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COLUMBIA-NORTH PACIFIC REGION COMPREHENSIVE FRAMEWORK STUDY OF --ETC(U)
AUG 71 W O BASHAM, R B HATCH, G C HOARE

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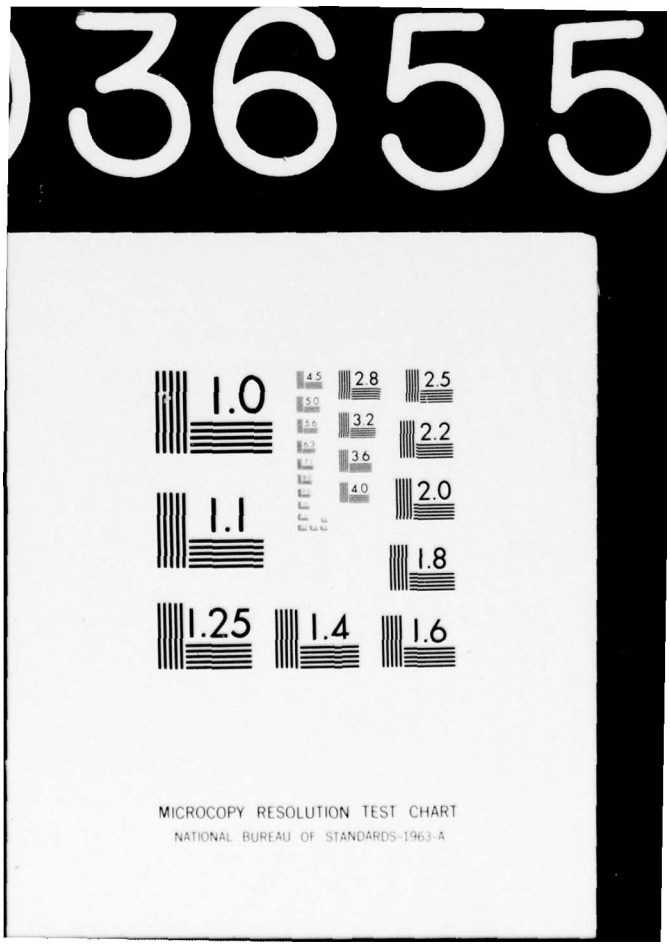
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Columbia-North Pacific Region

Comprehensive Framework Study
of Water and Related Lands

APPENDIX X

NAVIGATION

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SUBMITTED BY

PACIFIC NORTHWEST RIVER BASINS COMMISSION
1 COLUMBIA RIVER, VANCOUVER, WASHINGTON

AUGUST 1971

This appendix is one of a series making up the complete Columbia-North Pacific Region Framework Study on water and related lands. The results of the study are contained in the several documents as shown below:

Main Report

Brochure Report

Appendices

I. History of Study

II. The Region

III. Legal & Administrative Background

IV. Land & Mineral Resources

V. Water Resources

VI. Economic Base & Projections

VII. Flood Control

VIII. Land Measures & Watershed Protection

IX. Irrigation

X. Navigation

XI. Municipal & Industrial Water Supply

XII. Water Quality & Pollution Control

XIII. Recreation

XIV. Fish & Wildlife

XV. Electric Power

XVI. Comprehensive Framework Plans

Pacific Northwest River Basins Commission
1 Columbia River
Vancouver, Washington

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APPENDIX X

Columbia-North Pacific Region
Comprehensive Framework Study

of Water and Related Lands. Appendix X. Navigation,

Walter O. Basham, Roscoe B. Hatch,
Gordon C. Hoare, Floyd Schultz
Lewis R. Smith

August 1971

263 p.

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Submitted by

Pacific Northwest River Basins Commission
Vancouver, Washington

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AB

APPENDIX X
Navigation

Prepared under the direction of the
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Basic data were obtained from various State and Federal agencies too numerous to record. Members of the Navigation Study Group wish to thank each one for his contribution and cooperation which made completion of this manuscript possible.

This appendix to the Columbia-North Pacific Region Framework Report was prepared at field level under the auspices of the Pacific Northwest River Basins Commission. It is subject to review by the interested Federal agencies at the departmental level, by the Governors of the affected States, and by the Water Resources Council prior to its transmittal to the President of the United States for his review and ultimate transmittal to the Congress for its consideration.

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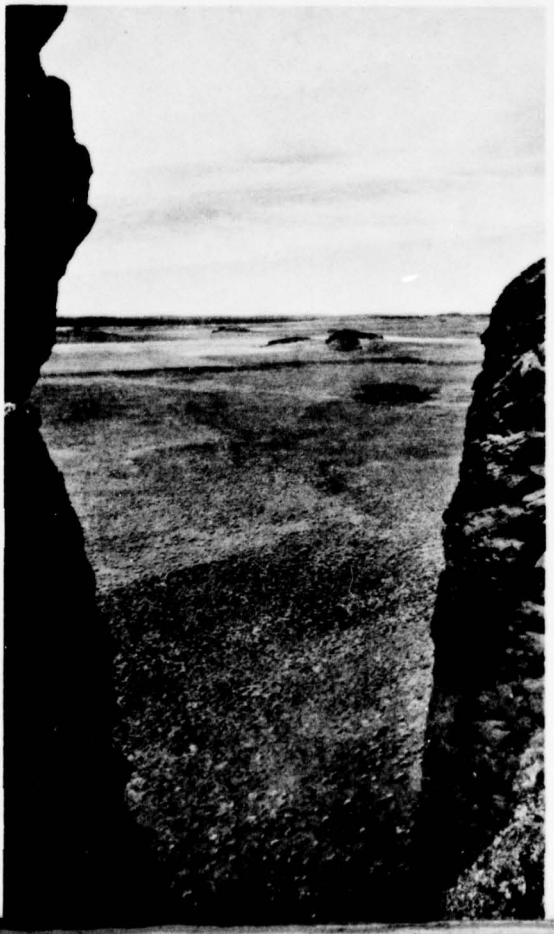

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INTRODUCTION

PURPOSE AND SCOPE

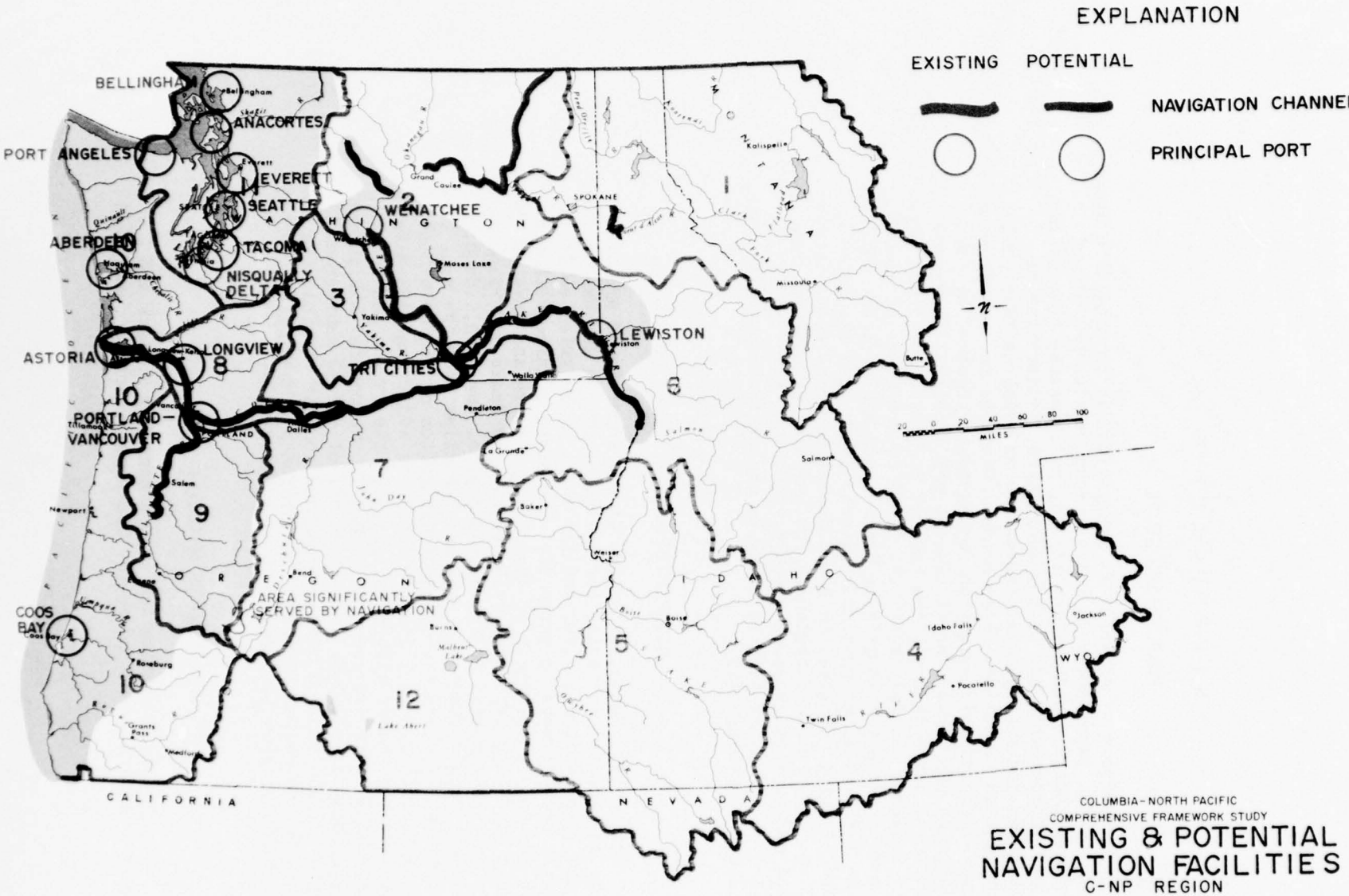
The purpose of Appendix X, Navigation, is to provide a broad picture of the important role water transportation has played in the economic development of the region, an inventory of existing waterway improvements and harbor facilities, projections of future needs and some general indication of measures that could be constructed to satisfy those needs. Measures to satisfy needs include all facets of navigation improvements required by commercial deep and shallow draft vessels and smaller fishing and recreational boats that ply the Pacific Ocean along the 500 miles of the region's coastal front, the 2,500 square miles of almost landlocked salt water comprising Puget Sound and adjacent waters, and the 2,880 miles of navigable rivers, lakes, and estuaries as defined by Act of Congress or court decisions or as designated by the U. S. Army Corps of Engineers for purposes of administering the Act of Congress approved March 3, 1899 (30 Stat. 1151; 33 U.S.C. 403) and other Acts relating to use of the navigable waters of the United States. (19)

DESCRIPTION

The Pacific Ocean, waterways of the Puget Sound area in Washington, coastal estuaries and rivers of Oregon and Washington, plus the lower Columbia River and its major tributaries constitute a network of waterways to serve the waterborne transportation needs of the region. Development of channels and locks and dams on the Columbia River and its major tributaries, the Snake and Willamette Rivers, provides access to Pasco, Washington; Lewiston, Idaho; and Albany, Oregon about 300, 465 and 220 miles from the sea, respectively. (Future extension of navigation on the Columbia River to Wenatchee, Washington would add an additional 125 miles to the system.) Major waterways, ports of the region and subregional boundaries are shown on Figure 1. Commercial navigation is significant or could be developed in 7 of the 12 subregions. Subregions 2 and 6, 7, 8, and 9 cover portions of the Columbia River Basin, Subregion 10 covers the Oregon and Washington coastal areas, and Subregion 11 covers the Puget Sound area.

PRESENTATION OF MATERIAL

The appendix is organized into a regional summary and 7 subregion chapters, which cover the areas pertinent to commercial



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

EXISTING & POTENTIAL NAVIGATION FACILITIES
C-NP REGION
1970

FIGURE 1

navigation. The regional summary presents a historical picture of the role water transportation has played in the development of the region and its contribution to the region's growing economy. Existing navigation facilities, types of vessels and a general description of the types and amounts of commerce are presented. A broad range of the region's needs are projected for the years 1980, 2000, and 2020. Measures to satisfy needs cover all facets of navigation improvements to accommodate the future fleet of vessels serving the region. Each subregion chapter is similarly organized but includes a minimum of historical coverage. For this appendix in discussions of navigation, the boundaries of subregions 8, 9, and 10 have been modified to include all of the deep draft navigation on the lower Columbia River, including Portland harbor, in a single presentation under Subregion 8. Details are given in the subregion chapters.

AGENCY CONTRIBUTIONS

The Corps of Engineers was designated lead agency for the navigation study. Much of the data and information utilized in the study were furnished by the Department of Transportation, the States of Oregon, Washington, and Idaho and numerous local port authorities.

REGIONAL SUMMARY

THE REGION

HISTORY

Present day waterborne commerce has roots deep in Pacific Northwest history as much of the exploration, settlement, and development of the region was accomplished by the use of water transportation. The Pacific Ocean provided access to the coastal bays and rivers in the early days and has been used since in the establishment of significant coastwise and foreign trades. Transportation on the Columbia and other rivers was vital to the opening and settlement of the interior and has been important in building internal and supplementing external commerce.

Exploration

A host of famous early explorers, including Cabrillo, Cook, Drake, Heceta, Meares, and Perez sailed along the north Pacific coast prior to 1785 and charted points along the Oregon and Washington coasts. In 1792 Captain Robert Gray, an American, entered the Columbia River. In 1804, President Jefferson sent the Lewis and Clark party to explore the overland route from St. Louis, Missouri, to the Pacific Ocean. Their instructions included the following: "The object of your mission is to explore the Missouri River, and such principal stream of it, as, by its course and communication with the waters of the Pacific Ocean, may offer the most direct and practicable water communication across this continent, for the purposes of commerce." (2)

By 1810, fur traders, in dealing with the Indians, were pioneering water routes into the interior with canoes and other small craft. Interest in the fur trade led to the founding of several trading posts. American fur traders established Astoria at the mouth of the Columbia River. Later, the operation was taken over by the British and moved to Vancouver, 100 miles upstream, in 1825. Vancouver became the noted regional trading and supply center and the port of call for many ships.

Settlement

After 1840, Americans came in even greater numbers to the Oregon Country. Most of the early settlers were headed for the Willamette Valley, and later groups spread out into the Puget Sound and coastal areas. The main route of the "Oregon Trail" followed

the course of the Columbia River as far as The Dalles whence many groups were ferried down river through the Columbia Gorge while others detoured through the Cascade Range south of Mt. Hood. As the region's population increased, agriculture, lumbering, and fishing became the principal industries. Products of these new industries were shipped to California, the east coast, Europe, and other world areas. The period 1850 to 1900 was the colorful era of the river steamboat. Sternwheeler service on Puget Sound and the Columbia River system provided for the internal distribution of imported goods and the movement of products for export through the major ports of Seattle and Portland. The first cargo of export lumber was loaded from the wharves at Portland in 1851 and the first export shipments of ship spars originated from Puget Sound ports in 1853. From the days of the first settlement until completion of the transcontinental railroad in 1883, the region was almost entirely dependent on water transportation for the movement of commerce.

Development

Early navigation along the regional coastline was extremely hazardous; storms were frequent, and coastal river entrances had treacherous bars and many shoals. The only natural deep water port areas that offered emergency protection were located in Puget Sound waters.

Lower Columbia

Until the Columbia River entrance was improved with construction of the south jetty (1885-1895) and later with a north jetty (1913-1917) sailing ships had extreme difficulty in crossing the entrance bar. It has been estimated that about 2,000 vessels, from small fishing craft to deep-sea cargo ships, and 1,500 lives have been lost at or near the Columbia River entrance. Prior to 1900, the river had from one to three constantly changing channels at its mouth, so that shoaling and breakers were common. In spite of these difficulties, commerce increased steadily.

The upriver route to Portland was tortuous and the channel not well marked. As ships in the world fleet increased in size and draft, Portland became more difficult to reach from the sea. Dredging of the river channel was initiated in 1873, but maintenance of a 25-foot depth was not fully effective until after 1900.

Coastal

A number of coastal entrances were also improved during the period 1880 to 1900. Coos and Yaquina Bays, Coquille and Siuslaw Rivers and Grays Harbor were all improved by entrance jetty systems to serve the needs of navigation. Shipping from these and other coastal points increased as products from logging, fishing, and agriculture developed.

Mid Columbia

The Columbia River and the larger tributaries were navigated by river craft from the days of early settlement, but some reaches of the river above Vancouver were very difficult or impossible to navigate. In the 1850's portages were established at Cascade Rapids and Celilo Falls. Freight costs were high because of the many loadings and unloadings associated with such portages. Nevertheless river traffic developed and prospered until 1882, when a railroad parallel to the south bank of the river from Wallula to Portland interposed serious competition. Shortly afterward river service was abandoned. Sporadic attempts to revive navigation were made later but difficulties of navigating the river could not be overcome with profit to the operators although considerable work was performed by the Federal government to improve critical locations.

Cascade Locks, bypassing Cascade Rapids, were completed in 1896; and The Dalles-Celilo Canal, around Celilo Falls, was completed in 1919, extending through navigation to Pasco-Kennewick. However, major interest in navigation above Vancouver did not pick up until about 1933, about the time that construction was started on a lock and dam at Bonneville. Construction of other dams greatly improved navigation conditions on the middle Columbia, and river traffic has increased with the completion of each dam. The Bonneville Lock was opened in 1938, McNary in 1953, The Dalles in 1957 and John Day in 1968. On the Snake River four locks and dams, Ice Harbor, Lower Monumental, Little Goose and Lower Granite, (under construction), provide slackwater navigation to Lewiston, Idaho.

Willamette River

Steam vessels were introduced on the Willamette River above the falls in 1851, and regular runs were established to Salem and Albany. Some traffic was extended all the way to Eugene. Locks were constructed around the falls at Oregon City in 1873, but traffic on that river also dwindled after completion of the

railroads in the 1880's. However, commerce never completely stopped as on the Columbia although movement of rafted logs is about the only commerce above Oregon City at this time.

Puget Sound Area

In the Puget Sound area, navigation has developed without a great deal of channel improvements because natural deep water obtains into the bays and inlets used for port development. Early channel work comprised primarily clearing and snagging with minor dredging at the mouths of the Snohomish, Skagit, and Stillaguamish Rivers. Lake Washington Ship Canal, constructed in 1916, connects Lake Washington and Lake Union to deep water in Puget Sound. The major port of Seattle developed along Elliott Bay and has been extended to additional industrial areas along Duwamish Waterway by dredging. Tacoma Harbor developed along Commencement Bay and has been expanded onto the delta of the Puyallup River by dredging deep draft access channels and using the spoil to fill surrounding areas. Other ports in the Puget Sound area that handle significant portions of the waterborne commerce include Everett, Anacortes, Port Angeles, Bellingham, and Olympia.

Stimulating Factors

Growth of waterborne commerce has closely paralleled that of population and economic expansion in the region. The discovery of gold and development of the mining industry in California and later at several locations in the region occurred when water routes provided virtually the only means of transport. Growth in the Puget Sound area was stimulated by the transcontinental railway system in the 1880's, and the discovery of gold in Alaska in 1897 caused a dramatic increase in activity on the Seattle waterfront. Probably the most important single event in the long-term development of navigation in the region, however, was the opening of the Panama Canal in 1914. Much of the more recent increases may be attributed to the general economic growth of the Pacific Northwest and to the improvements that have been made in rivers and harbors. The following table illustrates the more recent growth in volume of oceanborne commerce and the contribution of each of the three major areas of the region.

Table 1 - Oceanborne Commerce, Columbia-North Pacific Region

Year 1/	Puget Sound Area	Columbia R. System	Coastal Area	Regional Total
		(1,000,000 short tons)		
1937	11.7	6.3	1.8	19.8
1947	10.2	6.6	1.1	17.8
1957	13.1	13.1	2.6	28.8
1967	18.6	16.6	5.1	40.3

1/ Three-year average.

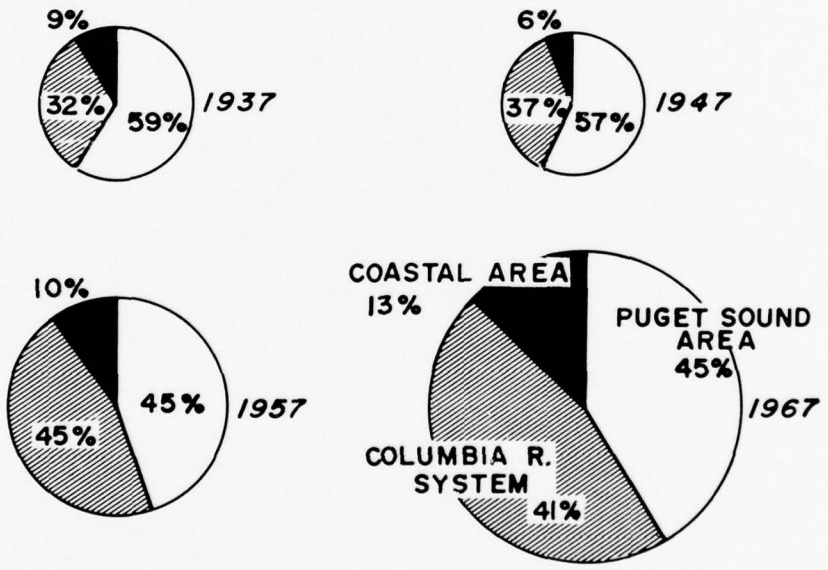


Figure 2. Distribution of Oceanborne Commerce, Columbia-North Pacific Region

REGIONAL ECONOMY

The Columbia-North Pacific Region has a young but maturing economy. The population has increased from about 13,000 in 1850 to nearly 6 million in 1970. This growth resulted from increasing economic activities based primarily on the utilization of abundant natural resources. Forests, farmlands, minerals, and fish have been the historical foundation of its development, increasingly supplemented by more intensive use of water resources for irrigation, hydroelectric power, and navigation. In the recent past,

the historical dominance of the natural resource industries has been reduced by the growth of other industries which have created a broader economic base.

Regional population growth rates have exceeded the national rates in all but 2 of the last 10 decades. Between 1940 and 1965, the population grew by 70 percent compared with national growth of 47 percent. The population density in 1965 was just over 22 persons per square mile, a density well short of the national average of 55 per square mile. The population is unevenly distributed, however. Nearly two-thirds of the people live in the one-fifth of the region west of the Cascade Range and the population density in that area exceeds the national average. The greatest density is around Puget Sound and in the Willamette Valley where favorable factors of climate, rich soil, water transportation, and timber resources have been conducive to the establishment of centers of industry and trade. East of the Cascades smaller population concentrations have developed in the rich irrigated agricultural areas of the Snake River Plain and the Columbia Plateau and in the mining centers of the Rockies.

The forests and agricultural lands have been historically the greatest wealth of the region. Forest lands comprise 86 million acres or approximately half of the total land area, and wood products account for 35 percent of all manufacturing employment. Out of the 174 million acres in the region, 21 million acres are cropland and 59 million are rangeland. Agriculture production in 1964 amounted to over $1.5 billion and production is expanding. Because of rapid productivity gains, agriculture employment declined from 18 percent of total employment in 1940 to 7 percent in 1960. Mining is important in some parts of the region. Copper, lead, zinc, and phosphate are major mineral products. Anadromous fish populations in the Columbia River system and coastal and Puget Sound streams have supported a commercial fishing industry since the middle of the 19th Century, and sport fishing for salmon, steelhead, trout, and other species is increasing.

The changing character of the economy has been most evident in the changes in its manufacturing sector in recent years. Manufacturing grew from 19 percent of total employment in 1940 to nearly 23 percent in 1960. During this same period, employment in the resource-based industries of food processing and timber industries increased 40 percent. Growth of other manufacturing was so great, however, that food processing and forest products manufacturing declined in relative importance, from 70 percent of total manufacturing employment in 1940 to about 50 percent in 1960. Principal among the expanding industries have been transportation equipment, electronics, electrometals, and machinery.

Utilization of water resources for transportation has been significant in the region's economic development. Most important in this respect has been the region's location adjacent to the Pacific Ocean and the two major waterways, Puget Sound and Columbia River, which provide access to a large part of the interior. Foreign and coastwise trade have been essential in the region's growth, permitting export of its surplus agricultural and forest production and importation of consumer goods and raw materials required for manufacturing. In addition to the Puget Sound and Columbia River outlets, a number of coastal harbors have been developed for the shipment of lumber and other forest products. These and other smaller harbors provide a base of operations for a large fishing fleet, supporting one of the region's major industries. Recreational boating use in the region is among the highest in the country, fostered by the abundance of navigable waterways, both natural and improved.

EXISTING NAVIGATION IMPROVEMENTS

Navigation facilities are discussed in the following categories: Deep-draft habors and channels, shallow-draft harbors, interior shallow draft channels, port facilities, and small boat facilities. Vessels with draft in excess of 18 feet are considered deep draft. Harbors, channels, and facilities to accommodate such vessels are referred to herein as deep draft. Vessels with total draft of 18 feet or less are considered shallow draft. Small boats include all self-propelled vessels other than tugs or towboats less than 50 feet in overall length.

Deep-Draft Harbors and Channels

There are 16 harbors in the Columbia-North Pacific Region considered as principal deep-draft ports capable of handling ocean-going vessels. Puget Sound and the Columbia River are the two most important bodies of water in the region's ocean trade, serving respectively its two largest metropolitan areas, Seattle and Portland, and other important centers of industry and trade. Foreign and coastwise commerce of the Puget Sound and Columbia River ports account for approximately 86 percent of total regional shipping in these two categories.

Puget Sound and the adjacent inland waters, with direct access to the Pacific Ocean through the Strait of Juan de Fuca, are essentially a huge natural harbor with depths capable of accommodating the world's largest super carriers. Entrances to most harbors within the sound permit unrestricted access and are protected from ocean waves and storms. Depths at berths and docks

vary from 25 to 70 feet. There are seven major deep draft ports on the sound: Bellingham, Anacortes, Everett, Seattle, Tacoma, Olympia, and Port Angeles. Anacortes and Olympia have controlling depths at the harbor entrance of 50 feet and 40 feet, respectively, while the remaining five have unrestricted depth. In varying degrees of specialization, these ports serve the general cargo trade, the export grain trade, foreign and coastwise shipments of lumber products, and receipts of crude oil and shipments and receipts of petroleum products.

The Columbia River, together with the Willamette River to Portland, provides the principal waterborne outlet for a large part of Oregon, Washington, and Idaho. Its entrance channel, improved to a depth of 48 feet, and 40-foot interior channels extend deep draft navigation service 106 miles upstream to Vancouver, Washington, and 12 miles on the lower Willamette River to Portland, Oregon. Portland, at the head of the existing deep-draft channel, is the principal general cargo port on the river and the major trans-shipment point for commerce moving to and from the interior. Export grain and shipments of forest products are among the principal outbound items of commerce. There are no major refineries on the Columbia River; a large part of the area's requirements for petroleum products is brought into the Columbia River by deep-draft tanker and distributed by barge and truck into the interior. Alumina and other ores for the area's industries are important import items of commerce. Other major ports on the Columbia River include Vancouver, which handles large quantities of grain, wood products, chemicals, and ores; Longview ships large quantities of grain and forest products; Kalama and Astoria are important in the export grain and log trade, respectively. In addition, many industries along the river have specialized facilities for their particular shipping needs.

Deep-draft ports on the Oregon and Washington coast have been developed primarily to serve the forest products industry. Principal among the lumber shipping ports is Coos Bay, Oregon, which has a harbor depth of 30 feet. Other lumber shipping ports are Yaquina Bay, Oregon, and Grays Harbor and Willapa Bay, Washington, with authorized channel depths of 30, 30, and 24 feet, respectively.

Shallow Draft Harbors

The deep-draft waterways and harbors on Puget Sound, in the Columbia River, and along the Pacific Coast are extensively used by small commercial craft and recreational boats. In addition, many other harbors in the region, both natural and improved, are used exclusively by shallow draft commercial and recreational

traffic. In the Puget Sound area, approximately 100 minor harbors and waterways are used primarily for rafting of logs, barge shipments of sand and gravel, ferry traffic, and for fishing and recreational boats.

Side channels along the deep-draft channel in the lower Columbia River provide harbors for tugs and barges, fishing boats, and recreational craft. Ocean-going tugs and barges use this section of the river and there is considerable barge movement of sand and gravel, petroleum products, and forest products on the waterway. Movement and storage of log rafts comprise a large part of internal movements on the waterway. Channels and basins specifically for use of fishing craft and other small boats have been provided at four locations in the estuary of the river. Some 8 or 9 small tributary streams and sloughs between Astoria and Portland have also been improved in their lower reaches, primarily for movement of log rafts.

Several shallow draft harbors along the Oregon coast have been improved for use by commercial fishing craft and recreational boats and for barge movement of lumber in the coastwise trade.

Harbor facilities along Willamette River at Portland. (Ackroyd Photo)

These include entrances at Chetco, Coquille, Rogue, Umpqua, and Siuslaw Rivers; Port Orford; and Tillamook Bay. Protected moorage basins limited to fishing and recreational craft are located at Depoe Bay, Oregon, and the mouth of the Quillayute River, Washington. In addition, two natural harbors along the Strait of Juan de Fuca are used by sport and commercial fishing boats and for shipment of rafted logs.

Interior Shallow Draft Channels

The most important inland waterway in the region is the Columbia-Snake barge channel which, upon completion in 1975, will extend from the head of deep water navigation at Vancouver to the Pasco-Kennewick area on the Columbia and to Lewiston on the Snake River, 465 miles from the sea. An open river channel is maintained to a minimum depth of 15 feet from Vancouver to Bonneville Dam. The remainder of the waterway is a slack water channel with locks at eight dams on the Columbia and Snake Rivers. Lock dimensions are 86 by 675 feet, with a minimum sill depth of 15 feet, except at the lowermost dam, Bonneville, which has a lock chamber 76 by 500 feet and sill depth of 24 feet. Minimum channel dimensions are 14 by 250 feet. This important waterway connects the agricultural hinterland with the deep draft ports on the lower Columbia River. Downriver movement of grain for transshipment to export markets is a major movement on the Columbia-Snake waterway; upbound commerce includes petroleum products, fertilizer, and other supplies for the interior region.

The Willamette River above Portland has an improved open river channel with a depth of 8 feet to Oregon City, 6 feet thence to the confluence with the Santiam River, 5 feet to Albany, and 2-1/2 feet to Corvallis, and a series of four locks at Willamette Falls, 37 by 175 feet, with a minimum sill depth of 6 feet. The channel is used primarily for towing log rafts and, in its lower reaches, for barge movement of sand and gravel.

An open river channel in the Snake River extends 90 miles above Lewiston. Commerce is not large but the channel is significant in that it provides the route for a regular mail boat run carrying supplies to isolated areas along the river. Other rivers in the region are not used for commercial navigation except for local movements of log rafts and sand and gravel on their tidal reaches. Among these are the Snohomish and Skagit Rivers in the Puget Sound area as well as a number of inlets and channels in Puget Sound waters. The tidal reaches of some of the Oregon coastal rivers are used similarly, chiefly the Umpqua, Yaquina, Siuslaw, and Smith Rivers.

Recreational boating enthusiasts in increasing numbers are taking advantage of the through inland waterway as it has been extended upstream. In addition, the individual reservoirs are used extensively for recreational boating. Marinas have been established or are being planned on many reservoirs. Small boat basins have been built at many locations along the Columbia River.

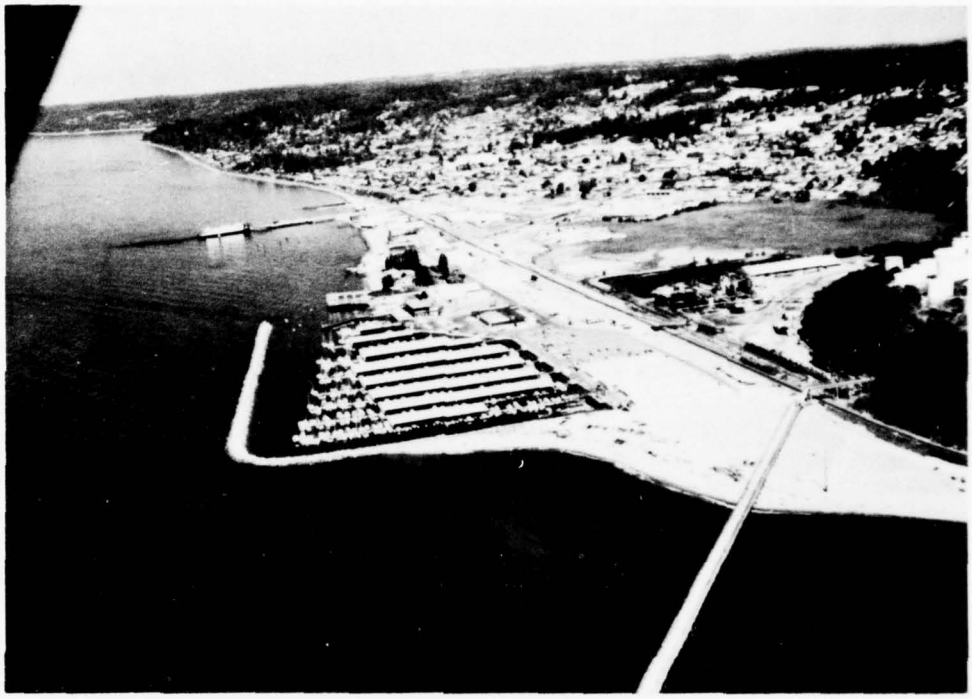
Port Facilities

Port facilities are available throughout the region to meet the requirements of vessel traffic and commerce at each port. The major ports, such as Seattle and Portland, have extensive terminal facilities, including general cargo wharves, grain elevators, facilities for containerized cargo, petroleum and chemical storage facilities, and bulk cargo handling facilities. Terminal facilities along the Columbia-Snake inland waterway include grain elevators, petroleum storage tanks, and facilities for storage of bulk cement and fertilizer.

Excellent dry dock facilities are available on Puget Sound and at Portland for repair of marine vessels in commercial service and the Navy maintains a repair yard at Bremerton. The facilities are capable of handling the largest vessels which call at the regional ports. Similar facilities are available for small boats at most port cities in the region. Adequate bunkering facilities are available throughout the region.

Small Boat Facilities

Nearly 28,000 small boat moorage spaces are available on the navigable waterways throughout the region. Not included are unattended moorages at parks or recreational areas, private moorages at yacht clubs, or single-owner moorages. Most small boat moorages also provide fuel, stores, and other marina services. In addition to the moorages there are launching facilities for trailered boats numbering nearly 600 lanes of ramps or equivalent hoists. Fifty-seven percent of the moorage facilities and 37 percent of the launching facilities are located in the Puget Sound area. In 1966 there were 21 public and 119 private marinas in the Puget Sound area to serve the needs of small fishing and pleasure boats. In the eastern part of the region, boat launching ramps are usually associated with picnicking and camping facilities.



Small boat facilities at Edmonds harbor. (USCE)

Harbor facilities at Anacortes. (USCE)

EXISTING COMMERCE

In 1968, nearly 106 million tons of commerce were moved over waterways in the region. This total comprised 28.4 million tons of foreign imports and exports (27 percent), 16.4 million tons of coastwise shipments and receipts (15 percent), and 61.0 million tons of internal and local movements (58 percent). Although the region has only 3 percent of the Nation's population and produces only 3 percent of the total output, about 6 percent of the Nation's oceanborne commerce moves over the region's waterways. By like comparison, the region's share of foreign imports was about 3 percent but it handled 10 percent of total foreign exports; its share of the coastwise commerce was a little over 7 percent. The two principal ports of the region, Seattle and Portland, ranked 9th and 10th nationally; handled 40 percent of the region's oceanborne commerce. Table 2 presents waterborne statistics for the principal ports and regional totals for foreign imports and exports, coastwise shipments and receipts, and internal movement of commerce for the year 1968. Additional data on tonnages by commodity groups are shown in the subregion discussions.

Foreign Trade

The export trade, 20 million tons, comprised primarily forest products, 60 percent, and grain, 30 percent. Although destinations included countries in all parts of the world, the major proportion of the outbound cargo was destined for Japan and southeast Asia. Imports, totaling more than 8 million tons in 1968, were more varied and a larger proportion was classified as general cargo. The major bulk movement was mineral ores, primarily alumina and limerock. To these shipments were added iron ore slurry from Peru in 1970. General cargo imports are primarily from Japan and Europe.

Coastwise Trade

In 1968, 16.4 million tons of domestic coastwise freight was handled by ports in the region. This trade includes intraregional port movements as well as movements between Columbia-North Pacific ports and other regions--California, Alaska, Hawaii, and the East Coast. The principal commodities are forest products, petroleum, and chemicals for the forest and agriculture industries There is some coastwise barge movement, primarily to California, Alaska, and Hawaii.

Table 2 - Waterborne Commerce at Principal Ports & Waterways, 1968 Columbia-North Pacific

	Total	Foreign Inbound	Coastwise Receipts	Total Inbound	Foreign Exports	Coastwise Shipments	Total Outbound	Internal Movement
				(1,000 short tons)				
Puget Sound								
Seattle	16,036	2,419	2,921	5,340	1,354	999	2,353	8,343
Anacortes	5,969	34	1,957	1,991	118	2,252	2,370	1,608
Tacoma	7,460	1,942	294	2,236	2,247	116	2,363	2,861
Port Angeles	2,986	105	73	178	998	24	1,022	1,786
Everett	5,442	334	-	334	934	7	950	4,158
Bellingham	1,923	509	26	535	171	183	354	1,034
Port Townsend	798	155	16	171	19	-	19	608
Olympia	1,517	-	2	2	772	-	772	743
Port Gamble	247	-	-	-	-	-	-	247
Other Ports	10,443	577	-	577	178	520	698	9,168
Columbia River								
Portland	15,560	1,084	4,080	5,164	3,906	261	4,167	6,229
Longview	4,936	227	572	799	2,814	67	2,881	1,256
Vancouver	2,985	511	20	531	593	5	598	1,856
Astoria	2,385	39	30	69	1,237	120	1,357	959
Kalama	899	1	42	43	582	-	582	274
Other Ports	3,939	-	9	9	-	144	144	3,786
Coastal								
Coos Bay	5,747	-	364	364	2,551	389	2,940	2,443
Grays Harbor	2,878	9	147	156	1,606	67	1,673	1,049
Yaquina	417	-	71	71	-	42	42	304
Umpqua	910	-	56	56	-	122	122	732
Coquille	481	-	32	32	-	150	150	299
Willapa	217	-	-	-	-	194	194	23
Other Ports	706							706
Inland Waterways								
Willamette River above Portland	5,326	385	-	385	-	-	-	4,941
Vanc. to The Dalles	4,338	-	-	-	-	-	-	4,338
The Dalles to McNary	1,319	-	12	12	-	-	-	1,307
TOTAL	105,864	8,331	10,724	19,055	20,089	5,662	25,751	61,038

Internal Traffic

Internal waterborne commerce is movement of commodities within and between ports on the same internal waterway. In 1968, traffic along the region's waterways totaled 61 million tons with almost all of this traffic moved by shallow draft tugs and barges. Traffic through Bonneville, the first lock on the Columbia-Snake River system, exceeds 2.5 million tons per year. The principal product shipped downriver is grain, and petroleum upriver. These commodities, together with various chemicals and forest products, account for over 90 percent of the traffic. Internal barge transportation on the lower Columbia River reach, including Portland harbor, amounted to 8.7 million tons in 1968 and consisted principally of forest products, sand and gravel, and petroleum products. Nearly 30 million tons of internal traffic moved over waterways in the Puget Sound area; the principal commodities are the same as on the lower Columbia. Additional data on tonnages by commodity groups are shown in the individual subregion discussions.

VESSELS AND VESSEL TRAFFIC

The fleet of vessels that moved the 1968 waterborne commerce of the region comprise about 1,400 deep-draft ships; 1,100 tugs, towboats and barges; about 8,000 commercial fishing vessels; and 25 ferries. Characteristics of these vessels vary greatly as to type of cargo, trade routes, and limitations of channels and harbors. In addition to the commercial fleet, it is estimated that there are nearly 423,000 recreational boats in the region, see Appendix XIII, Recreation, of which about 110,000 utilize the navigable waterways.

Deep-Draft Vessels

Approximately 70 percent of the total fleet of 1,400 deep-draft vessels are general cargo ships, 20 percent are bulk carriers, and 10 percent are tankers. The general cargo ships, including container ships, range in capacity from less than 8,000 to more than 20,000 deadweight tons (d.w.t.), but most vessels are from 10,000 to 15,000 d.w.t. with loaded drafts of 25 to 33 feet. Bulk carriers range in size from 12,000 d.w.t. to more than 50,000 d.w.t.; the predominant class ranges from 16,000 to 30,000 d.w.t. with loaded drafts of 30 to 36 feet. Tankers range in size from 12,000 to more than 50,000 d.w.t. with drafts of 27 to 40 feet. Seventy percent are between 16,000 and 22,000 d.w.t. and have loaded drafts of 30 to 33 feet. Table 3 shows the characteristics of vessels in the self-propelled deep-draft fleet.

Table 3 - Self-Propelled, Deep-Draft Vessels, Columbia-North Pacific Region

Capacity Deadweight tons 1/	Draft (feet)	Percent of total vessels
GENERAL-CARGO VESSELS:		
Less than 8,000	Less than 25	9.1
8,000-10,000	25-29	12.6
10,000-12,000	27-31	18.9
12,000-15,000	29-33	22.4
15,000-20,000	30-34	6.3
20,000 & over	32-35	.7
BULK CARRIERS:		
10,000-16,000	27-31	3.2
16,000-20,000	30-33	7.6
20,000-25,000	32-35	3.2
25,000-30,000	32-36	2.6
30,000-35,000	34-37	1.0
35,000-50,000	35-49	2.2
50,000 & over	40+	.2
TANKERS:		
Less than 16,000	27-29	.3
16,000-22,000	30-33	6.7
22,000-35,000	33-36	2.6
35,000 & over	37-40	.4

1/ Deadweight ton--The gross carrying capacity in long tons.

Tugs, Towboats, and Barges

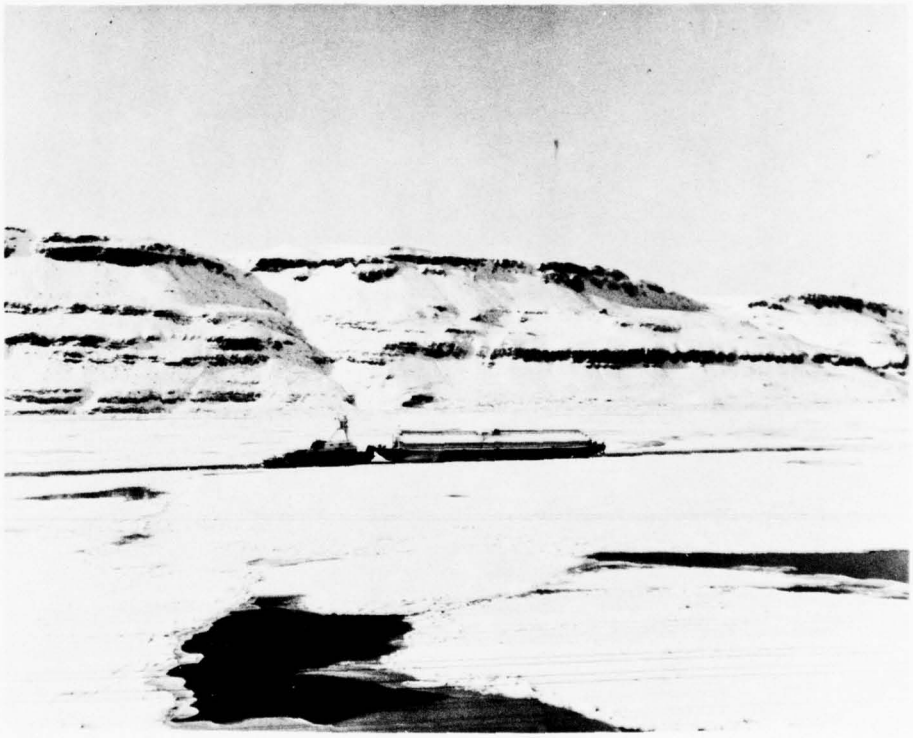
The fleet of tugs, towboats, and barges is divided into two general categories--a coastwise fleet and an inland fleet. The coastwise fleet generally operates between the regional coastal ports and southern California or between mainland ports and Hawaii or Alaska. The inland fleet operates primarily in the Puget Sound area and on the Columbia, Snake, and Willamette Rivers but also includes the smaller tugs and barges operating within coastal bays and their tributaries. The coastwise fleet comprises approximately 30 tugs and 40 barges. Tugs range from 600 to 5,000 horsepower with a typical tug having the characteristics of 1,400 horsepower, 90-foot length, 25-foot beam, and 11-foot draft. Barges range from about 2,000-short ton capacity to more than 10,000 tons. The largest in regular service is the Kenai, with a capacity of 15,500 tons. It was specially constructed to haul fertilizer from Alaska to Portland and Pasco. Typical barges used

to haul forest and petroleum products have about a 4,000-ton capacity. The larger barges are used primarily to haul rail cars between Puget Sound and Alaska.

A modern towboat in use on Columbia River. (PAC photo)

The inland fleet comprises approximately 400 tugs and towboats and 600 barges. The tugs vary in size according to use: about 60 percent with less than 400 horsepower are normally used to pull log rafts or as workboats. They generally are about 70 feet long, 18-foot beam, with draft less than 6 feet. About 25 percent of the tugs are in the 400 to 1,500 horsepower range and are used mostly in the Puget Sound area. These tugs typically are about 125 feet long, 30-foot beam, with a draft of 11 feet or less. The remaining 15 percent, which range between 1,500 and 3,600 horsepower and include about 10 towboats, are used primarily to push larger barges between Portland and the upper Columbia River region. The larger of these vessels are about 122 feet long, 44-foot beam, with a draft of 14 feet. A typical barge used in the Columbia River or Puget Sound area has a 1,400-ton

capacity, length of 204 feet, 35-foot beam, and a draft of 11 feet. Approximately 15 barges in use on the Columbia and Snake Rivers above Portland are equipped with both hoppers and tanks and can transport solid and liquid commodities separately or simultaneously. They are used primarily for hauling fertilizer and petroleum products up river and grain down.



Hopper-Tank barge on McNary Pool (Lake Wallula) during winter freeze. (USCE)

Ferries

Approximately 25 ferries operate on Puget Sound and adjacent waters. They range in capacity from 35 to 160 vehicles and in draft from 8 to 17 feet. Most are owned by Washington State Ferries and are used to carry passengers and highway traffic across the sound and to the many islands in the area. A privately owned line operates across the Strait of Juan de Fuca between Port Angeles and Victoria, British Columbia. A few smaller ferries operate across rivers and on lakes in other portions of the region but such traffic is not significant to navigation.

Commercial Fishing Fleet

The commercial fishing fleet of about 8,000 boats includes both offshore vessels that use the coastal harbors and waterways and smaller boats that operate primarily on the inland waterways. The larger vessels are from 40 to 100 feet long with drafts of 4 to 12 feet. Typical smaller boats are 20 to 40 feet long.

Recreational Boats

Recreational boat usage in the region, particularly in the Puget Sound Subregion, is among the highest in the Nation. It is estimated that there are nearly 423,000 recreational boats of all types located in the region of which 187,000 are registered with state or Federal regulatory agencies. Approximately 110,000 of the registered boats use the navigable waterways and account for nearly 95 percent of the recreational use of such waters. Over half of this boat usage is in the Puget Sound area. Farther inland most of the recreational usage is on lakes and reservoirs not connected to the navigable waterways. Such use is described in Appendix XIII, Recreation. In Oregon, about 88 percent of all boats are trailered to the waterway for each usage; in the Puget Sound area, the percentage is about 70.

Vessel Traffic

The number of trips by commercial vessels reported on the lower Columbia and Willamette Rivers from Portland and Vancouver to the sea exceeded 91,000 in 1968 including 754 with drafts of 30 feet or more. In addition, larger numbers of small fishing and recreational craft increase the congestion on the waterway At the Port of Seattle, where commercial fishing vessels also are reported, the total number of commercial vessel trips exceeded 121,000 and the number with drafts of 30 feet or more was 221. Table 4 illustrates the trend of total vessel trips and the use of large vessels.

The need for additional channel widths, particularly in the Columbia River system, is to a certain extent related to the density of commercial vessel traffic. As the density of traffic and size of ships increase, safe navigation on restricted channels becomes increasingly difficult. Ship operators in the Puget Sound area also are becoming concerned with the hazards of collisons during inclement weather and poor visibility although broad natural deep water channels obtain and navigation is not as restricted.

Table 4 - Trends in Vessel Traffic

	Total number of Vessel Trips		Number of Vessel Trips with draft of 30 feet or more			Total Ocean Commerce in 1000 short tons		
	Lower Columbia and Willamette Rivers	Port of Seattle 1/	Coos Bay	Columbia River	Puget Sound 2/	Coos Bay	Columbia River	Puget Sound 2/
1920	2,000	65,000	0	3	0	379	1,529	5,463
1930	27,000	50,000	0	4	370	549	6,766	10,934
1940	51,000	81,000	0	7	377	484	6,625	9,681
1950	79,000	135,000	1	398	284	927	10,594	9,216
1960	83,000	123,000	15	563	745	1,377	12,493	15,440
1968	91,000	121,000	30	754	522	3,304	16,786	17,937

1/ Includes commercial fishing vessels.
2/ Ports of Seattle, Tacoma, Everett, and Anacortes.
Source: Annual report, Chief of Engineers prior to 1960, subsequently Waterborne Commerce of the United States, Part 4.

Future Fleet Composition

Only moderate increases are projected in the total number of self-propelled, deep draft vessels calling at the region's ports. However, material increases are expected in the size of vessels and in cargo handling efficiency and some increases are expected in vessel speed. The tug and barge fleet is expected to increase in total number and average size. More and larger ferries will inevitably be added on Puget Sound although a temporary reduction would result from construction of a cross-Sound bridge. Larger vessels will be incorporated into the fishing fleet but the overall number of vessels in the fleet will probably not change materially in the immediate future. A large increase in the number of recreational boats is anticipated.

Traditionally, fleet operators have built some vessels to the maximum size that could be accommodated at major ports with the concept that these vessels could operate at somewhat less than full efficiency at other ports. This trend is expected to continue and to maintain a need for continued harbor and channel improvements.

General Cargo Ships

Container ships are expected to replace a large share of the general cargo vessels on trade routes that have relatively balanced two-way cargo and specialized port facilities. A new type of container vessel called LASH (lighter aboard ship) also is expected in the regional trade routes. These vessels are designed to pick up river barges (lighters) of about 200-ton capacity and carry them from one seaport to another. Towboats move the barges to inland ports at either or both destinations.

The majority of the container ships are expected to be about 600 to 700 feet long with beams of 80 to 95 feet and loaded drafts of 33 to 40 feet. LASH-type ships are a little larger, presently up to 860 feet long, with 107-foot beam and a loaded draft of 37 feet. Other general cargo vessels are expected to range up to 700 feet in length, with an 85-foot beam and a loaded draft of about 35 feet. The majority of these ships will be less than 600 feet long with loaded drafts of 27 to 33 feet.

Bulk Carriers

The trend in bulk carriers, including dry and liquid cargo types, is to larger, faster ships with improved loading and discharging equipment. A typical vessel is expected to be 700 to 900 feet in length, 95 to 125-foot beam, a loaded draft of 35 to 45 feet with a capacity of about 50,000 to 75,000 d.w.t.

Petroleum Tankers

The tanker ships bringing crude oil into Puget Sound are expected to be the largest ships of the region's future fleet. These vessels are expected to range in size from 80,000 to more than 100,000 d.w.t. with a loaded draft of 45 to 55 feet. The petroleum products tankers serving regional ports are expected to be smaller because of channel limitations and the requirements of the local market area. Petroleum product tankers are not expected to exceed 40,000 d.w.t. with loaded draft of 36 feet.

Tugs, Towboats, and Barges

The region's fleet of tugs, towboats, and barges is expected to nearly double in number to accommodate the expected increase in commerce. The maximum sizes are not expected to increase significantly, but the averages will increase as the older, smaller, and less efficient vessels are replaced.

Typical tugs in the coastwise trade are expected to range from 2,400 hp to 5,000 hp, but no significant changes in sizes are expected. Typical coastwise barges are expected to have capacities of 4,000 to 6,000 tons with loaded drafts of about 18 feet.

Of the inland fleet, no significant changes are expected in the characteristics of the small tugs used as work boats and for local movements of log rafts and gravel barges, but additional boats will be needed for all types of traffic except log rafts. The power of tugs used for longer hauls, especially of gravel barges in the Puget Sound area, is expected to increase to about 2,000 hp. For the long haul on the Columbia River above Vancouver, more towboats of 3,000 to 3,600 hp are expected and the new vessels are expected to have improved rudder systems and to make more efficient use of their power. The average barge size on the upriver run will increase to about 2,500 tons and more dual purpose barges will be employed.

Innovations

Industry spokesmen expect that some of the techniques that are innovations today will have major impacts on future navigation. One example would be that inland barge operators may soon become involved in the Nation's export-import container traffic as a result of the recently established service of oceangoing barge-carrying vessels (LASH). The domestic barge industry (nationwide) may need to increase its carrying capacity from 250 to 500 percent within the next few years to accommodate the LASH ships presently being planned, designed, and constructed.

Barges of the Kenai-type also may affect the inland navigation of the region. Nationwide, many such barges are in use or under construction to haul bulk commodities directly between inland ports and foreign or coastwise origin or destination.

The region's significant export of wheat and other small grains could be accommodated by either of these types of service.

Commercial Fishing Vessels

There is a trend to the use of larger vessels in some regional fisheries which in time may reduce the overall number of vessels in the fishing fleet. An increased effort on tuna catch will require larger vessels capable of operating at sea for extended periods. There is a recent and growing interest in exploitation of bottom fishery resources which are found in abundance in the coastal waters of Oregon and Washington. Use of large vessels which will accommodate heavy gear have typified operations in this fishery. On the other hand, the smaller boats

presently used for sport and commercial salmon fishing are not expected to change significantly in size, but increased numbers of boats can be expected with regional population growth. The overall fishing fleet will probably remain at present levels for a considerable period of time.

Recreational Boats

Recreational boating in the region will continue to increase commensurate with the growth in population, income and leisure time. The number of recreational boats in use on the navigable waterways is projected to increase from 110,000 at the present time to 165,000 by 1980, 310,000 by 2000, and 585,000 by 2020.

PROSPECTIVE COMMERCE

Detailed and exhaustive economic studies would be required to accurately evaluate the many interrelated forces that will determine future traffic levels and to assess the effect of technological changes in shipping and distribution. Studies of this complexity were far beyond the scope of this investigation. Only the general factors affecting commerce could be considered and the projections are presented not as precise determinations by time frame and location but as broad approximations of a general magnitude.

Total waterborne commerce will be directly related to the economic development of the region. It can be expected that future shipping needs will be governed in many respects by economic production patterns already established in the region. Agricultural and forest products production will continue to be important facets of the region's economy, with continuation of shipping requirements for exporting surpluses to national and world markets. The manufacturing base of the region will expand and become more diversified with increasing requirements for importation of raw materials and export of finished products. As population expands, there will be a greater demand for petroleum products and other consumer goods which must be imported. The national and regional projections of population, employment, income and production which were prepared for water planning use by the Departments of Commerce and Agriculture have been utilized to provide the broad economic parameters for projecting future trends in production and consumption of many commodities pertinent to waterborne commerce. These have been supplemented as necessary by general projections from other sources and by more detailed analyses of future traffic movements wherever available from other studies.

The projected levels of production and consumption of major bulk commodities are shown in table 5. The projections were made as a guide in estimating waterborne commerce requirements and accordingly they cover only that share of the commodities expected to move (in part) by water.

