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US Army Corps
of Engineers®
Portland District

# Appendix 1-C to Willamette Master Water Control Manual

# Water Control Manual for Cougar Lake

## Oregon

July 1964
Revision 3, July 28, 2017

NOTICE TO USERS OF THIS MANUAL

Regulations specify that this Water Control Manual be published in loose-leaf form, and only those sections, or parts thereof, requiring changes will be revised and printed. Therefore, this copy should be preserved in good condition so that inserts can be made to keep this manual current. Changes to individual pages must carry the date of revision, which is the Division's approval date.

| Change No. | Page / Paragraph / Section | Statement of Review or Change | Approval Date |
|---|---|---|---|
| Rev. 0 | | Initial Cougar Dam Water Control Manual | Jul 1964 |
| Rev. 1* | Exhibit 1 added<br>Paragraph 7-00 added | An Interim Water Control Plan is added after the Plates as Exhibit 2, and includes Interim Risk Reduction Measures memorandums. Add paragraph 7-00 to Section VII for discussion of the Interim Water Control Plan. | Aug 14, 2013 |
| Rev. 2 | Exhibit 2 added<br>Paragraph 9-21 added | Add MFR "Implementation of Environmental Flows in the Willamette Valley" as Exhibit 2. Add paragraph 9- 21 to Section IX for discussion of the Environmental Flows. | Oct 1, 2015 |

*Rev. 1 is an Interim Water Control Plan describing modified spillway gate and flood operations as a result of Interim Risk Reduction Measures (IRRM). This interim plan is to be used until the spillway gates are repaired. IRRMs are in place because an analysis has shown that the spillway tainter gates are overstressed and need to be strengthened to be compliant with EM 1110-2-2702. For simplicity, Exhibit 1 and page 43a will be revised as needed or removed when the IRRM is rescinded. No changes to the table of contents are made for this revision.

EMERGENCY REGULATION ASSISTANCE PROCEDURES

In the event that unusual conditions arise during duty hours, contact between Rogue River Basin Project staff and Reservoir Regulation and Water Quality staff (CENWP-EC-HR) can be made by calling the CENWP-EC-HR phone line at (503) 808-4896. If CENWP-EC-HR is unstaffed, further assistance can be achieved by contacting (in the order listed) one of the following persons assigned to be on call during non-duty hours:

1. Willamette Basin Regulator
   Work: (503) 808-4869
   Cell: (503) 927-4642

2. Backup Regulator
   Work: (503) 808- 4891
   Cell: (503) 475-2492

3. Backup Regulator
   Work: (503) 808-4960
   Cell: (503) 819-9823

4. Backup Regulator
   Work: (503) 808-4833

5. Chief, Reservoir Regulation and Water Quality Section
   Work: (503) 808-4887
   Cell: (503) 819-4189

6. Willamette Basin Project
   Lookout Point (541) 937-2131 or (541) 937-3072
   Detroit Dam Control Room (503) 854-3150
   Foster Dam Control Room (541) 367-5124 x0

**DEPARTMENT OF THE ARMY**
**CORPS OF ENGINEERS, PORTLAND DISTRICT**
**PO BOX 2946**
**PORTLAND OR 97208-2946**

REPLY TO
ATTENTION OF

CENWD-PDW 1 OCT 2015

MEMORANDUM THRU Laurie Nicholas, Chief, Reservoir Regulation and Water Quality Section (CENWP-EC-HR)

FOR Lance Helwig, Chief, Engineering and Construction Division (CENWP-EC)

SUBJECT: Response to Request for Review and Approval for Incorporation of the Environmental Flow Recommendations Memo into the Water Control Manuals for Willamette Valley Projects

1. This memorandum is in response to the subject request, dated 14 September 2015, for review and approval of the permanent revisions to the Cougar, Detroit, and Lookout Point water control manuals to incorporate Environmental Flow Recommendations as part of the Sustainable Rivers Project.

2. In reviewing the changes, several of the Environmental Flow Targets note Operational Considerations of which regulators should be aware when considering releases to meet such targets. It is imperative that all Standard Operating Procedure (SOP) documents be updated to reflect the latest notification procedures for applicable thresholds identified in the Targets.

3. Subject to the items noted in paragraph 2, the Columbia Basin Water Management Division approves the revisions to the water control manuals for the projects listed in paragraph 1 to incorporate the Environmental Flow Recommendations.

STEVEN B. BARTON
Chief, Columbia Basin Water Management Division

CF:
CENWD-PDW-R (Ammann)
CENWD-PDW-H (Proctor)
CENWP-EC-HR (Nicholas)
CENWP-OD-V (Petersen, Bengtson, Bardy)
CENWP-PM-FP (Budai)

WATER CONTROL MANUAL STATUS SHEET

PROJECT: COUGER LAKE

| CHAPTER | STATUS | PLANNED ACTION |
|---|---|---|
| I. INTRODUCTION | *** 2 *** | Update and revise RRMAN Section I, Introduction; add additional material |
| II. DESCRIPTION | *** 2 *** | Update and revise RRMAN Section II, Bassin Description, and Section III, Project Description; add addl. material |
| III. HISTORY | *** 4 *** | Compile a new chapter using existing records and additional information |
| IV. WATERSHED CHARACTERISTICS | *** 2 *** | Update and revise RRMAN Section II, Basin Description |
| V. DATA COLLECTION | *** 4 *** | Update and revise RRMAN Section IV, Climatology; Section V, Hydrology; and Section X, Hydrometeorological Facilities; Add additional material |
| VI. HYDROLOGIC FORECASTS | *** 4 *** | Update and revise RRMAN Section V, Hydology; add additional material |
| VII. WATER CONTROL PLAN | *** 2 *** | Update and revise RRMAN Section VI, Seasonal Regulation; Section VII, Flood Control Regulation; Section VIII, Storing For Conservation; add additional material |
| VIII. EFFECT OF WATER CONTROL PLAN | *** 4 *** | Update and revise RRMAN Section VIII, Storing For Conservation; Section IX, Utilization Of Stored Water; add additional material |
| IX. WATER CONTROL MANAGEMENT | *** 4 *** | Update and revise RRMAN Section XI, Responsibilities And Emergency Instructions Add additional materials |
| SUPPPORTING INFORMATION (photo, pertinent data, tables, graphs, etc) | *** 4 *** | Selected tables, charts, and graphs req. revision and update |

STATUS CODES:
1 - approved, up to date
2 - approved, needs revision
3 - preliminary draft
4 - incomplete and/or outdated

NOTE: RRMAN=Reservoir Regulation Manual

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* scheduled for update and revision

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# COUGAR DAM AND RESERVOIR

## PERTINENT DATA

1. Project location:

| | |
|---|---|
| Public land survey | SE 1/4 Section 31, T. 16 S., R. 5 E., Willamette Meridian |
| Stream | South Fork McKenzie River |
| Above mouth (South Fork) | 4.4 river miles |
| Above mouth (McKenzie River) | 61 river miles |
| From Coburg (River mile 3) | 58 river miles |
| Distance from Eugene, Oregon | 42 airline miles |
| Distance from Portland, Oregon | 96 airline miles |

2. Project basin, description and hydrology:

| | | |
|---|---|---|
| Drainage area | 208 | square miles |
| Mean elevation (1929 adj., USC&GS) | 4,020 | feet, m.s.l. |
| Highest elevation | 6,650 | feet, m.s.l. |
| Elevation at damsite (low water) | 1,274 | feet, m.s.l. |
| Normal annual basin precipitation | 71 | inches |
| Average annual runoff (1948-1961) | 673,300 | acre-feet |
| Average annual discharge (1948-1961) | 930 | c.f.s. |
| Maximum observed flood peak (Dec. 1945) | 24,500 | c.f.s. |
| 100-year flood | 28,400 | c.f.s. |
| Spillway design flood (reservoir inflow) | 86,000 | c.f.s. |
| Standard project design flood | 40,000 | c.f.s. |
| Minimum daily flow (1948-1961) | 200 | c.f.s. |
| Minimum mean monthly flow (1948-1961) | 220 | c.f.s. |
| Maximum mean monthly flow (1948-1961) | 3,484 | c.f.s. |

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COUGAR DAM AND RESERVOIR

PERTINENT DATA (Cont'd)

3. Reservoir data:

| Feature | Elevation, (feet, m.s.l.) | Water surface area (acres) | Storage 1,000 (acre-feet) |
|---|---|---|---|
| Low point in reservoir | 1274.0 | -- | 0 |
| Minimum power pool | 1516.0 | 595 | 54.1 |
| Minimum flood-control pool | 1532.0 | 642 | 64.0 |
| Spillway crest | 1656.75 | | 169.7 |
| Maximum conservation pool | 1690.0 | 1,230 | 208.0 |
| Full and maximum pool | 1699.0 | 1,280 | 219.3 |
| Top of dam | 1705.0 | -- | -- |

4. Storage allocation:

| | | |
|---|---|---|
| ~~Dead~~ storage | (1274-1516) | 54,150 acre-feet |
| Power | (1516-1532) | 9,900 acre-feet |
| Total flood control | (1532-1699) | 155,230 acre-feet |
| Usable total | (1516-1699) | 165,130 acre-feet |

5. Spillway:

| | |
|---|---|
| Type | Concrete gravity, gated, ogee section |
| Crest length, gross | 89 feet |
| Crest length, effective | 80 feet |
| Crest elevation | 1656.75 feet, m.s.l. |
| Gate sill elevation | 1655.67 feet, m.s.l. |
| Maximum head on crest | 42.25 feet |

COUGAR DAM AND RESERVOIR

PERTINENT DATA (Cont'd)

| | |
|---|---|
| 5. Spillway (Cont'd) | |
| Design discharge | 76,140 c.f.s. |
| Number of gates | 2 |
| Type of gates | Radial (Tainter) |
| Gate width | 40.0 feet |
| Elevation, top of gates | 1699.0 feet |
| Gate height (sill to top) | 43.32 feet |
| Gate hoist | Cable lift |
| Gate operation | Electric motors, push button |
| Approach channel elevation | 1635.0 feet, m.s.l. |
| Discharge channel | Concrete chute, 90 feet long |
| 6. Minimum flow: | |
| (February - June) | 300 c.f.s. |
| (July - November) | 200 c.f.s. |
| Flood periods | 100 c.f.s. |
| 7. Outlets: | |
| Type of gates | Slide |
| Size of gates | 6'6" x 12'6" |
| Number of regulating gates | 2 |
| Number of emergency gates | 2 |
| Gate operation | Hydraulic |
| Tunnel diameter | 13'-6" |
| Tunnel slope | One percent |
| Tunnel length, steel lined | 124 feet |

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COUGAR DAM AND RESERVOIR

PERTINENT DATA (Cont'd)

