WATER UTILIZATION AND DEVELOPMENT IN THE WILLAMETTE RIVER BASIN

by

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Typed by Kate D. Humeston

TABLE OF CONTENTS

CHAPTER PAGE

LIST OF FIGURES

Figure Page

LIST OF TABLES

WATER UTILIZATION AND DEVELOPMENT IN THE WILLAMETTE RIVER BASIN

CHAPTER I

INTRODUCTION TO THE STUDY

Statement and History of the Problem

The most casual observer of the development of the Pacific Northwest is continually brought to an awareness of the problem of water utilization and development. The stream run-off from this area alone is greater than from all of the remaining area west of the Mississippi River (18, 15). In the fall of 1948, the U. S. Bureau of Reclamation initiated a study known as the United Western Investigation. This study was undertaken to determine what surpluses over the maximum projected local needs might exist in streams of the Northwest. Irrigation needs were assumed for all farm lands that would ever conceivably need them. The inventory made of such lands listed about 25 million acres. Nevertheless, the future maximum consumption in the Northwest thus estimated, was dwarfed by the surplus which would be four times as great. It was found that approximately 240 million acre-feet per year of water from the streams would be wasted to the sea even under optimum conditions when full development was realized.

The potential benefits of the Northwest water resources are only beginning to be approached. Controversial issues in this field as in all others are frequently not discussed or presented with any degree of rationality. Judgment values, based solely on vested interest rights, are expressed in many cases. Frequently these interests are contradictory in nature. Views of some of the current major controversies relating to the larger issues such as, "A Columbia River TVA," "Water from the Pacific Northwest for Deserts of the Southwest," "Private Versus Public Dam Construction on the Snake River," and others, would be better judged upon values other than those of vested interest groups, political affiliation, and propaganda.

We face, in Oregon, the development and utilization of the water resources of the Willamette River and its tributaries only as a part of the development of such resources in the Northwest as a whole. It is believed that an intensive and comparatively non-technical study of this smaller segment would be profitable. Therefore, this analysis is concerned only with the problems innate to this limited area. Summarized, the problem set up for this thesis was:

(1) to obtain pertinent information contained in published studies relative to water utilization and development of the Willamette River, and to review such literature;
(2) to select and incorporate into this study such data as would be of value in understanding the problems of the area; and
(3) survey the existing as well as the proposed development of this area's water resources.

Historical Recorded Data

Data on published studies in this area were furnished by the Corps of Engineers and are chronologically arranged in Table 1. From this table it appears that the first local study was made in 1897 and related to navigation on a tributary. The same tributary came under a similar investigation in 1926. Actual studies of multipurpose development and control seem to be one of the beneficial effects of the depression, so called, "make work projects."

A request to Senator Wayne Morse of Oregon for additional historic studies was graciously fulfilled. House Document Number 214, 82nd Congress, 1st Session, on Improvement of Rivers and Harbors giving a compilation of all preliminary examinations, survey and review reports of river and harbor and flood control improvements made up to July 1, 1950, was sent to this writer. The extracts pertinent to this study are shown in Table 2.

Through the courtesy of Senator Morse, the Library of Congress Legislative Reference Service did much to assist in determining available cross references not included in either Tables 1 or 2 which superseded the basic reports with current review surveys since July 1, 1950.

Procedure Used to Explore the Data

The procedure consisted of integrating the data in the following manner:

(1) Photostatic copies of basic engineering drawings and maps made by the Portland District, Corps of Engineers, of the Willamette River Basin were made to be used as a skeletal framework of reference on which both watershed and development facts could be integrated.

(2) The latest published report of the Chief of Engineers, United States Army, Columbia River and Tributaries, was scanned for data pertinent to the Willamette River.

(3) A review was made of the literature and all relevant data was extracted in the form of notes and integrated with the maps and drawings of the area.

(4) Selection was made from amassed information of data lying within reasonably abbreviated limits to serve as an overview of the area studied, in reference to existing and proposed water utilization and development.

Table 1. Showing data from prior published reports pertaining to the use or development of water resources of the Willamette River Sub-basin.

Reference	Scope	Stream	by	Date	Remarks
1. H. Doc. 127, 55th Cong., 2nd Session	Preliminary Examination	Long Tom River	War Dept.	1897	Navigation
2. H. Doc. 467, 69th Cong., 1st Session	Preliminary Examination	Long Tom River	War Dept.	1926	Navigation
3. H. Doc. 263, 72nd Cong., 1st Session	Survey	Willamette River	War Dept.	1931	Multipurpose
4. Water Supply Paper 637c	Power	McKenzie River	U.S. Geological Survey	1931	
5. H. Doc. 544, 75th Cong., 3rd Session	Review Survey	Willamette River and Tributaries	War Dept.	1938	Multipurpose
6. S. Doc. 185, 76th Cong., 3rd Session	Review	Pudding River	War Dept.	1940	Food Control
7. Water Supply Paper 890	Ground Water Resources	Willamette River	U.S. Geological Survey	1942	Willamette Valley
8. S. Doc. 138, 79th Cong., 2nd Session	Survey	Amazon Creek	War Dept.	1946	Flood Control

Source: 48, 1688

Table 2. Preliminary examination and survey reports made prior to July 1, 1950.

Locality	Preliminary Examination Date of Report	Surveys Date of Report	Congressional Documents: Where Published: House or Senate: Number, Congress, Session.	Annual Report of Chief of Engineers Year	Page
Willamette River					
Above Oregon City		Dec. 23, 1870	S. Ex 14-41-3	1871	905
	July 28, 1892		H. Ex 36-52-2	1893	3529
and Tributaries	Dec. 7, 1931		H. 263-72-1		
Flood Control		Apr. 17, 1937	H. 544-75-3		
At the Falls	Nov. 29, 1902		H. Ex 99-58-3	1905	2497
Clackamas Rapids	Nov. 19, 1890	Sept.30, 1891	H. 28-52-1	1892	2840
Columbia and Lower	Oct. 6, 1890	Sept. 8, 1891	H. 38-52-1	1892	2850
Willamette Rivers	Apr. 6, 1899	Apr. 12, 1900	H. Ex 673-56-1	1900	4416
Corvallis to Eugene	Nov. 13, 1916	Dec. 30, 1916	H. 195-65-1		
Eugene to Springfield		Apr. 17, 1937	H. 544-75-3		
Falls at Oregon City	Feb. 23, 1910	Apr. 24, 1911	H. Ex1060-62-3		
Near Corvallis	Nov. 19, 1890	Oct. 30, 1891	H. 28-52-1	1892	2840

Continued on the next page

Table 2. (Continued)

Locality	Preliminary Examination Date of Report	Surveys Date of Report	Congressional Documents: Where Published: House or Senate: Number, Congress, Session.	Annual Report of Chief of Engineers Year	Page
Opposite Albany	July 23, 1902	Apr. 13, 1903	H. Ex 476-58-2	1904	3564
Opposite Salem		Oct. 8, 1897	H. 120-55-2	1898	3051
Oregon City to Eugene	Jan. 19, 1910	Dec. 3, 1910	H. 13-62-1		
	Nov. 21, 1913		H. 790-64-1		
Portland to Eugene		Feb. 3, 1896	H. 260-54-1	1896	3309
	Jan. 26, 1931	Feb. 3, 1933			
		Apr. 17, 1937	H. 544-75-3		
Portland to Oregon City	Aug. 14, 1902	May 1, 1903	H. 504-58-2	1904	3559
	Oct. 28, 1910	May 17, 1911	H. 438-62-2		
	Jan. 13, 1931		H. 748-71-3		
Portland to Salem	Mar. 13, 1928	Feb. 21, 1929			
		Dec. 21, 1929	H. 372-71-2		
Ross Island and West Side of Swan Island	Nov. 19, 1890	Sept.30, 1891	H. Ex 28-52-1	1892	2840
	Nov. 18, 1890		H. Ex 74-51-2	1891	3373
Willamette Falls Canal and Locks	Apr. 30, 1899	Nov. 24, 1899	H. 202-56-1	1900	4368

Source: 59, p 468

Organization of the Data

The legislation embodied in House Document Number 308, 69th Congress, 1st Session, 1928, and enacted into law in the River and Harbor Act of Jan. 21, 1927 initiated a fact finding system which makes studies of this nature possible. It directed the Chief of Engineers, United States Army, to prepare technical reports on the principal river systems of the United States from the four-fold standpoints of navigation, flood control, power development, and irrigation.

The impressive collection of "House Document Number 308 Reports," published between 1928 and 1938 helped to establish the concept of basin development and multiple purpose reservoirs. Subsequent surveys and review surveys of Federal Agencies and private engineers, as well as other professional people , have continued the steady stream of basic data.

Chapter II of this study is in reality an extraction of the basic hydrology of the Willamette River and its tributaries from the amazing mass of data which began to accumulate with the "308 Reports." In so far as possible the government tabulations and statements have been cross checked for agreement with local interested agencies. The data selected is regarded as critical to an understanding of all water utilization and development projects.

Chapter III represents the developmental thinking which originated with the first preliminary flood control investigation by the Corps of Engineers in 1934 which was followed by more detailed studies in 1935 and 1936. The culmination of these projects was the 1938 Flood Control Act as the Willamette Basin Project. To this overall unitary planning has been added all other governmental and private developments utilizing water which has been officially reported within the basin.

Chapter IV is a summarization of the existing and under construction projects of water utilization of the Willamette River and its tributaries. The latest published report (1951) on the Columbia River and Tributaries by the Secretary of the Army has been cross checked and brought up to date (July 28, 1953) by personal rechecking of the data with the Portland Office of the Corps of Engineers and a review of latest pertinent technical reports available at the Portland Public Library and the Oregon State College Library.

CHAPTER II

THE WILLAMETTE RIVER WATERSHED

Orientation

The Willamette River and its tributaries occupy a watershed area of 11,200 square miles, which is roughly rectangular in shape, with a maximum north-south dimension of about 150 miles and an average width east-west of approximately 75 miles. This basin flows northward and empties into the Columbia River near Portland. Figure 1 shows the relationships between the Willamette River and its tributaries. Figure 2 shows the network of the basin.

Orography

The valley floor is located slightly west of the center of the Willamette Valley. The sides of the floor slope upwards to foothills and terminate in the mountains on the east, south, and west. The valley floor proper extends from Eugene almost to the mouth of the river. The major portion, 3,500 square miles in area, lies below an elevation of 500 feet, mean sea level.

To the west, the Coast Range (highest elevations 3,000 to 4,000 feet) separates the Willamette River watershed from that of the coastal slope and plain.

To the east, the Cascade Range (elevations in excess of 10,000 feet) forms a boundary which separates the

Willamette River watershed area from that of the Deschutes River.

To the south, the Calapooya Mountains (elevations rising to 5,000 feet) separate the Willamette and the Umpqua River watersheds.

The Willamette River proper has its origin at the confluence of its Coast and Middle Forks above Eugene (435 feet elevation). It flows for 188 miles through fertile farmlands, passes the Kiezer and Windsor Island Rapids below Salem, drops 47.45 feet at Willamette Falls and finally joins the Columbia River.

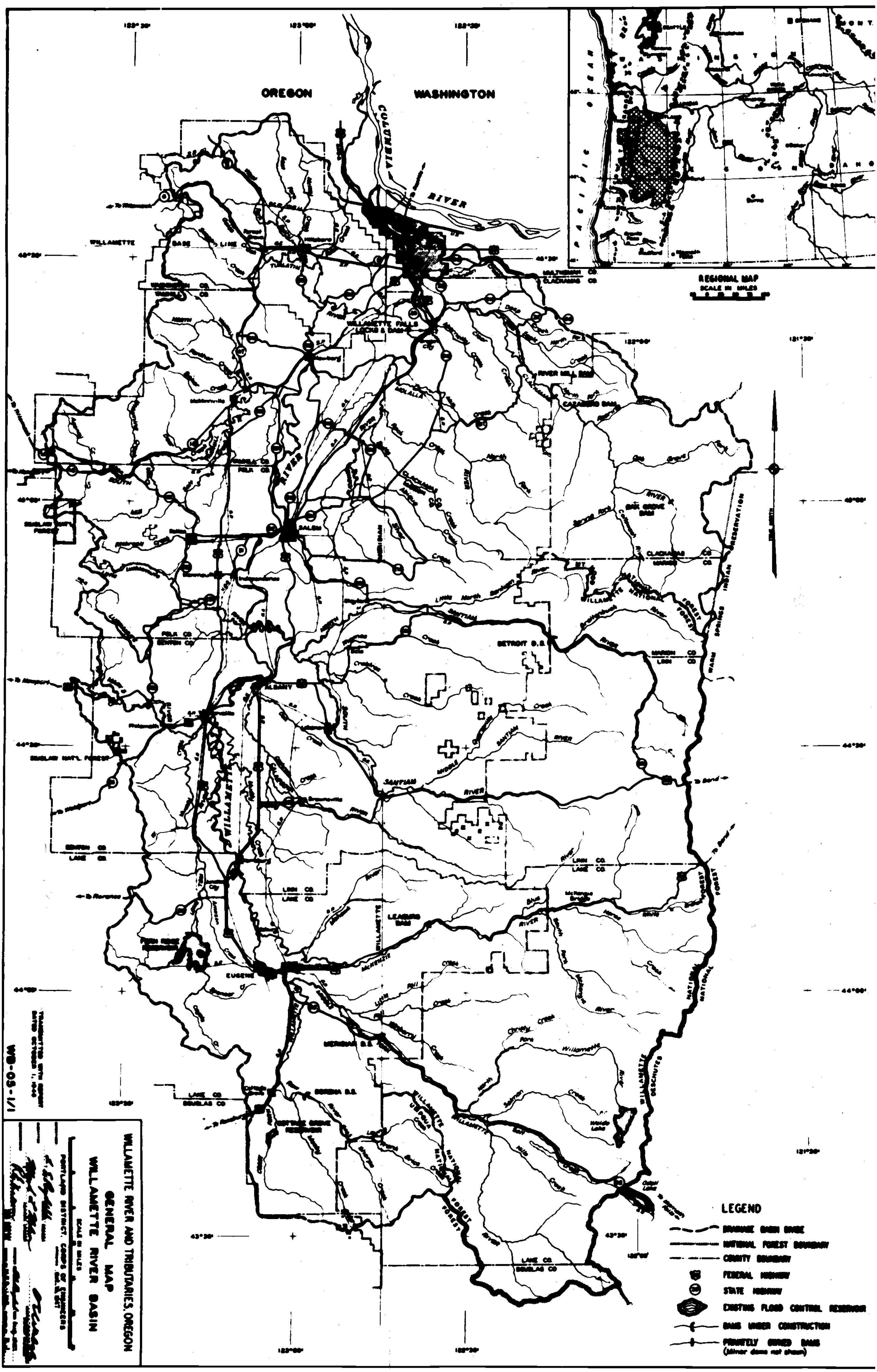
Many tributaries, ranging from small mountain streams to prominent rivers in their own right, flow down the mountain sides and then meander across the valley floor to join the Willamette River. The headwaters of the majority of the west side tributaries originate at elevations of 1,000 to 2,900 feet, while those on the east rise in the Cascade Range at elevations in excess of 6,000 feet. Figures 3, 4, and 5 show specific basin profiles of the Willamette River and its major tributaries.

Geology

The Willamette Valley is a portion of a trough, partly structural and partly erosional. The Willamette Valley of Oregon and the trough of Puget Sound through Queen Charlotte

Figure 1

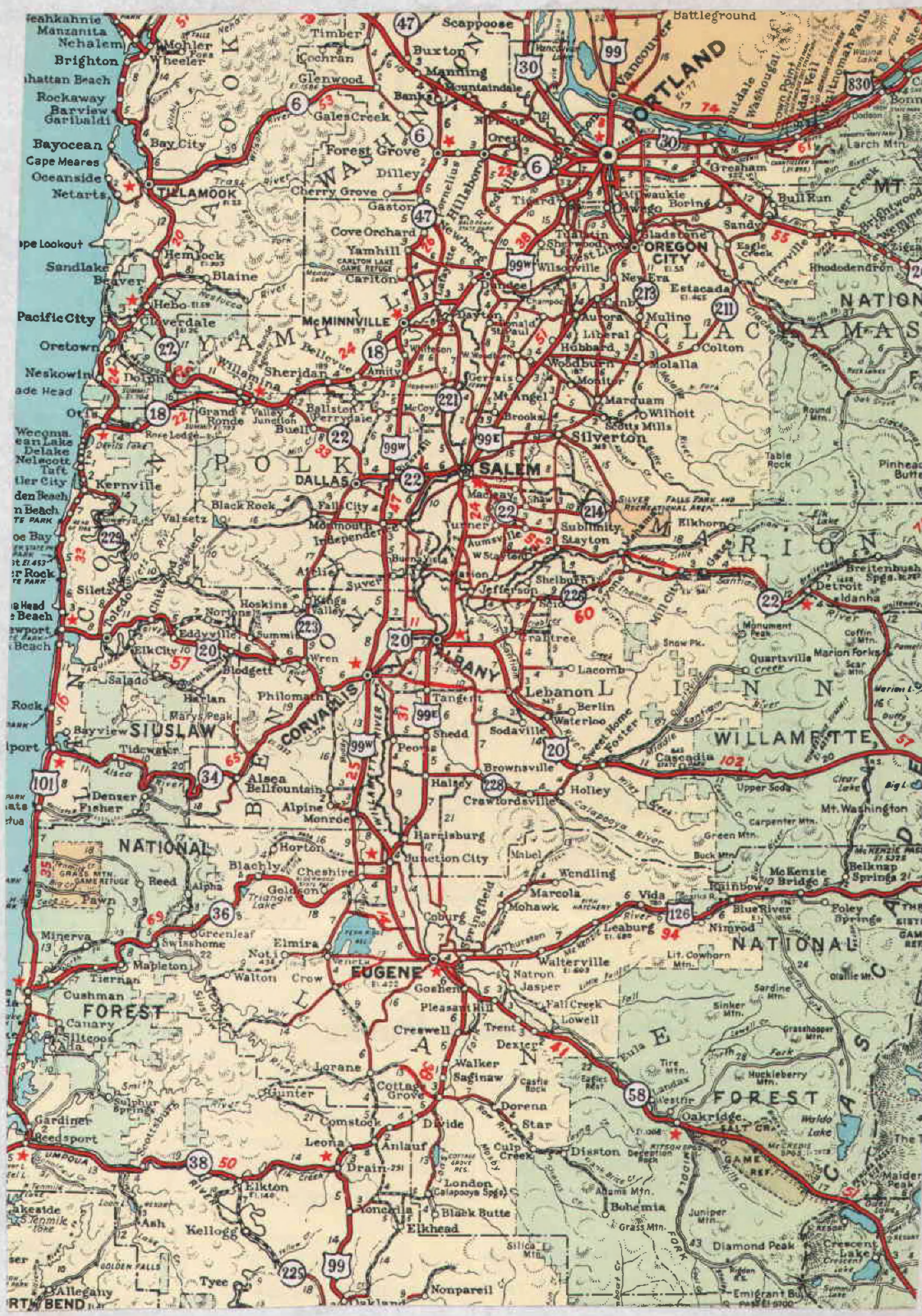
General Map, Willamette River Basin



WILLAMETTE RIVER AND TRIBUTARIES, OREGON
GENERAL MAP
WILLAMETTE RIVER BASIN
PORTLAND DISTRICT, CORPS OF ENGINEERS
WB-03-1/1
OREGON
WASHINGTON
COLUMBIA RIVER
REGIONAL MAP
SCALE IN MILES
WILLAMETTE FALLS LOCKS & DAM
RIVER MILL DAM
CAZADERO DAM
OAK GROVE DAM
DETROIT D.S.
SALEM
ALBANY
EUGENE
LEABURG DAM
MERIDIAN D.S.
DORENA D.S.
COTTAGE GROVE RESERVOIR
FERN RIDGE RESERVOIR
SANTIAM RIVER
McKENZIE RIVER
WILLAMETTE RIVER
WARM SPRINGS INDIAN RESERVATION
WILLAMETTE NATIONAL FOREST
DESCHUTES NATIONAL FOREST
SIUSLAW NAT'L FOREST
MARION CO.
LINN CO.
LANE CO.
BENTON CO.
POLK CO.
DOUGLAS CO.
MULTNOMAH CO.
CLACKAMAS CO.
WASHINGTON CO.
YAMHILL CO.
LEGEND
DRAINAGE BASIN DIVIDE
NATIONAL FOREST BOUNDARY
COUNTY BOUNDARY
FEDERAL HIGHWAY
STATE HIGHWAY
EXISTING FLOOD CONTROL RESERVOIR
DAMS UNDER CONSTRUCTION
PRIVATELY OWNED DAMS
(minor dams not shown)

Figure 2

Oregon State Highway Map, Willamette
River Basin Quadrangle


PORTLAND
Battleground
Vancouver
Scappoose
Timber
Buxton
Manning
Cochran
Glenwood
Banks
Mountaindale
Gales Creek
Forest Grove
Dilley
Cherry Grove
Gaston
Cove Orchard
Yamhill
Carlton
Gresham
Boring
Milwaukie
Oswego
Tigard
Sherwood
Wilsonville
Gladstone
OREGON CITY
Eagle Creek
Sandy
Bull Run
Larch Mtn.
Rhododendron
New Era
Estacada
Mulino
Aurora
Hubbard
Woodburn
Molalla
Colton
Monitor
Marquam
Wilhoit
Scotts Mills
Silverton
Mt. Angel
Brooks
SALEM
McMINNVILLE
Dayton
Amity
Whiteson
Sheridan
Willamina
Grand Ronde
Valley Junction
Ballston
Perrydale
Buell
DALLAS
Falls City
Black Rock
Monmouth
Independence
Turner
Aumsville
Sublimity
Stayton
Elkhorn
Breitenbush
Detroit
Idanha
Jefferson
Shelburn
Scio
Crabtree
Albany
Lebanon
Lacomb
Berlin
Waterloo
Sodaville
Sweet Home
Foster
Cascadia
Brownsville
Halsey
Crawfordsville
Holley
Harrisburg
Junction City
Tangent
Shedd
Peoria
CORVALLIS
Philomath
Wren
Summit
Blodgett
Kings Valley
Hoskins
Airlie
Eddyville
Elk City
Nortons
Toledo
Siletz
Kernville
Valsetz
Alsea
Bellfountain
Alpine
Monroe
Horton
Blachly
Cheshire
Triangle Lake
Greenleaf
Swisshome
Mapleton
Tiernan
Cushman
Canary
Siltcoos
Gardiner
Reedsport
Elmira
Noti
Walton
Crow
Veneta
EUGENE
Goshen
Pleasant Hill
Creswell
Trent
Dexter
Lorane
Cottage Grove
Walker
Saginaw
Dorena
Star
Comstock
Divide
Leona
Anlauf
Drain
Elkton
London
Black Butte
Elkhead
Kellogg
Tyee
Nonpareil
Oakland
Allegany
NORTH BEND
Ash
Coburg
Springfield
Thurston
Walterville
Natron
Jasper
Fall Creek
Lowell
Marcola
Mohawk
Wendling
Mabel
Vida
Leaburg
Nimrod
Blue River
McKenzie Bridge
Rainbow
Belknap Springs
Foley Springs
Oakridge
Westfir
Landax
Disston
Culp Creek
Bohemia
Diamond Peak
Crescent Lake
Emigrant Butte
Waldo Lake
Mt. Washington
Upper Soda
Quartzville
Marion Forks
Coffin Mtn.
Snow Pk.
Table Rock
Pinhead Butte
Manzanita
Nehalem
Mohler
Wheeler
Brighton
Rockaway
Barview
Garibaldi
Bay City
Bayocean
Cape Meares
Oceanside
Netarts
TILLAMOOK
Hemlock
Sandlake
Beaver
Blaine
Hebo
Cloverdale
Pacific City
Oretown
Neskowin
Otis
Delake
Nelscott
Taft
Kernville
Siletz
Salado
Harlan
Marys Peak
Tidewater
Bayview
Denzer
Fisher
Reed
Alpha
Minerva
Pawn
Gardiner
WASHINGTON
YAMHILL
POLK
MARION
BENTON
LINN
LANE
CLACKAMAS
LINCOLN
TILLAMOOK
SIUSLAW
NATIONAL
FOREST
WILLAMETTE
NATIONAL
FOREST
CASCADE

Sound are parts of one continuous trough separating the Cascade Range from the Coast Range on the west. Condon's original evaluation of the geology of Oregon (10, pp 52-83, 134-147) is still valuable. Umbgrove's data on basins and troughs (47, pp 43-65) makes correlations easier to integrate.

