

## I. INTRODUCTION

### A. PURPOSE

This document reports on the operation of reservoirs and associated water management activities in the Columbia River Basin and the Pacific Northwest during Water Year 1997 (October 1996 through September 1997). It is prepared by the Columbia River Water Management Group (CRWMG), an interagency coordination group composed of representatives from federal and state agencies in the Pacific Northwest. (See inside the front cover for the [charter](#) and inside the back cover for [agency representatives](#)). Because the management of the Columbia River is a multi-faceted effort involving the resources of several agencies and the support of many others, this report reflects the collective input of as many as 15 different agencies. The 1997 report represents the 27<sup>th</sup> "Blue Book" published since the CRWMG initiated publication of the report in 1971. (Smaller reports were made for 15 years proceeding the 1971 report.) The history of the CRWMG and its predecessor organization, the Columbia Basin Interagency Committee (CBIAC), is contained in Chapter V.

This report is a record of the activities surrounding the regulation of the major reservoirs in the Columbia Basin and other river drainages in the Northwest. It includes a description of the weather, the forecasts of runoff, project operation data, plots and descriptions of reservoir regulation, and summary statistics on the accomplishments associated with the system operations. In addition, this report contains a brief summary of Group meetings and planning and regulatory activities undertaken during the water year by state and federal members of the CRWMG.

This report contains nine chapters and four appendices. They describe the weather and hydrology (Chapter II), reservoir operation (Chapter III), flood control events, power generation, fisheries management, and other water resource related activities (Chapters IV to

VIII), and a chapter (IX) with acknowledgments. [Appendices A, B, and C](#) contain static information on definitions, abbreviations, and pertinent data on the major dams, powerhouses, and reservoirs in the Northwest. [Appendix D](#) contains graphic displays of the annual weather, project operation, and streamflow.

### B. BASIN DESCRIPTION

This report discusses the water resources of the Pacific Northwest, which includes those in the Columbia River basin and its tributaries, plus the coastal streams of Washington and Oregon ([Figure 1](#)). It includes all the state of Washington, most of Oregon and Idaho, western Montana, southeastern British Columbia, and portions of Wyoming, Nevada, Utah, and California. The Columbia Basin itself covers 670,800 sq km (259,000 sq mi) and the coastal drainages of Oregon and Washington, including Puget Sound, cover 96,089 sq km (37,100 sq mi), for a total area of 766,900 sq km (296,100 sq mi).

The dominate physiographic features of the Northwest are the Pacific Ocean, the mountain ranges and the Columbia River Basin. The Pacific Ocean affects the region because it is the source of all moisture entering the region. The landmass is traversed by three major mountain ranges, the Coast Range, the Cascade Range, and the Rocky Mountains, crossing the region in a roughly north-south direction. As storms are driven across the Northwest by the prevailing westerly winds, the mountains force the removal of moisture from the airmass, as indicated by the higher rainfall west of the mountains than in east-side valleys. The Coast Range (excluding the Olympic Mountains), with a few peaks that extend over 915 m (3000 ft), generally lie within 30 km (20 mi) of the Pacific Ocean. The Olympic Mountains also lie adjacent to the Pacific Ocean, but have a different geological history, have peaks over 2130 m (7000 ft). The 100 km (62 mi) wide Puget Sound/Willamette Valley trench,

which extends from British Columbia to southern Oregon, separates the Coastal/Olympic and Cascade mountain ranges. The Cascades, a volcanic range with several peaks over 3050 m (10,000 ft), has an average crest elevation near 1830 m (6000 ft). East of the Cascade Range is the Columbia River Basin that drains the remainder of the Northwest. It is bordered on the east by the Continental Divide and the Rocky Mountains, on the south by the low divide into the Great Basins of Utah and Nevada, and on the north by the Monashee (a range within the Rockies) and Cascade mountains in British Columbia.