7. Outlets (Cont'd)

| | |
|---|---|
| Tunnel length, concrete lined | 869 feet |
| Total tunnel length | 993 feet |
| Invert elevation at intake tower | 1478.75 feet, m.s.l. |
| Approach channel elevation | 1470.0 feet, m.s.l. |
| Capacity of tunnel at minimum flood control pool, elevation 1532.0 | 5,920 c.f.s. |
| Capacity of tunnel at maximum pool, elevation 1699 | 12,050 c.f.s. |
| Trash racks: | |
| Width, clear opening | 3.67 feet |
| Gross area | 2,011 square feet |
| Effective area | 1,300 square feet |

8. Dam:

| | |
|---|---|
| Type | Rockfill |
| Elevation, roadway | 1705.0 feet, m.s.l. |
| Width of roadway | 20 feet |
| Height (average tailwater to crest) | 452 feet |
| Freeboard above full pool | 6 feet |
| Length (overall) | 1,500 feet |

9. Power facilities:

Penstocks:

| | |
|---|---|
| Type | Pressure tunnel, steel |
| Number and size | Single 10'-6" diameter. Branches into two 7'-6" diameter wyes. |

COUGAR DAM AND RESERVOIR

PERTINENT DATA (Cont'd)

9. Power facilities (cont'd)

Penstocks (cont'd)

| | |
|---|---|
| Invert elevation – | 1419.50 ft. m.s.l. |
| Intake centerline elevation | 1424.75 feet, m.s.l. |
| Operating control | Wicket gates |
| Emergency closure | Butterfly valves |
| Maintenance and dewatering | Bulkhead gates |

Powerhouse:

| | |
|---|---|
| Location | Left abutment |
| Length overall | 115'-0" |
| Width overall | 74'-6" |
| Spacing of units | 34'-0" |
| Length of erection bay | 44'-0" |
| Number of units | 2 |
| Elevation draft tube invert | 1240.5 feet, m.s.l. |
| Elevation centerline turbine distributor | 1255.5 feet, m.s.l. |
| Elevation operating deck | 1260.25 feet,m.s.l. |

Turbines:

| | |
|---|---|
| Type | Francis |
| Manufacturer | Leffel Co. |
| Throat diameter of turbine runner | 63.25" |
| Revolutions per minute | 400 |
| Rated horsepower | 17,250 |
| Rated head | 321 feet |

COUGAR DAM AND RESERVOIR

PERTINENT DATA (Cont'd)

9. Power facilities (Cont'd)

Generators:

| | |
|---|---|
| Rating (nameplate) each | 12,500 kilowatts |
| Rating (guaranteed overload) | 14,375 kilowatts |
| Power factor | 0.95 |
| Kva rating | 13,158 kva |
| Manufacturer | Elliott Co. |

General:

| | |
|---|---|
| Maximum head (gross) | 449 feet |
| Minimum head (gross) | 263 feet |
| Rated head | 321 feet |
| Maximum turbine discharge | 1,308 c.f.s. |
| Tailwater elevation at maximum turbine discharge,1,308 cfs(no flow through outlets) | 1253.6 feet, m.s.l. |
| Nominal prime power | 9,450 kilowatts |
| Nominal firm power | 11,800 kilowatts |
| Total energy, average annual | 120,503,000 kwh |

COUGAR RESERVOIR REGULATION MANUAL

SECTION I - INTRODUCTION

1-01. Authority. - Authority for preparing this manual is contained in paragraph 5 of ER 1110-2-240, dated 25 March 1963. Its preparation has been in accordance with instructions presented in EM 1110-2-3600, dated 25 May 1959.

1-02. Purpose and scope. - The function of this manual is to document the plan of reservoir regulation and to provide a reference source for higher authority and for personnel who will be responsible for the regulation and coordination of Cougar Reservoir with other Willamette Valley reservoirs for flood control, power, and other conservation uses.

1-03. The manual contains a concise description of the river basin and project, the coordinated plan of basin development, information necessary for understanding the objectives of the project, and instructions for regulating the reservoir. Full coverage is given to method of regulation, operating rules and schedules, hydrologic network, forecasting procedures, organization of reservoir regulation personnel, communication facilities, and emergency instructions.

1-04. Revisions to manual. - Changes and revisions to the manual will be made by the Engineering Division of the Portland District as techniques of regulation and forecasting are developed which will improve the effectiveness of the project. Any change in the manual which affects the authorized functions of the reservoir or involves a significant deviation from the approved plan will be submitted through the North ~~Pacific~~ Division Office to the Office, Chief of Engineers for prior approval. All revision will be dated and a master file will be kept by the Portland District.

1-05. - Drought Contingency Appendix. - A drought contingency appendix was added to the manual in September 1992 to meet the requirements or ER 1110-2-1941, "Drought Contingency Plans", dated 15 September 1981.

## SECTION II - BASIN DESCRIPTION

2-01. Location. - The McKenzie River Basin is located in western Oregon on the west slope of the Cascade Range, approximately 100 miles south and east of Portland, Oregon. The South Fork McKenzie River, on which Cougar Dam Reservoir is located, is a major tributary of the McKenzie River and joins the main stem at river mile 57. Plate 1 and the frontispiece show the location of the project and basin with respect to other major geographical features in western Oregon, including the system of storage projects that are existing, under construction, and authorized for the Willamette River Basin.

2-02. Drainage area. - South Fork McKenzie River drains a rectangular-shaped area of 216 square miles. The basin lies entirely within the Willamette National Forest and the terrain is rugged and heavily forested. Ninety-six percent of the basin, 208 square miles, is above Cougar Dam. The mean elevation of the basin above Cougar Dam is 4,020 feet, varying from 1,274 feet at the dam to 6,650 feet on the east rim of the watershed. Chart 1 shows an area-elevation curve for the area above the dam. The McKenzie River Basin above Coburg, a key downstream control station, varies in elevation from 396 feet at Coburg to 10,354 feet at South Sister, on the extreme east boundary of the basin.

2-03. Streams. - Plate 1 shows the stream system of the entire McKenzie River Basin, of which the South Fork is a principal tributary. South Fork McKenzie River flows generally in a northwesterly direction. Major tributaries of the South Fork in upstream order are: East Fork, Walker Creek, French Pete Creek, Rebel Creek, August Creek, Roaring River, and Elk Creek. There are numerous smaller tributaries. All of the streams flow in deep canyons and have steep gradients.

2-04. The gradient of the South Fork McKenzie River is approximately 70 feet per mile through the reservoir reach. At the headwaters of the many tributaries the stream gradients are in excess of 200 feet per mile. These steep gradients contribute to fast-flowing streams, which respond quickly to intense storms that frequent the basin during the period, November through April. On the main McKenzie River, the river gradient varies from 25 feet per mile at the confluence with South Fork McKenzie River to approximately 7 feet per mile in the 10-mile reach below Mohawk River.

2-05. Forest cover. - Most of the terrain above Cougar Dam is mountainous and is covered with a heavy stand of coniferous trees. Logging in this area has been less severe than in other parts of the McKenzie River Basin and a reforestation program is in effect to restore the forest cover. Approximately 80 percent of the watershed above Cougar Dam is government-owned and is administered by either the Forest Service or the Bureau of Land Management. The forest cover provides several beneficial effects, namely: (1) shields the soil mantle from intense storms and resulting erosion, (2) improves the permeability and infiltration capacity of the soil, and (3) shields the basin snow cover which results in a more controlled snowmelt runoff.

2-06. Population. - Approximately 75 percent of the population of Oregon resides in the Willamette Valley, with the greatest concentration at the northern end of the basin in the Portland metropolitan area. Other large metropolitan areas are Salem, Albany, Corvallis, and Eugene-Springfield. Parts of these areas are subject to flooding from Willamette River and will benefit from the operation of Cougar Reservoir. Outside of the major urban centers, the valley population resides on farms and in small towns. Willamette Valley has sustained a rapid increase in population since 1900, and present indications are that this trend will continue. Population in Springfield, at the head of the valley, tripled between 1940 and 1950, and nearly doubled between 1950 and 1960. The following tabulation shows the increase in population between 1940 and 1962 at principal cities and towns in the upper Willamette area.

| City or town | Population in year | | | | Percent increase in population | |
|---|---|---|---|---|---|---|
| | 1940 | 1950 | 1960 | 1962 | 1950-1960 | 1950-1962 |
| Eugene | 20,838 | 35,879 | 50,977 | 55,413 | 42 | 54 |
| Springfield | 3,805 | 10,807 | 19,616 | 20,717 | 82 | 92 |
| Coburg | 456 | 693 | 754 | 727 | 9 | 5 |
| Harrisburg | 622 | 862 | 939 | 936 | 9 | 9 |
| Junction City | 1,187 | 1,475 | 1,614 | 1,688 | 9 | 14 |

2-07. The population of the McKenzie River Basin is estimated to be 15,000. Within a 50-mile radius of Cougar project the population is estimated to be about 150,000. The area above the reservoir is unhabited. Springfield and Eugene, the principal cities nearest to the project, are located approximately 40 miles west of Cougar Dam.

2-08. <u>Industry and resources</u>. - The Springfield-Eugene metropolitan area is the industrial center of the upper Willamette Valley. At the present time the economy of this area is dependent to a major degree upon the production of lumber and wood products, and, to a lesser degree, upon agricultural products. Ten wood products industries are located in the Springfield area, the headquarters for more than 40 logging and lumber operations. The annual lumber production within the McKenzie River Basin is estimated to be 100,000,000 board feet. About 15 additional logging and lumber operations are distributed among the small communities along the McKenzie and Mohawk Rivers.

2-09. There is no agricultural development above Cougar Reservoir. Agricultural lands within the McKenzie Basin are located on the valley floor downstream from Cougar Dam. They are divided by usage as follows: field and special crops, 55 percent; pasture 25 percent; fruits and nuts, 20 percent. At the present time much of the McKenzie River flood plain is irrigated for the production of the more valuable crops. The McKenzie Ditch Company diverts water at river mile 26 for irrigating along the left bank in the vicinity of Thurston. Muddy Creek Irrigation Company diverts water near river mile 8 for use along East Muddy Creek below Coburg. Many farmers irrigate with water pumped directly from the stream. Present irrigation water rights in the McKenzie River Basin total about 300 c.f.s.

2-10. Mineral deposits in the McKenzie Basin are of minor importance. Small amounts of gold have been extracted, but no commercial operations are known to be active. There are three known points where mineral hot springs exist.

2-11. Power is now generated on the main McKenzie River at two hydroelectric plants located at Leaburg and Walterville. These plants, owned and operated by the Eugene Water and Electric Board, are both essentially run-of-river projects. The installed capacities of the two plants are: Leaburg, 13,500 kilowatts; and Walterville, 8,000 kilowatts. In the headwaters of the McKenzie River, the Board operates the Carmen-Smith project which has an installed capacity of 90,000 kilowatts. The outputs of both the Leaburg and Walterville plants will be firmed up when Cougar Reservoir and other headwater storage reservoirs become operative.

2-12. At present, power is transmitted from the Leaburg and Walterville plants to Eugene, through a Eugene Water and Electric Board 69 kv line. The Eugene Water and Electric Board also has a 115 kv line from the Carmen substation to the Cougar Switchyard, where it connects with the Bonneville Power Administration's 115 kv line between Cougar Dam and Eugene.

