CHAPTER 3: COLUMBIA RIVER BASELINE ASSESSMENT

3.1 Introduction

This Chapter describes the physical and institutional aspects of the Columbia River system. It provides baseline data necessary to address water allocation and protection of instream flows as part of a sustainable water management program in the Columbia Basin from the Washington-Canada border to Bonneville Dam.

Much of the relevant water resources information about the Columbia River is compiled and reported at different physical and socio-political scales (e.g., by state, County, WRIA, tributary, river reach, service area, irrigation district, and other). This report attempts to compile and present information at a common scale, where water use and availability is comparable and consistent. A County scale was selected as the most common management unit for available water-related data. Much of the available information is presented by County, and in some cases, can be presented for the one-mile zone around the Columbia River (by County). The one-mile zone around the Columbia River is called the Management Zone in this report. WRIA reaches that divide the Management Zone by WRIA boundaries are a secondary management unit. Pool reaches (the reach of the river between two dams) are a third management unit. Figure 3-1 shows how these management units overlie each other.

Although the legislation authorizes a "one-mile" Management Zone, this baseline assessment addresses water resources within all the watersheds that contribute flow to the Columbia in Washington State. Activities that occur in tributary watersheds will influence flows in the Columbia River, some more directly and with less of a time lag, than others.

3.1.1 Columbia River

The Columbia River drains 219,000 square miles in seven western states (including parts of Montana, Idaho, Washington, Oregon, Wyoming, Utah and Nevada) and 39,500 square miles in British Columbia, Canada (Volkman, 1997). The Columbia River originates on the west slope of British Columbia's Rocky Mountains and flows 1,214 miles to the Pacific Ocean. The basin covers approximately 67% (47,878 square miles) of Washington. Slightly less than 750 miles of the 1,214 mile length of the Columbia River flow through the state with about 600 miles in the study area. The major tributaries in the United States are the Kootenai, the Flathead/Pend Oreille, the Snake, and the Willamette Rivers. Many more large rivers to small streams flow into the Columbia River on its way to the Pacific Ocean.

The Columbia River and its tributaries are the predominant river system in the Pacific Northwest and the fourth largest in the United States with respect to discharge. The mean annual flow of the Columbia River at the mouth (measured at The Dalles) is approximately 190,000 cubic feet per second (cfs), of which, approximately 40% originates in Canada. During a low water year, the Columbia River's annual discharge at The Dalles is about 120,000 cubic feet per second (cfs) and rises to 260,000 cfs in a high water year (Ecology, 2006a). The river flow nearly doubles between the international boundary and The Dalles, mainly due to the inflow of the Snake River, which is the largest of the Columbia River tributaries, comprising approximately 44% of the total mean annual flow of the Columbia River. Oregon tributaries (the Willamette and Deschutes Rivers) also contribute a significant amount of discharge to the Columbia.

Estimates of average and minimum annual water supply from the Columbia River at Priest Rapids and Bonneville Dams, based on BPA's Hyd-Sim model are:

- Priest Rapids: Average annual volume of 86,100,000 AF. Annual minimum volume of 60,467,000 AF.
- Bonneville Dam: Average annual volume of 135,355,000 AF. Annual minimum volume of 90,518,000 AF.

Using the mainstem Columbia River at Priest Rapids volumes listed above, an out-of-stream current use estimate of 3,500,000 AF (which excludes the Yakima Basin), and available flow volume estimates from BPA's Hyd-Sim model of 20,938,000 AF average and 938,000 AF minimum which account for BiOp flow objectives (Reclamation, 2006d), the following supply and demand comparisons can be made:

- Current out-of-stream demands use about 4% to 6% of the Columbia River supply.
- Instream demands (as represented by BiOp flows) use between 76% (average) and 98% (dry) of the Columbia River supply.

These comparisons do not account for the variability in supply and demand throughout the year.

3.1.2 Columbia River Tributaries

There are 30 major tributaries to the Columbia River with mean annual flows of greater than 400 acre-feet (AF) per day. Figure 3-2 shows some of the major tributaries and their mean annual flows. Table 3-1 summarizes the 30 major tributaries by river mile, including contributing drainage area and mean annual discharge. Drainage areas and mean annual flows were obtained from USGS gages on the corresponding tributaries nearest to the mouth.

The Pend Oreille and Spokane Rivers provide the largest annual tributary contributions to flow on the Columbia in the upper reach between Canada and Grand Coulee Dam. These two tributaries provide over 30,000 cfs of flow to the Columbia on a mean annual basis.

Tributaries to the Columbia River between the Okanogan River and the Snake River contribute a total of approximately 14,000 cfs. The Okanogan, Wenatchee, and Yakima Rivers combine to contribute about 60% of the inflow in this segment of the Columbia. The Snake River is the Columbia's largest tributary, and provides approximately 54,000 cfs. Below the Snake River downstream to Bonneville Dam (lower reach) mean annual tributary inflow totals approximately 14,000 cfs of which 63% of the flow is generated in Oregon. The Columbia River's discharge increases at a fairly steady rate of 2,000 – 3,000 cfs between dam pools in the reach from Bridgeport (below the Grand Coulee Dam) to Priest Rapids.

3.2 Physical Factors Affecting the Columbia River

Annual and seasonal flows in the Columbia River are shaped by many factors. This section presents a general overview of six important factors: climate, reservoirs and hydropower, navigation, land cover and land use, agriculture, and population.

3.2.1 Climate

The precipitation that falls in the Columbia River Basin generates runoff that, in turn, becomes streamflow in the Columbia River. Most precipitation occurs in the winter with the largest share falling in the mountains as snow. The moisture that is stored in the snowpack is released in the spring and early summer, providing about 60 percent of the natural runoff to the Columbia River during May, June, and July (Ecology and WDFW, 2004; USGS, 2002). The Columbia River drains from a snowmelt dominated watershed. Such a basin typically exhibits two runoff peaks, a smaller one occurring in late autumn in response to increased precipitation as rain (not evident in some arid regions), followed by a trough as rain changes to snow, and then another larger peak occurring in late spring and early summer due to melting of mountain snowpack.

The summer months, from approximately June through August, are often critical because precipitation is low and streamflow is naturally decreasing due to diminishing snowpack. Water temperatures also increase during the summer due to increasing air temperatures and lower flows. It is during these critical months, in part, that instream flow rules are designated so that the river may accommodate its competing uses.

Research of the impacts of climate change on water resources in the Pacific Northwest indicates that predictions of increased temperature and precipitation over the next 50 years may result in reduced snow packs, earlier snowmelt, increased flood potential, and lower summer flows.

Climate change is becoming an increasingly important component of water demand and supply forecasting. While the topic is subject to debate, a number of scientific assessments have concluded that the Earth's average temperature will likely increase during the twenty-first century (Hamlet et al., 2001). Climate models used in these assessments predict that both temperature and precipitation will significantly increase in the Pacific Northwest over the next 50 years. The potential consequences to water resources in the Pacific Northwest associated with warmer temperatures, greater precipitation, and a shift in winter precipitation type from snow to rain include reduced snow packs, higher winter streamflows and accompanying increased flood potential, earlier snowmelt-generated peak flows, and lower summer flows (Hamlet et al., 2001). During the last 100 years, the sub-basins of Washington have seen the median of the seasonal runoff shift earlier in time by 1 to 16 days and a 3% to 25% shift of spring-summer seasonal flows to the autumn-winter season (Dittmer, 2005). Similarly, rivers fed by glacial melt waters may be adversely affected by climate change. Pronounced reductions in the area covered by glaciers can result in significant reductions in the amount of water released to downstream rivers (Environment Canada, 2000; Ecology, 2006b).

3.2.2 Reservoirs and Hydropower

The construction and operation of the Columbia River dam and reservoir system has significantly affected the hydrograph of the Columbia River. Fifty-five major dams have been constructed by federal agencies, PUD's, and British Columbia agencies on the Columbia River and its tributaries. Hundreds of smaller impoundments have also been developed. Hydropower projects on the Columbia River mainstem and other storage developments in its tributaries within the entire basin have a total active storage capacity in excess of 46 million acre-feet; one-third of the mean annual flow of the Columbia River at The Dalles, Oregon (Ecology and WDFW, 2004). Figure 3-3 shows the locations of the major hydropower dams in the Columbia River Basin.

Although most of the River's development has been in the United States, there are three dams on the Columbia River in Canada. They were built as part of the Columbia River Treaty, initially signed in 1961 and ratified in 1964. As a result of this treaty, the Duncan Dam (maximum storage 1.38 MAF), the Hugh Keenleyside Dam (maximum storage 7.1 MAF), and the Mica Dam (maximum storage 12 MAF) were constructed. Combined, these reservoirs hold approximately 20.5 MAF of storage, primarily for hydropower and flood control uses.

The seasonality in streamflow on the Columbia River has been "flattened" to some degree as a result of reservoir storage. The original high spring/summer flows have decreased and the low autumn/winter flows have increased. However, the Columbia River still has very large seasonal and annual variations in streamflow. Figure 3-4 illustrates average monthly Columbia River flows in an average (2003) and dry water year (2001) at three locations: downstream of Priest Rapids Dam, downstream of McNary Dam, and downstream of Bonneville Dam.

The Columbia River is highly managed for hydropower generation. The Bureau of Reclamation has developed a model (MMS System) to simulate the Federal Columbia River Power System (FCRPS) which is widely accepted as accurately simulating current operation of the Columbia River system. The power industry uses the "Hyd-Sim" model to understand flow availability in the system and to balance power supply reliability with adequate resource protection (Reclamation, 2006d). Hyd-Sim uses the current FCRPS system operating requirements for each project and historic hydrologic flow conditions. It contains a data set of runoff to determine impacts to various resources and obligations (such as irrigation, flood control, power, instream flow, other contract obligations, project authorizations, and biological opinions). The hydrologic data used to determine "normal" and "dry" years and to evaluating operating scenarios is relatively old (Reclamation, 2006d).

The Bureau of Reclamation has recently used output data from BPA's Hyd-Sim for the FCRPS to determine the quantity of water available for diversion for the CBP. This work included an estimate of the volume of water available in the system in excess of biological flow objectives (Reclamation, 2006d). Although the analysis considers BiOp flow objectives, it did not incorporate other potential demands on flow (Reclamation, 2006d). The BPA model simulates coordinated system reservoir operation on a monthly basis given a reservoir operating capacity. Hyd-Sim is an effective tool for analyzing the reservoir system operation under a range of project inflows and a given operating policy.

Resource adequacy is an important aspect of energy management, and is undergoing current analysis throughout the country. The Energy Policy Act of 2005 may result in mandatory implementation of resource adequacy standards established at the regional level through the North American Electric Reliability Council (NERC). The Pacific Northwest Resource Adequacy Forum (PNRAF, 2005) initiated discussions in June 2005 on this issue, with the intent of developing resource adequacy metrics and targets appropriate for the northwest. Hydropower operations are a key component of the analysis. Issues such as out-of-region surplus electrical capacity and the "critical water" standard for the hydropower system are key aspects of setting resource adequacy targets. While no final recommendations have been made by PNRAF, it is possible that hydropower management objectives and preferences could change in the future.

Managing the river for hydropower generation is different than managing the system for water allocation. However, these tools will only be useful for other management purposes (e.g., water supply and allocation) if reliability concepts used in hydropower management can be integrated into an assessment of consumptive water supply reliability. This will require a collaborative effort between hydropower interests, Ecology, and other stakeholders.

3.2.3 Navigation

Navigation needs on the Columbia and Snake Rivers are met by natural streamflow and normal operating procedures of reservoir releases and minimum reservoir depths (FCRPS, 2001). The Columbia and Snake Rivers are separated into two segments.

1. The first segment, from the Pacific Ocean to Vancouver, Washington, only requires the natural streamflow and periodic dredging to satisfy navigation requirements (FCRPS, 2001).
2. The navigation needs of the second segment, from Vancouver, Washington to Lewiston, Idaho, are met by the Corps' reservoir operating procedures that incorporate the navigation requirements in establishing maximum and minimum reservoir levels (FCRPS, 2001).

