Appendix M: Integrating Fish & Wildlife and Power Planning

SUMMARY OF KEY FINDINGS

The Columbia River Basin hydroelectric system is a limited resource that is unable to completely satisfy the demands of all users under all circumstances.[1] Conflicts often arise that require policy makers to decide how to equitably allocate this resource. The Council's *Columbia River Basin Fish and Wildlife Program* and *Electric Power and Conservation Plan* must provide measures to "protect, mitigate, and enhance fish and wildlife affected by the development, operation, and management of [hydropower] facilities while assuring the Pacific Northwest an adequate, efficient, economical, and reliable power supply."

The regional power supply has reliably provided actions specified to benefit fish and wildlife (and absorbed the cost of those actions) while maintaining an adequate, efficient, economic and reliable energy supply. This is so even though the hydroelectric operations specified for fish and wildlife have a sizeable impact on power generation. The Council's current assessment[2] indicates that new resources and conservation are required to maintain the power supply's adequacy, in particular for summer peaking needs.

On average, hydroelectric generation is reduced by about 1,200 average megawatts, relative to an operation without any constraints for fish and wildlife.[3] For perspective, this energy loss represents about 10 percent of the hydroelectric system's firm generating capability.[4] Since 1980, the power system has addressed this impact by acquiring conservation and generating resources, by developing resource adequacy standards, by implementing strategies to minimize power system emergencies and events that might compromise fish operations, and by using revenues generated by the system to cover costs. As described at the conclusion of Chapter 13,

---

[1] Some of the many uses of the Columbia River hydroelectric system include flood control, power generation, irrigation, recreation, navigation and protection for fish and wildlife.
[2] See Chapter 14.
[3] The comparison study, which includes no actions for fish and wildlife, is represented by hydroelectric operations prior to 1980.
[4] Firm hydroelectric generating capability is about 11,900 average megawatts (2007 Bonneville White Book) and is based on the critical hydro year, which is currently defined to be the 1937 historical water year.

Bonneville estimates its total financial obligation for the fish and wildlife program to be between $750 to $900 million per year, combining ordinary and capital expenditures, power purchases, and foregone revenues associated with operations to benefit fish and wildlife (when compared to a scenario with no such operations). Increased costs and reduced revenues due to operations for fish result in increased electricity prices, but the power system remains economical in a broad affordability sense.

Looking toward the future, there remain a number of uncertainties surrounding the operation of the hydroelectric system, which must be addressed in the development of the power plan. These uncertainties can have both positive and negative effects. For example, spillway weirs offer the potential to reduce bypass spill while providing the same or better passage survival. On the other hand, current bypass spill levels may change due to adaptive management or litigation. Climate change has the potential to alter river flows, which affect both power production and fish survival. The potential of dam removal or of operating reservoirs at lower elevations would further reduce power production. The Council recommends that the region continue to monitor fish and wildlife activities and to continue to develop better analytical methods to assess both power and biological impacts.

Outside of the Council's own power planning effort, there is no forum or process in the region that specifically addresses long-term planning issues related to the integration of power planning and fish and wildlife operations. The Council will investigate using existing forums to facilitate such discussions or, if necessary, explore the possibility of creating a separate forum where fish and wildlife managers and power planners could jointly explore longer-term strategies to improve both fish and wildlife benefits and hydroelectric power operations. In such a forum, synergistic effects between fish and wildlife operations and power planning could be examined.

INTEGRATING THE FISH AND WILDLIFE PROGRAM AND POWER PLANNING UNDER THE NORTHWEST POWER ACT

The many storage and hydroelectric facilities built in the Columbia River Basin provide a number of benefits to the citizens of the Pacific Northwest and Canada. This includes the fact that, on average, the US portion of the hydroelectric system provides nearly 75 percent of the electricity needs for the northwest.[5] Development of the hydroelectric system, however, has also had adverse effects on salmon and steelhead and other native species of fish and wildlife in the basin. In the Northwest Power Act, Congress directed the Council to lead an on-going effort to find the best ways to operate the hydrosystem and further develop the region's power supply so as to improve the survival of fish and wildlife affected by the system while also meeting the region's growing electricity demands with the least-cost conservation and generating resources.[6]

The Northwest Power Act directs the Council to integrate planning for fish and wildlife and electric power resources in a recurring two-step planning process. The first step is to develop or amend the fish and wildlife program; the second is to include the fish and wildlife program in the

[5] Hydroelectric generation in the Pacific Northwest averages about 16,000 average megawatts and annual demand is about 21,000 average megawatts.

[6] The development and operation of the hydroelectric system also affects flood control, irrigation, navigation, recreation, water for municipal and industrial uses, Native American cultural resources, and water quality. All of these effects must be taken into account as the relevant agencies plan and operate the system. But the Power Act has a particular focus on the relationship between fish and wildlife and electrical energy, and so that is the focus here.

power plan, developing the coordinated resource plan described throughout this power plan that accommodates the fish and wildlife requirements while meeting the changing electricity demands of the region. This is the Council's central fish and wildlife/power "integration" function under the Power Act. Thus the first part of this appendix is devoted to explaining how the power planning process and the power system add least-cost resources over time to keep the electricity supply in balance while accommodating all the changes that affect that load/resource balance, including the effects of fish and wildlife operations. This part of the appendix also briefly discusses the matter of the costs of integrating fish and power operations.

The second part of this appendix discusses future uncertainties that would affect the fish and wildlife program and the power supply. These include uncertainties and risks related to (1) possible future changes in the fish and wildlife program; (2) an evolving power system that must integrate different kinds of generating resources, which will put more stress on the hydroelectric system; (3) possible modifications in Columbia River Treaty operations; and (4) climate change effects on the amount and timing of runoff and on electricity demands that would pose problems for both fish and wildlife and power generation.

POWER RESOURCE PLANNING THAT ACCOMMODATES THE POWER SYSTEM EFFECTS OF THE FISH AND WILDLIFE PROGRAM

This part of the appendix is devoted to explaining how the power planning process and the power system add least-cost resources over time to maintain an adequate power supply while accommodating all the changes that affect the load/resource balance, including the effects of the fish and wildlife operations.

Prior to the development of the first power plan, the Power Act directed the Council to call for recommendations and adopt the *Columbia River Basin Fish and Wildlife Program*. Prior to each five-year review of the regional power plan, the Council must first call for recommendations and amend the fish and wildlife program. Leading into the Sixth Power Plan, for example, the Council recently completed amendments to the fish and wildlife program, resulting in the *2009 Columbia River Basin Fish and Wildlife Program* (www.nwcouncil.org/fw/program).

In this first stage in the planning sequence, the Power Act requires the Council to adopt fish and wildlife program measures that will "protect, mitigate, and enhance fish and wildlife" affected by the development and operation of the basin's hydroelectric facilities, and to do so while also assuring the region an "adequate, efficient, economical, and reliable power supply." To this end the Council's fish and wildlife program contains, among other measures, mainstem flow and passage measures (such as bypass spill) that affect hydroelectric system operations. These flow and passage measures have evolved over time, differing with each new version of the program. The changing flow and passage measures alter power generation at the mainstem dams, shifting flows and generation from winter to spring and summer as reservoir storage operations have changed to benefit fish and wildlife, and reducing potential generation in spring and summer by increasing bypass spill at run-of-the-river dams to improve fish passage survival.