The Columbia River is the largest river in the Pacific Northwest and, with a length of 1953 km (1214 mi), is the 15th longest in North America. From its source at Columbia Lake at an elevation of 809 m (2650 ft) in Canada's Selkirk Mountains it first flows north-westward through eastern British Columbia, then turns southward toward the United States. It crosses the US-Canadian border north of Spokane, Washington, then flows southward across central Washington where it is joined by the Snake River, which drains southeastern Washington, eastern Oregon and southern Idaho. The Columbia then turns westward, forming the border between Washington and Oregon, flows through the Columbia River Gorge through the Cascade Mountains and on to its mouth at the Pacific Ocean near Astoria, Oregon.

The Columbia ranks sixth in North America in terms of runoff after the Mississippi, MacKenzie, St Lawrence, Nelson, and Yukon rivers and is ranked 32<sup>nd</sup> among rivers of the world in area drained. The major tributaries to the Columbia are the Kootenai and Flathead/Pend Oreille rivers which drain southeastern British Columbia, western Montana, and northern Idaho, the Snake River which drains western Wyoming, most of Idaho, eastern Oregon and southeastern Washington, and the Willamette River of western Oregon (Figure 2). There ten large drainages in the coastal basin of Washington, including Puget Sound (Figure 3), and four on the Oregon coast (Figure 4).

The climate of the region ranges from continental arid in parts of the Columbia Basin interior to alpine in the Coast and Cascade mountains to maritime rainforest in coastal areas. In parts of eastern Washington, eastern Oregon, and the Snake River basin an average of less than 200 mm (8 in.) of precipitation occurs annually. In contrast, some the coastal mountain rain forests receive more than 5100 mm (200 in.) of annual precipitation.

### C. WATER RESOURCE DEVELOPMENT

Before the river systems of the Northwest were

developed, the water resources mainly provided habitat for fish and wildlife, with people living along the shoreline to use the available food sources and to use the rivers for transportation. However, with the growth of both settlement and industry, the rivers have been developed for additional uses to meet the needs of the region: energy production, water supply, recreation, and flood control.

The first navigation locks constructed in the region were those on the Willamette River at Oregon City in 1873, which allowed navigation around the Willamette Falls, and in 1876 on the Columbia River two miles upstream of the present day location of Bonneville Dam, which allowed navigation around the treacherous cascades. The Willamette Locks are still in operation while the Cascade Locks were no longer needed when the construction of Bonneville Dam and Locks provided slack-water navigation up to The Dalles, Oregon. The lock walls, without the gates, can still be seen in the park at Cascades Locks, Oregon.

Hydroelectric development in the Northwest began in the late 1880's when electric "dynamos", now called generators, were installed on the Spokane River in Spokane, on the Willamette River at Oregon City, and on the Snoqualmie River at Snoqualmie Falls, east of Seattle. Harnessing the energy of the mainstem Columbia River did not begin until the Chelan County PUD #1 completed the construction of Rock Island Dam near Wenatchee in 1932, followed closely by the construction of Grand Coulee and Bonneville dams in the late 1930's. Bonneville was constructed with state-of-the-art fish ladders to assist the passage of returning salmon.

There were two other main periods of federal dam construction in the basin. The first was in the 1950's when Hungry Horse, Chief Joseph, The Dalles, McNary, Albeni Falls, and Ice Harbor dams were built, and the second was in the mid-1970's when the Columbia River Treaty projects (Libby, Mica, Duncan, and Keenleyside), Dworshak, and three lower Snake projects (Lower Granite, Little Goose, Lower Monumental) were built. Most of the construction of public utility and privately owned dams was also during these periods.