2-13. Electric service in the McKenzie Basin is furnished from Springfield to a point about 10 miles east of Leaburg by the Eugene Water and Electric Board. From this point east to about McKenzie Bridge, service is furnished by the Lane County Electric Cooperative, whose source of energy is Bonneville Power Administration's Cougar-Eugene transmission line. A substation at Blue River transfers energy to the Cooperative's line. When needed, the Eugene Water and Electric Board will provide a feeder line from the Carmen-Smith project to service the area east of McKenzie Bridge. A small area in the Springfield vicinity is supplied by the Eugene Water and Electric Board, Lane County Electric Cooperative, and Pacific Power and Light Company. All distribution lines in the area are nominally 12.5 kv. Telephone service is provided by Pacific Northwest Bell Company.

2-14. Transportation. - U. S. Highway 126 follows the McKenzie River from Springfield to Belknap Springs, a distance of about 75 miles, and across the Cascade Divide to Bend. A paved side road extends from Belknap Springs, following the McKenzie River upstream past Clear Lake to U. S. Highway 20. About 42 miles from Eugene, a gravel road branches off from U. S. Highway 126 and follows the South Fork McKenzie River a distance of about 3 miles to Cougar damsite. Improved roads parallel the larger tributaries and logging roads provide access to timber areas.

2-15. Major bridges crossing the McKenzie River are: (1) Hayden Bridge which carries traffic from Springfield to Marcola, (2) Hendricks Bridge which crosses near Walterville, and (3) McKenzie Bridge which crosses about 10 miles east of Blue River, Oregon.

2-16. The Weyerhaeuser Company logging railroad crosses the river near Hayden Bridge and follows a course up the Mohawk Valley. Regular bus service is available on U. S. Highway 126 and charter service on other roads. Irregular freight truck service is available on all roads.

2-17. Flood damages. - Flooding in the Willamette Valley has been extensive and extremely damaging in the past years. The Eugene-Springfield industrial area, which has been subjected to many damaging floods in past years, was the major damage center in the southern part of Willamette River Basin before the upstream reservoirs were constructed.

With the completion of four flood-control reservoirs above Eugene, the Eugene-Springfield area is relatively free of flooding. Downstream from Eugene, the cities of Junction City, Harrisburg, Corvallis, Albany, Salem, Oregon City, and Portland, as well as many small communities and intervening agricultural areas, have experienced serious flood damages. These areas all benefit substantially from the construction of upstream flood-control reservoirs.

2-18. Properties within the flood plains of the McKenzie River and Willamette River, as surveyed in 1955, are valued at approximately $70,000,000 and $350,000,000, respectively. It is estimated that about 31 miles of the lower McKenzie River are subject to various degrees of flooding. Without flood control at Cougar Reservoir, the average annual damages would be $1,080,000 in the McKenzie Basin, based on 1962 price levels, and existing channel conditions. The corresponding average annual damages along the main Willamette River without reservoir control are estimated to be $8,350,000. Flood damages have been appraised for the 1943, 1945, 1955, and 1961 floods, and estimated for a repetition of the 1861 flood. At 1962 prices and development in the flood plain, the damages that would result from the recurrence of the above uncontrolled floods are as follows:

| Date of Flood | McKenzie River | Main Stem Willamette River |
|---|---|---|
| February 1861 | $5,000,000 | $63,000,000 |
| December 1942 - January 1943 | 1,001,000 | 13,020,000 |
| December 1945 | 3,360,000 | 15,100,000 |
| December 1955 | 797,000 | 15,850,000 |
| February 1961 | 620,000 | 15,540,000 |

2-19. Numerous floods of smaller magnitude, which often occur several times during a year, would do damage along McKenzie River without flood regulation at Cougar Reservoir. Operation of Cougar Reservoir will reduce damages by about 40 percent along the McKenzie River and 6 percent along the main stem of the Willamette River.

## SECTION III - PROJECT DESCRIPTION

3-01. General. - Need for flood control was recognized early in the history of the Willamette Valley, but control by reservoirs was not generally considered feasible. As late as 1932, the Corps of Engineers reported that no extensive flood-control project was warranted. After that date, population growth and industrial development was rapid. With the accelerated growth of the region, demands for flood protection became increasingly urgent, leading to the development of a general comprehensive plan for the control and utilization of the water resources of Willamette River Basin. The plan included a single dam on the main stem of McKenzie River. Strong opposition to a single dam led to the authorization of dams on three headwater tributaries. Cougar is the largest of these three projects. Location of Cougar Dam and the two additional sites are shown on the frontispiece.

3-02. Project authorization. - The first investigation of the water resources of Willamette River Basin by the Corps of Engineers was made under authority of House Document 308, 69th Congress, 1st session, and the Rivers and Harbors Act approved 21 January 1927. The original plan of improvement for McKenzie River Basin, which consisted of a single dam on the main stem at the Quartz Creek site, was authorized by the Flood Control Act of 1938, 75th Congress, 3rd session. Local objections to the original single-dam plan led the 81st Congress, 2nd session, to consider and authorize the Cougar and Blue River projects on South Fork McKenzie River and Blue River tributaries, respectively, in lieu of a main stem reservoir. Subsequently, specific authorization for the construction of power-generating facilities at Cougar Dam was provided in the Flood Control Act of 1954 (Public Law 780, 83rd Congress, 2nd session). Authorized functions for Cougar project are found in House Document 531, 81st Congress, 2nd session. In addition to Cougar and Blue River projects, a third project on Gate Creek was authorized in the Flood Control Act of 1962. It previously had been recommended in House Document 531, 81st Congress, 2nd session, as a unit in the comprehensive plan of reservoirs in the Willamette River Basin.

3-03. Project purpose. - Cougar project is a major unit in the reservoir system proposed for the comprehensive development of the water resources in Willamette River Basin. One of the principal functions of the project is flood control. Benefits from flood control will be greatest along the lower reaches of the McKenzie River, in the vicinity of Coburg, and along the Willamette River in the Harrisburg area, where overbank flows are experienced several times each winter. Cougar Reservoir alone will not provide complete flood protection to the lower McKenzie River flood plain. Only about 16 percent of the McKenzie drainage area lies above Cougar Dam, which is inadequate for effective flood regulation. Blue River and Gate Creek Reservoirs, when completed, will increase the area in the McKenzie Basin above the three reservoirs to 27 percent, leaving 73 percent of the area above the mouth of the McKenzie River still uncontrolled. This is considerably less than the amount normally considered essential for effective flood control. In addition to flood regulation, Cougar Reservoir will supply water for power generation, irrigation, navigation, and water quality control. Increased flows during the low water season will also provide added power benefits at the existing Eugene municipal plants on the McKenzie River and at a private power plant on the Willamette River at Oregon City. The project also offers public recreation potential in and around the reservoir.

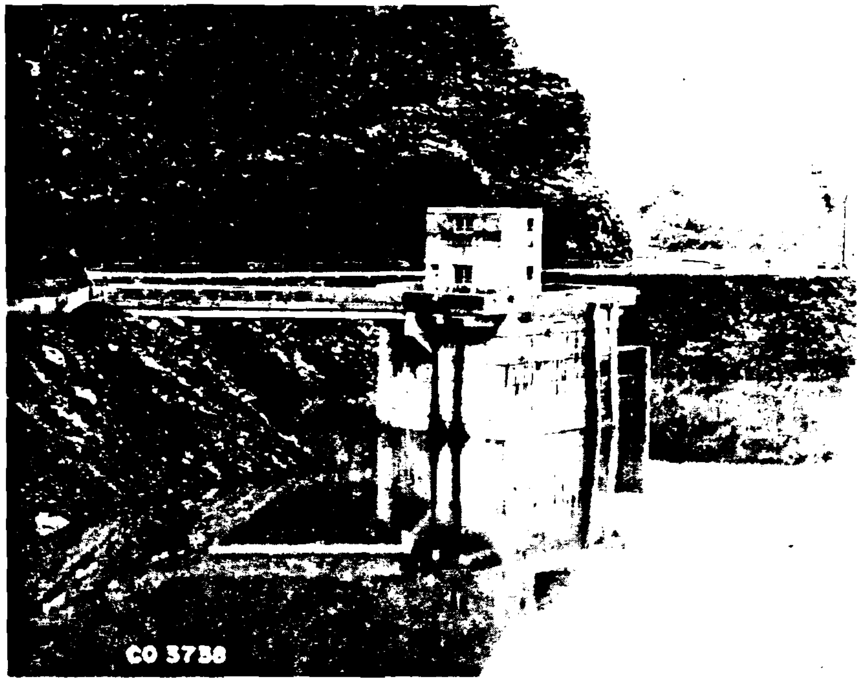
3-04. Location of project. - Cougar Reservoir is located 4.4 miles above the mouth of South Fork McKenzie River. The dam is located 42 airline miles east of Eugene, Oregon, and 61 river miles upstream from the mouth of McKenzie River. The frontispiece shows the geographical location of the project.

3-05. Cougar Project boundary. - The permanent boundary of the project encompasses a narrow strip of shoreline lying below contour elevation 1704 and a limited area in the vicinity of the dam considered necessary for permanent operation and maintenance purposes. The project is wholly on withdrawn public domain lands. In accordance with departmental agreement, management of the shorelands for timber production, recreation, and other uses extraneous to the operation of the project for its primary purposes, will be the responsibility of the U. S. Forest Service.

3-06. Cougar Dam. - Cougar Dam is a rock-fill embankment about 1500 feet long and 452 feet high from average tailwater to crest of dam. The gated ogee-type spillway is 89 feet long, is located in the right abutment, and has a design capacity of 76,140 c.f.s. which discharges into a 90-foot long chute. There is no stilling basin. The service outlet and power tunnels are located in the left abutment and have a common intake structure. The outlet capacity is 5,920 c.f.s. at minimum flood control pool, elevation 1532. The power plant has an installed capacity of 25,000 kilowatts and is located at the toe of the rock-fill dam. Plate 2 shows the general plan of the embankment and the principal features of the project. The spillway discharge rating curve is shown on chart 11.