Each time the Council considers and adopts a revised fish and wildlife program, it must also assess how the revised program measures will affect the region's power supply, and then evaluate, albeit in a preliminary way, if it will be possible to accommodate these changes and still assure the region an adequate, efficient, economical, and reliable power supply. The power system evaluation at this stage is necessarily preliminary. This is because what will follow immediately will be a comprehensive power planning effort that will assess whether and how to adapt the power system and add resources to accommodate changing loads and resources, including the effects on power supply of the revised fish and wildlife program.

The power plan process is then the second step in the integration of fish and wildlife program measures and power system expansion under the Northwest Power Act. The Northwest Power Act describes a regional conservation and power planning process, with an element of that planning effort focused on Bonneville's obligations and its federal system resources. As described in the main text of the power plan above, the Council projects a range of electricity demand scenarios over the next 20 years, and also assesses the amount and status of current electric power resources in the region. The Council then develops a plan for adding the lowest-cost new resources to the regional system, including (as a first priority) cost-effective conservation, and evaluates how well that plan will accommodate projected demand and other effects on the region's power supply and still maintain an adequate and reliable system. The act also calls for the plan to include a forecast of the resources required to meet Bonneville's load obligations and the portion of such obligations the Council determines can be met by conservation and by various categories of generating resources.

What's important here is that the Power Act makes the just-amended fish and wildlife program one element of the power plan. Knowing the latest flow and passage operations of the fish and wildlife program is an important part of assessing the current generating capability of the hydroelectric system at different periods in the year, and the amount of hydroelectric generation available is then one contributor to knowing the total generating capability of current regional power resources. A change in hydroelectric generation due to a change in operations for fish and wildlife is conceptually similar, in terms of the Council's power planning responsibilities under the Power Act, as any other change that will or might affect the load-resource balance and thus need to be accommodated in the resource plan, including an increase in demand for electricity.

The least-cost resource plan the Council develops has to be able to accommodate these current operations, including the fish and wildlife constraints, as well as meet other regional power system needs. The Council's resource plans have emphasized, both for the region and for Bonneville, the acquisition of all cost effective conservation on an ongoing basis, and that ongoing conservation program has contributed the most to maintaining an adequate and reliable power system. The Power Act obligates Bonneville to have that ongoing conservation program and acquire other resources, if necessary, consistent with the Council's power plan to meet its contractual load obligations for electricity and "to assist in meeting the requirements of section 4(h) of this Act" -- that is, to meet the requirements of the Council's fish and wildlife program and Bonneville's corresponding obligation to protect, mitigate, and enhance fish and wildlife in a manner consistent with the Council's program and power plan.

This is not just an "energy" issue. New or revised fish and wildlife operations alter the amount of overall energy that the hydropower system can produce, but they also alter the peaking capability of the hydroelectric system in winter and reduce the flexibility of the system to follow load and balance other variable resources, which is a growing issue with the regional power system. The Sixth Power Plan is looking at regional resource needs in all these categories --

energy, capacity, and flexibility. Changes in fish and wildlife operations can affect the power system in all three categories.

The 2009 Fish and Wildlife Program and Current Fish Operations

Fish and wildlife actions identified in the 2008 NOAA Fisheries FCRPS Biological Opinion have been recognized in the Council's 2009 Fish and Wildlife Program as the baseline for fish and wildlife operations in the near future. Current operations are actually a combination of flow and passage measures in the 2008 Biological Opinion and additional spill agreed to by the parties and ordered by the federal court in the Biological Opinion litigation in recent years.

The authors of the biological opinion attempted to use best available science to develop a least-harm hydroelectric project operations plan by assessing the magnitude of potential adverse effects on fish resulting from a wide range of operational scenarios. The biological effects of the operational scenarios were estimated using the NOAA Fisheries' COMPASS (Comprehensive Passage and Survival) model, designed specifically for the reaches of the Columbia and Snake rivers extending from Lower Granite Dam to Bonneville Dam.

These provisions have substantive effect with regard to the operation of the mainstem hydropower system in the Columbia and Snake rivers. The mainstem portion of the fish and wildlife program consists of two major types of actions to promote anadromous fish survival that will also affect the power supply: 1) storage reservoir operations to affect flows; and 2) bypass spill for fish passage.[7]

Reservoir Operations

The Biological Opinion/Fish and Wildlife Program operations call for federal storage reservoirs in the United States to be at, and not below, the maximum level specified for flood control operations in early April. This has the effect of requiring system operators to keep water levels behind these dams higher in winter and early spring than they would have (in most years) for an optimum power operation. Monthly flow objectives are then provided for both the Snake and Columbia rivers during a part of the juvenile and adult salmon migration season in spring and summer (April through August) and during the spawning season for Kootenai River white sturgeon below Libby Dam. The reservoir operation in spring largely works toward project refill while otherwise passing the snowmelt runoff downstream to try to achieve the flow objectives.

The fish and wildlife operations target reservoirs for refill by end of June. The Biological Opinion then specifies federal storage reservoirs to draft, up to limits specified in the opinion, in order to augment summer flows to aid in fish survival. This operation results in higher flows over this period than would be normal under a purely power-focused operation. For more than a decade, the federal agencies have also entered into supplemental operating agreements with B.C. Hydro to release water from Canadian storage projects to benefit fish migration in the U.S. in ways that would not occur under ordinary Columbia River Treaty operations. Finally, the operating agencies also release water in late fall and early winter to support chum flow spawning

[7] The Fish and Wildlife Program contains other measures that do not affect system operations, but which do require expenditures by Bonneville, including capital costs for fish passage and the direct cost of other fish and wildlife program actions. These elements of the program are described in more detail below. *See* the Council's 2009 Fish and Wildlife Program and NOAA Fisheries' 2008 Biological Opinion.

and rearing in the lower Columbia, and control operations in the mid-Columbia River to support fall Chinook spawning and rearing in the Hanford Reach.

The main effect of this operation on the power supply is to reduce the generating capability of the hydroelectric system over the winter, at the time of the region's peak loads, and to increase generation when runoff is passed through in the spring and when it is released from storage in the summer, generally producing surplus generation over native regional demand. There is not a one-to-one shift in energy production from winter to spring/summer because of bypass spill requirements.

Bypass Spill

Bypass spill is the re-routing of river flows away from turbine intakes and into fish passage and spillway systems. The survival of migrating juveniles diverted into fish passage systems and over spillways is considerably higher than fish survival rates through the turbines although not always higher than fish that are transported. The Fish and Wildlife Program and NOAA Fisheries Biological Opinion call for the eight federal dams on the lower Snake and Columbia rivers to divert part of their flows through fish bypass systems during spring and summer. As noted above, additional spill has occurred in recent year as a result of a court-approved agreement among the parties to the Biological Opinion litigation. It is not clear whether such additional bypass spill will be required in future years, therefore it was not assumed in the analysis.