The Coast Range in Oregon lies on a north-south axis. The highest point in this range is Mary's Peak with an elevation of 4,097 feet above sea level (41, p 43). The rocks occurring on the west side of the Willamette Valley in the Coast Range are a series of sediments, both marine and continental together with some volcanics. These formations range in age from the middle Eocene to the middle Miocene, and in general lie unconformably on each other. In the northern part of the range the middle Miocene Columbia River basalt unconformably overlies this sedimentary and volcanic series. Most of the rocks dip generally to the east, probably extending under the valley floor (48, p 1685).

The ages of the rocks of the Cascade Range on the east vary from Eocene to Pleistocene, and are almost entirely composed of lava flows and associated pyroclastics and stream deposits. These rocks are divided into a High Cascade and a Western Cascade series. The High Cascade rocks are found on the range summit and occur along the eastern end of the Willamette watershed. These rocks,

Figure 3

Basin Profiles, East Side Tributaries,
Sheet Number 1

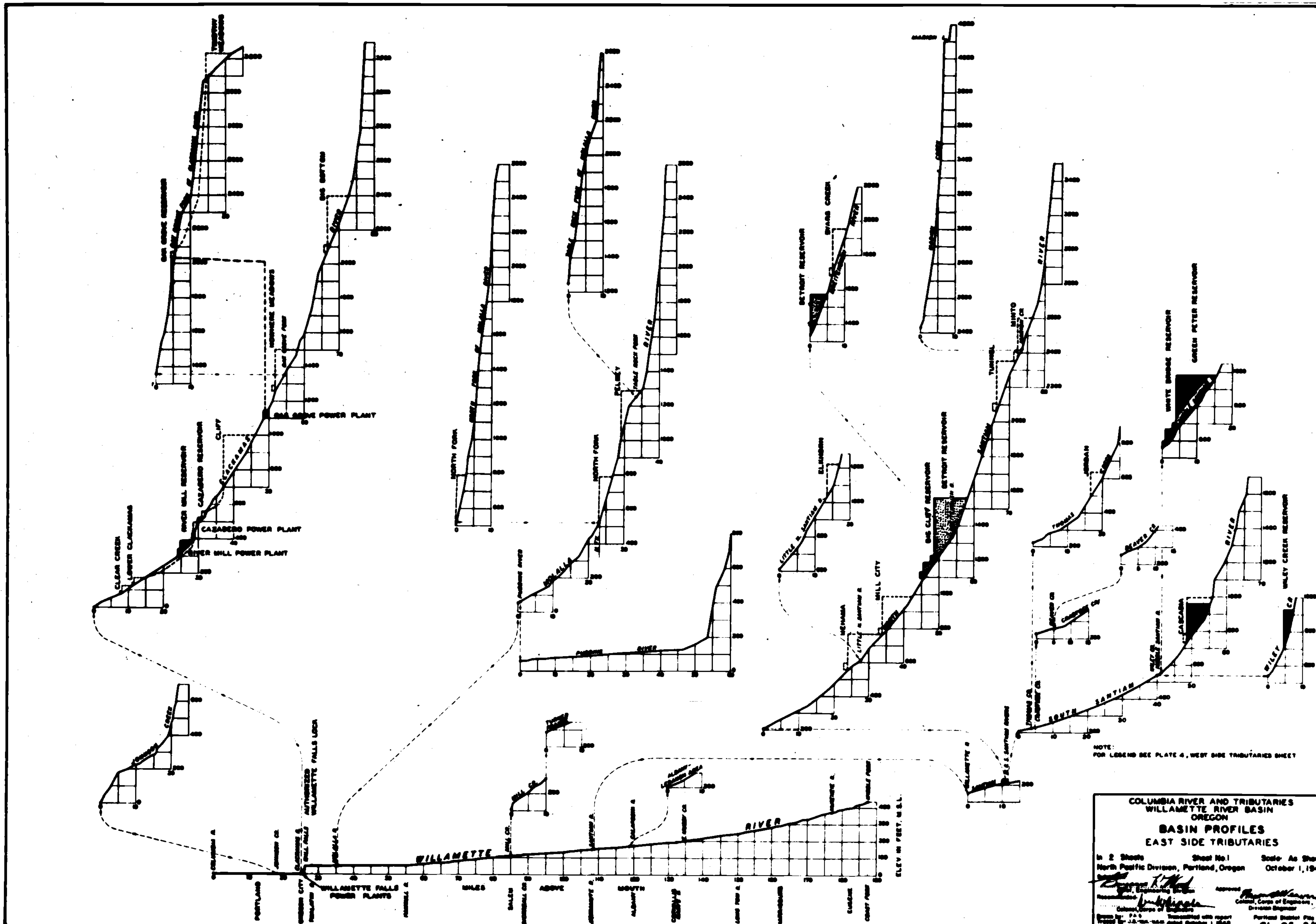
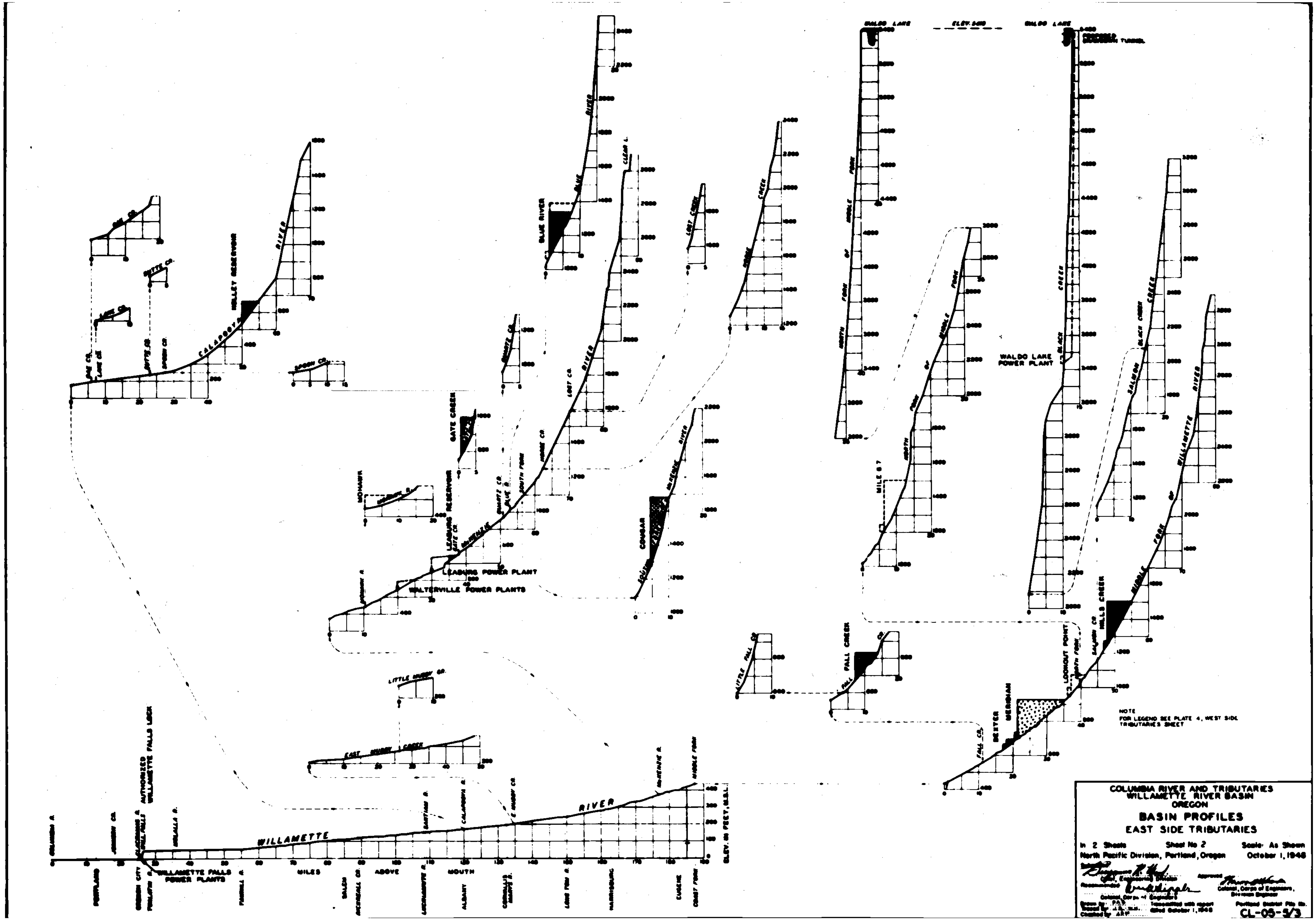

CLACKAMAS
BIG CLIFF RESERVOIR
DETROIT RESERVOIR
MILL CITY
WHITE BRIDGE RESERVOIR
GREEN PETER RESERVOIR
WILEY CREEK RESERVOIR
SOUTH SANTIAM
WILLAMETTE
RIVER
WILLAMETTE FALLS POWER PLANTS
MILES ABOVE MOUTH
ELEV IN FEET, M.S.L.
NOTE:
FOR LEGEND SEE PLATE 4, WEST SIDE TRIBUTARIES SHEET
COLUMBIA RIVER AND TRIBUTARIES
WILLAMETTE RIVER BASIN
OREGON
BASIN PROFILES
EAST SIDE TRIBUTARIES
In 2 Sheets
Sheet No. 1
Scale: As Shown
North Pacific Division, Portland, Oregon
October 1, 1948
Colonel, Corps of Engineers, Division Engineer
CL-05-3/2

Figure 4

Basin Profiles, East Side Tributaries,
Sheet Number 2.



COLUMBIA RIVER AND TRIBUTARIES
WILLAMETTE RIVER BASIN
OREGON

BASIN PROFILES

EAST SIDE TRIBUTARIES

In 2 Sheets — Sheet No 2 — Scale: As Shown

North Pacific Division, Portland, Oregon — October 1, 1948

Colonel, Corps of Engineers — Approved: Colonel, Corps of Engineers, Division Engineer

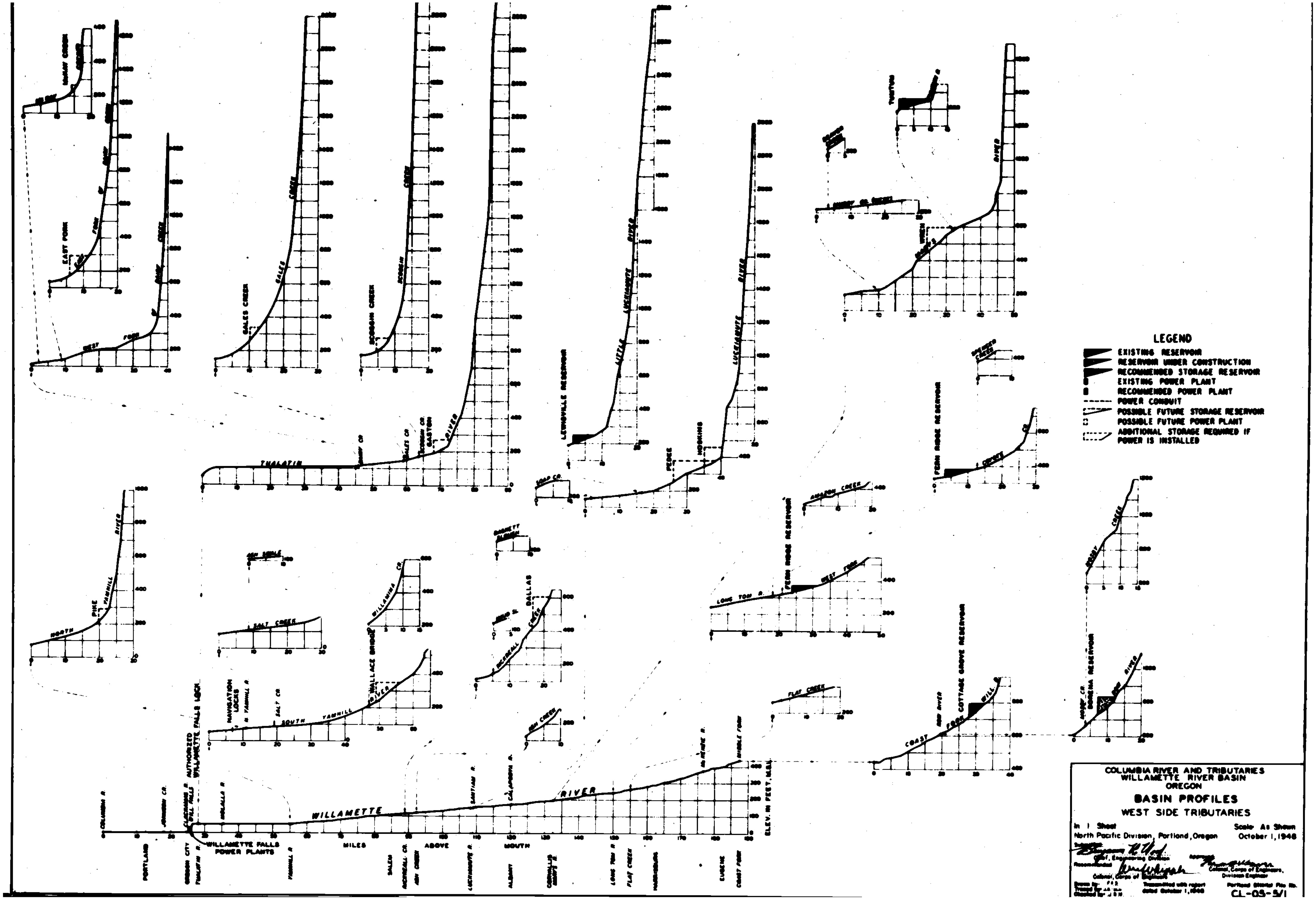
Drawn by: P.A.S. Traced by: J.S., M.M. Checked by: A.R.P.

Transmitted with report dated October 1, 1948

Portland District File No. CL-05-5/3

Figure 5

Basin Profiles, West Side Tributaries



COLUMBIA RIVER AND TRIBUTARIES
WILLAMETTE RIVER BASIN
OREGON

BASIN PROFILES

WEST SIDE TRIBUTARIES

In 1 Sheet — Scale As Shown

North Pacific Division, Portland, Oregon — October 1, 1948

CL-05-5/1

Pliocene and Pleistocene in age, consist generally of basalt flows upon which rest andesitic cones and show comparatively little stream dissection. The Western Cascade series are andesitic flows and extensive beds of pyroclastic rocks with minor amounts of black basalt along the western edge near the valley floor. The age of the Western Cascade series ranges from Eocene to Lower Pliocene and the rocks of this series show much more stream dissection than those of the High Cascades. In general, the latter series are bent into broad, gentle folds, (48, p 1685) (3, pp 199-212). Hussey gives detailed relevant basic data (19, pp 10-24).

The valley is filled with gravel and sand deposits, and bedrock does not occur near the surface except in a few places, mainly in the Salem Hills and at Oregon City. During Eocene and Oligocene times sedimentary formations, both marine and continental, were deposited in the valley. This period of deposition was interrupted at intervals by slight tilting of the land mass and by volcanic activity. During the same time, generally speaking, the lavas and volcanics were being erupted in the Western Cascades. During Miocene times the Columbia River basalt was poured out, especially in the northern portion of the present valley area. In early Pliocene the entire rock sequence was folded, producing a broad structural trough. Later in the Pliocene this trough was filled with alluvium, mostly sand

and gravel, and as there was a relative rise in sea level, the alluvial material collected to a depth of several hundred feet. The valley was uplifted in late Pliocene times, while the Cascade Range was subjected to glaciation, so that some additional alluvium and glacial outwash was deposited in the valley floor.

The Willamette River and its tributaries flow with considerable velocity through narrow, rock-walled canyons in the upper reaches. The character changes upon the flat valley floor. The velocities decrease thereby dropping much of the stream load and the streams tend to spread laterally. The main stem of the Willamette River from Eugene to the mouth of the Yamhill River, and also the lower reaches of the main tributaries, meander extensively. Their flood plains are characterized by braided channels, oxbows, and poorly drained swamps, (48, pp 1685-86).

Soil Types

A detailed cooperative Federal-State soil survey was started in Oregon in 1917. To date some 11,020,617 acres have been mapped. This includes all Willamette Valley counties. The work of Powers, Togerson, and Dannen on identification and productivity of Willamette Valley soil types (38), the work of Selby and Fryer (43) on Willamette Valley land adaptability, and the work of Powers and

Ruzek (39) on soil fertility in the Willamette Valley is of inestimable value in any evaluation of the resources base of this area. Figure 6 is a pictograph of the soil types found (38, p 11). Figure 7 shows a soil profile of Dayton Silty Clay Loam (38, p 10).

Climate

The Willamette Valley, lying between the 42nd and 46th parallels, is in the same latitude as Italy and Southern France. Like those lands, it enjoys a particularly benevolent climate. Extremes of heat and cold are practically unknown and there is freedom from the enervating high humidities during the summer.

The Willamette Valley climate may be designated as a mild sub-coastal type with wet, mild winters, a dry harvest season in late summer, and a remarkably prolonged growing season. Prevailing westerly winds bring the modifying effect of the ocean. The coldest winter weather and the warmest summer weather are associated with the advent of continental air masses from the north or east. These extreme conditions are modified by a change in air circulation back to a westerly component which again introduces the modifying effect of the Pacific Ocean.

The temperature of the basin is quite equable. The normal variation between the winter average and the summer average is small, ranging at lower levels from about 40 degrees in January to about 67 degrees in July. Minimum temperatures rarely drop below zero degrees, and maxima seldom exceed 100 degrees. With increased elevations the temperature usually decreases at the rate of approximately 3 degrees per thousand feet. Table 3 gives temperature data for representative stations in the Willamette Valley. Table 4 shows dates of killing frost and average growing season for three stations along the north to south axis of the valley.

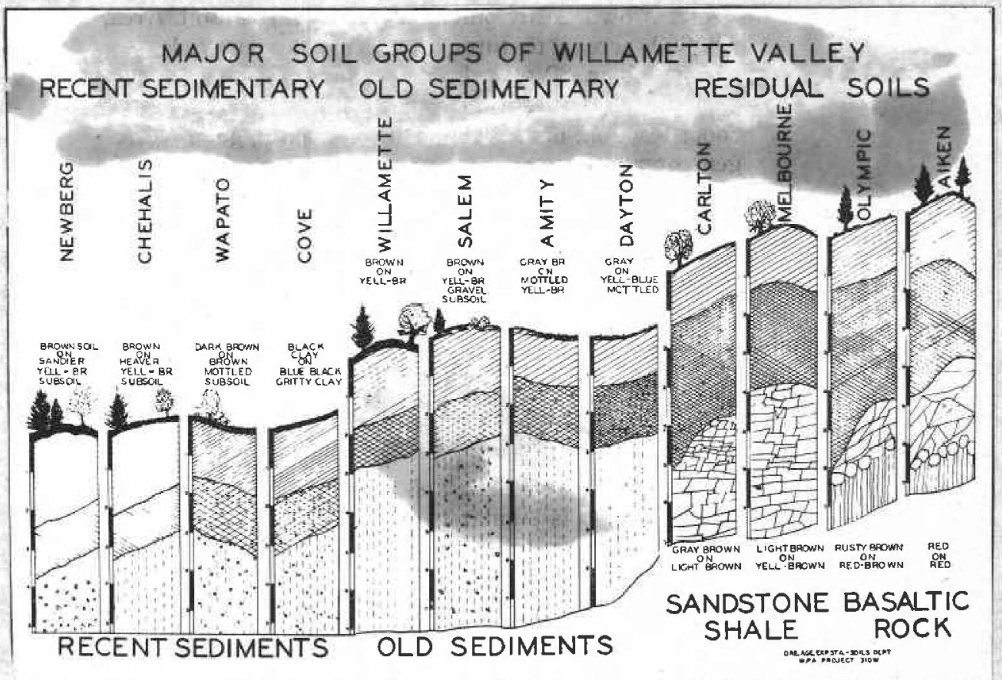
Weather records at Oregon State College have been published by Powers for a period 1889 to 1950. Table 3 is a direct extract from his report. Since the climate at Corvallis is fairly representative of the Willamette Valley the information is pertinent to this overview.

Precipitation

The average annual precipitation over the basin is 61 inches, but totals vary considerably. The precipitation exceeds 140 inches over small areas of the Coast Range, decreases rapidly on the lee slope to average less than 40 inches in the alluvial plain. It approaches a minimum of 30 inches near the center of the valley floor, then increases on the Cascade slopes to more than 120 inches. Figure 8 is a reproduction of the isohyetal map for this

Figure 6

Major Soil Groups of the Willamette Valley
Source (38, 11).



MAJOR SOIL GROUPS OF WILLAMETTE VALLEY
RECENT SEDIMENTARY
OLD SEDIMENTARY
RESIDUAL SOILS
NEWBERG
CHEHALIS
WAPATO
COVE
WILLAMETTE
SALEM
AMITY
DAYTON
CARLTON
MELBOURNE
OLYMPIC
AIKEN
BROWN ON YELL-BR
BROWN ON YELL-BR GRAVEL SUBSOIL
GRAY BR ON MOTTLED YELL-BR
GRAY ON YELL-BLUE MOTTLED
BROWN SOIL ON SANDIER YELL-BR SUBSOIL
BROWN ON HEAVER YELL-BR SUBSOIL
DARK BROWN ON BROWN MOTTLED SUBSOIL
BLACK CLAY ON BLUE BLACK GRITTY CLAY
GRAY BROWN ON LIGHT BROWN
LIGHT BROWN ON YELL-BROWN
RUSTY BROWN ON RED-BROWN
RED ON RED
SANDSTONE SHALE
BASALTIC ROCK
RECENT SEDIMENTS
OLD SEDIMENTS
ORE. AGR. EXP. STA. - SOILS DEPT
WPA PROJECT 310W

Figure 7

Soil Profile, Dayton Silty Clay Loam
Source (38, 10).