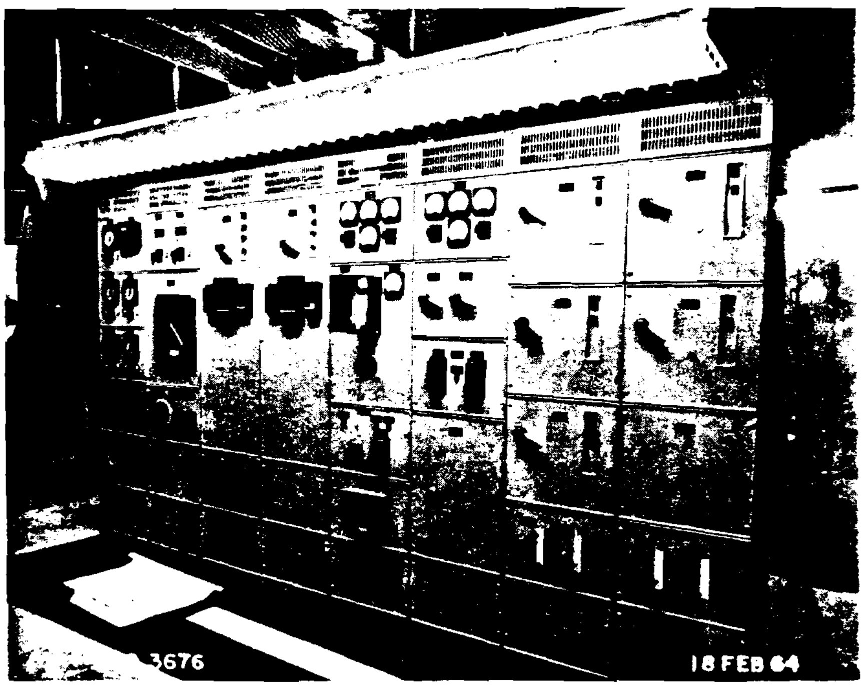
3-07. Cougar Reservoir. - At full pool, elevation 1699, Cougar Reservoir is about 6.5 miles long, 0.7 miles wide at maximum width, and has a surface area of 1,280 acres. At this level, the capacity of the reservoir is 219,300 acre-feet, of which 165,130 acre-feet are usable. Of the usable storage, 155,230 acre-feet are assigned to flood control during the winter months, and 9,900 acre-feet to exclusive power storage. Following the flood season 143,930 acre-feet of the space reserved for floods is filled and the stored water released during the low water season for conservation uses. There are 54,150 acre-feet of dead storage below minimum conservation pool, whose primary function is to provide power head. Backwater studies indicate that the reservoir will be practically level except during flood periods and then the only significant backwater effect in the pool will be confined to the upper end where the reservoir pool intersects the natural river level.

3-08. Regulating outlets. - The regulating outlets, including the intake structure and upstream control, are located in the left abutment. The overall length of the 13.5-foot diameter regulating tunnel, including the intake, is 993 feet. Each of the two entrances to the intake tower is equipped with two identical 6-foot 6-inch by 12-foot 6-inch slide gates. One serves as an operating gate; the other serves as an emergency gate. In addition, there are bulkhead guides upstream from




INTAKE STRUCTURE

Penstock, Regulating Outlet, and Fish Facility




POWER CONTROL PANEL

Outlet, Spillway and Emergency

the emergency gate in which stop logs can be placed. The outlets will discharge 5,920 c.f.s. when the pool is at minimum flood control level, elevation 1532, and 12,050 c.f.s. at full pool level, elevation 1699. Discharge rating curves for the regulating outlets are shown on charts 2 and 3, and in tabular form on table 8.

3-09. Power generating facilities. - A single intake tower serves both the power generating facilities and the regulating outlet works. The intake to the penstock is an 8-foot 3-inch by 10-foot 6-inch rectangular section with a transition between the intake and the penstock. The 10-foot 6-inch diameter main penstock is 1,030 feet long in rock. The penstock at the lower end branches into two 7-foot 6-inch diameter conduits which lead to the turbines in the powerhouse.

3-10. The powerplant consists of two 12,500-kw units. Until a reregulating reservoir is constructed below Cougar Dam, the units will operate at a daily load factor of not less than 80 percent. The head on the turbines will vary from a minimum of 265 feet, between normal tailwater and minimum power pool, and a maximum of 449 feet between minimum tailwater and maximum or full pool.

3-11. Principal changes in the authorized project. - The plan presented in the project document (House Document 531, 81st Congress, 2nd session), proposed construction of an earth- and gravel-fill dam about 445 feet high, an ungated spillway on the left abutment discharging into a stilling basin, a 2,000-foot long power penstock, a surge tank, and a powerhouse with a single generator with a capacity of 25,000 kilowatts. Departure from the project document provided for a rock-fill dam in lieu of the earth- and gravel-fill structure, a gated spillway on the right abutment instead of an ungated spillway on the left abutment. The outlet and power penstock tunnels were constructed through the left abutment instead of through the right abutment. A surge tank for the penstock was eliminated as well as a stilling basin for the spillway. The power installation was changed to two 12,500 kw units in place of the proposed single 25,000 kw unit. Roads were constructed on both sides of the reservoir in lieu of the single road proposed in House Document 531.

3-12. The General Design Memorandum, dated 6 August 1956, outlines the studies and justifications for the above changes. The changes were approved by the Office, Chief of Engineers, with certain comments and recommended revisions that were made in subsequent design memorandums. Page i and ii show a complete list of design memorandums and the dates they were issued.

3-13. <u>Resume of construction activities</u>. - Construction of Cougar Project was initiated 18 May 1956 with the start of the diversion tunnel. The tunnel was completed 21 February 1957 but diversion of South Fork McKenzie River through the tunnel was not effected until 19 April 1960. ~~Stipping~~ Stripping and clearing the damsite area was started on 21 June 1957. Construction of the main dam was started on 22 June 1959 and was approximately 90 percent complete on 1 September 1963. Construction of the powerhouse was initiated on 9 January 1962 and the installation of the generators began on 25 March 1963.

## MAJOR CONSTRUCTION CONTRACTS ON COUGAR PROJECT
Costs as of 31 March 1963

| Contract Item | Principal Contractor | Contract Award Date | Contract Cost | Status of Cost |
|---|---|---|---|---|
| Clearing | (Nine separate contracts) | (1956-1959) | $ 528,524 | * - - - |
| Diversion Tunnel | Northwood, Inc. | 18 May 1956 | 622,000 | Final |
| Stripping & Excavating Abutments & Clearing Portion of Reservoir | Donald M. Drake Co. | 14 Jun 1957 | 957,000 | Final |
| Dams and Appurtenances | Merritt, Chapman & Scott | 9 Jun 1959 | 26,654,000 | Open |
| Furnish and Deliver two 17,250 HP Turbines | The James Leffel & Co. | Apr 1960 | 326,090 | * Open |
| Furnish & Install two 13,158 KVA Generators | Elliott Company | 21 Nov 1960 | 612,500 | Open |
| Powerhouse Construction | S.S. & C. Inc. & West Coast Electric | 12 Dec 1961 | 1,362,689 | * Open |
| Road Construction | J. W. Briggs | 20 Sep 1957 | 2,222,200 | Final |
| Road Construction | Henry Miller | 27 Sep 1957 | 1,839,200 | Final |
| Road Construction | Cedar Creek Logging Co and Forber & Sherwood Logging Co | Oct 1957 | 572,032 | * - - - |
| Road Construction | Hamer Corporation | 16 Jun 1958 | 846,100 | Final |
| Road Construction | Merritt, Chapman & Scott | 9 Jun 1959 | 1,106,000 | Final |
| Road Construction | MacGregor Triangle Company | 21 Apr 1960 | 1,218,600 | Final |
| Road Construction | | May 1963 | 220,000 | Open |

* - - Original bid cost

A breakdown of construction costs as of 1 July 1963 is as follows:

| Project Feature | Construction Cost |
|---|---|
| Lands & damages | $ 10,900 |
| Relocations | 8,088,400 |
| Reservoir clearing | 657,000 |
| Dam (spillway & non-overflow) | 34,119,000 |
| Power Plant facilities | 2,981,400 |
| Roads and bridges | 15,000 |
| Fish facilities | 765,600 |
| Buildings, grounds & utilities | 210,400 |
| Permanent operating equipment | 270,900 |
| Preauthorization studies, engineering, design, supervision, administration | 7,581,400 |
| Total | $54,700,000 |

The above costs represent approximately the total cost of the project.

3-15. Public use facilities. - Development and management of recreation facilities by the Corps of Engineers, other agencies, groups, or individuals under agreement with the Chief of Engineers at reservoir projects are authorized under Section 4 of the Flood Control Act approved 22 December 1944, amended by Section 207 of the Flood Control Act of 23 October 1962, Public Law 87-874 (76 Stat 1195).

3-16. As Cougar Reservoir is located within the Willamette National Forest, the development and administration of project lands for recreation will be administered by the U. S. Forest Service. While the project is not considered particularly adaptable to extensive public-use development it is expected to contribute materially to the recreational attraction of the immediate region, in that it will provide added opportunity for lake fishing, boating, and water sports. The greatest need will be for access to the reservoir for fishing and boat launching. The steep and extremely rugged shoreline definitely limits the opportunity for public-use development. Development provided by the Corps of Engineers will be limited to facilities and viewpoints in the immediate vicinity of the dam.

3-17. Administration of project lands by U. S. Forest Service. - Except for a limited area in the immediate vicinity of Cougar Dam, which will be withheld by the Corps of Engineers for operational purpose, the occupancy and use of all other project lands will be administered by the U. S. Forest Service. The Corps of Engineers, however, will retain primary control over the reservoir and adjacent lands to the extent required to effectively operate the project to fulfill its primary functions.

3-18. In accordance with a memorandum of understanding between Secretaries of Agriculture and Army, immediate supervision of the above-mentioned lands, other than the lands reserved by the Corps of Engineers, will be the responsibility of the District Ranger, McKenzie Bridge Ranger Station, located on U. S. Highway No. 126, about 7 miles northeast of Cougar Dam. The Willamette National Forest Supervisor's office, located in Eugene, Oregon, will be responsible for the nature and extent of development, initiation and coordination of activities relative to policies and regulation, coordination with other agencies, and the issuance of special use permits and concession contracts.

The district forest ranger and his staff will enforce such rules and regulations as are necessary to meet local conditions, protect Government property, and induce safe public-use habits. The Forest Service will develop the type of recreation areas they deem necessary as funds for that purpose become available.

3-19. Debris control. - The South Fork McKenzie River watershed above Cougar Reservoir is mountainous and heavily wooded. Logging operations in the area will be a constant source of debris which will accumulate on the pool. Debris control at the dam is achieved by a floating boom anchored across the reservoir upstream from the dam. Periodical disposal of the floating debris will be accomplished by beaching and burning.

3-20. Fish facilities. - Reference is made to "Design Memorandum No. 16, Fish Facilities, Cougar Reservoir", in which a detailed account is given on the type and migrating habits of fish in South Fork McKenzie River and the facilities provided for their safe passage. The fish facilities at Cougar Project comply with the recommendations of the Fish and Wildlife Service. In general, the fish facilities consist of a barrier at the downstream end of the regulating outlet channel to divert the upstream migrating adults toward the powerhouse tailrace adult fish collector and a fingerling multilevel bypass facility which discharges as much as 300 c.f s. into the outlet channel during the fingerling downstream migration period. The operation of the fishways will be closely coordinated with a fish evaluation program that will be conducted during the first 3 or 4 years the project is in operation. Unless the evaluation program proves otherwise, the present method of fish passage will be continued until Strube reregulating dam is constructed. When Strube Dam is constructed the adult fish collector will be moved below Strube Dam.

