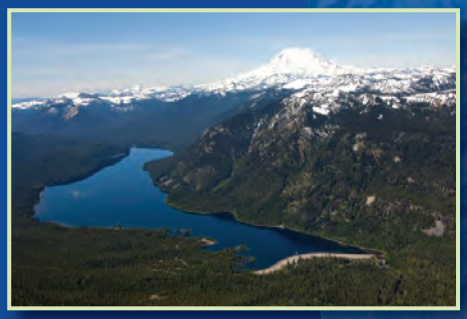
Yakima River Basin Study

Volume 1
Proposed Integrated Water Resource Management Plan



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DEPARTMENT OF ECOLOGY
State of Washington

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April 2011

Yakima River Basin Study

Volume 1
Proposed Integrated Water Resource Management Plan

U.S. Bureau of Reclamation
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Acronyms and Abbreviations
(A full glossary with terms and definitions is located at the back of this Integrated Plan.)

AF	Acre-feet
AHA	All H (habitat, hatchery, harvest and hydropower) Analyzer model
ASR	Aquifer storage and recovery
Basin Study	Yakima River Basin Study
BPA	Bonneville Power Administration
C	Celsius
CFS	Cubic feet per second
YRDSS	Yakima River Decision Support System model
Ecology	Washington State Department of Ecology
EDT	Ecosystem Diagnosis and Treatment model
EIS	Environmental impact statement
EQ	Environmental Quality
ET	Evapo-transpiration
FEIS	Final environmental impact statement
FWS	United States Fish and Wildlife Service
FWIP	Future without Integrated Plan
Integrated Plan	Proposed Integrated Water Resource Management Plan for the Yakima Basin
IP	Integrated Plan
K to K	Lake Keechelus to Lake Kachess (pipeline)
KRD	Kittitas Reclamation District
MAF	Million acre-feet
NED	National Economic Development
NEPA	National Environmental Policy Act
O&M	Operation and maintenance
OPCC	Opinion of probable construction cost
OSE	Other Social Effects
PL	Public Law
PR/EIS	Planning report/environmental impact statement
Reclamation	United States Department of the Interior, Bureau of Reclamation
RED	Regional Economic Development
SEPA	State Environmental Policy Act
SOAC	System Operations Advisory Committee
TWSA	Total water supply available
USGS	United States Geological Survey
WDFW	Washington Department of Fish and Wildlife
WIP	Wapato Irrigation Project
Workgroup	Yakima River Basin Water Enhancement Project Workgroup
WSDA	Washington State Department of Agriculture
YRBWEP	Yakima River Basin Water Enhancement Project

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1.0 Introduction and Purpose

This document describes the proposed Integrated Water Resource Management Plan (Integrated Plan) for the Yakima River Basin in central Washington (see Figure 1-1), and is Volume 1 of the two volume Yakima River Basin Study report. The Integrated Plan offers a proposed approach to improving water management in the Yakima River Basin. The goals of the Integrated Plan are to protect, mitigate, and enhance fish and wildlife habitat; provide increased operational flexibility to manage instream flows to meet ecological objectives, and improve the reliability of the water supply for irrigation, municipal supply and domestic uses. Volume 2 includes technical appendices that provide more detailed information and analysis used as the basis for the Integrated Plan.

The Integrated Plan includes an overview of past and current planning efforts, followed by a description of water resource needs in the Yakima Basin; the Integrated Plan elements; expected outcomes; implementation considerations and next steps.

The Integrated Plan was developed from studies initiated in 1979 and culminating in the Yakima River Basin Study, which was conducted through a planning partnership of the U.S. Bureau of Reclamation (Reclamation) and Washington State Department of Ecology (Ecology). The Yakima River Basin Study was conducted at an appraisal level, which means the targeted level of detail was to provide sufficient information to decide whether to proceed with a more detailed study and evaluation of the Integrated Plan and other appropriate alternatives. Appraisal studies rely primarily on existing data and information for meeting current and projected needs and problems in an area, and in identifying and evaluating potential solutions (Reclamation 2000). The development of a more detailed planning report and alternatives evaluation is the next step, combined with an environmental impact statement (PR/EIS), which would meet the requirements of the National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) at the programmatic level.

The Yakima River Basin is affected by a variety of water problems that impact fish, agriculture, and municipal and domestic water supplies. Since at least the 1970s, the basin's federal, state and local agencies, and Yakama Nation (YN) natural resource managers have participated in federal and state planning efforts to identify solutions to water shortages and restore native fisheries. Building on previous planning efforts, the Integrated Plan is the most comprehensive effort to date in proposing water resource and habitat protection and restoration solutions in the Yakima Basin.

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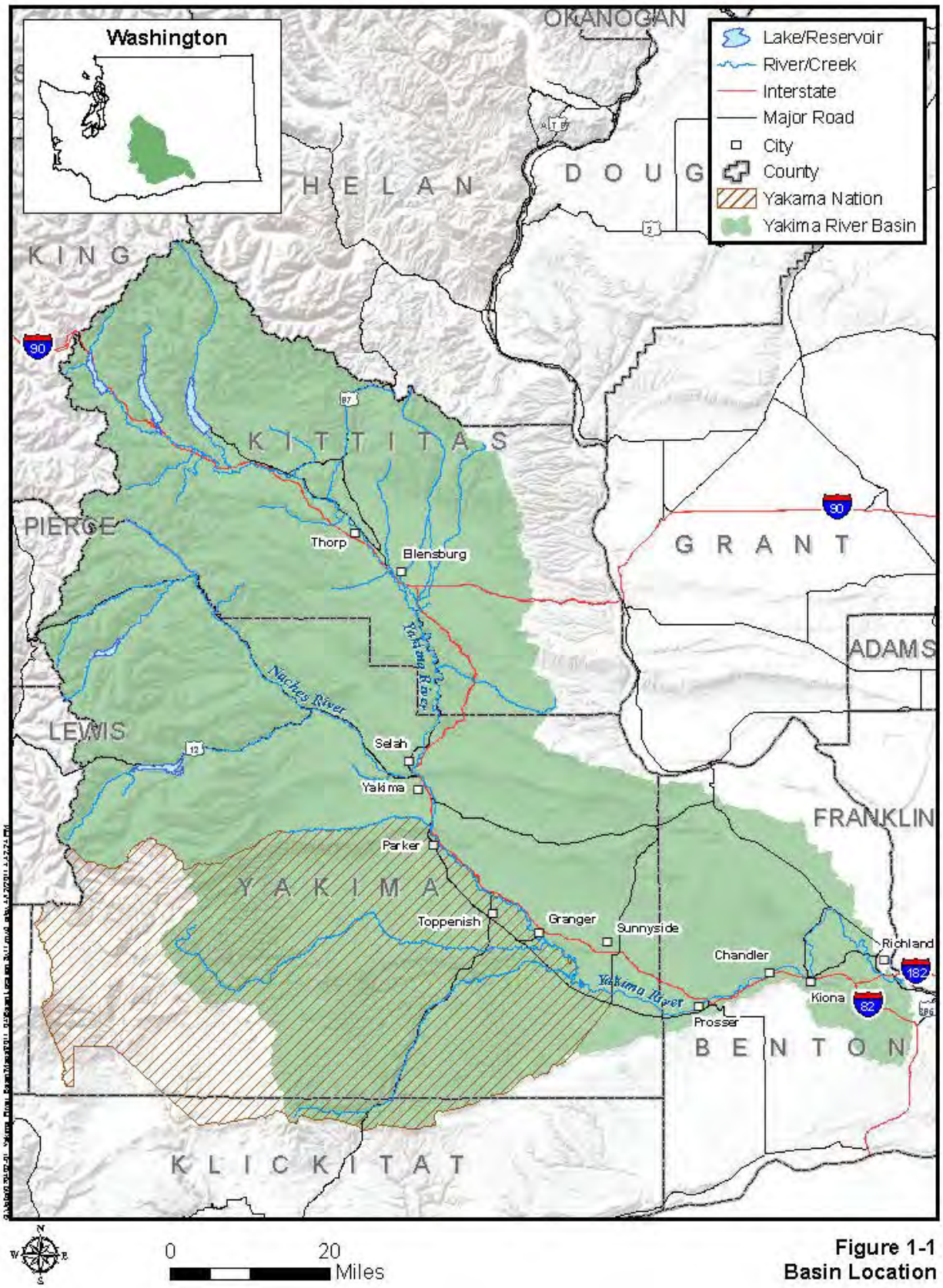

Figure 1-1
Basin Location

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1.1 Elements Included in the Integrated Plan

The Integrated Plan includes seven elements: 1) fish passage 2) structural and operational changes 3) surface water storage 4) groundwater storage 5) habitat protection and enhancement 6) enhanced water conservation and 7) market-based reallocation. It addresses water resource and habitat problems that exist today that are readily resolved through regional solutions, while providing an adaptive management framework to address potential future changes in water needs or hydrology, including potential climate change effects. Table 1-1 displays the proposed actions included in the Integrated Plan. The total cost of all actions in the plan is estimated to be approximately $4 billion. Funding is subject to further review and authorizations at the federal, state and local levels. If funded, the actions listed in Table 1-1 would be carried out over a period of approximately 15 to 20 years. Figure 1-2 shows locations of projects that are identified for particular sites in the basin (programmatic actions that are more dispersed geographically are not shown).

1.2 Overview of Yakima Project and Water Resource and Habitat Problems

Yakima Project

The Yakima Project is a federal reclamation project authorized in 1905. It is operated by Reclamation and provides irrigation water for fertile land that extends for 175 miles along both sides of the Yakima River in south-central Washington. The irrigable lands presently being served total approximately 464,000 acres.

There are seven divisions in the project: Storage, Kittitas, Tieton, Sunnyside, Roza, Kennewick, and Wapato. The Wapato Division is operated by the Bureau of Indian Affairs, but receives most of its water supply from the Yakima Project for irrigation of 136,000 acres of land. Over 45,000 acres not included in the seven divisions are irrigated by private interests under water supply contracts with Reclamation. Storage dams and reservoirs on the project are Bumping Lake, Clear Lake, Tieton, Cle Elum, Kachess, and Keechelus. Other project features are five diversion dams, canals, laterals, pumping plants, drains, two powerplants, and electrical transmission lines. Figure 1-3 identifies Yakima Project facilities and irrigation divisions.

Table 1-1. Elements and Associated Actions Included in Integrated Plan

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

KRD = Kittitas Reclamation District

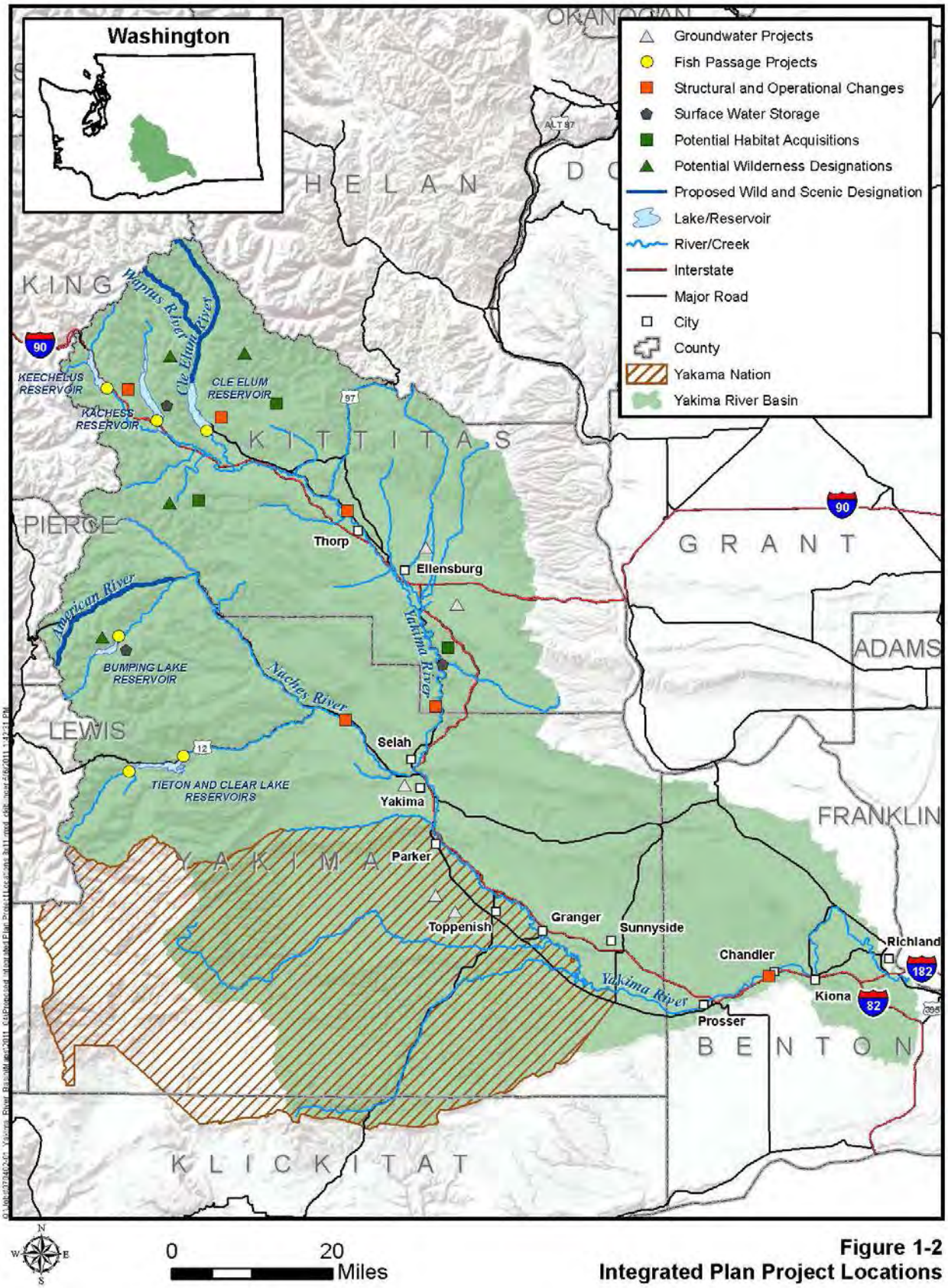

Figure 1-2
Integrated Plan Project Locations

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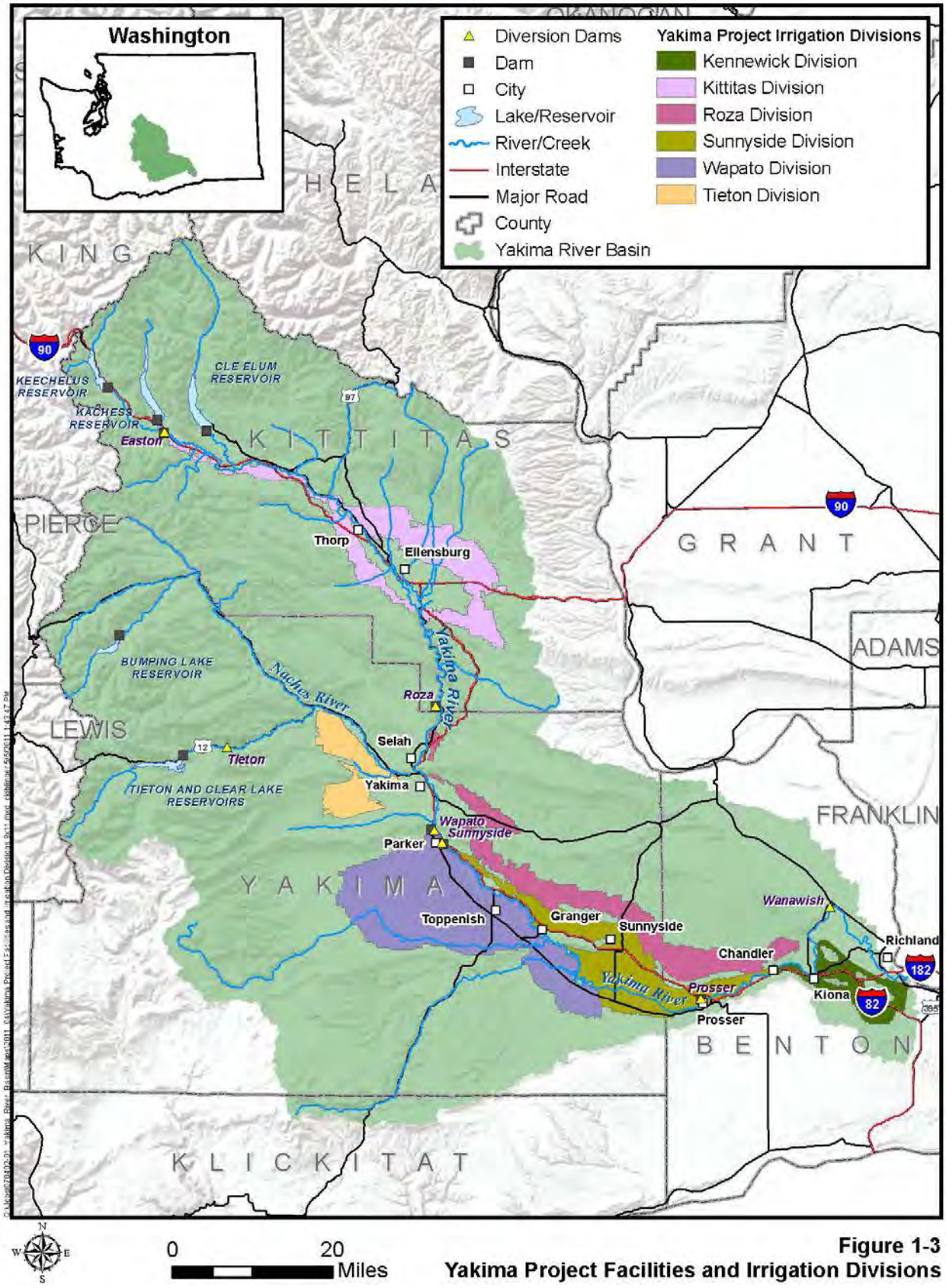

Figure 1-3
Yakima Project Facilities and Irrigation Divisions

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Fish

The Yakima River historically supported large runs of anadromous salmonids, with estimated runs of 300,000 to 960,000 fish a year in the 1880s. These numbers have declined drastically, and three salmon species were extirpated (eliminated) from the basin – sockeye, summer Chinook, and coho. The causes for the declines and extirpations are many, including the following:

- In the 1900s, crib dams on the four natural glacial lakes contributed to the extirpation of sockeye.
- Construction of Reclamation's five storage dams eliminated access to previously productive spawning and rearing habitat for sockeye, spring Chinook, coho, and steelhead salmon, and resident fish populations such as bull trout.
- Irrigation operations have altered stream flows, resulting in flows at certain times of the year that are too high in some reaches and too low in others to provide good fish habitat. This problem is worse during drought years.
- Land development, including road construction, diking, gravel mining, and agriculture has degraded riparian habitat and increased sediment in streams and rivers.
- Irrigation diversions have reduced flows and created fish-passage barriers in tributary streams.

Conditions outside the Yakima River Basin also affected Yakima anadromous fish populations. These include Columbia River dams, and historic fishing pressures in the Columbia River and Pacific Ocean.

While still well below historic levels, in more recent years anadromous fish populations have improved through a combination of fisheries management, habitat, facility improvements, hatchery supplementation and reintroduction efforts. Habitat conditions are improving for steelhead. Reintroduction efforts by the YN using hatchery fish have re-established naturally reproducing coho salmon. YN and Washington Department of Fish and Wildlife (WDFW) have begun reintroduction of sockeye and summer Chinook salmon.

The adverse conditions for anadromous species described above also affect bull trout populations and habitat. Historic bull trout abundance is not well defined in the basin, but there is recognition that its historic distribution was broader than is presently observed, with many distinct populations. The basin was recently designated as critical bull trout habitat, and there is a need to reinstitute year-round connectivity of bull trout habitat between lakes and reservoirs and mainstem rivers, including the Columbia River.

The Economy

Water supply and management problems also affect the local economy. Drought conditions have occurred an average of once every four years in the last 20 years, reducing proratable water supplies well below 70 percent – the supply identified by irrigators to meet minimum crop requirements.

Proratable water users served by the Yakima Project (see box) received 58 percent of their proratable entitlement in 1992; 67 percent in 1993; 37 percent in 1994 (Reclamation 2002); 37 percent in 2001, and 42 percent supply in 2005 (Reclamation 2008).

University of Washington and Reclamation forecasts indicate that climate change would further reduce available supplies and increase the frequency of drought conditions (Reclamation 2011). This could have significant impacts on the local economy.

Two Types of Water Entitlements

Water entitlements served by the Yakima Project are divided into two classes: **nonproratable and proratable.**

Water users with **nonproratable** entitlements are served first and are not reduced until all the proratable entitlements are regulated to zero.

Under drought conditions, **proratable** entitlements receive reduced (prorated) supplies. Over half of the surface-water entitlements in the basin are proratable under a 1945 Consent Decree.

The Yakima Basin is the leading agricultural region in Washington State, accounting for an estimated $3.4 billion of the state's crop, livestock and food processing economy (WSDA 2009). Water shortages will continue to affect the basin's economy.

In addition to economic losses, droughts limit the crops that can be grown and cause conflicts over water use for municipal growth and development in the basin.

1.3 Authority and Scope for Yakima River Basin Study

The Yakima River Basin Study was conducted by Reclamation and Ecology as part of the U.S. Department of the Interior's WaterSMART program. The study supplements information provided through previous efforts to evaluate water supply and aquatic resource problems in the basin and identifies potential remedies.

It characterizes and quantifies basin water resources and current and future water needs for both instream and out-of-stream uses (see box). The analysis and evaluation included the following key components:

- Assessment of instream and out-of-stream water needs.
- Evaluation of various actions for meeting water supply needs, including both surface and groundwater storage and non-storage options; demand reduction; conservation measures; and water banking, marketing, leases, and acquisitions.
- Updated cost estimates for actions considered in the plan.

Out-of-stream and Instream Water Uses

Out-of-stream uses require water to be diverted from surface streams or pumped from groundwater aquifers. For example, these include agricultural irrigation, domestic uses, industrial uses, and water for livestock.

By contrast, **instream** uses leave water in streams and rivers to support ecosystem functions such as maintenance of fish habitat.

- Use of hydrologic modeling for improved understanding of the effects of the Integrated Plan and Future without the Integrated Plan (FWIP).
- A preliminary evaluation of the economic effects of an Integrated Plan.
- Evaluation of the potential impacts of climate change on determined water needs.
- Integrated analysis to evaluate how efforts to improve water supply can be coordinated with efforts to achieve other aquatic resource objectives, including fish passage at major Reclamation reservoirs in the basin and aquatic habitat restoration.
- Review of potential effects of proposed actions on environmental conditions, potential impacts on power users, and other action-specific effects that could require mitigation to implement.

1.4 Previous Activities, Recent Studies and Accomplishments

Yakima River Basin Water Enhancement Project

The Yakima River Basin Water Enhancement Project (YRBWEP) was initiated by Congress in 1979 in recognition of the extreme water shortage problems of the basin. YRBWEP has the following objectives: develop a plan that would provide 1) supplemental water for presently irrigated lands, 2) water for new lands within the Yakama Indian Reservation, 3) water for increased instream flows for aquatic life, and 4) a comprehensive plan for efficient management of basin water supplies. Since 1979, state and federal YRBWEP feasibility study activities have been ongoing with the objectives to develop and implement a comprehensive solution for efficient management of Yakima Basin water supplies (see Figure 1-4).

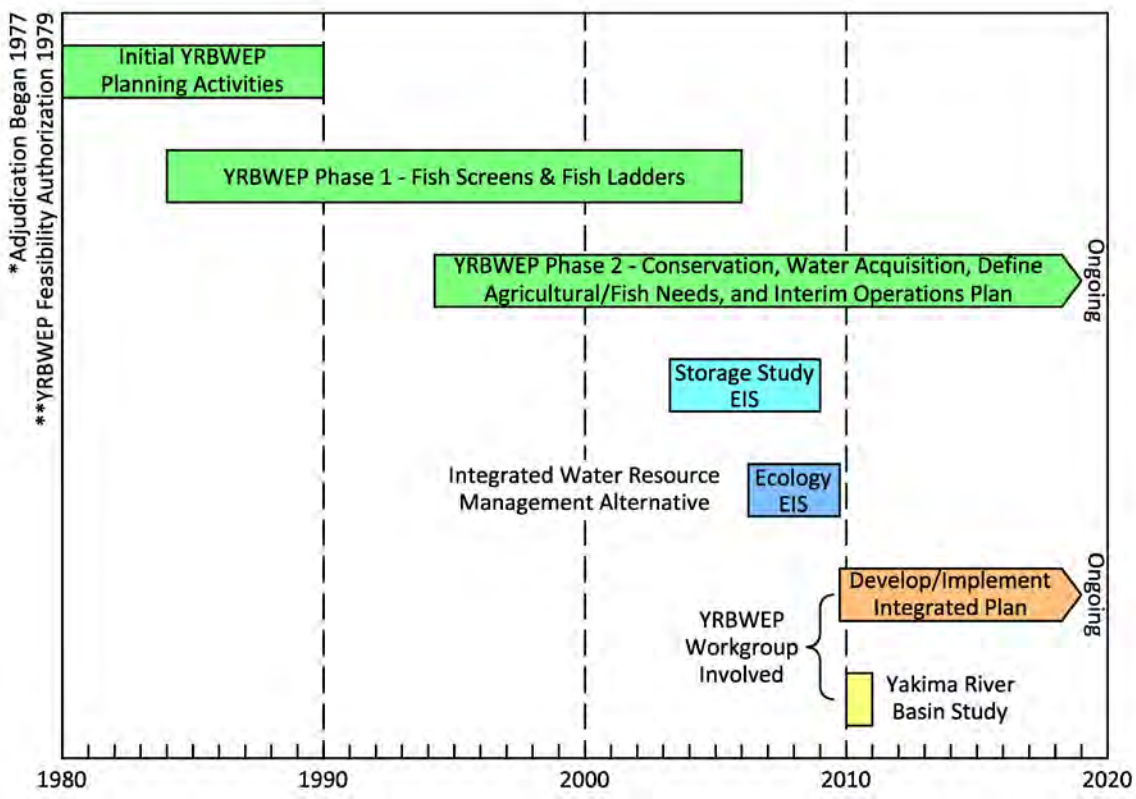

Figure 1-4. Yakima River Basin Water Enhancement Project Timeline

Early in the YRBWEP study process, fish passage problems were identified as needing immediate attention. Congressional legislation in 1984 (Public Law 98-381) authorized Reclamation to design, construct, and operate fish passage facilities within the Yakima River Basin that are in accordance with the Northwest Power and Conservation Council's (NPCC) Columbia River Fish and Wildlife Program (YRBWEP Phase 1). A companion law was enacted August 22, 1984, to provide, among other things, for operations and maintenance costs related to fish facilities (Public Law 98-396, 98 Stat. 1379).The YRBWEP efforts proceeded through the 1980s, but were not fully completed, primarily due to issues and uncertainties associated with basin surface water rights adjudication. In 1994 Congress passed legislation for YRBWEP Phase 2 (Public Law 103-434), which provided for significant water conservation and acquisition activities; studies to define the long-term water needs of fish and irrigators; improvements to the Wapato Irrigation Project; and development of an interim operations plan for management of basin water supplies.