The river resource development responded to the region's population that had grown from approximately 2.8 million in 1933 to more than eight million today. Storage projects on the Columbia and lower Snake basins contain more than 53 billion cubic meters (43 million af) of usable flood control space and were authorized primarily for flood control, hydroelectric energy generation, irrigation, and navigation. Other uses include fish and wildlife enhancement, recreation, low-flow augmentation, and municipal and industrial water supply. Figure 5

is a schematic drawing of the interrelationship of the operation of the projects in the Northwest. It also includes some of the key streamgages whose data are used in regulating the many reservoirs in the region.

#### **D. TYPES OF RESERVOIR PROJECTS**

Many so-called "reservoir" projects are actually "run-of-river," or "pondage" projects that have little or no storage capacity in comparison to their streamflow. Since these projects cannot store streamflow they generate electric energy with the water as it flows past the project. Bonneville, The Dalles, and McNary on the lower Columbia, the projects on the mid-Columbia (Priest Rapids to Chief Joseph), and Ice Harbor to Lower Granite on the lower Snake River are examples of pondage projects.

Some projects are designed specifically for daily reregulating of outflows from an upstream project. Big Cliff and Dexter Reservoirs in the Willamette Basin are examples of this type of reservoir, because they regulate and smooth out the peaking discharges caused by fluctuations in power generation at Detroit and Lookout Point dams, respectively, while their own outflows remain relatively constant.

A true storage reservoir is one that generally fills and drafts on an annual cycle. Some are "annual" storage reservoirs which are drafted to the minimum conservation pool and yet refill every year. Foster, Pend Oreille Lake, and Kootenay Lake are examples of annual reservoirs. Other storage reservoirs are "cyclic" because they may not refill each year. The amount of drawdown of cyclic reservoirs is based on volume inflow forecasts. Dworshak, Libby, Hungry Horse, Mica, Keenleyside, and Duncan dams are examples of cyclic reservoirs.

Another feature of storage reservoirs is the existence of at-site power generating facilities. Arrow and Duncan dams, for example, do not have at-site generation but yet have significant power benefits because water released from them can be timed to pass through many powerhouses downstream at times of peak power demands.

#### **E. ANNUAL REGULATION CYCLE**

There are two different regulation cycles for storage reservoirs in the Northwest. In the Northwest interior, where springtime snowmelt is the main source of river flows in the Columbia River, water is released from reservoirs during the cold winter period to generate electricity to meet the higher power demands and to prepare the reservoirs to store the snowmelt of the next spring and summer. In years with large snowfalls, flood control requirements may require additional drafting before snowmelt begins. The reservoirs are then filled during the snowmelt period, April through August, retaining the stored water for the next cycle and achieving flood control objectives in the process. After filling, the reservoirs generally remain as full as possible until the end of the summer recreation season, then they are lowered again in the fall to repeat the cycle.

West of the Cascade Mountains, where much of the winter precipitation falls as rain, the regulation is quite different. During the late summer and fall, reservoirs are lowered (drafted) to provide flood control space for possible winter rain-produced floods. Winter drafting of reservoir below set flood control limits, even for electric power generation, may reduce the chances of spring refill for summer use as flow augmentation and recreation. If winter flood control operation is required, the stored water is released as soon as possible after the flood to regain storage space for controlling subsequent floods. Most of the reservoirs west of the Cascades begin seasonal refilling during February in proportion to the decreasing magnitude and possibility of flooding. This operation continues until the reservoirs finally reach their maximum level which is normally during late May. The reservoirs are usually held as full as possible during the summer for recreational use, although some downstream water uses may require some reservoir drafting. Drawdown must begin in the fall so that by November or early December there is sufficient storage space for winter flood control.