Table 5 - Projections of Major Bulk Commodities Produced or Consumed, Columbia-North Pacific Region

	Base Year 1/	1980	2000	2020
		(1,000 short tons)		
Agriculture Commodities	24,000	41,260	54,260	71,700
Food Manufactures	8,600	13,500	19,100	26,000
Forest Products	108,500	115,000	129,500	132,500
Primary Metals	1,961	4,685	9,670	11,931
Minerals	81,522	114,698	162,052	211,071
Steel Scrap	667	733	1,100	1,500
Petroleum Products	12,300	17,300	28,800	46,000
Fertilizer	740	2,270	4,360	5,390
Totals	238,290	309,446	408,842	506,092

1/ 1964, except primary metals 1969, and steel scrap and petroleum products, 1960.

Estimates of prospective waterborne commerce considered total commodity production and consumption in each subregion's sphere of influence, the historical trends in waterborne commerce, locational factors of population and industry which would affect the division of traffic among transportation modes, and the location of markets and sources of raw materials for the industrial requirements of the region. Where recent studies were available which presented estimates based on detailed analysis of origin, destination, and savings for existing or considered waterway projects, these were used. Projections for the Columbia and lower Willamette River, for the Columbia-Snake inland waterway, and for a prospective waterway in the upper Columbia River were derived from such studies. Current comprehensive studies of the Willamette Basin and the Puget Sound area provided data for those subregions.

Detailed information on prospective waterborne commerce is presented in the individual subregion discussions. A summary of the region's projected waterborne commerce for the years 1980, 2000, and 2020 is shown in table 6.

Table 6 - Prospective Waterborne Commerce
Columbia-North Pacific Region

	1968		1980		2000		2020	
Subregion	Internal	Foreign & Coastwise	Internal	Foreign & Coastwise	Internal	Foreign & Coastwise	Internal	Foreign & Coastwise
				(1,000 short tons)				
2	170		4,300		6,000		7,800	
6	470		1,800		3,600		6,700	
7	1,410		8,700		12,100		15,300	
8	11,500	16,800	11,600	29,400	14,800	43,600	20,100	57,500
9	5,330		6,400		7,700		14,100	
10	8,200	6,200	8,200	7,300	8,200	7,600	8,200	8,600
11	25,200	22,300	31,800	35,000	57,800	67,700	118,400	133,600
Total	52,300	45,300	72,800	71,700	110,100	118,900	190,600	199,700

PRESENT AND FUTURE NAVIGATION PROBLEMS

Large oceangoing vessels, which normally operate in wide open spaces, must move slowly and cautiously in restricted channels especially during periods of reduced visibility or when numerous smaller vessels and recreational craft abound. Portland and Seattle, the principal ports in the region are 110 and 140 miles from the ocean, respectively. Portland is on the 600-foot wide Columbia and Willamette River channel; Seattle is reached via thk less restricted Strait of Juan de Fuca and Puget Sound. Other deep draft ports except Astoria, Coos Bay, and Aberdeen are comparably located. Future navigation in restricted waterways is expected to become more difficult as vessel sizes and speed capabilities increase and as small boats become more numerous.

The navigation locks at Willamette Falls are obsolete and the lock at Bonneville is obsolescent. Problems at these structures are discussed under Subregions 9 and 8, respectively. The locks at Willamette Falls are presently used at nearly full capacity and are a definite limit on expansion of navigation on the waterway. The lock at Bonneville, together with its approach problems, delays traffic but is not unduly restrictive at this time. The problems will become more acute with anticipated increases in traffic volumes.

Two bridges should be altered to facilitate navigation. The problems at the railroad bridge across the Columbia River at mile 323, about a mile downstream from the mouth of the Snake River, are described under Subregion 7. The railroad bridge over the Clearwater River at mile 0.6 is an impediment to port development at Lewiston since the best site for development of facilities in Idaho is on the north shore of the Clearwater River immediately upstream from the bridge. Authority for Federal assistance in reconstruction of these bridges is not clearly defined, and the railroad company that owns them is understandably reluctant to spend its money in favor of a competing form of transportation.

The problems of disposal of dredge material do not directly affect navigation at this time, but may have significant impacts in the future. In inland areas, dredge spoil is frequently used to reclaim low-lying lands near navigation channels for industrial or commercial uses. Along the lower Columbia River, dredge spoil has been successfully used with permeable groins to build up shallow areas and thereby increase the flow velocities in the navigation channel and make the channel self maintaining. After these initial areas are filled and developed, subsequent spoil must be transported greater distances at increased cost. In estuarine areas, dredge spoil has been placed in diked areas, used to fill intertidal areas, or dumped at sea. Recent critical examinations of these practices have revealed instances of deleterious effects on water quality and greater care will be required in the selection of future disposal areas. In all probability, future costs for dredge disposal in estuarine areas also will be greater than at present and the economic feasibility of some future navigation improvements will be imperiled.

MEASURES TO SATISFY NEEDS

Navigation needs have been expressed in terms of increasing quantities of commodities which must be moved to support a growing population and expanding economy and of the larger, more efficient, and more numerous vessels that will be required to move them. The navigation measures which would satisfy these needs comprise all facets of navigation improvements including harbors, channels, locks, port facilities, and aids to navigation. The necessary measures including estimated costs in each subregion are detailed in the respective subregion chapters. A summary of the needed improvements is presented in table 7, and the following paragraphs discuss the improvements from a regional aspect.

Seaborne Commerce

Seaborne commerce--domestic, coastwise, and foreign--is projected to increase more than 300 percent from about 45 million tons to nearly 200 million by 2020. Much of this increase is expected to be accommodated by larger and faster ships and improved cargo handling techniques to the extent that the number of vessels will not be greatly increased. However, the larger vessels will have problems at most harbors and in the Columbia River unless further improvements are made. In Subregion 11, the Puget Sound Area, 24, 21, and 6 miles of channels leading from deep water in the outer harbors to dockside will need improvement during 1970 to 1980, 1980 to 2000, and 2000 to 2020, respectively. Some of the later work will be further deepening of channels deepened during the early period. In the coastal area, Subregion 10, the harbors of Coos Bay and Grays Harbor, comprising 35 miles of access channel, will require improvement prior to 1980; the harbor at Willapa Bay will require deepening prior to 2000. A total of 38 miles of shallow draft channels at other coastal harbors will require improvement after 1980. The channel on the lower Columbia and Willamette Rivers, Subregion 8, to Portland and Vancouver will probably require enlargement sometime in the 1980-2000 period.

Internal Commerce

Internal commerce is projected to increase from 51 million tons in 1968, to 190 million tons per year by 2020. This commerce is expected to be accommodated by larger and more numerous barges and tows of four or five barges. Tugs are expected to be more numerous, powerful, and efficient, but not significantly larger. Improvements to support this commerce would include a 125-mile extension of the channel in the upper Columbia River, Subregion 2, including 3 new locks at existing dams; a 62-mile extension of slack water navigation in the lower Snake River, Subregion 6, including completion of a dam and lock under construction and construction of another; improvement of the open river channel in the Willamette River for 96 miles above the falls at Oregon City; and reconstruction of the locks at Oregon City on the Willamette River and at Bonneville Dam on the Columbia.

Recreation

In addition to the increase in commercial usage the number of recreational boats on the region's navigable waterways is projected to increase from 110,000 in 1966 to 585,000 by 2020. These vessels will use the channels and locks improved for commercial

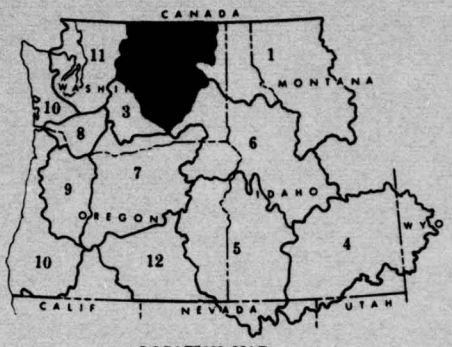
vessels as well as other unimproved portions of the waterways. However, they will need more than 200,000 spaces at supervised moorages and 3,000 lanes of launching ramps to provide adequate shoreside support. These estimates concern only the recreational usage of the navigable waterways. Other usage will be made of lakes, reservoirs, and non-navigable stream reaches and will require similar facilities. Estimates of such facilities are included in Appendix XIII, Recreation.

This summary does not include port facilities which will also be needed to support the projected commerce. Such facilities have historically been provided at local expense in anticipation of prospective commerce, and competition among ports for commerce has maintained a slight surplus capability. This practice is expected to continue. Discussions of future port facility needs are included in the subregion chapters.

Table 7 - Estimated Measures to Satisfy Navigation Needs, 1/
Columbia-North Pacific Region

SUB-REGION	NAV CHANNELS Deep Draft			NAV CHANNELS Shallow Draft			LOCKS			MOORAGE BASINS			LAUNCHING RAMPS		
Year	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020	1980	2000	2020
SUB-REGION	(miles)			(miles)			(number)			(spaces)			(lanes)		
2	-	-	-	125	0	0	3	0	0	90	180	300	-	11	56
6	-	-	-	32	30	0	1	1	0	150	390	710	20	50	90
7	-	-	-	0	0	0	0	0	0	350	1100	2000	40	70	120
8	0	120	0	0	0	0	0	1	0	0	3400	10,600	165	285	520
9	-	-	-	96	0	0	1	0	0	10,000	7600	9,100	25	20	40
10	35	20	0	0	35	3	-	-	-	3,100	9100	20,600	20	100	250
11	24	31	6	0	0	0	0	0	0	31,500	36,100	63,500	190	334	605
TOTALS	59	171	6	253	65	3	5	2	0	45,190	57,870	106,810	460	870	1681

1/ Incremental measures required prior to stated year.



LOCATION MAP

SUBREGION 2

SUBREGION 2

UPPER COLUMBIA

GENERAL

Subregion 2 comprises 22,451 square miles in eastern Washington and contains the main Columbia River and all tributaries except the Spokane River from Canada to the mouths of the Yakima and Snake Rivers. It is bounded on the west by the Skagit and Snohomish Basins across the Cascade Range, on the southwest by the Yakima River Basin, on the southeast by the Snake River Basin, on the east by the Spokane and Pend Oreille River Basins, and on the north by Canada. The subregion is 145 miles wide at the International Boundary and 190 miles long from the Boundary to the mouth of the Yakima River. See figure 3.

Topography

Below the confluence with the Spokane River the Columbia River flows west, south, and east in a large semicircle known as the Big Bend, and divides the topography of the subregion into two distinct parts. The section north and west of the Big Bend is mountainous, with crests rising from 4,000 feet near Wenatchee and 6,000 feet in the northeast corner of the state to over 10,000 feet in the north Cascades. South and east of the Big Bend lies the Columbia Plateau, a lava-formed table land sloping gently southward from 3,000 feet elevation near Grand Coulee Dam to less than 1,000 feet at Pasco. The valley of the Columbia is a narrow, generally rock-walled gorge 300 to 2,000 feet below the surface of the adjoining plateau. In the wider portions of the valley, benches and terraces are found at various heights above the river surface.

Climate

The climate combines features of both maritime and continental types. Summers are dry and warm, and winters moderately cold and wet. Average annual precipitation decreases from over 100 inches along the higher Cascade slopes to less than 7 inches on the Columbia Plateau. About 75 percent of all precipitation falls during the period October through March, most stations recording maximum monthly amounts in December. However, many stations record occasional heavy showers and thunderstorms during

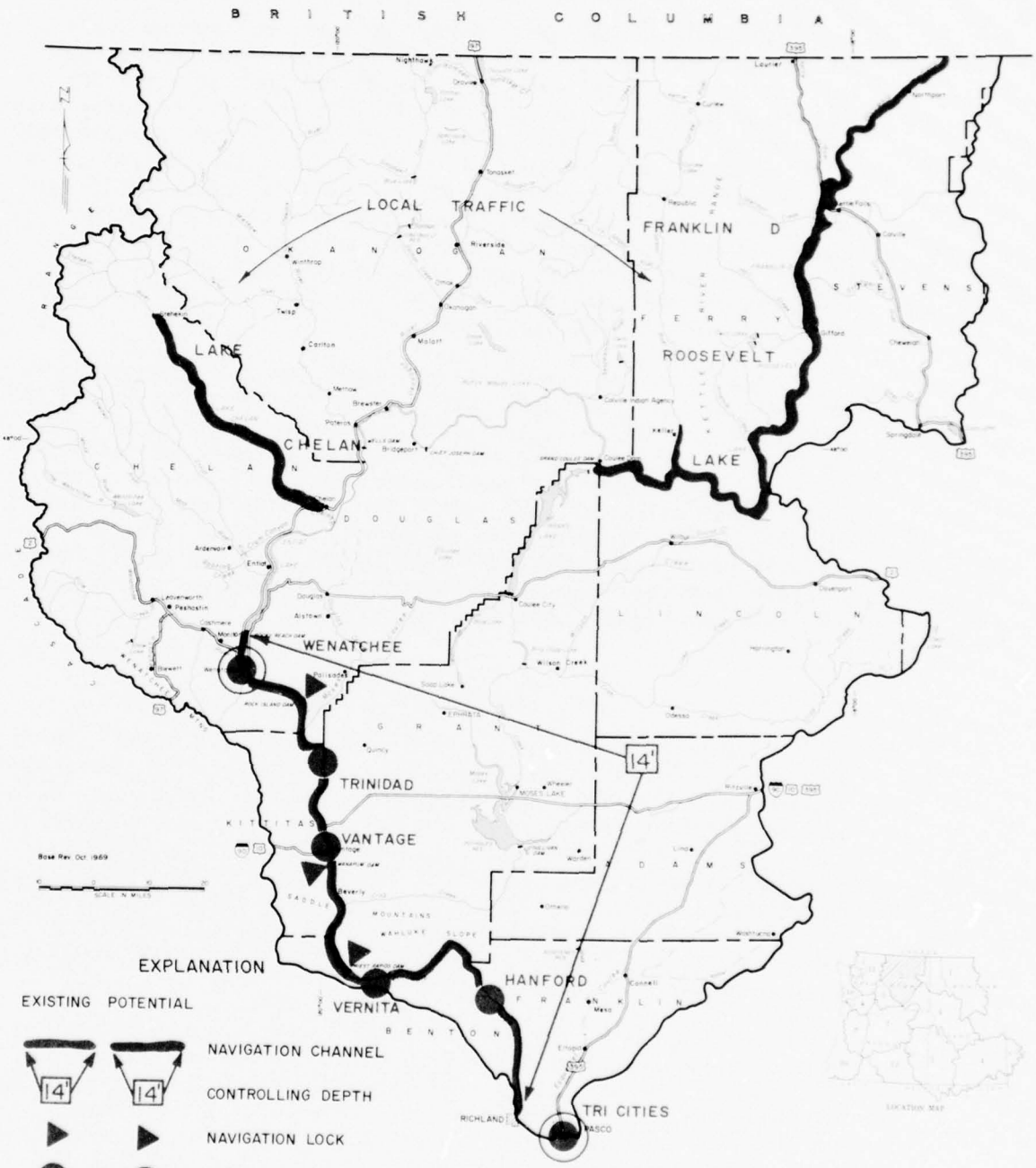
May and June. Most wintertime precipitation falls as snow, remaining on the ground at higher elevations after mid-November. Average annual snowfall ranges from 300 to 500 inches on the highest slopes of the Cascades to less than 10 inches on the Columbia Plateau. In an average winter, maximum temperatures range from 25° to 35°F. in the northern valleys and 30° to 40°F. in the southern areas. Minimums vary from 5° to 15°F. in some areas to 20° to 30°F. in others. Coldest temperatures occur when continental arctic air pushes into the basin from the north. Temperatures below 0°F. are not uncommon under these conditions, and ice forms on lakes and slack water areas in streams to a depth of about 4 inches. However, the duration of such icing is seldom more than a week or two and navigation has moved during similar ice periods on the Columbia River through Subregion 7. Summertime temperatures range from approximately 90°F. in the afternoons to nighttime lows of 50°F. Temperatures exceed 100°F. 1 or 2 days each year.

Streams

The Columbia River follows a zigzag course for 417 miles through the subregion. Throughout most of its length it is contained in the pools behind a series of seven power or multiple-purpose dams. Pertinent data on these dams are shown in table 8.

Table 8 - Dams on the Columbia River, Subregion 2

Dam	River Mile	Surface Area Acres	Height Tailwater to Forebay	Owner or Agency
Priest Rapids	397	7,200	78	PUD, Grant Co.
Wanapum	415	14,610	80	PUD, Grant Co.
Rock Island	453	3,470	43	PUD No. 1, Chelan Co.
Rocky Reach	474	9,800	92	PUD No. 1, Chelan Co.
Wells	516	9,700	75	PUD, Douglas Co.
Chief Joseph	545	7,800	165	Corps of Engineers
Grand Coulee	597	83,000	341	Bureau of Reclamation



COLUMBIA - NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

EXISTING & POTENTIAL NAVIGATION FACILITIES

UPPER COLUMBIA SUBREGION 2

1970

FIGURE 3

Franklin D. Roosevelt Lake, the reservoir behind Grand Coulee Dam, extends to the Canadian border, and in Canada the river is navigable by means of a navigation lock at Arrow Dam with clear dimensions of 50 by 290 feet to the head of Arrow Lakes. Below Priest Rapids Dam, the river flows freely for approximately 57 miles with a drop of 66 feet to the head of Lake Wallula, the pool behind McNary Dam (Subregion 7). In this reach, the river is navigable but the channel dimensions are not adequate for the type of vessels engaged in commercial navigation on the lower river. Navigation would be possible on the reservoirs but through navigation is not available. All of the dams below Chief Joseph have provisions for future locks.

The principal tributaries in Subregion 2 include the Kettle, Colville, Sanpoil, Okanogan, Methow, and Wenatchee Rivers and Lake Chelan. All of these rivers and the Spokane River, which enters the Columbia River in this reach, are considered minor tributaries, and none is navigable by modern standards. Lake Chelan is navigable for 50 miles into the foothills of the Cascade Range but is not connected by a navigation channel to the Columbia River. The Okanogan River was navigated during the pioneer era and is legally a navigable river. Pertinent data on Columbia River and Subregion 2 tributaries are given in table 9.

Economic Development

The population of Subregion 2 in 1965 was 198,600. There are three cities with populations greater than 10,000: Wenatchee, 17,800; Pasco, 15,800; and Moses Lake, 10,159. Seven other cities have populations in excess of 2,000. Since 1940, the population has increased by 52 percent, but the subregion portion of the regional total has decreased from 3.8 to 3.4 percent. Total employment in 1960 was 70,546. Employment in basic industries included 15,433 in agriculture and food processing, 3,520 in lumber, paper and other forest products processing, and 1,032 in mining and primary metal processing.

Economically, the subregion comprises 9 counties and generally divides along topographic lines. The counties in the mountain section are Chelan, Okanogan, Ferry and Stevens. Chelan and Okanogan Counties are noted for the production of fruit, apples being a specialty of the Wenatchee area. Hay, grains and livestock are produced in Ferry and Stevens Counties. Ninety-eight percent of the forest land of the subregion is also in the mountain counties. Lumber production consists principally of rough green ponderosa pine which is shipped to manufacturing plants outside the subregion for box stock and dimension lumber. These counties are also rich in mineral resources including gold, copper,

Table 9 - Streamflow Summary for Selected Sites, Subregion 2

Stream	Total Drainage Area (sq mi)	Enters Columbia River at Mile	Gaging Station Location	Gaging Station Drainage Area (sq mi)	Annual Flow 1/ (cfs) Mean	Annual Flow 1/ (cfs) Max.	Annual Flow 1/ (cfs) Min.	Momentary Flow 2/ (cfs) Max.	Momentary Flow 2/ (cfs) Min.
Columbia River	59,700		International Boundary	59,700	95,800	129,400	72,500	550,100	18,000
Kettle River	4,140	706	Laurier	3,800	2,852	4,159	1,700	35,000	88
Colville River	1,020	695	Kettle Falls	1,007	299	540	75	3,230	1
Sanpoil	979	616		890	Not Available			3,920	32
Okanogan River	8,340	533	Tonasket	7,280	2,894	4,588	1,241	40,900	126
Methow River	1,794	524	Twisp	1,330	1,376	2,348	681	40,800	134
Chelan River	924	503	Chelan	924	2,003	3,307	1,279	16,000	0
Wenatchee River	1,327	468	Peshastin	1,000	3,010	5,386	1,729	32,300	183
Columbia River	96,000		Priest Rapids Dam	96,000	114,100	159,000	86,600	692,600	4,120

1/ Regulated values for base period (1929-1958) 1970 conditions.
2/ Observed values for period of record.

SOURCE: Appendix V.

clays, diatomite, limestone, pumice, epsomite, sand and gravel. The availability of large blocks of hydroelectric power has resulted in the establishment of an aluminum plant and an electrometals plant near Wenatchee.

On the Columbia Plateau portion of the subregion, which includes Douglas, Lincoln, Grant, Adams, and Franklin Counties, wheat is dry farmed where soil moisture permits. The Columbia Basin Irrigation Project has resulted in the production of grains, vegetables, seed, feed, and beef on irrigated farms. Food processing is expanding.

The subregion has tremendous natural resources of forests, agricultural lands, water, and unexploited mineral deposits. Its hydroelectric power developments have an existing capacity of more than 6 million kw, and planned future additions will bring the total capacity to 13 million kw. At the present time, the counties of Chelan, Douglas, Ferry, and Okanogan are classified by the Department of Labor as areas of chronic and persistent unemployment. Depressing factors include limited local markets and relatively high transportation costs, especially for low value bulk commodities.

Other Forms of Transportation

Railroads

Two major railroads, the Burlington Northern and the Chicago, Milwaukie, St. Paul and Pacific, serve the area. They are generally oriented in an east-west direction and connect with market and port areas on the west coast and throughout the United States. A branch line of the Burlington Northern serves the Okanogan Valley and extends into Canada. Another branch extends from Spokane through the Colville Valley to Kettle Falls where it forks; one fork follows the Columbia River into Canada, the other extends along the Kettle into Canada, crosses to the Sanpoil Basin, and follows the Sanpoil to Republic.

Highways

Major east-west highways are U. S. 2 through Wenatchee and Interstate 90 through Moses Lake. There is no through east-west route in the northern half of the subregion. Major north-south routes include U. S. 97 through Wenatchee and the Okanogan Valley and U. S. 395 from Pasco to Spokane and north through the Colville and Kettle River Valleys. A network of state highways and all weather county roads serves all communities in the area.

Air

A major airline has scheduled flights to Wenatchee, Pasco, and Ephrata and charter flights can be arranged to many other cities. Air freight service is available at Moses Lake.

Pipelines

Refined petroleum products are transported by pipeline from Salt Lake City, Utah, to Pasco, Washington, and from Pasco to Spokane. Another petroleum product pipeline from Billings, Montana, serves Spokane and a small branch line was constructed from Spokane to Moses Lake to serve the now inactive Larson Air Force Base complex.

EXISTING NAVIGATION

Existing Projects

Waterway

There is no current Federal navigation project in Subregion 2. During the early development of the area, the more easily navigable reaches of the main river were used for transportation and some channel work was accomplished by the Federal government between Wenatchee and Kettle Falls. This project, adopted March 2, 1907 and June 25, 1910, provided for rock removal and construction of dikes and wing dams between Wenatchee and Bridgeport, 79 miles (Act of March 2, 1907); and for rock removal to obtain a low water channel 7 feet deep from Bridgeport to Kettle Falls, 163 miles (Act of June 25, 1910). The project, Wenatchee to Bridgeport, was completed in 1912 to the extent justified by commerce at that time. Construction of Grand Coulee, Chief Joseph, Wells, and Rocky Reach Dams interrupted through navigation in this reach of the river, but facilitated navigation between dams. The FPC licenses for all of the dams from Priest Rapids to Wells, inclusive, required provision for future lock facilities and such provisions have been made.

Navigation Aids

The Coast Guard maintains 40 channel markers and other navigation aids on Roosevelt Lake. Channels are marked as far upstream as Kettle Falls, and markers are being extended to the Canadian Border.

Bridges

Bridges across the Columbia River in Subregion 2 with pertinent data on clearances that would affect navigation are listed in table 10.

Table 10 - Bridges over the Columbia River, Subregion 2

River Mile	Description	Horizontal Clearance	Vertical Clearance 50-yr Flood
388	Vernita, State Highway 24, Fixed	250 feet	21.0 feet
412	Beverly, CMSTP&P Railroad, Fixed	250 feet	45.0 feet
420	Vantage, Interstate Highway 90, Fixed	390 feet	70.0 feet
457	Malaga, BN Railroad, Fixed	350 feet	50.0 feet
464	Wenatchee, U. S. Highway 2, Fixed	340 feet	72.0 feet
465	Utility Bridge, Highway Department	470 feet	68,0 feet
504	Beebe, State Highway 151, Fixed	460 feet	35.0 feet
530	Brewster, State Hwy 173, Fixed	200 feet	22.0 feet
544	Bridgeport, State Hwy 17, Fixed	50 feet	38.0 feet
596	Grand Coulee, State Hwy 155, Fixed	530 feet	30.0 feet
699	Kettle Falls, US Hwy 395, Fixed	300 feet	59.0 feet
703	Kettle Falls, BNRR Fixed	456 feet	45.0 feet
734	Northport, State Hwy 25, Fixed	224 feet	75.0 feet

Commercial Port Facilities

Storage, distribution, terminal, and transfer facilities available at Pasco and Kennewick are described with other such facilities in Subregion 7. Numerous log rollways and receiving stations adequate for the existing commerce are located on Franklin D. Roosevelt Lake and Lake Chelan. Moorage facilities consist of floating walkways and rafts adjacent to each of the receiving mills. Minimal dock facilities are located at Chelan and several small communities on the lake. Port authorities on the reach of the Columbia River between Pasco and Rocky Reach Dam have development plans for land and facilities to support waterborne commerce whenever the river is improved for barge navigation.

Commercial Traffic

Existing commercial navigation in Subregion 2 is limited to the movement of log rafts on Franklin D. Roosevelt Lake and Lake Chelan, delivery of small amounts of general cargo to isolated communities on Lake Chelan, excursion-passenger traffic on Lake Chelan, and shipment of bulk commodities to the Atomic Energy Commission facility at Hanford. Approximately 275,000 tons of logs were transported on Roosevelt Lake in 1964, but the traffic was reduced to 85,000 tons by 1968 and indications are that further reductions will occur. Log movements on Lake Chelan amounted to 20,000 tons in 1966. Since the formation of the Lake Chelan National Recreation Area, the Forest Service and National Park Service have announced that sale of timber will be discontinued and the mill which moved logs on the lake is expected to close. Barge traffic on Lake Chelan has remained fairly steady at about 1,800 tons and is expected to continue at this level. Commodity movements to Hanford amount to 85,000 tons annually and no change is anticipated.

Vessel Traffic

Three tugboats operate on Roosevelt Lake and two on Lake Chelan. These vessels have drafts of 6 to 7 feet and range from 90 to 300 horsepower. A self-propelled barge with 165 horsepower and 70 tons capacity at 6-foot loaded draft operates on Lake Chelan.

Difficulties Attending Navigation

Through navigation is not possible in Subregion 2 at present because of shallow bars in the channel below Priest Rapids Dam and the barriers created by dams on the Columbia River. Lake Chelan is isolated from the Columbia River by a dam and 4 miles of river with a total drop of nearly 400 feet. Rafting operations on both Roosevelt Lake and Lake Chelan are hampered by insufficient depths at log rollways and receiving stations when the lakes are drawn down for power production. These periods of drawdown occur between December and May on Roosevelt Lake and during the winter on Lake Chelan.

Recreational Boating

In 1970, there were 17,131 recreational boats in the nine counties of Subregion 2 estimated from records of the Coast Guard and the Washington State Tax Commission and the number of licensed boat trailers. These boats represent approximately 90

percent of the pleasure boat usage in the subregion, the balance deriving from transients and metropolitan areas outside the subregion. From a survey of pleasure boat owners made in connection with this study, it is estimated that the principal usage of 1,350 of these boats is on the Columbia River and that the annual number of boat-days usage on the Columbia River itself is about 60,000. Facilities on the Columbia River Lakes above Lake Wallula (McNary Reservoir) include 33 boat launching ramps, with a total of 44 lanes, and moorages with spaces for 150 boats.

Boats used for recreation on the Columbia River are chiefly outboard runabouts, less than 18 feet in length and having less than 75 horsepower. About 91 percent are carried by trailer or car top and generally removed from the water the same day they are launched. The primary activities are cruising and sightseeing and water skiing.

Within the reservoirs, depths are generally more than adequate for recreational boats. There are, however, a few high points within a few feet of the normal water surface which are hazardous during periods of reservoir drawdown. The reach from Pasco to Priest Rapids Dam, while not hazardous for experienced boaters, is not recommended for a novice. Mooring facilities meet the minimal needs of boaters desiring rental moorages and there is an ample number of launching ramps, but access is limited in some areas and better shore associated facilities would increase the use of the waterway.

PROJECTED CONDITIONS AND NEEDS

Economic Outlook

The material for the economic outlook of Subregion 2 was derived from projections prepared for Appendix VI, Economic Base and Projections.

Population, Employment, and Income

The population is projected to grow at a rate slightly less than regional to total 253,000 in 1980; 334,000 in 2000; and 431,000 in 2020. Agricultural employment is expected to decline slightly, resulting in the future population growth being in urban areas. Except in primary metals, employment in most of the present basic industries is projected to decline or to grow at a rate less than the total population, but employment in ancillary industries is projected to expand. Total personal income is

projected to increase at about the regional rate. Table 11 is a summary of estimated population and employment trends.

Table 11 - Population and Employment Projections, Subregion 2

	1960	1980	2000	2020
Population	193,600	253,000	334,000	431,000
Per Capita Income ($)	2,271	4,112	7,161	12,411
Total Personal Income ($1 Million)	447	1,041	2,392	5,353
Total Employment	70,500	98,700	133,600	172,500
Agric., Forestry & Fishery	14,700	14,370	12,950	11,110
Forest Products Manufacture	3,520	3,100	2,550	2,130
Mining & Primary Metals	1,000	2,900	3,500	3,800

Source: Appendix VI, Economic Base and Projections

Commodity Projections

Major bulk commodities that might be expected to move over a navigable waterway are shown in table 12. Commodities such as agricultural and forest products are produced locally and the quantities shown are the entire subregion production that would be shipped to outside markets by all modes of transportation. Other commodities such as petroleum products and fertilizer would be shipped in to serve local needs.

Agricultural Commodities

While agricultural employment is projected to decline, production of agricultural commodities will increase dramatically in the forecast period. Estimates of production of the major commodities (shown in table 12) indicate increases from 3.9 to 16.4 million tons annually, an increase of 320 percent. Nearly half of the total tonnage increase is projected to occur before 1980. Food processing is projected to increase at comparable rates.

Forest Products

Forest products (expressed in terms of raw wood consumed by processing mills) is expected to increase from 2.375 to 4.25 million tons annually. The greatest rate of increase will be in pulp and paper production. Remanufacture of lumber and plywood into end products will increase.

Minerals and Metals

The minerals and metals projections shown in table 12 include the raw material requirements and ingot output of the metal industries presently operating in the subregion, the needs on a per capita basis for sand and gravel and cement, and the output of scrap by population and industry. No estimate is made of potential production of local minerals which are not presently mined.

Petroleum Products

Petroleum products to meet the needs of agriculture, transportation, and heating are projected to increase from the present 457,000 tons annually to 1,694,000 tons in 2020.

Table 12- Projections of Major Bulk Commodities Produced or Consumed, Subregion 2

	Base Year	1980	2000	2020
		(1,000 short tons)		
Agricultural Commodities	3,900	9,180	12,310	16,400
Processed Foods	260	430	670	1,010
Forest Products	2,375	3,325	3,900	4,250
Primary Metals	145	360	740	1,225
Minerals	3,100	4,590	6,460	8,855
Steel Scrap	25	25	40	50
Petroleum Products	495	695	1,090	1,680
Fertilizer	85	155	280	400

1/ 1964, except primary metals 1969, and steel scrap and petroleum products 1960.

The Role of Transportation

Rail and highway facilities are the only means of satisfying the present needs for bulk transportation in the area and are expected to expand to meet essential future needs. However,

through navigation on the Columbia River would add flexibility to the transportation system and benefit users and producers of commodities that move in bulk. Specific commodities in the present economy that might move at lower cost on the waterway than by present mode include alumina, aluminum ingots, silica rock, steel scrap, ferrosilicon, petroleum products, coke, cement, fertilizer, grain, and miscellaneous agricultural products. Other commodities which might move if both shipper and receiver were located on the waterway include wood pulp and wood chips for pulp and sand, gravel, and crushed stone. In addition, low cost water transportation might be the key that would encourage development of some of the local minerals which are not now being mined. However, the Columbia-North Pacific economic projections do not indicate a need for these minerals in the foreseeable future.

Prospective Waterborne Commerce

Development of any reach of the river would affect some but not all of the commodities produced and used in the subregion. The 1969 study, "Columbia River and Tributaries, Washington," (14) which considered extension of navigation to Wenatchee, found that such a project would benefit a 10-county area including Subregion 3, but not Ferry County in Subregion 2. That study found that the commerce on the proposed project would amount to 4.3 million tons in 1980, 5.9 million in 2000, and 7.8 million in 2020. Table 13 is a breakdown of this commerce by principal groupings.

Table 13- Prospective Waterborne Commerce, Columbia River, Pasco to Wenatchee

Commodity Group	1980		2000		2020	
	Up	Down	Up	Down	Up	Down
	(1,000 short tons)					
Primary Metals	830	90	1,400	100	1,990	140
Chemicals	140		240		230	
Petroleum	230		350		540	
Agriculture Products		2,160		2,820		3,650
Non-Metallic Minerals	190	80	280	100	440	120
Forest Products		580		640		670
Miscellaneous	30		30		40	
Totals	1,420	2,890	2,300	3,660	3,240	4,580

Source: SD 112, 91st Cong. (14)

Extension of navigation beyond Wenatchee would affect chiefly agricultural products, fertilizers, and petroleum products. The projections indicate only moderate increases in forest products and none in extraction of local minerals. Forest products most likely to move on the waterway would be wood chips from sawmills and plywood plants to pulp mills located adjacent to the waterway.

Extension through Rocky Reach and Wells Dams would attract additional commerce from Chelan, Douglas, and Okanogan Counties. Evaluation of production in these counties indicates the additional waterborne traffic that might be generated would amount to no more than 65,000 tons in 1980, 70,000 tons in 2000, and 80,000 tons in 2020. Further extension through Chief Joseph and Grand Coulee Dams would benefit Lincoln, Ferry, Stevens, and Spokane Counties in the United States and the area around Trail and Castlegar in British Columbia. Spokane would not generate any significant commerce as the city is 35 miles from any possible port development on Roosevelt Lake. Commerce that might develop out of Lincoln, Ferry, and Stevens Counties would amount to about 200,000 tons in 1980, 220,000 tons in 2000, and 250,000 tons in 2020. Reference is made to Subregion 7 for forecasts of total through commerce.

Future Outlook of Recreational Boating

Future recreational boating activity was projected on the basis of anticipated population and income. For study purposes it was assumed that the number of boats will increase in proportion to the population and per capita income. The projections of total boat days usage also include a factor for increased mobility and leisure time and a higher percentage of use by residents of more populated areas outside the subregion (table 14).

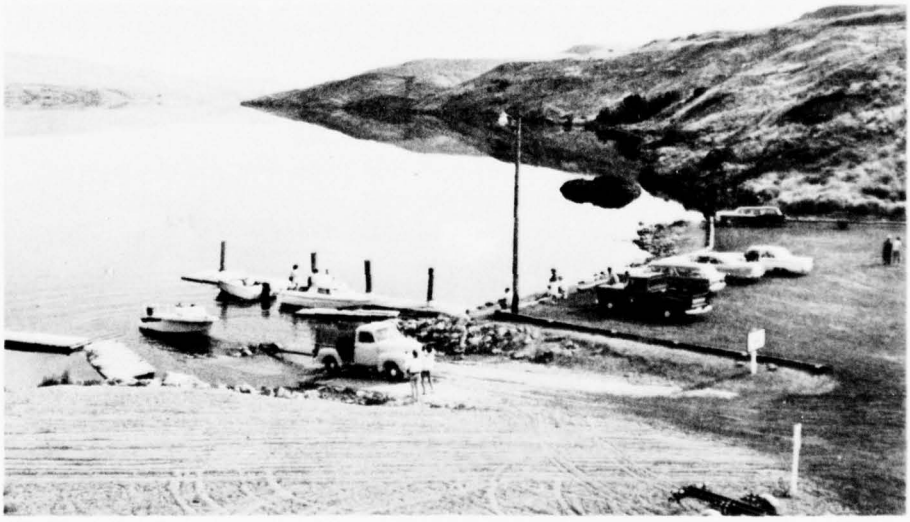
It is expected that cruising and sightseeing and waterskiing will continue to dominate the usage on the river. This picture could change if a more fruitful resident fishery were developed. Any such development would result in increased boating activity.

With a length of more than 400 miles and a surface area of 120,000 acres, the Columbia River could easily accommodate the projected 500,000 boat days annual usage in 2020. A similar analysis of the capability of the other bodies of water in the subregion to accommodate the balance of the boating demand reveals that usage will be much more concentrated, and some of the demand could shift to the Columbia River. The water areas of the Columbia would not be overly crowded if the actual future usage were to be double the amount shown in table 14.

Table 14 - Recreational Boating Activity Projections, 1/
Subregion 2

Item	Year			
	Present 2/	1980	2000	2020
Estimated total number of boats in Subregion 5/	17,130	18,800	33,600	61,800
Estimated boats used on a full-season basis on the contiguous waterway	1,500	2,350	4,400	8,000
Annual boat-day use	60,000	105,000	228,000	500,000
Moorage capacity needs	150 3/	240	420	720
Boat launching lane needs	18 4/	30 4/	55	100

1/ On contiguous waterways usable for commodity navigation.
2/ 1966 except 1970 for total boats in subregion.
3/ Presently available.
4/ Forty-four presently available.
5/ From Appendix XIII.



Recreational boating development near Bridgeport on pool above Chief Joseph Dam. (USCE)

SUMMARY OF NEEDS

Immediate Needs

There is a need to extend shallow-draft navigation into Subregion 2 to aid in the economic development of the area. Such navigation is not possible at the present time because of the shallow bars in the Columbia River below Priest Rapids Dam and barriers formed by dams across the river. The tributaries are not navigable by modern standards except that Lake Chelan provides the only surface access to the developing recreational area at the head of the lake.

The economy of the subregion is based on agriculture, extraction and processing of timber resources, and a minor amount of primary metals processing. All of these activities are dependent on movement of large quantities of bulk commodities and would benefit from lower cost of transportation. The area is rich in untapped mineral resources and has extensive hydroelectric developments, but contains four counties classified by the Department of Labor as areas of chronic and persistent unemployment. One economic depressant factor is the high cost of commodity transport to and from other market areas.

The immediate recreational boating needs are primarily for launching facilities adjacent to areas not now readily accessible.

Future Needs

Projections of future conditions indicate an expanding economy with requirements for shipments of larger quantities of bulk commodities. These changes will intensify the need for through shallow-draft navigation.

The projections of expanding economy and increasing population also indicate a future need for additional facilities for recreational boating.

MEASURES TO SATISFY NEEDS

Commercial

Recent studies have found that extension of through shallow-draft navigation on the Columbia River to Wenatchee would allow movement of more than 4 million tons of commodities by 1980 at costs less than by land transport. The report considered a 125-mile extension of the navigation channel on the Columbia River

from the McNary pool through Rock Island pool to Wenatchee by means of a channel 14 feet deep and 250 feet wide from McNary Dam pool, river mile 340, to Priest Rapids Dam, river mile 397, and locks 86 feet wide, 675 feet long with 15 feet of depth over the sills at Priest Rapids, Wanapum, and Rock Island Dams, and such further modifications and fish and wildlife mitigation features as detailed studies may find advisable. The estimated first cost would be about $104,000,000 for construction and $710,000 annually for operation, maintenance and replacements, excluding aids to navigation. The project would meet the present navigation needs of the subregion.

Other costs which would be associated with the project include aids to navigation, bridge alterations, and port facilities. The initial cost of aids to navigation would be about $1.1 million and the annual maintenance costs would be about $120,000.

The project would necessitate immediate modification of the Washington State Highway Bridge at Vernita at an estimated cost of $550,000 for construction and about $40,000 annually for operation and maintenance. The Chicago, Milwaukee, St. Paul and Pacific Railway bridge at Beverly would also require modification. However, because of greater vertical clearance, the bridge at Beverly would not require modification until 2000 or 2020 when containerized barges are expected. The estimated cost of raising that structure is $750,000. The annual cost of operating and maintaining the Vernita Bridge would be non-Federal; there would be no incremental annual cost at Beverly.

Port and transfer facilities to handle the estimated cargo in 1980 would be needed at Hanford, Vernita, Vantage, Trinidad, and Wenatchee. The port at Hanford would be required to handle general cargo and bulk commodities. Ports at Vernita, Vantage, and Trinidad would handle primarily fertilizers and small grains, mostly wheat. A complete port facility would be needed at Wenatchee. There is ample land suitable for port development at all locations, but access roads will require improvement. Port districts have plans for development if the navigation project is built. Based on the cost of recent development at Umatilla and Pasco in Subregion 7, it is estimated that port facilities needed immediately after completion of the project would cost from $3 to $4 million and that subsequent expansion would cost another $1 million. All costs would be non-Federal.

Extension of through navigation beyond Wenatchee does not appear to be essential unless a need arises to develop mineral resources not presently being exploited. Projections in the Columbia-North Pacific study do not indicate such a need, but future studies should look into this possibility if mineral development occurs.

Recreation

Recreational boating and associated activities will require additional mooring and launching facilities. Total moorage needs on the basis of continuing present usage patterns would be for 240 spaces in 1980, 420 in 2000, and 720 in 2020. It is estimated that the present cost of each berth in marinas that do not require extensive protection is about $1,500. On that basis the cost of providing rental moorage spaces would be $135,000 by 1980; $405,000 by 2000; and $860,000 by 2020. Most moorages are expected to be provided by private concessionaire operators as demands develop.

A single lane of launching ramp can handle as many as forty boats into and out of the water in a single day. Assuming that no more than 40 percent of the boats in an area are used in any one day and allowing an increase of 25 percent for distribution, each lane of launching ramp would meet the minimal needs of eighty trailer and car top boats. Based on the number of boats shown on table 13, the total number of launching ramp lanes needed on the Columbia River would be 30, 55, and 100 in 1980, 2000, and 2020, respectively. Considering that there are presently forty-four ramp lanes, eleven more will be needed by 2000 and fifty-six by 2020. Based on costs of existing launching facilities, it will cost approximately $50,000 per lane for launching ramps and essential lands, access roads, and associated sanitary facilities. On that basis the cost of adding the needed launching ramps will be $550,000 by 2000 and $2,800,000 by 2020. Annual operating and maintenance costs would be about $1,000 per lane.

Effect of Waterway Improvement

Extension of through navigation into Subregion 2, as needed for commercial navigation, is not an essential need for recreational boating. However, all types of recreational boats would benefit from such a project through increased usage. The greatest benefit would be to the larger cabin cruisers and cruising houseboats. A through navigation project would greatly extend the range of these boats and allow extended cruises throughout the length of the waterway. Using the boats presently maintained at moorages as an index, it is estimated that if locks are built as far as Wenatchee, boats on extended cruises would increase the total number of boats on the waterway by about 10 percent. These boats would be dependent on launching ramps or rental moorage spaces within the subregion. The smaller runabouts and day cruisers that comprise about 80 percent of the boats on the waterway would usually limit their cruising to the pools adjacent to the pool where launched and the availability of locks would not significantly increase the usage of these boats.

Summary of Costs

The costs of providing the navigation facilities and priorities by time periods of the subregion are summarized in table 15.

Table 15 - Summary of Costs, Navigation Facilities, 1/ Subregion 2

	1980	2000 ($1,000)	2020
First Costs			
Channels & Locks	104,000	0	0
Aids to Navigation	1,100	0	0
Bridge Modification	550	750	0
Port & Transfer Facilities	3,500	500	500
Moorages	135	270	355
Launching Ramps	0	550	2,250
Total First Cost	109,285	2,070	3,105
Annual O&M			
Channels & Locks	710	0	0
Aids to Navigation	120	0	0
Bridges	40	0	0
Port & Transfer Facilities	250	50	50
Mooring Facilities	27	54	71
Launching Ramps	0	11	45
Total Annual Costs	1,147	115	166

1/ Incremental costs in 1968 dollars prior to date shown.

SUBREGION 6

LOCATION MAP

SUBREGION 6

LOWER SNAKE

GENERAL

The Lower Snake Subregion comprises the drainage area of the Snake River from the mouth to about 11 miles downstream from Oxbow Dam (river mile 262). The area is 35,081 square miles, of which 24,562 square miles are in central Idaho, 4,956 in northeastern Oregon, and 5,562 in southeastern Washington. See figure 4.

Topography

This subregion has three distinct types of topography. The northwest portion of the area, about 10 percent, is characterized by wide expanses of fairly flat land lying at 1,000 to 2,000 feet in elevation and cut only by shallow canyons along the drainage courses. Adjoining the flat lands to the east, is benchland area that comprises another 10 percent of the subregion and extends in elevation from 2,000 to 3,000 feet. This area is characterized by narrow valleys, higher benches and bordering hills that generally are capped by stands of timber. The remaining 80 percent of the subregion is mountainous, extremely rugged, and generally covered by timber. Elevations range from about 1,000 feet in the Snake River Canyon to over 12,000 feet in the Lost River Range of the Sawtooth Mountains. In the eastern and southeastern parts of the subregion many peaks rise to elevations from 10,000 to 12,000 feet. Peaks along the southern and western rims of the subregion range from 6,000 to nearly 10,000 feet in elevation.

Climate

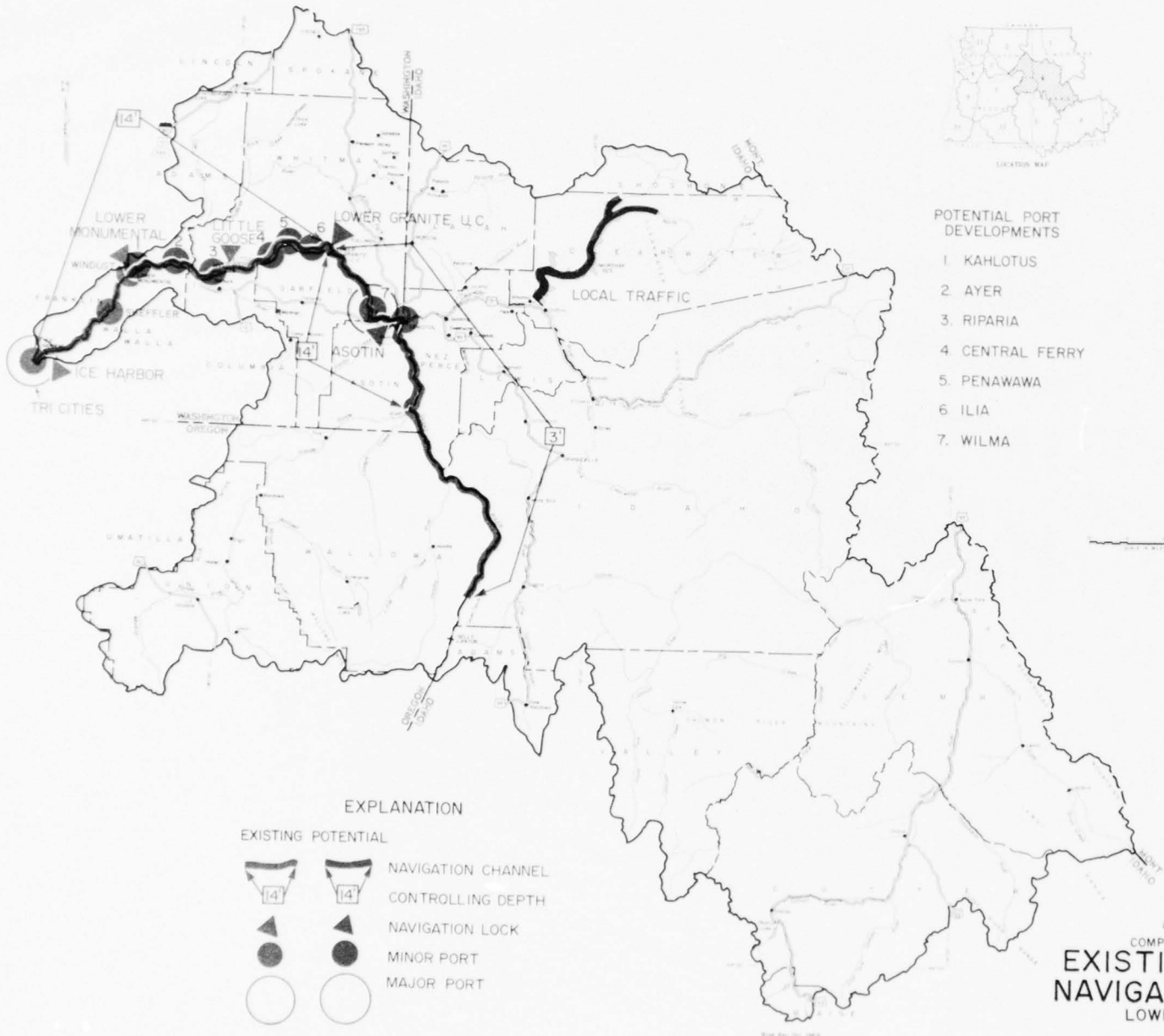
This subregion has a considerable variance in climate and length of growing season, chiefly because of a wide range of elevations. Eastward moving Pacific maritime airmasses, though modified by intervening topographic barriers, have sufficient moisture content to produce considerable precipitation upon being lifted over the mountains within the area. The Clearwater River Basin, in particular, has relatively heavy precipitation because it is so oriented that most Pacific airmasses are subjected to both vertical lifting and horizontal convergence. Other portions of the subregion, while having less efficient rain-producing features, receive reasonably large amounts of precipitation because of

topographic variations. Of the entire Snake River Basin, this subregion has the smallest percentage of arid area. Average annual precipitations range from about 7-1/2 inches near the mouth of Snake River, where little orographic lifting occurs, to more than 60 inches in the headwaters of the Clearwater River. Average annual precipitation over the entire area is about 28 inches. The combination of relatively generous winter precipitation and high elevations produces extensive snow fields which augment summer streamflows. Occasionally, cold continental air invades the area and produces brief periods of severely low temperatures at all elevations. The continental influence also results in occasional periods of high temperature in the summer. Storms affecting the area are of several types. The most significant storms occur during the winter and originate in the Pacific Ocean. Summer thunderstorms in the foothills produce high intensity precipitation for short periods, but are limited to small areas and have little effect on agriculture.

Streams

The Snake River flows northward through the western half of Subregion 6, then turns and flows in a westerly direction to its confluence with the Columbia River--a total distance of aboutt 250 miles. The river enters the subregion at an elevation of about 1,800 feet and falls about 1,500 feet to the mouth. Mean annual flow for the period of record used in Appendix V, Water Resources, at Ice Harbor Dam, river mile 10, is 45,984 cfs; observed flows have ranged from a maximum of 298,000 cfs to a minimum of 11,800 cfs. The principal tributaries of the Snake River in this subregion are the Salmon and Clearwater, which drain the eastern two-thirds of the subregion. The Grande Ronde and Imnaha Rivers drain from the west and the Palouse River drains from the north. Streamflow summaries are given in table 16.

The Snake River has slack water for navigation to the Lower Granite damsite, mile 107.5, through the reservoirs of Ice Harbor, Lower Monumental, and Little Goose Dams; and on completion of Lower Granite Dam, will have slack water to Lewiston, mile 140. Data on dams across the navigable streams in Subregion 6 are given in table 17.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

EXISTING & POTENTIAL NAVIGATION FACILITIES

LOWER SNAKE SUBREGION 6

1970

FIGURE 4

Table 16 - Streamflow Summary, Subregion 6

Stream	Total Drainage Area sq. mi.	Gaging Station Location	Gaging Station Drainage Area sq. mi.	Flows, cfs Annual 1/ Mean	Annual 1/ Max.	Annual 1/ Min.	Momentary 2/ Max.	Momentary 2/ Min.
Imnaha	950	Imnaha	622	500			6,650	16
Salmon	14,100	White Bird	13,550	10,690	15,891	5,792	106,000	1,580
Grande Ronde	4,070	Rondowa	2,555	2,044	3,271	1,175	24,700	225
Asotin Creek	320	Asotin	170	71			2,720	13
Clearwater	9,640	Spaulding	9,570	14,573	22,447	9,826	177,000	500
Tucannon	510	Starbuck	431	164			77,980	15
Palouse	2,980	Hooper	2,500	543	1,072	256	33,500	0
Snake	109,000	Ice Harbor Dam	108,500	45,984	66,398	31,029	298,000	11,800

1/ Regulated values for base period, 1970 conditions
2/ Observed values for period of record.

Source: Appendix V.

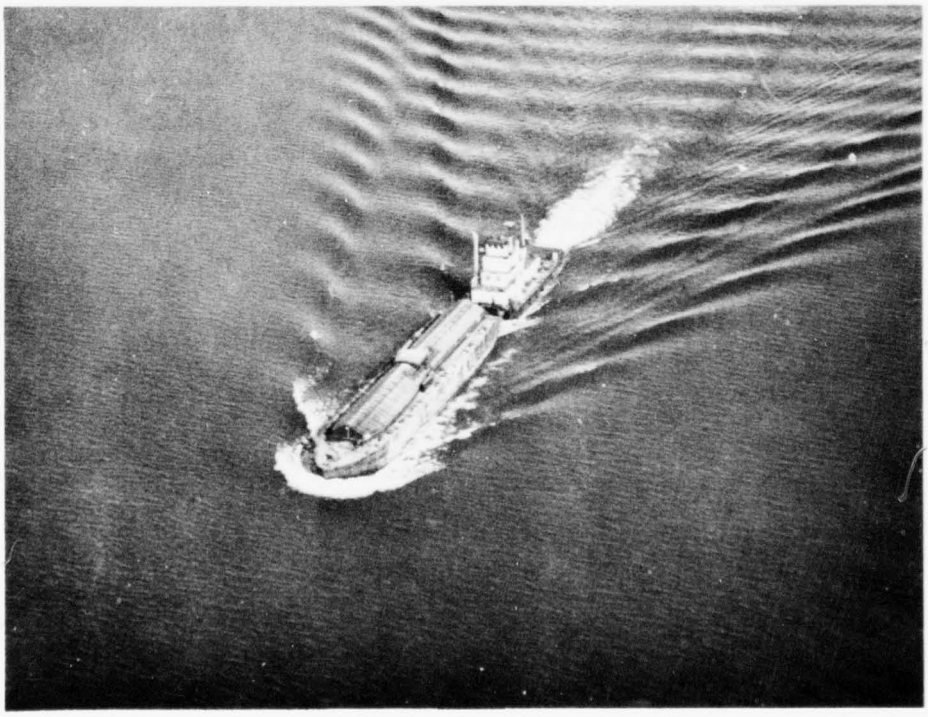
Table 17 - Dams on Navigable or Potentially Navigable Streams, Subregion 6

Dam	Stream	River Mile	Surface Area acres	Height or Head
Ice Harbor	Snake	10	9,200	100
Lower Monumental	Snake	42	6,590	100
Little Goose	Snake	70	10,000	98
Lower Granite 2/	Snake	108	8,900	100
Hells Canyon	Snake	247	1,864	218
Washington Water Power	Clearwater	5	730	25 1/
Dworshak 2/	NF Clearwater	2	16,970	624

1/ Reduced to head of 25 feet by Lower Granite pool backwater.
2/ Under construction.

Above Lewiston, small pleasure craft operate nearly 30 miles upstream to near the mouth of the Grande Ronde River, mile 169, and small boats specially designed for use in rapids or white water navigate as far as Johnson Bar, about 90 miles above Lewiston. Rapids and the Hells Canyon Dam preclude navigation beyond Johnson Bar.