Hydropower generation is reduced from what it would be without bypass spill, which is provided in spring and summer months. Bypass spill can affect the firm generating capability of the hydroelectric system, but in most years it translates into a loss of non-firm or surplus power available for sale on wholesale power markets. Surplus power sales are made to serve peak loads or to displace more expensive resources for both Northwest and Southwest utilities. The main effect of surplus sales for Bonneville is to generate revenue that helps to cover the cost of its operation of the federal hydropower system, reducing its debt to the Treasury, and covering other costs, including those for fish and wildlife. Under certain conditions, spill can also reduce reactive support for the transmission system, which leads to reduced transmission capability and could potentially reduce system reliability.[8]

The Biological Opinion/Fish and Wildlife Program specify additional operational limitations, including turbine operating criteria and limits on how fast flows may be ramped up or down through changes in project discharge levels. These constraints have little effect on the total energy production of the system, but instead reduce the system's flexibility to follow load and accommodate varying wind output. These effects are difficult to model or estimate quantitatively, but are real nonetheless.

Modeling the Power System

As part of the power plan effort, the Council has to estimate the current generating capability of the hydroelectric system. Operations for fish and wildlife are only part of this effort, and must

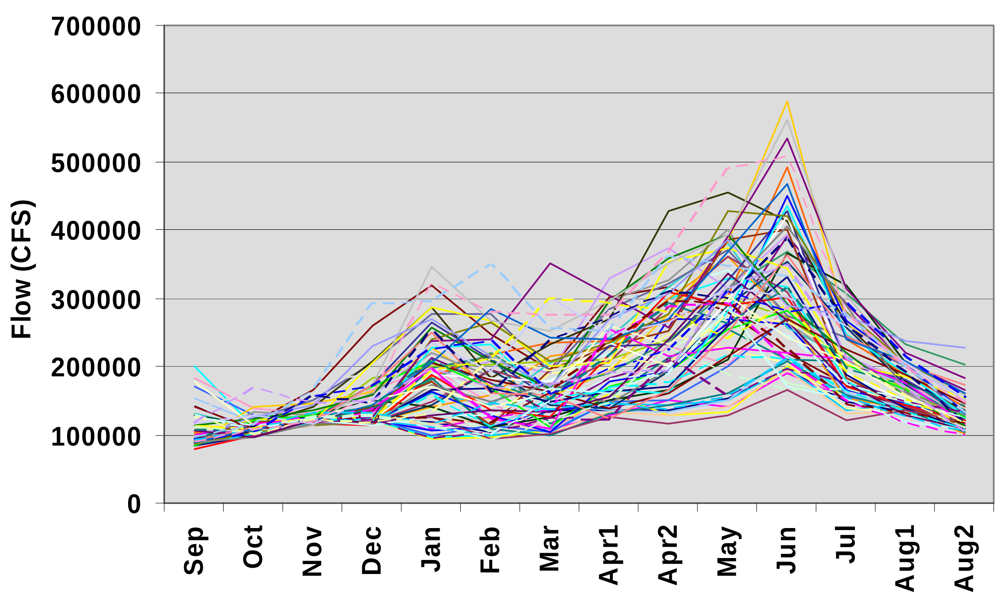
[8] See the Memorandum dated February 24, 1998, memorandum from John Fazio to the Council regarding the transmission impacts of drawing down John Day Reservoir and other fish and wildlife operations (Council document 98-3).

be combined with the runoff pattern (both amount and shape), with operational requirements and constraints for purpose of flood control (which are significant) and navigation, irrigation and other non-power purposes (relatively minor on overall system operations), and power system objectives (i.e., load objectives). The end result is a series of monthly reservoir elevation and flow profiles, and then, especially, monthly generation patterns (bi-monthly in April and August). The modeling effort can be done on a planning basis, using different runoff patterns representing the 70-year historical water record (and the Council and Bonneville both do this), or on an "actual" basis, looking at a past year's actual runoff and generation (Bonneville does this).

The analysis of system operation and hydroelectric generation is performed with the GENESYS model.[9] The model simulates the operation of regional resources including hydroelectric facilities over many different future conditions. For the hydroelectric system, key outputs include regulated outflows, reservoir elevations, and generation. (Another output is cost, but that is addressed in the second part of the appendix.) GENESYS simulates both a monthly and hourly dispatch of available resources to meet regional load. In the monthly mode, it simulates the operation of individual hydroelectric facilities. In the hourly mode, however, the hydroelectric system is operated in aggregate and the peaking capability of that system is approximated using linear programming techniques.

This model is designed to address both energy (monthly and annual) needs and capacity (hourly) needs. The results depicted below are based on the use of GENESYS to analyze the operations outlined in the Council's Fish and Wildlife Program, consistent with those in NOAA Fisheries' 2008 Biological Opinion. Figures M-1 and M-2 show the range of outflows at Lower Granite and The Dalles dams for each of the 70 water conditions modeled. Figure M-3 shows the range of system generation in average megawatts by month and Figures M-4 through M-7 show the range of elevations by month at Libby, Hungry Horse, Grand Coulee and Dworshak dams.

Figure M-1: Flow at The Dalles



[9] See http://www.nwcouncil.org/genesys.