3.2.4 Land Cover and Land Use

The Columbia Basin covers approximately 67% of Washington State and exhibits a wide range of land cover classification types. Figure 3-5 shows the various types of land cover as classified by the USGS using 1992 satellite imagery. Individual acreages associated with each land cover type are summarized in Table 3-2, by County. Appendix B has a table with the acreages by WRIA. Approximately 26% of the total land area in the Columbia Basin (excluding water, barren lands, natural vegetation, and wetlands) has been modified from natural conditions in some way, and is either agriculture, residential, urban, or commercial-industrial. Most (95%) of this modified land is classified as either irrigated or non-irrigated agriculture, with the remaining 5% classified as residential, urban and commercial industrial. All of these land classification types have associated water use, including forested lands, wetlands, and other "natural" land covers. The degree to which these lands are managed in relation to water resources varies, but water supply in the Columbia River is linked to various levels of land use management that occur in the basin.

Land use differs from land cover in that it is linked to County planning and zoning. Land use represents what the land could be used for, not what is currently occurring on the land. Table 3-3 summarizes land use data for counties in the Management Zone. The data were extracted from a parcel database by Ecology, and grouped into residential, agricultural, undeveloped, and other uses for each County (Ecology, pers. comm., 2006d). Information was not available for Ferry, Skamania, or Walla Walla Counties within the Management Zone. The parcel database indicates that, within the Management Zone, the primary land use type is residential. Agriculture land-use types are the smallest within the Management Zone.

3.2.5 Agriculture

Agriculture has historically been the primary economic driver in the Columbia Basin, and continues to play a significant role in the economy of Washington State. Agriculture accounts for one-fifth of the state's annual gross product (Trade Development Alliance of Greater Seattle, 2006). The Columbia River Basin's water is used to irrigate over 65 million acres or 37% of the total cropland in the basin. Agriculture accounts for over 93% of the daily water used in the basin. Farmers grow potatoes, sugar beets, hops, fruit, vegetables, mint, wine grapes, hay, grain and more. Agriculture and related services account for roughly 10% of the basin's employment (National Research Council, 2004).

3.2.6 Population

Population continues to increase throughout Washington, including areas "east of the mountains" within the Columbia Basin. The Washington State Office of Financial Management (OFM) population estimate for 2006 based on data from Census 2000 indicates a total population of 1.4 million people for Counties in the Columbia Basin (Table 3-4 and Figure 3-6), representing 22% of the population in Washington State (OFM, 2006). The OFM estimated annual growth rate between 2000 and 2006 is also presented. An average growth rate of 1.83% is estimated. If this growth were to be sustained, population would increase to 1.9 million in 20 years, and would double in about 50 years. In some Counties, such as Benton, Franklin, Grant, Kittitas, Adams, Chelan, Douglas, Stevens, and Yakima, growth is occurring more rapidly than the basin-wide average, and population could double in about 30 years if those growth rates were sustained.

The OFM predicts that the predominantly rural nature of Eastern Washington is not expected to change as rural counties do not have the economic base to support or attract large numbers of people. However, tourists, retirees, and recreationists are increasingly drawn to Eastern Washington, and economies associated with this population continue to thrive.

3.3 State Institutional Factors Affecting the Columbia River

Many state laws and programs influence the ability to use water in the Columbia River and its tributaries. In recent years, Washington State has enacted and implemented new laws and programs addressing a range of water resource-related issues, such as water resource planning, conservancy boards, trust water rights, instream flows, metering, and reclaimed water. Many of these laws and programs directly or indirectly affect the management of the Columbia Basin as authorized under ESSHB 2860.

Key state laws regarding the regulation of surface and ground water, water rights, water quality, well development, and minimum water flows are summarized in Table 3-5 and described below.

3.3.1 Water Rights and Instream Flow Rules

Water rights and instream flow rules are the most significant state-managed institutional factors affecting water supply. Water rights are a legal entitlement to beneficially use waters of the state. Beneficial use under a water right from the Columbia River or one of its tributaries may be consumptive (e.g. evapotranspiration) or may return water to the river (e.g. return flows). Water rights to ground water that would otherwise discharge to the Columbia River also represent a potentially irretrievable source of water to the river. Water rights are discussed in detail in Chapter 4.

Instream flow rules are considered a water right for the stream, with a priority date of the effective date of the rule. Therefore, any permits issued by Ecology subsequent to the adoption of an instream flow rule must be conditioned to protect the minimum flows. Water rights granted subsequent to an instream flow rule are considered “interruptible” during periods when the stream is not meeting the instream flow levels specified in the rule. Setting an instream flow does not “guarantee” that the flows set by rule will be met every year, even if interruptible rights are curtailed. In relation to the Columbia River and its tributaries, instream flow rules provide a means for Ecology to require reductions in water use during periods of low streamflow. However, there is no guarantee that reductions in use will result in reaching a flow target. Flow targets are also set in the federal Biological Opinion (BiOp). See Section 4-2 for more detail on BiOp flow targets. A water right is not subject to interruption based upon BiOp flows, although such flows are considered when Ecology is considering issuing a new water right. Instream flow rules and flow targets are an important portion of the water management regime on the river and do have an effect on the amount of water in the river at a given place and time.

Prior to 1980, there were no instream flows set for the Columbia River. Ecology established minimum instream flows for the mainstem Columbia River in 1980 as part of its Instream Resources Protection Program (IRPP) (Table 3-6). Domestic and municipal rights were exempt from the rule. Ecology amended the rule in 1998 and provided that all water right applications filed after July 27, 1997 would be subject to evaluation for impacts on fish as well as existing water rights. The mainstem Snake River is currently under adjudication in Idaho and the instream flow rule (WAC 173-564) expired on July 1, 1999.

The Columbia River mainstem instream flow rule is subordinate to senior water rights and any water withdrawal at the request of the Bureau of Reclamation for the complete development of the Columbia Basin Project (RCW 90.40.030, RCW 90.40.100). The instream flow rights on the Columbia are also subordinate to any federal agency or tribal reserved water right established before 1980. Thus, this collection of various rights (existing pre-1980 rights, pre-1980 reserved water rights, and additional water withdrawn for the Columbia Basin Project) are essentially senior to the instream flow right.

Water rights issued subsequent to the 1980 rule (interruptible rights) can be curtailed in low flow conditions in order to maintain adequate flows for fish. Low flow conditions occur when the March 1 forecast for April through September runoff at The Dalles Dam is less than 60 million acre-feet. Therefore, users with interruptible water rights do not have guaranteed water in low flow years (Ecology, 2006b). One of the objectives of the Management Program as specified in ESSHB 2860 is to convert interruptible water rights to non-interruptible rights through mitigation using conserved water or storage water.

Washington State has adopted instream flow rules at nine locations along the mainstem Columbia River (Table 3-6). Figure 3-7 shows how discharge at Priest Rapids Dam, McNary Dam, and Bonneville Dam in 2001 and 2003 compares with the state instream flow rules:

- A year-round state instream flow rule exists at Priest Rapids, with a minimum instantaneous flow of 50,000 cfs, except during September and early October when flows must exceed 36,000 cfs. In water year 2001, which was a year of low discharge, state instream flows were not met in late October, in May, and in July. Instream flows were met throughout the average year of 2003.
- Year-round state instream flow rules at McNary Dam vary from 20,000 cfs in the winter to 70,000 cfs during the late spring. Columbia River discharge at McNary consistently meets the instream flow rules during both average and dry years.
- No state instream flow control point exists at Bonneville Dam.

Instream flows are also set for many of the major tributaries to the mainstem Columbia. Table 3-7 shows existing and proposed flow rules for the Colville, Okanogan, Foster, Methow, Entiat, Wenatchee, and Walla Walla Rivers. The flow requirements represent flows at the control point nearest the confluence with the Columbia. Some stream systems, such as the Methow and Wenatchee Rivers have multiple instream flow control points in the upper reaches of the tributary, or in smaller creeks or streams feeding the major tributary.

3.3.2 Watershed Planning (RCW 90.82)

The Watershed Planning Act (RCW 90.82) provides an opportunity for local entities to participate in watershed planning for each Water Resource Inventory Area (WRIA). Local watershed planning groups consist of representatives from County, city, tribal and state governments, as well as local stakeholders including developers, farmers, water purveyors, environmental groups, and local citizens.

Ecology is obligated, subject to various conditions and shared responsibilities, to implement programs proposed in approved watershed plans. This essentially provides local stakeholders a means to take an active part in water management in their watersheds. The Columbia River itself is not a WRIA, but the effects of watershed planning in its tributaries can affect flows in the Columbia River. Not all tributary basins to the Columbia River have undertaken watershed planning, and many that have are still in various stages of the process. Until all watershed plans are approved and implementation has begun, it is not clear how they will affect flows in the Columbia River. Table 3-8 and Figure 3-8 indicate the status of watershed planning in the Columbia Basin. Chapter 4 contains inventory information taken from available documents prepared by the WRIA Planning Units.

3.3.3 Other Ecology Rules and Programs

3.3.3.1 <u>Metering WAC 173-173</u>

Metering is a tool for water management and does not, in and of itself, affect flows in the Columbia River. However, better information on water withdrawals and return flows will support improved analysis in future water supply and demand forecasts. Water measuring also allows planners and water managers to better understand seasonal and annual variations in demand and can identify what causes variations in water use. Measuring can also provide a good understanding of the efficiency of water conveyance and on-farm water delivery systems.

The requirements for measuring and reporting water use are defined in Chapter 173-173 WAC. This rule "…seeks to ensure the reliable, accurate measurement of state water that is diverted, withdrawn, stored and used so that sound decisions may be made in administering state water laws and regulations" with the specific goals of quantifying available water, enforcing water right compliance, protecting instream resources and making informed decisions regarding state water management. This rule affects all surface water rights and any ground water rights where the withdrawal of water may affect surface water bodies with depressed or critical salmonid stock.

3.3.3.2 <u>Odessa Subarea (173-128A and 130A)</u>

The Odessa Ground Water Management Subarea (Odessa Subarea) (Figure 3-9) is an important agricultural region of the Columbia Basin that relies on irrigation water currently provided by ground water wells that are experiencing significant declines. As part of the Columbia Basin Water Management Program early actions, additional water stored in Lake Roosevelt is proposed to be delivered to the Odessa Subarea to replace some ground water withdrawals and decrease the rate of ground water decline. Flow in the Columbia River is therefore directly (through Roosevelt drawdown) and indirectly (through general agricultural importance) related to activities in the Odessa Subarea.

Ecology began permitting irrigation wells in the area in the 1960s and 1970s in anticipation of the completion of the Columbia Basin Project (CBP), though only a portion of the Odessa Subarea is within the CBP. Irrigators were advised that this source would not be permanent, but anticipated that the CBP would continue to be developed, eventually replacing ground water with surface water. Steady declines in ground water levels prompted Ecology to designate approximately 2,000 square miles under the eastern-most portion of the authorized CBP, east of the East Low Canal as a ground water management subarea in 1988 (Reclamation, 2006b; WAC 173-128A and 130A; Ecology, 2006b). The cause of the declining groundwater levels is related to the amount of pumping from the deep basalt aquifer, and may also be related to the way in which some wells have been completed over the years, allowing interconnections between various water-bearing zones in the aquifer.

The purpose of establishing the Odessa Ground Water Management Subarea (Odessa Subarea) was to "…provide a procedure for managing ground water within the Odessa ground water subarea to insure the maintenance of a safe sustaining yield from the ground water body within a reasonable and feasible pumping lift" (WAC 173-130A-040).

Constraints on water use in the Odessa Subarea are based on controlling the rate of decline in the water level, establishing a maximum lowering of the water table level, regulating withdrawal of ground water to protect senior water right holders, limiting new water users and limiting the location where new wells may be drilled. As water levels continue to decline, irrigators have begun to look for other water sources, including water from the Columbia River (Reclamation, 2006b).