The Clearwater River is navigable at times as far as the confluence of the North Fork for the same type of small boats that use the Middle Snake; however, through navigation from the Snake River is barred by a dam on the Clearwater near Lewiston. The North Fork Clearwater is barred by a dam on the Clearwater near Lewiston. The North Fork Clearwater is used for log drives, but this type of use will be discontinued when the river is closed by Dworshak Dam. Log towing will be possible on the 53-mile long reservoir and liftout facilities will be provided near the dam for reloading from the pool. A few boaters in special white-water boats and rafts drift down the Salmon River from below the town of Salmon, mile 259, to Riggins, mile 86. Other streams in the subregion are not navigable. For additional information on streams, see Appendix V.



The Snake River is a valuable navigation artery. (USCE)

Economic Development

The economic subregion comprises seven counties in Idaho, three in Washington, and two in Oregon as follows: Idaho--Clearwater, Custer, Idaho, Latah, Lemhi, Lewis, and Nez Perce; Washington--Asotin, Garfield, and Whitman; Oregon--Union and Wallowa. The population in 1965 was 163,250. A generalized distribution is 43 percent rural and 57 percent urban. Nearly two-thirds of the population is concentrated in the counties which occupy the flat and bench land areas around and downstream from Lewiston. Idaho, Lemhi, and Custer Counties, with nearly 47 percent of the total area, have only 14 percent of the population. The principal cities are La Grande, Oregon; Pullman and Clarkston, Washington; and Lewiston and Moscow, Idaho, with respective 1960 populations of 9,014, 12,957, 6,209, 12,691, and 11,183. Five other cities had populations in excess of 2,500 and 25 between 500 and 2,500.

About 65 percent of the land in the subregion is publicly owned. The approximate pattern of total land use is shown in table 18.

Table 18 - Land Use, Subregion 6

	1,000 Acres	Percent of Total Area
Cropland	3,078	13.8
Range and forest areas	18,579	83.0
Miscellaneous areas	714	3.2
Total	22,371	100.0

The principal basic industries are agriculture, food processing, and extraction of timber resources. Mining and metal processing have been significant factors in the past, but there is little activity at this time. Total employment in 1960 was 55,600. Table 19 shows the employment by selected categories.

Table 19 - Employment by Selected Categories, Subregion 6

Category	Number Employed
Total Employment	55,600
Agric., Forestry & Fishery (total)	10,750
Agriculture	10,229
Mining	251
Manufacturing (total)	9,311
Forest products	7,074
Food and kindred products	1,040
Armed Forces	256
Non-Commodity	35,032

Other Forms of Transportation

Railroads

The subregion is served by both main and branch line railroads, individual segments of which are owned by the Union Pacific Railroad and Burlington-Northern, Inc. The Burlington Northern route extends along the north bank of the Snake River from Pasco to Snake River Junction, river mile 42, thence northerly to Spokane. The Spokane branch of the Union Pacific Railroad extends up south bank of the Snake River from near the mouth at Wallula to the Joso Bridge at river mile 59, thence northerly to Spokane. A branch line takes off from the Spokane line at the Joso Bridge and extends up the Snake River to Riparia with a branch line to serve Pomeroy and from Riparia it extends northerly to Spokane. The Camas Prairie Railroad, jointly owned by Union Pacific and Burlington Northern, starts at Riparia at a junction with the Union Pacific Railroad and extends up the Snake River to Lewiston with branch lines from Lewiston up the Clearwater River to Kooskia and thence to Craigmont and Grangeville. A Burlington Northern branch line extends between Lewiston and Spokane. The Grande Ronde Basin is served by the Union Pacific main line at La Grande and Union. A branch line extends down the Grande Ronde River and up the Wallowa River to Enterprise and Joseph. A Union Pacific branch line runs from Weiser in Subregion 5 to New Meadows, near

the head of the Little Salmon River, but there is no other rail service to Salmon Basin.

Highways

Major U. S. Highways are shown on figure 4. A network of state and county roads provides access to all agricultural areas and parts of the timbered zones. Large tracts of the mountainous timbered areas remain remote from all surface transporation routes.

Air

Scheduled airline service is available at the Lewiston-Clarkston and the Pullman-Moscow airports. Charter flights can be arranged to many of the small towns throughout the subregion.

Pipeline

Refined petroleum products are transported by pipeline from Salt Lake City, Utah, to Pasco, and from Pasco to Spokane. The pipeline terminal at Pasco is located near mile 2 on the Snake River in Subregion 6. This terminal facility has provision for barge loading and unloading and also for truck and rail loading. Petroleum products are transshipped from there by these other modes, including barges, to areas not on the pipeline.

EXISTING NAVIGATION

Existing Projects

Waterway

Federal projects provide for all present navigation improvements in Subregion 6. The Lower Snake River project provides for a navigation channel from the mouth of the Snake River to Lewiston with a depth and width of 14 and 250 feet, respectively, at minimum regulated flow, and for four dams with navigation locks, each lock with clear dimensions of 86 feet wide and 675 feet long, and with 15 feet of depth over the sills. Three of the dams, see table 17, are complete and the fourth, Lower Granite, is under construction and scheduled for completion about 1975. The River and Harbor Acts of 1902 and 1935 provided for open-river navigation improvement from Lewiston upstream to Johnson Bar. No channel dimensions have been specified for this reach of the river but an attempt has been made to maintain a minimum depth of 3 feet at a flow of 10,000 cfs.

Barge two on Ice Harbor Pool. (USCE)

Navigation Aids

The U. S. Coast Guard maintains channel markers and other navigation aids for the main channel on the Snake River to Lower Granite Damsite and will extend them to Lewiston upon completion of the dam. The Corps of Engineers maintains channel markers through critical reaches from the damsite to Johnson Bar.

Bridges

Bridges over the navigable waterways in Subregion 6, as listed by the U. S. Coast Guard, are shown in table 20. Eight

Table 20- Bridges over Navigable Waterways, Subregion 6

River Mile	Location	Type and Purpose of Bridge	Horizontal Clearance, ft.		Vertical Clearance, Ft Low Water	Vertical Clearance, Ft High Water 2% line
Snake River						
1.5	Burbank (under construction)	Vert. Lift, Railroad	380		60	58
2.2	Pasco-Burbank	Fixed Highway	400	Low End High End	61 64	60 62
9.7	Ice Harbor Lock & Dam	Fixed Road	86		70	58
41.6	Lower Monumental Lock & Dam	Fixed Road	86		65	59
58.5	Joso	Fixed Railroad	238		152	152
59.2	Lyons Ferry	Fixed Highway	400 200	 Central	51 74	51 74
61.8	Sargent	Fixed Railroad	400		51	50
70.3	Little Goose Lock & Dam	Bascule, road Bascule, foot	86 86		Unlimited Unlimited	Unlimited Unlimited
83.2	Central Ferry	Fixed Highway	510		60	60
107.5	Lower Granite Lock & Dam	Bascule, road Bascule, foot	86 86		Unlimited 94	Unlimited 91
139.6	Lewiston-Clarkston	Vert. Lift, Highway	160		42	42
Clearwater River						
0.6	Lewiston, Idaho 1/	Swing Railroad	100		Unlimited	Unlimited
2.0	Lewiston, Idaho	Fixed Highway	100		23	21

1/ The bridge will be raised prior to filling of Lower Granite Pool in 1975.

other bridges cross the lower reaches of the Clearwater and North Fork Clearwater Rivers, and 15 bridges cross the Salmon River below the town of Salmon.

Commercial Port Facilities

Existing port facilities are listed in table 21. The facilities at Pasco, East Pasco, and Burbank have been in use for several years. Grain facilities at Sheffler and Windust are new. Prior to 1950 there were several small port developments along the Snake River and some grain was shipped in barges on the open-river channel. Most of these facilities have been or will soon be flooded by the reservoirs. Reconstruction has not been completed on the reach above Lower Monumental Dam. The grain terminals at Lewiston listed in table 21 will require modifications to be used on the improved waterway.

Table 21 - Commercial Port and Terminal Facilities, Subregion 6

Location	River Mile	Available Port Land (acres)	Available Water Frontage (feet)	Type of Land Access	Barge Capacity	Development
Pasco	2	3	800	RR, Hwy, Pipeline	3	Petroleum storage 27 million gallons
Burbank	2	65	2,500	Hwy	2	Grain 750,000 Bu.
East Pasco	3	46	1,800	RR, Hwy	5	Petroleum, cement, fertilizer, asphalt, and general cargo
Sheffler	28	18	5,000	RR, Hwy	2	Grain - 480,000 Bu.
Windust	38.5	5	3,000	RR, Hwy	2	Grain - 160,000 Bu.
Lewiston	140	2	350	RR, Hwy	0	Grain - 250,000 Bu.
Lewiston	140.5	5	3,000	RR, Hwy	0	Grain - 550,000 Bu.

Commercial Traffic

Commerce

Commerce on the Snake River amounted to about 900,000 tons in 1967. Most of this tonnage moved on the lower 8 miles of the Snake River with only 210,000 tons being destined to or originating at points above Ice Harbor Dam. Agricultural products and fertilizers constituted nearly 65 percent of the total tonnage. The balance comprised petroleum products, cement, asphalt, and

miscellaneous commodities. More than 80 percent of the petroleum products, about 200,000 tons, were shipped from the pipeline terminal near the mouth of the Snake River downriver, either to the Portland market area or to refineries for reprocessing. Commerce above Lewiston amounts to less than 100 tons annually of supplies to isolated ranches in the Snake River canyon. About 3,000 passengers are carried annually on the reach of Snake River above Lewiston. The Clearwater River has been a carrier of logs by open river drives during spring freshets. The annual log volume has averaged nearly 50 million board feet. Dworshak Dam will eliminate the present log runs on the North Fork, but log towing will be possible on the pool.

Vessel Traffic

Commerce below Lower Granite Dam under present conditions and below Lewiston upon completion of that dam will be carried in barges powered by towboats. The equipment is described in the regional summary. In 1966, the total number of barges entering the Snake River was 890 of which nearly 300 went through the Ice Harbor lock. The number of towboats was 935 at the mouth and 225 at Ice Harbor. The numbers were slightly higher in 1967. The traffic above Lewiston consists of weekly trips by a motor launch built for use in swift water with a cargo capacity of about 10 tons at a draft of 30 inches. Frequent trips by excursion boats are made during the recreation season.

Difficulties Attending Navigation

The full potential of the Snake River waterway cannot be realized prior to completion of Lower Granite Dam and extension of slack water navigation to Lewiston. Completion of Ice Harbor Dam (1962), Lower Monumental (1969), and Little Goose (1970), has provided slack water navigation to the Lower Granite site, river mile 107.5, but swift water and a shallow narrow channel limit navigation above that point. Above Lewiston swift currents and limited channel dimensions in the Snake, Clearwater, and Salmon Rivers restrict navigation to special boats. Navigation from the Snake to the Clearwater is precluded by the Washington Water Power Company dam at mile 4.6 on the Clearwater River.

Recreational Boating

Based on State of Washington boat trailer license records and boat registration records of the Coast Guard and the States of Oregon and Idaho, it is estimated that there were about 5,800

recreational boats in Subregion 6 in 1966. Of these, 3,530 are considered tributary to the Lower Snake River. Other boats such as kayaks and car top boats, which are not registered or carried on trailers, also make limited use of the navigable waterways. A survey of boat owners showed that boats are used an average of 40 days per year and that the primary activities are fishing, cruising and sightseeing, and water skiing. Outboard motorboats predominate; most are stored on trailers and launched each time at the scene of the day's activity. However, there are about 370 boats in the Lewiston-Clarkston-Asotin area that are kept at moorages on a year-round basis.

Recreational boats at Fishhook Park, Ice Harbor Pool. (USCE)

Several charter boats operate in the canyon reaches of the Snake and Salmon Rivers. Most of these are jet propelled with capacities of about 10 passengers. Non-powered boats float down the main Salmon River from North Fork to Riggins and the Middle Fork through the primitive area. The total annual boating day use on the canyon reaches of the Snake and Salmon Rivers is estimated to be about 63,000. This activity is increasing rapidly but is too new to have accurate growth rates established.

Facilities on the navigable waterways for recreational boating include five marinas with spaces for 370 boats, nine marine parks with picnic and camping facilities and a total of forty-two lanes of launching ramps. Other facilities on land locked water are covered in Appendix XIII, Recreation.

PROJECTED CONDITIONS AND NEEDS

Economic Outlook

Population, Employment, and Income

Both population and total employment are projected to grow at rates substantially less than the total region. The employment fields which now provide the basic support for the subregion economy--agriculture, food processing, and timber and paper processing--are projected to decline. Employment in other industries and per capita income are projected to grow at rates above the regional norm. Table 22 is a summary of population and employment projections.

Table 22 - Population, Income & Employment Projections, Subregion 6

Item	1960	1980	2000	2020
Total Population	156,000	193,500	234,600	274,300
Total Personal Income ($ 1 million)	326	729	1,556	3,264
Per Capita Income	2,032	3,770	6,629	11,897
Total Employment	55,600	72,900	91,500	113,600
Agric., Forestry & Fishery	10,750	8,580	6,690	5,140
Agriculture	10,230	7,400	6,100	4,900
Mining	250	480	420	360
Manufacturing	9,310	12,250	15,060	18,360
Forest Products	7,074	5,935	4,608	3,617
Food Processing	1,040	1,002	979	892
Armed Forces	256	280	280	280
Non-Commodity	35,032	51,346	69,063	89,474

Source: Appendix VI, Economic Base and Projections

Commodity Projections

Major bulk commodities that might be expected to move over a navigable waterway are shown in table 23. Commodities such as agricultural and forest products are produced locally and the quantities shown are the entire subregion production that would be shipped to outside markets by all modes of transportation. Other commodities such as petroleum products and fertilizer would be shipped in to serve local needs.

Table 23 - Projections of Major Bulk Commodities, Subregion 6

	Base Year 1/	1980	2000	2020
	(1,000 short tons)			
Agricultural Commodities	2,300	3,060	3,545	4,150
Food Manufactures	110	200	280	310
Forest Products	6,075	7,150	7,875	7,775
Primary Metals	-	-	-	-
Nonmetallic minerals	2,125	2,840	4,470	5,100
Steel Scrap	20	20	25	30
Petroleum Products	350	495	740	1,055
Fertilizers	85	130	235	335

1/ 1964, except primary metals 1969, and steel scrap and petroleum products 1960.

Agricultural Commodities and Fertilizers

Wheat and other small grains are produced in the areas around and downstream from Lewiston. Production in 1964 amounted to 1,500,000 tons. Other commodities include hay, 500,000 tons; dry beans and peas, 150,000 tons; potatoes and miscellaneous fruits and vegetables. Total commodities are projected to increase to 3,060,000 tons in 1980; 3,545,000 in 2000, and 4,150,000 tons in 2020. The raw material for the fertilizers shown would originate in petroleum producing areas outside the subregion and be processed here for shipment to the cropland areas of this subregion and others.

Forest Products

Most of the forest land is in the area upstream from Lewiston. Processing plants are located at Lewiston and throughout the upstream area. Finished products are shipped by rail, truck, or truck and rail to markets throughout the United States and to coastal ports for overseas shipment. Commodities included in the projection include lumber, plywood, pulp and paper, chipboard, and waste material shipments from lumber and plywood plants to pulp mills.

Nonmetallic Minerals

Nonmetallic minerals comprise sand, gravel, and cement projected to be used in the subregion. Sand and gravel are generally available and are usually produced close to the site where used. Cement is produced in Subregions 1, 5, 9, and 11 and shipped to the subregion from these and other areas outside the region. The Columbia-North Pacific economic and mineral projections do not specifically show any change in this pattern. An independent study by the Corps of Engineers (38) showed that an additional cement plant would be needed to serve the Columbia Basin Area by about 2000 and at that time, the logical source of limestone would be from extensive deposits in the vicinity of the mouth of Grande Ronde River. Approximately 1,050,000 tons of limestone would be produced to support this plant. These findings are within the total needs as projected in the Columbia-North Pacific study and are accepted herein.

The Role of Transportation

Railroad and highway facilities meet the present needs of the developed areas in the subregion and are expected to expand to meet future needs. However, there is and will continue to be a need for additional highway development in the remote timbered areas of the Salmon and Clearwater Basins. The railroads are oriented along the Snake River from the mouth to Lewiston and farm produce moves toward the river for shipment. This movement of produce toward the river is expected to increase after completion of the presently authorized waterway to Lewiston. The principal advantage that will accrue from the navigable waterway is expected to be in the movement of petroleum products, fertilizer and agricultural products. Other commodities that should move include forest products, primary metals, and minerals. Economical transportation could be the factor that would initiate use of the extensive limestone deposits along the Snake River about 30 miles above Lewiston.

Prospective Waterborne Commerce

Slack Water Project to Lewiston

Commerce expected to move on the slack water project to Lewiston when completed is listed in table 24. Commerce that would be attracted to the waterway by extension beyond Lewiston is considered in the analysis of that reach. Major commodity groups are discussed below.

Table 24 - Projected Commodity Movements on Snake River Waterway to Lewiston, Subregion 6

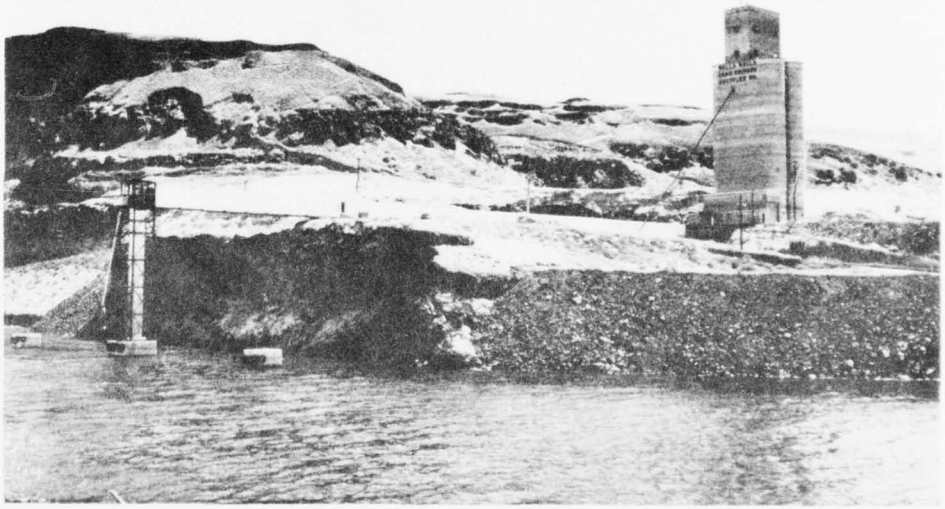
	1980		2000		2020	
	Up	Down	Up	Down	Up	Down
	(1,000 short tons)					
Chemicals incl. Fertilizers	95	18	194	20	280	25
Petroleum Products	296	210	446	150	560	30
Agric. Products		850		1,000		1,080
Forest Products		185		556		920
Miscellaneous	80	60	100	72	115	85
Totals	471	1,323	740	1,798	955	2,140

Agricultural Commodities and Fertilizers

Cropland areas expected to be served by the waterway to Lewiston include the flatland areas along the Snake River below Lewiston and the benchland areas in Latah, Nez Perce, Lewis, and Idaho Counties, Idaho, and Garfield and Asotin Counties, Washington. These areas include nearly 90 percent of the cropland area in Subregion 6. The agricultural commodities expected to move on the waterway consist mostly of wheat and other small grains. Quantities are shown in table 24. Bulk fertilizers are projected to be shipped on the waterway to serve the same areas. Quantities are included with other chemicals in table 24.

Grain from north central Montana has been trucked to Pasco and transshipped by barge to the deep-draft ports on the Lower Columbia River. Some of this grain moves via U. S. Hwy 12 through

Lewiston to Pasco. Upon completion of Lower Granite Dam, the truck haul can terminate at Lewiston and will be 130 miles shorter. One of the companies supplying fertilizers to the Columbia Basin expects to ship fertilizer from Pasco to the Midwest. Some of this fertilizer also could move via this route. No tonnages from these potential movements are included in the estimates in table 24.



Grain loading terminal on Ice Harbor Pool. (USCE)

Petroleum Products

The Lewiston area is potentially a petroleum distribution center for serving Asotin, Garfield, and Whitman Counties in Washington and Latah, Nez Perce, Clearwater, Lewis, and Idaho Counties in Idaho. Petroleum products are hauled by truck and rail to Lewiston from barge and pipeline terminals at Pasco. With completion of the navigation project to Lewiston, nearly all of the supplies for the above area are expected to move by barge to Lewiston or nearby terminals. Prospective commerce including asphalt is projected to be 296,000 tons in 1980, 446,000 in 2000,

and 560,000 tons in 2020. The downstream shipments from the pipeline terminal near Pasco are projected to decline to 30,000 tons by 2020.

Other Commodities

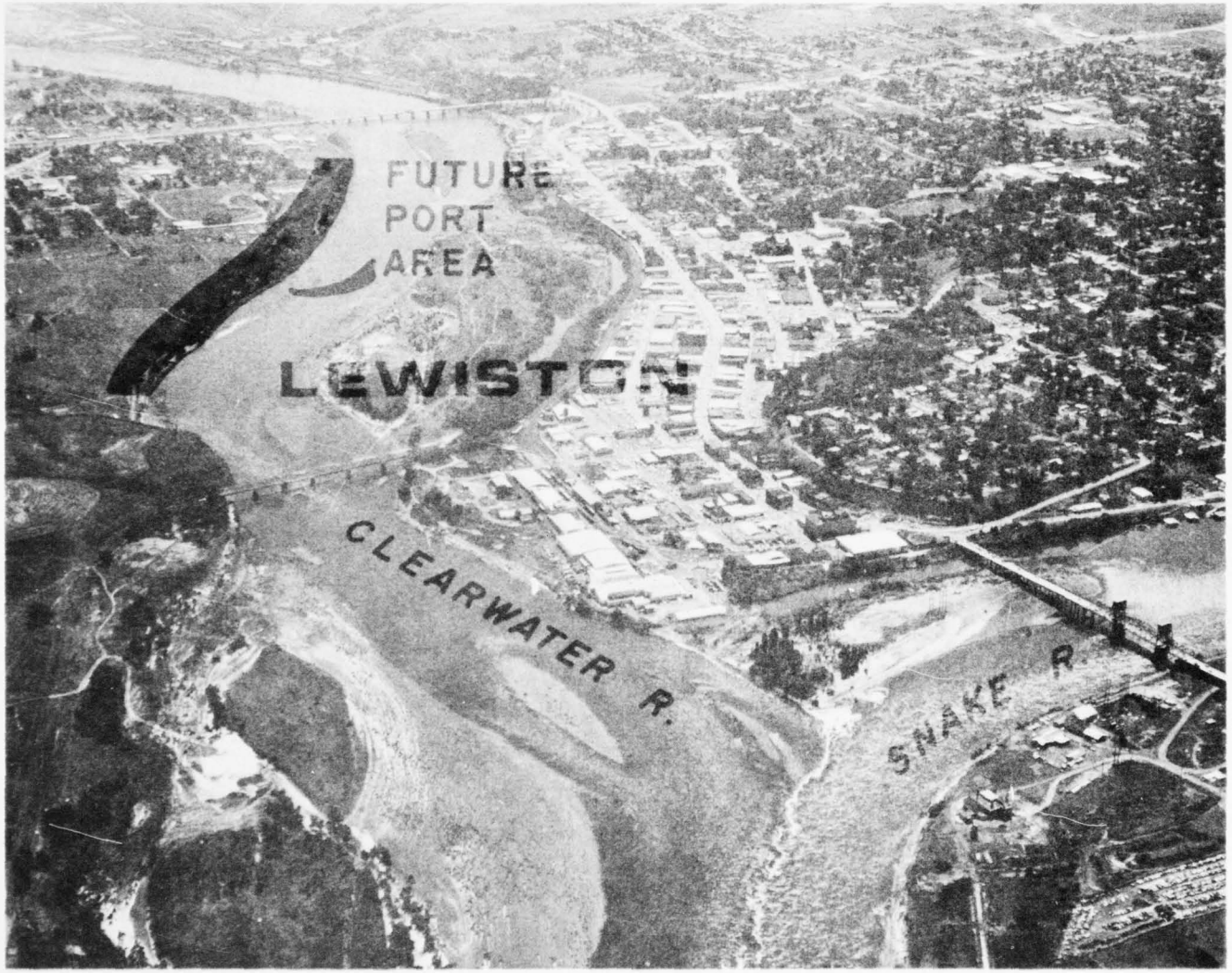
Some of the lumber and plywood products presently shipped by rail to California markets and coastal ports for shipment to Hawaii or foreign markets are projected to move on the waterway. Depending on ownership, logs or wood chips may also move from Lewiston to plants near the mouth of the river. Growth rate in movement of residue timber materials to processing plants along the lower Snake and Columbia Rivers will increase as demands for wood chips for manufacturing paper and construction materials increase. Other commodities which would logically move on the waterway include chemicals for pulp and paper production, and miscellaneous general cargo.

Navigation beyond Lewiston

Existing Project on Snake River to Johnson Bar With no further improvement of Snake River for navigation, future navigation will use the present type and size of craft and will be limited to moderate expansion of existing traffic. Recreational use of the river is projected to expand at the regional growth rate for recreational activities. Commodity shipments, which support isolated ranches and recreational activities in the Snake River canyon, are projected to grow at a comparable rate.

Extension of Slack Water Navigation to Grande Ronde River Extensive limestone deposits in the vicinity of the mouth of Grande Ronde River could be reached by slack water navigation which would be formed by the authorized Asotin Dam. However, the authorization for Asotin Dam does not include a navigation lock, which would be required. This limestone would then be competitive as basic material for a cement plant to serve the Columbia Basin (essentially Subregions 2, 3, 6, and 7). Population and per capita use projections indicate that a plant with an annual capacity of about 5 million barrels of cement would be needed by about 2000. The limestone requirements for a plant of this size would be about 1,050,000 tons per year.

Snake River from Grande Ronde River through Hells Canyon into Subregion 5 Extension of the waterway on the Snake River through Hells Canyon into the central Snake River valley of Idaho and Oregon could attract 2 to 3 million tons of commerce annually. Agricultural products would be the principal items shipped, with



Lewiston, Idaho, showing potential port development area. (USCE)

other bulk products such as lumber and mill by-products making up most of the balance. However, this extension of shallow-draft navigation would be extremely costly and would not have a major impact upon the subregion's economy as other forms of transportation are already available.

Salmon River to Salmon, Idaho Transportation is now confined to truck routes which are limited to the main valleys of the Salmon River except the main stem which is without through road travel. The commerce volume available for shipment to coastal areas is considered large. In addition, much of the resource is not utilized to its full potential. Commodities would include logs and other forest products, basic metal ores, and some nonmetallic minerals. Area needs would be petroleum and miscellaneous consumer goods which could move upriver. Without a waterway, most of these commodities represent resources that will not be fully developed and those that will develop will move at considerable cost by other modes of transportation. Thus the project on the Salmon River would materially increase the total traffic on the lower Snake and Columbia Rivers. However, the projections do not indicate a need for development of the resources that would be used as a result of the Salmon River navigation project. In addition, this is one of the streams under consideration as part of the wild river system.

Clearwater River to Kooskia The Clearwater River from its mouth at Lewiston to Kooskia, a distance of about 80 miles, could possibly be utilized as a canalized waterway by improvement with a series of dams. Such a waterway would attract an estimated one million tons of commerce annually, including agricultural and forest products downstream and petroleum products and miscellaneous consumer needs upstream. Many of these commodities are now moved by rail to destination or trucked to Lewiston or other shipping centers. Of this one million tons, approximately 300,000 tons would be shipped on the lower Snake waterway through Lewiston if the Clearwater extension were not built, but the balance would be additional to the commerce shown in table 24. However, studies do not indicate that the volume of waterborne commerce would support such a waterway development.

Future Outlook for Recreational Boating

Growth factors for recreational boating are related to population, income, mobility, and leisure time, the same factors that influence other forms of outdoor recreaton. Boating activity will increase initially on the lower Snake due to formation of additional slack water areas and elimination of dangerous rapids. Emphasis on fishing on this reach will reduce as steelhead, the

principal game fish, are not easily taken in the reservoirs. This will be balanced by increases in cruising and sightseeing and water skiing. Table 25 shows the number of boats and boating days activity expected on the waterway.

Table 25 - Recreational Boating Activity Projections, 1/
Subregion 6

Item	Year			
	Present 2/	1980	2000	2020
Estimated total number of boats in subregion 5/	5,800	6,500	11,200	20,600
Estimated boats used on a full-season basis on the contiguous waterway	3,530	5,160	9,090	16,200
Annual boat-day use	143,000	220,000	456,000	937,000
Moorage capacity needs	370 3/	520	910	1,620
Boat launching lane needs	45 4/	65	115	205

1/ On contiguous waterways usable for commodity navigation.
2/ 1966 except 1970 for total boats in subregion.
3/ Presently available
4/ Forty-two presently available.
5/ From Appendix XIII

No projections are made for boating activities in the canyon reaches. These activities are generally self sufficient and navigation improvements would detract from the natural recreational experiences desired by participants.

Summary of Needs

Immediate Needs

The most pressing immediate needs are for completion of the slack water system to Lewiston and development of port and terminal facilities for handling grain, petroleum, fertilizer, and other commodities thereon. Development of port and terminal facilities at Lewiston would be facilitated by increasing the horizontal clearance of the bridge at mile 0.6 on the Clearwater River. One of the best areas in Idaho for port development is located on the north bank of the Clearwater River immediately

upstream from this bridge, but full barge tows could not reach this the area through the present draw span.

Navigation on the open-river reach of the Snake from Asotin to Johnson Bar is dependent upon adequate flow to maintain depths on the many rapids. A minimum release of 9,500 to 10,000 cfs from Hells Canyon Dam would assure an adequate depth of at least 3 feet on all rapids. However, the license for the operation of the dam requires a minimum release of only 5,000 cfs.

Future Needs

Extension of a slack water navigation to the mouth of Grande Ronde River and provision of port or terminal facilities to handle limestone will be needed prior to the year 2000. Additional recreation facilities will be required throughout the reach of waterway for launching boats, mooring during boating season, and dry and wet storage at Lewiston and Clarkston to serve increased boat numbers. Facilities to accommodate the projected number of recreational boats are shown in table 25.

MEASURES TO SATISFY NEEDS

Snake River, Mouth to Lewiston, Mile 140

Measures to satisfy the subregional needs will include a number of port terminals throughout the 140-mile reach below Lewiston. In addition, there will also need to be shoal removals and widening to allow multiple tow use along sailing channels through reservoirs.

The port and terminal facilities which will need to be expanded or developed are shown in table 26.

Snake River Lewiston, Mile 140, to Weiser, Mile 350

Asotin project, which is presently authorized for hydroelectric power only, would require the addition of a navigation lock. The lock would provide navigation access to valuable limestone deposits near the mouth of Grande Ronde River. The upper section of river is currently developed by a series of three dams which create pools aggregating 103 miles in length. To carry navigation through these dams would require multiple stage locks at each dam with a total lift of 602 feet. In addition, development of the 80 miles of Snake River between the Grande Ronde and Hells Canyon would require a lift of another 640 feet. This

Table 26 - Port and Terminal Facility Needs, Subregion 6

Location	River Mile	Area Needs (Acres)	Terminal Needs
Matthews	40 Left bank	100	Grain
Kahlotus	42 Right	147	Grain
Riparia	67 R	400	Grain
Ayer	52 L	68	Grain
Tucannon	62 L	59	Grain
Central Ferry, Whitman Co. Central Ferry, Garfield Co.	83 Both	600	Grain, Fertilizer, Petroleum
Penawawa	92 R	160	Grain
Ilia	102 L	270	Grain
Almota	103 R	80	Grain
Chief Timothy	131 L	44	Grain
Wilma	134 R	700	Industrial
Lewiston Area	140 B	500	Grain, Fertilizer, Petroleum
Asotin	145 L	160	Grain

reach has been studied for its power potential, and several possible dams are described in Appendix XV, Electric Power. No cost estimates of navigation facilities have been made and site suitability at the existing dams and potential damsites has not been determined. It is not considered that slack water navigation from Lewiston to Weiser will become feasible, from either an economic or engineering aspect within the Columbia-North Pacific time frame.

There is, however, some call to transfer recreational boats around the existing dams, and demand for such service is expected to warrant installation of some facilities by 1980.

Clearwater River, Mouth to Kooskia

A series of small dams with locks to create slack water navigation on the Clearwater River would involve a total lift of 550 feet to extend the waterway to Kooskia, a distance of 80 miles. Four dams to develop the power potential of the reach below the North Fork are listed in Appendix XV, Electric Power, but neither

the possibility of including navigation locks in those dams nor of developing the reach from the North Fork to Kooskia has been studied. The power potential, per foot of head, of the Clearwater is roughly one-third that of the Lower Snake. Cost of navigation facilities would be greater because more locks would be required. It is, therefore, not considered that such structures would be feasible within the Columbia-North Pacific framework time period. However, any power dams constructed on the lower Clearwater River should include provisions for adding navigation facilities when needed.

Salmon River to Salmon, Idaho

The change in elevation between the mouth of Salmon River and Salmon, Idaho is more than 3,000 feet. Several dams that would develop most of the reach for power and flow regulation have been studied but navigation has not been included as a function. Most of the studies have considered dams with high head and large reservoir fluctuations that would not be easily adaptable to navigation. No cost estimates for a navigation project have been made, but it is not considered to be economically feasible within the Columbia-North Pacific time frame. Further, the Salmon River from its mouth to the community of North Fork has been designated for study for inclusion as a component of the National Wild and Scenic River System.

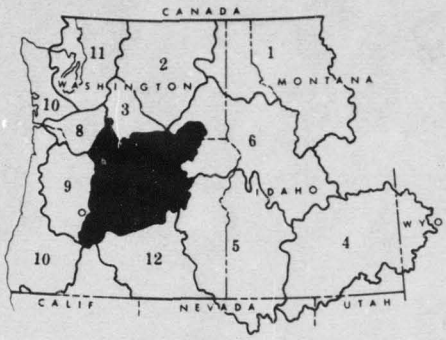
Summary of Measures and Costs

The slack water navigation project to Lewiston and appurtenant features should be completed prior to 1980 to meet the low-cost transportation needs of the area. The work remaining to be done includes completion of Lower Granite Lock and Dam and construction of appropriate port facilities. Between 1980 and 2000, the project should be extended through Asotin damsite to the extensive limestone deposits in the vicinity of the mouth of Grande Ronde River. Needed works will include Asotin Lock and Dam and appropriate port facilities. Further extension of slack water navigation or improvement of the swift water reaches for navigation is not envisioned, but port facilities on the slack water project will need to be expanded through 2020 as traffic increases. Facilities for recreational boats also will need to be expanded as the number of boats and usage thereof increases. There is an immediate need for control of releases at Hells Canyon Dam to insure adequate minimum flows at all times. Estimated total costs for navigation features are as follows.

Table 27 - Summary of Costs, Navigation Facilities, 1/
Subregion 6

	1980	2000	2020
		($1,000)	
First Costs			
Channels & Locks	27,420	25,113	0
Aids to Navigation	30	309	0
Port & Transfer Facilities	6,680	4,238	3,092
Moorages	225	585	1,065
Launching Ramps	1,150	2,500	4,500
Total First Cost	35,505	32,745	8,657
Annual O&M			
Channels & Locks	120	115	0
Aids to Navigation	2	55	0
Port & Transfer Facilities	668	424	309
Mooring Facilities	45	117	213
Launching Ramps	23	50	90
Total Annual Costs	858	761	612

1/ Incremental costs in 1968 dollars prior to date shown.



LOCATION MAP

SUBREGION 7

S U B R E G I O N 7

M I D - C O L U M B I A

GENERAL

Subregion 7, Mid-Columbia, comprises the drainage area of the Columbia River below the mouths of the Yakima and Snake Rivers to Bonneville Dam. In this appendix the navigation discussion is limited to the reach from the mouths of the Yakima and Snake Rivers to below John Day Dam. For coverage of navigation on the river reach from John Day Dam to Bonneville Dam see Subregion 8.

Topography

Much of the perimeter of Subregion 7 is rough and mountainous. The Cascade Range on the west includes six peaks above 10,000 feet but is cut almost to sea level by the Columbia Gorge. The Blue Mountains on the east have several peaks above 9,000 feet. Foothills from the mountain ranges extend into the subregion and form the northern and southern boundaries. Gentle rolling plateaus ranging in elevation from 700 to 5,000 feet occupy much of the interior. Much of the rolling plateaus, particularly in the John Day and Deschutes basins and along the Columbia River, are sharply cut by canyons with steep, rocky walls.

Climate

The climate, except the mountainous areas and the valleys of the White Salmon, Wind, and Hood Rivers, is semi-arid and characterized by cool-to-cold winters and warm, dry summers. About 75 percent of the precipitation occurs from November through April, and rainfall during July and August is generally limited to occasional localized convective storms. Winter storms generally result in heavy precipitation near the crest of the Cascade Range and on the western slopes of the Blue and other mountains. Average annual precipitations range from 9 to 15 inches on the lowlands and in the rain shadow of the Cascades to 60 to 120 inches on the higher mountain areas. A significant part of the precipitation falls as snow at the higher elevations; as much as 250 to 350 inches occur annually in the higher Cascades and from 100 to 150 inches in the Blue Mountains. At elevations above 5,000 feet, snow normally remains on the ground from December through May. On rare occasions warm winter storms combine snowmelt and heavy rainfall at all elevations. The valleys of the White Salmon,

AD-A036 555 PACIFIC NORTHWEST RIVER BASINS COMMISSION VANCOUVER WASH F/G 8/6
COLUMBIA-NORTH PACIFIC REGION COMPREHENSIVE FRAMEWORK STUDY OF --ETC(U)
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Wind and Hood Rivers, which lie within the Cascade Range, have a range of mean annual precipitation from 30 to 120 inches, increasing with elevation. Temperatures are generally warmer in winter and cooler in summer than those areas to the immediate east.

Temperature characteristics throughout the subregion generally vary with elevation but also reflect the maritime climate controls as modified by the intervening Coast and Cascade Ranges. Temperatures above 90 degrees are common at lower elevations during the summer but decrease in frequency at higher elevations. Subfreezing temperatures are common in winter except in the lower Cascade valleys, where rainfall predominates.

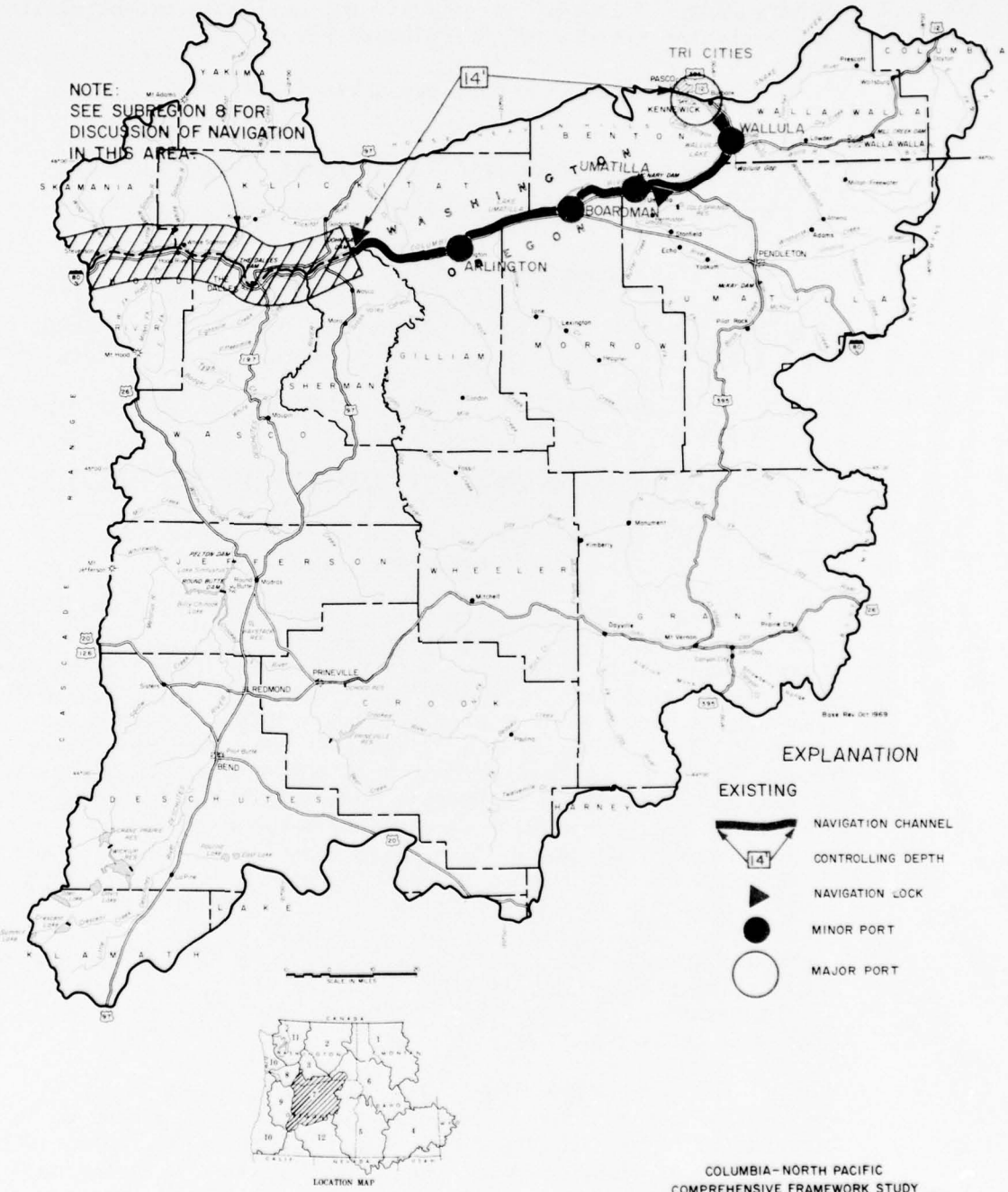
Streams

The Columbia River flows west-southwest in the northern extreme of Subregion 7 for a total distance of about 205 miles. The river enters the subregion at about elevation 340 and falls a total of about 330 feet through McNary, John Day, The Dalles, and Bonneville Dams. The principal tributaries of Columbia River in Subregion 7 are the Klickitat and White Salmon Rivers to the north; the Walla Walla River to the east; Umatilla River to the southeast; and the Hood, Deschutes, and John Day Rivers to the south. Table 28 lists pertinent data on the principal streams. For additional information on streams and streamflow characteristics see Appendix V, Water Resources.

Table 28 - Streamflow Summary for Selected Sites, Subregion 7

Stream	Total Drainage Area sq. mi.	Enters Columbia R. at R.M.	Gaging Station Location	Gaging Station Drainage Area sq. mi.	Annual Flow, cfs Mean	Annual Flow, cfs Max.	Annual Flow, cfs Min.	Momentary Flow, cfs Max.	Momentary Flow, cfs Min.
Walla Walla	1,760	314	Touchet	1,657	555	897	237	33,400	2
Umatilla	2,290	289	Umatilla	2,290	420	913	158	19,800	0
John Day	7,840	218	McDonald Ferry	7,580	1,925	3,669	630	42,800	4
Deschutes	10,500	204	Moody	10,500	5,186	7,340	3,940	75,500	2,400
Klickitat	1,350	180	Pitt	1,297	1,565	2,809	826	31,000	445
Hood River	329	170	Hood River	329	1,072	1,684	582	34,000	165
White Salmon	386	168	Underwood	386	1,176	1,755	659	9,700	158
Columbia			Bonneville Dam	240,000	177,400	247,300	131,400	1,240,000	35,000

Source, Appendix V, Water Resources



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

EXISTING & POTENTIAL NAVIGATION FACILITIES

MID COLUMBIA SUBREGION 7

1970

FIGURE 5

The Columbia River has slack water navigation throughout the reach considered herein in the reservoirs of John Day and McNary Dams. Tributary streams are not navigable except within the backwater effects of the Columbia River.

Data on these two dams are given in table 29.

Table 29 - Dams on Columbia River, Subregion 7 1/

Dam	Reservoir	River Mile	Surface Area acres	Height or Head	Agency
John Day Lock & Dam	Lake Umatilla	215	51,000	108	Corps of Engineers
McNary Lock & Dam	Lake Wallula	292	38,800	72	Corps of Engineers

1/ For information on Bonneville & The Dalles, see Subregion 8.

Economic Development

The economic subregion includes Columbia, Klickitat, and Walla Walla Counties in Washington; and Crook, Deschutes, Gilliam, Grant, Hood River, Jefferson, Morrow, Sherman, Umatilla, Wasco, and Wheeler Counties in Oregon. The estimated population in 1965 was 210,500, with 147,100 in Oregon and 63,400 in Washington. A generalized distribution is 47 percent urban and 53 percent rural. Cities with populations of 10,000 or more include Walla Walla, Washington, and Pendleton, Bend and The Dalles, Oregon. There are eight towns with populations between 2,500 and 10,000 and 20 between 500 and 2,500. Large areas in the southeastern portion of the subregion are virtually uninhabited. The Tri-Cities area, Pasco, Kennewick, and Richland, Washington, is located at the junction of Subregions 2, 3, 6, and 7. For economic study and projections, Kennewick and Richland in Benton County are included in Subregion 3, and Pasco in Franklin County in Subregion 2. For navigation studies, the Tri-City area is included in Subregion 7.

The subregion, with 18,947,800 acres, covers about 11 percent of the region. The approximate land use pattern of this area is 20 percent agricultural crop-producing land, 33 percent rangeland, 44 percent forest land, and 3 percent miscellaneous (i.e. urban and barren areas, roads, etc.). Of the crop-producing land, about 2.8 million acres are devoted to small grain

production, principally wheat. Other crops are feed grains and forage, livestock, vegetables and fruit. Industries based on forest and agricultural products form a substantial part of the subregion's economy. The 1960 total employment was about 73,000. Of this total, 11,750 were employed in agriculture, 2,740 in food processing and 7,300 in lumber and forest products processing. Food and forest products processing make up over 80 percent of all manufacturing. Table 30 shows the distribution of the labor force.

Table 30 - Employment in Selected Categories, Subregion 7

Total employment	73,054
Agric., Forestry & Fishery	12,465
Agriculture	11,753
Mining	187
Manufacturing	12,678
Armed Forces	217
Non-Commodity	47,507

Other Forms of Transportation

Railroads

Rail service is provided by main lines of the Union Pacific Railroad and Burlington Northern, Inc. and several branch lines. A main line of the Burlington Northern follows the north bank of the Columbia River through the subregion and the Union Pacific follows the south bank from Bonneville Dam to Boardman, then proceeds easterly through the Umatilla Valley and into Subregion 6 near La Grande. A major north-south route originates at the Columbia River near The Dalles, extends southerly through the Deschutes Basin, and joins the main Southern Pacific line near Chemult in the Klamath River Basin. Branch lines extend to most major communities not on a main line.

Highways

Highway facilities provide the basic transportation network in the subregion. Interstate 80N (U.S. 30) follows the south bank of Columbia River from Bonneville to Boardman, then continues easterly through Pendleton and into Subregion 6 near La Grande. The subregion is also crossed by U.S. 20 and 26 in an east-west direction and U.S. 97 and 395 in a north-south direction. U.S. 12 crosses the northeast tip of the subregion through Walla Walla. State and county roads provide all-weather access to all populated areas.

Air

Scheduled airline service is available at Pendleton, Walla Walla and Pasco.

Pipeline

Refined petroleum products are transported into the subregion by pipeline from Salt Lake City, Utah, to terminals near Pendleton and Pasco. Both terminals have provisions for truck and rail loading and the Pasco terminal for barge loading.

EXISTING NAVIGATION

Existing Project

The Federal navigation project for the Columbia and Lower Snake Rivers provides for slack water navigation through Subregion 7 with minimum channel dimensions of 250 feet wide by 14 feet deep at minimum regulated flows. Locks at the two dams have clear dimensions of 86 feet wide by 675 feet long and 15 feet of depth over the sills.

Waterway

The Columbia River is navigable for vessels with drafts to 14 feet and is used for barges hauling wheat, petroleum products, cement, and other commodities, with tows ranging to 10,000 tons capacity. The waterway is being extended to provide some 460 miles of inland navigation.

Navigation Aids

The Coast Guard maintains channel markers and other navigation aids for the main and side channels on the Columbia River.

Bridges

Bridges over the navigable waters of the Columbia River in Subregion 7 are shown in table 31.

Table 31- Bridges over Columbia River, Subregion 7 1/

River Mile	Location	Type of Bridge	Horizontal Clearance	Vertical Clearance Low Water Ft.	Vertical Clearance High Water 2% Line
215.6	John Day Lock & Dam	Fixed, Hwy	86'	91	83
290.5	Umatilla	Fixed, Hwy	335'	88	77
292.0	U.S. Army Corps of Engrs McNary Lock & Dam	Bascule, Hwy	86'	Unlimited	Unlimited
323.4	Burbank	Swing, RR	113'	Unlimited	Unlimited
328.0	Pasco-Kennewick	Lift, RR	280'	70	67
328.5	Pasco-Kennewick	Fixed, Hwy	420'	53	50
330.0	Pasco	Fixed, Hwy	500'	62	58

1/ Above John Day Dam; for bridges below John Day Dam see Subregion 8.

There are 21 other bridges on John Day and McNary project pools which cross tributary streams. These bridges generally have a clearance of 20 feet or less above normal pool level, sufficient to accommodate small pleasure craft.

Commercial Port Facilities

Existing port facilities are listed in table 32. Port facilities located on McNary pool have been under development since 1954, while those on John Day pool are now being developed to replace facilities flooded out by the pool.

Table 32 - Commercial Port & Terminal Facilities, Subregion 7

Location	River Mile	Avail. Port Lands (acres)	Avail. Water Frontage (feet)	Type of Land Access	Barge Capacity	Owner and Development
Arlington, Oreg	242	3	1,300	Hwy	2	Port of Arlington Grain 300,000 Bu.
Morrow Grain Elev., Oreg	278	3	1,000	Hwy	1	Morrow County Grain 670,000 Bu.
Umatilla, Oreg	292.5	18	2,000	Hwy	2	Umatilla Port Dist. Grain 340,000 & Petroleum
Kennewick, Wash						Kennewick Port Dist.
Hover	316	13	4,200	Hwy, RR	2	Fertilizer (Amt unavail.)
Finley	319	140	3,800	Hwy, RR	2	Chemical 150,000 T/yr.
Hedges	323	75	5,000	Hwy, RR	2	Fertilizer 100,000 T/yr.
Ivy Street	328	4.5	550	Street, RR	2	Grain 3.75 Mill. Bu. Cement - storage
Port Kelly, Wash	312	14	1,000	Hwy	2	Walla Walla Grain Growers Grain 1,700,000 Bu.
Walla Walla, Wash	314	5	1,000	Hwy, RR	2	Walla Walla Port Dist. Grain 1.06 Mill. Bu. Chemical 21 Mill. Gal/yr. General cargo
Wallula, Wash	315	10	1,000	Hwy, RR	2	Walla Walla Port Dist Pulp Mill
Pasco, Wash						Port of Pasco
Gen. Port Area	325	575	800	Hwy, RR	1	Warehousing
	328.5			Hwy, RR	2	Grain 2.5 Mill. Bu.
	328.5	28	500	Hwy, RR	1	Petroleum 17 Mill. Gal.
	328.5			Hwy, RR	1	Cement 5.5 Thous Bb
	328.5			Hwy, RR	1	General Cargo

Commercial Traffic

Commerce

Waterborne commerce on the Columbia River comprises principally grain movement downriver to Portland, Vancouver, Longview, and Kalama. Petroleum moves upstream to Umatilla and Pasco, and some petroleum products are moved downriver from a pipeline terminal at East Pasco, Washington. Commerce movement from the Snake River has not yet reached a growth level where it is stabilized. Table 33 shows waterborne commerce for 5 typical years. Commerce as reported through The Dalles Lock was taken as representative of the total traffic on the Columbia River through Subregion 7.

Table 33 - Waterborne Commerce, Subregion 7

	1958	1961	1964	1967	1970
			(short tones)		
UPBOUND					
Petroleum Products	537,672	522,078	381,535	265,461	287,367
Miscellaneous	65,209	175,956	177,688	163,608	244,646
Total Upbound	602,881	698,034	559,223	429,069	532,013
DOWNBOUND					
Petroleum Products	91,712	20,016	7,607	211,676	21,584
Grain	654,378	756,358	886,519	1,325,727	1,706,109
Miscellaneous	9,541	38,860	29,437	37,323	28,257
Total Downbound	755,631	815,234	923,563	1,574,726	1,755,950
TOTALS UPBOUND & DOWNBOUND	1,358,512	1,513,268	1,482,786	2,003,795	2,287,963

Source: Lock Report, The Dalles Dam

Vessel Traffic

Commerce on the Columbia River is carried in barges powered by towboats. The equipment is described in the regional summary. In 1967, the total number of barges moved through the reach into McNary Lock was 1,738 upbound and similar number downbound. Towboats used in the towing operation were reported as 2,190 craft upbound and similar number downbound. The traffic would be representative over the entire reach.

Difficulties Attending Navigation

The Union Pacific Railroad bridge across the Columbia River at mile 323, about a mile downstream from the mouth of the Snake River, restricts barge traffic. Multiple barge tows are now broken up and moved through the bridge as single-barge units. When winds are strong, navigation is halted due to hazard of passage through the swing span. The bridge has a swing span opening of 113 feet without benefit of guide walls to protect the opened swing span or to prevent the tows from being swept beneath

Union Pacific Railroad Bridge with sunken barges, river mile 323, Columbia River.

the adjoining spans. In 1969, a collision of a tow attempting passage through the bridge resulted in about $1,000,000 damage to tow, cargo, and bridge structure, and the waterway was closed 4 days for repair of the bridge and removal of the sunken barge. Shoals in the upper reach of Lake Umatilla are a hazard to navigation and necessitate reduction in barge loading when the pool is drawn down for power peaking or when lowered for flood control storage in advance of spring freshets.

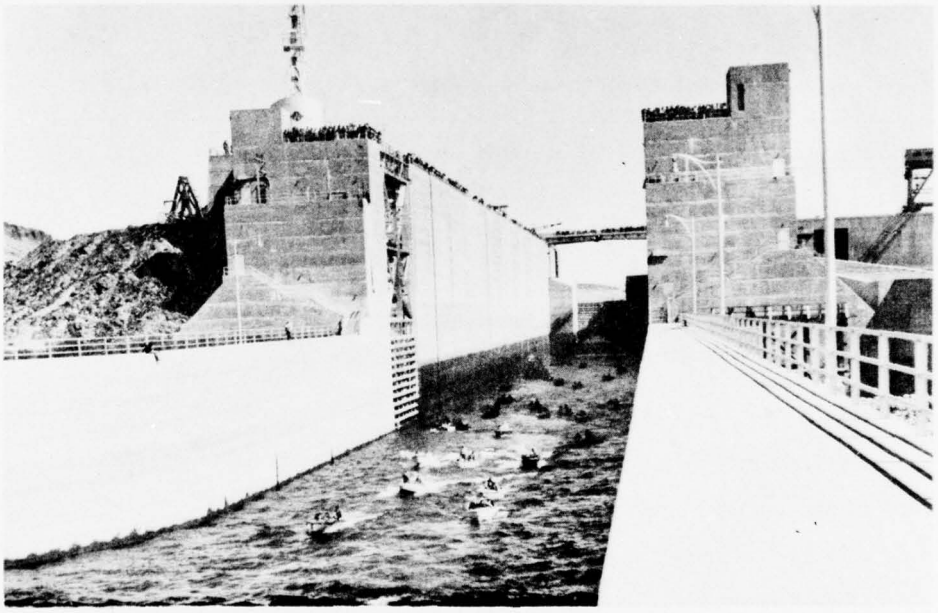
Recreational Boating

The total number of recreational boats in Subregion 7, as estimated from records of the State Tax Commission of Washington and the Oregon Marine Board, is 12,100. Of these, approximately 5,540 are used principally on the Columbia River, see table 38; the others are used on lakes, reservoirs, and other streams. Most of the boats are stored at the owners' homes and transported on trailers to the waterways for each use. Surveys of pleasure boat owners indicate that the number of boat days use on the Columbia River is about 218,000.