In compliance with the 1994 YRBWEP Act (Phase 2 Legislation – Public Law 103-434), Reclamation and Ecology are cost-sharing partners in the Basin Conservation Program, with Reclamation funding 65 percent of the cost and Ecology and irrigation districts making improvements each funding 17.5 percent. Under this program, two-thirds of the water savings remains in the river, and the irrigation district retains one-third.

Ongoing conservation measures that are applied to irrigation delivery systems increase system efficiency and can reduce the amount of irrigation water diverted, thus increasing flow in the river reach between the point of diversion and the delivery system's downstream return flow. While these flow improvements can be highly beneficial, it is important to recognize that many conservation actions for irrigation systems have no direct effect downstream of the affected reach. This is because water formerly "lost" from the irrigation system actually returns to the river, either from groundwater return flow or operational spills, as characterized in Figure 1-5.

As of June 2010, Reclamation, Ecology, and irrigation entities have cost-shared to develop eight Comprehensive Conservation Plans and two conservation Feasibility Investigation Reports for Yakima Basin irrigation systems. For more information see the Reclamation web site at: http://www.usbr.gov/pn/programs/yrbwep/phase2/basinconservation.html.

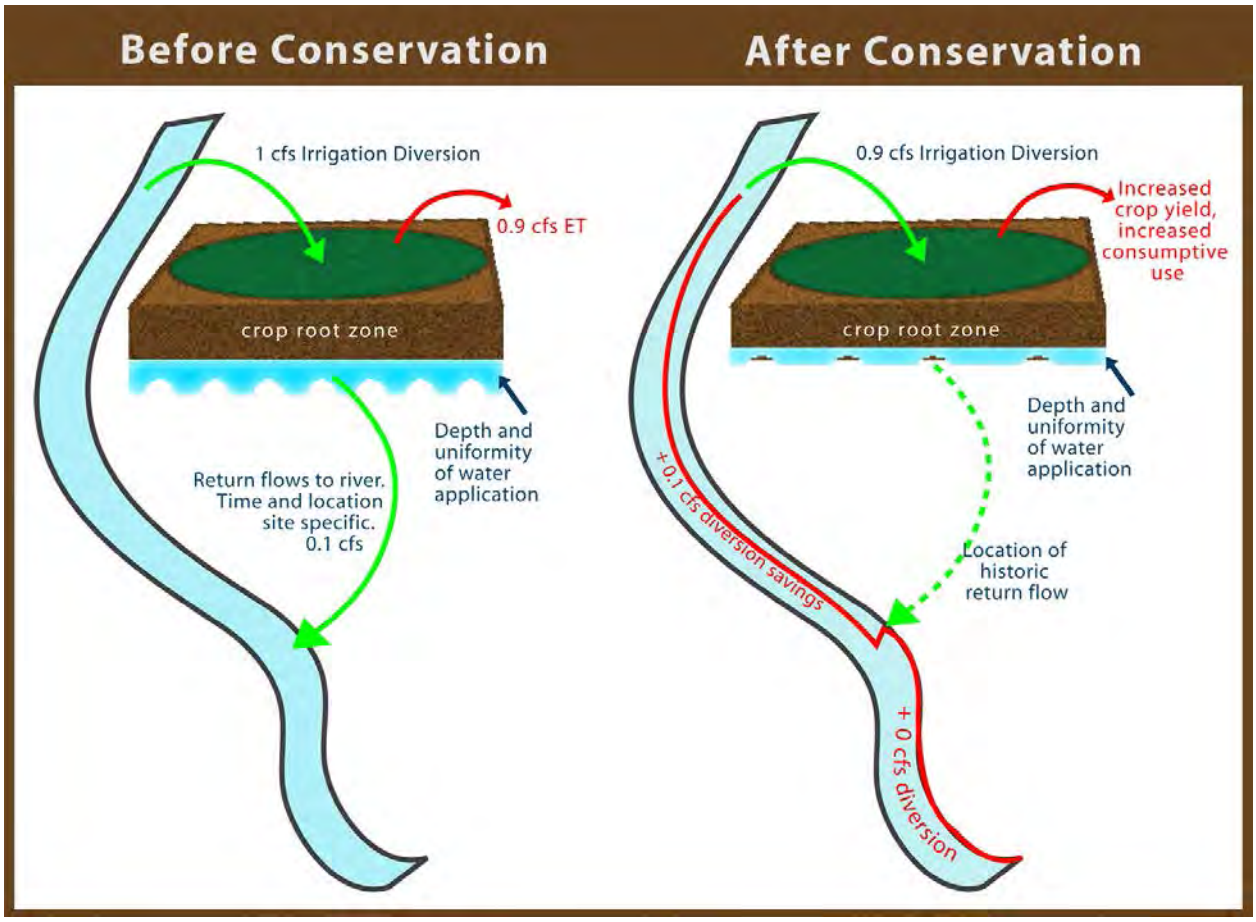

Figure 1-5. Reach Benefits from Conservation

Sunnyside Valley and Benton irrigation districts are in the process of implementing conservation measures identified in their Feasibility Investigation Reports. Several YRBWEP Phase 2 projects have been implemented or are currently in the planning or design phase, including diversion reductions through improvements in irrigation system efficiency, water rights acquisition, and habitat restoration and fish passage at reservoirs and on several tributaries.

Even with these substantial planned or implemented conservation and other improvements, existing and future water needs still exceed available supply as described in Section 2.0. As characterized in Figure 1-5, conservation savings primarily benefit specific reaches where water withdrawal is reduced, and savings do not necessarily accumulate downstream.

An example where this situation is particularly apparent is the Kittitas Valley, which is in the northern portion of the basin. Water not used for crops in this area infiltrates primarily into the shallow, unconfined aquifers and returns to the Yakima River for downstream flows and water supply. Conservation measures in the Kittitas Valley reduce withdrawals and affect flow timing but do not necessarily improve total water supply available (TWSA) in the basin.

Total Water Supply Available (TWSA)

The **total water supply available** for the Yakima River basin is measured above the Parker gage for the period April through September. The Parker gage is located just south of the City of Union Gap on the Yakima River (Reclamation 2002).

Yakima River Basin Water Storage Feasibility Study and Development of the Integrated Plan Alternative

Ecology and Reclamation operated as joint lead agencies throughout Phase 1 and part of Phase 2 of YRBWEP. In 2003 under the direction from Congress and the Washington State Legislature, the two agencies initiated the Yakima River Basin Water Storage Feasibility Study (Storage Study) as authorized by the Omnibus Appropriations Act of 2003 (P.L. 108–7). The Storage Study examined the feasibility and acceptability of storage augmentation in the Yakima River Basin, with an emphasis on a proposed Black Rock Reservoir. This alternative would use Columbia River water in exchange for Yakima River water to provide additional water storage to benefit threatened and endangered species, irrigated agriculture, and future water supply. Other storage alternatives included Wymer Dam and Reservoir, and Wymer Dam Plus Yakima River Pump Exchange Alternative. In January 2008, Ecology and Reclamation released a Draft PR/EIS for the Storage Study (2008). They received comments on the document stating that it had not considered a sufficiently wide range of alternatives and that the alternatives should include an integrated approach to benefit all resources, including fish passage and aquatic habitat improvements in addition to improved storage. The Reclamation Final PR/EIS (completed December 2008) concluded that none of the action alternatives evaluated met federal criteria for an economically and environmentally sound water project and recommended the No Action Alternative as the preferred alternative. While the Black Rock and other alternatives would have provided significant benefits, Reclamation determined that the associated impacts and costs did not justify moving forward with any of the evaluated alternatives. In April 2009, Reclamation wrote a concluding letter to Ecology to complete the Storage Study.

Draft and Final State Alternative and Environmental Impact Statement

Based on the comments received on the Draft Storage Study PR/EIS, Ecology began a separate evaluation of an alternative solution to the Yakima Basin's water supply problems, including consideration of aquatic habitat and fish passage needs. In mid-2008, Ecology prepared a Supplemental Draft EIS that proposed additional storage options integrated with aquatic habitat and fish passage improvements. This alternative was named the “Integrated Water Resource Management Alternative.” A Final Environmental Impact Statement (FEIS) was issued in June 2009 (Ecology 2009). This FEIS proposed an Integrated Water Resource Management Alternative (IWRMA) using a range of water management and habitat-improvement approaches comprised of seven major elements: fish passage, structural/operational changes, surface storage, groundwater storage, fish habitat enhancements, enhanced water conservation, and market-based reallocation of water resources. This framework provided the basis of the YRBWEP Workgroup’s (Workgroup) activities on the Yakima River Basin Study and Integrated Plan, which are described below. Figure 1-6 characterizes the relationship between the Storage Study and FEIS planning processes, and how this led to the Workgroup planning effort.

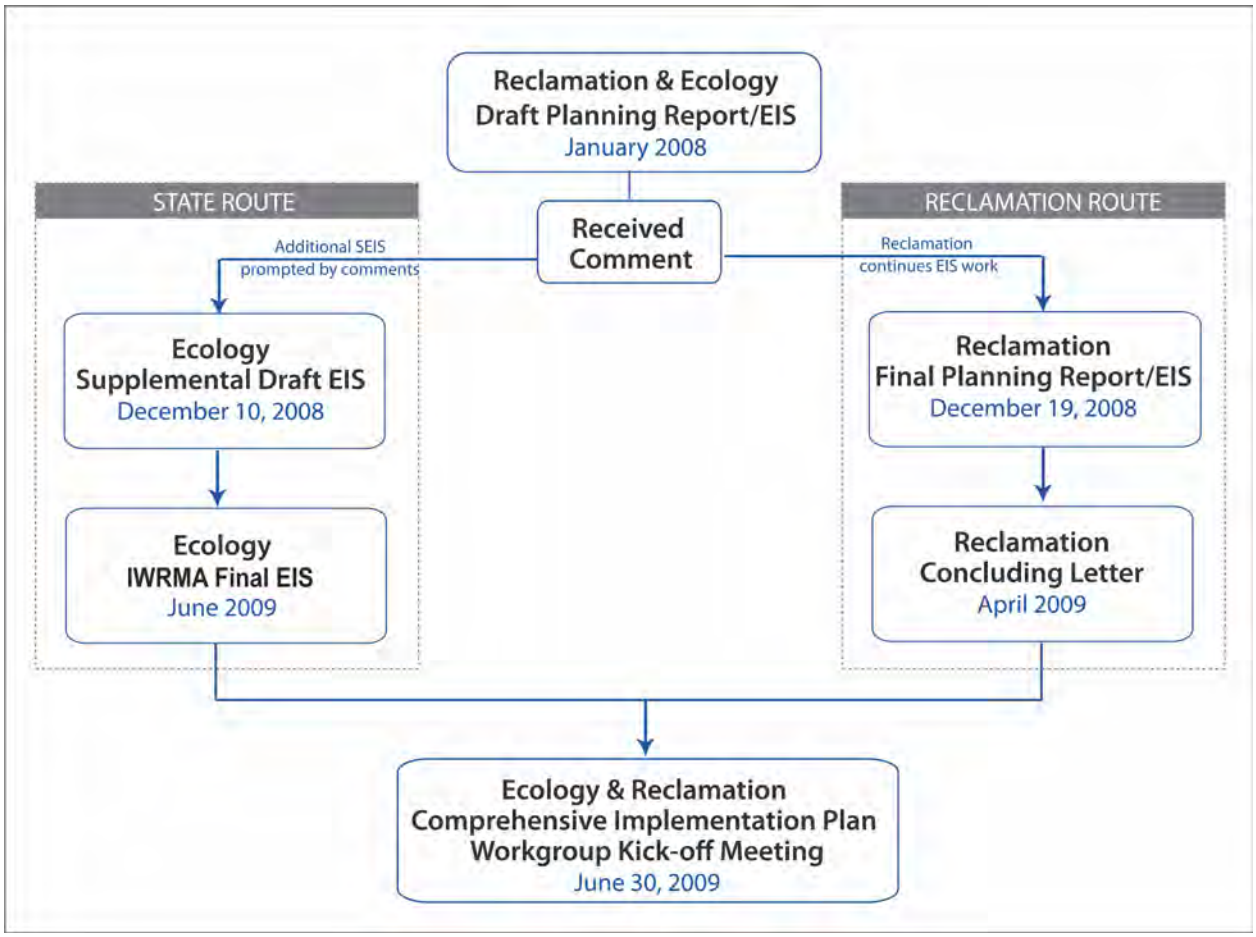

Figure 1-6. Storage Study and IWRMA FEIS Planning Processes Lead to Establishing Workgroup and Integrated Planning Process

1.5 YRBWEP Workgroup Efforts

In 2009, Reclamation and Ecology convened the Workgroup to more thoroughly review studies and information produced over the past 30 years, including Ecology's FEIS, and formulate a comprehensive and integrated solution for the basin's water resource problems and ecosystem restoration needs. The Workgroup is composed of representatives of the Yakama Nation, federal agencies, Washington State and local governments, an environmental organization, and irrigation districts (see Workgroup membership rosters inside front cover). Staff representing the state's congressional delegation also attended regularly to observe Workgroup discussions. All meetings have been open to the public with opportunities for public input; public attendance regularly numbered 20 to 30 individuals.

The Workgroup held its first meeting on June 30, 2009 (see Figure 1-6), and meetings continued every two weeks through 2009. The Workgroup drew on the 30-plus years of studies and information to support its planning efforts.

Preliminary Integrated Plan Developed

The Workgroup agreed early in 2009 that a comprehensive and integrated plan would include the seven elements outlined in Ecology's FEIS. The Workgroup developed a preliminary Integrated

Plan and at the end of 2009 agreed to move forward with it. This plan included as part of the seven elements, a list of potential water supply actions for surface and groundwater, proposed modifications to existing operations, fish passage at existing reservoirs, a proposed fish habitat enhancement program, and actions related to market reallocation. Hydrologic and fish habitat benefits and funding requirements were also roughly estimated, and a preliminary implementation approach and schedule was outlined. The preliminary Integrated Plan is available at: http://www.usbr.gov/pn/programs/yrbwep/reports/iwrmp/index.html.

While not every Workgroup member supported all of the preliminary Integrated Plan elements, they unanimously supported further evaluation and analysis of the plan through the Basin Study, which was jointly conducted in 2010 by Reclamation and Ecology.

Through the Basin Study and associated interaction with the Workgroup and its subcommittees, basin needs were specified in greater detail, and actions were further defined, evaluated, and updated. Expected hydrologic, fish habitat, fisheries, and economic effects for the Integrated Plan and FWIP were also characterized.

Subcommittees Provided Input

During preparation of the preliminary Integrated Plan and the Basin Study, Workgroup subcommittees provided input on the Integrated Plan and the supporting technical work (see subcommittee membership rosters inside front cover). Results and recommendations were then reviewed by the Workgroup. Further information on specific technical work is summarized in other sections of this document and Volume 2, Technical Appendices. Following is a list of the Workgroup subcommittees and their main areas of focus:

- Fish Passage Subcommittee – Developed recommendations for fish-passage improvements and scheduling at the six Reclamation dams.
- Habitat Subcommittee – Developed a program description for mainstem floodplain and tributary habitat enhancement.
- Out-of-Stream Needs Subcommittee – Characterized existing and future needs for municipal, industrial, domestic and agriculture water uses; and reviewed water conservation opportunities and market-based reallocation potential.
- Instream Needs Subcommittee – Characterized reach-specific objectives for 15 mainstem Yakima River and Naches River reaches, and for certain tributaries where potential actions in the Integrated Plan could also improve flow conditions.
- Modeling Subcommittee – Provided input to hydrologic modeling, which incorporated water supply changes that would result from potential actions identified in the Integrated Plan. Several different scenarios were analyzed, including climate change scenarios, to characterize effects on identified needs (TWSA, prorationing levels, and instream flow objectives).

Parallel with subcommittee efforts, potential actions for inclusion in the Integrated Plan were characterized through engineering analyses to refine available information and consider alternative project configurations. Analyses results, along with cost estimates, assessments of barriers and risks, and potential economic effects from the Integrated Plan, were presented at Workgroup meetings during the summer and fall of 2010. Work products were then updated based on Workgroup feedback.

As part of the planning effort, the Workgroup also worked with Reclamation and Ecology to produce a short video about the Integrated Plan, entitled: “Yakima Basin Solutions Now and For

the Future." The video, finalized in early November 2010, provides an overview of the Yakima River Basin Study goals and objectives, water uses, resource management challenges, and commentary from Workgroup members on changes needed to meet these challenges. The video can be viewed on Reclamation's web site at: http://www.usbr.gov/pn/programs/yrbwep/2010workgroup/index.html.

Integrated Plan Summary Support Document Approved

An Integrated Plan summary support document was compiled for Workgroup deliberation in the fall of 2010. The summary included proposed Integrated Plan elements and actions, instream and out-of-stream water needs, water supply and fisheries benefits, and a preliminary schedule identifying plan implementation timing, implementation sequence, and triggers for adjusting the plan. It also outlined an approach for plan review and future adaptations, including principles to guide future plan adjustments.

While the Workgroup was preparing to take action on the summary support document, a supplemental effort was underway to strengthen the ecosystem protection and restoration portions of the plan. A group of natural resource conservation community stakeholders developed a proposal for watershed enhancements and a broadly structured advance mitigation program to further enhance the plan's watershed, water supply and ecological restoration goals. The findings from this process were accepted by the Workgroup and incorporated into the Integrated Plan summary support document and this plan (see Section 3.1.5).

In March 2011, after 21 months of meetings, modeling and studies, the Workgroup unanimously approved the Integrated Plan summary support document, establishing the elements and actions to include in the Integrated Plan. Reclamation and Ecology plan to move the proposal forward for further consideration.

As part of the summary plan approval, Workgroup members reaffirmed their intent to work together to develop a strategy and agreement for advancing the Integrated Plan. The Workgroup also approved organizing an Implementing Subcommittee comprised of tribal, state, and local government representatives, and one representative of environmental interests to oversee efforts to advance the plan. Implementing Subcommittee members will be drawn from the existing Workgroup participants. The Implementing Subcommittee will report progress back to the Workgroup which will continue to meet periodically to receive updates on the PR/EIS process.

The next step is preparing a PR/EIS under NEPA and SEPA at the programmatic level. The final planning report and NEPA/SEPA processes would consider the Workgroup-proposed Integrated Plan along with other alternatives that may be identified for solving the basin's water resource problems and ecosystem restoration needs. A programmatic review typically is focused on a group of actions, and provides a foundation for more project-specific environmental review that would follow during plan implementation. The PR/EIS process is described in more detail in Section 6.0.

Figure 1-7 characterizes the major steps in the planning processes described above, and where the Workgroup has interacted. It also identifies the planning report and programmatic review, and other steps that could follow.

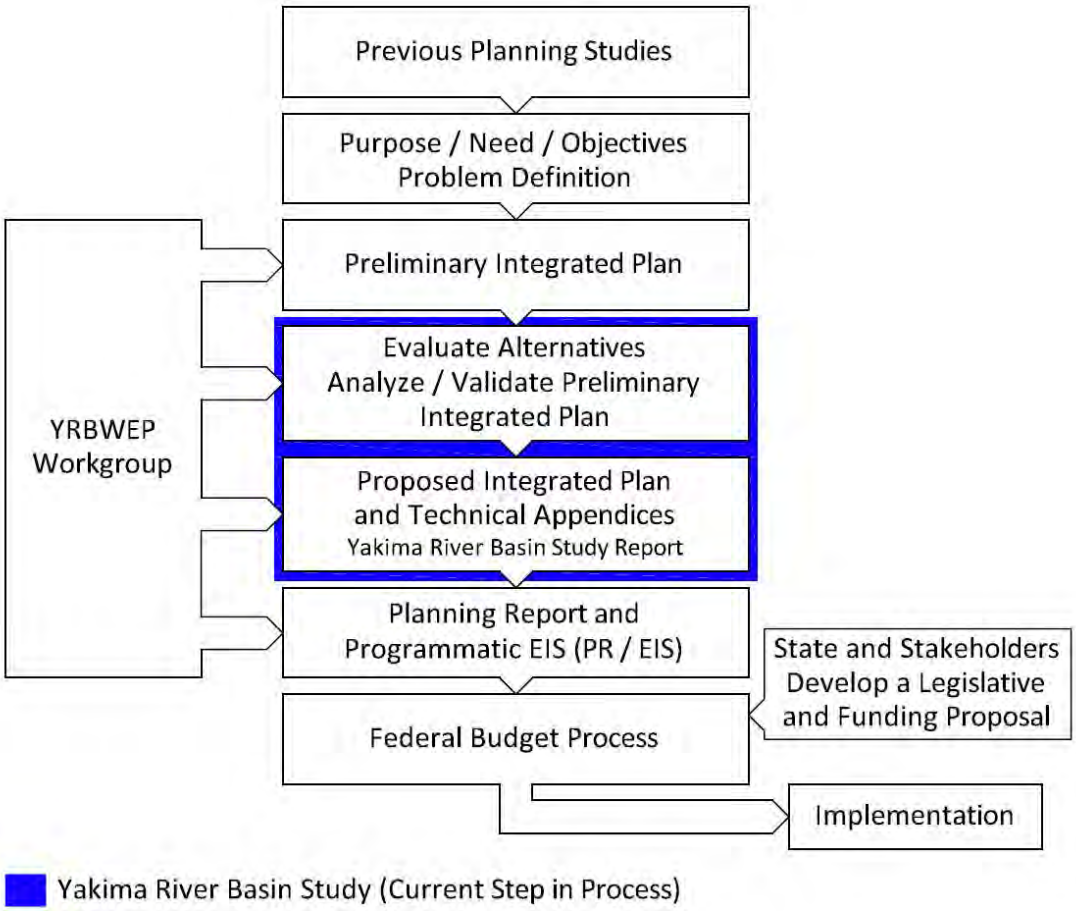

Figure 1-7. Yakima River Basin Integrated Water Resource Management Planning Process

1.6 Document Organization

The Yakima River Basin Study is comprised of two volumes:

- **Volume 1 – Proposed Integrated Water Resource Management Plan**. In addition to Section 1, Introduction and Purpose, this volume includes the following sections:
- Section 2 – Water Resource Needs in the Yakima Basin
- Section 3 – Proposed Integrated Water Resource Management Plan
- Section 4 – Expected Outcomes
- Section 5 – Implementation Considerations
- Section 6 – Next Steps
- **Volume 2 – Technical Appendices**. This volume is comprised of technical memoranda prepared under the Yakima River Basin Study. The technical memoranda provide more detailed information on water resource conditions, water supply and fish passage projects and other actions, economic effects, costs, hydrologic modeling and policy and legal barriers.

2.0 Water Resource Needs in the Yakima Basin

The Yakima River Basin is affected by a variety of water resource constraints that adversely impact agriculture, anadromous and resident fish, and municipal and domestic water supply. Building from the past 30 years of studies including Ecology's Integrated Plan Alternative FEIS, the Workgroup listed the following factors contributing to water resource constraints in the basin):

- Demand for irrigation water cannot always be met in years with below-average runoff, leading to reduced (prorationed) irrigation water for junior water-right holders in those years.
- Farming and related income are reduced in dry years. Consecutive dry years put the basin's perennial crops at extreme risk.
- Dams, changes in water temperatures, other obstructions and inadequate stream flow, block fish passage to upstream tributaries and spawning grounds.
- Floodplain modifications such as diking, channelization, wetland draining, gravel mining, and road construction prevent proper floodplain functions.
- Riparian habitat has been degraded by past and present land-use practices.
- In most years, spring flows in the middle and lower Yakima River are insufficient to optimize survival of outmigrating smolts.
- In most years, summer flows in the Wapato reach and immediately downstream from Prosser Diversion Dam to the mouth of the Yakima River are too low to provide key habitat functions.
- Unnaturally high summer flows from storage and release operations persist in the upper Yakima and Cle Elum rivers, impacting rearing habitat for juvenile salmonids.
- The annual late-summer river operation known as flip-flop (shifting of water demand from the upper Yakima Basin reservoirs to the Naches system reservoirs) disrupts salmonid habitat and has adverse impacts on aquatic insect populations, especially on the Tieton and lower Naches rivers, which experience unnaturally high late summer flows during flip-flop.
- Winter flows in the upper Yakima, Cle Elum, and Tieton rivers are low and controlled for water storage, potentially impacting the survival of overwintering juvenile salmonids.
- Surface water rights are fully appropriated in the basin. Since groundwater systems are connected to surface water, it is difficult to acquire water rights to meet future municipal and domestic water demand.
- Pumping groundwater for irrigation, domestic, and municipal uses reduces surface water flows in most (or many) locations, which can affect existing water rights.
- Hydraulic continuity between groundwater and surface water in the basin creates uncertainty over the status of groundwater rights, since most of these are junior to surface water rights in the Yakima Basin under the Washington State Water Code.