The declining aquifer is not only of concern to irrigators, but also municipalities in the Odessa Subarea which rely on the aquifer for municipal and industrial water supply (Reclamation, 2006b; Ecology, 2006b). The Bureau of Reclamation is investigating the possibility of continuing development of the Columbia Basin Project to deliver project water to lands currently using ground water in the Odessa Subarea (Reclamation, 2006b). The Bureau of Reclamation anticipates the Odessa Special Area Study will take five years, beginning in 2006, and will conclude with a planning report and the appropriate National Environmental Policy Act documents. The Bureau of Reclamation has posted the Plan of Study and the Initial

Alternative Development and Evaluation reports on its website.[1]

3.3.3.3 Aquifer Storage and Recovery (ASR) (WAC 173-157)

Aquifer storage and recovery (ASR) is a water storage technique that uses underground aquifers as storage reservoirs. ASR is permitted by Ecology under WAC 173-157 and provides an opportunity for utilizing underground storage, provided certain technical conditions are met. Use of ASR water could affect Columbia River flows. When water that is artificially recharged to an aquifer is recovered for further use, this special application of artificial recharge is called ASR. Water may be introduced into permeable geological formations by infiltration from the ground surface, or direct injection using wells. Water may be stored for a period of weeks, months or longer, and then recovered for potable or other uses.

ASR is being used throughout the world with facilities operating in many different environments, including Oregon, California, Nevada, Utah, Texas, Arizona, New Mexico, Florida, and New Jersey. The Salem Heights wellfield for the City of Salem, Oregon is the only fully permitted and operational ASR system in the Pacific Northwest. Seattle Public Utilities has operated the Highline Wellfield for a number of years in an extended testing mode. The Cities of Yakima, Pendleton, Kennewick, and Walla Walla are involved in a number of promising feasibility and pilot projects. Basalt aquifers, which are prevalent throughout the Columbia Basin, are good candidate aquifers for ASR from a geologic standpoint.

A series of technical water supply issues must be adequately satisfied for ASR to be feasible. These include: legal source of water, adequate infrastructure, suitable receiving aquifer, good water quality, and a demand profile that can take advantage of the stored water.

ASR can be used for different purposes and can be optimally configured for each purpose. In general there are three primary purposes for which ASR can be considered:

1. To seasonally shift sources of water supply from direct surface or ground water withdrawal to ASR during critical low flow periods. Here, ASR provides the direct replacement for potable water supply;
2. To improve or divert poor quality ground water from higher quality ground water near pumping wells; and,
3. To enhance river flows either by withdrawal of stored water and discharge to streams, or by leakage from the aquifer in which water is stored.

The main regulatory and permitting issues to consider for ASR strategies relate to water rights, well construction (Ch. 173-160 WAC), water quality (Ch. 173-200 WAC) and Underground Injection Control rules (Ch. 173-218 WAC).

3.3.4 Other State Agency Programs

In addition to Ecology's role in the management of water resources, other agency actions or

1 http://www.usbr.gov/pn/programs/ucao_misc/odessa/index.html

responsibilities can affect water quantity, quality and instream flow. These agencies include:

- Washington State Department of Health (DOH), which manages programs or components of programs involving water protection, wastewater, water conservation, aquaculture and water quality for recreation and consumption.
- Washington Department of Fish and Wildlife (WDFW), which manages fish, shellfish and wildlife species and their habitats. Programs include the regulation of hatcheries, habitat protection and restoration, harvest regulations, data and population management and enforcement.
- Washington State Conservation Commission (WSCC), which exists to assist and guide conservation districts and manages multiple conservation programs, two of which (Conservation Reserve Enhancement Program (CREP) and the Irrigation Efficiencies Program) may affect irrigated agriculture or water demands in the Columbia River Basin.

Additional information about the roles, responsibilities, and programs provided by these agencies is provided in Appendix B.

3.4 Other Institutional Factors Affecting the Columbia River

Washington State Department of Ecology's authority to manage Columbia River streamflows is affected by the jurisdiction and authority of federal, Tribal and international governments. Laws and agreements that have a bearing on federal operations of the Columbia River system include:

- Enabling legislation for federal projects that proscribe certain operations, such as irrigation, flood control, navigation, and hydropower.
- Endangered Species Act (ESA): A federal law that protects threatened and endangered species of plants and animals. They include several species of fish that live in or migrate through the Columbia and Snake Rivers. Biological Opinions (BiOp) have been prepared for the Federal Columbia River Power System (FCRPS) that provide requirements for the federal agencies to operate the river to comply with the Endangered Species Act (ESA).
- Fish and Wildlife Coordination Act: A federal law that requires FCRPS to mitigate the impacts of its dams on fish and wildlife.
- Clean Water Act (CWA): A federal law that requires Section 401 CWA certifications for FERC-licensed hydro projects.
- National Environmental Policy Act (NEPA): A federal law that requires environmental review of actions proposed by federal agencies.
- Columbia River Treaty: An agreement between United States and Canada regarding flood control and power production on the Columbia River.
- Pacific Northwest Coordination Agreement: An agreement between federal project operators and hydroelectric generating utilities of the Northwest that calls for annual planning that must accommodate all authorized purposes of Columbia River projects.
- Columbia Storage Power Exchange and Canadian Entitlement Allocation Agreements: Agreements between utilities to divide power benefits and obligations.
- Non-Treaty Storage Agreement: An agreement between Bonneville Power Administration and BC Hydro to increase the amount of storage water covered by agreement from 2 million ac-ft to 4.5 million ac-ft. BPA and BC Hydro equally share the power generating benefits from this storage. This agreement expired in 2003.

- Tribal Treaties and Executive Orders: Agreements between sovereign tribal nations and the United States Government in the cession of land originally in 1855. The U.S. Government is obligated to provide services that protect and enhance Indian lands and resources, which includes the need to maintain harvestable stocks of anadromous fish.
- Pacific Northwest Electric Power Planning and Conservation Act of 1980: Passed by Congress that created an eight-member council (2 members each from Washington, Idaho, Oregon, and Montana) to adopt a Fish and Wildlife Program for the Columbia Basin. The Fish and Wildlife Program contains a number of goals for restoring and protecting fish populations while encouraging an energy conservation program.

3.4.1 Tribal Governments

There are seven tribes that are Columbia River Treaty Tribes, are participating in the Columbia/Snake River Total Maximum Daily Load (TMDL) Study and/or have reservation land in the Washington portion of the Columbia River Basin upstream of Bonneville Dam. These Tribes have reservation lands in excess of 3.7 million acres in the Columbia Basin (Table 3-9). Tribes are active participants in water management, both directly and indirectly. Many Tribes directly manage water through water management rules or regulations for their tribally managed lands. Tribal water management interests extend significantly into other natural resource areas such as fisheries. Tribes may also set and manage water quality standards on reservations under the Clean Water Act when delegated by the Environmental Protection Agency.

Tribes ceded land to the United States through negotiated treaties and, after 1871 Congressional legislation changing the process, through executive orders. Tribes have implied water rights based on the water necessary to effectuate the purposes of their reservations. These reserved rights vest as of the date of the establishment of the reservation or treaty and are not lost if unused on land held by the tribe or its members. Tribal water rights have been partially adjudicated on the Yakama Reservation, the Colville Reservation, and the Spokane Reservation. In these cases, reservation purpose has included irrigation and fisheries. While ceding title to land under treaty, tribes reserved certain rights including the right to hunt and fish in usual and accustomed places (U&A's). These are rights that were held by the tribe before treaty time and reserved through treaty provisions. Hunting and gathering rights, not yet defined by federal courts, are not limited by the drainage basins and may not exactly correspond to the U and A's associated with fishing rights. Tribes assert that the treaty reserved right to fish carries with it the implied right to have water in off-reservation streams sufficient to ensure the survival of harvestable numbers of fish.

Of the seven tribes, the Confederated Tribes and Bands of the Yakama Indian Nation, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation of Oregon and the Nez Perce Tribe have rights to anadromous fish in the Columbia River from the 1855 treaties with the United States.

3.4.2 Federal Authority

Federal agencies own and operate many of the dams on the Columbia River and its major tributaries, especially the large water storage reservoirs. The federal agencies are subject to a variety of environmental regulations which affect how the Columbia River Basin dams and reservoirs are operated and maintained. Other dams on the Columbia River and its major tributaries are operated by PUDs, private power companies, B.C. Hydro, and other entities. Operation of these dams and reservoirs is highly coordinated to maximize the multiple beneficial uses they provide. The power operations of the Columbia River dams are coordinated through the Pacific Northwest Coordination Agreement.

1. The Corps operates 12 of the 14 major federally-owned dam and reservoir projects in the Columbia River Basin. The Corps is responsible for flood control operations at all reservoirs in the basin both in the U.S. and Canada. It shares responsibility with BPA and B.C. Hydro in determining how the Columbia River treaty reservoirs will be operated. The Corps has also constructed and maintains all navigation channels to accommodate barges and other river traffic (FCRPS, 2001).
2. The Bureau of Reclamation operates Grand Coulee and Hungry Horse Dams, the other two major federal water storage projects in the Columbia River Basin. It also operates the major irrigation projects in the basin: the Columbia Basin Project and the Yakima Project.
3. The BPA markets wholesale electrical power generated from the 31 federal hydro projects in the Columbia Basin and one non-federal nuclear power plant and owns, operates, and markets transmission services in the Pacific Northwest from its high voltage transmission system. BPA is a self-financed agency which pays for its costs through power and transmission sales. The Northwest Power Planning and Conservation Act directs BPA to fund and implement measures to protect, mitigate, and enhance fish and wildlife affected by the development and operation of any federal hydroelectric project on the Columbia River and its tributaries.

Operation of the FCRPS is also subject to many operational requirements which are set by the BiOp and other agreements. Hydro operations for the protection of endangered and threatened species include the following:

Minimum Operating Pool (MOP)

The Minimum Operating Pool (MOP) is the minimum elevation that a reservoir behind a dam can be at and still be able to operate for navigation. The purpose of the MOP operation is to reduce juvenile salmonid travel time through the reservoirs. The lower Snake River Dams–Lower Granite, Ice Harbor, Lower Goose, and Lower Monumental–operate at MOP from approximately April 3 through the end of August.

In addition, the John Day Reservoir is operated at the Minimum Irrigation Pool (MIP) from April 10 to September 30. MIP is the lowest pool elevation at which it is still possible for irrigators to reach the reservoir. Operating at MIP reduces juvenile salmonid travel time through the reservoir.

Bonneville Tailwater Flows to Protect Chum

From approximately the beginning of November to the middle of April, Bonneville is operated with a minimum tailwater elevation of 11.3 feet. Between 7 AM and 9 PM the tailwater elevation fluctuates only between 11.3 feet and 11.7 feet. By operating Bonneville to these tailwater elevations, the chum habitat is kept watered during spawning and the redds are kept underwater.

Flow Augmentation

Operation of Columbia River dams is also subject to flow targets set by Biological Opinions (BiOp) to protect endangered and threatened species. Storage from Grande Coulee, Hungry Horse, Libby, Dworshak, and other storage projects are used to augment flows for migrating salmonids during the spring and summer. Flow targets have been recommended at the Bonneville, McNary, and Priest Rapids Dams through the federal BiOp (NMFS, 2004). Table 3-10 summarizes the BiOp targets. Figure 3-7 shows how discharge at Priest Rapids Dam, McNary Dam, and Bonneville Dam in 2001 and 2003 compares with the recommended BiOp flows:

- Priest Rapids Dam: Recommended BiOp flow targets are generally not currently met. BiOp flows at Priest Rapids are 135,000 cfs from mid-April through June and were not met in either 2001(dry year) or 2003 (normal year).
- McNary Dam: BiOp flow targets extend from mid-April through August and range from 220,000 to 260,000 cfs. Recommended BiOp flow targets are generally not currently met.
- Bonneville Dam: The recommended BiOp target ranges from 125,000 to 160,000 cfs from November through the period of salmonid species emergence. Columbia River flows in 2001 (dry year) were approximately 70% of the BiOp target on average, although the end date of the target is unique for each year. Flows in 2003 (average year) did not meet this target from November through March by an average of 71%.

