Conflicts Over the Columbia River

Seminar Conducted by

WATER RESOURCES RESEARCH INSTITUTE

Oregon State University

Spring Quarter 1980

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July 1980
Preface

A recent report of the Pacific Northwest River Basins Commission speaks of the Columbia River in the following words:

"How can we characterize the Columbia River? Small in developed surface storage compared to the Missouri and Colorado Rivers; large in hydroelectric energy generation capability compared to the Mississippi River; more diverse than rivers on the east coast. Another way to describe the river is to point out that the Columbia River produces, in an average year, 10 times the water produced in the Colorado River and 2.5 times the water produced in the Nile River, the river in Africa that played a major role in man's struggle toward civilization.

"But those characteristics alone do not tell the complete story of the Columbia River. As painfully discovered during the 1977 drought, the Columbia has more demands placed on it than can be accommodated. The fact is: as conditions exist today in the Pacific Northwest, with the present storage, usable water supplies are not adequate to serve all demands to the extent desired! Anticipated future increases in demands will worsen the situation. This makes it necessary to examine the goals and objectives for the river, the needs and issues, and the alternative actions that can be taken to meet present and future demands for the river's water. This involves consideration of not only the physical management of the water and related resources, but also the existing institutional system of legal, political, legislative, and administrative management of these resources."

To examine some of the factors involved, a seminar series was conducted Spring Quarter at Oregon State University. The weekly presentations were open to faculty, students of all ages, and the general public.

Peter C. Klingeman,
Director

Corvallis, Oregon
July, 1980

Funds for this publication were provided by the Office of Water Research and Technology, U.S. Department of the Interior, under the provisions of Public Law 88-379, as amended.
The Water Resources Research Institute, located on the Oregon State University Campus, serves the State of Oregon. The Institute fosters, encourages and facilitates water resources research and education involving all aspects of the quality and quantity of water available for beneficial use. The Institute administers and coordinates statewide and regional problems of multidisciplinary research in water and related land resources. The Institute provides a necessary communications and coordination link between the agencies of local, state and federal government, as well as the private sector, and the broad research community at universities in the state on matters of water-related research. The Institute also administers and coordinates the inter-disciplinary graduate education in water resources at Oregon State University.

This seminar series is one of the activities regularly undertaken by the Institute to bring together the research community, the practicing water resources specialists, students of all ages and interests, and the general public, in order to focus attention upon current issues facing our state.
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River of Many Uses

Thank you for asking me to be part of your seminar to discuss the Columbia as the "River of many Uses." This title appears in the current BPA annual report. From that report I include 4 pages. The first two pages discuss the multiple purposes use of water, including some strain among certain uses during power shortage. The other two pages present a table showing how the investment in the 30 Federal hydroelectric dams is allocated among the purposes. Let me read several paragraphs from the report (Figure 1).

Beauty

The beauty of the Columbia River is that it serves so many purposes:

• It still produces more than 80 percent of the electricity consumed in the region.
• It provides water for most of the 8 million irrigated acres in the region.
• It is the spawning grounds for a great anadromous fishery.
• It provides navigation all the way to Lewiston.
• It provides boating and other recreation for local residents and serves as a tourist lure.
• It provides water for municipal and industrial uses.

Many of the present benefits result from upstream storage. The natural flow of the Columbia varies widely from season to season and year to year. More reservoirs on the headwater tributaries could increase these benefits, and the Corps of Engineers is studying a number of potential sites.
RIVER OF MANY USES

"Operation Fish Run" photo shows truck movement of frylings past a Columbia River dam, while three inset photos illustrate irrigation, navigation and recreational uses of the river. Navigation photo shows the sternwheeler S.S. Portland passing through the locks at Lower Monumental Dam. Recreation photo shows beach scene behind John Day Dam.

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- It provides water for most of the 8 million irrigated acres in the region.
- It is the spawning grounds for a great anadromous fishery.
- It provides navigation all the way to Lewiston.
- It provides boating and other recreational opportunities for local residents and visitors at a low cost.
- It provides water for municipal and industrial use.

Many of the present benefits result from upstream storage. The natural flow of the Columbia varies widely from season to season and year to year. Many reservoirs could increase these benefits, and the Corps of Engineers is studying a number of potential sites.

...And the Beast
The trouble with the Columbia River is that it no longer has sufficient capacity to meet all the demands on it.
And that causes a lot of differences of opinion. It wasn't all that long ago that people didn't have to chose between fish and power, or irrigation and power, or other competing uses. There was enough to go around for all uses.

As the Tri-City Herald editorialized September 24, 1979, "It was considered a joke in 1952 when former Gov. Lena Jordan told a congressional committee that it was Idaho's goal to dry up the Snake River at Hells Canyon by using all of the water for irrigation. Nobody is laughing now. Idaho Power Co. is in federal district court in Boise suing Idaho and several state agencies. It charges that irrigation upstream from its power dams is diverting water to which the company has a priority right."

Well, this Annual Report is no place to attempt to resolve that question of basic rights. It is a place to observe, however, that for every gallon of water diverted upstream a half gallon on average is lost forever for downstream power production. The power producing capability of this water is lost over and over at each power dam below the point of diversion. In the case of water taken out of the Snake River for irrigation at the Minidoka Reservoir, it is lost 18 times over - at 14 dams on the Snake and four downstream on the lower Columbia.

The BPA has computed that the water used to irrigate 11 million acres would produce 1000 megawatts of power. That doesn't take into account the "double whammy" effect of having to use large amounts of electricity to pump a lot of the water that goes into irrigation. Nor does it mean that the jobs and food that irrigation produces are not worth the loss of power. The people, through the Congress, have repeatedly found otherwise. But it does illustrate that the Columbia River isn't as big as it used to be in terms of satisfying all the competing demands.

Power needs now take a back seat not only to irrigation, but also to fish protection. And power operations now take into account recreation - even the results races above McNary Dam and suction, and all the other multiple uses. It's a matter of trade off, to some extent, backtracking.

Power and Fish
Some of the more difficult tradeoffs involve power and fish, or irrigation and power. That doesn't take into account the "double whammy" effect of having to use large amounts of electricity to pump a lot of the water that goes into irrigation. The BPA has computed that the water used to irrigate 11 million acres would produce 1000 megawatts of power. That doesn't take into account the "double whammy" effect of having to use large amounts of electricity to pump a lot of the water that goes into irrigation.

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DOWNSTREAM POWER BENEFITS OF THE HUNGRY HORSE PROJECT

YEAR-AROUND DEPENDABLE ENERGY PRODUCTION OF DOWNSTREAM PLANTS

Coordinated System Operation based on 1962-63 Installations & Load Estimates
... And the Beast

The trouble with the Columbia River is that it no longer has sufficient capacity to meet all the demands on it.

And that causes a lot of differences of opinion.

It wasn't all that long ago that people didn't have to choose between fish and power, or irrigation and power, or other competing uses. There was enough to go around for all uses.

At the outset it should be clear that my purpose is to cover the subject of beauty. I'm not licensed to talk about beasts. As the annual report suggests, the beauty of the Columbia River lies in its ability to serve so many purposes. Moreover these uses of water have been largely compatible, complementary, and indeed mutually supportive. One seldom hears the good news, like the harmonious and cooperative uses of water. The loud noise is when competition occurs, or when the squeeze is on.

The best example of compatibility is the dual use of Hungry Horse reservoir for power and flood control. In summer the Hungry Horse Dam in western Montana captures the snow melt and thus provides flood control. Then in winter when power is most needed, water is released to generate power at Hungry Horse and 19 downstream dams (Figure 2). Thus flood control and power go hand in hand. The two purposes are fully compatible.

On the other hand, at Willamette River projects flood control and power overlap somewhat and the dams are used first for flood control and only incidentally for power. Even then the planners worked out the tradeoffs between flood control and power to optimize the project.

INVESTMENT FIGURES

Let me call your attention now to Table A showing the allocation of the investment cost of each of the 30 Federal hydroelectric dams to the multiple purposes. It shows $8.5 billion total investment of which power users are repaying 83½ percent. Obviously Congress authorized and financed these dams mainly for power and that decision has made possible the economical inclusion of other project purposes. This illustrates how one of the multiple purposes can be supportive for other purposes.

Support takes another form in the case of irrigation investment where the farmer repays 29 percent of the irrigation investment while electricity users pay 71 percent. This is a subsidy authorized by Congress to help irrigation.

The column on fish and wildlife shows only the allocation to enhancement or betterment. The main cost of some $200 million in fish ladders is charged to the project to provide fish passage.
TABLE A

Schedule A
Federal Columbia River Power System
Schedule of Amount and Allocation of Plant Investment
as of September 30, 1979 (Millions of Dollars)

<table>
<thead>
<tr>
<th>Project in Service</th>
<th>Total</th>
<th>Commercial Power</th>
<th>Irrigation</th>
<th>Nonreimbursable</th>
<th>Percent of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Revenues</td>
<td>Revenues</td>
<td>Construction</td>
<td>Reimbursable</td>
</tr>
<tr>
<td></td>
<td></td>
<td>as of 1979</td>
<td>as of 1979</td>
<td>Work in Progress</td>
<td>1979</td>
</tr>
<tr>
<td>Transmission Lines (BPAM)</td>
<td>2.105,791</td>
<td>$1,815,474</td>
<td>$13,754</td>
<td>$13,754</td>
<td>$13,754</td>
</tr>
<tr>
<td>Lower Klickitat (ET)</td>
<td>32,722</td>
<td>32,722</td>
<td>$2,802</td>
<td>$2,802</td>
<td>$2,802</td>
</tr>
<tr>
<td>Bonneville (ET)</td>
<td>65.958</td>
<td>5.880</td>
<td>2,507</td>
<td>7,987</td>
<td>7,987</td>
</tr>
<tr>
<td>Chief Joseph (ET)</td>
<td>479,118</td>
<td>699,118</td>
<td>325,108</td>
<td>414,089</td>
<td>414,089</td>
</tr>
<tr>
<td>Columbia Basin (BPAM)</td>
<td>1,195,167</td>
<td>1,195,167</td>
<td>392,528</td>
<td>798,042</td>
<td>798,042</td>
</tr>
<tr>
<td>Contra (ET)</td>
<td>463,758</td>
<td>463,758</td>
<td>149,724</td>
<td>149,724</td>
<td>149,724</td>
</tr>
<tr>
<td>Detroit Dam (ET)</td>
<td>225,946</td>
<td>225,946</td>
<td>107,312</td>
<td>107,312</td>
<td>107,312</td>
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<tr>
<td>Hanford (ET)</td>
<td>353,219</td>
<td>353,219</td>
<td>120,994</td>
<td>120,994</td>
<td>120,994</td>
</tr>
<tr>
<td>Gemini, Peter (ET)</td>
<td>22,184</td>
<td>22,184</td>
<td>7,326</td>
<td>7,326</td>
<td>7,326</td>
</tr>
<tr>
<td>Hells Canyon (ET)</td>
<td>59.844</td>
<td>59.844</td>
<td>19.169</td>
<td>43,845</td>
<td>43,845</td>
</tr>
<tr>
<td>Humprey, Horse (BPAM)</td>
<td>101,615</td>
<td>76,985</td>
<td>39</td>
<td>76,985</td>
<td>76,985</td>
</tr>
<tr>
<td>Ice Harbor (ET)</td>
<td>140,224</td>
<td>130,561</td>
<td>2,610</td>
<td>132,171</td>
<td>132,171</td>
</tr>
<tr>
<td>John Day (ET)</td>
<td>1,147,645</td>
<td>284,780</td>
<td>49</td>
<td>285,278</td>
<td>285,278</td>
</tr>
<tr>
<td>Little Geese (ET)</td>
<td>251,355</td>
<td>179,619</td>
<td>2,134</td>
<td>181,753</td>
<td>181,753</td>
</tr>
<tr>
<td>Lower Palouse (ET)</td>
<td>489,758</td>
<td>489,758</td>
<td>150,670</td>
<td>639,428</td>
<td>639,428</td>
</tr>
<tr>
<td>Lower Granite (ET)</td>
<td>1,169,745</td>
<td>408,510</td>
<td>2,291</td>
<td>410,801</td>
<td>410,801</td>
</tr>
<tr>
<td>Lower Monumental (ET)</td>
<td>2,201,217</td>
<td>323,417</td>
<td>2,141</td>
<td>345,558</td>
<td>345,558</td>
</tr>
<tr>
<td>McNames (ET)</td>
<td>392,162</td>
<td>265,545</td>
<td>2,048</td>
<td>267,593</td>
<td>267,593</td>
</tr>
<tr>
<td>Mendota Rapids (BPAM)</td>
<td>141,845</td>
<td>11,111</td>
<td>30</td>
<td>11,141</td>
<td>11,141</td>
</tr>
<tr>
<td>Yacoma Harbor (BPAM)</td>
<td>72,963</td>
<td>40,008</td>
<td>4</td>
<td>40,012</td>
<td>40,012</td>
</tr>
<tr>
<td>Irrigation assistance at 11 projects having no power generation</td>
<td>77,998</td>
<td>77,998</td>
<td>77,998</td>
<td>77,998</td>
<td>77,998</td>
</tr>
<tr>
<td>Plant investment</td>
<td>87,012,695</td>
<td>5,099,965</td>
<td>834,655</td>
<td>5,904,620</td>
<td>5,904,620</td>
</tr>
<tr>
<td>Repayment obligations retained by Columbia Basin Project</td>
<td>2,211</td>
<td>1,752</td>
<td>1,158</td>
<td>2,369</td>
<td>2,369</td>
</tr>
<tr>
<td>Total</td>
<td>$60,516,301</td>
<td>$5,099,965</td>
<td>$834,655</td>
<td>$6,099,713</td>
<td>$6,099,713</td>
</tr>
</tbody>
</table>
The subject matter of your seminar was discussed in 11 articles in the Oregon Journal December 17-29, 1979, under the overall title, "Crisis on the Columbia."

These articles focus on conflict, with virtually no mention about the achievement of much cooperation and coordination. The conflict rises in part from the rising water demands for fishery use and irrigation use, but it should also be noted that the squeeze comes mainly in a low water year like 1977. Thus much of the conflict is really a measure of water shortage in a low water year.

The most constructive idea in the Oregon Journal series of articles came from Kahler Martinson, director of the U.S. Fish and Wildlife Service regional office in Portland. He lists four alternatives for meeting the water needs:

1. Increase existing storage capacities,
2. Recharge ground water supplies by pumping surplus spring run off into the ground,
3. Make more efficient use and reuse of existing supplies, and
4. Develop new storage sites.

Thus Martinson pins his hopes for the future mainly on getting more upstream storage. I will come back later to the need for more storage.

HISTORICAL TRENDS

Mr. Buckley suggested in our telephone conversations that I bring in the historic approach to water resource development. I'll try to highlight this briefly with emphasis on U.S. experience. The diversion of water for irrigation has been traced back thousands of years in the Near East, in Asia, Egypt, South America, in Mexico, and Arizona. The Romans built the famous aqueducts to carry drinking water. They also improved the water wheel. Incidentally one of the Roman mistakes that was not recognized until quite recently, was the piping of their high quality water into the homes of the patricians by means of lead piping. The slow poisoning went undetected.

In the United States two important water-use trends became established around 1880. In the eastern States, as in Europe, water borne disease resulted in terrible epidemics. City governments took over the job of furnishing treated and filtered water. In fact, this became a major function of city government. Dr. George M. Kober gave a classic paper at the White House Conference on Conservation in 1908 entitled, "Conservation of Life and Healthy by Improved Water Supply."

The other event was the publication in 1878 of John Wesley Powell's "Arid Lands Report" which pointed out that the limiting factor in western States development was not land but water. More studies followed and in 1901 President Theodore Roosevelt asked Congress to build large, upstream, storage dams to
capture the flood waters for later release for irrigation. Roosevelt in many messages called for integrated river development, using the entire river basin as the unit, and to do so on a multiple purpose basis so that "one use can often be made to assist another." Let me give you that quotation in full:

"Every stream should be used to its utmost. No stream can be so used unless such use is planned in advance. When such plans are made, we shall find that, instead of interfering, one use can often be made to assist another. Each river system from its headwaters in the forest to its mouth on the coast, is a single unit and should be treated as such."

President Theodore Roosevelt in transmitting preliminary report of the Inland Waterways Commission to the Congress 1908.

In 1925 Congress placed a little paragraph in the River and Harbor Act calling upon the Corps of Engineers and the Federal Power Commission jointly to submit to Congress an estimate of what it would cost to survey and investigate only those navigable streams of the United States and their tributaries whereon power development appears feasible and practicable, with a view to the formulation of general plans for improving such streams for four purposes: 1. electric power, 2. navigation, 3. flood control, and 4. irrigation.

In 1926, the Army reported with the cost estimates, and in 1927 Congress ordered the Army to go ahead. One result was the 1845-page report on the Columbia River and Minor Tributaries which was completed March 1932 and which recommended 10 dams on the main stem of the Columbia. The unsung hero of that report was Major John S. Butler, the Seattle District Engineer, who recommended Grand Coulee Dam over the opposition of his boss, the Division Engineer.

Bonneville and Grand Coulee

The next year, in 1933, President Franklin D. Roosevelt authorized the start of construction of Bonneville and Grand Coulee Dams. The Federal system has since grown to 30 hydroelectric projects. The predominant multiple purposes are still power, navigation, flood control, and irrigation, but other purposes have been added in later projects including some recreation.

One of the many controversies which occurred during the planning of Columbia River projects was a disagreement around 1952 as to the realistic amount of the potential water power. Some utility leaders estimated 12.5 million kilowatts while the Bonneville Administrator said 30 million. It so happened that the Federal Power Commission had the numbers to back up the 30 million figure but the data was buried in the FPC files. As a result of the 1952 controversy, FPC launched a new publication in 1953 listing every existing hydroelectric project in the United States and every potential project. This FPC publication on developed and potential water power in the United States is published every 3 or 4 years. The 1976 edition shows that the North Pacific Major Drainage has a physical water power potential of 61.2 million kilowatts of which about one half had been developed or was in progress. Of the 61.2
million kW, the Columbia River has 54.0 million kW potential and the rest is on the coastal streams of Washington and Oregon.

These numbers refer to the physical potential water power. The sites appear feasible from an engineering standpoint. Any developer would need to study the proposed project to determine economic and environmental feasibility. Incidentally the Federal Power Commission has been renamed the Federal Regulatory Commission.

When you hear that the hydro potential of the Columbia has already been developed, the statement refers to the main stem of the Columbia, where only the Ben Franklin site is unharnessed. Most of the undeveloped potential is on the upstream tributaries. Of the remaining 30 million kilowatts in potential sites, about 5 million kilowatts have been set aside in wilderness and recreation areas.

To understand the importance of the region's remaining potential water power, and particularly of the upstream storage possibilities east of the Cascade Mountains, we need to review the history of upstream storage in the Columbia River basin. We have already noted that John Wesley Powell and Theodore Roosevelt advocated upstream storage dams for the western arid States to capture the flood waters for irrigation use. Major John S. Butler in his 1932 study of the upper Columbia called for upstream storage, for example at Hungry Horse, for river regulation to serve all purposes.

The region's outstanding expert on the need for headwater storage was Ben Torpen, Head Engineer of the Portland District of the Corps of Engineers. In 1937 he drafted a study which he called "Where Rolls The Oregon" in which he identified the need for regulating the Columbia. By 1945 he developed his idea into a more formal 95-page report in which he said,

"Storage is the key to complete development of the Columbia River... without storage only about 20 percent of a hydroelectric power site's potential firm capability can be realized... 80 percent of the potential power depends on storage..."

"When properly planned, conflict seldom arises between the use of storage for power and the use of storage for these various purposes; rather, they complement and benefit each other."

He advocated a minimum goal of 60 million acre-feet of useable headwater storage. Repeatedly he pointed out that upstream storage opened the door for optimum, balanced, multiple purpose development. He found that the same upstream storage project could reduce floods, provide a full reservoir for summer recreation, increase minimum flow for power, navigation and fish, and increase water availability for irrigation. He summarized this point,

"The fundamental basis for the application of the multiple use principle is STORAGE."
TREATY WITH CANADA

In part as a result of Ben Torpen's studies, the Corps of Engineers in 1944 asked the International Joint Commission to study the Libby Dam opportunity. The Libby Dam reference of 1944 resulted in 15 years of studies and 5 years of negotiations which led to the Columbia River Treaty of 1964 between the United States and Canada. Since 1964 the Treaty led to the completion of three storage dams in Canada and our Libby Dam which together gave us about half of the 42.8 million acre-feet of upstream storage now available in the Columbia watershed. Libby Dam, incidentally, solved the local flood control problem of the Bonners Ferry, Idaho area, and also helped to solve the flood problem along the Columbia River's main channel (see Table B).

The Treaty with Canada serves to underline an important fact about the Columbia River. It is an international river. About 43 percent of the summer peak flow comes from Canada. The Treaty reserves to Canada the right to divert the Kootenay River into Columbia Lake. The Treaty has termination dates applying to certain rights spread over the next 75 years. This means that Canada can make some changes that would affect the flow of water in various rivers in the United States.

The Columbia River has a number of characteristics which affect its ability to produce electric power and serve other uses. First, the river is steep, dropping 2 feet per mile compared to the slow moving Mississippi which drops only 6 inches per mile. Second, the river flows in a channel of solid rock suitable for dam foundations. Third, the river is virtually free of silt, assuring long reservoir life of hundreds of years. Fourth, the Columbia discharges 73 percent of its natural flow in the six summer months and only 27 percent in the six winter months, when electric energy is most needed. It is this last ratio of 73 to 27 that the engineers are changing by means of upstream storage. Finally, as a fifth characteristic the Columbia historically had peak flows as high as 1,240,000 cubic feet per second measured at The Dalles in June 1894. That great flood reached an elevation as high as the second floor of many buildings in downtown Portland, Oregon.

At the other extreme the Columbia had a low flow in January 1937 of only 35,000 cubic feet per second. The ratio of the highest to the lowest flow is 35 to one. It has been one of the goals of upstream storage to reduce that ratio from 35 to 1 to the present 5 to 1. We have cut the maximum flood down to about 600,000 cfs and we have brought up the low flow to more than 100,000 cfs.

For comparison purposes the St. Lawrence River is one of the steadiest flowing rivers in the world. The peak flow has never been more than double the minimum flow. The steady flow results from the upstream storage provided naturally by the five Great Lakes. The Columbia will never reach a 2 to 1 ratio, but there is still plenty opportunity for more upstream storage to improve the existing ratio.

Last summer the Pacific Northwest River Basins Commission issued its 3-volume report called "Water - Today and tomorrow". This report addresses the need for more upstream storage especially in response to the pressure from
<table>
<thead>
<tr>
<th>Project</th>
<th>Stream</th>
<th>Stream Mile (from mouth</th>
<th>Date Operational</th>
<th>Reservoir Elevation (feet)</th>
<th>Humble Power Storage - AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>MICA* (Canada)</td>
<td>Columbia</td>
<td>1018.1</td>
<td>Mar 29, 1973</td>
<td>2475.0</td>
<td>7,000,000*</td>
</tr>
<tr>
<td>Koosleydile* (Canada)</td>
<td>Columbia</td>
<td>790.6</td>
<td>Oct 10, 1968</td>
<td>1444.0</td>
<td>7,100,000*</td>
</tr>
<tr>
<td>Libby*</td>
<td>Kootenai</td>
<td>222.0</td>
<td>Jul 25, 1974</td>
<td>2459.0</td>
<td>4,993,670*</td>
</tr>
<tr>
<td>Duncan* (Canada)</td>
<td>Duncan</td>
<td>8.3</td>
<td>Jul 31, 1967</td>
<td>1892.0</td>
<td>1,400,000*</td>
</tr>
<tr>
<td>Corna Linn (Canada)</td>
<td>Kooteney</td>
<td>16.1</td>
<td>Oct 1951</td>
<td>1745.3</td>
<td>648,790</td>
</tr>
<tr>
<td>Hungry Horse</td>
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<td>Kerr</td>
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<td>May 1939</td>
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<td>Palouseea</td>
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<td>American Falls</td>
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<td>Minidlian</td>
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<td>S. P. Boise</td>
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<td>Drumhuk</td>
<td>H. F. Clearwater</td>
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<td>Williams</td>
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<td>Green Peter</td>
<td>M. Santin</td>
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<td>Detroit</td>
<td>N. Santin</td>
<td>60.0</td>
<td>Oct 31, 1953</td>
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<td>Timothy Meadows</td>
<td>Oak Grove P. Clackamas</td>
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<td>Swift #1</td>
<td>Lewis</td>
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<td>Yole</td>
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<td>Cowlitz</td>
<td>65.5</td>
<td>May 20, 1968</td>
<td>770.5</td>
<td>1,356,280</td>
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* Canada-Columbia River Treaty

BPA - Branch of Power Resources

May 18, 1977
the fishery people for higher minimum flow, and pressure by the irrigators for more water for irrigation. The report lists more than 26 million acre-feet of potential storage reservoir sites available upstream from The Dalles. A second table identifies another 20 million acre-feet of storage sites which are now in wild and scenic or recreation areas or proposed areas. These two lists total about 47 million acre-feet of potential storage which compares to about 42.8 million acre-feet in existing storage projects including those in Canada.