Small boat harbors at Arlington, Umatilla, Kennewick, Pasco, and Port Kelley have mooring spaces for about 250 boats where property protection is afforded. Two marinas are located in the Kennewick-Pasco area. Semi-protected moorage areas are

located at Boardman, Plymouth, and Crow Butte. Altogether, there are 26 harbors of refuge on the Columbia River through Subregion 7 with a total capacity of about 1,800 boats. There are 26 ramps with a total of about 50 lanes. Ultimate capacity of the existing harbors of refuge is considered to be about 3,500 boats.

Because of periods of high winds during the principal boating season, additional harbors of refuge are needed, particularly on Lake Umatilla, where distances between good harbors are as great as 30 miles along one side of the river or the other. When it is necessary to seek a harbor of refuge, it is also hazardous to cross the reservoir. Waves 4 feet or more in height occur frequently.



Recreational boats leaving McNary Lock during dedication ceremonies, 1954.

PROJECTED CONDITIONS AND NEEDS

Economic Outlook

Population, Employment and Income

The employment fields which now provide the basic support for the economy are agriculture, food processing, forest management, and timber and paper processing. The projections indicate that employment in these fields will decline from a present total of about 22,400 to 17,300 by 2020. Employment in other industries and per capita income are projected to grow at rates slightly below the regional total. Table 34 provides a condensed summary of population and employment trends.

Table 34 - Population, Income & Employment Projections, Subregion 7

Item	1960	1980	2000	2020
Total Population	198,665	251,000	322,000	404,000
Total Personal Income ($1 million)	453	1,039	2,326	5,065
Per Capita Income	2,237	4,100	7,200	12,500
Total Employment	73,054	100,600	128,700	161,700
Agric., Forestry & Fishery	12,465	10,863	9,149	7,521
Agriculture	11,753	8,900	8,400	6,800
Mining	187	90	100	110
Total Manufacturing	12,678	19,276	24,848	31,455
Forest Products	7,359	6,956	6,223	5,449
Food & Kindred Products	2,741	3,047	2,931	2,846
Other Manufacturing	2,578	9,273	15,694	23,160
Non-Commodity	47,724	70,343	94,650	122,663

Source: Appendix VI, Economic Base and Projections

Commodity Projections

Estimates of bulk commodities produced in Subregion 7 or needed to support the population projections for the years 1980, 2000, and 2020 are shown in table 35. Agricultural, forest, primary metal, and nonmetallic mineral commodities are discussed in the following paragraphs; other commodities are self-explanatory.

Agricultural Commodities and Fertilizers Wheat, barley, and other small grains are grown on the dryland benches of eastern Washington and north central Oregon. Production in 1964 amounted to 1,175,000 tons. Other dryland crops are limited to a band of lands along the base of the Blue Mountains in eastern Washington and Oregon where field peas are produced for processing into canned food. The production of green peas in 1964 was 96,500 tons out of a total vegetable production of 137,000 tons. Potato production was an additional 139,000 tons. Livestock production is often combined with grain growing to utilize the broken terrain and forested areas adjacent to the fields for summer pasture. Related to the livestock operation was the production of 564,000 tons of hay and forage. Berries and orchard crops grown on irrigated lands totaled 100,000 tons in 1964. Sugar beet growing also provided an important input to the economy by supplying 77,000 tons towards the Nation's sugar needs in 1964. Dry beans and peas and miscellaneous crops accounted for the other 18,000 tons of production, making a total agricultural production for market, including local consumption, of 2,210,000 tons for the base year. Agricultural production and consumption for this subregion is expected to increase by nearly 50 percent by 1980, and to nearly double by 2000. Fertilizer consumption is projected to increase from about 70,000 tons to 300,000 tons annually by 2020. Local fertilizer production is expected to increase proportionately and raw materials to be shipped in by barge and other means.

Forest Products Forest areas of the subregion are located in the Blue Mountains in the eastern portion, on the east slopes of the Cascade Range, and in the Ochoco Mountains along the southern edge. These areas produce large volumes of timber, most of which are processed in the subregion. The timber products and waste materials used for pulp and manufactured board are moved both west of the Cascade Range and to eastern points by rail, truck, and water. The forecast tonnage expected to be produced within Subregion 7 is estimated at 7,250,000 tons by 1980. Increase in timber products demands, including pulp products, would increase the volume to 8,400,000 tons by year 2000.

Grain and petroleum terminal at Pasco, Washington, on the Columbia River. (USCE)

Primary Metals Aluminum production is now associated with the waterside development on lower reaches of the Columbia River between the mouth and The Dalles, Oregon. A newly announced light metals plant is now planned on the Columbia River near The Dalles to produce magnesium metal and chlorine. As further new expansion, an aluminum plant is under construction on the John Day pool about 15 miles from Goldendale, Washington. The requirement for raw minerals for reduction to primary metals is expected to reach about 150,000 tons annually by 1980.

Nonmetallic Minerals It is estimated that consumption of cement will increase from 2.4 barrels per capita in 1980 to 3.0 barrels in 2000 and 4.0 barrels in 2020. The estimate for cement consumption is in accord with forecasts of population growth and industrial needs in the subregion. Sand and gravel are available as native products to provide basic elements for other construction materials which would include precast concrete

Table 35 - Projections of Major Bulk Commodities Produced or Consumed in Subregion 7

Item	Base Year 1/	1980	2000	2020
	(1,000 short tons)			
Agricultural Commodities	2,210	3,285	4,035	5,240
Food Manufactures	450	750	1,040	1,430
Forest Products	6,425	7,250	8,400	8,950
Primary Metals	85	150	390	650
Nonmetallic Minerals	3,040	4,025	5,580	7,345
Steel Scrap	25	25	35	50
Petroleum Products	490	665	1,025	1,550
Fertilizer	70	100	185	300

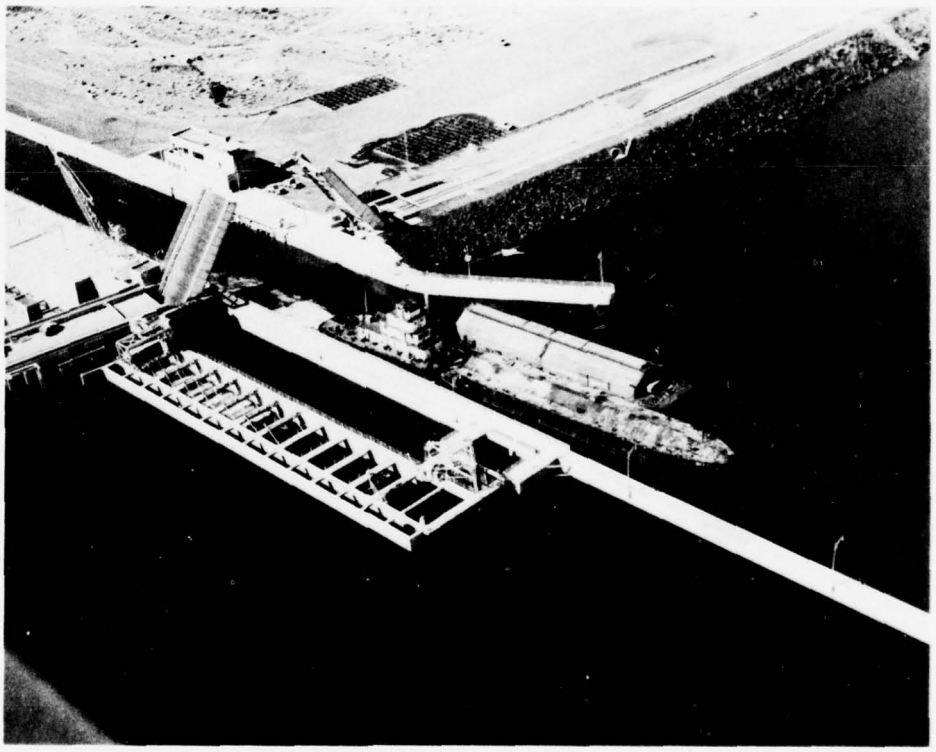
1/ 1964, except primary metals 1969, and steel scrap and petroleum products 1960.

members, forms and beams. The total volume of this commodity is expected to increase 30 percent from about 3,040,000 tons estimated for the subregion at present to 4,025,000 tons by 1980. Growth is expected to continue to increase to 5,580,000 tons by the year 2000.

The Role of Transportation

The adequacy of the transportation system within an area is a large factor in its growth. All facilities, rail, water, highways, airways, and pipelines, must continue to be expanded and improved. In this subregion, all principal routes of land, water, and air commerce follow the same general east-west direction along the Columbia River. Portland, Oregon serves as one of the principal western focal points for shipments originating from and moving toward Pacific domestic ports as well as Hawaii, Alaska, and the Orient. Rail and highway routes follow both banks of the waterway from there to Pasco. Branch line railroads and highways fan out from this central artery to the fringe areas of the subregion to serve the shipping needs of grain, lumber, and other commerce. Major rail lines move products and raw materials into the subregion from midwest points as well as from the west coast. Interstate Freeway 80N serves as a major carrier of commerce between points in southern Idaho and the waterway.

Competitive transportation between land and water carriers has served to attract and expand industry as well as to encourage development of port transfer and storage facilities at waterside. Completion of near slack water conditions on the Columbia River in 1968 now provides a total waterway system of some 400 miles, including some 70 miles on the Snake River. Products are now moving by oceangoing barge as far as Pasco.



Tug and barges leaving McNary Lock, Columbia River.

Prospective Waterborne Commerce

Agricultural Commodities

Agricultural lands along the Columbia River produce large volumes of grain, of which it is estimated about 630,000 tons would be available for downriver transport by 1980. The grain

shipped from the subregion would originate in some 14 counties but much of the volume would be from the counties adjacent to the waterway. The combined tonnage would increase from 630,000 tons in 1980 to 940,000 tons by 2000. The present grain shipments from subregion 7 also include grain now trucked in excess of 100 miles to the waterway from points in Subregions 6 and 2. With completion of the authorized Snake River navigation project, more of the waterborne tonnage will originate on the Snake River system and move through Subregion 7.

Chemicals and Fertilizers

Present chemical shipping on the waterway is about 56,000 tons, primarily composed of caustic soda. Because chemicals are expected to be an expanding commerce, this volume is projected to increase to 87,000 tons by year 2000, including products moving both up and downriver. Bulk movement of fertilizer is presently about 19,000 tons, but is expected to reach 180,000 tons by 2020 as demands for agricultural production increase, making it an important part of the commerce moving on the waterway. The combined tonnage of chemicals and fertilizers is estimated at 226,000 tons by year 2000 with continuing growth to 287,000 tons through 2020.

Primary Metals

The waterway provides an opportunity for low-cost movement of raw materials to processing plants in the subregion. The principal raw material now expected to move over the waterway from tidal ports is bauxite. The volume of bauxite and other minerals expected to move upriver by water by 1980 is 230,000 tons, increasing to 370,000 tons by year 2000. Refined metals, such as processed aluminum, are expected to move downriver in tonnages of about 40,000 by 1980.

Nonmetallic Minerals

Building cement has moved on the waterway in the past and a good possibility exists that such movements may be resumed. Consumption in the subregion is projected to increase from about 76,000 tons at present to about 86,000 tons by 1980. Total consumption in the entire area served by the waterway including portions of Subregions 2, 3, 6, and 7 is expected to be 148,000 tons by year 2000. At that time it may prove more economical to produce cement locally from limestone deposits along the Snake River than to continue to ship it in from other production centers.

Other nonmetallic minerals comprise principally sand, gravel, and crushed stone for production of concrete and for highway surfacing. These products are usually obtained locally and not transported more than a few miles.

Petroleum Products

Waterborne shipments of petroleum will continue to move into the subregion from coastal ports, increasing in volume as population and industrial demands grow. Petroleum will move to Pasco-Kennewick storage terminal areas as the major distribution point for some twelve counties in Washington and Idaho, most of which lie outside this subregion. Petroleum shipments to Umatilla, Oregon, will continue to serve the needs of eastern Oregon extending to Baker and Wallowa Counties, also outside this subregion. A pipeline terminal near Pasco distributes petroleum for various companies. Some of these companies also ship petroleum westward over the waterway to tidewater for further refining on the west coast. Prospective waterborne petroleum movements which would be required to meet Subregion 7 needs are estimated at 890,000 tons by 1980, increasing to 1,216,000 tons by the year 2000.

Forest Products

Forest products expected to move on the waterway consist of lumber and wood by-products including wood chips. Lumber is an early prospective commerce which would move out of the subregion to coastal ports. The volume is expected to remain near constant at about 50,000 tons annually through the period 1980 to 2020 based primarily upon sustained timber yields. With greater utilization of by-products from timber harvest, the volume of wood chips moved on the waterway is projected to reach about 8,000 tons by the year 2000 and remain nearly constant thereafter.

Miscellaneous

Miscellaneous other commodities are expected to move on the waterway in both directions. Various types would include fabricated steel and wood structural members, tanks, and miscellaneous other products not suited to highway and railroad dimension limits. The volume is expected to reach about 232,000 tons by 1980 and rise to about 316,000 tons by around the year 2000.

Projected types of commerce and volume which are forecast to originate on the Columbia River in Subregion 7 are shown in following table 36.

Table 36 - Projected Commodity Movement on Columbia River Waterway Originating or Destined for Ports on John Day or McNary Pools, Subregion 7

	1980		2000		2020	
	Up	Down	Up	Down	Up	Down
	(1,000 short tons)					
Petroleum Products	890		1,216		1,586	
Agriculture Commodities		630		780		940
Primary Metals	230	40	370	120	480	150
Chemicals & Fertilizers	132		201	25	262	25
Nonmetallic Minerals	86		148		15	
Forest Products		50		58		58
Miscellaneous	160	72	244	72	320	90
Totals	1,498	792	2,179	1,055	2,663	1,263

Forecast of Total Through Commerce

The total commerce on the Columbia River in Subregion 7 includes not only that which serves Subregion 7 but also that which serves Subregions 2 and 6, the Upper Columbia and Lower Snake, respectively. Reference is made to Subregions 2 and 6 for details on waterborne commerce projected to move to or from those subregions.

Table 37 shows the projected total waterborne commerce by types and amounts.

Table 37 - Projected Total Commodity Movements on Columbia River, Subregion 7

	1980		2000		2020	
	Up	Down	Up	Down	Up	Down
	(1,000 short tons)					
Petroleum Products	1,411	210	2,012	150	2,686	30
Agriculture Commodities		3,640		4,600		5,670
Primary metals	1,302	194	2,078	300	2,878	382
Chemicals & Fertilizers	367	18	635	45	772	50
Nonmetallic Minerals 1/	276	80	428	100	455	120
Forest Products		815		1,254		1,648
Miscellaneous	270	132	374	144	475	175
Totals	3,626	5,089	5,527	6,593	7,266	8,075

1/ Limestone to move to Pasco, not on through Subregion 7.

Future Outlook of Recreational Boating

Recreation boating on the Columbia River will expand as a direct result of increased numbers of people and the continued increase in normal spendable income and leisure time. Improved highway access routes to the Columbia River also provide rapid access from greater distances.

Growth factors in boating are related to basic expansion in population throughout the subregion as well as in other adjoining subregions which have limited boating waters. The trend in greater travel distance of trailer-hauled boats will contribute to the number of boats using the Columbia River. A problem of the Columbia River in Subregion 7 related to John Day pool is the prevailing high summer winds which blow up the Columbia and create waves too high for small craft during periods of the boating season.

The projected boating level anticipated to develop on the Columbia River is based upon boaters being drawn to the Columbia River from four counties within the subregion and surrounding area. Registered boats in the subregion total about 11,140, based on 1968 composite records. It is considered that only about

5,450 craft would use the river on a regular seasonal basis with the balance using other water bodies, some at greater distances. Boating days on the waterway per boater have been reduced as a result of occasional rough water conditions on the John Day pool during the boating season. Table 38 shows boats available and those which would use the waterway along with estimated boating days for the study periods.

Table 38 - Recreational Boating Activity Projections, 1/
Subregion 7

Item	Year			
	Present 2/	1980	2000	2020
Estimated total number of boats in Subregion 5/	12,100	13,550	26,400	47,800
Estimated boats used on a full-season basis on the contiguous waterway	5,540	7,250	12,750	22,740
Annual boat-day use	218,000	290,000	510,000	910,000
Moorage capacity needs	250 3/	360	650	1,200
Boat launching lane needs	65 4/	90	160	285

1/ On contiguous waterways usable for commodity navigation.
2/ 1968, except 1970 for total boats in subregion.
3/ Presently available.
4/ Fifty presently available.
5/ From Appendix XIII.

MEASURES TO SATISFY

Immediate Needs

The completion of slack water on the Columbia River in Subregion 7 to River Mile 340 fulfills the needs of a navigation system. Investment in port facilities will be needed throughout the length of the subregion to serve the growth of industry and shipping. Site locations have been reserved to meet these future needs of industrial expansion in cooperation with public port districts. Extent of land site development and waterway approach channel improvements needed will depend upon types of industrial uses. The need also exists for additional terminal facilities for handling grain, petroleum, fertilizer, and other agricultural

commodities. Sites needed for development will be in areas serving agricultural lands with reduced land haul to waterside terminals. Investments would be largely by private capital in cooperation with port districts. Channel deepening in scattered shoals in the upper reach of John Day pool is needed in order to provide full project depth and to allow tows to operate at full barge loading throughout the year. Modification of the Union Pacific Railroad bridge over McNary pool at river mile 323 also is needed.

Harbors of refuge for recreational boats are needed on Lake Umatilla, but present financial criteria prevent construction.

Future Needs

Additional port and terminal facilities will be needed to meet the future levels of waterborne commerce. During the period 1970 to 1980, water shipping will expand to assume its normal share of total commerce. Following the initial period, further expansion is projected at the growth rate for economic activity in the subregion. The following table lists the locations where port and terminal facilities will need to be developed or expanded.

Table 39 - Port and Terminal Development, Subregion 7

Port Facilities	River Mile	Area Needs (acres)	Type of Terminal Needs
Arlington	241	6	Fertilizer & Petroleum
Heppner Junction	252	23	Grain & Industrial
Alderdale	258	40	Grain
Patterson	277	57	Grain
Plymouth, Kennewick Port District	288	250	Grain & Industrial

Mooring basins for recreational boats will continue to need development and expansion and more launching facilities will be needed to keep pace with the increasing numbers of boats. Locations for development are not as clearly defined as for commercial navigation but moorages generally will be needed

adjacent to communities and launching sites at more remote sites. Small protected anchorage areas will be needed adjacent to overnight campgrounds. Such areas would also serve as harbors of refuge.

Summary of Costs

Table 40 shows a schedule of costs to meet the existing and future needs of navigation in Subregion 7.

Table 40 - Summary of Costs, Navigation Facilities, 1/
Subregion 7

	1980	2000	2020
		($1,000)	
First Costs			
Channels	4,740	0	0
Bridge Modification	5,670	0	0
Port & Transfer Facilities	8,600	5,300	5,400
Moorages	165	435	825
Launching Ramps	1,250	2,500	6,250
Total First Cost	20,425	8,235	12,475
Annual O&M			
Bridges	10	0	0
Port & Transfer Facilities	860	0	0
Mooring Facilities	33	87	165
Launching Ramps	25	50	125
Total Annual Costs	928	137	290

1/ Incremental costs in 1968 dollars prior to date shown.

LOCATION MAP

SUBREGION 8

SUBREGION 8

LOWER COLUMBIA

GENERAL

Subregion 8 comprises 5,103 square miles in southwestern Washington and northwestern Oregon and includes all of the drainage into Columbia River from the north between Bonneville Dam and Grays Bay on the estuary, and from the south between St. Helens and Clatskanie, Oregon. For this appendix the navigation discussion for Subregion 8 includes the Columbia River, from John Day Dam to and including the mouth, and Portland Harbor (figure 6).

Topography

The crest of the Cascade Range, which forms the eastern boundary of the subregion, rises to over 12,000 feet at Mt. Adams, but generally ranges from 4,000 to 8,000 feet above sea level. Elevations decrease westward to the Willamette-Puget Sound Trough, the major physiographic province, and are generally below 1,000 feet. The western boundary of the subregion is the low Coast Range, which rises to about 2,000 feet elevation.

Climate

Climatic conditions of the subregion are similar to those of the Pacific Coast, characterized by dry summers, wet winters, and a comparatively narrow range of temperature. Average annual precipitation ranges from 40 inches in the lower elevations to over 100 inches in the higher mountain areas. About 75 percent of the annual precipitation occurs in the period October through March. In the lower elevations, snowfall is light, rarely exceeding 10 to 15 inches, and seldom remains for more than a few days; in the higher mountains, snow can be expected in October and to remain on the ground from mid-November until June or July. At elevations above 5,000 feet, the snowfall ranges from 300 to 500 inches. Winter mean temperatures range from about 30 to 40 degrees in the lower valleys, and 20 to 30 degrees in the mountains. Temperatures of zero and below occur occasionally but are usually of short duration. Summer average temperatures range from about 75 degrees in the afternoon to nighttime lows of approximately 50 degrees at lower elevations.

Streams

The Columbia River flows west-northwest about 215 miles from John Day Dam to the Pacific Ocean. From John Day Dam to Bonneville Dam it is in Subregion 7 but is considered herein for navigation purposes. From Bonneville Dam (mile 145) to the mouth of the Willamette River (mile 101) and from the mouth of the Clatskanie River (mile 50) to the mouth of Grays River (mile 22) it forms the southern boundary of the subregion. Between the Willamette and the Clatskanie Rivers, the Columbia flows through the southern part of the subregion. In passing through The Dalles and Bonneville Dams on this reach, the river falls about 150 feet; pertinent data on the dams are shown in table 41.

Table 41 - Dams on Columbia River in Subregion 8

Dam	Reservoir	River Mile	Surface Area (Acres)	Height (WS to WS)	Owner or Agency
Bonneville	Lake Bonneville	145.5	20,400	59	Corps of Engineers
The Dalles	Lake Celilo	191.5	11,650	88	Corps of Engineers

Principal tributaries in this subregion are the Cowlitz, Lewis, Washougal, and Kalama Rivers in Washington, and the Clatskanie in Oregon. Table 42 lists pertinent data on Columbia River and streams. For additional information on streams and streamflow characteristics, see Appendix V, Water Resources.

Navigable waterways include the entire reach of the Columbia River, the lower reaches of the Lewis and Cowlitz Rivers, numerous sloughs and side channels along the Columbia River, and the mouths of many minor tributaries within the backwater effects of the Columbia.

Table 42 - Streamflow Summary for Selected Sites, Subregion 8

Stream	Total Drainage Area, sq mi	Enters at Col. River Mile	Gaging Station Location	Gaging Station Drainage Area, sq mi	Annual flow cfs 1/ Mean	Annual flow cfs 1/ Max.	Annual flow cfs 1/ Min.	Momentary flow cfs 2/ Max.	Momentary flow cfs 2/ Min.
Washougal	211	121	Washougal	108	-	-	-	17,700	41
Lake	115	88	None	-	-	-	-	-	-
Lewis	1,046	87	Ariel	731	4,752	7,069	3,090	129,000	1
			Heisson	125	741	1,065	462	15,600	29
Kalama	205	73	Kalama	201	-	-	-	16,000	155
Cowlitz	2,480	68	Castle Rock	2,238	8,932	12,484	5,776	139,000	998
Clatskanie	96	50		53	-	-	-	2,000	3
Elochoman	73	36	Cathlamet	66	368	516	219	8,530	18
Grays	124	21		56	-	-	-	10,700	23
Columbia	259,000	-	Mouth	-	235,123	329,700	170,200		

1/ From Appendix V.
2/ Observed values for period of record.

Tides

Ocean tides are noticeable throughout the lower Columbia River. At Astoria, about river mile 14, tides have been as high as +12 feet MLLW 1/ and as low as -3 feet MLLW. The mean high is +7.2 feet and the mean low is +1.10 feet. The tidal effect at low river flows is about 2.5 feet at Vancouver, about 106 miles upstream, and about 0.3 feet at Bonneville Dam, 145 miles upstream from the mouth.

Economic Development

Subregion 8 includes the counties of Clark, Cowlitz, Lewis, Skamania, and Wahkiakum in Washington and Columbia County in Oregon. 2/ The population was 240,100 in 1965, an increase of

1/ See glossary.
2/ Although Portland Harbor is included in Subregion 8 for purposes of the navigation appendix, the economic development of the area is included in Subregion 9.

COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

EXISTING & POTENTIAL NAVIGATION FACILITIES

LOWER COLUMBIA SUBREGION 8

1970

FIGURE 6

12.2 percent since 1950. Principal cities are Vancouver and Longview. The 1960 national census recorded 32,464 residents in Vancouver and 23,349 in Longview. Three other cities had populations in excess of 2,000 at that time.

Land use is classified by area as 83.7 percent forest land 6.1 percent cropland, 2.1 percent rangeland, and 8.1 percent other (i.e. urban and barren areas, roads, and miscellaneous occupancy). Nearly 2.5 million acres are classed as commercial forest lands. The major species is Douglas fir; other significant species are red alder, hemlock, and the true firs. Sixty percent of the commercial forest area is in the sawtimber class. Only 65,000 acres of the commercial forest land are in the reserved category; the remainder supports over 96.5 billion board-feet of timber, supplying raw material for a forest products industry which accounts for two-thirds of the manufacturing employment in the subregion. In 1964 over 11 percent of the total timber harvest of the Columbia-North Pacific Region was taken from Subregion 8. In addition to the timber harvest, the forest lands also support hunting, fishing, and other recreational activities and are the source of domestic water for 68 percent of the urban population.

Nearly 95 percent of the 201,100 acres classified as cropland is devoted to forage crops, with row crops, specialty crops, orchards and vineyards, and field crops comprising the balance. Less than 10 percent of the cropland is irrigated; however, growing demand for the higher value specialty crops will probably increase the amount of irrigated farmland.

Some deposits of copper-gold-silver with minor amounts of associated lead, zinc, and vanadium are located in the subregion but there are no known large ore bodies. Commercially economic deposits of sand and gravel occur in a wide belt along the lower Columbia River and in the lower part of the Lewis River Basin in Cowlitz County. Ferruginous bauxite deposits cover a large area in Columbia County, Oregon; however, no commercial production has been made. Mercury has been the most important metallic mineral produced in the past. While there is no present production, some potential exists.

Employment in 1960 totaled 77,736, of which nearly one-fourth were engaged in lumber and wood products and the pulp and paper industry. About 57 percent of the employment is in the non-commodity classification.

Basic Transportation Network

Railroads

Three major railroads--Burlington Northern, Inc., Chicago, Milwaukie, St. Paul, & Pacific; and Union Pacific--serve the area. The Burlington Northern is generally oriented in an east-west direction and connects west coast port areas with eastern points. The Union Pacific; Chicago, Milwaukie, St. Paul, and Pacific; and connection lines of the Burlington-Northern run in a north-south direction parallel to Interstate 5, linking all highly populated areas from Portland-Vancouver to the Puget Sound area. Branch lines connect coastal areas to the principal north-south lines.

Highways

The major north-south highway, Interstate 5, goes through the most highly populated areas; I 80N (U. S. 30) parallels the Columbia River on the south, and U. S. 12 extends east-west through the upper Cowlitz Basin. A network of State and county highways serves all of the communities in the subregion.

Airlines

Nine major airlines have terminals at Portland in Subregion 9, but no regularly scheduled airline service is available in Subregion 8.

Pipelines

The Portland area serves as a storage and distribution center for supplying southwestern Washington and north-central and northwestern Oregon with petroleum products. The Olympic Pipeline Company operates a 14-inch pipeline originating at refineries in the Puget Sound area and terminating at tank farms in northwest Portland. The El Paso Natural Gas Company has a main line which comes down the Washington side of the Columbia River, with a 20-inch lateral crossing the Columbia River near Camas and an 18-inch lateral crossing northwest of Portland.

EXISTING NAVIGATION

Navigation Improvements

Channels and Locks

The entrance channel at the mouth of the Columbia River is maintained to a depth of 48 feet below mean lower low water over a width of a half mile. It extends a total distance of about 5 miles from deep water in the ocean through an outer bar seaward of the ends of the jetties and an inner bar between the jetties to deep water inside the entrance. An authorized 40-foot deep by 600-foot wide channel, under construction, provides for deep-draft navigation from the mouth to Vancouver and Portland. A channel 27 feet deep and 300 feet wide is authorized from Vancouver to The Dalles. This channel is presently maintained to a 15-foot depth to Bonneville Dam. A single lift navigation lock 76 feet wide and 500 feet long provides passage past Bonneville Dam. Depth of water over the lower lock sill is 24.2 feet. This is based on an adopted low water elevation below the dam of plus 8.2 feet MSL (known as the "Columbia River Datum") and a sill elevation of minus 16.0 feet MSL. A single lift lock at The Dalles Dam, 86 feet wide and 675 feet long, extends the navigable waterway into Lake Celilo. Minimum depth over the lower sill is 15 feet. A navigation channel 250 feet wide and 14 feet deep extends upstream to and beyond John Day Dam.

At one time a navigation channel in the Cowlitz River extended to Toledo, river mile 35.5. However, in recent years, it has not been maintained above Kelso, mile 5.5 and the controlling depth is less than 1 foot at low water. The controlling depth below Kelso is 9 feet. The Lewis River is navigable to Woodland, at about river mile 7, and the East Fork of the Lewis River is navigable to La Center, about 6 miles from the Columbia River. Elochoman Slough, at the mouth of the Elochoman River, is navigable to about river mile 1.5. A 6-foot deep by 40-foot wide navigation channel extends from the Columbia River to the town of Clatskanie, Oregon, at about river mile 4 on the Clatskanie River.

The tributary streams above Bonneville Dam are not considered navigable as the only reaches with sufficient depths are in the reservoir areas of Lakes Bonneville and Celilo.

Navigation Aids

The Coast Guard maintains channel markers and other navigation aids for the main and side channels on the Columbia River to provide adequate aid to ocean vessels and smaller craft. Navigation aids are provided, where necessary, for navigable streams and sloughs tributary to the Columbia River.

Bridges

Bridges in Subregion 8, with pertinent data on clearance that would affect navigation, are listed in table 43.

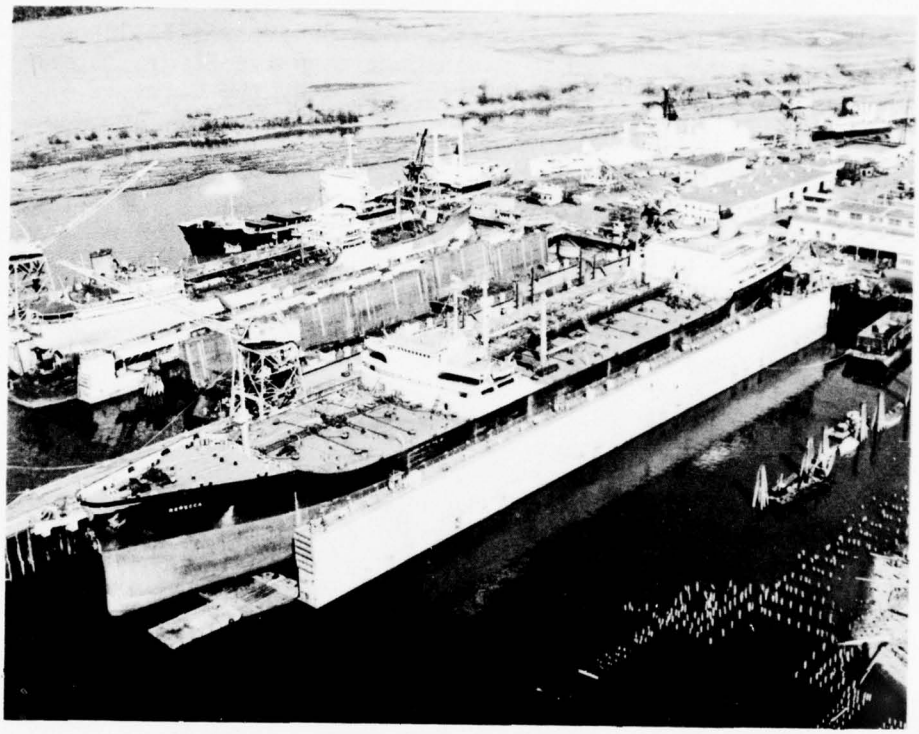
Table 43 - Bridges Over Navigable Waterways, Subregion 8

River mile	Stream	Location	Type	Clearance (feet) Horizontal	Clearance (feet) Vertical open (high water)
13.5	Columbia River:	Astoria, Oreg.	Highway-fixed		
	Main channel			1,070	198
	Side channel			200	41
66.0	Columbia River	Longview, Wash.	Highway-fixed	1,085	169
105.6	Columbia River	Vancouver, Wash.	Railroad-swing	200	UNL
106.5	Columbia River	Vancouver, Wash.	Highway-vertical lift (2 parallel Bridges)	263	153 (open)
148.3	Columbia River	Cascade Locks, Oreg.	Highway-fixed	284	124
169.8	Columbia River	Hood River, Oreg.	Highway-vertical lift	246	134
191.4	Columbia River	The Dalles, Oreg.	Highway-fixed	250	78
200.2	Columbia River	Wishram, Wash.	Railroad-vertical lift	300	75
208.1	Columbia River	Maryhill, Wash.	Highway-fixed	300	75
1.5	Cowlitz River	Longview, Wash.	Railroad-bascule	136	UNL
1.8	Cowlitz River	Longview, Wash.	Highway-fixed	280	42
5.5	Cowlitz River	Kelso, Wash.	Highway-vertical lift	100	47
5.6	Cowlitz River	Kelso, Wash.	Highway-fixed	240	38
7.1	Cowlitz River	Kelso, Wash.	Railroad-fixed	227	40
5.9	Willamette River	St. Johns (Portland)	Highway-suspension	1,068	177
6.9	Willamette River	St. Johns (Portland)	Railroad-swing	230	UNL
11.1	Willamette River	Fremont St. (I 40.)	Highway-fixed (UC)	1,225	146
11.7	Willamette River	Broadway St. (Portland)	Highway-bascule	251	UNL
12.1	Willamette River	Glisan St. (Portland)	RR & Hwy-vertical lift	200	131
12.4	Willamette River	Burnside St. (Portland)	Highway-bascule	205	UNL
12.8	Willamette River	Morrison St. (Portland)	Highway-bascule	185	UNL
13.1	Willamette River	Hawthorne Ave. (Port.)	Highway-vertical lift	200	129
13.5	Willamette River	Marquam (Portland) (I-5)	Highway-fixed	350	90
14.0	Willamette River	Ross Island (Portland)	Highway-fixed	330	90

Port and Terminal Facilities

Deep-draft port and terminal facilities are located at Portland, St. Helens, and Astoria in Oregon and Vancouver, Kalama, and Longview in Washington. Several other piers, each serving a single industry, are located adjacent to deep water at other points along the river. About 50 deep-draft vessels could be berthed at one time. The total length of berthing space with depths of 30 feet or greater is about 40,000 feet. Most of the berths have 35 to 40 feet of depth. Of these facilities, 10 are adapted to handle primarily grain cargoes, 12 primarily petroleum, 11 primarily ores and other dry bulk, and 17 general cargo. Some are capable of handling two or more types of cargo.

The Port of Portland owns and leases to private operators a ship repair facility including three floating drydocks, one of which can lift vessels up to the 50,000 dwt class.



Floating drydocks, Portland Harbor. (Port of Portland)

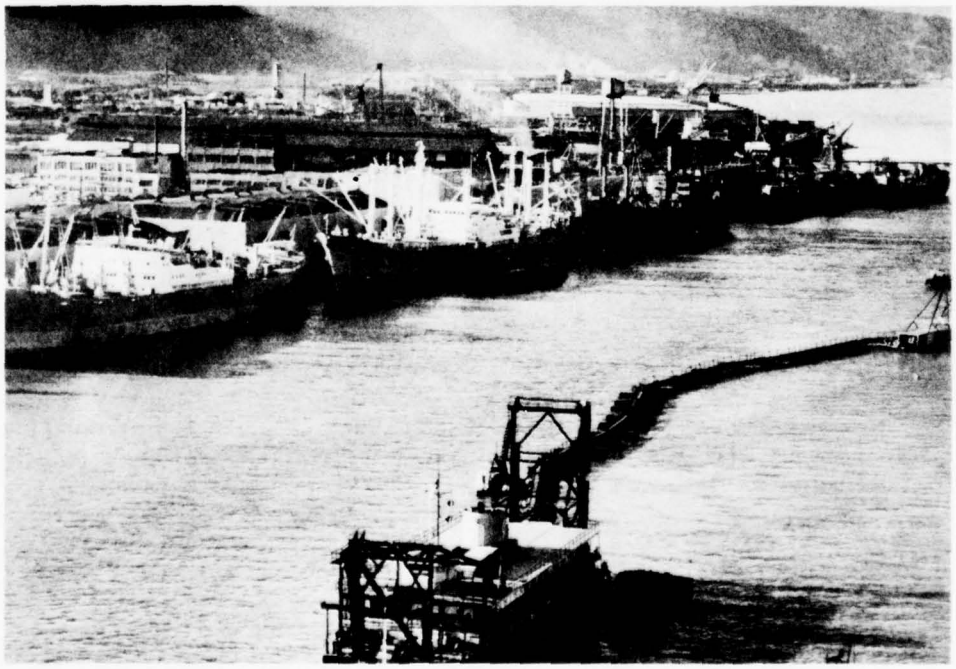
Docks for loading and unloading barges are located at the above deep-draft ports and at many other locations along the river. One particular barge terminal is worthy of note. It has been described (7) as having the largest single-level terminal warehouse in the Nation and as being a unique, ultra-modern cargo handling system. It handles much of the output of three large paper plants with a combined annual output of nearly 900,000 tons of paper products. Over 1,400 stock items and several thousand specialty items are handled at the terminal. At peak inventories over 40,000 tons of cargo are stored. From the terminal, a complete range of paper products can be shipped on the day ordered. Seven barges can be unloaded simultaneously and as many as 56 rail cars and 70 trucks can be spotted for simultaneous loading.

Additional information on port and terminal facilities can be found in House Document 452, 87th Congress (11), Appendix I, Navigation of the Willamette Basin Comprehensive Study (6), and in Port Series Numbers 33 and 34 published by the Corps of Engineers, U.S. Army. (23 and 21)

Commercial Traffic

Commerce

Waterborne commerce on the lower Columbia River is increasing steadily as shown in table 44 and now totals nearly 30 million tons per year. From 1960 to 1968, total waterborne commerce increased from 21.9 to 28.2 million tons per year. Nearly all of the increase was in foreign commerce, which increased from 5.9 to 11.4 million tons. Export of agricultural products, principally wheat and other small grains, and import of primary metals, largely alumina, gained considerably. Domestic commerce remained about constant with increases in internal balancing decreases in coastwise. Internal movements of sand and gravel are increasing



Harbor facilities at Portland, pipeline dredge, Oregon, in the foreground. (Port of Portland)

rapidly and more modest increases are occurring in local movements of paper products and receipts of grain from upriver ports. Movements of rafted logs are declining. The biggest decrease in coastwise tonnage has been in the receipt of petroleum products, which decreased from an average of 6.5 million tons from 1955 through 1966 to about 4 million in 1968 when the pipeline from Puget Sound refineries to Portland was completed.

In terms of total ocean tonnage handled, the major ports in Subregion 8 rank in the following order; Portland, Longview, Astoria, Vancouver, and Kalama. Portland handles about 56 percent of the ocean commerce and the three Washington ports, Longview, Vancouver, and Kalama, about 32 percent.

Table 44 - Waterborne Commerce, Subregion 8

Year	Foreign	Domestic Coastwise	Domestic Internal	Total
		(1,000 short tons)		
1960	5,860	6,627	9,379	21,866
1962	5,645	6,744	9,869	22,258
1964	7,667	7,043	11,563	26,273
1966	9,579	5,917	10,573	26,069
1968	11,375	5,405	11,454	28,234

The movements of principal commodity groups are shown in table 45. Petroleum and petroleum products are shipped from Puget Sound and California refineries and comprise largely fuels for transportation and industry. Primary metals foreign traffic includes imports of iron and steel products, export of scrap, and import of various ferrous ores. Alumina is the principal domestic coastwise receipt. Nonmetallic minerals moved include local shipments of sand and gravel, imports of limerock, and domestic coastwise receipts of building cement. Forest products in table 5 include export of logs, wood chips, paper products, and miscellaneous other products and internal movements of log rafts. Export of wheat is the principal movement of agricultural products. Fresh frozen tuna fish is imported for processing at Astoria, other fish products include dungeness crab, shrimp, bottom fish largely fed to mink raised for fur or prepared as pet food, and salmonid fish.

Table 45 - Waterborne Movements of Principal Commodity Groups, 1968, Subregion 8

Commodity Group	Foreign	Domestic Coastwise	Domestic Internal
	(1,000 short tons)		
Petroleum Crude & Products	50	4,054	869
Primary Metals & Ores	699	288	7
Nonmetallic Minerals	601	155	3,455
Forest Products	3,890	366	4,619
Agricultural Products	5,054	51	892
Miscellaneous & Prepared Products	1,070	490	1,580
Fresh Fish & Shellfish	11	0	32
Totals	11,375	5,405	11,454

The fish taken in the Columbia River comprise salmonid species such as steelhead trout, and chinook, coho, and sockeye salmon. Also caught are smelt, shad and sturgeon. In good years the catch runs about 8 million pounds with a value of about $3 million. Commercial fishing in the Columbia River has been declining for some time and its future existence will depend upon continuance of the salmonid fish runs and controls of fishing activities.

Vessel Traffic

Commercial navigation in Subregion 8 ranges from lografts on the Columbia River and side channels to large oceangoing cargo vessels. Liberty, Victory, C-2, C-3, C-4, and C-5 cargo vessels, T-2 tankers, and foreign equivalents are the principal types of deep-draft vessels presently serving the subregion. Drafts of these vessels vary from about 26 to 38 feet. Bulk carriers and tankers in the 22,000 and 33,000 deadweight-ton class call for export shipments of wheat and other small grain.

About 60 separate companies or operators of transportation lines operate about 200 tugs and 300 barges on the Columbia River. Of this group, 34 operators move on the Willamette River also and

a few engage in ocean hauling. Tugs and towboats range from 200- to 3,600-horsepower with 4- to 18-foot drafts and from 35- to 150-foot lengths. Barge dimensions vary from about 110 to 500 feet in length and 33 feet to about 65 feet in width. Capacity of the smaller barges is about 250 tons, while the larger ones range up to 15,000 tons. Drafts of the barges range from 6 to 18 feet.

In 1967, the five major ports of the subregion (Portland, Astoria, Vancouver, Longview, and Kalama) accommodated 38,000 vessel-trips inbound and an equal number outbound. Towboats and tugboats comprised 24,000 of the trips and 11,000 were by non-self-propelled craft.

About 800 licensed gill net fishermen drift fish from small boats in the lower Columbia River.

Navigational Problems

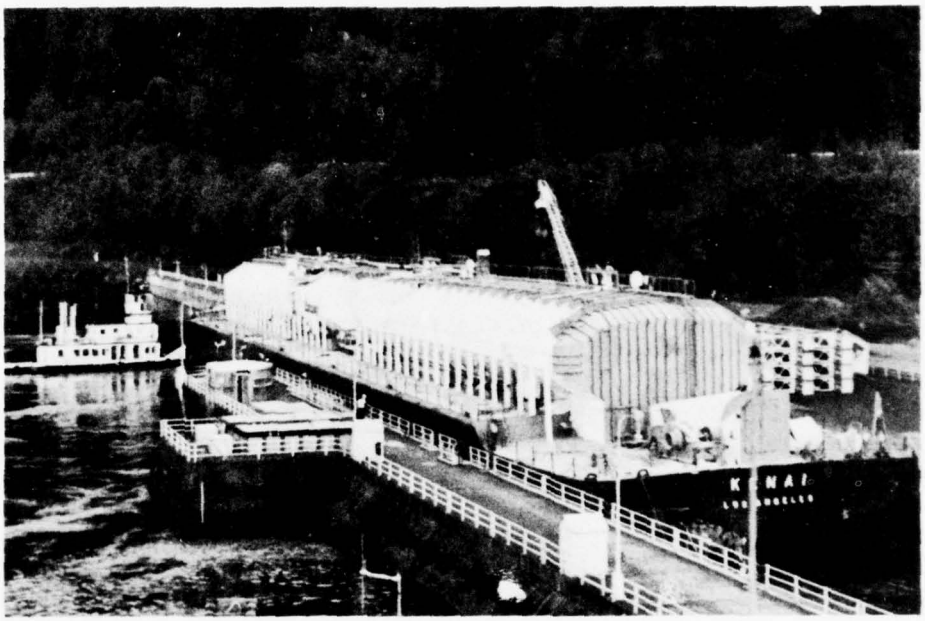
Deep-Draft Vessels

The primary difficulty attending navigation in the Columbia River by deep-draft, ocean vessels is the relatively restrictive channel dimensions. During periods of poor visibility, ships may try to proceed at reduced speed, but have some loss of steerage, the danger of collision with another ship, or the possibility of going aground outside the channel. If a ship anchors to await better conditions, it may swing on the anchor chain with changing tides and face similar risks. During periods of high water, ships must operate at limited speeds to lessen the danger of bank erosion caused by wave wash. Also, delays occur at the entrance to the Columbia River which are primarily caused by poor visibility or by heavy seas outside the entrance which prevent the transfer of bar pilots.

Bonneville Lock

Because of the size of Bonneville Lock, 76 feet wide by 500 feet long, barge tows that make full use of the upstream locks must be disassembled. All of the locks upstream from Bonneville can accommodate tows 650 feet long by 84 feet wide.

High current velocities for about 1 mile downstream of the lock and often adverse wind conditions in the Columbia River Gorge make entrance to the lock from downstream difficult. The entrance angle above the lock also detracts from efficiency of the locking operations.



Barge Kenai leaving the Bonneville Lock. (USCE)

Fluctuations in flows actuated by rapid changes in power generating needs at Bonneville produce adverse current conditions which make entrance to the lock difficult. These fluctuations are most pronounced during periods of low river flow when the peak river traffic occurs.

Conflicts between Deep-Draft and Shallow-Draft Vessels

Various techniques have been employed to minimize dredging costs and maintain project depths in the navigation channel. One of the most successful has been use of permeable pile-dike structures as constrictions across the shallower portions of the river to obtain higher velocities in the main channel. Shallow draft vessels, particularly tugs with log rafts moving upstream, prefer the shallow portions of the river where velocities are lower. Thus the maintenance of the deep-draft navigation channel imposes hardship on the other traffic. The areas constricted by pile-dike structures have been used also by commercial gill net fishermen. Another problem develops during the peak of the fall salmon runs when thousands of recreational fishing boats operate in the estuary and interfere with the passage of ocean vessels.

Recreational Boating

Boating has become a prime recreational activity on the Columbia River, with use also being made of tributary streams, lakes, and reservoirs. Oregon State boat registration data for 1966 indicates about 1,000 boats in the Oregon portion of the subregion. Coast Guard registrations for the State of Washington show about 6,000 boats in the Washington portion, for a total of 7,000 registered boats. Neighboring counties in other subregions indicate a 1966 boat registration of about 23,000 of which about 70 percent are considered to use the navigable waters of this subregion. The 1966 report by the Oregon State Marine Board noted an average annual boat usage of about 48 days. On that basis, the the annual boat-day use of the navigable waters would be about 1,100,000. There are 106 boating facilities in the subregion each with ramps and service locations. Ramps have at least one lane each. Service locations include gas, repairs, marine supplies and foods, although each location does not necessarily supply all the services listed. The existing moorage facilities have a capacity for approximately 6,000 boats.

About 95 percent of the boats used for recreation on the Columbia River and its tributaries are outboards 21 feet or less in length. About 75 percent of the boats greater than 21 feet in length contain inboard power and are moored or stored at the launching sites. The primary activities of the small-boat owners are fishing and water skiing, with cruising and sightseeing the main activity of the larger boat owners.

The most needed types of improved boating facilities, indicated by the owners of the smaller craft, are more and improved launching ramps, camping areas near moorages, more and improved piers and docks, and breakwaters to shelter mooring areas. Facilities at the mouth of the Columbia River are presently overcrowded.

Maintenance

Annual maintenance dredging of the 40-foot channel from Portland-Vancouver to the mouth involves the removal of about 10 million cubic yards of sediment at a cost of over $2,500,000. In addition, the annual maintenance cost of the pile-dike structures used to stabilize the channel is about $50,000. Minor maintenance dredging of the shallow-draft channel between Vancouver and Bonneville Dam is required. Adequate depths in the entrance are maintained throughout the year by dredging. In the 5-year period from July 1965 through June 1969, maintenance costs averaged $622,377 annually.

PROJECTED CONDITIONS AND NEEDS

Economic Outlook

Population Employment and Income

The population of Subregion 8 is projected to total 277,906; 349,369; and 441,325 for the years 1980, 2000, and 2020, respectively. The projected rate of population growth is less than that of the region. Employment in the basic industries, agriculture, food processing and forest products processing is projected to decline. Employment in other industries and total personal income are projected to increase at the regional rate. Table 46 summarizes the population and employment projections. More detailed figures are given in Appendix VI, Economic Base and Projections.

Table 46 - Population Income and Employment Projections, Subregion 8

Item	*1960*	*1980*	*2000*	*2020*
Total Population	224,500	277,900	349,400	441,300
Total Personal Income ($1 million)	502	1,115	2,453	5,423
Per Capita Income	2,165	4,012	7,022	12,287
Total Employment	77,736	108,295	139,027	175,440
Agriculture, Forestry, & Fishing	5,490	4,385	3,410	2,600
Agriculture	4,880	3,600	3,300	2,500
Mining	75	250	230	220
Total Manufacturing	28,111	37,811	45,629	54,654
Food & Kindred Products	2,264	2,110	2,082	2,095
Forest Products	19,207	17,784	16,590	13,866
Non-Commodity	43,898 2/	65,849 2/	89,760 2/	117,966 2/

Source: Appendix VI Economic Base and Projections

Projections of Bulk Commodities

Major bulk commodities that might be expected to move over the navigable waterways are shown in Table 47. Commodities such as agricultural and forest products are produced locally and the quantities shown are the entire subregion production that would be shipped to outside markets by all modes of transportation. Other commodities such as petroleum products and fertilizer would be shipped in to serve local needs.

Agricultural Commodities

Production and use of agricultural commodities is expected to increase. More extensive use of irrigation and intensity of management are expected to increase productivity. Estimates shown in table 47 show an increase from 180,000 tons annually to 390,000 tons annually. Food processing is projected to increase at a comparable rate.

Forest Products

Forest products and forest products manufacturing (including pulp and paper production) are expected to continue to be the subregion's predominant industry. Forest products are projected to total 20.8 million tons annually by 2020. The projected growth rate of this industry shows a noticeable decline during the last 20 years of the projection period.

Minerals and Metals

The minerals and metals projections of table 47 include raw materials and output of the metal industries presently operating in the subregion; the expected demand for sand, gravel, and cement; and the output of scrap. No estimate is made of potential production of local minerals which are not presently mined.

Petroleum Products

The petroleum products demand of the subregion is projected to increase from the present 480,000 tons annually to 735,000 tons in 2020. Fuel needs for heating and transportation generate most of the petroleum products demand.

Table 47 - Projections of Major Bulk Commodities Produced or Consumed, Subregion 8

Item	Base 1/	Year 1980	2000	2020
		(1,000 short tons)		
Agricultural Commodities	180	260	310	390
Food Manufactures	200	310	430	590
Forest Products	13,575	15,975	20,240	20,850
Primary Metals	185	570	1,750	5,380
Minerals	2,205	3,320	6,100	13,790
Steel Scrap	15	15	20	25
Petroleum Products 1/	450	630	1,000	1,600
Fertilizer	5	10	15	20

1/ 1964, except primary metals 1969, and steel scrap and petroleum products 1960.

The Role of Transportation

Transportation plays a key role in this subregion's economy. With its excellent ports accessible both to the Pacific Ocean and the Columbia River waterway and the excellent rail and highway networks connecting to them, this subregion plays an important role in the collection and distribution of commodities both foreign and domestic, not only for itself but other subregions as well. Rail, water, highway, airway, and pipeline facilities must continue to expand and improve to meet the needs of a considerable and continuing expansion of both domestic and foreign commerce. The agricultural, mining, forestry, and fishing industries of the subregion and bordering subregions are largely oriented to the location of natural resource inputs and are dependent upon transportation to deliver their products, often over great distances, to domestic and foreign markets.

All forms of transportation have a role to play. In order for the inland waterways to perform their function of moving bulk commodities, both dry and liquid, land transportation, rail, highway, and pipeline, must be linked to it in an effective and efficient manner. The commercial capacity of these waterways is expanding rapidly in response to need and opportunity. The amount of growth in cargo tonnage moved over the waterways in the future depends to a large extent on how well the inland waterway haulers and deep-draft shippers meet the demand for more efficient and economical means of transshipment.

Use of containerization in inland waterborne and maritime commerce is increasing. This multi-ton packaging innovation may greatly increase general cargo movement on inland waterways. The new containers carry about 30 tons, are loaded by shippers

or carriers, and result in reduction of handling of commodities in transit since a large package can be handled as a single unit. The new ships serving the subregion's ports will be equipped to handle containers, barges carrying containers, and bulk loaded barges in any reasonable mixture or in shipload lots. Capitalization on the potentials of this container technique will bring about enormous change in existing patterns of transportation methods.

Prospective Waterborne Commerce

Projections of future waterborne commerce are shown in tables 48 and 49. For purposes of analysis, deep-draft (seagoing) and shallow-draft commerce are considered separately.

Deep Draft

The projections of deep-draft waterborne commerce, which include foreign and domestic coastwise as shown in table 48, are based on the most recent navigation study of the lower Columbia and Willamette Rivers (11). That study included an in-depth analysis of the industries using and producing commodities moved by water, projections of markets and sources of supply for these industries, and past trends in waterborne commerce of

Table 48 - Projected Waterborne Commerce (Seagoing), Subregion 8

Commodity Group	Year			
	Base 1/	1980	2000	2020
	(1,000 short tons)			
Agricultural Products	4,700	6,400	8,400	9,000
Petroleum and Products	5,400	10,000	13,000	13,600
Forest Products	2,400	2,900	3,500	4,700
Primary Metals	1,000	5,200	14,400	23,800
Nonmetallic Minerals	800	1,400	2,600	3,700
Miscellaneous Commodities	400	800	1,700	2,700
Total	14,700	29,400	43,600	57,500

1/ Average 1964, 1965, 1966.

the region. The volume of deep-draft commerce as projected by that study for 1965 compares reasonably well with the actual commerce for the 3 years 1964, 1965, and 1966. This 3-year average is the base shown on table 48.

Commodity groups comprise the following:
Agricultural products: Coffee, sugar, inedible molasses, grain and grain preparations, animal products, foodstuffs, seeds and drugs, fertilizers.

Petroleum: Petroleum products and crude.

Forest products: Wood products, paper and paper products, paper and paper pulp.

Primary metals: Metals, alloys, ores, concentrates, and scrap.

Nonmetallic minerals: Salt, sand and gravel, limerock, coal, coke, and lignite; and nonmetallic minerals n.e.c. 1/

Miscellaneous commodities: Machinery, vehicles, chemicals, textiles, and fibers; commodities n.e.c.

Shallow-Draft Commerce

The projections of shallow-draft commerce assume that the Snake River improvement to Lewiston, Idaho, will be completed as scheduled, and that the upper Columbia River improvement to Wenatchee will be substantially completed by 1985. They include traffic to and from Subregions 2, 6, 7, and 9, and internal movements of Subregion 8. Movements of rafted logs are not included but are expected to average between 4 million and 5 million tons annually.

