APPENDIX B

HYDROPOWER AVAILABILITY IN RESPONSE TO SALMON RECOVERY

The Columbia River is the foundation upon which the Pacific Northwest has grown and prospered. This large and complex river system provides water for irrigation and municipal and industrial needs. It is an avenue for navigation and provides sites for recreation and fisheries. The series of dams built in the basin generate about three quarters of the electricity in the region and provide protection against flooding.

The Columbia River Basin is also the home of one of the world's largest salmon populations. Over the years, however, the number of salmon and steelhead in the river has decreased dramatically. Some species are dangerously close to becoming extinct and others continue to decline in numbers. Dam construction, river flow changes, habitat losses, harvest changes, artificial production practices and poor water conditions have all contributed to the decline. Since the inception of the Council, the region has attempted to reverse this trend. Many measures have been proposed and implemented to improve the survival of both anadromous and resident fish and wildlife. Some of those measures change the way in which dams are operated and, consequently affect the production of power. This appendix addresses only those measures that affect the operation of the Northwest's hydroelectric power system.

Currently, the region is implementing the National Marine Fisheries Service's 1995 Biological Opinion.[1] It includes actions to hold more water in reservoirs during winter months for later release during the juvenile fish migration season in spring and summer. It also calls for some dams to operate at lower than normal elevations and restricts their flexibility to fill and draft water for power generation. In addition, until better fish bypass facilities are built, it calls for some portion of the river flow to be spilled in order to improve juvenile fish passage survival. All of these actions reduce the flexibility of the hydroelectric power system. Some energy is lost when it is spilled and some energy is shifted out of winter months, when demand and prices are high, to spring and summer months when demand and prices are lower.

Congress has recently implemented a budget limitation on Bonneville's expenditures for salmon restoration, including costs for fish-related power purchases and lost revenues. This could provide an adequate budget to maintain current river operations. However, as more information is gathered and more research is conducted, the operation of the river may be further modified. This could lead to more or fewer constraints, depending on the results of the research.

It is impossible to predict what set of fish and wildlife measures the region will eventually implement. Besides current operations, the Council's Columbia River Basin Fish and Wildlife Program[2] and the Columbia River Anadromous Fish Restoration Plan[3] are other salmon recovery plans. Each suggested operation is different and affects the hydroelectric system's capability to produce electricity in different ways. Each scenario would change, to varying degrees, the hydroelectric system's ability to provide both energy and peaking capacity. Each scenario could lead to a different set of resource actions for the region. To provide a more robust resource strategy for the Northwest, this power plan analyzes a wide range of river operations.

The current base case analysis uses an estimate of the availability of hydroelectricity based on the National Marine Fisheries Service's biological opinion. The Council's 1995 Fish and Wildlife program is similar to current operations and as such does not make a very interesting scenario with respect to resource planning. To provide an idea of the size of changes that could be faced, three additional scenarios were analyzed and are described below. They span a range of potential river operations with impacts that are between a gain of 500 average megawatts to a loss of 3,000 average megawatts compared to the biological opinion. Table B-2 summarizes the impacts of the base case and three additional scenarios relative to current

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[1] *Proposed Recovery Plan for Snake River Salmon,* March 1995, U.S. Department of Commerce National Oceanic and Atmospheric Administration.

[2] Document #94-55, *Columbia River Basin Fish and Wildlife Program,* December 14, 1994, Northwest Power Planning Council.

[3] *Wy-Kan-Ush-Mi Wa-Kish-Wit - Columbia River Anadromous Fish Restoration Plan of the Nez Perce, Umatilla, Warm Springs and Yakama Tribes,* Vol. 1, June 15, 1995, Columbia River Inter-Tribal Fish Commission.

operations. The energy figures shown are the net energy losses. No attempt was made to determine the change in the firm energy load carrying capability (FELCC) of the system.

Water budget operation: This scenario assumes river operations as they were in 1991. It represents an operation with energy and capacity gains compared to current operations. It was the operation in place for the 1991 Power Plan.

Drawdown proposal: This scenario reflects a hypothetical operation that produces both higher energy and capacity losses than current operations. It includes a drawdown of the four lower Snake River dams to natural river elevations year round. All of the energy and capacity from those projects is lost. It should be noted that this is not the same river operation as is contained in the Council's Columbia River Basin Fish and Wildlife Program's Strategy for Salmon.

Tribal proposal: This scenario represents an operation that reduces both the firm energy and capacity of the system well beyond current levels. The operation proposed in the Columbia River Anadromous Fish Restoration Plan is used for this case. This operation calls for higher flow augmentation in both the Snake and Columbia rivers and a drawdown to natural river elevations year round at the four lower Snake River dams and at the John Day Dam.