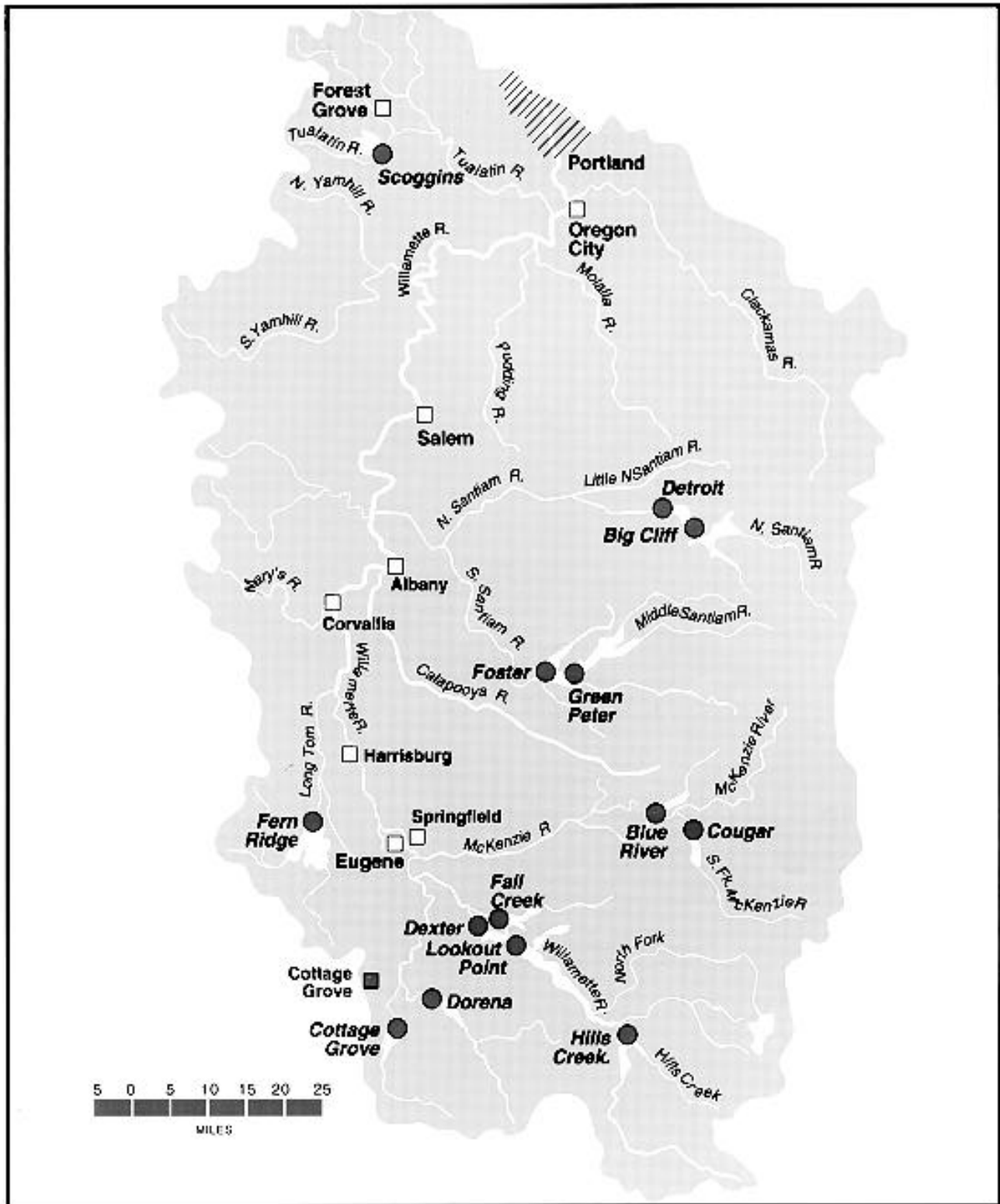


Figure 2. WILLAMETTE RIVER BASIN MAP

