The Columbia-Snake: Challenges for Multiple-Use River Management

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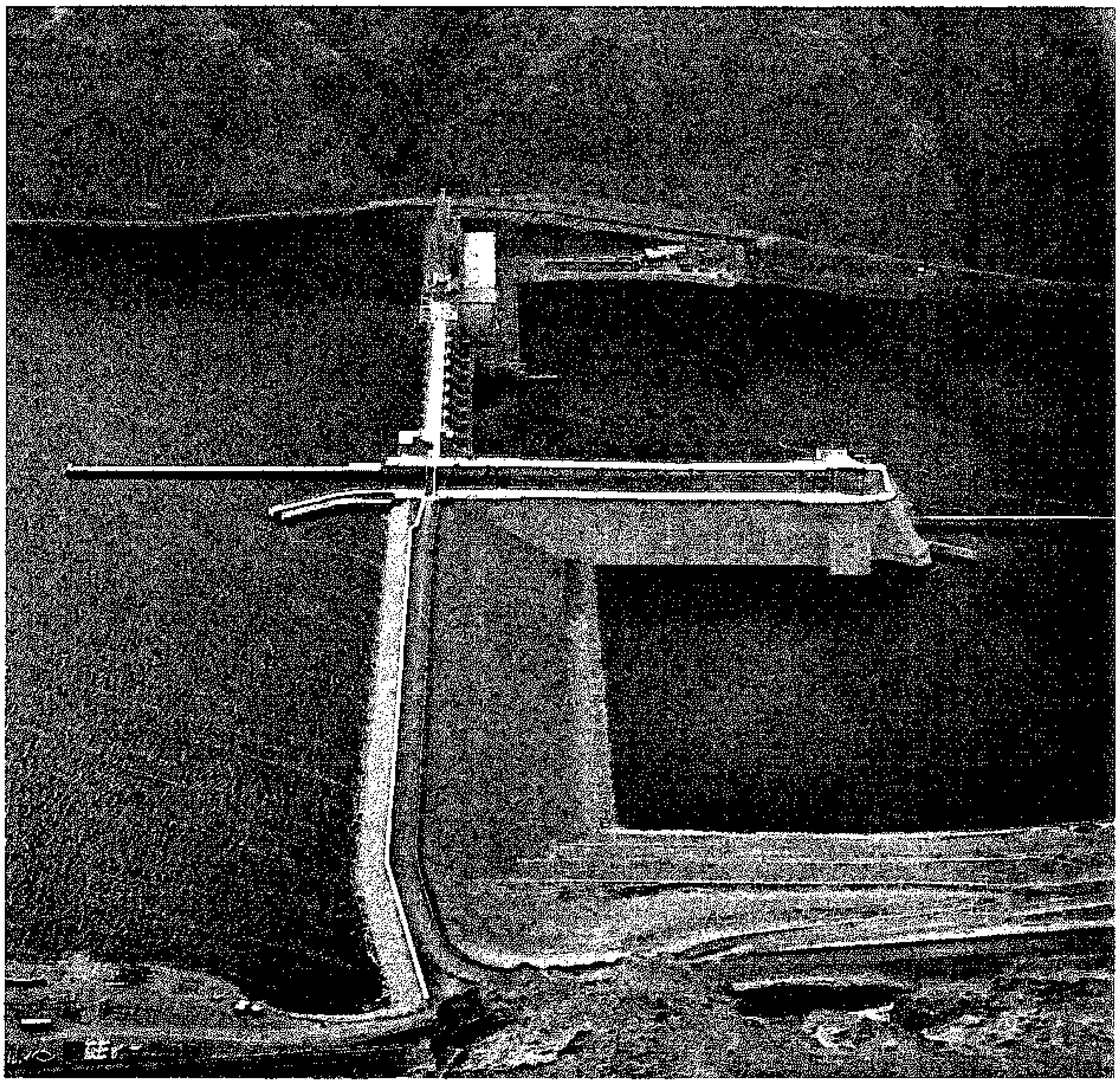

The Columbia-Snake: Challenges for Multiple-Use River Management

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THE TWO GREAT RIVERS of the west, the Columbia and the Snake, have historically been the source of abundant water and a high quality natural environment; the foundation upon which the Pacific Northwest has grown and prospered.

The Columbia/Snake drains significant portions of Washington, Oregon, and Idaho as well as southern British Columbia in Canada and smaller parts of Montana, Wyoming, Utah, and Nevada. It provides the Pacific Northwest with hydroelectric energy and water for irrigation, fisheries, recreation, and navigation. However in recent years, the capacity of the Columbia to meet all the demands for alternative uses has been severely tested. The region is fast approaching an era of decision; one in which policy makers and the public will be impelled to make difficult choices about competing uses of the river's resources. The region confronts the necessity of trading off water use in one area or application to accommodate needs or demands in another location or use. This bulletin identifies and discusses the major trade-off issues surrounding allocation of the Columbia/Snake resource.

Physical Characteristics

Of the rivers in the Western hemisphere which empty into the Pacific, the Columbia is the largest. Further, it is second in size only to the Mississippi system on the North American continent.

The main stem of the Columbia has its headwaters high in the Canadian Rockies of British Columbia, and meanders south then westward through the United States for more than 1,200 miles before reaching the sea.

The Snake River joins the main stem of the Columbia some 325 miles from the Pacific, after itself travelling more than 1,000 miles from its origin. System wide, the Columbia drains a basin in excess of 259,000 square miles, a land area comparable in size to France (Fig. 1).[1]

[1] *Water Today and Tomorrow*, *Vol. II, The Region*, Pacific Northwest River Basins Commission, June, 1979.