Malcolm Karr, of the river basins commission in a recent speech said this,

"Among the recognized means to increase water availability on a timely basis, only that of additional storage development has the potential to support major increases in the level of water use."

May 22, 1979

The Corps of Engineers in its 1948 and 1958 review of the 308 Reports on the Columbia called attention to the need for storage not only for regional flood control but also for local flood control on particular tributaries. Since 1968 the Treaty projects have completed bringing under control the floods on the main stem of the Columbia. There remain the flood risks on the tributaries--risks which now prevent or discourage other development and use. The need for flood control today is on the tributaries, the Methow, Similkameen, Okanogan, Clark Fork, Flathead, John Day, and many others. In each case the local improvement from upstream storage will incidentally provide both at site and downstream power benefits, and various other benefits which differ from one stream to another.

DEVELOPMENT OF THE COLUMBIA

I especially call attention to some misunderstanding about the degree of completeness of our development of the Columbia River. The main stem on the Columbia is almost completely developed but many tributaries are undeveloped. By comparison the Tennessee Valley Authority completed the dams on the main stem of the Tennessee River by about 1950 and then shifted gears to what became known as TAD, Tributary Area Development. In the Tennessee River tributaries, the main interest was on flood control, water for irrigation, and other purposes with particular emphasis on all forms of water oriented recreation and on water quality. In the case of the Columbia River tributaries, some of which are as large as the Tennessee, the opportunity remains for considerable multiple purpose development including the harnessing of water power.

The key to such future development is upstream storage, but there will be little development unless there is grass roots support by local people. In the TVA area the people living in the individual tributary basins organized themselves as an advocacy association which then steered the planning for their subregion or area, put forward the program of development, and then provided the political support.

The history of water resources development in the United States has emphasized three ideas, an integrated basin-wide approach, a multiple purpose
approach, and the regulation and control of the river by upstream storage.

Now let me turn quickly to the future, and for one man's perspective for the future let me mention Mr. Doxiadis. President Lyndon Johnson in 1967 convened an international conference in Washington, D. C., on the theme of Water for Peace. Among the keynote speakers was the famous city planner Constantinos Doxiadis of Athens, Greece. Speaking on Water and Environment, Doxiadis estimated that around the middle of the 21st century the world population would stabilize at about 20 billion people of which 17 billion would live in cities. Water use would have increased 15 times. He looked upon the intervening hundred years as a transition period of grace during which to get our water management under control and in order.

He proposed to solve the enormous water problems by what he called a plan for the universal city and the universal garden. In this plan water is used and reused in a virtually closed system which includes gardens as part of a natural filtration scheme. The cycle is much like the bloodstream of the human body and like the hydrologic cycle itself.

The broad, imaginative approach of Doxiadis can be a useful spur to our thinking. Instead of separating and isolating each of the many uses of water, he proposed to combine the multiple uses in what he calls a balanced, dynamic system.

We should bear in mind that what may appear economically infeasible or unattractive at one time, can become quite interesting and even practical at another time. Even if Doxiadis' "universal city" and "universal garden" approach seems fanciful and impractical now, many factors can combine over time to make it or alternative approaches the place where the "smart money" goes.

In summary, first, the main stem of the Columbia is pretty much developed; second, there is much work to be done on the tributaries, and third, the key to tributary development is upstream storage which is useful for many purposes. I think the developmental future of the Columbia is on the tributaries.
Concern Over the Columbia Estuary

The Columbia River Estuary is an artifact of the Missoula floods, which occurred 18,000 to 20,000 years ago, and of the rise in sea levels throughout the world during the last 2,000 years. The first evidence of human habitation in the Columbia River area about 15,000 years ago indicates that nomadic peoples followed the Pacific coastline and major tributaries in their quest for food and shelter. By the time Sebastian Viscaíno saw the Oregon coast in 1602, Indian cultures were well developed with trade links as far north as Alaska. In 1792, the British Captain, Robert Gray, discovered and mapped the entrance to the Columbia River. Based on these maps and Lewis and Clark's reports about the New World in 1804, John Jacob Astor and the Hudson’s Bay Company made the first major land use decisions regarding the estuary. The town of Astoria was founded in 1811 by 30 British subjects and 3 Hawaiians.

From that time until 1968, little planning for development within the estuary occurred. Decisions were based on the needs of the user, rather than the limits of the resources of the estuary. What planning there was, was undertaken to control the river. Little thought was given to the resources supported by the river with the exception of the fisheries and power.

During the Twentieth Century, substantial declines in fish resources, particularly salmonids, occurred. These declines are often attributed to dam building which had a major effect. However, substantial reductions in fish stocks and catches had occurred prior to dam construction due to intensive fishing pressures. The need to allocate the use of the Columbia River's resources has forced government to plan, make judgments, and enforce these judgments through a variety of mechanisms. The way government makes these choices will affect each of you. This paper discusses how the CREDDP is organized to assist decision-making, the work in progress, and the products of the program to date.

* The author is Program Manager for the Columbia River Estuary Data Development Program (CREDDP) of the Pacific Northwest River Basins Commission, P.O. Box 908, Vancouver, Washington 98666.
** ( ) Refers to bibliographic citations listed at end of text.
The Estuary. The Columbia River, which drains 1,210 miles, is the largest river on the Pacific coast of North America (see Figure 1). At 95,000 acres (150 sq. miles), its estuary is the ninth largest in the United States, yet less is known about the Columbia River Estuary than about any other estuary of comparable size or importance. Depths are generally less than 30 feet except in the lower estuary. For purposes of the Columbia River Estuary Data Development Program, the estuary is deemed to extend to River Mile 46, even though salinity seldom encroaches beyond River Mile 23.

Planning. During the early 1960's, concern by the Atomic Energy Commission, regarding the fate of radioactive materials from the Hanford Research Facility, led to the first organized attempt to study the Columbia River Estuary. Except for the AEC's investigations in 1965, no comprehensive study of the estuary's resources has occurred until recently. Fisheries concerns continued to increase as a result of the effects of upstream dams, substantially enlarged fisheries programs, and the U.S. Army Corps of Engineers maintenance of the navigation channel. The heightened concern for the Columbia's systems was brought about by increased awareness during the 1960's of the limits of natural systems. Passage of the National Environmental Policy Act of 1969 led to renewed efforts to coordinate investigations of man's effect on the Columbia River and its estuary.

Local efforts to bring about a state or regional integrated research/planning effort were initiated in 1970. At the same time, concern for the coasts of the United States was increasing nationally. In response to the President's Commission on Marine Resources and Engineering Development, the Congress passed the Coastal Zone Management Act of 1972 (P.L. 92-583). This Act led to formation of coastal planning organizations in 28 States including Oregon and Washington. Washington furthered the intent of the Coastal Zone Management Act with the passage of its own Shorelines Management Act which required the preparation of coastal plans by each of the coastal counties. Oregon approached the question of coastal zone management more broadly with the passage of statewide land use planning legislation (S.B. 100) in 1975.

In an attempt to reconcile the planning efforts of the two states, the Columbia River Estuary Study Taskforce (CREST) was established in 1975 to prepare a local comprehensive plan for the Oregon and Washington counties surrounding the Columbia River Estuary. As originally conceived, the planning was to have been coincident with a major five-year data development effort. The results of these estuarine investigations were to have provided the technical basis for land use decisions in areas adjacent to the estuary.

The Pacific Northwest River Basins Commission. The Pacific Northwest River Basins Commission (PNRBC) was the first of six river basins commissions to be established under the Water Resources Council by Executive Order in 1967. The Water Resources Council is an independent agency of the Federal government. It was created in 1965 by Public Law 89-80, the Water Resources Planning Act. The Commission is comprised of the States of Oregon, Washington, Idaho, Montana, and Wyoming acting together with the eleven federal agencies and councils represented on the Water Resources Council, and representatives from Canada and the Indian tribes.

The PNRBC is responsible for the coordination of water resource activities in the five Pacific Northwest states. The functions of the PNRBC
are: 1) to serve as the principal agency for the coordination of Federal, state, interstate, local and nongovernmental plans for the development of water and related land resources in its area; 2) to prepare and keep up to date a comprehensive regional plan; 3) to recommend regional priorities for planning and construction of projects; and 4) to undertake special studies of water and related land resources. The Columbia River Estuary Data Development Program falls into the last category.

To meet its responsibilities, the Commission uses a staff of 19 including 4 technical representatives delegated from key federal agencies. The 17 Commission member agencies or states meet quarterly to discuss and resolve resources issues affecting the 5 Pacific Northwest states and Canada. Commission decisions are by consensus; objection by one or more members results in the deferral of decision on an issue or program.

Funding for Commission activities is shared. The states contribute collectively 28 percent of the Commission's operating expenses; the Federal Government contributes the balance. As the only federally authorized regional body for resources conflict resolution, the Commission plays a major role in water and related land resource decisions.

The Commission published in June 1976 a "Proposal to Study" which outlined the need for and purposes of an estuary study, how such a study would be organized and managed, and an estimated budget. This proposal was submitted to the Water Resources Council as part of the Commission's total program budget request for FY 1978, along with the endorsements of the Governors of two states and the Columbia River Estuary Study Taskforce. The study did not receive authorization for FY 1978 as a special study with 100 percent federal funding as requested, although $50,000 was included in the appropriation for the Commission's FY 1978 operating budget. That minor funding was for the purpose of initiating preparation of a Plan of Study.

The Commission resubmitted its request for authorization and full federal funding as part of the Commission's total program budget request for FY 1979. Funds for the program, however, were not included in the President's FY 1979 budget. Subsequent Congressional support and action resulted in authorization of the program and funding was provided under the appropriation authorities of the October 1978 Public Works Bill, P.L. 95-482. The Plan of Study detailing the scope, organization, work elements, schedules and budgets for the program was completed and approved by the PNRBC on March 15, 1979.

Purpose. The purpose of the Columbia River Estuary Data Development Program is twofold: to increase understanding of the Columbia River Estuary as a system, and to acquire information needed for making specific land/water management decisions. When completed, the program will provide much of the information necessary to support future management decisions concerning use of the Columbia River Estuary through greater insight into how the Columbia estuarine system functions.

P.L. 95-482 provided $828,900 for FY 1979 to complete program planning and initiate FY 1979 program activities; the FY 1980 budget provided an additional $991,000. Program participants are agencies, universities, and private organizations having demonstrated expertise in particular technical
The program's elements are divided into 26 work units that can be accomplished by a mix of participants. Requests for Proposals were solicited and after review of qualifications, approved participants were asked to submit formal proposals for CREDDP work. A total of 28 program contractors were selected. The total cost of the program over a six-year period is estimated at $6,204,000 with 100 percent federal funding.

The Data Development Program is based on the following assumptions:

- The Columbia River Estuary is an interdependent system (one in which physical and biological elements relate)
- The Columbia River Estuary Data Development Program will use and expand present data and programs, not replace them
- Data will be developed to both understand and facilitate management of the Columbia Estuary
- The program will focus equally on the biological and physical processes of the estuary; little emphasis will be placed on land resource, social, or economic studies
- The program will collect only usable data
- Contractors will be selected on the basis of their qualifications and the merits of their proposed research

Process. Assuming continued funding, the program will be accomplished in seven phases over a six-year period. These include program planning, contracting, implementation, three data acquisition field years, and a summation phase. Each contractor's effort is reviewed annually and contracts modified on the basis of their performance and the availability of funds. The out-puts of the program will include a variety of technical reports for each work element, "summaries" for decision-makers, an annual report which outlines program progress and results, and a series of conferences and special reports for technical and lay audiences, newsletters, and reports on key management issues.

Organization and Management. A schematic diagram of the program organization and management is shown in Figure 2. Policy guidance will be provided by the Pacific Northwest River Basins Commission primarily through its Program Committee and the Chairman. Technical guidance for the program will come from a Technical Advisory Committee (TAC) working through a Program Manager who is a member of the Commission staff. The work of the program is being performed by a mix of 18 federal/state agencies, academic institutions, and private contractors or individuals working on 28 contracts. Public input through a citizen advisory committee will be used throughout the study to identify local problems that require information or application of research results.

Policy Guidance

Pacific Northwest River Basins Commission. Regional policy guidance will come from the PNRBC. The policies of the Water Resources Council will be provided through the Commission and the PNRBC Chairman. The functions
of the Commission as they relate to the Columbia River Estuary Data Development Program follow.

1. Approval of the Plan of Study and subsequent revisions if required.

2. Review and approval of annual budget submissions prior to transmittal to the Water Resources Council.

3. Provision of general policy guidance and coordination of the related policies or actions of member agencies.

4. Resolution of major policy issues or disputes arising from contractor selection or performance if referred to it by the Chairman or Program Committee.

Program Committee. The Program Committee consists of all PNRBC members. This committee is concerned with all phases of the PNRBC planning program, and its responsibilities regarding this program include:

1. Review and recommend to the PNRBC appropriate action on the initial and all revised Plans of Study.

2. Review program progress and budgets and recommend Commission action.

3. Review contractual agreements and resolve conflicts on contracts or memoranda of agreement referred to it by the Chairman or the subcommittee.

4. Perform other activities assigned by the Commission.

The Estuary Program Subcommittee of the Program Committee consists of Commission representatives or alternates from Oregon and Washington and representatives from the Departments of Defense, Commerce, Interior, Agriculture, and the Environmental Protection Agency. The committee has the following responsibilities related to the Estuary Program:

1. Provide, on behalf of the Program Committee, program guidance to Program Manager, including review of the Plan of Study, overall work priorities and study objectives; make recommendations to the Program Committee for approval or revision.

2. Approve contractor recommendations from the TAC and Program Manager prior to solicitation of detailed scope and cost proposals.

3. Resolve policy or contractor selection disputes when referred by the Chairman. Major policy issues may be referred to the Committee or Commission as appropriate.

4. Monitor progress of CREDDP work program. Provide a forum for discussion of agency concerns and disputes regarding the CREDDP work program.
5. Review annual report and budget request prior to submission to Program Committee.

6. Perform other program related responsibilities as determined by the Committee.

Chairman. The Chairman of the PNRBC and his staff are responsible for implementing the program. The Chairman, working with the approval of the Commission, performs the following functions:

1. Provide detailed policy and program guidance and review of CREDDP progress.

2. Coordinate program activities with member agencies as needed, and inform Commission of CREDDP progress.

3. Approval of contractor selections, contract negotiations, contracts, and Memoranda of Agreement.

4. Resolution of policy or contractual disputes referred to him by PNRBC staff or Program Manager.

5. Review and approval of annual report and budget request prior to submission to full Commission.

6. Approve limited use of consultants upon recommendation of Program Manager.

Technical Guidance

It is the responsibility of the Technical Advisory Committee (TAC) and Program Manager to give the program direction and continuity. Implicit to the program is the assumption that all research will be undertaken by contract on a competitive basis. The roles of the Program Manager and TAC are identified as follows:

Program Manager. The Program Manager is a member of the PNRBC staff and responsible to it. His functions are as follows:

1. Work with the TAC to develop a draft Plan of Study for submittal for Commission approval.

2. Develop Requests for Proposals with TAC assistance based on the approved Plan of Study.

3. Establish a proposal review and contractor selection process for the program work components.

4. Serve with Commission's Planning Director and TAC member as contractor negotiating panel chairman.

5. Manage all contracts and Memoranda of Agreement entered into by the Commission under this program including fiscal management, monitoring of field work, and coordination of related work components.
6. Develop a system for storage and retrieval of data generated by program work components so that data are quickly available in a usable format.

7. Prepare for the Commission quarterly progress reports and an annual report to the Water Resources Council.

8. Testify before the Water Resources Council or Congress as requested by the Chairman.

9. Provide liaison with CREST and identify appropriate Commission participation in the CREST work program.

10. Keep Commission member agencies and others informed of program progress.

Technical Advisory Committee. The TAC is an advisory rather than decision-making group and plays a major technical role in guiding the program.

The designation of specific TAC members was based on the following assumptions. First, all major disciplines that will be a part of the program will be represented where possible by people who perform or manage research in each of the disciplines. Second, important management interests will be represented, but no agency will have more than one representative. Third, a balance between disciplines and between science and management will be sought. Fourth, membership will be voluntary and members will be reimbursed for services rendered, either by the program or from their parent agency. Finally, TAC members can also be contractors, but will not be allowed to evaluate those specific tasks for which they were competing. Most important is the assumption that the TAC will function principally as a disciplinary forum; policy considerations and agency concerns will be primarily the responsibility of the PNRBC and conflicts will be resolved there.

The functions of the TAC are as follows:

1. Review and comment on the program. During the first year, the TAC will play a major advisory role to the Program Manager in the formulation of the Plan of Study and the work program which derives from it. Subgroups to the TAC will review the Plan of Study, the draft Requests for Proposals, and will suggest hypotheses, methods, instrumentation, and/or techniques needed to implement the Data Development Program. Annually, the TAC will review the draft of the annual report and will develop a list of appropriate tasks for use in preparing Requests for Proposals.

2. Advise on the selection of contractors. The TAC will evaluate preliminary conceptual proposals and statements of potential contractor qualifications provided in response to Requests for Proposals issued by PNRBC following approval of the Plan of Study. Working with the Program Manager, it will designate disciplinary work groups to evaluate and recommend those contractors from whom detailed conceptual and cost proposals will be requested. Based on the review of the detailed proposals received, the TAC will recommend proposal modifications and contractor rankings for
consideration by the Program Manager, and approval by the Chairman
and the Commission prior to negotiation of level of effort and cost
proposals. The TAC will designate, based on interest and availability,
one member to assure that the negotiating team includes the identified
concerns of the work group.

3. Meet quarterly to review the program. The TAC will meet quarterly
to evaluate the progress of the program and identify new research
directions, data needs, or program emphasis. It will review con-
tractor reports, evaluate contractor performance, and keep abreast of
the information developed for the estuary. In order to do so, the
TAC will chair or participate in an annual research conference and
appropriate workshops. It will annually review the program and make
recommendations to the Program Manager concerning program emphasis or
reduction. In formulating recommendations, the TAC will have to be
cognizant of the research programs of federal and state agencies and
the needs of local, regional, and governmental managers.

Contractors. The work program for the Data Development Program will
be implemented by contract. A basic program assumption is that a mix of federal/
state, institutional, and private contractors or individuals will be used based
on the merits of their response to Requests for Proposals. Contractors are
expected to meet quarterly or less frequently at the request of the Program
Manager.

Three of the potential contractors should be described in detail. The
first is the "management contractor". This contractor has the difficult function
of insisting that the TAC and other program contractors think in holistic, system
terms and then helping them to do so. The management contractor does not collect
field data. Many of the key management and key research questions cannot be
answered within the confines of any one discipline. Thus, some of the most
important results that will emerge from the program will have to come from the
management contractor or the management contractor working with other program
contractors. The management contractor must also ask the difficult and important
questions as to the meaning of the information already obtained, so that the
Program Manager can rework the program.

The management contractor has a number of special requirements. He
must have access to the data of other contractors before the publication stage,
since publication will generally occur too late for the management contractor
to provide meaningful feedback to redirect the program. Interchange of data
between contractors will also be necessary in some instances and the Program
Manager will have to indicate this in the RFPs or contracts. Workshops will be
organized, literature reviews compiled, research questions formulated, and
equipment scheduled or coordinated by this contractor. The function of the
management contractor in organizing data collection and providing an overview
will be the greatest toward the end of the program, and thus they may continue
working after other contracts are completed. The budget for the management
contractor initially can be quite small, but will increase as the program
progresses. If possible, the same contractor will be retained for the entire
program. The functions of the management contractor are as follows:

1. Organize and coordinate an annual research conference. Print
proceedings.
2. Prepare an annual program report to the TAC following the annual meeting. This report will identify problems in coordination, performance by individual contractors, new areas of research, and other appropriate activities of TAC concern.

3. Prepare an impartial program evaluation for the Program Manager to be used in the Annual Report and with the budget request.

4. Perform other duties as necessary and appropriate to technical program coordination.

A second contractor is called the "editorial contractor". Individual program contractors will be required to provide executive summaries, but it may be too much to expect that the contractors will provide reports in language that can be understood by the Citizens Advisory Committee, the informed layman, and decision-makers on the local, state, and federal level. The translation step is viewed on the local level as being extremely important; a separate contractor will be used to perform these functions.

The function of the biological-physical interactions contractor is to integrate the various program elements. This integrative and analytical role will require that substantial time be spent creating the necessary conceptual models to describe various estuarine processes. Hence, this contractor started in March and will work with the individual program contractors to synthesize and evaluate the outputs of individual program elements. The integrative function generally will not require the acquisition of new data; the data of other program researchers would be used or modified to meet the needs of this contractor. The activities of the biophysical contractor will be supplemented by the integrative efforts of all the other program contractors. The end result of this contract will be an understanding of the interrelationships of the many aspects of the estuary.

PNRBC Services. The PNRBC provides the following services to the Columbia River Estuary Data Development Program:

1. Provide management and accounting services for program funds.
2. Print research reports as required.
3. Oversee contractor payments and billing procedures.
4. Provide program office space and clerical staff required.
5. Perform other administrative services as needed.

Citizen Involvement. To assure that management needs are addressed throughout the program, the data development program will have an independent link to the local community. The Citizen Advisory Committee's functions will include:

1. Advise the Program Manager on the overall focus of the program and local problems that should be addressed.
2. Review products for usefulness to and understandability by the public and local decision-makers.
Other opportunities for citizen involvement include:

1. An annual meeting that will provide the public an opportunity to comment.

2. Inquiries and concerns sent directly to the Program Manager.

3. Comments to the program made through the local Citizen Advisory Committee.

4. Through agency representation on the Commission, citizen views may be provided.

5. Annual contract modifications will be responsive to changing public needs and citizen concerns.

The Work Program. As of April 1980, a total of 28 contracts had been awarded to undertake the estuarine activities. A summary of these follow.

**Emergent Plant Production, Science Applications, Inc., $150,045.**

This work unit has four goals: 1) to review relevant primary productivity research; 2) measure primary production for key emergent plant species and marsh vegetation types; 3) assess detrital import-export relationships; and 4) evaluate other contributions of emergent vegetation habitats to adjacent ecosystems.

**Benthic Primary Production, Oregon State University, $298,156.**

The work unit will attempt to determine the mechanics that control the production dynamics of benthic plants relative to physical processes and changing patterns of nutrient distribution in the estuary. Research will focus on the effects of chemical and physical gradients on the structural and functional attributes of micro- and macro-algal assemblages, and on the productivity and biomass of the benthic primary food supply.

