman, R.J., and H. Décamps, 1997. "The Ecology of Interfaces: The Riparian Zone," *Annual Review of Ecology and Systematics,* 28:621–658.

Naiman, R.J., K.L. Fetherston, S. McKay, and J. Chen, 1998. "Riparian Forests," *River Ecology and Management*, R.J. Naiman and R.E. Bilby, editors. Springer-Verlag, New York, New York, pp. 289–323.

Naiman, R.J., and J.J. Latterell, 2005. "Principles for Linking Fish Habitat to Fisheries Management and Conservation," *Journal of Fish Biology,* 67:166–185.

Naiman, R.J., H. Décamps, J. Pastor, and C.A. Johnston, 1988. "The Potential Importance of Boundaries to Fluvial Ecosystems," *Journal of the North American Benthological Society,* 7:289–306.

National Academy of Sciences and National Academy of Engineering, 1972. *Water Quality Criteria 1972: Report of the Committee on Water Quality Criteria*. Environmental Studies Board, National Academy of Sciences, Washington, DC.

National Audubon Society, 2002. *The Christmas Bird Count Historical Results*. Available at: <http://www.audubon.org/bird/cbc>. Accessed September 9, 2008.

National Marine Fisheries Service, 1996. *Factors for Decline, A Supplement to the Notice of Determination for West Coast Steelhead Under the Endangered Species Act*. National Oceanic and Atmospheric Administration - Fisheries, Protected Resources Branch, Portland, Oregon. <http://www.krisweb.com/biblio/gen_nmfs_nmfs_1996_stlhffd.pdf>. Accessed September 9, 2008.

National Marine Fisheries Service, 2004a. *Operation of the Federal Columbia River Power System (FCRPS) Including 19 Bureau of Reclamation Projects in the Columbia Basin (revised and reissued pursuant to court order, NWF* v. *NMFS, Civ. No. CV 01-640-RE [D. Oregon]).*

National Marine Fisheries Service, 2004b. *Critical Habitat Analytical Review Team (CHART) Report.* Department of Commerce, National Oceanographic and Atmospheric Administration.

National Marine Fisheries Service, 2008. *Remand of 2004 Biological Opinion on the Federal Columbia River Power System (FCRPS) Including 19 Bureau of Reclamation Projects in the Columbia Basin (revised pursuant to court order, NWF* v. *NMFS, Civ. No. CV 01-640-RE [D. Oregon]).*

National Technical Advisory Committee, 1968. *Water Quality Criteria 1968: Report of the National Technical Advisory Committee to the Secretary of the Interior*. Federal Water Pollution Control Administration, Washington, DC.

Natural Resources Conservation Service, 1997. *Water Quality and Agriculture Status, Conditions, and Trends*. U.S. Department of Agriculture.

Natural Resources Conservation Service, 2002. *Water Quality Technical Note Number 10: Water Quality Indicator Tools*. U.S. Department of Agriculture.

Natural Resources Consulting Engineering, 2001. *Vol. 1: Irrigation Water Conservation and Management Plan for the Wapato Irrigation Project: Draft Report*. Fort Collins, Colorado, pp. 6–50/51.

Naugle, D.E., C.L. Aldridge, B.L. Walker, T.E. Cornish, B.J. Moynahan, M.J. Holloran, K. Brown, G.D. Johnson, E.T. Schmidtmann, R.T. Mayer, C.Y. Kato, M.R. Matchett, T.J. Christiansen, W.E. Cook, T. Creekmore, R.D. Failse, E.T. Rinkes, and M.S. Boyle, 2004. "West Nile Virus: Pending Crisis for Greater Sage Grouse," *Ecology Letters* (2004), 7:704–713.

Negishi, J.N., M. Inque, and M. Nunokawa, 2002. "Effects of Channelisation on Stream Habitat in Relation to a Spate and Flow Refugia for Macroinvertebrates in Northern Japan," *Freshwater Biology*, 47(8):1515–1529.

Neitzel, D.A. (editor), 2005. *Hanford Site National Environmental Policy Act Characterization*, PNL-6415, Rev. 17. Pacific Northwest National Laboratory, Richland, Washington.

Nelson, L.M., 1979. *Sediment Transport by Irrigation Return Flows in the Lower Yakima River Basin, Washington, 1975 and 1976 Irrigation Seasons*, USGS Open File Report 78-946, Tacoma, Washington, 76 pp.

Nelson, S.M., 2004. *Aquatic Invertebrates Associated with Unregulated Tributaries and Reservoir Tailwaters in the Yakima Area: A Comparison with Other Reclamation Dams and Examples of Downstream Recovery*, Technical Memorandum No. 8220-05-01. U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.

Nelson, S.M., 2005. *Stream Macroinvertebrate Surveys in the Cle Elum and Bumping River Watersheds, Storage Dam Fish Passage Study, Yakima Project, Washington*, Technical Series No. PN-YDFP-002. Bureau of Reclamation, Boise, Idaho.

Nelson, S.M., and M. Bowen, 2004. *Environmental Parameters Associated with Chinook Salmon Redds in the Yakima and Cle Elum Rivers in Washington: Final Report*, Technical Memorandum No. 8220-04-01. U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.

Nesler, T.P., R.T. Muth, and A.F. Wasowicz, 1988. "Evidence for Baseline Flow Spikes as Spawning Clues for Colorado Squawfish in the Yampa River, Colorado," *American Fisheries Society Symposium,* 5:68–79.

Nilsson, C., and M. Svedmark, 2002. "Basic Principles and Ecological Consequences of Changing Water Regimes: Riparian Plant Communities," *Environmental Management*, 30:468–480.

Northwest Power Planning and Conservation Council, 2001. *Yakima Subbasin Summary,* Laura Berg, editor. Portland, Oregon, 336 pp.

Novitsky, P., 2005. Personal communication. U.S. Forest Service, Cle Elum Ranger District, June 9, 2005.

Northwest Power Planning Council (NPPC), 2001. *Yakima Subbasin Summary*, Laura Berg, editor. Portland, Oregon, 376 pp.

NRC, 1996. *Upstream: Salmon and Society in the Pacific Northwest.* National Research Council, Committee on Protection and Management of Pacific Northwest Anadromous Salmonids, National Academy Press, Washington, DC, 452 pp. Available for order at <http://www.nap.edu/openbook.php?isbn=0309053250>. Accessed September 9, 2008.

NRC, 2004. *Managing the Columbia River: Instream Flows, Water Withdrawals and Salmon Survival.* National Research Council of the National Academies. The National Academies Press, Washington, DC. Available for order at: <http://books.nap.edu/catalog.php?record_id=10962>. Accessed September 9, 2008.

NRC, 2005. *Valuing Ecosystem Resources: Toward Better Environmental Decision-Making.* National Research Council of the National Academies. The National Academies Press, Washington, DC. Available for order at: <http://www.nap.edu/openbook.php?isbn=030909318X>. Accessed September 9, 2008.

Nugent, J., T. Newsome, M. Nugent, W. Brock, P. Hoffarth, and P. Wagner, 2002a. *1999 Evaluation of Juvenile Fall Chinook Salmon Stranding on the Hanford Reach of the Columbia River*. Prepared for the Bonneville Power Administration and the Public Utility District No. 2 of Grant County, BPA Contract No. 9701400 and GCPUD Contracts Document 97BI30417. <http://wdfw.wa.gov/fish/papers/hanford_reach/1999_juv_fall_chin_stranding.htm>. Accessed September 9, 2008.

Nugent, J., T. Newsome, M. Nugent, W. Brock, P. Hoffarth, and P. Wagner-Washington, 2002b. *2000 Evaluation of Juvenile Fall Chinook Salmon Stranding on the Hanford Reach of the Columbia River*. Prepared for the Bonneville Power Administration and the Public Utility District No. 2 of Grant County, BPA Contract No. 9701400, GCPUD Contracts Document 97BI30417, 92 electronic pages, BPA Report No. DOE/BP-00004294-2. <http://wdfw.wa.gov/fish/papers/hanford_reach/ 2000_juv_fall_chin_ stranding.htm>. Accessed September 9, 2008.

Nugent, J., T. Newsome, P. Hoffarth, M. Nugent, W. Brock, and M. Kuklinski, 2002c. *2001 Evaluation of Juvenile Fall Chinook Salmon Stranding on the Hanford Reach of the Columbia River*. Prepared for the Bonneville Power Administration and the Public Utility District No. 2 of Grant County, BPA Contract No. 9701400 and GCPUD Contracts Document 97BI30417, 57 electronic pages, BPA Report DOE/BP-00004294-3. <http://wdfw.wa.gov/fish/papers/hanford_reach/ 2001_juv_fall_chin_stranding.htm>. Accessed September 9, 2008.

O'Connor, J.E., M.A. Jones, and T.L. Haluska, 2003. "Flood Plain and Channel Dynamics of the Quinault and Queets Rivers, Washington USA," *Geomorphology,* 51:31–59.

Paller, M.H., W.L. Specht, and S.A. Dyer, 2006. "Effects of Stream Size on Taxa Richness and Other Commonly Used Benthic Bioassessment Metrics," *Hydrobiologia,* 568:309–316.

Parker, P.L., and T.F. King, 1998. *Guidelines for Evaluating and Documenting Traditional Cultural Properties*, National Register Bulletin No. 38. National Park Service, Washington, DC. <http://www.nps.gov/history/nR/publications/ bulletins/nrb38/>. Accessed September 9, 2008.

Partridge, M., and D. Rickman, 2003. "The Waxing and Waning of Regional Economies: the Chicken-Egg Question of Jobs Versus People," *Journal of Urban Economics,* 53:76–97.

Payne, J.T., A.W. Wood, A.F. Hamlet, R.N. Palmer, and D.P. Lettenmaier, 2004. "Mitigating the Effects of Climate Change on the Water Resources of the Columbia River Basin," *Climatic Change*, 62(1–3):233–256.

Pearsons, T.N., G.A. McMichael, S.W. Martin, E.L. Bartrand, J.A. Long, and S.A. Leider, 1996. *Yakima Species Interactions Studies: Annual Report FY 1994*, BPA Report DOE/BP 99852 3. Bonneville Power Administration. <http://pisces.bpa.gov/release/ documents/documentviewer.aspx?pub= P99852-3.pdf>. Accessed September 9, 2008.

Pearsons, T.N., K.D. Ham, G.A. McMichael, E.L. Bartrand, A.L. Fritts, C.W. Hopley, 1998. *Yakima River Species Interactions Studies: Progress Report 1995–1997*, BPA Report DOE/BP-64878-5. Bonneville Power Administration, Portland, Oregon.

Pearsons, T., 2002. Personal communication. Ongoing conversations between T. Pearsons, fish biologist, Washington State Department of Fish and Wildlife, and Walter Larrick, fish biologist, U.S. Department of the Interior, Bureau of Reclamation.

Pfeifer, B., J.E Hagen, D. Weitkamp, D.H. Bennett, J. Lukas, and T. Dresser, 2001. *Evaluation of Fish Species Present in the Priest Rapids Project Area, Mid-Columbia River, Washington*. Prepared by Grant PUD. <http://wdfw.wa.gov/fish/papers/hanford_reach/2001_juv_fall_chin_stranding.htm>. Accessed September 9, 2008.

Phelps, S.R., B.M. Baker, and C.A. Busack, 2000. "Genetic Relationships and Stock Structure of Yakima River Basin and Klickitat River Basin Steelhead Populations" Washington Department of Fish and Wildlife Genetics Unit, Olympia, Washington, 56 pp. (unpublished report) <http://www.osti.gov/energycitations/servlets/purl/885224-blsSNT/885224.PDF>. Accessed September 9, 2008.

PNNL, 2006. *Summary of the Hanford Site Environmental Report for Calendar Year 2005,* PNNL-15892. Prepared for the U.S. Department of Energy by Pacific Northwest National Laboratory, Richland, Washington. <http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15892sum.pdf>. Accessed September 9, 2008.

PNNL, 2007. *The Black Rock Reservoir Study: Results of the Borehole Hydrologic Field Testing Characterization Program at the Potential Damsite Southern Abutment Location*. Pacific Northwest National Laboratory, Richland, Washington.

Poff, N.L., and J.V. Ward, 1989. "Implications of Streamflow Variability and Predictability for Lotic Community Structure: A Regional Analysis of Streamflow Patterns," *Canadian Journal of Fisheries and Aquatic Science,* 46:1805–1817.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg, 1997. "The Natural Flow Regime: A Paradigm for River Conservation and Restoration," *Bioscience,* 47:11 769–784.

Poole, G.C., and C.H. Berman, 2001. "An Ecological Perspective in In-Stream Temperature: Natural Heat Dynamics and Mechanisms of Human-Caused Thermal Degradation," *Environmental Management*, 27:787–802.

Potter, A., J. Fleckenstein, S. Richardson, and D. Hays, 1999. *Washington State Status Report for the Mardon Skipper*. Washington Department of Fish and Wildlife, Wildlife Management Program, Olympia, Washington.

Power, M.E., A. Sun, G. Parker, W.E. Dietrich, and J.T. Wootton, 1995. "Hydraulic Foodchain Models," *BioScience,* 45:159–167.

Pratt, H.D., and C.G. Moore, 1993. *Mosquitoes of Public Health Importance and their Control.* Self-study course 3013-G, Vector-Borne Disease Control. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention. <http://www.cdc.gov/ncidod/dvbid/westnile/education.htm>. Accessed September 9, 2008.

Pringle, C.M., R.J. Naiman, G. Bretschko, J. Karr, M. Oswood, J. Webster, R. Welcomme, and M.J. Winderbourn, 1988. "Patch Dynamics in Lotic Systems: The Stream as a Mosaic," *Journal of the North American Benthological Society,* 7:503–524.

Quinn, J.M., and C.W. Hickey, 1994. "Hydraulic Parameters and Benthic Invertebrate Distributions in Two Gravel-Bed New Zealand Rivers," *Freshwater Biology*, 32:489–500.

Ralph, S.C., G.W. Poole, L.L. Conquest, and R.J. Naiman, 1994. "Stream Channel Morphology and Woody Debris in Logged and Unlogged Basins of Western Washington," *Canadian Journal of Fisheries and Aquatic Science,* 51:37–51.

Ratliff, D.E., and P.J. Howell, 1992. "The Status of Bull Trout Populations in Oregon," *Proceedings of the Gearhart Mountain Bull Trout Workshop*, P.J. Howell and D.V. Buchanon, editors. Oregon Chapter of the American Fisheries Society, Corvallis, Oregon, pp. 10–17.

Reclamation and Service, 1966. *Bumping Lake Enlargement Joint Feasibility Report.* U.S. Department of the Interior, Bureau of Reclamation and U.S. Fish and Wildlife Service, Boise, Idaho, January 1966.

Reclamation, 1979. *Proposed Bumping Lake Enlargement, Final Environmental Impact Statement*.

Reclamation, 1988. *Addendum: Geologic Report for Wymer Damsite, Yakima River Basin Water Enhancement Project, Washington.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Division of Design and Construction, Geology Branch, December 1988, 18 pp.

Reclamation, 1996. *Yakima River Basin Water Enhancement Project Plan of Study for Preparation of a Programmatic Environmental Impact Statement.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho.