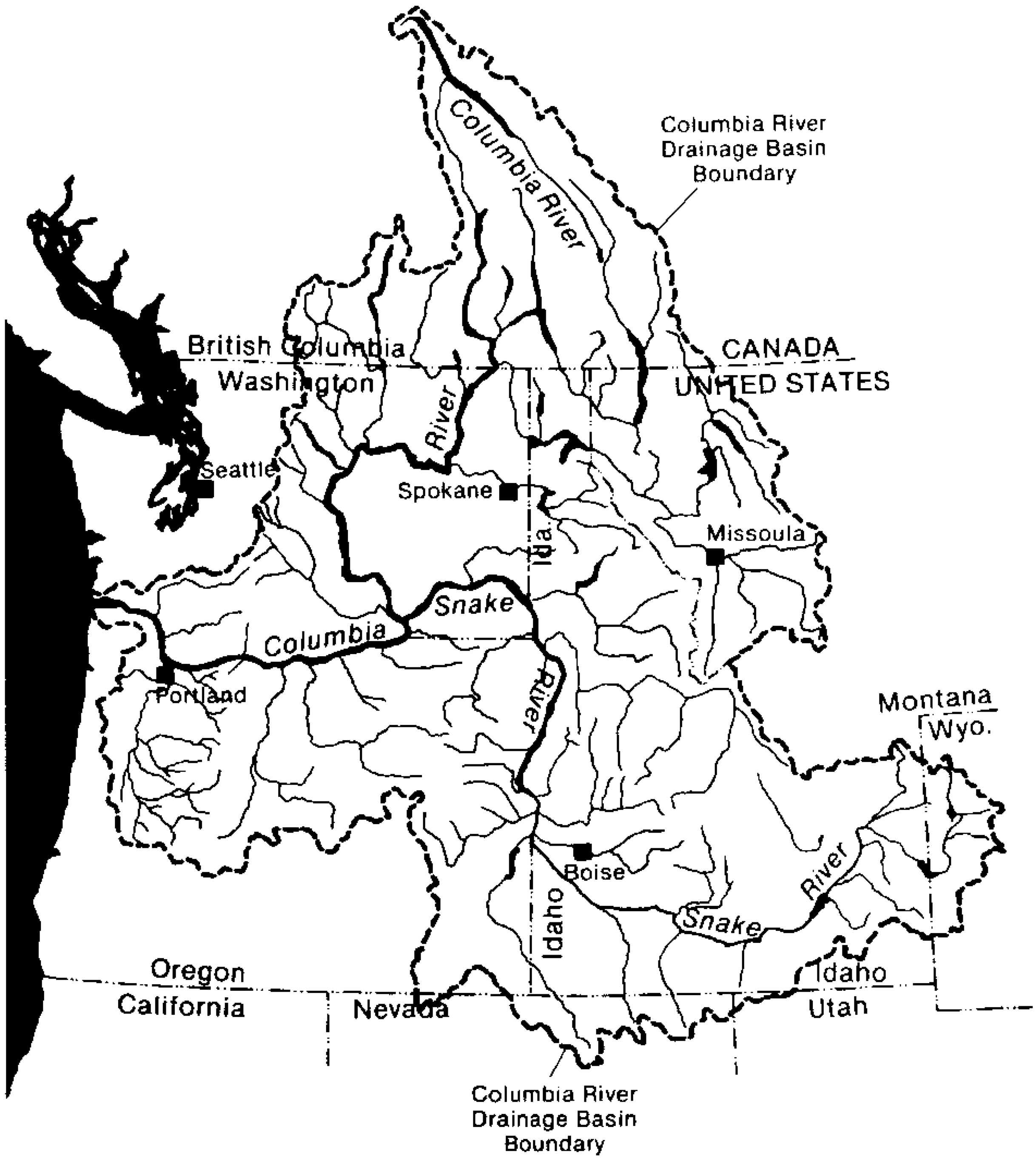

Figure 1-The Columbia/Snake Drainage System

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Before the construction of eleven major main stem dams on the Columbia and an additional four dams on the lower Snake, the average maximum rate of flow at the mouth of the Columbia exceeded 660,000 cubic feet per second (c.f.s.).[2] That converts to something over 4.9 million gallons per second discharged into the Pacific Ocean during peak flows. At present, there are some 192 impoundments within the entire Columbia/Snake river system, permitting a managed and regulated flow. Still with all these considered, the Columbia provides an average annual flow at its mouth of over 268,000 c.f.s., or more than 2 million gallons per second.

With such vast quantities of fresh water mixing with the saltwater of the sea, the mouth of the Columbia is a dynamic environment. The river's outflow creates a plume of fresh water which is detectable several hundred miles out into the Pacific. Early explorers relied upon such phenomena to detect the presence of great rivers. Scientists now think that anadromous fish, such as salmon and steelhead, use the river's plume in the same way to retrace their path to the spawning grounds of their origin.

The Columbia River Bar, where the river meets the sea, has long been regarded as the Pacific's most violent, dangerous, and unpredictable bar for ships to navigate. In most respects it remains so today, challenging even the largest vessels and the most experienced pilots.

The extended zone of fresh and salt water mixing near the river's mouth is responsible for a biologically productive and unique estuary. The estuary encompasses approximately 90,000 acres and extends approximately 25 miles upstream from the river's mouth. It ranks as the nation's ninth largest. The high rate of freshwater flushing creates an environment which differs significantly from other estuaries in the region, making it a highly valued and irreplaceable resource.[3]

A Multiple-Use Resource: Issues and Trade-Offs

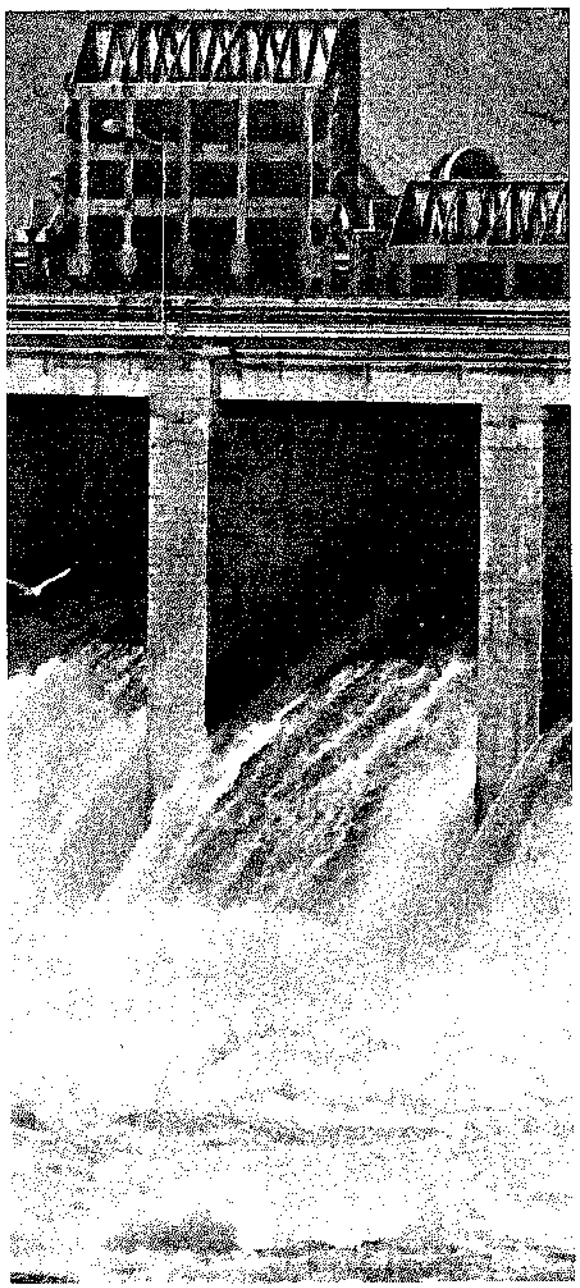
With an average flow of more than 2 million gallons per second at the river's mouth, some may wonder why there is concern over water use on the Columbia. But it would be naive to assume that since water continues to flow into the sea, it has somehow been "wasted." Far from being unused, water discharged at the river's mouth has driven hydroelectric turbines at perhaps as many as 26 dams, irrigated farmlands, sustained fish and wildlife populations, provided recreation and aesthetic value to the people in the region, supported maritime commerce, supplied municipal and industrial water needs, and carried away waste, to name but a few of its contributions.