**Avifauna, Jones and Stokes Associates, Inc., $223,977.**

The work unit goal is to provide information on the function of avian species in the estuarine ecosystem. A number of bird species considered to be key components of the ecosystem will be selected for field investigation, including rare and endangered species, game species, abundant species and members of the merganser, grebe, cormorant, heron, murre and shorebird families.

**Wildlife Research (Mammals), Washington Department of Wildlife, $159,500.**

The work unit will develop information of feeding habitats, reproduction and nesting behavior of key species including nutria, muskrat, beaver, river otter, mink, raccoon, opossum, long-tailed weasel, short-tailed weasel, Columbian white-tailed deer, black-tailed deer, deer mouse, and shrews.
Current Studies; Shoaling Patterns, Mathematical Sciences NW; Dobrocky

SEATECH, Ltd. and Northwest Cartography, Inc., two contracts, $1,168,800.

Studies of currents and shoaling patterns will be undertaken as a unit. Circulation patterns within the estuary, at the mouth, and in peripheral areas of the river will be studied. Yearly, tidal and weather-related fluctuations in these patterns will be investigated.

Sedimentation, University of Washington, $474,946.

Contemporary and historical patterns of sedimentation within the estuary are to be investigated. Documentation of the pattern of sediment distribution will be developed for seasonal, ten-year, and one hundred-year periods. Sediment rates, paths, and volumes will also be investigated.

Simulation, SAI Northwest, $198,016.

The goal of the study is to gain a greater quantitative understanding of the physical oceanographic processes in the Columbia River. A further goal is to be able to predict changes resulting from topographic or physical alterations, for later use by estuary managers and scientists.

Characterization of Water Quality, Envirosphere Co., $19,610.

The work unit will serve to consolidate all available water quality, sediment chemistry, wastewater discharge and insolation data for the study area.

Water Column Primary Production, Oregon State University, $398,826.

The contract is closely linked with the benthic primary production work unit. The study will examine discrete components of the estuarine system to determine their interrelations with primary production and the coupling of their components within an ecosystem model of the estuary.

Zooplankton and Larval Fishes, University of Washington, $379,000.

The three-year field study will collect information on the life history stages and sizes of the animals, their distribution and abundance, and the energy budget of the second trophic level using carbon transfer.

Benthic Infauna, Oregon State University, $250,994.

This work unit will concentrate on a structured investigation of benthic animal distribution and food chain dynamics to determine habitat relations; map spatial/temporal distributions; critical life stages; and food chain relationships. Field data collection will continue through early 1984.
Epibenthic Organisms, Dames and Moore, $200,000.

A detailed quantitative assessment of epibenthic fauna will be conducted to document species and life history stage composition, density, and standing stock for habitat-stratified sites along the estuary. Epibenthic microfauna will also be sampled in order to identify and quantify their role in the estuarine ecosystem.

Non-salmonid and Salmonid Fishes, National Marine Fisheries Service, $824,000.

The two contracts will provide information on key habitats, migration routes, predator-prey relationships and other factors of importance to resource managers.

Higher Trophic Levels, Marine Mammals, Oregon Dept. of Fish and Wildlife, $50,000.

The contractor will identify and quantify the importance of marine mammals in the estuary. This will be done through verification of marine mammal food and feeding behavior, habitat type, population density, abundance, mortality, and reproductive rates. Marine mammal-fisheries interactions and their trophic level relationship to base fish stocks will be examined.

Integration of Estuarine Processes, Science Applications, Inc. $245,970.

The contractor will use outputs from current research units to develop working units' hypotheses which will lead to conceptualization of the inner workings of the estuary in a form that is appropriate for system description. Information appropriate to describing the system for resource management purposes will be modeled.

Log Storage Effects, Enviosphere Co., $9,665.

The objective of this work unit is to determine the impacts of inwater log storage on the estuary.

Management Contractor, Envirosphere Co., $169,266.

This contractor serves primarily as an interface between the PNRBC Program Manager and work unit contractors.

Data Systems, Boeing Computer Services Co., $50,000.

The contractor will provide data management throughout the CREDDP program.

Editorial Contractor, Oceanographic Institute of Washington, $100,000.

Using an integrated production system, the contractor will provide data based management for document and manuscript collection,
maintenance and retrieval; communications support, text editing and other editorial functions.

Progress. As of January 1980, 28 contracts have been awarded. The program has leased a 39' vessel and purchased a 22' vessel as well as several smaller boats and equipment. A local office and field station has been established in Warrenton, Oregon. Field work on a limited scale was initiated October 1979, with full scale field effort scheduled for March 1980.

A number of reports have been completed by the CREDDP. These include:

- Wetlands Maps (Department of Interior, NWI)
- Bibliography of Columbia River Estuarine Research (Oregon State University)
- Guide to Organisms of the Columbia (Department of Commerce/Corps of Engineers)
- History of the Columbia River Estuary (Oregon Historical Society)
- A Style Guide for report preparation (PNRBC)
- Basemaps at a variety of scales (Oceanographic Institute of Washington)

Others planned for release in 1980 include a quarterly newsletter (April/July/September), review of all historic research activities (April), Data Quality Assurance Manual (March), Key Species Life Histories (March), and a variety of short technical reports.

The Columbia River Estuary Data Development Program is a product of many resource concerns and investigations which have preceded it. The historic limitations of earlier Columbia River estuarine efforts have been evaluated and management techniques for dealing with these shortcomings have been included within the program. Recognition of past deficiencies does not assure future success; it does provide a base from which to plan for future contingencies, to integrate the activities of the many participants, and to understand the function and resources of the Columbia River estuary more fully. Early progress and success of the program and its organizational structure has been substantial. Let us hope the longer term results are equally worthwhile.


The cause of the decline of once great runs of salmon and steelhead in the Columbia River is really quite simple. The needs of the industrially based economy of modern man are in direct competition with the habitat requirements of salmon and steelhead. The farther inland a fish must go to reach ancestral spawning and rearing areas, the greater the impact of man's activities upon the chances of reproducing its kind. Each activity by itself has little impact upon the total run entering the river except for large dams without fish passage such as Grand Coulee, Hells Canyon and Dworshak dams, which have completely eliminated access to large spawning and rearing areas. The effect of man's activities has been a cumulative one = "The straw that broke the camel's back" syndrome. A road here, an irrigation diversion there, "one more dam won't make that much difference," "a few more cattle grazing a watershed couldn't possibly affect fish."

Given all of the insults that man has bestowed upon his environment, it is truly unreasonable to expect upriver runs to have survived. They should have been gone 10 years ago and yet they persist, although their numbers dwindle with each spawning season. Because the factors affecting the salmonid decline are cumulative and the decline gradual, it is difficult for many people to associate the cause with the effect.

The average citizen relying solely upon news accounts of fishery problems in the Northwest most likely has the impression that the greatest difficulty faced by fish managers is the constant conflict among user groups ... the offshore troll fishery, the lower Columbia River gill net fishery, the treaty Indian fishery, and the various sport fisheries. These conflicts may consume a great deal of our time, but they are not the source of the fish problem in the Columbia River. The conflicts result from declining fish runs and, in the heat of these conflicts, charges of overfishing by one group or another are often heard. And overfishing does occur on some stocks, especially where intensive fisheries operate on mixed stocks of wild and hatchery fish, since hatchery fish can tolerate a much higher harvest rate than wild stocks. But the effect of overfishing is easily reversed and insignificant compared to the long-term devastation that results from habitat degradation.
I am going to discuss some of the ways that critical habitat has been lost or degraded and the kind of impact that this has had upon the anadromous fish runs in the Columbia River. One of the first of man's activities to impact fish habitat was logging. Timber harvest and associated streamside road-building has resulted in siltation of spawning beds, low summer stream flows, and high temperatures from lack of streamside cover. This has greatly reduced the productivity of these streams and the amount of rearing space available. Irrigation diversions have reduced rearing habitat and contributed to higher stream temperatures by reducing summer flows. Livestock use has caused accelerated erosion of watersheds from overgrazing and has destroyed stream banks and the streamside vegetation --- resulting in more erosion and higher summer stream temperatures.

Dams on tributary streams have blocked large areas where salmon and steelhead once spawned and reared. Main-stem dams have altered the conditions fish encounter going to and from the ocean. The Columbia River has been changed from a free-flowing river characterized by a strong spring freshet as the snow melts in its headwaters, to a series of lakes, the flow of which is controlled to correspond more closely to the need for hydropower than to the needs of anadromous fish that have evolved with a dependency on the natural character of the river.

The cumulative effect of main-stem dams in addition to the severe degradation of headwater rearing habitat has placed a burden upon these runs that has become nearly impossible for them to bear and many are no longer able to reproduce themselves. Fish migrating from the Snake and upper Columbia River tributaries have 8 or 9 dams to pass as both downstream migrating juveniles and upstream migrating adults.

The effect of these dams on juveniles is the most severe. The most obvious source of loss is a 10% direct mechanical loss at each dam from turbine passage. This is also the easiest source of mortality to address, and reasonably efficient traveling screens that divert up to 80% of the migrants entering the turbine intake are being installed at Corps' dams. A less conspicuous but equally important source of loss is from the delay in migration associated with the slowing of the river by the large pools behind dams and by the large Canadian storage projects which hold spring snow-melt for later release. Migrants now take an additional month to get to the ocean from the Snake River in average years and much longer in low flow years. Losses associated with this delay are probably higher than any other source of mortality during years of below average flow.

Another important cause of losses associated with dams is predation. The primary predator is the squawfish, and it is particularly effective at dams where fish are delayed both in the forebay immediately above the dam and in the backroll of the turbine boil in the tailrace immediately below the dam. Delay throughout the pools created by the dams results in increased exposure time to the large population of predators found there.

Another important source of loss associated with delay is residualism. Fish have evolved to begin their downstream migration so they arrive at the
ocean when they are physiologically prepared to adjust to living in salt water. Studies have indicated that this period of salt water readiness lasts for an average of three weeks. When extensive delays occur, this timetable cannot be met and migratory behavior may cease. If migrants continue to migrate, many will be unable to adjust to salt water. Others may become residents of the reservoir, hence the term "residualism", and never contribute meaningfully to returning runs of adults although some are harvested in sport fisheries now developing in the large pools such as John Day reservoir.

MINIMUM FLOWS ESSENTIAL

The resource management agencies, through the Columbia River Fisheries Council, have adopted minimum flows necessary to move migrants through the reservoirs so they arrive at the ocean within the time allotted to them — according to their ability to adapt to salt water. In the upper Columbia, these flows are relatively easy to attain because of large storage reservoirs such as Grand Coulee. However, in the Snake system, no comparable storage exists to provide the flushing flows needed to bring migrants down to the Columbia. As a direct result of the lower water velocity, salmonid runs into the Snake River have declined drastically, while similar runs are at least maintaining themselves in the upper Columbia. The fishery agencies have been attempting to get adequate flows for fish by supporting fish protection language in the Regional Power Bill currently being considered in Congress. If adopted, this language would cause the needs of fish to be considered along with those of power and other users of this valuable resource. Presently, flows are being provided by informal agreements with water management agencies that must be negotiated annually.

Adult losses at dams, though less severe than the loss of juveniles, are still a major factor in the decline of upriver stocks. These losses result from direct loss while fighting the strong currents around the dam, and from the loss of migratory behavior associated with the cumulative effect of delays in passage at a number of dams. These delays result from the difficulty in finding the relatively small attraction flows coming from fishway entrances during periods of high runoff. The loss of adults may exceed 20% at some dams, particularly if flows are excessive at passage time.

By now you must be thinking that things are so bad that there is no real hope for the future of upriver runs in the Columbia River. That is very close to the truth. Resource management agencies are conducting an all-out battle to save these runs, but it could well be a case of too little, too late. Logging practices have improved tremendously in recent years with the use of buffer strips along streams; helicopter logging of steep slopes and restrictions on road-building along streams. Grazing allotments have been reduced somewhat on public lands and a few streams have been fenced to protect streamside from livestock abuse. Irrigation diversions have been screened to keep downstream migrants from winding up as fertilizer for the farmer's crops, but water withdrawal continues to diminish the critical summer flows of nursery streams.

The Corps of Engineers has spent millions on bypass systems at mainstem Columbia and Snake river dams and will spend millions more in coming years. Corps-funded research designed to solve fish passage problems is being conducted.
throughout the system, but it was begun about 20 years late. Research on the new technology necessary to solve fish passage problems always seems to lag far behind the construction of dams. The same is true of mitigation. Hatcheries are currently being constructed to compensate for losses caused by Corps-built dams in the Lower Snake River that will return their first fish in the mid-1980s --- 20 years after the dams were built.

Hatcheries are also being constructed to compensate for losses caused by Idaho Power Company's upper Snake River dams and Public Utility District dams in the upper Columbia. So there is reason to be hopeful that these upriver runs can be saved.

The early 1980s will be a transition period for Columbia River salmon and steelhead, and accomplishments during the next five years will be critical to the survival of upriver runs. If improved bypass methods are implemented throughout the main stem Columbia and Snake rivers and adequate flows provided to transport downstream migrants to the ocean, then there is reason to be hopeful that runs can be sustained at survival level until planned hatcheries can be brought into production over the next 10 to 20 years.

When compensation now planned is achieved, there should be enough fish to provide for healthy sport and commercial fisheries in both the ocean and river, while still meeting our treaty commitments to the Indians. Whether we get there from here will depend on the willingness of the public and other water users to allow fish a share of the water that was once theirs alone.
The Columbia River: Protein, Power, Preservation, and Politics

The Nature of the Resource

The Columbia River is an enormous natural resource exposed to many diverse and competing uses. Rising in Columbia Lake on the west slope of the Rocky Mountain range in Canada, it flows for 1214 miles before joining the Pacific Ocean at Astoria, Oregon. Along the way, it drains approximately 39,500 square miles in Canada and another 219,000 square miles in the states of Washington, Oregon, Idaho, Montana, Wyoming, Nevada and Utah. The surface water runoff at the mouth annually averages 256 million acre feet, representing a continuous flow of 350,000 cubic feet per second. The early spring snow melt season contributes approximately 120 million-acre feet to the


3. In terms somewhat more relevant to everyday life, one acre foot equals 1000 liters or 264 gallons. Thus, the average surface water runoff at the mouth equals 67,584,000,000 gallons. This is about 1.16 times the total annual water consumption of approximately 90% of the residents in King County (including Seattle) Washington.

4. TODD, supra note 1, at 119. The Columbia is the 19th largest river in the world. Id. One cubic foot per second equals 1.98 acre feet per day, or 645,184 U.S. gallons per day.
average annual runoff during the April through August period. The active operational storage capacity of the system is 43,565,000 acre feet. In terms of average annual runoff at the river's mouth, existing active storage projects retain less than one-quarter of the annual flood runoff.

The use of average annual or total numbers can be misleading; the Columbia is not a limitless resource. Any quantification of its flow must account for seasonal annual, and local changes from the average. Peak runoff, influenced by snow melt, usually occurs in May or June. Maximum demand for power occurs in December through January. If all the peak runoff ran naturally to the ocean, floods would occur in the late spring, and power generation capability would be lost in the winter. The low water years of 1973-74 and 1977 clearly illustrate that the volume of water changes each year.

COMPETING DEMANDS FOR A LIMITED RESOURCE

Not too long ago our perspective of the Columbia River was of its vast hydroelectric development potential. Dams were developed, and much of our region's power is now being produced by these facilities. Seventy-nine hydroelectric projects, each with capacity of fifteen megawatts or more, have been developed in the Columbia Basin. The installed generating capacity in 1975 was 29,011 megawatts (MW) with less than half again as much under construction. Over 126 billion megawatt hours of hydroelectric power was generated by the dams on the Columbia in 1978; an energy equivalent of about sixty-eight billion


6 Id. at V-13. Compare average runoff of the Missouri River at 27 million acre feet with existing storage capacity of 90 million acre feet; and average runoff of 15 million acre feet with present storage capacity of 60 million acre feet for the Colorado River, and the issue of increased storage on the Columbia is clearly exposed.


8 Natural flow has varied at The Dalles, Oregon, from a peak discharge of 1,240,000 cfs in June, 1948 to a low flow of 12,100 cfs on April 16, 1968. UNITED STATES GEOLOGICAL SURVEY, WATER RESOURCES FOR WASHINGTON 553 (1976).


10 Id.
barrels of oil annually. It is important, however, to realize that the river is not just a power resource. It is used extensively for transportation, flood control, irrigation, recreation, water supply, flow augmentation, fishing, tourism, and habitat for anadromous and resident fish, wildlife, and water fowl. Each of these uses is significant.

The river has been called on to serve a population which has increased from under three million in 1933 to more than seven million today. As the population of the Columbia Basin increases, the demands for river use increase. Projections of future demands reflect presumptions we have made about how the river can and will be used. Just as the numbers used to describe the river are huge, so also are the projected increases in demands. An additional two to four million acres of land are expected to be irrigated twenty years from now. Power forecasts in the next forty years are expected to range from 160 to 320% above the current average loads. With maximum development of the anadromous fish carrying capacity of the system, fish numbers could quadruple by the year 2000. Commercial tonnage passing through the Bonneville lock is estimated to increase from six to almost sixteen million tons by the year 2000. Can the Columbia, as accommodating as it is, satisfy all of these increased demands?

The problems of increasing demand are not necessarily new, unforeseen problems. But as our perspectives change, so do our questions regarding future uses of the Columbia. For example, one of the problems we recognize today concerns the effect hydroelectric development has on the anadromous fish which depend upon the Columbia. Even with the maximum use of our present hydroelectric facilities, increasing power demands will require new thermal power plants. What will be the effect of this expansion? How will storage and release at expanded hydroelectric facilities and consumptive water use in thermal plant cooling cycles affect fish, navigation, and local water quality and availability? Our efforts to augment anadromous fish runs increase with our understanding of the causes for their depletion. Should the anadromous fish be able to depend upon the river because we have decided that they constitute a beneficial use? Should a reservation of minimum water flow in the Columbia River be considered a beneficial use so as to preclude additional diversions or consumptive uses?

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14 Id. at 5-1.
15 Id. at 4-11.
16 United States Army Corps of Engineers, Bonneville Lock and Dam, Oregon, Washington-Columbia River and Tributaries 17 (September, 1978).
Our increasing attention to the effect of dam operations on anadromous fish runs demonstrates that our perspectives of the river's capabilities do change. As another example, consider irrigation. Presently, irrigation accounts for ninety percent of the current water diversion and consumptive use of the Columbia River. What type of return flow rate can be anticipated in various areas of the Columbia River Basin? What is the effect of nonpoint source discharges on the river's water quality as a result of irrigation diversions? How does the demand for irrigation affect power demands and instream flows?

Must the competition between instream flows for anadromous fish, diversions for irrigation and hydroelectric power production be resolved to the absolute detriment of anyone? Can there be a reasonable compromise?

We cannot even say with certainty what water is legally available to us today. Many water rights are unadjudicated: many water rights have been granted but are unused. The quantity of legal claims potentially available to the Indian nations or the Federal Government is undecided.

18. 2 P.N.R.B.C. supra note 13, at 5-3.

19. Norman K. Whittlesey of the Department of Agricultural Economics at Washington State University has estimated that the division of one acre foot of water from the American Falls Reservoir pool in Idaho is equivalent to the loss of 1.82 megawatt hours of electric power from the acre foot passing through the 21 hydroelectric facilities lying between the pool and the mouth of the Columbia. N. Whittlesey, Irrigation Development in the Pacific Northwest: A Mixed Blessing, 10 ENV'T'L L. (1980). The state of Washington has estimated that irrigation development of the lower Snake River area will increase from 30,000 acres in 1970 to about 200,000 acres in the year 2020. Requiring an added diversion of as much as 2000 cubic feet of surface water annually, this irrigation development approximates an average annual loss of about 30 megawatts in hydro generation from the lower Snake and Columbia Rivers. Washington State Department of Ecology, Snake River in Washington-Policy 1-3 (1974). Looking at the entire basin, the Corps of Engineers has estimated that if total basin irrigation is 11 million acres and if instream flows were maintained to maximize fish resources, there would be a loss of about 1.116 megawatts of prime average annual energy from the Columbia, or the equivalent of two Bonneville Dams. These conditions would result in a peaking loss of about 2700 megawatts. Based upon a 15% plant peaking operation, a total of about 1500 megawatts, the energy equivalent of about 22,309,000 barrels of oil, would be lost. U.S.A.C.E. Report, supra note 2, at V-2. This amount of oil is equal to approximately 15 days of oil flow through the Alaska Pipeline.

uncertainties and claims, what residual authority do our states really have over the river? Should uses be limited in light of these uncertainties? Limitation of uses assumes that we accept as a constraint the existence of a minimum base flow in the river and then permit diversions only as it is available above that point. Does this require a no-growth management philosophy for our people and their land use? Is this what we want for our region today and tomorrow? If so, what is the effect upon population, economy and the quality of life in our area? Is this concept consistent with our perspective of the Columbia and its relationship to the maintenance and enhancement of the quality of life in our area? Should more water be made available?

We cannot make new water, but perhaps we can use the water that we have more efficiently. For example, conservation in irrigation will achieve water savings. To minimize the impact of seasonal or annual fluctuation differences due to the natural availability of water, storage capacities could be increased. Outside of our wild and scenic rivers or recreation areas in the Columbia River Basin we have the potential for increased storage of about 26 million acre feet. Are these conservation and storage measures desirable or necessary?

We must do more than simply ask questions; we must seek answers through informed judgments. Choices will become necessary. As the Corps of Engineers reported recently:

With current and expected increases in river uses, it is evident that existing water supply with the present Columbia River system is not adequate to meet all expected consumptive and instream river uses. Any future commitment of the waters of the Columbia water system will involve a cost or tradeoff to some other river use.

The logical result of resource limitation is conflict.

21 P.N.R.B.C. supra note 13, at 6-23.
22 Id. at 6-28 to 6-31.
23 U.S.A.C.E. Report, supra note 2, at V-2. Another result is stated by Wilbur Hallauer, Director, Washington State Department of Ecology, when he described DOE's policy of handling irrigation, power and instream flow needs in a low water year as a policy "to insure a sharing of the shortage during low water years." See Dept. of Ecology Report, supra note 9, at 1.
In summary, conflicts among river uses are already occurring in our increasingly severe and low water years. If demands on the available resource continue to grow as projected, the competition for the existing storage supplies will increase substantially in the next decade. Past flexibilities are fast disappearing. Decisions on the use of existing supplies for hydropower irrigation in supplementing minimum instream flows will involve a definite limit in allocation to one or more of the competing uses.

Is our collective wisdom sufficient and reasonably based so that we can decide what should be done on the Columbia? As the late Justice William O. Douglas claimed for trees, perhaps rivers should have standing.

Conflicts can and do occur whenever two parties desire the same object; but, the conflict resolution is easier when the parties recognize that they share the same objective. What perspective of the river can we all share which will direct us to a common objective? The perspective which I believe we all share is that the Columbia River is a single natural resource with interdependent relationships between the land and the people in the area through which it flows. This perspective suggests a goal for all work on the Columbia River: to maintain and enhance the quality of life for the people, the industry, the animals, the birds and the fish which depend upon or relate to the river. Each of us has a different perspective as to the river's value, worth, advantages, and uses. Our perspectives are fashioned by our individual histories -- particularly, personal, educational, occupational, and recreational. But regardless of our individual perspectives of the river and its uses, there is but one Columbia River.

Let us recognize that we are united by the Columbia. There is a physical reality that should unite us even if our perspectives and our experience do not. The physical unification engendered by the Columbia River's territorial vastness must cause us to accept political interdependence when dealing with the river. Let us accept that what we do in any one locality may

24 U.S.A.C.E. Report supra note 2, at V-16.


26 Conflicts over water allocation and use are not new to mankind. Consider the comments by Sir William Blackstone:

The support of these cattle made the article of water also a very important point. And therefore the book of Genesis (the most venerable monument of antiquity, considered merely with a view of history) will furnish us with frequent instances of violent contentions concerning wills; the exclusive property of which appears to have been established in the first digger or occupant, even in such places where the ground and herbage remained yet in common.