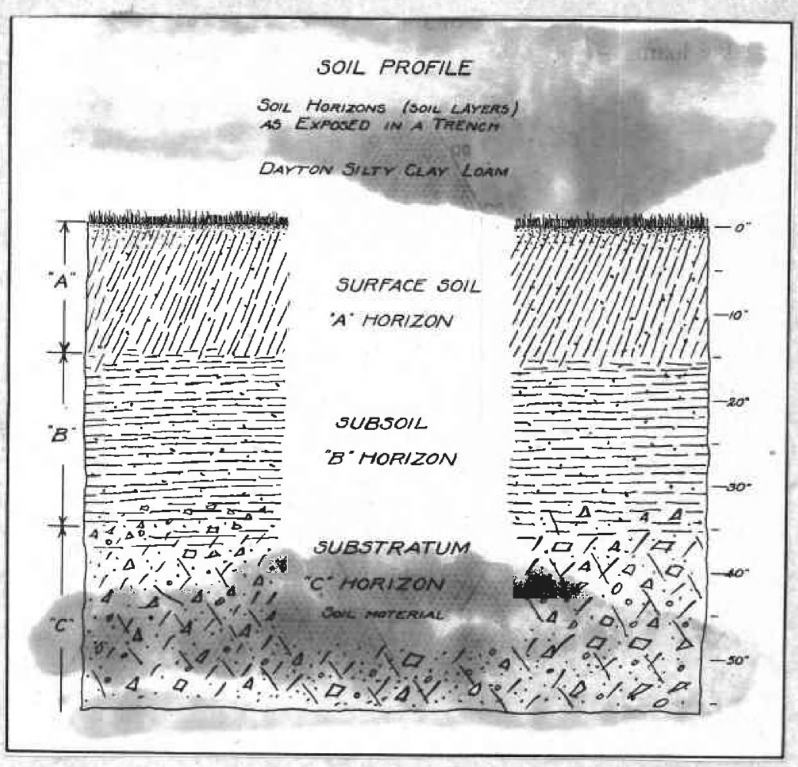

SOIL PROFILE
SOIL HORIZONS (SOIL LAYERS)
AS EXPOSED IN A TRENCH
DAYTON SILTY CLAY LOAM
"A"
"B"
"C"
SURFACE SOIL
"A" HORIZON
SUBSOIL
"B" HORIZON
SUBSTRATUM
"C" HORIZON
SOIL MATERIAL
0"
10"
20"
30"
40"
50"

Table 3. Showing Temperature Data for Representative Stations in the Willamette Valley.

Station	Elevation (feet).	Length of record, (years).	Annual mean	Jan. mean	July mean	Temperatures in Degrees Recorded Maximum	Minimum
Cazadero	503	30	52.7	39.4	65.6	109	-6
Eugene	450	40	52.5	40.1	65.9	104	-4
McKenzie Bridge	1,372	20	50.1	35.0	65.6	108	-3
Oakridge	1,313	15	53.0	36.9	67.7	110	0
Portland	30	40	53.1	39.4	66.7	107	-2
Salem	164	40	52.8	39.7	66.6	108	-6

Source: (48 p 1687).

area, based on Corps of Engineer data.

The outstanding characteristics of the precipitation regimen are the winter maximum and the summer minimum.

Table 4. Showing dates of killing frosts and average growing season for three stations along the north-south axis of the valley.

Station	Period of record. (years)	Dates of Killing Frost		Growing Season in days.
		Last in spring.	First in fall.	
Portland	76	Mar. 6	Nov. 24	263
Salem	55	Apr. 1	Oct. 31	213
Eugene	53	Apr. 13	Nov. 4	205

Source: (48, p 1688).

About 60% of the annual precipitation normally occurs during November, December, January, and February. Only about 10% of the annual total occurs during June, July, August, and September. November, December, and January each receive over 15% of the annual precipitation, in contrast to the 1% received during each of the months of July and August. Table 6 gives data furnished by the Corps of Engineers of monthly distribution of precipitation at representative stations. Table 7 gives precipitation normals and extremes, and evaporation losses as computed by the Oregon State College Department of Soils, Drainage and Irrigation, for the years of 1889 to 1950 at Corvallis.

Only a small percentage of the precipitation at lower levels occurs as snow. The average snowfall of 6 to 16 inches over the valley floor has a water equivalent of roughly 2% of the total precipitation. At elevation 2,000 feet, about 10% occurs as snow, while at 5,000 feet and 7,000 feet levels 50% and 75% of the total precipitation falls as snow.

Precipitation occurring in other forms is a minor factor. Some hail is produced during the summer months; usually this is confined to the higher levels of the Cascade Range. Sleet, freezing rain, glaze storms cause some damage, but are infrequent.

Storms

Flood-producing storms in the Willamette River Basin generally occur during November, December, and January. Such storms also occur during the earlier and latter months but with lesser frequency. The average rate of occurrence for flood-producing storms is somewhat less than one per year. Summer storms normally affect only small areas, but if more general, then they are of relatively light intensity.

Table 5. Temperature, Relative Humidity, and Wind Movement, Corvallis, 1889 to 1950.

Month	Temperature					Average relative humidity (5:00 p.m.)	Hourly wind velocity	
	Monthly average	Average maximum	Average minimum	Highest	Lowest		*Average	Highest
	Degrees	Degrees	Degrees	Degrees	Degrees	Per cent	Miles	Miles
December	40.8	62.8	41.8	65.0	-14	83.9	4.60	25**
January	39.3	45.4	32.9	64.0	-1	83.3	4.24	25
February	42.3	50.1	35.0	69.0	-5	76.2	4.76	24
Winter	42.1	52.8	36.6	-	-	81.1	4.53	
March	46.2	55.5	37.0	79.0	13	67.8	5.35	24**
April	50.9	61.8	40.0	89.0	24	60.8	5.65	29
May	55.7	67.8	44.0	95.0	28	55.4	5.83	25
Spring	50.9	61.7	40.3	-	-	61.3	5.61	
June	60.9	73.4	48.0	102.0	32	54.1	5.97	30
July	66.2	80.6	51.2	107.0	36	47.5	5.97	25**
August	66.2	81.3	51.3	102.0	37	47.4	5.62	26
Summer	64.4	78.4	50.2	-	-	49.7	5.85	
September	61.0	74.7	47.1	105.0	26	49.5	4.75	25
October	53.6	64.8	42.2	90.0	13	65.8	3.75	20**
November	45.4	53.0	37.8	73.0	10	79.5	4.02	32
Autumn	53.3	64.2	32.4	-	-	58.3	4.17	
Average 60 years	52.4	62.8	41.8	-	-	64.4	5.04	

* 1934 to 1943. **More than once.

Figure 8

Isohyetal Map, Normal Annual Precipitation
Western Oregon

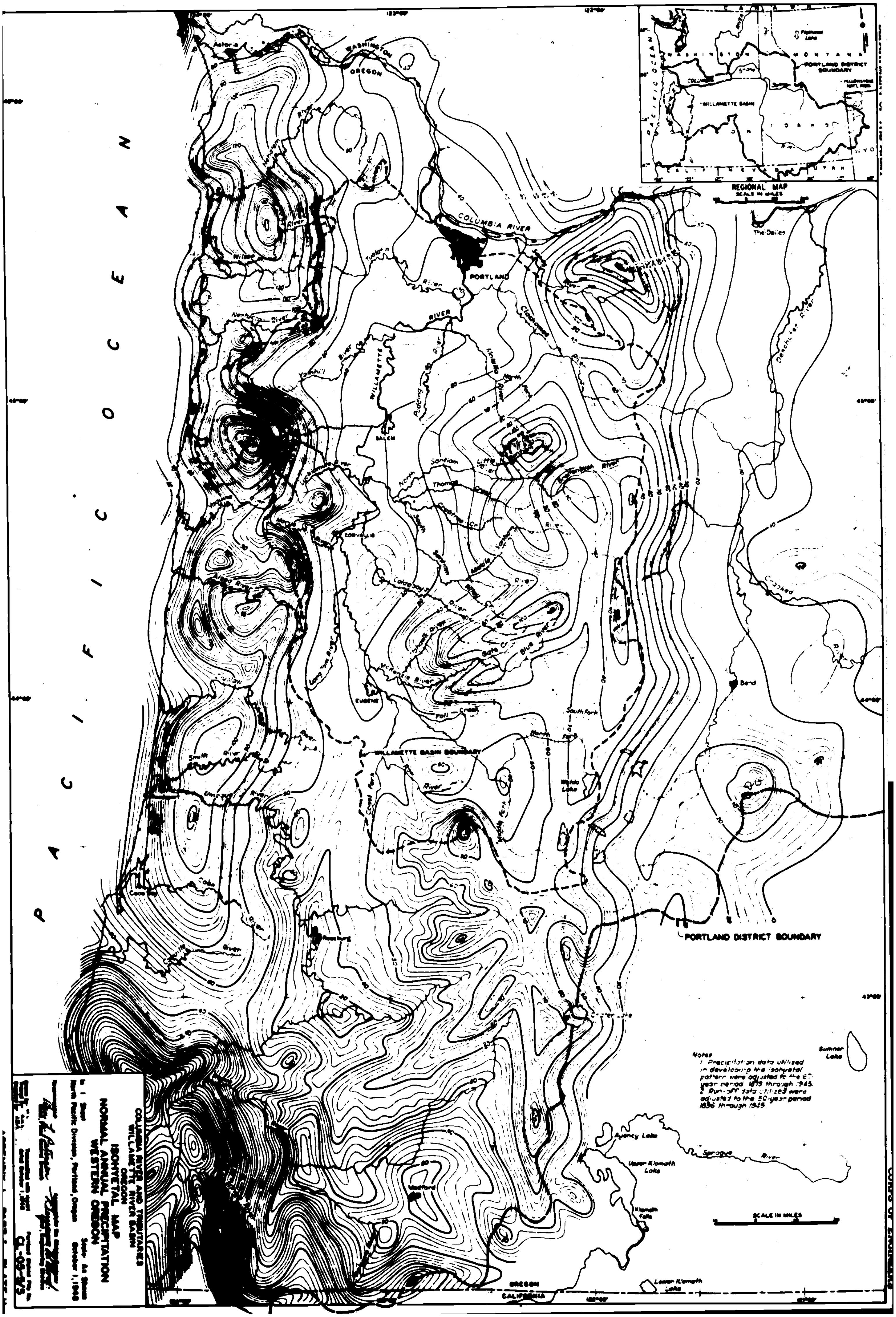

COLUMBIA RIVER AND TRIBUTARIES
WILLAMETTE RIVER BASIN
OREGON
ISOHYETAL MAP
NORMAL ANNUAL PRECIPITATION
WESTERN OREGON
North Pacific Division, Portland, Oregon
October 1, 1948
Scale: As Shown
CL-09-9/5
PACIFIC OCEAN
WASHINGTON
OREGON
CALIFORNIA
COLUMBIA RIVER
PORTLAND
SALEM
CORVALLIS
EUGENE
Roseburg
Medford
Bend
The Dalles
Astoria
Klamath Falls
Agency Lake
Upper Klamath Lake
Lower Klamath Lake
Sumner Lake
Waldo Lake
Sprague River
WILLAMETTE BASIN BOUNDARY
PORTLAND DISTRICT BOUNDARY
REGIONAL MAP
SCALE IN MILES
Notes
1. Precipitation data utilized in developing the isohyetal pattern were adjusted to the 67 year period 1879 through 1945.
2. Run-off data utilized were adjusted to the 50-year period 1896 through 1945.

Table 6. Monthly Distribution of Precipitation.

Item	Estacada	Eugene	McKenzie Bridge	Oakridge	Portland	Salem
			Station			
Elevation, mean sea level	414	450	1,372	1,313	30	164
Period of record year	38	55	27	30	76	55
			Mean monthly precipitation			
January	7.50	5.31	10.05	5.62	6.60	5.64
February	6.08	4.65	8.14	4.89	5.36	4.65
March	6.19	3.97	7.49	4.11	3.91	4.00
April	4.31	2.71	4.32	3.31	2.87	2.59
May	3.52	2.37	4.08	2.47	2.19	2.10
June	2.52	1.53	3.00	1.74	1.52	1.27
July	.72	.35	.86	.44	.61	.39
August	.97	.48	.80	.50	.64	.46
September	2.57	1.88	2.64	1.52	1.98	1.67
October	4.50	2.90	5.77	2.81	3.12	3.02
November	8.01	5.64	10.58	5.41	6.10	5.99
December	8.09	6.04	10.60	5.36	6.72	6.64
Mean annual precipitation	54.99	37.88	68.33	38.18	41.62	38.42

Source: (48, 1704).

Table 7. Precipitation Normals and Extremes, also Evaporation, OSC Department of Soils, Drainage and Irrigation, Corvallis, 1889-1950.

Month	Average precip-itation	Wettest month	Driest month	Maximum 24 Hours	Maximum 1 Hour	Average	Highest snowfall	Evaporation Tank loss average month
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
December	6.14	14.15	2.33	2.78	.28	1.10	20.0	-
January	6.47	13.61	1.99	3.43	.21	3.84	23.0	-
February	5.15	15.23	0.12	2.56	.35	.95	12.0	-
Winter	17.76	-	-	-	-	5.89		
March	4.13	11.70	0.43	1.89	.29	.10	6.5	-
April	2.56	7.99	0.22	1.44	.21	Trace	1.5	2.88
May	1.88	5.71	0.16	1.30	.18	0	0	4.16
Spring	8.57	-	-	-	-	0.10	-	-
June	1.14	3.58	0.00	1.68	.34	0	0	5.90
July	0.28	2.72	0.00	1.08	.20	0	0	6.44
August	0.43	2.76	0.00	0.70	.13	0	0	6.06
Summer	1.85	-	-	-	-			
September	1.57	5.40	Trace	1.57	.71	0	0	3.89
October	2.88	9.05	Trace	2.26	.26	0	0	-
November	6.43	16.69	0.22	3.16	.28	Trace	2.5	-
Autumn	10.88	-	-	-	-			
Average 60 years	39.06	-	-	-	-	2.5	-	29.33

Source: (37)

Flood-producing storms for general purposes may be very broadly classified into the following three categories:

(1) Storms which are of short duration and marked intensity, usually associated with well developed and fast moving fronts.

(2) Storms which are of extended duration, and marked by rainfall of intermittent intensity. Such storms have a large areal extent.

(3) Storms which are of exceptionally long duration, and which may actually be produced by a sequence of lesser storms so closely associated, both with respect to time and general pressure pattern, as to appear to be a single storm of long duration but variable intensity.

Most of the major floods which have occurred in the Willamette River Valley have resulted from storms of the third type. (48, pp 1703-04)

Physical Characteristics of the River

The Willamette River proper, formed by the junction of the Coast and Middle Forks near Springfield, Oregon, has a total length of approximately 188 miles. It flows northward over the valley floor in a meandering channel for a distance of 133 miles to the mouth of the Yamhill River. In the 24 mile reach from the mouth of the Yamhill downstream to New Era, the river flows in a fairly well defined channel, with a comparatively narrow flood plain, most of which is located on the right bank. The next five miles from below New Era to Willamette Falls at Oregon City the river flows through a gorge. The falls are surmounted by a fixed crest power dam. During the low water stages, the backwater effect from this dam reaches upstream approximately twenty-three miles to the vicinity of Newberg. The last twenty-six miles from Oregon City to its mouth, the Willamette River is tidal in character and is affected by backwater from the Columbia River during the high stages of the Columbia. The low water profile of the Willamette River above Willamette Falls is typical of a stream with an unstable bed. It consists of a series of relatively long, deep pools and short, steep bar crossings (48, 1684). Table 8 shows the physical characteristics in tabular form. Figure 9 presents the same graphically.

Physical Characteristics of the Major Tributaries

Most of the major tributaries of the Willamette rise in the Cascade Range at elevations of 6,000 feet or higher. The Coast Fork rises in the Calapooya Mountains and many of the smaller tributaries rise in the Coast Range. Important tributaries entering the Willamette River from the east (See Figures 3 and 4) are the Middle Fork, McKenzie, Calapooya, Santiam, Molalla, and Clackamas Rivers. The Pudding River is a major east side tributary which joins the Molalla River about one mile from its mouth. Important tributaries entering the Willamette River from the west (see Figure 5) are the Long Tom, Luckiamute, Yamhill, and Tualatin Rivers. Minor tributaries entering from the west are Mary's River and Rickreall Creek. West Muddy Creek is a minor west side tributary which joins Mary's River just a few miles upstream from Corvallis. Minor tributaries entering from the east are East Muddy Creek, Mill Creek, and Johnson Creek.

The Long Tom, Calapooya, Lower Pudding, and Tualatin Rivers are primarily valley streams with physical and hydraulic characteristics typical of flat slopes and wide flood plains. The other major tributaries, in the mountainous sections, flow in narrow v-shaped canyons with steep gradients and high velocities. In the lower reaches, slopes flatten and channels meander between gravel terraces. Upon reaching the valley floor the major tributaries flow on relatively flat slopes into the Willamette.

Surface Water Supply

A large percentage of the surface run-off in the Willamette Valley is the direct result of rainfall, and therefore is not uniformly distributed throughout the year.

Table 8. Physical Characteristics of the Willamette River

Location on Stream	Miles from Mouth	Low Water Elevation feet (mean sea level)	Reach in Miles	Slope feet per mile
Mouth of Willamette River	0.0	1.10		
Oswego	20.1	1.89	20.1	.04
Below Willamette Falls	26.2	2.45	6.1	.10
Above Willamette Falls	26.6	49.90	.4	Falls
Mouth of Yamhill River	54.9	53.85	28.3	.14
Corvallis	131.8	191.80	76.9	1.80
Two Miles above Mouth of Long Tom River	152.0	248.70	20.2	2.83
Harrisburg	163.0	292.70	11.0	4.40
Three Miles above Mouth of McKenzie River	180.0	390.30	17.0	5.74
Eugene	182.2	396.50	2.2	2.82
Two Miles above Eugene	184.2	422.10	2.0	12.30
Mouth of Middle Fork Willamette River	188.3	434.50	4.1	3.03

Sources: (48, 1684) (16, 48)

Table 9. Showing the Physical Characteristics of the Main Tributaries of the Willamette River.

Tributary Basin	Enters Willamette River at river mile	Drainage Area Square Miles	Drainage Area Per Cent of basin total
Coast Fork Willamette River	188.3	670	5.9
Middle Fork Willamette River	188.2	1,360	12.2
McKenzie River	176.4	1,320	12.0
Long Tom River	149.8	410	3.7
East Muddy Creek	135.0	140	1.2
Mary's River	132.3	300	2.7
Calapooya River	120.3	362	3.3
Santiam River	109.4	1,820	16.2
Luckiamute River	108.2	310	2.8
Rickreall Creek	89.0	106	0.9
Mill Creek	84.5	135	1.2
Yamhill River	54.9	770	6.9
Molalla River	35.5	890	7.9
Tualatin River	28.4	710	6.3
Clackamas River	25.0	930	8.3
Johnson Creek	18.0	54	0.5
Miscellaneous Tributaries	- - - -	913	8.0
Total		11,200	100.0

Source: (48, 1685)

At Albany the average run-off over a 50 year period has been 38 inches or 9,961,000 acre-feet. Of this amount, 76% occurs during the six months of heavy rainfall, November through April, and only 7% during the three dry months, July through September. This percentage distribution of run-off applies in general to all principal tributaries excepting the McKenzie River. The McKenzie originates in an area covered by lava flows. The porous lava beds store the rain and snow run-offs at the head of the basin and release them through the summer and fall months. Due to this storage the McKenzie has a sustained summer flow that is proportionally three to five times as great as that of other Willamette tributaries.

Sustained flow is one of the elements upon which power potentialities depend. The degree to which natural flows are sustained is illustrated by Table 10, a tabulation showing natural flows equalled or exceeded for various percentages of time.

From the standpoint of high sustained flow, the McKenzie, Middle Fork, North Santiam, South Santiam, and Clackamas Rivers offer the greatest potentials for power.

Under the present stream-flow regimen a large amount of dredging is required to provide an adequate channel depth for barge and log traffic on the Willamette River during July, August, September, and October.

Table 10. Showing Natural Flows Equalled or Exceeded for Various Periods of Time for Willamette River Tributaries.

Tributary	Station	Period: Length in years	Period: Mean flow sec. per feet	Mean monthly discharge in second-feet equalled or exceeded for per cent of time shown: 100%	80%	50%	Drainage area in square miles
Coast Fork Willamette River	Saginaw	21	1,210	33	125	700	528
Middle Fork Willamette River	Eula	22	2,415	490	800	1,900	941
McKenzie River	Vida	21	3,565	1,310	1,750	3,025	930
Calapooya River	Holley	10	385	19	50	250	100
South Santiam River	Waterloo	22	2,665	111	400	1,800	640
North Santiam River	Mehama	24	3,030	495	900	2,450	665
Long Tom River	Monroe	24	715	12	25	210	391
Luckiamute River	Suver	11	905	34	105	410	236
Pudding River	Aurora	17	1,060	50	100	850	493
Tualatin River	Willamette	17	1,315	42	180	550	710
Clackamas River	Cazadero	36	2,500	670	1,000	2,150	665

Source: (48, 1707)

Run-Off Characteristics

In general, the discharge pattern for the Willamette River system follows closely the precipitation pattern, and the stream-flow characteristics reflect the topographic, geologic, and meteorologic features of the area. The annual run-off per square mile of the larger tributaries is in general greater for those rising in the Cascade Range than for those rising in the Coast Range.

Discharge Records

Practically all existing discharge records for streams in the Willamette Basin have been made by the United States Geological Survey, the United States Weather Bureau, or the State Engineers of Oregon. A few records are available for relatively long periods, but stream flow data for sparsely settled tributary areas are non-existent.

Records for the gaging station at Salem are indicative of run-off in the main Willamette River. Published records are available for the period extending from October 1909 to December 1916 and for the period from October 1927 to September 1954. Salem, which is downstream from all major flood-producting tributaries, records run-off from a drainage area of 7,280 square miles, or 65% of the total basin.

The average annual discharge at Salem is 15,670,000 acre feet or, expressed in terms of depth over the drainage basin, 40 inches. This run-off is equivalent to a mean annual discharge of 21,440 second-feet. Extremes which have been recorded are 25,600,000 acre-feet in the water year 1916, and only 9,890,000 acre-feet in the water year of 1931. The largest known discharge of the Willamette at Salem occurred in December 1861 and has been estimated on the basis of high water marks to have been 530,000 second-feet. This is equivalent to an instantaneous discharge from the basin of 72.8 second-feet per square mile. The minimum recorded flow, 2,470 second-feet, occurred in August 1940. (48, 1705-06) Table 11 shows critical months stream flow recorded at Eugene and Albany. Table 12 shows the same for Salem and Oregon City. Stream flow characteristics in Table 13 show interrelationships and varabilities, based on discharge records.