A more specific description of the actions called for under each of these packages is provided in TableB-1. The measures in that table describe only the actions that would affect the hydroelectric system's ability to produce power. Each plan also includes other measures that address habitat, harvest and hatchery practices. Because those elements do not affect the hydroelectric system directly, they are not included in this appendix.

Key for Table B-1

FC	Flood Control
FPE	Fish Passage Efficiency
MOP	Minimum operating pool (elevation)
Maf	Million acre-feet (volume)
Kaf	Thousand acre-feet (volume)
Kcfs	Thousand cubic feet per second (flow)

Table B-1
Comparison of River Operation Scenarios

Project	Water Budget	Biological Opinion	Natural River	Tribal Proposal
Upper Snake	No additional water	Use up to 427 Kaf for flows at Lower Granite Dam.	Use up to 1.427 Maf for flows at The Dalles Dam.	Use 1 to 3 Maf for flows at The Dalles Dam.
Brownlee	**May:** Use up to 110 Kaf depending on runoff forecast.	**Jan-Apr15:** shift system FC to Grand Coulee. **May:** up to 110 Kaf (2,069') **June:** pass inflow **July:** up to 137 Kaf (2,067') **Aug:** pass inflow **Sept:** 100 Kaf (2,059')	**Jan-Apr15:** shift system FC to Grand Coulee. **Apr16-30:** up to 110 Kaf (2,069') **May:** up to 110 Kaf (2,069') **June:** pass inflow **July:** up to 137 Kaf (2,067') **Aug:** pass inflow **Sept:** 100 Kaf (2,059')	**Apr-Aug:** Use up to 450 Kaf for spring and summer target flows at The Dalles Dam.
Dworshak	**May:** Use up to 600 Kaf, of which 300 Kaf is shapeable.	**Sep-Apr15:** operate to flood control elevations, shift system FC to Grand Coulee. **Apr16-June:** up to 1.5 Maf **July-Aug:** draft limit 1,520' (80')	**Sep-Apr15:** operate to flood control elevations, shift system FC to Grand Coulee. **Apr16-June:** up to 1.0 Maf **July:** draft limit 1,520' (80') **Aug:** refill **Sept:** 200 Kaf	**Spring:** 1.5 Maf for target flows at The Dalles Dam **Summer:** 1.0 Maf for target flows at The Dalles Dam
Lower Granite	Normal pool elevation **Flow Target:** **May:** 85 Kcfs	**Apr16-Aug:** near MOP **Flow Targets:** **Apr16-June:** 85-100 Kcfs **July-Aug:** 50-55 Kcfs	**All year:** natural river elevation **Flow Targets:** No flow targets	**All year:** natural river elevation **Flow Targets:** No flow targets
Little Goose	Normal pool elevation	**Apr16-Aug:** near MOP	**All year:** natural river elevation	**All year:** natural river elevation
Lower Monumental	Normal pool elevation	**Apr16-Aug:** near MOP	**All year:** natural river elevation	**All year:** natural river elevation
Ice Harbor	Normal pool elevation	**Apr16-Aug:** near MOP	**All year:** natural river elevation	**All year:** natural river elevation