Reclamation, 1999. *Yakima River Basin Water Enhancement Project, Washington, Final Programmatic Environmental Impact Statement.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington.

Reclamation, 2000. *Biological Assessment: Yakima Project Operations and Maintenance: Supplement to the December 1999 Biological Assessment on the Federal Columbia River Power System.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington, 236 pp.

Reclamation, 2001. *Keechelus Safety of Dams Modification, Final Environmental Impact Statement.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho.

Reclamation, 2002a. *Interim Comprehensive Basin Operating Plan, Yakima Project, Washington.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington.

Reclamation, 2002b. *Scoping Summary: Kennewick and Columbia Irrigation Districts Pump Exchange Planning Report and Environmental Impact Statement, Yakima Project, Washington.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington.

Reclamation, 2003a. *Phase I Assessment Report: Storage Dam Fish Passage Study.* September 2003 (revised April 2005). U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho.

Reclamation, 2003b. *Summary of Upper Yakima River Steelhead Movements: Winter 2002/2003.* U.S. Department of the Interior, Bureau of Reclamation. Prepared in cooperation with the Yakama Nation and the University of Idaho.

Reclamation, 2003c. *Endangered Species Act, Section 7 Consultation, Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act: Essential Fish Habitat Consultation.* U.S. Department of the Interior, Bureau of Reclamation.

Reclamation, 2003d. *Yakima Hydromet Archive Data Access.* U.S. Department of the Interior, Bureau of Reclamation. <http://mac1.pn.usbr.gov/yakima/yakwebarcread.htm>. Accessed September 9, 2008.

Reclamation, 2004a. *Summary Report, Appraisal Assessment of the Black Rock Alternative*, Technical Series No. TS-YSS-7. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho.

Reclamation, 2004b. *Probabilistic Seismic Hazard Assessment for Appraisal Studies of the Proposed Black Rock Dam*, Technical Series No. D-8330-2004-14. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho.

Reclamation, 2004c. *Appraisal Assessment of the Black Rock Alternative Facilities and Field Cost Estimates*, Technical Series No. TS-YSS-2. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado. <http://www.usbr.gov/pn/programs/storage_study/facilities-fieldcost.html>. Accessed September 9, 2008.

Reclamation, 2004d. *Preliminary Appraisal Assessment of Columbia River Water Availability for a Potential Black Rock Project*, Technical Series No. TS-YSS-1. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Regional Office, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-01/watavail.pdf>. Accessed September 9, 2008.

Reclamation, 2004e. *Appraisal Assessment of the Black Rock Project Delivery System for Roza, Terrace Heights, Selah-Moxee, and Union Gap Irrigation Districts*, Technical Series No. TS-YSS-3. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Construction Office, Yakima, Washington. <http://www.usbr.gov/pn/programs/storage_study/roza.html>. Accessed September 9, 2008.

Reclamation, 2004f. *Appraisal Assessment of the Black Rock Alternative Delivery System for Sunnyside Division,* Technical Series No. TS-YSS-4. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/sunnyside.html>. Accessed September 9, 2008.

Reclamation, 2004g. *Appraisal Assessment of Geology at a Potential Black Rock Damsite*, Technical Series No. TS-YSS-5. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/geology.html>. Accessed September 9, 2008.

Reclamation, 2004h. *Appraisal Assessment of Hydrogeology at a Potential Black Rock Damsite*, Technical Series No. TS-YSS-6. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/reports/ ts-yss-06/ts-yss-06.pdf>. Accessed September 9, 2008.

Reclamation, 2004i. *Sunnyside Division Conservation Project Final Environmental Assessment*. Sunnyside Division Board of Control Water Conservation Project, U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington. <http://www.usbr.gov/pn/programs/ea/wash/sunnyside/ea.pdf>. Accessed September 9, 2008.

Reclamation, 2005. *Steelhead Movements in the Upper Yakima Basin, Winter 2003–2004*, Technical Memorandum 8290-05-01. Prepared in cooperation with the Yakama Nation and the University of Idaho. U.S. Department of the Interior, Bureau of Reclamation. <http://www.usbr.gov/pmts/fish/Reports/KarpSteelheadUpperYakima2005.pdf>. Accessed September 9, 2008.

Reclamation, 2006a. *Yakima River Basin Storage Alternatives Appraisal Assessment,* Technical Series No. TS-YSS-8. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-08/fullreport-yakima_alternatives_appraisal_assessment.pdf>. Accessed September 9, 2008.

Reclamation. 2006b. S*torage Study Team Technical Information and Hydrologic Analysis for Plan Formulation*. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington. <http://www.usbr.gov/pn/programs/storage_study/reports/techinfo/fulldocument.pdf>. Accessed September 9, 2008.

Reclamation, 2006c. *2006 M&I Water Rate Survey Data*. Bureau of Reclamation, Office of Program and Policy Services, Contract Services Office, Denver, Colorado.

Reclamation, 2006d. *Columbia River Water Exchange Direct Delivery Appraisal Study*, Technical Series No. TS-YSS-9. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-09/report.pdf>. Accessed September 9, 2008.

Reclamation, 2006e. *Appraisal Assessment of the Yakima River Pump Exchange Alternative Delivery System for Roza and Sunnyside Valley Irrigation Districts*, Technical Series No. TS-YSS-11. Prepared by Golder Associates for the U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-11/report.pdf>. Accessed September 9, 2008.

Reclamation, 2007a. *Modeling Groundwater Hydrologic Impacts of the Potential Black Rock Reservoir,* Technical Series No. TS-YSS-19. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-19/index.html>. Accessed September 9, 2008.

Reclamation, 2007b. *One-Dimensional Hydraulic Modeling of the Yakima Basin*, Technical Series No. TS-YSS-14. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-14/fullreport.pdf>. Accessed September 9, 2008.

Reclamation, 2007c. *Wymer Dam and Reservoir Appraisal Report*, Technical Series No. TS-YSS-16. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-19/>. Accessed September 9, 2008.

Reclamation, 2007d. *Yakima River Fishery Economics Technical Report.* U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Economics and Resource Planning Group, August 2007, Denver, Colorado.

Reclamation, 2007e. *Potholes Reservoir Supplemental Feed Route Draft Environmental Assessment.* U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington. <http://www.usbr.gov/pn/programs/ea/wash/potholes/index.html>. Accessed September 9, 2008.

Reclamation, 2007f. *General Description of Yakima Basin Irrigation Project*. Bureau of Reclamation, August 10, 2007. <http://www.usbr.gov/dataweb/html/yakima.html>. Accessed September 9, 2008.

Reclamation, 2007g. *Recreation Demand and User Preference Analysis*, Technical Series No. TS-YSS-10. U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado. < http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-10/index.html>. Accessed September 9, 2008.

Reclamation, 2007h. *Identifying Stream Habitat Features with a Two-Dimensional Hydraulic Model*, Technical Series No. TS-YSS-12. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-12/2Dmodel.pdf>. Accessed September 9, 2008.

Reclamation 2007i. *Sediment Transport Modeling of the Yakima Basin*, Technical Series No. TS-YSS-17. U.S. Department of the Interior, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-17/sediment-report.pdf>. Accessed September 9, 2008.

Reclamation, 2007j. *Supplemental Report for Appraisal Assessment: Geology and Hydrogeology, Right Abutment, Black Rock Damsite*, Technical Series No. TS-YSS-18. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-18/index.html>. Accessed September 9, 2008.

Reclamation and Ecology, 2007a. *Yakima River Basin Water Storage Feasibility Study, Planning Report and Environmental Impact Statement, Scoping Summary Report, Yakima Project, Washington, Pacific Northwest Region*. U.S. Department of the Interior, Bureau of Reclamation and Washington State Department of Ecology.

Reclamation and Ecology, 2007b. *Appraisal Evaluation of Columbia River Mainstem Off-Channel Storage Options*. U.S. Department of the Interior, Bureau of Reclamation and Washington State Department of Ecology. <http://www.ecy.wa.gov/programs/wr/cwp/cr_mainstem_storage.html>. Accessed September 9, 2008.

Reclamation, 2008a. *Modeling Mitigation of Seepage from the Potential Black Rock Reservoir*, Technical Series No. TS-YSS-25. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho.

Reclamation, 2008b. *System Operations Technical Document,* Technical Series No. TS-YSS-21. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-21/fullreport.pdf>. Accessed September 9, 2008.

Reclamation, 2008c. *Yakima River Basin Reservoir and River Recreation Survey Report of Findings,* Technical Series No. TS-YSS-15. Prepared by Aukerman, Haas, and Associates, LLC, for U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-15/recreation-survey.pdf>. Accessed September 9, 2008.

Reclamation, 2008d. *Assessment of the Effects of the Yakima Basin Storage Study on Columbia River Fish Proximate to the Proposed Intake Locations*, Technical Series No. TS-YSS-13. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-13/index.html>. Accessed September 9, 2008.

Reclamation, 2008e. *Aquatic Ecosystem Evaluation for the Yakima River Basin,* Technical Series No. TS-YSS-22. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-22/fullreport.pdf>. Accessed September 9, 2008.

Reclamation, 2008f. *Geologic Report for Appraisal Assessment: Wymer Dam and Reservoir*, Technical Series No. TS-YSS-20. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Boise, Idaho. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-20/index.html>. Accessed September 9, 2008.

Reclamation, 2008g. *Economics Technical Report for the Yakima River Basin,* Technical Series No. TS-YSS-23. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-23/fullreport.pdf>. Accessed September 9, 2008.

Reclamation, 2008h. *A High-Level Class 1 Inventory of Cultural Resources for the Yakima River Basin Storage Study in Benton, Kittitas, and Yakima Counties, Washington*, Technical Series No. TS-YSS-24. U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Upper Columbia Area Office, Yakima, Washington. <http://www.usbr.gov/pn/programs/storage_study/reports/ts-yss-24/fullreport.pdf>. Accessed September 9, 2008.

Reclamation, 2008i. *Cost-Risk Analysis for Black Rock and Wymer Alternatives,* Technical Series No. TS-YSS-26. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado.

Reclamation, 2008j. *Economics Technical Report for the Yakima River Basin Water Storage Feasibility Study Final PR/EIS*, Technical Series No. T S-YSS-27. U.S. Department of the Interior, Bureau of Reclamation, Technical Service Center, Denver, Colorado, <http://www.usbr.gov/pn/programs/storage_study/reports/eis/techreports.html>. Accessed November 26, 8008.

Reisen, W., H. Lothrop, R. Chiles, M. Madon, C. Cossen, L. Woods, S. Husted, V. Kramer, and J. Edman, 2004. "West Nile Virus in California," *Emerging Infectious Diseases,* 10(8):1369–1378.

Resh, V.H., A.V. Brown, A.P. Covish, M.E. Gurtz, H.W. Li, G.W. Minshall, S.R. Riece, A.L. Sheldon, J.B. Wallace, and R. Wissmar, 1988. "The Role of Disturbance in Stream Ecology," *Journal of the North American Benthological Society*, 7:433–455.

Reveal, J.L., F. Caplow, and K. Beck, 1995. "*Eriogonum codium* (*Polygonaceae: Eriogonoideae*): New Species from Southcentral Washington," *Rhodora,* 97(892):350–356.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun, 1996. "A Method for Assessing Hydrologic Alteration Within Ecosystems," *Conservation Biology,* 10:1163–1174.

Rieman, B.E., and J.D. McIntyre, 1993. *Demographic and Habitat Requirements for Conservation of Bull Trout,* General Technical Report INT 302. U.S. Department of Agriculture, Forest Service, Intermountain Research Station, Ogden, Utah, 38 pp.

Rieman, B.E., D.C. Lee, and R.F. Thurow, 1997. "Distribution, Status, and Likely Future Trends of Bull Trout within the Columbia River and Klamath River Basins," *North American Journal of Fisheries Management,* 17:1111–1125.

Rinella, J.F., S.W. McKenzie, and G.J. Fuhrer, 1992a. *Surface-Water-Quality Assessment of the Yakima River Basin, Washington: Analysis of Available Water-Quality Data through 1985 Water Year*, USGS Water Resources Investigations Report No. 91-454, Portland, Oregon.

Rinella, J.F., S.W. McKenzie, and G.J. Fuhrer, 1992b. *Surface-Water-Quality Assessment of the Yakima River Basin, Washington: Pesticide and Other Trace Organic-Compound Data for Water, Sediment, Soil, and Aquatic Biota, 1987–1991,* USGS Open File Report 92-644, Portland, Oregon.

Rinella, J.F., P.A. Hamilton, and S.W. McKenzie, 1993. *Persistence of the DDT Pesticide in the Yakima River Basin*, USGS Circular 1090, Portland, Oregon.

Rinella, J.F., S.W. McKenzie, J.K. Crawford, W.T. Foreman, G.J. Fuhrer, J.L. Morace, and G.R. Aiken, 1999. *Surface-Water-Quality Assessment of the Yakima River Basin, Washington: Distribution of Pesticides and Other Organic Compounds in Water, Sediment, and Aquatic Biota, 1987–91* (with a section on dissolved organic carbon in the Yakima River basin), USGS Water Resources Investigations Report No. 2354-B, Portland, Oregon.

Ring, T.E., and B. Watson, 1999. "Effects of Geologic and Hydrologic Factors and Watershed Change on Aquatic Habitat in the Yakima River Basin, Washington," *Watershed Management to Protect Declining Species,* R. Sakrison and P. Sturtevant, editors, TPS-99-4. American Water Resources Association, Middleberg, Virginia, pp. 191–194.

RMC Water and Environment and McBain and Trush, Inc., 2007. *Upper Tuolumne River: Description of River Ecosystem and Recommended Monitoring Actions*, chapters 1–5. San Francisco Public Utility District, San Francisco, California.

Rood, S.B., J.M. Mahoney, D.E. Reid, and L. Zilm, 1995. "Instream Flows and the Decline of Riparian Cottonwoods Along the St. Mary River, Alberta," *Canadian Journal of Botany/Revue Canadienne de Botanique,* 73:1250–1260.

Roundtable Associates, 2003. *Water Exchange in the Yakima Basin*. October 6, 2003. <http://www.roundtableassociates.com/ ywe/WB%20Final/ Yakima%20Water%20Bank%20ver%205.1%20(Final%20Draft).pdf>. Accessed September 9, 2008.

Roundtable Associates, no date. *Water Exchange in the Yakima Basin: Additional Speaker Notes in Brackets*. <http://www.roundtableassociates.com/ ywe/WB%20Final/YWE%20Presentation%20Script%20with%20notes.doc>. Accessed September 9, 2008.

Ryker, S.J., and J.L. Jones, 1995. *Nitrate Concentrations in Ground Water of the Central Columbia Plateau*, USGS Open File Report 95-445, 4 pp.

Saldi, K.A., R.L. Dirkes, and M.L. Blanton, 2007. *Surface-Water Surveillance*. July 10, 2007. <http://www.pnl.gov/env/Surface-Water_Surveillance.html>. Accessed September 9, 2008.

Schaible, G.D., 2000. "Economic and Conservation Tradeoffs of Regulatory vs. Incentive-Based Water Policy in the Pacific Northwest," *Water Resources Development,* 16(2):221–238.

Schlosser, I.J., 1985. "Flow Regime, Juvenile Abundance, and the Assemblage Structure of Stream Fishes," *Ecology,* 66:1484–1490.