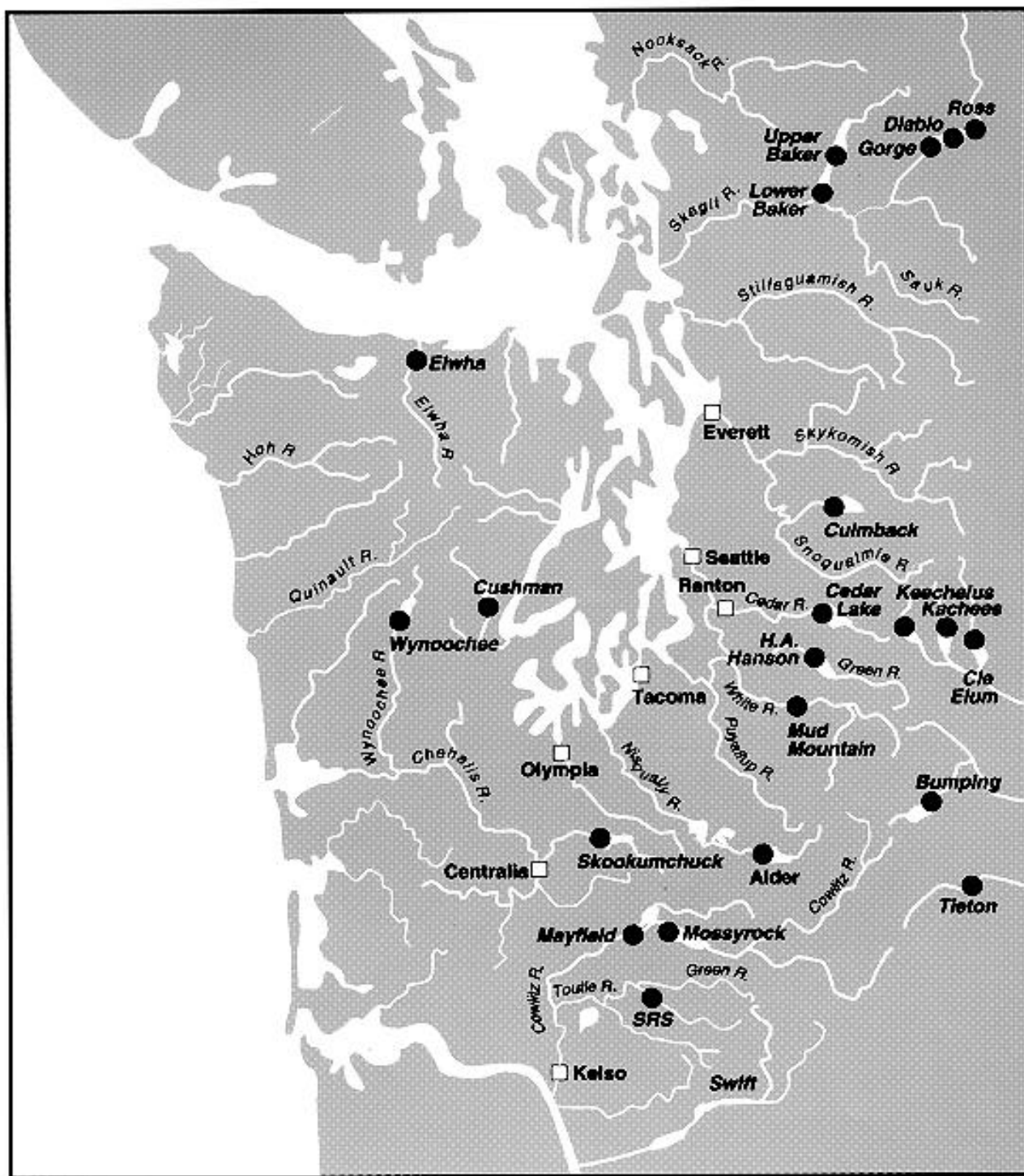


Figure 3. **WESTERN WASHINGTON MAP**