II. W. BLACKSTONE. COMMENTARIES ON THE LAWS OF ENGLAND 5-6 (Christian ed. 1830).
have major short and long-term implications either to the benefit or detriment of other local areas, whether within an individual state or not.

The Pacific Northwest River Basin Commission has given us one view of how functionally and politically we may be united by working together at the technical level. The experience each person associated with the Commission has had must have some beneficial impact, if for no reason other than the interpersonal communication that has resulted. Unfortunately, the Commission’s final report will resolve nothing, since the report only has a force of logic. It neither makes nor establishes a decision for us.

We must give explicit recognition to the limitations of this river resource and the functional interdependence of all users and all states. Without such a specific recognition, the Balkanization of the River will result.

INSTITUTIONAL APPROACHES TO MANAGEMENT AND ALLOCATION

With a limited resource, used by all and uniting all, should we act to resolve anticipated conflicts before crisis occurs? A meritorious argument could be made for forestalling action until a specific dispute arises, leaving its resolution to existing mechanisms, the courts or the Congress. Anticipating the difficult types of questions to be posed about the exclusivity of river control and uses, a retrenchment before a basin-wide institution system of management is seriously considered must be expected. Indeed, it is somewhat presumptuous to assume that we, today, are knowledgeable and wise enough to take an action that will eliminate future conflicts. To take such a position is essentially counter to three characteristics of our pluralistic society: (1) People and governments will continue to have a diversity of interests, demands and objectives; (2) our political system is most responsive to immediate and contingent problems; and (3) the demands upon our river will change as people

27 For example, the state of Idaho benefits from the navigation development downriver even though there is little navigation in the state itself. Montana, whose dominant consumptive use in the Western portion of the state is for irrigation, is a major beneficiary of the downstream navigation in the moving of grain. This inter-dependence of the upstream states with downstream uses raises itself to a possible conflict with Montana's concern over how it can legally secure its future water requirements against loss to downstream states. Downstream, Oregon projects about a 40% increase by the year 2000 in irrigated acreage. What is done upstream to legally secure future water requirements against loss to downstream states can significantly impinge upon the projection of irrigated acreage and of fish runs downstream.


29 Id. at 3.
and perspectives change — long after we have had our say. To fulfill our duty as a trustee of the river for future generations, we need to coordinate our plans and programs today.

Present institutional arrangements affecting the Columbia are numerous and diverse. Each state in the basin has its own body of law governing rights to water. The 1964 Columbia River Treaty between the United States and Canada established an Operating Committee to coordinate the operation of Treaty projects. This treaty provides operational guidelines to insure usability of the Columbia River for downstream generating plants under certain conditions. Between 1853 and 1864, the United States made about fourteen treaties with Indian Nations which assure rights to fish. There is a Columbia River Fish Compact between the States of Oregon and Washington. There is a Pacific Marine Fisheries Commission Compact to promote better utilization and protection of the Pacific Coast fisheries. The Pacific Northwest River Basin Commission, the Pacific Northwest Regional Commission, various federal and state agencies, task forces, and other groups study the river. Federal licensing of hydroelectric facilities and federal/state issuance of discharge permits under the Federal Water Pollution Control Act Amendments of 1972 affect the manner of river use.

Alternatives to this piecemeal method of river management may be few, but several are obvious. First, we can litigate. This may not promote communication or conciliation, nor result in the best and wisest use of our resource for the benefit of all. Second, we can wait for national or project legislation from Congress. This approach may be undesirable because of the

30 See 42 U.S.C. § 4331(b)(1); WASH. REV. CODE ANN. § 43.21c.020(2)(a).
32 Id.
35 See Dept. of Ecology Report, supra note 9, Appendix H and Appendix I.
37 "Where the need to choose between cherished, but conflicting values threatened to disrupt society, the simplest path was decision by a shamon of wizard, who claimed special and miraculous insight." D. Bazelon, Risk and Responsibility, 65 A.B.A.J. 1066 (1979). By litigating, perhaps we would be following the same principle and substituting a judge for the shamon.
states' interest in managing their own resources. 38 Third, we can pursue ad hoc solutions, such as imposing conditions on hydroelectric facilities, restricting or conditioning the issuance of water withdrawal rights, allocating discharge waste loads, or calling conferences with hope that agreement will emanate from a commonality of concern.

Institutional approaches utilized to seek ad hoc solutions have included federal/state interagency committees, ad hoc coordinating committees, and river basin commissions. Interagency committees started in the 1940s and were basically federal bodies. States were represented, but did not necessarily have full representation. No statutory mandate and no centralized direction necessarily existed. The committees worked most effectively when dealing with localized, discrete problems susceptible of treatment by a one-time comprehensive study. Interagency committees seemed institutionally incapable of providing long-range, basinwide planning. Ad hoc coordinating committees developed in the late 1950s and early 1960s. These committees relied principally upon staff and funds from their member agencies; they are thus inherently limited by the institutional perspectives carried in from these agencies. River basin commissions were a creation of Title II of the Water Resource Planning Act. 40 These commissions are required to prepare updated, coordinated, comprehensive joint water resource plans for development of water and related land resources in a basin. The commissions were designed to serve as the coordinating agency for federal, state, interstate, local and governmental plans, and to recommend long-range priority schedules. Decisions, reached by consensus, act as recommendations only, because the commissions possess no implementing authority.

This brief review of institutional models used in water resource planning demonstrates the evolving perception of the need to look at a river basin as a whole -- not as a segmented, independent series of uses or river

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38 Reflecting the concept of local control is an editorial in the Sunday Portland Oregonian, which in discussing the future of the Columbia River gorge, stated:

On the one extreme there would be no change. That is unacceptable. On the other is federal management. That is undesirable. The message is for local, state, regional, federal and private agencies, and groups to get together and place a hand on gorge development, restraining but not halting it, with a goal of protecting this nature's wonderland.

Oregonian, Nov. 25, 1979 at D2, col. 2.

39 Dept of Ecology Report, supra note 9, at 36-37.


stretches. When the progress of these entities is examined in more detail, it becomes apparent that they will exist only so long as they fulfill the functions required properly to manage the water resources in response to constituent desires. Only an institution with capacity to respond to commonly held objectives or widely perceived needs can survive and fulfill its raison d'être. If we perceive a need to carry out far-reaching programs with ambitious goals for the Columbia River, these three institutional models may be temporarily helpful, but will not be successful in the long run, since their decisional responsibilities are asymmetric with their representation and authority.

The interstate compact is an institutional approach inherently distinguishable from the previously discussed entities: the compact has the force of law over its parties. Subsequent state law in conflict with a compact is invalid and unenforceable. The compact can be as extensive or as limited as the party states agree with Congressional ratification. Because of this need for multi-governmental agreement, compacts have been criticized for their inflexibility and for their tendency to realize the lowest common denominator in resolving disputes or setting standards. Compacts need not be so limited however, since they can explicitly provide both generic criteria and representative mechanisms for identifying expectations and resolving present and future disputes.

Today we have a River Basin Commission but no compact for the Columbia River. Why are we planning but not implementing? History suggests that a compact's acceptability for the Columbia River does not rest upon a rational, objective evaluation of its operation, political, and institutional advantages, but rather upon the political and organizational perceptions of how a compact can help or hurt a member entity. If each organization is free to pursue its own institutional interest, it will do so at a minimum sacrifice to itself, with a concomitant disregard of the costs to others. Such an entity can be expected to participate in voluntary associations to the extent it serves the entity's purpose. Even mandated participation in an organization that has no sanction

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44 A memorandum of understanding is currently being pursued for the purpose of establishing working arrangements between the water resources administering agencies to assure full consideration of mutually beneficial and complementary water resource policies in the states of Idaho, Oregon and Washington. It is interesting to note this is being done under the aegis of the Pacific Northwest Regional Commission and only involves those three states in the Columbia Basin.
or control over its members generally fails to mitigate organizational self interest.

ELEMENTS FOR CONFLICT RESOLUTION

The use of the Columbia, when each use is not capable of coexisting with each other use, requires a system of allocation which would preclude systematic limitation of politically or legally weak users. An effective allocation system must account for a diversity of interests and demands because of the pluralistic interests, federal and state, in the Columbia. Such a system must take into account the relationship of demand to supply, varying with seasonal, annual, and local fluctuations where one use impinges upon another. It must be based upon the concerns, perceptions, decisional rules, and mechanisms for change commonly accepted by users of the Columbia.

The choice of an allocating system is a political one, not an economic one, although the two viewpoints obviously interrelate. The problem we share is when and how to establish a system which provides for consensus, and for constraint when consensus fails. If, for example, upriver states fear that entering into a basinwide institution will decrease their authority to provide reasonable returns from Columbia River water to their constituents, they are not likely to become a party to such an institution. No politically responsive entity can afford to improve another entity at its own expense. The political issue, therefore, may depend on whether our elected representatives and their constituents perceive basin-wide institutional control of our river to be better or worse than piecemeal management by independent state and federal authorities.

The federal responsibility is not to manage the states' water resources; but federal agency interests and responsibilities for our river must be recognized. Subject to water rights specifically reserved for the federal

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45 The complex and personal interrelationships affecting personal conflicts are no less applicable to the institutions which people represent. A thoughtful study is available in V. Ostrom, Institutional Arrangements for Water Resource Department. (1971).

46 Under the implied reservation doctrine, sufficient water is reserved from a water body to fulfill the requirements for water by lands withdrawn or reserved from the public domain by the federal government. See Winters v. United States, 207 U.S. 564 (1908) (applied doctrine to an Indian Nation); Arizona v. California, 373 U.S. 546 (1963) (extended doctrine to all federal reserves); Cappaert v. United States, 426 U.S. 128 (1976) (applied doctrine to water necessary to protect aquatic biota in a national monument); United States v. New Mexico, 438 U.S. 696 (1978) (quantified reserved water rights for national forest land). UNITED STATES v. NEW MEXICO, however, limited the reserved water rights on federal lands to the amounts necessary to accomplish the original purposes of the reservations.
government and the Indian Nations, the states must manage their water resources. Cooperative self-determination in our federalist system in the context of the Columbia River means that the federal government is available to assist the states as they request assistance so long as certain federal responsibilities established by the Constitution and Congress are fulfilled.

An institutional system to deal with the Columbia River should build upon what we know and accept. It should provide a generic method of dispute resolution that recognizes the reasonable claims of each party without sacrificing the interests of uninvolved or politically inactive users. A reasonable accommodation must be made between instream and out-of-stream water users, and among users in each category. Recognition should be given to future needs and the reality that present perceptions of reasonable uses will vary. All users should be represented. Nonparticipation or nonresponsiveness should be discouraged. While these ideals suggest the desirability of a compact between the states and the federal government, political realities may prevent the fruition of an interstate compact for the Columbia in this century.
Presented April 24, 1980 by GEORGE D. DYSART, Trial Attorney, Land and Natural Resources Division, United States Department of Justice, Portland, Oregon.*

Indian Fishing on the Columbia River

I appreciate the opportunity to discuss with you this afternoon the subject of Indian fishing rights as they may be relevant to the general theme of this seminar series on "Conflicts Over the Columbia River". I note from your schedule that you already have had speakers on "Fish Management and Protection" and "Legal and Political Decisions in Columbia River Controversies". I have not seen copies of the remarks of the speakers on those topics, and I hope there is not too much duplication between their presentations and mine. I will assume that the biological and habitat characteristics of the Columbia River anadromous fishery resources were covered in Mr. Young's talk and I'm not going to cover that today. Instead, I'm going to concentrate on some of the more recent developments pertaining to Indian fishing rights and the role those rights may play in resolving conflicts over multiple uses of the Columbia River and its waters. I'm going to focus principally on the Columbia River Allocation and Management Agreement for the anadromous fish stocks that go above Bonneville Dam that was approved by the United States District Court in February of 1977, and also on some of the recent litigation concerning the effect of Indian fishing rights on allocation and use of water and alteration of habitat.

I will also discuss some of the ways in which the Indian fishery right may be the vehicle for affording greater legal protection to fisheries protection and improvement for the benefit of all users of the fishery resource.

The two major rivers of the 260,000 square mile Columbia Basin—the Columbia and the Snake—have for many years produced the world's largest runs of chinook salmon and steelhead trout. In-river commercial harvests in 1880, for example, amounted to nearly seven million fish. In recent years, however, it has become increasingly necessary to impose restrictions on the harvest of the salmon and steelhead runs of the Columbia Basin. In 1975, upriver spring chinook fishing was prohibited throughout the entire main-stem Columbia for the first time in history. Steelhead fishing on both the Columbia and Snake Rivers (and their tributaries) was prohibited in both 1975 and 1976. Certain upriver stocks of salmon and steelhead are now being reviewed by the National Marine Fisheries Service and the U.S. Fish and Wildlife Service for possible designation

* The views expressed herein are those of the author and do not necessarily represent the views of the Department of Justice or any other federal agency.
as threatened or endangered species under the Endangered Species Act. If they should be found to be within the "endangered" category, this would have very drastic consequences for all fishermen including the ocean fishery during times when any such stocks are in the areas being fished.

A number of factors have contributed to this startling decline in the abundance of the Basin's anadromous fish runs. They include (1) the construction and operation of hydroelectric dams, which may reduce water quality and quantity and block or impair the up and downstream migration of salmon and steelhead; (2) irrigation, which can impair fish migration and spawning by reducing the amount of water in the streams; (3) logging, which impairs water quality by removing ground cover (and thus increasing water temperature) and increasing the sediment load in streams; and (4) over-fishing, particularly in the ocean.

**INDIAN TREATIES**

Not surprisingly, increasing attention has been directed toward means that may be employed to avoid or reduce the adverse impacts of these factors that have brought the fish runs to such depleted levels. Of particular interest is the possible role that the 19th century treaties reserving to certain Indian tribes of the Columbia Basin the "right of taking fish" could play in the effort to halt the downward spiral and to restore the salmon and steelhead runs nearer to their once-abundant levels.

When the United States opened the Pacific Northwest to settlement, it elected to acquire title to the land of this region through treaty with the Indians, rather than by conquest. Such an approach not only had the effect of avoiding the loss of many lives, but also expedited the settlement of this region by our ancestors. In negotiating the treaties, the Indians insisted that they retain the right to fish not only on the reservations set aside for them, but also at the places where they had fished since time immemorial. The Indian negotiators emphasized to the representatives of the United States that they regarded the "right of taking fish" as essential to their very survival. This right remains of vital importance to the tribes today.

The federal courts of Oregon and Western Washington have interpreted these treaties as reserving to the signatory tribes the opportunity of catching approximately half of the harvestable fish destined for the tribes' usual and accustomed fishing grounds. The Supreme Court of the United States recently affirmed this interpretation of the treaties. The rights vindicated by these decisions, however, lose much of their meaning to the Indians as the number of fish available for harvest declines.

The question that logically arises, then, is whether, in signing the treaties, the Indians reserved not only a right of taking whatever fish may be available at some future time, but also reserved a right to prevent others from acting or failing to act in a manner that jeopardizes the continued abundance of fish.

Of particular interest in the Columbia Basin is whether the treaties reserve to the tribes the right to prevent (a) facilities that constitute
unreasonable obstructions or diversions to fish up or downstream passage, (b) destruction of spawning grounds, (c) pollution of waters, and (d) artificial impairment of streamflows below the quantity and quality needed for the continued availability of salmon and steelhead.

**RECENT COURT DECISIONS**

The likely answer to this question may be found in several recent federal district court decisions and in litigation now pending in the federal district court for Western Washington.

Before discussing the recent litigation, it is necessary to examine the nature of Indian treaty rights. A landmark decision of the United States Supreme Court, *Winters v. United States*, is helpful in this regard.

*Winters* involved a treaty that had set aside an Indian reservation in exchange for the cession of vast areas of land to the Government. The treaty recited that one of its purposes was to help the Indians "become self-supporting, as a pastoral and agricultural people **". The Court held that the treaty impliedly reserved to the Indians the right to enough water to enable them to use the reservation land as they had before the treaty, "whether ** for hunting, or grazing roving herds of stock or turned to agriculture **."  

The Supreme Court adhered to this doctrine in *Arizona v. California*, which involved a dispute among certain states and Indian tribes. In holding that the states could not appropriate water to the detriment of the Indians, the Court observed:

"It is impossible to believe that when Congress created the great Colorado River Indian Reservation and when the Executive Department of this Nation created the other reservations they were unaware that most of the lands were of the desert kind -- hot, scorching sands -- and that water from the river would be essential to the life of the Indian people and to the animals they hunted and the crops they raised."

Two recent federal district court decisions have interpreted the *Winters* doctrine as reserving to Indian tribes specific quantities of water for fish and game needs. *United States v. Anderson*, decided July 23, 1979, involved the Spokane Indian Reservation in Eastern Washington. The Spokane Indians had relied on the fishery resources of a stream running through the reservation for their subsistence since time immemorial, and the court accordingly held that, in agreeing to accept this reservation, the tribe reserved the right to sufficient water to preserve fishing in the stream.

The court determined that the amount of water needed to effectuate the reserved fishing right was related to both water quantity and water quality. The evidence revealed that the fish could not survive at stream temperatures in excess of 68 degrees and that a streamflow of at least 20 cubic feet per second was required to maintain that temperature. Accordingly, the court held that the tribe had a reserved right to sufficient water to maintain the water temperature at 68 degrees or less and to a minimum streamflow of 20 cfs.
priority date for this reservation of water was either "time immemorial or the
date of the creation of the Spokane Indian Reservation." The court did not
need to decide which since under either date the tribe's right was superior to
the non-Indian claims.

In United States v. Adair, the United States District Court for
Oregon found that one of the purposes for creating the Klamath Indian Reservation
was to protect the Indians' right to pursue their traditional culture and means
of livelihood (hunting and fishing) while encouraging them to develop agricul-
ture. The 15,000 acre Klamath Marsh -- part of the original reservation -- had
historically supported large numbers of migratory birds and other wildlife. As
withdrawals of water from the river system running through the reservation in-
creased, however, the marsh began to dry up. Only ten percent of the marsh is
open water today, compared with fifty percent 75 years ago. This decline in
the amount of open water drastically reduced the marsh's capacity to support
wildlife.

This decline in the amount of water reaching the hunting and fishing
areas of the Klamath Tribe impaired the hunting and fishing rights secured to
the tribe by the treaty that created the reservation. The tribe and the United
States, therefore, brought suit against the private property owners who were
withdrawing water from the river system in order to obtain a declaration as to
the amount of water, if any, to which the tribe was entitled. The court held
that, when the Government reserved land from the public domain and created the
Klamath Reservation to preserve Indian hunting, fishing, and gathering rights
and to encourage agriculture, it impliedly granted the tribe the right to as
much water on the reservation as was needed for those purposes. "If the
preservation of these rights requires that the Marsh be maintained as wetlands
and that the forest be maintained on a sustained-yield basis," the court
observed, "then the Indians are entitled to whatever water is necessary to
achieve those results." The court fixed the priority date for the water rights
necessary to preserve hunting, fishing, trapping, and gathering rights as "time
immemorial" since these were reserved rights. The priority date for water
needed for irrigation and domestic purposes was 1864, the date of the creation
of the reservation.

Interestingly, the court reached this holding even though the Klamath
Tribe no longer owns so much as one acre of the reservation. The court pre-
viously had held that the Klamath Termination Act which authorized disposal of
the reservation land did not abrogate the tribe's fishing and hunting rights on
the lands of the former reservation. "Without sufficient water to preserve fish
and wildlife on the reservation lands," the court remarked, "Indian hunting and
fishing rights would be worthless."

**COLUMBIA BASIN TRIBES**

Unlike the agreement and treaty involved in Anderson and Adair, the
treaties to which certain Columbia Basin tribes are parties reserved not only
on-reservation fishing rights, but off-reservation fishing rights as well.
These rights extend to all areas where the tribal members usually and customarily
fished prior to and during the time the treaties were made. The courts have
long held that these rights were pre-existing rights which the tribes reserved rather than rights which the United States initially granted in the treaties. It is, therefore, quite possible that these principles of the Anderson and Adair decisions might be applied to requiring the maintenance of water flows and other conditions necessary to fish runs that are the subject of the Indians' off-reservation fishing rights as well as their on-reservation fisheries. This is precisely the theory that the United States and the tribes who are parties to United States v. Washington (the "Boldt" decision) are advancing in what is known as "Phase II" of that litigation.

The United States and the tribes argue there that (1) the treaty fishing right presupposes a measure of environmental protection for the salmon and steelhead runs; (2) the treaties must be construed to effect the purposes for which they were signed; (3) constitutional limitations on state authority forbid the destruction of the subject matter of a federal treaty right (which, under the Constitution, is the "Supreme Law of the Land"); and (4) the state's conservation authority carries with it a conservation duty.

The State of Washington contends that the treaty secures to the tribes, only a right to be allowed to take a share of the fish that are in fact available from time to time and not an interest in the resource itself. The state also asserts that, even if it be assumed that the treaties mandate protection of the resource, the state is not responsible for enforcing that right against other persons whose actions have harmed the resource -- even if those persons act under state license or permit. Persons conducting logging operations, polluters, and water users in general, the state argues, must observe any restraints imposed upon them by the treaties, and the state is not liable for any violation of the treaty right by such persons.

The federal court decisions interpreting the treaties as mandating an allocation of the fish between Indians and non-Indians have, of course, been criticized by nontreaty fishermen, and the criticism may well continue. But, as competition between power, agriculture, navigation, and fisheries interests for the valuable water resources of the Basin grows more intense -- and it is certain that in the coming decades it will drastically intensify -- the Indian treaties may well provide the only insurance that our valuable salmon and steelhead runs will be maintained.

These treaties have, in fact, already contributed to the viability of the migratory fish of the Columbia Basin.

For example, several of the Basin's Indian tribes (which include the Yakima, Umatilla, Warm Springs, Nez Perce, and Shoshone-Bannoc Tribes) have been active participants in proceedings before the Federal Energy Regulatory Commission, which has regulatory authority over the operation of five federally licensed dams on the mid-Columbia and three on the middle Snake River. Armed with a federally protected "right of taking fish," these tribes have undeniably strengthened the hand of other fishery interests -- including the state and federal fisheries agencies -- in obtaining beneficial changes in the operations of those dams. The tribes have also been active in proceedings being conducted by the Washington Department of Ecology with respect to allocations of Columbia River water for maintenance of minimum in-stream flows and for future off-stream appropriation for non-fishery purposes.
In 1977 the Washington Department of Ecology developed a proposed water resources management program for the John Day and McNary pools of the Columbia River. Its November 1977 review draft of that proposed program stated:

"The primary goal of the [program] is to insure that the waters of the Columbia River are utilized for the greatest benefit to the people of the State of Washington."

"This management policy will not affect existing water rights, including valid vested water rights. Table 1 tabulates existing recorded water rights."

It is significant that Table 1 does not include any vested water rights for fish passage or habitat. In fact, the Department's December 1977 draft environmental impact statement on the project stated:

"In-stream uses of Columbia River water for such purposes as hydropower generation, navigation, fish and wildlife production, and recreation are established uses, but these uses are not generally recorded as water rights with the Department of Ecology. Out-of-stream uses, including domestic and stock watering, irrigation, municipal, industrial, and thermal power use are established and future uses that are or will be recorded with the Department as water rights."

The draft EIS further reported that attendees of a workshop sponsored by the Department listed existing uses as highest priority; out-of-stream uses next; navigation, industrial, and thermal-power medium priority; and in-stream flows beneficial to fish, wildlife and recreation and hydropower were of low priority. From this the Department determined that for future development irrigation and municipal use are highest priority consumptive water uses in this reach of the Columbia River.