Some commodities are moved by both river and deep-draft carriers between their points of origin and destination and appear as tonnages in both tables. For example, between 15 and 20 percent of the export grain is delivered to deep-draft loading facilities in barges from upriver ports and essentially all of the petroleum products shipped upriver arrive at Portland in deep-draft tankers.

1/ n.e.c. - not elsewhere classified.

Table 49 - Projected Waterborne Commerce (Shallow-draft/inland), Subregion 8

Commodity Group	Year			
	Base	1980	2000	2020
		(1,000 short tons)		
Agriculture	1,300	3,600	4,600	5,600
Petroleum	1,000	2,200	2,800	3,600
Forest Products	1,100	1,500	1,900	2,300
Primary Metals	40	1,200	2,000	2,800
Nonmetallic Minerals	700	2,300	2,300	4,300
Miscellaneous Commodities	100	800	1,200	1,500
Total	4,240	11,600	14,800	20,100

Prospective Vessel Sizes

A recent study by the American Association of Port Authorities (1) predicts use of tankers and bulk carriers of 80 to 150,000 d.w.t., with drafts of 45 to 55 feet, in the United States trade by the year 2000. In specialized cases, coal and other ore vessels of 100,000 d.w.t. and over may serve selected ports; the largest of these vessels will have drafts of about 53 feet. General cargo vessels and container ships are expected to range in size from 950 to 1,000 feet in length, and have drafts ranging from 33 to 35 feet. The navigation study of the lower Columbia and Willamette Rivers (11) concluded that the future tankers delivering petroleum products to the Columbia River would be in the 26,000 to 33,000 deadweight ton class but that tankers used for shipping grain would be as large as could be accommodated on the river. The study further found that ultra large bulk ore vessels probably would not call at the Columbia River ports and that the size of general cargo vessels would not be as great as other types of ships. Developments since that study was completed do not point to any other conclusions except in the size of general cargo ships. The containerization technique has considerably increased the practical size limitation of general cargo ships.

Tanker Manhattan, 108,400 dwt, under the St. Johns Bridge, Portland Harbor. (Port of Portland)

Shallow-draft vessels, primarily barge tows, are expected to require channel depths of 14 feet in the main channels. The multiple tow flotillas will range in size up to the maximum dimensions of the locking structures of the upper river dams. Individual barges are expected to range from 500 to 3,000 tons, and tugs from 1,000- to 5,000-horsepower.

Future Outlook of Commercial Fishing

There has been a long-term decline in commercial fishing activity in the Columbia River and the future number of boats will depend upon the continuation of runs of salmonid fish.

Future Outlook of Recreational Boating

Future recreational boating was projected by growth factors determined on the basis of anticipated population and income. The number of boats was estimated to increase at a rate equal to the population growth plus a factor for increased per-capita income.

Boating activity was projected at a higher rate due to more leisure time and greater mobility of the public. Above the estuary, boat usage on the river is primarily fishing, water skiing, cruising, and sightseeing. Sports fishing at the mouth of Columbia River and offshore generates many thousand boat-days usage annually. No significant change in the type of boating activities is anticipated (table 50).

Table 50 - Recreational Boating Activity Projections 1/, Subregion 8

Item	Year			
	Present 2/	1980	2000	2020
Est. total number 4/ of boats	15,700	29,700	57,400	106,200
Est. number of boats on contiguous waterway	23,000	35,300	62,500	110,700
Annual boat-day use	1,104,000	1,906,200	3,906,300	7,948,800
Moorage capacity needs	6,000 3/	6,000 3/	9,400	16,600
Boat launching lane needs	212 3/	375	660	1,180

1/ On contiguous waterways used for commodity navigation.
2/ 1966, except 1970 for total boats in subregion.
3/ Presently available.
4/ From Appendix XIII.

Based on the projections shown in table 50 above, the present moorage capacity would be adequate until about 1982. However, a survey by the Oregon State Marine Board (4) found that localized shortages exist and that additional moorage spaces are needed in the Portland metropolitan area and near the mouth of the Columbia River. The needs near the mouth are for launching and mooring facilities in close proximity to the mouth; spaces are usually available at Astoria. Assuming that one lane of launching ramp should be provided for each 80 boats, approximately 40 additional lanes are needed to adequately serve the existing boats.

SUMMARY OF NEEDS

For purposes of analysis and discussion, future navigation needs of the subregion are divided into commercial, non-commercial, and policy needs. Commercial needs are for channels and locks of adequate widths and depths and expanded onshore support facilities, including ship berths, ship repair, adequate warehousing, storage and transfer facilities. Non-commercial needs are for access channels, moorages, marinas, and launching ramps. Both commercial and non-commercial navigation need land-use and waterway-use regulations and policies that are fitting for safe, efficient use of the river resource.

Commercial Needs

Oceangoing

Berthing areas are generally adequate in size and number at present. The trend in shipbuilding to longer, wider, deeper vessels having greater payload capacities will necessitate lengthening of piers and slips and deepening of berthing areas. The number of ship berths required is expected to double by the end of the projection period. This number will be greater if the projected increase in tonnage is not partially offset by increased payload per vessel. The land area adjacent to the waterfront required for storage and transfer facilities is expected to increase four to six times present requirements although this need also can be offset by more efficient handling equipment. Bulk loading equipment, traveling container cranes and other cargo lifting machines also will require improvement.

Shallow Draft

Navigation channels and shore support facilities are generally adequate at present with the exception of Bonneville Lock. The lock will require replacement with a structure at least comparable to the locks of the upriver dams.

Non-Commercial

Recreational boating activity is projected to increase by factors of 1.7, 3.5, and 7.2 for the years 1980, 2000, and 2020, respectively. To support the projected boating activity, launching facility requirements will increase by comparable factors, and moorage requirements by factors of 1.5, 2.7, and 4.7. Land requirements are expected to parallel increases in boat-day use.

Immediate needs are for more and improved launching ramps and mooring facilities in heavy use areas.

Policy and Regulation

Conflicts between recreational and other users of the waterway have increased in recent years and are expected to become more numerous. Regulations should clearly state the rights and responsibilities of all users, and all users must be apprised of such regulations.

Areas for disposal of dredge-spoil material are becoming critical in some reaches. If patterns of land use in these areas continue, dredged material must be hauled to more distant locations for disposal. This alternative would result in greatly increased channel maintenance costs. Policies should be adopted that would insure availability of future spoil disposal areas as needed at reasonable cost.

MEASURES TO SATISFY NEEDS

Commercial Navigation

Deep Draft

Port facilities are generally adequate for existing deep draft navigation but will need to be expanded and improved to accommodate the additional traffic forecast to use the waterway. It is expected that port facilities will continue to precede the actual needs through the competitive efforts of port authorities and private industry to each improve its own proportion of the total trade. On that basis, more than $500 million will be expended on improvement of port facilities prior to 2020. For lack of more definite information, a uniform schedule of expenditures is proposed.

The continuing trend to use of larger vessels will probably mean that a deeper channel will be needed in the Columbia River to Portland and Vancouver. Determination of the needed depth is beyond the scope of this report, but it appears reasonable that a depth of 45 to 50 feet would be desirable. The cost of such a project would be in the order of $70 million for construction and $2 million for spoil-disposal lands. Annual maintenance costs would be increased about 5 percent of the construction costs. At this time it appears that the additional depth will be needed shortly after 1980.

An alternative to providing greater depth in the Columbia River would be development of loading facilities at the estuary. This alternative would entail duplication of facilities existing at upstream ports and expansion of land transportation facilities.

Shallow Draft

Navigation to Subregions 2, 6, and 7 and to the reach of Columbia River above Bonneville Dam considered with this subregion would be facilitiated by replacement of the lock at Bonneville Dam. The new lock should have dimensions commensurate with the locks at the dams farther upstream and both the upstream and downstream approaches should be improved to enable towboats to bring in tows that make full use of the lock. The new lock would cost in the order of $50 million dollars and should be included in the 1980 action program.

Recreational Boating

Moorage Basins

Facilities to meet the immediate needs for recreational boat moorages are being planned. The Port of Portland proposes to build a moorage basin with a total capacity of approximately 3,600 boats as part of its airport expansion program. It is planned that half of the moorage spaces would accommodate boats larger than 25 feet in length. It is estimated that nearly $5-1/2 million would be required for landside facilities and another $5-1/2 million water-related construction. The airport expansion program has been opposed because of the noise of the jet airplanes over the river and because of possible effects on the flow of the Columbia River. However, permits have been issued and the initial dredging for the airport work is underway. Unless the work is stopped in the courts, the expansion program including the boat basin will proceed and the basin will be available before 1980. A cost estimate for the basin itself is not available.

Two developments are being considered at the mouth of the Columbia River. One is for expansion of the facilities at Ilwaco, Washington, to provide for a total of about 2,000 boats. The initial phase would add about 200 new berths for a total of 1,000 in the existing basin, a breakwater for a new basin, and mooring facilities for 400 boats in the new basin. Additional berths up to 1,000 would be added in the new basin as needed. The cost for the initial phase is estimated to be $2.3 million; the subsequent moorages would be financed from operating revenues.

The other development would be a basin at Hammond, Oregon, with a capacity of about 300 boats. It would cost about $1 million and is programmed for construction between 1975 and 1980.

These three projects would meet most of the immediate needs for moorages in the subregion and the needs at the mouth of the Columbia River to about 2000. Additional moorages are expected to be provided by private operators in response to specific needs.

Launching ramps

An immediate need exists for an additional 40 lanes of launching ramp. Some launching facilities will be included in the above moorage basin development. However, to meet the needs of the subregion a program should be initiated to provide an additional 15 lanes per year. Assuming a cost of $50,000 per lane, the program should be funded with about $750,000 annually.

Summary of Costs

The costs of providing navigation facilities for Subregion 8 and priorities by time periods are summarized in table 51.

Table 51 - Summary of Costs, Navigation Facilities 1/, Subregion 8

	$1,000		
	1980	2000	2020
First Costs			
Channels & Locks	122,000	0	0
Port & Transfer Facilities	100,000	200,000	200,000
Moorages	14,300 2/	5,100	10,800
Launching Ramps	7,500	15,000	25,000
Total First Cost	243,800	220,100	235,800
Annual O&M			
Channels & Locks	350	0	0
Port & Transfer Facilities	10,000	20,000	20,000
Mooring Facilities	1,500	1,000	2,000
Launching Ramps	150	300	500
Total Annual Costs	12,000	21,300	22,500

1/ Incremental costs in 1968 dollars prior to date shown.
2/ To improve and modernize existing substandard facilities.

SUBREGION 9

LOCATION MAP

SUBREGION 9

WILLAMETTE RIVER BASIN

GENERAL

Subregion 9 includes the drainage basins of the Willamette and Sandy Rivers and the small streams that enter the Columbia River from the south between Bonneville Dam and St. Helens, and covers a roughly rectangular area of 12,046 square miles in northwestern Oregon.

The discussion on navigation in Subregion 9 is limited to the shallow-draft navigation on the Willamette River and tributaries above Portland. The Ross Island Bridge, which is generally considered the upstream limit of the Portland Harbor, is taken as the demarcation line. Ocean shipping terminating at Portland and activities in the Portland Harbor are discussed with Subregion 8, Lower Columbia River. The discussion herein on small boats is concerned only with recreational activities on the Willamette River below Eugene; boating on the lakes, reservoirs, and tributary streams is covered in Appendix XIII, Recreation.

Topography and Climate

The basin is generally low in elevation, with the Cascade Range to the east, the Coast Range to the west, the Calapooya Mountains to the south, and the Columbia River to the north, comprising its boundaries. Notable is the abrupt change from steep mountains and foothills to the nearly level valley floor which is the principal topographic feature affecting the subregion's climate and characteristics of runoff. Other factors affecting the climate include the proximity of the Pacific Ocean and generally prevailing westerly winds. All of these contribute to the annual pattern of arid summers and wet winters. Annual precipitation varies from about 200 inches in parts of the Coast Range to less than 40 inches on the valley floor. Topography and climate are described in detail in Appendixes IV - Land and Mineral Resources, and V - Water Resources.

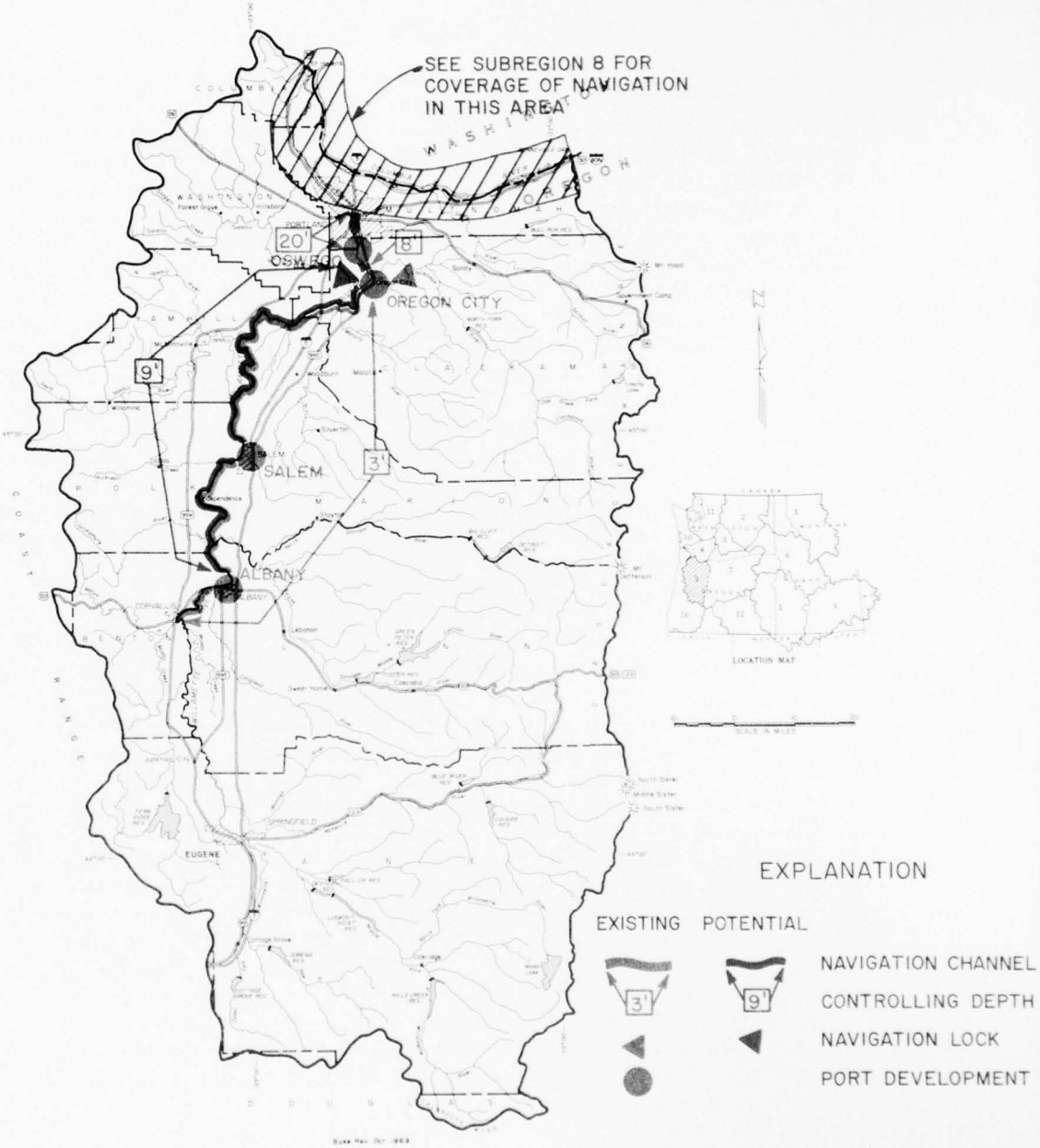
Streams

The Willamette River flows from Eugene, 175 river miles south of Portland, to Oregon City, and from Oregon City through Portland to the confluence with the Columbia River, without rapids or falls. A falls at Oregon City, approximately 50 feet high, is circumnavigated through a canal with locks. Below the falls, the river is subject to tidal influence and Columbia River backwater effects. Above the falls it is essentially slack water for 25 miles to Newberg, and slopes about 2 feet per mile from Newberg to Corvallis, 81 miles; 3 feet per mile from Corvallis to Harrisburg, 30 miles; and 5 feet per mile from Harrisburg to Eugene, 21 miles. The lower reaches of several of the larger tributaries are navigable but do not support commercial navigation. Many lakes and reservoirs are used for recreational boating, and sport fishermen drift McKenzie River and, rarely, some of the other tributaries such as the Santiam and Clackamas Rivers in specially designed white-water boats. Another major stream in the subregion, Sandy River, drains from the high Cascade area directly into the Columbia River. Table 52 lists pertinent data on streams. For additional information on streams and streamflow characteristics, see Appendix V, Water Resources.

Table 52 - Streamflow Summary for Selected Sites, Subregion 9

Stream	Gage Station	Drainage Area (sq. mi.)	Annual Flow 1/ Mean (cfs)	Annual Flow 1/ Max. (cfs)	Annual Flow 1/ Min. (cfs)	Momentary Flow 2/ Max. (cfs)	Momentary Flow 2/ Min. (cfs)
Sandy River	Bull Run	440	2,302	3,360	1,368	84,400	45
Mid. Fk. Willamette R.	Jasper	1,340	3,916	6,319	2,130	94,000	366
Coast Fk. Willamette	Goshen	642	1,512	2,700	705	58,500	36
McKenzie River	Coburg	1,337	5,508	8,242	3,170	88,200	1,250
Long Tom River	Monroe	391	770	1,534	328	19,300	0
Mary's River	Philomath	159	441	759	237	13,600	4.7
Calapooia River	Holley	105	438	662	221	12,600	18
Willamette River	Albany	4,840	14,111	23,744	7,646	266,000	1,840
North Santiam River	Niagara	453	2,102	3,175	1,424	63,200	19 3/
South Santiam River	Waterloo	640	2,856	4,509	1,741	95,200	96
Santiam River	Jefferson	1,790	7,596	11,722	4,656	197,000	260
Luckiamute River	Suver	240	903	1,414	462	32,900	13
Willamette River	Salem	7,280	22,991	36,334	13,529	348,000	2,470
South Yamhill River	Whiteson	502	1,611	2,944	844	47,200	8.5
Molalla River	Canby	323	1,135	1,822	638	43,600	20
Pudding River	Aurora	479	1,215	1,980	695	25,400	26
Tualatin River	West Linn	710	1,443	2,643	671	29,300	13
Willamette River	Oregon City	10,008	29,900	43,694	17,660	-	-
Clackamas River	Estacada	671	2,674	3,710	1,712	86,900	50

1/ Regulated values for base period (1929-58) with estimated 1970 conditions of development.
2/ Maximum and minimum observed instantaneous values for period of record.
3/ Minimum due to operations of Detroit Dam, minimum daily is 430 cfs.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

EXISTING & POTENTIAL NAVIGATION FACILITIES

WILLAMETTE SUBREGION 9

1970

FIGURE 7

History

Water transportation played an important part in the early settlement of the Willamette Basin. The first settlers located on land adjacent to the river, and the first towns grew on the riverbanks. Later settlers were forced onto lands farther back from the river, and the early settlements became communication centers. It is estimated that nearly 15,000 people followed the Oregon Trail across the plains and mountains during the 1840's and most of them settled in the Willamette Valley, partly because the area was readily accessible by water transportation. Early historical writings mention the use of bateaux and other flatbottomed boats on the Willamette River between 1840 and 1850 but state that the service was costly and unreliable. Ocean sailing ships came as far inland as Portland, and in 1849 a small steamer began operating between Portland and Oregon City. The first steamboat above Willamette Falls was constructed in 1851, and by 1855 there were three steamboats operating as far upriver as Corvallis. Regular service was extended to Eugene in 1856, and traffic on the river continued to expand rapidly until the 1880 decade when railroads were extended through the valley and connected to the transcontinental system.

The early riverbank settlements that had not been destroyed by floods were provided with rail service and became transportation hubs. Early access to water transportation was the principal influencing factor in the location and growth of the cities of Portland, Milwaukie, Oregon City, Salem, Albany, Corvallis, Harrisburg, Eugene and McMinnville. The locks around Willamette Falls at Oregon City were opened to traffic in 1873. Navigation's portion of the total transportation in the Willamette Basin began to decline shortly after the railroads were established, but river packet boats continued to operate until 1935 when service by the last two sternwheelers was discontinued. From 1935 to the end of World War II, traffic above Newberg was limited to the movement of log rafts. Following World War II, shipments of petroleum products from Portland to Salem and Albany increased to more than 200,000 tons per year but dropped off sharply when a products pipeline was constructed in 1957. More recently, wood chips for pulp have been shipped in significant quantities on the lower river. Also following World War II, the dumping of raw, domestic sewage into the river was discontinued, and low-water flows have been supplemented by reservoir releases. These two items have made the river attractive for recreational use, and the extra water has assisted commercial navigation.

Log rafts continue to be moved on the Willamette River from as far upstream as Corvallis. Supplies are carried to the paper mills at Oregon City, and pulp, paper, and paper products are shipped therefrom. Sand and gravel are dredged from the stream between Portland and Oregon City and barged to processing plants in the Portland area and to other cities along the Columbia River which do not have local supplies.

Economic Development

Subregion 9 includes the counties of Multnomah, Clackamas, Marion, Linn, Lane, Benton, Polk, Yamhill, and Washington in Oregon. Population of the subregion was 1,338,900 in 1965. The urban population of about 918,000 was centered in the principal cities, Portland, Salem, Albany, Corvallis, Eugene, and Springfield.

Of the 7.7 million acres in the subregion, about 5 million acres, or two-thirds of the land area, are classed as commercial forest land. Timber stands in the basin contain 146 billion board feet of sawtimber, about 10 percent of all softwood timber in the Nation. Douglas fir (69 percent) and western hemlock (15 percent) are the dominant species. Processing these timber resources accounts for 4 percent of the manufacturing employment in the subregion. Lumber output in 1963 exceeded 3 billion board feet which was about 9 percent of the Nation's total. Also produced were 34 percent of its softwood veneer and plywood and 3 percent of the wood pulp. Total value of output in 1964 exceeded $500 million. Of the 2.4 million acres used for agricultural purposes, 1.3 million acres are classified as cropland. Nearly 60 percent of this is devoted to small grains, hay, and grass seed production, with vegetables and fruits and nuts comprising about 11 percent; the balance being other crops and cropland pasture. About 244,000 acres of cropland are classified as irrigated. Estimated value of production is greatest on the 11 percent growing vegetables, fruits and nuts, amounting to about 50 percent of the value of all crops.

With the exception of a very small amount of mercury, the mineral resources and associated industry in Subregion 9 are composed almost entirely of nonmetallics such as sand and gravel, basalt and miscellaneous stone, limestone and clays.

Total employment in 1960 exceeded 430,000. Employment in basic industries was 34,600 in agriculture and food processing; lumber and wood products manufacture, 40,100; and mining and primary metals processing, 5,200.

Other Forms of Transportation

Railroads

Three major railroads provide service to the subregion. Branch lines radiate east and west from the central corridor and service most of the principal communities.

Highways

There is an excellent highway network in the subregion, with Interstate 5 providing the central north-south route and Interstate 80N linking the area with the rest of the Continental United States to the east. Other Federal and State highways enter or cross from east and west providing additional access to areas outside the subregion.

Air

Air freight and passenger service is provided at Portland International Airport by nine domestic and overseas airplanes. Salem, Corvallis, and Eugene also are served by commercial airlines. Charter services available at the principal airports make all parts of the subregion readily accessible.

Pipelines

A majority of Subregion 9's requirements for petroleum products are redistributed from the Portland area, which also serves as a storage and distribution center for supplying southwestern Washington, and north-central and northwestern Oregon. Petroleum products are shipped to the Portland area via deep-draft tankers, barges, and a pipeline. A 14-inch pipeline originates at refineries in the Puget Sound area and terminates at tank farms in northwest Portland along the lower reaches of the Willamette River. Products are redistributed throughout the subregion via pipeline, auto-freight, and rail. An 8-inch petroleum products pipeline extends from Portland to Eugene. This line transports gasoline and distillates, moving about 500,000 barrels per month. Residual fuel oils are moved by truck, railroad, and occasionally by barge.

Bulk natural gas is piped to the Pacific Northwest from the Southwest and distributed throughout the subregion.

EXISTING NAVIGATION

Existing Projects

Waterways and Channels

The present Federal project was authorized by the River and Harbor Act of 3 June 1896, and modified by the River and Harbor Acts of 25 July 1912 and 30 June 1930; the Permanent Appropriations Repeal Act of 26 June 1934; and the Flood Control Act of 1938. It provides for improvement of the Willamette River between Portland and Oregon City (12 miles) by a channel 8 feet deep at low water, 200 feet wide below Cedar Island and 150 feet wide thence to Oregon City; for such channel improvement and contraction works as may be necessary to secure with streamflow regulation, controlling depths of 6 feet at low water from Oregon City to the mouth of the Santiam River (mile 108.5) and 5 feet thence to Albany (mile 120); for a channel 2.5 to 3.5 feet deep at low water and of no prescribed width from Albany to Corvallis (mile 132); for a channel 2 to 2.5 feet deep from Corvallis to Eugene (mile 185). In 1904, the reach between Harrisburg and Eugene was determined unworthy of improvement and no work has been accomplished. The project also provides for a channel in the Yamhill River 4 feet deep at low water and 60 feet wide from its mouth to McMinnville (mile 18) secured by means of a lock and dam near Lafayette and by the removal of obstructions. The Port of Portland maintains the channel in the Willamette River from Ross Island Bridge (mile 14) to Lake Oswego (mile 20) to a depth of 20 feet. The project is not being maintained above Corvallis (mile 132) or on Yamhill River above mile 4. Maintenance of the lock and dam on the Yamhill River at Lafayette (mile 8) was discontinued in 1954, and the lock and adjacent property were declared surplus to the needs of the Federal government and turned over to Yamhill County in 1959. The county later destroyed the dam as it had deteriorated with age and was in danger of being washed out.

Present controlling depths at adopted low water are 20 feet to Lake Oswego (mile 21), 8 feet to Oregon City (mile 26), and 3.5 feet to Corvallis. Release of stored water from the completed multiple-purpose reservoirs provides additional depth during the low-water season.

Locks

The lock system around Willamette Falls at Oregon City comprises four locks in series plus a guard lock. Each lock chamber is 175 feet long and 37 feet wide. The controlling depth

over the sills is 6 feet, but barges are limited to a practical maximum of 4-1/2 feet draft. The total lift of the system is 50.2 feet at low water. The locks were constructed by private enterprise and opened for business in 1873. They were purchased by the Federal Government in 1915 and have been maintained, with minor improvements, and operated by the Corps of Engineers since that date. The Flood Control Act of 1938 and the River and Harbor Act of 1945 authorized construction of a new single-lift main lock and guard lock to replace the existing structures. Controlling dimensions of the new lock would be 400 feet long by 56 feet wide by 9.5 feet minimum depth over the sills.

Navigation Aids

The U. S. Coast Guard maintains navigation aids on the Willamette River.

Bridges

The navigable portion of the Willamette River above the Ross Island Bridge is crossed by 23 bridges, 6 of which are railroad and 17 highway. These bridges are either high enough to clear boat traffic, or are so constructed that they can be opened to permit passage of river traffic. Table 53 lists the bridges.

Commercial Port and Terminal Facilities

Between the Ross Island Bridge and Willamette Falls at Oregon City, terminal facilities include privately owned mill docks, sand and gravel wharves, a cement loading facility, a small shipyard, oil-receiving stations, and a dock for receipt of limerock. A wharf about 850 feet long located adjacent to the canal basin between the guard lock and lock No. 4 at Oregon City, is used to receive mill supplies and ship paper and paper products. A facility about 3 miles above the falls at Oregon City has rail connections for transshipment of paper, paper products, and clay used in processing paper. Sand and gravel facilities are located at Wilsonville (mile 38) and Newberg (mile 50). A 420,000-gallon fuel tank at Salem is serviced (occasionally) by tanker barge. Numerous log rollways with rail or truck connections are located along the river as far upstream as Corvallis (mile 132) for rafting logs to paper, plywood, and sawmills along the lower Columbia and Willamette Rivers. The port and terminal facilities are considered to be adequate for the existing commerce. Table 54 lists the principal facilities.

Table 53 - Willamette River Bridges, Subregion 9 (Above Ross Island Bridge 1/)

Miles above Mouth	Location	Type and Purpose of Bridge	Clear Width Normal to Channel (ft.)	Clear height of lowest point of superstructure (in feet) above Mean low Water	Clear height of lowest point of superstructure (in feet) above High Water
16.6	Sellwood	Fixed, hwy	270	74	43
20.0	Oswego	Fixed, RR	280	74.3	34
25.5	Oregon City-West Linn, I-205	Fixed, hwy	260	77	31
26.0	Oregon City	Fixed, hwy	181	74.0	28
38.5	Wilsonville, I-5	Fixed, hwy I-5	240	75	31
38.8	Wilsonville	Fixed, RR	187	75	31
48.4	Newberg	Fixed, hwy	240	68	17
84.8	Salem (Union Street)	Vertical lift, RR	118	87	52
84.9	Salem (Marion Street)	Fixed, hwy	240	69.2	33
85.0	Salem (Center Street)	Fixed, hwy	120	68.6	33.2
97.1	Independence	Fixed, hwy	90	68.0	36
119.6	Albany	Swing, RR	110	----	--
120.0	Albany	Fixed hwy	195	54.0	23
131.6	Corvallis (Harrison Street)	Fixed, hwy	184	48.0	26
131.7	Corvallis (Van Buren)	Swing, hwy	102	----	--
162.8	Harrisburg	Fixed, hwy	172	24.0	8
164.2	Harrisburg	Fixed, RR	190	25.0	9
164.3	Harrisburg	Swing, RR	103	Unlimited	Unlimited
178.2	Eugene (Beltline)	Fixed, hwy	180	16.3	7.1
181.4	Eugene ("Q" St. interch.)	Fixed, hwy	133	25.8	8
182.2	Ferry St. Eugene	Fixed, hwy	250	27.0	18.0
184.3	Eugene	Fixed, hwy	133	35.0	18.0
185.0	END OF FEDERAL PROJECT				
183.2	HEAD OF NAVIGATION - WILLAMETTE RIVER				

1/ See also Subregion 8.

Table 54 - Commercial Terminal Facilities Subregion 9 (Above Ross Island Bridge)

LOCATION (miles above mouth)	IDENTIFICATION	DESCRIPTION	SPECIAL EQUIPMENT	ADJACENT TRANSPORTATION FACILITIES
R.B., 14.0 mi.	Wharf-Tait sand and Gravel Co. owner & operator	Mooring piles 80 ft. 1/	One fixed revolving shipyard-type crane with 110 ft. boom and 3 cu.yd.clamshell bucket mounted on elevated platform; hopper serving a belt conveyor system.	
L.B., 14.3 mi.	Loading Pier Pacific Building Materials, owner & operator	Face 35 ft., lower & upper sides 135 ft. each Depth alongside at l.w.20 ft. for face Load capacity per sq.ft. 500 lbs.	Hopper on wharf served by 30 in. conveyor system or via truck ramp	
L.B., 14.3 mi.	Receiving Pier Pacific Building Materials, owner & operator	Face 30 ft., lower side 85 ft., upper side 70 ft. Depth alongside at l.w.20 ft. for face Load capacity per sq.ft. 500 lbs.	One fixed revolving crane with 120 ft. boom and 4 cu. yd. clamshell bucket serving 30 in. belt conveyor system.	
N.W. portion of Hartack Island approx.14.5 mi.	Mooring-Ross Island Sand and Gravel Co. owner & operator	Mooring piles 1200 ft. Depth alongside l.w. 12 ft.	One fixed revolving crane on elevated platform with 80 ft. boom and 4 cu.yd. clamshell bucket serving hopper and 24 in. belt conveyor system. Aerial tramsway with 18-3/4 cu.yd. buckets from offshore tower on Hardtack Island to ready-mix concrete plant. Shipyard crane on Hardtack Island at prestressed concrete beam plant, 110 ft. boom, capacity 45 tons.	
L.B.,approx.15.3 mi.	Wharf-Capital Investment Co., owner & operator	Face 135 ft.,lower side 61 ft.,upper side 100 ft. Depth alongside at l.w.5 ft. for face Load capacity per sq.ft. 500 lbs.	5 ton stiff-leg derrick with 60 ft. boom. Not used. Log dump-leased by B.P. John for their exclusive use.	Plant trackage in rear connects with SP R.R.
R.B.,approx.18.6 mi.	Log Dump-Publishers Paper Co.,owner; Caffall Bros., lease & operator	Face 60 ft. Solid cofferdam construction. Depth alongside 16 ft. at l.w.	Stiff leg log dumper.	Connection with SP R.R.
R.B., 18.7 mi.	Mooring Wharf-Milwaukie Sand & Gravel Co., owner & operator	Face 225 ft. Depth alongside at l.w. 15 ft.	Stiff leg crane with 2 yd. bucket, 80 ft. boom	Connection with SP R.R.
L.B.,approx.21.0 mi.	Oregon Portland Cement Co.,owner & operator-Wharf	Face 77 ft. Depth alongside at l.w. 35 ft.	36 in.belt conveyor from face of wharf to plant in rear, capacity 645 tons per hr. 30 ton elevator at lower end of platform.	Plant trackage in rear connects with SP&S R.R. & Burlington Northern

1/ Low water, see glossary.

Table 54 (Cont'd)

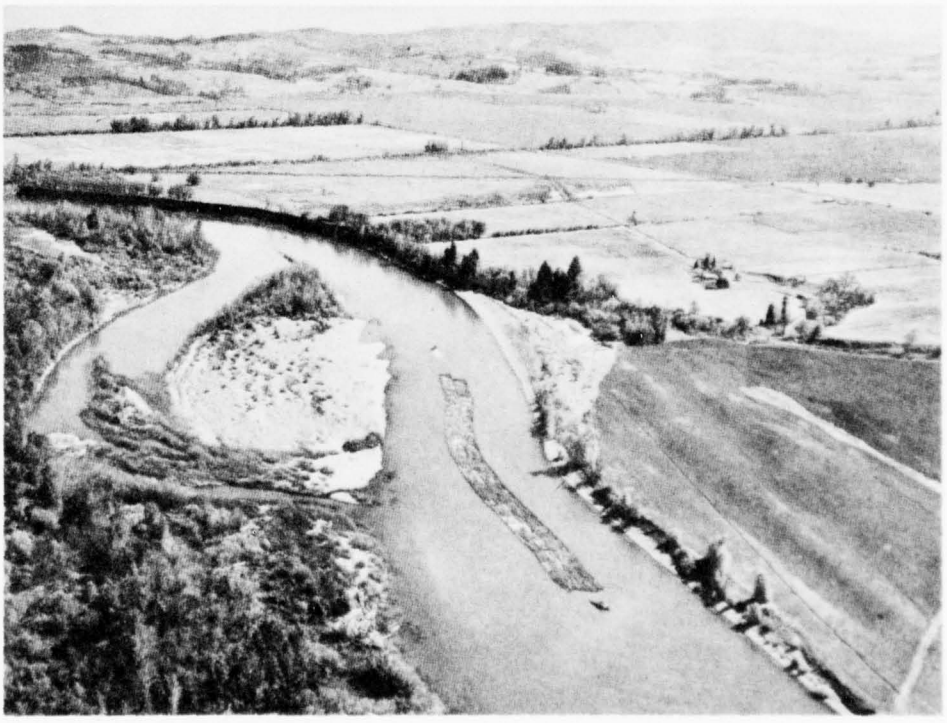
L.B., 25.4 mi. immediately below locks.	Boom Walkway (floating)-Crown Zellerbach owner & operator	Face 465 ft.	Mooring winch	
L.B., 26.5 mi. between river and Willamette Falls locks	Paper Mill Loading Dock(Wharf)-PGE Co. owner of land, U.S. Government leased bldg.owned by Crown Zellerbach, West Linn Div.	855 ft.loading dock face on lock basin Concrete and wood decking. No special load limit. 6 ft.deep over the miter sills at l.w.	Three hydraulic loading ramps Bascule lift bridge (easement) on lock side. Power boom & sulphite liquor pipeline	SP R.R.-on R.B. at Pulp, Oregon
R.B., 28.6 mi.	Wharf-intransit-Crown Zellerbach owner & operator	Face 70 ft.-finger dock to transit shed	Marine Elevator Berger overhead crane Power conveyor for unloading chips from rail to barge.	SP R.R. spur track
R.B., approx.33.1 mi.	Log Dump-Weyerhaeuser Timber Co., owner & operator	50 ft. concrete face. Depth at l.w. 6-9 ft.	A-frame log dumper. Electrically operated winch, capacity 30 tons.	Highway-private road
R.B,approx.33.8 mi.	Log Dump-Crown Zellerbach,owner &operator	50 ft. face Depth at l.w. 6-9 ft.	Berger overhead crane, electrically operated, 60 ton capacity. Concrete base supporting overhead crane	Highway-private road
L.B., 39.7 mi.	Mooring-C.A.Young owner land;Wilsonville Concrete Products lease and operator	Face 50 ft. 3 mooring dolphins Depth at l.w.30 ft.	One floating clamshell crane, 90 ft. boom, 3 yd. capacity One floating clamshell crane, 60 ft. boom, 2-1/2 yd.capacity bucket Portable conveyor to crushing and grading hoppers	Highway-private road
L.B.,approx.53.3 mi.	Log Dump-Crown Zellerbach, owner & operator	50 ft. face-wooden dock approach. Depth at l.w.4-6 ft.	A-frame log dumper Diesel operated winch, 25 ton	Highway
R.B., 85.2 mi.	Log Dump-Boise Cascade Corp., Western Timber Div., owner & operator	Face 50 ft. concrete to booming area at river Depth at l.w.5 ft.	Electrically operated winch A-frame dumping boom, 30 ton capacity	Oregon Electric R.R. track, track at front of plant (Burlington Northern)
R.B., 85.4 mi.	Mooring-Boise Cascade Co.,owner & operator	Mooring Dolphins	Shipyard crane,110 ft. boom. 6 in. oil boom,hoses & pipe for unloading from barges (not used during low water)	
R.B., 116.2 mi.	Mooring-Western Kraft Corp., owner & operator	Barge mooring dolphins	Pump on barge supplying water to plant.	SP R.R. at plant
R.B., 119.4 mi.	Log Dump & Booming Area-land owned by Oregon Electric, Dump owned by G.P. Corp.,leased by Murphy Bros. Logging Co.	50 ft. face-log skids to water, protected by chain	Stiff leg a-frame log dumper, diesel operated. capacity 50 ton.	Oregon Elec. at rear of dump (not used)
L.B., 131.3 mi.	Log Dump-Pope and Talbot, owner & operator	Face 60 ft., log face, steel chain protected concrete footing. Depth at l.w.6 ft.	A-frame log dumper Electrically operated yarder winch,capacity 20 tons.	Highway
L.B., 132.5 mi.	Mooring-Corvallis Sand & Gravel, owner & operator	Concrete footing at water's edge. Dolphin to secure 2/ gravel barge. Depth at l.w.10ft.	Electrically driven belt conveyor.	Highway

2/ See glossary.

Commercial Traffic

Present Commerce

Commerce on the Willamette River above Portland amounts to more than 4 million tons annually (table 55). The largest commodity groups are sand, gravel and crushed stone, and rafted logs and piling. Sand and gravel are dredged from the Willamette River. Most of it originates below Willamette Falls and is used in the Portland area. A small amount originates and is used above the falls, and a token amount moves downstream through the locks. Logs are dumped into the Willamette River as far upstream as Corvallis and towed in rafts to mills on the Willamette and Columbia Rivers. Most of the logs are destined for pulp and paper mills; many of the rafts are held in storage before moving to destination. Other commodities shown in significant quantities in the table include limestone, waste, and paper and paper products. The limestone is imported from an island off British Columbia to a cement plant at Lake Oswego. It is shipped in bargeloads of about 11,000 tons, and the company uses about three loads per month. Shipment of waste material was only a temporary means of disposal and has been discontinued. The paper and



Tug and log raft on Willamette River. (Oregon State Highway Department)

products and most of the miscellaneous commerce shown in the table develop at the Oregon City and West Linn paper mills. Shipment of wood chips for pulp in significant quantities has developed since 1967 and does not appear in the table.

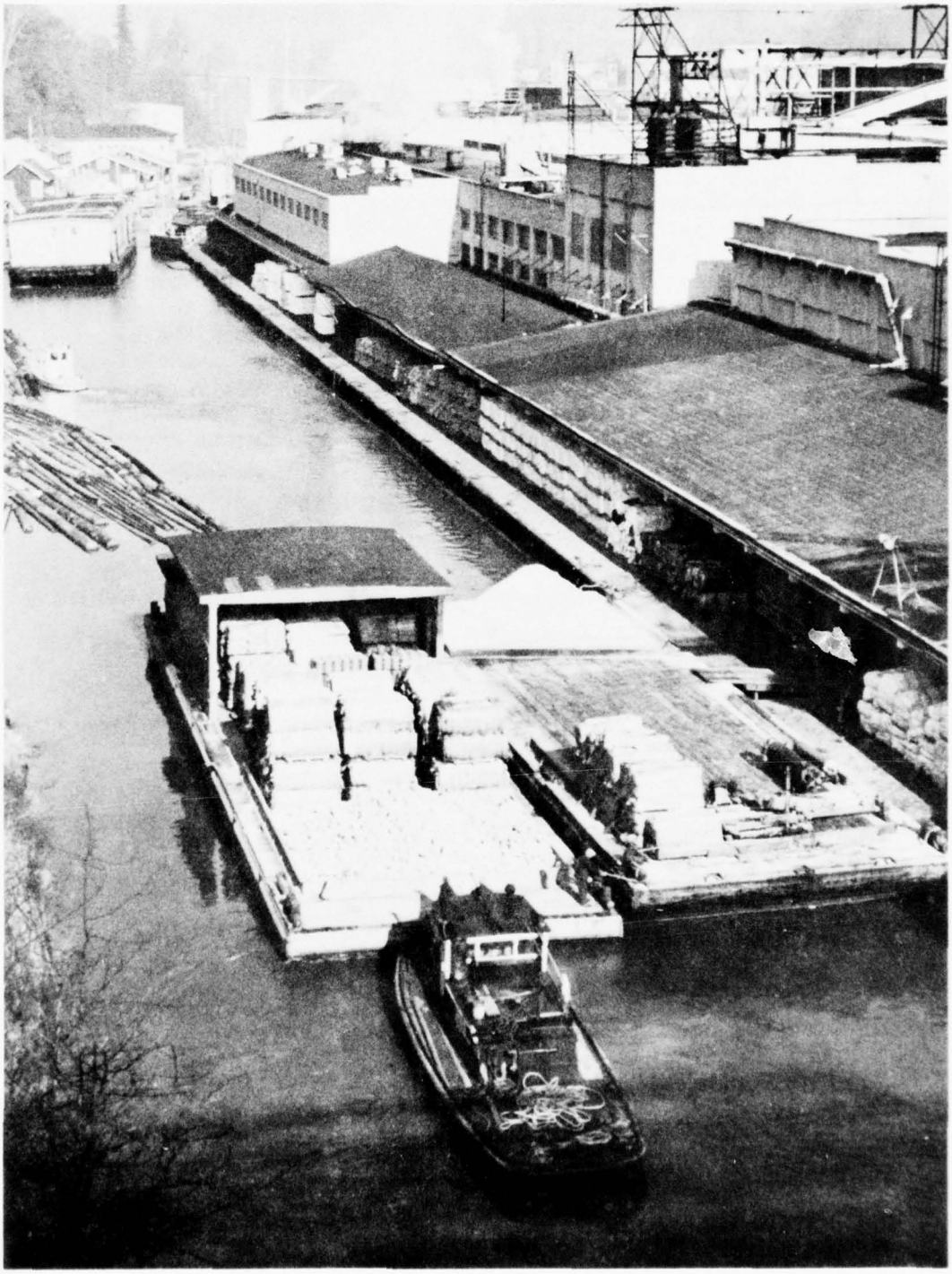
Vessels

About 25 small tugs and towboats and an equal number of boom boats operate in the Willamette River above Oregon City. These boats have drafts of from 2-1/2 to 6 feet and range in power from 100 to 600 horsepower. The tugboats are generally used for the movement of logs from dumps to mills and to assist in gravel-dredging operations. A few barges are used above Oregon City to supply dredges and other work crews on the river. An occasional bargeload of petroleum products is delivered to Salem. Additional tugs and barges to 650-ton capacities (130 feet long, 36 feet wide, 8-foot draft) are used in the extensive sand and gravel operation below Oregon City, and oceangoing barges with cargo capacities of about 11,000 tons are moved up the river as far as Lake Oswego.

Table 55 - Commerce on Willamette River above Portland, Subregion 9

Commodity Group	1963	1964	1965	1966	1967
		(1,000 Short Tons)			
Forest Products	1,753	2,028	1,022	815	1,046
Petroleum Products	14	12	12	9	14
Nonmetallic Minerals	2,437	2,508	2,821	2,980	2,746
Miscellaneous 1/	400	410	600	569	453
Subregion Total	4,604	4,958	4,455	4,373	4,259
Total Willamette Falls Locks	1,184	1,091	1,018	1,053	1,292
Total Ton-Miles (1,000,000)	55	63	60	32	44

1/ Includes 250,000 to 300,000 tons paper mill waste liquor, shipment of which has been discontinued.



Tugs and barges in the canal at Willamette Falls Locks. (USCE)

Difficulties Attending Navigation

The dimensions of the Willamette Falls Locks limit the size of equipment that can navigate the Willamette River, and channel sinuosity and river currents above the falls prevent the use of multiple tows. Depths of channel upstream from the falls also prevent the use of larger sized equipment presently used in Portland harbor and Columbia River. These limitations prevent movement of bulk commodities in large consignments which would offset the advantage that competing forms of transportation have in being able to reach more distribution centers. They also prevent the use in the Portland area of sand and gravel from extensive deposits along the Willamette River above Oregon City. Flood stages, which may go as high as 25 feet at Eugene, 35 feet at Salem, and 45 feet at Wilsonville, complicate the development of shoreside facilities and add a further economic burden to water transportation.

Navigation causes some pollution that will need to be reduced through more stringent control measures or through elimination of offending practices. Logs in the stream are a serious problem. Loose bark and other debris are carried into water with the logs, pollutants are leached from the logs; and large rafts in storage prevent sunlight from penetrating into the water. These problems are under study, but it is probable that much greater care will be required in preparing the logs for rafting and that in-transit storage will be sharply curtailed or eliminated. Dredging for maintenance of the navigation channel stirs up turbidity in the stream, but material is generally coarse sand, gravel, and cobbles and the turbidity quickly settles out. In some areas, the sand and gravel operators can work in pools separated by a berm from the river.

Maintenance is a problem because bars form each high water and have to be removed every year. The stream cannot be stabilized with pile dikes as can the Columbia River. Also, dredging a bar at the lower end of a pool lowers the water surface in the pool.

High velocities, slope, and limited water preclude open-river navigation (except extremely shallow-draft) above Harrisburg to Eugene.

Recreational Boating

The primary recreational boating activities on the Willamette River include fishing, water skiing, cruising and sightseeing, and hunting. The most concentrated usage is fishing for spring chinook salmon in the reach between Portland and

Oregon City. The Oregon State Game Commission estimates that this activity amounts to more than 35,000 boat trips per year. Above Oregon City, the predominant activity is water skiing. No data are available as to the number of boats using this reach of the river but a partial record at the Wallace Park ramp in Salem gives an indication. In 60 days of the summer of 1964, more than 1,900 boats were launched; assuming that the boat season lasted 100 days, more than 3,000 boats would have been launched over this one ramp. More recent counts are not available because the ramp was destroyed by the flood of December 1964 and only partially restored by 1967.

In 1966, approximately 700 boats were moored along the Willamette River above Ross Island Bridge. Of these, 65 percent were along the reach below the falls at Oregon City. All were moored at privately-owned moorages open to the public on equal terms. Moorages are available at Portland, Milwaukie, Oregon City, West Linn, Wilsonville, Salem, Corvallis, and Eugene. In addition, many landowners along the river moor boats at their own properties, and several clubs maintain moorages for their members.

Based on data from "Pleasure Boating in Oregon" (4) prepared by the Oregon State Marine Board, the number of registered pleasure boats in the subregion in 1966 was 37,200. Of these, 21,700 were registered in Multnomah, Clackamas and Washington Counties and are tributary to Subregion 8 as much as Subregion 9. No data are available on the number of boats utilizing the Willamette, however, it appears to be increasing rapidly. The survey does indicate that approximately 80 percent of the boats are stored at the owners' homes and transported to the water each time they are used. There are about 35 ramps open to the public where boats can be launched into the Willamette or the lower reaches of the major tributaries.

PROJECTED CONDITIONS AND NEEDS

Economic Outlook

Population, Employment and Income

The population of Subregion 9 is expected to grow at a faster rate than that of the region. From a 1965 population of 1,218,000, OBERS projections are for populations of 1,727,000 in 1980, 2,398,000 in 2000, and 3,237,000 by 2020, which represents an average growth rate of about 1.7 percent annually over the 60-year period. Corresponding figures given in the Willamette Basin Comprehensive Study are 1,339,000 in 1965, 1,768,000 in 1980, 2,422,000 in 2000, 3,591,000 in 2020, and an average growth rate

of 1.8 percent annually. Most of the growth is expected to occur in the Portland, Salem, Albany-Corvallis, and Eugene-Springfield areas.

Agricultural production is expected to increase significantly; however, agricultural employment will decline because of improving technology, increasing yields, better labor utilization, and greater capital investment per worker. Increased output is envisioned in many manufacturing industries. Growth in employment is expected to occur in the chemical and allied products industries, in the primary metals industries (both ferrous and nonferrous), in nonresource-based manufacturing, and in the residentiary industries. The subregion is developing a diversified and expanding complex of manufacturing industries and provides numerous residentiary services for much of Oregon and southern Washington.

Basic population, income, and employment data, as projected for the Columbia-North Pacific Study and the Willamette Basin Comprehensive Study are shown in table 56.

Table 56 - Population, Income and Employment Projections, Subregion 9

Item	Columbia-North Pacific				Willamette Basin Comprehensive			
	1960	1980	2000	2020	Present	1980	2000	2020
Total Population (1,000)	1,169	1,727	2,398	3,237	1,339	1,768	2,422	3,591
Total Personal Income ($1 million)	2,834	7,212	17,012	39,775	2,792	6,478	13,720	31,240
Per Capita Income (Dollars)	2,328	4,175	7,096	12,287	2,357	3,665	5,665	8,700
Total Employment (1,000)	431	680	949	1,280	532	653	803	1,307
Agriculture, Forestry & Fishing	23,336	20,489	17,217	13,987	27,300	18,700	14,200	11,000
Total Manufacturing	97,333	155,401	202,850	259,720	104,500	117,500	164,100	250,400
Lumber & Paper processing	40,100	30,800	26,600	23,700	40,000	33,000	26,000	23,000
Food processing	12,900	12,200	11,900	11,900	14,800	12,600	12,000	11,700
Other Industries (1,000)	308	501	726	1,003	384	495	682	1,017

Source: Appendix VI, Economic Base and Projections

The basic differences between the two projections are that the Willamette Study shows greater increases in population and employment whereas the Columbia-North Pacific shows greater increases in per capita and total personal income. Additional information on population and economic projections is shown in Appendix VI, Economic Base and Projections.

Commodity Projections

Estimates of bulk commodities produced in Subregion 9 or needed to support the projected population for the years 1980, 2000, and 2020 are shown in table 57. Projections of agricultural, forest, primary metals, and nonmetallic mineral commodities are discussed in the following paragraphs; other commodity projections are based primarily on population growth. Since these commodities are adapted to movement by water transportation, their growth is an indicator of increased water transportation use.

Table 57 - Projections of Major Bulk Commodities Produced or Consumed, Subregion 9

Item	Year			
	Base 1/	1980	2000	2020
	(1,000 short tons)			
Agricultural Commodities	1,300	2,050	2,590	3,300
Food Manufactures	1,510	2,240	3,090	4,320
Forest Products	23,275	19,600	20,800	21,850
Primary Metals	320	890	2,390	6,060
Nonmetallic Minerals	18,500	28,000	40,900	61,400
Steel Scrap	165	185	290	410
Petroleum Products	2,400	3,925	6,950	11,500
Fertilizer	145	175	320	390

1/ 1964, except primary metals 1969, and steel scrap and petroleum products 1960.

Agricultural Commodities Projections are that total acreages in crop production will continue to decline, but yields per acre will increase enough to more than offset this. Manufacturing and processing of food and kindred products is projected to increase 50 percent by 1980 and nearly three times by 2020. In regard to the types of commodities produced in the subregion, volume is not a completely accurate gage of the value represented.

Forest Products Projected changes in production in the basin's forest products industry are based on national and regional supply and demand estimates made by the Forest Service. Growth of the industry will be limited by the economically available supply of timber, hence a larger national growth would have only a minor effect on this industry.

Primary Metals Output of primary metals in the subregion is mainly the processing of imported raw materials. Much of the finished product must be exported to regional and national markets and production rates are therefore geared quite closely with national population and GNP growth rates.

Nonmetallic Minerals The bulk of the mineral output serves the construction industry and road building and maintenance projects, and in this regard is expected to show continued gains as population and their related needs continue to increase.

The Role of Transportation

An adequate transportation system is a large contributor toward the growth of an area's economy. All facilities, rail, air, highway, and waterway, must continue to improve and expand to meet the needs of the continuing expansion in domestic commerce. Agricultural, mining and forestry industries are particularly influenced by transportation as they produce large volumes of bulky items which must be transported long distances from their point of origin to point of manufacture or use. There is generally keen competition between rail, highway, and waterway modes for these large volume customers.

Prospective Waterborne Commerce

The future need for navigation depends primarily on the need to move large volumes of commodities adapted to water transportation along routes parallel to the available waterway. Historically, such cargo movements have been more economically handled by water haul than by any alternative mode of transport. This advantage of water transportation is expected to continue. Projections of future waterborne commerce are based to a large extent on studies made for the Willamette Basin Comprehensive Study (6). Future tonnages of rafted logs, wood chips, petroleum products, and agricultural supplies were taken directly from that study. Pulp, paper products, and supplies and limestone, which move only on the lower river below Oregon City, were not projected in the Willamette Basin study, but are included herein. Only nominal savings would result from moving sand, gravel, and crushed stone from above the falls at Oregon City to serve

the Portland area. For this reason, the Willamette Basin Study did not include this commodity with future waterborne commerce. However, significant tonnages were included, herein, for reasons cited below. Expected waterborne commerce in these commodities is discussed in the following paragraphs. Table 60 summarizes the projections of commerce that would move over the Willamette River provided an adequate barge channel were available between Portland and Albany.

Preliminary studies show that improvement of the river to provide open-river navigation for modern barge traffic in the reach between Albany and Eugene would not be practical within the time frames considered in this study. Projections of waterway commerce, therefore, exclude potential traffic that a channel would carry to serve the Eugene area.