Figure M-2: Flow at Lower Granite

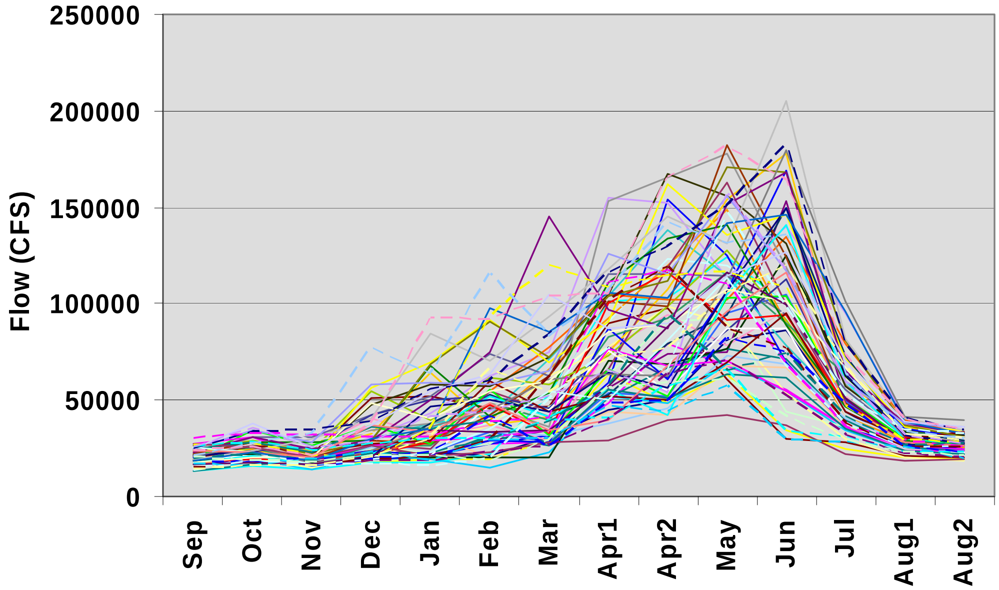


Figure M-3: Hydroelectric Generation

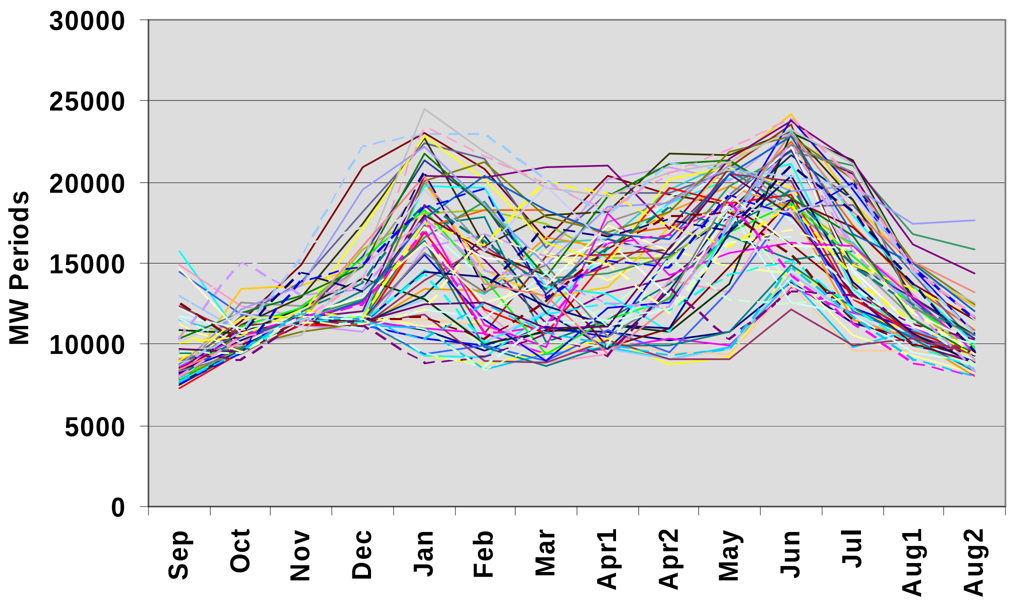


Figure M-4: Elevation at Libby Dam

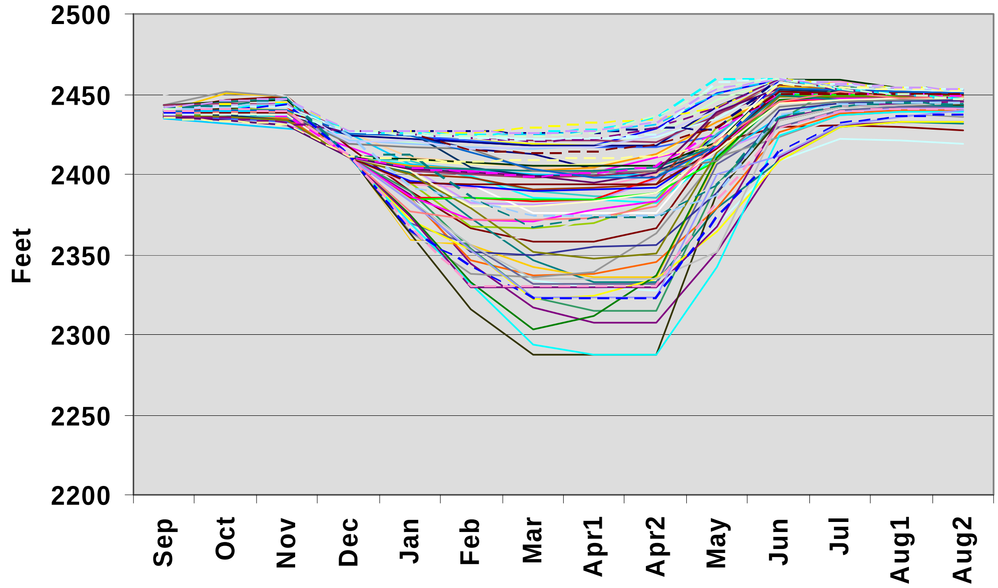


Figure M-5: Elevation at Hungry Horse Dam

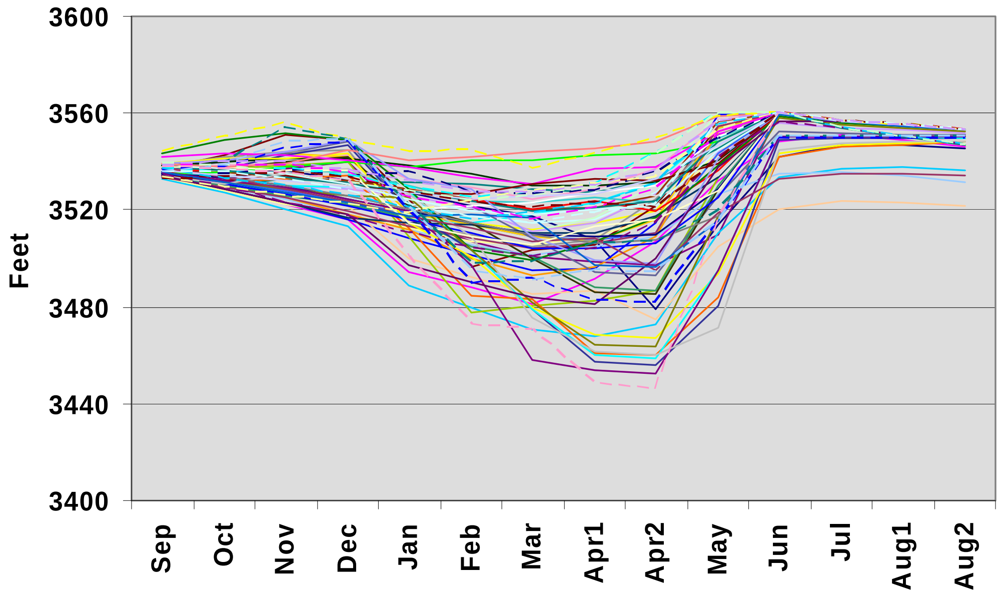


Figure M-6: Elevation at Grand Coulee Dam

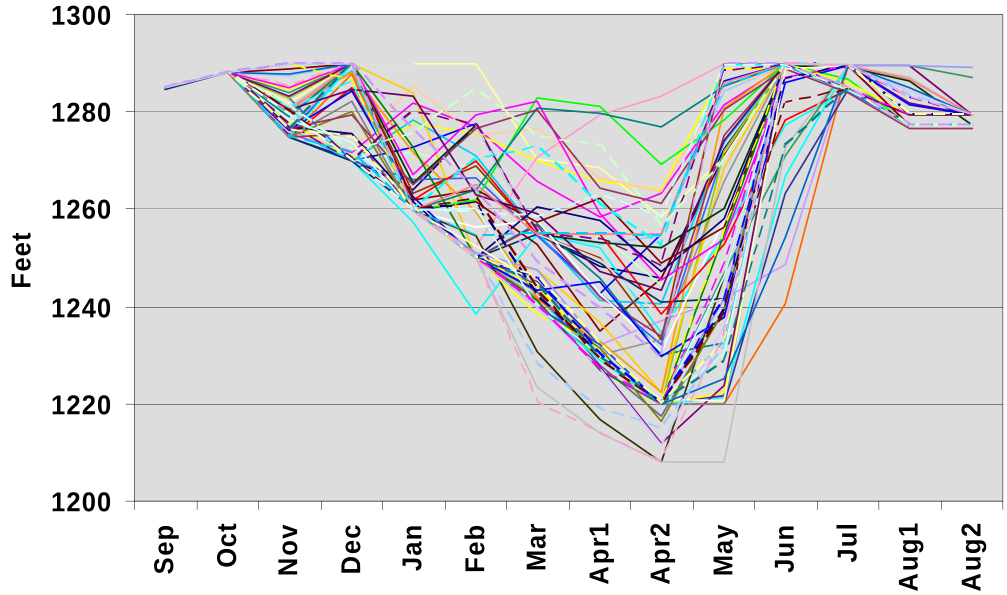
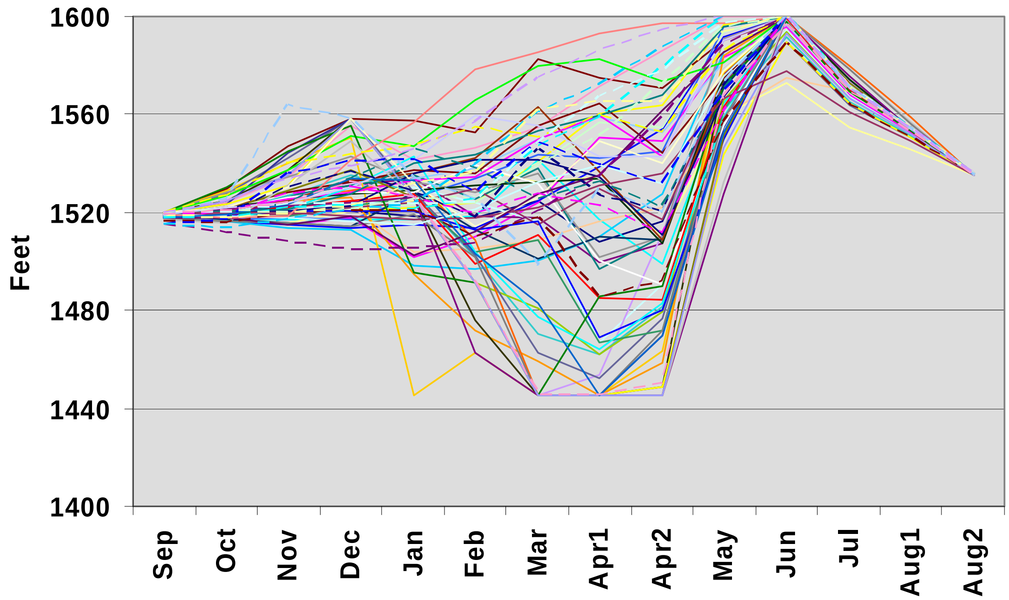


Figure M-7: Elevation at Dworshak Dam



For current resource planning purposes, of course, the more important information is the change in the firm power generating capability since the last iterations of the Fish and Wildlife Program (2003 Mainstem Amendments/2000 FCRPS Biological Opinion) and Power Plan (Fifth Power Plan, December 2004). We did not begin shifting flows and thus generation from winter to spring/summer just recently -- the fish and wildlife program was built to current levels from the original water budget in 1982, with major evolutions ever since. And resource planning and resource acquisitions have accommodated these changes in hydroelectric power production and peak capacity. Although the overall loss of generation attributed to operations for fish are significant, the recent additions to that loss are relatively small. For example, the annual average incremental loss of hydroelectric generation since 2005 due to fish operations is on the order of 20 average megawatts.