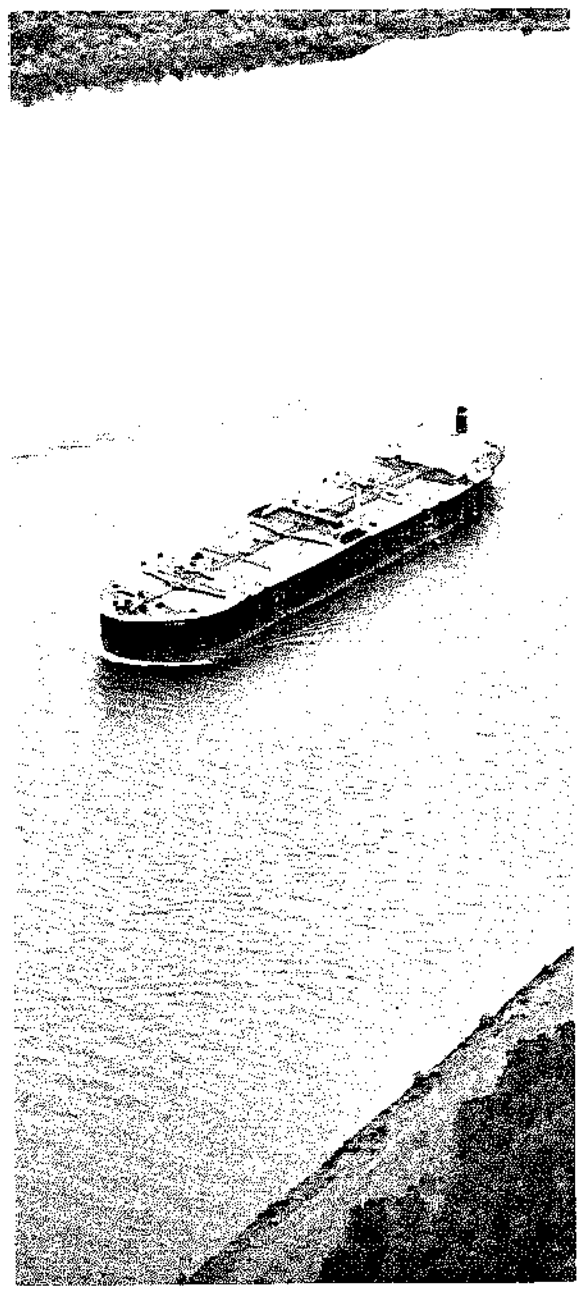
Even when it reaches the lower river, this volume of water supports a biologically indispensable habitat for numerous organisms, all of which contribute to the commercially important fish and shellfish found in the river or just offshore. In addition, sustained flows are required to maintain the self-scouring deep draft navigation channel upon which so much of the region's economy depends.

The problem of water scarcity within the Columbia system revolves around three basic dimensions: time, place, and use. Since, in fact, water is neither created nor destroyed as it passes through the Columbia system, conflicts over access involve at least one, and often a combination, of these dimensions. The simple truth is the Columbia can no longer supply water to meet all of the demands placed upon it, at all times, and at every location within its drainage basin. The time has arrived when trade offs will have to be made between users and uses of the river's resources.

[2] *Columbia River Estuary Inventory*, Columbia River Estuary Study Task Force

[3] *Columbia River Estuary Inventory*.