Forest Products

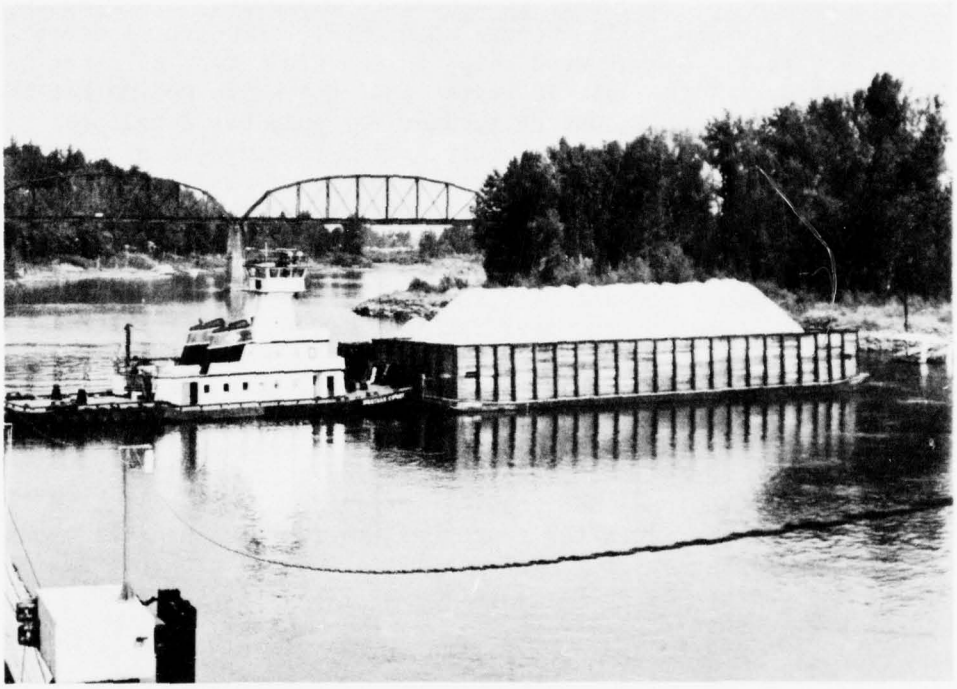
Harvesting and processing the timber resource into primary wood products is the major industry of the subregion. Future growth will be limited by the sustained-yield capacity of timber resources. The following projections are based on the Willamette Basin Comprehensive Study (6) which used studies by the Pacific Northwest Forest and Range Experiment Station, U.S.D.A. Forest Service. Logs, wood chips and other by-products, pulp and paper products, and miscellaneous papermill supplies are the major forest-product commodities expected to move over the waterway.

Rafted Logs Log rafts are expected to continue to move on the river. Estimated consumption of round wood was obtained from projections by the Pacific Northwest Forest and Range Experiment Station (8). Estimated tonnage to be moved over the waterway is based on the consumption projections and the record of log movement of the past 10 years. Most of the logs presently moved over the waterway are destined for pulp and paper mills along the Columbia and lower Willamette Rivers. Use of the logs for pulp and paper is expected to continue throughout the projection period. About 20 percent of the total log tonnage movement is upbound. This percentage is included in the projections of total log traffic.

The practice of storing the logs in the river will have to be severely curtailed or eliminated in the interest of water quality and it may be necessary to clean the logs before putting them into the river. However, these restrictions will not materially reduce the traffic. Rafts will comprise bundles of logs when warranted by navigation-channel depths. Total estimated tonnages are shown in table 60.

Wood Chips and Other By-Products Marketable by-products of lumber and plywood mills include wood chips, sawdust, planer shavings, and bark. Use of wood chips in the production of paper has developed during the last 10 years, and most mills now market their chips. More recently, use of sawdust for pulp has developed. Limited quantities of sawdust pulp, which is composed of short fibers and is not suitable of itself for paper production, can be used with other pulp to improve the texture of the paper without appreciably weakening it. The sawdust requires special handling and, to date, has been shipped by truck only but is expected to be moved by other modes in the future. Bark and sawdust are used as soil conditioners and other landscaping practices. Sawdust has been successfully marketed in pressed-log form for open-fire fuel. Planer shavings and sawdust also have been used for flakeboard and fiberboard manufactures. These by-products are characterized by large volume and low unit value and adapt well to water transportation. Until recent years, most of these materials were burned, but growing awareness of air pollution and reluctance to waste the resources are restricting this method of disposal. Markets for better utilization are growing, and increased use of the material presently wasted is expected. Woodchips and sawdust expected to move on the waterway will be produced in the middle and upper areas of the basin and shipped primarily to the mills on the Columbia and lower Willamette Rivers. Estimates of projected waterborne wood chip tonnage are developed from projections of log consumption of the Willamette Basin Comprehensive Study (6). Published data show sawmill and plywood operations average about 0.5 unit of wood chips per 1,000 feet board-measure of logs processed. Shipping weight per unit varies by timber species and moisture content and ranges between 3,000 and 4,000 pounds per unit.

These average values were applied to log-consumption projections to forecast wood chip production. Presently, more than 70 percent of the area's pulp- and paper-plant capacity is located along the Columbia and lower Willamette Rivers. The site advantages of these plants relative to water supply, availability of low-cost water and other transportation facilities, and availability of labor cannot be matched by alternative upriver locations. Further, the fact that the industry as a whole will not expand indicates that production will continue at the existing plants and few new ones will be built. Therefore, it is assumed the present distribution of production capability will remain throughout the forecast period. Based on projections of log consumption for lumber and wood products, published by the Forest Service, 85 percent of the wood chip and waste-residue volume will be generated in the middle and upper portions of the Willamette Basin in the period 1980 to 2020.



Tug and ship barges on Willamette River near Lake Oswego. (USCE)

The middle and upper portions of the basin will use only part of their wood chip and residue production; the remainder is expected to be shipped to the lower Willamette, Columbia River or coastal paper plants or to coastal ports. Table 60 shows estimated tonnages of wood chips that would move from upriver, primary timber processing plants to pulp and paper plants of the lower Willamette and Columbia Rivers if an adequate navigation channel is available.

The projected waterborne wood chip tonnage represents about 20 percent of the total production expected of the upper and middle basin areas. It is believed that more than these amounts will move to the lower areas but some is expected to be carried by other modes of transportation. The decrease in projected waterborne wood chip volume for 2000 and 2020 results from an expected decrease in roundwood consumption for saw logs and technological advances in processing that will decrease by-product materials.

Pulp, Paper Products, and Supplies Pulp, sulfur, clay, and miscellaneous supplies will continue to be shipped to the

Wood Chips and Other By-Products Marketable by-products of lumber and plywood mills include wood chips, sawdust, planer shavings, and bark. Use of wood chips in the production of paper has developed during the last 10 years, and most mills now market their chips. More recently, use of sawdust for pulp has developed. Limited quantities of sawdust pulp, which is composed of short fibers and is not suitable of itself for paper production, can be used with other pulp to improve the texture of the paper without appreciably weakening it. The sawdust requires special handling and, to date, has been shipped by truck only but is expected to be moved by other modes in the future. Bark and sawdust are used as soil conditioners and other landscaping practices. Sawdust has been successfully marketed in pressed-log form for open-fire fuel. Planer shavings and sawdust also have been used for flakeboard and fiberboard manufactures. These by-products are characterized by large volume and low unit value and adapt well to water transportation. Until recent years, most of these materials were burned, but growing awareness of air pollution and reluctance to waste the resources are restricting this method of disposal. Markets for better utilization are growing, and increased use of the material presently wasted is expected. Woodchips and sawdust expected to move on the waterway will be produced in the middle and upper areas of the basin and shipped primarily to the mills on the Columbia and lower Willamette Rivers. Estimates of projected waterborne wood chip tonnage are developed from projections of log consumption of the Willamette Basin Comprehensive Study (6). Published data show sawmill and plywood operations average about 0.5 unit of wood chips per 1,000 feet board-measure of logs processed. Shipping weight per unit varies by timber species and moisture content and ranges between 3,000 and 4,000 pounds per unit.

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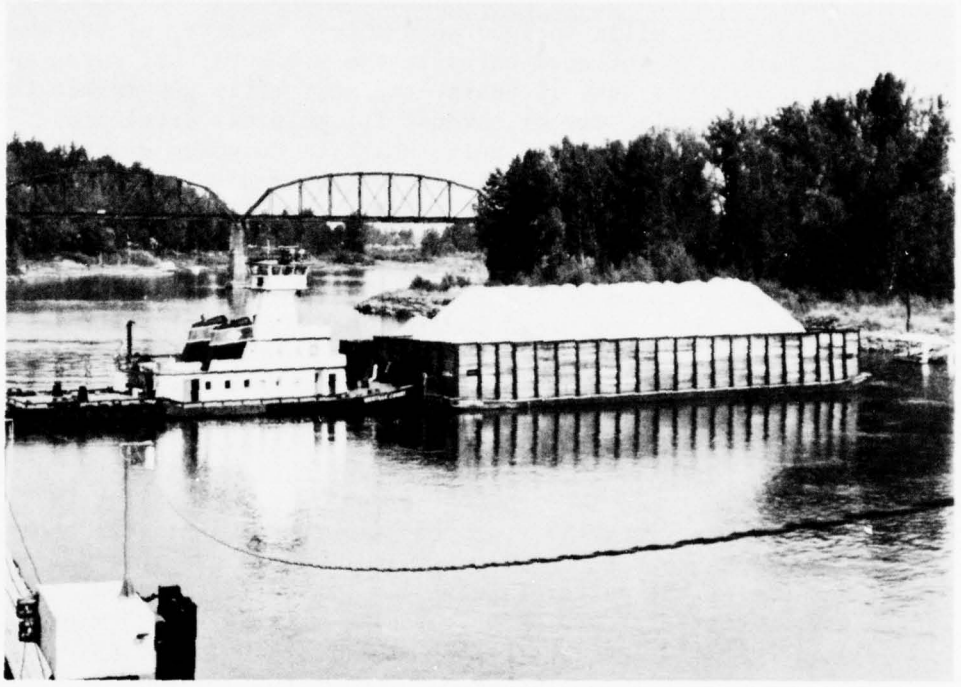

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Pulp, Paper Products, and Supplies Pulp, sulfur, clay, and miscellaneous supplies will continue to be shipped to the

paper mills at Oregon City and West Linn, and paper products will be exported. Indicated changes in operation of these plants are not expected to significantly change total waterway tonnage in these commodities within the time frame of this study. Table 60 shows projected waterborne commerce in pulp paper and related commodities. This is expected to remain constant from 1980 through 2020.

Petroleum Products

Petroleum products expected to move parallel to the Willamette River include gasoline, fuel oil, asphalt, greases and lubricating oils, and liquid petroleum gas (LPG). Needs for these commodities in the area that could be served by the Willamette waterway have been projected on the basis of population and per capita consumption and are shown in table 58.

Table 58 - Projected Consumption of Petroleum Products, 1/
Subregion 9

Commodity	Year 1980	2000	2020
	(1,000 short tons)		
Gasoline	1,053	1,686	2,715
Fuel Oil	847	888	936
Asphalt	163	242	369
Greases and Lubricating Oils	28	36	50
Liquid Petroleum Gas	28	29	34

1/ In area served by navigation above Oregon City.

Rate studies show that gasoline and fuel oil could be shipped as cheaply in the pipeline which runs from Portland through Salem and Albany to Eugene as on the waterway, but that other products could be barged at a savings.

For reasons of flexibility it is considered that 10 percent of the gasoline and fuel oils and 70 percent of the other products required by the areas that could be served by distribution centers at Albany and Salem would be carried by barge. The lower area of the basin would be served out of Portland. Applying per capita-consumption estimates to the population projections for the area

to be serviced by the Albany and Salem distribution centers gives the waterway tonnage projections of table 60.

Limestone

Shipment of limestone to the cement plant at Lake Oswego will not be affected by any improvement of the waterway at or above the falls. However, projected tonnages are shown to complete the picture of total use of the waterway. Projections are based on the assumption that production at the plant will grow at the rate of consumption of cement in the region, which is projected to increase at 1-1/2 percent per year. On that basis, total limestone shipments would be as shown in table 60.

Sand, Gravel, and Crushed Stone

Sand, gravel, and crushed stone needs for the Portland area and the total subregion are projected on the basis of population and per capita consumption as follows:

Table 59 - Annual Requirements of Sand, Gravel, and Crushed Stone, Subregion 9

Year	Portland Area	Subregion Total
	(1,000 short tons)	
1980	12,000	20,000
2000	17,000	27,000
2020	26,000	40,000

In the area above Willamette Falls, local sources have been developed that are believed capable of supplying the needs through the projection period, and only minor short-haul movements are expected on the waterway.

For many years the Portland area has been supplied from quarries east of town and in and adjacent to the Willamette River. Vast deposits underlie the entire east Portland area as far east as the Sandy River and similar deposits continue north underlying east Vancouver. However, these areas are now becoming suburban developments and the sand and gravel are not available for

exploitation. The deposits along the Willamette River are nearly depleted. New quarries are being studied and developed. Several deposits along the Willamette River above the falls are among the most promising from the standpoint of ease of development and quality of material. However, the limitations of the locks preclude full development at this time. Other deposits along the Columbia River and away from the river but within economical truck-haul distance are being considered. Rate studies show that these other deposits would be at least as economical to develop as those along the Willamette even with a new lock, but operators continue to be interested in the upriver sites. One operator is currently taking a token amount of gravel from a bar a few miles upstream from Oregon City through the locks. For these reasons and because some of the deposits along the Columbia River are in exclusive ownership, it is believed that from 20 to 30 percent of the Portland area needs will be derived from the Willamette River upstream of the locks. Expected quantities are included in table 60.

Agricultural Supplies

Fertilizer and lime used by agriculture are considered potential river commerce. Fertilizer is presently barged on the Columbia River and could be barged on the Willamette from the same sources of supply. Lime is needed throughout the basin to counter over-acid soils but has not been used extensively in the past because of high cost. Lime is presently distributed from the cement plant at Lake Oswego and from sugar refineries in Idaho and eastern Oregon and Washington where it is excess after having been used in the refining process. Projections of potential tonnages as developed for the Willamette Basin Review and used herein are based on the rate of usage during the period 1959 to 1964 in the area that would be served by the waterway.

It is assumed that 70 percent of the tonnage expected to be used in areas easily served by the distribution centers of Salem and Albany would be moved on the waterway. Projections of waterborne fertilizer and lime movements are shown in table 60.

Table 60 - Summary of Projected Waterborne Commerce on Willamette River above Portland

Commodity	Year 1980	2000	2020
	(1,000 short tons)		
Rafted Logs	933	1,164	1,264
Wood Chips	1,238	979	924
Pulp, Paper Products, & Supplies	407	407	407
Petroleum Products	219	307	453
Limestone	375	505	680
Sand, Gravel, & Crushed Stone	3,000	4,000	10,000
Agriculture Supplies	240	310	345
Total	6,412	7,672	14,073

Prospective Equipment Changes

The sizes of tugs and barges used on the Willamette River above the falls have been limited by the size of the locks, and this equipment will continue in use until worn out or until the volume of commerce makes the small equipment uneconomical. However, upon completion of a new lock, use would be made of other equipment presently in use in Portland harbor and on the Columbia River. A wide variety of barges, ranging from old wooden barges of 450- to 800-ton capacity to modern steel, dual-purpose barges of 3,000-ton capacity, is used on these waterways. Many of the newer barges have been converted from World War II invasion equipment; but significantly, several all-new barges, designed to completely fill the locks above Bonneville Dam when used in multiple tows, have been constructed. Although the improvements envisioned for the Willamette River would not permit multiple tows or possibly even full loading, it is expected that, when locks and channels allow and traffic demands, the equipment available on the Columbia River will be used on the Willamette. These barges will range from 1,700 to 3,000 tons, will be 175 to 225 feet long, 40 feet wide, and have loaded drafts of 12 to 13 feet.

Future Outlook of Recreational Boating

The Willamette River is a major recreational resource in the subregion, capable of satisfying nearly half the total water-related demand. At present, however, the recreation potential of the river is generally undeveloped. In some lower reaches the river is unsuitable for most recreation uses because of pollution. As population pressures on recreation facilities in the subregion increase, there will be accelerated demand for additional accesses and development of facilities along this waterway. Pressures also will increase for continued improvement of water quality. The number of pleasure boats in the subregion is projected to increase from 37,200 in 1966 to 57,000 in 1980, 108,000 in 2000, and 204,000 in 2020. An increasingly larger proportion of these will have to be accommodated by the navigable waterways. This increased usage by small boats could cause conflicts with commercial navigation users. See Appendix XIII, Recreation, for further discussion of recreational boating in the subregion.

Table 61 - Recreational Boating Activity Projections 1/, Subregion 9

Item	Year			
	Present 2/	1980	2000	2020
Estimated total number of boats in subregion 4/	76,100	117,900	233,600	439,100
Estimated boats used on a full-season basis on the contiguous waterway	4,200	6,500	13,000	24,300
Annual boat-day use	168,000	222,000	427,000	800,000
Moorage capacity needs	700 3/	1,100	2,150	4,000
Boat launching lane needs	35 3/	80	160	300

1/ On contiguous waterways usable for commodity navigation.
2/ 1966 except 1970 for total boats in subregion.
3/ Presently available.
4/ From Appendix XIII.

SUMMARY OF NEEDS

The need for navigable water is reflected by the summary of commerce that can be expected to move over the Willamette waterway provided the waterway is improved to meet the requirements of modern barge-service operation. The specific needs are new lock facilities at Willamette Falls and greater channel dimensions in the river between Oregon City and Albany. Additional public access to the river is needed for recreational boating.

MEASURES TO SATISFY NEEDS

Improvements to the Willamette River channel and to Willamette Falls Locks will be required to meet the subregion's future navigation needs. The existing lock facilities must be reconstructed and greater depth must be provided in the river channel. The authorized improvements to Willamette Falls Locks are considered adequate to meet the needs of projected equipment and traffic.

Cost of reconstructing the lock is estimated to be about $13,600,000. Operation and maintenance costs would be about the same as or slightly less than of the existing lock system. Modifications to the authorized plan of improvement should be studied prior to start of construction to determine the economics of conforming the new lock to the size of the locks in the Columbia-Snake River system, and any justifiable changes should be made at that time.

The channel between the falls and Albany can be improved by open-river methods. Water is available in multiple-purpose storage reservoirs to augment flows during the low water season. Increased channel depths can be obtained by flow augmentation, dredging, minor alinement improvements, and bank stabilization and contraction works. Several plans for deeper channels were studied during preparation of the Willamette Basin Comprehensive Study (6) for depths ranging up to 9 feet. Costs for the various channel depths studied ranged from $3 to $7 million, but determination of appropriate dimensions was not made.

The Willamette Basin Study considered an improvement to the channel between Albany and Corvallis (about 10 miles). The slope of the river and volume of water are favorable, but benefits for improving this reach are not great and would not justify the increased channel costs. Between Corvallis and Eugene, the general gradient of the river is too steep to permit development by the open channel method. Development by slack water or by a separate canal away from the river is possible but either

alternative would be very expensive and not justifiable by the potential commerce. Such development also would be possible between Willamette Falls and Albany but could not be justified by foreseeable potential commerce. However, further study of any or all of these alternatives may be warranted by significant increases in traffic.

Acquisition of land and development of basic facilities by public agencies will be required to satisfy recreational boating needs. Establishment of a Willamette Parkway or Recreational Waterway has been proposed. Overall coordination of recreational and commercial usages of the waterway will be required.

Continued development and use of navigation will involve unevaluated local expenditures for additional mooring, storage, transfer, and related facilities, as needs develop along the channel.

Table 62 - Summary of Costs, Navigation Facilities 1/, Subregion 9

	1980	2000	2020
First Costs			
Channels & Locks	20,600	0	0
Aids to Navigation	NA	NA	NA
Port & Transfer Facilities	NA	NA	NA
Moorages	600	1,575	2,775
Launching Ramps	2,250	4,000	7,000
Total First Cost	23,450	5,575	9,775
Annual O&M			
Channels & Locks	1,400	0	0
Aids to Navigation	NA	NA	NA
Port & Transfer Facilities	NA	NA	NA
Mooring Facilities	120	315	555
Launching Ramps	45	80	140
Total Annual Costs	1,565	395	695

1/ Incremental costs in 1968 dollars prior to date shown.

LOCATION MAP

SUBREGION 10

COASTAL

GENERAL

Subregion 10 comprises the coastal drainages between the California-Oregon border and the Strait of Juan de Fuca, with the exception of the Columbia River (see Subregion 8), and drainage into the Strait of Juan de Fuca east to, but not including, the Elwha River Basin near Port Angeles. It is bounded on the west by the Pacific Ocean, on the north by the Strait of Juan de Fuca, on the east by the Willamette-Puget Sound trough and on the south and southeast by California and the Klamath Basin. The area is 23,763 square miles. Generally, the navigation influence of the coastal ports does not extend inland beyond the crest of the Coast Range. Information on the ports on the Columbia River estuary can be found in the Subregion 8 discussion. Figure 8 is a map of Subregion 10.

Physiography

Except for the areas in the Chehalis, Rogue, and Umpqua Basins which lie easterly of the Coast Range, Subregion 10 occupies the coastal margin between the Pacific Ocean and the crest of the Coast Range. This coastal margin is dominated throughout the length of the subregion by mountainous uplands with narrow, deeply entrenched valleys and steep, forest-covered slopes. In most areas there is an abrupt change to the footslopes, fans, terraces, and bottomlands that occur along the narrow coast plain and extend inland along the main rivers and tributaries. While much of this lower area is also forested, it contains practically all of the limited cropland and economic development in the coastal margin. In several places, the mountains extend to the ocean and terminate in abrupt headlands which reach from several hundred feet above to 10 to 50 fathoms below sea level. The coastal margin streams have short, steep headwaters and steep gradients down to tidewater. Tidal reaches, extending inland from one to 20 miles, are generally navigable.

The interior of the Chehalis Basin occupies a portion of the Willamette-Puget Trough (see Subregions 9 and 11) and has low, almost indistinguishable divides separating it from the Deschutes and other Puget Sound drainages on the north and the Cowlitz Basin on the south. The rugged Olympic Range to the north cradles

the headwaters of all the major tributaries of the lower Chehalis, the Humptulips, and several short coastal streams--the Quinalt, Queets, Hoh, and Quillayute.

The Rogue and Umpqua Basins contain large interior valleys located between the Coast and Cascade Ranges. These valleys are again surrounded and broken by mountainous uplands with steep slopes and forest cover, but the forests are less dense and are interspersed with open, grassy, and brushy rangeland. There are gradual transitions from mountain slopes to valley floors, and the lowlands extend to several miles in width.

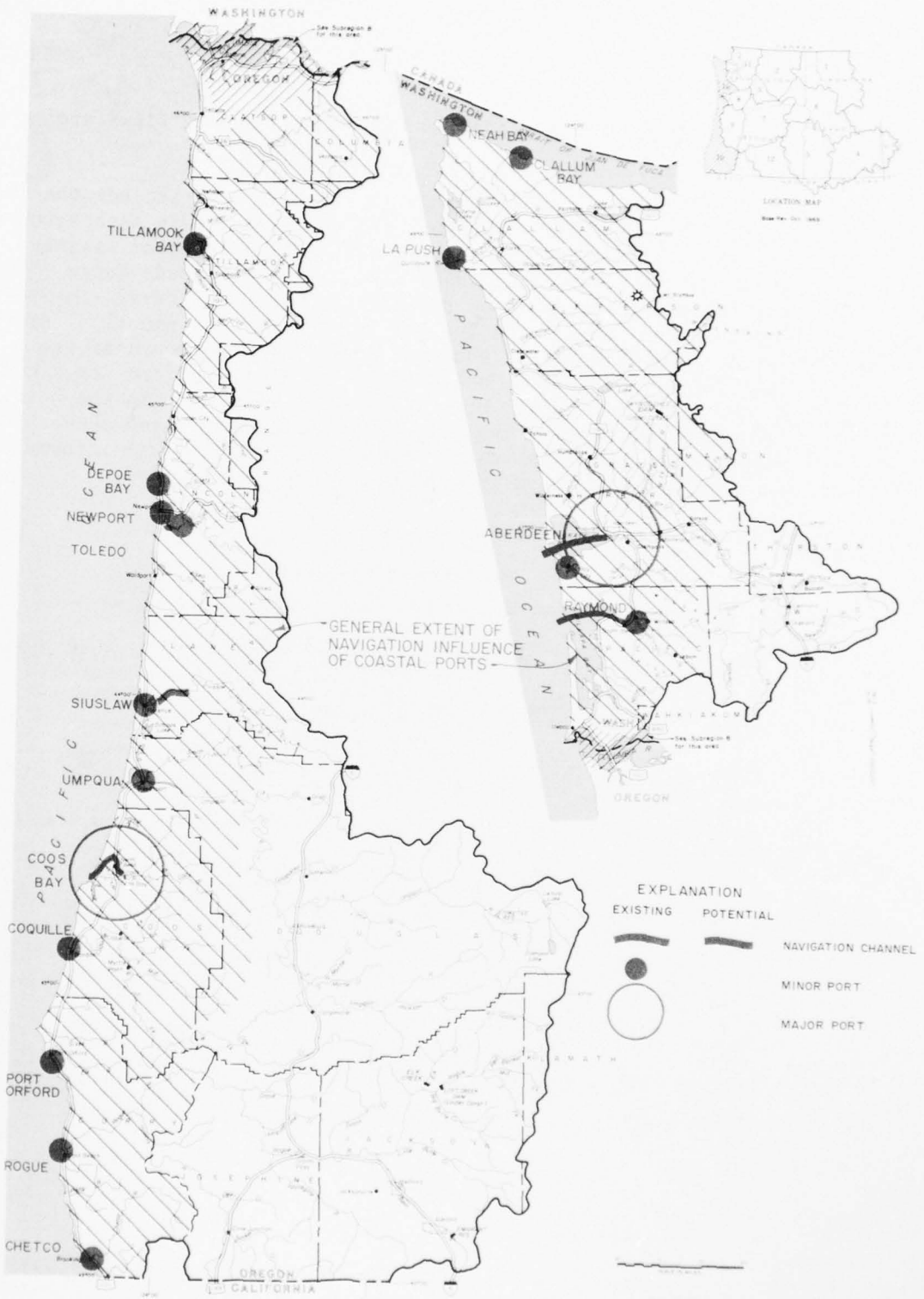
Climate

The areas of Subregion 10 have two distinctive climates. Along the coastal margin, the climate is moderate and humid. Temperatures near the ocean seldom rise above 90 degrees in the summer, or fall below 20 degrees in the winter. Annual precipitation ranges from 60 to 110 inches along the coast and to as much as 200 inches along the summit of the Olympic and Coast Ranges. During the winter months, the prevailing weather is characterized by persistent rainfall. Rain may continue almost uninterrupted for several days, or moderate to heavy rainstorms may produce 4 to 6 inches at the coastal towns in a 24-hour period. Approximately 80 percent of the annual precipitation occurs from October through March. Summer precipitation is generally limited to occasional light rains. Snowfalls vary from a trace near the coast to several feet at about 3,000 feet elevation, but it is only in the higher elevations of the Olympic Mountains that snow normally remains on the ground through the winter.

The climate of the Rogue and Umpqua interior basins is drier and more severe. Annual precipitations range from 20 inches at Medford and Ashland to as much as 100 inches in the higher mountains. Temperatures as high as 115 degrees and as low as -12 degrees have been recorded. The average annual snowfall at lower elevations ranges from 10 to 25 inches and increases fairly rapidly with elevation. At Crater Lake National Park headquarters, at nearly 6,500-foot elevation, the average annual snowfall is 575 inches.

Streams

The principal streams in Subregion 10 are listed in table 63. With few exceptions, the general characteristics of all the coastal streams are remarkably similar. Headwater areas are steep, and rock formations are relatively impervious. Streams



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

EXISTING & POTENTIAL NAVIGATION FACILITIES

COASTAL SUBREGION 10

1970

FIGURE 8

have steep gradients almost to tidewater. Summer flows are scant.

The streams which do not fit this pattern include the Rogue, Umpqua, and Coquille in Oregon, and the Chehalis in Washington. The Rogue and Umpqua Rivers have substantial interior drainage areas and derive much of their flow from the Cascade Range. Summer flows are sustained by snowmelt and good aquifers. The lower Coquille and Chehalis basins are relatively flat and tidal effects extend to Myrtle Point, about 36 miles from the mouth of the Coquille River, and to Montesano, about 10 miles from Grays Harbor on the Chehalis River. Most streams are navigable to the head of tidewater and some of the larger rivers are navigated above tidewater, mostly for fishing or sightseeing. Additional information on streams is included in Appendix V, Water Resources.

Table 63- Streamflow Summary, Subregion 10

Stream	Total Drainage Area (sq. mi.)	Gaging Location	Gage Drainage Area (sq. mi.)	Annual Flow 1/ Mean (cfs)	Annual Flow 1/ Maximum (cfs)	Annual Flow 1/ Minimum (cfs)	Momentary Flow 2/ Maximum (cfs)	Momentary Flow 2/ Minimum (cfs)
Chetco	365							
Rogue	5,060 4/	Grants Pass	2,459	3,235	5,938	1,156	152,000	195
Coquille	1,070	Coquille	943	3,129	5,267	1,569	3/	3/
Coos	420							
Umpqua	4,710	Elkton	3,683	7,353	13,350	3,150	265,000	640
Siuslaw	585							
Alsea	353	Tidewater	334	1,545	2,384	881	41,800	45
Yaquina	252							
Siletz	540	Siletz	202	1,521	2,168	879	32,200	48
Nestucca	330							
Trask	180	Tillamook	145	3/	3/	3/	20,000	42
Wilson	208	Tillamook	161	1,171	1,696	734	32,100	45
Nehalem	860	Foss	667	2,675	4,127	1,582	43,200	54
Naselle	133	Naselle	55	425	573	264	11,100	19
Willapa	258	Willapa	130	3/	3/	3/	11,400	15
North	252	Raymond	219	941	1,610	589	35,000	21
Chehalis	2,114	Grand Mound	895	2,761	4,444	1,569	48,400	90
Humptulips	245	Humptulips	130	3/	3/	3/	33,000	82
Quinault	434	Quinault Lake	264	2,766	3,571	1,780	50,200	276
Queets	499							
Hoh	299	Forks	208	1,991	2,576	1,396	38,700	247
Quillayute	629	Fairholm	84	597	832	359	23,500	51

1/ Regulated values for base period from Appendix V.
2/ Observed flows during period of record.
3/ Not available.
4/ Includes approximately 150 square miles in California and outside Columbia-North Pacific Region.

Tides

Tides have the diurnal inequality typical of the eastern Pacific Ocean. The diurnal range varies from 6 or 7 feet along the southern Oregon coast to 8 or 10 feet on the Washington coast.

In most areas the extreme low tides are about 3 feet below mean lower low water 1/, the plane of reference, and extreme high tides about 10 or 11 feet above. The extreme tidal range is about 19 feet in Willapa Bay and 18 feet in Grays Harbor.

Economic Development

For the purpose of economic studies, Subregion 10 includes Grays Harbor and Pacific Counties in Washington, and Clatsop, Coos, Curry, Douglas, Jackson, Josephine, Lincoln and Tillamook Counties in Oregon. Physically, it also includes the west half of Jefferson and Clallam, the southwest corner of Thurston and the most populated portion of Lewis Counties in Washington and the westernmost portion of Lane County in Oregon. The 1965 estimated population of the subregion was 405,500 of which approximately 83 percent were in Oregon and the balance in Washington. Approximately 40 percent of the population is urban, with one city, Medford, Oregon, having more than 25,000 population. Except for Jackson and Josephine Counties, most of the population centers are along the coast with the largest concentrations on bays or natural harbors. The rural population includes some 85 towns ranging from 250 to 2,500 residents. The economy is centered on forest-oriented industries, which employ nearly 30 percent of the total work force. Other significant industries include agriculture, estuarine and deep-sea fisheries, and the processing of fishery and farm products. Tourism and sport fishing activities contribute significantly to the support of service industries.

The 1960 total employment was about 132,000. Of this total about 8,000 were employed in agriculture, 4,000 in food processing and 37,000 in forest products manufacture. Forest products manufacture alone makes up more than 80 percent of all manufacturing. Table 64 shows the distribution of the labor force in 1960.

1/ Refer to glossary.

Table 64 - Employment in Selected Categories,
Subregion 10

Total Employment	131,780
Agrigulture, Forestry & Fishing	10,236
Agriculture	8,117
Mining	467
Manufacturing	45,184
Forest Products	37,363
Food and Kindred Products	3,973
Armed Forces	1,835
Non-Commodity	74,058

Source: Appendix VI, Economic Base and Projections.

Other Forms of Transportation

Railroads

The subregion is served by four major railroad lines, the Burlington-Northern; Union Pacific; Chicago, Milwaukee, St. Paul and Pacific; and Southern Pacific, giving transcontinental service. Other smaller railroads provide local service.

Highways

U. S. 101 runs the entire length of the subregion and passes through all major cities on the coast. Interstate 5 passes through eastern portions of the subregion both in Washington and Oregon. There are seven principal east-west highways which are U. S. 12, 30, 26, and 20 and Oregon State highways 6, 18, and 38. Many State and county highways also serve the area to provide access to all small towns and communities.

Air

Several small airports serve communities in the subregion but scheduled commercial air service is limited to five cities.

Pipelines

A light oil pipeline originating in Subregion 11 and supplying products to ports in Oregon passes through the eastern portion of the subregion located in Washington. Distribution is made from this line to the Centralia-Chehalis area.

EXISTING NAVIGATION

Harbors and Channels

Federal Projects

The present Federally supported harbors and channels are listed in table 65. Except as noted, all harbor entrances are secured by two rubblemound jetties 1/ and are maintained to specified dimensions measured from mean lower low water, the plane of reference. Four projects listed as deep draft actually support deep-draft traffic; two others, Port Orford and Umpqua River, have depths suitable for minimal deep draft vessels, but do not support any such traffic at this time. Two harbors, Depoe Bay and Quillayute River are suitable for small boats only and do not support any other traffic. The Coos and Smith River projects are used for rafted logs only. The Nehalem project is not suitable for commercial vessels. All other harbors are used for commercial and recreational fishing, barge shipments of timber products, and minor amounts of other commodities.

1/ Refer to glossary.

Table 65 - Federal Navigation Projects, Subregion 10

Project	Controlling Dimensions					Remarks
	Entrance		Interior			
	Depth ft	Width ft	Depth ft	Width ft	Length miles	
			Deep Draft Harbors			
Coos Bay	40	1/	30	300	14	
Yaquina Bay	40	400	30	300	2	
Willapa Bay	26	500	24	200	20	no jetties
Grays Harbor	30	600	30	350	20	
			Shallow Draft Harbors			
Chetco River	14	120	14	120	0.2	
Rogue River	13	300	13	300	0.5	
Port Orford	2/	2/	2/	2/	2/	3/
Coquille R	13	1/	4/	4/	24	
Coos River	-	-	5	50	22	Connects to Coos Bay
Umpqua River	26	2/	22	200	11	
Smith River		-	6	100	16	Connects to Umpqua R
Siuslaw R	8	300	16	200	5	
Yaquina R	-	-	10	150	12	Connects to Yaquina R
Depoe Bay	8	50				Breakwater, no jetties
Tillamook B	18	2/	18	200	3	
Nehalem R	2/	2/	2/	2/	2/	
Quillayute R	10	100	10	75	0.8	One jetty
Neah Bay	2/	2/	2/	2/	2/	3/

1/ Suitable
2/ Not specified
3/ Federal Project provides only for breakwater
4/ Clearing and snagging

Non-Project Waterways

In addition to the Federally supported projects, the following unimproved waterways also are used. Most of the traffic on these waterways is recreational, but some commercial fishing is included.

Shallow-draft mail and excursion boats run the Rogue River from the mouth to Agness, about 28 miles.

The Umpqua River is used to the head of tidewater, about 15 miles above the Federal project, by tugs, barges, and dredges procuring sand and gravel.

Several bays and tidal reaches including Alsea, Siletz, Nestucca, and Netarts are used by commercial and recreational fishermen some of whom cross the bar into the ocean when conditions are right.

Dories are launched and retrieved through the surf at Cape Kiwanda near the mouth of the Nestucca River. This is largely a recreational activity but includes an occasional commercial fisherman and several charter boats.

Clallam Bay on the Strait of Juan de Fuca is used by commercial and recreational fishermen and for rafted logs.

Navigation Aids

The U. S. Coast Guard maintains navigation aids as needed at all Federally supported harbors and marks hazards to navigation.

Bridges

Bridges across navigable waters in the subregion are listed in table 66.

Table 66 - Bridges Over Navigable Water, Subregion 10

Stream or Estuary	Location	Purpose	Clearance, feet		Type of Bridge
			Horizontal	Vertical (above mean high water)	
Rogue River, Gold Beach	Gold Beach, Oreg	Highway	150	30	Fixed
Coquille River	Bandon, Oreg	Highway	75	74	Vertical lift
Coos Bay	North Bend, Oreg	Railroad	197	unlimited	Swing
Coos Bay	North Bend, Oreg	Highway	515	123	Fixed
Coos River	Eastside, Oreg	Highway	60	54	Vertical lift
Isthmus Slough	Eastside, Oreg	Highway	110	29	Fixed
South Fork Coos River	Dellwood, Oreg	Highway	130	39	Fixed
Umpqua River	Reedsport, Oreg	Highway	195	unlimited	Swing
Umpqua River	Reedsport, Oreg	Railroad	150	unlimited	Swing
Smith River	Reedsport, Oreg	Highway	55	unlimited	Removable span
Siuslaw River	Florence, Oreg	Highway	110	unlimited	Bascule
Siuslaw River	Florence, Oreg	Railroad	100	unlimited	Swing
Siuslaw River	Mapleton, Oreg	Highway	25	unlimited	Removable span
Yaquina Bay	Newport, Oreg	Highway	395	124	Fixed
Yaquina River	Toledo, Oreg	Highway	150	34	Fixed
Depoe Bay	Depoe Bay, Oreg	Highway	30	42	Fixed
Nehalem Bay	Nehalem, Oreg	Highway	92	unlimited	Swing
S. Fork, Willapa River	Raymond, Wash	Railroad	125	unlimited(open)	Swing
S. Fork, Willapa River	Raymond, Wash	Highway	95	95	Fixed
N. Fork, Willapa River	Raymond, Wash	Highway	125	unlimited(open)	Swing
Chehalis River	Aberdeen, Wash	Railroad	125	unlimited(open)	Swing
Chehalis River	Aberdeen, Wash	Highway	125	unlimited(open)	Bascule
Chehalis River	Montesano, Wash	Highway	300	29	Fixed
Chehalis River	Montesano, Wash	Railroad	100	unlimited(open)	Swing
Hoquiam River	Hoquiam, Wash	Railroad	125	unlimited(open)	Swing
Hoquiam River	Hoquiam, Wash	Highway	125	unlimited(open)	Bascule
Wishkah River	Aberdeen, Wash	Railroad	75	unlimited(open)	Swing
Wishkah River	Aberdeen, Wash	Highway	125	unlimited(open)	Bascule

Commercial Traffic

Waterborne Commerce

Waterborne commerce in 1968 is summarized in table 67. Commodities include forest products shipped to foreign and domestic markets, petroleum fuels to serve the needs of the marketing areas around the major ports, and gravel moving within the harbors and between harbors within the subregion, raw fish and shellfish being brought in from offshore fisheries, and small amounts of general cargo.

Table 67 - Waterborne Commerce, 1968, Subregion 10

Ports	Foreign		Domestic Coastwise					Domestic Internal		
	Misc	Forest Products	Misc	Forest Products	Petroleum Products	Non-metallic Minerals	Fresh Fish & Shellfish	Forest Products	Non-metallic Minerals	Fresh Fish & Shellfish
							(1,000 short tons)			
Chetco River				122			1.6			
Rogue River				94						
Coquille River				182			.1	299		
Coos Bay	6	2,543		391	271	82	6.3	2,464		
Coos River								1,268		
Umpqua River				26	56	96	2.1	606	124	
Smith River								600	15	
Siuslaw River				121		13		30		
Yaquina Bay			9	115			3.6	51		
Yaquina River					26			303		
Depoe Bay							.2			
Tillamook Bay							.4			
Willapa Bay	1	134	2	51				9		22.1
Grays Harbor	2	1,593		67	148			678	365	6.1
Hoquiam River								607	73	.2
Quillayute River							1.2			
Neah Bay					4		.8	319		
Total	9	4,270	11	1,169	505	191	16.3	7,594	577	28.4

Forest Products

Logs, lumber, and wood chips are exported to Far East markets in deep draft vessels. The export of logs has generated some controversy, and restrictions have been placed on the shipments. Export of lumber has declined at most ports in recent years. Export of chips is relatively new and increasing rapidly. Special ships are being built for the trade. Lumber shipments to domestic markets were made in self-propelled coastwise schooners and deep draft vessels until recent years but such traffic has virtually ceased. Lumber presently is being barged to markets in southern California and Hawaii. Some interport barge shipments of wood chips are being made. Prior to World War II, log rafts were moved on the ocean but such traffic

has been discontinued. Log rafts are moved within harbors and from Neah and Clallam Bays to ports on Puget Sound.

Petroleum Products

Gasoline and fuel oils are brought into Coos Bay and Grays Harbor by deep draft tankers and tank barges from refineries on Puget Sound and in California. Heavy fuel oils are barged into Yaquina Bay and Umpqua Rivers to serve paper mills in the area.

Nonmetallic Minerals

Sand and gravel is dredged from deposits in the Umpqua River and Grays Harbor for local consumption. Umpqua River sand and gravel also is barged to other ports in the subregion and at times to ports in northern California.

Fresh Fish and Shellfish

Fish and shellfish are harvested offshore and in the bays. Offshore fisheries include salmon, albacore tuna, bottom fish, and Dungeness crabs. Oysters are raised in Willapa Bay, Grays Harbor, Tillamook Bay, and Yaquina Bay.

Vessel Traffic

Vessel movements through Subregion 10 ports are summarized in table 68. Descriptions of vessels are included in the regional summary.

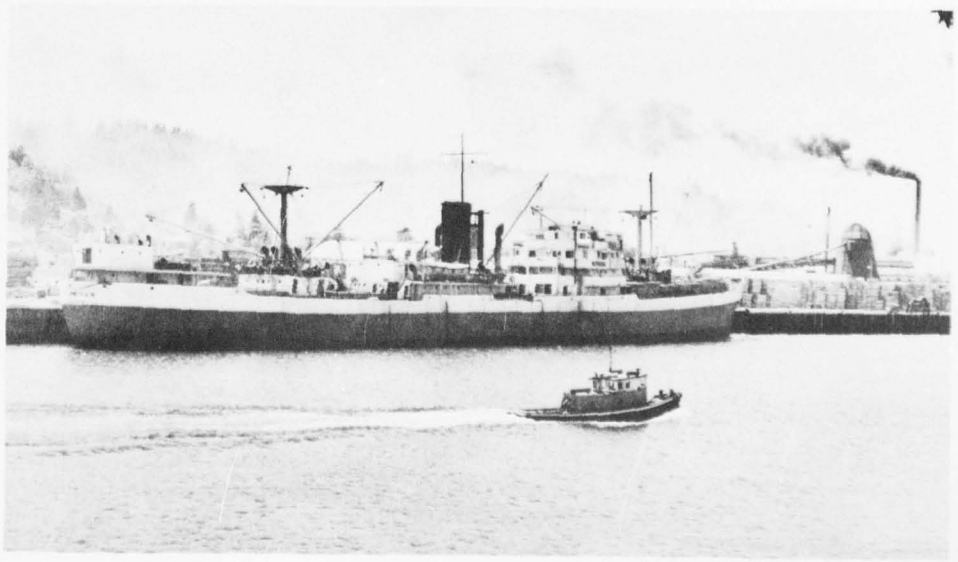
Table 68- Vessel Movements Through Ports, 1967, Subregion 10

Port	Self-Propelled				Non-Self-Propelled			
	Passenger or Dry Cargo							
	18' draft & less	Over 18' draft	Tanker	Towboat or Tugboat	Dry Cargo	Tanker	Other	Total
Chetco River								251 1/ 2/
Rogue River								1877 1/ 2/
Coquille River	860 2/ 3/				34	6		900 2/
Coos Bay	102 2/	275	21	4177	156	64		4795 2/
Coos River				2489				2489
Umpqua River				940	563	12		1515 2/
Smith River				458	347			805
Siuslaw River								842 1/ 2/
Yaquina Bay	56 2/	31		322	262	9		680 2/
Yaquina River				560	313	9		882
Depoe Bay								0 2/
Tillamook Bay								0 2/
Willapa Bay	7067 4/	18		124	30	2		7241
Grays Harbor	5710 4/	125	23	3304	533	12	1	9708
Hoquiam River	1168 4/			2131	291			3590
Quillayute River								17676 1/ 4/
Neah Bay	7868 4/			135	1	8		8012

1/ Breakdown not available
2/ Does not include commercial fishing boats
3/ Includes towboats and tugboats
4/ Primarily commercial fishing vessels

Deep Draft Port Facilities

Coos Bay, Yaquina Bay, Willapa Bay, and Grays Harbor have facilities for deep draft vessels. In total, these harbors have about 35 deep draft berths.



Port facilities at Coos Bay. (Oregon State Highway Department)

Coos Bay

Waterfront facilities in Coos Bay comprise numerous wharves and docks throughout the harbor. The major deep-draft facilities are located in upper Coos Bay near the towns of Coos Bay and North Bend. Nine docks are equipped to handle lumber and one dock handles general cargo in addition to lumber. Six of the docks have rail connections and the remainder are accessible by highway. Two of the docks have inclosed storage areas. Three of them are also equipped with wood chip loading facilities. A dock exclusively used for wood chip loading has been recently constructed. No floating, heavy lifting equipment is based in Coos Bay, so generally, heavy cargo is moved to and from the vessels with ship's gear.

Five waterfront facilities are equipped to receive petroleum products. Three receive shipments from barges and the other two from deep draft tankers.

Yaquina Bay

Yaquina Bay deep-draft facilities comprise one pier with three berths. The pier is equipped to handle logs, lumber, plywood, and paper products. Barge loading and unloading facilities also are available.

Willapa Bay

Facilities at Willapa Bay comprise two piers at Raymond. One terminal, owned by the port district, is 600 feet long with a 60-ton crawler crane and several 30-ton cranes for handling general cargo. It has railroad connections and a separate barge unloading berth. The other is a 500-foot pier owned by a private lumber company.

Grays Harbor

Seven terminals in Grays Harbor are suitable for deep draft commerce. The largest of these is the Port of Grays Harbor Terminal No. 1 in Aberdeen, which provides 2,473 feet of berthing space with a depth of 34 feet and is used for general cargo, log and chip exports, and receipt of petroleum products. Port Terminal No. 4, just upstream, has 600 feet of berthing space and a 22-acre storage yard. A pier owned by a pulp and paper company in Hoquiam has 846 feet of berthing space at a depth of 30 feet for shipment of pulp and receipt of fuel oil and log rafts.

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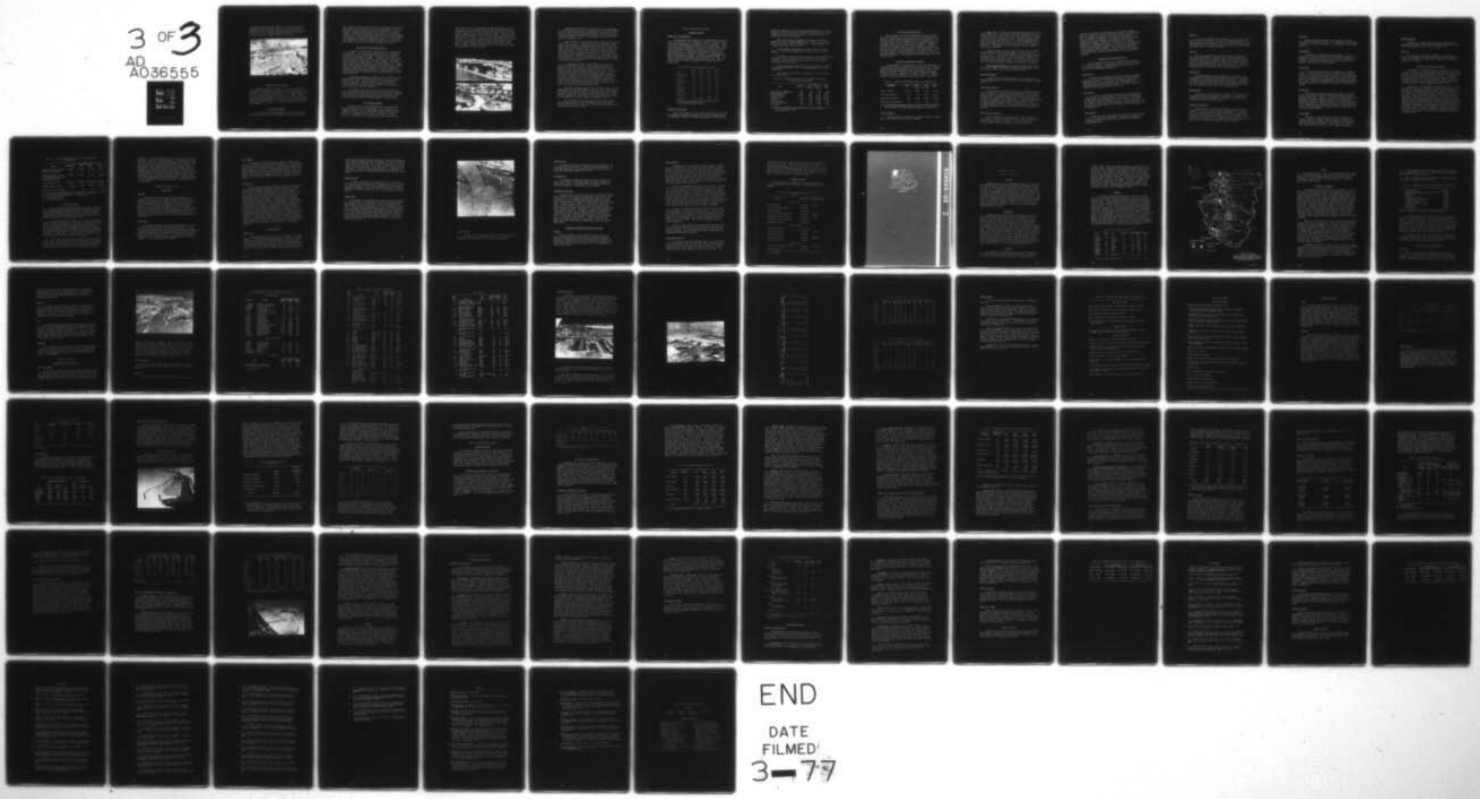

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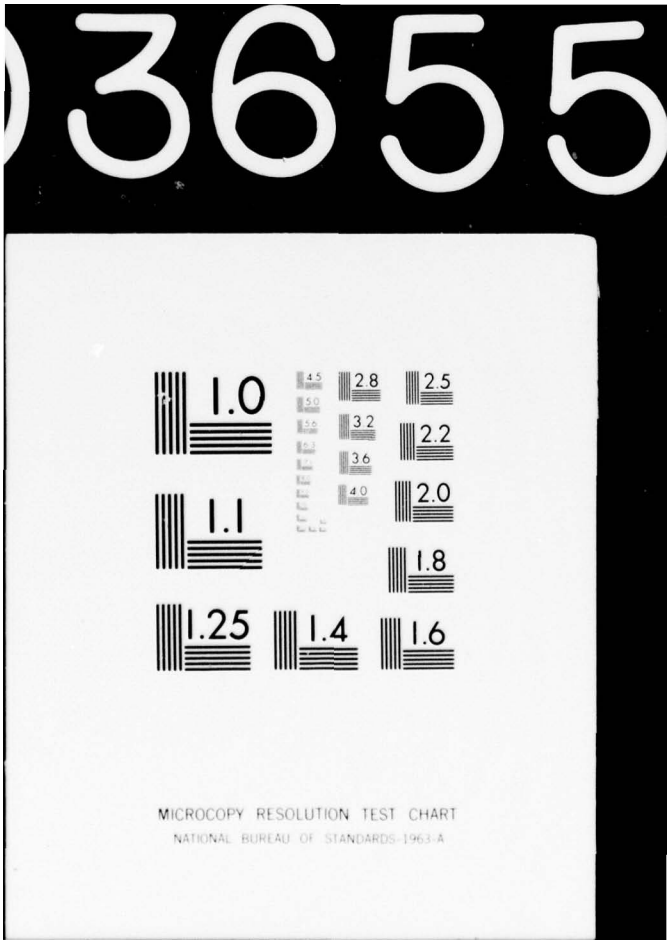
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Three piers owned by lumber companies in Aberdeen and South Aberdeen provide a total of 2,347 feet of berthing space at depths of 24 to 30 feet for shipment of lumber and receipt of log rafts. One oil company pier at Aberdeen has 200 feet of berthing space with a depth alongside of 50 feet.

Port facilities at Aberdeen on Grays Harbor. (USCE)

Barge and Raft Facilities

Barge and log rafts facilities are located at harbors throughout the subregion as needed for existing commerce. In addition to the docks for deep-draft vessels, approximately 35 to 40 berths are available where barges can be brought alongside a pier or quay for loading or unloading. Log raft facilities vary from elaborate dumps where trucks can be unloaded and rafts assembled on a production-line basis to simple mooring dolphins for tying rafts in storage. No inventory of these facilities is available.

Fish Handling Docks

Fish handling docks are located at nine harbors on the Oregon Coast and at five in Washington. Commercial fishermen

move along the coast during the several fishing seasons and try to stay close to the places where fish are being caught. They also prefer the harbors which have easy access during all types of weather. The most popular ports in the subregion for offshore fishing are Coos Bay, Yaquina Bay, Umpqua River, and Chetco River, in that order. Each of those ports has two or more fish handling docks operated by competing processing companies. Most of the other ports have only one. Mooring facilities for fishing boats are included in the discussion of recreational facilities.

Difficulties Attending Navigation

Navigation is hindered to varying degrees at all ports by lack of depth. The most serious problems occur at Yaquina Bay and Rogue River where maintenance dredging has been unable to keep the channels clear of shoals. The south jetty at Yaquina Bay is being extended in an effort to correct the problems there and the troubles at Rogue River are being studied. Inadequate channel depths are under study at Coos Bay, Umpqua River, Siuslaw River, Yaquina River, Willapa Bay, and Grays Harbor also. These studies are concerned with the adequacy of the authorized channels whereas the Rogue River and Yaquina Bay problems concern the maintenance of the authorized channels. Although problems occur at most other ports, the channels are generally adequate for the existing traffic.

In addition, navigation is delayed at the entrances to all ports during periods of low visibility and when waves make the entrances too rough. The percentage of time that such delays affect navigation is dependent on conditions at each port. Generally vessels have less trouble at ports with deep entrances than at ports with shallow entrances.

Port Orford, Neah Bay, and Clallam Bay do not have bars across the entrances and vessels can enter to dockside during any wave condition in which they are safe on the open ocean. However, these ports are only partially protected and waves from some directions sweep through the harbors relatively unattenuated.

Recreational Boating

Oregon's pleasure boat registration as of January 1966 showed 13,390 boats in the eight counties of Subregion 10. A comparable number in the two Washington counties would be about 3,500 for a subregion total of 16,900. However, the number of boats in the subregion is not a fair measurement of boating activity in the area as the coastal waters attract many boaters

from interior areas. No records of actual boat usage are available, but a survey of Oregon boaters (4) found that local owners accounted for only 10 to 25 percent of the boat usage in Clatsop, Curry, Douglas, Lincoln, and Tillamook Counties. Additional usage derives from outside the state of Oregon, particularly along the southern coast. Usage is similar in the Washington portion of the subregion. The inflow to the Washington coast comes not so much from the Puget Sound metropolitan area as from interior areas such as Yakima, Spokane, and Walla Walla and Lewiston, Idaho. Boaters from the Portland metropolitan area also use Grays Harbor and Willapa Bay for sport fishing.

Small boat harbors at Westport on Grays Harbor and Depoe Bay. (USCE)

Approximately 7,500 boats in Oregon are used predominantly on the ocean and coastal bays. Assuming that 25 percent of these are used on the mouth of the Columbia River, usage on the other coastal waterways in Oregon would be about 5,600 and considering the smaller number of harbors in Washington, usage there would probably be about 2,800.

Sports fishing is the primary activity engaged in by boaters in the coastal waters. Cruising, sightseeing, and other miscellaneous uses account for approximately 10 to 20 percent of the total. About 81 percent of boats 21 feet and over in length moor near the use site, whereas about 78 percent of smaller boats are stored on trailers. However, many of the latter are moored in boat basins during the period of maximum use. Boats 21 feet and over are used on an average of 81 days per year and smaller boats an average of 46. Assuming a weighted average of 48 days annual use per boat, the total usage on the ocean and coastal bays would be about 400,000 boat days.