For an historical perspective, however, it is important to note total changes in hydroelectric operations since before fish and wildlife measures were first adopted. This information is not important for resource planning or for fish and wildlife decision making, but it is useful for understanding the full magnitude of changes over time. The following charts display these differences.

Figure M-8: Average Outflow at The Dalles Dam

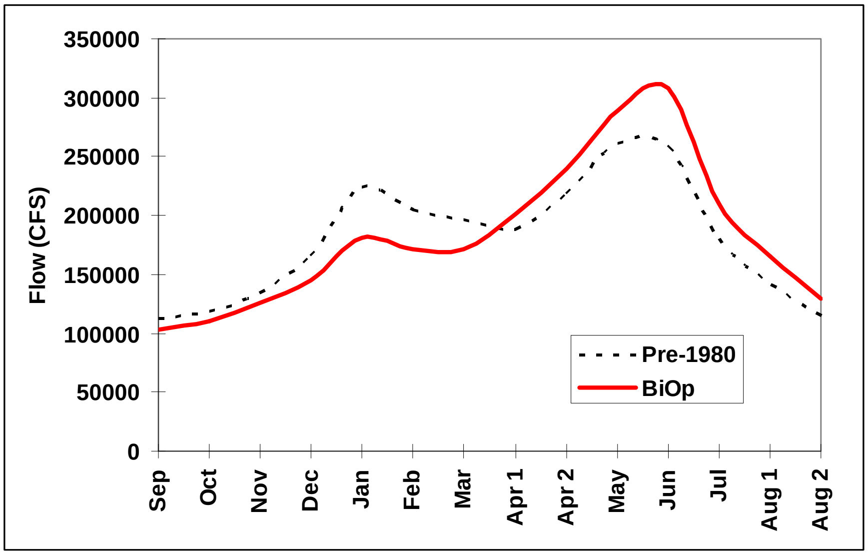
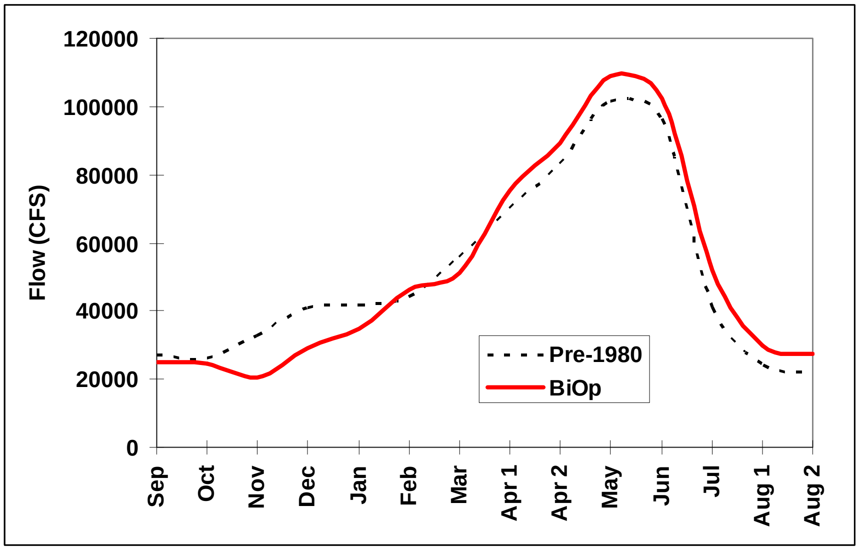


Figure M-9: Average Outflow at Lower Granite Dam



In order to reshape river flows, water in reservoirs that would have been used for power production during winter months is kept in storage for later release during spring and summer. The following four charts (Figures M-10 to M-13) show the average reservoir content for Libby, Hungry Horse, Grand Coulee and Dworshak dams, in units of thousands of second-foot days or

KSFD (one KSFD is equal to about 2000 acre feet or 2 KAF). The pattern of keeping more water in these reservoirs during winter months is clearly apparent in these charts. Additional water is also released at these projects over the summer months, which leaves these reservoirs at lower elevations by the end of August or September. On average, Dworshak reservoir is 80 feet below full, Libby and Hungry Horse are 10 to 20 feet lower and Grand Coulee is between 10 and 12 feet lower by summer's end.