Spill

All of the federal projects with fish passage on the Snake and Columbia Rivers spill water to provide passage for out migrating juvenile salmonids. Water that is spilled over the dam is not used to generate electricity. The level and duration of spill varies at each project.

1% Efficiency

During the salmonid out migration Bonneville, The Dalles, John Day, McNary, Ice Harbor, Lower Monumental, Little Goose, and Lower Granite operate their turbines within 1% of peak efficiency. When the dams are operated at 1% of peak efficiency a smooth flow is created through the turbines. This benefits fish that pass the dams through the power house. Often this is also beneficial for power because the generators are being operated at their near optimal level of efficiency. However, it occasionally restricts a more preferable operation that allows a higher volume of water to pass through the turbines to generate more electricity (albeit at a lower level of efficiency).

Other Operations

The federal agencies also perform reservoir operations to benefit many other species such as: sturgeon, bull trout, kokanee, and other ESA-listed and non-ESA-listed fish and wildlife.

As part of the Hanford Agreement, BPA, the Washington Department of Fish and Wildlife, and the Mid-Columbia utilities manage flow levels below Priest Rapids Dam to ensure that Fall Chinook salmon spawn at an elevation which allows the redds to remain underwater during fluctuations in flow.

Currently, a new BIOP is being developed by the Federal action agencies, the Columbia River Tribes, and the States. See Table 3-11 for more detail on FCRPS operations for fish.

3.4.2.1 Columbia Basin Project

The Columbia Basin Project (CBP), operated by the Bureau of Reclamation, is an important project for the Columbia Basin Management Program because it involves a significant diversion of water that is not used solely for hydropower and therefore does not stay in the Columbia River. The CBP is a congressionally authorized multipurpose development located in the central part of Washington State. The key structure, Grand Coulee Dam, is on the mainstem of the Columbia River about 90 miles west of Spokane, Washington. The extensive irrigation works extend southward on the Columbia Plateau 125 miles to the vicinity of Pasco, Washington, where the Snake and Columbia Rivers join.

The Columbia Basin Project was begun with the allocation of funds for Grand Coulee Dam pursuant to the National Industrial Recovery Act of June 16, 1933. The project was specifically authorized for construction by the Rivers and Harbors Act approved August 30, 1935 (49 Stat. 1028, 1039-1040, Public Law 74-409). The Columbia Basin Project Act of March 10, 1943 (57 Stat. 14, Public Law 78-8), reauthorized the project, bringing it under the provisions of the Reclamation Project Act of 1939.

The authorized purposes are the control of floods, improvement of navigation, regulation of streamflow, storage, and delivery of stored water for reclamation of lands, and other beneficial uses, and the generation of electric energy. Storage and delivery of water for municipal and industrial purposes is a beneficial use and a project purpose.

In the 1970s, the court confirmed that fish and wildlife was also a project purpose pursuant to the Fish and Wildlife Coordination Act of August 12, 1958 (72 Stat. 563, Public Law 85-624).

3.4.3 International Agreements

There are four international treaties that define the water rights relationship between Canada and the state of Washington (Table 3-12).

3.4.3.1 Boundary Waters Treaty of 1909

The Boundary Waters Treaty ratified in 1909 created the bilateral International Joint Commission (IJC) to address water rights disputes between Canada and the United States. Under the terms of the Treaty, if additional Columbia River water was to be diverted by Canada, a downstream water user in Washington could contest that diversion before the IJC with the same standing as a Canadian citizen (National Research Council, 2004; Ecology, 2006b).

However, the principles of jurisdiction and control over water in the Treaty are somewhat contradictory and any protest would have to work its way through the IJC, which is a slow process. "Canada likely has an unquantified but, for purposes of prior appropriation in Washington, a senior claim based [upon] its equitable interest in the river. Additional U.S. water diversions in the Columbia River may remain subject to additional Canadian development, the latter of which would be entitled to priority. [However,] this [discussion] does not consider any water-related claims of indigenous people north of the forty-ninth parallel" that might exist and be determined valid (National Research Council, 2004, p. 73).

3.4.3.2 Columbia River Treaty of 1961

The Columbia River Treaty was signed in 1961 and approved by Canada in 1964. The Treaty has no termination date. The Treaty allows either Canada or the U.S. the option to terminate the Treaty in 2024 with a 10 years advance notice. If neither party chooses termination, the Treaty can continue into perpetuity without any changes. The Treaty provided for the construction of four upper Columbia River storage dams—three in Canada and one in Montana. The dams provide flood control and increased hydropower generation benefits in both Canada and the United States.

Under the Treaty, Canada has rights to divert up to 1.5 million acre-feet per year from the Kootenay River into the headwaters of the Columbia River. For 40 years after the Treaty expires, until 2064, Canada can divert an unspecified quantity of water from the Kootenay River into the Columbia as long as the flow of the Kootenay at the border is 2,500 cubic feet per second (cfs) or the natural flow. Canada pledged in the Treaty not to divert water in such a way that the flow crossing the boundary is altered. This does not include consumptive uses or the option for Canada to divert the Kootenay into the Columbia. Canada did promise not to divert the Columbia water out of the basin (i.e. into the Frasier River or to eastern provinces) (National Research Council, 2004).

3.4.3.3 Pacific Salmon Treat

The Pacific Salmon Treaty was ratified in 1985 by Canada and the United States. The Treaty provides for a four-person delegation for each country that will cooperate in the management, research, and enhancement of Pacific salmon stocks.

In Attachment E of Annex 4 to the Treaty, the parties pledge "[t]o use their best efforts, consistent with applicable law, to: (a) protect and restore habitat so as to promote safe passage of adult and juvenile salmon and achieve high levels of natural production, (b) maintain and, as needed, improve safe passage of salmon to and from their natal streams, and (c) maintain adequate water quality and quantity" (Pacific Salmon Treaty, 1985, p. 95). The Pacific Salmon Treaty focuses on salmon harvest limits, not regulating the quantity of water in the Columbia River (National Research Council, 2004).

3.4.3.4 Lake Roosevelt-Columbia River Treaty and Tributary Systems

"This agreement delineates cooperation and coordination on water quality discharges and large consumptive use withdrawals above 10 cubic feet per second on the Columbia River or tributary systems to the Columbia River that affect both Washington and Canada. Most of this agreement is focused on waste discharges in Canada and not water allocation. However, consultation was initiated in July 2002 surrounding the Cascade Power Project on the Kettle River in Canada. Agency staff from Washington and Canada inspected the proposed hydro-power site and discussed water policy issues and implications. The Cascade Power Project is a river power plant, non-consumptive and should not come under the agreement. Canada decided to consult with Washington anyway due to cross border water issues" (Ecology, 2003).

3.4.4 Interstate Agreements

Washington has signed two water allocation agreements with its border states, Idaho and Oregon. Each agreement is fairly limited in scope and represents cooperative efforts rather than allocation of water between the two states. Both agreements do not limit the states from allocating water but merely share information on which decisions can be made (Ecology, 2003).

3.4.4.1 Oregon

Washington has a Memorandum of Agreement (MOA) with Oregon regarding the delivery of water from certain interstate streams in Oregon to Washington in the Walla Walla Basin. Washington and Oregon signed this agreement in 1992 as part of a stipulation before the U.S. Supreme Court. The MOA outlines the process and procedure for Watermasters of the two states to use in delivering water from Oregon to Washington for certain interstate streams.

The Columbia River Compact provides authority to adopt seasons and rules for Columbia River commercial fisheries. The Oregon and Washington agency directors, or their delegates, acting on behalf of the Oregon Fish and Wildlife Commission (OFWC) and the Washington Fish and Wildlife Commission (WFWC) administer the Compact. In addition, Columbia River treaty tribes have authority to regulate treaty Indian fisheries (National Research Council, 2004; Ecology, 2006b).

3.4.4.2 Idaho

There is an agreement between the Department of Ecology and Idaho Department of Water Resources on the coordinated management of the Pullman-Moscow aquifer. Signed in April 1992, the agreement outlines coordination measures between the two states and the Pullman-Moscow Water Resources Committee. The states agreed to share information about new requests for water rights within the zone of influence of the aquifer. Washington and Idaho also began discussing aquifer management options for the Spokane-Rathdrum Prairie Aquifer in April 2002 (Ecology, 2003).

3.5 Monitoring and Forecasting on the Columbia River

3.5.1 Stream Gages and Reservoir Levels

An extensive network of stream gages exists along the Columbia River and its tributaries. For a majority of the stream gages, data are collected on a real-time basis. Table 3-13 presents a list of stream gages on the mainstem Columbia River while Table 3-14 presents a list of stream gages on major tributaries to the Columbia River. The stream gages shown include only the gages that are located nearest to the Columbia River. The agency with primary responsibility to maintain the stream gages and publish data is the United States Geological Survey (USGS). Other agencies may provide funding assistance to the USGS to operate the gages but the USGS publishes the data. The other agency which collects and publishes data on the mainstem Columbia River is Environment Canada for data collected in British Columbia, Canada.

Many additional stream gages are present within the tributaries to the Columbia River. The USGS operates additional gages in the tributaries. A list of those gages and data can be obtained at http://waterdata.usgs.gov/wa/nwis/current?type=sitelist. The Bureau of Reclamation operates a network of automated hydrologic and meteorologic monitoring stations on rivers and reservoirs located throughout the Pacific Northwest. This network is called "Hydromet". Within Washington State, the Hydromet network collects and publishes data for the Yakima Project within the Yakima River Basin.

The data available through Hydromet can be viewed at http://www.usbr.gov/pn/hydromet/.

Ecology operates a network of stream gages in the tributaries, for which information can be viewed at http://www.ecy.wa.gov/programs/eap/flow/shu_main.html. Other smaller networks of gages are also present, such as gages installed for Watershed Planning Units or other agencies and private parties. The information for the tributaries was not included in this report as we focused on flow data for the Columbia River and data recorded at the mouth of major tributaries.

3.5.2 Irrigation Demand

Real-time data on crop irrigation water demands are available through two public websites operated by the Bureau of Reclamation (AgriMet) and Washington State University Public Agricultural Weather System (PAWS).

- AgriMet is a Bureau of Reclamation program that started in 1983. It consists of a network of 72 automatic agricultural weather stations located throughout the Pacific Northwest. Real-time data is transmitted from stations every 1-4 hours to the Bureau of Reclamation's receiver site in Boise, Idaho. The information is then processed and made available to the public through the Bureau of Reclamation website http://www.usbr.gov/pn/agrimet/. Data collected differs depending on the specific site. All 72 sites collect air temperature, precipitation, dew point, relative humidity, wind direction, and wind speed. Other parameters collected by sites include solar radiation, soil temperature, pan evaporation, crop canopy temperature, barometric pressure, and leaf wetness. AgriMet uses weather data collected to estimate evapotranspiration (crop water use) for crops grown in the area of the weather station. Specific crop evapotranspiration rates are calculated based on the reference crop alfalfa. AgriMet crop water use charts are updated daily on its website.

- The Public Agricultural Weather System (PAWS) is a weather forecast system from Washington State University created to assist growers in management decisions. The PAWS network consists of 59 weather stations with the majority in the irrigated areas of Eastern Washington. These stations collect parameters such as air temperature, wind speed and direction, relative humidity, leaf wetness, soil temperature, soil moisture, solar radiation, and rainfall, and they provide near real-time data. Data are collected every 10 seconds, averaged every 15 minutes (for 15 minute files) and every 60 minutes (for hourly files), and transmitted to data collection stations every hour. Subscribers can log on to the website to download data. Information and reports from PAWS are used to promote a scientific method of irrigation scheduling from evapotranspiration rate, protect and warn against frost, model pests, and diseases, and provide daily values of water usage in crops. Growers can use the information from PAWS in combination with the Washington Irrigation Scheduling Expert (WISE) to better manage irrigation scheduling. Data can be obtained through the PAWS website http://www.paws2.wsu.edu/.