Schmidtmann, E., R.T. Mayer, C.Y. Kato, M.R. Matchett, T.J. Christiansen, W.E. Cook, T. Creekmore, R.D. Falise, E.T. Rinkes, and M.S. Boyce, 2004. "West Nile Virus: Pending Crisis for Greater Sage-Grouse," *Ecology Letters,* 7:704–713.

Schroeder, M.A., D.W. Hays, M.F. Livingston, L.E. Stream, J.E. Jacobsen, and D.J. Pierce, 2000. *Changes in the Distribution and Abundance of Sage Grouse in Washington.* Washington Department of Fish and Wildlife and Engineering and Environment, Inc.

Schroeder, M.A., and W.M. Vander Haegen, 2006. *Use of CPR Fields by Greater Sage-Grouse and Other Shrubsteppe Associated Wildlife in Washington.* Washington Department of Fish and Wildlife, Wildlife Program Science Division, October 2006.

SCM Consultants, Inc., 1999. *Columbia Irrigation District Water Conservation Plan,* 1999 revision, prepared for the Columbia Irrigation District.

Scott, M.J., L.W. Vail, J. Jaksch, C.O. Stockle, and A. Kemanian, 2004. "Water Exchanges: Tools to Beat El Nino Climate Variability in Irrigated Agriculture," *Journal of the American Water Resources Association,* 40:15–31.

Scott, M.J., L.W. Vail, R. Prasad, 2006. “What Can Adaptation to Climate Variability in Irrigated Agriculture Teach Us About Dealing with Climate Change?” PNWDSA-7396, submitted to *Journal of the American Water Resources Association*, Battelle, Pacific Northwest Division, Richland, Washington.

Sedell, J.R., P.A. Bisson, F.J. Swanson, and S.V Gregory, 1988. “What We Know About Large Trees that Fall into Streams and Rivers,” *From the Forest to the Sea: A Story of Fallen Trees,* General Technical Report PNW-229. U.S. Department of Agriculture, Forest Service, Portland, Oregon, pp. 347–380.

Seegrist, D.W., and R. Gard, 1972. “Effects of Floods on Trout in Sagehen Creek, California,” *Transactions of the American Fisheries Society,* 10(1):748–482.

Service, 1992. “Endangered and Threatened Wildlife and Plants; Final Rule to List the Plant *Spiranthes diluvialis* as a Threatened Species,” *Federal Register,* 57-2048.

Service, 1995. *Ute Ladies’-Tresses (Spiranthes diluvalis) Recovery Plan.* U.S. Fish and Wildlife Service, Denver, Colorado.

Service, 1998. *Bull Trout Status Summary and Supporting Documents Lists: Klamath River and Columbia River Distinct Population Segments*.

Service, 2002. *Draft Recovery Plan for Bull Trout in the Middle Columbia Recovery Unit*. Draft Recovery Unit Chapter 21.

Service, 2007a. *Biological Opinion Regarding the U.S. Fish and Wildlife Service’s Proposal Issuance of Permits Under the Template Safe Harbor Agreement for the Columbia Basin Pygmy Rabbit*. U.S. Fish and Wildlife Service, Spokane, Washington.

Service, 2007b. *Yakima River Basin Water Storage Feasibility Study Fish and Wildlife Coordination Act Report: Draft Report*. U.S. Department of the Interior, Fish and Wildlife Service, Upper Columbia Fish and Wildlife Office, Spokane, Washington.

Service, 2007c. *Ute Ladies’-tresses orchid discussion*. U.S. Fish and Wildlife Service, Mountain Prairie Region, Endangered Species Program. <http://www.fws.gov/mountain-prairie/species/plants/uteladiestress/>. Accessed September 9, 2008.

Short, H.L., 1984. *Habitat Suitability Index Models: Brewer’s Sparrow,* FWS/OBS-82/10.83. U.S. Fish and Wildlife Service, 16 pp.

Snow, W.E., 1956. "Production and Control of Floodwater Mosquitoes Incidental to Water Level Operations on Reservoirs of the Tennessee Valley Authority," *Proceedings of the Tenth International Congress on Entomology,* 3:745–750.

Snyder, D., 2005. Personal communication.

Snyder, E.B., and J.A. Stanford, 2001. *Review and Synthesis of River Ecological Studies in the Yakima River, Washington, with Emphasis on Flow and Salmon Habitat Interactions*. Final Report to the Bureau of Reclamation, Upper Columbia Area Office, Yakima, Washington.

Snyder, E.B., C.P. Arango, D.J. Eitemiller, J.A. Stanford, and M.L. Uebelacker, 2002. "Floodplain Hydrologic Connectivity and Fisheries Restoration in the Yakima River, USA," *Verhandlung der Internationalen Vereingung fur Theortische und Angewandte Limnologie (International Association of Theoretical and Applied Limnology),* 28:1653–1657.

SOAC, 1999. *Report on Biologically Based Flows for the Yakima River Basin,* May 1999. System Operation Advisory Committee, Washington, pp. 1–4.

Soil Conservation Service, 1978. *Co-operative River Basin Study, 1978: Draft Report*. U.S. Department of Agriculture, Soil Conservation Service and Forest Service, Spokane, Washington.

Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer, 2001. "Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival," *Canadian Journal of Fisheries and Aquatic Science,* 58:325–333.

Sonnichsen, R., 2007. Personal communication. U.S. Department of the Interior, Bureau of Reclamation, Ephrata Field Office, Ephrata, Washington.

South Central Washington Shrub Steppe/Rangeland Conservation Partnership, 2006. Memorandum of Understanding.

Sparks, R.E., 1995. "Need for Ecosystem Management of Large Rivers and their Floodplains," *Bioscience,* 45:168–182.

Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki, 1996. *An Ecosystem Approach to Salmonid Conservation*, TR-4501-96-6057. ManTech Environmental Research Services Corporation, Corvallis, Oregon.

Stanford, J.A., and J.V. Ward, 1993. "An Ecosystem Perspective of Alluvial Rivers: Connectivity and the Hyporheic Corridor," *Journal of the North American Benthological Society,* 12(1):48–60.

Stanford, J.A., E.B. Snyder, M.N. Lorang, D.C. Whited, P.L. Matson, and J.L. Chaffin, 2002. *The Reaches Project: Ecological and Geomorphic Studies Supporting Normative Flows in the Yakima River Basin, Washington*. Final Report to the U.S. Department of the Interior, Bureau of Reclamation, Upper Columbia Area Office, Yakima, Washington, and Yakama Nation, Toppenish, Washington. BPA Report No. DOE/BP-00005854-1, Bonneville Power Administration, Portland, Oregon. <http://www.osti.gov/bridge/product.biblio.jsp?osti_id=828280>. Accessed September 9, 2008.

Stanford, J.A., J.V. Ward, W.J. Liss, C.A. Frissell, R.N. Williams, J.A. Lichatowich, and C.C. Coutant, 1996. "A General Protocol for Restoration of Regulated Rivers," *Regulated Rivers,* 12:391–413.

Statzner, B., J.A. Gore, and V.H. Resh, 1988. "Hydraulic Stream Ecology: Observed Patterns and Potential Applications," *Journal of the North American Benthological Society*, 7(4):307–360.

Stella, J., and Stillwater Sciences, 2006. *Restoring Recruitment Processes for Riparian Cottonwoods and Willows: A Field-Calibrated Predictive Model for the Lower San Joaquin Basin.* CALFED Bay-Delta Ecosystem Restoration Program, Sacramento, California; Berkeley, California.

Stephenson, J., 2007. Personal communication. Yakama Nation Wildlife, Vegetation, and Range Programs.

Stillwater Sciences, 2001. *Merced River Restoration Baseline Studies, Vol. II: Geomorphic and Riparian Vegetation Investigations Report*. Merced River Technical Advisory Committee, Berkeley, California.

Stinson, D.W., J.W. Watson, and K.R. McAllister, 2001. *Washington State Status Report for the Bald Eagle*. Washington Department of Fish and Wildlife, Olympia, Washington. <http://wdfw.wa.gov/wlm/diversty/soc/status/baldeagle/finalbaldeaglestatus.pdf>. Accessed September 9, 2008.

Stinson, D.W., D.W. Hays, and M.A. Schroeder, 2004. *Washington State Recovery Plan for the Greater Sage-Grouse*. Washington Department of Fish and Wildlife, Olympia, Washington, 109 pp.

Sullivan, K., D.J. Martin, R.K. Cardwell, J.E. Toll, and S. Duke, 2000. *An Analysis of the Effects of Temperature on Salmonids of the Pacific Northwest with Implications for Selecting Temperature Criteria*. Sustainable Ecosystems Institute, Portland, Oregon, 192 pp. <http://www.sei.org/downloads/reports/salmon2000.pdf>. Accessed September 9, 2008.

Suren, A.M., B.J.F. Biggs, M.J. Duncan, L. Bergey, and P. Lambert, 2003. "Benthic Community Dynamics during Summer Low-Flows in Two Rivers of Contrasting Enrichment Invertebrates," *New Zealand Journal of Marine and Freshwater Research*, 37:71–83.

Swanson, D., and T. Wright, 1978. "Bedrock Geology of the Northern Columbia Plateau and Adjacent Areas," *The Channeled Scablands: Guide to the Geomorphology of the Columbia Plateau, Washington,* V. Baker and D. Nummedal, editors. NASA Office of Space Science, Planetary Geology Program, Washington, DC, pp. 37–57.

Sweeney, B.W., and R.L. Vannote, 1986. "Growth and Production of a Stream Stonefly: Influences of Diet and Temperature," *Ecology,* 67(5):1396–1410.

Tadzhieva, V.S., Z.M. Khaidarova, S.A. Zainiev, Z.A. Galina, V.V. Atarskaya, and M.S. Muminov, 1979. "Formation of a Focus of Mass Mosquito Breeding in Arnasaisk - Lowering of the Uzbek SSR," *Communication I. Med. Parasitol. Parasit. Bolezn.,* 48(2):46–50 (in Russian with English abstract).

Thomas, J., and K. Bovee, 2007. Personal communication. Separate conversations with Jeff Thomas, U.S. Fish and Wildlife Service, and Ken Bovee, October 2007. Subject: Methodology Used to Determine the Critical Passage Criteria of Bull Trout Spawners from Kachess, Keechelus, and Rimrock Reservoirs into their Spawning Tributaries.

Trepanier, S., M.A. Rodriguez, and P. Magnan, 1996. "Spawning Migrations in Landlocked Atlantic Salmon: Time Service Modeling of River Discharge and Water Temperature Effects," *Journal of Fish Biology,* 48:925–936.

Tri-County Water Resources Agency, 2002. "Chapter 2, Existing Conditions," *Watershed Plan Document, Yakima River Basin*.

Trumbull, J.W., 2007. Personal communication. Manager, Industry and Public Projects, Union Pacific Railroad, October 9, 2007.

Trush, B., S. McBain, and L. Leopold, 2000. "Attributes of an Alluvial River and their Relation to Water Policy and Management," *Proceedings of the National Academy of Sciences*, 97:11858–11863.

Tsukamoto, G., 2000. *The Rattlesnake Hills (Hanford) Elk Strategic Management Plan.* Washington Department of Fish and Wildlife, Olympia, Washington, 34 pp.

University of Washington, 2006. Columbia River DART Web site. <http://www.cbr.washington.edu/dart/>. Accessed September 9, 2008.

U.S. Army Corps of Engineers, 1978. *Yakima Valley Regional Water Management Study,* vols. 1–4. Seattle District, Seattle, Washington.

U.S. Army Corps of Engineers, 1991. *National Economic Development Procedures Manual: Overview Manual for Conducting National Economic Development Analysis*, IWR Report 91-R-11, October 1991. Water Resources Support Center, Institute for Water Resources.

U.S. Army Corps of Engineers, 1999. *U.S. Army Corps of Engineers 1999 Total Dissolved Gas Monitoring: Colombia and Snake Rivers.* U.S. Army Corps of Engineers, North Pacific Water Management Division, Reservoir Control Center Water Quality Section, Portland, Oregon.

U.S. Army Corps of Engineers, Northwest Division, 2002. *Lower Snake River Juvenile Salmon Migration Feasibility Report/Environmental Impact Statement, Appendix I – Economics*. Walla Walla District.

U.S. Army Corps of Engineers, Northwest Division, 2003. *U.S. Army Corps of Engineers' Dissolved Gas and Water Temperature Monitoring Report, Columbia Basin.* U.S. Army Corps of Engineers, North Pacific Water Management Division, Reservoir Control Center Water Quality Unit, Portland, Oregon.

U.S. Bureau of the Census, 2000. <http://factfinder.census.gov/>. Accessed September 9, 2008.

U.S. Department of Agriculture, 1995. *Fruit and Tree Nuts Situation and Outlook*. Economic Research Service, Washington, DC.

U.S. Department of Commerce, 2006. "Local Area Personal Income. Tables CA1-3, CA25, and CA45." U.S. Department of Commerce, Bureau of Economic Analysis. <http://www.bea.gov/bea/regional/reis/>. Accessed September 9, 2008.

U.S. Department of Housing and Urban Development, 1991. *The Noise Guidebook*. Office of Communications, Planning and Development.

U.S. Fish and Wildlife Service. See Service.

U.S. Forest Service, 2005. Personal communication with recreation staff at Cle Elum and Naches Ranger Districts.

USGS, 1991. Water Resources Data: Washington.

USGS, 1997. *Nitrate Concentrations in Ground Water of the Central Columbia Plateau*. USGS Open File Report 94-445.

USGS, 2008. *Stream Network and Stream Segment Temperature Models Software*. <http://www.fort.usgs.gov/Products/Software/SNTEMP/>. Accessed September 9, 2008.

U.S. Water Resources Council, 1983. *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies*. March 10, 1983.

Vaccaro, J.J., 1986. *Simulation of Streamflow Temperatures in the Yakima River Basin, Washington, April-October, 1981*, USGS Water Resources Investigations Report 85-4232, Tacoma, Washington.

Vaccaro, J.J., and S.S. Sumioka, 2006. *Estimates of Ground-Water Pumpage from the Yakima River Basin Aquifer System, Washington, 1960–2000*, USGS Scientific Investigations Report 2006-5205, 56 pp.

Vaccaro, J.J., and T.D. Olsen, 2007. *Estimates of Ground-Water Recharge to the Yakima River Basin Aquifer System, Washington, for Predevelopment and Current Land-Use and Land-Cover Conditions*, USGS Scientific Investigations Report 2007-5007, 30 pp.

Vander Haegen, W.M., M.A. Schroeder, S.S. Germaine, S.D. West, and R.A. Gitzen, 2004. *Wildlife on Conservation Reserve Program Lands and Native Shrub Steppe in Washington: Progress Report for 2004*. Washington Department of Fish and Wildlife, Olympia, Washington, 51 pp.

Voss, F.D., C.A. Curran, and M.C. Mastin, 2008. *Modeling Water Temperature in the Yakima River, Washington, from Roza Diversion Dam to Prosser Dam, 2006–06*, USGS Scientific Investigations Report 2007-5070, 43 pp. <http://pubs.usgs.gov/sir/2008/5070/> Accessed September 9, 2008.