This view should be contrasted with that taken by the courts in the Anderson and Adair cases discussed earlier where the court recognized as a valid established use-right water needed by Indians for fish and wildlife maintenance. The Department of Ecology's November 1977 review draft stated:

"Recognizing the value of the Columbia River commercial, Indian and sport fishery, the State of Washington strongly recommends that the hydro-electric power system should be operated to provide for the in-stream flow needs of anadromous fish, resident fish and wildlife, and other in-stream values including recreation." (Emphasis added.)

In other words, use of water for electricpower generation should be subordinated to in-stream flow needs or fish but use of that water for out-of-channel diversion to irrigation and other consumptive uses should apparently take priority over minimum in-stream flow maintenance. In a March 1978 report on a proposed Columbia/Snake System planning program, the Department of Ecology listed as one of the constraints for such a program, "Existing water rights constrain future management options because they are a property right and thus cannot be taken or condemned without compensation." Another constraint listed in that report was:
"Claims for water rights related to fish and Indian fishing are not resolved. Allocations of water necessary to support Indian treaty fishing rights have not been interpreted for the Columbia system, although recent decisions have established that Indians have rights to a considerable proportion of the fish. Cases are pending in western Washington to determine the role of Indians in regulating activities affecting the fisheries."

On March 16, 1978, the Columbia River Inter-Tribal Fish Commission called for an across-the-board moratorium on any further Columbia River water withdrawals until a basin-wide multiple-use plan could be developed.

A March 1979 draft environmental impact statement of the Department of Ecology dealing with the Columbia River in-stream resource protection program contained several pages discussing treaties with Pacific Northwest Indian tribes and court decisions interpreting and enforcing those treaties.

RIVER BASIN DEVELOPMENT ACTIVITIES

There are also some recent federal court decisions which deal with the Indian treaty fishing right as it applies to other river basin development activities. In Confederated Tribes v. Callaway, Civil No. 72-211, District of Oregon, August 17, 1973, the U.S. District Court for the District of Oregon held that the operation of federal hydro-electric projects on the Columbia River for generation of "peak time" electric power does not permit the Bonneville Power Administration or the Corps of Engineers "to impair or destroy any fishing rights of (the tribes) secured by treaty with the Indians." The main thrust of that opinion was to acknowledge that the operations of the Columbia River Power System do have an impact on Columbia River fisheries and Indian treaty fisheries in particular and that the Government, as the operator of that system, may have some obligation to either mitigate such adverse effects on the treaty fishery or possibly make compensation for such effects. The judgment in that case required the Government to give certain notice to the plaintiff Indian tribe of any change in the operating limits for the Bonneville, The Dalles or John Day Pools and to provide periodic status reports for five years on all of the defendant's Columbia River and tributaries fishery research and studies.

That decision served as one of the bases for a 1976 Interior Department legal opinion which held that the Bonneville Power Administration had authority to participate in funding of a program to help restore the Columbia River anadromous fishery. That opinion concluded that an integral aspect of any electric utility's responsibility in this age of public concern for the environment is to find means and undertake or contribute to measures to minimize adverse effects of its operations on other significant aspects of the environment. For projects on the Columbia River system, this means that major attention must be given to anadromous fisheries protection.

"Meeting increased power needs without providing for such protection is no longer acceptable in the Columbia Basin.

"* * *"
"The federal courts have held that the Indian tribes * * * have vested fishing rights on the Columbia River System which the United States is obligated to respect and protect. Power operations of the federal Columbia River power system have an effect on those rights and certain contemplated power operations might be subject to curtailment if reasonable and appropriate restorative measures for fisheries are not undertaken." (Decision M-36885, 83 I.D. 589.)

Another case in which Indian treaty rights were used to challenge a Corps of Engineers river project was Confederated Tribes of the Umatilla Indian Reservation v. Callaway, Civil No. 74-991, District of Oregon, February 15, 1976. In this case the Umatilla Tribe challenged the congressionally authorized Catherine Creek Dam which the Corps of Engineers was planning to build in northeastern Oregon. The tribe contended that the project would impair its treaty fishing and hunting rights by flooding out certain usual and accustomed fishing places and by blocking access of steelhead to other places located upstream from the dam. It also contended that the project would impair its hunting rights on unclaimed lands outside the reservation by lessening the quality of the wildlife in the national forests around the project.

On the latter point the court held that the right "does not impose upon the United States the duty to keep the population of the various animals up to a certain level just to satisfy the terms of the treaty. The Indians knew that the land would be settled and changed and that this would affect their hunting." As to the fishing claims, however, the court, in a subsequent decision of November 10, 1977, (by which time the case had been redesignated as Confederated Tribes of the Umatilla Indian Reservation v. Alexander), found that the dam's two and a half mile reservoir would flood a number of the tribe's pre-treaty fishing holes located on Catherine Creek and consequently the "treaty rights in them will be destroyed by the project." It also held that the dam would prevent all wild fish from swimming upstream. Chinook were to be trapped and hauled above the dam but the steelhead run would be eliminated entirely at all stations upstream from the dam. "Whatever the merits of the Government's mitigation program, the treaty right to fish at all usual and accustomed stations will be destroyed as to those stations within the reservoir."

The need to give greater concern to the effect of water resource development projects on fish and wildlife resources was recognized a number of years ago by the United States Supreme Court. In Udall v. FPC, 387 U.S. 428, 437 (1967), the Court said:

"The importance of salmon and steelhead in our outdoor life as well as in commerce (footnote omitted) is so great that there certainly comes a time when their destruction might necessitate a halt in so-called 'improvement' or 'development' of waterways."

In the major fishing case on the Columbia River, United States v. Oregon and Washington, which the United States brought on behalf of the Yakima, Warm Springs, Umatilla, and Nez Perce Indian Tribes, the court, in 1977, approved a Five-Year Plan for Managing Fisheries on Stocks Originating from the Columbia River and its Tributaries Above Bonneville Dam. This Plan had been negotiated by the tribes and the States of Washington and Oregon with the United States also a signatory to the plan. It was designed to settle the
recurring problem of proper allocation of the fish run between the treaty and nontreaty fisheries. In that plan the Indians accepted a somewhat lower percentage of fish than the district court had tentatively held they were entitled to and than the percentage subsequently affirmed by the United States Supreme Court as the Indian entitlement. Part of the consideration for settlement on the allocations proposed in the plan was the agreement of the parties that the tribes and state and federal agencies were obligated to "diligently pursue and promote through cooperative efforts the upriver maintenance and enhancement of fish habitat and hatchery rearing programs, and so far as practicable, maintain present production of each run and rehabilitate runs to their maximum potential." The parties also pledged "to work cooperatively to maintain the present production of each run, rehabilitate runs to their maximum potential, and to work toward the enhancement and development of larger and additional runs where biologically and economically feasible." A technical advisory committee consisting of qualified fishery scientists representing each of the states of Washington, Oregon, and Idaho, each of the four treaty tribes which were parties to the lawsuit, and the National Marine Fisheries Service and the U.S. Fish and Wildlife Service was established to develop and analyze data pertinent to those subjects and to make recommendations to the managing fishery agencies to assure that the allocations would be realized.

Indian tribes are also intervening in administrative agency proceedings associated with the authorization of water or river development projects. They have intervened in proceedings of the Federal Energy Regulatory Commission to establish minimum stream flow requirements and other fisheries protective measures or facilities. They have appeared in proceedings on applications for permits for dredging, for construction of dolphins or piling structures, for waste discharge permits, and for water diversions, to name but a few. In short, the Indians' fishing right may become a factor in the consideration and authorization of all sorts of river-related activity that could affect fish.

**BURDEN ON THE COURTS**

I'd like to close these remarks with a note of caution about seeking to place too much of the burden of fishery management on the courts rather than to have fishery management functions performed by administrative agencies in a manner that recognizes the obligations of those agencies to all interests including the legally secured Indian treaty interest. The judicial branch of our government was not established to develop legislative policy or to perform a task of executing and administering the laws. Frequently, however, they have had to be called into the picture, usually because the agencies which are charged with the administration of legislative policy have not properly performed their function and in so doing have transgressed legal rights which the courts are called upon to protect. But the courts have neither the expertise nor the tools, including the power of the purse, to adequately perform a fisheries management role and they are often the first to recognize that fact.

Let me quote to you two statements from Chief Judge James M. Burns of the United States District Court for the District of Oregon that illustrate what I'm talking about. This first statement was contained in his concurring opinion when he sat on the United States Court of Appeals panel that affirmed

"As was suggested at oral argument, any decision by us to affirm also involves ratification of the role of the district judge as a 'perpetual fishmaster'. Although I recognize that district judges cannot escape their constitutional responsibilities, however unusual and continuing duties imposed upon them, I deplore situations that make it necessary for us to become enduring managers of the fisheries, forests, and highways, to say nothing of school districts, police departments, and so on. The record in this case, and the history set forth in the Puyallup and Antoine cases, among others, make it crystal clear that it has been recalcitrance of Washington State officials (and their vocal non-Indian commercial and sports fishing allies) which produced the denial of Indian rights requiring intervention by the district court. This responsibility should neither escape notice nor be forgotten."

A little over a year later, in 1976, Judge Burns, in a case involving the O&C grant lands in the State of Oregon, made the following observation:

"This case is symptomatic of the increasing number of instances in recent years in which the courts, particularly the federal courts, have been called upon to solve problems, as opposed to merely resolving conventional legal disputes.

"There is an increasing tendency for the other branches of government to so outrage one or more citizens that resort is had to the federal courts. Frequently, when federal courts do step in and discover, occasionally to their delight but more often to their horror, that they indeed have jurisdiction, the immediate beneficiaries stand on the sidelines and cheer.

"But their victory may well be short and Pyrrhic; it must never be forgotten that ours is a limited branch of government with a limited charter from the American people. If federal courts exceed the bounds of that charter and fashion remedies to problems which belong in other branches, the support and understanding of the American people which we have enjoyed and upon which we depend, slowly, and probably irrevocably, will erode. I suggest we all will be the losers.

"We have neither the purse nor the sword; neither the time nor the skills nor the staff; we have none of the bases of intimate contact with, nor responsiveness to, the populace to justify seeking out many of the jobs which we are called upon to do."

And still more recently, in June of 1979, the Ninth Circuit Court of Appeals had the following to say in an Indian fishing case, United States v. Montana:
"We must recognize that in this case, as in others in which we are required to fix the rights and powers of Indians in the latter part of the twentieth century in the light of treaties of an earlier century, our task is to keep faith with the Indian while effectively acknowledging that Indians and non-Indians alike are members of one Nation. Both seek power and gain through identical processes, viz., commerce, politics, and litigation. We must, however, live together, a process not enhanced by unbending insistence on supposed legal rights which if found to exist may well yield tainted gains helpful to neither Indians nor non-Indians.

"* * *

"Our holdings reflect a degree of precision not always present in the sources on which we must rely. We recognize this. Our justification is that the problems this case presents are serious and require resolutions whose outlines are reasonably sharp and clear. While the judiciary is frequently not the institution of government best suited to frame such resolutions, its ability to intervene upon being invoked by the plaintiff in a lawsuit enables it to provide provisional relief when it is perceived that legislative or executive solutions are unlikely to be offered within the reasonably foreseeable future."
Agriculture and Hydro-Power: Costs, Benefits, and Trade-Offs

Occupying a singular niche in the development of the Pacific Northwest, the Columbia River has provided a seemingly endless bounty of resources for multiple and diverse uses: agriculture, recreation, fishing, navigation, hydroelectric power generation, and others. As time has passed the multiple demands upon the river system have increased, and today these demands very nearly exhaust the capacity of the river's resources. The Army Corps of Engineers and Bonneville Power Administration warn that, within four or five years, water supplies system-wide will be fully utilized. Put differently, quite soon any increase in any one type of Columbia River resource use will likely be at the expense of a competing use. Tradeoffs will have to be seriously considered, and decisions will be made on the basis of the acceptability of those tradeoffs. One clear tradeoff will involve the benefits resulting from increases in irrigated agriculture in contrast with the opportunities foregone because of outstream diversion of system waters.

Presented here is a summary of the benefits, costs, and hydropower tradeoffs associated with possible future irrigation development in Oregon's Columbia River Basin. While the geographic area that has been selected for analysis serves, primarily, expository purposes, any empirical analysis of costs, benefits, and tradeoffs requires a comparable degree of specificity. This is because the impacts associated with water and other natural resource developments are dependent on the location, timing, and duration of those developments.

COSTS AND BENEFITS OF IRRIGATION DEVELOPMENT

Although the actual values of irrigation benefits, costs, and tradeoffs vary from case-to-case, the general approach to project evaluation is transferrable. The general approach, elaborated more fully elsewhere [2], is to appropriately identify, and using relevant procedures to accurately measure, water development project impacts.

Both identification and measurement are facilitated by commonalities among the various impact variables. Benefits and costs are conceptually quite similar, since the former relate to the "realized" and the latter the "foregone" values of those products or services which result from the development project.
When "tradeoffs" can be valued in the economic sense, they too can become part of the cost-benefit calculus. Such is the case with hydropower foregone as a consequence of irrigation gained.

Primary (direct), secondary (indirect), and public benefits and costs can be the consequence of irrigation development (7). Primary benefits and costs usually are estimated from the irrigators' production costs and/or returns, using farm budgets as the basic information service. Net primary benefits occur when net farm income (returns minus costs) increases because of the effects of irrigation on productivity, and/or when the value of farmers' perquisites (e.g., rental value of housing) increases.

Secondary or indirect costs and benefits are experienced off-farm but in the local area, as local suppliers of agricultural goods and services are "induced" to sell more to a developing irrigated agriculture; and as local processors and others increase their own economic activity "stemming from" the expansion in irrigated agriculture. Secondary benefits usually are relevant only for projects financed in part or wholly from local or state funds. In the purely national context, the assumptions used in project evaluation state that the economic system within which water development occurs is in equilibrium, and that the conditions of that equilibrium are such that no secondary benefits are possible. At the state and local levels, these assumptions generally are violated; and secondary benefits are, in fact, observed. Measurement of secondary benefits at the local level often is done using small area input-output models developed from primary inter-industrial transactions data.

Public benefits and costs also may be felt locally, although linking them to a specific water development project is difficult at best. For example, public benefits are said to result when, because of a resource development project, local communities find tax revenues sufficient to offer social service programs that could not be offered before. Or, public benefits are generated when a project contributes to long-term soil erosion control. For each such public benefit there may, however, be a countervailing public cost (increased tax rates or diminished reservoir storage capacity, for example).

Due to the difficulties in weighing public benefits and costs, both often are overlooked in project evaluation with the caveat that their effects "balance out". This simplifying approach has merit, especially when the impacts in question relate to the induced effects of water development projects on local supplies of and demands for public services.

The simplification has far less merit when water development generates a public cost that, while not born locally, adversely affects society as a whole. In the case of future irrigation development using water drawn from the Columbia River, an adverse effect on hydroelectric power generation is, in fact, anticipated. At issue to society is the cost of replacing the foregone hydroelectric power opportunity versus the benefits of new irrigation development in Oregon's Columbia River Basin. The actual value of that tradeoff is determined by the location, timing, and duration of future water development in the Columbia River region.
IRRIGATION DEVELOPMENT IN OREGON'S COLUMBIA BASIN

A historical perspective of agriculture in Oregon's Northern Columbia River Basin provides a useful background for evaluating the benefits and costs of future irrigation developments in the area. The 500,000 acre basin is bounded on the north by the Columbia River and extends through northeastern Gilliam, northern Morrow, and northwestern Umatilla Counties (Figure 1). Much of it receives less than eight inches of precipitation annually. Prior to 1965, the sands and sandy loam soils supported, at best, some dryland wheat production and some winter grazing of domestic livestock. In certain areas no form of production agriculture existed. Irrigation of some 50,000 acres was primarily from canals, using diverted flows of the Umatilla River, or lesser surface water and groundwater sources.

Between 1965 and 1976, sprinkler irrigation systems drawing water first from shallow wells, then deeper wells, and finally from the Columbia River itself, allowed 136,000 acres of relatively nonproductive basin lands to become agriculturally quite productive. By 1976, agricultural revenues in the three counties had increased four-fold relative to 1965, bringing a total of 145.8 million dollars into the Columbia River Basin economy. The three leading sources of agricultural revenues were potatoes, irrigated wheat, and alfalfa. During the same time period, population in the area increased by 20 percent.

The present agricultural base requires four times the water needs of a decade ago. As a result, certain shallow and deeper aquifers in the Columbia Basin area are being depleted. Barring the development of large surface impoundments, the Columbia River is viewed as the only significant source for additional irrigation water in the future. Unless the Columbia River is tapped, the present agricultural base may not be maintained, and future growth in irrigated acreage almost certainly will be precluded.

Tradeoffs are involved in sustaining present and future levels of productivity in Columbia Basin irrigated agriculture. With the exception of return flows, water used to irrigate crops cannot be used to produce energy, to support salmon runs, or for navigation. Are such tradeoffs acceptable? Do the net primary and secondary benefits exceed the opportunity costs of future irrigation development?

NET BENEFITS OF FUTURE IRRIGATION DEVELOPMENT IN OREGON'S COLUMBIA BASIN

Existing information suggests that, with current technology and prices, irrigation of an additional 195,000 acres in the Columbia Basin area may be feasible (Figure 2). Over 100,000 acres are sandy soils less than 500 feet in elevation above the McNary and John Day pools on the Columbia River; while the remaining irrigable lands are higher elevation loams (3). Assuming that local farmers are profit-maximizers using agronomically sound cultural practices, an expected cropping pattern for these potentially irrigable acres can be projected, along with a consistent set of input costs and product prices (4). From these price, cost, crop, and acreage projections, the net primary benefits of future irrigation development can be derived.
Figure 1. Oregon's Northern Columbia River Basin.
In the absence of future irrigation development, annual net returns averaging $3.50/acre can be expected to accrue to farmers growing summer fallow dryland wheat on 85,500 of the potentially irrigable acres (6, p. 19). The remaining 109,000 acres of low sands would remain nonproductive without supplemental water. For the area as a whole, the "without irrigation" condition would result in an annual primary benefit of about $300,000, or $1.54/acre.

With irrigation, 42-45 percent of the irrigable acres would be planted to wheat, a similar proportion to late potatoes, and 10-15 percent would be used for alfalfa production. Gross returns would average $706/acre, while production costs excluding interest on land investment, off-farm water delivery costs, and energy costs would be $484/acre. Correcting for primary benefits in the "without irrigation" condition, future "with irrigation" primary benefits might be as much as $43 million per year, or about $220/acre-year.

Actual primary benefits would average less than $220 because of water and energy charges. Drawing on a feasibility study for a proposed irrigation project in the central portion of the Oregon Columbia Basin area (the Stanfield-Westland Project), additional water and energy costs could amount to $118-183/acre-year (8). Correcting for the somewhat higher energy pumping costs that would be associated with a 195,000 acre project, these additional charges could total $185 per acre per year (6, p. 3b). Hence, net primary benefits due to new irrigation could be $32 ($220-$188) per acre on an annual basis, or over six million dollars annually for the "with irrigation" project area as a whole. This estimate of primary benefit is quite conservative since both management services and water are treated as production costs; and hence neither labor nor water is viewed as a residual claimant to farm income.

In a similarly conservative fashion, the net secondary benefits of irrigation development may be measured only as the return to labor (household income) induced by increases in the value of agricultural production. With irrigation, annual sales of crop products would be expected to increase from 110 to 244 million dollars, or by $134,000,000. Using a recent input-output model developed for a neighboring county (Union), the increase in local non-agricultural household income induced by the increase in value of agricultural sales is over 46 million dollars per year (5). This is equivalent to $237 per acre-year.

The net social benefits accruing to people living in the three county area would equal the sum of the net primary and secondary benefits. Drawing from the preceding discussion, the net benefits attributable to future irrigation development in Oregon's Columbia River Basin region should be expected to equal or exceed $52,000,000 or $270 per acre per year. A substantial proportion of this net benefit (over 80 percent) would be captured by local residents who are not farmers, but instead enjoy the secondary benefits induced by future irrigation.

Hydropower Tradeoffs

The benefit-cost calculus appearing above ignores the opportunity cost of diversion of Columbia River system waters -- especially the value of the lost hydroelectric generating capacity. Assuming an annual diversion requirement of about 3.8 acre-feet of water per irrigated acre, no return flow,
Figure 2. Oregon Columbia River Basin Areas with Potential for Future Irrigation Development.
and no spillover in any month during which waters are withdrawn, a loss of 945 kilowatt-hours of energy per acre per year is implied (6, p. 32). In addition, the newly-irrigated acres would require 3,361 kilowatt-hours per acre per year in pumping energy.

The "opportunity cost" of irrigation using waters withdrawn from the Columbia River is equal to the least-costly way of replacing the foregone electricity. How should this energy be valued? Recall that the 945 kilowatt-hours per acre in lost electricity assumes no spillover and no return flow. To further compound conservatism, it may be assumed that nuclear energy is the "least costly" alternative to hydroelectric power, and that the nuclear power costs 40 mills per kilowatt-hour to produce. The basic calculus results in an opportunity cost, measured on terms of replacing electricity power foregone, of $37.80 per acre.

The 3,361 kilowatt-hours per acre in pumping energy requirements may be expected to contribute, albeit slightly, to increasing demands for electricity in the Pacific Northwest. The impact on electricity consumption would be manifest in higher energy costs. The increase in energy costs, internalized with respect to Columbia Basin area irrigators, would be from 0.675 cents per kilowatt-hour in 1980 to 1.220 cents per kilowatt-hour in the year 2000 (6, p. 34). These internalized increases in energy pumping costs are contained in the net social benefit calculations reported above, and thus need be considered no further in the tradeoff analysis.

The "opportunity cost" of future irrigation in the Oregon Columbia River Basin area can be viewed as a public cost, although it is a cost borne by people throughout the Northwest rather than only by those living in the basin region. Viewed purely from an efficiency standpoint, the tradeoff is worthwhile. Columbia River water has a higher value in irrigation than in hydroelectric power generation. From an equity perspective the verdict is less clear, since the local beneficiaries of increased irrigation would not bear the public costs of replacing foregone electricity. However, remember that the net social benefit enjoyed locally is $270 per acre-year, while the replacement cost for foregone electricity is $37.80 per acre-year. Local beneficiaries could compensate nonlocal users of electricity by paying to replace that lost energy, and those local residents still would be better off ($270.00 - $37.80 = $232.20) than before the irrigation development (1). If such compensation did in fact occur, the tradeoff would be not only warranted on efficiency grounds, but fair and generally acceptable as well.

REFERENCES


INTRODUCTION

I'd like to express my appreciation for having been invited to discuss the water quality of the Columbia River. It's good to be back on campus again to see the many changes that have occurred in recent years.

To put your minds at ease, I'll start out by informing you that the Columbia River is "alive and relatively well." But the Columbia River is not a pristine stream. Indeed, it never was; and it has experienced some water quality problems over the years which have limited the use of those waters for various purposes. I'd like to discuss some of those problems today, both in terms of the causes of the problems and their solutions. Also, I'd like to discuss the future of Columbia River water quality and express some of the concerns that we in the environmental community have.

In order to appreciate the Columbia River water quality problems, it's important to understand some of the history of State and Federal water quality management efforts over the past 20 - 25 years. It's also important to appreciate the relationship of water quality and water quantity and to recognize water resource development activities in the Columbia River system which have occurred over the past several decades.

HISTORY OF WATER QUALITY PROBLEMS

The primary influences on water quality of the Columbia River have been land and water resource development in the basin, including major development of irrigated agriculture and the construction and operation of numerous multi-purpose and hydro-electric power dams. Secondly, and more localized in nature, has been significant industrial development particularly in the pulp and paper industry, the aluminum refining industry, and the nuclear industry on the Hanford Nuclear Reservation. The changes in the Columbia River water quality due to these influences have been relatively subtle and long-term in nature, however, mainly because the flow of the river is quite large.
The first significant water quality problems began occurring in the 1940's and 1950's in conjunction with land and water resource development activities. Construction of new dams and irrigated agricultural development began a slow rise in the overall temperature regimen of the river. Industrial development and municipal growth resulted in localized bacteriological problems which jeopardized some recreational uses of the river.