Ground Water Supply

The United States Geological Survey made an extensive study of the ground water supplies in the basin during 1935 and 1936. Their report published as Water Supply Paper 890 is basic in the study of the basin. An investigation by the same agency of the power potential on the McKenzie published in 1931 as Water Supply Paper 637c throws valuable light on that tributary.

Table 11. Showing the Stream Flow for Critical Months, in Cubic Feet Per Second.

Water Year	Willamette River at Eugene Drainage Area: 2,030 Sq.Mi. Aug.	Sept.	Oct.	Mean Annual	Willamette River at Albany Drainage Area: 4,840 Sq.Mi. Aug.	Sept.	Oct.	Mean Annual
1926	758	890	1,400	3,457	2,320	2,480	3,500	9,558
1927	865	1,420	2,990	6,346	3,110	3,960	8,030	16,988
1928	979	792	900	5,837	2,600	2,490	2,840	15,008
1929	902	686	663	3,678	2,970	2,390	2,460	10,333
1930	682	684	880	3,485	2,450	2,280	2,630	9,365
1931	603	621	1,280	2,786	2,300	2,150	3,720	7,993
1932	966	752	981	5,783	3,200	2,730	3,080	15,473
1933	1,110	1,150	1,046	6,121	4,000	3,740	3,697	16,035
1934	636	614	1,807	3,087	2,467	2,238	4,637	9,819
1935	764	682	935	5,608	2,820	2,664	3,063	14,500
1936	863	831	659	4,782	3,010	2,758	2,313	12,776
1937	1,027	927	1,672	4,925	3,619	3,128	4,309	13,130
1938	809	749	871	6,646	2,878	2,737	2,924	17,965
1939	788	736	1,058	4,165	2,645	2,503	2,932	10,881
1940	547	811	985	3,409	2,034	2,352	2,785	9,731
1941	887	1,342	1,380	3,050	2,589	3,698	3,295	8,164
1942	934	735	792	4,941	3,147	2,820	2,629	12,635
1943	1,259	1,134	2,420	7,961	4,115	3,421	6,275	20,200
1944	751	997	912	3,322	2,485	2,623	2,840	8,691
1945	869	1,163	898	4,621	2,823	3,189	3,567	12,335
Avg.	850	886	1,226	4,700	2,879	2,817	3,576	12,579

Source: Corps of Engineers (48) (16).

Table 12. Showing the Stream Flow for Critical Months, in Cubic Feet Per Second, of the Willamette River at Salem and Oregon City.

	Willamette River at Salem Drainage Area: 7,280 Sq.Mi.				Willamette R. at Ore. City Drainage Area:10,098 Sq.Mi.			
Water Year	Aug.	Sept.	Oct.	Mean Annual	Aug.	Sept.	Oct.	Mean Annual
1926	3,000	3,400	5,200	15,450	3,370	4,890	7,440	19,089
1927	4,500	6,100	14,600	26,267	4,540	8,100	17,780	34,186
1928	3,650	3,590	4,210	24,478	3,960	3,860	4,920	30,632
1929	3,810	3,390	3,290	16,661	4,170	3,640	3,620	20,068
1930	3,050	3,030	3,970	15,293	3,360	3,300	4,420	18,486
1931	2,950	2,680	5,120	13,696	3,190	2,960	6,020	17,075
1932	4,310	3,330	4,830	24,624	4,670	3,560	5,370	31,330
1933	5,100	5,960	5,888	25,974	5,530	6,780	7,160	32,524
1934	3,209	2,947	8,624	17,700	3,500	3,260	10,390	23,535
1935	3,706	3,397	4,403	23,726	4,010	3,690	4,970	30,323
1936	3,899	3,708	3,214	20,779	4,260	4,060	3,520	25,327
1937	4,792	4,133	6,836	21,278	5,290	4,680	7,870	26,012
1938	3,632	3,461	3,756	29,539	3,960	3,970	4,290	37,177
1939	3,311	3,300	4,447	17,370	3,530	3,572	4,940	20,899
1940	2,653	3,137	4,296	16,865	2,870	3,450	5,100	24,025
1941	3,445	6,190	6,835	13,676	3,740	7,130	8,070	16,885
1942	4,071	3,490	3,365	20,535	4,670	3,820	3,710	25,255
1943	5,455	4,585	10,760	32,115	5,860	4,890	12,930	39,746
1944	3,194	3,347	3,609	14,552	3,430	3,630	3,950	17,724
1945	3,466	4,152	4,463	20,368	3,760	4,810	6,250	24,679
Avg.	3,760	3,866	5,586	20,547	4,084	4,394	6,636	25,749

Source: Corps of Engineers (48)

Table 13. Showing Stream Flow Characteristics of the Willamette River and Some of Its Tributaries.

Stream	Willamette	Willamette	Willamette	Willamette	Long Tom	Molalla	Pudding	Tualatin
Location:	Eugene	Albany	Salem	Oregon City	Monroe	Canby	Aurora	Near Willamette
Period Considered:	1926-45	1926-45	1926-45	1926-45	1928-47	1929-46	1929-46	1929-46
Drainage Area Sq.Mi:	2,030	4,840	7,280	10,098	391	323	493	710
% of Total Stream Drainage:	18	43	65	90	96	36	--	100
Critical Months (Cu. Ft,/Sec.)	Aug.-Oct.	Aug.-Oct.	Aug.-Oct.	July-Sept.	July-Sept.	July-Sept.	July-Sept.	July-Sept.
Daily Minimum:	500	1,840	2,470	---	7	38	37	38
Single Mo. Minimum:	547	2,034	2,653	2,870	12	50	50	42
Minimum 3 Mo. (avg):	749	2,390	2,025	3,670	14	75	61	64
3 Months Mean:	986	3,091	4,400	5,038	55	130	105	107

Source: Corps of Engineers and the United States Geodetic Survey. (16)

On the basis of the Geolgical Survey Studies the ground water recharge and discharge in the southern portion of the valley is estimated to amount to about 500,000 acre feet annually. In comparison the withdrawals by pumping are relatively small.

Of sixty-four incorporated towns in the Willamette Basin, twenty-two pump all domestic water from wells and four others supplement supplies in that manner. The annual quantity so used is approximately 1,000,000 gallons or about 3,000 acre feet.

CHAPTER III

ANALYSIS OF POTENTIAL UTILIZATION AND DEVELOPMENT OF THE WILLAMETTE RIVER AND ITS TRIBUTARIES

Flood Characteristics

Winter and spring are the seasons of the greatest flood activity above Oregon City. Damaging floods may occur as early as the first of November and as late as the last of April. At least one flood is normal each year. Two major floods have occurred in a few recorded years.

The floods of the Willamette and its tributaries are flashy in character. In the tributary watersheds, streams rise from base flows to flood stages in a few hours, remain at crest stage for only an hour or so, and return to base flow in from four to seven days. Occasionally the passage of significant storms within several days of each other may result in a broad crested flood. As an average, a flood wave takes thirty hours to travel from Eugene to Albany, twelve hours from Albany to Salem, and thirty-five hours from Salem to Portland. Below the falls at Oregon City back water from the annual Columbia River flood causes high stages during May, June, and July. The highest stages on record in Portland Harbor were caused by the backwater from the Columbia (48, 1709).

Flood History

Major flood on the Willamette at Salem for which reliable historical records exist, recorded in order of magnitude are: 1861, 1890, 1881, 1907, 1923, 1909, 1943, 1901, 1903, and 1945. Frequency studies indicate that about one hundred eighty floods may be expected to exceed bankfull stages at Salem in a one hundred year period. Both the 1861 floods were the result of heavy rainfall occurring in a period of comparatively high temperatures, which followed an extended period of rain, snow, and low temperatures. During the high temperature period snow at the higher elevations melted and became an important run-off factor.

Although the major floods have been individually more destructive, the minor or secondary floods which occur almost every year probably have greater total damage values as far as flood history is concerned.

On the basis of the historical records the Corps of Engineers' estimate of probably magnitude of floods of different frequencies are shown in Table 14.

Provisional Standard Project Flood

A standard project flood represents a flood that would be exceeded only on rare occasions. Such a flood defines the upper limits of flood discharge and volume

Table 14. Showing the Probable Magnitude of Floods Having Frequencies of Once in Two, Five, Ten, Fifty, and One Hundred Years.

Stream and Station	Basic Discharge (sec.-ft.)*	Flood discharge at indicated frequency, (sec.-ft.) 2-year	5-year	10-year	50-year	100-year
Middle Fork Willamette River at Eula	10,000	29,500	43,000	55,000	82,000	95,000
Willamette River at Eugene	35,000	66,000	90,000	109,000	156,000	180,000
Willamette River at Albany	50,000	112,000	158,000	195,000	282,000	325,000
Willamette River at Salem	100,000	180,000	235,000	280,000	380,000	430,000
Coast Fork Willamette River at Saginaw	8,000	23,000	32,000	38,000	51,000	57,000
Row River near Dorena	5,000	15,000	20,000	23,500	30,000	33,500
McKenzie River near Vida	15,000	33,000	43,500	52,000	73,000	83,000
Long Tom River at Monroe	3,000	12,000	17,000	20,200	26,500	29,500
South Santiam River at Waterloo	15,000	48,000	63,000	74,000	96,000	106,000
North Santiam River at Mehama	15,000	40,500	56,000	67,000	92,000	102,000
Santiam River at Jefferson	30,000	86,000	106,000	122,000	162,000	182,000
Yamhill River at Lafayette	10,000	29,700	39,000	43,000	52,000	56,000
Tualatin River near Willamette	5,000	11,500	16,500	21,000	34,500	41,500
Clackamas River near Cazadero	12,000	27,000	40,000	50,000	74,000	83,000

*Discharge, not in excess of bankfull, at which damage may be expected to begin.

Source: (48, 1711)

against which any protective works installed would be designed to withstand. The standard adopted by the Corps of Engineers for the Willamette River Basin is the flood of 1861, the maximum flood of historical record.

Flood Plain

The area in the Willamette Valley subject to flooding extends for a total stream distance of approximately, 1,100 miles. The flood plains of separate streams are distinguishable only during years of minor and moderate floods. During major floods the streams merge to form a continuous flood plain. Figure 9 shows the location of the Flood Plains within the valley. Except in years of unusually low run-off about 100,000 acres are flooded annually. Frequently 150,000 to 270,000 acres are inundated. Floods similar to those of 1890 and 1861 would inundate about 485,000 and 513,000 acres respectively. The major flood plain is about 30 per cent of the total urban and rural area of the valley floor and about 20 per cent of the total urban, industrial, and agricultural area of the basin. Table 15 gives the acreages subject to inundation in representative floods (48, p 1716). About 85 per cent of the acreage subject to inundation is made up of agricultural and suburban tracts.

Twenty-nine communities, including cities, towns, and villages are situated in or adjacent to the flood plain. The six largest cities in the basin, Salem, Eugene, Corvallis, Albany, Oregon City, and Portland with an additional seven smaller cities are on the main Willamette. Sixteen cities, towns, and villa ges are located on the tributaries.

A number of streams in the basin have had major floods that were not coincident with floods on other tributaries; therefore, the Corps of Engineers made separate surveys for those streams. Chronologically, in 1941 surveys were made on the Yamhill River; in 1942 on the Tualatin River; in 1945 on the Pudding, Molalla, and Calapooya Rivers, and also on the East Muddy, Lake, and Amazon Creeks; in 1946 on the Mary's River, West Muddy Creek, Luckiamute River, Rickreall Creek, and Johnson Creek. In 1947 appraisals were also made of the flood of December 1946.

Flood Control

On the basis of engineering studies and overall basin evaluation, the Corps of Engineers has proposed two solutions either of which would alleviate or control for the foreseeable future the flood problem on the Willamette River and its tributaries.

Figure 9

Flood Plains of the

Willamette River and Its Tributaries

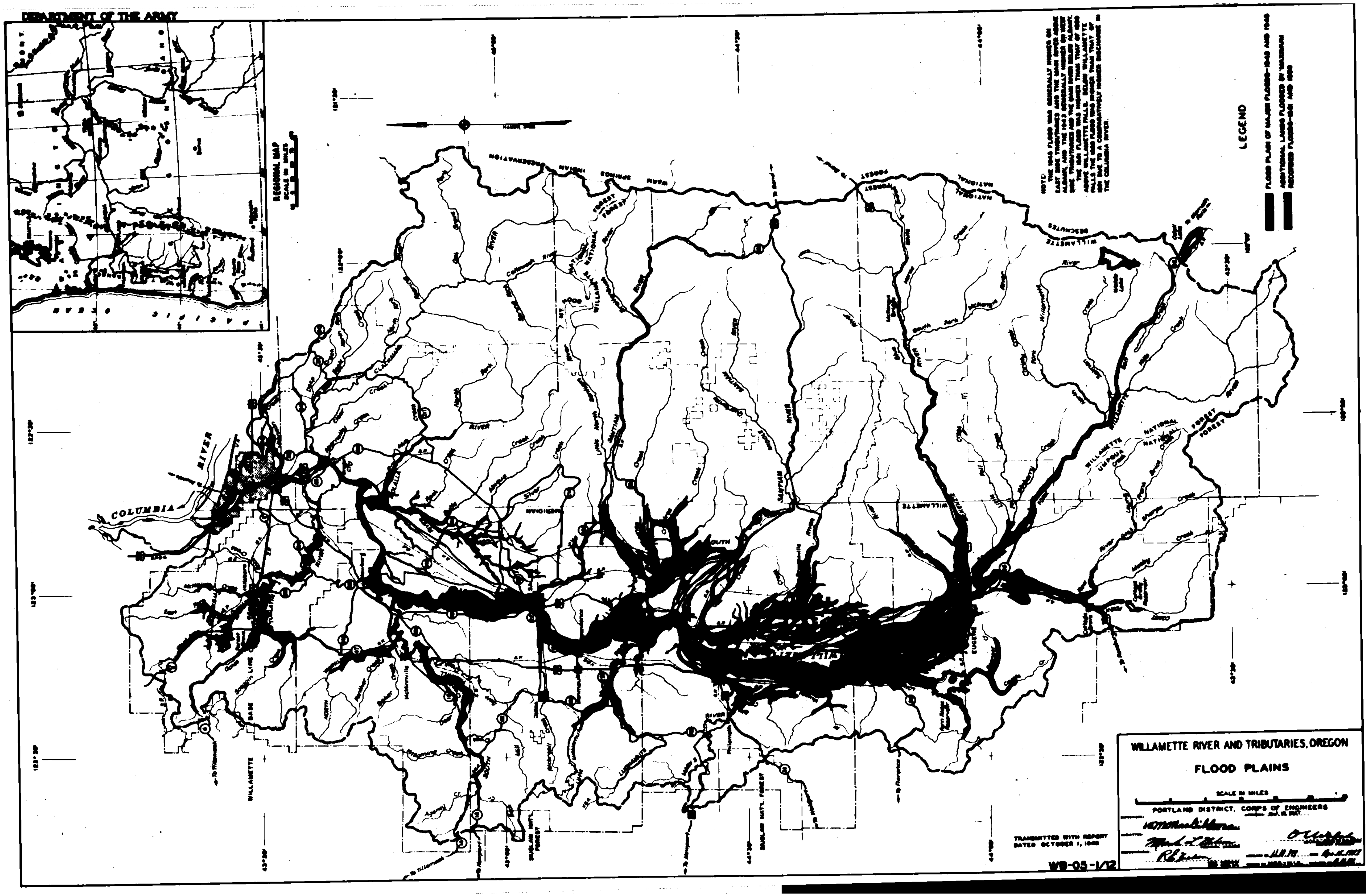

DEPARTMENT OF THE ARMY
REGIONAL MAP
PACIFIC OCEAN
COLUMBIA RIVER
WILLAMETTE BASE LINE
McMinnville
SOUTH SANTIAM RIVER
MIDDLE SANTIAM RIVER
LITTLE NORTH SANTIAM RIVER
WILLAMETTE NATIONAL FOREST
SIUSLAW NAT'L FOREST
UMPQUA NATIONAL FOREST
EUGENE
To Newport
To Florence
To Tillamook
NOTE:
THE 1945 FLOOD WAS GENERALLY HIGHER ON EAST SIDE TRIBUTARIES AND THE MAIN RIVER ABOVE ALBANY, AND THE 1943 GENERALLY HIGHER ON WEST SIDE TRIBUTARIES AND THE MAIN RIVER BELOW ALBANY.
THE 1861 FLOOD WAS HIGHER THAN THAT OF 1890 ABOVE WILLAMETTE FALLS. BELOW WILLAMETTE FALLS THE 1890 FLOOD WAS HIGHER THAN THAT OF 1861 DUE TO A COMPARATIVELY HIGHER DISCHARGE IN THE COLUMBIA RIVER.
LEGEND
FLOOD PLAIN OF MAJOR FLOODS—1943 AND 1945
ADDITIONAL LANDS FLOODED BY MAXIMUM RECORDED FLOODS—1861 AND 1890
TRANSMITTED WITH REPORT DATED OCTOBER 1, 1948
WILLAMETTE RIVER AND TRIBUTARIES, OREGON
FLOOD PLAINS
SCALE IN MILES
PORTLAND DISTRICT, CORPS OF ENGINEERS
WB-05-1/12

Table 15. Showing Acreages Subject to Inundation in Representative Floods.

Reach of main Willamette, including principal tributaries and minor streams.	Acreage inundated by floods 1927	1943	1945	1861	Per cent of total area flooded
Above Eugene	37,150	42,250	54,250	61,960	12-15
Eugene to Corvallis	97,020	112,140	120,520	172,930	32-34
Corvallis to Salem	95,380	101,170	114,550	155,190	29-31
Salem to Oregon City	67,170	80,980	73,700	116,240	20-24
Oregon City to Mouth	5,430	5,760	5,530	*6,680	1-2

*With Columbia River back water stages similar to 1927 or 1943, an 1861 flood would inundate about 8,200 acres.

Source: (48, p 1716)

The first solution would consist of an extensive levee system to confine the floods and reduce flood damages. High levees would be required on the lower reaches of the principal tributaries and the main stream. To provide adequate channel capacity between levees, it would be necessary to sacrifice a large acreage of the valley flood plain. Also, the benefits creditable to protection by levees would be limited to reduction of flood damages and increased land use behind the levees. No interference with fish and aquatic life would exist in any major degree. The disadvantage of this proposal is that the drainage of some areas could be accomplished only at high initial and annual cost, but the drainage of considerable acreage would be problematical, and the fact that this solution would be the most expensive to build and to maintain.

The second solution would consist principally of reservoirs located on the major flood producing tributaries and supplemented by a relatively small amount of levees, much lower than those required for control by levees only. These reservoirs would control, at damsite the run-off, and reservoir regulation would reduce flood stages. Water stored after flood season could be used for irrigation, domestic water supply, navigation, pollution abatement, recreation, fish life preservation, and power production. This is the over all basin plan recommended by the Corps of

Engineers, U. S. Army. The Figures 10 and 11 show this alternative plan to the one described above. In so far as this plan has much more in it than flood control, attention will be directed to other phases of basin development before studying the present and proposed development of this plan.

Drainage

Drainage has long been recognized as an essential need for agriculture in the Willamette River Basin. Data on total acreages and expenditures to date are not available. It has been estimated that about 60,300 acres of farm lands in the central valley have tile drains. About 48 per cent of the valley floor lands, or about 792,000 acres, lie in basins of the smaller tributaries on which no flood control and drainage investigations have been made. Therefore, it must be remembered that the following tabular and pictographic data excludes any judgment of 48 per cent of the valley floor lands. Table 16 gives the known acreages involved in drainage problems. Figure 13 maps the extent and location of the known problem areas. The solution of the drainage problem, involves reservoir control of natural channels, and the lowering of natural water stages therein. Construction of new channels where none exist is needed, so that outlets for interior and lateral drains would be operative: all of these factors are dependent on reservoir

Figure 10

Alternate Levee Plan with Reservoirs

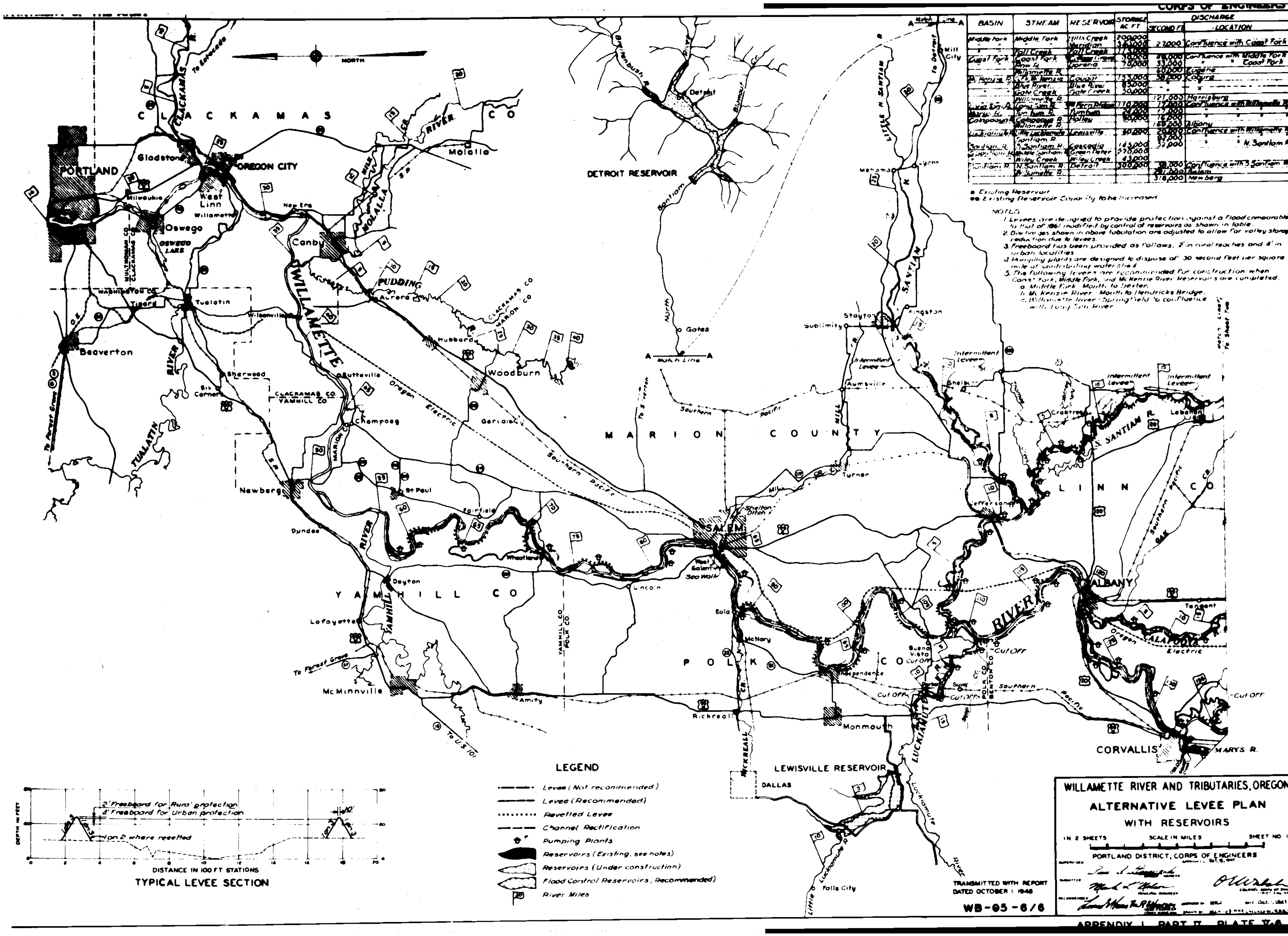
Sheet Number 1

CORPS OF ENGINEERS

BASIN	STREAM	RESERVOIR	STORAGE AC. FT.	DISCHARGE SECOND FT.	DISCHARGE LOCATION
Middle Fork	Middle Fork	Hills Creek	200,000		
" "	" "	Meridian	345,000	27,000	Confluence with Coast Fork
" "	Fall Creek	Fall Creek	115,000		
Coast Fork	Coast Fork	Cottage Grove	30,000	48,000	Confluence with Middle Fork
" "	Row R.	Dorena	70,000	33,000	" " Coast Fork
	Willamette R.			60,000	Eugene
McKenzie R.	S.Fk. McKenzie	Cougar	155,000	58,000	Coburg
" "	Blue River	Blue River	85,000	"	"
" "	Gate Creek	Gate Creek	30,000	"	"
	Willamette R.			121,000	Harrisburg
Long Tom R.	Long Tom R.	Fern Ridge	110,000	17,000	Confluence with Willamette R.
Marys R.	Yumbum R.	Yumbum	24,000	17,000	" " " "
Calapooya R.	Calapooya R.	Holley	90,000	16,000	" " " "
	Willamette R.			169,000	Albany
Luckiamute R.	Little Luckiamute	Lewisville	30,000	20,000	Confluence with Willamette R.
	Santiam R.			92,000	" " "
Santiam R.	S.Santiam R.	Cascadia	145,000	32,000	" " N. Santiam R.
S.Santiam R.	Middle Santiam R.	Green Peter	270,000		
" "	Wiley Creek	Wiley Creek	43,000		
N.Santiam R.	N.Santiam R.	Detroit	300,000	38,000	Confluence with S.Santiam R.
	Willamette R.			281,000	Salem
	" "			318,000	Newberg

• Existing Reservoir
•• Existing Reservoir Capacity to be Increased

NOTES
1. Levees are designed to provide protection against a flood comparable to that of 1861 modified by control of reservoirs as shown in table.
2. Discharges shown in above tabulation are adjusted to allow for valley storage reduction due to levees.
3. Freeboard has been provided as follows. 2' in rural reaches and 4' in urban localities.
4. Pumping plants are designed to dispose of 30 second feet per square mile of contributing watershed.
5. The following levees are recommended for construction when Coast Fork, Middle Fork, and McKenzie River Reservoirs are completed.
   a. Middle Fork Mouth to Dexter.
   b. McKenzie River Mouth to Hendricks Bridge.
   c. Willamette River - Springfield to confluence with Long Tom River.



