4.3 Generic Environmental Impacts

Section 4.4 of this EIS identifies environmental impacts and market responses to each Business Plan alternative. The market responses generally take the form of changes in generation and conservation development and operation, transmission development and operation, and consumer behavior.

This section prepares the reader for that discussion by describing *typical* environmental impacts of the market responses.

4.3.1 Resource Development and Operation

Typical impacts associated with the development and operation of generation and conservation resources were described in the Resource Programs Final EIS (DOE/EIS-0162, February 1993). New resources that might be developed and operated in the region in response to Business Plan alternatives are likely to be among the resource types described in that document. Table 4.3-1 summarizes information from the Resource Programs Final EIS on the typical environmental impacts per average megawatt of different generation and conservation resources. Figure 4.3-1 summarizes the nature of environmental impacts of various resource types. The Resource Programs Final EIS provides additional information about the nature of these impacts and typical mitigation measures taken to reduce or eliminate them. Figure 4.3-2 shows the level of key environmental impacts by resource type.

The key environmental impacts of energy resource types that are likely to serve the PNW are summarized below:

Conservation typically has minimal environmental impacts. The primary concern for many residential conservation programs—indoor air quality (IAQ)—can be effectively mitigated through a variety of means built into most residential conservation programs. Conservation programs in other sectors have few environmental impacts that need specific mitigation.

Renewable Energy Resources vary considerably in their environmental impacts. Geothermal energy's major environmental impacts are contaminants from geothermal steam (particularly hydrogen sulfide), waste heat, degradation of water quality, and solid waste. However, these impacts are very site-specific, and mitigation measures can minimize most of them. Large-scale solar energy projects can occupy large areas of land and require water for cooling. The primary concerns for wind energy stem from the significant land use requirements of large-scale wind energy facilities, and associated visual impacts. New hydroelectric projects can vary considerably in size and impacts. Environmental concerns include the alteration of surface water and stream habitat. Water temperature, water quality, stream flow, fish migration, and wildlife habitat may be affected.

Cogeneration involves the simultaneous production of heat for industrial uses and electricity. A variety of fuel types, including natural gas, coal, and biomass can be used for cogeneration; however, natural gas is becoming the fuel of choice and is assumed to be the fuel for the cogeneration projects discussed in this EIS. Impacts are typically similar to CTs; however, most cogeneration projects are located in existing industrial sites. Therefore, impacts on other land uses are limited. New cogeneration often replaces older boilers with higher air emissions, leading to a net reduction in air emissions and no new land use impacts.

Combustion Turbines are rapidly evolving in response to increased gas supplies, lower gas costs and increased energy efficiency of CTs. CTs are typically fueled by natural gas. A major concern for CTs has been air emissions, particularly nitrogen oxide (NO_X). However, NO_X emission rates of CTs recently proposed in the PNW are considerably lower than those of CTs proposed even 2 to 5 years ago, in some cases decreasing by two-thirds.

Table 4.3-1
Typical Environmental Impacts From Power Generation and Transmission(a) (b) (metric units)

Conservation and Generation	SO2 (ton/aMW)	NOx (ton/aMW)	CO2 (ton/aMW)	Particulates (ton/aMW)	CO (ton/aMW)	Consumed (m3/aMW)	Consumed (ha/aMW)	Discharge (mill. Joules/aMW)
Conservation	0.00	0.00	0	0.00	0.00	0	0.00	
Efficiency Improvements	0.00	0.00	0	0.00	0.00	0	0.00	
Renewables								
Geothermal (c)	0.80	0.00	636	0.00	0.00	55,260	0.11	138,205,000
Solar	0.00	0.00	0	0.00	0.00	481	2.43	24,265,000
Wind	0.00	0.00	0	0.00	0.00	0	9.55	
Hydro	0.00	0.00	0	0.00	0.00	0	0.00	
Cogeneration								
Solid Waste-Fired	13.63	70.18	13,256	3.00	2.69	0	0.81	
Wood-Fired	0.52	9.02	11,959	1.71	16.96	66,978	1.06	
Existing Natural Gas-Fired	0.03	5.27	3,542	0.03	2.02	4,194	0.06	30,384,000
Older Natural Gas Combustion Turbine	0.03	5.27	3,542	0.03	2.02	4,194	0.06	
Newer Natural Gas Combustion Turbine (d)	0.01	0.42	3,313	0.15	0.61	4,194	0.06	
Nuclear	0.00	0.00	0	0.00	0.00	19,736	0.91	44,310,000
Coal	8.63	21.56	8,843	1.30	1.53	13,186	0.54	44,310,000
Clean Coal								
Fluidized-Bed Coal	3.14	5.26	8,052	0.59	1.40	20,266	0.64	
Gasification Coal	1.47	3.86	7,551	0.24	0.14	20,056	0.30	
Fuel Switching (e)	0.00	2.27	2,550	0.03	1.07	0	0.00	
Power Purchases (f)	0.03	5.27	3,542	0.03	2.02	4,194	0.06	
Aluminum Smelter	1.06	0.01	335	1.77	64.34	13,545	0.00	1,287
Transmission (right-of-way land use) (g)							(ha/km of line)	
115-kV							2.67	
230 - 287-kV							3.43	
345-kV							3.93	
500-kV							4.42	

(a) Generation impact data taken from "Resource Programs Final EIS: Volume 1: Environmental Analysis," except as noted.

(b) Includes impacts from generation only. Highest impact estimates used when range given.

(c) Sulfur emitted as Hydrogen Sulfide.

(d) Air emissions average of predicted emissions from Tenaska II, Coyote Springs, U.S. Generating Hermiston.

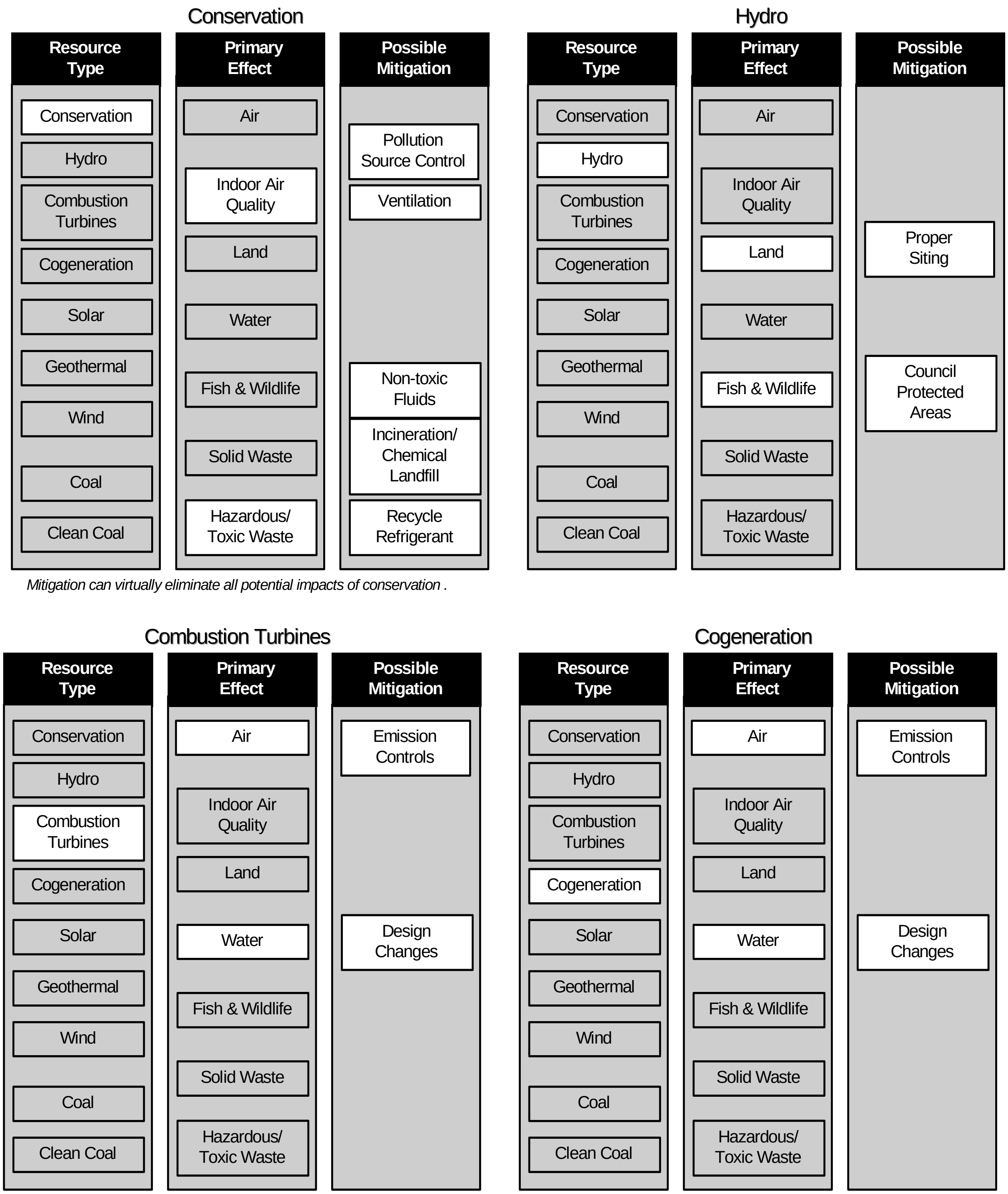
(e) Average of emissions rates for gas water heaters and gas furnaces.

(f) Assumed all combustion turbines.

(g) Based on average ROW width for BPA transmission lines in new corridors.

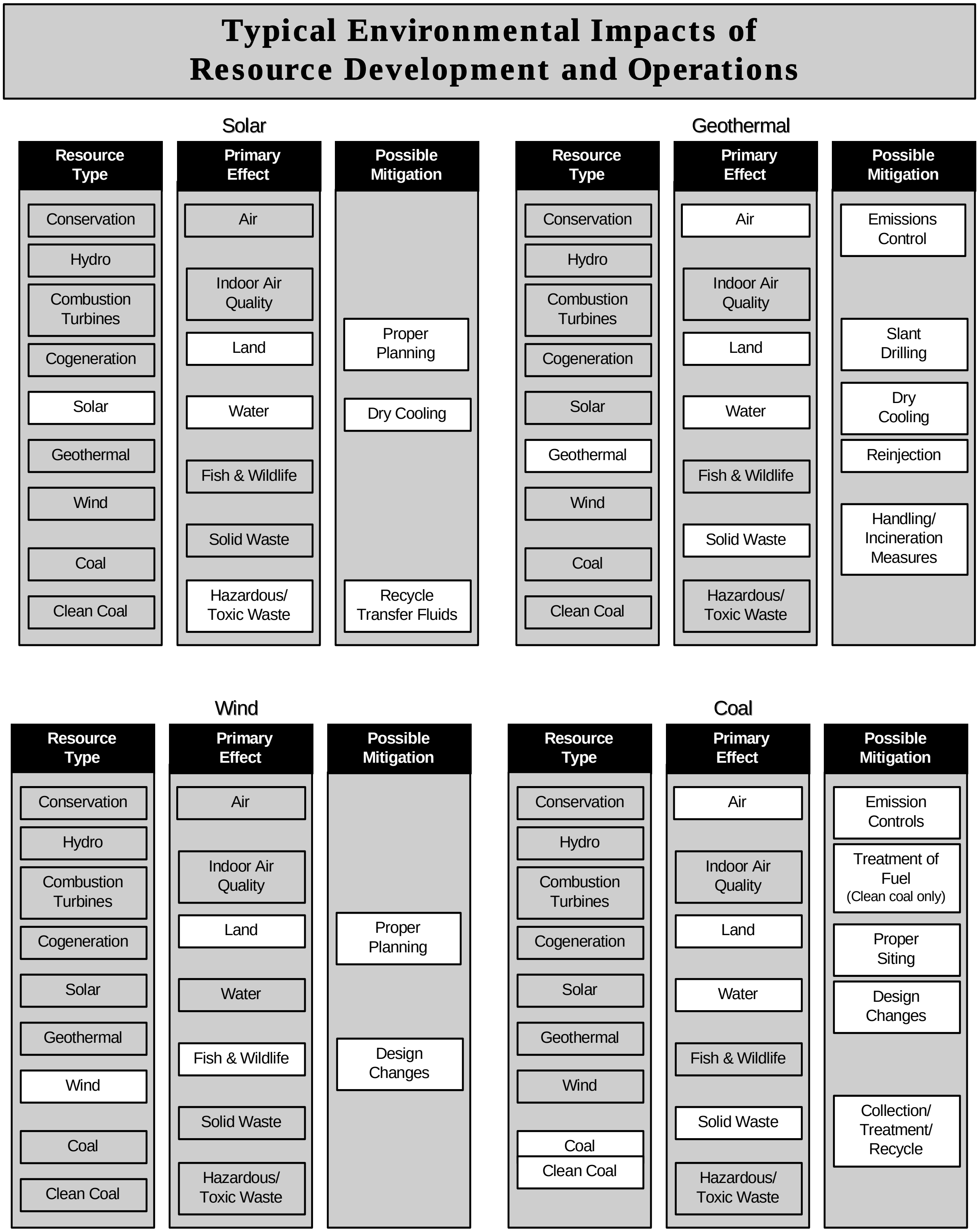
FIGURE 4.3-1

Typical Environmental Impacts of Resource Development and Operations



These charts are from BPA's Resource Programs Final Environmental Impact Statement (DOE/EIS-0162, February 1993).