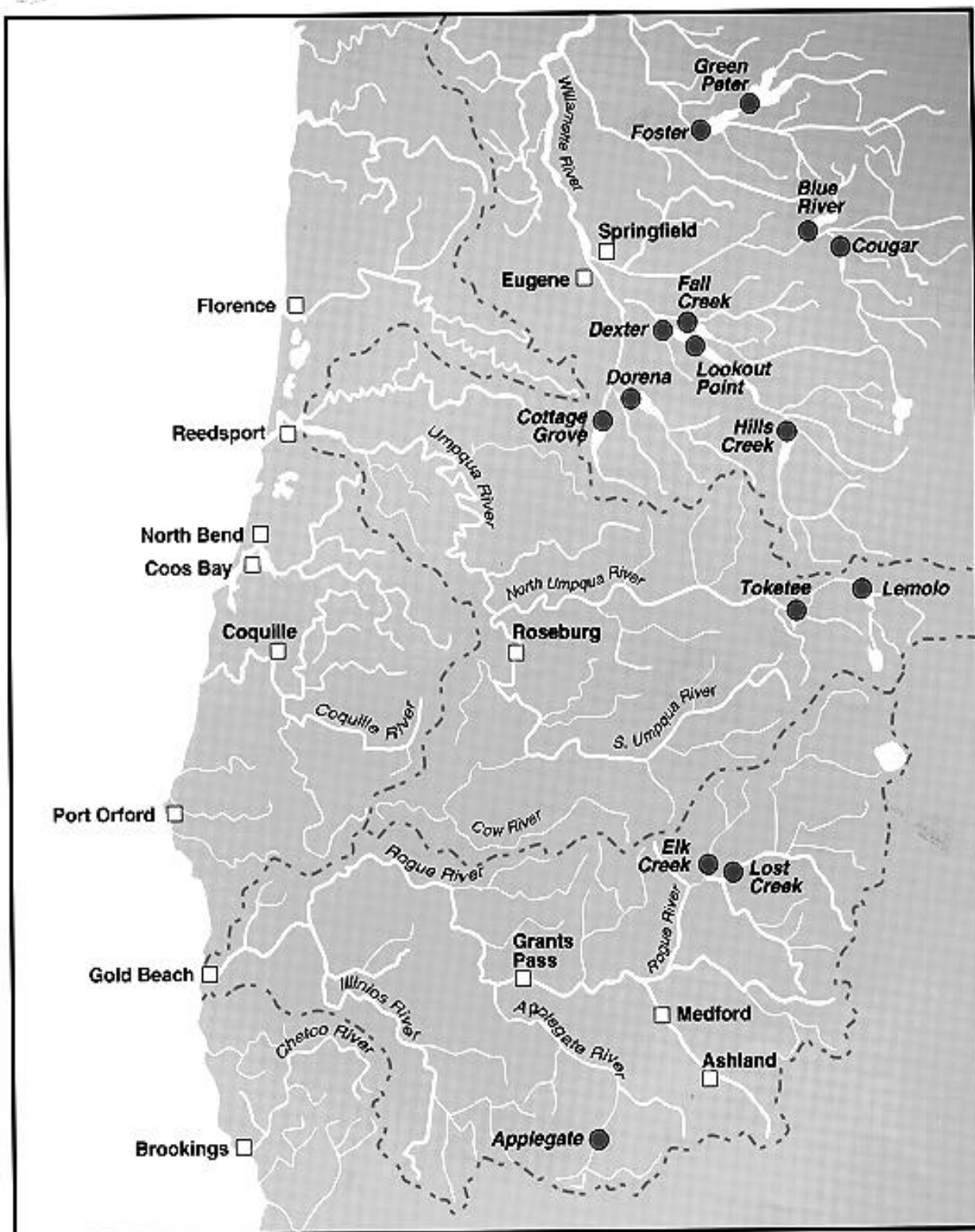


Figure 4. **SOUTHERN OREGON COASTAL BASINS MAP**