2.1 Out-of-Stream Needs

The Yakima River Basin Study included assessment of current and future out-of-stream water needs (see Volume 2 technical memorandum, *Water Needs for Out-of-Stream Uses*). Out-of-stream uses are summarized below.

Yakima Project Agricultural Irrigation

Diversions for the Yakima Project above the Parker gage averaged approximately 1.7 million acre-feet from 1990 to 2009, not counting drought years. An additional 100,000 acre-feet was diverted annually below the Parker gage by the Kennewick Division. In the past five non-drought years, diversions have averaged 1.6 million acre-feet. Total diversions have declined over the past 50 years through conservation practices, cropping and land-use factors, and changes in operations of the Yakima Project to improve instream flow.

During drought years, water supply is not adequate to serve all Yakima Project entitlements (water rights) above Parker gage, so deliveries to districts with proratable entitlements are reduced. Sunnyside Valley Irrigation District and Yakima-Tieton Irrigation District have some proratable entitlements, but have stated that at this time they do not foresee needing additional water. Roza Irrigation District, Wapato Irrigation Project (WIP), and Kittitas Reclamation District (KRD) are severely affected by prorationing during droughts (see Figure 2-1). Excluding Sunnyside Valley and Yakima-Tieton irrigation districts, these three districts have 96 percent of Yakima Project proratable water rights above the Parker gage. Therefore, consideration of drought-year shortfalls focuses on these three districts.

Kennewick Irrigation District (KID), although having proratable entitlements, has not been impacted to the same level as Roza Irrigation District, WIP and KRD because the KID is located downstream from Parker gage near the downstream end of the Yakima River Basin. Most of their water supply is derived from return flow from upstream irrigation districts which improves the reliability of their supply.

In prior Yakima River Basin water-planning processes, the irrigation community has consistently identified a prorationing level of 70 percent as a volume that meets minimal supply needs and prevents severe economic losses to farmers during a drought. The most recent droughts occurred in 1992-1994, 2001 and 2005. The 2001 drought was the worst single-year drought in recent history and was used to estimate the shortfall between a prorationing level of 70 percent and water deliveries that occurred that year. During the 2001 drought, prorationed supplies were only 38 percent of entitlements. The difference in diversions between 70 percent and 38 percent prorationed supply for Roza, WIP and KRD combined is approximately 355,000 acre-feet for that year. However, since KRD returns approximately one-half of its diversion back to the Yakima River as return flow during the irrigation season, the supply shortfall is estimated to be approximately 299,000 acre-feet. Table 2-1 identifies the full Roza, WIP and KRD entitlement, 70 percent proration, 2001 water supply and the difference between 2001 supply and the 70 percent proration level, which provided the basis for estimating the supply shortfall.

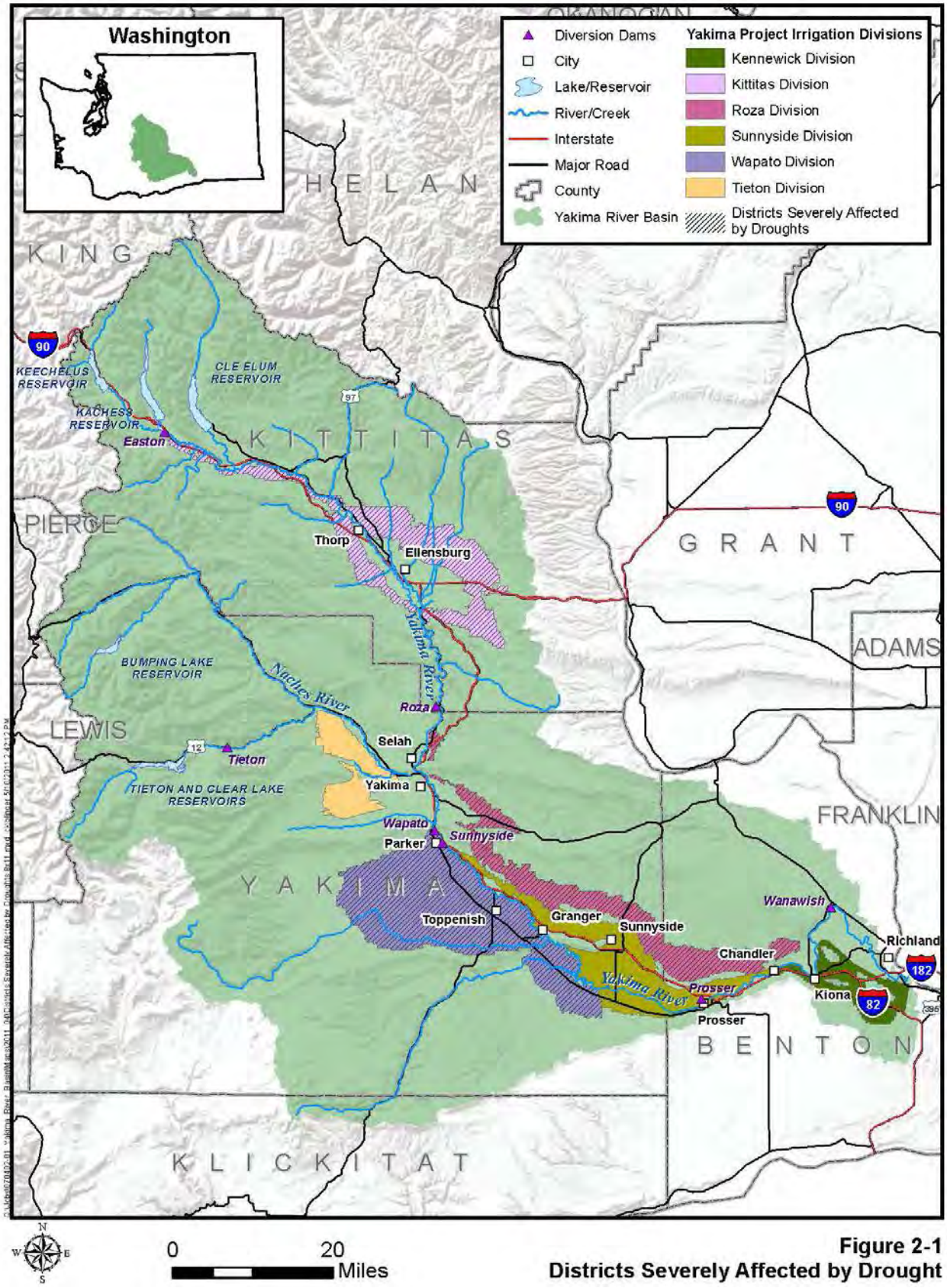

Figure 2-1
Districts Severely Affected by Drought

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Table 2-1. Roza, WIP and KRD Entitlements and Proration Levels (in acre-feet)

District	Roza	WIP[1]	KRD	Total
Full Entitlement	395,000	655,613	336,000	1,386,613
Full Entitlement after May 1 (Date of Proration for 2001)	337,500	581,270	329,280	1,248,050
70% Proration after May 1	236,250	485,720	230,496	952,466
2001 Diversions after May 1 (not including leased water)	119,912	359,228	117,914	597,054
Difference between 2001 and 70% (Shortfall)	116,338	126,492	112,582	355,412

[1] WIP's entitlement includes 350,000 acre-feet of proratable supply and 305,613 acre-feet of non proratable supply.

Climate change is expected to affect both water supplies and consumptive use by crops in the Yakima Basin. The estimated increase in consumptive use for Yakima Project irrigation districts is in the range of 8 to 10 percent. That totals approximately 95,000 acre-feet per year. Consumptive water use is the portion of water that evaporates, is used in products or crops, or consumed by humans or livestock. That estimate assumes current cropping patterns would continue in the future and therefore does not account for potential responses to climate change by farmers who may plant different crops. The estimate also assumes a full water supply is available for all currently irrigated crops; in drought years less water would be available and the increase in consumptive use would be less. Potential climate change effects are discussed further in Sections 2.3 and 4.6.

Agricultural Irrigation Supplied by Other Sources

Total water usage for Yakima Basin agriculture outside federally-supplied land is estimated to be 590,000 acre-feet in non-drought years. This includes irrigators on land adjacent to the major federally supplied areas, as well as irrigators along tributary streams that flow into the Yakima River. Approximately two-thirds of this comes from surface water supplies and one-third from groundwater (individual wells). A smaller quantity is used in drought years as surface water supplies are reduced. The water needs assessment does not estimate the drought-year supply deficiency in this category because the Integrated Plan is not intended to provide additional supplies for this category of water use.

Municipal and Domestic Uses

Water needs in this category are estimated to be 91,000 acre-feet in 2010. This includes 42,000 acre-feet for large public water systems serving the six largest cities of the Yakima Basin; 15,000 acre-feet for smaller public water systems; and 34,000 acre-feet for owners of domestic wells. The municipal uses include both surface and groundwater (including urban irrigation and potable uses), while the domestic wells are entirely groundwater. An estimated 60 percent of the water

use in this category is non-consumptive, meaning that water pumped or diverted returns to the Yakima River or groundwater aquifer.

Water needs for municipal and domestic uses are expected to increase due to ongoing population growth in the Yakima River Basin. Based on a population growth forecast of 1.5 percent annually through 2024, and one percent annually from 2025 to 2060, and without adjusting for other factors, this water use is projected to increase by 72,000 acre-feet in the 50 years if water can be made available to serve this use. Adjusting for existing trends in water conservation, and offsets from conversion of crop land to urban uses, the net increase is reduced to 49,000 acre-feet. When return flows are included, the net change in consumptive use is projected to be an increase of 20,000 acre-feet from 2010 to year 2060.

Other Uses

The Yakima River Basin has a number of other types of consumptive and non-consumptive water uses, including water supply diverted or withdrawn to support fish and wildlife propagation; commercial and industrial uses separate from municipal systems; livestock use; and non-community public water systems. These water uses are estimated to be about 26,000 acre-feet annually. Since this quantity is relatively small, the Workgroup determined that these uses did not need to be addressed by the Integrated Plan.

2.2 Instream Needs

Yakima Project surface water supplies come from the natural, unregulated runoff of the Yakima River and its tributaries, irrigation return flows, and releases of stored water from the five main reservoirs in the upper Yakima and Naches River basins: Keechelus, Kachess, Cle Elum, Tieton, and Bumping. The reservoirs store approximately 30 percent of the average annual runoff in the basin and are operated to meet irrigation demands, flood-control needs, and instream flow requirements. The Yakima Project also provides water for hydroelectric power generation, fish and wildlife benefits, and recreation.

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. Since the majority of spring and summer runoff is from snowmelt, 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.

Yakima Project operations cause reduced summer, early fall and winter stream flows, and unnaturally high summer flows in some river reaches, inhibiting migration, spawning, and rearing conditions for anadromous fish populations in the basin. In most years, as a result of Yakima Project operations, spring flows in the middle and lower Yakima River are not sufficient to optimize smolt outmigration. Summer flows in many reaches of the basin are too low in most years to provide desired conditions for salmonid survival and production. In other stream reaches, late-summer high flows related to project operations disrupt salmonid rearing

Through coordination with the Instream Flow Subcommittee, Yakima Basin reach-specific flow problems were characterized along with recommended flow objectives, reach prioritization (high, medium or lower), species benefitted, and actions to address the flow objectives, including both qualitative and quantitative targeted improvements. Fifteen mainstem reaches and eight

tributaries or groups of tributaries within the Yakima Basin were reviewed. Nine mainstem reaches with high priority flow objectives were identified.

In some reaches on the Yakima River a spring pulse was identified as a high priority flow objective but was not identified as a high priority in the adjacent downstream reach or reaches. The Subcommittee assumed those flow pulses would propagate downstream and downstream reaches did not have to be assigned the same high priority.

The Subcommittee also considered constraints to making changes to flip-flop operations even with Integrated Plan projects. A high priority was not assigned to changing the operations of Rimrock Reservoir and reducing flow in the Tieton and Naches rivers during flip-flop as hydrologic modeling has determined that flip-flop operations cannot be eliminated.

Specific instream flow numbers are not always provided in the reach analysis developed for the Yakima Basin Study, because scientific understanding of the relationship of flow to fish survival is limited in many instances. In addition, the objectives would vary with environmental conditions. For example, water that might have been directed to one ecological purpose may be more ecologically valuable elsewhere during water shortages.

Table 2-2 summarizes the reaches with high-priority flow objectives that were used in the RiverWare hydrologic model to test the effectiveness of actions or groups of actions in the various elements of the Integrated Plan. Figure 2-2 identifies where these reaches are located in the basin. The results of the hydrologic modeling are provided in Section 4.4.

Table 2-2. High Priority Reaches and Flow Objectives

Reach	High-Priority Flow Objectives
Yakima River, Keechelus Dam to Lake Easton	• Reduce flows to 500 cfs during July. • Ramp flows down from 500 cfs beginning August 1 to 120 cfs by the first week of September. • Increase base flow to 120 cfs year-round. • Provide one pulse flow (500 cfs peak) in early April. • In drought years, provide an additional pulse of 500 cfs in early May.
Yakima River, Easton Reach	• Increase September and October spawning flows to 220 cfs. • Increase minimum flows to 250 cfs all other times for rearing which provides access to side channels.
Cle Elum River	• Increase minimum flow to 500 cfs (previous analyses performed for Integrated Water Resource Management Alternative: Final EIS [Ecology, 2009] indicated 300 cfs could be provided so a range of 300-500 cfs will be tested in the hydrologic modeling). • Decrease flows by 1,000 cfs beginning the first of August.
Yakima River, Cle Elum to Teanaway River	• Ramp flows down starting July 1 to 1,000 cfs flow rate by August 31.
Yakima River, Teanaway River to Roza Dam (Ellensburg Reach)	• Reduce flow by 1,000 cfs beginning July 1. • Reach a flow of 1,000 cfs by August 31.
Yakima River, Roza Dam to Naches River	• Increase flows in the spring to a minimum of 1,400 cfs. • Increase flows in the fall and winter to a minimum of 1,000 to 1,400 cfs.
Tieton River	• Increase minimum flows to 125 cfs from late October to April 1.
Lower Naches River	• Increase minimum flow rate to 550 cfs from June 1 to November 1. • Change the ramping rates from spring to summer flows to a more gradual decline. • Reduce September flows to as close as possible to unregulated conditions.
Yakima River, Parker to Toppenish Creek (Wapato Reach)	• Provide a spring pulse of 15,000 to 20,000 acre-feet in early May in dry years. • Change ramping rate at end of high flows that occur in June-July in average to wet years.
Manastash, Taneum, Cowiche Creeks	• Replace current diversions with Yakima or Naches River water; deliver water directly to tributaries if supply replacement is not feasible. No specific flow objectives were identified.
Ahtanum Creek	• No flow objectives or augmentation alternatives were identified by subcommittee.

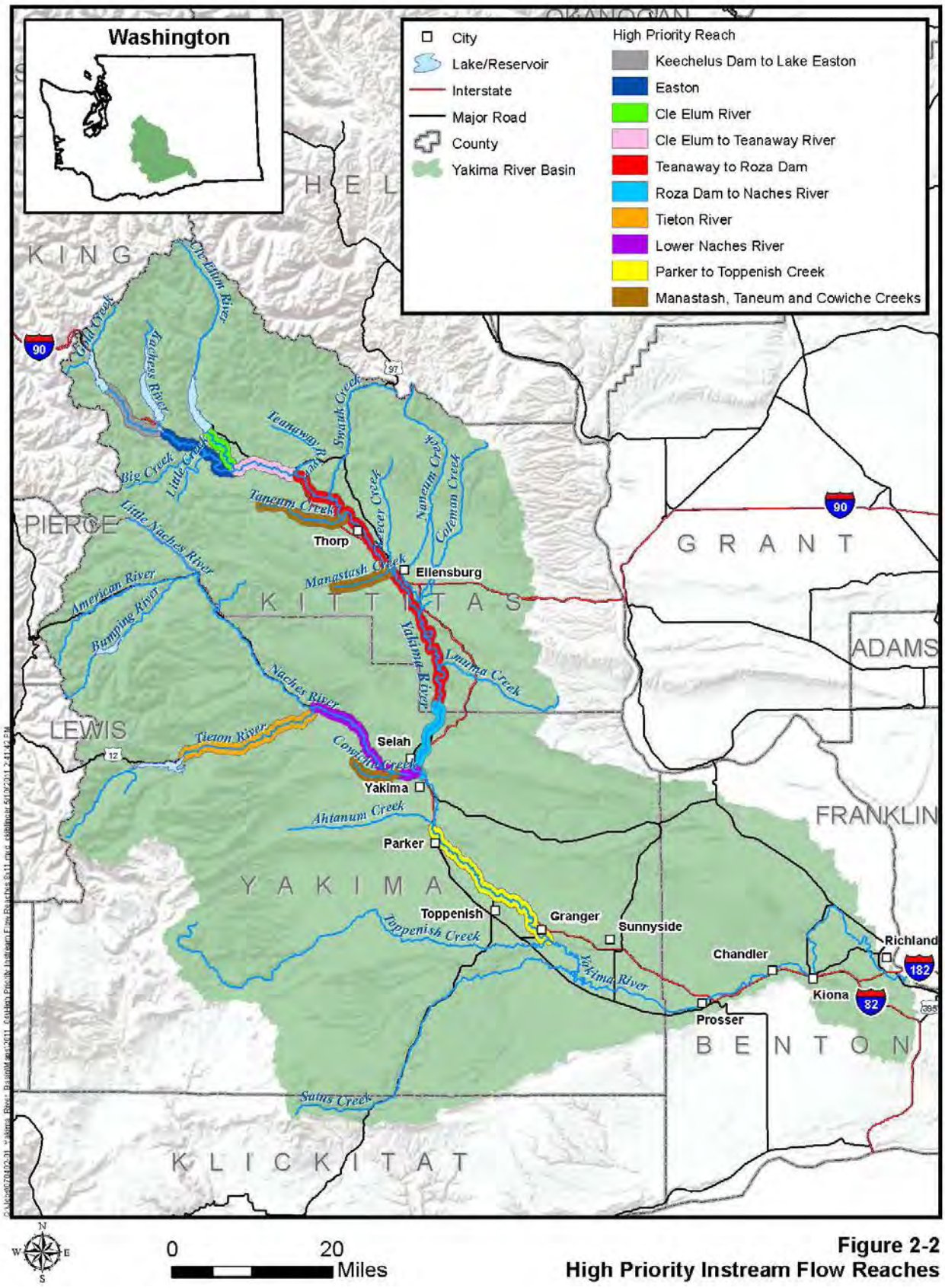

Figure 2-2
High Priority Instream Flow Reaches

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2.3 Climate Change

The Yakima River Basin could be affected by climate change in the years ahead. Climate change may affect the timing and quantity of precipitation, how precipitation is stored and released from snowpack, and the quantity and timing of consumptive use by farmers, businesses, residents and other water users. Section 4.6 describes how potential effects of climate change on water supplies were addressed in the Yakima River Basin Study.

Climate change may also affect the amount of water needed for agricultural and landscape irrigation. A rough estimate of these effects was developed by comparing expected evapo-transpiration (ET) rates under current conditions with those under projected climate change conditions (see Volume 2 technical memorandum, *Water Needs for Out-of-Stream Uses*). Based on these estimates, irrigation demands in the RiverWare model were increased by an average of 9 percent and municipal demands by 5 percent to represent potential climate change conditions. These values should be considered preliminary and are subject to uncertainties of at least plus or minus 50 percent.

Climate change is expected to affect stream flows in both magnitude and timing. In general, increased air temperatures would likely cause some precipitation to fall as rain rather than snow, which would increase winter and early spring rainfall and reduce snowpack runoff that occurs in the late spring and early summer. Additionally, higher air temperatures would cause snowpack runoff to begin earlier, which would shift the peak runoff period to a point earlier in the season. Climate change is also expected to affect water quality. Reduced snow pack and warmer air temperatures are anticipated to increase water temperature during certain times of the year.

In regulated stream reaches (Yakima, Kachess, Cle Elum, Bumping, Tieton, Lower Naches rivers) the stream flow hydrograph would still be shaped mainly to supply water for irrigation. The relative changes in stream flow from existing operations may be less than in unregulated rivers (Teanaway, Upper Naches rivers). However the capacity of existing reservoirs is not sufficient to store enough winter runoff to compensate for the effects of climate change; therefore reduced summer flows are likely.

In unregulated rivers it is predicted that winter flows would be higher, with spring and summer flows lower. In tributaries the same types of effects would be experienced. In addition, the combination of climate variability and climate change is predicted to increase the likelihood of droughts, which would decrease stream flow in both regulated and unregulated river reaches and tributaries throughout the year.

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3.0 Proposed Integrated Water Resource Management Plan

This section identifies elements and actions of the proposed Integrated Plan designed to meet the in and out of stream needs described in Section 2. Collectively, proposed plan actions would provide additional water supply, operational flexibility and habitat protections and enhancements to improve water supply reliability, improve instream flows to meet ecological objectives and protect, mitigate, and enhance fish and wildlife habitat. Section 4 characterizes the specific benefits that could be realized from the proposed Integrated Plan, and Section 5 identifies implementation considerations, including expected mitigation measures and an instream flow management framework for achieving ecological objectives.

The proposed Integrated Plan includes a wide range of actions organized into seven categories:

- Fish passage
- Structural and operational changes
- Surface water storage
- Groundwater storage
- Habitat protection and enhancement
- Enhanced water conservation
- Market reallocation

Following the discussion of actions, this section also includes information on costs and a preliminary implementation schedule for the proposed Integrated Plan.

A funding strategy for plan implementation has not yet been developed. This strategy would be developed after completing the final planning and environmental review process described in Section 6.0.

3.1 Integrated Plan Elements and Actions

The seven elements and associated actions of the Integrated Plan are described below. Volume 2 includes technical memoranda with supporting information for each action.

3.1.1 Fish Passage

Proposed fish passage actions are intended to restore access to habitat above the five existing large storage reservoirs and provide upstream and downstream passage for anadromous salmonids, bull trout and other resident fish (see Figure 3-1 for project locations and for new accessible habitat).

Passage would be constrained by the following:

- Fish passage facilities would be designed and operated within existing operational considerations and constraints outlined in the Interim Comprehensive Basin Operating Plan (Reclamation 2002), or subsequent Operation Plans.
- Operations would continue to serve existing Reclamation contracts.

- Potential operational changes would be considered that might enhance passage without adversely impacting existing contracts or irrigation water supply.

Providing unimpeded fish migration past the existing storage dams in the Yakima Basin would increase anadromous species abundance and spatial distribution; allow reintroduction of sockeye runs, and provide for genetic interchange for listed bull trout and other native fish. This would also help fish to cope with potential future climate change impacts by providing access to high-quality habitat at higher elevations if lower elevation habitat is no longer suitable for supporting fish life stages at certain times of year.

Clear Creek Dam

Upstream and downstream passage of adult bull trout would be improved by modifying the existing fishway or by constructing a new fishway at the spillway adjacent to the Clear Creek Dam.

Cle Elum Dam

Proposed fish passage facilities at the Cle Elum Dam consist of downstream passage facilities (i.e., bypass intake and pipe) that account for fluctuating reservoir levels during juvenile migration periods and upstream adult fish passage facilities. Upstream passage would consist of a fish ladder leading into an adult collection facility where fish would be captured and transported by tanker truck to areas upstream of the dam.

Bumping Dam

Upstream and downstream fish passage would be installed at Bumping Dam as part of the proposed Bumping Lake enlargement action described in Section 3.1.3, or at the existing dam if the enlargement is not authorized. Facilities proposed for the existing dam are similar to Cle Elum proposed fish passage facilities configuration.

Tieton, Keechelus and Kachess Dams

Upstream and downstream fish passage would be installed at Tieton, Keechelus, and Kachess dams, subject to further evaluation of alternatives to determine the most feasible approach for providing passage at each dam.

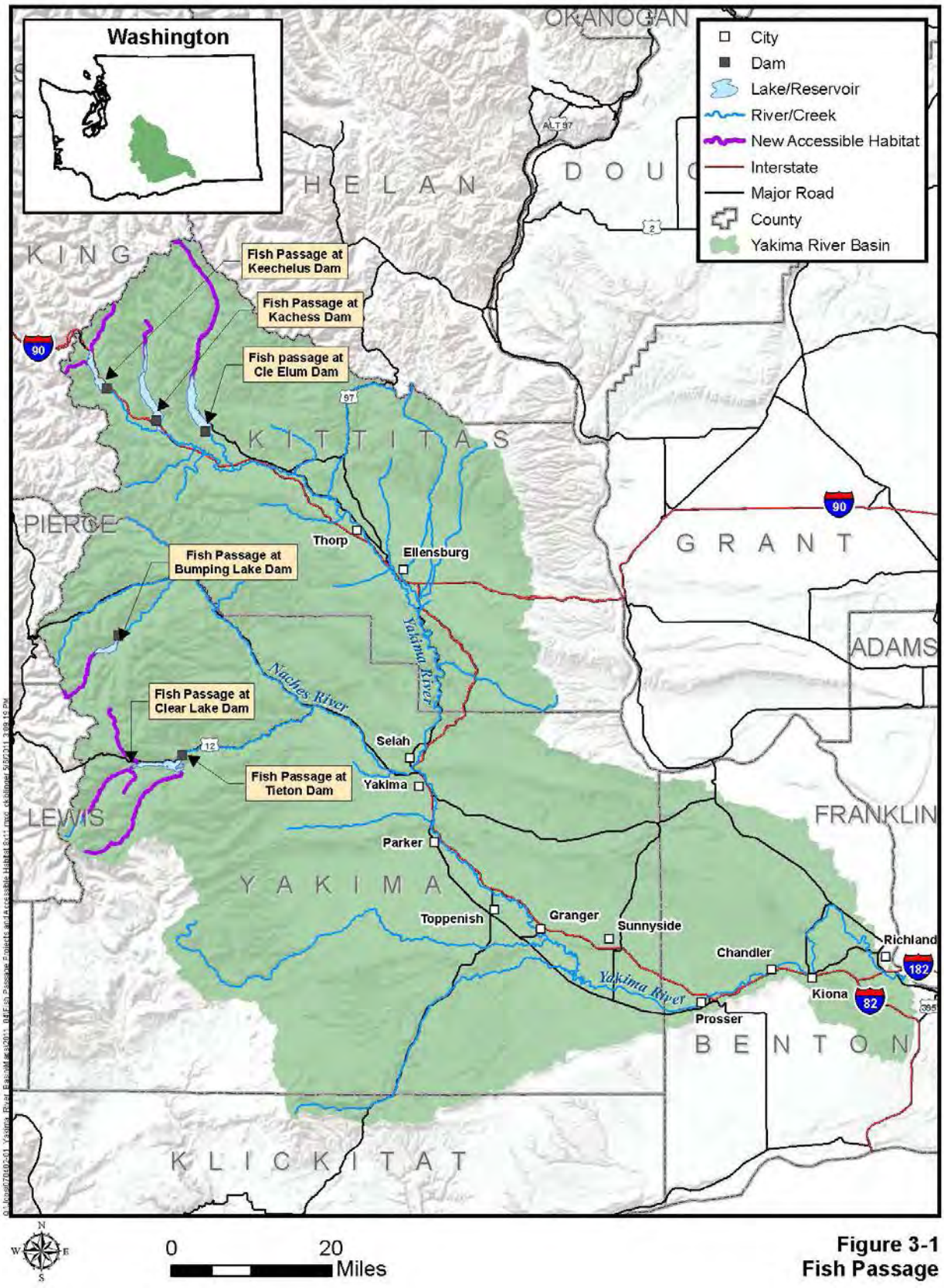

Figure 3-1
Fish Passage

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3.1.2 Structural and Operational Changes

This category involves modifying existing structures and operations to improve flows, fish bypass and smolt out-migration. Figure 3-2 shows the structural and operational actions.