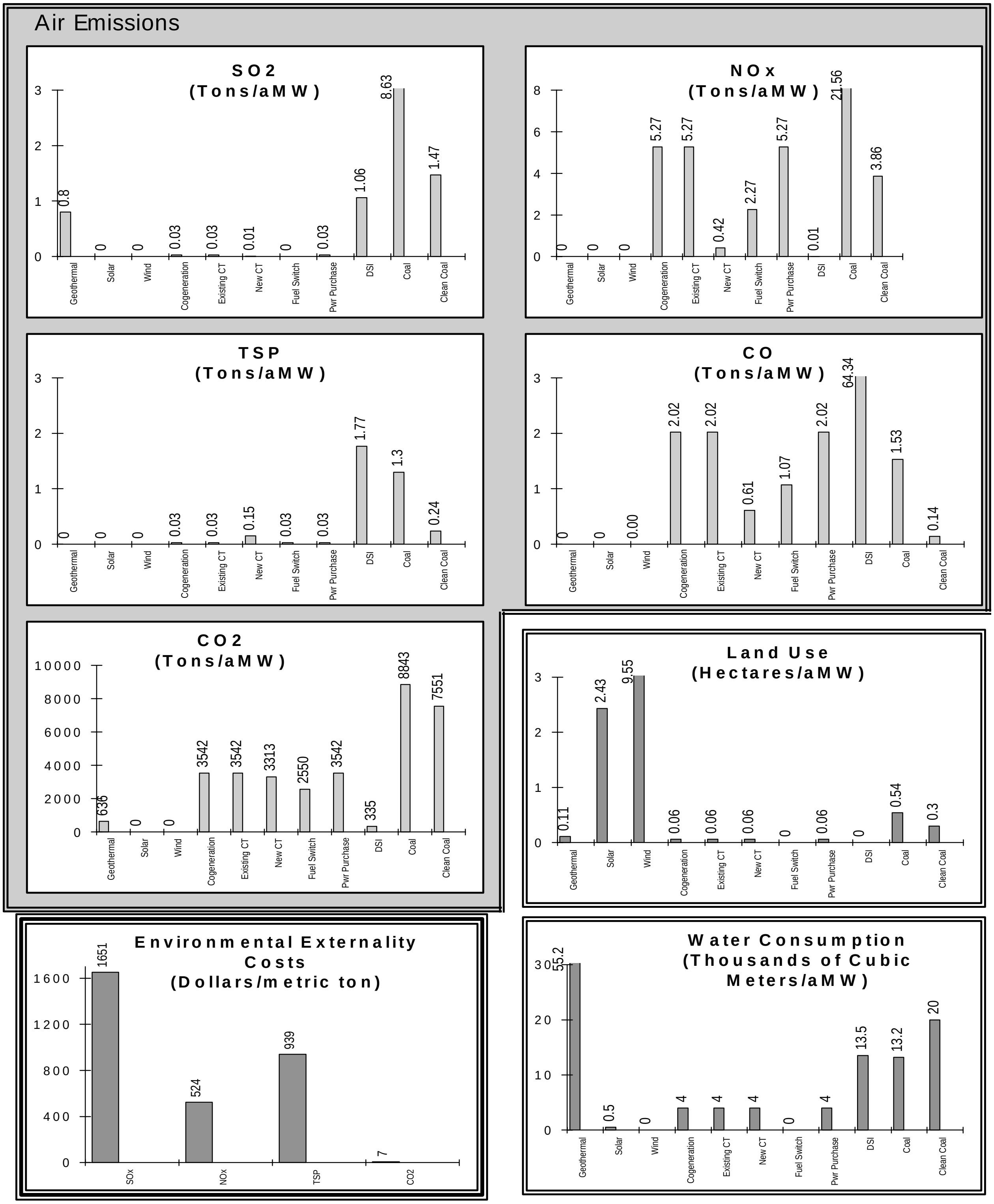
FIGURE 4.3-1 (continued)



These charts are from BPA's Resource Programs Final Environmental Impact Statement (DOE/EIS-0162, February 1993).

FIGURE 4.3-2

Level of Key Environmental Impacts By Resource Type Per aMW *



* Conservation was not included on the charts because it does not affect any of the key air, land, or water concerns.

Under development are improved combustor and blade designs allowing higher firing temperatures; and innovative recuperative cycles including intercooled, humid air, and chemically recuperated designs. Chemically recuperated designs can achieve thermal efficiencies in excess of 50 percent, compared to the 46- to 47-percent efficiencies typical of current CTs. Environmental control research focuses on combustion control of NO_x to reduce or eliminate the need for catalytic controls on the turbine exhaust. Combustion turbine research and development is expected to lead to smaller, more efficient, less costly, and environmentally cleaner generating plants (Northwest Power Planning Council, February 1994).

Because emission rates vary considerably between older CTs and newer technologies, and because CT technology is evolving so quickly, the emission rates in table 4.3-1 include separate air emission rates for existing and new CTs. Rates for existing CTs are taken from the Resource Programs Final EIS; emissions rates for new CTs are an average of predicted rates for three new existing or proposed PNW gas-fired plants with start-up dates ranging from 1991 through 1996.[3]

Fuel Switching occurs when end-use consumers change from electricity to another fuel. In the PNW, consumers most often switch from electricity to natural gas for home heating and water heating. Fuel switching has minor environmental impacts, primarily associated with the tiny amounts of NO_x and CO that can be emitted by gas water heaters and furnaces; however, these air emissions are accompanied by a reduction in environmental impacts associated with electrical generation, such as the air emissions from CTs.

Imports are electricity purchases or exchanges with other regions. A typical transaction between the PNW and California would involve a delivery of energy to California during that region's daytime summer peak loads. The energy would be returned at night to the PNW, and an additional payment in the form of energy would be delivered to the PNW during the PNW winter peak load season. The net environmental impact varies considerably according to the transaction; in this example, the delivery of energy from the PNW to California would be supported by increased hydroelectric generation to support fish migration flows (with a positive impact), and, in California, thermal generation and its air quality impacts would be moved from on-peak periods (when air quality concerns are greatest) to off-peak periods. Other imports could involve the purchase of energy during off-peak periods in other regions—for example, the purchase of energy from thermal resources in California or the ISW during nighttime or winter periods. Environmental impacts would be primarily the air emissions associated with thermal generation.

Natural gas serves a key role in the U.S. Administration's *Climate Change Action Plan*, with Administration strategies seeking to increase natural gas share of energy use as a means of reducing greenhouse gas emissions through substitution for other fossil fuels (Energy Information Administration, 1994). Nonetheless, natural gas does create its own environmental impacts in production. Although pipeline capacity exists to ship U.S.-produced gas supplies to supply cogeneration plants, most of the natural gas expected to supply those plants, CTs, or fuel switching would be produced in the western provinces of Canada (British Columbia and Alberta).

Development of gas wells and production facilities involves exploration, drilling, production, processing, transportation, and finally, decommissioning of facilities and site reclamation. Many of the associated facilities are linear: seismic lines, roads, pipeline rights-of-way, and power lines. Construction and use of these facilities can lead to increased habitat fragmentation and reduced habitat effectiveness for a variety of species; reduced ecosystem integrity resulting in reduced populations and increased risk of species extinction; water source contamination; degradation of the regional airshed; and potential increases in global warming from methane and carbon dioxide. See below (4.3.1.1 and 4.3.1.2) for additional information.

4.3.1.1 Health/Environmental Effects of Air Pollutants

Particulate Matter can discolor paint, corrode metal, and reduce visibility. Animal and plant health effects depend upon the size of the particulates and the pollutants contained in the particle. Particulate matter less than 10 microns in diameter travels deep into the lungs, where pollutants can rapidly diffuse into capillary beds. Elevated particulate concentrations are associated with an increase in the severity and frequency of

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[3] The plants are Coyote Springs, U.S. Generating Co. [Hermiston], and Tenaska II.

respiratory diseases. The EPA is currently considering lowering the primary PM-10 (particulate matter of 10 microns or less) standard because the existing standard (75 $\mu g/m^3$) does not adequately protect human health.

Carbon Monoxide can affect animals at low concentrations, although ambient concentrations do not measurably affect plants or materials. CO has 210 times more affinity for red blood cells than does oxygen, so continued exposure to CO interferes with the oxygen-carrying capacity of the blood. Prolonged exposure to low levels can impair physical coordination and cause dizziness. Continued exposure to CO above 750 parts per million (ppm) can cause death.

Sulfur dioxide negatively affects visibility. When combined with moisture, it forms sulfuric acid, which corrodes most building materials and causes lake acidification and loss of plant life. Sulfuric acid and SO_2 are both respiratory irritants. About 40 percent of the natural gas processed in the province of Alberta (Canada) contains sulphur and is termed "sour gas." Processing removes much of the sulphur in gas, recovering it as a salable by-product. Another by-product is sulphur dioxide, which can acidify and impoverish soils and have long-term effects on crops and forests, and possibly on nearby livestock.

Nitrogen oxide has effects similar to SO_2. NO_2 can also slow plant growth and reduce crop yield at relatively low concentrations. NO_2 is a respiratory irritant which, in the presence of sunlight, combines with hydrocarbons to form photochemical smog (ozone, peroxyacetyl nitrate (PAN), and peroxybenzoyl nitrate (PBN). Photochemical smog drastically reduces visibility and causes respiratory and eye irritation.

Ozone in the upper atmosphere protects the earth from ultraviolet radiation. Ground-level ozone, however, degrades rubber and is a respiratory and eye irritant. Ground-level ozone is created during a series of chemical reactions catalyzed by sunlight which involve NO_2 and hydrocarbons.

Carbon dioxide is a natural product of respiration. It is taken up by plants during photosynthesis; they use it as a building block for leaves and growth. Elevated concentrations are known to accelerate plant growth. Atmospheric CO_2 absorbs heat radiated from the earth, preventing heat loss to space. For this reason CO_2 is considered a greenhouse gas and has been linked to global warming. It has no health effects at atmospheric concentrations. CO_2 is also produced during the production of natural gas.