## SECTION IV - CLIMATOLOGY

4-01. Climate. - The climate of the area above Cougar Dam is characterized by relatively mild, wet winters and dry summers. During the year, maritime influences generally dominate the area with only occasional short periods of continental air mass control. Principal climatic controls are: (1) geographical location of the South Fork McKenzie River Basin which is near the center of the middle-latitude westerly winds, (2) proximity to the Pacific Ocean, and (3) topography. At the higher elevations above Cougar Dam, average winter temperatures are generally below freezing, and snow often accumulates to great depths. The area is subject to frequent winter storms of varied rainfall and snowfall intensities, but hail and thunderstorms occur infrequently.

4-02. Climatological records. - Climatological data are not available for the area tributary to Cougar Dam. Records are available at a number of locations in and adjacent to the McKenzie Basin; namely, Eugene, McKenzie Bridge, Leaburg, Walterville, Marcola, Vida, and Westfir. Climatological data for McKenzie Bridge, 7 miles northeast of Cougar Dam, are considered to be most representative of the climate at the project site. The longest and most complete record of climatological data in the general area extends from October 1890 to June 1945 at Eugene, located 42 airline miles west of Cougar Dam in the upper Willamette Valley. In December 1942 the Eugene station was moved to the Eugene Airport and records have been kept at that location since that time.

Plate 1 shows the location and length of record at each climatological station, stream gaging station, and snow course in and adjacent to McKenzie River watershed.

4-03. Precipitation. - Normal annual precipitation over the South Fork drainage area above Cougar Dam is approximately 71 inches, ranging from about 63 inches at the dam to 83 inches in the headwaters. About two-thirds of the annual amount normally occurs during the 5-month period, November through March. On the average, only about one-half inch of precipitation occurs during each of the months of July and August. Rainless periods of 30 to 60 days are not uncommon. A summary of precipitation for stations in the vicinity of the project is given on Plate 3.

4-04. The areal distribution of normal annual precipitation over the McKenzie River Basin, including the area tributary to Cougar Dam, is shown on plate 4. The normal annual isohyetal pattern was developed in 1945 as part of a comprehensive report for the Willamette River Basin. Available precipitation data, streamflow, snow course data, and topography were taken into consideration in preparing the annual isohyetal map for the basin.

4-05. At McKenzie Bridge Ranger Station, where weather and climatic conditions are considered to be similar to those at Cougar Dam, the greatest 1-day precipitation of record was 5.40 inches on 22 November 1909. The wettest month of record was December 1942 with 25.04 inches. On the average, 145 days per year experience 0.01 inch or more of precipitation. Tables 1, 2, and 3 present climatological data by months for McKenzie Bridge Ranger Station, Leaburg, and Eugene, respectively. Table 4 summarizes climatological data for selected stations adjacent to the basin.

4-06. Snow. - Approximately 10 percent of the precipitation at McKenzie Bridge Ranger Station falls as snow, and it is reasonable to assume that a similar percentage falls as snow at Cougar Dam. There are no snow courses in the project basin. Snow survey data for selected stations representative of snow conditions in South Fork McKenzie River drainage basin are shown in table 5. Snow survey records for the McKenzie snow course, elevation 4,800 feet, and located 12 miles northeast of Cougar Dam, indicate the average snow-water equivalent on 1 April, normally the maximum water content for the year, is 44 inches. Plate 3 graphically illustrates the variations in depth and water equivalent of the snowpack by months at representative snow courses. It is estimated at the mean elevation of the project basin, 4,020 feet, approximately one-third of the annual precipitation occurs as snow. In the highest 10 percent of the project basin, about 75 percent of the annual precipitation occurs as snow, which normally accumulates until March or April. Snow cover below 2,000 feet is transient and may accumulate and disappear several times during a winter season. Heavy rain accompanied by high temperatures occasionally results in a pronounced snowmelt which contributes appreciably to the volume and peak flow of a flood.

4-07. Temperature. - Because of the moderating influence of maritime air from the Pacific Ocean, seasonal variations of temperatures are comparatively small. Average monthly temperatures at McKenzie Bridge Ranger Station, as shown in table 1, range from 35.0 degrees F. in January to 66.2 degrees F. in July. The average daily minimums range from 27.5 degrees F. in January to 47.1 degrees F. in July. Average daily maximums for January and July are 42.5 and 85.0 degrees F., respectively. These temperatures are representative of conditions at Cougar Dam. With increase in elevation, temperatures decrease about 3 degrees F. per 1,000 feet. A summary of temperature data at stations adjacent to the basin is shown in table 4 and on plate 3.

4-08. Storms. - Flood-producing storms occur chiefly during the winter season but are not uncommon in late fall and early spring. The seasonal storm pattern is largely a result of the southward displacement of the Aleutian Low during the winter season. With increased pressure gradient between the Aleutian Low and the Pacific High, a strong westerly to southwesterly flow of moist maritime air develops over the area. Lifting of the air over topographic barriers, augmented by convergence and frontal lifting, results in precipitation of varied intensities, often of flood-producing proportions. Frontal activity generally consists of a series of north-south oriented occluded fronts moving eastward over the area. Frequently, however, a quasi-stationary front will develop over the ocean and extend over the area in an east-west direction. The strong westerly flow of moist air and minor waves associated with such fronts results in continuous precipitation, generally of high intensity, in the frontal area.

4-09. The storm of 21-25 November 1909 was the most severe of record over the southeastern Willamette River Basin. Synoptic data are not available for the 1909 storm, but recorded climatological data indicates that the storm was a series of frontal wave disturbances that had long trajectories over the Pacific Ocean. On the basis of very scanty precipitation data, it is estimated that the average basin precipitation above Cougar Dam during the November 1909 storm was 6.4 inches in 24 hours and 11.2 inches in 96 hours. Augmented by snowmelt, this storm produced very high stages on McKenzie River and its tributaries.

4-10. Winds. - No data are available on wind speed in the McKenzie River Basin. For study purposes wind data observed at Eugene, Oregon, from 1941 to 1962, were used. On the average, the wind at Eugene is 3 miles per hour or less about 37 percent of the time. Sixty-one percent of the time the wind speed is between 4 and 15 miles per hour, and most of the remaining 2 percent of the time the wind speed is between 15 and 31 miles per hour. Occasionally, sustained wind speeds reach 45 miles per hour with gusts in excess of 80 miles per hour. The highest wind of record occurred on 12 October 1962 with a maximum 1-minute velocity of 63 miles per hour and a gust of 86 miles per hour. Velocities ranging from 45 to 55 miles per hour were sustained for about 2 hours during this storm.

4-11. Evaporation. - The South Fork McKenzie River Basin is characterized by climatic conditions which are conducive to high rates of evapotranspiration during the summer months. No evaporation records are available for the McKenzie Basin area. Records at Fern Ridge Reservoir, located about 60 miles west of the basin, show an annual land pan evaporation of 38.1 inches, of which 40 percent occurs during July and August. Evaporation is negligible during the winter months. It increases progressively during the spring months and decreases during the autumn months. Table 6 shows estimated average monthly evaporation amounts for Cougar Reservoir. These values are based on data observed at Fern Ridge Reservoir which have been adjusted in accordance with the finding in the publication: "Water Loss Investigations, Lake Hefner Studies", U. S. G. S. Professional Paper, No. 269. Using 0.71 as the yearly conversion factor, it is estimated that approximately 2,700 acre-feet of water will evaporate each year from Cougar Reservoir.

4-12. As indicated in table 6, the monthly evaporation varies largely in accordance with the mean monthly air temperature which is primarily a function of solar and terrestrial radiation. Although wind is an important factor in the appraisal of daily evaporation amounts it is not a significant factor when evaluating mean monthly values. Records for the Willamette Basin show the average wind speed for each month of the year is nearly constant.

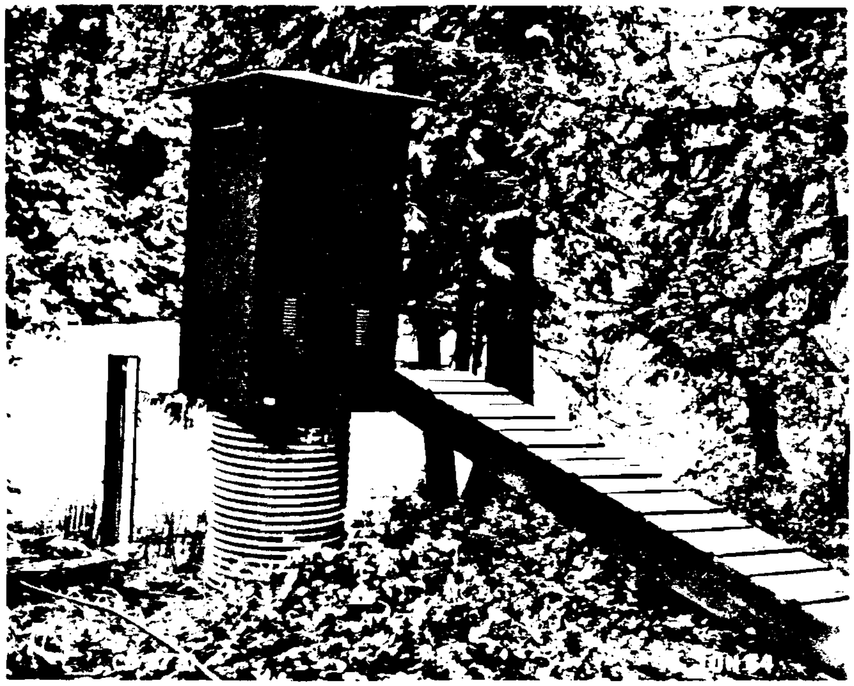
## SECTION V - HYDROLOGY

5-01. Discharge records. - Discharge records for South Fork McKenzie River near Rainbow are available from October 1947. The gaging station is located about 1 mile below Cougar Dam and the drainage area above the station is about the same as that above Cougar Dam. Therefore, discharges and runoff at Cougar Dam are assumed to be equal to those observed at the stream gaging station. The station will provide a record of river stages and reservoir releases until the proposed reregulating reservoir is constructed downstream from Cougar Dam. The station then will be moved downstream below the reregulating dam. A new stream gaging station was established in October 1957 at the head of Cougar Reservoir to record the inflows. Other stream gaging stations on streams in the McKenzie River Basin, together with their tributary drainage areas and lengths of discharge records, are shown on plate 1.