Cle Elum Dam Pool Raise

Raising the maximum water level of Cle Elum Lake 3 feet (from 2,240 feet to 2,243 feet above mean sea level) would increase the volume of available storage in Cle Elum Lake by approximately 14,600 acre-feet. Modifications would include shoreline protection, radial gate improvements, and mitigation of upstream inundation and recreation. The additional water was proposed for fish flow augmentation in the YRBWEP Phase 2 legislation (Title XII Authorization) but was treated as part of TWSA in modeling conducted for the Integrated Plan.

Kittitas Reclamation District Canal Modifications

Modifications to laterals of KRD's Main and South Branch canals would reduce seepage losses and allow greater flexibility in KRD supply management. The water saved or transferred would be used to enhance instream flows in tributaries to the Yakima River, including Taneum Creek, Manastash Creek, Big Creek, Little Creek, Tillman Creek, Spex Arth Creek, and others that cross the KRD Main Canal. Specific actions would include:

- Piping of irrigation laterals along the KRD Main Canal and South Branch Canal
- Construction of a re-regulation reservoir to capture KRD operational spills at Manastash Creek
- Construction of a pump station on the Yakima River to deliver flows to Manastash Creek water users

Tributary flow improvements would be coordinated with habitat protection and enhancement actions (described below) to target improved fish passage at KRD canal crossings.[5]

Keechelus to Kachess Pipeline

Water would be conveyed from Lake Keechelus to Lake Kachess (K to K) to reduce flows and improve habitat conditions during high flow releases below Lake Keechelus and provide more water storage in Lake Kachess for downstream needs. The pipeline may also help Lake Kachess refill after using inactive storage (see Section 3.1.3).

This project would include modifying the existing Lake Keechelus outlet tunnel, installing nearly 5 miles of large-diameter pipe, and installing a new control structure and outfall into Lake Kachess. This project also would include an evaluation of a potential new power generation facility at the outfall.

Every effort would be made to coordinate construction of the K to K pipeline interstate highway crossing with ongoing re-construction of I-90.

Subordinate Power at Roza Dam and Chandler Power Plant

Water diversions for power generation would be further subordinated at Roza Dam and Chandler Power Plant to support outmigration of steelhead, Chinook, sockeye, and coho juveniles, recognizing that power has already been greatly subordinated for several decades. Subordination

[5] The updated Habitat Enhancement program description presented to the Workgroup at the October 2010 meeting identifies improving four canal/creek crossings within the entire KRD system.

would be pursued subject to acceptable agreement on mitigation and approval by Reclamation, Bonneville Power Administration and Roza or KID, as applicable.

Wapatox Canal Improvements

Piping and/or replacing the lining along portions of the existing Wapatox Canal would reduce or eliminate the carriage water diverted into the canal for Wapatox Ditch Company water users. It would include installing new canal lining from the fish screen midway down the canal and replacing the existing canal downstream from that point with a pipeline, or installing pipe to replace the entire length of the existing canal downstream from the fish screen. This project could consolidate other diversions into the Wapatox Canal such as the Naches-Selah Irrigation District, the City of Yakima water treatment plant, and the Gleed Ditch. However, the benefits of consolidating those diversions may not be sufficient compared to the cost, and those water users may choose not to participate in the project.

3.1.3 Surface Water Storage

Additional surface water storage projects would be developed in the Yakima Basin to supply instream flow needs and out-of-stream needs, including agricultural and municipal and domestic uses. The first three surface water storage projects described below (Wymer Dam and pump station, Kachess Inactive Storage, and Bumping Lake Enlargement) reflect the Workgroup's intent to focus on in-basin solutions to address water supply and aquatic resource problems (see Figure 3-3).

Collectively, these projects represent just over 450,000 acre-feet of additional water supply for instream and out-of-stream uses in the basin. If one or more of the in-basin projects does not receive necessary permits and approvals for implementation, the Workgroup would select a replacement project (or projects) that would supply at least the equivalent quantity of water. With each of these projects, power generation opportunities would also be evaluated.

A portion of the additional supply should be made available for the municipal and domestic needs described in Section 2.1. This portion of supply should be allocated, in part, to serve needs in each of the three counties of the Yakima Basin. It is suggested that one-half of the municipal and domestic supply be allocated by county based on projected growth. The other half will remain unallotted and available to municipal and domestic users anywhere in the basin on a first-come, first-served basis after the allotted county portions are used up.

Figure 3-2
Structural and Operational Changes

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Figure 3-3
Surface Water Storage

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Wymer Dam and Pump Station

A new Wymer Dam would be constructed to create an off-channel storage facility in the intermittent stream-bed of Lmuma Creek Canyon, approximately 8 miles upstream of the Roza Diversion Dam. The storage capacity of the reservoir would be approximately 162,500 acre-feet. Water would be pumped into the reservoir from the Yakima River during winter, spring, and potentially summer, during high-flow periods from upstream reservoir releases, which has the potential to mitigate for artificially high summer flows. The facility would allow for increases in winter flows in the upper Yakima River to benefit fish. On average much of the storage capacity would be used annually to improve instream flows upstream and downstream of the reservoir. The remaining storage capacity would be used for carry over or drought relief storage.

Two pump station options are being considered, and a preferred option will be selected through the final planning report and environmental review process described in Section 6.0. Option 1 includes a new pump station at Thorp, including a new pipeline from the pump station to an upgraded KRD North Branch Canal system and a new tunnel to deliver water to the Wymer Reservoir. Option 2 would be a pump station on the Yakima River just upstream of Lmuma Creek, with water conveyance through a new pipeline that would deliver water to Wymer Reservoir.

Wymer Reservoir releases would pass through tunnels, a siphon, and a hydroelectric powerhouse to the Roza Canal at the existing Roza Canal intake structure. Another alternative could be to release water into the Yakima River at Lmuma Creek. The feasibility of removing the Roza Dam would be evaluated as part of implementing the Wymer project. The downstream conveyance alignment provides for connection with future potential storage sites within the Burbank Creek and Selah Creek drainages.

Lake Kachess Inactive Storage

The Lake Kachess Inactive Storage project would be located just east of Interstate 90 near Easton, Washington. The project would tap into Lake Kachess and allow the lake to be drawn down approximately 80 feet lower than the current outlet. This would provide the ability to withdraw another 200,000 acre-feet of water from the lake, when needed, for downstream uses during drought conditions.

Water would be conveyed through a pump station and outlet just downstream from Kachess Dam or a tunnel outlet to the Yakima River approximately 4.8 miles southeast of Kachess Dam.

This project will include fish passage improvements at Box Canyon Creek to improve access for bull trout.

Bumping Lake Enlargement

A new dam would be constructed 40 miles northwest of Yakima on the Bumping River about 4,500 feet downstream from the existing Bumping Dam. The dam would impound approximately 190,000 acre-feet at a pool elevation of 3,490, with a surface area of 4,120 acres. The existing dam would be breached following construction to allow full use of the existing pool. The proposed dam and reservoir would provide carryover storage against possible shortages of irrigation water for federally-served irrigable lands, instream flow and incidental flood-control benefits, and fish passage.

Study of Columbia River Pump Exchange with Yakima Storage

As the three in-basin surface-storage projects described above are implemented, appraisal- and, potentially, feasibility-level studies would commence on other water-supply enhancements, including the potential for an inter-basin transfer from the Columbia River. While the Integrated Plan is implemented, supply improvements would be measured at least every 5 years as part of a periodic needs assessment. The assessment would evaluate progress towards meeting the identified instream flow objectives, the 70 percent proratable supply goal for irrigation, and goals for other out-of-stream needs.

The need for additional water-supply enhancements would depend on the effectiveness of projects that are implemented as part of the Integrated Plan, how the Yakima Basin economy develops over time, and the timing of and manner in which climate change affects water supply availability.

The evaluation of a Columbia River to Yakima Basin transfer would involve an initial screening step and subsequent feasibility study, as outlined below. The feasibility study would be conducted only if the initial screening step demonstrates that an interbasin transfer is a viable option and the YRBWEP work group authorizes its inclusion as part of the Integrated Plan.

Step 1:

1. A detailed analysis of the physical and legal availability of water for diversion from the Columbia River,
2. A description of alternatives for configuration of pumping, routing, and storing Columbia River water in the Yakima Basin and options for instream and out-of-stream uses of that water,
3. Estimates of capital and operation and maintenance costs for each alternative, and
4. An evaluation of allocation of costs for each alternative.

The Columbia River water availability analysis in Step 1 would consider target flows under the Federal Columbia River Power System Biological Opinion (NMFS 2004 and 2010), effects on salmonids (migration, spawning and rearing), and cumulative impacts of other water withdrawal proposals.[6]

At the end of Step 1, the Workgroup would consider the results and decide whether to pursue Step 2.

Step 2:

Conduct more detailed, site-specific analyses of alternatives as part of a feasibility-level planning report and EIS specific to a potential project. Depending on the outcome of the Wymer dam and interbasin transfer project described above, an evaluation of Roza Dam removal and whether to serve all or a portion of the Roza diversion through Columbia River water supply would also be evaluated.

[6] e.g., Reclamation Odessa Subarea Special Study of continuing phased development of the Columbia Basin Project to deliver surface water from the project to lands currently using groundwater in the vicinity of Odessa, Washington.

3.1.4 Groundwater Storage

Two proposed groundwater storage actions would use surface water to recharge aquifers and store water for later withdrawal and use. Figure 3-4 shows potential groundwater storage project locations.

Shallow Aquifer Recharge

The objective of groundwater infiltration is to divert water into designed infiltration systems (ponds, canals, or spreading areas) prior to storage releases from Yakima Project reservoirs in early spring. Water users could then withdraw the infiltrated water in lieu of reservoir releases early in the irrigation season and infiltration systems could also be located to provide returns directly back to surface waters through passive recharge. The timing and scale of surface water diversions would be designed to allow continuation of natural high-flow events that provide biologic and channel configuration benefits. Infiltration can also help extend cooler water conditions into the summer for the lower Yakima River.

The groundwater infiltration program would have two phases: pilot-scale infiltration testing in two study areas, followed by full-scale implementation that occur in the study areas and/or other locations. Initially, a limited pilot study would be conducted to verify the feasibility and general design features of groundwater infiltration systems. Pilot-testing would take place in two study areas: the Kittitas Reclamation District (KRD) and the Wapato Irrigation Project. Two pilot-scale infiltration systems – 1 to 2 acres in size – would be constructed in each study area. The pilot tests would result in recommendations for implementation at these locations or other suitable locations in the basin

At full-scale implementation, it is anticipated that between 160 and 500 acres of infiltration area would be necessary to achieve a total infiltration capacity of at least 100,000 acre-feet. This volume was selected for modeling purposes and does not necessarily limit actual volumes that could be infiltrated. Total infiltration volumes may vary from year to year, depending on snowpack conditions and reservoir refill requirements. Full-scale infiltration on the KRD system would depend on construction of the Thorp Pump Station (See Wymer Dam discussion above). During the pilot phase, policy and legal protocols would be developed to ensure water stored through infiltration is not captured by unauthorized users. Passive recharge assumptions could also be tested and verified where possible.

Aquifer Storage and Recovery

With an aquifer storage and recovery system, the City of Yakima would divert approximately 5,000 to 10,000 acre-feet of water from the Naches River during the winter months and treat it at the City's existing water treatment plant. It would then be injected through wells and later pumped out for use by the City's residents and businesses during summer months when demand for water is highest. Aquifer storage and recovery may also be viable for other cities in the Yakima Basin. It would require a water treatment facility, one or more wells that could hold treated water, and a pump station for retrieving stored water.

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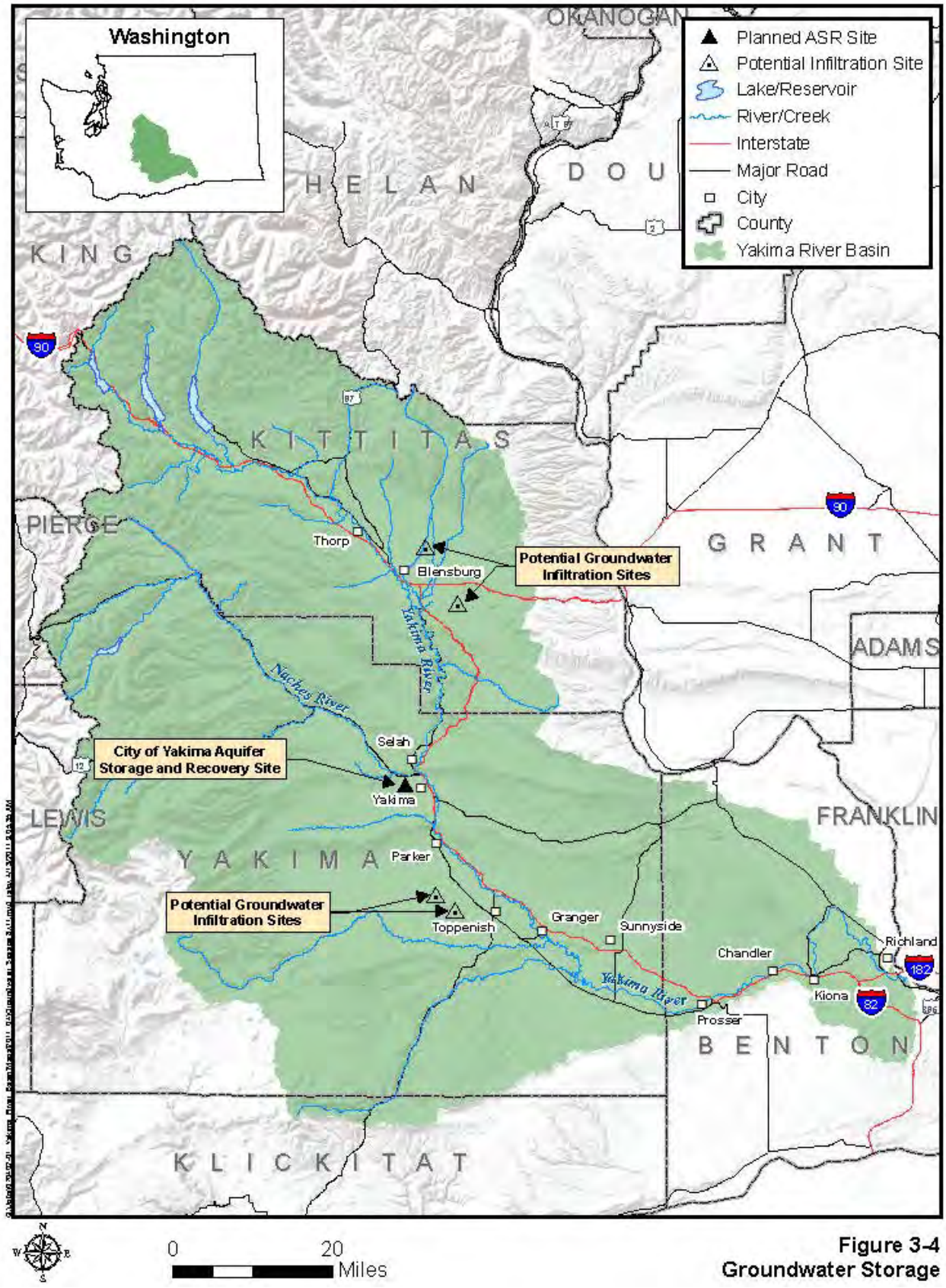

Figure 3-4
Groundwater Storage

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3.1.5 Habitat Protection and Enhancement

Targeted Watershed Protections and Enhancements

The watershed, water supply, and ecological restoration goals of the Integrated Plan would be furthered through the protection and restoration of key landscapes. The primary lands that enhance other components of the Integrated Plan are large tracts in the Yakima/Naches watershed that provide high potential for ecosystem and species conservation and restoration both within and outside of the immediate riparian corridor.

Three key areas in the Yakima/Naches River watershed are targeted for land acquisition actions that would help achieve the watershed, water supply, and ecological restoration goals of the Integrated Plan (see Figure 3-5). Protection and restoration of these key areas offer ecosystem, species conservation, and restoration potential both inside and outside the immediate riparian corridor by linking upper and lower watersheds. The targeted acquisitions include:

- 46,000 acre tract in the middle and lower Teanaway River Basin comprised of mid to high elevation mixed conifer forest, lower elevation grand fir and ponderosa pine, The Teanaway River flows into the Yakima River and provides fish passage and connectivity to high elevation colder water. Protecting this area would provide major ecosystem, water quality/quantity, and species benefits that would complement the habitats and species protected by the Plum Creek Central Cascades HCP, directly adjacent to the western portion of the area. The ponderosa pine forests are particularly significant due to their limited range and vulnerability to climate change. The property is important for maintaining high water quality, instream flow protection in an area that absent protection would be subject to impaired flows, protecting salmon and steelhead spawning grounds, and potential bull trout recovery. In addition, conservation of the Teanaway landscape fits well into the overall strategy of acquiring and protecting non-federal lands to ensure successful landscape-scale linkages envisioned by the Integrated Plan. The Teanaway landscape also provides significant recreational opportunities for a variety of users which would be protected and enhanced through inclusion in the Integrated Plan.
- 15,000 acre tract in the Yakima River canyon, including the valley bottom and eastern slopes, from the Yakima River to I-82. It is composed primarily of basalt cliffs and shrub- steppe vegetation, a critical habitat type. Eaton Ranch from Lmuma Creek up to the ridge to I-82 (~13,000 acres) is adjacent to the site of proposed Wymer Dam and provides an opportunity to protect a large swath of shrub-steppe habitat, consistent with mitigation needs of the dam expansion. In addition, the Yakima Canyon riparian area provides salmon, steelhead, and resident rainbow trout habitat, and contains high recreation values for hunting, fishing, boating and other types of recreation.
- 10,000 acres at the headwaters of the Little Naches River and lands surrounding the headwaters of Taneum and Manastash Creeks. Private lands in these watersheds are intermingled with national forest land, generally in a checkerboard pattern. This is primarily mid to upper elevation conifer forest, and the Little Naches is contiguous with land near Bumping Lake. Most has been logged and replanted, but some areas of old-growth forest remain. The upper reaches of the Naches, Taneum, and Manastash are important for water quality and maintaining cool temperatures for bull trout protection and restoration. They also protect water supply, provide current or potential salmon and

steelhead spawning grounds, as well as a substantial amount of recreation use, including segments of the Pacific Crest National Scenic Trail.

If these preferred sites cannot be acquired, a combination of alternative sites of equivalent conservation value may be selected as long as alternatives collectively meet the following targets:

- Conservation Target for High Elevation Watershed Enhancement: 45,000 acres
- Conservation Target for Shrub-Steppe Habitat Enhancement: 15,000 acres
- Conservation Target for Forest Habitat Enhancement: 10,000 acres

These conservation areas would complement the overall goals of the Integrated Plan by helping to maintain or improve water supply and quality, protecting sources of cold water and cold water habitat, providing (or providing linkages to) bull trout and/ or salmon and steelhead habitat and spawning grounds, and providing additional floodplain restoration opportunities.

Additional lands are eligible and/ or have already been recommended for federal Wilderness and Wild and Scenic River designation through other processes. In addition to the conservation targets provided above, protection of the following lands is consistent with values and objectives of the Integrated Plan:

- Wilderness designation should be pursued for the land around Bumping Lake that is not consumed by the reservoir expansion.
- Wilderness or other appropriate designation should also be sought for roadless areas in the Teanaway, in the area between Kachess and Cle Elum Lakes, and in the upper reaches of Manastash and Tanuem Creeks in order to protect headwaters streams, snow pack, and forests.
- Wild and Scenic River designation should be sought for the American, upper Cle Elum, and Waptus rivers. Other rivers determined eligible and recommended for designation in future forest plans should also be considered. The American River runs into the Bumping River downstream of Bumping Lake, and the upper Cle Elum and Waptus would receive increasing numbers salmon and steelhead as fish passage is completed at the dam on Lake Cle Elum.

All of these areas are eligible and have already been recommended for these designations through other processes. Designation would protect cold water habitat, spawning and rearing grounds and migration corridors for salmon, steelhead, and bull trout, and would help protect important natural sources of water supply consistent with the objectives of the Integrated Plan.

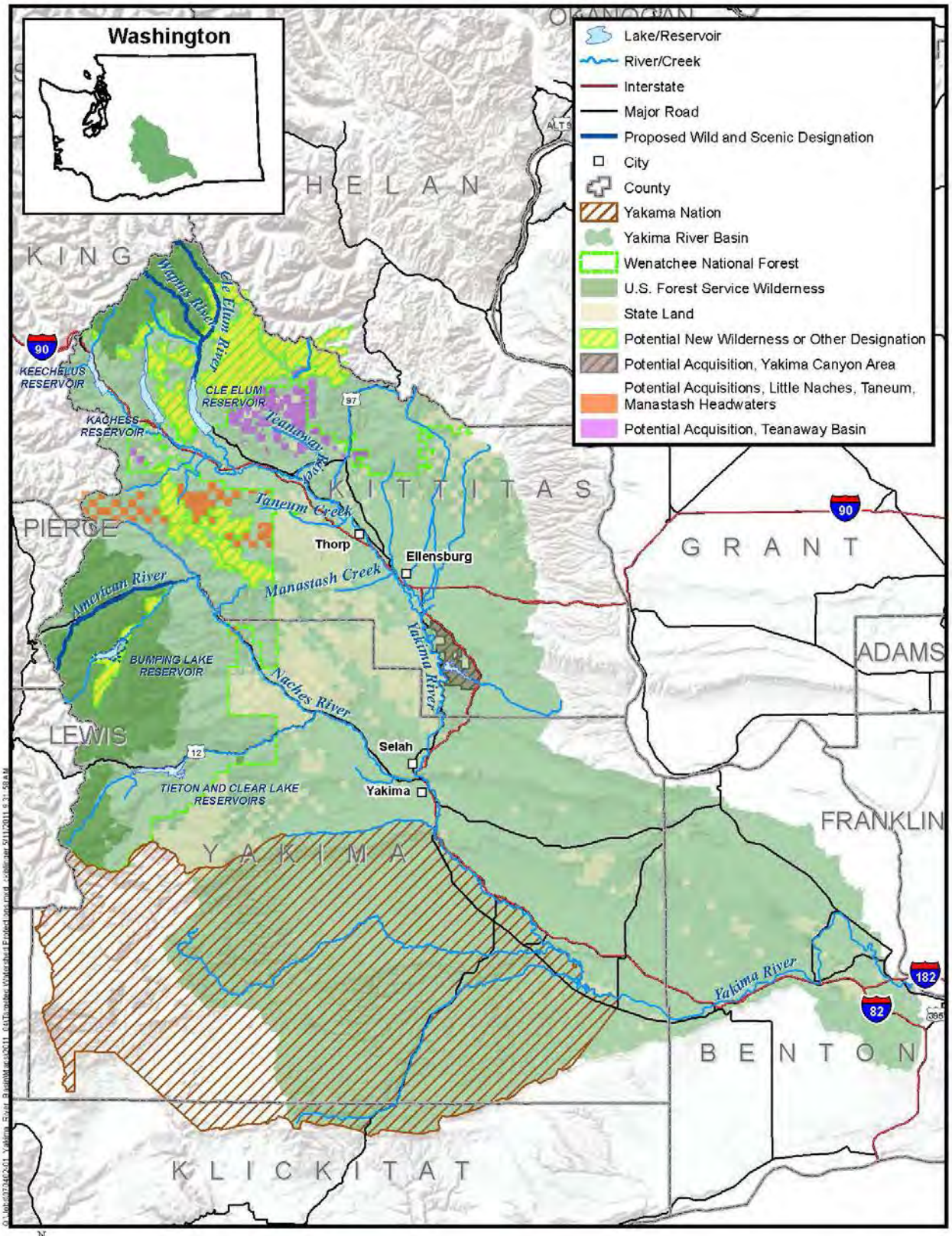

Figure 3-5
Targeted Watershed Protections

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Mainstem Floodplain and Tributaries Fish Habitat Enhancement Program

An extensive fish habitat enhancement program would address mainstem floodplain and tributary habitat restoration priorities through habitat enhancement, flow restoration, fish barrier removal, and screening diversions. These actions would significantly improve prospects for recovering fish populations to levels that are resilient to catastrophic events and the potential impacts of climate change. They would accelerate ongoing efforts to protect existing high-value habitats, improve fish passage, enhance flows, improve habitat complexity and functions, and reconnect side channels and off-channel habitat to stream channels. The program could also provide some flood risk reduction benefits.