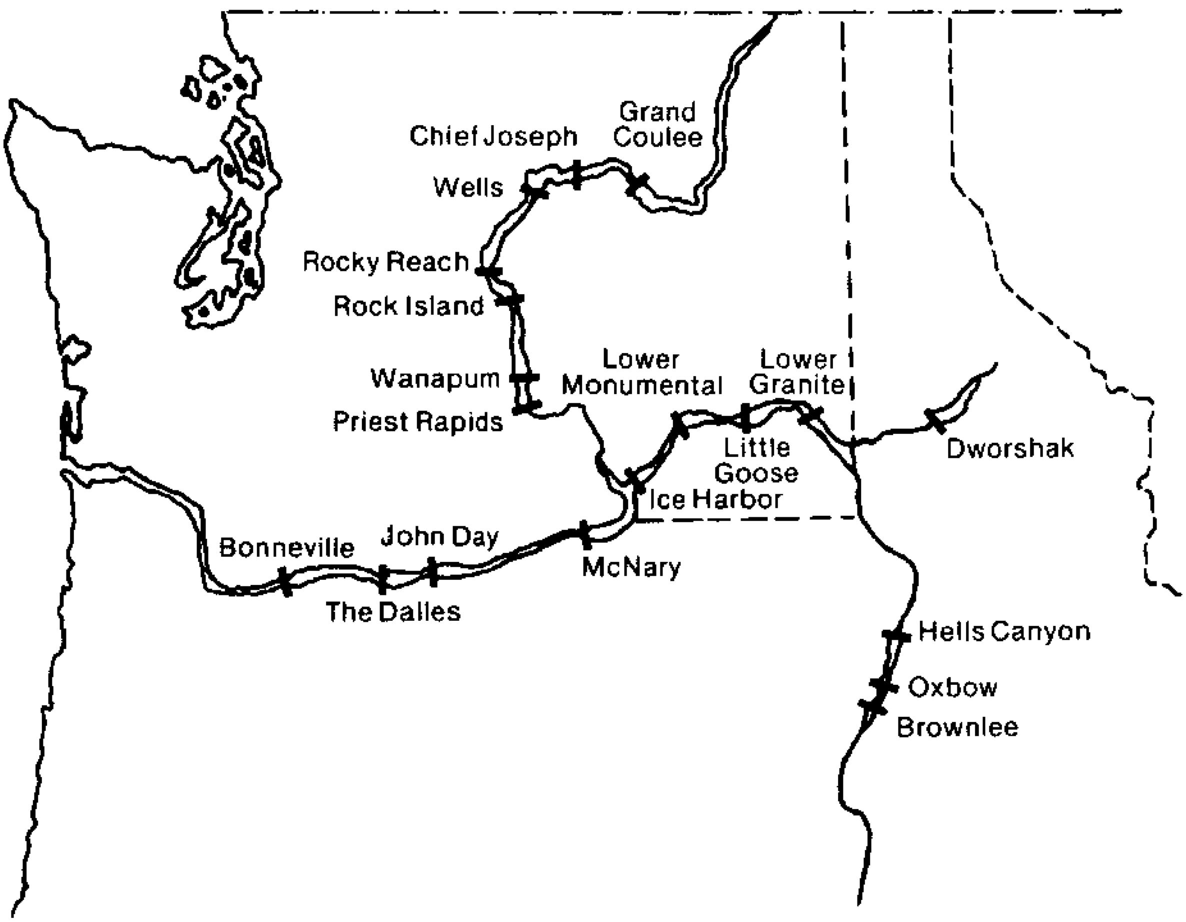


Figure 2-Major Hydroelectric Dams on Lower Columbia and Snake

Dam	Operator	River Miles To Columbia River Bar	Present Capacity	Planned Total Capacity
Bonneville	Army Corps of Engrs.	145 mi.	518,400 KW	1,078,400 KW
The Dalles	Army Corps of Engrs.	192 mi.	1,807,000 KW	1,807,000 KW
John Day	Army Corps of Engrs.	216 mi.	2,160,000 KW	2,700,000 KW
McNary	Army Corps of Engrs.	292 mi.	980,000 KW	2,030,000 KW
Priest Rapids	Grant Co. P.U.D.	397 mi.	774,000 KW	1,138,000 KW
Wanapum	Grant Co. P.U.D.	416 mi.	831,000 KW	1,225,000 KW
Rock Island	Chelan Co. P.U.D.	453 mi.	403,000 KW	NA
Rocky Reach	Chelan Co. P.U.D.	468 mi.	1,213,000 KW	NA
Wells	Douglas Co. P.U.D.	516 mi.	788,000 KW	NA
Chief Joseph	Water & Power Resources Service	545 mi.	1,689,000 KW	2,069,000 KW
Grand Coulee	Army Corps of Engrs.	597 mi.	6,195,000 KW	10,000,000 KW
Ice Harbor	Army Corps of Engrs.	334 mi.	603,000 KW	603,000 KW
Lower Monumental	Army Corps of Engrs.	366 mi.	810,000 KW	810,000 KW
Little Goose	Army Corps of Engrs.	395 mi.	810,000 KW	810,000 KW
Lower Granite	Army Corps of Engrs.	432 mi.	810,000 KW	810,000 KW
Dworshak	Army Corps of Engrs.	506 mi.	660,000 KW	1,060,000 KW
Hells Canyon	Idaho Power Co.	571 mi.	450,000 KW	580,500 KW
Oxbow	Idaho Power Co.	597 mi.	220,000 KW	265,500 KW
Brownlee	Idaho Power Co.	609 mi.	450,000 KW	NA

Sources: U.S. Army Corps of Engineers, Pacific Northwest River Basins Commission, Power Planning Committee, 1979, Bonneville Power Administration.

NA—Not Available

Hydroelectric Energy

As an example of this dilemma, consider the Columbia's role as an energy source. The river system accounts for one-half of the hydroelectric generating capacity in the entire United States. It has the most intensive level of hydroelectric development of any single river basin in the world. Inexpensive energy from federally developed projects on the river was crucial to the economic development of the region during the late 1930's and 1940's. As the major projects came on-line, the federal government established the Bonneville Power Administration (BPA) to market and distribute the electrical energy produced by the river. In the beginning there was a huge surplus of hydroelectric energy. Inexpensive electrical power encouraged new energy-dependent industries, notably aluminum manufacturers, to locate in the Northwest. Accompanying growth in residential and commercial consumption imposed new demands on the river, causing the electrical energy surplus once enjoyed in this region to be replaced by projected shortages and the need for new generating capacity.

At present there are 38 major hydroelectric projects within the Columbia system, managed by both federal agencies and private and public utility companies. Figure 2 lists those on the main stem of the Columbia to Grand Coulee and on the Snake/Clearwater below Brownlee. The West Group of the Pacific Northwest Utilities Conference Committee, made up of representatives from utilities and energy agencies in the region, estimates total 1979 main stem electrical generating capacity to be 26,311,000 kilowatts. This figure reflects only the West Group area and therefore does not include the capacity of Hells Canyon, Oxbow, and Brownlee dams, also listed in Figure 2. When these East Group dams are added, the total generating capacity grows to 27,651,000 kilowatts.[4]

[4]Communication from Pacific Northwest River Basins Commission.

The Bonneville Power Administration extends beyond the Columbia system, linking 55 hydroelectric dams in an eight-state grid, through a network of nearly 13,600 miles of high-voltage transmission lines.[5] This network of transmission interties permits BPA to sell surplus or off-peak electrical energy generated in the Northwest to energy-short consumers outside the basin.

In 1979, BPA sold 72,023,331,000 kilowatt hours of electrical power. System-wide demand for electricity is on the increase and long-term projections indicate continued growth in electrical consumption.[6] In response, several projects are under way to significantly expand the Columbia's total hydroelectric capacity (see Fig. 2, Planned Total Capacity). By and large these hydro expansion projects will increase the system's peak generation capacity. Several thermal plants, both coal fired and nuclear, are also under consideration. One management alternative proposes that thermal plants be used to provide "firm" or base load power, with hydro facilities used to accommodate peak demands. This scheme carries dramatic implications for other uses and users of the river. For example, when the new powerhouse projects come on line in the early to mid-1980's, it will be *possible* to use every drop of water in the system to turn hydroelectric turbines. In other words, every gallon of water used for fish passage, navigational lockings, irrigation, etc., will represent electrical energy foregone. Conversely, water retained to meet energy demands will constitute potential losses to other uses of that resource.

But what are the other major competing water uses in the Columbia system? One very important use is irrigated agriculture.

[5]The eight states served by the Bonneville Power Administration are Washington, Oregon, Idaho, Montana, Wyoming, California, Utah, and Nevada.

[6]*Review of Power Planning in the Pacific Northwest Calendar Year 1978*, Pacific Northwest River Basins Commission, April, 1979.

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Irrigation

Irrigation accounts for more than 90% of the total water diversion and consumptive use in the Columbia River drainage area. The total acreage in the Columbia drainage presently under irrigation is between 7 and 8 million acres.[7] In the next two decades an ***additional*** 2.2 to 4 million acres could potentially be added to this total.[8]

Among crops currently produced by irrigation in the Columbia River drainage area are wheat, other cereals, alfalfa, seed crops, mint, peas, dry beans, lentils, potatoes, tomatoes, sweet corn, asparagus, melons, apples, pears, cherries, and increasing quantities of wine grapes. The area also supports important commercial livestock production operations. Regionally, irrigated farm products were valued at roughly $3 billion in 1977 and represent an important component of the Northwest's economy. Much of this agricultural output finds its way into export markets and thus provides significant secondary employment as well as contributing positively to the nation's balance of trade.

However, water used in irrigating agricultural lands does not come without costs in terms of other uses of the resource. Much of the water that is diverted for irrigation does not re-enter the river. Loss through evaporation, plant retention, and percolation through sandy soils is high, particularly in older, less technically efficient projects. Water which does find its way back to the river does not, in several important instances, re-enter the pool from which it was drawn. The result is a significant loss of potential hydroelectric generation. Additionally, return flows may be delayed for several weeks or even months before rejoining the system, altering flow volumes and patterns.

Lifting and distributing irrigation water is also very energy consumptive. In the case of high-lift irrigation projects, the amount of energy required to lift the water from the river to the irrigated land may be as great, or in some cases greater, than the energy foregone by diverting the water from power generation.[9]

The energy demands required for high-lift pumping to the ***proposed*** irrigation projects would have to be met by new thermal production facilities, which, it is conservatively estimated, produce electricity at a cost of more than 10 times that of hydro projects. Because average cost pricing is used by electric marketers, much of the cost of energy for pumping water to newly irrigated lands would be borne by all electric consumers through higher energy costs.