3.5.3 Runoff Forecasts

Several agencies are involved in producing climate and streamflow predictions for the Columbia River Basin. Forecasts of climate range from short term daily weather forecasts to long-term predictions over several months based on changing large-scale climate patterns. Forecasts of water supply and streamflow typically include short-term predictions over days or weeks and long-term predictions over several months such as for a crop growing season. Agencies are able to use climate, water supply, and streamflow forecasts to make their own predictions such as for reservoir pool elevations, municipal water supply, or salmonid survival. The following sections describe the most broadly used forecasting products, including streamflow and water supply forecasts published by the Natural Resources Conservation Service (NRCS), National Oceanic and Atmospheric Administration's (NOAA) River Forecast Center, the Bureau of Reclamation, and the University of Washington. Table 3-15 presents a list of various forecasting activities, including those which involve the use of NRCS or NOAA forecasts for other applications. In addition, Ecology's website (http://www.ecy.wa.gov/programs/wr/ws/wtrsuply.html) provides links to specific types of information available from different agencies on climate, water supply, and streamflow forecasting relevant to water management in the Columbia River Basin (Table 3-16).

3.5.3.1 Natural Resources Conservation Service (NRCS)

The primary water supply forecast in the Columbia River Basin is published by the NRCS in the publication "Water Supply Outlook for the Western United States" which is available at http://www.wa.nrcs.usda.gov/snow/watersupply/. The information available includes:

- Monthly forecasts of seasonal water supply that are published from January to June for major tributaries to the Columbia River and the upper Columbia River upstream of Grand Coulee Dam. The forecast periods begin at the prepared forecast month and run to June and September;

- Five levels of forecasts with percent chance of exceedance ranging from 10% to 90%; and,
- Non-forecast information such as:
  - Precipitation maps
  - Snow cover maps
  - Mountain snowpack maps
  - Reservoir storage graphics

NRCS water supply forecasts are published in cooperation with the NOAA River Forecast Centers. Together, the NRCS and the Northwest River Forecast Center publish forecasts for 111 locations within the Columbia River Basin.

3.5.3.2 Northwest River Forecast Center (NWRFC)

Water supply and streamflow forecasts are available from the NWRFC, a division of NOAA at http://www.nwrfc.noaa.gov/nwrfc/info.cgi. NWRFC uses the National Weather Service River Forecast System (NWSRFS) to simulate soil, snow, stream, channel, and reservoir conditions. Streamflow forecasts are made for 0-14 days for a wide network of stream gage locations throughout the Columbia River Basin and 14-120 days for a smaller, although still extensive, group of stream gages. Forecasts of seasonal water supply are prepared monthly from January to June. Forecasts are published in cooperation with the NRCS.

3.5.3.3 Bureau of Reclamation Forecasts

The Bureau of Reclamation prepares forecasts of water supply available for Yakima Project water users. The forecast is named Total Water Supply Available (TWSA). TWSA represents the combined quantity of unregulated flow, return flow, and stored water available for use in the Yakima Project. The TWSA represents the estimated water supply available for the period of April through September at the Sunnyside Diversion Dam on the Yakima River. The forecast of TWSA is used to determine the adequacy of water supply to meet entitlements and since 1995 the forecast of TWSA is used to determine the magnitude of target flows over Sunnyside and Prosser Diversion Dams. The forecasts are prepared by the Bureau of Reclamation beginning each March and continuing through the irrigation season.

3.5.3.4 University of Washington

Experimental, real-time seasonal forecasts of western United States hydrologic conditions are available through the University of Washington's West-Wide Seasonal Streamflow Forecasting Project. The forecasts are updated monthly for river basins in the west including the Columbia River Basin. Among the products provided are:

- monthly streamflow forecast ensembles for 15 locations in the Columbia River basin and 20 locations in the Snake River Basin corresponding with USGS gage locations;
- spatial distributions of forecasted snow water equivalent, soil moisture and runoff; and
- forecasts of spatially-distributed snow water equivalent and soil moisture conditions.

The streamflow forecasts, spatial plots of hydrologic conditions (current and forecasted conditions), forecast data, and other information are available at http://www.hydro.washington.edu/forecast.

TABLES

Table 3-1. Major Tributaries of the Washington Portion of the Columbia River[1,2,3]

Tributary	Columbia River Mile	Drainage Area (sq. mi.)	Mean Annual Flow (cfs)	Percent of Total Tributary Flow
Pend Oreille River	735.1	24,900	26,266	15.4%
Kettle River	706.4	3,800	2,924	1.7%
Colville River	661.0	1,007	306	0.2%
Spokane River	638.9	4,290	6,689	3.9%
Sanpoil River	615.0	880	217	0.1%
Okanogan River	533.5	8,080	3,042	1.8%
Methow River	523.9	1,772	1,522	0.9%
Chelan River	503.3	924	2,042	1.2%
Entiat River	483.7	419	471	0.3%
Wenatchee River	468.4	1,301	3,231	1.9%
Crab Creek	410.8	4,842	201	0.1%
Yakima River	335.2	5,615	3,493	2.0%
Snake River	324.2	108,500	54,835	32.1%
Walla Walla River	314.6	1,657	568	0.3%
Umatilla River (OR)	289.0	2,290	555	0.3%
John Day River (OR)	218.0	7,580	1,258	0.7%
Deschutes River (OR)	204.1	10,500	5,767	3.4%
Klickitat River	180.4	1,297	1,572	0.9%
Hood River (OR)	169.4	329	1,099	0.6%
White Salmon River	168.3	386	1,115	0.7%
Little White Salmon River	162.0	134	547	0.3%
Wind River	154.5	225	1,199	0.7%
Washougal River	120.7	108	873	0.5%
Sandy River (OR)	120.5	436	2,259	1.3%
Willamette River (OR)	101.5	11,200	32,835	19.2%
Lewis River	87.0	731	4,762	2.8%
Kalama River	73.1	198	1,263	0.7%
Cowlitz River	68.0	2,238	9,092	5.3%
Elochoman River	39.1	66	375	0.2%
Grays River	20.8	60	527	0.3%

NOTES

Abbreviations: sq. mi.: square miles; cfs: cubic feet per second.

[1] Based on available U.S. Geological Survey (USGS) data for gages closest to Columbia River mainstem.

[2] The list of major tributaries of the Columbia River was obtained from Ecology and WDFW (2004).

[3] The USGS publishes a spatial data set that contains information about surface water features (the National Hydrography Dataset, or NHD). The most recent dataset, NHDPlus, contains mean annual flow and drainage area information for all NHD designated reaches of rivers and streams. Although the dataset has not yet been developed in all regions, it does exist for the Columbia River Basin. Sometimes large discrepencies in the mean annual flow between the NHDPlus dataset and USGS gage data (likely due to the use of naturalized flows in the NHDPlus dataset) prevented the use of the dataset in this inventory.

Table 3-2. Columbia Basin Land Cover Characteristics by County[1] (USGS, 1999)

County	Irrigated Agriculture (acres)		Non-Irrigated Ag.[3] (acres)	Low Intensity Residential (acres)	High Intensity Residential (acres)	Commercial/ Industrial/ Transpor-tation (acres)	Natural Vegetation[4] (acres)	Wetland[5] (acres)	Barren[6] (acres)	Water[7] (acres)
	Orchard/ Vineyard	Other Ag.[2]								
Adams	0	104,925	582,404	2,265	14	14,612	524,447	2,073	191	4,204
Asotin	0	489	83,245	3,631	0	1,347	314,557	46	2,572	4,086
Benton	7,359	130,562	295,024	23,520	151	16,731	612,876	319	670	39,029
Chelan	30,330	1,462	267	5,458	86	4,506	1,678,780	1,705	129,124	64,668
Columbia	0	4,917	194,697	720	0	1,585	350,795	20	2,660	3,777
Douglas	18,377	2,422	398,025	3,414	16	6,229	733,312	162	810	20,363
Ferry	10	17,333	4,573	1,580	0	2,052	1,293,161	827	86,553	38,457
Franklin	0	258,058	171,851	7,416	113	11,780	342,284	1,453	139	16,509
Garfield	0	3,026	171,925	523	0	820	269,426	19	9,116	4,849
Grant	15,824	310,304	422,126	11,552	46	25,698	903,957	9,542	1,496	85,872
Kittitas	2,391	61,009	32,911	4,381	22	9,235	1,264,253	1,170	90,526	27,306
Klickitat	3,413	34,565	118,238	2,948	1	5,392	995,154	914	35,479	22,710
Lincoln	1	17,286	761,122	2,089	0	12,680	677,358	4,772	504	21,261
Okanogan	40,322	64,035	8,736	3,441	3	11,885	3,134,586	2,505	92,887	42,103
Pend Oreille	2	28,023	23	2,230	0	2,358	796,720	1,566	61,576	19,920
Skamania	344	3,727	0	759	0	1,506	877,216	1,237	172,835	21,215
Spokane	4,712	81,466	366,727	49,917	568	26,705	570,989	4,222	21,414	14,651
Stevens[8]	22	90,517	35,202	8,029	0	4,911	1,351,866	2,067	89,624	41,929
Walla Walla	10,099	77,452	410,064	8,999	50	6,405	299,287	122	269	18,500
Whitman	0	6,743	1,067,787	4,735	85	10,123	289,646	801	105	13,647
Yakima	84,791	129,649	211,838	27,348	382	18,069	2,177,727	4,808	81,833	22,904
Totals	1,645,967		5,336,785	174,955	1,537	194,629	19,458,397	40,350	880,383	547,960

See notes on next page.

NOTES

Abbreviations: Ag: Agriculture

[1] Information based on the Washington Land Cover Dataset (USGS, 1999) that used 1992 land cover data.

[2] Includes pasture/hay, row crops and urban/recreational grasses land cover categories.

[3] Includes small grains and fallow land cover categories.

[4] Includes deciduous forest, evergreen forest, mixed forest, shrubland and grasslands/herbaceous land cover categories.

[5] Includes woody wetlands and emergent herbaceous wetlands land cover categories.

[6] Includes bare rock/sand/clay, quarries/strip mines/gravel pits and transitional land cover categories.

[7] Includes open water and perennial ice/snow land cover categories.

[8] Stevens County has an additional 32.91 acres that does not have any land cover data and are not included in this table.

Table 3-3. Land Use in the Management Zone[1]

County	Residential (acres)	Agricultural (acres)	Undeveloped (acres)	Other (acres)	Total Acreage in Management Zone
Benton[2]	4,100	25,713	2,797	51,447	84,057
Chelan	9,051	24,094	17,550	44,658	95,353
Douglas	4,688	51,324	11,813	1,830	69,655
Franklin	3,539	53,798	16,431	2,200	75,968
Grant	3,571	13,091	55,842	3,040	75,544
Kittitas	141	2,052	775	53,844	56,812
Klickitat	3,170	50,116	21,590	12,617	87,493
Lincoln	598	24,174	0	144	24,916
Okanogan	1,194	42,526	4,117	54,998	102,835
Stevens	5,480	4,416	8,641	139,848	158,385
Yakima	38	2,302	18	16,123	18,481
Totals	35,570	293,606	139,574	380,749	849,499

NOTES

[1] The Management Zone is defined as the area encompassing one-mile on either side of the Columbia River. Ferry, Skamania and Walla Walla Counties did not have any available land use information. Data provided by Ecology from its parcel database: Washington State Department of Ecology (Ecology). personal communication. 2006. Land Use Info. September 7, 2006.

[2] Benton County includes land use information for the cities of Kennewick and Richland.

Table 3-4. Population Summary[1]

County	2000 Census[1]	2006 OFM Estimate[1]	Average Annual Growth Rate
Adams	15,400	17,300	1.96%
Asotin	19,600	21,100	1.24%
Benton	131,000	160,600	3.45%
Chelan	61,300	70,100	2.26%
Columbia	4,200	4,100	-0.40%
Douglas	30,400	35,700	2.71%
Ferry	7,200	7,500	0.68%
Franklin	43,700	64,200	6.62%
Garfield	2,400	2,400	0.00%
Grant	66,400	80,600	3.28%
Kittitas	30,800	37,400	3.29%
Klickitat	18,700	19,800	0.96%
Lincoln	9,800	10,200	0.67%
Okanogan	37,500	39,800	1.00%
Pend Oreille	11,100	12,300	1.73%
Skamania	9,800	10,600	1.32%
Spokane	406,500	443,800	1.47%
Stevens	36,600	42,100	2.36%
Walla Walla	53,400	57,900	1.36%
Whitman	41,000	42,800	0.72%
Yakima	207,600	231,800	1.85%
Total	**1,244,400**	**1,412,100**	**1.83%**[2]

NOTES

[1] Source: Office of Financial Management, Forecasting Division. File: gmacountychange.xls From: www.ofm.wa.gov (accessed 9/06) Modified June 29, 2006.