Project	Water Budget	Biological Opinion	Natural River	Tribal Proposal
Arrow	Normal treaty operation	**Jan-Apr15:** store up to 1 Maf of "operational" volume.	**Jan-Apr15:** store "operational" volume (up to 4 Maf total at all projects)	Use as necessary for flow targets at The Dalles Dam. Also use Mica and Duncan if necessary.
Libby	Normal power operation	**Jan-Apr15:** operate to flood control elevations. **May-July:** sturgeon flows, **Apr16-May:** draft limit 2,420' (39' from full), **June-Aug:** draft limit 2,439' (20' from full)	**Jan-Apr15:** store "operational" volume. Operate to integrated rule curve draft limits year round.	Use as necessary for flow targets at The Dalles Dam. Additional water available in better than average runoff years.
Hungry Horse	Normal power operation	**Sep-Apr15:** operate to flood control elevations. **Apr16-Aug:** draft limit 3,540' (20' from full), max flow 13 Kcfs	**All Year:** Operate to integrated rule curve draft limits year round.	Use as necessary for flow targets at The Dalles Dam. Use additional water available in better than average runoff years.
Albeni Falls	Minimum Elevation 2,051'	Minimum Elevation 2,051'	Minimum Elevation 2,056'	Minimum Elevation 2,051'
Grand Coulee	**May:** Up to 3.45 Maf	**Mar-Apr15:** operate to flood control elevations. **Apr16-May:** draft limit 1,250' (40' from full) **June-Aug:** draft limit 1,280' (10' from full)	**Jan-Apr15:** store "operational" volume. Operate to retention-time draft limits year round. **July-Aug:** draft limit alternates between 1,288' and 1,283'	Use as necessary for flow targets at The Dalles Dam.
Priest Rapids Vernita Bar	**Dec-Apr:** 70 Kcfs **May:** 134 Kcfs	**Dec-May:** 70 Kcfs	**Dec-May:** 70 Kcfs	**Dec-May:** 70 Kcfs
John Day	Normal pool elevation	**All year:** near MOP	**All year:** near MOP	**All year:** natural river elevation
The Dalles/ McNary	No flow target	**Apr16-Apr30:** 200-230 Kcfs **May-June:** 220-260 **July:** 200 **Aug:** 200	**Apr16-Apr30:** 170 Kcfs **May-June:** 180-300 **July:** 200 **Aug:** 160	**Apr16-Jun15:** 220-300 Kcfs **Jun16-Jun30:** 200-250 Kcfs **July:** 200 Kcfs **Aug:** 160 Kcfs **Sep:** 120 Kcfs
Spill	**Apr15-Aug15:** to exceed 90% survival	**Apr15-Aug:** 80% FPE 120% gas cap	**Apr15-Aug:** 80% FPE 120% gas cap	**Apr15-Aug:** 90% FPE 125% gas cap

Each of the four scenarios described above affects power production in different ways. Both energy generation and peaking capacity are affected. All of them, to some degree, call for actions to hold water in winter for later release in spring and summer to enhance flows for migrating fish. Also, each calls for some level of spill to enhance passage survival.

When water is held in reservoirs during winter months, it cannot be used to generate electricity. In wet years, holding water back results in a reduction in nonfirm energy sales to both in-region and out-of-region utilities. In dry years, the region may have to purchase energy from out-of-region sources in order to meet firm Northwest demands. The cost of the winter operation is the combined cost of energy purchases and foregone revenues from lost nonfirm energy sales. Some of the cost for the winter operation can be recovered when flows are augmented in spring and summer months. However, because prices in spring and summer are lower than prices in winter, the total cost can never be fully recovered.

Spilling water during the migration season adds to the cost of salmon survival measures. Foregone revenues due to spill during spring and summer months can be as large or larger than energy purchase costs in winter. Table B-2 identifies how much hydroelectric energy is lost due to spill and efficiency losses.[4] In addition to this, some winter generation is shifted to spring and summer months. The magnitude of lost firm energy generating capability is a combination of lost energy due to spill and shifted energy. For example, the estimated loss of firm energy generating capability between the water budget and biological opinion operations is about 850 average megawatts. Of this total, a little more than half (about 500 average megawatts) is lost due to spill or reductions in efficiency. The remainder is energy that is shifted out of winter into the spring and summer period and only serves nonfirm markets.

Each scenario also constrains the daily flexibility of dams to store and release water for power production. This affects their ability to satisfy daily peak demands (capacity). Table B-2 also provides the approximate capacity impacts for each scenario relative to current operations. The capacity loss for the natural river scenario represents the total instantaneous generating capacity at the four lower Snake River dams. For the tribal proposal, the capacity loss includes the loss of generating capacity at John Day Dam. The capacity gain for the water budget operation represents the gain in sustained peaking capacity over current operations.

Table B-2

Hydroelectric System Energy and Capacity Impacts

Relative to the Biological Opinion Scenario

	Water Budget	**Natural River**	**Tribal Proposal**
Energy Gains or Losses (average megawatts)	+ 500	- 1,300	- 3,000
Capacity Gains or Losses (megawatts)	+ 800	- 2,700	- 5,200

Of the lost hydroelectric energy, some is made up by purchasing out-of-region energy. The rest translates into fewer energy sales to both Northwest and out-of-region markets. Because less nonfirm energy is available for sale, Northwest fossil-fuel burning resources are less often displaced and are consequently operated more often, generally in the fall and winter months.

[4] Efficiency losses occur when dams generate electricity at lower reservoir elevations.

Table B-3 illustrates a possible response to lost hydroelectric energy for each scenario.[5] Under the natural river scenario, for example, lost hydroelectric energy is estimated to total about 1,300 average megawatts. A possible reaction to that loss is to:

- forgo 650 average megawatts of sales to Northwest utilities, thus increasing thermal resource generation by a similar amount,
- forgo 500 average megawatts of sales to California, and
- purchase an additional 150 average megawatts of energy from out-of-region utilities.