Methane, a large component of natural gas, is also released during production and transportation. Methane has a global warming potential 21 times (weight basis) greater than that of carbon dioxide (USDOE, 1991). However, emissions of carbon dioxide attributable to production and use of natural gas are lower than those for coal and oil. Emissions of methane attributable to production and use of natural gas are a portion of total global methane emissions; other sources include agriculture (rice and cattle in particular) and coal mining (USDOE, 1991).

4.3.1.2 Effects of Road and Natural Gas Pipeline Building in Canada

Some natural gas development, carried out for export, could adversely affect a variety of species, including grizzly bears, caribou, elk, songbirds, and bull trout. The building of linear facilities such as roads and pipelines could dissect and fragment blocks of wildlife habitat, reducing their effectiveness in providing shelter, forage, and security to certain species, although not all effects apply to all species. Some species may avoid the area, and mortality rates may rise. Severe fragmentation may reduce a population's ability to sustain itself.

Fragmentation and road density pose particular concerns for species such as grizzly bear. Although there is no specific Endangered Species Act in Canada, several other statutes exist to provide protection for wildlife, including the Wilderness Areas, Ecological Reserves, and Natural Areas Act, which offers the opportunity to set aside areas for protection from development. Land use restrictions offer differing degrees of protection for portions of forested and wilderness areas, and new gas wells may be explored in agricultural rather than forested areas.

Newer exploration and drilling techniques helping to mitigate ecosystem effects are being used in British Columbia and Alberta. These include substituting helicopter-deployable seismic rigs in place of truck-deployable seismic rigs, and using horizontal and directional drilling to access multiple natural gas fields

(Natural Resources Canada, 1994). Both techniques reduce the requirements for access road construction and use.

4.3.2 Transmission Development and Operation

A number of environmental impacts are typically associated with the construction and operation of transmission lines, no matter where they are located. Figure 4.3-3 summarizes these impacts. The amount or severity of the impact can vary according to line location, voltage and structure; and with each utility's design, construction, and maintenance practices. The following description of typical transmission line environmental impacts is drawn largely from the Delivery of the Canadian Entitlement EIS (DOE/EIS-0197, February 1994).

4.3.2.1 Land Use

The amount of new and existing rights-of-way used directly affects land use. Building a transmission line where none has existed before could have a major impact on residential, commercial, agricultural, and forest land because new line segments and access roads would intrude on existing land use or eliminate some uses altogether. A transmission project that proposes to widen existing right-of-way or rebuild a line within the same width creates fewer impacts on most, though not all, land uses. Where visual quality has already been affected by existing transmission lines, for example, adding another may not change conditions significantly. (However, upgrading from lower to higher voltage may increase visual impacts in some areas because higher-voltage lines generally require taller towers.) An expanded right-of-way on commercial forest or farmland, on the other hand, could have a major impact because new land would be cleared or removed from production. High-voltage lines create long-term visual impacts on most land uses, although they may be more compatible with industrial areas.

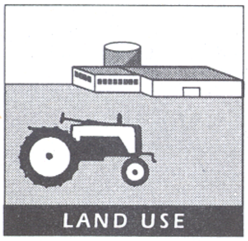
Land use impacts of transmission lines vary according to a number of factors, including voltage, insulation design, conductor, conductor tension, span lengths, structures, and conductor configuration and spacing. Typical right-of-way widths for single-circuit BPA transmission lines are shown in table 4.3-2. Table 4.3-1 (previous section) shows average amounts of right-of-way per kilometer of line.

Table 4.3-2: Typical Right-of-Way Widths of BPA Transmission Lines

Voltage	Structure Type	Right-of-Way Width (m/ft)
115-kV	Single pole wood	21/70
	H-frame wood	24-32/80-105
230-kV	H-frame wood	35-37/115-120
	Steel	32-35/105-115
500-kV	Steel	37-52/120-170

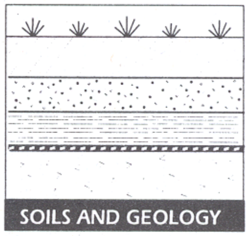
FIGURE 4.3-3

Typical Environmental Impacts of Transmission Lines



EFFECTS
- Farmland removed from production
- Forests cleared
- Aircraft hazards
- New roads

MITIGATIONS
- Location changes
- FAA marking requirements

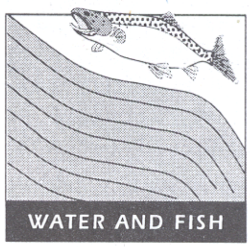


EFFECTS
- Erosion/soil movement from construction
- Stream sedimentation during/after construction
- Reduced line reliability from snow/ice /avalanches

MITIGATIONS
- Revegetation
- Road design
- Location changes

EFFECTS
- Vegetation/habitat destruction
- Soil compaction

MITIGATIONS
- Span small wetlands
- Mats or tracked construction equipment
- Off-site compensation

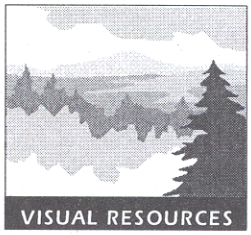


EFFECTS
- Reduced aquatic life survival from sedimentation
- Reduced habitat quality from herbicide use

MITIGATIONS
- Tower sites away from streambanks
- Span small streams
- Revegetation
- Silt fences

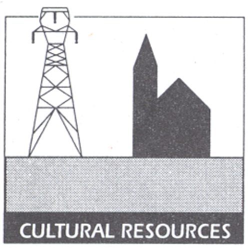
EFFECTS
- Vegetation/habitat changes
- Increased hunter access
- Wildlife disturbance during breeding, calving, critical seasons
- Bird collisions with conductors

MITIGATIONS
- Revegtation with low-growing species
- Construction timing
- Mark conductors with balls, etc.



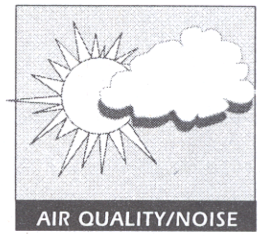
EFFECTS
- Structures incompatible with recreation, residential, scenic areas

MITIGATIONS
- Special tower designs
- Darkened towers in forests
- Non-shiny conductor
- Location changes



EFFECTS
- Disturbance of subsurface sites
- Visual intrusion on historic buildings/districts or religious sites

MITIGATIONS
- Pre-construction surveys
- Salvage or physical protection
- Location changes



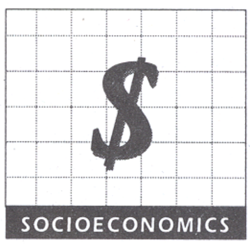
EFFECTS
- Fugitive dust
- Vehicle emissions
- Construction noise

} temporary, during construction

MITIGATIONS
- Federal, state, and local air quality and noise regulations

EFFECTS
- Electric shocks
- Conductor noise
- Electrical interference with electronic equipment
- Potential uncertain long-term health effects

MITIGATIONS
- Safety instruction to property owners
- Ground objects near lines
- Location/design changes
- Limit use of ROW



EFFECTS
- $280,000 – $688,000 per kilometer
- Temporary population increase in rural areas
- Increased access to private lands
- Strong objections to line's presence

Agricultural land would be permanently removed from production where towers are placed in cultivated fields; however, most access roads in farmland, other than existing roads, are used only during construction, after which the land is restored to its original use. Although structures could interfere with farming operations, often they can be located or designed to reduce impacts. Transmission lines most significantly affect irrigated farmland and cropland with perennial crops such as vineyards or orchards. It is difficult for farmers to cultivate around tower sites in the middle of fields and difficult and expensive to adjust irrigation equipment to tower sites. Loss of orchard land or vineyards to tower sites represents loss of a long-term investment, in addition to loss of annual income from the crops. (It is BPA's policy to compensate for such impacts.)

Commercial forest land (except Christmas tree farms or nurseries) would be removed from production for any new or expanded right-of-way and access roads, because only low-growing trees and shrubs are allowed on the right-of-way.

Effects on recreational land use are primarily visual (see Visual Resources).

Transmission lines near airports create significant hazards for aircraft. Normally, such locations are avoided. However, if a line must be located near an airport, towers are marked to Federal Aviation Administration (FAA) specifications to make them clearly visible to pilots. These markings may be an unwelcome visual impact on other users.

4.3.2.2 Soils and Geology

If construction occurs in areas with steep slopes and moderate soil erosion potential, soil may erode. This is true for construction in new, expanded, or existing corridors, although the greatest potential for impact would be in a new corridor because new right-of-way generally requires new access roads. If erosion is severe, vegetation recovery may be slow, and slumping (mass movements of soil down slope) and sedimentation of nearby streams may occur. Because line maintenance requires using access roads, soil impacts may continue over a long period.

Areas of severe weather conditions can create problems in maintaining a transmission line's reliability. Heavy snow or ice loads and avalanches can cause a line to fail by toppling towers or causing conductors to sag to the ground. While engineers can design towers to withstand such forces, such structures increase a line's cost. If possible, lines are sited to avoid such conditions.

4.3.2.3 Floodplains and Wetlands

Construction of structures and access roads may adversely alter wetlands and destroy vegetation and fish and wildlife habitat unless special construction practices are used. Long-term impacts are caused when heavy construction equipment compacts the soil, which changes the drainage patterns and sometimes vegetation types. Often, however, transmission lines can span or avoid smaller wetlands altogether, thus avoiding impacts entirely. If structures must be placed in a wetland, contractors use special tracked machines or mats to minimize impacts. If impacts still occur, section 404 of the Clean Water Act requires on-site or off-site mitigation or compensation.

4.3.2.4 Water and Fish

Clearing new right-of-way, expanding existing right-of-way, and constructing access roads can increase sediments in streams. The extent of the effect depends on the proximity of construction activity to a stream. Accumulation of sediment may change pool shape and size and may affect water quality. This in turn adversely affects aquatic life such as anadromous and resident fish. Use of herbicides to clear vegetation may also affect fish by removing vegetation that shades the water and keeps it cool. BPA meets state and Federal regulations for buffers beside streams and, if herbicides are used in these areas, they are sprayed by hand.

If sediment and turbidity are increased, then aquatic plant productivity is decreased. In turn, aquatic insect food sources are reduced. These impacts move up the food chain, eventually reducing fish numbers. The increased sediments hinder the emergence of alevins (baby fish) from their eggs in stream gravels and decrease winter survival by filling in channel pore spaces and reducing the channel's potential to produce food.

In most cases, proper erosion control practices result in only short-term sedimentation increases. For example, to protect its structures, BPA does not normally place them close to stream banks because erosion could undermine them, and does not allow construction equipment in streams. In steep areas, small streams usually are spanned. Revegetation to stabilize the soil and use of fabric fences to hold back silt also prevent sedimentation.

Transmission line options that use existing corridors would have the lowest impacts on water quality and fish because the right-of-way already would be cleared and most access roads would be in place.

4.3.2.5 Vegetation and Wildlife

Clearing new and expanding existing rights-of-way can create major impacts on vegetation. Existing vegetation is removed, and vegetation composition may change, most notably in forested areas where all tall-growing vegetation must be removed. Maintenance practices, including herbicide use and danger-tree cutting, ensure that only low-growing vegetation survives over the long term. Although disturbed areas can be reseeded with low-growing plants, success rates vary. If a line uses existing right-of-way, little or no additional clearing of existing vegetation is needed.

Right-of-way clearing for new corridors changes the habitat for wildlife and increases access for hunters. Expanding existing right-of-way would disturb wildlife or cause them to leave the area during construction. This impact can be especially severe during breeding, calving, or other critical seasons. Right-of-way expansion would change some habitat permanently. Using existing right-of-way would disturb wildlife during construction only.

4.3.2.6 Visual Resources

In areas used for recreation, particularly in undeveloped places, studies show that many users find transmission lines to be an unwelcome visual intrusion. Also, many citizens feel strongly that transmission lines near their homes are visually intrusive, and that some property values may be reduced. Adverse visual effects may be perceived up to several kilometers from the line. Transmission lines may be more compatible with industrial areas. The effectiveness of potential mitigation measures depends on the site, and some measures may substantially increase the cost of the project. Possible measures include darkened towers in forested areas; different tower designs more compatible with a particular environment; non-specular (non-shiny) conductor; and locations that avoid visually sensitive areas.