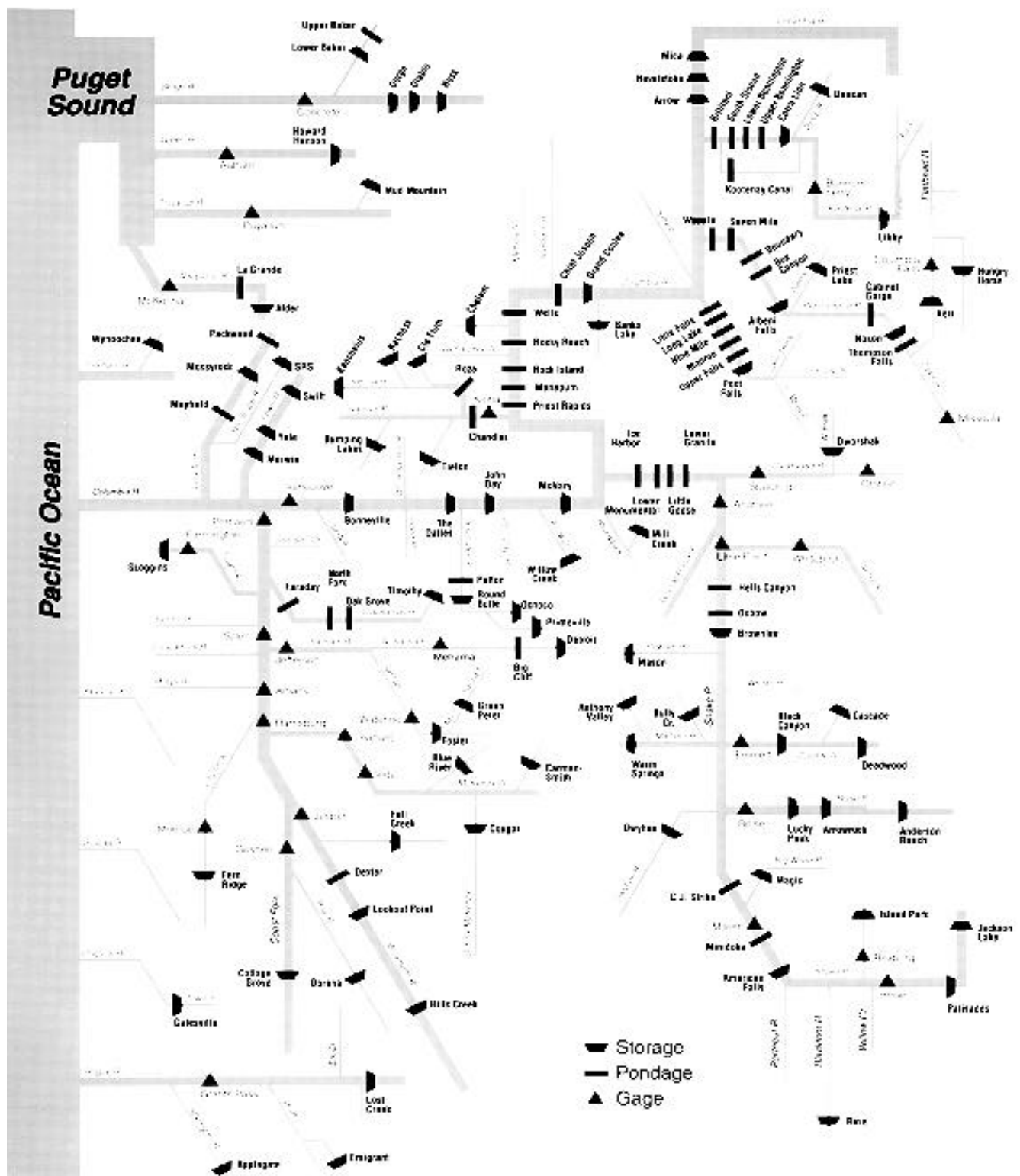


Figure 5. PACIFIC NORTHWEST RESERVOIR SYSTEM SCHEMATIC