Fish habitat enhancement actions would help create improved spawning, incubation, rearing, and migration conditions for all salmonid species in the Yakima Basin; implement key strategies described in the Yakima Subbasin Plan (YBFWRB 2004); and complete most of the actions described in the Yakima Steelhead Recovery Plan (YBFWRB 2009). Early mainstem floodplain improvements could include channel and habitat restoration in the Yakima River near Ellensburg and between Selah and Union Gap, and on the lower Naches River. Early tributary program actions could include completing screening and passage at diversions in the middle and upper Yakima Basin, bull trout habitat improvements and management actions, and implementing the Toppenish Creek Corridor restoration project, which is an ongoing restoration effort funded through the YRBWEP Title XII program. Figure 3-6 identifies the mainstem floodplain restoration reaches. Tributary habitat enhancements would primarily occur on tributaries to the Yakima and Naches rivers in the middle and upper parts of the basin, and on the Yakama Reservation.

The approach to implementation would be tailored to utilize existing organizations to review processes and plans, as applicable. Reclamation and Ecology may choose to establish an advisory group similar to the YRBWEP Conservation Advisory Group (see Section 3.1.6) to help develop a more detailed approach for project funding and scheduling.

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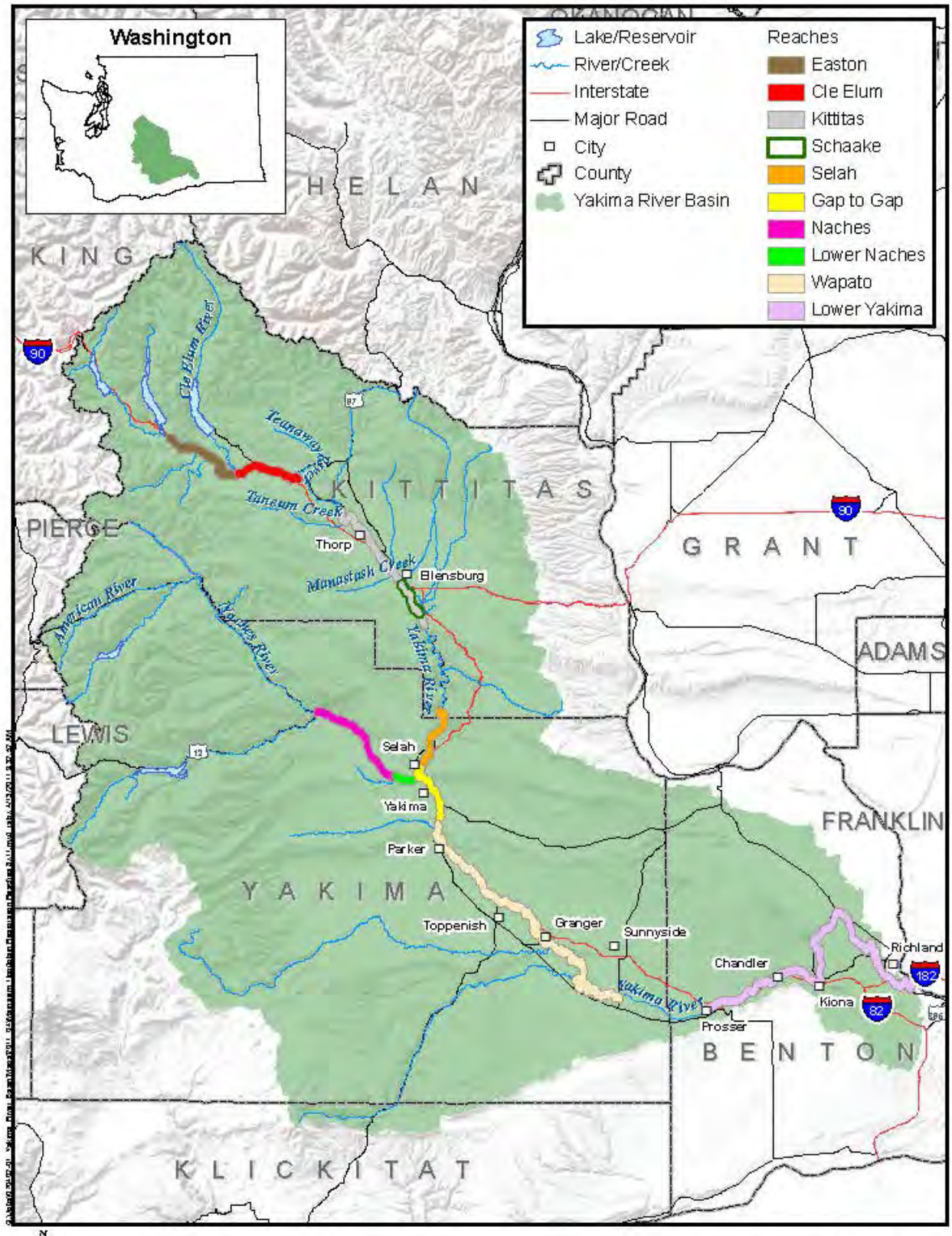

Figure 3-6
Mainstem Floodplain Restoration Reaches

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3.1.6 Enhanced Water Conservation

This element consists of additional agricultural conservation actions not included in current YRBWEP Title XII implementation plans, along with municipal and domestic water conservation programs.

Agricultural Conservation

An agricultural water conservation program could conserve up to 170,000 acre-feet of water in good water years, based upon a compiled list of potential projects that could be implemented under this proposed program (see Volume 2 technical memorandum, *Agricultural Water Conservation).* The program would include measures beyond those likely to be implemented in the existing YRBWEP Phase2 conservation program. Agricultural water conservation measures that could be implemented under this program include:

- Lining or piping existing canals or laterals
- Constructing re-regulating reservoirs on irrigation canals
- Installing gates and automation on irrigation canals
- Improving water measurement and accounting systems
- Installing higher efficiency sprinkler systems, drip, etc.
- Implementing irrigation water management practices and other measures to reduce seepage, evaporation, and operational spills

Although a list of specific projects was reviewed in developing the agricultural conservation program, this recommendation does not identify specific projects for implementation at this time. Projects that would be implemented under this program would be selected through detailed feasibility studies and evaluation by the existing YRBWEP Conservation Advisory Group. Irrigation districts eligible for project funding include federally and non-federally-served irrigation districts, private irrigation entities, and individual landowners.

Municipal and Domestic Conservation Program

This program would promote efficient use of municipal and domestic water throughout the Yakima Basin using voluntary, incentive-based actions that focus on landscape irrigation, and other consumptive uses. Municipal and domestic usage includes water that is delivered by public systems regulated by the Washington State Department of Health; used by individual homeowners served by exempt wells; used by commercial or industrial facilities; and water delivered by irrigation entities for outdoor landscape irrigation in developed areas of the basin. It includes residential, commercial, industrial, and urban recreational uses of water such as parks, ball fields, and golf courses.

The plan calls for convening a multi-stakeholder advisory committee on municipal and domestic water conservation (including local and environmental stakeholders) to organize outreach to local elected officials and provide liaison with Reclamation, Ecology, and the Washington State Department of Health. The advisory committee would focus on the following key efforts:

- Education, incentives, and other measures to encourage residential and commercial users to improve landscape irrigation efficiency where the source of supply is agricultural irrigation canals or ditches.

- Improving the efficiency of consumptive uses (i.e., water that evaporates or is otherwise consumed and does not return to surface streams or groundwater through wastewater treatment plants, septic systems or surface infiltration).
- Establishing best practice standards for accessing the new supply developed through the Integrated Plan and dedicated to municipal use and municipal/domestic mitigation (mitigation refers to water that is used to offset the increased water usage from new housing or businesses). The standards would be based on review of evolving practices in similar communities and similar climate zones of the western United States.
- Determining conditions for accessing the new supply that would apply to homeowners or developers seeking mitigation water for consumptive water use for homes supplied by individual household wells.

3.1.7 Market Reallocation

Water resources would be reallocated through a "water market" and/or "water bank," where water rights would be bought, sold, or leased on a temporary or permanent basis, to improve water supply and instream flow conditions in the Yakima Basin. This effort would include recommendations for legislative changes and funding requests to improve the efficiency and flexibility of water transfers. The proposal includes two phases: a near-term effort to build on the existing water market programs, and a longer term effort that requires more substantial changes to existing laws and policies.

The near-term program would continue existing water marketing and banking activities in the basin that involve water users and Ecology, but take additional steps to reduce barriers to water transfers. The long-term program would focus on facilitating water transfers between irrigation districts. This would allow an irrigation district to fallow land inside the district and lease water rights for that land outside the district.

To facilitate this process, agricultural conservation program funding (see above) would also be made available to non-federal irrigation entities to upgrade conveyance infrastructure to improve their operational flexibility and their ability to lease water to other irrigation districts, including federally-served districts.

3.2 Cost Estimates

Costs of the major capital projects included in the Integrated Plan (see Table 3-1) were determined in accordance with the Reclamation Cost Estimating Handbook (Reclamation 2007c). Estimates for each capital project include material and quantities, mobilization and demobilization, site preparation, and labor required for construction. The appraisal-level estimate is generally accurate within a range from 20 percent less than the estimate to 40 percent greater than the estimate. Design and permitting costs were assumed to be 30 percent of construction costs. Annual operation and maintenance costs include anticipated staff, electrical power, and routine maintenance, except where more specific information was available (see Volume 2 technical memorandum, *Costs of the Integrated Water Resource Management Plan*).

The agricultural water conservation program costs were derived from a list of projects that could be implemented in the Yakima Basin based on existing conservation plans prepared for individual irrigation districts and other information sources. The YRBWEP Out-of-Stream Needs

Subcommittee provided input to the project list and the recommended program funding level that was approved by the Workgroup.

Costs for the groundwater infiltration project were developed as documented in the Volume 2 technical memorandum, *Groundwater Infiltration Appraisal-Level Study*.

Actions for the habitat protection and enhancement program were identified in coordination with the YRBWEP Habitat Subcommittee. Costs were roughly estimated for individual action areas and then totaled to estimate the overall funding level for the habitat enhancement program, broken down by mainstem floodplain and tributary actions. However, costs for land acquisition related to targeted watershed protections and enhancements have not been estimated and are not included in Table 3-1. These costs would depend on available land parcels and acquisition negotiations.

Costs for the municipal conservation and market allocation programs were estimated based on professional judgment of the project's consulting team and Ecology.

Cost allocations among the Federal Government, State Government, water users or others would be completed as part of the administrative review process by Reclamation and Ecology (see Section 6.0).

The total cost of the Integrated Plan is estimated to be $4.0 billion, within a range of $3.2 to $5.6 billion based upon the appraisal level cost estimate accuracy. Operation and maintenance costs are estimated to be $10 million per year.

Table 3-1. Estimated Integrated Plan Costs

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

N/A = Not Applicable

Note: Cost of land acquisition for targeted watershed protections and enhancements have not been estimated and are not included in this table.

[1] Operation and maintenance (O&M) includes traditional O&M costs for projects and programmatic costs for nonproject actions.

3.3 Suggested Schedule for Implementing the Integrated Plan

Preliminary Schedule: Timing, Sequence, and Triggers

Figure 3-7 on the following page shows the preliminary implementation schedule for the actions in the Integrated Plan. This schedule is subject to revision as project feasibility, funding strategies, and implementation pathways are further defined. Colors are used in the figure to show four stages of activity: 1) authorization; 2) studies; 3) action-specific environmental review, permitting, and design; and 4) project construction or program activation.

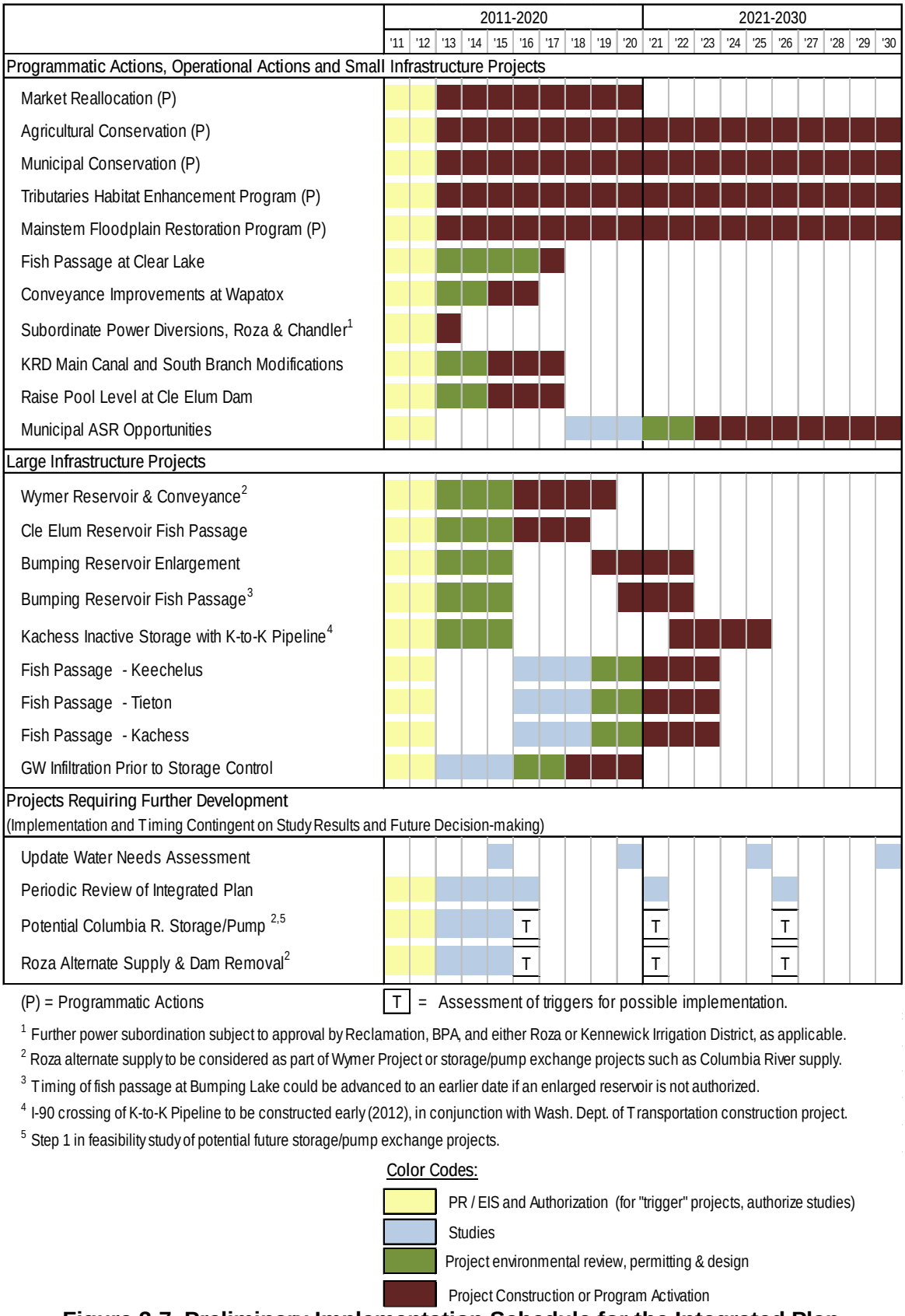

Figure 3-7. Preliminary Implementation Schedule for the Integrated Plan

Programmatic Actions and Small Infrastructure Projects

One goal of the Integrated Plan is to make rapid progress in areas where feasible. The programmatic actions and small infrastructure projects are grouped together because they can be launched relatively quickly if authorized and funded.

The programmatic actions (labeled "P") are those that would fund a variety of actions throughout the basin over a period of time. It is assumed these can be completed over a 20-year timeframe, with benefits growing over time. The implementation time frame depends on funding authorizations.

The schedule for Market Reallocation is slightly different since it is triggered when adopted reforms enable a freely-functioning market. The schedule shows a 10-year timetable to allow for experience with at least one drought year that could be expected over that time period. Market transfers would continue beyond the 10-year schedule to establish the market.

Large Infrastructure Projects

This category includes the large surface water storage and fish-passage projects that were identified for early action in the Integrated Plan.

The sequence for fish passage is based on preferences expressed by the Yakima Storage Dam Fish Passage Core Team (Reclamation and Yakama Nation Settlement Agreement 2006). Cle Elum Dam fish passage, which has been identified as the top priority, is being addressed by Reclamation through a separate environmental impact statement (EIS). A Draft EIS was released in January 2010 and a Final EIS is expected to be released in 2011. Fish passage at Bumping Dam is the next priority and would be constructed at the same time as the new dam for the enlarged Bumping Lake that is proposed for the Integrated Plan. (However, installation of passage is not dependent on authorization of the new dam.)

The sequence for implementing the large, in-basin surface water storage projects is subject to additional discussion. As recommendations for a funding and authorization approach are developed, the sequence of these three projects should be the same as those recommendations. The preliminary schedule identifies Wymer Dam first, followed by Bumping Lake Enlargement and then Kachess Inactive Storage (including Keechelus-to-Kachess Pipeline[7]). The first surface water storage project would be completed within 10 years, and all three would be completed within 15 years. This balances the interest in rapidly moving forward to improve supplies with the reality that major construction projects require time to secure funding and permits and to design and execute, including mitigating environmental impacts.

Projects Requiring Further Development

Several projects require further evaluation. Studies for these projects should be initiated in the first 10 years. The schedule shows that the Keechelus, Tieton, and Kachess fish-passage projects would be implemented starting in 2021 after further evaluation. After the initial studies are completed, implementation of the Columbia River and Roza alternate supply projects are shown as contingent on triggers related to need and feasibility. The need for additional water storage would depend on which of the earlier projects are completed and how effective they are, how the Yakima Basin economy develops over time, and whether and how quickly climate change occurs.

[7] I-90 crossing of K-to-K Pipeline to be constructed early (2012), in conjunction with WSDOT construction project.

For example, if one or more of the in-basin surface water storage projects (Wymer, Bumping and/or Kachess Inactive Storage) cannot be permitted or constructed, then the Workgroup would select a replacement project (or projects) to supply at least an equivalent water amount. The Roza alternate supply project could use supply from the new Wymer Reservoir, the Columbia River pump exchange project, or other potential sources yet to be identified. Because of linkages to other projects, this project also has triggers related to need and feasibility. It is suggested these triggers be assessed every 5 years in conjunction with updated water needs assessments.

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4.0 Expected Outcomes

The Integrated Plan can provide many benefits. Described in this section are the analytical approaches used to estimate expected outcomes; a description of the baseline scenario used to assess outcomes; and outcomes for water supply, stream flow and mainstem habitat, including potential water supply outcomes under climate change, and fish production. A summary of Integrated Plan benefits is also provided.

4.1 Analytical Approaches Used to Estimate Expected Outcomes

The Integrated Plan presented in Section 3 includes diverse actions intended to support and reinforce one another to improve water supply, stream flow and fish habitat conditions throughout the area affected by the Yakima River. Each of the techniques described below was applied to predict outcomes under existing climate conditions. Climate change scenarios were also assessed using the RiverWare model to assess outcomes for water supply and stream flow (does not include fish production and economic effects). The following three main techniques were used to predict outcomes:

- ***Water supply and stream flow*** outcomes were evaluated using a detailed hydrologic model of the Yakima Basin. The model, which operates in a RiverWare software platform and was originally developed by Reclamation to support Yakima Project operations, was adapted to support the Yakima River Basin Study (see Volume 2 technical memorandum, *Modeling of Reliability and Flows*). The hydrologic data under which the scenarios were modeled represent conditions that occurred historically from 1981 through 2005. This historic period was chosen to test future operations and facilities because it had the most complete data available on conditions in the basin. The period included multiple dry years and one period of three consecutive dry years (1992-1994). This 3-year drought has been the only occurrence in the past 70 years, although there have been three 2-year drought periods (1941-1942, 1944-1945, and 1977-1978) during this same time period.
- Adjustments to the model and assumptions on Yakima Project operations were discussed extensively with Reclamation's operations manager and fisheries experts from state and federal agencies. Results were reviewed with the Modeling Subcommittee of the Workgroup and presented at Workgroup meetings.
- ***Fish production*** was modeled using the Ecosystem Diagnosis and Treatment (EDT) model, the All H[8] Analyzer (AHA) model, and models of sockeye spawning per hectare. The models characterize habitat condition improvements that could result from implementing the habitat program and how the improvements would increase fish production for spring, summer, and fall Chinook, steelhead, coho, and sockeye. A qualitative effects analysis was conducted to characterize both positive and negative effects on bull trout populations (see Volume 2 technical memorandum, *Fish Benefits Analysis*. Modeling of fish production was discussed extensively at Habitat Subcommittee meetings with technical support provided by fisheries experts at the Yakama Nation, Reclamation, the Yakima Fish and Wildlife Recovery Board, and HDR. Results were also presented at Workgroup meetings for discussion.

[8] Habitat, hatchery, harvest and hydropower

- ***Economic effects*** of the Integrated Plan were estimated by converting predicted costs and benefits into monetary values, where feasible. Methods included use of a crop revenue model for agricultural production; public survey valuation methods for fisheries production; and comparison with prices paid for water rights in the Pacific Northwest for municipal water supply (see Volume 2 technical memorandum, *Economic Effects of Yakima Basin Integrated Water Resources Management Plan*).

4.2 Baseline Scenario: Future Without Integrated Plan

A baseline was prepared to assess outcomes of the Integrated Plan. Since many actions are ongoing in the Yakima Basin, the RiverWare modeling team developed a scenario called "Future Without Integrated Plan," or FWIP. The FWIP model incorporates current conditions and changes that can be expected even if the Integrated Plan were not carried out. These include water conservation projects and point of diversion changes that have been completed or are in the process of being completed under Phase 2 of YRBWEP. It also incorporates expected growth in municipal and domestic well water use that would require additional water in the future (either for supply or for mitigation of impacts to stream flow or other water users).

Water Conservation Measures

Water conservation measures modeled in RiverWare for the FWIP scenario include projects by the Roza, Sunnyside and Benton irrigation districts to reduce seepage and operational spills. Conservation water savings can be applied to a combination of irrigation or instream needs. Irrigation benefits include either increased water deliveries during water-short years or reduced reservoir releases in full-supply years. Instream flow benefits accrue to reaches located below a diversion and above a point of return flow to the river (see Figure 1-5 for an illustration). Depending on where the water savings occur, they can also improve flows at the Parker gage.

Water conservation projects implemented by the Roza Irrigation District are solely for irrigation benefit as they are paid for by the district, while projects implemented in the Sunnyside and Benton irrigation districts would have both instream flow and irrigation benefits (see Table 4-1) as they are federally and district funded.

Table 4-1. Conservation Savings Under Future Without Integrated Plan Scenario

Location	Total Conservation (acre-feet/year)	Instream Benefit (acre-feet/year)	Irrigation Benefit (acre-feet/year)
Roza	36,000	0	36,000
Sunnyside	54,600	36,400	18,200
Benton	6,870	5,420	1,450

Note: Conservation amounts are based on a full water supply. Proration would result in lower realized conservation. Irrigation benefit may accrue through decreased reservoir releases during a full water supply or increased diversions during prorated years to obtain a full irrigation supply.

Point of Diversion Changes

Two changes in points of diversion were modeled under the FWIP scenario. The Benton Irrigation District diversion at the Sunnyside Canal was modeled at a new downstream location on the Yakima River. A second change in points of diversion involved using Satus Creek pumps

to move approximately 50 cfs of diversion from the Wapato main canal to a location downstream of Granger.

Future Municipal and Industrial Consumptive Demands

The Yakima River Basin Study included assessment of water needs for future growth in municipal and domestic uses. Projected increases in M&I need from 2010 to 2040 were included in the RiverWare model under the FWIP scenario and were distributed across the Yakima Basin based on expected population growth. This includes potential mitigation needs associated with domestic wells (see Volume 2 technical memorandum, *Water Needs for Out-of-Stream Uses).*

4.3 Water Supply Outcomes

Reclamation's RiverWare model was used to predict effects of the Integrated Plan on water supply and stream flows. Modeled outcomes were compared with the FWIP baseline condition.

Future Without Integrated Plan Results

The FWIP scenario provides a baseline condition against which the effects of the planned actions can be compared. Table 4-2 summarizes the water resources conditions under FWIP compared to the Integrated Plan for the Yakima Project. Key statistics are as follows:

- Average TWSA – 2.79 million acre-feet
- Average April to September diversion – 1.61 million acre-feet
- Average end of irrigation season (September 30) reservoir storage totals – 230,000 acre-feet
- Average prorationing level – 80 percent

The table shows results individually for the four driest years since 1990. These include 1992 and 1994 (the second and third years of a 3-year drought), 2001, and 2005. Key statistics for the 4 dry years are as follows:

- Minimum TWSA – 1.71 million acre-feet (2005)
- Minimum April to September diversion – 1.23 million acre-feet (1994)
- Minimum end of irrigation season (September 30) reservoir storage totals – 40,000 acre-feet (1993)
- Minimum prorationing level – 21 percent (1994)

The model does not match perfectly with actual measured conditions in each year. For example, actual prorationing levels in these 4 dry years were 67 percent in 1993, 37 percent in 1994, 37 percent in 2001, and 42 percent in 2005. This is because the RiverWare model, like any model, cannot completely account for all aspects of Yakima Project facilities and operations. Therefore, when comparing the Integrated Plan to the FWIP, the change in the value of each statistic is more important than the specific value of the statistic.