4.3.2.7 Cultural Resources

Construction may disturb subsurface resources such as archeological sites and may intrude visually on historic buildings or districts. With careful preconstruction surveys and consultation with Native American and historical properties experts, impacts on most subsurface sites can be avoided or mitigated.

4.3.2.8 Air Quality and Noise

Construction of transmission lines has the potential to affect air quality of an area, particularly during dry periods in late summer, by disturbing the soil and raising fugitive dust. Standard construction practices keep such occurrences at a minimum. Construction contractors are required to comply with all Federal, state, and local air quality standards, including vehicle emissions standards.

Contractors must also comply with all noise regulations by observing maximum decibel levels for machinery and ceasing construction activity during certain hours to avoid disturbance to nearby residents.

4.3.2.9 Health and Safety

BPA recognizes strong public concern regarding the possible effects of the electrical properties of transmission lines on public health and safety. These effects include electric shocks, noise, and the potential long-term health effects of EMF.

Safety. All BPA lines are designed and constructed in accordance with the National Electrical Safety Code (NESC), which specifies the minimum allowable distances between the lines and the ground or other objects to minimize hazards from electric shocks. Grounding of certain objects near the line is standard construction practice to reduce the potential for shocks that may be induced by a line near objects such as wire fencing on wood posts. For more information, see the BPA publication, Living and Working Around High-Voltage Power Lines (DOE/BP-1821).

Corona Effects. Transmission lines produce corona, the molecular breakdown of air very near conductors that occurs when the electric field is greatly intensified at projections (such as water droplets) on the conductor. Although BPA lines are designed to meet all state and Federal audible noise standards, corona may cause noise and electrical interference to nearby homes or businesses. All problems are investigated and, if the BPA facility is involved, most effects can be mitigated by minor modifications to the lines or to the affected equipment. Studies have shown that the minute amount of ozone produced by corona generally is not detectable above average background levels.

Electric and Magnetic Fields (EMF). Both electric and magnetic alternating-current (AC) fields induce currents in conducting objects, including people and animals. These currents, even from the largest power lines, are too weak to be felt. However, some scientists believe that the currents may be harmful and that long-term exposure should be minimized.

Hundreds of studies on electric and magnetic fields have been conducted in the United States and other countries. Studies of laboratory animals generally show that these fields have no obvious harmful effects. However, a number of subtle effects of unknown biological significance have been reported in some laboratory studies (Frey, 1993).

Much attention at present is focused on several recent reports suggesting that workers in certain electrical occupations and people living close to power lines have an increased risk of leukemia and other cancers (Sagan, 1991; NRPB, 1992; ORAU Panel, 1992; Stone, 1992). Most scientific reviews, however, find that the overall evidence is too weak to establish a cause-and-effect relationship between electric or magnetic fields and cancer. For this reason, BPA is unable to predict specific health risks related to exposure to EMF.

There are no national standards for EMF. Six states, including Oregon and Montana, have electric field standards, but no PNW state has yet established a magnetic field standard. BPA has an electric field standard of 9 kilovolts per meter (kV/m) maximum on the right-of-way and 5 kV/m at the edge of the right-of-way. However, because of the scientific uncertainty and in response to public concern, BPA has taken additional steps. These include: developing Guidelines on EMF that name EMF as a major decision factor to be considered in locating and designing new BPA facilities; discouraging intensive uses of rights-of-way that would increase human exposure to EMF; and not increasing public and employee exposure to EMF where practical alternatives exist. A task force is currently reviewing guidelines.

More detailed information on effects of EMF or corona can be found in a BPA publication, Electrical and Biological Effects of Transmission Lines: A Review (DOE/BP-945).

4.3.2.10 Socioeconomic Effects

Typical construction costs for transmission lines range from $280,000/km ($450,000/mi) of 230-kV double-circuit line to $690,000/km ($1.1 million/mi) of double-circuit 500-kV line. How these costs are translated into the rates BPA charges its customers for transmission services depends on BPA's total costs and is decided in BPA's rate case process.

Construction crews for major lines would noticeably increase the population of some rural areas, a temporary effect. New access roads may increase access to private land, and individuals living near a transmission line may strongly object to the line's presence.

4.3.2.11 Differences in Transmission Lines Among Utilities

There are differences in the design, construction, and maintenance of transmission lines between BPA and other utilities; however, it is difficult to identify consistent differences between BPA transmission lines and other utilities' as a class. Differences can be attributed to such factors as clearance policy (BPA designs to NESC standards plus buffers, whereas other utilities may use other buffers), design criteria (not all designs at a given voltage have the same phase separation, structure types, or conductor designs, for example), design parameters (such as switching surge), and maintenance requirements. BPA typically avoids use of herbicides to maintain vegetation in transmission line right-of-ways; other utilities may use herbicides more frequently. BPA's transmission lines are all on separate right-of-ways; many other utilities have pole easements only for lower-voltage transmission lines.

4.3.2.12 Lower- Versus Higher-Voltage Lines

Higher-voltage lines are more efficient than lower-voltage lines in transferring power. For a given amount of power transfer, as the voltage level increases, the current level decreases. Because resistive losses increase as a function of the square of the current load, for a given amount of power transfer and a given conductor, higher-voltage lines have fewer resistive losses. More efficient transmission of power through the use of higher-voltage lines can lead to lower environmental impacts for two reasons.

First, the same amount of power can be transferred with fewer kilometers of high-voltage lines than with lower-voltage lines, so although higher-voltage lines require wider right-of-ways and have more massive structures, fewer lines have to be constructed. Higher-voltage lines can move more power from source to load for less cost per megawatt, less land-use per megawatt, and less raw material use overall per megawatt.

Second, more efficient transmission on higher-voltage lines means that less generation is required to serve the same amount of load. More efficient transmission lines can therefore be equated with energy conservation.

4.3.3 Consumer Behavior

Changes in BPA products, services and rates directly affect its customers—public and investor-owned utilities and DSIs. To the extent that utilities pass those changes through to their retail consumers, they can affect end-use consumers or change consumer behavior. The following sections describe typical impacts of changes in utility products, services and rates on each major retail consumer sector. They also address general impacts on DSIs. Figure 4.3-4 summarizes these effects.

4.3.3.1 Residential Sector

In the retail residential sector, the primary environmental impacts of changes in BPA's products, services, and rates would occur from residential conservation and fuel switching. Household incomes could also be affected by changes in home heating and lighting costs. In general, environmental impacts associated with both residential conservation and fuel switching are minimal. The following discussion of environmental impacts is summarized from the Resource Programs Final EIS (DOE/EIS-0162, February 1993).

Conservation

House-tightening measures may increase levels of radon gas within weatherized houses. Radon gas is a naturally occurring gas associated with increased rates of cancer in humans. Measures to reduce the build-up of radon within weatherized houses are now standard for BPA and other regional residential conservation programs, so no significant health impacts from radon are expected from those programs.

Fuel Switching

Fuel switching occurs when retail electricity users switch to some other energy source for some uses. Most typically, fuel switching in the residential sector involves changing from electricity to natural gas for space-and water-heating. Fuel switching can lead to minor environmental impacts in two areas: air quality and land and soil impacts of fuel line installation.

Air quality impacts of fuel switching result from the combustion of natural gas in the home for water- and space-heating. Although natural gas is a fairly clean fuel, burning natural gas in the home does produce small emissions of NO_x, CO, and CO_2 (see table 4.3-1). It should be noted that, overall, direct use of natural gas for water- and space-heating converts fuel to useful energy more efficiently than burning fuel to operate a CT to generate electricity for the same use. Overall, fuel-switching may produce fewer air emissions than generating electricity for the same end use; however, the emissions associated with fuel switching typically occur in populated areas with a greater potential for air quality problems, whereas (at least in the PNW) in many cases CTs are located outside major population areas.

The installation of gas distribution lines can create temporary impacts on soils during construction. Soils can be compacted, and construction site runoff must be managed to reduce the potential that might reach storm drains or streams. Overall, the environmental impacts of installing gas distribution lines are fairly minor, and typically regulated by state and local building and environmental protection codes.

Socioeconomic Impacts

If residential end users cannot conserve electricity to reduce the cost impacts of changes in BPA products, services, and rates, their costs for home heating and lighting could increase. The extent to which such increases would affect household net incomes would depend on many factors, including the degree to which retail utilities passed through changes, the amount of electricity consumed, options for changing consumption patterns (e.g., using programmed thermostats or shutting off more lights), and the share of electricity costs in total household budgets. In general, it is likely that any rate impact passed through by retail utilities would have a minor effect on most household incomes, but would have proportionately more impact on lower-income households. Where planners intend that some conservation potential be achieved through price signals, adoption of conservation measures in response to price would occur more frequently among higher-income consumers, and consumers unable to finance conservation measures would spend a larger portion of their income on electric energy. Some consumers might change their electricity use patterns if electricity cost more during peak-use times of the day or during certain seasons when power is less available.

4.3.3.2 Commercial Sector

In the commercial end-use sector, the environmental impacts associated with changes in BPA's products, services, and rates would be in three areas: commercial sector conservation, fuel switching, and the socioeconomic impacts associated with changes in costs or loads.

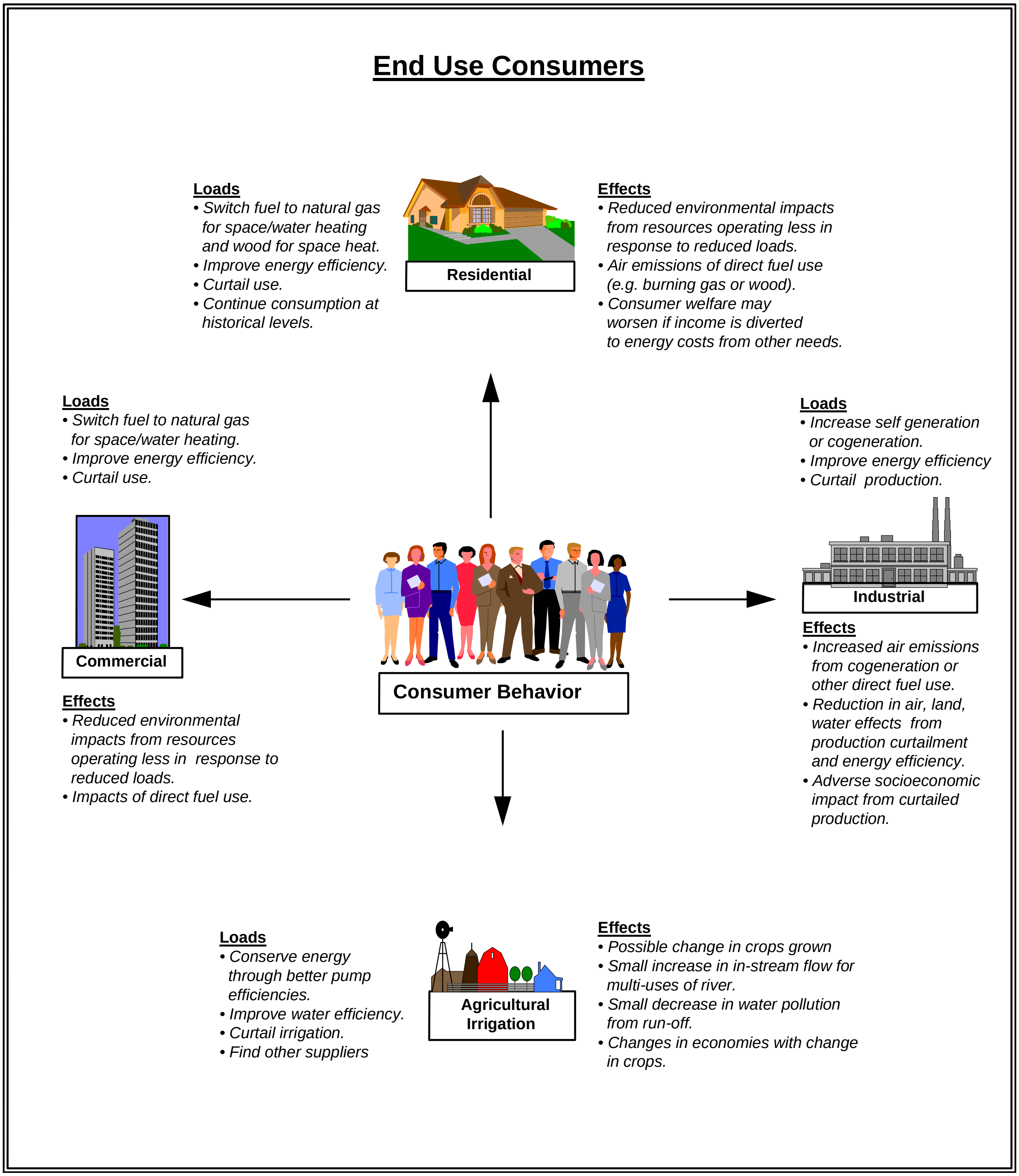
Conservation

The Resource Programs Final EIS (DOE/EIS-0162, February 1993) identifies potential environmental impacts associated with commercial sector conservation programs. In general, conservation would have positive environmental impacts overall by reducing new generating resource development; the only potential negative impacts (e.g., indoor air quality and the use of hazardous or polluting materials or technologies for energy efficiency) are generally effectively mitigated.