Walker, B.L., D.E. Naugle, K.E. Doherty, and T.E. Cornish, 2007. "West Nile Virus and Greater Sage Grouse: Estimating Infection Rate in a Wild Bird Population," *Avian Disease,* 51:000-000, 2007. Available for order at <http://cat.inist.fr/?aModele=afficheN&cpsidt=19137346>. September 9, 2008.

Ward, J.V., 1976. "Effect of Flow Patterns Below Large Dams on Stream Benthos: A Review," *Transactions of the American Fisheries Society*, vol. 2, J.R. Osborn and C.H. Allman, editors. Instream Flow Needs Symposium, Bethesda, Maryland.

Ward, J.V., K. Tockner, U. Uehlinger, and F. Malard, 2001. "Understanding Natural Patterns and Processes in River Corridors as the Basis for Effective River Restoration," *Regulated Rivers: Research and Management,* 17:311–323.

Washington State Department of Game, 1981. *Yakima River Basin Water Enhancement Project: Fish and Wildlife Problems and Needs*, prepared for the U.S. Department of the Interior, Bureau of Reclamation, 19 pp.

Washington State Department of Natural Resources, Washington Natural Heritage Program, and U.S. Department of the Interior - Bureau of Land Management, 1997. *Eriogonum codium. Umtanum Desert Buckwheat*. <http://www1.dnr.wa.gov/nhp/refdesk/fguide/pdf/erco.pdf>. Accessed September 9, 2008.

Washington State Department of Health, 2002. *Washington State Mosquito-Borne Disease Response Plan.*

Washington State Department of Transportation, 1997. "Railroads Active in Washington State, at 1:24,000," ArcInfo Coverage, GIS Implementation Team, Olympia, Washington.

Water Quality Research Group, 2007. *CE-QUAL-W2 Hydrodynamic and Water Quality Model.* < http://www.ce.pdx.edu/w2/>. Accessed September 9, 2008.

Waters, T.F., 1982. "Annual Production by a Stream Brook Charr Population and by its Principal Invertebrate Food," *Environmental Biology of Fishes,* 7(2):165–170.

Waters, T.F., 1995. "Sediment in Streams: Sources, Biological Effects and Controls," *American Fisheries Society Monograph 7*, Bethesda, Maryland.

Watson, J.W., and D.J. Pierce, 2000. *Migration and Winter Ranges of Ferruginous Hawks from Washington: Annual Report*. Washington Department of Fish and Wildlife, Olympia, Washington.

WDFW, 1995. *Washington State Recovery Plan for the Pygmy Rabbit - Wildlife Management Program*. Washington Department of Fish and Wildlife, Olympia, Washington, 73 pp.

WDFW, 1998. *Salmonid Stock Inventory. Appendix: Bull Trout and Dolly Varden.* Washington Department of Fish and Wildlife, Olympia, Washington.

Welcomme, R.L., 1992. "River Conservation: Future Prospects," *River Conservation and Management*, P.J. Boon, R. Calow, and G.E. Petts, editors. John Wiley and Sons, New York, New York, pp. 454–462.

Western Regional Climate Center, 2007. *Yakima WSO AP, Washington, Period of Record General Climate Summary.* Temperature Web page. <http://www.wrcc.dri.edu/cgi-bin/cliGCStT.pl?wa9465>. Accessed September 17, 2008.

Wetzel, R.G., 1990. "Reservoir Ecosystems: Conclusions and Speculations," *Reservoir Limnology: Ecological Perspectives,* K.W. Thornton, B.L. Kimmel, and F.E. Payne, editors. John Wiley and Sons, New York, New York, pp. 227–238.

Whiteman, K.J., J.J. Vaccaro, J.B. Gonthier, and H.H. Bauer, 1994. *Hydrogeologic Framework and Geochemistry of the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho*, USGS Professional Paper 1413-B, 73 pp.

WHO, 2000. *Human Health and Dams*. World Health Organization, WHO/SDE/WSH/00.01. <http://www.who.int/hia/evidence/whohia091/en/index.html>. Accessed September 9, 2008.

Willey, Z., and A. Diamant, 1994. *Restoring the Yakima River's Environment: Water Marketing and Instream Flow Enhancement in Washington's Yakima River Basin*. Environmental Defense Fund, March 1994.

Williams, D.D., A. Tavares-Cromar, D.J. Kushner, and J.R. Coleman, 1993. "Colonization Patterns and Life-History Dynamics of Culex Mosquitoes in Artificial Ponds of Different Character," *Canadian Journal of Zoology,* 71:568–578.

Williams, D.D., and H.B.N. Hynes, 1977. "The Ecology of Temporary Streams II: General Remarks on Temporary Streams," *Internationale Revue des gesampten-Hydrobiologie,* 62:53–61.

Williams, G.W., and O. Capps, Jr., 2005. *An Assessment of Future Markets for Crops Grown Along the Columbia River: Economic Implications of Increases in Production Resulting from New Agricultural Water Rights under the Columbia River Initiative*. September 2005.

Williamson, A.K., M.D. Munn, S.J. Ryker, R.J. Wagner, J.C. Ebbert, and A.M. Vanderpool, 1998. *Water Quality in the Central Columbia Plateau, Washington and Idaho, 1992–95*, USGS Circular 1144.

Wilzbach, M.A., K.W. Cummins, and J.D. Hall, 1986. "Influence of Habitat Manipulations on Interactions Between Cutthroat Trout and Invertebrate Drift," *Ecology*, 67(4):898–911.

Wissmar, R.C., J.E. Smith, B.A. McIntosh, H.W. Li, G.H. Reeves, and J.R. Sedell, 1994. "A History of Resource Use and Disturbance in Riverine Basins of Eastern Oregon and Washington (early 1800s–1900s)," *Northwest Science*, 68.

Wissmar, R.C., and S.D. Craig, 1998. "Factors Affecting Bull Trout Spawning Activity and Habitat Selection in an Altered Headwater Stream." Unpublished manuscript.

Wong, I., M. Hemphill-Haley, M. Dober, R. Schapiro, 2002. *Probabilistic Seismic Hazard Analyses, Bumping Lake, Clear Creek, French Canyon, and Tieton Dams.* Contract report prepared by URS Corporation, Seismic Hazards Group for the U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.

Wood, A.W., E.P. Maurer, A. Kumar, and D.P. Lettenmaier, 2002. "Long-Range Experimental Hydrologic Forecasting for the Eastern United States," *J. Geophysical Research-Atmospheres*, 107(D20):4429.

Wood, A.W., L.R. Leung, V. Sridhar, and D.P. Lettenmaier, 2004. "Hydrologic Implications of Dynamical and Statistical Approaches to Downscaling Climate Model Outputs," *Climatic Change*, 15(62):189–216.

Wydoski, R.S., and R.R. Whitney, 2003. *Inland Fishes of Washington*. University of Washington Press, Seattle, Washington and London, United Kingdom.

Yakama Nation, 2006. *Yakima/Klickitat Fisheries Project Monitoring and Evaluation.* The Confederated Tribes and Bands of the Yakama Nation, Project 1995-063-25, Contract No. 0022449, July 20, 2006.

Yakima County, 1997. *Plan 2015.* 1997 version.

Yakima County, 1998a. *Plan 2015*. 1998 update. (Note: this plan has been updated regularly.)

Yakima County, 1998b. *Zoning map*. < http://yakimap.com/>. Accessed September 9, 2008.

Yakima Regional Clean Air Authority, 2007. Personal communication. Yakima Regional Clean Air Authority, Yakima, Washington.

Yakima River Basin Conservation Advisory Group, 1998. *Basin Conservation Plan for the Yakima River Basin Water Conservation Program*. Prepared for the U.S. Department of the Interior, Bureau of Reclamation.

Yakima River Basin Watershed Planning Unit and Tri-County Water Resources Agency, 2001. *Watershed Assessment, Yakima River Basin*. Prepared by Economic and Engineering Services, Inc., Yakima, Washington.

Yakima River Basin Watershed Planning Unit and Tri-County Water Resources Agency, 2003. *Watershed Management Plan: Yakima River Basin*. Prepared by Economic and Engineering Services, Inc., in association with Montgomery Water Group, Inc., R.C. Bain and Associates, and McKenzie Consulting. Funded by Grant No. G0900288 and G0200298, provided by Washington State Department of Ecology.

Yakima River Watershed Council, 1996. *State of the Water Resources of the Yakima River Basin*. July 1996, Yakima, Washington.

Yakima River Watershed Council, 1997. *A 20/20 Vision for a Viable Future of the Water Resource of the Yakima River Basin: Draft*. Yakima, Washington.

Yakima Subbasin Fish and Wildlife Planning Board, 2004. *Yakima Subbasin Plan and Supplement: Final Plan*. Yakima Subbasin Fish and Wildlife Planning Board. Prepared for the Northwest Power and Conservation Council, Yakima, Washington.

Yakima Subbasin Fish and Wildlife Planning Board, 2005. *Yakima Subbasin Salmon Recovery Plan,* 238 pp.

Yakima Subbasin Fish and Wildlife Planning Board, 2008. *Yakima Steelhead Recovery Plan: Review Draft*. Extracted from the 2005 Yakima Subbasin Salmon Recovery Plan.

Yakima Valley Visitors and Convention Bureau, 2005. *Yakima Valley Visitors Guide.*

YBSA, 2007. *Recreation and Economic Development Analysis of Lands Around Black Rock Reservoir*. Yakima Basin Storage Alliance.

Ye-Ebiyo, Y., R.J. Pollack, A. Kiszewski, and A. Spielman, 2003. "Enhancement of Development of Larval *Anopheles Arabiensis* by Proximity to Flowering Maize (*Zea mays*) in Turbid Water and When Crowded," *American Journal of Tropical Medicine and Hygiene*, 68(6):748–752.

Young, M.K., K. Haire, and M. Bozek, 1994. "The Effect and Extent of Railroad Tie Drives in Streams of Southeastern Wyoming," *Western Journal of Applied Forestry,* 9(4):125–130

Yount, J.D., and G.J. Niemi, 1990. "Recovery of Lotic Communities and Ecosystems from Disturbance: A Narrative Review of Case Studies," *Environmental Management*, 14(5):547–569.

Zuroske, M., 2005. *Water Quality of Small Irrigation Return Drains to the Lower Yakima River, 2003 Irrigation Season: Draft Report*. South Yakima Conservation District, Sunnyside, Washington.

Zuroske, M., 2007. *Lower Yakima River Eutrophication Study: 2005 in Review: Draft Report*. South Yakima Conservation District, Sunnyside, Washington.

Zuroske, M., 2007. *Macrophyte Survey in the Yakima River near Kiona, August 2005 and September 2006: Draft Report*. South Yakima Conservation District, Sunnyside, Washington.

GLOSSARY

GLOSSARY

accretion	The return flow to the stream from surface recharge.
Acquavella	A Yakima River basin water adjudication court case in Yakima County Superior Court.
acre-foot	The volume of water that could cover 1 acre to a depth of 1 foot. Equivalent to 43,560 cubic feet or 325,851 gallons.
active capacity	The reservoir capacity or quantity of water which lies above the inactive reservoir capacity and normally is usable for storage and regulation of reservoir inflow to meet established reservoir operating requirements.
active recovery	When the recharged groundwater is subsequently recovered by pumping the water back out.
adfluvial spawner	Fish that spawn in tributaries and, as adults, reside in lakes.
adjudication	The judicial process through which the existence of a water right is confirmed by court decree.
alluvial	Composed of clay, silt, sand, gravel, or similar material deposited by running water.
anadromous	Fish that migrate from saltwater to freshwater to breed. Going up rivers to spawn.
antecedent flood	A flood or series of floods assumed to occur prior to the occurrence of an inflow flood used to design a specific dam.
anticline	A geologic fold that is convex upward.
appraisal-level design	Designs based on limited analyses, available design data, and professional assumptions, but of sufficient detail to provide satisfactory quantities and preliminary field cost estimates.
appurtenant	An accompanying part or feature of something; accessory.

aquatic biota	Collective term describing the organisms living in or depending on the aquatic environment.
aquifer	A water-bearing stratum of permeable rock, sand, or gravel.
aquifer storage and recovery	A system that injects potable water via wells into aquifers during periods of excess capacity and withdraws the water for municipal supply during periods of peak demand or limited supply.
aquitard	A geologic unit that restricts the movement of groundwater.
average water supply year	A water supply in the Yakima River basin between 2,250,000–3,250,000 acre-feet.
Avoided Cost Method	An economic analysis which focuses on cost differentials between the action alternatives and the No Action Alternative. If costs associated with the No Action Alternative would not be incurred under an action alternative, those costs would reflect an avoided cost benefit for that action alternative. This approach is employed when the benefits across alternatives are similar such that the primary difference between alternatives relates to the costs.
bank-full	The water level, or stage, at which a stream or river is at the top of its banks and any further rise would result in water moving into the flood plain.
bathymetric	The study of surfaces under water, such as a river or lake floor.
benefit-cost analysis	An economic analysis which compares the present value of a project's benefits to the present value of its costs.
benefit-cost ratio	In an economic benefit-cost analysis, the benefit-cost ratio reflects the present value of the benefits divided by the present value of the costs. For a project to be economically justified, the benefit-cost ratio must exceed one.
benthic	Relating to the bottom of a sea or lake or to the organisms that live there.