TRANSMITTED WITH REPORT DATED OCTOBER 1, 1948

WB-95-6/6

WILLAMETTE RIVER AND TRIBUTARIES, OREGON

ALTERNATIVE LEVEE PLAN WITH RESERVOIRS

IN 2 SHEETS — SCALE IN MILES — SHEET NO. 1

PORTLAND DISTRICT, CORPS OF ENGINEERS

APPENDIX I PART II PLATE V-6

Figure 11

Alternate Levee Plan with Reservoirs

Sheet Number 2

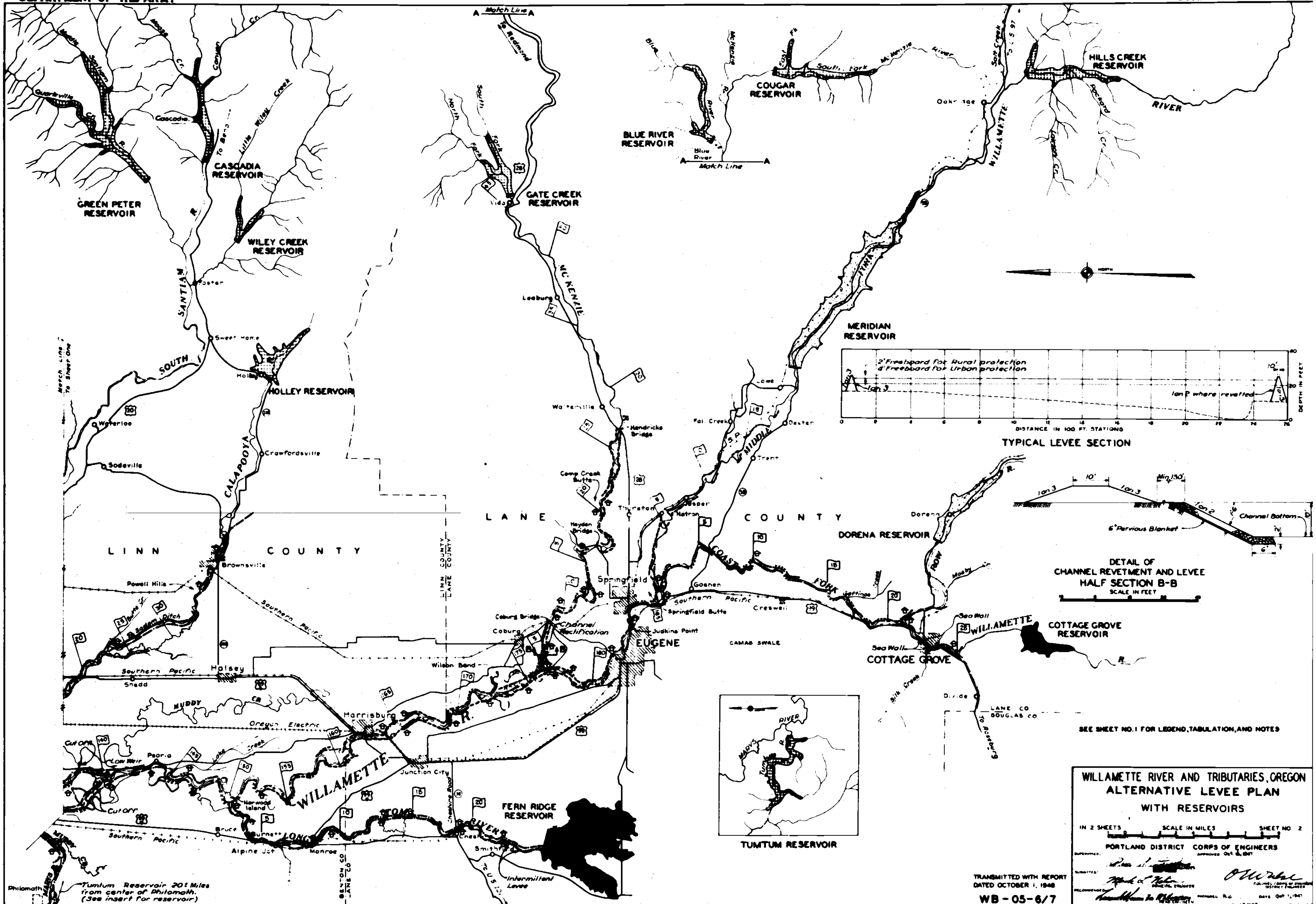

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
ALTERNATIVE LEVEE PLAN
WITH RESERVOIRS
IN 2 SHEETS
SCALE IN MILES
SHEET NO. 2
PORTLAND DISTRICT CORPS OF ENGINEERS
TRANSMITTED WITH REPORT DATED OCTOBER 1, 1948
WB - 05 - 6/7
SEE SHEET NO. 1 FOR LEGEND, TABULATION, AND NOTES
GREEN PETER RESERVOIR
CASCADIA RESERVOIR
WILEY CREEK RESERVOIR
HOLLEY RESERVOIR
GATE CREEK RESERVOIR
BLUE RIVER RESERVOIR
COUGAR RESERVOIR
HILLS CREEK RESERVOIR
MERIDIAN RESERVOIR
DORENA RESERVOIR
COTTAGE GROVE RESERVOIR
FERN RIDGE RESERVOIR
TUMTUM RESERVOIR
TYPICAL LEVEE SECTION
2' Freeboard for Rural protection
4' Freeboard for Urban protection
DISTANCE IN 100 FT. STATIONS
DEPTH IN FEET
DETAIL OF
CHANNEL REVETMENT AND LEVEE
HALF SECTION B-B
SCALE IN FEET
6" Pervious Blanket
Channel Bottom
LINN COUNTY
LANE COUNTY
EUGENE
SPRINGFIELD
COTTAGE GROVE
Harrisburg
Junction City
Halsey
Brownsville
Sweet Home
Crawfordsville
Coburg
Creswell
Oakridge
WILLAMETTE
McKENZIE
CALAPOOYA
SANTIAM
Match Line
Tumtum Reservoir 20½ Miles from center of Philomath. (See insert for reservoir)
Philomath
Intermittent Levee

Figure 12

Descriptive Data - Dams and Reservoirs

APPENDIX J, PART I - TABLE 54

Descriptive data - Dams and reservoirs, Willamette River sub-basin

(Constructed, authorized, or proposed for immediate construction)

Reservoir	Stream	Stream mile	Drainage area, sq. mi.	Proposed storage - acre-feet: Flood control: Primary 1/	Proposed storage - acre-feet: Flood control: Secondary 2/	Proposed storage - acre-feet: Flood control: Total	Proposed storage - acre-feet: Dead	Proposed storage - acre-feet: Power	Proposed storage - acre-feet: Total	Flood-control storage, inches 3/	Elevations-feet above mean sea level: Normal pool	Elevations-feet above mean sea level: Minimum pool	Elevations-feet above mean sea level: Minimum tailwater	Elevations-feet above mean sea level: Top of dam	Height of dam, feet 4/	Length of dam, feet	Reservoir area, acres: Normal pool	Reservoir area, acres: Minimum pool	Spillway capacity, second-feet	Outlet capacity, second-feet	Type of dam 5/	Primary use 6/
Cottage Grove 7/	Coast Fork Willamette River	28.0	104	30,000	--	30,000	3,000	--	33,000	5.4	791	750	718	808	73	2,070	1,160	293	40,800	2,300	C.G.& E.	FC-N-I
Dorena 7/	Row River	7.0	265	70,000	--	70,000	6,000	--	76,000	5.0	835	770.5	735	865.5	100	3,392	1,840	450	97,500	5,000	C.G.& E.	FC-N-I
Hills Creek	Middle Fork Willamette River	47.8	389	145,000	55,000	200,000	59,000	21,000	280,000	9.6	1,510	1,373	1,235	1,548	275	1,960	2,420	980 8/	146,000	6,400	G. & E.	FC-N-I-P
Waldo Lake	North Fork of Middle Fork Willamette River	41.0	30	--	--	--	--	220,000	220,000	--	5,410	5,370	--	--	--	--	6,100	5,000	--	800	--	P
Meridian 7/	Middle Fork Willamette River	21.3	991 9/	230,000	110,000	340,000	88,000	28,000	456,000	10.6 10/	929	811	691	946	238	3,106	4,360	1,860 8/	243,000	16,000	G. & E.	FC-N-I-P
Dexter	Middle Fork Willamette River	18.0	1,000	--	--	--	23,850	3,650	27,500	--	695	691	639	700	56	2,835	1,025	960 8/	244,000	--	C.G.& E.	RR-P
Fall Creek	Fall Creek	7.1	188	105,000	10,000	115,000	10,000	--	125,000	11.5	834	726	663	856	171	5,630	1,880	440	82,400	3,100	G. & E.	FC-N-I
Cougar	South Fork McKenzie River	4.4	202	125,000	30,000	155,000	28,000	27,000	210,000	14.4	1,683	1,474	1,260	1,705	423	1,630	1,415	380	76,000	5,000	G. & E.	FC-N-I-P
Blue River	Blue River	0.6	88	75,000	10,000	85,000	5,000	--	90,000	18.1	1,332	1,168	1,055	1,353	277	2,575 11/	1,010	100	30,900	4,000	G. & E.	FC-N-I
Gate Creek	Gate Creek	0.4	50	43,000	7,000	50,000	5,000	--	55,000	18.8	1,000	865	775	1,017	225	1,190	605	147	23,000	3,000	G. & E.	FC-N-I
Fern Ridge 7/	Long Tom River	23.6	252	95,000	15,000	110,000	7,000	--	117,000	8.2	373.5	353	337	381.5	36.5	11,040 11/	9,300	1,760	45,000	3,000	C.G.& E.	FC-N-I
Tumtum	Tumtum River	0.8	35	24,000	--	24,000	4,000	--	28,000	12.8	660	623	597	675	63	1,015	1,050	310	12,000	1,200	C. G.	FC-I-DWS
Holley	Calapooya River	49.7	99	80,000	10,000	90,000	7,000	--	97,000	17.0	660	584	530	679	130	4,700	2,120	400	38,000	2,500	G. & E.	FC-N-I
Cascadia	South Santiam River	59.8	179	115,000	30,000	145,000	15,000	--	160,000	15.1	967	832	728	991	239	1,170	1,700	470	82,000	6,000	R. & E.	FC-N-I
Green Peter	Middle Santiam River	4.0	279	200,000	70,000	270,000	38,000	52,000	360,000	18.2	984	827	663	1,010	321	1,180	3,580	910 8/	105,000	13,000	R. & E.	FC-N-I-P
White Bridge	Middle Santiam River	0.9	283	--	--	--	6,650	1,850	8,500	--	670	662.5	571	680	99	580	270	220 8/	108,000	--	C. G	RR-P
Wiley Creek	Wiley Creek	4.7	51	38,000	5,000	43,000	4,000	--	47,000	15.8	926	820	730	946	196	950	600	130	23,200	1,500	R. & E.	FC-N-I
Detroit 7/	North Santiam River	48.5	438	235,000	65,000	300,000	115,000	40,000	455,000	12.9	1,569	1,425	1,192	1,579	377	1,580	3,580	1,451 8/	162,000	17,000	C. G.	FC-N-I-P
Big Cliff 7/	North Santiam River	45.7	450	--	--	--	1,950	1,800	3,750	--	1,197	1,177	1,106	1,218	91	295	100	76 8/	165,000	--	C. G.	RR-P
Lewisville	Little Luckiamute River	1.4	80	54,000	6,000	60,000	5,000	--	65,000	14.0	249	217.5	195	264	54	10,190 11/	3,300	660	21,300	2,000	E.	FC-N-I
Totals				1,664,000	423,000	2,087,000	431,450	395,300	2,913,750													

1/ Primary storage is that storage which is allocated to flood control.
2/ Secondary storage is that storage which is allocated to joint use for flood-control, power, and other conservation uses.
3/ Inches of depth over drainage area above dam.
4/ Height of dam measured from minimum tailwater to normal pool.
5/ Abbreviations as follows: G & E - gravel and earth embankment. C. G. - concrete gravity. C.G.& E. - concrete gravity with earth embankment. R. & E. - rock and earth embankment. E - earth embankment.
6/ Abbreviations as follows: FC - flood control. N - navigation. I - irrigation. P - power. R.R. - reregulation. D.W.S. - domestic water supply.
7/ Authorized units of comprehensive plan.
8/ Power pool.
9/ Including drainage area above Hills Creek dam site.
10/ Excluding drainage area above Hills Creek dam site.
11/ Crest length of dam, including dikes.

construction.

Irrigation

Due to the lack of precipitation during the summer months crop production is greatly limited for all summer growing annual and perennial crops. W. L. Power's work on the value of supplemental irrigation in the Willamette Valley is a basic requirement for an understanding of all the factors involved.

The irrigated acreage in the valley has grown from some 1,000 acres watered in 1911 to 3,000 in 1930, and approximately 50,000 watered in 1946 (39, p 30). Irrigation equipment manufacturers state that the growth since 1946 has been even more rapid. Records of the State Engineer on file in 1948 indicated water rights had been granted for water to irrigate more than 145,000 acres. This total does not indicate lands irrigated from wells for which no water rights are required.

The possible impact that the proposed reservoirs could have on the irrigable land within the basin is shown by Table 17. These are the areas considered irrigable by the Bureau of Reclamation. Figure 14 is a map made by the Corps of Engineers showing irrigable areas and potential projects.

Table 16. Showing a Summary of Sub-basins with Major Flood and Drainage Problems.

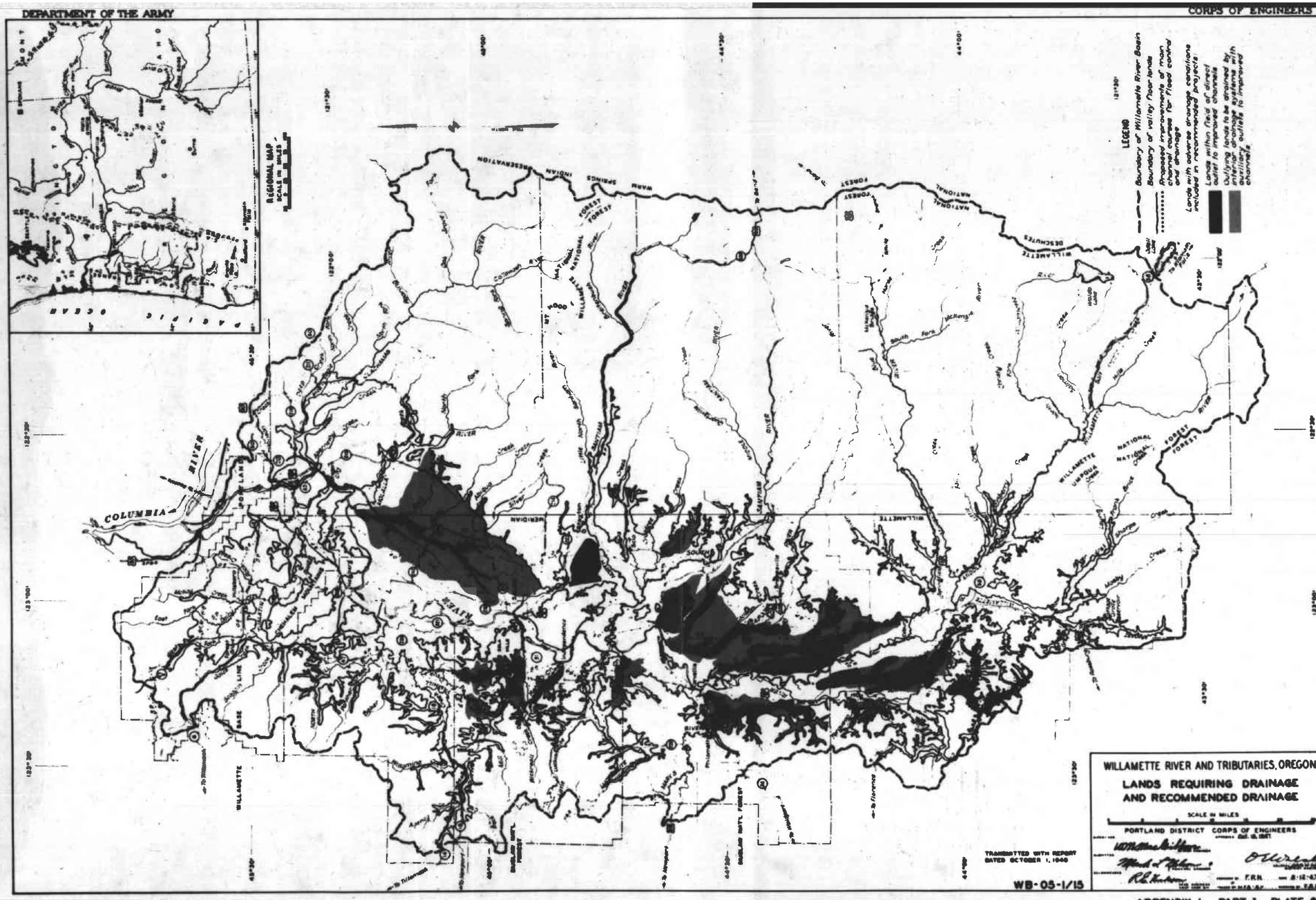
Sub-basin	Tributary to -	Total net acreage
Areas for which drainage opportunity would be afforded primarily by reservoir control of floods:		
Amazon Creek	Long Tom River	22,080
Flat Creek	Willamette River	21,900
Bear Creek	Long Tom River	3,470
Ferguson Creek	Long Tom River	3,140
East Muddy and Lake Creeks	Willamette River	55,330
West Muddy Creek and Mary's River	Willamette River	33,100
Calapooya River	Willamette River	58,000
Area east of Albany	Willamette River	16,200
Soap Creek	Luckiamute River	7,600
Pudding River	Molalla River	99,600
Subtotal		320,420
Areas not affected by reservoir control:		
Coyote and Spencer Creeks	Fern Ridge Reservoir	8,920
Beaver Creek	Crabtree Creek	11,700
Turner Prairie	Mill Creek	10,400
Mud and Baskett Sloughs	Rickreall Creek	13,100
Ash Creek	Willamette River	4,470
Salt Creek	Yamhill River	8,840
Ash Swale	Salt Creek	8,860
Tualatin River and tributaries	Willamette River	93,300
Subtotal		159,590
Total		480,010

Source: (48, p 1727)

Figure 13

Lands Requiring Drainage and Recommended

Drainage



DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
REGIONAL MAP
COLUMBIA RIVER
TRANSMITTED WITH REPORT DATED OCTOBER 1, 1948
WILLAMETTE RIVER AND TRIBUTARIES, OREGON
LANDS REQUIRING DRAINAGE AND RECOMMENDED DRAINAGE
SCALE IN MILES
PORTLAND DISTRICT CORPS OF ENGINEERS
WB-05-1/15
APPENDIX I PART 1 PLATE 83

Power

The Willamette River Basin is one of the most rapidly developing areas of the Pacific Northwest. The power load at present exceeds the generating capacity or facilities within the basin. The demand is currently being met from Federal power developments on the Columbia River, which are distributed by the Bonneville Power Administration. Generally, the power problem within the basin is merely a part of the problem of the Northwest as a whole. The over all power problem consists essentially of meeting the growing power demands. Instead of operating on a normal margin of ten to fifteen per cent of reserve generating capacity over demand, the total Northwest system peaking capability of about 3,600,000 kilowatts provided, leaves a margin of less than three per cent during protracted periods.

The Willamette Basin presents two distinct power problems. One problem is related to the Portland load area, while the other is related to the upper basin. The power problem of the Portland area is closely allied to the regional problem. The rapidly expanding power requirements, including those of aluminum and other heavy industries, are supplied partly by private generating plants on the Clackamas River. They have at present an installed capacity of 80,000 kilowatts, which is supplied partly by other local and nearby privately owned generating plants, and partly by

Table 17. Showing the Areas Considered as Irrigable by the Bureau of Reclamation.