Perhaps the first major water quality problem which directly impacted river users was the development of slimes associated with the sheath bacterium Sphaerotilus. These slime growths developed in colonies around wood fibers and other biological mass in the presence of nutrients from wood pulp and municipal wastes and flourished periodically in the 1950's and 1960's. The problem at times became severe when the slimes coated the nets and lines of commercial and sport fishermen. As a result of State and Federal enforcement actions against the pulp and paper industry in the mid-1960's, and increased levels of municipal waste treatment, the problem was eventually solved around 1970.

About the same time, in 1967, the Federal Water Pollution Control Act was amended to require adoption of water quality standards. These standards were to include identification of the beneficial uses to be protected, water quality criteria to support these uses, and implementation plans to be carried out by the States to achieve the specified water quality criteria. The implementation plans eventually resulted in additional municipal and industrial waste treatment facilities designed to achieve the beneficial uses and water quality criteria spelled out in the water quality standards.

Also, in the 1960's, portions of the Columbia River suffered from unsafe bacteriological levels due primarily to discharge of untreated municipal and industrial wastes. With installation of new waste treatment and disinfection systems, the problems were abated to some degree. But the lower portions of the river remain marginal even today. Recent controls over non-point sources of pollution are helping to resolve some of these bacteriological problems.

POLLUTION ACT AMENDED AGAIN

In 1972, the Federal Water Pollution Control Act was amended again to require waste discharge permits and major increases in funding for construction of municipal waste treatment systems were provided. As a result, most municipal and industrial waste discharges now have been brought under control, at least in terms of the conventional pollutants. Discharges of toxic pollutants, however, may still be a problem, and much new attention is being directed toward control of these pollutants.

About 1970, another major water quality problem in the Columbia River became apparent. That problem was known as "dissolved gas supersaturation," and had a major impact on the fishery resources of the Columbia system. Supersaturated dissolved gas levels developed as a result of large quantities of water spilling over the many dams of the Columbia system during period of high streamflow into stilling basins and then failing to reach equilibrium as the water passed through downstream reservoirs before reaching the next spillway. Columbia River fish, particularly the salmonid species, were subjected to the "gas bubble disease" through physiological processes similar to those experienced by divers.
when suffering the "bends." The result was major mortalities (sometimes as high as 80 - 90% in downstream migrants) in migrating salmon. The problem fortunately was lessened in the 1970's through installation of "flip lip deflectors" on many spillways along the Columbia system. In addition, installation of increased hydro-electric generating capacity at several major dams in the system served to lessen the dissolved gas problem -- although downstream migrants are subject to increased turbine mortalities unless turbine screening and other mitigating measures are employed successfully.

Perhaps the most pervasive water quality problem in the Columbia River is elevated temperature levels. Temperatures in many Columbia River reaches are far above optimum and approaching lethal levels for salmonid fish at certain times. Upstream migrants are heavily stressed, and downstream migrants are being subjected to increased disease and predation as a result of these high temperatures. The causes of the temperature problem are many. First of all, the construction of numerous dams and their associated operation have increased the Columbia River surface area, delaying the flows of the river and caused temperature stratification within the reservoirs. These effects generally are cumulative and cause higher temperatures to build in the lower reaches of the system. Point source heat discharges, such as those from the nuclear power generation facilities at Hanford and other major industrial discharges, have added to the temperature levels of the Columbia system. Because of the potential impact from these point source heat discharges, the environmental and fisheries agencies were successful in adopting a once-through cooling policy for the Columbia River in the late 1960's. Thus, cooling towers have been installed at the Trojan nuclear facility near Longview and are being installed in the Washington Public Power Supply System reactors under construction at Hanford. Irrigation withdrawals and return flows also contributed to temperature problems; as has continuing deforestation in the Columbia system. The environmental agencies are working with both the agricultural and forestry interests for the adoption and implementation of improved management practices to minimize the water quality impacts of these activities.

The temperature problem in the Columbia system, however, is not going to be solved in the near future. Indeed, the solutions to the problem are somewhat limited. The elevated temperature levels which occurred during the low flows of the 1977 drought give us a good indication of the future magnitude of the problem, and we should be concerned. Development of major new irrigation withdrawals and further construction and operation of nuclear hydroelectric power facilities must take into account their influence on Columbia River temperature.

Finally, there is a minor but continuing problem associated with the spills and other discharges of oil and hazardous materials. Perhaps we have been lucky, because we have not yet experienced any spills of major impact. But we have experienced some minor spills of materials such as oil, mercury, PCB's and radioactive materials which have caused localized problems, and we must continue to take necessary precautions to avoid future spills.
THE FUTURE

Probably the most significant problem in the future will be continuing elevated temperature levels in the Columbia system. The discharge of toxic and hazardous materials could become a problem, but major new emphasis in this area by the environmental agencies hopefully will preclude this as a problem. Certainly, new land and water resource development of the Columbia system, such as the long-proposed Ben Franklin Dam and major new irrigated agricultural projects, should be watched carefully.

The environmental agencies fortunately are blessed with many new regulatory tools which can be used to minimize future environmental impacts. As a result of the National Environmental Policy Act and associated state environmental policy statutes, all major Federal and many non-Federal projects are reviewed through the environmental impact statement process. In addition, the Fish and Wildlife Coordination Act places fish and wildlife on an equal level with other uses (even power and irrigation), and has served successfully to control development in other areas of the country. Finally, recent environmental legislation includes provisions for new source permits and performance standards which assure that new development will incorporate the best available control technology in order to minimize environmental impact.

There is a reason, therefore, to be mildly optimistic as to the future of water quality in the Columbia River. Many tradeoffs will have to be made in terms of environmental impact and future development. But I am convinced that major problems will be mitigated in advance or solved as a result of these more stringent environmental statutes. The public has a major stake in the outcome of these future planning efforts and has a responsibility to impact decisions on how the Columbia system is developed in the future. Many new opportunities for public participation in the planning and development process are available and must be exercised.
INTRODUCTION

A significant proportion of the total upstream storage capacity of the Columbia River system is located in Canada. Canada operates three storage reservoirs in accordance to provisions of The Columbia River Treaty* (herein-after the Treaty) that was finalized in 1964 after two decades of study and negotiation.

In general terms the Treaty reservoirs store water during the high flow period of April through July and release it during the fall and winter. This reduces the large flood damage potential downstream in the Portland-Vancouver metropolitan area and increases the generation of hydroelectric energy during the season of highest demand. Figures 1A and B illustrate the concept of "ironing out the hydrograph" as a means of increasing the output of water-related goods and services. How and why the provision and operation of storage reservoirs in Canada have been beneficial to both countries is now addressed.

BACKGROUND CONDITIONS TO THE TREATY

The Columbia River system is one of the world's major drainage basins, encompassing 259,000 square miles of the North American continent (Figure 2). The U.S.-Canadian boundary divides the Columbia Basin along the 49th parallel, providing yet another example of what may be termed "the triumph of geometry over hydrography". Indeed, the Treaty is only one of many political adjustments arising from international and transnational waters shared by the United States and Canada. Approximately 2200 of the 5500 miles of borders between the two countries are international waters, i.e., they are located along lakes and rivers; while dozens of transnational rivers flow across the U.S.-Canadian boundary, some several times. The political-hydrographic patterns in the Columbia Basin are of the latter type. These patterns illustrate a common

* Properly identified as the "Treaty Between Canada and the United States of America Relating to cooperative Development of the Water Resources of the Columbia River Basin."
FIGURE 1

EFFECT OF UPSTREAM STORAGE ON COLUMBIA RIVER HYDROGRAPH

but vexing problem facing water resources planners: the disconformity of units (areas) of water supply, units of demand for water-related goods and services, and areas having jurisdiction over water supply units.

Reflecting the number of different physical environments within the drainage area of the Columbia, sub-basins display a wide variety of runoff characteristics. Table 1 illustrates the size and contribution to total runoff by major sub-basin. Although only fifteen percent of the Columbia drainage area lies north of the 49th parallel, the mountainous terrain there with its associated large runoff accounts for approximately thirty percent of the river's total discharge (2). When tributaries west of the Cascades (G on Table 1) are excluded from consideration, Canadian contribution to runoff rises to about forty-four percent. This is significant because most of the hydroelectric generating capacity on the Columbia is located above Bonneville and is therefore affected by storage in Canada. Moreover, much of the potential flood damage in the U.S. portion of the Columbia is related to runoff originating in Canada and is therefore reduced by upstream storage projects in that country.

The natural regime of the Columbia restricted utilization of the river and its riparian lands. As Figures 1 A and 3 illustrate the unregulated discharge of the Columbia displayed a pronounced variation throughout the year. Although most of the precipitation in the watershed takes place during the cooler months, much of it is locked up in the form of ice and snow before the major period of thaw from April through July. Figure 3 illustrates that under unregulated conditions discharge at The Dalles, Oregon from October through February was normally only about twenty percent of that in the middle of June. Extreme fluctuations in streamflow have ranged from a minimum of 36,000 cfs in 1937 to a maximum of 1,240,000 in 1894, a ratio of 1 to 35 (3).

By the early 1950's, after approximately two decades of installing hydroelectric generating capacity on the Columbia, it became evident that utilities would find it increasingly difficult to consistently meet the growing peak demands placed on the system during the fall and winter seasons. This problem arose from the confluence of three interrelated phenomena. First, most of the hydroelectric generating capacity on the Columbia system was installed at run-of-river dams. These dams can only store water to meet the peak demands that occur within a twenty-four hour period. Without releases from upstream storage the seasonal output pattern of run-of-river plants is rather similar to the unregulated hydrograph of the Columbia. Figure 1 B graphically illustrates the role that upstream storage plays in increasing the output of down-stream run-of-river plants during the fall and winter; while Table 2 shows how much additional prime energy* can be generated on the Columbia system with the addition of just one upstream storage reservoir behind Hungry Horse Dam located on the South Fork of the Flathead River in Montana (Figure 2). Second, relatively little upstream storage had been provided in the system. And third, the seasonal demand pattern for electrical energy in the Pacific Northwest was 180 degrees out of phase with the unregulated regime of the Columbia.

This situation led to periodic shortfalls of electrical energy in the region during a period when population and per capita consumption of energy

* Hydroelectric energy which is assured to be available 100 percent of the time: specifically, the average energy generated during the critical period.
TABLE 1
DISTRIBUTION OF RUNOFF IN THE COLUMBIA BASIN
BY SUB-BASIN (1)*

<table>
<thead>
<tr>
<th>Sub-basin</th>
<th>Drainage Area, Square Miles</th>
<th>Percent of Total 1</th>
<th>Average Annual Runoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Main Stem above Pend River excluding the Kootenay River.</td>
<td>14,500</td>
<td>5.6</td>
<td>33</td>
</tr>
<tr>
<td>B. Kootenay River basin</td>
<td>19,200</td>
<td>7.4</td>
<td>21</td>
</tr>
<tr>
<td>C. Clark Fork-Pend Oreille basin</td>
<td>26,000</td>
<td>10.0</td>
<td>19</td>
</tr>
<tr>
<td>D. Main stem and tributaries from international boundary to Snake River</td>
<td>43,300</td>
<td>16.7</td>
<td>19</td>
</tr>
<tr>
<td>E. Snake River basin</td>
<td>109,000</td>
<td>42.1</td>
<td>37</td>
</tr>
<tr>
<td>F. Main stem and tributaries between Snake River and Cascade Range (Bonneville Dam)</td>
<td>28,000</td>
<td>10.8</td>
<td>9</td>
</tr>
<tr>
<td>G. Main stem and tributaries west of Cascade Range</td>
<td>19,000</td>
<td>7.3</td>
<td>42</td>
</tr>
<tr>
<td>Basin Total</td>
<td>259,000</td>
<td>---</td>
<td>180</td>
</tr>
</tbody>
</table>

1 Based upon estimated 50-year averages by Corps of Engineers.

2 Does not total 100% because of rounding.

<table>
<thead>
<tr>
<th>Dam</th>
<th>River</th>
<th>w/o Hungry Horse Storage kW</th>
<th>w/Hungry Horse Storage kW</th>
<th>Increase Due to Storage Release at Hungry Horse kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerr</td>
<td>Flathead</td>
<td>56,000</td>
<td>138,000</td>
<td>82,000</td>
</tr>
<tr>
<td>Thompson Falls</td>
<td>Clark Fork</td>
<td>26,000</td>
<td>38,000</td>
<td>12,000</td>
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<tr>
<td>Noxon Rapids</td>
<td>Clark Fork</td>
<td>91,000</td>
<td>167,000</td>
<td>76,000</td>
</tr>
<tr>
<td>Cabinet Gorge</td>
<td>Clark Fork</td>
<td>58,000</td>
<td>107,000</td>
<td>49,000</td>
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<tr>
<td>Albeni Falls</td>
<td>Pend Oreille</td>
<td>17,000</td>
<td>23,000</td>
<td>6,000</td>
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<tr>
<td>Box Canyon</td>
<td>Pend Oreille</td>
<td>34,000</td>
<td>50,000</td>
<td>16,000</td>
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<tr>
<td>Boundary</td>
<td>Pend Oreille</td>
<td>246,000</td>
<td>383,000</td>
<td>137,000</td>
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<tr>
<td>Waneta (Canada)</td>
<td>Pend Oreille</td>
<td>193,000</td>
<td>291,000</td>
<td>98,000</td>
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<tr>
<td>Grand Coulee</td>
<td>Columbia</td>
<td>1,527,000</td>
<td>1,689,000</td>
<td>162,000</td>
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<tr>
<td>Chief Joseph</td>
<td>Columbia</td>
<td>809,000</td>
<td>889,000</td>
<td>80,000</td>
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<tr>
<td>Wells</td>
<td>Columbia</td>
<td>348,000</td>
<td>380,000</td>
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<tr>
<td>Rocky Reach</td>
<td>Columbia</td>
<td>502,000</td>
<td>546,000</td>
<td>44,000</td>
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<td>Columbia</td>
<td>144,000</td>
<td>152,000</td>
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<td>Wanapum</td>
<td>Columbia</td>
<td>436,000</td>
<td>476,000</td>
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<td>Priest Rapids</td>
<td>Columbia</td>
<td>420,000</td>
<td>456,000</td>
<td>36,000</td>
</tr>
<tr>
<td>McNary</td>
<td>Columbia</td>
<td>504,000</td>
<td>538,000</td>
<td>34,000</td>
</tr>
<tr>
<td>John Day</td>
<td>Columbia</td>
<td>744,000</td>
<td>794,000</td>
<td>50,000</td>
</tr>
<tr>
<td>The Dalles</td>
<td>Columbia</td>
<td>603,000</td>
<td>649,000</td>
<td>46,000</td>
</tr>
<tr>
<td>Bonneville</td>
<td>Columbia</td>
<td>473,000</td>
<td>498,000</td>
<td>25,000</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>1,033,000</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Source: Bonneville Power Administration, Division of Power Management, 1969.
were increasing rapidly. For example, during the dry autumn of 1952, hydro-
generation on November 1st was only 2300 MW, less than fifty percent of the
system's rated capacity (4). In addition the supply of energy to the region's
electro-processing industries was not infrequently curtailed in accordance with
their contracts for interruptible power.* Calls for residential consumers to
voluntarily reduce their use of energy and a marked reduction of energy for
commercial uses (curtailed advertising lights caused "brownouts") made the
general public aware that something was amiss in a region noted for its abundance
of low-cost electrical energy.

Shortfalls in the planned additional increments of upstream storage
were at the root of the problem. In the Corps' lengthy 308 Report published in
the 1940's, a total of twenty million acre-feet of storage were to have been
provided in the U.S. part of the Columbia Basin. Storage in these six reservoirs
would have increased the firm energy in the hydroelectric system approximately
three fold (5).

* Power made available under agreements which permit curtailment of delivery
by the supplier.
But by 1959, a decade after serious shortfalls started, only thirteen million acre-feet of storage pertinent to hydroelectric development had been provided (6).

The inability of U.S. interests to provide adequate upstream storage south of the international boundary during the 1940's and 1950's may be attributed to several factors. First, most of the proposed storage sites were in the mountainous upstream states of Idaho and Montana. This reawakened latent intraregional conflict between those states and the relatively urbanized and industrialized downstream states of Washington and Oregon. Provision of upstream storage would inundate economic activities in the upstream states but most of the benefits from that storage would accrue to urban-industrial interests downstream. Residents of upstream states energetically opposed storage projects that would have required them to abandon productive agricultural lands and mines and to relocate communities so that the Portland-Vancouver metropolitan area would have increased flood damage mitigation and the residents and industries of Washington and Oregon more inexpensive hydroelectric energy. Congress honored the wishes of their colleagues from the upstream areas and did not authorize many of the proposed storage projects. This classic example of upstream-downstream conflict at the state level was extended across the forty-nine parallel when Canada refused to allow over forty miles of her territory to be flooded by the prime storage site proposed by the Corps of Engineers on the Kootanai* River near Libby, Montana (Figure 2).

Another obstacle to providing upstream storage in the U.S. was the continuation of a decades-long conflict between public and private interests over which one had the right to generate and sell hydroelectric energy. This conflict figured prominently in the ultimate failure to provide planned amounts of upstream storage at the proposed Nez Perce and Hells Canyon projects (Figure 2). The interests of the investor-owned (private) utilities -- who have little incentive to provide upstream storage for either flood control or the increase of hydroelectric generation at downstream plants owned by other interests -- were championed by the Eisenhower Administration which took office in 1953.

And third, growing public concern over the degradation of environmental values was developing in the region during the period when planned storage projects were being advocated. It became evident that provision of upstream storage would require tradeoffs with a variety of phenomena that could be included under environmental values. For example, construction of the proposed Glacier View project on the Flathead River would have inundated winter grazing grounds for elk as well as part of Glacier National Park. The proposed Nez Perce storage project and some of its related alternatives were strongly opposed on the grounds that they would jeopardize anadromous salmonid populations which at that time were still significant in Idaho's Salmon River.

These three factors combined to hold over thirty-four million acre-feet of upstream storage in suspension while demands for electrical energy

* Spelled Kootanay in Canada.
continued to increase rapidly in the Pacific Northwest (7). The growing potential for serious energy shortfalls made storage water in the Canadian part of the Columbia Basin increasingly attractive to U.S. interests.

THE COLUMBIA RIVER TREATY

The final agreement in 1964 between the U.S. and Canada on the Treaty was preceded by two decades of studies and negotiations. In 1944 a joint letter from the two countries requested the International Joint Commission (IJC) to "... determine whether a greater use than is now being made of the Columbia River system would be feasible and advantageous" (8). The IJC then established a Columbia River Engineering Board to carry out the studies. The Board submitted its final report fifteen years later in 1959.

The protracted study period has been attributed to several factors (9): absence of basic data from the Upper Columbia watersheds; no governmental agency in Canada possessing a large pool of trained water development specialists -- similar to those in the U.S. Army Corps of Engineers, U.S. Water and Power Resources Service (Bureau of Reclamation), and the Soil Conservation Service; and a lack of incentive on Canada's part to complete the studies due to viable alternative sources of potential hydroelectric energy and to relatively little flood-related problems in its portion of the basin. The devastating flood of May-June, 1948 and the growing problem of meeting peak seasonal energy demands without adequate upstream storage made U.S. interests eager for the Engineering Board to complete its report. In its 1959 report the Board presented three alternative plans for development and noted that there were storage sites in Canada that could be operated for the benefit of both countries (10).

The U.S. and Canada then requested the IJC to devise principles for the calculation and apportionment of the costs and benefits of cooperative development of the Columbia River system. In December, 1959 the IJC report was completed and contained the following seven principles (11).

1. Downstream power and flood control benefits in one country should be determined on the basis of an assured plan of operation of the storage in the other country.

2. The downstream power benefits should be determined in advance by computing the difference between the amount of power that can be produced at the downstream plants with and without the storage regulation.

3. The downstream power benefits should normally be expressed as the increase in dependable hydro-electric capacity in kilowatts and the increase in average annual usable hydro-electric energy output in kilowatt hours.

4. The downstream power benefits should be shared on a basis such that the benefit to each country, in power, will be substantially equal.
5. The monetary value of the annual flood control benefit to be assigned to the upstream storage should be the estimated average annual value of the flood damage prevented by that storage.

6. The upstream country should be paid one-half of the value of the estimated flood damages prevented.

7. Each country should assume responsibility for providing the facilities needed in its territory for the cooperative development.

Before the completion of the Board's report and enunciation of principles by the IJC could take place, U.S. parties had to ascribe to the principle of sharing downstream benefits. This principle may be defined as equal division of benefits between the upstream and downstream countries that accrue in the downstream country as a result of storage (or other actions) in the upstream country. Canadian parties in the cooperative study of the Columbia had long sought official recognition that the provision of upstream storage in Canada would result in substantial benefits in the downstream country, but until the late 1950's U.S. parties had been reluctant to do so. The announcement by the Government of British Columbia that it was planning to develop the hydroelectric potential of the Peace River, which meant it would therefore not need energy from the Columbia, is credited with persuading U.S. parties to accept the principle of sharing downstream benefits (12).

With U.S. acceptance of this principle, serious negotiation between the parties could begin. Negotiators had to face the extreme complexities associated with quantifying the downstream benefits that would result from Canadian storage (13). Despite these complexities, agreement was reached late in 1960. The Treaty was signed at Washington, D.C. on January 17, 1961 by Prime Minister Diefenbaker and President Eisenhower. Their action was followed relatively quickly by the U.S. Senate which ratified the Treaty on March 16, 1961.

Because the Treaty remains a unique example of cooperative international river basin management, the milieu in which it developed is briefly considered. In addition to the long history of generally amicable relations between the U.S. and Canada there are several additional background conditions that supported the successful negotiation of the treaty. In Le Marquand's review (14) of factors that may facilitate agreement between nations sharing international and transnational waters, several are clearly pertinent to the case in point.

First there was a common technical perception of the problem. The provision of upstream storage would increase the production of firm energy markedly at planned and existing run-of-river plants downstream, as well as mitigating flood hazards. Second, there were (and generally still are) similar tastes for the mix of water-related goods and services to be derived from development of the river system. Both parties agreed that the principal goals of the development were generation of hydroelectric energy, flood hazard mitigation, and irrigation (15). Third, there was and remains an extensive network of transboundary and intergovernmental linkages. The IJC had functioned since the Boundary Waters Treaty of 1909; the International Columbia River Engineering
Board had worked on the river system for fifteen years; and a complex web of electrical interties, lines of communication and transport networks link the two countries. Fourth, a common language facilitated communication. Fifth, a small number of actors were involved in negotiations. Initially representatives of the federal governments of the U.S. and Canada appeared to have been the principal actors, although British Columbia was also involved. The reasons for and consequences of increasing this number to three will be explained below. Nevertheless, three actors are notably less than the number required for many other international negotiations dealing with river basin development. And sixth, the development by one country of a water-related good or service for its own use may benefit the other country. This conditions is of course prerequisite to sharing downstream benefits, as explained in preceding paragraphs. Meeting the six general conditions outlined above is unusual, which helps to explain why the Treaty remains unique.

The major provisions of the Treaty are succinctly stated by Fernald. His summary is reproduced below (16).

a. For Power

1. Canada shall provide 15,500,000 acre-feet (19,118 million m³) of storage usable for improving the flow of the Columbia River through the construction of three dams:

   (a) On Columbia River near Mica Creek with approximately 7,000,000 acre-feet (8,635 million m³).

   (b) Near the outlet of Arrow Lakes with approximately 7,100,000 acre-feet (8,758 million m³).

   (c) On Kootenay River near Duncan Lake with approximately 1,400,000 acre-feet (1,727 million m³) or the equivalent thereof.

2. The United States shall maintain and operate specified hydroelectric power facilities to make most effective use of the improved streamflow resulting from operation of the Canadian storage for hydroelectric power generation.