Table 4-2. Water Resource Conditions under FWIP Compared to Integrated Plan (millions of acre-feet)

Resource Indicator (Measurement)	Future without Integrated Plan	Integrated Plan	Change from FWIP
Average for water years 1981–2005			
April 1 total water supply available (TWSA)	2.79	3.00	0.22
April–September Parker flow volume	0.64	0.60	-0.04
April–September diversion	1.61	1.69	0.09
Water remaining after irrigation season[1]	0.23	0.78	0.55
Irrigation proration level	80%	92%	12%
1993 dry-year			
April 1 total water supply available (TWSA)	2.06	2.24	0.18
April–September Parker flow volume	0.36	0.30	-0.06
April–September diversion	1.42	1.57	0.15
Water remaining after irrigation season[1]	0.04	0.46	0.42
Irrigation proration level	44%	70%	26%
1994 dry-year			
April 1 total water supply available (TWSA)	1.74	2.22	0.48
April–September Parker flow volume	0.31	0.25	-0.07
April–September diversion	1.23	1.52	0.29
Water remaining after irrigation season[1]	0.05	0.00	0.08
Irrigation proration level	21%	70%	49%
2001 dry-year			
April 1 total water supply available (TWSA)	1.76	2.45	0.69
April–September Parker flow volume	0.25	0.20	-0.05
April–September diversion	1.29	1.55	0.27
Water remaining after irrigation season[1]	0.06	0.42	0.36
Irrigation proration level	32%	70%	38%
2005 dry-year			
April 1 total water supply available (TWSA)	1.71	2.32	0.61
April–September Parker flow volume	0.25	0.18	-0.06
April–September diversion	1.25	1.53	0.28
Water remaining after irrigation season[1]	0.08	0.32	0.24
Irrigation proration level	28%	70%	42%

Green shading shows greater than 10% improvement from FWIP conditions, or prorationing >70%.
Pink shading shows greater than 10% decrease from FWIP conditions, or prorationing <70%.
FWIP = Future Without Integrated Plan
[1] Inactive storage pool in Lake Kachess (200,000 acre-feet) is accounted for in this quantity. In 1994 (third year of drought) it is assumed that pool is not available due to inadequate refill.

Integrated Plan Results

Table 4-2 also summarizes water supply conditions for the Yakima Project under the Integrated Plan scenario compared with the FWIP. Key statistics related to water supply are as follows:

- Average TWSA – 3 million acre-feet
- Average April to September diversion– 1.69 million acre-feet
- Average end of irrigation season (September 30) reservoir storage totals – 780,000 acre-feet
- Average prorationing level – 92 percent

Key statistics for the 4 dry years under the Integrated Plan are:

- Minimum TWSA – 2.22 million acre-feet
- Minimum April to September diversion – 1.52 million acre-feet
- Minimum end of irrigation season (September 30) reservoir storage totals – 0 acre-feet (this accounts for 200,000 acre-feet in Kachess Inactive, but assumes that pool would not be available by the third year of a three-year drought)
- Minimum prorationing level – 70 percent

As noted above, when comparing the Integrated Plan to the FWIP, the change in the value of each statistic is more important than the specific value of the statistic. For example, the level of prorationing modeled for dry-year 1994 improves from 21 percent under FWIP to 70 percent under the Integrated Plan, which is an increase of 49 percent.

4.4 Stream flow and Mainstem Aquatic Habitat Outcomes

Instream Flow Improvements

The Integrated Plan scenario includes reservoir releases to meet the reach-specific objectives outlined in Section 2.2. The relative success of achieving the simulated targets is summarized in Figure 4-1 and Tables 4-3 and 4-4. The color codes for the modeled or estimated outcomes described in Tables 4-3 and 4-4 are as follows:

- Blue = Significant improvement under the Integrated Plan
- Green = Minor improvement under the Integrated Plan
- Pink = Conditions become worse under the Integrated Plan

Hydrographs displaying the reach-by-reach flow improvements are included in Appendix C of the Volume 2 technical memorandum, *Instream Flow Needs*.

The modeling results show that the Integrated Plan would help meet flow objectives in 13 of 15 mainstem reaches, including substantial improvement in six of these reaches. In addition, approximately 330,000 acre-feet of additional water remained at the end of the irrigation season (September 30) as carryover storage (on average, not including Wymer Reservoir). That additional carryover storage would allow flexibility in operations to meet instream flow objectives. Also, power subordination at Chandler and Roza, and construction of the KRD South Branch project (which are not included in the modeling results) could also significantly improve flows in the Yakima River and in several flow-deficient tributaries in the Kittitas Valley.

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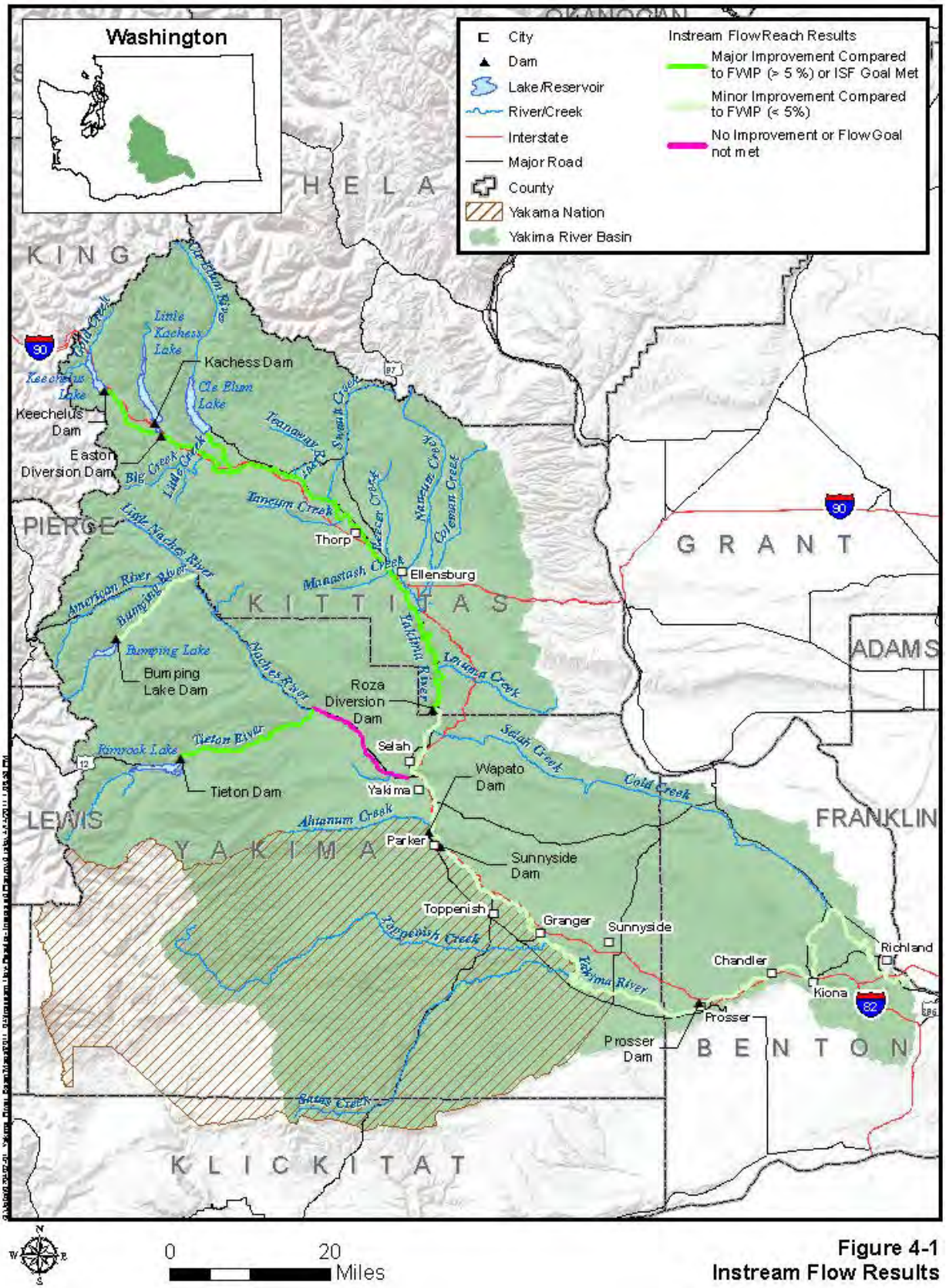

Figure 4-1
Instream Flow Results

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Table 4-3. Yakima Basin High-Priority Instream Flow Needs and Modeled Outcomes by Reach

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Yakima River, Keechelus Dam to Lake Easton	*Flow Objectives*: • Reduce flows to 500 cfs during July. • Ramp flows down from 500 cfs at August 1 to 120 cfs at the first week of September. • Increase base flow to 120 cfs year-round. • Provide one pulse flow (500 cfs peak) in early April.	High
	Modeled Outcome: Flows are reduced below 500 cfs in July with the Integrated Plan projects. Flows are also ramped down from about 500 cfs to 120 cfs at the first week of September. From that time through March, 120 cfs is exceeded 99.6% of the time under the Integrated Plan compared to 20.2% under the FWIP. Winter pulse flows would be available in most years because Keechelus Reservoir carryover storage is increased by 39,000 acre-feet on average.	
Yakima River, Easton Reach	*Flow Objectives*: • Increase September and October spawning flows to 220 cfs. • Increase minimum flows to 250 cfs all other times for rearing which provides connection to side channels.	High
	Modeled Outcome: November-to-March flows are above 250 cfs 98.6 percent of the time (average = 462 cfs) under the Integrated Plan compared to 64.9 percent under the FWIP (average = 407 cfs). Spawning flows are held at 220 cfs from October 1-10 in 21 out of 25 years under the Integrated Plan compared to 10 out of 25 years under the FWIP.	
Cle Elum River	*Flow Objectives*: • Increase minimum flow to 500 cfs (previous analyses performed for Integrated Water Resource Management Alternative: Final EIS [Ecology, 2009] indicated 300 cfs could be provided so 300-500 cfs will be tested in the hydrologic modeling). • Decrease flows by 1,000 cfs beginning the first of August.	High
	Modeled Outcome: Average fall/winter flows (October-March) have increased from 325 cfs in the FWIP to 436 cfs with the Integrated Plan. Higher fall/winter releases up to 500 cfs minimum were tested however storage was depleted in most years and a minimum release of 300 cfs was used in the final model runs. Average summer (July-August) flows have decreased from 2,779 in the FWIP to 2,280 cfs under the Integrated Plan. The flow reduction starts earlier (July) than the objective stated by the Subcommittee. Other flow benefits of the Integrated Plan include providing spring pulse flows in non-drought years. Additional pulse flows or flow variability would be available in most years with the Integrated Plan as Upper Yakima River Basin reservoir carryover storage is increased by 39,000 acre-feet and Cle Elum Reservoir carryover storage is increased by 84,000 acre-feet on average.	
Yakima River, Cle Elum to Teanaway River	*Flow Objective*: • Ramp flows down starting July 1 to 1,000 cfs flow rate by August 31.	High
	Modeled Outcome: Average flow in August has been reduced from 4,016 cfs under the FWIP to 3,005 cfs under the Integrated Plan. Average flow on August 31 has been reduced from 3,142 cfs under the FWIP to 2,174 cfs under the Integrated Plan. A flow rate of 1,000 cfs was not able to be attained under the Integrated Plan but summer flows are significantly reduced.	
Yakima River, Teanaway River to Roza Dam (Ellensburg Reach)	*Flow Objectives*: • Reduce flow by 1,000 cfs beginning July 1. • Reach a flow of 1,000 cfs by August 31.	High
	Modeled Outcome: Average summer (July-August) flows have been reduced from 3,204 cfs under the FWIP to 2,471 cfs under the Integrated Plan. Summer flows are significantly reduced but the objective of reaching 1,000 cfs was not able to be attained.	

Table 4-3. Yakima Basin High-Priority Instream Flow Needs and Modeled Outcomes by Reach (continued)

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Yakima River, Roza Dam – Naches River	*Flow Objectives*: • Increase flows in the spring to a minimum of 1,400 cfs.[9] • Increase flows in the fall and winter to between 1,000 and 1,400 cfs.	High
	Modeled Outcome: Some small flow benefits accrue to this reach because of increased flow in upstream reaches. However flows in this reach are primarily affected by diversions for hydropower. Subordination of hydropower was not modeled in this study. Additional flow would be provided and flow objectives met if subordination of Roza Powerplant flows is adopted.	
Tieton River	*Flow Objective*: • Increase minimum flows to 125 cfs from late October to April 1.	High
	Modeled Outcome: The high priority flow objective of 125 cfs in winter (November to March) was met 99.8% of the time under the Integrated Plan compared to 28.3% under the FWIP.	
Lower Naches River	*Flow Objectives*: • Increase minimum flow rate to 550 cfs from June 1 to November 1. • Change the ramping rates from spring to summer flows to a more gradual decline. • Reduce September flows as much as possible.	High
	Modeled Outcome: Compared to FWIP, the average summer (July and August) flow has decreased by approximately 157 cfs, resulting in an average flow of 867 cfs under the Integrated Plan. However, since the lower Naches River was not targeted by reservoir operation rules the outcome of reduced summer flow appears to be a result of the model not being able to properly balance storage and flows well in that reach. Carryover storage in Tieton and Bumping reservoirs is increased by about 207,000 acre-feet on average which will provide operational flexibility. It is expected that some of the carryover storage can be used to change the ramping rate and increase summer instream flows greater than shown in the model. The objective of reducing September flows (through changing flip-flop operations) was not achieved.	
Yakima River from Parker to Toppenish Creek (Wapato Reach)	*Flow Objectives*: • Provide a spring pulse of 15,000 to 20,000 acre-feet in early May in dry years. • Change ramping rate at end of high flows that occur in June-July in average to wet years.	High
	Modeled Outcome: Pulse flows in dry years were not modeled, but system carryover storage is increased by 330,000 acre-feet on average. The additional storage can be used to provide pulse flows during dry years as well as flow to change ramping rates in average to wet years. In addition, storage in Wymer Reservoir is available for fisheries purposes, some of which can be used for pulse flows, although Wymer is lower in the river system. The hydrologic modeling also indicates average spring flow has increased from 3,377 cfs in the FWIP to 3,578 cfs in the Integrated Plan, an increase of 201 cfs.	

[9] The Yakima Basin Joint Board has been working with Reclamation and others to conduct a study below Roza Dam to improve the biological basis for flow enhancements in this reach.

Table 4-3. Yakima Basin High-Priority Instream Flow Needs and Modeled Outcomes by Reach (continued)

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Tributaries		
Manastash, Taneum, Cowiche	*Flow Objectives*: • Replace current diversions with Yakima or Naches River water; deliver water directly to tributaries if supply replacement is not feasible. No specific flow objectives were identified.	High
	Modeled Outcome: Tributary flows were not addressed in the model at this time, but the KRD South Branch project included in the Integrated Plan can provide 27 cfs in Manastash, and Taneum Creeks. Cowiche Creek is not addressed in the projects at this time.	
Ahtanum Creek	*Flow Objective*: • No flow objectives or augmentation alternatives were identified by subcommittee.	High
	Modeled Outcome: Tributary flows were not addressed in the model at this time. No significant change in flow is anticipated in Ahtanum Creek under the Integrated Plan.	

Color Code for Modeled Outcomes:

	Significant improvement under integrated plan
	Minor improvement under integrated plan
	Conditions become worse under integrated plan
	No significant change

Table 4-4. Yakima Basin Lower-Priority Instream Flow Needs and Modeled Outcomes by Reach

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Kachess River	*Flow Objective:* • No change proposed – Kachess River is a lesser priority for improving river flow because of other objectives.	Lower
Yakima River, Easton Reach	*Flow Objective:* • Provide spring pulse of 1,000 cfs for 48 hours during dry years, occasionally augment spring flow for channel maintenance (5-years for riparian recruitment – bank full during wet years).	Medium
	Modeled Outcome: Spring pulse flows are provided in 18 of 25 years under the Integrated Plan compared to 12 out of 25 years under the FWIP. Additional storage is available in most years to provide additional pulses; in wet years sufficient storage should be available to provide channel maintenance flows if not provided in winter.	
Yakima River, Cle Elum to Teanaway River	*Flow Objectives:* • Provide channel shaping flows about every 5 years. • Provide flow variability; see Cle Elum River.	Medium
	Modeled Outcome: Additional September 30th carryover storage of 123,000 acre-feet in upper Yakima reservoirs (Keechelus, Kachess and Cle Elum), on average (not including Wymer Reservoir), would allow additional pulse flow or increases in flow variability. In wet years sufficient storage should be available to provide channel maintenance flows if not provided in winter.	
Yakima River, Teanaway to Roza Dam	*Flow Objectives:* • Provide channel shaping flows about every 5 years. • Provide flow variability, time pulses to match natural events.	Medium
	Modeled Outcome: Pulse flows are provided from upstream reservoirs. Additional system carryover storage of 123,000 acre-feet in upper Yakima Basin reservoirs would allow additional pulse flow or increases in flow variability. In wet years sufficient storage should be available to provide channel maintenance flows if not provided in winter.	
Yakima River, Roza Dam to Naches River	*Flow Objective:* • Provide flow variability.	Lower to Medium
	Modeled Outcome: Subordination was not modeled, so flow variability could be provided when desired if subordination of Roza Powerplant flows is adopted.	
Bumping River, Bumping Dam to Naches River	*Flow Objective:* • Reduce flows by 70-100 cfs from August through October.	Medium
	Modeled Outcome: Average daily flow from August through October has decreased from 189 cfs under the FWIP to 165 cfs under the Integrated Plan.	
Tieton River	*Flow Objective:* • Reduce September flows to as close as possible to unregulated conditions.	Medium
	Modeled Outcome: Average flow in September has decreased from 1,534 cfs under the FWIP to 1,166 cfs under the Integrated Plan. Flip-flop could not be eliminated.	
Yakima River, Naches River to Parker	*Flow Objective:* • Reduce high summer flows as much as possible.	Lower
	Modeled Outcome: The average summer flow under the Integrated Plan has decreased by approximately 215 cfs, resulting in an average flow of 3,185 cfs.	
Yakima River from Parker to Toppenish Creek (Wapato Reach)	*Flow Objective:* • Link to habitat needs.	No priority assigned[10]

[10] The reach from Parker to Toppenish Creek needs a better understanding of existing conditions. Design and implement research, monitoring and evaluation (RM&E) program to better understand improvements needed. Develop flow objectives from RM&E results.

Table 4-4. Yakima Basin Lower-Priority Instream Flow Needs and Modeled Outcomes by Reach (continued)

River Reach	Desired Flow Objectives and Modeled Outcomes of Integrated Plan	Priority
Yakima River: Toppenish Creek to Prosser Dam	*Flow Objective:* • See Wapato Reach.	See Wapato Reach
Yakima River-Prosser Dam to Chandler Powerplant	*Flow Objectives:* • Need greater than 1,000 cfs in September. • Although some subordination occurs to provide 1,000 cfs, need more flow in Spring	Lower
	Modeled Outcome: Average September flow has decreased from 650 cfs under the FWIP to 492 cfs under the Integrated Plan, but subordination of Chandler Powerplant was not modeled. Additional flow and habitat benefits would occur if subordination is adopted. Average flow in July has increased from 682 cfs under the FWIP to 758 cfs under the Integrated Plan. Average spring flows have increased by 188 cfs, resulting in an average spring flow of 2,490 cfs under the Integrated Plan. Additional storage is available for Spring pulse flows (see high priority flow objective for Wapato Reach).	
Lower Yakima River (Chandler Powerplant to mouth)	*Flow Objectives:* • See Wapato Reach for Spring flow objective. • Link summer flow objective to habitat needs	Lower
	Modeled Outcome: Pulse flows in dry years were not modeled, but system carryover storage is increased by 330,000 acre-feet on average. The additional storage can be used to provide pulse flows during dry years. In addition, storage in Wymer Reservoir is available for fisheries purposes including pulse flows.	
Tributaries		
Big, Little, Tillman, Spex Arth and Peterson Creeks	*Objective:* Increase summer and early fall flows.	Medium
Ahtanum Creek	*Objective:* Increase summer and early fall flows.	Medium
Wenas Creek	*Objective:* Increase summer and early fall flows.	Lower
North Side Kittitas Valley Tributaries	*Objective:* Improve passage	Lower
	Modeled Outcome: Tributary flows were not addressed in the model at this time. The KRD South Branch project can improve instream flow in Big, Little and other south side creeks however the flow available is also needed to increase flow in Taneum and Manastash creeks, which were rated a higher priority. No change in flow is anticipated in Ahtanum or Wenas Creek with projects under the Integrated Plan. The North Branch Canal has potential to improve flow conditions and passage in the north side Kittitas Valley tributaries by restoring flow or removing irrigation water conveyance through creeks and removing diversion structures.	

Color Code for Modeled Outcomes:

	Significant improvement under integrated plan
	Minor improvement under integrated plan
	Conditions become worse under integrated plan
	No significant change

Yakima River Decision Support System (YRDSS) Model Mainstem Habitat Results from Integrated Plan Flow Improvements

The Yakima River Decision Support System (YRDSS) uses output from RiverWare to calculate and summarize changes at four flood plain reaches in the Yakima Basin. Construction of the

habitat models for the target life stages involved data collection and calibration of two-dimensional hydraulic models, which was used to generate maps of suitable habitat for each life stage, for each discharge simulated with the hydraulic models. The YRDSS model was used to evaluate increases in the amount of mainstem habitat from the flow improvements modeled for the Integrated Plan.

Changes in habitat provided by flow scenarios were identified for the four Yakima Basin floodplains described below. A change in aquatic habitat (increase or loss) greater than 10 percent is considered biologically meaningful. Results are provided for the FWIP and the Integrated Plan scenarios.

Easton Floodplain – Results showed benefits for spring Chinook, coho and steelhead in the Easton floodplain. Spring Chinook showed a 16.5-percent increase and coho, a 10-percent increase in spawning/incubation habitat. Adult holding habitat increased 11.9 percent for spring Chinook and 14 percent for steelhead.

Kittitas Floodplain – Results for the Kittitas floodplain under the Integrated Plan scenarios showed a 17.3-percent increase in spring Chinook spawning/incubation habitat. Steelhead showed a loss in winter rearing habitat of 10.3 percent, and coho summer rearing habitat decreased by 10.3 percent.

Lower Naches Floodplain – Results with Integrated Plan scenarios showed a benefit in increased spawning/incubation habitat of 20.6 percent for spring Chinook, 36.7 percent for coho, and 14.4 percent for steelhead in the Lower Naches floodplain. Fry habitat increased 11.5 percent and adult holding, 36.7 percent for coho. Coho summer rearing habitat decreased 10.6 percent.

Wapato Floodplain – Results showed no significant benefits in habitat for salmon species in the Wapato floodplain from the modeled improvements to instream flow. However opportunities for flow releases from additional carryover storage may improve migration and habitat conditions in this reach.

4.5 Other Surface and Groundwater Considerations

As characterized above, the Integrated Plan would make major improvements in water supply and aquatic habitat conditions in the basin. The Integrated Plan also includes actions to address key surface water/groundwater interactions, such as flow and drought-year groundwater use.

Recent studies conducted by the U.S. Geological Survey (USGS) conclude that the surface and groundwater systems of the basin are interconnected. Areas within the basin, especially the deep basalt aquifer, are seeing significant declines in groundwater levels, which in turn are affecting stream flow and water supply available for irrigation. The USGS groundwater study initial estimate of deep basalt aquifer depletion is about 30,000 acre-feet annually (http://wa.water.usgs.gov/projects/yakimagw/summary.htm).

The Integrated Plan actions would provide drought-year surface water irrigation supply to reduce the existing groundwater demand for emergency irrigation wells that have historically been used to mitigate crop impacts from drought. Increased surface water storage would also help improve stream flows impacted by groundwater declines. Further, implementing the Integrated Plan actions would meet significant future municipal and domestic needs. Expanded surface water

supplies can reduce the need for new groundwater supplies for municipal growth and provide stream flow mitigation for new domestic wells outside the basin's urban areas.

4.6 Water Supply Outcomes under Climate Change

Hydrologic input for 19 climate change scenarios for the 2040s was provided by Reclamation's Technical Service Center (RMJOC 2010 and Reclamation 2011). The scenarios were developed from climate-specific hydrologic modeling conducted by the University of Washington.[11] Four of the climate-specific scenarios featured in RMJOC's report were selected for incorporation into the Yakima Project RiverWare model – one to represent existing conditions based upon historic climate trends and the others to represent a range of possible future climates. Table 4-5 summarizes the existing conditions and three climate change scenarios modeled for the Yakima River Basin Study.

Table 4-5. Summary of Climate Change Scenarios

Scenario	Average Temperature Change from Existing Conditions	Average Precipitation Change from Existing Conditions	Average Annual Reservoir Inflow (million acre-feet)
Existing Conditions (historically-based)	Not applicable	Not applicable	1.66
Less Adverse Climate Change	1.8 ºC average increase	13.4% increase	1.86
Moderately Adverse Climate Change	1.7 ºC average increase	3.7% increase	1.48
More Adverse Climate Change	2.8 ºC average increase	2.5% decrease	1.38

Climate change impacts on hydrology and water demands associated with the three climate change scenarios were incorporated into the FWIP and Integrated Plan scenario models. The three climate change scenarios affect the volume and timing of water flowing into the reservoirs and stream flow at each diversion location, thereby changing both the need for water from reservoir storage and the ability of the reservoirs to meet those needs.

Demands for water were also adjusted to account for climate change, based on information from Appendix C of the Volume 2 technical memorandum, *Water Needs for Out-of-Stream Uses*. Irrigation demands were increased by an average of 9 percent to represent climate change-impacted conditions. Municipal demands were increased by an average of 5 percent. These adjustments to demands should be considered preliminary and are subject to uncertainty of at least plus or minus 50 percent.

Table 4-6 summarizes the three climate change scenarios. For more information on methods and results, see Volume 2 technical memorandum, *Modeling of Reliability and Flows*.