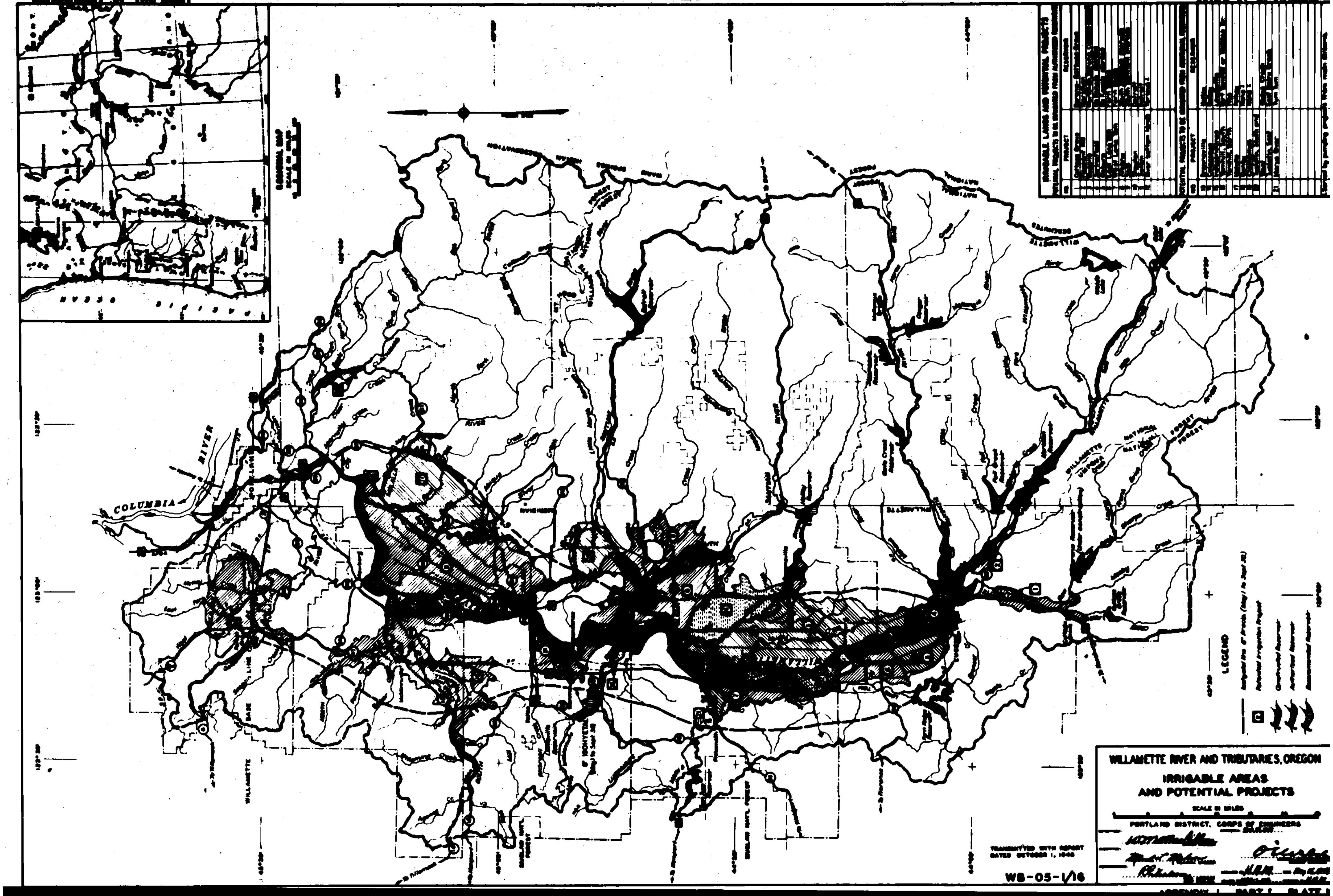
Project	Total Acres	Irrigable Acres	Water required ac.-ft.
Cottage Grove	16,400	8,710	18,400
Eugene	22,200	15,500	33,900
Pleasant Hill	2,100	1,490	3,400
Springfield	12,600	8,800	19,200
Coburg	124,000	52,500	97,300
East Long Tom	21,700	13,500	28,900
West Long Tom	18,500	10,200	23,400
Albany	45,000	31,800	59,800
Scio	37,000	25,800	50,100
Stayton	23,500	16,000	32,400
Salem	147,000	107,000	216,300
Brownsville	8,000	6,100	10,900
Calapooya	45,400	38,800	71,600
Independence	16,900	14,500	29,000
Mary's River	7,600	5,400	10,100
River-bottom lands	205,000	96,000	149,000
Subtotal, lands to be supplied with water from proposed reservoirs: * *	752,600	452,100	853,700
Molalla	86,000	43,300	77,700
Canby	1,800	1,700	3,000
Clackamas	3,900	2,700	5,400
Subtotal, lands to be supplied from other sources: *	93,700	46,700	86,100
Total	844,300	498,800	939,800

* Excluding Tualatin and Yamhill River Basins. Irrigation would increase water requirements to a total in those basins of about 1,194,000 acre-feet.

Source: (48, p 1730)

Figure 14

Irrigable Areas and Potential Projects



WILLAMETTE RIVER AND TRIBUTARIES, OREGON
IRRIGABLE AREAS
AND POTENTIAL PROJECTS
SCALE IN MILES
PORTLAND DISTRICT, CORPS OF ENGINEERS
TRANSMITTED WITH REPORT
DATED OCTOBER 1, 1940
WB-05-1/16
LEGEND
COLUMBIA
RIVER
WILLAMETTE
BASE LINE
REGIONAL MAP

Table 18. Showing a Summarization of the Districts Companies, and District Improvement Companies Which Have Been Organized Under Various Statutes of Oregon Law for the Control and Use of Surface Water in the Willamette Basin.

Purpose	Number	Area in acres
Flood control and/or drainage:		
District improvement companies	41	Not available
Drainage only:		
Public districts under Oregon Law.	5	5,674
Privately-owned companies	5	8,400
Total	10	14,074
Irrigation: Privately organized districts and companies	5	9,330
Soil Conservation: Organized public districts	1	94,850
Municipal water supply:		
Publically-owned	52	Not available
Privately-owned	6	
Nonreporting	6	
Total	64	

Source: (48, p 1699)

Columbia River power furnished through the Bonneville Power network.

The Willamette Valley load area, excluding the Portland market, includes all of the sub-basin south of Oregon City together with adjacent coastal counties to the west. The present firm power of about 160,000 kilowatts in this area is partly supplied by generating plants within the area and partly by power from sources outside the area. Generating plants within the area have a total installed capacity of 73,500 kilowatts. Of the power in the basin power area only 19.4 per cent is produced by hydroelectric plants, while 79.9 per cent is produced in steam plants, and 0.8 per cent is produced by internal combustion plants. The principal source of energy for the steam plants is hogged fuel, which is a waste product of the many sawmills of the area. The above figures do not take into account the first Federal Power Plant which is being completed and was recently inaugurated as a power producer at Detroit Dam. Its installed capacity is to be 100,000 kilowatts with an additional 16,000 kilowatts available when the Big Cliff Dam is completed. This should alleviate the general power pool situation. However, detailed studies by the Bonneville Administration anticipate a peak demand in the load area of 600,000 kilowatts by 1960. For the present, the contrasting stream-flow characteristics of the Columbia and Willamette are such that low flows on the Columbia occur during the season of high power demand which in turn coincides with the season of high run-off on the Willamette. These conditions favor the development of generating plants in the Willamette Basin which could be operated on a low load factor to supply a part of the peak power requirements of that load area, and to supplement Columbia Basin power during the low flow season on the Columbia. Requirements for long distance transmission facilities would thus be reduced and the required capacity of facilities to bring Columbia River power to the Willamette Basin could be more fully utilized with resulting increased efficiency.

Potential power resources of the Willamette Basin total 1,000,000 kilowatts of prime power and would require approximately 2,000,000 kilowatts of installed capacity for complete development. Of this potential approximately 387,000 kilowatts could be installed in connection with multiple purpose projects under consideration in the basin.

Table 19 shows the generating facilities located in the Willamette Valley in 1948. Figure 15 shows the location of potential, proposed, and existing hydropower, prime capability.

While the above data is mainly drawn from federal reports, a valid conclusion cannot be reached without adequate consideration being given to private power opinions and facts. Polhemus, as president of the Portland Electric Company (36, pp 10-11), has raised issues that cannot be slighted. The greater load carrying ability supplied by the steam plants is beneficial to the whole pool. The recent proposal (1952) by the Interior Department to authorize steam plant construction in the Pacific Northwest has serious merit which must be evaluated on overall value and not preconceived notions. Mr. Polhemus' suggestion that private capital retain control of steam plants and if additional plants are indicated that private capital be reimbursed for the additional cost involved, is a problem beyond the scope of analysis herein. Nevertheless, its inclusion is necessary if we are not to overlook or oversimplify the problem.

Table 19. Showing Generating Facilities in the Willamette River Basin.

Name	Owner	Location	Name plate rating kilowatts (Over 1,000 kilowatts as of Jan. 1, 1948) Hydro	Steam
Leaburg	City of Eugene	McKenzie River.....	6,000	-----
Walterville	City of Eugene	McKenzie River.....	2,630	-----
Springfield	Mountain States Power Company......	Springfield	-----	7,800
Eugene	City of Eugene.....	Eugene.........	-----	13,500
	Willamette Valley Lumber Company.....	Dallas.........	-----	5,250
Station H	Portland General Electric Company...	Salem..........	-----	2,500
Station B	Portland General Electric Company...	Willamette Falls......	4,890	-----
	Crown Willamette Paper Company......	Willamette Falls......	3,600	-----
	Hawley Pulp and Paper Company......	Willamette Falls......	1,740	-----
Station P	Portland General Electric Company...	Clackamas River.....	51,000	-----
Station G	Portland General Electric Company...	Clackamas River.....	15,250	-----
Station M	Portland General Electric Company...	Clackamas River.....	14,050	-----
Station E	Portland General Electric Company...	Portland..	-----	10,000
Station L	Portland General Electric Company...	Portland..	-----	75,500
Lincoln	Pacific Power and Light Company......	Portland..	-----	35,500
Pittock	Pacific Power and Light Company......	Portland..	-----	7,000
	Portland Gas and Coke Company.......	Portland..	-----	1,000
McMinnville	City of McMinnville	McMinnville....	-----	2,740*

Continued on the following page.

Table 19. Showing Generating Facilities in the Willamette River Basin. (Continued)

Name	Owner	Location	Name plate rating kilowatts (Over 1,000 kilowatts as of Jan. 1, 1948) Hydro	Steam
Station O	Portland General Electric Company	Sandy River	21,000	-----**
Total plants over 1,000 kilowatts			99,160	158,050
Total all types			259,950	

*Internal combustion is not included in the total for steam.

**Not included in the total.

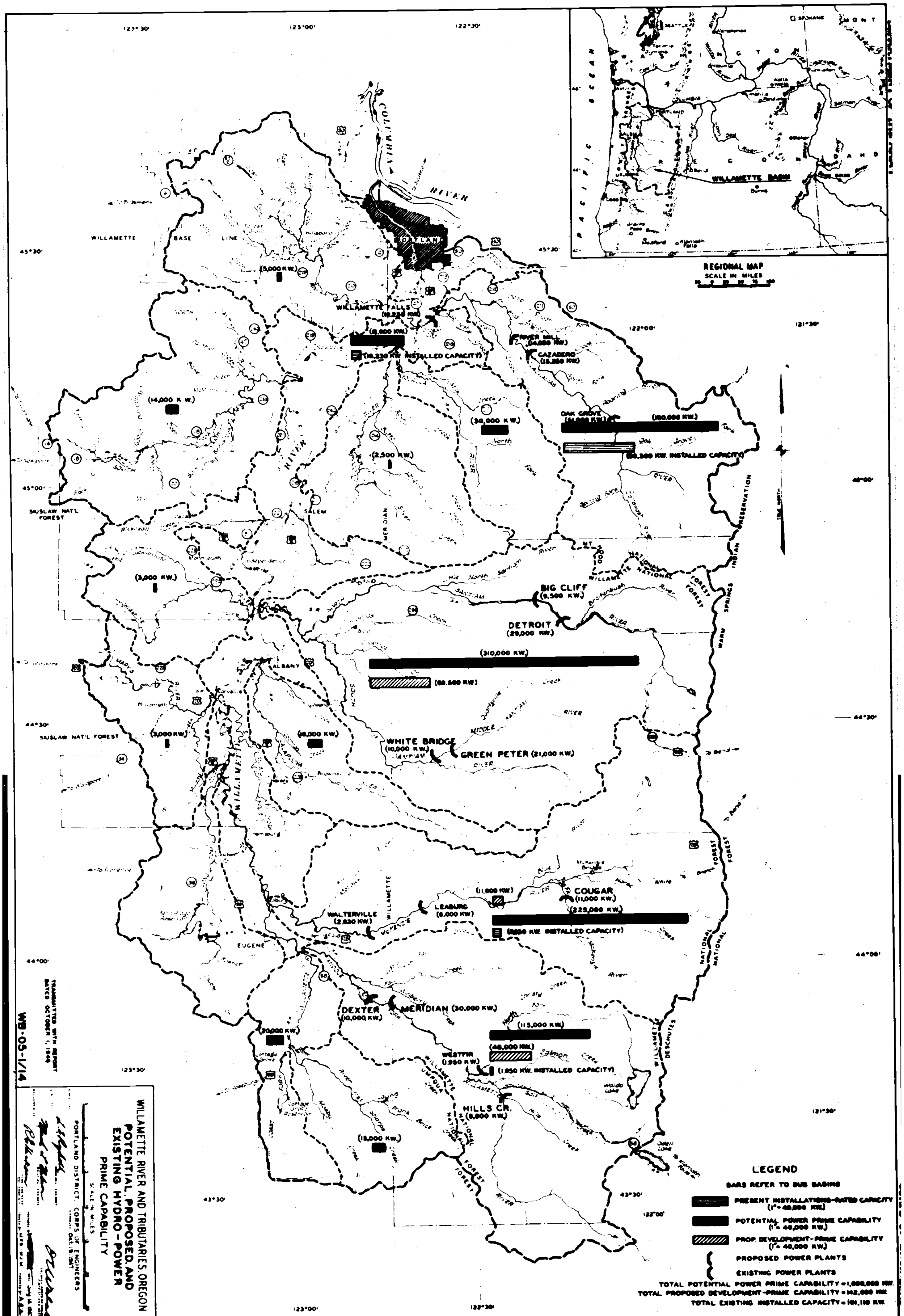
Note: Transmission facilities of the Portland General Electric Company, the Mountain States Power Company, the California-Oregon Power Company, and Bonneville Power Administration are tied into a large network through interconnections. Present transmission and generating capacity is no more than adequate for current loads, with no margin for load growth, and no important additions to these facilities are indicated, other than proposed Federal developments, with the exception of relatively small increases by the Eugene Water Board.

Source: (48, p 1696)

Figure 15

Potential, Proposed, and Existing

Hydro-power, Prime Capability


WILLAMETTE RIVER AND TRIBUTARIES, OREGON
POTENTIAL, PROPOSED, AND EXISTING HYDRO-POWER
PRIME CAPABILITY
PORTLAND DISTRICT, CORPS OF ENGINEERS
TRANSMITTED WITH REPORT DATED OCTOBER 1, 1948
WB-09-1/14
REGIONAL MAP
SCALE IN MILES
WILLAMETTE BASIN
PACIFIC OCEAN
COLUMBIA RIVER
PORTLAND
WILLAMETTE FALLS
SALEM
ALBANY
EUGENE
RIVER MILL
CAZADERO
OAK GROVE
BIG CLIFF (6,500 KW.)
DETROIT (26,000 KW.)
(310,000 KW.)
WHITE BRIDGE (10,000 KW.)
GREEN PETER (21,000 KW.)
COUGAR (11,000 KW.)
(225,000 KW.)
LEABURG (6,000 KW.)
WALTERVILLE
DEXTER (10,000 KW.)
MERIDIAN (30,000 KW.)
(115,000 KW.)
WESTFIR
HILLS CR. (8,000 KW.)
LEGEND
BARS REFER TO SUB BASINS
PRESENT INSTALLATIONS-RATED CAPACITY
POTENTIAL POWER PRIME CAPABILITY
PROP. DEVELOPMENT-PRIME CAPABILITY
PROPOSED POWER PLANTS
EXISTING POWER PLANTS

CHAPTER IV

PRESENT STATUS OF BASIN DEVELOPMENT

Land Distribution within the Basin

The land area of the basin is over 7,000,000 acres. About twenty-nine per cent is agricultural land, seventy-one per cent forest land, and less than one per cent waste land or in miscellaneous uses. Land distribution is summarized as follows:

Agriculture	2,112,330 acres
Forest land	4,589,130 acres
Range, waste, and miscellaneous	466,540 acres

A goodly portion of the total is taken up with reservations and other public land uses. A summarization is given below:

National Forests	
Willamette	1,615,000 acres
Mt. Hood	475,000 acres
Umpqua	140,000 acres
Siuslaw	20,000 acres
Subtotal	2,250,000 acres
Public Domain	750,000 acres

Continued next page.

State Parks.	3,000 acres
Municipal Lands.	10,000 acres
Total Public	3,013,000 acres

Forests cover more than 4,500,000 acres or fifty-two per cent of the basin area.

Willamette River Basin Project

The first comprehensive survey of the potentialities of basin development were published in House Document 263, 72nd Congress, 1st Session, in 1931. A review survey of multipurpose development was again published as House Document 544, 75th Congress, 3rd Session, in 1938. The Flood Control Act of June 28, 1938, approved the general comprehensive plan for development of the water resources of the Willamette River Basin as set forth in House Document 544. The plan included construction of a system of seven reservoirs in the interest of flood control, navigation, power development, and other purposes; channel improvement and contraction works necessary to secure, with stream flow regulation, controlling depths of six feet from Oregon City to the mouth of the Santiam River and five feet from there to Albany; and reconstruction and enlargement of Willamette Falls Locks at Oregon City. The latest official documentary report on the status to date is contained in House Document 531, 81st Congress, 2nd Session, published in 1951. Data pertaining to the various improvements comprising the comprehensive plan as outlined in the documents above listed or as later modified, are presented herein as the Willamette River Basin Project.

Fern Ridge Reservoir

This reservoir is one of the seven authorized in 1938. It is located on the Long Tom River. For location and general profile see Figure 5, Basin Profiles, West Side Tributaries, page 17. Its integration into an overall development as recommended by the Corps of Engineers is shown in Figure 11, Alternative Levee Plan with Reservoirs, Sheet Number 2, page 54. The Fern Ridge Reservoir Project consisted of an earth fill dam 6,300 feet long at the crest and two auxiliary dikes 850 and 3,650 feet long, along the northeasterly boundary of the reservoir. The reservoir has a usable capacity of 95,000 acre-feet, and is operated at present in the interest of flood control and navigation. For additional structural criteria see Figure 12, Descriptive Data - Dams and Reservoirs, page 55. The project also includes rectification of the Long Tom River channel downstream from the dam. The dam was essentially completed in 1942, and the reservoir has been in operation since that time. The channel improvement work is now nearly finished.

Cottage Grove Reservoir

This reservoir is located on the Coast Fork of the Willamette River, above Eugene. For profile and location see Figure 5, Basin Profiles, West Side Tributaries, page 17, and Figure 11, Alternate Levee Plan with Reservoirs, Sheet 2, page 54. This reservoir is formed by an earthfill dam having a height of 72 feet, measured from minimum tailwater to normal pool, and a length of 2,070 feet at the crest. The reservoir, having a usable capacity of 30,000 acre-feet, is operated at present in the interest of flood control and navigation. The dam and appurtances were essentially completed in 1942, and have been in operation since that time. More complete engineering data may be found in Figure 12, Descriptive Data - Dams and Reservoirs, page 55.

Dorena Reservoir

This reservoir is located on the Row River, a tributary of the Coast Fork. For profile and location see Figure 5, Basin Profiles, West Side Tributaries, page 17, and Figure 11, Alternative Levee Plan, Sheet Number 2, page 54. The reservoir is formed by the construction of an earth fill dam having a height of 100 feet measured from the minimum tailwater to normal pool, and a crest length of 3,392 feet. The reservoir, with a usable capacity of

70,000 acre-feet, is operated in the interests of flood control, navigation, and other multiple purpose uses. This is the third of the seven authorized in 1938, and is now completed.

Lookout Point Reservoir

One of the authorized units in the comprehensive plan is the above Lookout Point reservoir, whose location had to be changed. Now known as the Meridian site, it is located 15.5 miles downstream from the Lookout Point site as recommended in the report printed as House Document Number 544. For profile and location see the Middle Fork of the Willamette River in Figure 16, page 74, Figure 4, Basin Profiles, East Side Tributaries, Sheet Number 2, page 16, and Figure 11, Alternative Plan with Reservoirs, Sheet 2, page 54. The project, as now approved by the Office of the Chief of Engineers, will consist of an earth and gravel fill dam having a length of 3,106 feet at the crest, and a height of 236 feet measured from minimum tailwater to normal pool. The reservoir, which will have a usable capacity of 368,000 acre-feet, will be operated in the interests of flood control, navigation, pollution abatement, power, and other multipurpose uses. Provisions for future power development will be made in the dam. For additional description see Figure 12, Descriptive Data -

Dams and Reservoirs, page 55, under Meridian Dam. Present recommended basin development and detailed integration of the Meridian Dam Site is shown in Figure 16, Middle Fork Willamette River, Basin Map, page 75. This reservoir is expected to start functioning in the winter of 1953-54.