Biology Technical Work Group (BTWG)	A biologist work group consisting of technical representatives from National Marine Fisheries Service, U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, Washington Department of Ecology, the Yakama Nation, Yakima Basin Joint Board, Yakima Subbasin Fish and Wildlife Planning, and Reclamation's Upper Columbia Area Office and Technical Service Center.
Black Rock Summary Report	*Summary Report, Appraisal Assessment of the Black Rock Alternative*.
cfs	Flow rate in cubic feet per second.
connectivity	The relationship between groundwater and surface water.
cost allocation analysis	A financial analysis to determine reimbursable and nonreimbursable costs by project purpose and beneficiary.
cumulative effect	For NEPA purposes, these are impacts to the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such action.
de minimis	Latin term for "of minimum importance" or "trifling."
direct injection with passive recovery	Potable water that is injected into an aquifer during periods of excess capacity and allowed to become part of the natural groundwater system and flow to natural discharge areas (i.e., streams or springs).
dry water year	A water supply in the Yakima River basin less than 2,250,000 acre-feet.
Ecology	Washington State Department of Ecology.
economic benefits	An economics term measuring national economic welfare based on net values (e.g., net willingness-to-pay or consumer surplus for consumers and profit for producers).

economic feasibility	An economics term stemming from the results of the benefit-cost analysis. If a project's benefits exceed its costs, the project is deemed economically feasible.
economic impacts	An economics term measuring total economic activity within a given region using such indicators as output, income, and employment.
emergence	Refers to the fry lifestage of the salmon when they swim up through the substrate from their incubation nest (redd) to live along the stream edge.
endangered species	A species that is in danger of extinction throughout all or a significant portion of its range. To term a run of salmon "endangered" is to say that particular run is in danger of extinction.
entrained	The act of a juvenile fish entering, either passively or actively, a diversion canal at the point of diversion from a stream or entering a pumping plant canal.
Environmental Justice	The fair treatment of people of all races and incomes with respect to actions affecting the environment. Fair treatment implies that there is equity of the distribution of benefits and risks associated with a proposed project and that one group does not suffer disproportionate adverse effects.
Environmental Quality account (EQ)	An account that measures the degree to which the alternative would affect the quality of the natural and cultural resources and ecological systems of the area.
escapement	The act of adult salmon and steelhead successfully arriving at their spawning areas by avoiding harvest and predation.
ethnographic	Relating to the branch of anthropology that deals historically with the origin and filiation of races and cultures.
eutrophiccation	The process by which a body of water becomes enriched in dissolved nutrients that stimulate the growth of aquatic plant life, usually resulting in the depletion of dissolved oxygen.

feasibility study	Detailed investigation specifically authorized by the Congress to determine the desirability of seeking congressional authorization for implementation of a preferred alternative, normally the NED Alternative, which reasonably maximized net national economic development benefits.
financial feasibility	A financial term stemming from the cost allocation and repayment analyses. A project is deemed financially feasible if project beneficiaries are able to pay their assigned reimbursable costs.
fingerling	A juvenile fish during its first summer after emergence, usually under 3 inches long (see also fry and smolt).
flip-flop	An operational action in the upper Yakima River basin in late summer to encourage anadromous salmon to spawn at lower river state levels so that the flows required to keep the redds watered and protected during the subsequent incubation period are minimized.
flow	The volume of water passing a given point per unit of time.
flow objectives	The desired monthly streamflow used to guide RiverWare model operation criteria. Also used to evaluate alternative performance in terms of how closely they meet the desired monthly streamflow.
fluvial spawner	Fish that spawn in tributaries and, as adults, reside in rivers.
freed-up Yakima River water	Yakima River water currently used by potential exchange participants that would not be diverted by those participants but, instead, would be used for instream flow, dry-year proratable irrigation water rights, and future municipal supply needs.
freshet	A great rise or overflowing of a stream caused by heavy rains or snowmelt.

fry	The life stage of fish between the egg and fingerling stages. Depending on the fish species, fry can measure from a few millimeters to a few centimeters in length (see also fingerling and smolt).
habitat	The combination of resources and the environmental conditions that promotes occupancy by individuals of a given species and allows those individuals to survive and reproduce.
Hanford reach	Columbia River reach extending from 15 miles upstream of the mouth of the Yakima River to Priest Rapids Dam.
historic property	Any building, site, district, structure, or object (that has archeological or cultural significance) included in, or eligible for inclusion in, the *National Register*.
hydraulic conductivity	The rate at which the water can move through an aquifer.
hydraulic grade line	The surface or profile of water flowing out of hydraulic gradient; the slope of the hydraulic grade line is under pressure; the hydraulic grade line is the actual level to which water would rise in a small vertical tube connected to the pipe.
hydraulic gradient	The slope of the surface of open or underground water.
HYDSIM	The Bonneville Power Administration computer model used as the hydrologic basis for the 2000 Biological Opinion; it includes the significant United States Federal and non-Federal dams and the major Canadian projects on the mainstem Columbia River and its major tributaries.
hyporheic invertebrates	Aquatic insects that complete all or a portion of their lifecycle beneath the riverbed.
in situ	With reference to cultural resources, an object, feature, or strata situated in its original, meaningful depositional context; undisturbed.

inactive capacity	The reservoir capacity or quantity of water which lies beneath the active reservoir capacity and is normally unavailable for withdrawal because of operating agreements or physical constraints.
Indian sacred site	A specific, discrete, narrowly delineated location on Federal land that is identified by an Indian Tribe or Indian individual determined to be an appropriately authoritative representative of an Indian religion, as sacred by virtue of its established religious significance to, or ceremonial use by, an Indian religion.
Indian trust assets (ITA)	Legal interests in property held in trust by the United States for Indian Tribes or individuals. They are rights that were reserved by or granted to American Indian Tribes or Indian individuals by treaties, statutes, and Executive orders. These rights are sometimes further interpreted through court decisions and regulations.
instream flows	Waterflows for designated uses within a defined stream channel, such as minimum flows for fish, wildlife, recreation, or aesthetics.
integrated alternative	An alternative after it has been added to the No Action Alternative (existing Yakima Project plus YRBWEP conservation measures) for operation, maintenance, and management.
interbed	Term given to the sediments deposited between basalt flows in the Columbia Plateau Basalt Group.
interest during construction (IDC)	An economic calculation representing the opportunity cost of forgone interest earned on Federal funds during the construction period. IDC provides the basis for converting construction costs occurring throughout the construction period to a cost as of the end of the construction period.
interflow	Term given to the zone where most of the lateral groundwater flow occurs in the Columbia River basalts. Consists of a combination of the permeable bottom of one basalt flow and the adjacent flow top of the underlying basalt flow.
k	Hydraulic conductivity.

Kh	Horizontal hydraulic conductivity.
liquefaction	A loss of material strength during earthquake shaking that can result in large areas of slope failure or settlement of the ground surface.
littoral zone	The area between the high and low water marks.
metamorphic rock	Refers to rocks that have changed in form from their original rock type (sedimentary or igneous) in response to extreme changes in temperature, pressure, or chemical environment (i.e., limestone into marble).
million acre-feet (maf)	The volume of water that could cover 1 million acres to a depth of 1 foot.
multiplier effect	Results from a regional economic impact analysis which include not only the initial direct effect but also the secondary indirect effect (effects upon industries providing inputs to a directly affected sector) and induced effect (effects from the spending of household income by those employed in the directly affected sectors).
National Economic Development account (NED)	An account that measures how the alternative would yield positive changes in the economic value of the national output of goods and services.
natural (unregulated) flows	The flow regime of a stream as it would occur prior to development, that is, the predevelopment landscape with a flow regime similar to that defined for unregulated flows.
natural flow	Riverflow that originates from a source other than reservoir storage.
net benefits	In an economic benefit-cost analysis, net benefits reflect the difference between the present value of the benefits and the present value of the costs (i.e., present value benefits minus present value costs). For a project to be economically justified, net benefits should be positive.
nonprorated water rights	Pre-Yakima Project senior water rights related to natural flows that are served first and cannot be reduced until all the proratable rights are regulated to zero.

nonuse values	An economic term referring to the benefits individuals hold for a resource even if they never intend to use it. For this study, the nonuse values related to threatened and endangered fish species.
normative flows	Flows that mimic the natural frequency, duration, and magnitude in the rise and fall of the river stage to the greatest extent possible given the cultural, legal, and operational constraints associated with river basin development.
oligotrophic	Lacking plant nutrients and usually containing plentiful amounts of dissolved oxygen without stratification.
operation criteria	Rules used in the RiverWare model specific to each alternative that dictate how Yakima River basin flow is used to address irrigation and instream flow objectives.
Other Social Effects account (OSE)	An account that measures the extent and magnitude to which the alternative would affect the quality of life and social well-being in the area.
overburden	A thick deposit of sediments overlying bedrock.
passerine	Of or relating to the largest order of birds, which includes over half of all living birds and consists chiefly of songbirds of perching habitats.
passive recovery	Recharging water (placing water) in the aquifer system and allowing it to become part of the natural groundwater system and flow to natural discharge areas (i.e., streams or springs). The water is “recovered” when it reaches the stream and is available for instream or out-of-stream uses.
Peak Horizontal Acceleration (PHA)	A measure of very high-frequency earthquake ground motions that can be estimated through a Probabilistic Seismic Hazard Assessment.
phreatic surface	Free-standing water level; surface water level.

present value	An economic calculation which converts cost and benefits to the same point in time for subsequent comparison. For this study, costs and benefits were converted to the start of the benefits period (equivalent to the end of the construction period). Moving a cost or benefit ahead in time is referred to as compounding and back in time is referred to as discounting.
Principles and Guidelines (*P&Gs*)	*Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.*
Probabilistic Seismic Hazard Assessment (PSHA)	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.
prorated water rights	Newer junior water rights related to storage water that, in water-short years, receive less than their full right on a prorated basis.
prorationing	The process of equally reducing the amount of water delivered to junior (i.e., "proratable") water right holders in water-deficient years.
Quaternary	A period of geologic time which began about 3 million years ago and continues to the present day.
Reclamation	U.S. Department of the Interior, Bureau of Reclamation.
redd	The nest that a spawning female salmon digs in gravel to deposit her eggs.
Regional Economic Development account (RED)	An account that measures the degree to which the alternative would affect the region's income, employment, population, economic base, and social development.
regional economic impact analysis	An economic analysis which estimates the effect of changes in expenditures and revenues on the local economy of the study region.
repayment analysis	A financial analysis to determine if project beneficiaries are able to pay assigned reimbursable costs.
riparian	Relating to, living in, or located on a watercourse.

RiverWare (Yak-RW)	Yakima Project RiverWare model; a daily time-step reservoir and river operation computer model of the Yakima Project created with the RiverWare software.
Roza Division	Division of Yakima Project comprised of the Roza Irrigation District.
Roza Powerplant	The existing powerplant located at Roza Canal milepost 11.
sediment	Any very finely divided organic or mineral matter deposited by water in nonturbulent areas.
Service	U.S. Fish and Wildlife Service.
shoal	A place where the water of a sea, lake, river, pond, etc., is shallow; a shallow.
shrub-steppe	A vegetation type consisting of a mix of woody shrubs, grasses, and forbs, generally dominated by Wyoming big sagebrush and blue bunch wheatgrass.
slopewash	Soil and rock material that has moved downslope, assisted by running water that is not channelized.
smolt	Adolescent salmon or steelhead, usually 3 to 7 inches long, that are undergoing changes preparatory for living in saltwater (see also fry and fingerling).
spawner	Adult salmon that has left the ocean and entered a river to spawn.
specific yield	The potential storage in an unconfined aquifer.
Storage Study	Yakima River Basin Water Storage Feasibility Study; a multiyear evaluation of the viability and acceptability of several storage augmentation alternatives, including a potential water exchange, for the benefit of fish, irrigation, and municipal water supply within the Yakima River basin.
Storage Study Technical Work Group (SSTWG)	A fisheries biologist work group formed to assist on fishery technical matters related to the Storage Study.
storage water	Water that has been stored and purposefully released.

storativity	The potential storage in a confined aquifer.
stream depletion factor	The time when 28 percent of the recharge has accrued to the stream.
Sunnyside Division	A division of Yakima Project comprised of Sunnyside Valley Irrigation District and eight other irrigation districts, companies, and cities.
surface recharge with passive recovery	Diverting and infiltrating surface water into a recharge basin during periods of high streamflow and allowing it to discharge naturally back to a stream.
System Operations Advisory Committee (SOAC)	Committee comprised of the Yakima Basin Joint Board, Yakama Nation, Washington State Department of Fish and Wildlife, and the U.S. Fish and Wildlife Service.
target flows	Flows quantified in Title XII of the Act of October 31, 1994, for two points in the Yakima River basin (Sunnyside and Prosser Diversion Dams).
taxa	A grouping of animals or plants that share a common set of physical and/or life history characteristics.
terrestrial	Of or relating to land as distinct from air or water.
thalweg	A line drawn along the entire length of a streambed that defines the deepest part of the river channel. The thalweg is almost always the line of fastest flow in any river.
threatened species	A species that is likely to become endangered within the foreseeable future.
Title XII target flows	Specific instream target flows established for Yakima Project operations at Sunnyside and Prosser Diversion Dams by Title XII of the Act of October 31, 1994 (Public Law 103–464).
toe plinth	A concrete pedestal or footing located beneath the base of a dam's concrete face.
total capacity	The total reservoir capacity or quantity of water which can be impounded in the reservoir below the maximum water surface elevation.

total water supply available (TWSA)	The total water supply available for the Yakima River basin above the Parker gage for the period April through September.
transmissivity	The product of the thickness of the aquifer unit and the hydraulic conductivity.
ungulate	A four-legged, hoofed animal.
unregulated flows	The flow regime of a stream as it would occur under completely natural conditions; that is, not subjected to modification by reservoirs, diversions, or other human works.
use values	An economic term referring to benefits individuals experience from using a resource. For this study, the use values referred to the commercial, recreational, and Tribal harvest values associated with the fishery resource.
vesicular basaltic rock	Rock that contains many small holes or cavities formed as the rock solidifies.
viremic	The presence of viruses in the blood.
wasteway	A channel for conveying or discharging excess water.
water year	The 12-month period from October through September. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. For example, the year ending September 30, 1992, is called the “1992 water year.”
watershed	The total land area draining to any point in a stream.
wet water year	A water supply in the Yakima River basin greater than 3,250,000 acre-feet.
wetland	Generally, an area characterized by periodic inundation or saturation, hydric soils, and vegetation adapted for life in saturated soil conditions.
Yakima Alternatives Appraisal Assessment	*Yakima River Basin Storage Alternatives Appraisal Assessment*.

Yakima fold belt — One of three informally designated physiographic subprovinces of the Columbia Plateau. Consists of northwest-southeast-trending ridges (anticlines) separated by broad, flat valleys (synclines) that were folded and faulted under north-south compression.

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Attachment A

U.S. DEPARTMENT OF ENERGY VIEW CONCERNING THE BLACK ROCK RESERVOIR ALTERNATIVE

Department of Energy
Washington, DC 20585

October 23, 2008

Mr. David Kaumheimer
Environmental Programs Manager
Upper Columbia Area Office
Bureau of Reclamation
U.S. Department of the Interior
1917 Marsh Road
Yakima, WA 98901-2058

Dear Mr. Kaumheimer:

This letter transmits the Department of Energy's (DOE) view on the Black Rock Reservoir Alternative in the Bureau's *Yakima River Basin Water Storage Feasibility Study Planning Report Environmental Impact Statement*. In accordance with agreements reached among our staffs, it is my understanding that DOE's view will be included in the EIS Summary and in the main volume.

We appreciate this opportunity to work with you and will look forward to continued cooperation in the future on this matter. If you have any further questions, please contact me at (202) 586-5216.

Sincerely,

Inés Triay

Inés R. Triay (Acting for)
Assistant Secretary for
Environmental Management

Enclosure

Enclosure

U.S. Department of Energy (DOE) View Concerning the Black Rock Reservoir Alternative

DOE understands that the No Action Alternative may be the Bureau of Reclamation's (BOR's) preferred alternative; nevertheless, DOE believes it is important to address significant issues related to the Black Rock Reservoir Alternative. The Department does not believe that the analyses contained in this Environmental Impact Statement (EIS) would be adequate to support a decision to proceed with the Black Rock Reservoir.

The western boundary of the Hanford Nuclear Reservation (the Hanford Site) is approximately 5 miles from the proposed Black Rock Reservoir, which is one of the alternatives being evaluated by BOR in the *Yakima River Basin Water Storage Environmental Impact Statement (EIS)*. DOE is a cooperating agency on this EIS.

From 1943 to 1989, Hanford's principal mission was the production of weapons-grade plutonium. To produce this material, uranium metal was irradiated in production reactors. The uranium metal, known as spent nuclear fuel, was then sent to chemical processing plants at Hanford to recover the plutonium and enriched uranium.