Fuel Switching

Some commercial end users may switch to natural gas for heating loads. Fuel switching could have minor air quality impacts from combustion. There might also be minor environmental impacts associated with gas delivery (e.g., excavation for distribution pipelines), but these types of in-ground impacts are typically regulated locally and typically have minimal net long-term environmental impacts.

CONSUMER BEHAVIOR
LOADS AND EFFECTS FROM INCREASED RETAIL RATES



Socioeconomic Impacts

Changes in BPA products, services, and rates, to the extent passed through by retail utilities to end-use consumers, could affect the energy costs experienced by commercial businesses. For marginally profitable businesses, increased energy costs could be enough to cause these firms to fail, reducing employment and local incomes. However, the potential for this type of impact to have any significance on a regional or commercial-sector scale is small, and impacts on individual businesses would depend on the businesses' energy costs, total operating costs, opportunities to reduce electricity consumption, and market prices for their products and services.

4.3.3.3 Industrial Sector

The primary impact of changes in BPA's products, services, and rates passed through to the industrial sector would be associated with fuel switching, self-generation and cogeneration, industrial sector conservation programs, and socioeconomic impacts (e.g., employment and income changes).

Fuel Switching

Switching from electricity to natural gas or other fuels is an option in some PNW industries. The most likely fuel choice in many areas would be natural gas, although some wood products firms may be able to use wood waste. The environmental impacts would vary according to the fuel used and the industrial process; in general, fuel switching to natural gas would have minor air quality impacts.

Self-Generation and Cogeneration

Some large industrial firms could replace electricity purchases from their local retail utility by developing their own generation (on-site generation to substitute in part for purchased electric power) or cogeneration (on-site cogeneration facilities to produce heat and steam for industrial uses and to generate electricity for plant use and/or for sale to utilities). The most likely technology would be natural gas-fired cogeneration or CTs. The typical environmental impacts of CTs and cogeneration are described in section 4.3.1. Cogeneration projects at many large industrial sites (particularly in the pulp and paper industry) often replace wood-waste or diesel-fired boilers with gas-fired boilers, leading to a net improvement in air quality at the site.

Conservation

Industrial conservation measures vary considerably by industry, but generally include the following types of measures:

- High-efficiency motors
- Adjustable/variable speed drives
- Energy-efficient motor rewinds
- Heat recovery equipment
- Thermal storage
- Insulation
- Process heat equipment
- Compressed air systems
- Lighting efficiencies
- Energy management improvements
- Materials handling improvements

- Power factor improvements
- Cooling tower conservation
- Pump and fan efficiencies
- Distribution transformer improvements
- Dehumidifiers
- Furnace upgrades
- Water recycling processes
- Refrigeration system improvements.

Most of the measures listed above do not alter existing mechanical processes in ways that lead to increases in waste streams or adverse environmental impacts; in fact, many industrial sector conservation programs simultaneously reduce electricity use and waste streams. In most industrial applications, there is sufficient environmental regulation to address any potential adverse impacts that result from process modifications to reduce energy use. In most cases, energy conservation would have positive impacts by reducing the need for new generation and increasing the efficiency of the industrial process, thereby reducing other waste streams.

Socioeconomic Impacts

If rate changes were passed through to the industrial customer, and if that customer could not reduce electricity costs by conservation, fuel-switching, or process changes, some marginal firms could experience changes in overall production costs that could threaten their economic viability. Specific impacts are difficult to predict, but industries primarily affected would be marginally viable ones for which electricity costs are a large share of total production costs and which have limited ability to shift to other fuels or to reduce consumption.

4.3.3.4 Agricultural Sector

The environmental impacts associated with rate design changes passed through to irrigation sector end users would include impacts from irrigation sector conservation, socioeconomic impacts on the agricultural sector, and, potentially, land use changes from shifts in cropping patterns.

Conservation

The Resource Programs Final EIS (DOE/EIS-0162, February 1993) addresses potential environmental impacts associated with irrigation sector conservation programs. The EIS notes that the environmental impacts associated with most of the energy conservation measures result in a new positive environmental impact, because both energy and water consumption are reduced and equipment life is extended. The EIS goes on to explain that the few potential negative environmental impacts of irrigation conservation measures, largely due to the potential for increased soil erosion from some sprinkler irrigation methods, are mitigable.

Socioeconomic and Land Use Impacts

If changes in electricity products, services, and costs are passed through to the farmer, total farm operating costs could change. If energy costs increase, some marginal operations could become uneconomical. The most vulnerable operations would probably be high-head pumping operations, primarily in arid areas of the PNW with mostly sandy soils, and crops for which pumping is a larger share of total costs (e.g., wheat). For many of these vulnerable operations, grazing is probably the chief alternative use of the land.

In other cases, increased irrigation costs could cause farmers to change cropping patterns to crops that use less irrigation water in order for their operations to remain viable.

4.3.3.5 Direct Service Industries (DSIs)

The Direct Services Industry Options Final EIS (DOE/EIS-0123F, 1986) addressed the environmental and socioeconomic impacts of all the Northwest primary aluminum smelters, all of which are DSIs. While some conditions have changed, the EIS continues to be a substantially accurate assessment of the environmental and socioeconomic impacts of the smelters. The Reynolds Troutdale smelter, an old prebake plant, is currently closed. All PNW smelters re expected to continue operating at full capacity for the near future due to low prices for power.

Past practices of smelters caused some environmental problems when environmental regulations were less stringent and the effects of smelter air and water pollutant discharges and solid wastes were less well understood. Aluminum smelters are major sources of a number of important air pollutants, including CO, SO_2, particulate matter, and CO_2. They also emit several hazardous air pollutants (HAP) and greenhouse gases. Current practices and regulations reduce smelter discharges, so now operations generally do not cause appreciable harm (Direct Services Industry Options Final EIS, Appendix A).

The greenhouse gases associated with aluminum smelter emissions are CO_2, carbon tetrafluoride (CF_4), and carbon hexafluoride (C_2F_6). Typical CO_2 emissions from aluminum smelters (expressed in terms of emissions per aMW of load placed on BPA) are presented in table 4.3-1; impacts of DSI operations in each of the alternatives are shown in table 4.4-19, under section 4.4.3.8. The global warming potential of carbon tetrafluoride is approximately 5,000 times that of CO_2, and that of carbon hexafluoride approximately 10,000 times more potent than CO_2, due to the long atmospheric lifetimes associated with these compounds. CF_4 remains in the atmosphere for decades and C_2F_6 remains in the atmosphere for hundreds of years. The quantity of CF_4 and C_2F_6 emissions from aluminum smelters depends upon computer technology; the more precisely aluminum smelters can control the amount of electricity supplied to the aluminum pots, the less CF_4 and C_2F_6 will be emitted. Smelters using computer-controlled potlines emit a fraction of what older smelters emit. Typical CF_4 emissions range from 0.2 to 1 kilogram (kg) (0.44 to 2.2 pounds (lb)) per metric ton of aluminum produced and C_2F_6 emissions range from 0.04 to 0.16 kg (0.08 to 0.35 lb) per metric ton of aluminum produced.

One-hundred eighty-nine HAPs are now regulated under the Clean Air Act as revised in 1990. Aluminum smelters emit significant quantities of hydrogen fluoride, a respiratory irritant, which is one of these HAPs. Aluminum smelter hydrogen fluoride emissions range from 0.1 to 1.2 kg (0.2 to 2.6 lb) per metric ton of aluminum produced. Aluminum smelters also emit significant quantities of carcinogenic polycyclic aromatic hydrocarbons (PAH), which are also regulated HAPs. The quantity of PAH emitted depends upon each smelter's potline technology. PAH emissions range from 0.25 to 3 kg (0.55 to 6.6 lb) PAH per metric ton of aluminum produced. The EPA is in the process of setting aluminum industry emission control requirements for both PAH and hydrogen fluoride.

The recent decline in wholesale prices for electricity has benefited the region’s aluminum smelters because BPA is no longer the least-cost supplier of electricity in the Northwest. Smelters that were formerly considered “at risk” of closure can now operate through most swings of the aluminum price cycle if they can purchase power at an average cost of 20 mills/kWh, as some offered power sales demonstrate. However, if load growth on the west coast reduces the electricity surplus and gas prices rise, forcing up prices on the wholesale electric market, then some of the region’s smelters could face closure as their cost of electricity rises.

4.3.4 Impacts of Potential Hydro Operation Strategies

4.3.4.1 Introduction and Background

The discussion below of hydro generation and its impacts covers operations of the river system, and is summarized directly from the Systems Operations Review Draft Environmental Impact Statement (DOE/EIS-0170), which focused on potential changes in operations of Federal Columbia River mainstem projects. Decisions made on how to operate the river are *not* within the scope of the Business Plan EIS.

(Similarly, decisions made within the Business Plan EIS do not influence the SOR process or limit its ability to make decisions.)

The BP EIS examines changes in business practices. However, the consequences of those business changes may vary, depending on which river operations strategy is selected in the SOR process. Therefore, the discussion of hydro operations strategies below is provided for the BP EIS reader.