3. Canada shall operate the Canadian storage in accordance with hydroelectric operating plans prepared jointly under a procedure specified in Annex A to the Treaty.

4. The United States and Canada shall divide the resulting downstream power benefits equally, the benefits to be determined according to principles and procedures specified in Annex B to the Treaty.

5. Canada's share of the downstream benefits shall be delivered to Canada or, by mutual agreement, may be sold by Canada in the United States.
b. For Flood Control

1. Canada shall operate 8,450,000 acre-feet (10,423 million m³) in the above Canadian storages for the control of flood flows in accordance with operating plans and procedures provided for in Annex A to the Treaty.

2. For the flood control to be provided by Canada, the United States shall pay specified amounts totaling $64,400,000 upon commencement of operation of each of the storages. This figure represents one half the capitalized flood control benefits within the United States estimated to accrue from operation of the Canadian storage.

3. The United States may call for flood control operation of any additional storage available in Canada and may continue to call for the use of available storage after the expiration of the 60-year period of the Treaty for the payment of additional monies and other compensation.

c. Other Provisions

1. The United States shall have a five-year option to commence construction of Libby Dam to develop a reservoir on Kootenai River not to exceed an elevation of 2,459 feet (750 m). Canada at its own expense shall provide the reservoir area for the 42 miles required in Canada because of downstream benefits which will accrue in Canada.

2. Canada shall have the right, after expiration of 20 years from ratification date, to divert not more than 1,500,000 acre-feet (1,860 million m³) annually from Kootenay River in Canada to the Columbia River. It also has the right to diversion of additional amounts in later years.

3. Canada and the United States shall each designate entities empowered and charged with the duty to formulate and carry out operating arrangements necessary to implement the Treaty.

4. A joint Permanent Engineering Board shall be established to report activities to the two governments and to assist in reconciling differences that may arise between the entities.

5. Differences arising under the Treaty may be referred by either country to the International Joint Commission and in the continued absence of decision the matter will be referred, for arbitration, to a specially appointed international tribunal.
Although the Treaty was signed by the heads of state in 1961 and ratified by the U.S. Senate two months later, the Protocol finalizing the Treaty was not signed until 1964. The three-year delay resulted in large part from the lack of agreement between the governments of British Columbia and Canada over the disposition of Canada's share of the downstream benefits. While Ottawa insisted that Canada's share of the energy be used in that country, as it was the least expensive source of electrical energy, Victoria was equally emphatic that Canada's share of the energy be sold in the U.S. In the early 1960's, British Columbian leaders saw little near-term need for energy from the Columbia River because they had embarked on a program to develop large blocks of hydroelectric energy on the Peace River, over 500 miles north of the load centers concentrated in the southwestern corner of the Province. Moreover, development of both the Peace and Columbia Rivers would have severely strained British Columbia's financial capacity. Between 1959 and 1964 the relationship between Ottawa and Victoria "... oscillated between forms of cooperative and competitive federalism." (17) Since the Canadian portion of the Columbia system lies entirely within British Columbia, and because under the Canadian federal system ownership of the lands and waters are vested in the provinces, both Victoria and Ottawa could veto the other in matters of the international development of the Columbia (18).

THE PROTOCOL

Ottawa's eventual concurrence with British Columbia's position led to renewed U.S.-Canadian negotiation in the spring of 1963. These negotiations resulted in a protocol that satisfied a number of reservation Canadian interests had had about the Treaty. The sale of Canada's energy (the Canadian Entitlement) also required U.S. interests to devise means first of absorbing large blocks of unexpected power, and second of making a very large lump sum advance payment for thirty years worth of the Entitlement and flood control benefits. Major points of the protocol are included below.

1. That Canada sell in advance its share of downstream benefits for the first half of the 60-year life of the Treaty. This required the U.S. to pay $254 million for the Canadian Entitlement and another $64 million for flood control. Because flood control had been designated a national responsibility by Congress in 1936, the U.S. federal government paid Canada (British Columbia) for that water-related service. But complex institutional arrangements had to be devised for a bond sale to finance the $254 million for the advance purchase of the Canadian Entitlement. A total of forty-one public and private utilities in the region formed a nonprofit corporation known as the Columbia Storage Power Exchange (CSPE). Each of the utilities agreed to pay CSPE a proportionate share of the bond interest, amortization, and other expenses for a proportional share of the Canadian Entitlement (19). Purchase of the Canadian Entitlement also required completion of additional complex arrangements:

(a) a long-term coordination agreement between utilities in the Pacific Northwest in order for them to fully realize the benefits of Canadian storage;
(b) Congressional approval of an extra high voltage electrical intertie between the Pacific Northwest and Southwest -- with an anticipated investment of $700 million; and

(c) assurances of a market in California and other parts of the Pacific southwest. The complex relationships between multiple actors is shown in Figure 4.

It is noteworthy that the availability of extra high voltage technology -- which increased the economical distance of energy transmission from about 300 to almost 1000 miles -- not only made the Peace River project feasible in British Columbia thereby contributing to the impasse between Ottawa and Victoria, but it also allowed the Treaty negotiations to move forward to final agreement by providing accessibility to load centers in the Pacific Southwest where the Canadian Entitlement and other surplus electrical energy from the Pacific Northwest could be purchased.

2. Canada was allowed to select the particular role that the reservoirs would play in providing storage for downstream interests (i.e., how much of the active storage in the three Treaty reservoirs would be used for hydroelectric generation and flood hazard mitigation. Many of the earlier concerns expressed by Canadians had been about the operation of the Mica project. This project not only has the greatest volume of active storage in the system (12 million acre-feet) but it is also at the top of the system, thus providing the most valuable storage in the Columbia Basin. Maximum benefits would accrue to the United States if Mica were drawn down rapidly early in the storage withdrawal period, but such operation would result in irregular and inefficient hydroelectric generation at Mica and at planned Canadian run-of-river plants downstream from Mica. Thus, Canada decided that Mica would provide less than one percent of the 8.45 million acre-feet of flood control required in the Treaty (21). Most of the flood control storage is in the Arrow project which then functions as a buffer between Canadian hydroelectric plants on the Columbia and U.S. generating plants downstream.

3. If the U.S. requests additional flood control storage in Canada, it may receive it only if three conditions are met:

   a) no additional flood control storage is available at U.S. reservoirs;

   b) Canada is paid an additional $1,875,000 for each of the first four requests; and

   c) Canada receives from the U.S. an equivalent amount of electrical energy foregone in Canada as a result of the requested flood control operation (22).
FIGURE 4

COLUMBIA STORAGE POWER EXCHANGE

BONDHOLDER

CANADIAN ENTITY

BRITISH COLUMBIA HYDRO

UNITED STATES ENTITY

BONNEVILLE POWER ADM.

BONNEVILLE POWER ADM.

NORTHWEST COORDINATING UTILITIES.

ALLOCATION AGREEMENT

NON-FEDERAL PROJECTS

FEDERAL PROJECTS

COORDINATION AGREEMENT

TREATY PROTOCOL NOTES

ASSURED PLAN OF OPERATION

EXCHANGE AGREEMENT

B.C. HYDRO-C.S.P.E. AGREEMENT

BONDS AND BOND INDENTURE

COLUMBIA STORAGE POWER EXCHANGE

PARTICIPANT

4. Canada may divert water from the Columbia Basin at any time for the purposes of irrigation and domestic supply. This was to placate interests in the Prairie Provinces who feared the Treaty as written in 1961 would preclude any possibility of a Trans-Rocky Mountain diversion from the Columbia Basin. Such an interbasin diversion appeared highly desirable to interests east of the Rockies because waters of the Columbia would augment flows of the South Saskatchewan River which was heavily used in the subhumid southern parts of Alberta and Saskatchewan. That such a diversion will actually take place however is highly improbable. First, British Columbia as the owner of the Columbia in Canada would have to agree to the diversion. Such a diversion would reduce generation of hydroelectricity on the Columbia system in British Columbia and lessen the downstream benefits British Columbia shares with the United States. And second, diversions into the South Saskatchewan River would be much less costly from other rivers east of the Rocky Mountain Range. Whereas the costs of a transmountain diversion from the Columbia system into the South Saskatchewan were estimated in 1964 to run between $7.50 and $10.50/acre-foot, water from the North Saskatchewan, Athabasca, and Peace Rivers, which are all in Alberta, were estimated to cost 40c, $3.50, and $4.60/acre-foot, respectively (23).

5. The U.S. is obliged to operate Libby Dam on the Kootenay River so as to optimize hydroelectric generation at downstream run-of-river plants in Canada and the U.S. It is noteworthy that in this instance, Canada which is the downstream beneficiary, does not share benefits with the U.S.

Additional modifications made between the Treaty of 1961 and the protocol of 1964 that made the final agreements on cooperative development of the Columbia more attractive for Canada include: First, extending for ten years the period of flow records used to calculate hydroelectric generation on the Columbia system. Whereas the Treaty had used a twenty-year period from 1923-48, the protocol used 1928-58, thereby including years of heavier runoff to balance the droughty years of the 1930's and 40's. As a result of including this ten-year extension of flow records, Canada's benefits increased by approximately 500 million kilowatt hours or by almost eighteen percent (24). And second, including in the analysis the electrical energy used for pumping irrigation water at Grand Coulee Dam (to supply the 500,000 acres of irrigated land in the Columbia Basin Irrigation Project), increased by five to seven percent the credits given to Canadian storage capacity (25).

CONCLUSIONS

A unique international agreement for the cooperative management of the Columbia River was developed over a period of two decades. Finalizing the agreement required the gathering of basic data, complex analysis, and intensive intra and international negotiations. The agreement was reached against the backdrops of new technologies and of changing political administrations on each side of the international boundary. While it is debatable which country received
more benefits, observers generally conclude that both derived substantial benefits in the form of large blocks of electrical energy that is markedly less expensive than that from alternative sources developed independently. Benefits from flood hazard mitigation were also received by both countries, with the U.S. deriving considerably more than Canada.

Although modern societies usually derive a number of water-related goods and services from managing their rivers, the Treaty only included two—hydroelectric generation and flood hazard mitigation. When the Treaty is renegotiated in 1994 the inclusion of additional water-related goods and services may well receive serious consideration. Likely candidates for consideration include flow augmentation for the passage of juvenile salmonids in the U.S., water quality enhancement, irrigation, and recreation. That both parties to the Treaty are aware of possible additional benefits of upstream storage was illustrated during the low flows of 1977 when fish-oriented interests in the U.S. sought to obtain releases from Canadian reservoirs in order to enhance downstream migration of juvenile salmonids. Canadian officials were willing to release water for such a purpose for $6/acre-foot. This price was not accepted by U.S. interests who turned instead to "... makeshift remedial measures."

Whether or not the inclusion of additional water-related goods and services becomes important when the Treaty is renegotiated in 1994, U.S. parties may expect hard bargaining from their Canadian counterparts based on the markedly increased value of hydroelectric energy relative to 1964.

REFERENCES


(4) Ibid., 44-5.


These projects included:
### Storage Locations

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>ACTIVE STORAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grand Coulee</td>
<td>5,120,000 acre feet</td>
</tr>
<tr>
<td>Hungry Horse</td>
<td>2,980,000</td>
</tr>
<tr>
<td>Albeni Falls</td>
<td>1,140,000</td>
</tr>
<tr>
<td>Glacier View</td>
<td>3,160,000</td>
</tr>
<tr>
<td>Libby</td>
<td>4,250,000</td>
</tr>
<tr>
<td>Hells Canyon</td>
<td>3,880,000</td>
</tr>
<tr>
<td></td>
<td>20,530,000 acre feet</td>
</tr>
</tbody>
</table>


Storage was located at the following sites:

<table>
<thead>
<tr>
<th>PROJECT</th>
<th>ACTIVE STORAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kootenay Lake</td>
<td>673,000 acre feet</td>
</tr>
<tr>
<td>Hungry Horse</td>
<td>2,982,000</td>
</tr>
<tr>
<td>Flathead Lake</td>
<td>1,217,000</td>
</tr>
<tr>
<td>Albeni Falls</td>
<td>1,153,000</td>
</tr>
<tr>
<td>Colur d'Alene Lake</td>
<td>225,000</td>
</tr>
<tr>
<td>Grand Coulee</td>
<td>5,072,000</td>
</tr>
<tr>
<td>Chelan</td>
<td>676,000</td>
</tr>
<tr>
<td>Brownlee</td>
<td>1,034,000</td>
</tr>
<tr>
<td></td>
<td>13,032,000 acre feet</td>
</tr>
</tbody>
</table>

(7) Marts, op. cit., 49.


(11) MacNabb, op. cit., 130-1. For the full report see: Canada, op. cit., 39-56.


(13) For an analysis of these complexities see: John V. Krutilla, The Columbia River Treaty: The Economics of an International River Basin Development (Baltimore, Maryland: The Johns Hopkins Press, 1967, 209 pp.).
As preservation becomes more important, the U.S. and Canada may well agree less often on how transnational rivers should be used. This is attributable to the relative densities of population and levels of development along the U.S.-Canadian border. Whereas boundary waters in the U.S. are usually in a lesser developed state than those further south, they often become prime candidates for inclusion in the Wild and Scenic System. But in Canada transnational rivers are often in relatively densely populated parts of Canada near centers of traditional economic activities. Canadian interests therefore often view these rivers as prime candidates for traditional utilitarian modes of development; and naturally select their northern rivers for preservation. Bruce and Quinn point out how this situation causes lack of agreement between the two countries over the transnational Flathead River in the Columbia Basin. See:


Ibid., 16-17.


MacNabb, op. cit., 133-4.

Ibid., 134.

Ibid.

Navigation as an Alternative Use

INTRODUCTION

Most residents of the Pacific Northwest have at least a casual appreciation of the fact that the region is blessed with a very valuable and productive multiple use resource, the Columbia River and its tributaries. For example, most people know that the river system generates hydroelectric power, provides water for irrigation and fisheries, and is a valuable recreational resource. A complete and accurate measure of this resource contribution to the economy and lifestyle of the region would be very complex. Nonetheless, the following brief overview may provide some insight to the river's economic and social value.

1. In 1978, approximately 126,346,000 megawatt hours of hydroelectric power was generated by the dams on the Columbia.

2. In 1979, approximately 7.7 million acres of agricultural land in Oregon, Washington, and Idaho were irrigated with water from the river system. Total water used for irrigation is estimated at between 6 and 7 million acre feet.


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1 Wilkins, John. Bonneville Power Administration.
4. In 1978, the Columbia River provided over 1.2 million recreational boating day-people (for fishing, sailing, skiing, cruising, etc.) to residents of Multnomah and Columbia counties in Oregon alone. Thus, it is a heavily utilized recreational resource.

While a great deal of attention has been focused on the economic activities mentioned above, there is relatively little public knowledge about another important contribution of the river, freight transportation by commercial navigation. In 1979, nearly 8 million tons of freight (1.9 million ton-miles of service) moved via the river (Snake-Columbia). Yet, until very recently, navigation has been what might be called the silent river use. That is, while commercial navigation has been a principal regional transportation mode for a number of years, it has not, in general, interfered or competed with other water uses. Consequently, navigation has been of little concern to regional water policymakers.

However, as the multi-use capacity of the river is approached, conflicts between transportation and other uses are beginning to occur. Policy-makers are being, and will continue to be, forced to make decisions regarding the allocation of the river resource among the alternative uses, including commercial navigation. Moreover, the extent to which the river is utilized for transportation affects a variety of other activities, including economic growth of adjacent communities, rural roads and bridges, and regional port development.

This paper will examine the relationship between other river uses and these ancillary activities. Specifically, the paper will:

1. Review river navigation activity and facility development.
2. Characterize commodities shipped, volumes, nature of equipment, and operating practices.
3. Identify benefits and beneficiaries of commercial navigation on the river.
4. Identify and estimate public and private costs of commercial navigation on the river, and the incidence of these costs.
5. Specify areas of conflict, complementarity, and tradeoffs for river use alternatives and related economic activities.

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5 Unpublished report to the Northwest Agricultural Development Project, by Transportation Study Section, Oregon State University, and U.S. Army Corps of Engineers, Waterborne Commerce Statistics for U.S.
NAVIGATION DEVELOPMENT

History of Navigation and Corps of Engineers’ Construction on the River System

Commercial navigation on the Snake-Columbia River system dates back to the Nineteenth Century when sternwheelers plied the untamed rapids, moving provisions and productive inputs upstream and produce downstream. With the advent of the railroads, at the turn of the century, waterborne commerce waned. More recently, navigational improvements have given rise to a rebirth of transportation activity on the river. These improvements were part of a project to develop a system of dams on the river, dams built principally for energy and other purposes. Today, commercial waterborne transport service extends 465 miles upriver to the Port of Lewiston, Idaho (see Figure 1).

The construction of eight locks in the multipurpose dams, and a naturally deep channel (14 feet), make the Snake-Columbia system ideal for large-scale barge shipments. It is the deepest inland navigation system in the United States. Barges up to 3200 tons capacity can be accommodated on the Snake-Columbia, compared with a 1500 ton capacity common on the Mississippi system. The development of the system, through the construction of these navigational aids, has been an evolutionary process.

The U.S. Army Corps of Engineers completed the first lock, Bonneville, in 1937. This lock is the furthest downstream, and currently the smallest, measuring 76 feet wide, 500 feet long, and 24 feet deep. Construction of the other locking facilities (all 86 feet x 675 feet x 15 feet) continued until 1975, when the Lower Granite Lock and Dam was completed. The Corps of Engineers estimates that construction costs for navigation aids at the eight facilities totaled $166,505,000 between 1938 and 1975. Note that this is the only construction cost directly assignable to the aids to navigation --- locks at each location. Table 1 provides data on the size and completion dates of the other navigational aids on the Snake-Columbia.

Until recently, the river roadway and all navigational aids were provided to commercial water carriers free of charge. That is, all expense for construction, maintenance, and operations associated with navigation were financed from public funds. On the Snake-Columbia system, annual operating expense amounts to approximately $370,000. Routine maintenance expenditures

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6Bonnewille, $6,072,000; The Dalles, $16,450,000; John Day, $21,202,000; Mcnary, $20,610,000; Ice Harbor, $31,654,000; Lower Monumental, $20,179,000; Little Goose, $25,312,000; Lower Granite, $25,025,000; from Bonnewille Lock and Dam, Oregon and Washington; Feasibility Study for Lock Modification, U.S. Army Corps of Engineers, January 1977. p. A-14.

7Users were provided free access to, and use of, inland waterways under the Northwest Ordinance of 1787, and the Rivers and Harbors Act of 1882.

8This amounts to roughly $35 per lockage. Computed from Corps of Engineers, Bonneville Lock and Dam Feasibility Study, January 1977.
Figure 1. Columbia/Snake River System
<table>
<thead>
<tr>
<th>Dam/lock (year operational)</th>
<th>River miles from Pacific Ocean</th>
<th>Location (river mile)</th>
<th>Pool elevation (feet)</th>
<th>Vertical lift (feet)</th>
<th>Lock dimensions (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bonneville (1938)</td>
<td>145</td>
<td>Columbia 145</td>
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<td>59</td>
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<tr>
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<td>160</td>
<td>88</td>
<td>86 x 675 x 15</td>
</tr>
<tr>
<td>John Day (1968)</td>
<td>216</td>
<td>Columbia 216</td>
<td>265</td>
<td>105</td>
<td>86 x 675 x 15</td>
</tr>
<tr>
<td>McNary (1953)</td>
<td>292</td>
<td>Columbia 292</td>
<td>340</td>
<td>75</td>
<td>86 x 675 x 15</td>
</tr>
<tr>
<td>Ice Harbor (1962)</td>
<td>335</td>
<td>Snake 9.7</td>
<td>440</td>
<td>100</td>
<td>86 x 675 x 15</td>
</tr>
<tr>
<td>Lower Monumental (1969)</td>
<td>367</td>
<td>Snake 41.7</td>
<td>540</td>
<td>100</td>
<td>86 x 675 x 15</td>
</tr>
<tr>
<td>Little Goose (1970)</td>
<td>395</td>
<td>Snake 70.1</td>
<td>638</td>
<td>98</td>
<td>86 x 675 x 15</td>
</tr>
<tr>
<td>Lower Granite (1975)</td>
<td>432</td>
<td>Snake 107.5</td>
<td>738</td>
<td>100</td>
<td>86 x 675 x 15</td>
</tr>
</tbody>
</table>

\(^1/\) Maintained at normal water levels.

SOURCE: Portland District, Corps of Engineers.
are about $340,000 per year. Non-routine maintenance expenditures vary, depending upon the severity of the problem which must be corrected. For example, the cost of repairing cracks in the lock at John Day is estimated to be $5.1 million over a three-year period. The Dalles and Lower Monumental Locks will also require non-routine repairs in the very near future.

Under legislation enacted by Congress in 1978, users will pay a fee aimed at recovering a portion of the regular cost associated with navigational facilities' maintenance and operations. This user fee will impose a tax on fuel, which begins at 4 cents per gallon, and increases incrementally to 10 cents per gallon in 1985. It is estimated that the user fee will recover between 10 to 20 percent of operating and routine maintenance costs.

Beyond their responsibilities for navigational aids in the river system, the Corps of Engineers also is charged with the task of maintaining the Columbia River channel (and its tributary to the Willamette) from the ocean ports of Vancouver, Longview, and Kalama, Washington, and Portland, Oregon, to the Columbia mouth. To permit access of ocean vessels to these ports, 40 feet of channel depth are required. This necessitates a continual dredging operation.

Volumes and Composition of Freight Traffic on the River

The benefits and costs of navigational use of Columbia Basin water are directly related to the volume of movements on the river. Total tonnage of freight moved on the river increased slowly and erratically from 1950 to 1969. In 1968, a rapid upward trend in traffic began. Between 1968 and 1978, total freight traffic more than tripled, increasing to over 7 million tons (see Table 2).

Much of the growth in waterborne tonnage has been the result of increased production of grain in the region and expanded grain exports. About 90 percent of the region's grain output is exported. Of this, nearly 60 percent of the Columbia River ports' outbound grain movements arrive at export terminals via barge.

As Table 3 indicates, downstream movements account for 75 percent of total waterborne tonnage. When measured in dollar value of traffic, the dominance downstream over upstream shipments is somewhat less pronounced. This is because relatively higher value per unit shipments of petroleum and fertilizer move upstream. These are principal inputs for agricultural production.

9 At the mouth, the channel is maintained at 48 feet. The inland channel, from mouth to the ports, is about 600 feet wide.
10 Measured as tons passing through the Bonneville Lock.
11 Results from NCSR National Grain Flow Survey conducted by Oregon State University, Washington State University, and the University of Idaho.
<table>
<thead>
<tr>
<th>Year</th>
<th>Tons</th>
<th>Year</th>
<th>Tons</th>
</tr>
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<tbody>
<tr>
<td>1938</td>
<td>161,920</td>
<td>1964</td>
<td>1,800,815</td>
</tr>
<tr>
<td>1950</td>
<td>1,143,901</td>
<td>1965</td>
<td>2,346,670</td>
</tr>
<tr>
<td>1951</td>
<td>1,357,852</td>
<td>1966</td>
<td>2,266,210</td>
</tr>
<tr>
<td>1952</td>
<td>1,521,616</td>
<td>1967</td>
<td>2,555,907</td>
</tr>
<tr>
<td>1953</td>
<td>1,343,575</td>
<td>1968</td>
<td>2,163,091</td>
</tr>
<tr>
<td>1954</td>
<td>1,373,725</td>
<td>1969</td>
<td>2,653,522</td>
</tr>
<tr>
<td>1955</td>
<td>1,578,865</td>
<td>1970</td>
<td>3,120,363</td>
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<tr>
<td>1956</td>
<td>1,518,924</td>
<td>1971</td>
<td>3,107,150</td>
</tr>
<tr>
<td>1957</td>
<td>1,481,590</td>
<td>1972</td>
<td>4,550,080</td>
</tr>
<tr>
<td>1958</td>
<td>1,702,752</td>
<td>1973</td>
<td>4,751,891</td>
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<tr>
<td>1959</td>
<td>2,043,494</td>
<td>1974</td>
<td>4,093,395</td>
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<tr>
<td>1960</td>
<td>2,316,362</td>
<td>1975</td>
<td>4,951,928</td>
</tr>
<tr>
<td>1961</td>
<td>1,962,065</td>
<td>1976</td>
<td>6,010,512</td>
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<tr>
<td>1962</td>
<td>1,940,273</td>
<td>1977</td>
<td>6,022,315</td>
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<td>1963</td>
<td>2,215,955</td>
<td>1978</td>
<td>7,018,449</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1979</td>
<td>7,527,918</td>
</tr>
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</table>

\(^a/\) Includes both upbound and downbound commerce.