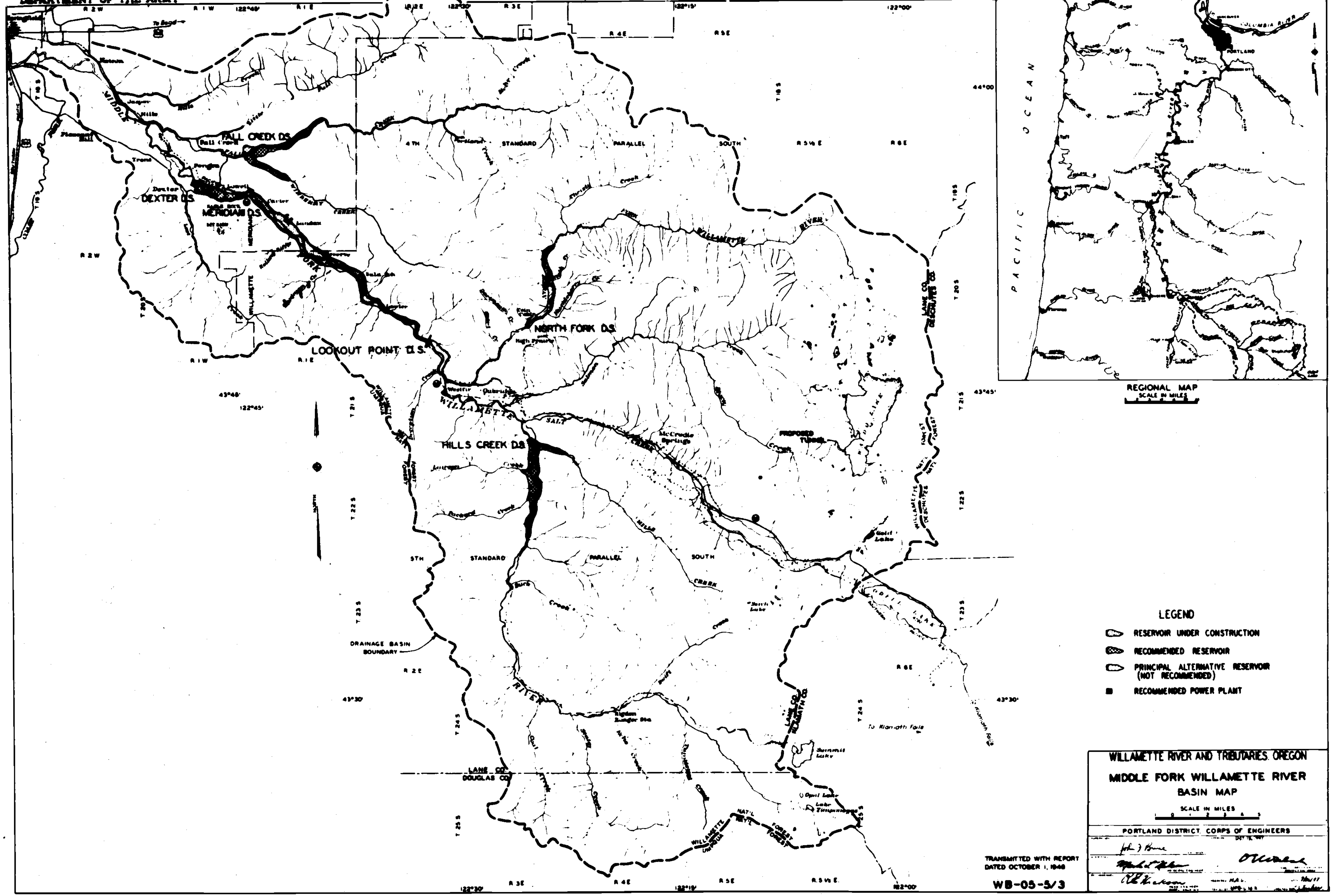
Detroit Reservoir

While approved in 1938 as part of the comprehensive plan, this dam's first release of power in 1953 was hailed with state ceremony, marking its completion in essentials. The project consists of a concrete gravity dam 1,579 feet long at the crest, and approximately 371 feet in height, measured from tailwater to normal pool. Provision for future generating of additional power is included in the project. The reservoir will have a usable capacity of 340,000 acre-feet, and will be operated in the interests of flood control, power generation, navigation, pollution abatement, irrigation, and other multipurpose uses. For detailed integration in the Santiam River, proposed developments, see Figure 17, Santiam River, Basin Map, page 77. For profile details, additional location, and structural data, see Figure 3, Basin Profiles, East Side Tributaries, Sheet Number 1, page 15; Figure 10, Alternative Levee Plan, Sheet Number 1, page 53; and Figure 12, Descriptive Data - Dams and Reservoirs, page 55.

Figure 16

Middle Fork Willamette River,

Basin Map


FALL CREEK D.S.
DEXTER D.S.
MERIDIAN D.S.
LOOKOUT POINT D.S.
NORTH FORK D.S.
HILLS CREEK D.S.
WILLAMETTE
RIVER
PROPOSED TUNNEL
McCredie Springs
4TH STANDARD PARALLEL SOUTH
5TH STANDARD PARALLEL SOUTH
DRAINAGE BASIN BOUNDARY
LANE CO.
DOUGLAS CO.
LANE CO.
DESCHUTES CO.
LANE CO.
KLAMATH CO.
To Klamath Falls
REGIONAL MAP
SCALE IN MILES
PACIFIC OCEAN
PORTLAND
COLUMBIA RIVER
LEGEND
RESERVOIR UNDER CONSTRUCTION
RECOMMENDED RESERVOIR
PRINCIPAL ALTERNATIVE RESERVOIR (NOT RECOMMENDED)
RECOMMENDED POWER PLANT
WILLAMETTE RIVER AND TRIBUTARIES, OREGON
MIDDLE FORK WILLAMETTE RIVER
BASIN MAP
SCALE IN MILES
PORTLAND DISTRICT, CORPS OF ENGINEERS
TRANSMITTED WITH REPORT DATED OCTOBER 1, 1948
WB-05-5/3

As of July 1953 this reservoir has one installed generator which started delivering 50,000 kilowatts, prime capability, but is now (July 28, 1953) producing 30,000 and 35,000 kilowatts, due to low water.

Big Cliff Dam was authorized in 1948, as a regulating dam below Detroit Dam to take care of high surges of water when a large head is needed for power. Construction on this has started.

Quartz Creek Reservoir

The plan set forth in House Document Number 544 recommended a reservoir having a usable capacity of 560,000 acre-feet on Quartz Creek, a tributary of the McKenzie River. The site has been abandoned due to local opposition to any construction on the main stem of the McKenzie River, an important recreational stream. For the present status of planning see Figure 18, McKenzie River, Basin Map, page 78. As far as the present outlook is concerned, this is one of the seven reservoirs which were part of the approved comprehensive plan of 1938, the project is definitely out. How much of the planning shown in the Figure 18, McKenzie River, Basin Map, page 78, and described in Figure 12, Descriptive Data - Dams and Reservoirs, page 55, will be executed, is problematical.

Figure 17

Santiam River, Basin Map

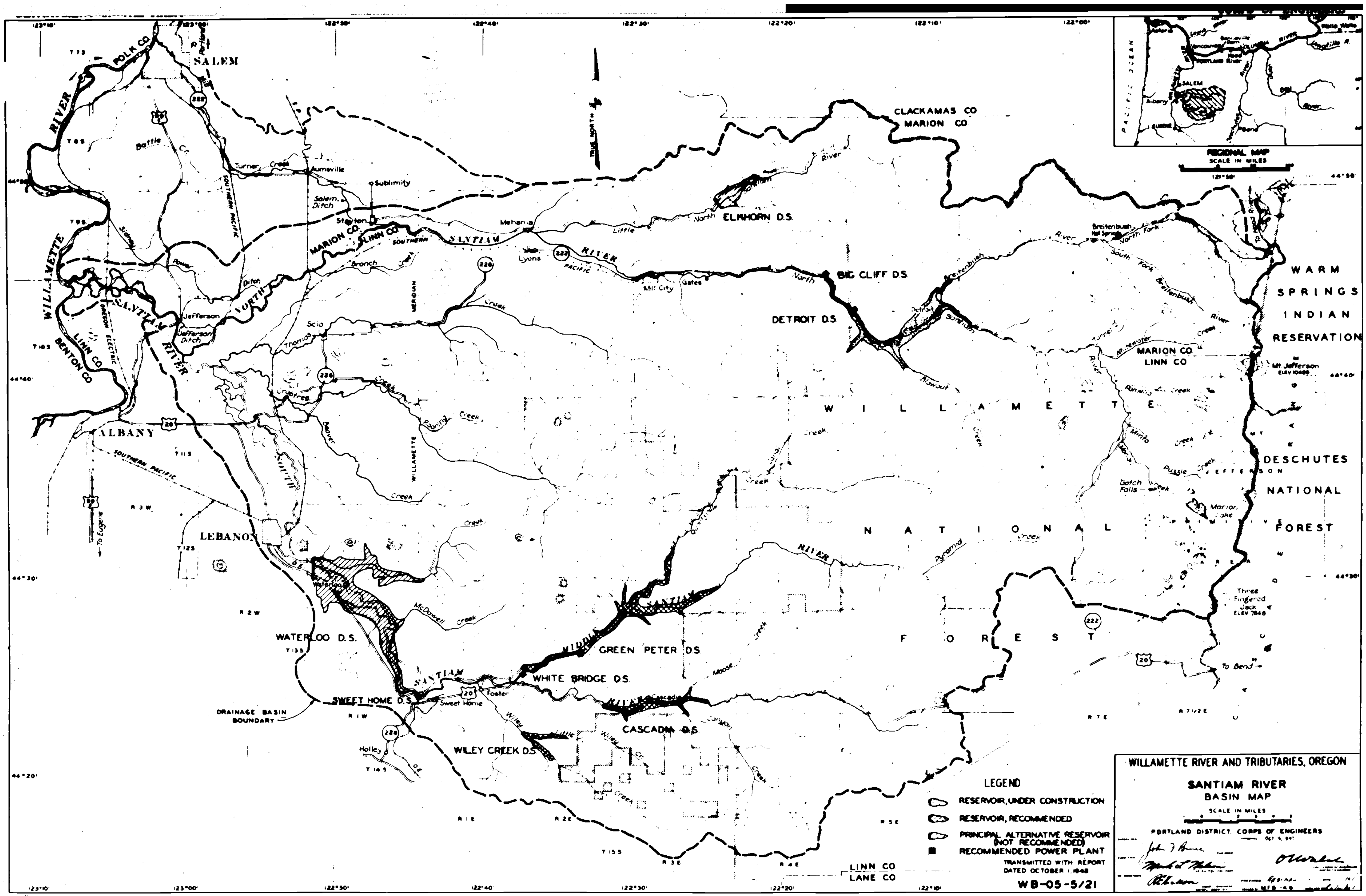
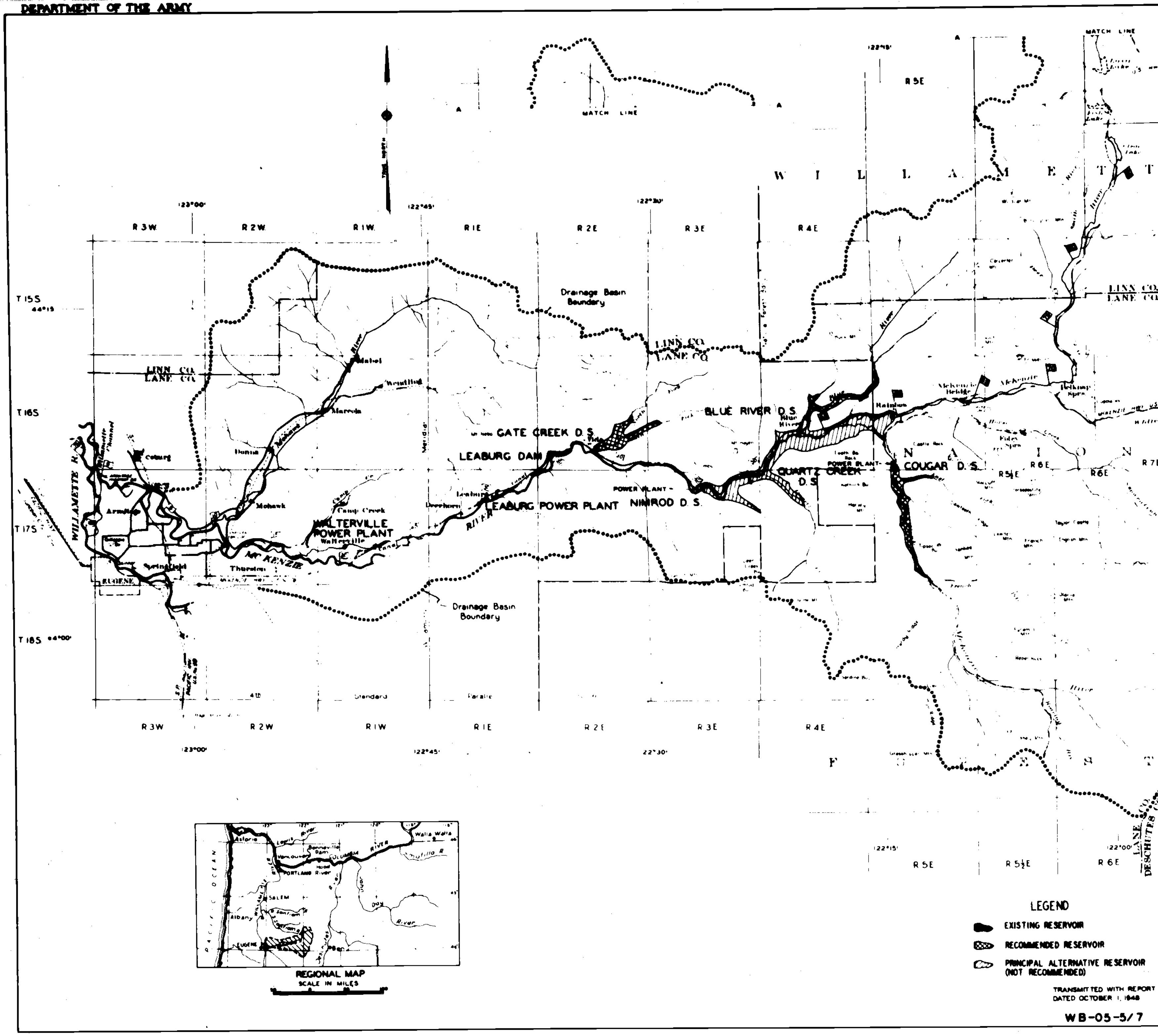

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
SANTIAM RIVER
BASIN MAP
SCALE IN MILES
PORTLAND DISTRICT, CORPS OF ENGINEERS
LEGEND
RESERVOIR, UNDER CONSTRUCTION
RESERVOIR, RECOMMENDED
PRINCIPAL ALTERNATIVE RESERVOIR (NOT RECOMMENDED)
RECOMMENDED POWER PLANT
TRANSMITTED WITH REPORT DATED OCTOBER 1, 1948
WB-05-5/21
REGIONAL MAP
SCALE IN MILES
SALEM
ALBANY
LEBANON
CLACKAMAS CO
MARION CO
POLK CO
LINN CO
BENTON CO
LANE CO
WILLAMETTE RIVER
SANTIAM RIVER
NORTH SANTIAM RIVER
SOUTH SANTIAM
MIDDLE SANTIAM
ELKHORN D.S.
BIG CLIFF D.S.
DETROIT D.S.
GREEN PETER D.S.
WHITE BRIDGE D.S.
WATERLOO D.S.
SWEET HOME D.S.
CASCADIA D.S.
WILEY CREEK D.S.
DRAINAGE BASIN BOUNDARY
WILLAMETTE NATIONAL FOREST
WARM SPRINGS INDIAN RESERVATION
DESCHUTES NATIONAL FOREST
MARION CO
LINN CO
Mt Jefferson ELEV 10499
Three Fingered Jack ELEV 7848
Marion Lake
Stayton
Sublimity
Aumsville
Turner
Mehama
Lyons
Mill City
Gates
Detroit
Jefferson
Scio
Sweet Home
Foster
Holley
Breitenbush Hot Springs
To Bend
To Eugene
SOUTHERN PACIFIC
OREGON ELECTRIC
TRUE NORTH

Figure 18

McKenzie River, Basin Map



WILLAMETTE RIVER AND TRIBUTARIES OREGON

McKENZIE RIVER

BASIN MAP

SCALE IN MILES

PORTLAND DISTRICT CORPS OF ENGINEERS

Sweet Home Reservoir

The approved comprehensive plan of 1938 called for a reservoir having a usable capacity of 310,000 acre-feet on the South Santiam River. The original site has been abandoned, the alternative planning for this tributary is shown in Figure 17, Santiam River, Basin Map, page 77. However, no conclusive alternative has been made.

In studying Figure 12, Descriptive Data - Dams and Reservoirs, page 55, five of the original reservoirs are found in being, two completely off the list, and Big Cliff Dam added. The Big Cliff Dam has been added to the Detroit Dam Project, and is now under construction. Details about it are shown in connection with the Detroit Project references.

As of July 27, 1953, the authorized units of the comprehensive plan have been augmented by:

(1) Hills Creek Reservoir, on the Middle Fork of the Willamette River.

(2) Fall Creek Reservoir, on Fall Creek.

(3) Cougar Reservoir, on the South Fork of the McKenzie River.

(4) Holley Reservoir, on the Calapooya River.

(5) Green Peter Reservoir, on the Middle Santiam River.

(6) White Bridge Reservoir, on the Middle Santiam River.

This authorization, allocated no monies, so that for all purposes the status is unchanged, in so far as all of these were included in Chapter III as potentials.

Bank Protection, Channel Clearing, and Snagging

Bank protection works along the Willamette River were authorized as a part of the coordinated plan. Up to June 30, 1948, $840,000 has been available under that authorization. However, much more has been spent under other appropriations. Funds to the extent of $300,000 were allocated from the Emergency Relief Act of 1935, for bank protection works. The Flood Control Act, approved June 22, 1936, (Public, Number 738, 74th Congress) authorized $2,430,000 for bank protection on the Willamette River and certain of its tributaries. Total costs under existing projects of the Corps of Engineers, to June 30, 1948 have been $3,048,078. Approximately $300,000 has been spent by county and state highway commissions, railroads, private industries, and local land owners.

The problem of bank protection, channel clearing, etc. is innate in the characteristics of an alluvial basin. The Willamette River from the juncture of the Middle and Coast Forks to New Era flows through an alluvial plain of erosible material, however, its banks are composed of materials which erode at different rates.

The Coast and Middle Forks of the Willamette River, as well as, the McKenzie and Santiam Rivers, may be classed together in a group characerized by fairly steep stream slopes of very friable, alluvial topsoil, underlaid by medium to coarse gravel. The areas next to the banks had been covered by a heavy growth, but in recent years, this brush and tree growth has been partly cleared, and the clearing is continuing.

Clackamas and Molalla Rivers have steeper slopes, narrower valley floors, and lower peak discharges, than the tributaries in the group mentioned above. Erosion areas on these two streams are limited in number but, the channels have deteriorated to a serious degree. No reservoirs are proposed on these two streams.

The Calapooya and Pudding Rivers have flat slopes, and sluggish flows, which have in the past produced little erosion. However, the low velocities, plus very heavy growths of timber and brush along the banks have contributed to the development of badly constricted and deteriorated channels.

Erosion and channel clearing problems of the Yamhill, Long Tom, Tualatin, Mary's, and Lukiamute Rivers; and East and West Muddy Creeks, as well as a number of smaller streams, are somewhat similar.

For a more detailed understanding of sub-basin problems, see Figure 19, Calapooya River, Basin Map, page 83, and Figure 20, Mary's River, Lukiamute River, and Rickreall Creek, Basin Map, page 84.

New Willamette Falls Navigation Lock

Control of Willamette Falls Canal and Locks was acquired by the Federal Government, under authority contained in the River and Harbor Act of June 25, 1910. This act provided for the purchase, rehabilitation, and deepening to six feet at low water of the existing canal and locks.

The present navigation lock consists of four chambers, each with a maximum length of 175 feet, and a clear width of 37 feet, with controlling depths of 8.4 feet in the lower lock, and 6.0 feet in the upper lock. The total lift is 50.2 feet.

The project was approved as a part of the comprehensive plan in 1938, and will provide a single lift main lock, and guard lock, with clear dimensions of 56 feet by 400 feet, and a minimum depth over the sills of 9.5 feet. The plans and specifications have been completed, but no work has been done.

Rafted logs are the major item of commerce now carried

Figure 19

Calapooya River, Basin Map

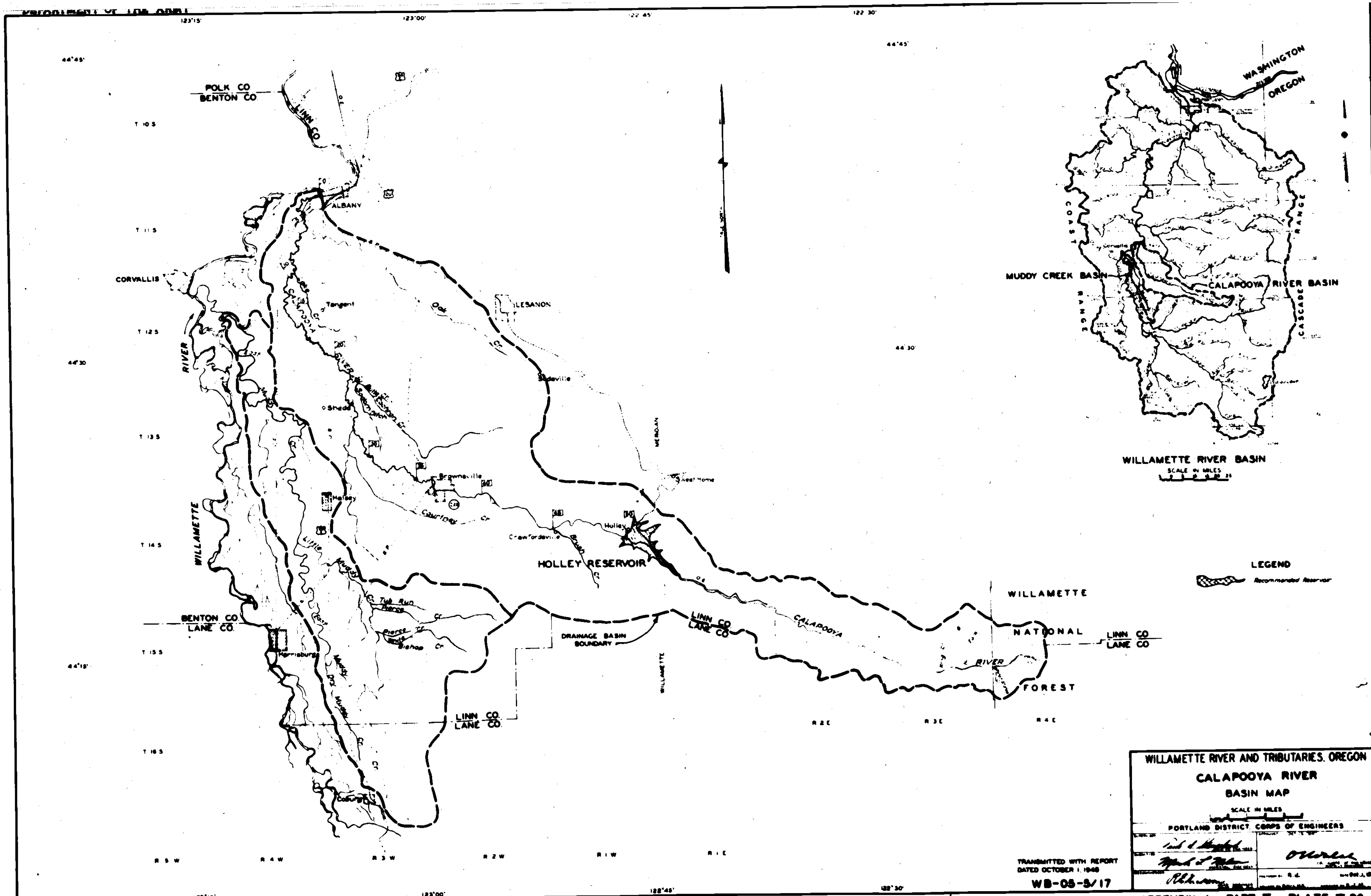
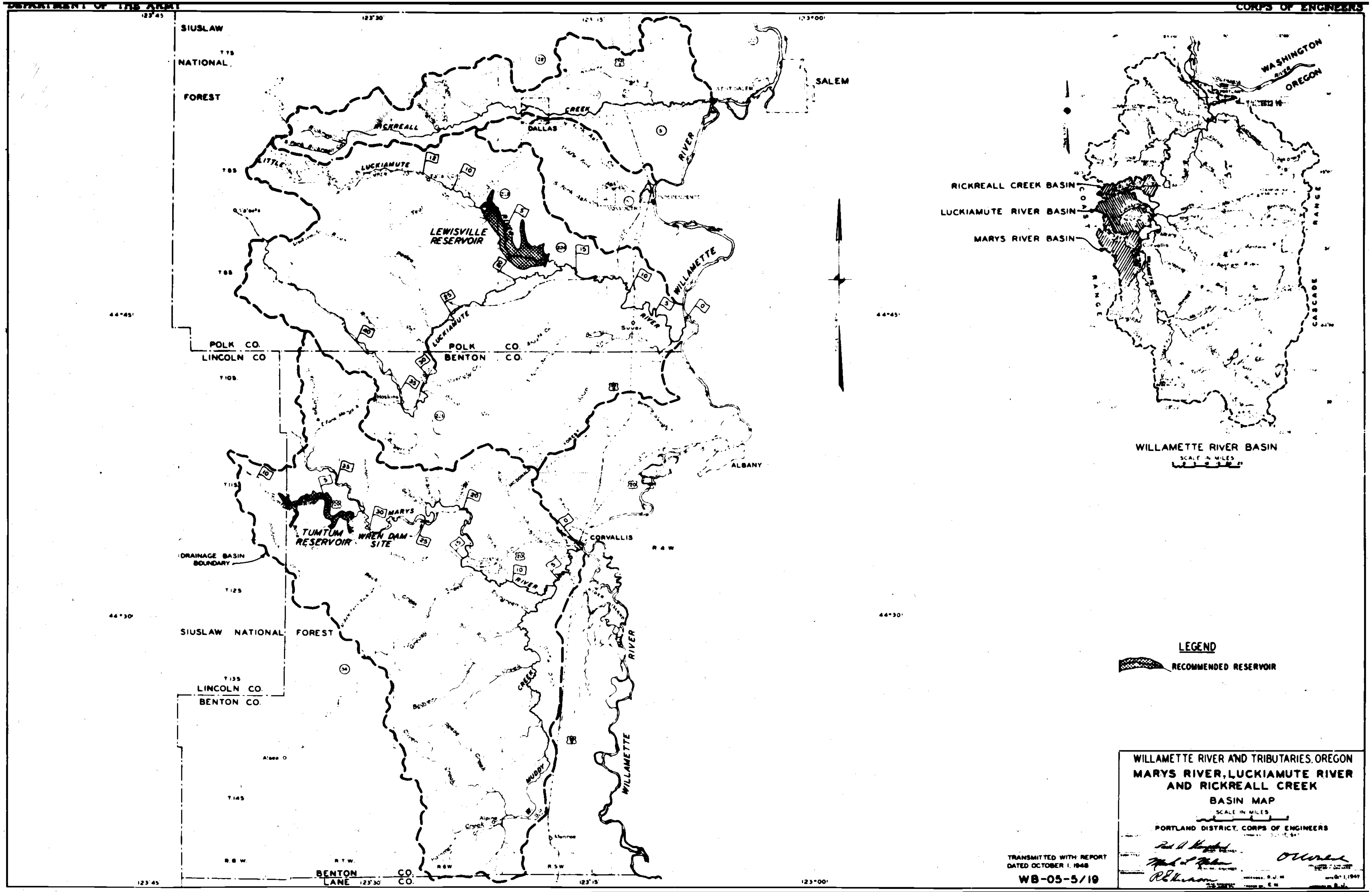