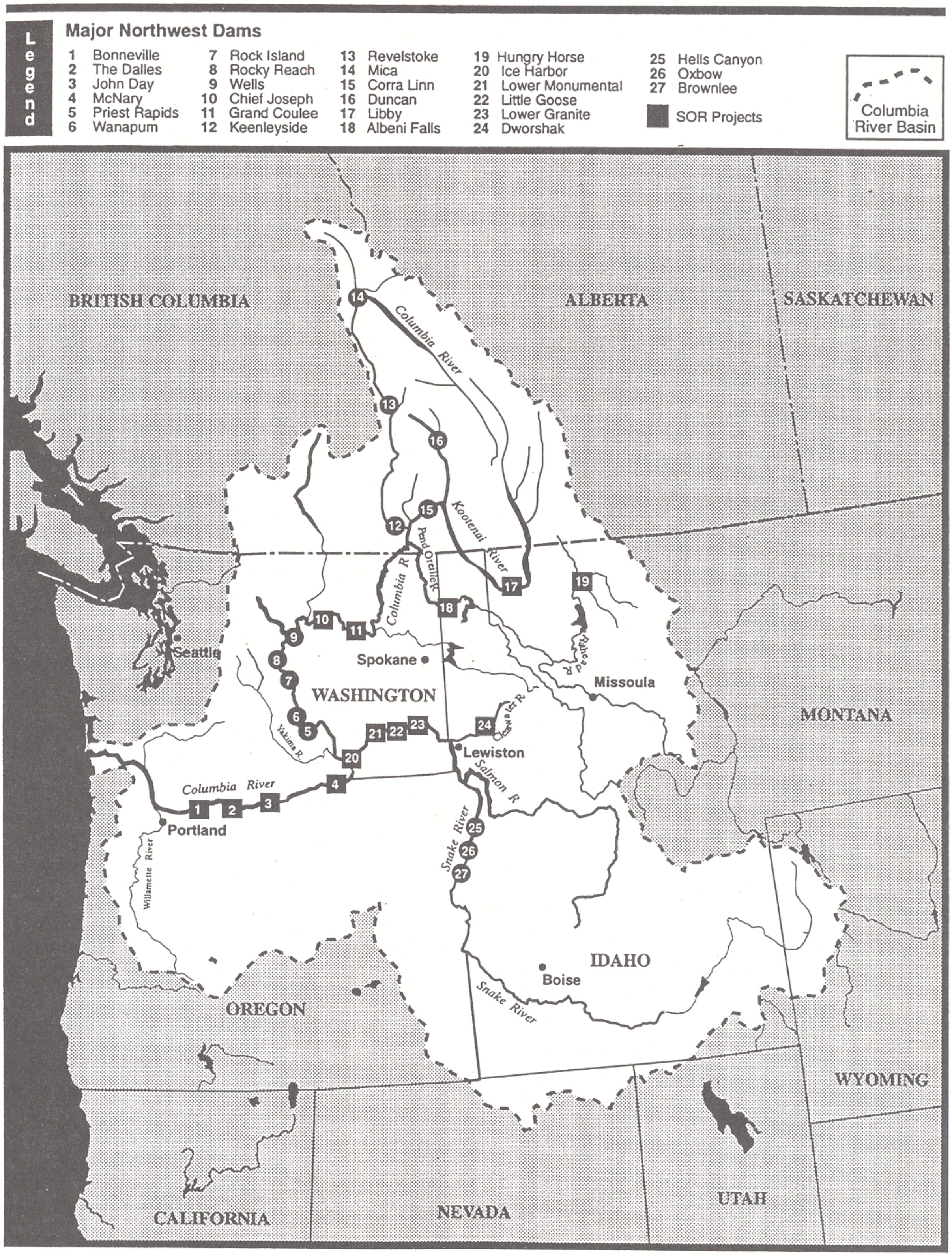
The range of river operation changes turns on the issue of how to reverse the rapid decline of anadromous salmon stocks in the river system, and particularly in the Snake River. Current river operations and the dams and turbines affect the ability of anadromous fish to migrate oceanward and return, by placing obstacles in their way and rendering them vulnerable to predators for a longer period of time before they reach the ocean, by killing fish that pass through turbines at the dams, and by increasing the difficulty of passage around dams on their return. Scientists, interested groups, agencies, and Tribes seek to address these problems, but they do not agree on the best solutions. In particular, there is disagreement in three areas: flow, spill, and in-river migration versus transportation of fish. These issues are briefly characterized below.

- **Flow.** A number of scientists believe that a key to increasing anadromous fish survival is to speed up downstream migration of juvenile anadromous fish, which is slowed by as many as nine dams. There is some disagreement as to how much an increase in flow(s) may help or how that increase may be related to travel time. However, the NMFS and the Council think that a mix of water release measures (increased water to augment flows, drawdown, and more spill) should help this situation. Consequently, the Draft SOR EIS proposed a range of strategies for operating the Federal system. These System Operating Strategies (SOSs) combine the three measures in various ways and to varying degrees.

- **Spill.** When additional water is allowed to flow over dam spillways, fish migrating downstream are attracted to the increased current and "flushed" around dams more quickly. However, when water falls from a height, the amount of nitrogen in the water increases: the water becomes supersaturated with the gas, which can have debilitating and potentially lethal effects on fish through gas bubble disease. There is disagreement on what percentage of gas saturation is acceptable. The threshold has been 110 percent; some parties believe that 120 or 125 percent (one result of greater amounts of spilled water) would not appreciably affect fish mortality but would successfully speed more fish oceanward. Another consideration is the physical location of spill: it occurs at locations different from the fish ladder entrances and exits. (For distinctions between run-of-river and storage dams, please see 4.3.4.2, below.) Fish seeking upstream passage can be attracted to the increased flow from spill, where there is no way upstream, and may consequently fail to reach their spawning grounds.

  In-river migration versus transportation. Before there were dams, anadromous fish negotiated their way first downriver, then back upriver and over rapids and falls into the far reaches of the Columbia River system. Now, anadromous fish cannot get around storage dams at all (see figure 4.3-5). To increase fish migration *downstream*, the COE has been diverting fish away from turbine intakes and into channels either for bypass around dams or for transport downstream on barges or trucks (the fish are then released back into the river). Researchers estimate that more than 70 percent of Snake River steelhead and yearling spring and summer chinook smolts, and up to 40 percent of subyearling fall chinook arriving downstream, are transported around dams. Some fish die when they are transported, through shock or injury. Some fish die when instead they continue in-river over or past dams: they may be injured or killed if they pass through turbines or through gas bubble disease (see **Spill**, above). There is disagreement over whether transport is sufficiently helpful and acceptable, or whether in-river migration only would be both a feasible and superior goal.

Figure 4.3-5: Major Northwest Dams



The text below first provides background on the impacts of a full range of hydro operations, then on impacts from two Strategies from the Draft SOR EIS. These two represent likely endpoints for a range of impacts for business practices.[4]

- "**Current Operation"** (System Operating Strategy 2c) represents "No Action" in the SOR: that is, operations would continue to develop as at present, with some flow augmentation. This alternative would represent the likely least-cost option for power production and revenues.
- **"Coordination Act Report Operation"** (SOS 7a) was intended to assist anadromous fish migration through a combination of spill, increased flow augmentation, and drawdown. Of the SOS's examined in the Draft SOR EIS, it would have the most serious impacts on power production and revenues.

4.3.4.2 General Effects of Changes in Hydroelectric Operations

The text below is summarized from the Draft SOR EIS, and discusses river operations (storage and release of water) using the existing projects on the Columbia and Snake Rivers. It does not examine impacts from building and beginning operation of a new dam because the building of such dams is not part of the scope of the SOR EIS.

Hydro generation involves the control of flowing water to produce electricity. Environmental impacts derive from the storage, release, and/or diversion of water from its natural course through the dams and turbines that produce electricity. There are two types of hydroelectric projects. Storage dams store and release (draft) large amounts of water for power production and other uses. They can shift the timing of natural runoff downstream, by holding water back for later release. Run-of-river dams have limited storage capacity, and relatively minor fluctuations in water level.

Water to produce hydro power is most available in *late spring* and *early summer* when the snowpack melts. However, the heaviest demand for power in the Pacific Northwest comes in the *winter* months, largely from winter heating loads.

Under current operations, water from spring snowmelt and runoff is stored during the spring and summer and then released later in the year to supplement flow through turbines at dams and produce power. Water is also released to meet other needs, including additional water flows (Water Budget and other flow augmentation) to assist juvenile anadromous fish in their migration to the ocean.

Storage and release of water may have effects on a wide range of resources: both resident and anadromous fish, soils, vegetation, water quality, wildlife, cultural resources, recreation, navigation, irrigation, municipal uses, flood control, and power production. The following sections provide detail on effects of changes in hydroelectric operations. Storage and release often have conflicting effects: a benefit provided by one may be a drawback under the other, and vice versa. Both benefits and drawbacks are described below.

Fourteen Federally recognized Native American Tribes, each with its own reservation, are located within the SOR study area. The existing tribal and reservation structure has been shaped by treaties between the United States government and the Tribes in the mid-1800s. The right to fish and hunt on their reservations is reserved to the Tribes; Tribes generally manage fish and wildlife resources on the reservations. Off-reservation rights also include fishing, hunting, gathering activities, and use of sacred and religious sites. Anadromous fish were, and still are, central to the subsistence, culture, and religion of most Columbia Basin Tribes. Courts have reaffirmed the treaty rights of Indians to share equitably in the harvest of anadromous fish, and to continue to fish in their "usual and accustomed places." Some of those places, flooded by dams for hydroelectric projects, have been replaced by five "in-lieu" fishing sites in the Bonneville and The Dalles pools. Additional in-lieu fishing sites are being developed by the Corps of Engineers.

Indian lands also include trust lands owned by the Federal government and administered by the Bureau of Indian Affairs (BIA) for the exclusive use of Indians. Indian trust and Tribal lands are managed for a variety

[4] The two Strategies are based on the Draft SOR EIS issued in July 1994. The Strategies are under reconsideration and revision; for current developments, see section 4.3.4.3.

of purposes by the BIA or the Tribes. Trust assets include lands, minerals, hunting and fishing rights, and water rights. The United States has a trust responsibility to protect and maintain such rights, and to deal with the Tribes on a government-to-government basis.

Storage

Storage of water behind dams may occur at several levels: maximum operating pool (highest operating level), minimum operating pool (lowest level within the normal operating range), and minimum irrigation pool (lowest level that can meet irrigation withdrawal needs; a characteristic of John Day reservoir only).

Storage of water can have a number of *benefits*. Water stored during a season or from one year to the next can provide a "bank" for dry years, when less snow falls and melts to refill reservoirs. More water can then be made available for irrigation, navigation, and power production. Relatively inexpensive hydro power can reliably be produced to supply regional needs when the load occurs, with less need to buy more expensive power from elsewhere. Storage capacity also provides flood control: high flows that might otherwise cause flooding can be caught and then released in quantities and at intervals that do not threaten communities or resources downstream, a social and economic benefit.

When sudden or extended drafts of water are delayed or do not occur at all, there is less opportunity for erosion and slumping of soils along the sides of the reservoir. When water is retained later into the year and reservoir pool level fluctuation is minimized, more stable conditions result for fish living in the reservoirs and for wildlife that depend on the wetland and riparian habitat bordering reservoirs for foraging and nesting. (Some reservoirs, especially storage reservoirs, have such steep sides that little valuable habitat borders them; others support more wetland/riparian habitat.) Greater pool surface provides better habitat for waterfowl; islands remain isolated from shorelines and thus sheltered from predators. Benthic organisms that grow in shallow-water conditions and provide a food supply for fish can grow under steady-state conditions. Steadily maintained higher pool elevation provides access to in-flowing rivers and streams up which some species of fish swim to spawn.

Extended storage also benefits recreation at upstream reservoirs by providing stable bodies of water that encourage leisure-time activities such as boating, fishing, and sightseeing, which can bring associated tourist income to the area. If, however, downstream flows are not stable, fixed-elevation facilities can become unusable; submerged objects downstream from reservoirs can become a greater danger to windsurfers or boaters; and fishing success may change.

With a more consistent water level in reservoirs, cultural resources near or below shoreline are not exposed to the fluctuations in water level that erode and can destroy the sites/artifacts themselves; they are also not exposed to freeze-thaw cycles, to disturbance, or potential vandalism. Reservoirs kept full during the growing season (April - October) provide maximum benefits to those farmers who use pumps to withdraw water from projects to irrigate their crops and provide their livelihood: water is available and the pumps can function successfully. If reservoirs are kept at or above minimum operating pool, then shallow draft navigation throughout the river system and log transport across Dworshak Reservoir can continue for the full commercial season, another economic benefit.

There are also *drawbacks* to high or extended storage levels, or to storage at times when water is needed downstream for other purposes such as flows for fish migration. If reservoirs are kept full through the winter, there may not be enough "space" to store snowmelt and prevent flooding. If water is not released to flow through turbines downstream, power production is diminished and becomes more costly because it depends on the amount of water flowing into the reservoir from upstream. If flows are not sufficient, either alternative generation sources have to be built or power purchased from elsewhere.