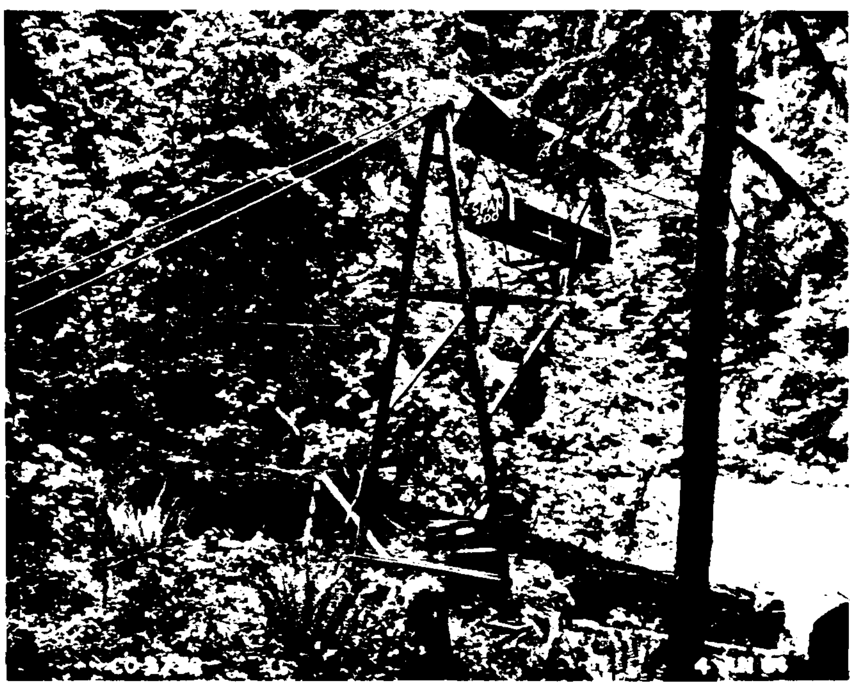
5-02. The regulated flows of Willamette River above the mouth of McKenzie River are observed at Eugene. Immediately downstream from the mouth of McKenzie River the regulated flows are measured at the Harrisburg gage, a key control station on the main stem of the Willamette. The key station on the McKenzie River is Coburg, which is used as the control point during periods of flood regulation. Both the Coburg and Harrisburg stations are equipped with telemetering equipment which will transmit in code the current river stages when the stations are interrogated by telephone. Reservoir inflow and outflow gage heights, as well as the tailwater and pool levels, are continuously recorded in the Cougar powerhouse by means of telemetering equipment.

5-03. Runoff characteristics. - The streamflow regimen of South Fork McKenzie River is similar to the seasonal precipitation pattern. Low flows prevail during the July-September period, which is the dry season, and high flows during the November-April period, which is the rainy season. Plates 5 to 7 show daily discharge hydrographs for a number of stations in the McKenzie River Basin. These hydrographs illustrate the streamflow pattern, the frequency of high water occurrences, and the flashy character of the floods. Nearly 90 percent of the annual runoff occurs during the 8-month period, November through June.

5-04. During late spring and early summer, melting snow adds substantially to the streamflow and together with the large volume of ground water that flows from the porous lava formations in the headwater areas, the base flow of South Fork McKenzie River remains relatively high throughout the summer season. Chart 4 shows a frequency curve of annual minimum daily flows at Cougar Dam based on a 16-year record. The smallest of the 16 annual minimum daily flows is 200 c.f.s. and the largest is 277 c.f.s. These are relatively high minimum flows, compared to similar flows in other streams which are not sustained by underground natural storage. At Fall Creek damsite (190 square miles, approximately the same drainage area as Cougar) the minimum daily flows varied from 24 to 74 c.f.s. during the same 16-year period. The two watersheds are adjacent to each other but Fall Creek has no lava formations in its drainage basin.



DOWNSTREAM GAGING STATION
South Fork McKenzie River near Rainbow, Oregon



DOWNSTREAM CABLEWAY

5-05. A runoff summary of minimum, maximum, and mean monthly flows for South Fork McKenzie River, including a flow duration curve, are shown on chart 5. These data show that the inflow to Cougar Reservoir, based upon past records, will equal or exceed 820 c.f.s. 50 percent of the time and will equal or exceed 250 c.f.s. 90 percent of the time. Annual runoffs observed at Cougar Dam, for the period 1948-1961, are shown in table 7 and are also illustrated graphically on chart 5. The mean annual runoff for this 14-year period is 673,300 acre-feet, with extremes of 943,700 acre-feet observed in 1956 and 330,900 acre-feet observed in 1941.

5-06. <u>Flood characteristics</u>. - Floods on South Fork McKenzie River are usually produced by intense precipitation of 2 to 4 days duration, augmented in many instances by snowmelt. The snowmelt contribution is largely from areas of low and intermediate elevations and generally increases the flood volume with relatively little effect on the flood peak. At the high elevations, snow accumulates through the winter months and usually melts and runs off in late spring and early summer without damaging effects. When periods of intense rainfall, which occur frequently during the rainy season, are preceded by an extended period of moderate precipitation that saturates the ground, a major flood develops. Double-crested floods are not uncommon.

5-07. Above Cougar Reservoir, South Fork McKenzie River flows through a mountainous country where there is no flooding. Duration of floods along the lower river is usually for periods of 3 to 6 days, but a series of storms have at times extended the periods of downstream flooding to a week or more. December and January are the months with the highest and most frequent floods. However, as shown on table 7 and on the daily discharge hydrographs, the maximum annual high water can occur in any month from October through June.

5-08. Flood frequencies. - Recorded maximum annual discharges for the period of record through 1962 were considered in the derivation of the maximum annual flood frequency curve shown on chart 4. The following tabulation shows computed peak discharges at Cougar Dam for selected recurrence intervals:

| Average recurrence interval in years | Maximum discharge in c.f.s. |
|---|---|
| 5 | 13,300 |
| 10 | 16,700 |
| 25 | 21,100 |
| 50 | 24,600 |
| 100 | 28,400 |

5-09. Past floods. - The largest historical flood on McKenzie River occurred in December 1861. On the basis of very limited information, the 1861 peak discharge at Cougar Dam was estimated to be 25,000 c.f.s. The next largest flood occurred in February 1890 and had an estimated peak of 24,500 c.f.s. From high water marks, the December 1945 flood peak was estimated to be 24,500 c.f.s. Volumes of these three floods were larger than the volumes of any subsequent floods. The maximum flood peak observed, since the establishment of the Cougar gage in 1947, was 17,600 c.f.s. which occurred in December 1956.

5-10. Channel velocities. - South Fork McKenzie River and its tributaries have average low-water surface gradients of approximately 80 feet per mile upstream from Cougar Reservoir. Such steep gradients produce high velocities in stream channels, particularly during flood periods. Chart 6 shows the discharge-velocity curves for the natural channel sections at two stream gaging stations on South Fork McKenzie River. One station is located at the head of Cougar Reservoir and the other just below Cougar Dam. The following table gives the average and maximum velocities for various flows at these two stations:

| Discharge cfs | Average velocity, ft/sec: Above Cougar Reservoir (160 sq.mi.) | Average velocity, ft/sec: Just below Cougar Dam (208 sq.mi.) | Maximum velocity, ft/sec: Above Cougar Reservoir (160 sq.mi.) | Maximum velocity, ft/sec: Just below Cougar Dam (208 sq.mi.) |
|---|---|---|---|---|
| 100 | 1.2 | 0.8 | 1.9 | 1.3 |
| 200 | 1.7 | 1.1 | 2.6 | 1.8 |
| 500 | 2.7 | 1.9 | 3.8 | 2.9 |
| 1,000 | 3.9 | 2.8 | 5.3 | 4.1 |
| 5,000 | 8.8 | 7.2 | 10.8 | 9.4 |
| 10,000 | 12.4 | 10.6 | 14.9 | 13.2 |
| 25,000 | 18.5 | 16.9 | 22.0 | 20.0 |

High as the velocities are during floods, erosion is not expected to seriously impair the usable capacity of Cougar Reservoir. Low-water surface profiles are shown on plate 8.

5-11. Channel capacities. - South Fork McKenzie River has ample capacity to contain floods of major proportion. No serious flood problem exists along McKenzie River above river mile 31. Below this point, however, the valley widens and the banks are low. Releases from Cougar Reservoir during periods of flood regulation will be based on river stages along the lower McKenzie River, using the stream gaging station at Coburg as an index. Bankfull capacity of this lower reach of the main stem is 22,000 c.f.s. at Coburg, but since Cougar Reservoir controls only 16 percent of the area above Coburg, this discharge will be exceeded during major floods from runoff from the uncontrolled drainage area.

5-12. The station on Willamette River at Harrisburg, 13 miles below the mouth of McKenzie River, is a key index station for scheduling the flood regulation at upstream reservoirs. Bankfull capacity of the Willamette River near Harrisburg is 42,500 c.f.s. This discharge will be exceeded at Harrisburg on an average of once every 4 years from the uncontrolled runoff above the station.

5-13. Outlet capacity. - The outlet works for Cougar Reservoir is designed to discharge approximately 6,000 c.f.s. at minimum flood control pool, elevation 1532. This outlet capacity, plus 500 c.f.s. through the turbine, permits a maximum flexibility of operation at Cougar Reservoir both prior and subsequent to a flood. Premature storing can be avoided at the start of a flood and evacuation of stored flood waters can be effected at a maximum rate consistent with storage releases from other upstream storage reservoirs and downstream bankfull capacities. A full reservoir at Cougar can be evacuated within a 20-day period without exceeding 6,500 c.f.s. Bankfull capacities that must be taken into consideration in the operation of Cougar Reservoir in downstream order are: Coburg on McKenzie River, 22,000 c.f.s.;

Harrisburg on Willamette River, 42,500 c.f.s.; and Albany on Willamette River, 70,000 c.f.s.

5-14. Since during a flood, the uncontrolled area between Cougar Dam and Coburg will often contribute runoff sufficient to exceed the bankfull capacity in the lower McKenzie River and in Willamette River at Harrisburg, the release from Cougar Reservoir may be limited to the amount necessary to generate firm power, approximately 750 c.f.s., with no flow through the outlet works. Turbine release, however, will be cut off completely if a significant reduction in critical downstream flood conditions can be accomplished. Normally, during major floods, the turbines will be shut off and the outlet release will be reduced to 100 c.f.s.

5-15. Following a flood, the stored flood water in Cougar Reservoir will be evacuated as rapidly as permissible with the rate of evacuation governed by downstream bankfull capacities. As the flow from the uncontrolled area diminishes, Cougar reservoir releases will be increased but not to exceed a maximum of 6,500 c.f.s. Release through the turbines will be considered as a component of the reservoir release. The following table shows the number of days required to evacuate a full reservoir of 155,230 acre-feet with various reservoir releases and average reservoir inflows during the evacuation period:

| Reservoir release | Reservoir inflow, c.f.s. | | |
|---|---|---|---|
| c.f.s. | 1000 | 1500 | 2000 |
| 4,000 | 26 days | 31 days | 39 days |
| 5,000 | 19 | 22 | 26 |
| 6,000 | 16 | 17 | 19 |

5-16. During a spillway design flood, the reservoir outlet will complement the spillway. The turbines are assumed to be shut down. The capacity of the outlet is 12,050 c.f.s. at elevation 1699, maximum pool elevation. The spillway capacity at elevation 1699 is 76,140 c.f.s. The combination of outlet and spillway will discharge a total of 88,190 c.f.s., which is more than adequate to pass the spillway design flood. Discharge rating of the Cougar Reservoir outlet is given in table 8, and shown on charts 2 and 3.