Figure M-10: Average Reservoir Content at Libby Dam

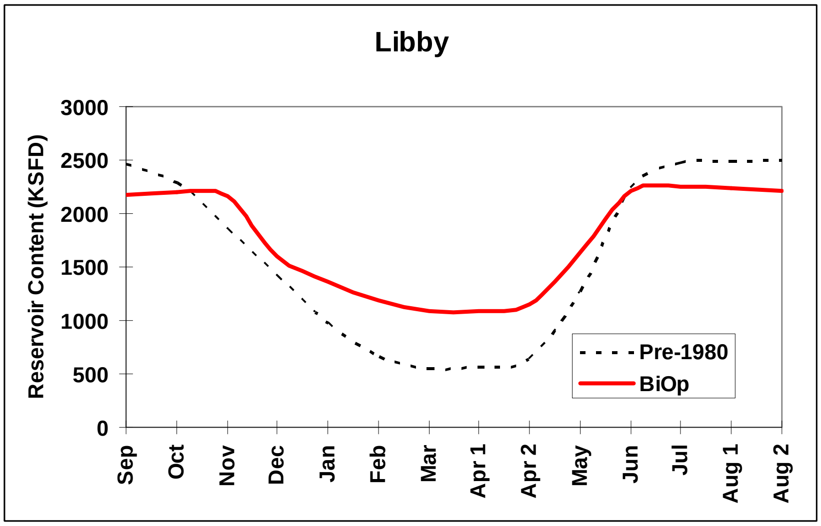


Figure M-11: Average Reservoir Content at Hungry Horse Dam

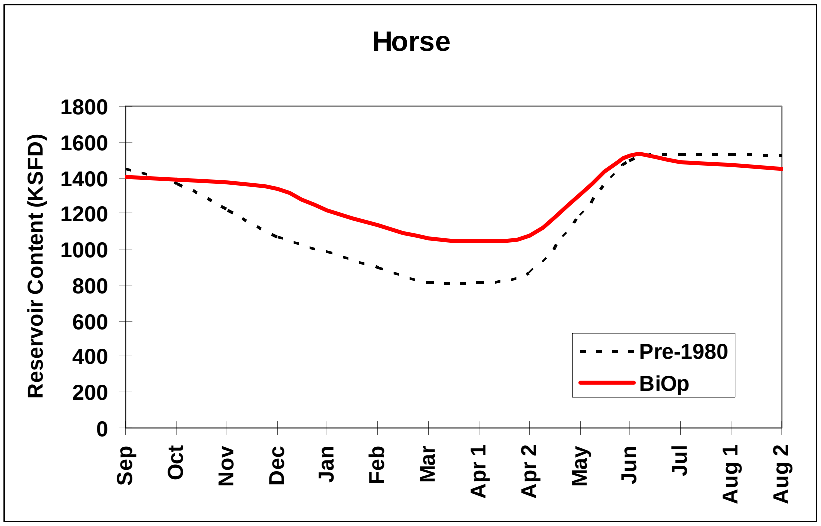


Figure M-12: Average Reservoir Content at Grand Coulee Dam

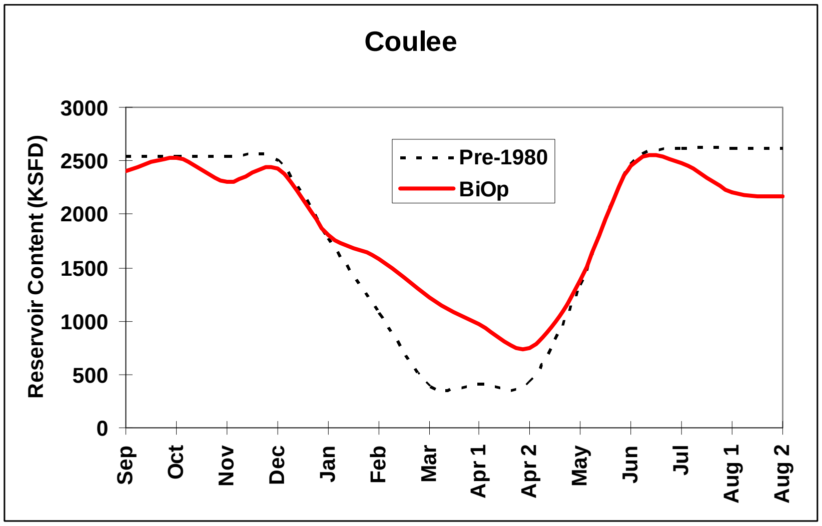
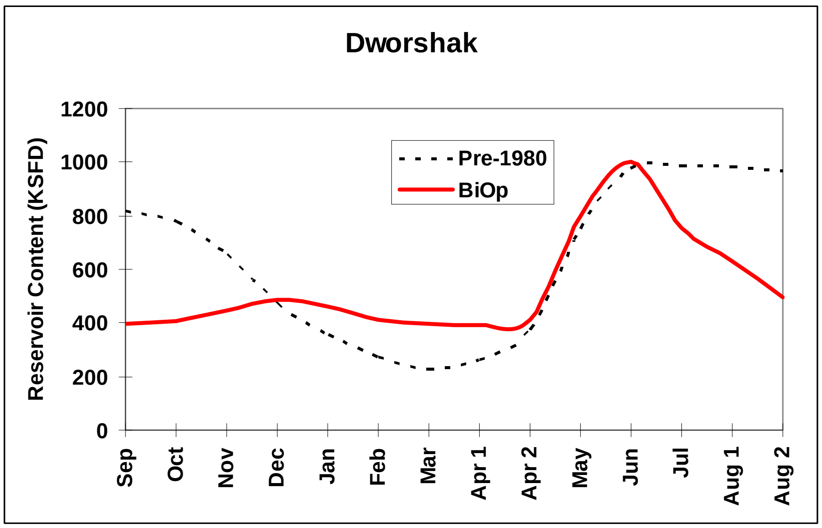


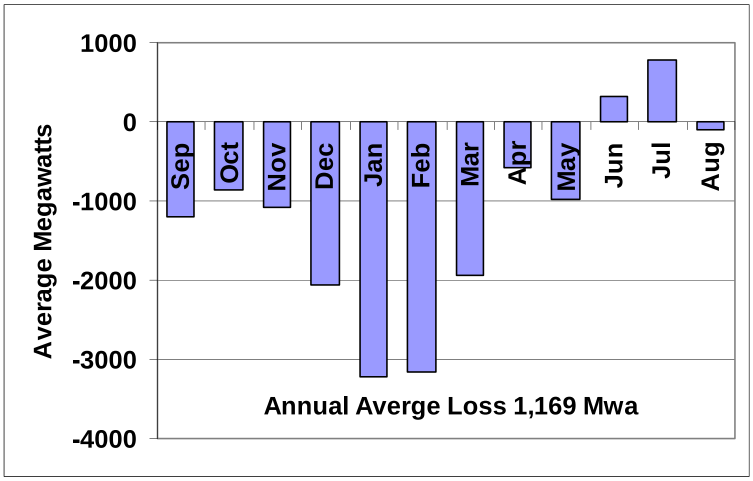
Figure M-13: Average Reservoir Content at Dworshak Dam



Council analysis indicates that, on average, implementation of the program will reduce hydroelectric generation by about 1,200 average megawatts relative to an operation without any constraints for fish and wildlife. For perspective, this energy loss represents about 10 percent of the hydroelectric system's firm generating capability.[10] Figure M-14 below shows the monthly average change in hydroelectric generation between current operations and a pre-1980 operation, which includes no fish and wildlife constraints.