Irrigated land presently in production is unquestionably an important and viable part of this region's economy. However, several of the proposed future developments in the Columbia River Basin have come under criticism. Much of the proposed development would require enormous inputs of water, energy, and chemical fertilizer. If the marketplace were free to work, the high cost of these inputs would likely have an adverse effect on the profitability of most *new* irrigated farming ventures. Because federal funding will underwrite several of the large-scale water projects, the real cost of the water input will be subsidized by the taxpayer and only a small fraction of the true cost actually charged the user.

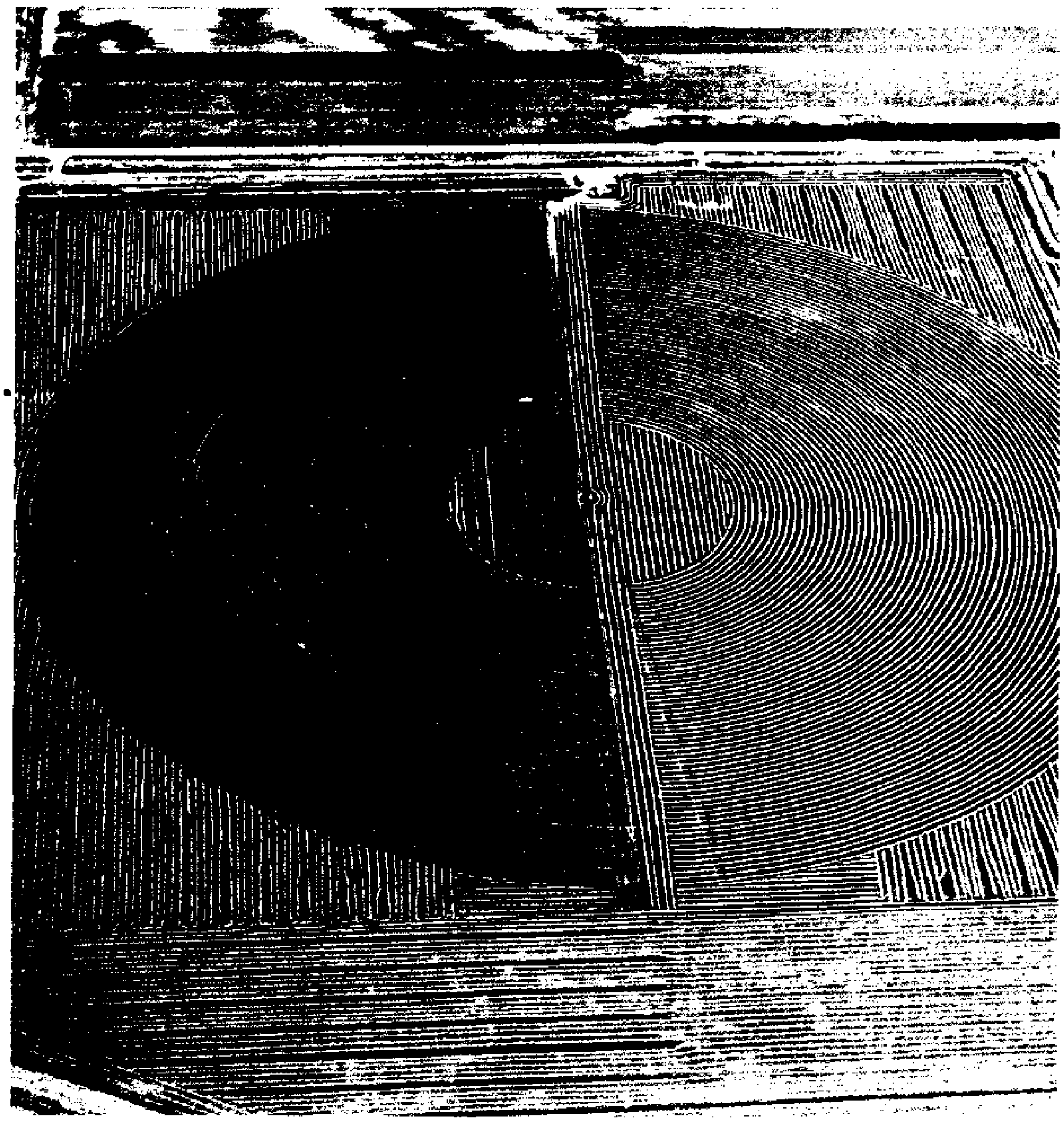
Irrigation withdrawals also affect total river flow, particularly in low flow years. If the increase in irrigation reaches the upper projected level of 4 million acres, annual stream flow in the Columbia drainage would be reduced approximately 10.8 million acre feet.[10] This represents approximately 6% of the flow at The Dalles in an ***average*** water

[7] *Water Today and Tomorrow, Vol. II, The Region.*

[8] *Washington's Water Resources, Recommendations to the Legislature*. Department of Ecology, January, 1977.

[9] *Benefits and Costs of Irrigation Development in Washington, Vol. II, Final Report*, Department of Agricultural Economics, Washington State University, October, 1976.

[10] *Washington's Water Resources*, Department of Ecology, June, 1979.



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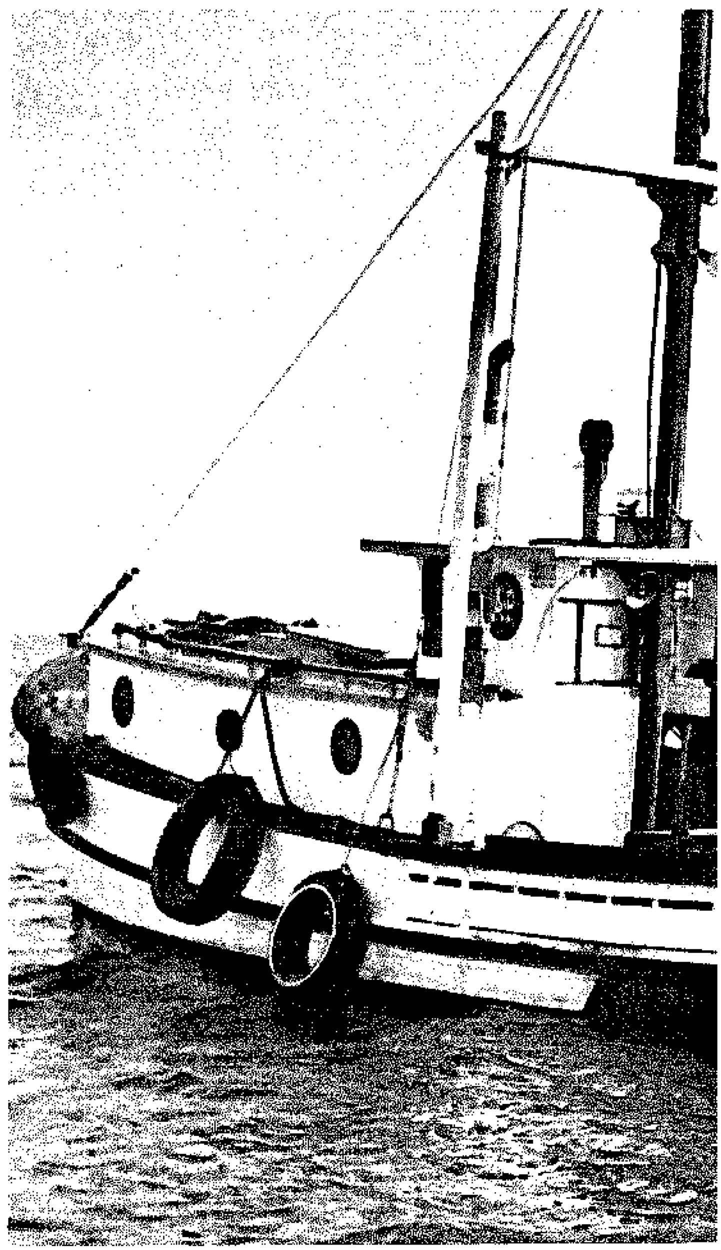
year, but more than 10% in low flow years like 1973 and 1977. These figures represent *net* reductions. During some periods of the year the reduction could be even more severe. Reductions of this magnitude would adversely affect such instream uses as anadromous and resident fish, wildlife, navigation, and recreation, as well as hydro power generation.[11]