Source: Portland District, U.S. Army Corps of Engineers.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
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<td>Grain</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>downbound</td>
<td>2705.0</td>
<td>3485.9</td>
<td>4467.4</td>
<td>4784.0</td>
<td>5575.0</td>
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<td></td>
<td>total</td>
<td>2705.0</td>
<td>3485.9</td>
<td>4467.4</td>
<td>4784.0</td>
<td>5575.0</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>upbound</td>
<td>125.5</td>
<td>188.8</td>
<td>224.5</td>
<td>385.1</td>
<td>392.7</td>
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<td>9.1</td>
<td>4.7</td>
<td>21.1</td>
<td>10.0</td>
<td>10.0</td>
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<tr>
<td></td>
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<td>193.5</td>
<td>245.6</td>
<td>395.1</td>
<td>402.7</td>
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<td>Petroleum</td>
<td>upbound</td>
<td>875.2</td>
<td>1142.8</td>
<td>1536.7</td>
<td>984.5</td>
<td>531.1</td>
</tr>
<tr>
<td></td>
<td>downbound</td>
<td>5.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>880.4</td>
<td>1142.8</td>
<td>1536.7</td>
<td>984.5</td>
<td>531.1</td>
</tr>
<tr>
<td>Other*</td>
<td>upbound</td>
<td>200.5</td>
<td>364.0</td>
<td>196.1</td>
<td>287.1</td>
<td>363.2</td>
</tr>
<tr>
<td></td>
<td>downbound</td>
<td>606.3</td>
<td>1024.9</td>
<td>1082.1</td>
<td>6940.0</td>
<td>8990.5</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>806.8</td>
<td>1388.9</td>
<td>1278.2</td>
<td>7227.1</td>
<td>9353.7</td>
</tr>
<tr>
<td>Total</td>
<td>upbound</td>
<td>1201.2</td>
<td>1506.8</td>
<td>1957.3</td>
<td>1656.7</td>
<td>1287.0</td>
</tr>
<tr>
<td></td>
<td>downbound</td>
<td>3325.6</td>
<td>4515.5</td>
<td>5570.6</td>
<td>11734.5</td>
<td>14575.5</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td>4526.8</td>
<td>6022.3</td>
<td>7527.9</td>
<td>13391.2</td>
<td>15826.5</td>
</tr>
</tbody>
</table>

*Includes sand and gravel, general cargo, wood chips, paper and wood products, logs, and miscellaneous liquid and dry bulk.

Grain, which moves downstream, is relatively lower valued per unit. As suggested by Corps of Engineers' projections, grain's dominance over total waterborne tonnage is expected to intensify.

PNW grain traffic is drawn to the river from a corridor along the river in eastern Oregon and Washington and western Idaho. Most of this traffic moves to river loading elevators via truck from inland elevators. A small portion of this traffic moves directly from the farm to the river. Eastern hard red wheat flows to the river, primarily via truck, from Montana, North Dakota, South Dakota, and Wyoming. This PNW trans-shipment volume will be discussed in more detail in a later section.

The basic waterborne shipping container for grain on the Snake-Columbia is a 3000 ton capacity jumbo hopper barge. These units are usually combined in three to five barge tows. Total static grain shipping capacity, as of 1977, was 129,850 tons. Multiple use barges, which can handle both petroleum and grain, are now being employed. Container barges are also being used for general freight traffic. Four major barge lines, operating 62 barges, provide service on the river.

There are about 28 ports, operated by 15 port authorities, on the river system. Total elevator capacity at these ports exceeds 20,000,000 bushels. Several large capacity liquid storage facilities serve shippers. Also, there are nine general cargo docks, at least three of which are now equipped for container transfer.

**BENEFITS AND BENEFICIARIES OF WATERBORNE TRANSPORTATION**

Evaluation of the conflicting uses of Columbia River water can be accomplished by delineating specific benefits and costs, and the incidence associated with each use. This is the main thrust of the remainder of this paper. The benefits from commercial navigation are evaluated in this section and are categorized as arising from on-river downstream movements, off-river movements, upriver movements, capacity availability, and developmental influences.

**On-River Movements**

As implied earlier, waterborne transportation is ideally suited for the movement of certain types of freight. In general, shipment via barge is very efficient for freight that: (a) is shipped in bulk or breakbulk form; (b) is relatively low valued per unit of volume or weight; (c) is not susceptible to spoilage or damage; (d) does not require speedy delivery. Consequently, grain, bulk fertilizer and chemicals, petroleum products, and sand and gravel tend to be moved via barge. As discussed previously, grain tends to dominate these shipments on the Snake-Columbia.

The present low cost of barge transportation directly benefits shippers (producers) and ultimately consumers of these products. Economic theory suggests that the costs of transportation for agricultural output is borne, at least in the short run, by the producer. That is, the price received by farmers for their grain can be expressed as follows:
\[ P_F = P_R - M \]

where \( P_F \) is the price at the farm level; \( P_R \) is the price at the final market; and \( M \) is the cost of marketing, largely the transportation cost between the farm and final market.

A relatively small value for \( M \) means a relatively large value for \( P_F \), given \( P_R \). Therefore, if transportation is inexpensive, \( M \) is minimized and the farmer's share of final price is maximized. Relatively low cost barge transportation has the effect of increasing grain prices received by farmers who have access to river transportation.

The exact value of the gain to farmers who ship via barge is difficult to measure. An estimate of this benefit can be derived by estimating the rate difference between water carriage and the alternative mode railroad (Table 4). The estimate is computed by multiplying total PNW waterborne grain shipments times the assumed rate differential. Since rates for barges during these years were roughly 5 to 15 cents lower per hundredweight than rail, depending on origin, the table indicates an approximate range of transportation savings. Again, most of this saving accrues to producers in the short run.

Table 4. Transportation Savings from Barge Rates Less Than Rail Rates on PNW Wheat

<table>
<thead>
<tr>
<th>Year</th>
<th>Total savings if barge is 5 cents/cwt. less than rail</th>
<th>Total savings if barge is 15 cents/cwt. less than rail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1977</td>
<td>$3,486,000</td>
<td>$10,458,000</td>
</tr>
<tr>
<td>1978</td>
<td>$4,638,000</td>
<td>$13,915,000</td>
</tr>
</tbody>
</table>

In the longer run, it can be argued that transportation savings are shared by producers and consumers. The savings to consumers occurs as a result of a positive supply response on the part of producers. The higher short-run price, created by minimizing \( M \), induces farmers to increase production. Larger supplies push down market price.

Off-River Movements

Beyond the direct savings to producers who ship via water, shippers of grain via rail in the region benefit from lower rail rates caused by intermodal competition, even though the movements never even touch the water. For an
example of the effect of low barge rates on rail rates for Whitman County, Washington, to export ports, see Table 5. Note that the rail rates dropped in 1961, 1968, and 1972. These rail rate reductions correspond nicely, with a slight lag, to the opening of new locks which opened barge traffic to shippers farther upstream. The obvious implication is that expanded water carrier service caused railroads to drop their rates.

If this intermodal competition caused rail rates to be 5 cents per cwt., below what they would otherwise have been, PNW shippers of grain by rail realized savings over $6.7 million dollars in 1977. If rates were 15 cents per cwt. lower, the savings in 1977 is estimated at over $20 million.

Upriver Movements

Thus far, only the benefits from downriver movements have been addressed. A similar situation exists on upriver shipments. Low barge rates reduce the delivered price of commodities shipped to upriver areas. Prices of petroleum products, chemical, and bulk fertilizer are minimized. Likewise, intermodal competition depresses rail rates on these products as well. Users of these products realize the benefits from lower prices.

By and large, upriver shipments are agricultural inputs. Therefore, producers gain from lower production costs, as well as high output prices, in the short run. Again, in the long run, higher returns on production, resulting from lower production costs, may cause a positive supply response and lower output prices to consumers.

Capacity Availability

Shippers and receivers of commodities in the region also benefit from the expanded transportation capacity created by water carriage. A typical transportation problem facing many regions of the country is peak period shortage of transportation capacity. In the PNW, the presence of a high capacity barge system tends to dampen this peak period problem. The capacity available in barges provides short-term excess storage capacity as well.

Rural Economic Development

Waterborne transportation contributes to economic development of regions and communities along the river corridor in several ways. First, economic activity associated with transportation results in a multiplier effect on regional economic activity. Impact multipliers for various economic activities in the PNW were estimated at Washington State University recently (Table 6).

The three multipliers can be interpreted as follows. A one dollar increase in final demand for each productive activity increases the value of the final economic output for the region by a factor equal to its output multiplier. An additional job provided by each productive activity ultimately increases total regional employment by a factor equal to its employment multiplier. One additional dollar of income generated by each activity will increase total regional activity by the income multiplier. An additional dollar of demand for transportation output eventually results in $1.12 worth of output value in the
Table 5. Example of Rail Rates from Whitman County to Portland and Seattle

<table>
<thead>
<tr>
<th>Year</th>
<th>Rate in cents per hundredweight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1931</td>
<td>24</td>
</tr>
<tr>
<td>1939</td>
<td>23</td>
</tr>
<tr>
<td>1949</td>
<td>34-1/2</td>
</tr>
<tr>
<td>1958</td>
<td>45-1/2</td>
</tr>
<tr>
<td>1961</td>
<td>26-1/2</td>
</tr>
<tr>
<td>1966</td>
<td>26-1/2</td>
</tr>
<tr>
<td>1967</td>
<td>29-1/2</td>
</tr>
<tr>
<td>1968</td>
<td>21</td>
</tr>
<tr>
<td>1970</td>
<td>25-1/2</td>
</tr>
<tr>
<td>1972</td>
<td>21</td>
</tr>
<tr>
<td>1973</td>
<td>22</td>
</tr>
<tr>
<td>1974</td>
<td>26</td>
</tr>
<tr>
<td>1975</td>
<td>28-1/2</td>
</tr>
<tr>
<td>1976</td>
<td>30-1/2</td>
</tr>
<tr>
<td>1977</td>
<td>33</td>
</tr>
</tbody>
</table>
Likewise, each additional job in transportation increases total regional employment by 1.12 jobs. And, one dollar's worth of income in transportation increases total regional income by $1.12.

<table>
<thead>
<tr>
<th></th>
<th>Output multiplier</th>
<th>Employment multiplier</th>
<th>Income multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crops</td>
<td>1.17</td>
<td>1.24</td>
<td>1.46</td>
</tr>
<tr>
<td>Mining</td>
<td>1.11</td>
<td>1.02</td>
<td>1.01</td>
</tr>
<tr>
<td>Construction</td>
<td>1.25</td>
<td>1.24</td>
<td>2.60</td>
</tr>
<tr>
<td>Transportation</td>
<td>1.12</td>
<td>1.12</td>
<td>1.12</td>
</tr>
</tbody>
</table>


Note that transportation's multipliers are lower than those for crops and construction. Nonetheless, transportation activity does have an expansionary effect on the region's economy. Moreover, these multipliers are regional in nature. It is safe to assume that the impact is greater in the immediate subregion. Thus, regional transportation multipliers are a minimum and certainly understate the impact of water transportation on the subregion adjacent to the river.

Second, the availability of efficient and abundant transportation contributes to the "critical mass" required for industrial development. Water transportation provides impetus for the creation of port authorities and other institutional entities which serve to attract industrial development investment. Industrial development results in construction activities. The multipliers associated with construction, shown in Table 6, then begin to impact on subregional areas and the region in total. It can be argued that inland water transportation indirectly stimulates economic growth through industrial development.

Benefits from economic growth and business activity accrue to a wide range of individuals and groups. It is, however, impossible, within the scope of this paper, to identify specifically the value and distribution of these benefits.
Port Development

The river has been the primary corridor for grain shipments to export both intra- and interregionally. Grain traffic via barge has contributed to the development of a large grain exporting industry at the Columbia River export ports (Portland, Oregon; Longview, Kalama, and Vancouver, Washington). These ports have overshadowed the other regional ports on Puget Sound (Seattle and Tacoma, Washington) in terms of handling international grain shipment. Commercial navigation has provided the Columbia River ports with a strong advantage in exporting wheat. The impact on regional port development, therefore, creates a bias in favor of Columbia River ports. An analysis of the net effect on the region's growth and on subregional economic activity is beyond the scope of this paper. It is, however, important to note that a decision regarding the increased navigation has implications for planners at the major international ports.

COSTS OF COMMERCIAL NAVIGATION

While commercial navigation on the river system creates a variety of benefits, it also imposes certain costs. These costs occur in two levels. Direct costs are those costs which are explicitly associated with transportation activities. Indirect costs may be thought of as either the cost in terms of other river use foregone, or as costs which are incurred tangential to actual waterway transportation activity.

Direct Costs

Many of the direct costs have already been discussed. These include the costs of construction, maintenance, and operation of navigation aids incurred by the U.S. Army Corps of Engineers. In general, the incidence of these costs accrue to the taxpaying public. While a portion of these costs are now being covered under the fuel tax on water carriers as user charges, a substantial portion continues to be funded from general government funds.

In effect, the public is subsidizing water transportation. Taxpayers' funds are used to reduce the costs of operations for water carriers, and thus reduce the rates paid by waterborne shippers. It should be remembered that other modes receive public subsidies, in one form or another, as well. In any case, the direct beneficiaries of water carriage do not always pay the full costs associated with the benefits received.

In the longer run, it could even be argued that public expenditures on water transportation may serve to subsidize foreign consumers of PNW wheat. Positive production responses, induced by low transportation costs, tend to ultimately reduce prices foreign consumers pay for PNW wheat. In this sense, U.S. government funding of water transport facilities and operation creates an income transfer from U.S. taxpayers to foreign consumers of wheat.

Indirect Costs

Indirect costs are more difficult to precisely measure, but are as real and as significant as direct costs, and may well be very important in
evaluating alternative uses of Columbia water. A significant indirect cost of navigation on the river is the cost of energy generation foregone as a result of lockage activities. Assuming that each lockage operation at each dam moves an average of 3,000 tons of freight and that upriver shipments account for 25 percent of river tonnage, then approximately 16,324 lockages were necessary to move 1977 tonnage. Since each lockage uses about 107 acre feet of water, the loss of power generation caused by not having this water to turn hydroelectric turbines can be computed. It is estimated that 1977 navigational activities reduced power generation by about 116 million kilowatt hours. Valuing electricity at 35 mills per kilowatt hour (which may be an underestimate), the estimated dollar value of loss in one year is about $405,000.\textsuperscript{13}

The loss of hydroelectric capacity may increase the demand for less desirable, or "dirty", energy sources. As demand for electricity pushes against supply capacity of hydroelectric dams, the economic incentives and political pressure for further nuclear power development increase. Some find this an unacceptably high cost alternative and, therefore, an unacceptable solution to the energy crisis.

The impact of navigation on irrigation is difficult to assess, since the state of water availability in the river, in any given time period, will directly affect the way in which these activities interrelate. In a dry year, navigation may adversely impact on irrigation from any particular river pool. The water loss from the pool, due to locking through barge traffic, will reduce, by 107 acre feet, the water available from the pool. On the other hand, both irrigation and navigation require some minimum stream flow. Consequently, river management policy favorable to navigation may also be favorable for users of irrigation water, particularly in a normal or wet year.

An indirect cost of river navigation, which can be estimated, is the cost incurred by communities adjacent to the river and associated with road damage from truck traffic feeding barge loading facilities. Often, this cost is overlooked or underassessed in cost-benefit studies of navigation expansion plans. An example of the magnitude of this cost is the highway damage to feeder roads serving the Port of Lewiston, Idaho. Using the N18 factor as a measure of pavement damage imposed by a loaded 5-axle tractor and trailer (42 tons gross weight, 24 tons payload), it can be estimated that 1.724 N18 passes are imposed per highway mile. On a bituminous surface designed for 1,000,000 N18 per mile passes with a resurfacing cost of $100,000 per mile, the cost per N18 per mile is 10 cents, or 17.24 cents per loaded truck pass.

In 1978, 39,328,266 bushels of grain were trucked into the Lewiston port. Assuming 800 bushels per truckload, this amounts to 49,160 loaded truck passes. Thus, the loaded damage from grain trucking caused an estimated $8,475 per mile in highway wear. This estimate does not include additional highway wear created by the return movements of these trucks.

Truck operators do repay a portion of the damage cost through fuel taxes. However, most studies indicate that fuel tax revenues fail short of the costs inflicted by the larger, heavier trucks. Further, most fuel tax receipts accrue to the federal government, while a substantial portion of local road maintenance must be financed locally.

Since a large share of the grain freight originates outside the local region, local taxpayers may then be subsidizing shippers in other regions. Returning to the Lewiston example, 59 percent of the grain trucked to port in 1978 originated outside Idaho, largely in Montana. These shipments resulted in an estimated $4,999 per mile damage (of $8,475 per mile total) on local highways and roads. Local communities realized little tax or other revenue from this traffic.

Thus, the economic development benefits which arise from river port activities are not without costs. Though a specific comparison of the value of benefits, relative to costs, is beyond the scope of this paper, it can be inferred that most local policymakers in port communities view the ratio as greater than one. This can be inferred from the fact that most of these communities have actively pursued increases in this type of traffic volume.

An additional indirect cost of navigation, which deserves recognition but is not easily measurable, is the cost of damage to the river ecology which results from navigation. Two general types of damage may occur. One is the continual impact of barge operation. For example, there is some evidence that the propellor action of tow equipment disturbs the bottom material of the channel. Also, propellor wash may incrementally increase erosion on the river shores.

The second type of damage is the impact of occasional barge spills. The likelihood of a spill or accident increases as navigational activity expands. The potential environmental damage from spills becomes more critical when petroleum or chemical products are involved. A recent spill (October 6, 1979) of 60,000 gallons of diesel fuel near Boardman, Oregon, underscores the potential threat from growth in this traffic on the river.

14 In 1977, 21,962,967 bushels of grain accounted for 27,453 loaded truck passes on $4,232 damage per mile.
15 The cost of this traffic originating out of Idaho is estimated at $1,675 per mile in 1977, using the N18 factor.
16 In June 1978, 65,000 gallons were accidentally released into the river at Kelley Point.
The preceding discussion outlined some of the benefits and costs associated with commercial navigation as an alternative use of Columbia Basin water. What should be clear is that water use policy involves tradeoffs and conflicts. When a decision to expand or promote one use is made and imposed, it may result in limiting certain other uses. Or, alternatively, such a decision may create positive externalities in terms of some uses. Table 7 attempts to summarize the implication of navigational use of the river with respect to energy, irrigation, recreation, and fisheries, along with related economic activities.

Energy and navigation clearly are conflicting water resource uses, especially since energy demands and new regional energy allocation schemes have eliminated spillage of any water. Water lost through locks is water foregone for energy generation. A value for this lost energy has already been presented.

Irrigation and navigational use may or may not represent a tradeoff, depending upon the river level. Conflict will only occur in low water situations where further irrigation is not allowed because of minimum stream flow necessary for navigation.

Aids to navigation also serve recreational users of the river. Boaters and fisherpersons are entitled to lockage privileges at the dams. Though these aids were originally built to accommodate commercial river traffic, all river vehicles receive lockage services free of direct charge. Conflicts do arise from congestion by both types of users demanding lockage. As recreational boating has increased, barge operations have been slowed. Likewise, barge traffic creates safety hazards for other river users.

Navigation has both positive and negative effects on fisheries. Minimum stream flow required for navigation does contribute to successful fisheries activities and vice-versa. Moreover, barges have been used to transport salmon smolts around dams thus assuring maximum effective production.

Conversely, dredging and construction activity adversely affect fisheries. Damage to fisheries may also occur from contamination arising from spills or barge accidents. Rural communities, adjacent to the river, benefit from the economic multiplier effects of transportation and induced industrial development. However, the implications of navigation encourage grain exports through the Columbia River ports, probably at the expense of the Puget Sound ports.

Increased freight traffic to the river, via truck, accelerated the deterioration of rural roads and bridges. The incidence of repair and maintenance expenses may fall heavily on adjacent communities, while a substantial share of the benefits may accrue out of the region.

The significant point to be emphasized is that transportation, while conflicting with some water resource uses, may complement other uses as well. Policy tradeoffs designed to allocate this resource must be sensitive to these conflicts and complementarities. In some instances, values of cost and benefit
Table 7. The Impact of Navigation on Other River Resources Uses and Related Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydroelectric generation</td>
<td>(-) Loss of water for generation due to lockage.</td>
</tr>
<tr>
<td>Irrigation</td>
<td>(-) Minimum stream flow and pool depth required during periods of low river levels.</td>
</tr>
<tr>
<td></td>
<td>(N) Minimum stream flow during periods of normal or high river levels will not measurably affect pool depth.</td>
</tr>
<tr>
<td>Fisheries</td>
<td>(-) Possible water contamination due to construction of navigational aids or barge spillage from accidents.</td>
</tr>
<tr>
<td></td>
<td>(+) Minimum stream flow required, use of barges to transport salmon smoots around dams.</td>
</tr>
<tr>
<td>Recreation</td>
<td>(-) Conflict in use of river and locks.</td>
</tr>
<tr>
<td></td>
<td>(+) Lock availability and maintenance, minimum stream flow.</td>
</tr>
<tr>
<td>Rural Community Development</td>
<td>(+) For communities with access to river transportation through income, employment multiples of transportation and industrial &quot;critical mass&quot;</td>
</tr>
<tr>
<td>Rural Roads and Bridges</td>
<td>(-) Increased feeder truck traffic to river.</td>
</tr>
<tr>
<td>Export Port Development</td>
<td>(-) Puget Sound ports.</td>
</tr>
<tr>
<td></td>
<td>(+) Columbia River ports.</td>
</tr>
</tbody>
</table>

(+): Positive affect of transportation or activity.
(-): Negative affect of transportation or activity.
(N): Neutral relationship between transportation and other activity, or indeterminant.
relationships can be estimated. In other instances, they can only be recognized and assessed in a non-quantitative (political) context.

CONCLUDING COMMENTS

Navigational use of the rivers' water resources in the Pacific Northwest makes a variety of contributions to the economy of the region. It provides low cost, energy efficient service to shippers and receivers of bulk freight in the region and links the PNW to other eastern markets. It provides strong inter-modal competition to railroads, stimulating system efficiency and minimizing transport rates to producers and consumers. Navigation stimulates economic development at inland river ports, export ports, and adjacent subregions. In some instances, it complements other river uses.

Navigation service is no longer a free water resource use. Opting for commercial navigation involves explicit and implicit (opportunity) or indirect costs. Explicit costs arise from public provision (subsidy) of navigation aids and way. Frequently, the direct beneficiaries of these aids do not bear the incidence of the associated costs. However, it is often argued that society is served from such subsidies in that transportation efficiency is served and the service transfer involved is consistent with national equity objectives.

Until recently, the water resource base of the PNW seemed almost limitless. Conflicts in use appeared minimal and expansion of each use was encouraged. We have entered an era, however, when growth will increasingly demand public decisions on resource allocation. An understanding of, and an appreciation for, the interrelatedness of Columbia Basin water uses will be critical in making and implementing allocation policy. Commercial navigation must be considered along with other uses in the policymaking process.