[10] Firm hydroelectric generating capability is about 11,900 average megawatts (2007 Bonneville White Book) and is based on the critical hydro year, which is currently defined to be the 1937 historical water year.

Figure M-14: Change in Monthly Average Hydroelectric Generation since 1980



Resource Planning

As described above, the central purpose of the power plan is to assess the current and projected demand for electricity for the next 20 years and current resources and then develop a plan for acquiring all cost-effective conservation and, if necessary, generating resources to add to that system in order to maintain an adequate and reliable power supply in the Pacific Northwest at the least cost and least risk. Accommodating the effects of the fish and wildlife program is just one part of that resource analysis. The relevant resource analysis and the plan to add resources are described in the main chapters of the Power Plan and in the Action Plan.

Providing an Adequate Operation for Power and Fish

Bonneville and the other federal operating agencies implement the fish and wildlife operations, and the rest of the Fish and Wildlife Program, consistent with the Northwest Power Act, the federal Endangered Species Act, the project authorizations, and other applicable law. The hydroelectric operations to improve fish survival that are specified in the Council's Fish and Wildlife Program also become a part of the power plan. The power plan must be designed to provide both an adequate and reliable power supply and allow for effective implementation of the fish and wildlife operations as part of the program to protect, mitigate, and enhance fish and wildlife resources. The impacts of those fish and wildlife operations are substantial and would definitely affect the adequacy and reliability of the power system, if implemented over a short period of time. However, this has not been the case. As described above, since 1980, the region has periodically amended fish and wildlife-related hydroelectric operations and in each case, the power system has had time to adapt to these incremental changes and has maintained an adequate and reliable power supply.

The Council staff produced a preliminary assessment of the impacts of fish operations on the adequacy and reliability of the power supply during the recent fish and wildlife program amendment process. A more detailed adequacy and reliability assessment is provided in this power plan. That assessment (Chapter 14) indicates that the regional power supply can reliably provide the actions specified to benefit fish and wildlife (and absorb their cost), respond to other challenges to the reliability and adequacy of the regional system described in that chapter, and maintain an adequate, efficient, economic, and reliable energy supply. The assessment indicates that in order to accomplish this task, the region must acquire new resources and conservation over the study horizon period (also see Chapters 9 and 10). Moving forward, the Council's resource adequacy standard provides a minimum threshold for resource development that keeps the likelihood of curtailments to both power and fish operations within acceptable levels.

In addition to the adequacy standard, power planners have become more cognizant of non-emergency situations, such as isolated low flow events, night-time over-generation conditions, and rapid load changes that have compromised fish operations in the past. Planners are actively developing operational protocols to address these situations and to alleviate the pressure to curtail fish operations. For example, the U.S. Army Corps of Engineers (Corps) describes how it intends to deal with these situations in its planned operations for fish passage for 2009 (Corps document number 1693-2, "2009 Spring Fish Operations Plan").

In spite of best laid plans, however, emergencies sometimes occur, and all utilities have contingency actions in place to avoid potential curtailments. We do not and cannot plan and build for 100% assurance of power system operations, nor the same for the operations specified for fish. What we can do is reduce the likelihood of emergencies to an acceptable level (mostly through adding sufficient resources to the system), and then have contingency plans in place to deal appropriately with power and fish emergencies.

Hydro flexibility is one method for dealing with power system emergencies. During periods of rapid load changes or the loss of a major resource or transmission line, reservoirs can be drafted below their normal operating elevations to sustain electricity service. This use of additional hydroelectric generation is often referred to as "hydro flexibility." Hydro flexibility is generally used during cold snaps or heat waves when no other resources are available, including imports from out of region. The additional water drafted to produce extra energy is replaced as soon as possible, even if energy must be imported. Most often reservoirs can recover and get back to required refill elevations. However, in the event that hydro flexibility can not be replaced by early spring, less water would be available for the spring flow operation for fish and wildlife augmentation. The power plan, resource additions, and in-season planning strategies should be designed to reduce the likelihood of situations in which hydro flexibility cannot be replaced prior to the migration season.

Both bypass spill requirements and reduced mainstem reservoir operating limits imposed by the program limit the flexibility of the hydroelectric system. This is important because less flexibility means a reduced ability to meet peaking requirements, provide ancillary services, and integrate wind and other variable resources. Once system flexibility is used up, additional resources may need to be added along with variable generators to provide a reliable supply. This will clearly increase the cost of meeting renewable portfolio standards and may also increase carbon emissions. As discussed in Chapter 12, creative strategies for operating the system to balance renewable resources, and then careful planning to add least-cost resources to meet the system's capacity and flexibility requirements are key to preserving reliable implementation of fish and wildlife operations while maintaining power system reliability.

The FCRPS Biological Opinion allows for curtailment of fish and wildlife operations during power system emergencies, as happened in the very low water year of 2001, but it does not specify an upper bound for such actions. It also includes comparable language that allows deviations from normal power system operations during rare occasions when emergency fish passage conditions occur.

Whenever the region's generating capability lags behind demand growth (as happened in the late 1990s), the risk of having to curtail fish and wildlife operations will increase. Using curtailment of fish and wildlife operations as a last-resort alternative during rare emergencies is allowed under the Biological Opinion language[11]. The key word in the previous sentence is "rare." Analysis showing a high frequency of curtailment to fish and wildlife operations would indicate that the power supply is not adequate. Curtailment of fish and wildlife operations cannot be used in lieu of acquiring resources to maintain an adequate regional power supply. In the same way, power system operations should not be jeopardized an inordinate amount to deal with fish emergencies.[12]

Physical and economic analysis of specific fish and wildlife measures can aid in the development of a fish and wildlife curtailment policy, in the event of a power emergency. It would be in the region's interest to have these policies in place prior to an emergency, in order to minimize the risk to fish. Action item F&W-2 (see the Action Plan) calls for the Council to work with fish and wildlife managers and regional power planners to review existing contingency plans to ensure that they are consistent with the fish and wildlife program and the power plan.

DEALING WITH AN UNCERTAIN FUTURE

Adequately integrating the needs of fish and wildlife and the region's power consumers is a difficult task even when all relevant parameters are known. However, the future will undoubtedly present a number of uncertainties that will continue to challenge planners in their attempts to provide for all river users. These include the uncertainties and risks related to (1) possible further changes in the operations to benefit fish and wildlife; (2) an evolving power system, which must integrate variable output resources (such as wind) that put new and different requirements on the hydropower system; (3) possible modifications in Columbia River Treaty operations over the next decade, for both power and non-power reasons; and (4) climate change effects that are likely to change the amount and shape of runoff and regional electricity demands. This part of the appendix addresses these future uncertainties and their associated risks.