[2] Represents average annual growth rate for all counties listed in the table.

Table 3-5. Key Washington and Federal Water Regulations

Regulation Source	Subject Area	Code
Washington[1]	Administration and Regulation of Surface and Ground Water Codes	Chapter 508-12 WAC
		Chapter 90.03 RCW
		Chapter 90.44 RCW
Washington[1]	Appropriation Procedures	Chapter 508-12 WAC
		Chapter 90.03 RCW
Washington[1]	Beneficial Use	Chapter 90.14 RCW
		Chapter 90.54 RCW
		Chapter 90.44 RCW
Washington[1]	Construction of Water Wells and Driller Licensing	Chapter 173-160 WAC
		Chapter 173-162 WAC
		Chapter 18.104 RCW
Washington[1]	Fundamentals of Water Resources	Chapter 90.54.020 RCW
Washington[1]	Minimum Water Flows and Levels	Chapter 90.22 RCW
		Chapter 90.54 RCW
Washington[1]	Unauthorized Use of Water	Chapter 90.03.010 RCW
		Chapter 90.44.110 RCW
Washington[1]	Water Right Relinquishment	Chapter 90.14.130 RCW
Washington[1]	Water Rights Transfer or Change	Chapter 90.03.380 RCW
		RCW 90.44.100
		RCW 90.44.105
Washington	Water Resource Management	RCW 90.42
Washington[1]	Water Pollution Control Act	Chapter 90.48 RCW
Federal[2]	Clean Water Act	Title 33 Chapter 26
Federal[2]	Marine Protection, Research, and Sanctuaries Act Title 1	Title 33 Chapter 27
Federal[2]	Safe Drinking Water Act	Title 42 Chapter 6A Subchapter XII

NOTES

[1] Washington State Department of Ecology. 2006c. Washington State Water Law, A Primer. Publication #WR 98-152 Revised July 2006.

[2] United States Environmental Protection Agency. http://www.epa.gov/water/laws.html (Accessed 9/06).

Table 3-6. Mainstem Columbia River and Snake River Instream Flow Requirements

Date	WAC 173-563: Columbia River[1] Effective: June 24, 1980 (revised 1997) Expiration: None (Minimum Q_i in kcfs)							Snake River is under Adjudication in Idaho
	Chief Joseph	Wells & Rocky Reach	Rock Island & Wanapum	Priest Rapids	McNary	John Day	The Dalles	
January	10	10	10	50	20	20	20	An instream flow rule adopted by Ecology did not specify instream flow quantities and expired on July 1, 1999 (WAC 173-564-040).
February	10	10	10	50	20	20	20	
March	10	10	10	50	50	50	50	
April 1-15	20	20	20	50	50	50	70	
16-25	20	30	30	50	70	70	70	
26-30	20	50	50	50	70	70	70	
May	20	50	50	50	70	70	70	
June 1-15	20	50	50	50	70	70	70	
16-30	10	20	20	50	50	50	50	
July 1-15	10	20	20	50	50	50	50	
16-31	10	50	50	50	50	50	50	
August	10	50	50	50	50	50	50	
September	10	20	20	36	50	50	50	
October 1-15	10	20	20	36	50	50	50	
16-31	10	20	20	50	50	50	50	
November	10	10	10	50	50	50	50	
December	10	10	10	50	20	20	20	

NOTES

Abbreviations: Q_i: instantaneous flow; WAC: Washington Administrative Code; kcfs: thousand cubic feet per second

[1] WAC 173-563 also reports instream flow requirements as a minimum average weekly flow in kcfs which are not included in this table. See the WAC for more detail concerning implementation of the instream flow rule.

Table 3-7. Existing and Proposed Instream Flow Requirements for Tributaries to the Mainstem Columbia River[1]

Month	Day	Colville River[2] WAC 173-559 (cfs)	Okanogan River[3] WAC 173-549 (cfs)	Foster Creek[4] Proposed (cfs)	Methow River[5] WAC 173-548 (cfs)	Entiat River[6] WAC 173-546 (cfs)	Wenatchee River[7] WAC 173-545 (cfs)	Wenatchee River[7] Proposed[9] (cfs)	Walla Walla River[8] Proposed (cfs)
January	1-14	80	860	5.0	350	185	820	1,867	250
	15-31	80	830	5.0	350	185	820	1,867	250
February	1-14	80	820	5.0	350	185	820	1,867	250
	15-28	100	850	5.0	350	185	800	2,400	250
March	1-14	124	880	5.3	350	185	800	2,400	350
	15	157	900	5.3	350	185	1,040	2,400	350
	16-31	157	900	5.3	350	250	1,040	2,400	350
April	1-14	200	925	9.5	590	250	1,350	2,400	350
	15	200	1,100	9.5	860	250	1,750	2,400	350
	16-30	200	1,100	9.5	860	350	1,750	2,400	350
May	1-14	200	1,750	6.3	1,300	474	2,200	2,400	250
	15	135	3,800	6.3	1,940	474	2,800	2,400	250
	16-31	135	3,800	6.3	1,940	720	2,800	2,400	250
June	1-14	90	3,800	4.2	2,220	898	3,500	2,400	stream closed
	15	70	3,800	4.2	2,220	898	2,400	2,400	stream closed
	16-30	70	3,800	4.2	2,220	617	2,400	1,600	stream closed
July	1-14	55	2,100	2.8	2,150	359	1,700	1,600	stream closed
	15	43	1,200	2.8	800	359	1,200	1,600	stream closed
	16-31	43	1,200	2.8	800	268	1,200	1,600	stream closed
August	1-14	33	800	1.3	480	185	800	1,600	stream closed
	15	33	600	1.3	300	185	700	1,600	stream closed
	16-31	33	600	1.3	300	185	700	900	stream closed
September	1-14	40	620	1.5	300	185	700	900	stream closed
	15	49	700	1.5	300	185	700	900	stream closed
	16-30	49	700	1.5	300	185	700	1,338	stream closed
October	1-14	60	750	2.7	360	185	700	1,723	stream closed
	15	70	960	2.7	425	185	700	1,723	stream closed
	16-31	70	960	2.7	425	185	700	2,427	stream closed
November	1-14	84	950	3.9	425	185	800	2,800	stream closed
	15-30	100	950	3.9	425	185	800	2,800	stream closed
December	1-14	100	930	5.0	390	185	800	1,867	250
	15-31	90	900	5.0	350	185	800	1,867	250

See notes on next page.

NOTES

Abbreviations: cfs: cubic feet per second

[1] The numbers in this table represent flows set by rule and are not necessarily representative of actual flows. See Figure 3-7 for a comparison of state instream flow rule flows and the average annual Columbia River flows. The instream flow requirement is reported for the measuring point closest to the junction of the tributary and the mainstem of the Columbia River. The proposed instream flow rule for the Washougal River in WRIA 28 was not included in this table because its confluence with the mainstem of the Columbia River is downstream of Bonneville Dam and therefore outside the study area. The WRIA 35 Planning Unit intends to develop instream flow recommendations in the final draft of the Watershed Management Plan, but that information has not been finalized at this time (HDR, 2006, Draft WRIA 35 Watershed Management Plan). Instream flows in the Yakima River Basin (WRIAs 37, 38 and 39) were not recommended in the Watershed Plan because the river already has target flows established for the Yakima River under the federal Yakima River Basin Water Enhancement Program (YRBWEP) (EES, et al. 2003, Watershed Plan).

[2] As measured at gage #12409000.

[3] As measured at the Okanogan River at Malott gage (#12447200).

[4] Based on the recommendation in the Watershed Management Plan as measured at the Bridgeport irrigation diversion dam (RM 1.03) on Foster Creek (Foster Creek Conservation District, Management Plan, 2004).

[5] As measured at the Methow River near Pateros gage (#12449950).

[6] As measured at the Keystone gage (USGS gage #12452990).

[7] As measured at the Monitor gage (USGS gage #12462500).

[8] As measured on the Walla Walla River below the confluence of West Little Walla Walla. There is no existing gage at this location (HDR, WRIA 32 Watershed Plan, 2005).

[9] Based on the proposed instream flow in the Watershed Plan (WRIA 45 Planning Unit, 2006, Table 4-2).

[10] Other instream flow requirements exist in upper portions of major tributaries or in smaller streams.

Table 3-8. Status of Watershed Planning in the Columbia Basin

WRIA No. & Name	**Phase I** Organization and Scope	**Phase II** Assessment	**Phase III** Planning	**Phase IV** Implementation Plan and Projects		
				Phase IV Awarded	DIP Completed	Projects
27 & 28 Lewis/ Salmon-Washougal			Approved by County, July 2006			
29 Wind-White Salmon			Approved by PU (west half), Dec. 2005			
30 Klickitat			Approved by County, Aug. 2006			
31 Rock-Glade						
32 Walla Walla			Approved by Counties, June 2005	Jan. 2006	June 2006	
33 Lower Snake	Not Planning					
34 Palouse			Anticipated Summer 2007			
35 Middle Snake			Anticipated Summer 2007			
36 Esquatzel Coulee	Not Planning					
37, 38 & 39 Lower/Upper Yakima & Naches			Approved by Yakima and Benton Counties, Nov. 2005	Sept. 2006		
40a Stemilt Squilchuck						
40b Alkali	Not Planning					
41 Lower Crab	Not Planning					
42 Grand Coulee	Not Planning					
43 Upper Crab-Wilson			Anticipated Summer 2007			
44 & 50 Moses Coulee & Foster Creek			Approved by Counties, Nov. 2004	Feb. 2005	Feb. 2006	
45 Wenatchee			Approved by County, June 2006			
46 Entiat			Approved by County, Sept. 2004	Feb. 2005	Feb. 2006	
47 Chelan	Not Planning					

See next page for notes.

WRIA No. & Name	Phase I Organization and Scope	Phase II Assessment	Phase III Planning	Phase IV Implementation Plan and Projects		
				Phase IV Awarded	DIP Completed	Projects
48 Methow			Approved by County, June 2005			
49 Okanogan						
51 Nespelem	Not Planning					
52 Sanpoil	Not Planning					
53 Lower Lake Roosevelt	Not Planning					
54 Lower Spokane						
55 & 57 Little Spokane & Middle Spokane			Approved by County, Jan. 2006			
56 Hangman			Approved by County, Sept. 2005	Oct. 2006		
58 Middle Lake Roosevelt	Not Planning					
59 Colville			Approved by County, Nov. 2004	March 2005	April 2006	
60 Kettle			Planning Discontinued July 2004			
61 Upper Lake Roosevelt	Not Planning					
62 Pend Oreille			Approved by County, May 2005	Sept. 2005		

NOTES

<u>Abbreviations</u>: PU: Planning Unit; DIP: Detailed Implementation Plan

Phase Complete

Phase in Progress

Table 3-9. Columbia River Treaty Tribes, Columbia/Snake River TMDL Tribal Contacts, and Tribes with Land in the Washington portion of the Columbia River Basin[1]

Tribe	Location	Population/Area[2]	Water Regulations
Confederated Tribes and Bands of the Yakama Indian Nation[3]	Central Washington	8,870 / 1,371,918 acres	Yakama Nation Water Code Title 60
Confederated Tribes of the Colville Reservation	North central Washington	8,882 / 1,300,000 acres	Tribal Code: Chapter 4-10 Water Resources Use and Permitting
Confederated Tribes of the Umatilla Indian Reservation[3]	Northeast Oregon	2,000 / 157,982 acres	Umatilla Water Code
Confederated Tribes of the Warm Springs Reservation of Oregon[3]	Central Oregon	3,755 / 641,000 acres	Chapter 431: Warm Springs Water and Sewer System Act
Kalispel Tribe	Northeast Washington	250 / 4,600 acres	Water Quality Standards Applicable to Waters within the Kalispel Indian Reservation
Nez Perce Tribe[3]	Northern Idaho	3,010 / 88,314 acres	Water infractions and water use and conservation (pertaining to utility department) discussed in Tribal Code.
Spokane Tribe	Eastern Washington	2,153 / 154,000 acres	Not Available

NOTES

[1] Other Tribes are present in the Columbia Basin, but do not have reservation lands in Washington State.