Reservoirs maintained at a high or extended storage mode can slow the passage of juvenile anadromous fish through the reservoir itself, as well as make their passage downstream in river reaches slower and more difficult. Anadromous fish undergo a process called "smoltification" which sends them downstream to the ocean and prepares them for life in saltwater; the condition does not last indefinitely and, if the fish are delayed too long, they may not be able to make the biological transition. Slower times downriver may also mean increased opportunity for predators or disease to kill fish.

Reduced downstream flows can also affect resident fish living in the downstream reaches. Shallower water becomes warmer, a condition that encourages growth of benthic organisms on which fish feed and thus growth of fish as well. However, some fish—such as trout—grow best under cooler (and deeper) water conditions.

Release

Release or drafting of water from behind dams for power production occurs in two primary ways. At storage projects, much larger volumes of water are released, resulting in pool level changes of up to 68.3 m (224 ft) at a specific project. At run-of-river projects, water is passed along in flows, creating daily fluctuations in pool level of 0.9 to 1.5 m (3 to 5 ft) (gradually lower in the daytime as more water is passed through for power production; gradually higher at night as the pool refills).

Drawdown, one of the components in SOR strategies, affects run-of-river projects not by changing the fluctuation but by setting the acceptable range of pool elevation considerably lower than at present (for instance, where current operations may range between 244.3 and 246.0 m (733 and 738 ft) at a project, drawdown may change the range to 235.0 and 236.7 m (705 and 710 feet). Flow augmentation adds water from storage to increase river flows: the goal is to get fish through the reservoirs and rivers *between* dams. Spill is the release of water over the dam spillway(s). Its purpose is to attract fish to safe passage *past or over* dams (avoiding passage through turbines).

Release of water through drafting offers a number of *benefits.* It is regularly used today to augment river flows in fall and winter to produce power when it is needed. Drafting is also used to reduce water levels in reservoirs before snowmelt begins so that there is reservoir storage space to use for flood control.

When the level of water behind the dam is reduced through drafting or drawdown, the velocity of the river water increases through the reservoirs. Increased velocity may help juvenile anadromous fish migrate through the reservoir more quickly. Where drawdown lowers the pool surface elevation to a level that essentially removes the impoundments behind a series of run-of-river dams, conditions begin to return to those of a "natural river." Anadromous fish in-river survival rate would generally improve so long as direct passage were provided (for instance, the dams were essentially removed and lower-level outlets substituted). Some believe that such actions may reduce or eliminate the need for transporting fish. Long-term water quality could improve, keeping water temperatures downstream lower and reducing levels of dissolved gas which can kill fish (see Spill, below).

However, there are also *drawbacks* to major releases of water through pool fluctuations caused by drafting or drawdown. Shorelines are exposed; soils erode and slump; and large amounts of sediment may initially move downstream. Cultural resources located along the reservoirs can be damaged, through site erosion, human disturbance, vandalism, and freeze-thaw cycles in exposed sites. Drawdowns or drafting within a reservoir can disrupt and compress resident fish habitat, preventing access to in-flowing rivers and streams up which fish ascend to spawn, drying out eggs, stranding young in backwater pools, and drying out food supplies. As water levels change, the acreage of wetland and riparian habitat changes: plants are drowned or dried out, and exposed sand and gravel create a barren drawdown zone which can leave some wildlife (such as nesting waterfowl) more exposed to predators. Wildlife habitat and food sources in lower river reaches can be destroyed by increased flows from drawdown, affecting waterfowl, shorebirds, aquatic furbearers, and so on.

If pool levels at run-of-river projects are drawn down below the current minimum operating range, navigation locks, fish ladders, irrigation pumps, and other equipment cannot operate without modifications. With significant drawdown under some SOSs, there still might not be enough water available for all irrigators in some years, and farm income could drop. As less water becomes available to produce inexpensive hydro power, wholesale rates could rise significantly, and backup generation resources could be required, carrying with them their own set of environmental impacts, such as air pollution or land use changes from construction and operation of CTs.

Recreational opportunities associated with reservoirs are generally reduced as water levels fall: fixed-water-level facilities become unusable below certain pool levels. There is an associated economic consequence for local communities benefiting from reservoir-based tourism. Reduced pool level can restrict or preclude shallow draft navigation if water levels do not permit sufficient draft or if locks are inoperable in spring and summer, the major times for commercial activity on the river. Logging transport via reservoir (at Dworshak) can be reduced as water levels fall. Port activity may shift elsewhere; shipping would have to be rescheduled or carried out by other modes of transportation. These impacts have socioeconomic consequences for both cost and quality of living.

Flow augmentation provides *benefits* primarily for anadromous fish migration downstream. It takes two forms: release of specific amounts of water from reservoirs and lakes, or release to achieve certain targets—levels of water or rates of flow—in downstream river reaches. Flow augmentation offers the possibility of moving juvenile anadromous fish more quickly (and potentially with less mortality) downstream to the ocean. Higher spring flows could nourish additional habitat along river shores downstream. Greater flows might also benefit spawning for the Kootenai River white sturgeon, a species listed under the Endangered Species Act.

Flow augmentation has *drawbacks* for a number of other resources, however. Under some SOSs, in drier years, some reservoirs might have to be emptied significantly, leaving broad bands of barren drawdown zones. Resident fish populations in these bodies of water could thus be reduced significantly, with a smaller habitat area and reduced food supply as benthic organisms dry out. Water temperature on the surface of the pool generally rises in the absence of nearby overhanging vegetation. Wetland and riparian habitat associated with reservoirs can dry out, reducing cover and forage for wildlife, including waterfowl, nesting birds, and aquatic furbearers. Downstream, higher spring flows can, in some reaches, drown riparian habitat and reduce its use. Chances for pool refill in a following, dry year can be reduced, extending possible negative impacts on wildlife and fish from one year into the next. Recreation opportunities also diminish where fixed-elevation facilities such as boat ramps cannot be operated when water falls below a specified level, and as reservoirs become less attractive areas to visit. There would be corresponding economic consequences for nearby communities.

Flow augmentation in the spring and summer (when juvenile fish migrate to the ocean) requires storing more water in the winter, a time when it would be most valuable for use as a generating source for electricity. As flow targets are increased, the match between power loads (need) and hydro power supply worsens, and more power must be supplied from other, possible more costly sources with their attendant impacts on air or land. Wholesale rates for power are likely to increase as flows are increased. When water levels of storage projects are lowered more often, the chances of a complete refill each year are lessened, with consequent effects on power production for the succeeding year (including the need for additional backup resources).

Finally, spill provides *benefits* by releasing water over and around dams to channel juvenile anadromous fish away from turbines and downstream more quickly. If these fish move more quickly to the ocean, they are exposed for shorter times to predators and are more likely to make a successful physiological transition to their salt-water adaptation.

However, spill has its *drawbacks* as well. Heavy spill can super-saturate the water with nitrogen, causing "gas bubble disease," which may kill migrating juvenile and adult fish. High spill in spring may also reduce Snake River adult spring chinook passage by distracting them away from the fish ladders and toward the spill area, which provides no passage upstream. Spill represents a lost opportunity for power production, increasing potential power costs by requiring that lost hydro generation be replaced using other types of generation. The shift of available water from reservoirs under spill can also create impacts similar to those for flow augmentation, above.

Finally, both storage and the variations on release may affect the ability of Indian Tribes to exercise their reserved rights. Issues that particularly concern Tribes with respect to the SOR include treaty rights, impacts on fishing, and the protection of graves and cultural resource sites. System operations described in the SOR could affect anadromous and resident fish and wildlife, regarded as trust assets, with possible direct influence on fishing sites. The Tribes consulted in the SOR process felt that it would be increasingly difficult for the U.S. government to meet treaty and trust responsibilities tied to issues of hunting, fishing and gathering capabilities, and to damage to cultural resource sites. The SOR EIS is fully examining the potential impacts of the SOS alternatives on treaty rights and trust assets.

4.3.4.3 Impacts From Draft SOR Strategies "Current Operation" and "Coordination Act Report Operation"

"Current Operation" (SOS 2c) was the SOR's "No Action" alternative: that is, it most resembled current river operating strategy in place when the Draft SOR was being developed.[5] It included Water Budget flows and up to 3 million additional acre-feet of flow augmentation to assist anadromous fish migration.

"Coordination Act Report Operation" (SOS 7a) provided increased flow augmentation, higher spill, and Snake River drawdown in an effort to construct a package of options that increased amounts and velocity of water flowing through reservoirs and rivers, and thereby improved survival of anadromous fish.

These "alternative futures" are examined in the Business Plan EIS as the two ends of a range of impacts for business consequences: SOS 2c would have the least severe impacts on power production; SOS 7a the most.

Current Operations

Soils/Water

Moderate-to-severe soil erosion and mass wasting from drafting would continue, as currently, at storage reservoirs. Erosion at John Day and lower Snake River projects would increase in the short term; erosion would accelerate slightly at Brownlee (see figure 4.3-5 for location of hydro projects). There would be no significant sediment transport. Gas supersaturation would be reduced in the mid-Columbia reach, but increased somewhat in the lower Snake and Columbia Rivers as this strategy continues to be carried out.

Fish

Survival rates for juvenile anadromous passage and adult returns would fall in the middle of all SOR alternative strategies. With juvenile transportation, this SOS would have one of the higher survival rates. Conditions for some resident fish would be worsened: Dworshak kokanee and smallmouth bass, Brownlee smallmouth bass, and other warmwater fish. More shallow drafting would increase the probability of refill in Lake Koocanusa, resulting in a slight increase in kokanee growth (due to better food supply). However, conditions for resident fish elsewhere would remain the same. The chance of spawning of the Kootenai River white sturgeon (last documented spawning in 1974) would be very low, as increasing spring/summer flows believed to be associated with spawning success would seldom occur. This alternative would produce the lowest levels of aquatic productivity and fish growth at Hungry Horse, which supports a healthy population of westslope cutthroat trout and bull trout. Drafting at Lake Pend Oreille would force shore-spawning kokanee to spawn in less suitable areas in fall; they could also block access to river spawning grounds for other species. Drafting in winter and spring could dry out eggs, affect spawning success of warm water species (bass) in shallow waters, and strand the young. At Lower Granite reservoir, however, smallmouth bass habitat would benefit from more stable reservoir elevations in spring/summer.

Wildlife/Vegetation

Wildlife populations would continue their long-term downward trend; nesting waterfowl productivity at John Day would be slightly reduced as water levels are lowered. Lake Umatilla, which harbors one of the largest summer populations of waterfowl, would be down 0.3 m (1 ft) during April-June, reducing pool surface. This SOS might also reduce breeding duck and Canada goose numbers slightly. Large seasonal drafts from storage projects would continue to restrict wetland areas to current levels. Late winter and early spring drafting could expose significant amounts of shoreline at storage projects; there would be minimal shoreline exposure at run-of-river projects compared to past practices.

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[5] Although it represents "No Action" (no change from current operations), impacts reported in this discussion will note that some effects will be "better" or "worse": this is because the current strategy has been in place only a few years, and consequences over time will continue to increase or decrease in response to those strategies.

Recreation

Historical levels of recreational use would be slightly less than that experienced under typical historic conditions (pre-Water Budget and flow augmentation). Grand Coulee would be fully operational through the summer, but some Lower Granite facilities would not be usable during periods when the reservoir is operating at minimum pools.

Flood Control/Navigation/Irrigation/Power/Economics

Expected flood incidents and damage would not be likely to change. Costs of flood damage are estimated at about $3.3 million. Normal conditions would be expected for shallow-draft navigation, and a slightly shorter operating season for Dworshak log transport. For power, wholesale rates would continue at today's level. All irrigation needs would be served. Total system (economic) cost would be about $1.094 billion. SOS 2c would be the least-cost option.