In addition, agricultural return flows pose a water quality problem. Often return flows carry not only eroded soil particles but also pesticides, herbicides, and chemical fertilizer compounds. Since flow rates, volume, and water quality are fundamentally important to several other major uses of the river, it is necessary to consider the likely implications of altered and/or expanded water uses for the two "predominant" uses—hydroelectric energy and irrigated agriculture.

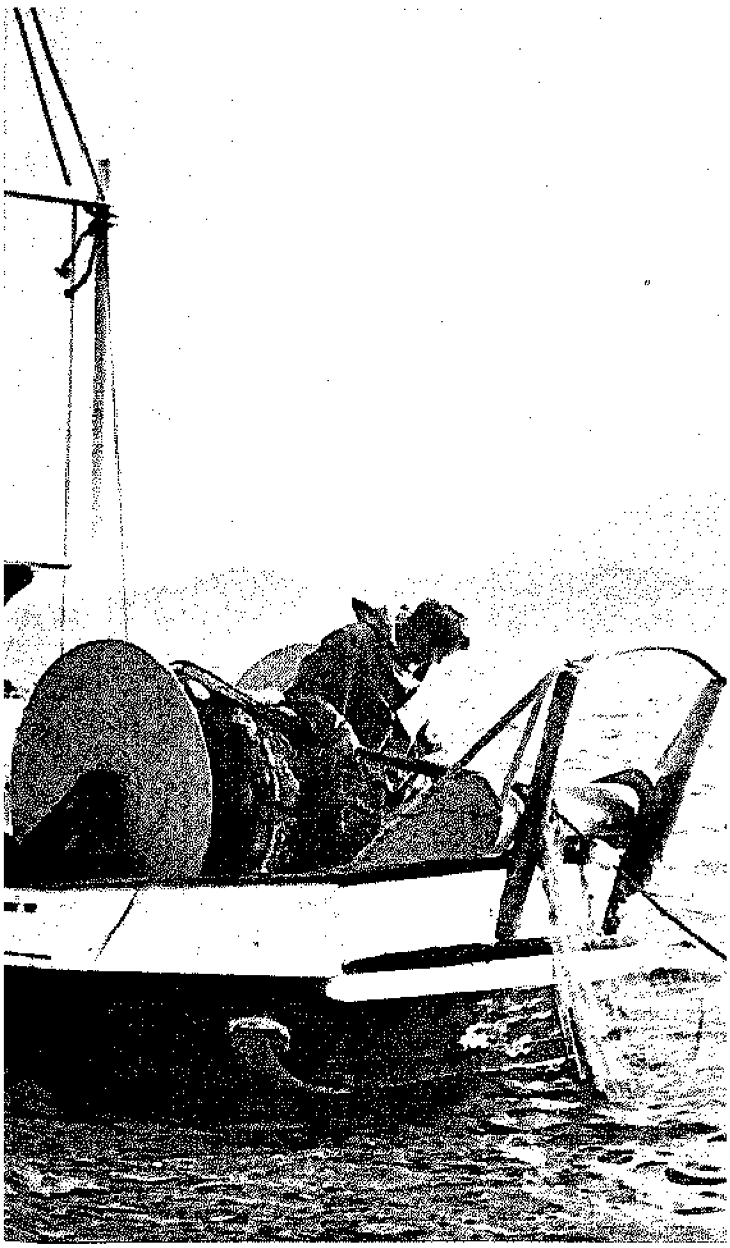
Recreation/Tourism

One of the most economically and socially important, yet often unconsidered, uses of the Columbia's water is recreation/tourism. Water-related recreation (fishing, power boating, sailing, swimming, water skiing, etc.) is a Northwest tradition and contributes many millions of dollars to the region's economy through retail sales, equipment wholesaling and manufacturing, and support/service enterprises. Tourism is the fourth largest industry in the Northwest in terms of employment. The BPA predicts that by the year 2000, it will be the largest industry.[12] While not all of the region's tourism and recreation depends upon the Columbia and Snake, the river accounts for a significant and growing share. Pacific Northwest River Basins Commission projections are that outdoor recreation will gain in importance as population grows and leisure time and disposable family income increase. They further project that in the next 20



[11] *Water Today and Tomorrow*.

[12] *Columbia River Estuary Inventory*



years, water-related recreation in the Columbia system will increase by 150%.

Much of the attraction in terms of recreation and tourism depends upon continued access to a clean and safe natural environment. Managing hydroelectric dams to meet peak loads, as discussed earlier, could seriously limit and perhaps even preclude this access. Under such a management scheme, reservoir levels fluctuate rapidly in response to peak generation needs. At Grand Coulee, for example, peaking would result in a very rapid 23- to 36-foot fluctuation in the river level below the dam twice a day.[13]

With the entire Columbia/Snake system managed in this way, many recreation facilities would be unsafe and virtually unusable during peak generation periods. Rapid reservoir fluctuations combined with increased irrigation drawdowns, accompanying low stream flows, and water quality problems during the summer would strand boat ramps and docks, create difficult and perhaps dangerous access to the shoreline, and produce aesthetically unattractive settings. The implications for recreation/tourism, a basic sector of the Northwest's economy, are clear.