As a result, a large amount of waste was produced and stored in underground tanks, or disposed of in cribs and trenches. In some cases, chemicals and radionuclides from this material have leaked or were discharged to the ground. The cleanup of the contamination present at the site is being done under the Resource Conservation and Recovery Act or Comprehensive Environmental Response, Compensation and Liability Act. At present DOE spends approximately $2 billion a year on cleanup at Hanford and expects completion of this effort to take decades. There are currently several plumes of contamination in the groundwater beneath the Hanford Site, and these contaminant plumes may represent a threat to the Columbia River. DOE would be very concerned about any additional contamination beneath the site.

DOE has advised BOR that the proposed Black Rock Reservoir could adversely affect the existing groundwater contamination at Hanford in a number of ways. For example, seepage from the Black Rock Reservoir would increase the groundwater flow in the aquifer under the Hanford Site, including the groundwater beneath the 177 underground waste tanks containing approximately 54 million gallons of hazardous chemicals and highly radioactive substances with approximately 98 million Curies. To date, DOE's groundwater monitoring system has identified contaminants in some areas of the Hanford Site already above Drinking Water Standards for some radionuclides and chemicals (See Section 4.6.1 Affected Environment). The half life of the radionuclides ranges from approximately 12 years to 4.5 billion years.

DOE believes that the current analysis of the Black Rock Reservoir Alternative does not adequately assess the potential adverse consequences of contaminant mobilization in the soils and groundwater. DOE is continuing to study the issue based on available information and plans to present its analysis in the DOE Draft Tank Closure and Waste Management EIS (TC&WM EIS), scheduled for issuance in early 2009.

DOE's preliminary analysis shows that the Black Rock Reservoir Alternative has the potential for seepage that could produce an elevation in the water table beneath the Hanford Site. In turn, this could increase the movement of contaminants from the central part of the site, referred to as the Central Plateau, toward the Columbia River. Such an increase in groundwater flow has the potential to change containment plume shapes, travel times, and peak concentrations of radionuclides. The hydraulic conductivity distribution is different beneath the eastern and western portions of the Central Plateau, so it is likely that an increase in groundwater flow will have differential impacts across the site.

BOR has investigated potential mitigation measures to reduce the water which might reach the Hanford Site. DOE remains concerned that BOR's current impact and mitigation analyses for the Black Rock Reservoir do not adequately evaluate the long-term effectiveness of the mitigation measures. For example, the analyses do not adequately address the following:

- Evaluation of operational failure mechanisms of the Reservoir, whether it be an earthquake, intentional destructive acts or some other mechanism and the associated impacts to the Hanford Site
- Potential failure of the mitigation measures and associated impacts to Hanford
- The potential effects on Hanford cleanup of seepage, if it can not be mitigated, to the extent identified in the *Yakima River Basin Water Storage Environmental Impact Statement* based on the limited data in this area.

Based on public comments received for the Draft EIS, DOE understands that the Washington State Department of Ecology (Ecology) has decided to prepare environmental impact analyses of additional alternatives not evaluated by the BOR in separate State Environmental Policy Act (SEPA) documentation.

DOE understands that BOR plans to publish its Final EIS before Ecology has completed its SEPA process and before DOE has completed the TC&WM EIS process. Therefore, it appears that these issues will not be resolved prior to BOR's planned Record of Decision.

In summary, DOE believes that the development of the Black Rock Reservoir has the potential to cause severe environmental injury to the Hanford Site and the Columbia River that has not been fully evaluated. Therefore, DOE believes that the Black Rock Reservoir Alternative should not be selected.

Attachment B

SECTION IV, "RECOMMENDATIONS," OF THE YAKIMA RIVER BASIN WATER STORAGE FEASIBILITY STUDY FISH AND WILDLIFE COORDINATION ACT REPORT AND RECLAMATION'S RESPONSES

ATTACHMENT B

This attachment includes Section IV, "Recommendations," of the *Yakima River Basin Water Storage Feasibility Study Fish and Wildlife Coordination Act Report* (CAR), October 10, 2007, prepared by the U.S. Fish and Wildlife Service, Upper Columbia Fish and Wildlife Office, Spokane, Washington, and Reclamation's responses to the CAR recommendations. This attachment also includes Section IV, "Recommendations," contained in a November 24, 2008, addendum (Addendum) to the CAR and Reclamation's responses to these recommendations. The recommendations contained in the Addendum were made in response to the seepage mitigation measures for the Black Rock Reservoir Alternative that have been incorporated in the Final PR/EIS.

The CAR discusses the Joint Alternatives with respect to the environment and offers recommendations from the Service regarding mitigating impacts to the environment.

The entire CAR report and Addendum are available on the Storage Study Web site: http://www.usbr.gov/pn/programs/storage_study/index.html.

IV. RECOMMENDATIONS

During the process of formulating recommendations to mitigate for potential impacts associated with Reclamation's three proposed action alternatives described in this CAR, the Service relies on established Mitigation Policy (FWS Manual, 501 FW 2) (Policy). In accordance with this policy, the definition of mitigation includes: a) avoiding the impact altogether by not taking a certain action or parts of an action; b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and e) compensating for the impact by replacing or providing substitute resources or environments (40 CFR Part 1508.20(a-e)). The Service has also considered its responsibilities under Endangered Species Act, Migratory Bird Treaty Act, Bald Eagle Protection Act, and the National Environmental Policy Act (USFWS, 1981).

The Service has numerous concerns regarding adverse effects to fish and wildlife resources associated with Reclamation's three action alternatives. Among these concerns are: (1) the continuing and cumulative loss of shrub-steppe habitat; (2) fragmentation and degradation of remaining upland habitat through introduction of non-native invasive plants; (3) likely development of the area (suitable for building) adjacent to the proposed reservoir sites (e.g., water based recreation facilities, access roads, housing); (4) increased fire danger associated with increased human use; (5) disruption of established migratory corridors for large and small mammals and other wildlife, especially the greater sage grouse, through the formation of barriers to wildlife movement, both during and after construction of the proposed facilities (e.g., large bodies of water, pipelines, access roads, construction activities); (6) disturbance of nesting migratory birds during construction and subsequent use of the proposed facilities; (7) Flow alteration in the Yakima River may change fish species composition; and (8) Augmentation of flows in the Yakima River utilizing Columbia River water may alter spawning behavior in bull trout.

The Service considers shrub-steppe habitat as meeting the criteria of Resource Category 2, that is; "The habitat to be impacted is of high value for evaluation species and is scarce or becoming scarce on a national basis or in the ecoregion section." Thus the Service's mitigation goal for this habitat type is "No net loss of in-kind habitat value." Furthermore, the Service "will recommend ways to avoid or minimize losses . . ." (USFWS, 1981). Shrub-steppe habitat within the Black Rock valley, Rattlesnake Hills and Yakima Training center have been identified by the state of Washington as very important habitat for wildlife (Stinson et al., 2004; TNC, 1999; WDFW, 1996).

IV-1) <u>Service's Recommended Alternative</u>

After careful consideration of fish and wildlife resources analyzed in the CAR, the Service has determined that the most limited and endangered resource is shrub-steppe. All action alternatives, if implemented, would impact this resource. For that reason, based on our review and evaluation of the information acquired during preparation of the CAR, particularly the significant loss and/or fragmentation of shrub-steppe habitat, the Service recommends that the "No Action" alternative be selected with the following qualification: The Service further recommends that water conservation measures continue to be explored and implemented as a means to increase the availability of water for native aquatic species in the Yakima River corridor.

We recognize that there will likely be a net-loss of wetlands in the lower Basin as existing water delivery systems are made to be more efficient. To mitigate for any lost wetlands, the Service recommends that Reclamation consider reconnecting the floodplain and restore historic wetlands along the Yakima River.

IV-2) <u>Mitigation Recommendations: Action Alternatives</u>

If Reclamation proceeds with any of the three action alternatives, the Service recommends that the following mitigation measures be implemented:

Aquatic

- The following Service recommendations to avoid or mitigate potential adverse impacts or enhance these resources are based on current information about the proposed alternatives. If these alternatives are subsequently modified, the Service may modify recommendations as appropriate.

- In the accompanying Environmental Impact Statement (EIS), analyze additional alternatives. These would include, but are not limited to, the Keechelus Lake to Kachess Lake Pipeline, commonly referred to as the K-K Pipeline. In addition, an analysis of aquifer storage and water banking should also be considered in the EIS. These alternatives have the potential for benefits to bull trout and resident fish.
- Conduct Instream Flow Incremental Methodology (IFIM) studies below Reclamation facilities to quantify changes in fish habitat resulting from the release of flow augmentation; compare results against existing model data.
- Examine the effect of Black Rock or Wymer Reservoir flow releases on water quality in the Yakima River Basin.
- Ensure Black Rock or Wymer Reservoir flow releases are compatible with migration, spawning, and rearing of resident fish that utilize the Yakima River Basin.
- Investigate whether Columbia River water used for flow augmentation in the Yakima River Basin alters spawning behavior of anadromous fish, bull trout, and resident fish within the basin.
- If the Black Rock or Wymer Reservoir is constructed, Reclamation should monitor flow augmentation releases from the reservoir and effects on riparian and wetland habitats in the Yakima River Basin.
- Develop studies that examine the change in resident fish species distribution and abundance in the Yakima River Basin.
- Maintain Yakima River Basin reservoirs at levels that enable adult bull trout to migrate into spawning tributaries.
- Monitor entrainment of bull trout and resident fish in Yakima River Basin reservoirs and compare to flow augmentation regimes and accompanying reservoir levels.
- Coordinate all bull trout and resident fish studies with the Service.

Wildlife

Wildlife Mitigation Common to the Three Action Alternatives

- During construction, minimize or avoid all vegetation removal during avian nesting season to minimize the effect of the action on federally protected migratory birds. Typically nesting season in this part of Washington occurs between March and August each year.

- Centralize any construction staging areas and locate them in areas that would provide minimal disturbance to wildlife and damage to shrub-steppe habitat. Existing degraded habitat may be the most suitable for this purpose.

- Bury pipelines underground and restore native vegetation along the pipeline corridor. The Service would be willing to provide a list of native plants for this purpose. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success of this mitigation effort.

- To compensate for the loss of shrub-steppe habitat, and also to ensure that residential, recreational and agricultural developments are compatible with Project resource mitigation objectives, an area equal to that lost to the project should be acquired around the periphery of the reservoir. Within the acquired land, agriculturally converted former shrub-steppe habitat and degraded shrub-steppe habitat should be fully restored. This would require a contiguous area of land for the purpose of providing habitat benefits for wildlife species displaced by the proposed action. The Service would be willing to assist Reclamation in identifying suitable sites as well as provide a list of native plants for this purpose. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success or this mitigation effort.

- If a suitable area for shrub-steppe restoration cannot be found in the immediate project area, then another location will need to be selected in the Affected Area and evaluated in the CAR for the three action alternatives. If a suitable area for shrub-steppe restoration cannot be found in the Affected Area, then Reclamation should work with the Service to find a mutually agreeable location in the mid-Columbia area.

- There are currently several state and federal agencies, as well several private organizations and public groups, that have signed a South Central Washington Shrub steppe/rangeland Conservation Partnership Memorandum of Understanding, which created a partnership dedicated to the protection and preservation of shrub-steppe habitat. Reclamation should work with that group to identify areas of shrub-steppe habitat that could be protected or restored as mitigation for any shrub-steppe lost during the creation of the selected reservoir.

- Unregulated cattle grazing would continue to degrade wildlife habitat and would also impede development or enhancement of riparian, wetland, and upland habitats. Cattle should be excluded from all wildlife mitigation lands including restored shrub-steppe habitats, created wetland/riparian habitats, and acquired mitigation lands.

- Human activities may displace wildlife from high value habitats to less suitable habitat. New recreation facilities should be located away from important wildlife areas including wildlife mitigation lands. The Service would be willing to work with Reclamation to identify appropriate sites for new recreation facilities.

- The Service recommends that Reclamation work with the Washington Natural Heritage Program to identify and protect any existing federal and state threatened and endangered candidate, federal species of concern, and state sensitive plant species and their associated habitats, that may occur within the Affected Area.

Mitigation for each Action Alternative

Black Rock Reservoir Site

- Although there is currently limited wetland and riparian habitat identified within the Black Rock footprint, the creation of the reservoir could provide the potential for creation of at least low quality wetland and riparian habitats. This would attract species that utilize these habitats. Based on this, the Service recommends that Reclamation construct dikes in shallow water areas within the reservoir, and if necessary pump water into these areas to maintain adequate water levels for the production of wetland/riparian vegetation. The Service would be willing assist Reclamation in identifying suitable sites as well as provide a list of native plants for this purpose. The north boundary and upper end of the reservoir likely contain suitable sites for dike construction and wetland and riparian habitat development. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success of this mitigation effort.

- Based on the significant loss of wildlife habitat that would occur with the creation of this reservoir, the Service recommends that Reclamation work to establish a wildlife management area adjacent to the reservoir in areas that would be able to provide suitable wildlife habitat. This would likely attract some replacement species associated with open waterbodies, such as shorebirds and waterfowl. The northern boundary of the Black Rock footprint falls near the southern end of the U.S. Army's Yakima Training

Center. Reclamation could inquire as to the availability of any lands that could be protected to further protect that adjacent area.

- Based on the continuing loss, degradation and fragmentation of shrub-steppe habitat within eastern Washington, the Service recommends that Reclamation consider the construction of a smaller reservoir at this site, in order to reduce the amount of lost shrub-steppe habitat.

- Although there are currently no existing trees or snags within the footprint of the Black Rock Reservoir, this site is an important area for several raptor species. The creation of the reservoir could bring in other raptor species (i.e.,bald eagle, osprey), especially if a fishery were to be established. Large trees and snags are used by raptors and many other birds as perches for foraging and roosting. Artificial perches should be installed on selected areas adjacent to the new reservoir to provide perches for raptors. These structures would significantly enhance the habitat for raptors and other birds within the Black Rock Affected Area. The Service would be willing to work with Reclamation to identify appropriate sites and specifications for artificial perches.

- Based on HEP analyses conducted within the potential Black Rock Reservoir footprint, the Service determined that 1692 average annual habitat units for the brewer's sparrow would be lost if the reservoir were created. The Service recommends that Reclamation work to create, restore and/or protect the amount of shrub-steppe habitat that would lead to production of a similar number of habitat units, elsewhere within the Yakima River Basin.

- Plant surveys should be conducted for Columbia milk-vetch (federal species of concern), prior to final selection of this alternative, in any habitats that are suitable for its existence within the Black Rock Reservoir Affected Area. The Service would be willing to assist Reclamation in the completion of plant surveys.

- Protect any discovered populations of Columbia milk-vetch that are located adjacent to the Black Rock Reservoir from recreation, residential and agriculture field development, grazing, and invasion of non-native plants. Protection measures may include obtaining a conservation easement for the land containing the population or acquiring the land. The area could be fenced to exclude livestock and a weed control program developed to prevent invasion of non-native plants.

Wymer Reservoir Site

- The creation of a reservoir at the Wymer site would result in the loss of sixty acres of wetland, riparian and cottonwood forest habitat. Based on the loss of this habitat, the Service recommends that Reclamation design the new reservoir to include construction of dikes in shallow water areas within the reservoir, and if necessary pump water into these areas to maintain adequate water levels for the production of wetland/riparian vegetation. If a similar number of acres cannot be replaced on site, Reclamation should replace the same number of wetland and riparian acres by identifying, creating or restoring similar habitats elsewhere in the Affected Area. The Service would be willing assist Reclamation in identifying suitable sites as well as provide a list of native plants for this purpose. The upper end of the reservoir likely contains suitable sites for dike construction and wetland and riparian habitat development. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success or this mitigation effort.