[11] Additional information on the University of Washington's climate change models can be found here: http://www.hydro.washington.edu/2860/

Table 4-6. Climate Change Scenario Simulation Results (millions of acre-feet)

Resource indicator (measurement)	Less Adverse		Moderately Adverse		More Adverse	
	FWIP	Integ Plan	FWIP	Integ Plan	FWIP	Integ Plan
Average for water years 1981–2005						
April 1 total water supply available (TWSA)	2.64	2.79	2.31	2.47	1.84	2.02
April–September Parker flow volume	0.60	0.53	0.51	0.43	0.36	0.30
April–September diversion	1.67	1.79	1.51	1.64	1.29	1.43
Water remaining after irrig. season[1]	0.10	0.59	0.08	0.37	0.07	0.20
Irrigation proration level	74%	88%	54%	72%	30%	50%
1993 dry-year						
April 1 total water supply available (TWSA)	2.50	2.65	1.86	2.00	1.61	1.69
April–September Parker flow volume	0.57	0.57	0.38	0.27	0.29	0.28
April–September diversion	1.61	1.65	1.30	1.46	1.16	1.24
Water remaining after irrig. season[1]	0.05	0.45	0.03	0.04	0.08	0.03
Irrigation proration level	58%	70%	30%	52%	7%	23%
1994 dry-year						
April 1 total water supply available (TWSA)	1.73	2.24	1.51	1.60	1.30	1.43
April–September Parker flow volume	0.25	0.20	0.29	0.27	0.23	0.21
April–September diversion	1.29	1.56	1.10	1.20	0.97	1.09
Water remaining after irrig. season[1]	0.05	0	0.08	0	0.10	0
Irrigation proration level	32%	70%	9%	25%	0% [2]	14%
2001 dry-year						
April 1 total water supply available (TWSA)	1.69	2.26	1.58	2.16	0.85	1.38
April–September Parker flow volume	0.29	0.22	0.33	0.26	0.23	0.20
April–September diversion	1.24	1.56	1.11	1.49	0.53	1.07
Water remaining after irrig. season[1]	0.05	0.20	0.05	.14	0.07	0.02
Irrigation proration level	25%	70%	9%	61%	0% [2]	10%
2005 dry-year						
April 1 total water supply available (TWSA)	2.20	2.29	1.76	2.02	1.48	1.58
April–September Parker flow volume	0.39	0.35	0.33	0.26	0.30	0.25
April–September diversion	1.56	1.63	1.27	1.46	1.08	1.16
Water remaining after irrig. season[1]	0.05	0.49	0.04	0.08	0.07	0.05
Irrigation proration level	59%	70%	27%	61%	4%	21%

Green shading shows greater than 10% improvement from FWIP conditions, including effects of climate, or Prorationing >61%.

Pink shading shows greater than 10% decrease from FWIP conditions, including effects of climate, or Prorationing <61%.

FWIP = Future Without Integrated Plan

[1] Inactive storage pool in Lake Kachess (200,000 acre-feet) is accounted for in this quantity. In 1994 (third year of drought) it is assumed that pool is not available due to inadequate refill.

[2] A value of 0 percent indicates that nonproratable rights are not fully satisfied.

All three sets of climate change results show that the Integrated Plan improves water supply conditions by increasing TWSA and prorationing. Instream flow conditions are also improved, and extra water remains in end of September reservoir storage that could be used to further improve instream flows. Beyond these common results, the three climate change scenarios lead to very different outcomes.

Under the ***less adverse*** climate change scenario, there is actually more water available in the basin than historically. Under these conditions, the Integrated Plan increases the average TWSA by 150,000 acre-feet, or about 6 percent. The average prorationing level is increased from 74 percent to 88 percent, and the minimum year (2001) prorationing level is increased from 25 percent to 70 percent. Under the Integrated Plan, the end of September average reservoir storage is increased by 490,000 acre-feet.

Under the ***moderately adverse*** climate change scenario, there is about 180,000 acre-feet, or 11 percent, less water available as runoff into the basin reservoirs, compared with historical conditions. Under these reduced-flow conditions, the Integrated Plan increases the average TWSA by 158,000 acre-feet, or about 7 percent. The average prorationing level is increased from 54 percent to 72 percent, and the minimum year (1994) prorationing level is increased from 9 percent to 25 percent, significantly short of the irrigation community's goal. Under the Integrated Plan, the end of September average reservoir storage is increased by 289,000 acre-feet.

Under the ***more adverse*** climate change scenario, there is about 280,000 acre-feet, or 17 percent, less water available as runoff into the reservoirs in the basin than historical conditions. Under these reduced-flow conditions, the Integrated Plan increases the average TWSA by 178,000 acre-feet, or about 10 percent. The average prorationing level is increased from 30 percent to 50 percent, and the minimum year (2001) prorationing level is increased from 0 percent to 10 percent. This is far below levels that would support irrigation by proratable water users in those years. However, this still represents an improvement over FWIP, where even nonproratable diversions cannot be fully supplied in several dry years. Under the Integrated Plan, the end of September average reservoir storage is increased by 129,000 acre-feet.

The scenarios reviewed above represent a range of possible climate change effects, but actual effects cannot be predicted with certainty. Both climate change and actions taken by water users to adapt over time represent sources of uncertainty. Farmers may be forced to change the crops they grow, and some farmers may cease irrigating their land if climate conditions become increasingly severe.

Actual climate conditions would be assessed as part of the periodic review of Yakima Basin water resource conditions described in Section 5.3, using new information that is developed to better understand how the basin's water resources are affected. Findings from the reviews can then be used to make adjustments to Integrated Plan actions, if needed.

4.7 Fish Production from Passage Improvements and Habitat Enhancement

The fish habitat enhancement program included under the habitat protection and enhancement element of the Integrated Plan was evaluated using the following tools:

- 2004 Ecosystem Diagnosis and Treatment (EDT) model (Reclamation 2010),

- All H Analyzer (AHA) (Reclamation 2010) ("All H" refers to four conditions that strongly affect fish: habitat, hatcheries, harvest, and hydropower), and
- Spawners per hectare (sockeye only) models (Reclamation 2007a and 2007b).

Model results characterized improved habitat conditions that could result from implementing the habitat program and how this may increase fish production for anadromous fisheries in the basin, including spring, summer and fall Chinook, steelhead, coho, and sockeye. Improvements would also help with Endangered Species Act (ESA) recovery efforts for steelhead by increasing both production and spatial distribution. A qualitative effects analysis was conducted by Yakima Basin fisheries managers to characterize both positive and negative effects on bull trout populations, also listed under the ESA. Any potential negative effects on bull trout would require appropriate mitigation measures.

Anadromous Species

Modeling results show significant benefits for spring, summer and fall Chinook, steelhead, coho, and sockeye comparing the baseline to three scenarios. The baseline represents existing habitat conditions and fish population levels in the Yakima Basin, and the three scenarios are described below:

- FWIP – Represents fish population increases from habitat improvements that would continue under current programs and funding levels. This represents an average of 18-percent improvement for fish populations over baseline conditions.
- Restoration – Represents fish population increases from habitat improvements that would result from implementing the fish habitat enhancement program. The actions identified in the Yakima Steelhead Recovery Plan were used as a surrogate in the modeling effort to characterize habitat improvements that would result from the Integrated Plan fish habitat enhancement program. (YBFWRB 2009).
- Restoration with Fish Passage (Integrated Plan) – Represents fish population increases from the Habitat Restoration scenario plus providing fish passage at Cle Elum, Keechelus, Kachess, Bumping, and Tieton dams.

The model results described below and listed in Table 4-7 summarize the expected outcomes under the Integrated Plan for the following anadromous species, both individually and combined, without sockeye. Table 4-8 lists sockeye results. The values provided in these two tables are "recruitment" population values. Recruitment population values are an estimate of the ocean population at the mouth of the Columbia River. Ocean harvest was not included because it was either minimal or not applicable to the species. Other model results for species, such as harvest and escapement, are provided later in this section.

The reason for including results with and without sockeye is due to the large effect sockeye results have on the total estimated population increases that would result from the Integrated Plan. Projected sockeye population increases represent more than 70 percent of the total improvement for all anadromous species and are dependent on the proposed fish passage improvements at the five major reservoirs.

- **Spring Chinook** – Spring Chinook show benefits under both scenarios, with average run sizes increasing 56 percent from FWIP for Restoration, and increasing 87 percent for Restoration with Passage.

- **Steelhead** – For steelhead populations, natural production is not bolstered by hatchery production like spring Chinook in the Yakima Basin. However, steelhead run sizes for the Restoration scenario increased 90 percent from FWIP, and for the Restoration with Passage scenario, the average run size more than doubled the FWIP run size.
- **Coho** – Coho also show improvements in run sizes for modeled scenarios, with a 20-percent average run size increase from FWIP data for Restoration and 26 percent increase under the Restoration with Passage scenario.
- **Fall Chinook** – Fall Chinook runs increased approximately 51 percent from FWIP for both the Restoration and Restoration with Passage scenarios. There was no difference in the abundance numbers between the Restoration and Restoration + Passage scenarios. This is because fall Chinook complete their entire freshwater life cycle downstream of the five Reclamation storage dams and are not affected by the provision of fish passage, which is the only difference in restoration/passage actions between these two scenarios.
- **Summer Chinook** – Summer Chinook show a significant benefit from FWIP to the Restoration and Restoration with Passage scenarios, more than doubling the average run sizes for both. There was no difference in the abundance numbers between the Restoration and Restoration + Passage scenarios. This is because summer Chinook complete their entire freshwater life cycle downstream of the five Reclamation storage dams and are not affected by the provision of fish passage, which is the only difference in restoration/passage actions between these two scenarios.
- **All Species Combined (without sockeye) –** All species combined show benefits with average run sizes increasing 51 percent from FWIP for the Restoration scenario and increasing 65 percent for Restoration with Passage.

Table 4-7. All Species Combined Population Improvements (Without Sockeye)

Species		Baseline	Future Without Integrated Plan	Restoration	Restoration + Passage (Integrated Plan)
Spring Chinook	Max.(1)	33,653	38,434	59,949	72,058
	Ave.	10,153	11,494	17,909	21,503
	Min.(2)	5,109	5,748	9,149	10,905
Steelhead	Max.	8,995	11,954	23,868	27,904
	Ave.	2,871	3,699	7,041	8,198
	Min.	1,263	1,589	3,207	3,646
Coho	Max.	27,926	38,098	46,648	48,791
	Ave.	8,806	11,983	14,396	15,069
	Min.	4,686	6,414	7,671	8,026
Fall Chinook	Max.	29,857	31,082	47,259	47,259
	Ave.	8,385	8,724	13,170	13,170
	Min.	3,198	3,300	4,920	4,920
Summer Chinook	Max.	10,692	11,775	24,877	24,877
	Ave.	3,308	3,694	7,390	7,390
	Min.	1,464	1,529	2,372	2,372
All Species Combined (w/o Sockeye)	Max.	111,122	131,343	202,601	220,899
	Ave.	33,523	39,593	59,906	65,329
	Min.	15,719	18,581	27,318	29,868

(1) Represents the highest recruitment value in a 100 generation simulated run generated by the AHA model.
(2) Represents the lowest recruitment value in a 100 generation simulated run generated by the AHA model.

- **Sockeye -** Sockeye were evaluated through a separate modeling effort. Two approach variations were applied to provide a range of potential increases in population abundance from reintroduction efforts associated with passage and restoration actions in the Integrated Plan. Both variations rely on the adult spawners per hectare of reservoir surface area method (Reclamation 2007a and 2007b) and use conservative assumptions to estimate potential sockeye abundance. Low, medium, and high estimates are based upon 5 percent egg-to-smolt survival and from 1 to 4 percent smolt-to-adult survival, and evaluated by *median* and *full* reservoir surface area for all five reservoirs to provide a range of results. Table 4-8 contains the range of results. The "low" abundance estimate was based upon median reservoir pool surface area, a 5 percent egg-to-smolt survival rate and a 1 percent smolt-to-adult survival rate. The "medium" abundance estimate was based upon full reservoir pool surface area, a 5 percent egg-to-smolt survival rate and a 2 percent smolt-to-adult survival rate. The "high" abundance estimate was based upon full reservoir pool surface area, a 5 percent egg-to-smolt survival rate and a 4 percent smolt-to-adult survival rate.

Table 4-8. Increase in Sockeye Population Abundance from Reintroduction Associated with Integrated Plan Actions

Scenario	Low	Medium	High
Restoration + Passage			
Recruitment	112,243	340,627	681,255
Columbia R. Harvest	8,979	27,250	54,500
Yakima River Mouth	92,039	279,315	558,629
Columbia R. Migration Loss	11,224	34,063	68,125
Yakima R. Harvest	13,806	41,897	83,794
Yakima R. Migration Loss	4,602	13,966	27,931
Escapement	73,631	223,452	446,903

All Species Combined (with sockeye*)* – Table 4-9 summarizes results for all species by each of these categories. In addition to the recruitment population increases provided in the tables above, additional categories are also characterized in this table to provide a more complete depiction of modeled results:

- **Columbia River Harvest** – Includes Columbia River commercial, sport and Tribal harvest, but not migratory losses.
- **Yakima River Harvest** – Includes Yakima River sport and Tribal harvest but not migratory losses.
- **Yakima River Mouth** – Population that returns to the mouth less Columbia River harvest and migratory losses.
- **Broodstock Removal** – Fish taken for the Yakama Nation hatchery programs for spring, fall and summer Chinook and coho.
- **Sockeye Columbia River Migratory Loss** – Assumed 10% loss of the sockeye recruitment estimate.
- **Sockeye Yakima River Migratory Loss** – Assumed 5% loss of population estimate at the Yakima River mouth.
- **Total Escapement** – Population that returns to Yakima River spawning grounds after harvest and migratory losses.

These improvements would likely result in a range of total adult salmon recruitment between 140,000 during low survival years and more than 900,000 adults in years of high survival. Harvest would be as much as seven times greater than the FWIP. The number of fish reaching Yakima Basin spawning grounds would grow from a maximum return of 91,000 adults if the plan were not implemented to over 600,000 if the Integrated Plan is implemented.

Table 4-9. All Species Combined Results by Scenario

Scenario	Minimum	Average	Maximum
Baseline			
Recruitment	15,719	33,523	111,122
Columbia R. Harvest	3,443	7,472	24,893
Yakima River Mouth	12,277	26,051	86,229
Yakima R. Harvest	993	2,238	7,610
Broodstock Removal	1,047	1,214	2,030
Escapement	10,236	22,599	76,589
FWIP			
Recruitment	18,581	39,593	131,343
Columbia R. Harvest	4,035	8,739	29,016
Yakima River Mouth	14,545	32,201	106,619
Yakima R. Harvest	1,118	2,546	8,802
Broodstock Removal	1,288	1,480	2,297
Escapement	12,139	26,828	91,580
Restoration			
Recruitment	27,318	59,906	202,601
Columbia R. Harvest	5,671	13,032	44,204
Yakima River Mouth	21,647	46,875	158,397
Yakima R. Harvest	1,884	4,164	14,621
Broodstock Removal	1,330	1,491	2,297
Escapement	18,433	41,220	141,479
Restoration + Passage (Integrated Plan)			
Recruitment	142,111	405,957	902,143
Columbia R. Harvest	26,218	75,050	169,183
Sockeye Columbia R. Migration Loss	11,224	34,063	68,125
Yakima River Mouth	115,893	330,907	732,960
Yakima R. Harvest	20,551	60,601	128,364
Sockeye Yakima R. Migration Loss	4,602	13,966	27,931
Broodstock Removal	1,334	1,500	2,325
Escapement	94,008	268,806	602,271

Minimum values include sockeye low values.
Average values include sockeye medium values.
Maximum values include sockeye high values.

Bull Trout

Bull trout were not addressed through the EDT model approach. Instead, a matrix and accompanying narrative was developed discussing population status, limiting factors and current impacts, changes to populations, actions completed in recent years, and information gaps.

Additional bull trout management actions were identified for the habitat enhancement program recommendations (See Section 3.1.5), focused on further mitigating existing operational impacts and potential impacts from surface water storage actions included in the Integrated Plan.

The following identifies the Yakima Basin fisheries managers' expected changes in bull trout population viability with Integrated Plan implementation. In most cases, the plan would improve habitat conditions and increase available habitat. For Deep and Box Canyon creeks, and for the Bumping and Kachess rivers, the Integrated Plan would result in adverse impacts without commensurate mitigation. As previously stated, any potential adverse effects on bull trout would require appropriate mitigation.

Table 4-10. Bull Trout Benefits and Impacts

Stream	Integrated Plan
Ahtanum	+
Indian Creek	++
South Fork Tieton	+++
North Fork Tieton	+++
American	+
Crow Creek	+
Rattlesnake Creek	+
Deep Creek	-
Bumping River	-
Kachess River	-
Box Canyon Creek	-
Gold Creek	+++
Cle Elum/Waptus	+
Upper Yakima	++
Teanaway	+

- = Negative impact (would require mitigation)
+ = Some benefit from habitat actions or Bull Trout Task Force
++ = Additional benefit, either re-connectivity as dam passage is addressed, or another project that addresses a specific limiting factor for a population (e.g. SF Tieton falls, Gold Creek Hydrological Assessment).
+++ = Multiple passage or population specific projects

4.8 Summary of Integrated Plan Benefits

Table 4-11 compares water supply outcomes under the FWIP and Integrated Plan in all water years modeled, without the impacts of climate change. Modeling results show that the Integrated Plan can increase prorationing to 70 percent in all water years modeled, which represents a significant improvement in water supply reliability. Table 4-11 also shows how elimination of any one or all of the major surface water storage projects from the Integrated Plan affects water supply outcomes and costs of the plan. Elimination of surface water storage projects would have the greatest effect during multiple-year droughts such as 1994, which was the last year of a 3-year drought.

One of the indicators listed in Table 4-11 is "Water Remaining After Irrigation Season" (or, carryover water). This water would be left over if the exact operational procedures modeled were followed in each year. In reality, Reclamation operators would consult with the System Operations Advisory Committee over the course of the year to determine how to use that water. It could be held in the reservoirs as a hedge against drought the following year; or it could be

released during the summer and fall to improve fish habitat conditions. Thus, this value provides one measure of how the Integrated Plan could improve operational flexibility to meet multiple needs.

Table 4-12 compares instream flow and fish production under FWIP and with the Integrated Plan. Results from RiverWare modeling indicate that 13 of 15 mainstem reaches and certain Yakima River tributaries could benefit from improved flows due to the increased supply and operational flexibility available under the Integrated Plan. One reach (Lower Naches River) would experience negative flow impacts; and another reach (Kachess River) would see no change in flows. Based on results of the fisheries modeling described in Section 4.7, fish populations would see substantial increases in the Lower Columbia River and Yakima River as a result of the Integrated Plan.

Table 4-13 summarizes modeling results from three climate change scenarios. The Integrated Plan would substantially improve water supply conditions during dry years under all three scenarios. However, under the "moderately adverse" and "more adverse" climate scenarios, water supplies would fall far short of the 70 percent proration goal and could fall as low as 10 percent (based on current cropping patterns). Due to uncertainties associated with climate change, the Integrated Plan includes an adaptive management framework, with triggers for potential development of additional water supplies, if needed (see Section 5.3).

These results were determined prior to completion of the targeted watershed protections discussed in Section 3.1.5. Therefore the benefits summarized in this section do not include benefits from those actions.

Table 4-11. Water Supply Benefits of Integrated Plan

Benefits	Future Without Integrated Plan	Integrated Plan (IP)	IP without Bumping Lake Enlargement	IP without Kachess Inactive Storage and K to K Pipeline	IP without Wymer Reservoir	IP without New Surface Storage Projects
Out-of-Stream Supply Benefits						
Average for Water Years 1981-2005						
Total Water Supply Available (TWSA) on April 1 (million acre-feet)	2.79	3.00	2.96	3.00	2.88	2.87
Prorationing Level	80%	92%	91%	91%	85%	81%
Water Remaining After Irrigation Season (thousand acre-feet)	230	780	630	590	550	270
1994 Dry Year (3rd year of drought)						
TWSA on April 1 (million acre-feet)	1.74	2.22	2.09	2.01	1.89	1.79
Prorationing Level	21%	70%	68%	56%	48%	22%
Water Remaining After Irrigation Season (thousand acre-feet)	50	0	0	70	0	40
2001 Dry Year						
TWSA on April 1 (million acre-feet)	1.76	2.45	2.30	2.25	2.23	1.86
Prorationing Level	32%	70%	70%	70%	70%	37%
Water Remaining After Irrigation Season (thousand acre-feet)	60	420	270	210	230	50
2005 Dry Year						
TWSA on April 1 (million acre-feet)	1.71	2.32	2.16	2.13	2.10	1.80
Prorationing Level	28%	70%	70%	70%	70%	33%
Water Remaining After Irrigation Season (thousand acre-feet)	80	320	180	150	160	70
Costs						
Construction Plus Non Contract Costs ($ Million)	NA	$3,990	$3,588	$3,546	$2,351	$1,504
Annual O&M (includes pumping) ($ Million)	NA	$10	$10	$10	$6	$5
Other Considerations						
Municipal/Domestic Supply	NA	+	+	+	+	0
Flood Management	NA	+	+	+	+	0
Net Change in Annual Energy Consumption	NA	(-)	(-)	(-)	0	0
Adaptation to Climate Change	NA	+	+	+	+	0
Job Creation	NA	+	+	+	+	+

+ = Positive Effect; (-) = Negative Effect; 0 = Negligible Effect
NA = Not Applicable

Table 4-12. Stream Flow and Fish Benefits of Integrated Plan

Benefits	Future Without Integrated Plan	Integrated Plan
Stream Flow Benefits		
Yakima River from Keechelus Dam to Lake Easton	NA	++
Yakima River - Easton Reach	NA	++
Cle Elum River	NA	++
Yakima River from Cle Elum River to Teanaway River	NA	++
Yakima River from Teanaway River to Roza Dam	NA	++
Yakima River from Roza Dam to Naches River	NA	+
Yakima River from Naches River to Parker Gage	NA	+
Yakima River from Parker Gage to Toppenish Creek	NA	+
Yakima River from Toppenish Creek to Prosser Dam	NA	+
Yakima River - Chandler Reach	NA	+
Yakima River from Chandler Power Plant to Columbia River	NA	+
Bumping River from Bumping Dam to Naches River	NA	+
Tieton River	NA	++
Lower Naches River	NA	(-)
Manastash, Taneum, Big, Little and other Tributaries	NA	+
North Side Kittitas Valley Tributaries	NA	+
Other Tributaries – including Cowiche and Ahtanum	NA	0
New Water Available for Pulse Flows or other flow improvements	NA	+
Fish Production and Habitat Area		
Annual Adult Salmon recruitment from Pacific Ocean (thousands of fish)	19-131	236- 836
Annual Salmon Harvest (thousands of fish)	5-37	24-108
Annual Adult Salmon Entering Yakima Basin (thousands of fish)	15-107	71-324
Annual Salmon Escapement (Spawners) in Yakima Basin (thousands of fish)	12-91	60-273
++ = Significant Positive Effect; + = Slight Positive Effect; 0 = Negligible Effect; (-) = Negative Effect NA = Not Applicable		

Table 4-13. Water Supply Effects of Three Climate Change Scenarios

Benefits	Less Adverse Climate		Moderately Adverse Climate		More Adverse Climate	
	Future Without Integrated Plan	Integr. Plan	Future Without Integrated Plan	Integr. Plan	Future Without Integrated Plan	Integr. Plan
Average for Water Years 1981-2005						
Total Water Supply Available (TWSA) on April 1 (million acre-feet)	2.64	2.79	2.31	2.47	1.84	2.02
Prorationing Level	74%	88%	54%	72%	30%	50%
Water Remaining After Irrigation Season (thousand acre-feet)	100	590	80	370	70	200
1994 Dry Year (3rd year of drought)						
TWSA on April 1 (million acre-feet)	1.73	2.24	1.51	1.60	1.30	1.43
Prorationing Level	32%	70%	9%	25%	0%	14%
Water Remaining After Irrigation Season (thousand acre-feet)	50	0	80	0	100	0
2001 Dry Year						
TWSA on April 1 (million acre-feet)	1.69	2.26	1.58	2.16	0.85	1.38
Prorationing Level	25%	70%	9%	61%	0%	10%
Water Remaining After Irrigation Season (thousand acre-feet)	50	200	50	140	70	30
2005 Dry Year						
TWSA on April 1 (million acre-feet)	2.20	2.29	1.76	2.02	1.48	1.58
Prorationing Level	59%	70%	27%	61%	4%	21%
Water Remaining After Irrigation Season (thousand acre-feet)	50	490	40	80	70	50

4.9 Economic Outcomes

This section summarizes findings from an assessment of expected economic effects of the Integrated Plan on the Yakima River Basin. Information currently exists to quantify some, but not all, of the costs and benefits of implementing the Integrated Plan – some financial in nature and others that can be considered only in qualitative terms (see Volume 2 technical memorandum, *Economic Effects of the Yakima Basin Integrated Water Resource Management Plan*).

The economic assessment was not designed to provide all of the information required under the Federal Principles and Guidelines for evaluating water resource projects (U.S. Water Resources Council 1983). However, it provides some initial information on the expected economic performance of the Integrated Plan. Further assessment as required by the Principles and Guidelines is planned for the next phase of investigation, as outlined in Section 6.0.

Quantified Costs and Benefits

The potential financial costs to implement the Integrated Plan over a 100-year period, through 2110, would have a present value of about $3 billion.[12] These costs primarily involve expenditures for capital, operations, and maintenance of new facilities. Lesser amounts represent planned expenditures to implement programs to promote conservation and market-based reallocation.

The estimated present monetary value of the three types of benefits listed below is $2.2 billion to $3.8 billion, broken down as follows:

- Increased net farm earnings from irrigated crops during future severe droughts – $400 million
- Increased supply of up to 50,000 acre-feet of water for M&I and domestic use – $100 million
- Increased production of salmon and steelhead – $1.7 to $3.3 billion.

Unquantified Costs and Benefits

The Yakima River Basin Study has not determined whether the Integrated Plan's potential benefits are smaller than, equal to, or larger than its potential costs. Further analysis would be necessary to make this determination.

Insufficient information exists to calculate the value of two categories of potential costs that likely would accompany implementation of the Integrated Plan. They are:

- Loss of recreational opportunities and habitat for species from lands that would be occupied by new or expanded reservoir sites under the Integrated Plan.
- Reduced net farm earnings for farmers who compete with those who would benefit directly from the Integrated Plan.