Fish

Low flow, reduced water quality, and extreme reservoir fluctuation also impair fish survival, both resident and anadromous stocks. The Columbia/Snake system was once the single most productive salmon and steelhead area in the world. Prior to development of the river and intense exploitation of the fish runs, the river produced more than 50 million pounds of salmon and steelhead annually. Today total production is only about half that, including both natural runs and hatchery fish. Despite huge investments in stock enhancement projects and fish by-pass systems at many of the dams (some estimates place the investment figure

[13] Estimates by U.S. Army Corps of Engineers

in excess of $500 million) both salmon and steelhead have been unable to re-establish themselves in anything like their original numbers. Fisheries biologists agree that much of the reason lies in the radical physical changes in the river itself. Once unencumbered and fast flowing, the Columbia and Snake have, with construction of the major dams, become a series of still, deep lakes. Spawning gravel has been silted over as a result of bank erosion and of agricultural practices or submerged in the depths of the reservoirs. Where spring freshets once rapidly transported juvenile salmon and steelhead to the sea, the slow-moving flows of the present-day system often delay downstream migration, causing a high rate of mortality and "residualization."[14]

Rapid reservoir fluctuation strands immature fish on sand bars and in shallows. Juveniles that do find their way from reservoir to reservoir are often drawn through the turbines, accounting for an estimated 5 to 15% loss at *each* dam.[15]

Salmon and steelhead that do reach the sea and return to the river as mature fish may encounter low stream flows, concentrations of pesticides and chemical fertilizers, heavy fishing pressure by the commercial and sport fisheries, and inadequate fish passage systems at the dams. In fact, when Grand Coulee Dam was constructed without fish passage facilities, it effectively cut off the upper 600 miles of spawning grounds (roughly half the main stem of the Columbia). Later, Hells Canyon Dam on the Snake eliminated fully two-thirds of that river's spawning area.

Despite the complete loss of some races of anadromous fish and the serious depletion of nearly all other stocks, salmon and steelhead remain important commercial, recreational, and cultural resources of the river. A strong public commitment to the continued existence of these fish is reflected in state and federal legislation. Fisheries mitigation projects are, for example, an explicit requirement of the construction permits and funding legislation authorizing the river's hydroelectric and flood-control dam network. The concept of mandating minimum stream flows to protect and enhance fish runs has gained support throughout the Columbia system. Judicial rulings, including several by the U.S. Supreme Court on behalf of Native American treaty fishing rights, have served to reinforce these commitments to the perpetuation and enhancement of the salmon and steelhead resource.

Navigation

Commercial navigation on the Columbia and Snake is another instream use of considerable economic importance. River-based navigation and commerce both influence and are influenced by other major river uses. As competition over allocation and management of water becomes more acute, navigation interests will be drawn into the conflict.

In considering river-borne commerce, the Columbia system can be divided into four segments: (1) The main stem upper Columbia above Kennewick, Washington; (2) The mid-Columbia and lower Snake between Lewiston, Idaho, and Portland/Vancouver; (3) The mid and upper Snake above the confluence of the Snake and Clearwater Rivers; and (4) The lower Columbia extending from Portland/Vancouver to the Pacific (Fig.3).

At present, commercial river transportation is not possible on either the main stem upper Columbia (1) or the mid and upper Snake (3) although two

[14] *Residualization*: Some downstream migrants unable to reach the sea quickly enough remain in reservoirs, failing to grow and mature through their normal life cycle.

[15] Estimates from National Marine Fisheries Service and Washington Department of Fisheries.