5-17. Reservoir capacity. - The principal criterion, in determining the flood-control storage requirement for Cougar Reservoir, was that the reservoir should be capable of holding back the runoff of a flood the magnitude of the 1861 flood until such time that the controlled spill would not result in a secondary flood crest on the lower McKenzie River in excess of that caused by the runoff from the uncontrolled area between the dam and Coburg. A reservoir capacity equal to 155,230 acre-feet, which meets this criterion, is about 90 percent of the estimated volume of the 1861 flood. All other floods of record can be completely controlled by Cougar Reservoir with the adopted flood control storage, which is equivalent to 14.0 inches of runoff over the basin.

5-18. Total capacity of Cougar Reservoir at full pool, elevation 1699, is 219,280 acre-feet. Of this amount, there is 54,150 acre-feet of dead storage below minimum pool, elevation 1516; 9,900 acre-feet of storage, between elevations 1516 and 1532 for exclusive power generation; and 155,230 acre-feet between elevations 1532 and 1699, for flood control. After the flood season, approximately 144,000 acre-feet of the space reserved for flood control will be filled and the

stored water used for conservation uses. Reservoir storage and area curves are shown on chart 7.

5-19. Powerhouse tailwater. - Powerhouse tailwater rating curves are found on chart 8. As shown on plate 2, the tailrace channel and the regulating outlet channel converge at a point about 900 feet below the powerhouse. Tailwater elevations at the powerhouse will fluctuate under various flow conditions as indicated on chart 8. The powerhouse tailrace gage should be used only to determine head differential between the pool and tailrace levels. The flow of the river will be determined from gage readings obtained at the gaging station located about one mile downstream from the dam.

5-20. Sedimentation. - The high velocities in the McKenzie River, especially during floods, are capable of eroding and transporting sediment and bedload material of considerable size and amount. Above Cougar Reservoir this problem is of little consequence as the material is not available to erode. The dense forest cover with its heavy undergrowth, particularly along the water course, is a barrier against erosion and virtually eliminates the siltation problem.

5-21. Sedimentation studies made in the Willamette River Basin from 1949 to 1951 showed that suspended sediment concentrations in local streams were not significant except during flood periods. In addition to the 1949-1951 suspended sediment studies, reservoir surveys have been made at Cottage Grove, Fern Ridge, and Dorena Reservoirs which show that siltation has not significantly affected the capacities of existing reservoirs. The channel of South Fork McKenzie River is typical of the tributaries of the Willamette River which originate high in the Cascade Range.

5-22. No suspended sediment observations have been made in the vicinity of Cougar Reservoir. Between 1959 and 1951, 331 samples of suspended sediment were taken at Coburg. Analyses of these samples showed that during low flows only a trace of sediment was evident. A maximum concentration of 240 parts per million was observed in a sample taken during a flood. On the basis of these suspended sediment data and prior reservoir surveys, it is estimated that the average annual rate of silt and bedload deposition in Cougar Reservoir will be approximately 0.25 acre-feet per square mile of tributary area for an annual silting rate of about 52 acre-feet per year. Much of the estimated deposition will take place below minimum flood-control pool. The rate of siltation will not affect the effectiveness of the reservoir during its economic life.

5-23. Five permanent index-type sedimentation ranges have been established and surveyed at Cougar for evaluating degradation and aggradation of the river channel above and below the reservoir and the future silting in Cougar Reservoir. Experience at existing reservoirs in Willamette River Basin indicates silting will be a minor problem at Cougar and resurveys would be infrequent. For more information on the sedimentation ranges refer to the report "Sedimentation Ranges Established 1963" dated 1964.

5-24. River temperatures. - Reservoir inflow and outflow temperatures are being recorded on South Fork McKenzie River. Water temperature records were started at the inflow station in November 1958 and at the outflow station in July 1955. The daily extremes for each year of available record are as follows:

| Year | Above Cougar Reservoir (160 sq.mi.) | | | | Below Cougar Dam (208 sq.mi.) | | | |
|---|---|---|---|---|---|---|---|---|
| | Maximun | | Minimum | | Maximum | | Minimum | |
| | Date | °F | Date | °F | Date | °F | Date | °F |
| 1955 | -- | | -- | | July 15 | 62 | -- | |
| 1956 | -- | | -- | | July 21 | 63 | Feb 1 | 35 |
| 1957 | -- | | -- | | July 10 | 63 | Feb 1 | 36 |
| 1958 | July 28 | 59 | Feb 28 | 38 | July 28 | 68 | Dec 5 | 39 |
| 1959 | July 20 | 59 | Jan 4 | 37 | Aug 1 | 66 | Jan 4 | 36 |
| 1960 | July 18 | 60 | Feb 28 | 34 | July 18 | 65 | Jan 18 | 36 |
| 1961 | June 18 | 59 | Jan 2 | 38 | July 22 | 65 | Jan 4 | 38 |

The above table shows that within a 12-mile reach, the maximum river temperatures at the downstream station are 5 to 9° F. warmer than at the upstream station. Generally, the maximum temperatures for the year occur in July and the minimums occur in January or February. Plates 9 and 10 show the daily maximum and minimum river temperatures available for the two stations on South Fork McKenzie River. The difference between daily extremes may be as small as 1° F. in winter and as high as 10° F. in summer. A fairly well defined relationship exists between mean monthly air temperature at McKenzie Bridge and the corresponding mean monthly river temperature at the head of Cougar Reservoir.

5-25. Reservoir temperatures. - Cougar Dam is not instrumented to record reservoir temperatures. Water temperatures observed at Detroit Project, where thermohms are installed at 25-foot intervals on the upstream face of the dam, indicate that temperature of the released water through the turbines is materially cooler during the summer than the temperature of the water flowing into the reservoir. In late spring and summer, reservoir surface-water will be somewhat cooler during the day and warmer at night than the air temperature. Maximum water surface temperatures of about $70^{\circ}$ F. are expected to occur in July and August of each year. During the winter the temperature of the reservoir will drop to about $40^{\circ}$ F., and the frequent filling and emptying operations and the lack of surface heating will keep the reservoir water completely mixed and at a near-constant temperature throughout its entire depth. The temperature of the reservoir during this period will be approximately equal to the temperature of the inflow, $39^{\circ}$ to $41^{\circ}$ F.

## SECTION VI - SEASONAL REGULATION

6-01. General. - Regulation of Cougar Reservoir will be coordinated with the regulation of existing reservoirs in the Willamette River Basin in order to effect an efficient use of their combined storages. Cougar is the fourth multiple-purpose storage project in Willamette Basin, having flood control and power generation as primary functions. The seasonal distribution of precipitation and surface runoff in the South Fork McKenzie River Basin are such that flood control and water conservation can be accomplished with the same storage space. Floods occur during the winter months, at which time the storage space is reserved for flood regulation. As the flood potential diminishes in the spring, the same storage space is gradually filled and the stored water used for conservation purposes during the summer and early fall. Conservation interests that benefit from the release of stored water are: power generation, irrigation, navigation, water quality control and recreation. Potentially, an enhancement to the fishery resources should be realized through improvement in the quantity, temperature, and quality of downstream water.

6-02. The seasonal regulation of Cougar Reservoir is divided into three phases:

1. Major flood season, 1 December - 31 January.
2. Conservation storing season, 1 February - 10 May.
3. Conservation release season, 11 May - 30 November.

These functional divisions of the seasonal regulation schedule are illustrated in figure 1 on plate 11 and are discussed in the following paragraphs.

6-03. Major flood season (1 December - 31 January). - Maximum flood control space will be reserved in Cougar Reservoir from 1 December to 31 January, the period of maximum flood potential. During that season the reservoir will be evacuated after each flood to minimum flood-control pool, elevation 1532, except for water retained in the secondary flood-control space, under appropriate conditions, for use in power generation. Utilization of secondary flood-control space for power generation is only permitted when the Northwest Power Pool is unable to meet its hydroelectric firm power commitments with forecasted streamflow and available upstream storage and there is no serious flood potential. The critical power situation will vary with basin hydro capabilities and area power demands. The decision of Bonneville Power Administration will weigh heavily in establishing the critical power year. The flood-control regulation of Cougar Reservoir will be closely coordinated with the regulation of other reservoirs in Willamette Basin both during storage and evacuation of floodwaters. Section VII of this manual describes in detail the proposed flood-control regulation schedule for Cougar Reservoir.

6-04. Conservation storing season (1 February - 10 May). - Normally the flood potential of South Fork McKenzie River decreases after 1 February, permitting a gradual filling of Cougar Reservoir for conservation purposes. The seasonal storage regulation schedule on plate 11 shows a gradual filling of the reservoir. The reservoir is scheduled to reach maximum conservation pool, elevation 1690, on 10 May. The 11,300 acre-feet between elevations 1690 and 1699 will be reserved for regulation of late spring and summer freshets. Conservation storage between minimum flood-control pool and maximum conservation pool is 143,930 acre-feet. In addition, there are 9,900 acre-feet below 1532, which is used exclusively for production of power. The filling schedule shown on plate 11 and table 9 establishes the maximum reservoir elevation on any date between 1 February and 10 May. This schedule provides adequate reservoir space to regulate any flood that might occur during that period. Further discussion of the seasonal filling of Cougar Reservoir is presented in Section VIII.

6-05. Conservation releases season (11 May - 30 November). - Regulation of Cougar Reservoir during the period 11 May - 30 November provides for release of the stored water for the most effective overall conservation benefits. Normally, a major portion of the stored water in Cougar Reservoir will be released after 1 September as releases made after that date are more effective for power generation than those made prior to 1 September. A definite schedule for conservation releases is not practicable because the volume of water stored in Cougar and other reservoirs in Willamette Basin and the conservation demands for stored water, as well as the natural streamflow, will vary from year to year. Therefore, a schedule of releases will be prepared each year prior to initiation of conservation releases, approximately 1 July. Section IX of this manual discusses the releases for various uses of stored water during the conservation season.

## SECTION VII - FLOOD CONTROL REGULATION

7-01. Basic method of flood regulation. - Regulation of Cougar Reservoir for flood control will be closely coordinated with the regulation of existing flood-control projects in the Willamette River Basin, both during and following each flood. Because of the relatively large bankfull capacity of the McKenzie River above Leaburg, the flood-control regulation schedule for Cougar Reservoir is based on bankfull stages near Coburg on the McKenzie River and Harrisburg and Albany on Willamette River. The allotted space for storing flood flows in Cougar Reservoir is 155,230 acre-feet. If, during or after a flood, the forecasted volume of a flood indicates that the available space will be exceeded under the normal regulation schedule, a special flood regulation schedule will be used to make maximum use of the remaining storage space. The special schedule calls for an increase in the reservoir release, thus avoiding a subsequent abrupt increase in outflow. The result is a lower maximum release than that which would occur if the reservoir were permitted to fill and spill using the normal release schedule.

7-02. Flood-control storage. - Flood regulation studies illustrated on plate 12 show that 125,500 acre-feet of usable storage space will effectively regulate all floods of record on South Fork McKenzie River, with the exception of the historical flood of December 1861 and is referred to as primary flood-control storage. It is about 80 percent of the 155,230 acre-feet reserved for flood control. A secondary flood-control storage in the amount of 29,680 acre-feet is justified by power benefits in excess of that accrued from exclusive use of 9,900 acre-feet for the generation of prime power. Thus, the secondary flood-control storage serves a dual purpose and requires special consideration, involving water management decisions during both flood and filling seasons.