The power plan has a 20-year planning horizon, which requires that potential future changes in the hydroelectric system or for fish and wildlife needs over that time period must be assessed. The resource strategy developed in this power plan must be sufficiently robust to accommodate these potential changes in order to continue to provide benefits for fish and wildlife and an adequate and reliable power supply. The challenge is to identify the uncertain but possible areas of change, assess the possible range of effects and develop a set of actions to accommodate these changes. This implies that the power plan must be flexible and dynamic so that it can deal with uncertainties if and when they occur.

Likely categories for significant change include modifications in operations for fish, reduction in hydroelectric system flexibility due to increasing amounts of variable resources, possible changes in the Columbia River Treaty, climate change, and potential bypass spill reductions associated with spillway weirs.

---

[11] This refers to Reasonable and Prudent Action item 8 in NOAA Fisheries' 2008 FCRPS Biological Opinion.
[12] This refers to Reasonable and Prudent Action item 9 in NOAA Fisheries' 2008 FCRPS Biological Opinion.

The Council along with other regional entities, including the Independent Economic Analysis Board[13] recently examined the interactions between fish and power operations and identified several important factors to be considered in the development of this plan:

- In the long term, hydroelectric generation could increase due to installation of spillway weirs at federal dams. Spillway weirs are designed to increase juvenile migrant passage survival while reducing the volume of bypass spill. However, the Council assumed no long-term increase in hydroelectric generation due to spillway weirs.

- There remains a great deal of uncertainty regarding the amount of future bypass spill. It is possible that long-term hydroelectric generation will change due to adaptive management or litigation. However, quantifying this potential change is difficult. The Council's resource strategy analysis does not include changes in bypass spill as an uncertainty. It assumes that bypass spill levels are fixed, as specified in the 2008 Biological Opinion. Additional court-ordered spill, which has been implemented since 2005, is not included in the analysis because it is uncertain whether it will be incorporated into long-term Biological Opinion operations. The additional spill essentially requires dams to spill up to their maximum allowable dissolved gas levels (e.g., within the states' Clean Water Act standards). On an annual basis, court-ordered spill reduces hydroelectric generation by an average of about 150 average megawatts, relative to about a 1,200 average megawatt loss for the 2008 Biological Opinion mainstem operation. However, bypass spill is only provided in spring and summer. Looking at the additional loss seasonally, court-ordered spill decreases generation by an average of about 200 average megawatts during spring (April through June) and by an average of a little under 600 average megawatts during summer (July and August). The losses in any given year, obviously, will vary depending on water conditions.

- Mainstem operations for fish and wildlife tend to reduce the hydroelectric system's flexibility and increase the cost of integrating wind resources. Flexibility of electricity supplies is vital to ensuring a reliable power system. Efforts are underway to quantify this loss of flexibility. Some, but not all, of the effects of this loss of flexibility were captured in the Council's analysis for the plan. However, the Council recommends continued regional participation in discussions and analysis of this issue.

- New water management strategies or development of new storage facilities would clearly affect hydroelectric generation in the long term. However, given the long lead time required to develop and implement these projects, it is not likely to happen in the short term, if at all. Thus the Council assumes that no new water management strategies or storage facilities will be implemented for the power plan analysis.

- Terrestrial and wetland habitat protection and restoration funded by the fish and wildlife program may create opportunities to develop carbon credits. Discussions of potential benefits to the power system are just barely underway. No assumptions regarding potential future carbon credits for habitat development were included in the plan.

Other potential long-term changes may include additional or different operations for fish such as:

[13] See the IEAB report at http://www.nwcouncil.org/library/ieab/ieab2009-1.htm

- Lower operating elevations during the migration season (e.g., John Day Dam at minimum operating pool elevation instead of minimum irrigation pool elevation);
- Changes in the volumes of water for flow augmentation;
- Different pattern of water releases during the migration season;
- Removal of one or more mainstem federal dams;
- Revised Columbia River Treaty operations;
- Revised use of non-treaty storage; and
- Changes to flood control operations

The potential effects of climate change show impacts to both power and fish. Current analysis indicates that the Northwest is likely to see higher winter river flows and lower summer flows, with peak flows shifting to earlier periods in the spring. At the same time, winter demand for electricity should decrease and summer demand would increase with rising temperatures. This effect should ease the pressure on the hydroelectric system in winter but make it more difficult over summer months, especially with the addition of more and more variable resources. Therefore, climate change may increase pressure on the power system in the summer by increasing loads and reducing hydropower generation and at the same time adversely affect fish because of higher water temperatures. A summary of the Council's analysis of potential physical climate change impacts is presented in Appendix L.

Current renewable portfolio standards have already affected resource acquisition strategies and will likely continue to do so if they are modified or replaced by federal legislation. Potential carbon tax or cap-and-trade mechanisms will also alter future resource plans.

Ongoing changes in power markets and westwide power integration may also bring changes to the way we use and value the power system (e.g. generation in summer may become more and more profitable). These kinds of changes present challenges for fish and wildlife operations. For example, releasing more stored water during summer months may increase power revenues and provide higher river flows for migrating smolts, but may also adversely affect resident fish above and below the federal projects.

For this plan, long-term uncertainties already include load, fuel and electricity prices, runoff conditions and carbon penalties. Uncertainties not explicitly incorporated into resource plan development include the physical effects of climate change, modifications to fish operations or changes in the Columbia River Treaty. Because of difficulties in quantifying the range and magnitude of these latter uncertainties, it is best to assess these by means of sensitivity analysis. Studies can be performed to determine the potential effects of these changes, either independently or in combination. However, the magnitude of potential impacts must be considered in conjunction with the likelihood of occurrence, that is, a potential uncertainty may have a large impact but might be extremely unlikely. The region should continue to explore and analyze such scenarios to be better prepared should these unlikely events occur.

While there is much the Council can do as part of both the fish and wildlife program and the power planning process to analyze and respond to these long-term considerations, regional cooperation is also needed. Federal agencies have already formed several committees to deal with in-season operational issues affecting fish and power. For example, the Technical Management Team (TMT) consists of technical staff from federal, state, and tribal agencies that usually meet on a weekly basis during the fish migration seasons to assess the operation of the hydroelectric system. Requests for variations to those operations can be made and discussed at TMT meetings. Conflicts that cannot be resolved at the technical meetings are passed on to the Regional Implementation Oversight Group (RIOG), which consists of higher policy-level staff.

While the existing committee structure is intended to solve in-season problems, no currently active process exists to address long-term planning issues related to both power planning and fish and wildlife operations. The Council will investigate using existing forums to facilitate such discussions or, if necessary, explore the possibility of creating a separate forum where fish and wildlife managers and power planners could jointly explore longer-term strategies to improve both fish and wildlife benefits and hydroelectric power operations. In such a forum, synergistic effects between fish and wildlife operations and power planning could be examined. For example, conservation savings in irrigation can also provide savings in water quantity and energy, which could benefit both in-stream flows for fish and reduce load on the power system. Also, the State of Washington is currently exploring options for new storage sites, which could benefit fish, power and irrigation. And finally, potential carbon emission mitigation benefits of actions to acquire or improve fish and wildlife habitat should be assessed.

Action Plan items F&W-1 (long-term planning forum); F&W-3 (analytical capability), F&W-4 (Columbia River Treaty), and F&W-5 (climate change) are intended to help the Council and the region to develop the tools needed to address these uncertainties.