- The creation of the Wymer Reservoir would result in the loss of existing large trees and snags within the footprint of the reservoir. Large trees and snags are used by raptors and many other birds as perches for foraging and roosting. Artificial perches should be installed on selected areas adjacent to the new reservoir to provide perches for bald eagles, osprey and other raptors. These structures would, in the short term, replace trees and snags that would be lost due to the creation of the Wymer Reservoir. The Service would be willing to work with Reclamation to identify appropriate sites and specifications for artificial perches.

- Based on HEP analyses conducted within the potential Wymer Reservoir footprint, the Service determined that 378 average annual habitat units for the brewer's sparrow would be lost if the reservoir were created. The Service recommends that Reclamation work to create, restore and/or protect the amount of shrub-steppe habitat that would lead to production of a similar number of habitat units, elsewhere within the Yakima River Basin.

- Plant surveys should be conducted for the Sukdorf's monkey-flower (federal species of concern), prior to final selection of this alternative, in any habitats that are suitable for its existence within the Wymer Reservoir Affected Area. The Service would be willing to work with Reclamation in completion of plant surveys.

- Protect any discovered populations of Suksdorf's monkey-flower that are located adjacent to the Wymer Reservoir from recreation, residential and agriculture field development, grazing, invasion of non-native plants and possible spray drift from adjacent agriculture fields. Protection measures may include obtaining a conservation easement for the land containing the population or acquiring the land. The area could be fenced to exclude livestock and a weed control program developed to prevent invasion of non-native plants.

- Plant surveys should be conducted for basalt daisy (federal Candidate species), prior to final selection of this alternative, in any habitats that are suitable for its existence within the Wymer Reservoir Affected Area. The Service would be willing to work with Reclamation in completion of plant surveys.

- Protect any basalt daisy populations, discovered during new surveys that are located adjacent to the Wymer Reservoir from recreation, residential and agriculture field development, grazing, invasion of non-native plants and possible spray drift from adjacent agriculture fields. Protection measures may include obtaining a conservation easement for the land containing the population or acquiring the land. The area could be fenced to exclude livestock and a weed control program developed to prevent invasion of non-native plants.

- Based on the significant loss of wildlife habitat that would occur with the creation of this reservoir, the Service recommends that Reclamation work to establish a wildlife management area adjacent to the reservoir in areas that would provide suitable wildlife habitat. This would likely attract some replacement species associated with open water bodies, such as shorebirds and waterfowl. The U.S. Army's Yakima Training Center owns property along the extreme eastern end of the potential reservoir footprint. Reclamation could inquire as to the availability of any lands that could be protected to further protect that adjacent area.

Wymer Reservoir with the Yakima River Pump Exchange

Bury pipelines underground and restore native vegetation along the pipeline corridor. The Service would be willing to provide a list of native plants for this purpose. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success of this mitigation effort.

Locate any above ground structures in areas that would cause minimal disturbance to wildlife and associated habitats. Potential disturbances to be avoided include; creation of any barriers to, or fragmentation of movement corridors, loss of habitat, degradation of remaining habitat, and invasion of exotic species.

LITERATURE CITED IN OCTOBER 10, 2007, RECOMMENDATIONS

Stinson, D.W., D.W. Hayes and M.A. Schroeder. 2004. Washington State recovery plan for the greater sage grouse. Washington Department of fish and Wildlife. Olympia, Washington.

The Nature Conservancy. 1999. Species Management Abstract. Brewer's sparrow (Spizella breweri). The Nature Conservancy, Arlington, Virginia, USA.

USFWS. 1981. U.S. Fish and Wildlife Service Mitigation Policy. Notice of Final Policy, Federal Register, Vol. 46, No. 15, January 23, 1981, (As corrected in the *Federal Register* of February 4, 1981), Washington, DC.

WDFW. 1996. Washington State recovery plan for the ferruginous hawk. Washington Department of Fish and Wildlife. Olympia, Washington.

RECLAMATION'S RESPONSES TO SERVICE RECOMMENDATIONS

IV-1) Service's Recommended Alternative

After careful consideration of fish and wildlife resources analyzed in the CAR, the Service has determined that the most limited and endangered resource is shrub-steppe. All action alternatives, if implemented, would impact this resource. For that reason, based on our review and evaluation of the information acquired during preparation of the CAR, particularly the significant loss and/or fragmentation of shrub-steppe habitat, the Service recommends that the "No Action" alternative be selected with the following qualification: The Service further recommends that water conservation measures continue to be explored and implemented as a means to increase the availability of water for native aquatic species in the Yakima River corridor.

We recognize that there will likely be a net-loss of wetlands in the lower Basin as existing water delivery systems are made to be more efficient. To mitigate for any lost wetlands, the Service recommends that Reclamation consider reconnecting the floodplain and restore historic wetlands along the Yakima River.

- Reclamation will continue to restore floodplains and riparian areas through the Yakima River Basin Water Enhancement Program (YRBWEP). This program has purchased land along the Yakima, Naches, and Teanaway Rivers for this purpose.

IV-2) Mitigation Recommendations: Action Alternatives

Aquatic

In the accompanying Environmental Impact Statement (EIS), analyze additional alternatives. These would include, but are not limited to, the Keechelus Lake to Kachess Lake Pipeline, commonly referred to as the K-K Pipeline. In addition, an analysis of aquifer storage and water banking should also be considered in the EIS. These alternatives have the potential for benefits to bull trout and resident fish.

- The K-K pipeline was analyzed as part of the planning study but eliminated from further consideration as outlined in the Draft PR/EIS. Aquifer storage and water banking or water acquisition are analyzed in the Draft PR/EIS as State Alternatives.

Conduct Instream Flow Incremental Methodology (IFIM) studies below Reclamation facilities to quantify changes in fish habitat resulting from the release of flow augmentation; compare results against existing model data.

- Should an action alternative be selected, further modeling would likely occur.

Examine the effect of Black Rock or Wymer reservoir flow releases on water quality in the Yakima River Basin.

- Water quality of Black Rock or Wymer reservoir flow releases has been analyzed in the Draft PR/EIS.

Ensure Black Rock or Wymer reservoir flow releases are compatible with migration, spawning, and rearing of resident fish that utilize the Yakima River Basin.

- Releases from Black Rock reservoir will be to the Roza and Sunnyside Division canals. As such they would not affect migration, spawning, or rearing of resident fish. Releases from Wymer reservoir in all but low water years will be for fish enhancement purposes. While specific operational details of the proposed reservoirs have not yet been developed, the proposed releases from Wymer reservoir assessed in the Draft PR/EIS provide benefits for resident fish.

Investigate whether Columbia River water used for flow augmentation in the Yakima River Basin alters spawning behavior of anadromous fish, bull trout, and resident fish within the basin.

- This issue is addressed in the Draft PR/EIS; no effect to spawning behavior should occur.

If the Black Rock or Wymer Reservoir is constructed, Reclamation should monitor flow augmentation releases from the reservoir and effects on riparian and wetland habitats in the Yakima River Basin.

- This may be accomplished as a part of other studies in the basin.

Develop studies that examine the change in resident fish species distribution and abundance in the Yakima River Basin.

- Reclamation is not a fishery manager and would not likely undertake such a study.

Maintain Yakima River Basin reservoirs at levels that enable adult bull trout to migrate into spawning tributaries.

- It is unclear what reservoir elevations are needed to enable bull trout migration. This appears to involve a complex interaction involving stream discharge, reservoir elevation, migration run timing and perhaps other variables. Operation details of the proposed reservoirs have not yet been developed, but consultation with fish biologists will occur prior to implementation to assure the best operations scenario for fish. This scenario will have to balance a variety of needs and tradeoffs between competing needs, such as spring migration flows and end-of-season reservoir elevations. The operations outlined in the Draft PR/EIS generally benefited bull trout migration from the reservoirs.

Monitor entrainment of bull trout and resident fish in Yakima River Basin reservoirs and compare to flow augmentation regimes and accompanying reservoir levels.

- Currently, such studies are not planned as part of this project.

Coordinate all bull trout and resident fish studies with the Service.

- Should such studies be conducted they will be coordinated with the Service and other appropriate parties.

Wildlife

Wildlife Mitigation Common to the Three Action Alternatives

During construction, minimize or avoid all vegetation removal during avian nesting season to minimize the effect of the action on federally protected migratory birds. Typically nesting season in this part of Washington occurs between March and August each year.

- Reclamation will work with the Service and other agencies to minimize impacts from construction activities. The period outlined, however, is the prime construction season and cannot likely be avoided.

Centralize any construction staging areas and locate them in areas that would provide minimal disturbance to wildlife and damage to shrub-steppe habitat. Existing degraded habitat may be the most suitable for this purpose.

- Staging areas will be designated prior to construction. For large facilities like the dams and reservoirs they will likely be located in the reservoir.

Bury pipelines underground and restore native vegetation along the pipeline corridor. The Service would be willing to provide a list of native plants for this purpose. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success of this mitigation effort.

- Reclamation would revegetate those areas disturbed by construction activities but not occupied by facilities.

To compensate for the loss of shrub-steppe habitat, and also to ensure that residential, recreational, and agricultural developments are compatible with

Project resource mitigation objectives, an area equal to that lost to the project should be acquired around the periphery of the reservoir. Within the acquired land, agriculturally converted former shrub-steppe habitat and degraded shrub-steppe habitat should be fully restored. This would require a contiguous area of land for the purpose of providing habitat benefits for wildlife species displaced by the proposed action. The Service would be willing to assist Reclamation in identifying suitable sites as well as provide a list of native plants for this purpose. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success or this mitigation effort.

- The Service conducted a HEP analysis for the project and mitigation lands should be evaluated similarly. This may result in more or less acreage required to mitigate for impacts of the project. This recommendation will be implemented as budget and land availability, allow.

If a suitable area for shrub-steppe restoration cannot be found in the immediate project area, then another location will need to be selected in the Affected Area and evaluated in the CAR for the three action alternatives. If a suitable area for shrub-steppe restoration cannot be found in the Affected Area, then Reclamation should work with the Service to find a mutually agreeable location in the mid-Columbia area.

- Reclamation will look for shrub-steppe mitigation in the areas outlined above.

There are currently several state and Federal agencies, as well several private organizations and public groups, that have signed a South Central Washington Shrub steppe/rangeland Conservation Partnership Memorandum of Understanding, which created a partnership dedicated to the protection and preservation of shrub-steppe habitat. Reclamation should work with that group to identify areas of shrub-steppe habitat that could be protected or restored as mitigation for any shrub-steppe lost during the creation of the selected reservoir.

- Should an action alternative be selected, Reclamation would work with all parties interested in preserving and protecting shrub-steppe.

Unregulated cattle grazing would continue to degrade wildlife habitat and would also impede development or enhancement of riparian, wetland, and upland habitats. Cattle should be excluded from all wildlife mitigation lands including restored shrub-steppe habitats, created wetland/riparian habitats, and acquired mitigation lands.

- Reclamation concurs.

Human activities may displace wildlife from high value habitats to less suitable habitat. New recreation facilities should be located away from important wildlife areas including wildlife mitigation lands. The Service would be willing to work with Reclamation to identify appropriate sites for new recreation facilities.

- Some public use of mitigation lands may be desirable but public access sites and recreational areas will be sited to minimize impacts to habitat and wildlife.

The Service recommends that Reclamation work with the Washington Natural Heritage Program to identify and protect any existing Federal and State threatened and endangered, candidate, Federal species of concern, and state sensitive plant species and their associated habitats, that may occur within the Affected Area.

- To the extent practicable, Reclamation will undertake this action should an action alternative be selected.

Mitigation for Each Action Alternative

Black Rock Reservoir Site

Although there is currently limited wetland and riparian habitat identified within the Black Rock footprint, the creation of the reservoir could provide the potential for creation of at least low quality wetland and riparian habitats. This would attract species that utilize these habitats. Based on this, the Service recommends that Reclamation construct dikes in shallow water areas within the reservoir, and if necessary pump water into these areas to maintain adequate water levels for the production of wetland/riparian vegetation. The Service would be willing assist Reclamation in identifying suitable sites as well as provide a list of native plants for this purpose. The north boundary and upper end of the reservoir likely contain suitable sites for dike construction and wetland and riparian habitat development. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success of this mitigation effort.

- The Draft PR/EIS concludes that some vegetation will naturally establish in the upper end of the reservoir. If this area can be expanded with the use of low dikes, it will be considered.

Based on the significant loss of wildlife habitat that would occur with the creation of this reservoir, the Service recommends that Reclamation work to establish a wildlife management area adjacent to the reservoir in areas that would be able to provide suitable wildlife habitat. This would likely attract some replacement species associated with open waterbodies, such as shorebirds and waterfowl. The northern boundary of the Black Rock footprint falls near the southern end of the

U.S. Army's Yakima Training Center. Reclamation could inquire as to the availability of any lands that could be protected to further protect that adjacent area.

- As outlined above, Reclamation will mitigate for impacts to wildlife with the initial focus at the reservoir site.

Based on the continuing loss, degradation, and fragmentation of shrub-steppe habitat within eastern Washington, the Service recommends that Reclamation consider the construction of a smaller reservoir at this site, in order to reduce the amount of lost shrub-steppe habitat.

- The reservoir was sized to meet the three goals of the Storage Study.

Although there are currently no existing trees or snags within the footprint of the Black Rock Reservoir, this site is an important area for several raptor species. The creation of the reservoir could bring in other raptor species (i.e., bald eagle, osprey), especially if a fishery were to be established. Large trees and snags are used by raptors and many other birds as perches for foraging and roosting. Artificial perches should be installed on selected areas adjacent to the new reservoir to provide perches for raptors. These structures would significantly enhance the habitat for raptors and other birds within the Black Rock Affected Area. The Service would be willing to work with Reclamation to identify appropriate sites and specifications for artificial perches.

- Should it appear that the development of artificial perches successfully enhance the area for raptors, Reclamation would work with the Service and others to site and install the perches.

Based on HEP analyses conducted within the potential Black Rock Reservoir footprint, the Service determined that 1692 average annual habitat units for the brewer's sparrow would be lost if the reservoir were created. The Service recommends that Reclamation work to create, restore and/or protect the amount of shrub-steppe habitat that would lead to production of a similar number of habitat units, elsewhere within the Yakima River Basin.

- As outlined above, Reclamation concurs that using HEP is the appropriate way to assess mitigation needs.

Plant surveys should be conducted for Columbia milk-vetch (Federal species of concern), prior to final selection of this alternative, in any habitats that are suitable for its existence within the Black Rock Reservoir Affected Area. The Service would be willing to assist Reclamation in the completion of plant surveys.

- Should an action alternative be selected, this recommendation will be implemented.

Protect any discovered populations of Columbia milk-vetch that are located adjacent to the Black Rock Reservoir from recreation, residential and agriculture field development, grazing, and invasion of non-native plants. Protection measures may include obtaining a conservation easement for the land containing the population or acquiring the land. The area could be fenced to exclude livestock and a weed control program developed to prevent invasion of non-native plants.