In the Oregon portion of the subregion, excluding the mouth of Columbia River, public and private boat basins and marinas have a total capacity to moor nearly 4,000 boats. In addition, there are 41 launching ramps and 25 hoists, dollies, or marine ways for launching and recovering small craft. In the Washington area, there are about 375 moorage spaces available for private pleasure craft and an equivalent number of ancillary facilities. However, the increase in popularity of offshore recreational fishing and charter boat fishing expeditions has severely taxed existing small boat facilities at harbors with good access to the ocean to the extent that there is little or no space available for mooring additional craft.

For owners of boats under 21 feet, the most needed types of improvements are more and improved launching ramps, camping areas near mooring or launching sites, and sanitary facilities. Owners of boats 21 feet and over need more overnight moorage facilities, more and improved piers and docks, more protected mooring areas, and also camping areas near mooring or launching sites.

The similarity between the coastal waters of the Oregon and Washington sectors of the subregion and the usage made of them are such that these needs can be considered applicable to the Washington coastal waters also.

PROJECTED CONDITIONS AND NEEDS

Economic Outlook

Population and Employment

The population of Subregion 10 is projected to increase to a total of 465,500 in 1980; 575,400 in 2000; and 708,900 in 2020. Agricultural employment is expected to decline slightly, resulting in the future population growth being in urban areas. Except in primary metals, employment in most of the present basic industries is projected to decline or grow at a rate less than the total population, but employment in ancillary industries is projected to grow to support the population. Total personal income is projected to increase to a total of $1,652,400,000 in 1980; $3,601,000,000 in 2000; and $7,794,200,000 in 2020. Table 69 shows estimated population and employment trends. More detailed figures are given in Appendix VI, Economic Base and Projections.

Table 69- Population, Income & Employment Projections, Subregion 10

	1960[1/]	1980	2000	2020
Population	381,400	465,500	575,400	708,900
Total personal income ($1,000)	769,600	1,652,400	3,601,000	7,794,200
Per-capita income	$2,034	$3,550	$6,258	$10,995
Total employment	131,800	182,100	232,200	289,100
Agriculture, Forestry, & Fishing	10,236	9,562	8,533	7,284
Agriculture	8,117	7,100	6,500	5,400
Total Manufacturing	45,184	62,399	78,444	96,837
Lumber & Paper processing	37,363	25,526	21,414	18,793
Food & kindred prod.	3,973	4,211	4,034	3,715
Mining & primary metals	700	2,700	5,500	5,600
Non-commodity	74,100	108,300	143,400	183,200

1/ Estimated from Census of Population and Office of Business Economics data. 1962 data for income; 1959 data for earnings.
Source: Appendix VI Economic Base & Projections.

Commodity Projections

Major bulk commodities that might be expected to move over the navigable waterways are shown in table 70. Commodities such as agricultural and forest products are produced locally and the

quantities shown are the entire subregion production that would be shipped to outside markets by all modes of transportation. Other commodities such as petroleum products and fertilizer would be shipped in to serve local needs.

While agricultural employment is projected to decline, production of agricultural commodities is projected to more than double by 2020 to a total of 660,000 tons. Food manufacturing is expected to about triple by 2020.

Forest products are projected to remain about constant; however, a decrease of approximately eight percent is expected by 2020.

Minerals and primary metals are expected to show significant increases by 2020. Minerals will increase from 5,580 tons to 19,990 tons, and primary metals will increase from 20 tons to 4,710 tons by the year 2020.

Petroleum products and fertilizers are expected to increase considerably to meet the needs of transportation, heating, and agriculture.

The output of steel scrap is expected to increase from 45 to 85 tons by 2020.

Table 70 - Projections of Major Bulk Commodities Produced or Consumed, Subregion 10

Item	Year			
	Base 1/	1980	2000	2020
	(1,000 short tons)			
Agricultural Commodities	300	385	500	660
Food Manufactures	320	530	730	1,010
Forest Products	25,550	23,900	24,300	23,750
Primary Metals	20	320	1,350	4,710
Minerals	5,580	7,510	11,345	19,990
Steel Scrap	45	50	65	85
Petroleum Products	810	1,065	1,680	2,535
Fertilizer	25	35	55	70

1/ 1964, except primary metals 1969, and steel scrap and petroleum products 1960.

The Role of Transportation

Rail, highway, and water transportation presently serve the needs of Subregion 10, but will need to be expanded and improved to support projected population and economic growth. The railroads which serve the coastal areas, while adequate for the existing economy, are all branch lines and would be inadequate to support a major port or industrial development. Highway facilities are equally limited. Water transportation has been limited to movement of forest products, petroleum products, fresh fish and shellfish, and sand and gravel and would require extensive improvement to support major port developments or other bulk commodity industries. Coos Bay and Grays Harbor would be the most easily improved.

Prospective Waterborne Commerce

Future commerce is projected on the basis of population and economic growth and on studies of resource availability. Commodity groups pertinent to navigation in Subregion 10 include forest products, petroleum products, nonmetallic minerals, and fresh fish and shellfish. Projections of total foreign and coastwise shipments of these commodities are shown in table 71. Internal traffic is expected to remain about constant and is not shown.

Table 71 - Projected Waterborne Commerce 1/, Subregion 10

Commodity	1967	1980	2000	2020
		(1,000 short tons)		
Forest Products	4,132	5,500	4,750	4,000
Petroleum Products	571	750	1,200	1,800
Nonmetallic Minerals	490	1,000	1,500	2,600
Fresh Fish and Shellfish	58	85	110	150

1/ Total foreign and domestic coastwise except fresh fish and shellfish which includes domestic internal, see table 67.

Forest Products

Forest products significant to waterborne commerce include logs, wood chips, lumber, and other products.

Logs Logs are moved in rafts on protected waterways between forests and mills. This traffic fluctuates depending on the locations where logs are being cut but is not projected to increase. Logs also are being exported to Japan. The total amount shipped in 1967 was about 1,350,000 tons. The Japanese government estimates that their needs for logs will increase through 1980 but decline thereafter as their own National forests come back into production. Projections of future exports of forest products reflect this estimate.

Chips The export of wood chips has been the most rapidly expanding segment of waterborne commerce in Subregion 10 in recent years. At Coos Bay for example, the first export shipment was made in April 1965, and by 1968 total exports through that port amounted to 1.9 million tons. The present outlook is for continued modest expansion to about 3 million tons from the subregion by 1980 and steady shipments of that amount thereafter.

Other Forest Products No significant change is foreseen in the total amount of shipments of other forest products including lumber, plywood, pulp, and bulk paper products.

Petroleum Products

Shipments of petroleum products by water are projected to increase proportional to the total usage in the subregion as shown on table 71.

Nonmetallic Minerals

Sand and gravel suitable for concrete or highway surfacing is not available at all locations along the coast. The present commerce comprises shipments from the Umpqua to Coos Bay and the Siuslaw River. Additional supplies, not presently being used, are available at the mouth of the Rogue River. The projections assume a modest development of this source prior to 1980 to supply any of several areas including Yaquina or Tillamook Bays or the Portland metropolitan area. After 1980, the traffic is projected to expand proportional to the subregional need for nonmetallic minerals.

Fresh Fish and Shellfish

Current landings of anadromous fish, crabs, and shrimp are expected to remain relatively constant. The Fish and Wildlife Appendix projects an increase in the anadromous fish resource through improved management techniques, but the

increase is expected to be absorbed by recreational fishermen. Crabs and shrimp are presently harvested at about the maximum rate that the resource can sustain. The production of oysters in several estuaries is projected to increase in proportion to population needs on the assumption that plantings will increase in proportion to demand. Imports of frozen tuna will increase proportional to population demands. Landings of scrap bottom fish for pet and animal food are projected to increase in proportion to the overall regional economy. The use of bottom fish for human consumption is expected to increase greatly with expansion of prepared frozen dinners and development of fish-based frankfurters.

Adequacy of Existing Facilities

Port and terminal facilities are generally adequate for the existing traffic but a continual pressure exists at all ports to use larger equipment. Problems and needs at each port are discussed in the following paragraphs.

Chetco River

Both water and land areas suitable for harbor development are very limited at the mouth of Chetco River, and any major expansion is unlikely. Facilities are adequate, however, for a modest increase in lumber shipments and to accommodate the anticipated commercial offshore fishery. The harbor entrance is protected from most storm and wave activity.

Rogue River

The harbor at the mouth of the Rogue River is plagued by large quantities of sand and gravel which are moved downstream by Rogue River and alongshore by littoral forces. Considerably more tonnage would move through the port if adequate interior and entrance channels could be maintained. The estimate that sand and gravel will move from the port assumes that the channels will be maintained.

Port Orford

Lumber has been shipped from Port Orford but none is moving at this time and none is projected. The harbor is adequate for commercial fishing boats and is being improved to accommodate recreational boats.

Coquille

Facilities at Coquille are adequate for the existing commerce and no increase is forecast. However, the Coquille entrance is rough during periods of moderate waves and impassible during storms. Improvement of the entrance would facilitate the existing movements and might result in increased tonnages.

Coos Bay

Dock and terminal facilities at Coos Bay are adequate for existing timber products traffic and are being expanded to meet anticipated needs in the immediate future. However, some crowding occurs at the petroleum terminals. Some of the larger vessels, especially those hauling wood chips when fully loaded, can use the existing channels at high tide only and delays up to a day occur. Delays also occur due to wave action at the entrance bar.

Umpqua River

Dock facilities and inside channels at the Umpqua River are adequate for existing and anticipated traffic but the entrance is dangerous under certain wind and wave conditions. A modification of the jetty system is needed and a model study to determine the best solution has been made. Whether the needed improvements can be justified by current criteria is problematical.

Siuslaw River

The channel to Florence (mile 5) has been recently completed but experience has not determined its adequacy. It should be extended to the head of tidewater at Mapleton (mile 19) to serve several mills located along the river.

Yaquina Bay and River

The entrance and channel to dockside at Newport would be adequate if maintained to full project dimensions. An extension of the south jetty, presently under construction, is expected to facilitate maintenance of the channels, but full usability cannot be guaranteed. Additional dock facilities will be needed. The channel to Toledo (mile 14) is inadequate for existing traffic and would need to be improved to support increased tonnages.

Depoe Bay

Although Depoe Bay supports some commercial fishing, it is primarily a recreational port. It is adequate for its present traffic but the size of the harbor area precludes any significant expansion.

Tillamook Bay

Facilities at Tillamook Bay are inadequate. Delays at the entrance have prevented reliable service and traffic has not developed to warrant construction of facilities. Conditions are expected to improve after completion of the south jetty but complete port facilities will be needed.

Nehalem Bay

The entrance at Nehalem Bay is inadequate for commercial traffic. The bar is about 1,000 feet offshore and frequently shoals to 2 or 3 feet at mean lower low water. Waves break over the entire stretch from the bar to the ends of the jetties under all but the smoothest ocean conditions. The entrance to Nehalem Bay is only 8 miles from Tillamook Bay and a major improvement to the entrance cannot be justified on the basis of transportation savings.

Willapa Bay

Shifting of the entrance channel and exposure to storms and waves are major problems affecting all vessels entering or leaving Willapa Bay. Further, the authorized channel depths are inadequate for modern deep-draft vessels. The location of Willapa Bay between the better harbors in the Columbia River and Grays Harbor makes it problematical whether a major improvement in the channels can be justified on the basis of transportation savings. Dock facilities are adequate for the traffic that can use the existing channels.

Grays Harbor

Terminals in Grays Harbor are generally adequate for existing commerce. However, larger ships are forced to wait as long as 2 days for favorable tides to negotiate the 30-foot channel with adequate clearance. Some delays are encountered when high winds and waves make the bar channel impassible.

Quillayute River

Commerce at Quillayute River comprises commercial and recreational fishing. Facilities are adequate except that crowding occurs during the peak of the recreation season.

Neah Bay

Facilities at Neah Bay are adequate for existing and prospective commerce, but additional breakwater protection would improve its usability and might reduce the amount of shoaling adjacent to the docks.

Outlook for Recreational Boating

The number of recreational boats is projected to increase from 30,200 in 1966 to 44,200 by 1980, 84,700 by 2000, and 156,400 by 2020. Future usage from outside the subregion is expected to continue with local usage continuing to account for a small fraction of the total. Assuming that usage on coastal waterways increases proportional to the total number of boats, the number of boats that will be used predominantly on coastal waters will be 12,300 in 1980, 23,000 in 2000, and 41,500 in 2020.

Facilities are not adequate for recreational boats. Generally channels which can accommodate commercial navigation are adequate for recreational boats. However, several harbors which are adequate for hauling barge loads of lumber once or twice a week, are not safe for small boats at all times and thus limit the usage. Other harbors that are usable at all times when sea conditions are safe for small boats are overcrowded in mooring and launching areas during peak-use periods. Operators of boat basins at most of the popular ports report waiting lists of people desiring mooring spaces. How much unsatisfied demand exists is not known. Undoubtedly, some boaters are on such waiting lists even though they are using less desirable moorages. Some may even be on more than one list. However, it appears logical that a 15 percent increase in the number of moorage spaces would be promptly filled.

Table 72 - Recreational Boating Activity Projections 1/, Subregion 10

Item	Year			
	Present 2/	1980	2000	2020
Estimated total number of boats in subregion 4/	30,200	44,200	84,700	156,400
Estimated boats used on a full-season basis on the contiguous waterways	8,400	12,300	23,000	41,500
Annual boat-day use	400,000	530,000	1,040,000	1,900,000
Moorage capacity needs	4,375 3/	7,500	13,500	25,000
Boat launching lane needs	73	95	175	325

1/ On contiguous waterways usable for commodity navigation.
2/ 1966 except 1970 for total boats in subregion.
3/ Presently available.
4/ From Appendix XIII.

Summary of Needs

Greater entrance and channel depths are needed at Coos Bay and Grays Harbor to accommodate deep-draft navigation. Yaquina Bay is being improved for deep draft and if traffic develops will require greater depths also. Willapa Bay is too close to the Columbia River and Grays Harbor to warrant improvement for deep draft on the basis of transportation savings.

The other ports in the subregion will remain shallow draft. Of these ports, the entrances to the Rogue, Coquille, and Umpqua need to be improved although the work may not be justified on the basis of current criteria. The entrance to the Siuslaw has recently been improved and its adequacy has not been determined; the Siuslaw channel should be extended to the head of tidewater. The channel in Yaquina River to Toledo should be deepened. The entrance to Tillamook Bay is being improved and should be evaluated for adequacy and for its value to navigation.

A need exists for more and better facilities for recreational boats. Ports which have ready and relatively safe access to the ocean are overcrowded during the peak of the recreational season, and boaters make their way to the ocean through other entrances that are unsafe during all but the most favorable

conditions. The present number of ports may not suffice for the projected increase in recreational boats. Optimum usage of the ocean for recreational fishing would require safe harbors spaced not more than 25 or 30 miles apart along the entire coast. This would require three additional harbors in Oregon and three in Washington. These harbors would also provide refuge for boats cruising along the coast in case of difficulty or bad weather. Although such harbors might be desirable, actual demand for them is not foreseen. The ocean is not overcrowded around even the most popular fishing ports and cruising along the coast constitues a minor portion of total boating usage. A change in either of these conditions, however, would create a demand for additional harbors.

MEASURES TO SATISFY NEEDS

Deep Draft

Coos Bay

Improvement of the Coos Bay harbor by deepening the entrance to 45 feet and the interior channels to 35 feet would accommodate the prospective commerce with a minimum of delays. Such an improvement would cost about $12 million and would increase the cost of annual maintenance of the project about $200,000. This work has been authorized and is included in the Corps of Engineers program for construction prior to 1980. Dock and terminal facilities are generally adequate but congestion exists at the oil terminals. Additional berthing areas and underground pipelines to correct this situation would cost about $1 million.

Yaquina Bay

The channels provided for by the authorized project will be adequate for the existing and prospective commerce. It is expected that the work underway on the south jetty will assure full project dimensions with a normal maintenance dredging schedule. The only remaining needs for deep-draft navigation will be additional dock and berthing facilities. It is expected that these facilities will be provided locally commensurate with assured commerce. No cost estimates are available.

Grays Harbor

The entrance and interior channel depths at Grays Harbor should be increased to 45 and 35 feet, respectively. Such deepening of the entrance might necessitate rehabilitation and extension of the north jetty to avoid excessive dredging and to assure full project depths at all times. Preliminary estimates of costs are $33 million for initial construction and $1.2 million for maintenance. Model studies are planned to assist in design. Dock and terminal facilities are adequate for existing and projected commerce.

Willapa Bay

The present entrance to Willapa Bay could be made adequate for existing deep-draft commerce by constructing jetties and deepening the channels to about 30 feet. The jetties would stabilize the entrance, help maintain the entrance channel, protect vessels in the entrance against high waves, and assist in controlling erosion on the north side of the harbor entrance. Construction cost is estimated to be $200 million and annual maintenance to be $1.5 million. An alternative to improvement of the present entrance to the bay would comprise a 30-foot deep channel from existing facilities in Willapa Bay to connect with the Columbia River channel. Construction cost is estimated to be $65 million and annual maintenance to be nearly $2 million. The project would include a lock between the Columbia River estuary and Willapa Bay, but enough fresh water might lock through to affect the oyster industry in Willapa Bay. Further study is needed before the project could be given an unqualified recommendation. Preliminary estimates indicate that annual transportation savings that could be realized by either plan of improvement would be about $2.5 million. An additional $1.5 million of ancillary benefits would accrue to stabilization of the existing entrance.

Shallow Draft

Rogue River

An extension of the north jetty at the mouth of the Rogue River at a cost of about $2.5 million with an increase in annual maintenance of about $40,000 would improve the entrance and facilitate maintenance. The project would also need additional interior channels and dock facilities for which no cost estimates are available. The harbor at Rogue River is very difficult to maintain. The river carries a heavy bed load of sand and gravel

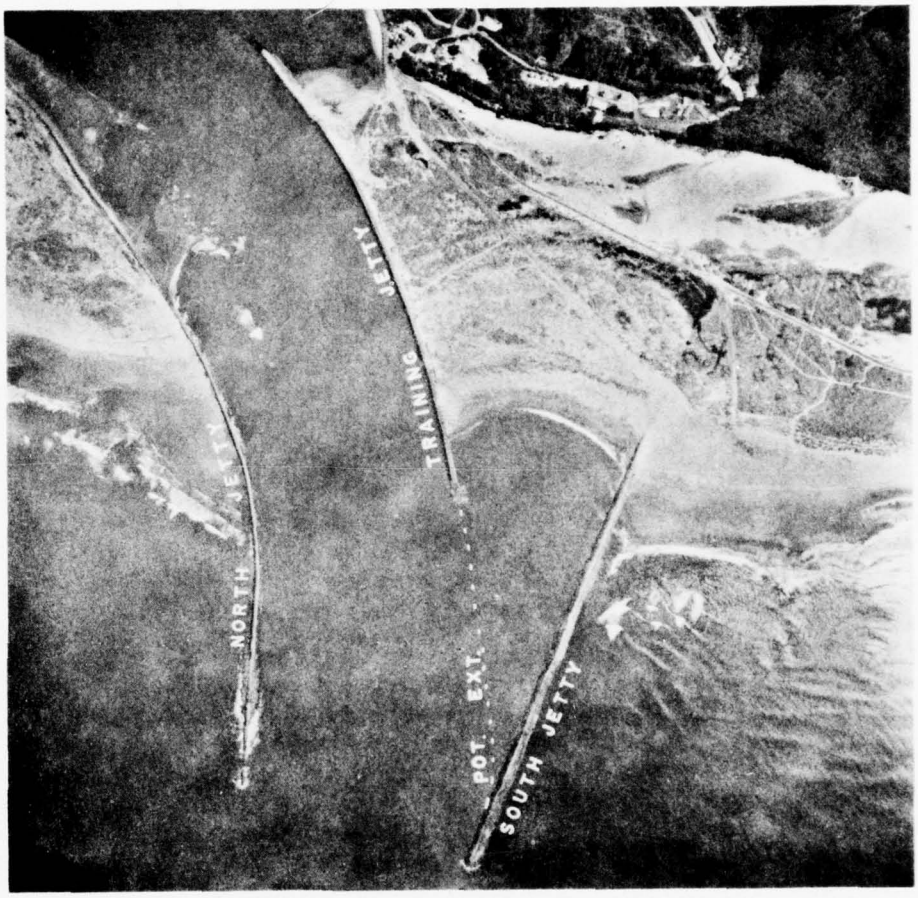
which moves extensively during high water. Tidewater extends less than 4 miles upstream and there is essentially no bay or estuary. Tidal exchange is insufficient to keep the entrance clear of sand carried by littoral action. Major floods on the Rogue River are capable of washing out any but the most massive structures within the stream. In view of these difficulties, it is doubtful if a satisfactory harbor can be developed within practical cost limitations.

Coquille River

A deeper entrance to the Coquille River, an extension to the north jetty, and extension of the channel to the U. S. Highway 101 crossing (about mile 3) would accommodate the existing and prospective commerce. Such a project was considered in 1965 and found not economically feasible. Costs were estimated to be $6.5 million.

Umpqua River

The entrance to the Umpqua River would be greatly improved by extension of the training jetty along a curved alinement to the present end of the south jetty. The tidal exchange would then maintain a deep water channel on an easy alinement along the jetty. Northwest winds and waves would cross the channel causing some navigational difficulties, but breakers would not normally occur in the channel and the entrance would be usable during all but the most severe conditions. Dock and terminal facilities are adequate for existing and projected commerce but any major increase would necessitate additional facilities. No cost estimates are available.



Entrance to Umpqua River showing needed extension to the training jetty. (USCE)

Siuslaw River

The cost of extending the channel to the head of tidewater in the Siuslaw River is estimated to be $1.1 million and the additional maintenance cost is estimated to be $75,000.

Yaquina River

A deeper channel from Yaquina Bay to Toledo would cost in the order of $3 to $4 million. Unless carefully controlled, the additional dredging to develop and maintain the deeper channel could harm the oyster industry in the bay.

Tillamook Bay

The presently authorized channel and jetty project, now under construction, is believed adequate for the existing and prospective commerce. Additional dock and terminal facilities will be needed but no cost estimates are available.

Intercoastal Waterway

A proposal for constructing a waterway between the Columbia River and Puget Sound by way of Willapa Bay, Grays Harbor, and Chehalis River, has cropped up periodically since the turn of the century. Such a waterway would provide protected passage between Columbia River, Willapa Bay, Grays Harbor, and Puget Sound ports. Recent studies by the U. S. Army Corps of Engineers found little feasibility for constructing the entire waterway but the segments from the Columbia River to Willapa Bay and Grays Harbor might be feasible. Increases in container shipping and utilization of barges for intermodal shipment of commodities could make the entire project feasible in the distant future. Cost of a deep draft canal between Willapa Bay and the Columbia River is estimated at $65 million. A similar canal between Grays Harbor and Willapa Bay is estimated at $104 million. A barge canal from Grays Harbor to Puget Sound would cost nearly $400 million.

Commercial Fishing and Recreational Boats

Channels

Channels adequate for deep draft or barge traffic are generally satisfactory for small boats and the only channels needed at commercial ports are for special access to small boat facilities. Locations of such access channels will depend on future siting of boat basins, and costs will be included in the overall basin costs.

Mooring Basins

An immediate need exists for about 600 additional moorage spaces in Subregion 10. The additional spaces should be spread along the entire ocean front, that is to say that an additional basin with 600-boat capacity at one location would not necessarily meet the needs of the subregion. There will be a continuing need for additional spaces and by 1980, a total of 7,500 should be available; by 2000, 13,500; and by 2020, the total number of spaces should be 25,000. This estimate is based on the assumption that ocean fishing will continue to draw its present proportion of the total regional boating activity.

The cost of developing boat basins varies widely depending on the amount of construction necessary to provide the basin and the facilities provided. As an average, the construction cost for access channels, moorage basins, and breakwaters at location within an existing estuary is assumed to be about $1,200 per space. The cost of piers, utilities, shore facilities, and parking areas would be about $1,800 per space. On that basis, a program for provision of small boat basins should be funded with about $900,000 a year through 2000 and $1.7 million thereafter. Current criteria would ascribe about 20 percent (half the cost of channels and breakwaters) of the total cost to the Federal Government.

In 1968, the Corps of Engineers estimated costs of small boat improvements at Neah Bay and Clallam Bay. Rock breakwaters at the entrance to Neah Bay and removal of rock pinnacles to 24 feet below MLLW were estimated to cost $2,870,000, with annual maintenance cost of $15,000. These costs were much greater than benefits to accrue through storm damages prevented and more intensive use of Neah Bay. This was not a typical small boat basin development.

Cost of a rock breakwater at Clallam Bay to protect a 310-boat basin was estimated at $1,930,000 and annual maintenance costs at $13,000. The value of the protected moorage provided and the probable increased rental boat business would make the improvement economically feasible.

Launching Facilities

The present number of launching ramps, hoists, and marine ways for launching and recovering small craft is theoretically sufficient for the boats using the coastal waterways. However, crowding occurs at many ramps and other facilities and most boaters consider that additional facilities are needed. This

situation will prevail whenever facilities are barely adequate to meet essential needs. A more realistic approach would be to provide an excess capacity of 25 to 50 percent, but each facility must be carefully located to insure that it meets a need. The theoretical number of additional facilities or lanes of launching ramp that will be needed is 20 by 1980, 100 by 2000, and 250 by 2020. Minimal costs would be $50,000 per lane.

Summary of Costs

The following table summarizes the measures needed to provide for navigation in Subregion 10 including costs and time periods.

Table 73 - Summary of Costs, Navigation Facilities, 1/
Subregion 10

Project	Initial Cost	Annual Maintenance
1970 to 1980		
Coos Bay Channel	$12,000,000	$ 200,000
Coos Bay Docks and Terminals	1,000,000	
Yaquina Bay Docks	not available	
Grays Harbor Channels and Jetties	33,000,000	1,200,000
Rogue River Channels and Jetties	2,500,000	40,000
Tillamook Bay Docks and Terminal	not available	
Small Boat Facilities	10,000,000	
1980 to 2000		
Umpqua River Jetties	not available	
Siuslaw River Channels	1,100,000	75,000
Yaquina River Channels	4,000,000	
Willapa Bay Channels	65,000,000	2,000,000
Small Boat Facilities	22,000,000	
2000 to 2020		
Coquille River, Channels and Jetties	6,500,000	300,000
Small Boat Facilities	37,500,000	

1/ In 1968 dollars.

LOCATION MAP

SUBREGION 11

SUBREGION 11

PUGET SOUND

GENERAL

Subregion 11 lies in the northwest corner of the State of Washington, between the Cascade and Olympic Mountains with near sea level lowlands forming a trough about 50 miles wide as shown on figure 9. It comprises 13,355 square miles of land and fresh water areas and nearly 2,500 square miles of almost landlocked salt water forming Puget Sound, Hood Canal, portions of the Straits of Georgia and Juan de Fuca, and contiguous bays and inlets. The lands vary from bare glacier-covered peaks through forested slopes to fertile farmlands and urban centers on river deltas and shorelands. The Strait of Juan de Fuca provides direct access to the Pacific Ocean and the Strait of Georgia is the beginning of an inland passage route to Alaska. Twenty rivers flow into Puget Sound and adjacent waters.

Topography

Mountain ranges occupy much of the periphery of the subregion and ridges extend into the area and separate the river basins. In the Cascade Range to the east, the higher ridges generally reach altitudes of 8,000 feet in the north and 5,000 feet in the south. Mount Baker (10,778 feet), Glacier Peak (10,541 feet), Mount Rainier (14,410 feet) and other major peaks rise prominently above the main ridge lines. The Olympic Mountain Range to the west is generally lower in altitude than the Cascade Range. The sharp peaks and ridges that characterize this mountain range reach altitudes of 6,000 feet. The valley floors and lowland areas are generally a few feet above sea level rising gently to rolling hills in turn giving way to mountain ranges. The Straits of Georgia and Juan de Fuca break through the mountains that generally surround the subregion and the divide on the south between the Deschutes Basin in this subregion and the Chehalis Basin in Subregion 10 is low and almost indistinguishable.

Climate

The presence of the mountain ranges protects Subregion 11 from most cold Arctic airmasses and ocean storms. Maritime air which enters from the west has a moderating influence on the

climate in both winter and summer and makes the waters ice free the year around. Mean annual precipitation varies from less than 20 inches in the lowlands of the Elwha and Dungeness Basins to 120 to 180 inches along the upper reaches of the Cascade Range. Seventy-five percent of the precipitation occurs in the 6-month period, October through March, with winter precipitation falling as rain below 1,500 feet altitude, as snow or rain between 1,500 and 2,500 feet, and as snow at higher altitudes. Although temperatures as high as 95°F. to 100°F. have been recorded in the lower valleys, summer daytime high temperatures usually range from 85°F. to 90°F. Mean temperatures range from 70°F. during the summer to 30°F. or 40°F. during the winter.

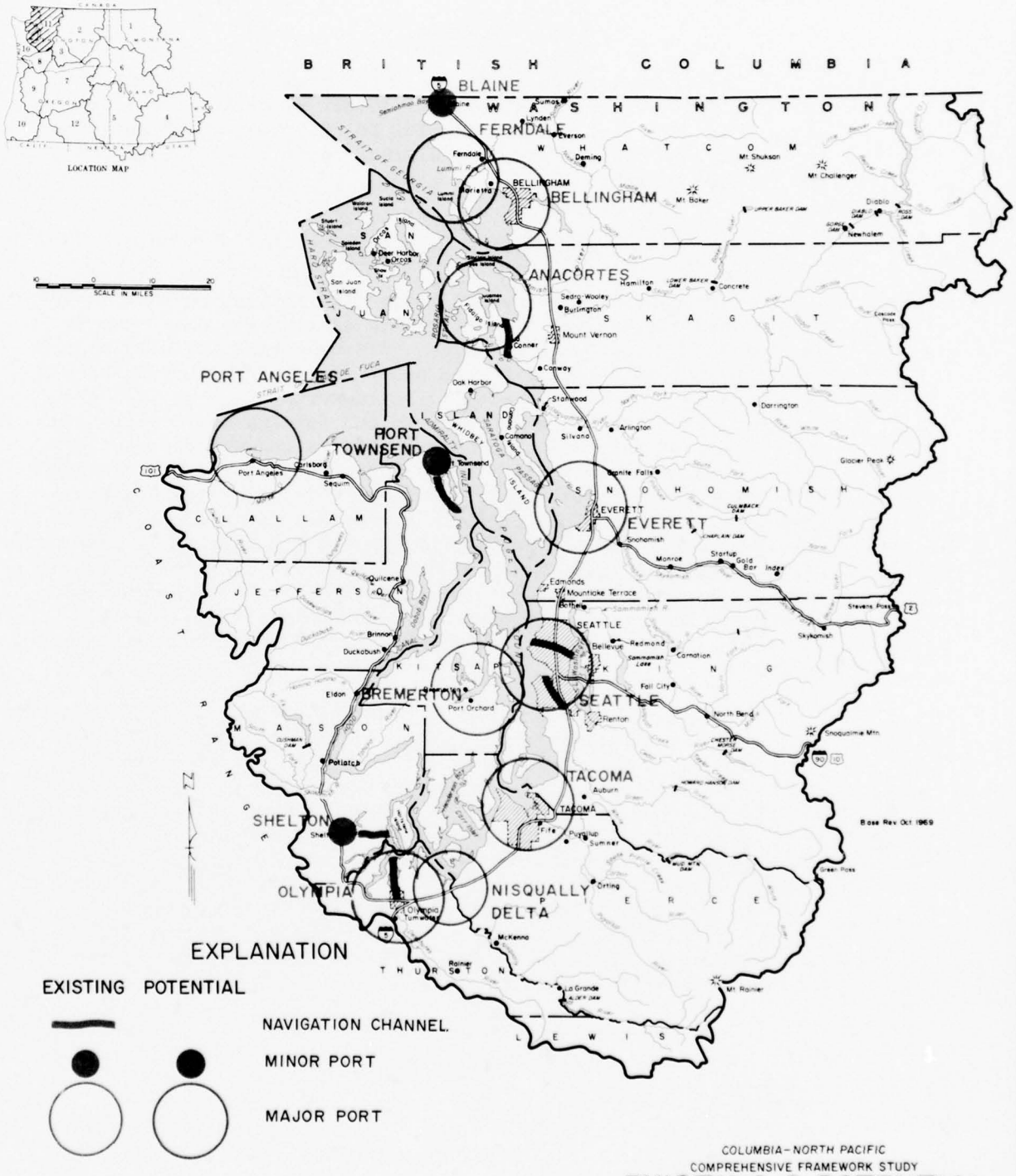
Streams

The rivers vary from a few miles to 135 miles in length. Glaciers, located at the higher elevations, are the source for many of these streams extending stabilizing influences on summertime low flows. The upper portions of most basins are characterized by narrow mountain valleys with steep gradients which drain forested areas. In the lowlands, rivers follow meandering courses across the flood plains. The total annual runoff for the Puget Sound area during the period 1931-1960 averaged about 38,865,000 acre-feet. Average annual runoff ranges from 15 inches in some of the northern lowlands to as much as 140 inches in a few mountain areas. The characteristics of the principal streams are given in table 74 and additional information on streams is contained in Appendix V, Water Resources. The lower reaches of several of the larger streams and the tidal reaches of all streams are navigable for shallow draft vessels. The only fresh water that is navigable for deep-draft vessels is in Lakes Union and Washington.

Table 74 - Streamflow Summary for Selected Sites, Subregion 11

Stream	Drainage Area (sq. mi.)	Gage	Gage Drainage Area	Flow in c.f.s. Average	Maximum	Minimum
Nooksack	826 1/	Deming	584	3,217	43,200	502
Skagit	3,105 1/	Mt. Vernon	3,060	16,670	144,000	2,740
Stillaguamish	684					
North Fork		Arlington	262	1,853	30,600	117
South Fork		Granite Falls	119	1,071	32,400	55
Snohomish	1,708	Snohomish	1,720	-	136,000	-
Sammamish	240	-	-	-	-	-
Cedar	188	Renton	197	698	6,640	30
Green-Duwamish	483	Auburn	399	1,306	28,100	81
Puyallup	972	Puyallup	948	3,292	57,000	400
Nisqually	712	La Grande	292	1,385	20,700	0
Deschutes	162	Rainier	90	263	5,620	16
Skokomish	240	Potlatch	230	NA	27,000	NA
Hamma Hamma	85	Eldon	85	366	6,010	39
Duckabush	77	Brinnon	67	392	8,960	45
Dosewallips	116	-	-	-	-	-
Big Quilcene	68	-	-	-	-	-
Dungeness	198	Sequim	156	371	8,400	77
Elwha	321	McDonald Bridge	269	1,456	41,600	10

1/ 777 and 2,705 sq. miles, respectively, in U.S.



COLUMBIA-NORTH PACIFIC
COMPREHENSIVE FRAMEWORK STUDY

EXISTING & POTENTIAL NAVIGATION FACILITIES

PUGET SOUND SUBREGION II

1970

FIGURE 9

Tides

The diurnal range of tides in the Puget Sound area varies from 7.2 feet at Port Angeles to 14.5 feet at Olympia; the extreme range from 14.5 feet at Port Angeles to 22.5 feet at Olympia. At Seattle, in Elliott Bay, the diurnal range is 11.3 feet and the extreme range is 19.3.

Economic Development

The economic development began with navigation in the early 1800's with the arrival of settlers in sailing vessels, soon to be replaced by steampowered ships. Sternwheelers operated on the Duwamish, Snohomish, Skagit, and other rivers transporting settlers, freight, and mail. Coastwise commerce began in 1848 with shipments of piling to San Francisco and foreign commerce in 1853 with export of ship spars to China. Navigation and the economy of the area received a major boost about the turn of the century when Puget Sound ports became the support base for the Alaska gold rush. A phenominal economic growth has occurred during the last 3 decades, and the population reached 1.9 million by 1965. Studies indicate that the subregion population will continue to grow faster than the population of the region. Twelve counties (Whatcomb, Skagit, Island, San Juan, Snohomish, King, Pierce, Thurston, Mason, Kitsap, Jefferson, Clallam) comprise the economic subregion.

Snohomish, King and Pierce Counties account for approximately 80 percent of the total population. An almost continuous metropolitan area extends through Everett (50,500), Seattle (567,500) and Tacoma (152,000), the largest cities in the subregion. There are eleven other cities, eight in the above metropolitan area, with populations in excess of 10,000. The 1965 population (1,904,100) was approximately 32 percent of the Columbia-North Pacific regional total (5,876,100). The economy of the metropolitan area is heavily oriented toward activities in aerospace, shipbuilding, maritime trade, transportation and diversified manufacturing. The Boeing Company's aerospace industry is the leading industrial employer.

Government activities also play a major role in the economy. The Puget Sound Naval Shipyard, second largest industrial employer, dominates the economy of Bremerton and the Kitsap peninsula. McChord Air Force Base and Fort Lewis are major sources of personal income in the Tacoma area. Activities providing government services contribute heavily to the economy of Olympia, the State capitol, and vicinity.

In the remainder of the subregion, economic activities are based on forest product industries, commercial fishing, farming, and miscellaneous light industries.

Basic employment data from Appendix VI, Economic Base and Projections, is summarized in table 75.

Table 75 - Employment in Selected Categories, Subregion 11

Total Employment	667,745
Agriculture, Forestry & Fishing (Total)	20,973
Agriculture	17,824
Mining	681
Manufacturing (Total)	175,244
Transportation Equipment	71,016
Forest Products	36,546
Food and Kindred Products	16,994
Armed Forces	41,369
Non-Commodity	429,478

Source: Appendix VI, Economic Base and Projections

The subregion has varied natural resources, the primary resource being vast timber reserves followed by agricultural lands, minerals, and fisheries. In 1966, approximately 6,429,000 acres was classified as forest land, 591,000 acres as cropland, and 105,000 acres as rangeland. Mineral resources include large deposits of coal, sand and gravel, clay and stone throughout the subregion. Peat is found in the lowland areas. The mountainous area in the eastern part of the area has a large potential for producing limestone, copper, and other minerals.

The marine waters support a wide variety of fish, shellfish and anadromous fish. The value to commercial fishermen of the 1967 fish production was $16,414,094 (3) and an estimated $50 to $60 million is spent annually by sport fishermen.

Other Forms of Transportation

Railroads

Three major railroads: Burlington Northern; Chicago, Milwaukee, St. Paul and Pacific; and Union Pacific offer direct routings and expedited service to major cities throughout the Nation. Two of the lines have connections with Canadian lines

to the north, and all three have connections to the Portland-Vancouver area and thence to the south and east. Branch lines run to Bremerton and the Grays Harbor area in Subregion 10. A line between Port Townsend and Port Angeles is served by rail-barge connections.

Highways

A network of modern freeways, highways, and roads serves the area. The principal north-south artery is Interstate 5. Principal highways crossing the Cascade Range include Interstate 90 and U.S. 2 and 12. The western portion on the Olympic Peninsula is served by U. S. 101. Over 150 truck lines provide common contract and specialized transport.

Air

The largest airport for both passenger and cargo traffic is the Seattle-Tacoma International Airport, but a number of smaller airports serve other communities around Puget Sound. Domestic service is provided by seven major airlines. Service to Alaska is provided by four airlines. There are two transpacific airlines and two lines provide direct service to Europe. Major airlines handle import air cargo (in connection with transpacific steamship lines) on sea-air rates.

Pipelines

The trans-mountain pipeline originating in Canada delivers crude oil to refineries in the subregion. The 12-inch line has a capacity of 200,000 barrels daily. A products pipeline originates in the subregion and delivers refined products to areas south of the subregion.

EXISTING NAVIGATION

Improvements for Navigation

Existing Projects

The Strait of Juan de Fuca and the connecting channels provide natural deep water access from the Pacific Ocean to the many bays and inlets of Puget Sound and adjacent waters. The controlling depth is about 200 feet in the strait and at the entrance to Puget Sound and 50 feet or more at the entrance to all major

Hiram M. Chittenden Locks on Lake Washington Ship Canal with Puget Sound in the background. (USCE)

harbors except 40 feet at Olympia. Under these excellent natural conditions, navigation improvements have been limited to small boat basins, short channels from deep water to pierside, training dikes or jetties to prevent siltation from nearby streams, and shallow draft improvement of rivers or through island channels. A lock system connects Lake Washington to deep water in Puget Sound. Existing navigation projects, except small privately-owned small boat harbors, are shown in table 76.

Navigation Aids

The U.S. Coast Guard maintains navigation aids as needed and marks shoaled areas, rocks, sunken ships and other hazards to navigation.

Bridges

Bridges across navigable waters are listed in table 77.

Table 76 - Harbor and Channel Improvements, Subregion 11

Deep Draft Channels

Location	Project	Controlling Dimensions Depth (ft.)	Width (ft.)	Length (miles)
Bellingham	Whatcom Creek waterway	30	363	1.0
Bellingham	Squalicum Creek waterway	26	200	0.7
Bellingham	I & J St. waterway	18	100	0.6
Everett	East waterway	30	700-900	0.5
Seattle	Lake Washington Ship Canal below lock	34	150-300	1.2
Seattle	Lake Washington Ship Canal above lock	30	100	2.6
Seattle	East waterway	34	750	1.2
Seattle	East waterway	34	400	0.1
Seattle	West waterway	34	750	1.0
Seattle	Duwamish River	30	200	2.5
Seattle	Duwamish River 1/	20	150	0.1
Tacoma	City waterway	19-29	250-500	1.5
Tacoma	Port Industrial waterway 1/	35	300-600	2.0
Tacoma	Hylebos waterway 1/	30	200	2.6
Tacoma	Middle waterway	25-34	200	0.7
Tacoma	St. Paul waterway	25-34	100-500	0.7
Tacoma	Milwaukie waterway	30	150	0.6
Tacoma	Sitcum waterway	23-40	400	0.6
Olympia	Olympia Harbor 1/	30	300-500	1.8
Port Gamble	Channel	28	150	0.5

Shallow Draft Channels

Anacortes	Capsante waterway	12	150-250	0.6
Anacortes	Swinomish channel	12	100	11
Everett	Snohomish River	15	150-425	1.5
Everett	Snohomish River	8	150	4.8
Seattle	Duwamish River	15	150	2.0
Hamersly Inlet	Channel	13	150	0.5
Port Townsend	Portage Canal	15	75	0.9
Mats Mats Bay	Channel	8	100	0.7

Navigation Locks

Lock	Controlling Dimensions Depth (ft.)	Width (ft.)	Length (ft.)
Lake Washington Ship Canal, Main	29	80	825
Lake Washington Ship Canal, Small	16	30	123

1/ plus turning basin

Table 77 - Bridges Over Navigable Waters, Subregion 11

Miles Above Mouth	Location	Type of Bridge	Clearance (feet) Horiz-ontal	Clearance (feet) Vertical HW	Type of Traffic
	Skagit River				
3.1	North Fork--Rexville	Fixed	120	48	Hwy-FB
5.5	South Fork--Fir	Swing	115	UNL	Hwy
12.5	Mt. Vernon	Swing	105	UNL	Hwy-FB
16.8	1 Mi. N of Mt. Vernon	Fixed	110	17	Hwy-FB
17.0	1 Mi. N of Mt. Vernon	Swing	108	UNL	Hwy-FB
17.8	N of Mt. Vernon	Swing	80	UNL	RR
0.1	Canoe Pass-Anacortes	Fixed		100	Hwy-FB
0.5	Deception Pass-Anacortes	Fixed		104	Hwy-FB
0.2	Swinomish Slough near Anacortes	Swing	100	UNL	RR
0.5	Swinomish Slough near Anacortes	Vertical lift	100	16	Hwy-FB
5.4	Swinomish Slough, LaConner	Fixed		45	Hwy-FB
0.5	Samish River--Edison	Fixed	30	7	Hwy
0.5	Brown Slough, Conway	Fixed	44	5	Hwy
3.5	Tom Moore Slough--Militown	Fixed	60	5	Hwy
0.5	West Pass-Stanwood	Fixed	80	39	Hwy-FB
	Stillaguamish River				
4.6	Near Florence	Swing	86	UNL	Hwy
5.1	Stanwood	Fixed	28	8	Hwy-FB
0.5	Davis Slough--Stanwood	Fixed	16	5	Hwy-FB
	Snohomish River				
3.5	Everett	Swing	100	UNL	RR
3.6	Everett	Vertical lift	105	38	Hwy-FB
3.6	Everett	Vertical lift	105	38	Hwy-FB
6.1	Everett	Fixed	184	66	Hwy
6.7	Everett	Fixed	150	55	Hwy
6.8	Everett, Hewitt Ave	Vertical lift	105	37	Hwy-FB
14.9	Snohomish	Fixed	296	32	Hwy-FB
15.0	Snohomish	Swing	115	UNL	Hwy-FB
15.3	Snohomish	Swing	165	UNL	RR
15.5	Snohomish	Swing	100	UNL	RR
1.4	Ebey Slough, Marysville	Fixed	110	41	Hwy-FB
1.5	Ebey Slough, Marysville	Swing	108	UNL	RR
1.6	Ebey Slough, Marysville	Swing	110	UNL	Hwy-FB
7.5	Ebey Slough, Everett	Fixed	235	15	Hwy-FB
1.5	Union Slough, Marysville	Fixed	47	7	Hwy
1.6	Union Slough, Marysville	Fixed	47	6	Hwy-FB
1.0	Shilshole Bay, Seattle	Bascule	150	UNL	RR
	Lake Washington Ship Canal				
1.1	Seattle, 15th Ave NW	Bascule	150	UNL	Hwy-FB
1.6	Seattle, 8th Ave NW	Bascule	150 Open	UNL	RR
2.6	Seattle, Fremont Ave	Bascule	150	UNL	Hwy-FB
2.7	Seattle, Aurora Ave	Fixed	525	73	Hwy-FB
4.2	Seattle, Freeway Bridge	Fixed			
4.3	Seattle, University Bridge	Bascule	175 Open	UNL	Hwy-FB
5.2	Seattle, Montlake Bridge	Bascule	150	UNL	Hwy-FB
	Lake Washington				
	Seattle--Foster Is. Evergreen Pt.	Removable Span	202		Hwy
	Seattle--Foster Is. Evergreen East End	Fixed	207	55	Hwy
	Seattle--Foster Is. Evergreen West End	Fixed	206	42	Hwy
	Seattle--Mercer Island	Pontoon	200		Hwy-FB
	Mercer Is--East Channel Bridge	Fixed	200	38	Hwy-FB

Table 77 (Cont'd)

Miles Above Mouth	Location	Type of Bridge	Clearance (feet) Horizontal	Clearance (feet) Vertical HW	Type of Traffic
	Elliott Bay--Seattle				
0.3	East Waterway, W Spokane St	Fixed	14	6	Hwy-FB
0.4	East Waterway, Klickitat Ave	Fixed	14	8	RR
	Duwamish Waterway & River				
0.3	Seattle, W Spokane St	Bascule	150	UNL	Hwy-FB
0.3	Seattle, W Spokane St	Bascule	150	UNL	Hwy-FB
0.4	Seattle, N. P. Ry.	Bascule	150	UNL	RR
2.5	Seattle, 1st Ave S	Bascule	150	UNL	Hwy-FB
3.8	Seattle, 14th Ave S	Bascule	125	UNL	Hwy-FB
5.3	Seattle, Boeing Plant	Fixed	90	20	FB
6.4	2 Mi. S of Seattle	Fixed	180	5	Hwy-FB
6.8	Duwamish River Bridge	Fixed	202	5	Hwy-FB
	Commencement Bay--Tacoma				
0.6	City Waterway, S 11th St	Vertical lift	200	64	Hwy-FB
0.8	City Waterway, 14th St	Swing	100	UNL	RR
0.9	City Waterway, 15th St	Swing	100	UNL	Hwy-RR
1.1	Hylebos Waterway, E 11th St	Bascule	150	UNL	Hwy-FB
0.8	Port Industrial Waterway, E. 11th St	Bascule	150	UNL	Hwy
	Agate Passage--Puget Sound				
1.0	Suquamish	Fixed	520	35	Hwy-FB
	Burkes Bay--Puget Sound				
0.2	Brownsville	Fixed	24	14	Hwy-FB
	Case Inlet--Puget Sound				
10.0	Detroit	Fixed	20		Hwy-FB
11.0	Grapeview	Fixed	21	16	PR
0.0	Clam Bay--Manchester	Fixed	30	40	Hwy
1.5	Dogfish Bay--Keyport	Fixed	18	6	Hwy-FB
3.0	Hale Passage--Fox Island	Fixed	105	31	Hwy-FB
0.1	Hamma Hamma River, Eldon	Fixed	120	13	Hwy
0.0	Henderson Bay, Purdy	Fixed	184	12	Hwy-FB
0.4	Henderson Bay, Raft Island	Fixed	21	17	PR
	Port Washington Narrows				
0.3	Bremerton, Wash.	Fixed	231	82	Hwy-FB
0.5	Bremerton, Wash.	Fixed	220	80	Hwy-FB
0.0	Olalla Creek, Olalla	Fixed	32	9	Hwy
	Puyallup River				
0.8	Tacoma, E 11th St	Vertical lift	150	29	Hwy-FB
0.9	Tacoma, E 11th St	Swing	120	UNL	RR
1.5	Tacoma, S 21st St	Fixed	110	13	RR
2.0	Tacoma, Cleveland Way & E.O.	Fixed	124	12	RR
2.1	Tacoma, Hwy 99	Fixed	175	35	Hwy-FB
2.3	Tacoma, Wash	Fixed	135	24	RR
2.5	Tacoma, Wash	Fixed	150	14	RR
0.5	Days Island Waterway, Tacoma	Fixed	48	23	Hwy-FB
3.5	The Narrows, Tacoma	Suspension	2,565	159	Hwy-FB
	Port Townsend-Oak Bay Canal				
0.2	Port Townsend	Fixed	236	58	Hwy-FB
	Puget Sound--Hood Canal				
5.0	Port Gamble	Retractable Pontoon	602		Hwy
	Port Gamble, East End	Fixed	239	55	Hwy
	Port Gamble, West End	Fixed	239	35	Hwy

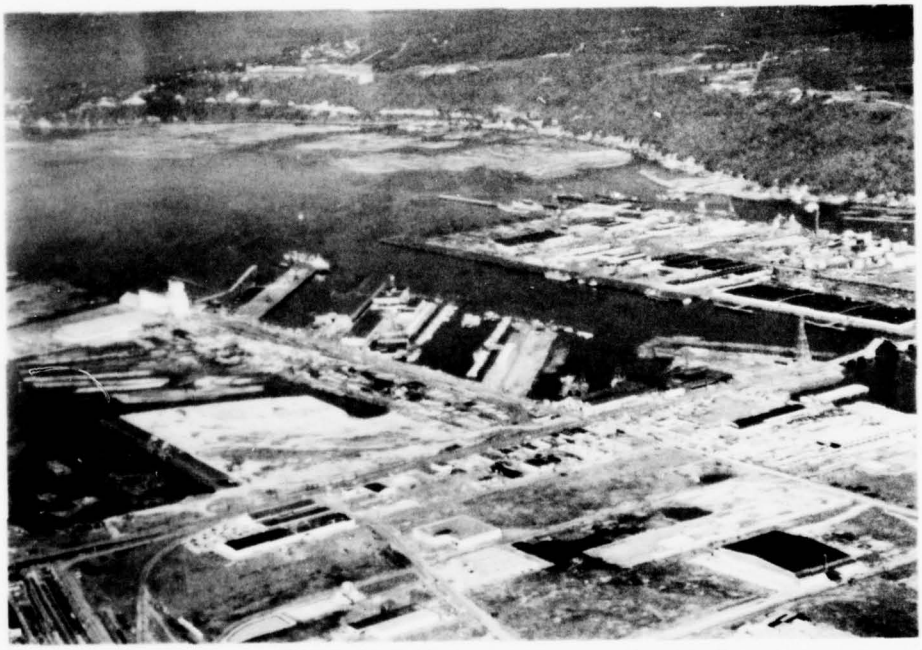
Terminal Facilities

Essentially all of the terminal facilities in Subregion 11 are located at seven principal ports. Cargo handling docks comprise 444 berths with a combined length of nearly 28.5 miles, table 78. Of these, 22 can accommodate vessels with drafts of 40 feet or more. Additional berths are available for construction or repair and for mooring while waiting for cargoes. Covered dockside cargo storage space comprises 77 acres and open storage more than 250 acres. Water frontage used for terminal facilities comprises 23.5 miles for cargo handling, 4.5 for construction and repair, nearly 5.0 for mooring, and 3,000 feet for ferry terminals, table 79. The total waterfront area amounts to 2,688 acres, table 80.

Piers 39 and 40, typical of the Seattle waterfront. (USCE)

In addition to the seven principal harbors, more than 90 small harbors have facilities for local commerce, ferry service, and small boats.

Additional information on terminal facilities is available in Appendix VIII, Navigation, of the Comprehensive Study of Water and Related Land Resources, Puget Sound and Adjacent Waters (5) and the U. S. Corps of Engineers Port Series Nos. 35, 36, and 37 (25, 22, and 24).



Tacoma Harbor. (USCE)

Table 78 - Terminal Facilities, 1967, Subregion 11

Location	Berths for Cargo Handling	General Cargo	Bulk Grain	Forest Products	Bulk Petroleum	Other Dry Bulk	Other Liquid Bulk	Total for Cargo	Ferry and Passenger	Construction and Repair	Mooring	Dock Side Cargo Storage (Covered Sq. Ft.)	Dock Side Cargo Storage (Open Acres)
					(Lengths of berthing space in feet)								
Port Angeles	23	3,783	0	1,090	1,340	515	830	7,558	SLIPS	5,220	1,717	56,300	.0
Anacortes	33	2,870	0	985	4,265	20	0	8,140	SLIPS	772	6,448	112,700	11.6
Bellingham	46	5,345	0	2,875	2,449	1,386	0	12,055	0	1,990	11,426	266,000	12.8
Everett	50	4,195	0	13,135	1,151	1,265	160	19,906	0	812	6,582	297,100	4.7
Seattle	189	31,987	2,113	7,525	11,690	7,940	1,807	63,062	1,545	38,822	17,966	1,568,600	117.3
Tacoma	74	9,118	1,790	13,594	2,771	6,759	168	34,200	SLIPS	3,324	9,126	860,000	90.0
Olympia	29	2,300	0	2,255	425	450	0	5,430	0	290	0	188,000	17.0
Totals	444	59,598	3,903	41,459	24,091	18,335	2,965	150,351	1,545[1/]	51,230	53,265	3,348,700	253.4

1/ Plus slips

Table 79 - Water Frontage (Terminal Facilities, 1967), Subregion 11

Area	General Cargo	Bulk Grain	Forest Products	Bulk Petro-leum	Other Dry Bulk	Other Liquid Bulk	Total For Cargo	Ferry & Passenger Terminals	Construc-tion and Repair	Mooring
					(feet)					
Port Angeles	1,750	0	2,800	1,100	280	0	5,930	200	1,300	2,000
Anacortes	3,000	0	3,050	2,900	0	0	8,959	900	500	1,650
Bellingham	3,200	0	2,600	1,900	1,200	0	8,900	0	1,400	2,850
Everett	1,050	0	12,430	1,600	600	200	15,880	0	1,050	2,300
Seattle	16,300	1,500	6,400	8,400	6,750	1,800	41,150	1,600	15,250	8,250
Tacoma	10,200	1,500	16,200	4,450	5,210	300	37,860	300	4,000	8,760
Olympia	2,200	0	2,600	800	600	0	6,200	0	550	0
Totals	37,700	3,000	46,080	21,150	14,640	2,300	124,870	3,000	24,050	25,810

Table 80 - Waterfront Area (Terminal Facilities, 1967), Subregion 11

Area	General Cargo	Bulk Grain	Forest Products	Bulk Petro-leum	Other Dry Bulk	Other Liquid Bulk	Total For Cargo	Ferry & Passenger Terminals	Construc-tion and Repair	Mooring
					(Acres)					
Port Angeles	20	0	27	20	1	0	68	3	15	16
Anacortes	48	0	38	270	2	0	358	14	9	38
Bellingham	36	0	29	45	33	0	143	3	12	33
Everett	17	0	100	10	7	2	136	4	8	40
Seattle	260	24	85	158	93	28	648	50	284	108
Tacoma	49	6	111	56	80	6	308	8	34	77
Olympia	12	0	28	6	5	0	51	0	7	0
Sub-Totals	442	30	418	565	221	36	1,712	82	369	312
Minor Harbors	54	0	36	73	11	4	178	2	0	33
TOTALS	496	30	454	638	232	40	1,890	84	369	345

Minor Harbors

The following harbors have a lesser degree of commercial activity:

Blaine, population 1,800, is at the Canadian border. A Federal project provides for a small-boat basin of 14.7 acres and 12 feet deep with a rock breakwater. Commercial fishing supports several fish packing firms. The only facilities other than small-boat moorages are the docks and wharfs associated with the respective fish processors.