[2] Data provided by Northwest Portland Area Indian Health Board. http://www.npaihb.org/profiles/tribal_profiles/interface.htm (accessed 9/06).

[3] Tribes in Columbia Basin with reserved rights to anadromous fish in the Columbia River from the 1855 treaties with the United States. Data provided by the Columbia River Inter-Tribal Fish Commission. http://www.critfc.org/text/tribes (accessed 9/06).

Table 3-10. Minimum Daily Dam Outflows and Flow Targets for Bonneville, McNary, and Priest Rapids Dams

	Bonneville Dam			McNary Dam				Priest Rapids Dam			
Date	2004 BiOp Flow Objective[1] (kcfs)	2001 (kcfs)	2003 (kcfs)	WAC 173-563 Min. Q_i (kcfs)	2004 BiOp Flow Objective[1] (kcfs)	2001 (kcfs)	2003 (kcfs)	WAC 173-563 Min. Q_i (kcfs)	2004 BiOp Flow Objective[1] (kcfs)	2001 (kcfs)	2003 (kcfs)
Oct 1-15	--	103	83	50	--	82	75	36	--	50	51
Oct 16-31	--	95	77	50	--	70	66	50	--	43	50
Nov	125-160[2]	126	116	50	--	99	95	50	--	67	67
Dec	125-160[2]	130	106	20	--	106	90	50	--	68	76
Jan	125-160[2]	120	108	20	--	94	83	50	--	68	71
Feb	125-160[2]	123	112	20	220-260[3]	81	89	50	135	67	71
Mar	125-160[2]	100	125	50	220-260[3]	92	106	50	135	66	71
Apr 1-2	125-160[2]	111	185	50	220-260[3]	89	169	50	135	66	96
Apr 3-9	125-160[2]	104	181	50	220-260[3]	91	173	50	135	64	73
Apr 10-15	125-160[2]	98	179	50	220-260[3]	81	161	50	135	64	84
Apr 16-25	125-160[2]	94	208	70	220-260[3]	81	174	50	135	65	99
Apr 26-30	125-160[2]	108	235	70	220-260[3]	110	206	50	135	64	109
May	125-160[2]	109	213	70	200	104	180	50	--	38	88
Jun 1-15	125-160[2]	116	260	70	200	107	239	50	--	68	106
Jun 16-20	125-160[2]	103	208	50	200	93	174	50	--	63	117
Jun 21-30	125-160[2]	113	189	50	--	95	162	50	--	59	88
Jul 1-15	--	76	142	50	--	67	100	50	--	38	65
Jul 16-31	--	78	133	50	--	69	104	50	--	37	67
Aug	--	78	126	50	--	73	95	50	--	44	61
Sep	--	76	74	50	--	55	63	36	--	42	43
Oct 1-15	--	103	83	50	--	82	75	36	--	50	51

See notes on next page.

NOTES

Abbreviations: Min: Minimum; Q_i: instantaneous flow; Avg.: Average; BiOp: 2004 Biological Opinion; WAC: Washington Administrative Code; kcfs: thousand cubic feet per second

[1] The 2004 BiOp is issued by the National Marine Fisheries Service (NMFS) regarding the Federal Columbia River Power System (FCRPS). The data in the table are from Bureau of Reclamation, Bonneville Power Administration, and U.S. Army Corps of Engineers (Action Agencies). 2004. Final Updated Proposed Action for the FCRPS Biological Opinion Remand. November 24, 2004.

[2] Objective varies based on actual and forecasted water conditions. The dates to which this flow objective applies include 11/1 to emergence (spring season) which may vary each year.

[3] Objective varies according to water volume forecasts.

Table 3-11. Federal Hydro System Operations for Fish

Location	Project	Action	Affected ESU	Timing	BiOp	Project Type
Lower Columbia Basin	**Bonneville BON**	Operate within 1% of peak turbine efficiency to create smooth, efficient flow over the blades.	Spring & Summer Salmon/Steelhead	Mar 15-Oct 31	Yes	Run of River
		If water conditions indicate that minimum flows of 125 kcfs below BON can likely be maintained: implement mainstem chum flows. If not, provide flows below BON to enable access to spawning areas.	Columbia River Chum	November 1-April	Yes	
		Special operations for hatchery release may include: powerhouse 2 priority operation, operation of bypass system, screens installed, spill.	Spring Creek Hatchery Fish Release	March	**No**	
	The Dalles TDA	Operate within 1% of peak turbine efficiency to create smooth, efficient flow over the blades.	Spring & Summer Salmon/Steelhead	Mar 15-Oct 31	Yes	Run of River
	John Day JDA	Operate within 1% of peak turbine efficiency to create smooth, efficient flow over the blades.	Spring & Summer Salmon/Steelhead	Mar 15-Oct 31	Yes	Run of River
		Operate within 1.5 feet of MOP to reduce juvenile travel time.	Spring Salmon/Steelhead	Apr 10-Sep 30	Yes	
		Operate within 1.5 feet of level that will allow irrigation to reduce juvenile travel time.	Summer Salmon/Steelhead	Mar 15-Oct 31	Yes	
	McNary MCN	Flow objective of 220-260 kcfs.	Spring Salmon/Steelhead	April 10-June 30	Yes	Run of River
		Flow objective of 200 kcfs.	Summer Salmon/Steelhead	July 1-August 31	Yes	
		Operate within 1% of peak turbine efficiency to create smooth, efficient flow over the blades.	Spring & Summer Salmon/Steelhead	Mar 15-Oct 31	Yes	
	BON, TDA, JDA, MCN	Spring Spill.	Spring Salmon/Steelhead	Approx. April 10-June 30	Yes	
	BON, TDA, JDA	Summer Spill.	Summer Salmon/Steelhead	Approx. July 1-August 31	Yes	

See notes at end of table.

Location	Project	Action	Affected ESU	Timing	BiOp	Project Type
Mid Columbia Basin	**Priest Rapids* PRD**	Flow objective of 135 kcfs.	Spring Salmon/Steelhead	Approx. April 10-June 30	Yes	Run of River
	Priest Rapids* PRD	Hanford Reach protection flows. Grant County PUD limits outflow to minimize juvenile fish stranding.	Salmon/Steelhead	Routinely	**No**	Run of River
	Priest Rapids* PRD	Vernita Bar protection flows. Flow management from Priest Rapids Dam to ensure that fall chinook salmon spawn at an elevation which allows the redds to remain under water. Flow fluctuations are limited from the time of fry emergence.	Upper Columbia River Fall Chinook Salmon	Approx. October-June	**No**	Run of River
Upper Columbia Basin	**Chief Joseph CHJ**	**No Special Operations.**				Run of River
	Grand Coulee GCL	Draft for summer flow augmentation, not to exceed reservoir draft limit.	Summer Salmon/Steelhead	July-August	Yes	Storage
		Operate Banks Lake 5 feet less than full to provide water for summer flow augmentation.	Summer Salmon/Steelhead	July-August	Yes	
		Consider opportunities for flood control shift with Brownlee and Dworshak for Lower Snake flow augmentation.	Summer Salmon/Steelhead	Routinely	Yes	
		Storage may be used to support chum flows.	Columbia River Chum	Fall-Winter	Yes	
		Fill to 1,283 ft. by Oct. 1 and maintain elevation of 1,283 to 1,285 or greater through October.	Kokanee	Fall-Winter	**No**	
	Libby LIB	Provide pulsed flows for sturgeon.	Kootenai White Sturgeon	October	Yes	Storage
		Operate to minimum flows and project ramp rates to minimize adverse affects to flow fluctuations.	Bull Trout	Year round	Yes	
		Storage may be used to support chum flows.	Columbia River Chum	Fall-Winter	Yes	
		Operate to meet flow objectives and June 30 refill.	Spring Salmon/Steelhead	Spring	Yes	
		Maintain low flows (considered annually).	Burbot	December-February	**No**	

See notes at end of table.

Location	Project	Action	Affected ESU	Timing	BiOp	Project Type
Upper Columbia Basin Cont.	**Albeni Falls ALF**	Maintain elevation of 2,055 feet until Kokanee fry emergence to provide Bull trout forage.	Bull Trout	Fall-Winter	Yes	Storage
		Storage may be used to support chum flows.	Columbia River Chum	Fall-Winter	Yes	
	Hungry Horse HGH	Operate to minimum flows and project ramp rates to minimize adverse affects to flow fluctuations.	Bull Trout	Year round	Yes	Storage
		Draft for summer flow augmentation, not to exceed reservoir draft limit.	Summer Salmon/Steelhead	July-August	Yes	
		Storage may be used to support chum flows.	Columbia River Chum	Fall-Winter	Yes	
Lower Snake Basin	**Ice Harbor IHR**	Operate within 1 foot of MOP to reduce juvenile travel time.	Spring & Summer Salmon/Steelhead	Approx. April 3 - late August	Yes	Run of River
		Operate within 1% of peak turbine efficiency to create smooth, efficient flow over the blades.	Spring & Summer Salmon/Steelhead	Mar 15-Nov 30	Yes	
	Lower Monumental LMN	Operate within 1 foot of MOP to reduce juvenile travel time.	Spring & Summer Salmon/Steelhead	Approx. April 3 - late August	Yes	Run of River
		Operate within 1% of peak turbine efficiency to create smooth, efficient flow over the blades.	Spring & Summer Salmon/Steelhead	Mar 15-Nov 30	Yes	
	Little Goose LGS	Operate within 1 foot of MOP to reduce juvenile travel time.	Spring & Summer Salmon/Steelhead	Approx. April 3 - late August	Yes	Run of River
		Operate within 1% of peak turbine efficiency to create smooth, efficient flow over the blades.	Spring & Summer Salmon/Steelhead	Mar 15-Nov 30	Yes	
	Lower Granite LWG	Flow objective of 85-100 kcfs.	Spring Salmon/Steelhead	April 3-June 20	Yes	Run of River
		Operate within 1 foot of MOP to reduce juvenile travel time.	Spring & Summer Salmon/Steelhead	Approx. April 3 - late August	Yes	
		Operate within 1% of peak turbine efficiency to create smooth, efficient flow over the blades.	Spring & Summer Salmon/Steelhead	Mar 15-Nov 30	Yes	
		Flow objective of 50-55 kcfs.	Summer Salmon/Steelhead	June 21-August 31	Yes	

See notes at end of table.

Location	Project	Action	Affected ESU	Timing	BiOp	Project Type
Lower Snake Basin Cont.	**Dworshak DWR**	Draft for summer flow augmentation and water temperature reduction, not to exceed reservoir draft limit.	Summer Salmon/Steelhead	Summer	Yes	Storage
		Storage may be used to support chum flows.	Columbia River Chum	Fall-Winter	Yes	
	IHR, LMN, LGS, LWG	Spring Spill, no voluntary spill at the Snake River collector projects (LMN, LGS, LWG) when seasonal average flows are forecast to be less than 85 kcfs.	Snake River Spring Salmon/Steelhead	Approx. April 3 - June 20	Yes	
	IHR	Summer Spill.	Snake River Summer Salmon/Steelhead	Approx. June 21-August 31	Yes	
Upper Snake Basin	**Black Canyon** **Boise Diversion** **Anderson Ranch** **Minidoka** **Palisades**	Reclamation will attempt to provide 427 kaf from Upper Snake projects for flow augmentation.	Snake River Spring & Summer Salmon/Steelhead	Spring & Summer	Yes	Storage, one diversion project

NOTES

Source: Bonneville Power Administration. 2006. Bonneville Power Administration Comments on the Water Supply Inventory and Long-Term Water Supply and Demand Forecast Draft Report. November 8, 2006.