Implementation of the plan also would yield several types of economic benefits that cannot be quantified with existing information. These additional potential benefits include:

[12] The present value is an amount, measured today, that is equivalent in value to an anticipated future stream of costs or benefits. Calculation of the present value involves discounting the cost or benefit in a future year to its equivalent present value. The current discount rate applicable to federal water-resources planning is 4.375 percent per year.

- Increases in net farm earnings from irrigated farming in the basin in drought years that are less intense than the severe drought that is the basis for the quantified benefits above.
- Unquantifiable benefits of higher fish populations, which likely would include cultural and spiritual values associated with increases in salmon and steelhead populations.
- Increases in the net value of recreational opportunities, other than those already reflected in the valuation of higher fish populations.
- Increases in the populations of other aquatic species in addition to salmon and steelhead.
- Improved resiliency and adaptability of the water system.
- Additional benefits associated with the Integrated Plan's impacts on production of irrigated crops, salmon and steelhead, and other goods or services in the context of anticipated climate changes.
- The economic outcomes of the Integrated Plan were evaluated prior to completion of the targeted watershed protections discussed in Section 3.1.5. Therefore the economic outcomes summarized in this section do not include costs or benefits from those actions.

Other Potential Economic Effects of the Integrated Plan

Plan-related expenditures on construction, operation and maintenance, and program implementation would affect jobs, incomes, and output in the local and statewide economies. The level and distribution of the effects have not been analyzed in detail. Effects include temporary increases in jobs related to construction, probably amounting to less than 1 percent of total employment in the local area. In the longer term, increases in agricultural production, municipal water supply, and fish production would all likely increase jobs and income in the Yakima Basin. While prior studies conducted by Reclamation are informative in this regard (e.g., study of the previous Wymer Dam proposal), they are not definitive. For more information, see the Volume 2 technical memorandum, *Economic Effects of Yakima Basin Integrated Water Resource Management Plan*.

5.0 Implementation Considerations

5.1 Potential Barriers to Plan Implementation and Mitigation Strategies

Environmental, policy, and legal barriers and associated mitigation strategies were identified for each Integrated Plan element. The term "barriers" is used instead of impacts because the analysis prepared at this time focuses on major issues that could prevent a project from moving forward. This analysis is not intended to be on the level of an environmental impact statement, but is a summary of the major issues associated with each project. The analysis of potential barriers is based largely upon the analysis conducted as part of the Final EIS prepared by Ecology on the Integrated Water Resource Management Alternative (Ecology 2009). Additional environmental review would be conducted on the proposed projects as they are carried forward.

Environmental barriers include potential impacts on natural resources such as water, habitat, and wildlife; cultural resources such as historic and archaeological resources; and social issues such as recreation and property acquisition. Policy and legal barriers include laws and regulations that may prevent or delay project implementation, some congressional and legislative authorizations that would need to be changed, and cultural issues or other public concerns. Cultural resources could be disturbed during construction of many of the projects. This may require additional mitigation, but would not necessarily pose a barrier to implementation. Mitigation strategies are proposed to address major environmental or policy barriers. Mitigation measures for specific environmental impacts would be developed as part of future environmental review.

Potential barriers for each of the seven plan elements are identified below, followed by the associated proposed mitigation strategies. For more information, see Volume 2 technical memorandum, *Environmental, Policy and Legal Barriers*.

Fish Passage Element

The fish passage element is not expected to present any environmental, policy, or legal barriers to implementation. Overall, the projects would benefit the environment. Most impacts associated with the facilities would be temporary during construction. Reclamation would operate the fish passage facilities to insure that existing Reclamation contracts are met and TWSA would not be affected. No mitigation strategies are proposed.

Structural or Operational Changes Element

Most environmental impacts associated with the Structural or Operational Changes Element would be related to temporary construction. Therefore, no environmental barriers are anticipated. Standard mitigation strategies would be employed to minimize construction impacts.

Raising the pool level at Cle Elum Reservoir would require significant property or easement acquisitions that could delay the project. Subordinating power at Roza Dam and Chandler Power Plant may require alternative power sources to replace the lost power and that agreements between Reclamation, Roza Irrigation District, and BPA be modified.

None of the other projects in this element are expected to create environmental or policy or legal barriers; therefore, no mitigation strategies are proposed.

New or Expanded Storage Element

Constructing a new Wymer Reservoir and its conveyance lines would cause impacts on shrub-steppe and greater sage-grouse habitat. Enlarging the existing Bumping Lake would impact bull

trout habitat, old-growth forest, habitat for the northern spotted owl, and existing recreational facilities.

The mitigation strategy for both the Wymer and Bumping Lake projects would involve acquiring, protecting, and restoring properties with similar habitat attributes as characterized in Section 3.1.5, as well as designing the project to minimize impacts to habitat for both the reservoir and conveyance lines. Additionally, the mitigation strategy for the Wymer project should include protection or restoration of areas to improve sage-grouse migration through the area. A similar strategy of property acquisition and restoration could be used for mitigating impacts to old-growth forest and spotted owl habitat from Bumping Lake enlargement.

The proposed Bumping Lake enlargement would inundate bull trout spawning habitat in Deep Creek, and the additional drawdown of Kachess Reservoir could affect bull trout access to tributary streams. Other projects included in the Integrated Plan would benefit bull trout, including the fish passage and habitat protection and enhancement elements. Mitigation strategies for bull trout would need to be explored, including a feasibility study of reintroduction or supplementation, but no specific strategies have been identified at this time.

Potential impacts to historic and cultural resources could be reduced by conducting appropriate surveys prior to construction. If the project would impact cultural resources, appropriate mitigation strategies would be developed in consultation with the Washington State Department of Archaeology and Historic Preservation and the Yakama Nation.

Existing recreational facilities at Bumping Lake would be inundated by the enlarged reservoir. Replacing those facilities would require coordination with the USDA Forest Service. No specific options have been identified at this time.

The proposed mitigation strategies may alleviate some public and agency concerns about the water storage projects. However, it is anticipated that public opposition would continue to be a barrier to constructing new storage projects.

Groundwater Storage Element

The groundwater storage element is not expected to cause adverse environmental impacts that would be considered environmental barriers. Both the shallow aquifer recharge and aquifer storage and recovery actions (targeting deeper basalt aquifers) are relatively new concepts that may encounter delays in permitting. Close coordination with the regulatory agencies would be required as the pilot studies are developed to ensure that state water quality standards and other requirements are met.

Habitat Protection and Enhancement Element

The proposed habitat protection and enhancement projects would benefit fish and wildlife throughout the Yakima River Basin and only cause temporary construction impacts for habitat restoration efforts. The large land acquisitions will require the cooperation of sellers; should a seller not be willing to enter a transaction, alternative lands may be identified and acquired. Acquisitions may also require that the holder of title or interest be capable of managing that land or interest under terms to be determined. Impacts to the local economy, such as loss of tax revenue or specific types of recreational opportunities should be identified and mitigated. For the land protection projects, impacts may be primarily in loss of certain recreational activities. To a great extent, these can be mitigated or avoided through structuring of the protection.

In addition to the large tracts of acquisition and protections, site-specific restoration projects may also require property acquisition, which could delay the projects. Because the restoration projects

are not expected to cause environmental barriers, no mitigation strategies are proposed. Best management practices would be employed and permit requirements would be met to minimize construction impacts. Overall, the habitat protection and enhancement projects would serve as mitigation for past environmental damage, and also help meet ecological restoration goals. Education and outreach efforts can help in identifying and developing solutions regarding landowner concerns about property acquisition and flood potential.

Enhanced Water Conservation Element

No environmental barriers are anticipated for this element. Neither agricultural nor municipal conservation would generate environmental impacts that would be barriers to implementation. Implementing municipal water conservation would require coordination among agencies and cooperation of water users that could present a policy barrier, but the coordinated, incentive-based program is intended to overcome that potential barrier. Because no environmental barriers are anticipated, no mitigation strategies are proposed.

Market-based Reallocation of Water Resources Element

This element would not generate environmental impacts that would be considered barriers to implementation. The proposal is intended to overcome existing policy and legal barriers to water transfers, and therefore is not expected to present policy or legal barriers. The legislative recommendations also include proposals to mitigate for third-party impacts. Therefore, no barriers to implementation are anticipated and no additional mitigation measures are proposed.

5.2 Instream Flow Management Framework

This section contains a framework for managing instream flows within the Yakima River Basin based on the Integrated Plan actions. For many years, flow management has focused on protecting spring Chinook salmon redds in the upper watershed and on spring flows in the Yakima River from Parker gage downstream to the river mouth. While each of these is important, the Integrated Plan seeks to improve other aspects of flow management as well. Broad flow management approaches are described for the lower and upper Yakima River, for winter and spring flows, and for tributaries. The framework described below would be further developed and refined during plan implementation.

Lower Yakima River

Despite the water supply facilities identified in the Integrated Plan, the fisheries managers (Federal and State Fish and Wildlife Agencies and the Yakama Nation) recognize that flow volumes during the spring of the driest years would be largely unchanged from present conditions. However, it is expected that aquifer recharge efforts would improve water quality, particularly summer water temperatures in downstream reaches. Flow targets for the lower river would be met as required in Title XII, based on TWSA (Reclamation 2002). The Title XII target flows established through YRBWEP for instream purposes range from 300 cfs to 600 cfs, depending on the estimate of TWSA. In addition, flow pulses would be provided as recommended by the System Operations Advisory Committee (SOAC). SOAC is an advisory board to Reclamation consisting of fishery biologists representing the U.S. Fish and Wildlife Service (FWS), the Yakama Nation, WDFW, and irrigation entities represented by the Yakima Basin Joint Board. SOAC provides information, advice, and assistance to Reclamation on fish-related issues associated with the operations of the Yakima Project (SOAC 1999).

The hydrologic modeling performed for the Integrated Plan shows that an additional 15,000 acre-foot block of water can be provided for flow pulses during drought years. That water is provided

in addition to the water needed to meet a 70 percent water supply for proratable water users and the volume required by Title XII. According to the recommendations of the SOAC, such flow increases may either be pulsed, episodic (for a subset of the irrigation season), or static (as Title XII flows are presently managed) (SOAC 1999).

In wetter years, the modeling indicated that stored water can be used to shape the river hydrograph, but specific modeling scenarios were not developed or analyzed to determine how this might occur. Reservoir releases in the future could be used to improve understanding of the relationship between flow releases and smolt outmigration survival rates. As shown in the modeling results in Section 4.4 and presented to the Workgroup, there would be times when unregulated discharge during the smolt migration is reduced, relative to present conditions, to fill new reservoirs. It would be important as part of any future effort to establish minimum river flows that would constrain reservoir refill operations.

Upper Yakima River High-Summer Flows

The proposed Wymer Reservoir and a larger Bumping Lake would provide additional operational flexibility by storing water in a network of more broadly distributed locations in the upper and middle parts of the Yakima Basin. Reclamation, consulting with the SOAC, would be able to control unnatural high flows in the Cle Elum, upper Yakima, and Tieton rivers, to the extent possible, without reducing proratable water supplies below 70 percent during drought conditions. The Keechelus to Kachess pipeline would also enable substantial reductions to the unnaturally high August flow regime below Keechelus Dam.

Winter Flows

Winter flows would be provided below the storage reservoirs as presently recommended (incubation flows for spring Chinook salmon would be maintained at or above spawning flows) or adjusted based upon new information that would suggest an adjusted operating regime. If providing higher flows during drought conditions would reduce proratable water supply below 70 percent of entitlements; then, winter flows may be reduced in consultation with the SOAC.

Spring Flows

When water is available, Reclamation, in consultation with SOAC, may provide pulse flows to encourage emigration of smolts out of heavily regulated reaches below the reservoirs. Yakima Basin fisheries managers have identified providing the required high spring migration flows in the reach below Roza Dam as a high priority.

Tributary Flows

While the Integrated Plan actions would provide limited opportunity to improve tributary flows, project facilities would be used where possible to deliver water directly to tributary water users and eliminate tributary diversions or to deliver water to tributaries to improve flows. The tributaries that would be improved, along with flow objectives are identified in Table 4-3.

5.3 Periodic Reviews and Adjustments

Review Process

It is recommended that Reclamation and Ecology, in cooperation with the Workgroup Implementing Subcommittee, jointly review and summarize progress on implementing the Integrated Plan annually through 2015, and at least every 5 years thereafter, until the plan is deemed fully implemented. Also, prior to 2015, an adaptive management plan should be

developed to further refine metrics or plan performance measures, triggers, and adaptive management measures for potential plan adjustments through time. The Integrated Plan review should include the following:

- Status of securing funding for implementation.
- Progress in setting up programmatic elements (e.g., market reallocation, water conservation, habitat restoration, and floodplain restoration).
- Progress in constructing identified infrastructure improvements.
- Assessment of outcomes for water supply and fish production, compared with the goals and applicable metrics.
- Effectiveness of revised Yakima Project operating rules[13] based on identified goals for meeting instream and out-of-stream needs.
- Significant changes, if any, in the underlying drivers for the Integrated Plan such as listing status of aquatic species; major shifts in cropping patterns or irrigation practices; and changes in the basin's population and economy, climate, snowpack, hydrology, and water needs.
- If plan adjustments are necessary, provide clear explanation of the basis and rationale for the recommended adjustments.

The review findings would be submitted to the Workgroup or its successor organizations. If the Workgroup no longer exists, then the review would be submitted to each of the local, state, federal and tribal agencies and environmental organizations that were represented on the Workgroup in 2011.

Future Adjustments to the Integrated Plan

The following principles should be applied if the review described above indicates a need for significant changes to the Integrated Plan:

- Every effort should be made to advance both water supply improvements and fisheries enhancements, consistent with the balanced nature of the Integrated Plan.
- If particular actions encounter insurmountable obstacles to implementation or are found unable to deliver the expected benefits, substitutes for those actions should be developed to achieve comparable outcomes.
- The agencies and organizations represented on the Workgroup would continue to work in good faith throughout the implementation period to secure resources as soon as possible to implement all of the Integrated Plan actions or to identify reasonable substitutes if one or more of the recommended actions cannot be implemented. This collaborative effort would continue until the entire plan has been implemented or further implementation is deemed infeasible based on the review process described above.

[13] Yakima Project operating rules should be revised as projects are implemented to meet instream and out-of-stream needs identified in the Integrated Plan.

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6.0 Next Steps

In March 2011, after 21 months of meetings, modeling, and studies, the Workgroup unanimously approved the Integrated Plan summary document, establishing the elements and actions to include in the Integrated Plan. Reclamation and Ecology plan to further evaluate the proposal, and are proceeding with the next step in the evaluation process.

The next step is to prepare a PR/EIS. This study will be conducted at a feasibility level, and is authorized by the existing Yakima River Basin Water Enhancement Project (P.L. 96-162, December 28, 1979). Feasibility studies differ from appraisal level studies in that they include additional data collection and analyses in developing and considering a full and reasonable range of alternatives (Reclamation 2000).

The NEPA and SEPA review processes are integrated and would be performed at a programmatic level. A programmatic review typically is focused on a group of actions, and provides a foundation for more project-specific environmental review that would follow during plan implementation. Both processes require analysis of new actions; evaluation of reasonable alternatives to a proposal and a "No Action" alternative; and evaluation of potential direct, indirect, permanent, temporary, secondary and cumulative impacts associated with each alternative and appropriate mitigation, land conservation, and adaptive management measures. Early efforts have been conducted to identify suitable mitigation for Integrated Plan actions that would have adverse impacts to the natural environment, such as Wymer Reservoir and Bumping Lake enlargement. After specific projects are authorized, additional, project-level NEPA/SEPA reviews would be developed.

The planning report would conform to the Federal Principles and Guidelines for Evaluating Water Resource Projects (U.S. Water Resources Council 1983). 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 a "four account" effects analysis 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 decision-making 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.

The planning report would also include further refinement of technical analyses. Some of the actions needing additional refinement and detail include power subordination, market reallocation, and aquifer recharge. For some actions, such as Kachess Inactive Storage, the preferred water withdrawal approach, tunnel or pump station needs to be determined. The report would also include action-specific cost allocation and repayment analysis.

Other typical elements of a planning report and programmatic EIS include describing the plan purpose and authority, and the need for the action; plan formulation (planning process overview); summary of public involvement efforts, comments received, and responses; and findings and conclusions. Substantial information and environmental analysis are contained in the previous studies described in Section 1.4. Those documents would be supplemented with the additional information and analyses generated in developing the Integrated Plan, and through preparing the planning report and programmatic EIS.

These efforts are expected to take approximately 18 to 24 months. Reclamation and Ecology anticipate a continued partnership and will each contribute funding to this effort.

The planning report and programmatic EIS draft work products will be shared with the Workgroup and its Implementing Subcommittee. The Workgroup will meet periodically during 2011 and 2012 to receive updates on the Federal and State administrative review process.

The planning process is flexible in addressing changes and conditions over time. The programmatic EIS can be supplemented periodically to reflect changing conditions. In addition, project-level environmental review would be conducted as individual projects move toward implementation.

Until facilities are sufficient to meet the 70 percent target in drought years, modifications to Yakima Project operations would continue to be proposed as elements undergo project-level environmental review, design and permitting. The programmatic EIS would also evaluate operational alternatives associated with implementation of the entire Integrated Plan.

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Glossary

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.
adjudication	The judicial process through which the existence of a water right is confirmed by court decree.
anadromous	Fish that migrate from saltwater to freshwater to breed. Going up rivers to spawn.
aquifer	A water-bearing stratum of permeable rock, sand, or gravel.
aquifer storage and recovery (ASR)	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.
Basin Study	Yakima River Basin Study
carryover storage	The water remaining in storage after the irrigation season at Keechelus, Kachess, Cle Elum, Bumping, and Rimrock Lake reservoirs.
cfs	Flow rate in cubic feet per second.
Comprehensive Conservation Plans	Plans that identify actions to improve the efficiency of water delivery and use within an irrigation district. Conserved water is targeted at improving stream flows for fish and wildlife, and for improving water supply reliability for irrigation.
consumptive use	The portion of water that evaporates, is used in products or crops, or consumed by humans or livestock.
domestic mitigation	Water used to offset impacts to surface water from domestic wells using groundwater in hydraulic continuity with surface water.
drought	A condition of water-supply scarcity that requires the Yakima Project to reduce deliveries to proratable (junior) water users below their full entitlements.
dry year	A year in which drought occurs, requiring the Yakima Project to limit deliveries to proratable (junior) water users below their full entitlements.
economic benefits	An economics term measuring an increase in economic welfare (e.g., the value of goods and services available to consumers, and

	profit for producers). Gross economic benefits measure the total increase in economic welfare, without consideration of the costs incurred to achieve them. Net economic benefits account for the costs.
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.
Endangered Species Act	16 U.S.C. §1531 et seq. (1973). The Endangered Species Act (ESA) provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found.
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 decision-making process.
escapement	The act of adult salmon and steelhead successfully arriving at their spawning areas by avoiding harvest and predation.
evapo-transpiration (ET)	The sum of evaporation (the amount of water returned to the atmosphere directly from the soil surface or standing water) and plant transpiration (the amount of water used by plants before being returned to the atmosphere).
exempt well	Groundwater withdrawals that are exempt from the water right permitting process through the Washington State Department of Ecology. Specific exemptions include withdrawal of groundwater for stock watering, irrigation of a lawn or non-commercial garden not exceeding one-half acre in size, single or group domestic purposes in amounts less than 5000 gallons per day, or industrial purposes in an amount less than 5000 gallons per day.
Feasibility Investigation Reports (feasibility study)	Detailed investigation specifically authorized by the U.S. Congress to determine the desirability of seeking congressional authorization for implementation of a preferred alternative.
fish passage	Providing facilities or management approaches at existing dams to achieve up and downstream passage of targeted fish species.

flip-flop	The annual late summer river operation where water is released from Cle Elum Lake as the primary water source for lower valley irrigation and water is stored in Rimrock Lake during the irrigation season. In the fall Reclamation shifts operations by significantly reducing flows out of Cle Elum Lake and increasing flows out of Rimrock Lake in the Naches River basin. This regime was devised in response to a court order to protect spring Chinook salmon redds in the upper Yakima and Cle Elum rivers.
flow	The volume of water passing a given point per unit of time. Often measured in cubic feet per second (cfs).
flow objectives	The desired monthly stream flow used to guide RiverWare model operation criteria. Also used to evaluate alternative performance in terms of how closely they meet the desired monthly stream flow.
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).
full-supply years	Years where all water users are able to receive their full entitlement of water supply.
groundwater infiltration	A hydrologic process where surface water is diverted and conveyed to a designed recharge system (ponds, canals, or spreading areas), where water moves downward from to the ground surface into the groundwater.
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.
harvest	Ocean and in-river harvest (commercial, sport and tribal) of fish.
instream flows	Water flows within a defined stream channel. Instream flows may support aquatic habitat, wildlife, recreation, or aesthetics.
mainstem	The principal channels (Yakima and Naches rivers) within the Yakima River Basin, into which all of the tributary streams in the drainage basin flow.
market reallocation	Voluntary transfer of water rights from willing sellers to willing buyers, on a temporary or permanent basis.
million acre-feet (maf)	A measure of water volume equal to one million acre-feet.

mitigation	To offset known impacts to an existing natural resource.
municipal mitigation	New water supply used to offset impacts to surface water from groundwater usage in hydraulic continuity with surface water.
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.
National Environmental Policy Act (NEPA)	A federal law that requires federal government agencies to consider the effects of their actions on environmental resources and the public and to seek public comment on those actions. 1969 as amended (Pub. L. 91-190, 42 U.S.C. 4321-4347, January 1, 1970, as amended by Pub. L. 94-52, July 3, 1975, Pub. L. 94-83, August 9, 1975, and Pub. L. 97-258, § 4(b), Sept. 13, 1982)
nonproratable water rights	Pre-Yakima Project senior water rights that are served first and cannot be reduced until all the proratable rights are regulated to zero. Defined in a 1945 Consent Decree.
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.
Parker Gage	A flow-measurement device on the Yakima River where the total water supply available (TWSA) is measured for the Yakima Project for the period April through September. The Parker gage is located just south of the City of Union Gap on the Yakima River.
Principles and Guidelines	A federal document that describes Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies.

proratable (entitlement/water rights)	Yakima Project junior water rights related to storage water that, in water-short years, receive less than their full right on a prorated basis. For the Yakima Basin, over half of the surface water entitlements are proratable under a 1945 Consent Decree, including all of the surface water supply for Roza Irrigation District and Kittitas Reclamation District, over half of the Yakama Nation's Wapato Irrigation Project, a large share of the Sunnyside Division, and many other irrigation water right holders.
prorationing	The process of equally reducing the amount of water delivered to junior (i.e., "proratable") water right holders in dry years.
pulse	Short-duration release from reservoir(s) to encourage smolt outmigration. Includes a flow ramp-up, peak flow for a few days, and flow ramp down.
recruitment	Ocean population at the mouth of the Columbia River, excluding any ocean harvest.
redd	The nest that a spawning female salmon digs in gravel to deposit her eggs.
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.
re-regulating reservoirs	A reservoir that captures water from a canal system that would otherwise be released from the system due to daily fluctuations in water demands.
riparian	Relating to, living in, or located on a stream or other watercourse.
RiverWare hydrologic model	Yakima Project RiverWare model; a daily time-step reservoir and river operation computer model of the Yakima Project created with the RiverWare software.

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.
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).
smolt outmigration	Refers to the period when smolt leave the Yakima River Basin and travel to the ocean.
spawner	Adult salmon that has left the ocean and entered a river to spawn.
State Environmental Policy Act (SEPA)	A state policy that requires state and local agencies to consider the likely environmental consequences of a proposal before approving or denying the proposal and provides for public comment (Chapter 43.21C RCW).
Storage Study	Yakima River Basin Water Storage Feasibility Study; a multiyear evaluation completed in 2009 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.
power subordination	Use of water for power production would become secondary during certain times to increase instream flows to improve habitat conditions for anadromous fish.
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.
Title XII target flows (target flows)	Specific instream target flows established for Yakima Project operations at Sunnyside and Prosser Diversion Dams in the Yakima Basin, and quantified in Title XII of the Act of October 31, 1994 (Public Law 103–464).
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.

U.S. Department of the Interior's WaterSMART Program	(Sustain and Manage America's Resources for Tomorrow). Reclamation Program, which is authorized by Section 2 of Reorganization Plan No. 3 of 1950 (64 Stat. 1262), as amended; the SECURE Water Act (P.L. 111-11, Subtitle F, Sections 9501 – 9510); and Executive Order 13514 on Federal Leadership in Environmental, Energy and Economic Performance. This program is working to achieve a sustainable water strategy to meet the Nation's water needs.
water bank	An institution designed 1) to accept deposit of a water use entitlement, which will not be used by the water right owner during the time it is in the bank, and 2) to make the entitlement available for withdrawal by the water right owner/depositor or someone else.
water market	An institutional process used to support voluntary transfers of water rights from a willing seller to a willing buyer, either temporarily or permanently.
water-short years	Years where the water available is not sufficient to meet the demands of all water users.
water transfers	Temporary or permanent water right exchanges between two parties.
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.
wetland	Generally, an area characterized by periodic inundation or saturation, hydric soils, and vegetation adapted for life in saturated soil conditions.
wilderness	"A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and community of life are untrammeled by man, where man himself is a visitor who does not remain… an area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation, which is protected and managed so as to preserve its natural conditions" The Wilderness Act of 1964 (Public Law 88-577).

wild and scenic	The National Wild and Scenic Rivers System was created by Congress in 1968 (Public Law 90-542; 16 U.S.C. 1271 et seq.) to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations.
Yakima Project	A federal land-reclamation project that provides irrigation water for a 175-mile strip of fertile land on both sides of the Yakima River in south-central Washington. There are seven divisions in the project: Storage, Kittitas, Tieton, Sunnyside, Roza, Kennewick, and Wapato. Storage dams and reservoirs on the project are Bumping Lake, Clear Lake, Tieton, Cle Elum, Kachess, and Keechelus. Other project features are 5 diversion dams, canals, laterals, pumping plants, drains, 2 powerplants, and transmission lines.