- Populations of Columbia milk-vetch could be included in mitigation lands acquired, depending upon the value of the lands for mitigation and the availability of the lands for acquisition. A land management plan would need to be developed for acquired lands to address issues like weed control.

Wymer Reservoir Site

The creation of a reservoir at the Wymer site would result in the loss of sixty acres of wetland, riparian and cottonwood forest habitat. Based on the loss of this habitat, the Service recommends that Reclamation design the new reservoir to include construction of dikes in shallow water areas within the reservoir, and if necessary pump water into these areas to maintain adequate water levels for the production of wetland/riparian vegetation. If a similar number of acres cannot be replaced on site, Reclamation should replace the same number of wetland and riparian acres by identifying, creating or restoring similar habitats elsewhere in the Affected Area. The Service would be willing assist Reclamation in identifying suitable sites as well as provide a list of native plants for this purpose. The upper end of the reservoir likely contains suitable sites for dike construction and wetland and riparian habitat development. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success or this mitigation effort.

- The lands included in the Wymer reservoir site are generally very steep and not conducive to impoundment by diking. While opportunities may exist they would likely be quite small. Some vegetation may develop along Lumuma Creek below the reservoir that could mitigate for losses at the site. Some areas along the reservoir shoreline may also develop wetland and riparian vegetation. Finally, depending upon which alternative is chosen that includes a Wymer reservoir, wetland and riparian vegetation may be enhanced along the Yakima and Naches Rivers as a result of the project. At this point it is premature to identify additional wetland and riparian mitigation that may be necessary.

The creation of the Wymer Reservoir would result in the loss of existing large trees and snags within the footprint of the reservoir. Large trees and snags are used by raptors and many other birds as perches for foraging and roosting.

Artificial perches should be installed on selected areas adjacent to the new reservoir to provide perches for bald eagles, osprey and other raptors. These structures would, in the short term, replace trees and snags that would be lost due to the creation of the Wymer Reservoir. The Service would be willing to work with Reclamation to identify appropriate sites and specifications for artificial perches.

- Should it appear that the development of artificial perches successfully enhance the area for raptors, Reclamation would work with the Service and others to site and install the perches.

Based on HEP analyses conducted within the potential Wymer Reservoir footprint, the Service determined that 378 average annual habitat units for the brewer's sparrow would be lost if the reservoir were created. The Service recommends that Reclamation work to create, restore and/or protect the amount of shrub-steppe habitat that would lead to production of a similar number of habitat units, elsewhere within the Yakima River Basin.

- As outlined above, Reclamation concurs that using HEP is the appropriate way to assess mitigation needs.

Plant surveys should be conducted for the Sukdorf's monkey-flower (Federal species of concern), prior to final selection of this alternative, in any habitats that are suitable for its existence within the Wymer Reservoir Affected Area. The Service would be willing to work with Reclamation in completion of plant surveys.

- Should an action alternative involving Wymer reservoir be selected, this recommendation will be implemented.

Protect any discovered populations of Suksdorf's monkey-flower that are located adjacent to the Wymer Reservoir from recreation, residential and agriculture field development, grazing, invasion of non-native plants and possible spray drift from adjacent agriculture fields. Protection measures may include obtaining a conservation easement for the land containing the population or acquiring the land. The area could be fenced to exclude livestock and a weed control program developed to prevent invasion of non-native plants.

- Populations of Suksdorf's monkey-flower could be included in mitigation lands acquired, depending upon the value of the lands for mitigation and the availability of the lands for acquisition. A land management plan would need to be developed for acquired lands to address issues like weed control.

Plant surveys should be conducted for basalt daisy (Federal Candidate species), prior to final selection of this alternative, in any habitats that are suitable for its existence within the Wymer Reservoir Affected Area. The Service would be willing to work with Reclamation in completion of plant surveys.

- Should an action alternative involving Wymer reservoir be selected, this recommendation will be implemented.

Protect any basalt daisy populations, discovered during new surveys that are located adjacent to the Wymer Reservoir from recreation, residential and agriculture field development, grazing, invasion of non-native plants and possible spray drift from adjacent agriculture fields. Protection measures may include obtaining a conservation easement for the land containing the population or acquiring the land. The area could be fenced to exclude livestock and a weed control program developed to prevent invasion of non-native plants.

- Populations of basalt daisy could be included in mitigation lands acquired, depending upon the value of the lands for mitigation and the availability of the lands for acquisition. A land management plan would need to be developed for acquired lands to address issues like weed control.

Based on the significant loss of wildlife habitat that would occur with the creation of this reservoir, the Service recommends that Reclamation work to establish a wildlife management area adjacent to the reservoir in areas that would provide suitable wildlife habitat. This would likely attract some replacement species associated with open water bodies, such as shorebirds and waterfowl. The U.S. Army's Yakima Training Center owns property along the extreme eastern end of the potential reservoir footprint. Reclamation could inquire as to the availability of any lands that could be protected to further protect that adjacent area.

- As outlined above, Reclamation will mitigate for impacts to wildlife with the initial focus at the reservoir site.

Wymer Dam Plus Yakima River Pump Exchange

Bury pipelines underground and restore native vegetation along the pipeline corridor. The Service would be willing to provide a list of native plants for this purpose. This measure would also require that Reclamation develop a vegetation maintenance and monitoring plan, performance criteria, and clear goals and objectives that would need to be met over a stipulated timeline, to ensure the success of this mitigation effort.

- Most of the pipeline corridor would be on private land, for which Reclamation would seek an easement, but not fee title ownership. Reclamation would have to work with the involved landowner on any revegetation plans and meet their needs as well. Large portions of the corridor would be on developed lands including agricultural, rural, and urban uses. Revegetation with native species would not be appropriate in most of these locations.

Locate any above ground structures in areas that would cause minimal disturbance to wildlife and associated habitats. Potential disturbances to be avoided include; creation of any barriers to, or fragmentation of movement corridors, loss of habitat, degradation of remaining habitat, and invasion of exotic species.

- As noted above, large portions of the corridor would be in developed areas including lands being used for agricultural, rural, and urban uses. Impacts to wildlife along the corridor are not expected to be significant. Where valuable habitat for wildlife is present, above-ground structures would be avoided to the extent practicable.

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PART IV. RECOMMENDATIONS

During the process of formulating recommendations to mitigate for potential impacts associated with Reclamation's three proposed action alternatives described in this CAR, the Service relies on established Mitigation Policy (FWS Manual, 501 FW 2) (Policy). In accordance with this policy, the definition of mitigation includes: a) avoiding the impact altogether by not taking a certain action or parts of an action; b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and e) compensating for the impact by replacing or providing substitute resources or environments (40 CFR Part 1508.20(a-e)). The Service has also considered its responsibilities under Endangered Species Act, Migratory Bird Treaty Act, Bald Eagle Protection Act, and the National Environmental Policy Act (USFWS, 1981).

The Service continues to have has numerous concerns regarding adverse effects to fish and wildlife resources associated with Reclamation's Black Rock Reservoir Alternative. Among these concerns are: (1) the continuing and cumulative loss of shrub-steppe habitat; (2) fragmentation and degradation of remaining upland habitat through introduction of non-native invasive plants; (3) likely development of the area (suitable for building) adjacent to the proposed reservoir sites (e.g., water based recreation facilities, access roads, housing); (4) increased fire danger associated with increased human use and project contribution of invasive weed species; (5) disruption of established migratory corridors for large and small mammals and other wildlife, especially the greater sage grouse, through the formation of barriers to wildlife movement, both during and after construction of the proposed facilities (e.g., large bodies of water, pipelines, access roads, construction activities); (6) disturbance of nesting migratory birds during construction and subsequent use of the proposed facilities; (7) flow alteration in the Yakima River may change fish species composition; and (8) augmentation of flows in the Yakima River utilizing Columbia River water may alter spawning behavior in bull trout. As originally stated in the October 10, 2007, the Service considers shrub-steppe habitat as meeting the criteria of Resource Category 2, that is; *"The habitat to be impacted is of high value for evaluation species and is scarce or becoming scarce on a national basis or in the ecoregion section."* Thus the Service's mitigation goal for this habitat type is *"No net loss of in-kind habitat value."* Furthermore, the Service *"will recommend ways to avoid or minimize losses . . ."* (USFWS, 1981). In addition, shrub-steppe habitat within the Black Rock valley, Rattlesnake Hills and Yakima Training center have been identified by the state of Washington as very important habitat for wildlife (Stinson et al., 2004; TNC, 1999; WDFW, 1996).

IV-1) Service's Recommended Alternative

Therefore, after careful consideration of both the benefits and detriments to fish and wildlife resources associated with the implementation of the Black Rock Reservoir Alternative with the addition of Reclamation's proposed seepage mitigation measures, the Service continues to recommend that the No Action Alternative is selected as the Preferred Alternative in the Final Environmental Impact Statement being prepared by Reclamation. As before, the Service is particularly concerned about the significant loss and/or fragmentation of shrub-steppe habitat associated with the selection of the Black Rock Reservoir Alternative with the implementation of Reclamation's seepage mitigation measures. The proposed seepage mitigation proposal would cause further degradation of this resource, primarily within the ALE Preserve of the Monument, specifically established to protect that endangered resource.

The Service continues to recommend that Reclamation explore the feasibility of implementing water conservation measures as a means to increase the availability of water for native aquatic species in the Yakima River corridor. We recognize that there will likely be a net-loss of wetlands in the lower Basin as existing water delivery systems are made to be more efficient. To mitigate for any lost wetlands, the Service recommends that Reclamation consider reconnecting the floodplain and restoring historic wetlands

If however, Reclamation selects the Black Rock Alternative along with the addition of the seepage mitigation measures, the Service recommends that Reclamation consider the following conservation measures to avoid, minimize and/or compensate for the effects of the proposed action to fish and wildlife resources found in the Affected Area.

IV-2) Mitigation Recommendations

Burrowing owl nest sites: Due to the presence of nesting burrowing owls and the vulnerability of their nest burrows to collapse, the Service recommends that Reclamation attempt to avoid construction activities within 200 meters of any active nests. In addition, Reclamation will need to conduct a survey, locate and map any active and inactive nest sites immediately prior to construction activities, and mitigate for any sites destroyed or potentially disturbed within 200 meters of activities.

- Reclamation will work with the Service and other agencies to minimize impacts from construction activities.

Migratory Bird Nesting: During construction, minimize or avoid all vegetation removal during avian nesting seasons to minimize the effect of the action on federally protected migratory birds. Typically nesting season in this part of Washington occurs between March and August each year.

- Reclamation will work with the Service and other agencies to minimize impacts from construction activities.

Migratory Birds: Prevention of Electrocution and Collision: Bury the new power line that runs between the existing substation and the proposed cut-off wall or use construction designs for above ground power lines with proper spacing of design elements as described in Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006, (APLIC). According to Reclamation (2008f); "Reclamation would agree to install above ground power lines with proper spacing of design elements as described in Suggested Practices for Avian Protection on Power Lines: State of the Art in 2006".

- Reclamation would agree to install aboveground power lines with proper spacing of design elements as described in *Suggested Practices for Avian Protection on Power Lines: The State of the Art* in 2006.

Shrub-steppe Restoration: Coordinate with the Refuge to identify and initiate shrub-steppe restoration opportunities within the ALE, as part of mitigation for implementation of the seepage mitigation proposal.

- Should this action alternative be selected, Reclamation would work with all interested parties in preserving and protecting shrub-steppe.

Rare, Threatened, and Endangered (RTE) Plant Surveys: Conduct RTE plant surveys in the affected area prior to initiating ground disturbance activities, and protect areas where RTE plants are found.

- Should this action alternative be selected, this recommendation will be implemented.

Habitat Surveys: Prior to final layout and construction of the cutoff wall, pipeline and access roads, surveys should be undertaken to identify any wetland, riparian, or rare plant habitats that fall within the footprint of the construction activities. Reclamation should take extra measures to conduct surveys during the appropriate time of year to detect specific plants (depending on the phenology of the plant), and to detect species of wildlife of concern (USFWS, 2008d). Alternative construction paths should be discussed, and if disturbance of identified areas is unavoidable, then restoration or mitigation opportunities should be identified and implemented.

- Should this action alternative be selected, this recommendation will be implemented.

Re-vegetation: Develop a re-vegetation plan for any sites disturbed by construction activities (i.e., staging areas, borrow areas, access routes, power line corridor, pipeline corridor, well sites, and the embankment on top of the cut-off wall). Native plants species that are typically found in the area should be used for planting. The emphasis should be to re-establish big sagebrush and effectively control cheatgrass and other non-native species. The re-vegetation plan should also address vegetation maintenance and monitoring to ensure the success of this mitigation measure. Reclamation should incorporate the cost of all of these activities (i.e., re-vegetating all sites with native species, controlling non-natives, preparing disturbed sites for restoration, follow-up monitoring for several years) into the project budget (USFWS, 2008d).

- Reclamation will work with the Service to develop a revegetation plan and revegetate those areas disturbed by construction activities but not occupied by facilities.

Mitigation Funding: Reclamation should incorporate the cost of all of these activities (i.e., re-vegetating all sites with native species, controlling non-natives, preparing disturbed sites for restoration, follow-up monitoring for several years) into the project budget (USFWS, 2008d).

- If an action alternative is chosen, this will be done as the budget allows.

Weed Management: Develop a weed management plan that includes monitoring disturbed sites for invasion of noxious weeds and implementing control activities where problems occur. The Executive Order on Invasive Species, February 3, 1999 requires that Federal agencies whose actions may affect the status of invasive species shall not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States.

- Reclamation will develop a weed management plan that would include monitoring and control of noxious weeds.

Riparian: Reroute pipeline and access roads away from the Dry Creek/Rattlesnake Springs Riparian Area, to minimize disturbance to its unique habitat values during construction and subsequent maintenance activities. According to Reclamation (2008f); "Current plans call for the pipeline to follow Dry Creek from the cutoff wall to SR-240, but this alignment will not disturb riparian areas. There will be setback from the creek channel; this will be determined in the final designs after consultation with the Service."

- Current plans call for the pipeline to follow Dry Creek from the cutoff wall to State Route 240 but will not disturb riparian areas. There will be setback from the creek channel; this will be determined in the final designs after consultation with the Service.

Groundwater Measurements: Reclamation should conduct groundwater measurements in Dry Creek channel as needed to determine the effect of the cutoff wall on the discharge at Rattlesnake Springs and the subsequent effect on the riparian plant community and habitat at that location. Groundwater measurements will need to be conducted both prior to and after construction to determine background flow and potential impact to Rattlesnake Springs. These measurements would be conducted for the life of the project. Reclamation may need to develop additional mitigation measures based on the outcome of these investigations. According to Reclamation (2008f),"Reclamation is agreeable to groundwater monitoring."

- Reclamation is agreeable to groundwater monitoring.

Contingency for seepage adversely affecting groundwater (USFWS, 2008d): Reclamation should identify additional measures for seepage control, in the event that the current proposal fails to prevent groundwater seepage from continuing toward the Hanford Works.

- This recommendation will be considered.

REFERENCE FOR NOVEMBER 24, 2008, ADDENDUM

Avian Power Line Interaction Committee (APLIC). 2006. *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006*. Edison Electric Institute and the Raptor Research Foundation. Washington, DC.