Table B-3

Impacts to Thermal Generation and Out-of-Region Sales and Purchases

Relative to the Biological Opinion Scenario

(average megawatts)

Scenario	Thermal Generation	Purchases	Sales
Water Budget	- 225	- 125	+ 150
Natural River	+ 650	+ 150	- 500
Tribal Proposal	+ 1,625	+ 450	- 925

Figure B-1 illustrates the average monthly hydroelectric generation for each scenario. Compared to the water budget operation, each subsequent scenario generates less energy in fall and winter months. In the spring and summer, the biological opinion operation generates more energy, on average, than the water budget. However, energy gains in the spring and summer do not balance the losses in fall and winter because the biological opinion calls for more spill in the those months.

For the natural river and tribal proposals, greater amounts of hydroelectric energy is withheld (stored in reservoirs) during winter months, as shown in Figure B-1. In addition, several dams are operated at natural river elevations year round, which eliminates their ability to generate electricity. Consequently, generation in spring and summer months for these scenarios is also lower than in either the biological opinion or the water budget operations. (Average hydroelectric energy losses are summarized in Table B-2.)

[5] These results are derived from the System Analysis Model simulation for each scenario.

Figure B-1
Hydroelectric Generation

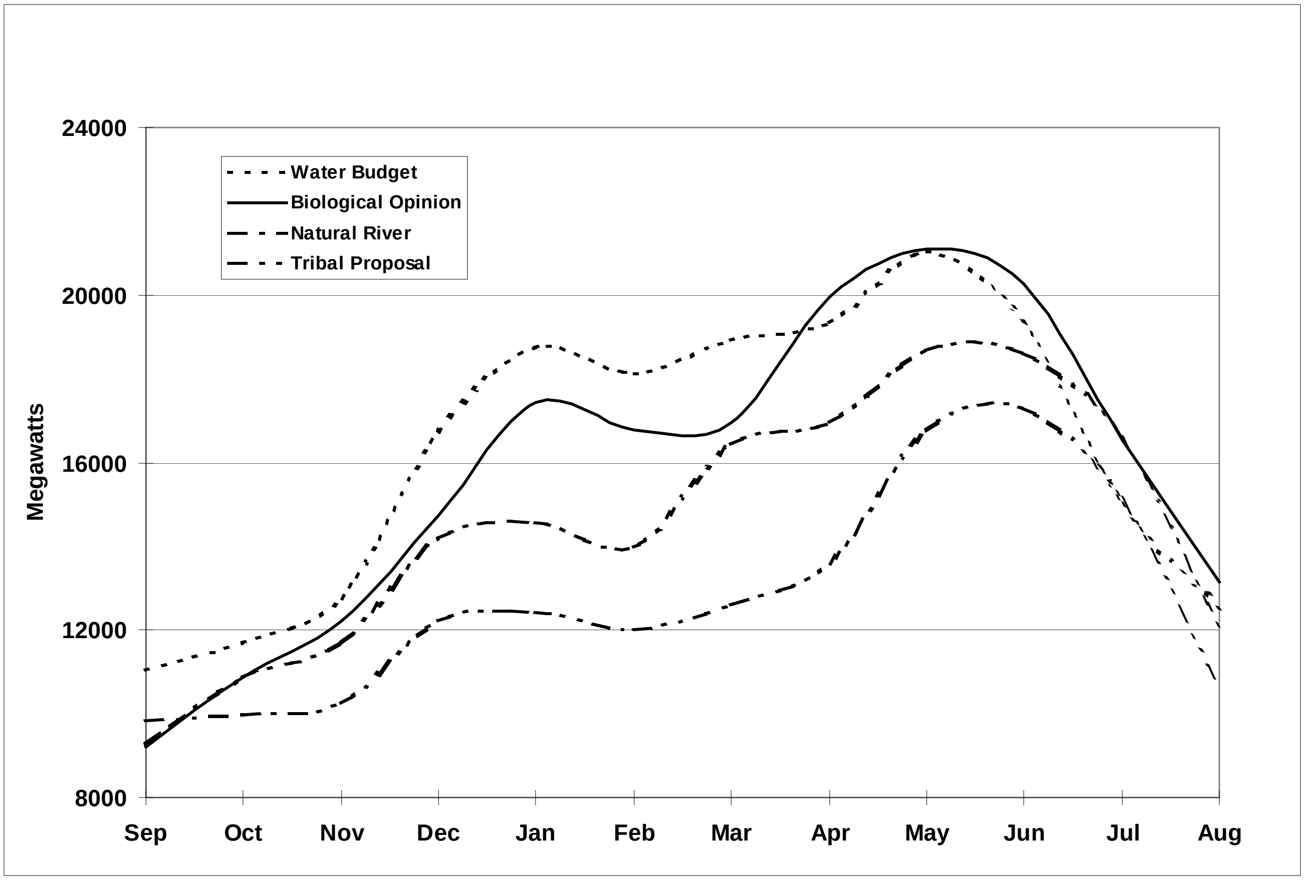
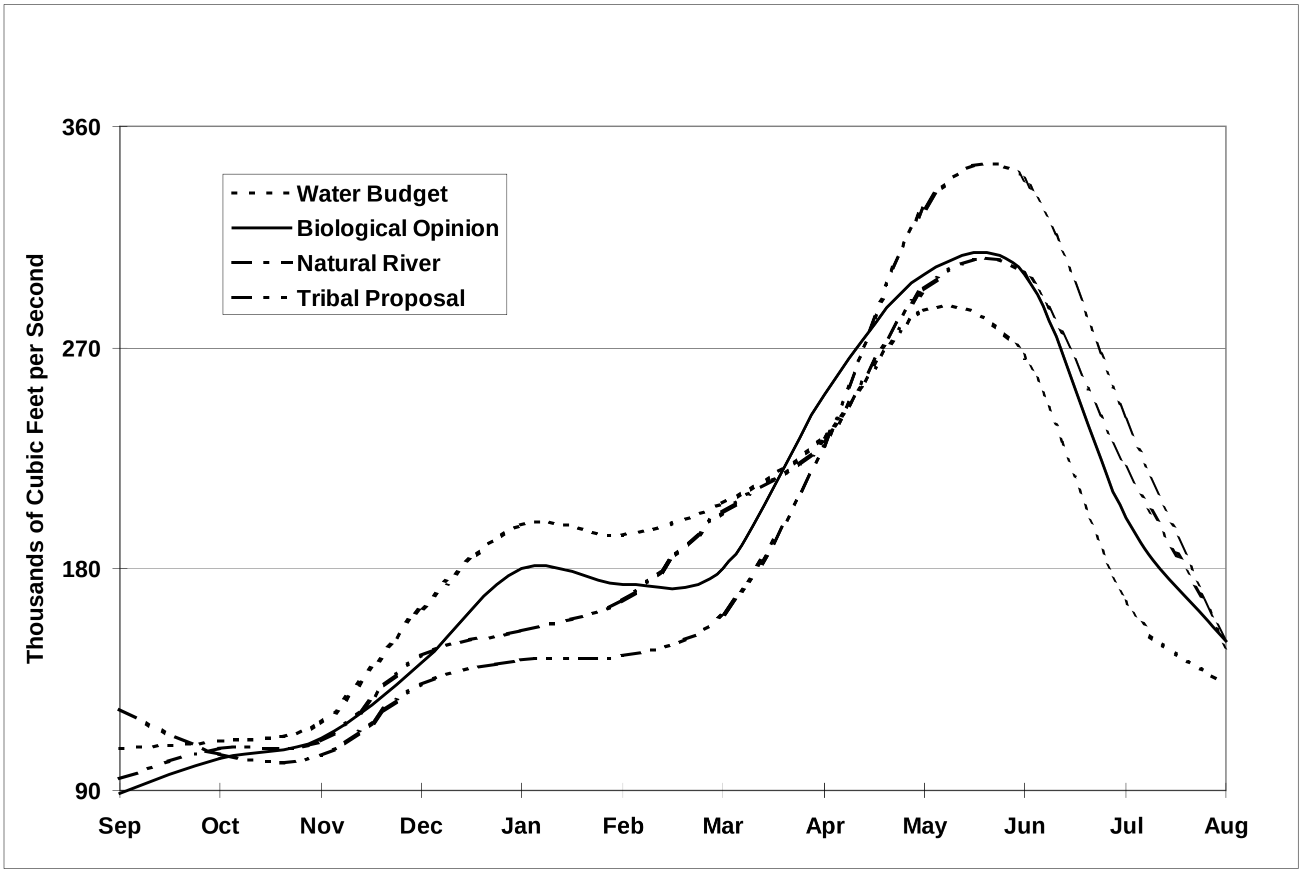


Figure B-2 illustrates the corresponding river flows at The Dalles Dam as a result of the actions in each of the four scenarios. Not surprisingly, the water budget scenario provides the lowest spring flows. The biological opinion and the natural river operations yield about the same average spring flows at The Dalles Dam because the operation for the Columbia River dams under these two scenarios is similar. The tribal proposal provides the lowest winter flows and the highest spring and summer flows.

Figure B-2
Average Flows at The Dalles Dam



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