WILLAMETTE RIVER AND TRIBUTARIES, OREGON
CALAPOOYA RIVER
BASIN MAP
SCALE IN MILES
PORTLAND DISTRICT CORPS OF ENGINEERS
TRANSMITTED WITH REPORT
DATED OCTOBER 1, 1948
WB-08-5/17
LEGEND
Recommended Reservoir
WILLAMETTE RIVER BASIN
SCALE IN MILES
WASHINGTON
OREGON
COAST RANGE
CASCADE RANGE
MUDDY CREEK BASIN
CALAPOOYA RIVER BASIN
POLK CO
BENTON CO
LINN CO
ALBANY
CORVALLIS
Tangent
LEBANON
Sodaville
Shedd
Brownsville
Halsey
Sweet Home
Holley
Crawfordsville
HOLLEY RESERVOIR
Harrisburg
Coburg
WILLAMETTE RIVER
CALAPOOYA RIVER
Oak Cr
Courtney Cr
Little Muddy Cr
Muddy Cr
Pierce Cr
Bishop Cr
DRAINAGE BASIN BOUNDARY
BENTON CO
LANE CO
LINN CO
LANE CO
WILLAMETTE NATIONAL FOREST
T 10 S
T 11 S
T 12 S
T 13 S
T 14 S
T 15 S
T 16 S
R 5 W
R 4 W
R 3 W
R 2 W
R 1 W
R 1 E
R 2 E
R 3 E
R 4 E
123°15'
123°00'
122°45'
122°30'
44°45'
44°30'
44°15'

Figure 20

Mary's River, Luckiamute River, and

Rickreall Creek, Basin Map

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS



on barges through the Willamette Falls locks.

Open River Navigation Improvement

The improvement project, as authorized, would provide a navigation channel eight feet deep at low water, between Portland and Oregon City. With contraction works, channel improvement, and stream flow regulation, a channel six feet deep at low water, from Oregon City to the mouth of the Santiam River would be provided. The same procedure would assure a five foot draft at low water to Albany. From Albany to Corvallis, depths of 2.5 to 3.5 feet would be maintained. Necessary snagging would be done between Corvallis and Harrisburg. The project would likewise provide a channel in the Yamhill River, four feet deep at low water from the mouth of the river to McMinnville, to be secured by means of a constructed lock and dam at Lafayette, and the removal of obstructions. Present controlling depths on the Yamhill are four feet from the mouth to the locks, and two feet thence to McMinnville.

Navigation, Lower Willamette River

This part of the comprehensive plan of 1938 has been completed. As a result, from Ross Island Bridge downstream to the Broadway Bridge in Portland, a 30 foot by 300 foot ship channel is being maintained. From the Broadway Bridge downstream to the Columbia River, and in the Columbia River to the Pacific Ocean, a 35 foot by 500 foot ship channel is maintained. These channels allow the entry of ocean going vessels to Portland Harbor.

At Portland there are at waterside fourteen general cargo docks, six grain elevators, six lumber docks, nine marine oil terminals, four ship outfitting docks, and drydocks, and marine railways. All are available to ocean and river craft. In the amount of water-borne tonnage handled, Portland ranked twelfth among the major seaports of the United States in 1945.

Fish Facilities and Stream Pollution

Provisions for surveys, investigations, and planning for fish facilities in connection with the comprehensive plan of improvement, were adopted as a part of the authorized project. Congress has recognized that the fish and wildlife resources affected by the dams are worth millions of dollars, and has generally strenthened the laws, that give to the Fish and Wildlife Service, United States Department of Interior, the responsibility for conserving these resources. This federal agency was formed in 1940, by consolidating the former bureaus of Fisheries and of Biological Survey. To implement this attitude Congress has enacted Public Law Number 732 (House of Representatives

Bill Number 6097) approved on August 14, 1946. This law is usually referred to as the revised "Coordination Act." Coordinator of the River Basin Studies in the Fish and Wildlife Service, Dieffenbach, gives an excellent presentation in a symposium on multiple purpose reservoirs, published by the American Society of Civil Engineers (24, pp 866-870). As was seen in the case of the Quartz Creek Reservoir the opposition locally on this issue lead to an abandonment of the site. The problem of the McKenzie River is still unsolved.

The Report on Water Pollution Control in the Willamette River Basin, prepared by the Public Health Service in 1950 (16) is definitive and authorative, no attempt is made here to even abstract that study. However, the article by Everts in the July 1953, Oregon State Game Commission Bulletin gives an encouraging summation briefly and aptly (15). Lee (21) gives a history of utilization of the river for water supply to the cities on its banks.

Pudding River Project

This project is not an integral part of the comprehensive basin development plan. It was reported in Senate Document Number 185, 75th Congress, 3rd Session, and was authorized as a separate project, by the Flood Control Act of August 18, 1941.

The main features of this project are the removal of log jams, drifts, and snags from the channel, as well as loosened trees and brush from along the banks, between the mouth and mile forty-seven. This project is partially complete and additional work is authorized.

Amazon Creek Project

This project is in the same category as the Pudding River project. It was authorized by the Flood Control Act, and approved July 24, 1946 (Public Law 526, Senate Document 138, 78th Congress, 2nd Session). It will consist of channel improvement on Amazon Creek from a point above the south city limits of Eugene, through the city to a diversion point; a diversion channel 3.5 miles long from Amazon Creek to Fern Ridge Reservoir; and an improved channel on Amazon Creek below the diversion point, from Clear Lake to the Long Tom River. See Figure 11, Alternative Levee Plan with Reservoirs, Sheet Number 2, page 54. Construction of the plan is still pending while modifications of it are being discussed.

CHAPTER V

EVALUATION AND CONCLUSION

In the whole realm of natural resources conservation, there is no subdivision where the term management has greater significance, than in the field of water utilization and development. Properly "water management" is basic to the optimum realization of our resources.

The emphasis of our research into water utilization and development of the Willamette River has been fact finding pertinent to water management. It should be stated at this time that facts in a study of this nature are not always matters of black and white. Futhermore, all the facts cannot be assembled on some of the situations without excessive expenditures of time and money. A Greek inscription from Aristotle on the National Academy of Science Building in Washington D. C. is deemed appropo to this study.

> "The search for truth is difficult. One cannot master it wholly - nor miss it completely. But, from all the facts assembled there emerges Knowledge." (19, p 19)

Water resources management is the concern of the United Nations, as reported in the United Nations World Resources Commission Report, in a set of seven volumes;

it is also that of the National Government as reported in the President's National Resources Policy Commission, in a set of three volumes; again it is a gigantic regional problem as reported in the Secretary of the Army's Columbia River Report, in a set of eight volumes.

Water resources management, in this writer's opinion, must begin with the small watersheds. It is here that the overall problem breaks down into its constituent parts. It is here that management, because of the interrelated interests of the people in the area, is affected, as well as, afforded the greatest opportunity. To the bigger picture, the McKenzie River has spelled power every since the United States Geological Survey published, Water Supply Paper 637c in 1931. To the people of the Willamette Basin, this overview is consistent only if other values may be safeguarded. To date the McKenzie River Basin remains a problem area to big time planners. It is on the small watershed, that people in the watershed can claim proprietary rights in the water. Their livelihood depends upon this water. Their standard of living depends upon the way they husband their water resources. It is only by full discussion of the conflicting interests that will make democracy work. It is by the challenge of demand for additional benefits that technology will advance.

The purpose of this study was to screen out from the amassed data of the larger Columbia System, data of concern directly to the Willamette River watershed. As the study progressed the wealth of discovery made abbreviation, elimination, and synthesis of data a major problem. A growing desire to spend more and more time on the individual streams in the watershed had to be curbed. Basin maps of the tributaries in so far as available or applicable were included to encourage more research in the smaller watershed, rather than to be considered as definitive findings of this study.

As the study was being concluded, a growing realization came to mind, that while a study of the Willamette River water was a limiting study of the larger Columbia River, it would be advantageous to break down the tributaries of the Willamette into separate definitive studies. It is hoped that future students may see fit, to evaluate the water utilization and development of the major tributaries of the Willamette. This would lead, at some subsequent period, to a truer synthesis of the Willamette River.

In conclusion, the writer wishes to reiterate, water resources management must begin with the small watersheds, and be developed on local interrelated people's proprietary interests. It is within these smaller watersheds that thoughtful people will subscribe to the creed of a

Nigerian chieftain who said, "I conceive that the land belongs to a vast family of which many are dead, few are living, and countless numbers are still unborn." (18, p 454).

BIBLIOGRAPHY

1. Bowman, James S., Trend toward multipurpose developments. Civil engineering 22:737-739. 1952.

2. Chamber of commerce, policy declarations on natural resources. Washington, chamber of commerce, 1952. 39p.

3. Coleman, Statis N., Volcanoes, new and old. New York, John Day, 1946. 222p.

4. Columbia and Lower Willamette rivers, Oregon and Washington. Statements before the committee on rivers and harbors, House of Representatives, 67th Congress, 2nd session, February 16, 1922, United States government printing office, 15p.

5. Columbia and Lower Willamette rivers, Oregon and Washington. Hearings before the committee on rivers and harbors, House of Representatives, 70th Congress, 1st session, March 22, 1928, United States government printing office, 1928, 30p.

6. Columbia river and minor tributaries, volume I, District engineers of Seattle, Washington and Portland, Oregon, house document number 103, 73rd Congress, 1st session, February 1932, 564p.

7. Columbia river and minor tributaries, volume II, District engineers of Seattle, Washington, and Portland, Oregon, house document number 103, 73rd Congress, 1st session, March 29, 1932, 1,845p.

8. Columbia river house document number 473, 81st Congress, 2nd session, volume I, United States Department of Interior, February 1950, 398p.

9. Columbia river, house document number 473, 81st Congress, 2nd session, volume 2, United States Department of the Interior, March 1950, 690p.

10. Condon, Thomas, Oregon geology, a revision of "The Two Islands." Portland, J. K. Gill, 1910. 187p.

11. Conklin, Harold. Utilization of ground-water storage in stream system development. Transactions, American society of civil engineers 111:275-354, 1946.

12. Corning, Howard McKinley. Willamette landings, ghost towns of the river. Portland, Binfords and Mort, 1947. 201p.

13. Delzell, Thomas W. Recommendations for federal power policy, submitted by Portland General Electric Co. to the Water Resources Policy Commission, June 1950, Portland, Portland General Electric Co., 1950. 11p.

14. Dixon, J. W. Social and economic implications of irrigation development. Civil engineering 22:689-690, 834-5, 839. September 1952.

15. Everts, Curtis M. Willamette clean-up, Oregon State Game Commission bulletin, 8:7, 3-5 July 1953.

16. Federal Security Agency, Public Health Service. Report on water pollution control. Willamette River Basin. Washington 1950, Public Health Service, Publication no. 123, 80p.

17. Geological survey. Floods of May - June 1948 in Columbia River Basin. Washington, government printing office, 1949, 467p. (Water supply paper 1080).

18. Guy, David J. Management of small watersheds. Journal of American water works association 45:450-456. May 1953.

19. Holson, Jesse E. Techno-economics. Washington, Industrial college of the armed forces, 1953. 26p. (Restricted L53-34)

20. Gleeson, George Walter. A sanitary survey of the Willamette river from Sellwood bridge to the Columbia river. Corvallis, Oregon state college. 1936, 32p. (Oregon state college engineering experiment station, bulletin series number 6)

21. Highsmith, Richard M. Jr. ed. Atlas of the northwest resources and development. Corvallis, Oregon state college, n.d. 124p.

22. Hussey, Russel C. Historical geology, the geological history of North America, 2nd ed. New York, McGraw-Hill, 1947. 465p.

23. Larrowe, Albertus E. The use and control of water prior to 1800. Thesis. Corvallis, Oregon state college, 1933, 79 leaves.

24. Lee, J. C. H. Relation of the Willamette valley project to water supply. Journal of the American water works association 33:721-731. April 1941.

25. Markwell, Kenneth. Fifty years of reclamation progress. Civil engineering 22:466-471. July 1952.

26. McCasland, S. P. Water from the Pacific Northwest for deserts of the Southwest. Civil engineering 22:143-146. February 1952.

27. Multiple purpose reservoirs: A symposium. Transactions, American society of civil engineers 115:790-908. 1950.

28. Oregon. Agricultural experiment station. Soil and water conservation and use by analysis, by a committee of the agricultural staff of Oregon state college, Corvallis 1952. 75p.

29. Oregon. Agricultural experiment station. The first fifty years of Oregon agricultural experiment station 1887-1937. Corvallis, Oregon state college, 1937. 28p. (Its station circular 125)

30. Portland chamber of commerce. The port of Portland and its facilities. Portland, n. d. 28 mimeo. sheaves.

31. Oregon state college extension service. Soil and water conservation and use in Oregon. Corvallis, Oregon state college. 1952. 22p. (Its extension bulletin 725)

32. Oregon state college extension service. Soil and water resources, an appraisal of the problems and a statement of recommendations. Corvallis, Oregon state college. 1953. 31p.

33. Oregon state highway commission. Oregon's climates. Salem, n. d. 1 sheet folder. (Travel information department publication)

34. Oregon state planning board. Present and potential land development in Oregon through flood control, drainage, and irrigation. United States works progress administration, 1938. 221p.

35. Oregon. Willamette river basin commission, Marion county. 1949, 1951. 26 mimeo. pages.

36. Polhemus, James H. Power in the Pacific Northwest, an address before the southeastern electric exchange at Boca Raton, Florida, April 23, 1952. Portland general electric co. 1952. 11p.

37. Powers, W. L. Climate and its relation to agriculture, Corvallis, Oregon area 1889-1950. Corvallis, Oregon state college. 1950. 13p. (Oregon agricultural experiment station, circular of information 487)

38. Powers, W. L., E. F. Torgerson and E. V. Dannen, Identification and productivity of Western Oregon soil types. Corvallis, Oregon state college, 1948. 29p. (Oregon. Agricultural experiment station, station circular 175)

39. Powers, W. L. and C. V. Ruzek. Twenty-two years of soil fertility investigations in the Willamette Valley of Oregon. Corvallis, Oregon state college, 1941. 23p. (Oregon. Agricultural experiment station, station bulletin 387)

40. Requardt, Gustave J. The importance of water supply for productive facilities. Washington, Industrial College of the armed forces, 1951. 160. (Restricted L51-118)

41. Roberts, Albert E. A petrographic study of the intrusive at Mary's Peak, Benton County, Oregon. Northwest science 27:2, 43-60. May 1953.

42. Scuddre, H. D. and E. B. Hurd. Graphic summary of agriculture and land use in Oregon. Corvallis, Oregon state college, 1935 reprinted 1949, 39p. (Oregon. Agriculture experiment station, station circular 114)

43. Selby, H. E. and Leland Fryer, Willamette Valley land adaptability. Corvallis, Oregon state college, 1937. 1 sheet 4 fold. (Oregon. Agricultural experiment station, station circular 120)

44. Sporn, Philip. Electric power in industrial mobilization. Washington, Industrial college of the armed forces. 1951, 30p. (Restricted L51-153)

45. Trefethen, Joseph M. Geology for engineers. New York, VanNostrand, 1949. 620p.

46. Truppner, William C. Facts for decision, Washington, Industrial college of the armed forces, 1952. 21p. (Restricted L52-115)

47. Umbgrove, J. H. F. The pulse of the earth, 2nd ed. The Hague, Martinus Nijhoff, 1947. 358p.

48. U. S. Army, Corps of Engineers. Columbia river and tributaries, Northwestern United States, letter from the Secretary of the Army, transmitting a letter from the Chief of Engineers, U. S. Army, dated June 28, 1949, submitting a report, together with accompanying papers and illustrations, on a review of reports on, and preliminary examinations and surveys of, the Columbia river and tributaries, Northwestern United States, made pursuant to several congressional authorizations listed in the report. In 8 vol., vol. 5. House document 531, 81st Congress, 2nd session, pp 1659-2314. Government printing office, 1951.

49. U. S. Army, Corps of Engineers. Reports on preliminary examination and survey of Columbia and lower Willamette rivers, below Portland, Oregon. Washington, Government printing office, 1911. 27p. (U. S. 61st Congress, 3rd session, House document 1278)

50. U. S. Army, Corps of Engineers. The Willamette river flood, December 31, 1942 - January 4, 1943. Portland, U. S. Army engineers, Portland Oregon District, 1943. 35p.

51. U. S. Army, Corps of Engineers. Willamette river and tributaries, Oregon. Letter from the Secretary of War transmitting a letter from the Chief of Engineers, U. S. Army, dated March 4, 1938, submitting a report together with accompanying papers and illustrations, on examination of, and review of reports on Willamette river and tributaries, Oregon, authorized by the Flood Control Act approved June 22, 1936, an Act of Congress approved June 13, 1934, River and Harbor Act approved August 30, 1935, and requested by resolution of the Committee on Commerce of the United States Senate, adopted September 27, 1933. Washington, U. S. government printing office, 1938. 104p. (U. S. 75th Congress, 3rd session, house document 544)

52. U. S. Army, Corps of Engineers. Willamette river, Oregon. Letter from the Secretary of War transmitting a report from the Chief of Engineers on Willamette River, Oregon, covering navigation, flood control, power development, irrigation, Washington, U. S. government printing office, 1932. 136p. (U. S.) (72nd Congress, 1st session, house document 263)

53. U. S. Army, Corps of Engineers. Willamette River, Oregon. Letter from the Secretary of War transmitting report from the Chief of Engineers on preliminary examination of Willamette River, Oregon, between Oregon City and Portland, including the locks at Oregon City. Washington, U. S. government printing office, 1931. 15p. (U. S.) (71st Congress, 3rd session, house document 748)

54. U. S. Army, Corps of Engineers. Willamette River, Oregon. Letter from the Secretary of War transmitting report from the Chief of Engineers on preliminary examination and survey of Willamette River, Oregon, between Portland and Salem. Washington, U. S. government printing office, 1930. 62p. (U. S.) (71st Congress, 2nd session, house document 372)

55. U. S. Bureau of Reclamation. The Columbia river basin. Report by the U. S. Department of the Interior, Secretary J. A. Krug, June 3, 1948. Washington, May 1949. 21p.

56. U. S. Congress. House committee on rivers and harbors. Columbia and lower Willamette rivers, Oregon and Washington. Statements of Hon. C. N. McArthur, a representative in Congress from the state of Oregon, Col. George H. Kelley, representing the Port of Portland commission, and Mr. W. D. B. Dodson, representing the Chamber of Commerce of Portland, on the subject of the improvement of the lower Willamette and Columbia rivers, Oregon and Washington, before the committee on rivers and harbors, House of Representatives, 67th Congress, 2nd session, February 16, 1922. Washington, government printing office, 1922. 15p.

57. U. S. Department of the Interior. Program for the Pacific Nortwest 1952-1957. Portland, Pacific Northwest Field Committee, n. d. 46p.

58. U. S. Federal Security Agency, Public Health Service. Pacific Northwest Drainage Basins, a cooperative state-federal report on water pollution. Washington, 1951. 79p. (Public health service publication number 87)

59. U. S. Secretary of the Army. Improvements of rivers and harbors. Letter from the Secretary of the Army transmitting a compilation of preliminary examination, survey, and review reports on river and harbor and flood control improvements, authorized by the River and Harbor Act approved on May 17, 1950. U. S. government printing office, 1952. 468p. (House document number 214, 82nd Congress, 1st session)

60. White, C. Langdon, and Edwin J. Foscue. Regional geography of Anglo-America. New York, Prentice Hall. 1949. 898p.

61. Winther, Oscar Osburn. The great Northwest, a history, 2nd ed. New York, Alfred A. Knopf, 1950. 491p.