Native American Concerns

Down-river Indian Tribes would face diminished populations of salmon (Burns Paiute Tribe, 1994, cited in SOR DEIS, 1994), which those Tribes note are critical to fulfillment of their reserved fishing rights and to the basis of their cultural and spiritual existence. Tribes also believe this alternative would result in a decline in resident fish populations, limiting the Federal government's ability to meet its trust responsibilities for both resident and anadromous fish.

Coordination Act Report Operation

Compared with "Current Operation," this SOR alternative would combine more flow augmentation, increase in spill, and Snake River drawdown, with the goal of assisting materially in anadromous fish migration. "Coordination Act Report Operation" (SOS 7a) would reduce impacts for some resources (by comparison with near-current conditions as described under SOS 2c), but would increase impacts for more.

The reader is reminded that, since the draft EIS was released, this alternative has been reexamined and essentially replaced with a new SOS, "Detailed Fish Operating Plan," which will likely include considerably more spill, drawdowns at more projects, and drafting to meet flow targets. The analysis for this BP EIS is based on more recent figures (superseding those used for the Draft SOR EIS). Impacts described below will vary (generally increase in intensity) for the newer SOS. See Anticipated Changes to SOSs, below.

Soils/Water

Erosion, mass wasting, and sedimentation would increase substantially at Lower Granite as a consequence of flow augmentation plus drawdown strategies; much of the resulting sediment would move down toward Little Goose. However, these effects would decrease substantially at Libby and Hungry Horse because pools would be maintained at more stable elevations, as well as at Dworshak, where the total annual draft would decrease. Grand Coulee would experience significant erosion and mass wasting as a result of a relatively large total annual draft, which would expose more shoreline. The total dissolved gas standard at Ice Harbor would be exceeded twice as often as under "Current Operations" (139 days vs. 61 days), as a consequence of flow targets and spill requirements for McNary and lower Snake River projects, and also because Lower Granite would be drawn down an average of 7.6 m (25 ft) below normal operating pool elevation. There would be some major sediment transport downstream, through scouring from Lower Granite should be deposited upstream of Ice Harbor Dam.

Fish

Although the elements of this alternative were intended to increase potential fish survival, "Coordination Act Report Operation" would result in lower survival rates for Snake River salmon (spring, summer, and fall), with or without transportation. High spill levels account for this result: they increase nitrogen supersaturation in the Snake reservoirs and substantially increase reservoir mortality (except for summer steelhead because they are released early in April before gas levels rise). If in-river passage only is accounted for, future adults escapements would be lower than all other alternatives for Snake River spring and summer chinook stocks. Even with transport, survival of all Snake River stocks would remain below that of SOS 2c (and most other SOSs). On the other hand, survival of spring chinook stock could be highest if the assumption were made that the increased gas supersaturation from high spill levels would have no negative effect on fish. Marked drawdowns could decrease food supply in the lower Snake for other anadromous fish.

Overall, this SOS turns out to be one of the worst for resident fish production, although it is expected to provide improvements of survival for Kootenai River white sturgeon. Other conditions for resident fish are generally worse. At Lake Koocanusa and at Hungry Horse, drafting would be shorter and less frequent, so that food supply and fish growth would be improved, and refill timing would enhance access to spawning, particularly for bull trout and westslope cutthroat in Hungry Horse. At Lake Roosevelt, minimum predicted elevations would be extremely low. Fish production would be worse, with high fish entrainment, reduced zooplankton production, and low fish growth. Similarly, Dworshak would have the poorest conditions for resident fish under "Coordination Act Report Operation": deep drafts, frequent refill failures, and high outflows, resulting in high entrainment rates of kokanee, and failed spawning for bass and other species. This SOS would be worst of all SOSs for Lower Granite, with month-to-month fluctuations in reservoir elevation, reducing spawning/rearing of bass and other fish.

Wildlife/Vegetation

At Libby and Hungry Horse projects, increased wetland and riparian vegetation would increase populations of most categories of wildlife. However, prolonged drafting of Grand Coulee would increase the drying out of the few wetlands and shallow waters, and prolong occurrences of broadband drawdown areas, reducing populations of waterfowl, non-game birds, aquatic furbearers, and amphibians, particularly in years when two separate drafts would occur during the winter/refill season (17 out of 50 years in the historical record). Early spring and summer drafts at Dworshak and Lower Granite would reduce populations of aquatic vegetation and organisms, adversely affecting most categories of wildlife at Lower Clearwater reach and Lower Granite project. There would be relatively severe declines in populations of waterfowl, colonial nesting birds, furbearers, and amphibians at Lower Granite, as water levels drop 7.6 m (25 ft) in May and June. Conditions at Lake Umatilla might improve because water levels would be raised, increasing protection against predators for waterfowl and other species which nest on islands.

Cultural Resources/Recreation

Site damage to cultural resources would increase significantly at Lower Granite: "Coordination Act Report Operation" is one of the SOSs with the greatest potential to accelerate erosion by augmenting flows. Rapid drafting of Dworshak could increase potential for land slumping on steep slopes, as water would fall below traditional pool levels, cutting new shoreline benches and exposing more land. This SOS would create the greatest overall amount of shoreline exposure at storage reservoirs (primarily Grand Coulee and Dworshak), affecting both esthetics and cultural resources. Recreational use visitation would be reduced below that for "Current Operation" as reservoirs are drawn down.

Flood Control/Navigation/Power/Irrigation/Economics

This SOS would have the highest flood risk of the SOS alternatives (primarily in upper Columbia tributaries), because following biological rule curves would keep reservoirs higher to benefit resident fish, reducing the ability to absorb flood runoff. Average annual damages are expected to be about $5.0 million. No shallow draft navigation would be possible on Lower Granite for 4 to 5 months during drawdown. The Dworshak log transport would have a much shorter operating season, compared with "Current Operation." Total navigation costs would be about $2.2 million more than under SOS 2c. The Gilford Ferry on Lake Roosevelt would be inoperable for at least 1 month each year, and possibly more.

Energy production would be significantly reduced by high spill and turning off turbines. Annual system generation costs would be about $467 million more than under “Current Operation” (if CTs are constructed to replace lost hydropower); about $325 million more than SOS 2c if replacement power were purchased. Wholesale rates would increase 16 to 21 percent, assuming such rate increases could produce revenue to pay replacement power costs.

In critical water years, irrigation pumps would not be able to keep up with irrigation demand, and some acreage would be without sufficient water as a consequence of the unusually low lake level at Grand Coulee. Economic impacts would increase over “Current Operation”: there would be increased costs/reduced benefits primarily for recreation, anadromous fish, power, and flood control and associated impacts from reduced employment. The cost of operating the power system is by far the largest element of any change. Total annual system cost would be $492.8 million higher than SOS 2.

Native American Concerns

Anadromous fish appear to fare slightly worse or the same as under “Current Operation.” Impacts on wildlife habitat affecting hunting rights and on vegetation conditions would vary from reservoir to reservoir. Wildlife resources would improve at Libby, Hungry Horse, Lake Umatilla, and along the Hanford Reach, but wildlife populations would decrease in the Lake Roosevelt area and at Lower Granite.

Anticipated Changes to SOSs

After publication of the SOR DEIS in the summer of 1994, a public comment period was held. That period has since closed, and the SOR interagency team is working on the FEIS. Through response to comments and further analysis, the several SOSs examined in the DEIS are being revised; in some cases new SOSs are replacing draft versions. The descriptions below represent changes as they relate to “Current Operation” (SOS 2c) and “Coordination Act Report Operation” (SOS 7a). The reader should bear in mind that the SOR FEIS is on a later schedule than this BP EIS, and that the descriptions below represent the direction of change but possibly not the final form of these SOSs.

- **SOS 2c (“Current Operation”)** has been supplemented by the addition of a new alternative labeled as **SOS 2d (“1994-1998 Biological Opinion”)**. It does contain minor changes from SOS c, and better reflects current practices, particularly in light of ESA consultations that occurred in 1994. It includes 4 MAF of flow augmentation rather than 3 MAF.
- **SOS 7a (“Coordination Act Report Operation”)** is being replaced by **SOS 9a (“Detailed Fish Operating Plan”)**. Although the measures would be the same, differences in degree of implementation and in impact are considerable. Drawdowns to near spillway crest would occur at all four lower Snake projects (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite). The impacts described above for SOS 7a at Lower Granite would therefore be likely to apply to all four projects, instead of at Lower Granite only. The high spill projected for Lower Granite and its consequences for gas supersaturation (anadromous fish mortality) and loss of power production potential would apply to all eight projects (at 120 percent daily average total dissolved gas). Finally, Hungry Horse and Libby would be drafted to meet flow targets downstream rather then using specific elevations designed to benefit resident fish and wildlife. This would reduce potential improvements for residential fish at Hungry Horse and Libby reservoirs and result in lower pool elevations sooner in the season and for more of the summer. There would be no fish transportation.

The current preferred alternative for the SOR EIS is based largely on the Biological Opinions released by the NMFS and the USFWS in March 1995. Its impacts for power production would fall in the middle of the range of impacts described above.

Summary

The discussion above has been provided to help the reader understand how the decisions in the SOR process may affect the business course BPA chooses for the future. That business course is the proper subject of this BP EIS. Issues centering on how operating the river will affect fish and wildlife survival and enhancement, trust obligations, access to salmon for treaty issues, and cultural resource impacts are fully analyzed in the SOR.

4.4 Cumulative Market Responses and Environmental Impacts of Alternatives

The following discussions address the cumulative market responses and environmental impacts of the alternatives addressed in this EIS. Market responses and impacts are first addressed under current hydro operations (4.4.2), followed by an illustrative numerical assessment of impacts (4.4.3). Market responses and environmental impacts are then assessed under DFOP hydro operations (4.4.4).

4.4.1 The Marketing Context

4.4.1.1 Evaluation of Alternatives in a Dynamic Electric Power Market

The rapid changes occurring in the electric power market (see sections 1.1 and 3.5) are a major factor in the need for BPA to evaluate its business policies. These changes also present significant challenges to the evaluation of market responses or environmental impacts. Since the Draft Strategic Business Plan and initial Draft Business Plan EIS were released in June 1994, the electric power market has continued to evolve in a manner unprecedented for the electric utility industry. The price of natural gas has declined, costs of new generation have declined, and many new prospective sellers have entered the PNW wholesale power market. The average cost of new generation has dropped by roughly one-quarter in the last year. With changes occurring so rapidly, it is difficult to make reliable estimates of gas prices, electricity rates, or electrical loads for the next 12 months, much less for the year 2002, the end-date study year for this EIS. Rate and load projections are subject to change from week to week to address new developments in the market. Despite this uncertainty, this EIS must try to show the effects of the different alternatives to enable readers and decisionmakers to assess their relative merits.

The key to the comparison of EIS alternatives is not the *numerical* estimates of power rates, resource amounts, or air emissions, but the relationships that determine those values. Although this EIS includes rough numerical estimates of the rate, load, resource, and environmental effects of the six alternatives, it is clear that these values, especially in relation to the dynamics of the market, are only a “snapshot” in time, an illustration of the relationships among the market influences; they are not conclusive as to the ultimate outcome.

4.4.1.2 Marketing Relationships Affecting the Balance Between BPA’s Costs and Revenues

Two relationships dominate the effects of the six EIS alternatives. They are:

- the effect of BPA’s rates, as compared to the price of alternative power supplies, on customers’ decisions on whether to buy from BPA (and therefore on BPA’s firm loads); and
- the effect of the terms of BPA service on customers’ decisions on whether to buy power from BPA.

In brief, if BPA’s firm power rates are close to or higher than the price of alternative power supplies, BPA’s firm loads will decline sharply, as more and more customers choose to buy their power from suppliers other