* Non-Federal Project

Table 3-12. Key International and Interstate Agreements

Agreement	Parties	Description/Terms[1]	Expiration
International			
Boundary Waters Treaty of 1909	United States and Canada	Created the International Joint Commission (IJC) to address international water right disputes.	None
Columbia River Treaty of 1961	United States and Canada	• Provided for the construction of four dams on the upper Columbia River for flood control and hydropower generation. • Canada can divert up to 1.5 million acre-feet of water from the Kootenay River into the headwaters of the Columbia River. • Canada can divert water until 2064 as long as the flow in the Kootenay River is 2,500 cfs at the border.	Option[2]
Pacific Salmon Treaty of 1985	United States and Canada	Maintain an adequate water quantity and quality to sustain salmon fisheries in the Columbia River.	None
Lake Roosevelt-Columbia River Treaty and Tributary Systems	Washington and Canada	Delineates cooperation and coordination on water quality discharges and large consumptive use withdrawals above 10 cfs on the Columbia River or tributary systems that affect both Washington and Canada.	None
Interstate			
Columbia River Compact of 1999	Washington and Oregon	Provides the authority for Washington and Oregon to adopt seasons and rules for Columbia River commercial fisheries.	None

NOTES

Abbreviations: cfs: cubic feet per second

[1] Based on information in National Research Council (2004) and Ecology (2003).

[2] Although the treaty has no expiration date, both countries have the option to terminate the Treaty in 2024 with a 10-year advanced notice.

Table 3-13. Columbia River Monitoring Network – Mainstem[1]

Gage Name	Gage No.	Agency	Real Time Data Available	Flow Data Available	Stage Data Available
Columbia River at Donald	08NB005	Environment Canada	Yes	Yes	Yes
Columbia River at Birchbank	08NE049	Environment Canada	Yes	Yes	Yes
Columbia River at International Boundary	12399500	USGS	Yes	Yes	Yes
Columbia River at Grand Coulee, WA	12436500	USGS	No	Yes	No
Columbia River at Bridgeport, WA	12438000	USGS	No	Yes	No
Columbia River below Wells Dam, WA	12450700	USGS	No	Yes	No
Columbia River at Rocky Reach Dam, WA	12453700	USGS	No	Yes	No
Columbia River below Rock Island Dam, WA	12462600	USGS	No	Yes	No
Columbia River below Priest Rapids Dam, WA	12472800	USGS	Yes	Yes	Yes
Columbia River on Clover Island at Kennewick, WA	12514500	USGS	No	No	Yes
Columbia River at The Dalles, OR	14105700	USGS	Yes	Yes	Yes
Columbia River below Bonneville Dam, OR	14128870	USGS	Yes	No	Yes
Columbia River at Vancouver, WA	14144700	USGS	Yes	No	Yes
Columbia River at Beaver Army Terminal Near Quincy, OR	14246900	USGS	Yes	Yes	Yes

NOTES
Abbreviations: No.: Number; WA: Washington; OR: Oregon; USGS: U.S. Geological Survey
[1] Data are available on the Environment Canada and USGS websites. The Environment Canada website is http://scitech.pyr.ec.gc.ca/waterweb/formNav.asp [Accessed September 13, 2006], and the USGS website is http://waterdata.usgs.gov/nwis/inventory/ [Accessed September 13, 2006].

Table 3-14. Columbia River Monitoring Network – Tributaries[1]

Gage Name	Gage No.	Agency	Real Time Data Available	Flow Data Available	Stage Data Available
Kicking Horse River at Golden	08NA006	Environment Canada	Yes	Yes	Yes
Kootenay River At Fort Steele	08NG065	Environment Canada	Yes	Yes	Yes
Pend Oreille River At International Boundary	12398600	USGS	Yes	Yes	No
Kettle River Near Laurier, WA	12404500	USGS	Yes	Yes	Yes
Colville River At Kettle Falls, WA	12409000	USGS	Yes	Yes	Yes
Spokane River At Long Lake, WA	12433000	USGS	No	Yes	No
Okanogan River At Malott, WA	12447200	USGS	Yes	Yes	Yes
Methow River Near Pateros, WA	12449950	USGS	Yes	Yes	Yes
Chelan River At Chelan, WA	12452500	USGS	No	Yes	No
Entiat River Near Entiat, WA	12452990	USGS	Yes	Yes	Yes
Wenatchee River At Monitor, WA	12462500	USGS	Yes	Yes	Yes
Yakima River At Kiona, WA	12510500	USGS	Yes	Yes	Yes
Snake River Near Anatone, WA	13334300	USGS	Yes	Yes	Yes
Walla Walla River Near Touchet, WA	14018500	USGS	Yes	Yes	Yes
Umatilla River Near Umatilla, OR	14033500	USGS	Yes	Yes	Yes
John Day River At Mcdonald Ferry, OR	14048000	USGS	Yes	Yes	Yes
Deschutes River At Moody, Near Biggs, OR	14103000	USGS	Yes	Yes	Yes
Klickitat River Near Pitt, WA	14113000	USGS	Yes	Yes	Yes
Hood River At Tucker Bridge, Near Hood River, OR	14120000	USGS	Yes	Yes	Yes
White Salmon River Near Underwood, WA	14123500	USGS	Yes	Yes	Yes
Sandy River blw Bull Run River, Nr Bull Run, OR	14142500	USGS	Yes	Yes	Yes
Willamette River At Portland, OR	14211720	USGS	Yes	Yes	Yes
Lewis River At Ariel, WA	14220500	USGS	Yes	Yes	Yes
Cowlitz River At Castle Rock, WA	14243000	USGS	Yes	Yes	Yes

See notes on next page.

NOTES

Abbreviations: No.: Number; WA: Washington; OR: Oregon; USGS: U.S. Geological Survey

[1] The closest active gaging station to the Columbia River on the tributary. Data are available on the Environment Canada and USGS websites. The Environment Canada website is http://scitech.pyr.ec.gc.ca/waterweb/formNav.asp [Accessed September 13, 2006] and the USGS website is http://waterdata.usgs.gov/nwis/inventory/ [Accessed September 13, 2006].

Table 3-15. Columbia River Basin Water Forecasting Activities

Forecast Parameter	Agency	Forecast Activity Description
Climate, Drought	NOAA Climate Prediction Center	Produces weekly drought forecasts based on the Palmer Drought Severity Index. Includes prognostic discussions for monthly outlooks. Also provides monthly and long-lead (3-month) climate forecasts for the entire US.
Excessive Rainfall Significant River Flood Outlook Water Supply Outlooks	NOAA National Weather Service Hydrological Information Center	Provides outlooks for where rain intensities could cause flash flooding, five-day flood forecasts, and information on water supply conditions, focusing on inflow forecasts for reservoirs.
Extreme Weather Risk, Climate	University of Washington Climate Impacts Group (CIG)	Produces forecasts of extreme events in the Pacific Northwest (such as warm days, cold days, extreme precipitation, heavy snowfall) based on statistical relationships between extreme events and climate indicators such as El Nino. Also produces seasonal climate forecasts.
Reservoir Elevations	Columbia Basin Trust, Water Initiatives (Canada)	Forecasts Upper and Lower Columbia Basin reservoir elevations based on projected weather patterns and load requirements.
Salmon	Washington Department of Fish and Wildlife	Produces seasonal forecasts of returning salmonid species to the Columbia River.
Streamflow	Bonneville Power Administration (BPA)	BPA's streamflow forecast "system is based on the operational National Weather Service River Forecast System (NWSRFS), which includes conceptual hydrologic models for snow cover simulation and soil moisture accounting, as well as hydrologic and dynamic streamflow routing models and a reservoir operations model. The system incorporates historical, current, and future meteorological and hydrologic conditions and provides forecast information for daily operations and seasonal planning purposes. Users are able to graphically examine meteorologic and hydrologic conditions throughout the basin, run models to simulate streamflow responses to precipitation and temperature, and analyze the results for the specified forecast window."
Streamflow	Natural Resources Conservation Service (NRCS)	Produces seasonal volume forecasts once per month for various stations in the western US using multiple linear regression techniques. Forecasts are are percent exceedence (10%, 30%, 50%, 70%, 90%) over periods from forecast date – June and forecast date –September. Mid-month forecasts and ensemble prediction forecasts are produced for select basins. Seasonal forecasts are produced in cooperation with the River Forecast Center.

Forecast Parameter	Agency	Forecast Activity Description
Streamflow	NOAA National Weather Service River Forecast Center	Produces streamflow forecasts three times per month for various western US stations and durations including 14 days, 120 days, season, and short-term peak flow. Forecasts use of regression-based methods and statistical methods (Ensemble Streamflow Prediction) to predict both regulated and unregulated streamflows. Seasonal forecasts are produced in cooperation with the NRCS.
Streamflow	U.S. Army Corps of Engineers (Corps)	Produces forecasts of streamflow and reservoir elevation. Also produces seasonal forecasts of flood control volumes in the Upper, Middle, and Lower Columbia River.
Streamflow	University of Washington Land Surface Hydrology Group	Produces experimental seasonal streamflow and volume forecasts once per month for various stations throughout the western US using the statistical Ensemble Streamflow Prediction method. Forecasts may be based on output from climate prediction models.
Water Supply	National Weather Service - Portland	Produces forecasts for water supply based on snowpack, precipitation, current and forecast streamflow and irrigation reservoir levels.
Water Supply	U.S. Department of the Interior, Bureau of Reclamation	Forecasts water supply based on the Modular Modeling System (MMS) used for research and operational applications.

Table 3-16. Data Sources for Climate, Water Supply and Streamflow Prediction[1]

Streamflow Forecasts	
Map and Data: Northwest River Forecast Center	
Climate Change/Prediction	
Map: Monthly and Seasonal Color Outlook	EPA's Global Warming Site
Report: West Coast Governors' Global Warming Initiative	British Columbia -Water, Air, and Climate Change Branch
University of Washington - Climate Impacts Group	Climate Change and Oregon
UW Climate Impacts Group quarterly electronic newsletter	California Climate Change Portal
Office of the Washington State Climatologist	United Nations Environmental Network - Climate Change
Pacific Climate Impacts Consortium	
Snowpack/Precipitation	
Map: NOAA Regional Snow Analyses: Northwest	**Summary:** NOAA SNOTEL Snow/Precipitation Update (choose Washington State for summary - current/average by basin)
Map: NOAA SNOTEL Current Snow Conditions	**Summary:** NOAA SNOTEL Pacific Northwest Region
Report NOAA SNOTEL	**Map:** Precipitation and Temperature Average Ecology
Summary: NOAA SNOTEL Snow water Equivalent Update Graph (percent of average by basin)	Snow/Precipitation Update (by basin with basin-wide percent of average)
Reservoirs	
Map: Yakima River Basin Major Storage Reservoirs (tea cup)	**Summary:** NRCS Basin Wide Reservoir Summary
Monthly Basin Reports/Forecasts	
Report: Washington State Basin Outlook Report	**Map:** Spring and Summer Streamflow Forecasts
Report: Western Snowpack Conditions and Water Supply Forecast Summaries	**Map:** Mountain Snowpack (first of every month)
Summary: 2005-2006 NOAA U.S. Winter Outlook	
Current and Seasonal Drought Information	
Map: Drought Monitor: Forecasts	**Map:** U.S. Seasonal Drought Outlook (updated quarterly)
Map: Drought Monitor: Current Conditions	**Map:** Animated Indicator Maps for U.S. Drought Monitor
Map: U.S. Drought Monitor (weekly update of drought conditions)	U.S. Water Monitor - A Portal To Federal Water Information

NOTES

Abbreviations: EPA: U.S. Environmental Protection Agency; NOAA: National Oceanic and Atmospheric Administration; NRCS: Natural Resources Conservation Service

[1] This table is a snapshot of a page from Ecology's website: http://www.ecy.wa.gov/programs/wr/ws/wtrsuply.html.

FIGURES