Port Gamble is an unincorporated community on a large bay off the east side of Hood Canal. A federal project consists of a 3,000-foot channel 28 feet deep and 150 feet wide from Port Gamble Bay into Hood Canal.

Shelton, population 6,500, is 6.5 miles up a narrow inlet at the southwesternmost reach of Puget Sound. The city is the location of a large wood products manufacturing firm with several diverse activities. The inlet is about 1,000 feet wide and channel 10.5 feet deep and 100 feet wide is available. A Federal project, adopted in 1910, which provided for 150-foot channel 13 feet deep, has never been completed and is inactive. Traffic consists mainly of log tows.

In addition, there are 91 small harbors which are used for local commerce, ferry service, or small-boat facilities. These harbors are listed in table 81.

Table 81 - Miscellaneous Small Harbors, Subregion 11

SAN JUAN ISLANDS

Friday Harbor, Roche Harbor and North Bay on San Juan Island.

Deer Harbor, West Sound, Orcas, and Olga on Orcas Island.

Reid Harbor and Prevost on Stuart Island.

Lopez, Richardson, and Upright Head on Lopez Island.

Shaw Island, Decatur Island, Waldron Island, Lummi Island and Guemes Island.

WHIDBEY ISLAND

Lake Crockett, Oak Harbor, Crescent Harbor, Coupeville, Langley, Columbia Beach, San de Fuca, and Cornet Bay.

EAST PUGET SOUND

Tulalip on Tulalip Bay, 4 miles northwest of Everett.

Mukilteo on the east side of Possession Sound and on Elliott Point.

Meadowdale on the east side of Possession Sound in Browns Bay, known locally as Haines Wharf.

Redondo on the east side of East Passage on Poverty Bay.

Dumas Cove or Bay, 2 miles west of Redondo.

Titlow Beach - Day Island Anchorage, 4.5 miles south of Point Defiance.

Steilacoom near Gordon Point at the north end of Cormorant Passage.

DuPont Wharf at the mouth of Sequalitchew Creek near the east end of Nisqually Reach.

Boston Harbor in Boston Cove just east of Dofflemyer Point.

Table 81 (Cont'd)

WEST PUGET SOUND

Bremerton and Port Orchard on Sinclair Inlet.

Vashon Heights Landing, Portage, Burton, Dockton, Tahlequah, Lisabuela and Cove on Vashon Island.

Port Madison, Winslow, Creosote, Eagledale, Port Blakely, and Manzanita on Bainbridge Island.

Kingston, Hansville, Indianola, Manchester, Harper, and Southworth on the west side of Puget Sound.

Hadlock, Mats Mats and Port Ludlow on the west side of Admiralty Inlet.

Diamond Point and Blyn on the south side of the Strait of Juan de Fuca.

Bangor, Seabeck, Brinnon, Pleasant Harbor, Holly, Eldon, Hoodsport and Union on Hood Canal.

Ilahee, Keyport, Poulsbo, and Brownsville on the west side of Port Orchard Channel.

Fragaria, Olalla, and Gig Harbor on the west side of Colvos Passage.

Sylvan on Fox Island.

Vega on Anderson Island.

Horsehead Bay, Home, Lakebay, and Blencove on Carr Inlet.

Gertrude, Bee, and McNeil Island Penitentiary on McNeil Island in Carr Inlet.

Herron Island.

Allyn, Windy Bluff and Herron on Case Inlet.

Grant on Pickering Passage.

Carlyon Beach on Tutten Inlet.

Quilcene Boat Haven on Quilcene Bay.

Nordland on Marrowstone Island.

Commercial Traffic

Ports

Ports with more than a million gross tons of commercial traffic, exclusive of rafted logs, include Anacortes, Bellingham, Port Angeles, Seattle, and Tacoma. Other important ports with foreign and domestic trade are Everett, Port Townsend and Olympia. A major naval shipbuilding yard and anchorage is at Bremerton, across the sound from Seattle. Several minor ports support local traffic which remains in Puget Sound and adjacent waters. Important ferry landings are located at Tacoma, Seattle, Edmonds, Everett, and Anacortes on the east side of the sound and Southworth, Winslow, Kingston, and Port Townsend on the west. Ferries provide the primary access to many islands including Vashon, Orcas, and San Juan.

Commerce

Waterborne commerce through Subregion 11 ports is described in Appendix VIII, Navigation of the Comprehensive Water Resource Study of Puget Sound and Adjacent Waters. (5) That study showed trends in movements of major commodity groups during 1952 through 1966 and a breakdown of commerce at principal ports in 1963. During that period total domestic coastwise and foreign commerce increased about 50 percent from 11 to 17 million tons per year and interport commerce within the subregion from about 20 to 25 million tons. The commodity groups shown in the study included general cargo, bulk grain, forest products, bulk petroleum, other dry bulk, and other liquid bulk. Local, intraport commerce was not shown, but was stated to be about four million tons annually. Commerce at the major ports during 1968 is summarized in table 82. The 1968 commerce continued the increasing trends shown for 1952 to 1966.

Table 82 - Waterborne Commerce, 1968, Subregion 11

Ports	Foreign						Domestic Coastwise					Domestic Internal 1/				
	General Cargo & Misc.	Forest Products	Petroleum & Products	Nonmetallic Minerals	Metals & Ores	Agricultural Products	General Cargo & Misc.	Forest Products	Petroleum & Products	Nonmetallic Minerals	Fresh Fish & Shellfish	General Cargo & Misc.	Forest Products	Petroleum & Products	Nonmetallic Minerals	Fresh Fish & Shellfish
	(1,000 short tons)															
Port Angeles	11	1,091	-	-	-	-	-	24	73	-	-	100	906	121	90	.069
Port Townsend	-	174	-	-	-	-	-	-	16	19	-	24	544	21	19	.330
Olympia	1	771	-	-	-	-	-	-	2	-	-	-	467	93	70	-
Tacoma	926	1,961	353	523	123	303	2	76	322	-	-	156	749	945	318	-
Seattle	414	677	166	1,311	287	942	1,188	203	2,453	31	21.139	1,479	1,163	2,463	2,675	10,798
Everett	2	1,256	-	21	-	-	3	4	-	-	-	108	2,163	34	73	2.140
Anacortes	3	102	25	22	-	-	40	-	4,169	-	.009	88	201	1,301	10	1,375
Bellingham	45	530	1	104	-	-	136	12	-	56	4.748	60	322	85	101	15,883
All Other	297	178	150	130	-	-	-	20	494	6	-	19	2,459	739	4,891	11,895
Total	1,699	6,740	695	2,111	410	1,245	1,369	339	7,529	112	25.896	2,034	8,974	5,802	8,337	42,490

1/ Lists both shipments and receipts; therefore, totals show double the actual tonnage moved.

Ferry Traffic

Ferry traffic is not included in the above waterborne commerce. Traffic on state-owned ferries has increased steadily from 2.1 million vehicles and 4.9 million passengers in 1952 to 3.1 and 6.3 million respectively, in 1966. Ferries also move approximately 17,000 railroad cars annually, connecting Port Townsend, Port Gamble, and Shelton with Seattle and Tacoma. Not included in the above traffic are ferries carrying highway vehicles and passengers between Port Angeles and Seattle (summers only) and Victoria, B.C. Table 83 lists movement by ferries at principal ports.

Table 83 - Major Ferry Service, 1967, Subregion 11

Harbor	Cargo (short tons)	Railroad Cars	Vehicles	Passengers
Anacortes	0	0	162,716	350,698
Bellingham	0	26	90,000 1/	334,000 1/
Seattle	311,600	16,795	1,599,272	3,530,527
Tacoma	16,940	300	81,402	114,724
Port Angeles	0	0	N.A.	N.A.
Port Townsend	11,630	12,087	55,816	80,950
Port Gamble	0	304	0	0
Shelton	0	2,730	0	0

1/ Estimated, 1966

Vessel Traffic

Steamship service is provided by thirty-two steamship lines and eight tankership companies. In addition, six barge lines serve Alaska, ten coastwise carriers of lumber and petroleum are operated for private use, and local freight is handled by two lines as well as the ferry system. The numbers of self-propelled vessels calling at the major ports in 1963 are listed in table 84.

Table 84 - Draft of Self-Propelled Vessels, 1963, Subregion 11

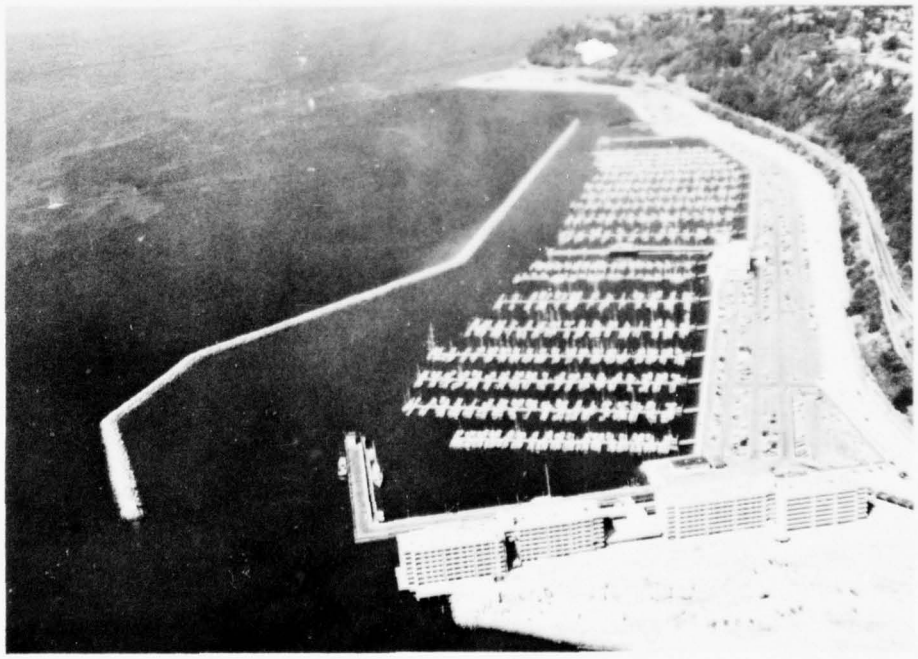
	Passenger & Dry Cargo			Tankers		
Port	Draft 18' & Less	Draft 18' - 40'	Total	Draft 18' & Less	Draft 18' - 40'	Total
Port Angeles	2,656	204	2,860	62	36	98
Anacortes	9,267	33	9,300	190	507	697
Bellingham	3,776	216	3,992	79	4	83
Everett	4,010	304	4,312	0	2	2
Seattle	50,410	1,809	52,219	356	646	1,002
Tacoma	13,068	891	13,959	148	178	326
Olympia	103	81	184	32	13	45

Difficulties Attending Navigation

Puget Sound provides natural channels of adequate width and depth for the largest vessels. Only in or near the mouths of rivers is maintenance dredging necessary. The major harbors generally have adequate protection from waves and adequate depths for commercial vessels with little or no maintenance dredging. Floating debris, particularly logs, occasionally constitutes a hazard to vessels moving at high speed in the sound. Oil pollution from vessels is increasingly causing concern. In general, there is adequate berthing space for commercial vessels. However, the trend towards larger deeper draft vessels will require increased depths at berthing facilities and additional backup areas to handle the cargo discharged by the larger vessels.

Recreational Boating

Hood Canal, Puget Sound, the Strait of Georgia, and the many inlets, channels, and islands are ideal for recreational boating. Lake Washington, which is 18 miles long and 2 miles wide and is connected by canal to Puget Sound, is heavily used by recreational boaters. Craft of all types from throughout the



Shilshole Bay Small-Boat Basin at Seattle. (USCE)

region, ranging from single-man sailboats and outboard motorboats to large cruisers, ply the waters of Subregion 11. During recent years, recreational boating has grown extensively and it is now estimated that there are 94 boats per 1,000 population in the subregion as compared with the national average of 41. A study of recreational boating conducted as part of the Puget Sound and Adjacent Waters Comprehensive Water Resource Study (5) found that 34 percent of the population engage in some form of pleasure boating, as compared to a national average of 20 percent. The study further found that the total number of recreational craft in the subregion was 186,000 in 1966 but that 95 percent of the total marine facility demand was accounted for by 62,100 recreational boats which are registered or documented 1/ by the Coast Guard. The study based most of its conclusions on a questionnaire survey of a representative sample of the owners of registered boats. Eighty-one percent of the registered boats are in the Olympia-to-Everett metropolitan area, nine percent are north of Everett, and ten percent are on the Olympic and Kitsap Peninsulas. Recreational boats fall into the following categories.

Table 85 - Recreational Boats,
Subregion 11

	Total	Registered or Documented
Inboard Motorboats	18,200	15,600
Outboard Motorboats	94,400	45,300
Auxiliary Sailboats	1,400	1,200
Sailboats without Power	6,300	0
Miscellaneous	65,700	0
Totals	186,000	62,100

1/ A recreation boat of over five net tons may be documented at the owners option. All commercial boats of over five net tons must be documented. All undocumented craft propelled by an engine of 10 hp or more and used on navigable waterways must be registered. See glossary.

The survey questionnaire requested information on the needs for both conventional rental moorage spaces and for rental dry storage with appropriate launching facilities. The returns indicated a need for a total of 37,120 rental spaces of which 29,710 would be for moorage, located as shown on table 86, which shows also the available rental moorage spaces as of 1966 and the indicated deficits. This report and the Puget Sound study show only the needs for moorage spaces although it is recognized that suitable dry storage may have to be substituted where development of conventional moorages is too expensive.

A total of 167 publicly owned boat basins and privately operated marinas supply a total of 15,975 rental moorage or dry storage spaces of which 12,297 are for moorage and are located as shown in table 86. There are 98 boat hoists at established marinas and 185 boat ramps with a total of 221 lanes located throughout the subregion. Twenty-three state parks and 14 state marine parks are located along the 2,350 miles of shoreline. About 9 miles of shoreline are occupied by pleasure boat facilities. In addition, there are several small public and private marinas and many single-owner boat moorages throughout the subregion.

Table 86 - Moorage Space Needs and Availability, 1966, Subregion 11

	Expressed Total Moorage Needs Boat Spaces			Available Moorage Spaces			Existing Shortages Moorage Spaces		
	Summer Only	All Year	Total	Summer Only	All Year	Total	Summer Only	All Year	Total
Port Angeles	310	670	980	0	275	275	310	395	705
Anacortes	1,030	690	1,720	0	555	555	1,030	135	1,165
Bellingham	450	260	710	22	192	214	428	68	496
Everett	730	2,290	3,020	90	774	864	640	1,516	2,156
Seattle	2,140	4,570	6,710	14	5,687	5,701	2,126	1,117*	1,009
Tacoma	810	1,860	2,670	0	1,348	1,348	810	512	1,322
Olympia	630	370	1,000	0	519	519	630	149*	481
West Puget Sound	4,250	3,730	7,980	266	2,058	2,324	3,984	1,672	5,656
Whidbey Island	2,010	900	2,910	16	86	102	1,994	814	2,808
San Juan Islands	1,620	390	2,010	185	210	395	1,435	180	1,615
Totals	13,980	15,730	29,710	593	11,704	12,297	13,387	4,026	17,413

*Available spaces in excess of expressed needs.

The study found a present need for 17,413 additional moorage spaces of which 4,026 should be suitably protected for year-around occupancy. It found also a need for 92 additional launching ramps and for additional picnicking and camping facilities adjacent to salt water. About 50 percent of all questionnaire returns indicated a need for harbors of refuge. Most existing basins can provide harbor-of-refuge protection for a

few transient craft during emergencies; however, space has not been designated for this purpose and additional havens are needed adjacent to remote areas.

More than 200 miles of shoreline was found to be suitable for development of small boat facilities considering such factors as approach depths, dredging requirements, land access, parking areas, beach material composition, and breakwater requirements.

PROJECTED CONDITIONS AND NEEDS

Economic Outlook

The economic outlook for the Puget Sound area has been the subject of two recent studies; one for the Puget Sound and Adjacent Waters Comprehensive Water Resource Study (PS and AW) (5), and the other a part of the Columbia-North Pacific Comprehensive Framework Study. Since the water resource development plan for Subregion 11 is taken from the Puget Sound and Adjacent Waters Study, the primary emphasis herein is on the economic outlook from that study. However, the projections for the Columbia-North Pacific Study also are shown so that a comparison can be made.

Population, Employment, and Income

The PS and AW economic study projected the population of Subregion 11 to increase from 1.87 million to 6.81 million by 2020 with employment to increase from 662,000 to 2.43 million. In contrast, the Columbia-North Pacific study projected population and employment to increase to 4.45 million and 1.77 million, respectively. Changes in the total income and per capita income were projected in the Columbia-North Pacific study whereas changes in gross regional product were projected in the PS and AW study. Inasmuch as income is derived from production, it, too, is an index of production. The per capita ratio of increase was similar in the two studies. Table 87 is a summary comparison of these data.

Table 87 - Population, Employment, and Personal Income Projections, Subregion 11

	C-NP				PS&AW Comprehensive			
	1962	1980	2000	2020	1963	1980	2000	2020
Population (1,000's)	1,833	2,450	3,345	4,448	1,870	2,727	4,301	6,809
Employment (1,000's)	668 1/	979	1,338	1,773	662	973	1,535	2,434
Per Capita Income ($)	2,633	4,358	7,447	12,659				
Total Personal Income or GRP 2/ ($1,000,000)	4,826	10,676	24,912	56,308	5,830	11,358	27,436	68,248

1/ 1960.
2/ C-NP income data is in 1958 dollars. PS&AW data is in terms of gross regional product (GRP) (1963 dollars), a measure roughly comparable to total personal income.

The Role of Transportation

Navigation will continue to play an important role in the transportation network of Subregion 11, but coastwise and internal shipments by water of forest products and bulk petroleum are not expected to maintain their current share of the total movements. This is because of the recent completion of pipelines for shipment of oil products and because of the importance of the log export market and the use of land storage and transport of logs. Air freight will also assume a greater share of commodity movements. Ferry traffic is estimated to increase to approximately 5,800,000 vehicles for 1975 and 10,000,000 vehicles for 1990. Construction of a cross-sound bridge sometime in the future would reduce some of the need for ferry service, but some service would still be required.

Prospective Waterborne Commerce

Future commerce as given in table 88 has been predicted on the basis of past trends and forecast commodity production, industrial production, and consumption, as described below. Projections are the same as those developed in connection with the Puget Sound and Adjacent Waters Comprehensive Water Resource Study. Although local and intraport waterborne traffic has amounted to over 4,000,000 tons in recent years, this traffic is not included in the projections. About 80 percent has been forest products, mostly rafted logs, and the volume of this traffic is expected to remain relatively constant for the foreseeable future.

Forest Products Logs, lumber, wood products, pulp, and paper are included under forest products. This commerce is limited by the available timber resource. Foreign and coastwise shipments decreased from about 1,000,000 tons in 1952 and 1954 to 760,000 tons in 1957 and then increased to approximately 2,700,000 tons in 1966, primarily as a result of the growing market for logs and chips in the Far East. The trend in this period had an average rate of growth of 107,000 tons annually. On this basis, future tonnages would be as shown in table 88. A possible decline in foreign demand for logs could occur because of legal restrictions on log export stemming from depletion of the domestic market resulting in an increase of log prices to the local consumer. Domestic internal commerce declined from about 12,000,000 tons in the early 1950's to 10,000,000 tons in 1957 and about 7,500,000 tons in 1966. This decrease results partly from greater use of land transport and partly from the better prices offered in foreign markets. A leveling off at about 6,000,000 tons is expected.

Table 88 - Waterborne Commerce Projections

Commodity	Type of 1/ Commerce	Base	1980	2000	2020
			(1,000 short tons)		
Forest Products	F&C	2,700	3,600	5,700	7,900
	DI	7,500	6,000	6,000	6,000
General Cargo	F&C	2,500	3,400	6,300	11,100
	DI	1,000	1,100	1,400	1,700
Bulk Grain	F&C	1,400	2,100	2,300	2,700
Other Dry Bulk	F&C	2,900	7,500	12,200	16,800
	DI	9,800	17,200	35,400	68,000
Petroleum	F&C	7,600	13,900	26,200	49,000
	DI	6,300	6,300	6,300	6,300
Other Liquid Bulk	F&C	150	280	570	1,120
	DI	50	70	160	280
TOTALS		41,900	61,450	102,530	171,000

1/ F&C = Foreign and Coastwise; DI - Domestic Internal.

General Cargo Although fluctuating in yearly volume, general cargo in foreign and coastwise trade increased from 1,600,000 tons in 1952 to 2,500,000 tons in 1966. However, projections at this rate would not fully reflect the recent effects of containerization and increasing trade with other nations, particularly the Far East. A more reliable factor is the national wholesale and retail trade index which historically has paralleled general cargo tonnage. This was used to obtain the foreign and coastwise projections. Domestic internal traffic grew from 741,000 tons in 1952 to 1,010,000 tons in 1966, an average annual compound rate of growth of about one percent. This rate was projected to obtain the internal volumes shown in table 97. Competition from land transportation and differences between subregional and national markets made use of the trade index impracticable for projecting domestic internal traffic.

Grain Grain movements consist almost entirely of bulk export of wheat from the western states. The average annual increase in foreign grain exports has been about 3.4 percent but is not expected to continue at this rate in the subregion because of limits to grain production. Projections are based on forecasts of grain production prepared by the Economic Research Service, Department of Agriculture.

Alumina Alumina receipts increased from 5,000 tons in 1963 to 392,000 tons in 1967. This gain followed construction of an aluminum smelter at Ferndale near Bellingham and the development of bauxite deposits in Australia. Alumina received in the subregion is destined both for local smelters and transshipment to plants in Subregion 1. Future receipts of this commodity are estimated on the basis of the forecast output of aluminum plants in Columbia-North Pacific Region, assuming that approximately two tons of alumina are required to produce one ton of aluminum. The aluminum plants in Subregion 11 are expected to reach a capacity of 620,000 tons in 1980 and then grow at an annual compound rate of three percent to 1,130,000 tons in 2000 and 2,060,000 tons in 2020. Those in Subregion 1 are expected to expand at the same rate from a total capacity of 328,000 tons in 1970 to 440,000 tons in 1980, 790,000 tons in 2000, and 1,420,000 tons in 2020.

Other Ores, Coal, and Dry Chemicals In 1963, foreign and coastwise receipts of ores other than alumina, coal, dry chemicals, and some other dry bulk commodities, amounted to 2,827,000 tons. Future receipts are estimated on the basis of forecast growth of the primary metals industry other than aluminum, which provides the market for most of these commodities.

Sand, Gravel, and Rock Materials from quarries and borrow pits move by barge within the subregion. The volume of these items varies from year to year, depending on construction activities, but has increased from 4,500,000 tons in 1956 to 9,800,000 tons in 1966. Projections are related to forecast construction and industrial activity at a rate considerably greater than past trends. Minor quantities of miscellaneous dry bulk commodities are included in the projections.

Petroleum Prior to 1954, most of the petroleum needs of the subregion was shipped in tankers from refineries in California. Between 1954 and 1964, refinery capacity was increased to 180,000 barrels per day along the shores of Puget Sound and adjacent waters and a pipeline was extended from oil fields in Alberta, Canada, to the area. Crude oil is now carried to the refineries in the pipeline and by tanker from foreign and domestic coastwise sources. Waterborne receipts of crude oil amounted to 2.4 million tons in 1968. Refined products are shipped by tanker, barge, and pipeline and received from outside the region by tanker. Total waterborne product movements in 1968 were more than 11 million tons, including 5.8 million tons of internal movements on Puget Sound and adjacent waters. Future foreign and domestic coastwise commerce is projected to increase in relation to regional economic growth. No increase is projected for domestic internal.

Other Liquid Bulk Receipts of alcohol, liquid sulphur, sulphuric acid, coal tar, and vegetable and animal oils are intended chiefly for use in chemical industries. From about 100,000 tons in the early 1950's, foreign and coastal receipts increased to about 150,000 tons in 1966. Domestic internal commerce, about 1,000 tons in 1953, subsequently increased to an average of 50,000 tons. Projections are based on forecast output of the chemical industry.

Prospective Commerce Based on Gross National Product

Total projected tonnages, as shown on table 88, fall well below total tonnages projected on the basis of predicted increases in gross national product. Totals projected using GNP alone are 6.6 percent greater for 1980, 23.2 percent greater for 2000, and 51.6 greater for 2020. This could indicate that the projections in table 88 are overly conservative and do not reflect all possible factors. In table 89, commodity projections have individually been increased by the above percentages. An exception is forest products, for which no increase appears justified. The general cargo projection was increased additionally by two million tons for 1980 to reflect above-average gains which could result from containerization.

Table 89 - Adjusted Waterborne Commerce Projections

Commodity	Type of Commerce 1/	Base	1980	2000	2020
			(1,000 short tons)		
Forest Products	F&C	2,700	3,600	5,700	7,900
	DI	7,500	6,000	6,000	6,000
General Cargo	F&C	2,500	5,600	7,800	16,800
	DI	1,000	1,200	1,700	2,600
Bulk Grain	F&C	1,400	2,200	2,800	4,100
Other Dry Bulk	F&C	2,900	8,100	15,000	25,600
	DI	9,800	18,200	43,600	103,000
Petroleum	F&C	7,600	15,200	33,700	77,500
	DI	6,300	6,300	6,300	6,300
Other Liquid Bulk	F&C	150	300	700	1,700
	DI	50	70	190	400
TOTALS - Adjusted on basis of predicted GNP		41,900	66,770	123,490	251,900

1/ F&C = Foreign and Coastwise; DI - Domestic Internal.

A number of circumstances in the subregion tend to support the tonnages in table 89.

General Cargo With the advantage of greater natural water depths and a shorter distance from the Northern Orient than any other continental United States port, the Puget Sound area has the long range prospects for greatly increased general cargo tonnages. Containerization is expected to increase the tributary area served by Puget Sound ports. A study in depth by the Port of Seattle in 1964 analyzed cargo suitable for containerization from the Far East in 1966 and estimated for the period 1967 to 1975 that containerized import cargo will grow at a rate of 15 percent annually and exports at 10 percent annually. With rapid industrialization of Japan and possible opening of other Pacific Rim markets there is a potential for an even greater increase in containerized general cargo in 1980 to 2020 because of savings in cost and time of handling.

The "land bridge" concept which uses the United States railroads to form a direct transportation route linking waterborne commerce of the Atlantic and Pacific to serve the Far East and Europe, could result in savings of up to 2-weeks time and overall costs. The implementation of such a plan is another long range potential for general cargo in the Puget Sound area.

Bulk Grain The export of Midwest grain to the growing markets of the Far Eastern countries has a potential for substantial increases when satisfactory unit train rates are established. This possibility together with the highly automated grain terminal constructed by the Port of Seattle could result in large future grain exports through the Puget Sound area.

Forest Products The constraints imposed on this commerce by level of output from the resource, legal and political considerations, and future United States market demands, limit the level of this commerce. There is no apparent basis for increasing these forecasts.

Bulk Petroleum and Other Liquid Bulk The Puget Sound area could undergo a large growth in refineries and associated waterborne commerce as a result of major oil discoveries in Alaska. The transportation pattern would be altered so that the area would become a net exporter of petroleum products. The expansion of refineries would also result in growth of the chemical industries. All of these factors indicate major upward trends in both bulk petroleum and other liquid bulk commerce.

Other Dry Bulk Alumina, a principal component of this commerce, was forecast at a three percent annual rate of growth as compared to reliable forecast of five percent for the Nation. The advantages of large electric power blocks which can be produced by thermal plants at low composite rates when combined with existing low cost hydroelectric, gives the Pacific Northwest a long-term advantage for attracting future aluminum plants. The Puget Sound waterborne commerce would, in turn, share this growth because of its attractive tidewater plant sites and its location as a transshipment point to inland plants.

Distribution of Commerce Among Ports

The proportion of total Puget Sound waterborne commerce which each port handles is expected to change with time. Growth of shipping at Bellingham is expected to increase more than average, reflecting the increase of refining activities based on Alaska crude oil. In contrast, some of the present domestic internal transport of refined oil from Seattle will probably be

carried by pipeline in the future. After 1980, a shortage of land for new industry and terminal facilities at Seattle and Tacoma may cause a shift of commerce to other areas such as Everett and the Nisqually delta. Table 90 shows the percentage of total subregion tonnage handled at each port in 1963 and projected for the future.

Table 90 - Distribution of Commerce Among Ports, Subregion 11

Port	1963	1980	2000	2020
		(percent of total)		
Port Angeles	3.0	2.6	2.1	1.6
Anacortes	16.6	13.3	10.1	11.6
Bellingham	3.7	7.2	10.1	11.6
Everett	6.8	5.8	8.6	19.3
Seattle	32.7	33.6	25.8	19.3
Tacoma	12.7	13.6	18.4	14.8
Olympia	1.9	1.3	1.7	2.4
Other 1/	22.6	22.6	23.2	19.4
Total	100.0	100.0	100.0	100.0

1/ Port Townsend, Shelton, Port Gamble, and about 80 landings on the west side of Puget Sound, Whidbey and Camano Island, and the San Juan Islands.

Industrial Lands

All major ports have substantial areas of nearby waterfront lands available for industrial expansion. Taken together, and not counting right-of-way for streets and highways, these amount to about 27,000 acres plus 4,500 acres where development would be somewhat more difficult and costly. Considerable additional space is available within a few miles of terminal areas. These lands are more than sufficient to accommodate the industrial expansion necessary to support the project increases in waterborne commodities described above. In 1966, existing industries were utilizing 5,190 acres of waterfront land. If the demand for industrial land is assumed to increase at the same rate as the projected commerce shown in table 97, an additional

3,000 acres would be needed by 1980, 10,000 acres by 2000, and 26,000 by 2020.

Trends in Vessel Design

Vessel types and sizes for future planning were developed from studies of recent trends in world merchant fleets, including ships under construction or design, modified to apply to conditions in Puget Sound and the Columbia-North Pacific Region. Information on vessel trends is contained in the Regional Summary.

Adequacy of Channels

For unrestricted access at mean lower low water, channel depths should be 5 to 8 feet greater than salt water draft, depending on vessel length and displacement. This allows for an increase of 2 or 3 percent of draft in fresh water, unbalanced trim fore or aft, and 2 to 3 feet clearance above the bottom. On the basis of trends in vessel design, waterways in the subregion should meet the dimensions shown in table 91 to accommodate vessels of maximum and average size in the future:

Table 91 - Required Channel Dimensions, Subregion 11

Vessel Type	1980	2000 - 2020
	(depth and width in feet)	
Freighters		
Maximum	44x200	46x220
Average	32x120	32x120
Bulk Carriers		
Maximum	64x250	78x320
Average	40x180	46x200
Tankers		
Maximum	106x420	112x450
Average	52x230	54x240

For comparison with required depths, waterway depths at major ports in the subregion are summarized in table 92. Table 92 shows that all major salt water harbors of Puget Sound are capable of providing offshore anchorage for the largest freighters and bulk carriers of the future. Future freighters of average

size will be able to utilize existing terminals and channels at Port Angeles, Seattle, Tacoma, and Olympia with little or no additional dredging. Future bulk carriers of average size and freighters of maximum size can be accommodated at existing piers at Seattle and Tacoma, with minimal dredging or pier extension. However, existing access channels will be completely inadequate for these vessels. The maximum size bulk carriers of the future will well exceed in draft the depths available at existing piers. Future tankers, whether of average or maximum size, will be beyond the capability of existing piers because of depth requirements. Even the largest, however, could anchor in the harbors of Port Angeles, Everett, Seattle, and Tacoma.

Table 92 - Harbor Depths, Subregion 11

Port	Natural Harbor Depths			Dredged across Channels		
	Entrance	Mid-Point	Pierhead Line	Depth	Width	Length
	(feet below MLLW)				(feet)	
Port Angeles	120+	120+	30		1/	
Port Townsend	80	75	20		1/	
Anacortes (Guemes Channel)	55	75	20		1/	
Bellingham (Bellingham Bay)	80	90	10	13-30	100-360	12,500
Everett (Port Gardner)	400	300	20	30	700-900	2,000 2/
Seattle						
Elliott Bay	300	250	40		1/	
Duwamish Waterway	-	-	30	30-34	200	18,000
Lake Union	40	40	40	30	100-200	34,000 3/
Tacoma (Commencement Bay)	550	400	50	19-35	200-600	38,000
Olympia (Budd Inlet)	90	35	5	30	500	13,000

1/ No major channel.
2/ East waterway.
3/ Lake Washington Ship Canal.

Major approach channels to harbors are more than adequate for all types of vessels from the entrance of the Strait of Juan de Fuca to Bellingham Bay in the north and Budd Inlet (Olympia) in the south.

The degree of protection from storms for vessels riding at anchor varies among harbors. Most severe storms occur in the winter with southerly winds. This condition favors the harbors at Port Angeles, Port Townsend, Tacoma, and Olympia.

Channel deepening is discussed under "Means to Satisfy Needs."

The predicted increase in waterborne commerce will necessitate a continuing large expansion of port facilities and this, in turn, may create a demand for new or extended access channels. Such developments cannot be forecast with accuracy as port growth may take place at any of a number of optional locations.

Adequacy of Terminal Facilities

As previously noted, in general there is adequate berthing space for today's waterborne commerce. The predicted increases in commodities will necessitate either improved efficiencies in handling equipment, or expansion of terminal facilities, or both. Probable advances in handling efficiency for various commodity groups are shown in table 93 under "Tons Per Acre." Terminal area requirements in acres were obtained by using commodity projections from table 89. No increase in terminal area is foreseen for forest and petroleum products, the increase in traffic being handled by installation of additional equipment on existing terminal lands. For general cargo, although loading and unloading rates will continuously improve, the steady gain in traffic will require a doubling of terminal land area by 2020. Other bulk commodity groups are expected to experience their major improvement in handling efficiency by 1980. As a result, expansion in area of bulk terminals may be delayed until after 1980 for liquids other than petroleum and after 2000 for grain.

Table 93 - Terminal Facilities, Subregion 11

Commodity	Base		1980		2000		2020	
	Tons Per Acre	Terminal Area (Acres)	Tons Per Acre	Terminal Area (Acres)	Tons Per Acre	Terminal Area (Acres)	Tons Per Acre	Terminal Area (Acres)
Forest Products	17,200	454	21,200	454	25,900	454	30,600	454
General Cargo	8,300	496	12,000	565	15,300	625	19,400	1,000
Bulk Grain	40,000	30	100,000	30	100,000	30	100,000	41
Other Dry Bulk	97,460	223	356,000	274	356,000	583	356,000	1,196
Petroleum	25,000	638	33,800	638	62,700	638	134,500	638
Other Liquid Bulk	4,500	40	9,000	41	9,000	100	9,000	236
Total		1,886		2,002		2,430		3,565
Increase in terminal area over base area				116		544		1,679

The Future Outlook for Recreational Navigation

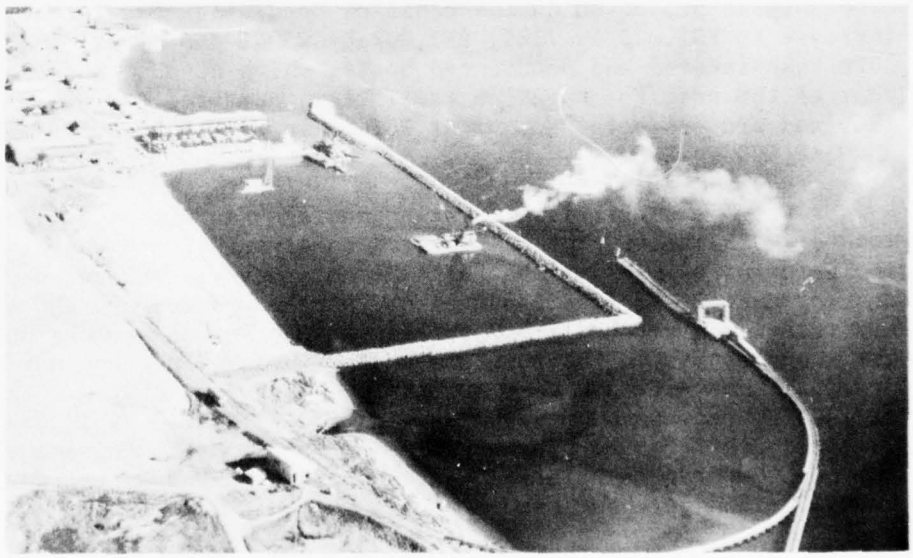
Number of Boats In 1966, the number of pleasure craft in Subregion 11 was estimated to be 186,000. Total pleasure boats ownership is projected on the basis of population and income to increase to 291,000 by 1980, 551,000 by 2000, and 1,040,000 by 2020. Registered and documented boats, which account for 95 percent of the need for nagation facilities, numbered 62,100 in 1966 and are projected to number 96,000 in 1980, 184,000 in 2000, and 348,000 in 2020.

Moorage Facilities Existing moorage facilities will accommodate 12,297 boats, but only 11,704 on a year-around basis. The information used in the Puget Sound study (5) indicated a current deficit of 4,026 spaces for year-around moorage and an additional deficit of 13,387 spaces for use during summers only. The study projected future needs on the basis of present needs and anticipated future boat numbers and estimated that a total of 143,440 moorage spaces would be needed by 2020. Table 94 gives a breakdown of future moorage space needs. Space requirements for small moorage facilities average .056 acres of water and .028 acres of land per boat space.

Table 94 - Future Rental Moorage Requirements[1/], Subregion II

	Total Moorage Requirements					
	1980		2000		2020	
	Summer Only	All Year	Summer Only	All Year	Summer Only	All Year
Port Angeles	470	670	810	1,110	1,110	1,530
Anacortes	1,440	960	2,360	1,570	3,920	2,620
Bellingham	620	370	1,020	600	1,700	1,000
Everett	1,190	3,730	2,280	7,250	4,420	14,100
Seattle	3,450	7,470	6,700	14,500	13,000	28,200
Tacoma	1,320	3,030	2,590	5,860	5,000	11,400
Olympia	730	400	1,220	730	1,690	1,010
West Puget Sound	5,640	5,280	10,210	9,390	16,800	16,100
Whidbey Island	2,870	1,300	4,820	2,250	8,270	3,920
San Juan Islands	2,260	550	3,690	910	6,150	1,500
Sub-Totals	19,990	23,800	35,700	44,170	62,060	81,380
Totals	43,790		79,870		143,440	

1/ Total requirements inclusive of existing facilities.



Expansion of small-boat facilities, Port Townsend. (USCE)

Existing moorages in 1966 occupied about 9 miles of shoreline. Future facilities may be expected to require about 3 feet of shoreline per moorage on the basis of a sampling of recently-constructed facilities. Therefore, an additional 25, 45, and 82 miles of shoreline would be required to meet the estimated summer moorage demands for 1980, 2000, and 2020, respectively.

Launching Ramps Present facilities comprise 98 boat hoists at established marinas and 185 boat ramps with a total of 221 lanes. The Puget Sound study found a present need for an additional 92 lanes of ramp. Future launching ramp demands may be assumed to follow the same growth rate as pleasure boat ownership. On this basis, 190, 524, and 1,129 lanes in addition to the facilities now available would be required by 1980, 2000, and 2020, respectively. Two acres of land are considered necessary for each launching ramp lane to provide adequate parking, maneuvering space, and access roads. Therefore, the Puget Sound area shorelands required for additional launching ramps in 1980, 2000, and 2020 would be 380, 1,048, and 2,258 acres, respectively. If combined with boat basin development, launching ramps would require only 1.5 acres of land per lane. These shoreland requirements do not include parking space for car top boats that do not require launching ramps. Additional shorelands of at least 40 percent of the above requirements for boat launchings will be required for car top boats.

Harbors of Refuge A need exists for harbors of refuge with protective breakwaters. Several of the larger public boat basins are able to afford some protection to transient small craft; however, moorages have not been set aside for this purpose. The growth of pleasure boat activity will intensify the need as more boaters are subjected to adverse wave actions during periods of high winds. Uncertainty of weather conditions and the many miles of shoreline without protected harbors reduces the cruising radius of many boaters.

Summary

In view of the predicted increase in waterborne commodities, port handling facilities will have to improve in efficiency and expand in land area. The deeper draft ships of the future can be accommodated within the harbors of Port Angeles, Everett, Seattle, Tacoma, and to some extent by existing piers at Seattle and Tacoma. However, all existing access channels will be inadequate by 1980 for anything more than average size freighters. Small boat facilities in the subregion are overtaxed. Additional facilities will be needed if the subregion is to keep pace with the dramatic increase in small boat usage.

MEASURES TO SATISFY NEEDS

Commercial Navigation

Harbors and Terminals

In this section, each major port of the subregion is examined to determine what improvements are possible to accommodate the projected increases in waterborne commerce. Consideration is given to pier extension, deepening of pier access channels, and land availability for terminals and industrial development.

Port Angeles Although the well-protected harbor of Port Angeles has depths capable of accommodating the largest vessel anticipated in the future, its remote location on the Strait of Juan de Fuca suggests that, as shown in table 25, its share of commerce will be comparatively small. Depths of 30 feet are now available close to shore, but pier extension may be desirable as vessel drafts increase. A 2,000-acre area of potential industrial land lies on the strait about 5 miles east of the harbor.

Anacortes The removal of high points in Guemes Channel to assure continuous depth of 54 feet for average tankers is estimated to cost $600,000. Additional dredging of shoals to 78 feet would permit passage of larger tankers and bulk carriers at a cost of about $4,000,000. Padilla Bay and Fidalgo Bay, now virtually undeveloped, together have a potential for 2,700 acres of industrial landfill which could be accomplished in conjunction with channel dredging. A mile-long 32-foot channel into Fidalgo Bay, costing about $900,000, could eventually be deepened to 46 feet for the largest predicted freighters for about $1,500,000 more. A 3.5-mile 46-foot channel into Padilla Bay, estimated to cost $4,500,000, would receive maximum-size freighters and, for approximately $2,500,000 more, could be deepened to 54 feet for use by average-size tankers.

Bellingham The petroleum refining industry is expected to play a major role in the Bellingham area also. Tankers of somewhat less than maximum draft could anchor offshore in Bellingham Bay. For use by average-size bulk carriers and larger than average freighters, Whatcom Creek Waterway could be deepened to 40 feet at an estimated cost of $700,000 and subsequently to 46 feet at an additional cost of about $500,000. A 46-foot channel 1 mile long, combined with a 1,800-acre landfill development in the Nooksack River delta on Bellingham Bay is estimated to cost $900,000. An additional 300 acres of waterfront land is still available for industrial development in the immediate vicinity of Bellingham. On the Strait of Georgia, a short distance north of Bellingham Bay near Ferndale, deep water close to shore and 4,700

acres of industrial land are expected to support an expanding petroleum refining operation.

Everett Deepening of channels at Everett Harbor could take place in the Snohomish River below the Interstate 5 bridge crossing and in the east waterway. Initial dredging of 3.5 miles of the river below the bridge to 32 feet for average-size freighters would cost an estimated $2,000,000. For about $3,500,000 additional, the depth could be increased to 46 feet for maximum-sized freighters. Navigation of large vessels above the bridge is not practicable. However, movement of large barges for 7 miles above the bridge would be made possible by dredging to 20 feet at an estimated cost of $2,300,000. About 3,500 acres of industrial land would be created in conjunction with this dredging. An additional 450 acres of undeveloped industrial land is still available in the vicinity of Everett. The east waterway could be deepened initially to 46 feet for about $300,000 and eventually to 78 feet for an additional estimated $2,000,000 to provide adequate depths for maximum-size bulk carriers and freighters.

Seattle Deep water for offshore loading of tankers and extended-pier handling of grain and other bulk carriers is available in Elliott Bay. In addition, the Duwamish Waterway could be deepened for use by maximum-size freighters, larger than average-size bulk carriers, and average-size tankers. This would require deepening the east and west waterways to 54 feet at an estimated cost of $1,200,000 and deepening the Duwamish Waterway below 1st Avenue South to 46 feet at an estimated cost of $1,750,000, and from 1st Avenue South to 8th Avenue South to 32 feet at an estimated cost of $300,000. There are 720 acres of potential industrial land still available adjacent to Elliott Bay and the Duwamish Waterway plus another 400 acres on the fresh water waterways in the Seattle area.

Tacoma The Hylebos Waterway could be deepened initially to 46 feet for about $1,750,000 to accommodate maximum-size freighters and eventually, for about $2,500,000, to 78 feet for use by maximum size bulk carriers. Even greater drafts could be accommodated in the Port Industrial Waterway. Initial dredging to 52 feet at an estimated cost of $2,150,000 would permit use by average-size tankers, large bulk carriers, and maximum-size freighters. At an added cost of about $2,000,000, the depths could be increased to 106 feet for use by all but the largest tankers. Sitcum Waterway could be made available to maximum-size bulk carriers by deepening to 78 feet at an estimated cost of $1,600,000. There are 2,400 acres of industrial land still available in the vicinity of the Port of Tacoma.

Olympia Deepening the channel in Budd Inlet to 40 feet at a cost of about $1,900,000 would permit use by larger than average-size freighters. Maximum-size freighters could eventually be accommodated by dredging to 46 feet at an additional estimated cost of $1,400,000. An additional 220 feet of 46-foot-deep channel could be dredged on the east side of the harbor for about $2,400,000. There are about 400 acres of potential industrial land at the head of Budd Inlet.

Nisqually Delta Approximately halfway between Tacoma and Olympia, the delta of the Nisqually River, with substantial flatlands and deep water close to shore, offers an attractive site for future port development. About 2,000 acres could be converted to industrial and terminal use by landfill in conjunction with channel dredging. A 78-foot deep channel, about one-half mile long, suitable for maximum-size bulk carriers is estimated to cost $2,500,000. As the Nisqually River is the boundary between the Tacoma and Olympia port districts, this development might be a cooperative effort. Conflicts with conservation interests need to be resolved, with balanced land-use planning to satisfy both interests.

Development Schedule

The timing of navigation improvements will depend to a considerable extent on the initiative of individual port districts. However, a possible sequence of major harbor improvements was developed in the Puget Sound Comprehensive Study and is summarized herein in table 95.

Table 95 -Channel Improvements, Subregion 11

Port	Existing	1980	2000	2020
	(depth in feet, MLLW)			
Port Angeles	30	46 1/	-	-
Anacortes				
Fidalgo Bay	-	32	40	46
Padilla Bay	-	-	46	54
Guemes Channel	2/	54	78	-
Bellingham				
Whatcom Creek Waterway	30	40	46	-
Nooksack Delta	-	-	46	-
Everett				
Lower Snohomish River	8-15	32	46	-
Upper Snohomish River	8	-	20	-
East Waterway	30	46	78	-
Seattle (Duwamish Waterway)				
East and West Waterway	34	54	-	-
Duwamish below 1st Ave. S.	30	46	-	-
Duwamish 1st to 8th Ave. S.	20	32	-	-
Tacoma				
Hylebos Waterway	30	46	78 3/	-
Port Industrial Waterway	35	52	106 3/	-
Sitcum Waterway	25-40	78	-	-
Olympia				
Existing Waterway	30	40	46	-
Eastside of harbor	0-5	-	46	-
Nisqually Delta	-	-	78	-

1/ Pier extension
2/ Generally over 50 but with irregular high points
3/ Below 11th St.

Recreational Boating

Potential Moorage Sites

The possibilities for developing additional moorage facilities throughout the subregion are described in the following paragraphs. Estimated costs are for breakwaters, channels, and navigation aids, but do not include piers, buildings, and utilities.

Port Angeles Five sites in the Port Angeles-Sequim area from the Elwha River to the Dungeness River would provide over 5,000 moorage spaces at an estimated cost of $4,500,000.

Anacortes Six sites in the Anacortes area would permit the development of 10,000 moorage spaces. These sites are located in Fidalgo Bay, at the north extremity of Padilla Bay, on Guemes and Sinclair Islands, on the west shore of Fidalgo Island, and at the south entrance of Swinomish Channel. Total cost would be about $12,000,000.

Bellingham A total of 7,500 moorage spaces could be provided by developing six sites in the Bellingham area. Three would be located in the vicinity of Bellingham Bay, and one each at Birch Bay, Blaine, and Point Roberts. Total estimated cost would be $5,200,000.

Everett Twelve sites in the Everett area could be developed to provide over 22,000 spaces. All are located on the shore of Possession Sound; five are north and seven are south of the Snohomish River. Complete development would cost about $46,000,000.

Seattle Over 12,000 moorage spaces would result from development of eight sites in the Seattle area. Five sites, including extensions of the existing Shilshole boat basin, are located on the shore of Puget Sound from Elliott Bay north to Edmonds. Two sites are within Elliott Bay, and one is to the south about halfway to Tacoma. Total cost of construction would be about $25,000,000.

Tacoma Three sites in the Tacoma area offer a potential of over 4,000 spaces. One site is in Commencement Bay and the other on Puget Sound a few miles each way. Total cost is estimated at $9,000,000.

Olympia Four sites in the Olympia area comprise two in Budd Inlet, one in Henderson Inlet to the east, and one at the mouth of the Nisqually River. Over 3,500 moorages could be provided at a total cost of about $7,500,000.

Other Areas In addition to small boat harbors in the vicinity of the more populated port districts, a large potential exists for development on the west side of Puget Sound, around Whidbey Island, and in the San Juan Islands. On west Puget Sound there are six known sites within 12 miles of Port Townsend, eight on the shores of Hood Canal, and nine clustered in the Bremerton-Bainbridge Island area, across the Sound from Seattle. Over 26,000 moorage spaces could be provided at a total estimated cost of $53,000,000.

There are ten sites at Whidbey Island, three on the west shore, five on the east, and two on nearby Camano Island. Over 14,000 spaces could be developed at an estimated cost of $29,000,000.

Another twenty sites are located in the San Juan Islands which would provide 9,000 spaces for about $13,000,000.

Small boat moorage needs through 1980 could be met in most localities by development of the above sites. However, by 2000 other developments will be needed for boat owners in Seattle and Tacoma or some will have to go to Everett or Olympia for moorages. By 2020, demand in the Everett-Olympia area will far exceed the potential for developing new moorages even if excess capability at Anacortes and Bellingham is utilized. The capacity of known suitable sites will also be exceeded on the west side of Puget Sound. Presumably greater use will have to be made of dry storage and trailering.

Launching Ramps

By providing launching ramps as part of small boat basin construction, the demand through 2020 can be met in all except three general areas - Seattle, Tacoma, and west Puget Sound. In these localities, consideration should be given to construction of launching ramps separate from those incorporated in boat basins.

Harbors of Refuge

Some of the needs for harbors of refuge will be met by the development of additional marinas and boat basins. However, boaters have expressed a current need for havens, solely for refuge, in areas where boat basins will not be needed until after 2000 and in areas where no boat basins are planned. Additional study is needed to develop a program for developing the harbors necessary for public safety.

Summary of Costs

Estimated construction costs and related annual operation and maintenance costs for the navigation program proposed in the PS&AW report are summarized by time periods in table 96. Additional details can be found in that report.

Table 96 - Estimated Construction Costs & O&M, Subregion 11

Time Period	Commercial		Recreation	
	First Costs	Annual O&M	First Costs	Annual O&M
Present to 1980	$15,150,000	$ 870,000	$ 57,000,000	$3,600,000
1981 - 2000	29,400,000	1,505,000	65,000,000	4,200,000
2001 - 2020	3,100,000	160,000	115,000,000	7,400,000

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13. U. S. Department of the Army, Corps of Engineers, Columbia River and Tributaries, Northwestern United States, House Document No. 531, 81st Congress, 1950.

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GLOSSARY

Adopted low water See low water.

Bunkering facilities Facilities for supplying ships with water, fuel, and stores.

Columbia River Datum See low water.

Deadweight ton The measure in long tons (2,240 lbs.) of a vessel's carrying capacity of cargo, fuel, and stores.

Deep draft Vessels having drafts in excess of 18 feet, also navigation facilities for such vessels and commerce carried. See also shallow draft.

Documented vessel A vessel carrying official documents or papers manifesting ownership and cargo, and permitting her to engage in international trade. All commercial vessels of over 5 net tons must be documented and recreational boats of over 5 net tons may be documented at the owner's option.

Entrance jetty system The entrances to bays or estuaries that discharge into the ocean through sand beaches shift along the beaches depending on the direction and force of waves and littoral drift. Jetty systems are used to stabilize the entrances and facilitate maintenance of adequate navigation channels. The jetties are constructed of large stones and are called rubblemound jetties.

LASH Lighter Aboard SHip. A container ship equipped to pick up and carry river barges (lighters) of about 200-ton capacity or other containers and carry them from one seaport to another.

Low water The depth of a navigation channel is generally referenced to the low water stage which coincides with the lowest sustained flow over a 15-day period. On most streams this is referred to as "adopted low water;" on the lower Columbia it is the "Columbia River Datum."

Mean lower low water Tides of the northeastern Pacific Ocean are characterized as mixed, with two unequal highs and two unequal lows daily. The plane of reference for navigation channels is the long term average of the daily lower lows, termed mean lower low water.

Open river channel A navigation channel in a natural river with improvements limited to removal of obstructions and dredging to obtain adequate depths. cf. Slackwater channel.

Rubblemound jetty See entrance jetty system.

Shallow draft Vessels having a maximum draft of 18 feet or less. Includes tugs, towboats, barges, and small boats. Also navigation facilities for such vessels and commerce carried. See also deep draft, small boats.

Sill depth The controlling depth of a navigation lock is the distance from the water surface to the sill of the upper or lower gate.

Slackwater channel A navigation channel in a canal or river where the water surface elevation is controlled by a dam or dams with locks.

Small boat basin A protected harbor for small boats--generally self-propelled boats less than 50 feet in overall length other than tugs.

Towboats, tugs Vessels for propelling barges or rafts and assisting larger vessels in close quarters and berthing. A towboat is used to push a flotilla of barges and is generally limited to protected waterways; tugs work at the end of a line or hawser.

Tributary area The area served by a navigation project.

White-water boats Small boats designed to operate in swift water with turbulent rapids.

PARTICIPATING STATES AND AGENCIES

STATES

Idaho	Nevada	Utah	Wyoming
Montana	Oregon	Washington	

FEDERAL AGENCIES

Department of Agriculture
- Economic Research Service
- Forest Service
- Soil Conservation Service

Department of the Army
- Corps of Engineers

Department of Commerce
- Economic Development Adm.
- National Oceanic & Atmospheric Administration
  - National Weather Service
  - National Marine Fisheries Service

Department of Health, Education, & Welfare
- Public Health Service

Department of Housing & Urban Development

Department of Transportation

Department of the Interior
- Bonneville Power Adm.
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Mines
- Bureau of Outdoor Recreation
- Bureau of Reclamation
- Fish and Wildlife Service
- Geological Survey
- National Park Service

Department of Labor

Environmental Protection Agency

Federal Power Commission