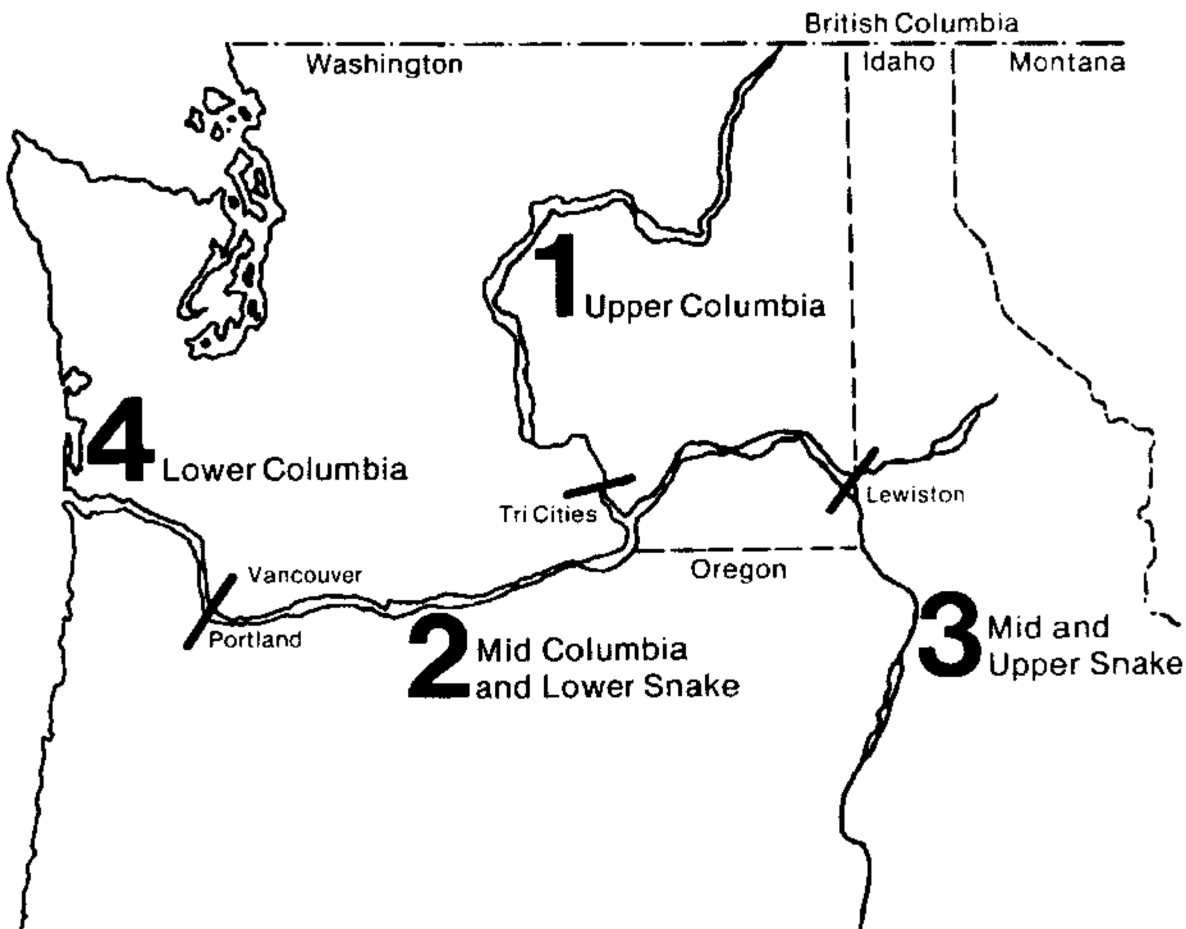


Figure 3-The Four Columbia-Snake Zones

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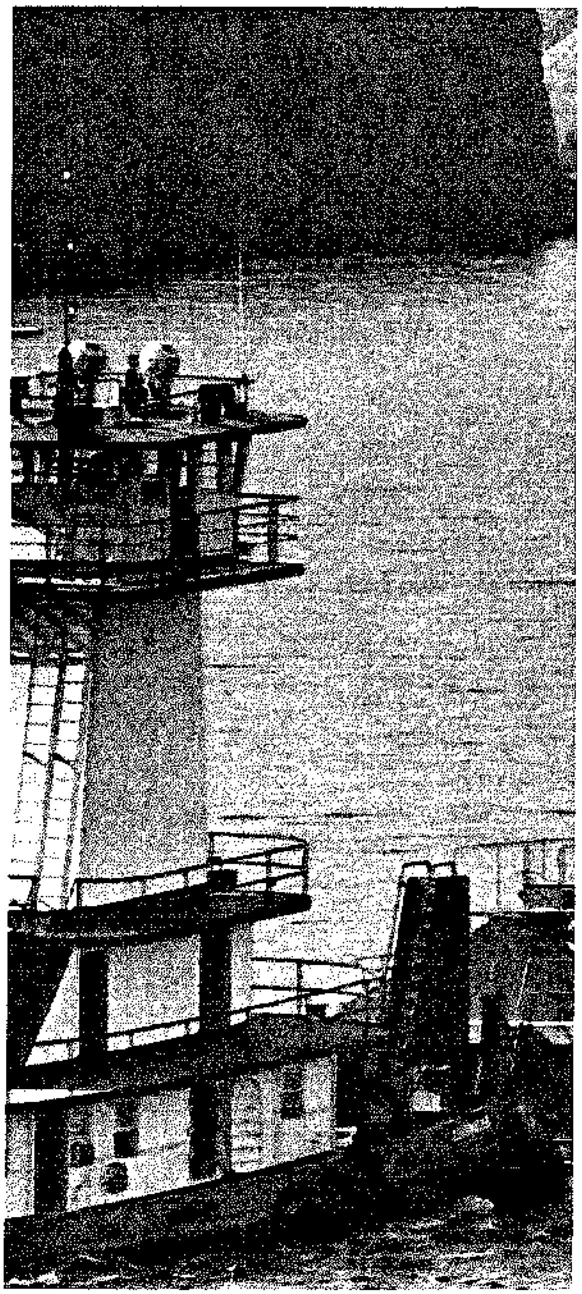

projects have been proposed that could change this. One project, the Ben Franklin lock and dam, could extend slack water navigation from the Tri-Cities to Wenatchee, Washington. However, the lake created behind the dam would inundate the Hanford Reach, the last free-flowing stretch of the Columbia in the United States. On the mid-Snake, the Asotin lock and dam project could extend commercial barge traffic beyond the present terminus at Lewiston. At present, both projects face stiff opposition on environmental and economic grounds.

Commercial navigation on the mid-Columbia/lower Snake (2) has evolved over time. Before this stretch of the river was dammed, shallow-draft sternwheelers challenged its unpredictable waters, carrying passengers, agricultural products, and freight. With the Bonneville dam and lock, put into operation in 1938, the Corps of Engineers had the first link in what would become an economical, safe, and practical eight-pool slack water navigational corridor to the Inland Empire. The remainder of the main stem Columbia facilities in the network are: The Dalles dam and lock, operational in 1957; John Day, dam and lock, 1968; and McNary, dam and lock, 1953. The four lower-Snake facilities are Ice Harbor dam and lock, in operation since 1962; Lower Monumental dam and lock, 1969; Little Goose dam and lock, 1970; and Lower Granite dam and lock, 1975. The completion of the last of these navigational aid projects linked the deep-draft terminals on the lower Columbia with ports as far inland as Lewiston, Idaho, 465 river miles from the Pacific. Shipments of agricultural commodities, wood and paper products, fertilizers and chemicals, as well as petroleum products and finished goods make the Columbia a vital artery in the economic activity of the Pacific Northwest.

Projections for total 1985 water-borne transportation, once criticized as wildly optimistic, were exceeded in 1977 and again in 1978. All indications are that rapid growth will continue unabated. Ports on the mid-Columbia/lower-Snake have received agricultural shipments for down-river export from as far east as Nebraska and the Dakotas, extending the Columbia's economic hinterland more than halfway across the continent.

Commercial navigation on the mid-Columbia/lower-Snake is shallow draft, typically a single tug and tow of four to six barges. The Corps of Engineers maintains the navigation corridor on the river, which averages a minimum of 15 feet in depth in the main shipping channel.

If peak load hydroelectric management of the Columbia's reservoir system occurs, barge traffic could be severely impaired. Rapid reservoir fluctuations would create hazardous surges and currents, expose submerged bars and rock outcroppings, and seriously delay movement between reservoir pools. Maintenance of the necessary 15-foot channel could require substantial and repeated dredging, since swift and frequent changes in pool level would cause serious shoreline erosion, with sediments settling out in the next pool as water is held for the following peak period. In short, peak load management, and to a lesser extent low flow levels resulting from greatly expanded irrigation withdrawals, could spell severe operational difficulties and increased costs for commercial navigation.

On the lower Columbia, commercial navigation is more diverse and less dependent upon management programs on the mid and upper reaches of the river. The Corps of Engineers maintains a 40-foot navigation channel between the mouth of the river and Portland/Vancouver, 105 nautical miles upriver. A 48-foot entrance channel across the bar extending 2 miles seaward allows deep-draft oceangoing vessels access to the Columbia. Ports on the Columbia, dominated by the Port of Portland, actively participate in world trade, bringing the benefits of this economic activity to the entire Columbia region.

At the present time, the Corps removes more than 2 million cubic yards of bottom material from the river's mouth each year in order to maintain the 48-foot deep, half-mile wide entrance channel. Projects designed to make the lower Columbia navigation channel self-scouring have reduced the necessary annual dredging along the remainder of the route to Portland/Vancouver (excluding, of course, the deposit made by the Mount St. Helens eruptions). Should significantly more sediments and debris be introduced into the river as a result of shoreline erosion on the upper system, increased channel maintenance costs are likely. Similarly, greatly reduced instream flows could impair deep-draft ship traffic in the lower Columbia and, as a result, seriously disrupt the region's economy.

Summary

The Columbia/Snake system, vast and rich as it is, can no longer simultaneously meet all of the demands placed upon it. Once thought to be infinite and inexhaustable, the river has begun to show its vulnerability to overuse and inadequate, uncoordinated, and inconsistent management. At the present time, more than 45 federal, state, regional, and local agencies exercise some degree of regulatory authority over the Columbia's use. As a result, coordination and cooperation among users of the river is difficult at best. Conflicts over use of the river will deepen in the future as competition for access by industrial, commercial, and public user groups intensifies. The future will increasingly demand trade-offs, since significant increases in one area or use will be possible only if equivalent reductions occur in other areas or uses. Difficult and complex decisions concerning *where* and *when* such reductions will occur will fall to those charged with managing the river.

Everyone in the region has a personal stake in the choices which will be made. The direction and form those decisions take will in large measure determine the economic and social character of the Pacific Northwest as we enter the 21st century.

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Photos. David C. Flaherty, Engineering Extension Service, Washington State University—cover, page 5 (right), page 9. Terence L. Day, Agricultural Research Center, WSU—page 5 (left), page 14. Washington State Department of Fisheries—page 10-11.

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