7-03. Primary flood-control space in Cougar Reservoir will be made available for flood regulation every year by 15 November, but the stored water in the secondary flood-control space may be reserved for power generation between 15 November and 1 February, if a need for power exists and a major flood potential is not imminent. A major flood potential exists when the basin above the reservoir has a snow cover with a water content of 3 inches or more at the dam, the soil is thoroughly saturated from an extended period of general rains of moderate intensity (approximately 6 inches in a 10-day period), and the long-range weather forecast calls for above-normal precipitation and above-normal temperatures. Primary flood control storage will effectively regulate all floods up to and including a 50-year flood; therefore, secondary flood-control storage would only be required in the most critical flood situation. It is estimated that critical power will occur on the average 1 year out of 4. Power is critical when firm hydro cannot be provided during the low-water period on Columbia River with natural runoff and existing upstream storage. When it becomes apparent that power demand will not be critical, secondary flood-control storage will be released during the next 15 days, making all of 155,230 acre-feet of space available in the reservoir for flood control. Should a flood potential develop when secondary flood-control storage is being held for power, secondary flood-control storage would be evacuated as quickly as possible as flood control has first priority on space in Cougar Reservoir during the flood season. A conflict between power and flood control is not likely to occur because a major flood potential in the McKenzie Basin, based upon past streamflow records, will be associated with good runoff conditions in the Columbia River Basin, a situation calling for the early evacuation of the secondary flood-control storage space in Cougar Reservoir.

7-04. Flood-control regulation schedule. - The flood-control regulation proposed for Cougar Reservoir is shown in figure 2 of plate 11. The scheduled pool elevation will not be exceeded as long as it is possible to pass the reservoir inflow without exceeding bankfull stage at one of the three downstream control points -- Coburg, Harrisburg, or Albany. When a runoff forecast based upon a precipitation index and the uncontrolled flow between Cougar Dam and Coburg indicates an overbank situation at Coburg, the release from Cougar Reservoir will be adjusted in accordance with values indicated in figure 2, plate 11. The McKenzie River channel capacity at Coburg is estimated to be 22,000 c.f.s., a discharge that will often be exceeded from the uncontrolled area alone. Flood regulation will be improved when Blue River and Gate Creek Reservoirs are added to the McKenzie River reservoir system. Even then the system will not control sufficient area to provide complete protection to developed areas on the lower McKenzie, particularly during major floods.

7-05. If power is critical during a flood, a release of approximately 750 c.f.s. will ordinarily be maintained through the turbines to generate power. Turbine release, however, will be cut off completely if a significant reduction in critical downstream flood conditions can be accomplished. Normally, during major floods, the outlet release will be reduced to 100 c.f.s.

7-06. <u>Rate of change in reservoir releases</u>. - Safety precautions preclude sudden large increases in the release from Cougar Dam prior to construction of the Strube reregulating reservoir. During and following floods, increases in the controlled release should not exceed 750 c.f.s. in any one-hour period. The increase can be made in one or more adjustments, and it is cautioned that the maximum rate of increase in the controlled reservoir release should be used only when the situation is most critical. Under normal operating conditions, the increase in release should be held to a rate of 500 c.f.s. per hour or less.

7-07. <u>Special flood-control regulation curves</u>. - Special flood regulation curves for Cougar Reservoir are shown in figure 3 on plate 11. They are to be used when continued regulation by the normal flood-control regulation procedure would result in a premature filling of the reservoir resulting in an excessive spill before the end of the flood. Figure 3 is so constructed that by entering the curves with the current pool elevation and the average hourly pool rise in the previous 3 hours, an outflow is indicated which will make effective use of the remaining flood-control space in the reservoir. Frequent determinations of the average hourly pool rise and corresponding release will hold the peak outflow to a minimum and will avoid the necessity for a sudden large increase in the reservoir outflow. Frequency of average hourly pool rise and outflow determination will normally be at 2-hour intervals when the special reservoir regulation curves are in use. In case of an exceptionally large flood the required release may exceed the capacity of the outlets, necessitating the use of the spillway. The probability of using the spillway is rather remote as the spillway is to be used only in an extreme emergency.

7-08. Maximum planned total release is 6,500 c.f.s., which includes 6,000 c.f.s. through the outlets and 500 c.f.s. through the turbines. The regulating outlet and stilling basin have been designed for a 6,000 c.f.s. discharge. Very little safety margin exists against jump sweepout; therefore, caution should be exercised to insure that a 6,000 c.f.s. release is not normally exceeded. If a release in excess of 6,000 c.f.s. plus the powerhouse discharge is indicated by figure 3 of plate 11, the increase will be through the regulating outlets in lieu of using the spillway unless it is forecasted that the spillway will ultimately have to be used. Outlet releases in excess of 6,000 c.f.s. or a discharge through the spillway will result in downstream damages. A discharge through the spillway washes out the access road to the powerhouse, a more expensive repair than the damage to the outlet stilling basin and fingerling evaluation facilities resulting from an excessive flow through the outlets. In order to minimize the possibility of accidental release of discharges in excess of 6,000 c.f.s., the regulating outlet operating gate controls have been provided with limit switches such that neither gate can be opened beyond 5.3 feet, (two-gate discharge of 6,000 c.f.s. at maximum pool), without inserting a special key into a selector switch and closing a bypass of the limit switch.

7-09. The river stage at the inflow station is recorded automatically in the Cougar powerhouse. These river stages will normally be the basis for determining the reservoir inflow. However, during major floods when river stage information may not be available because of equipment failure, the inflow to Cougar Reservoir may be computed from the rate of storage change plus the outflow.

7-10. Examples of flood regulation. - The effectiveness of Cougar Reservoir to control floods the magnitude of December 1861, December 1942, and December 1955 is illustrated on plate 12. The hydrograph of the 1861 historical flood at Cougar Dam was reconstructed from meager precipitation data. The December 1942 flood, the largest of recent floods from the standpoint of volume, was estimated from observed hydrographs and precipitation data in the McKenzie Basin. The December 1955 flood was the largest since the establishment of the stream gaging station below Cougar Dam. In computing regulated flows at Harrisburg it was assumed that Cottage Grove, Dorena, Lookout Point, Hills Creek, and Cougar Reservoirs were operative. Data shown for each example include precipitation, reservoir inflow, regulated outflow, pool elevation and the natural and regulated discharges at Coburg. Natural and regulated flows of Willamette River at Harrisburg illustrate the effectiveness of Cougar Reservoir with and without the upstream reservoirs on Coast Fork and Middle Fork Willamette Rivers.

7-11. The examples of flood regulation illustrated on plate 12 show the historical flood of 1861 required the use of the special flood regulation curves. The maximum controlled release of 6,500 c.f.s. occurred late in the flood. At the time of the peak inflow the release was 750 c.f.s., the scheduled discharge for generating firm power. The special regulation of Cougar Reservoir prevented Cougar Reservoir from filling prematurely. At the end of the flood, Cougar Reservoir was approximately 0.5 foot below full pool elevation. At Coburg, the peak flow of the 1861 flood was reduced from 102,000 to 79,000 c.f.s. and at Harrisburg, from 180,000 to 158,000 c.f.s. Pertinent facts relevant to the examples of flood regulation illustrated on plate 12 are summarized in the following tabulation.

| Item | Flood Dec. 1861 | Dec. 1942 | Dec. 1955 |
|---|---|---|---|
| Peak inflow at Cougar Dam, c.f.s. | 25,000[e] | 17,500[e] | 17,400 |
| Volume, acre-feet | 171,000[e] | 89,000[e] | 74,000 |
| Maximum reservoir releases, c.f.s. | | | |
| At time of peak inflow | 750[1] | 750[1] | 750[1] |
| During and following flood | 6,500 | 6,500 | 6,500 |
| Natural maximum flow at Coburg (without Cougar), c.f.s. | 102,000 | 69,000 | 73,500 |
| Regulated maximum flow at Coburg (with Cougar), c.f.s. | 79,000 | 55,000 | 60,000 |
| Maximum pool elevation during flood, feet, mean sea level | 1698.4 | 1631.7 | 1610.4 |
| Maximum flow at Harrisburg, c.f.s. (without Cougar) * | 180,000 | 112,000 | 114,500 |
| Maximum flow at Harrisburg, c.f.s. (with Cougar) * | 158,000 | 99,000 | 102,000 |

* - With Hills Creek, Lookout Point, Dorena, and Cottage Grove Reservoirs storing.

1 - Generating firm power. If power is not needed, release at time of peak inflow should be reduced to 100 c.f.s.

e - Estimate.

## SECTION VIII - STORING FOR CONSERVATION

8-01. General. - Willamette River Basin is unique in that floods occur primarily during the winter rainy season and that storage reservoirs in the basin can be scheduled for multiple-purpose use. Space reserved for flood control can be filled near the end of the flood season without jeopardizing the flood-control effectiveness of the project. After 1 February, storms that frequent the South Fork McKenzie River Basin decrease gradually in both intensity and frequency. By mid-May the probability of a flood has become almost nil; therefore, during ~~this period~~ 1 February through 10 May, storage space in Cougar Reservoir is filled for conservation use.

8-02. Filling schedule. - The filling schedule for Cougar Reservoir, shown on figure 1, plate 11, as well as in table 9, permits all the secondary flood-control space plus approximately a third of the primary flood-control space to be filled in February. The rate of filling during February is 2,213 acre-feet per day. After 1 March the filling rate is reduced to 1,155 acre-feet per day. This schedule insures filling of the reservoir to elevation 1690, maximum conservation pool level, by 10 May and at the same time provides adequate storage space to control probable floods during the filling season. The accelerated filling in February is based on the rapid decrease in the flood potential after 1 February and the desirability of filling the flood-control space for conservation use. The 11,300 acre-feet of space reserved above elevation 1690 for control of small summer floods may be partially filled after the flood potential has passed. This normally would be after 15 June. From 1 February through June a minimum release of 300 c.f.s. is planned. Up to this amount of flow may be required for operation of the fingerling bypass system.

8-03. Departures from the filling schedule shown on plate 11 may occur as the result of: (1) regulation of a flood, (2) an excessive snowpack above the reservoir, (3) an inadequate water supply, or (4) a critical power situation. Regulation of a flood during the conservation storing season will be in accordance with Section VII of this manual. Following a flood, stored water will be evacuated and the pool will be drawn down to the scheduled elevation for that date. Should an excessive snowpack exist above the reservoir, filling may be temporarily curtailed in the interest of providing greater flood reservation and increased power output. An excessive snowpack would exist when the forecasted runoff based upon minimum precipitation for the remainder of the storing period indicates a volume of runoff in excess of the storage space to be filled after providing for minimum downstream releases. In other years there is the possibility that the inflow will be inadequate to maintain the normal filling schedule. Any deficiency in filling, regardless of the reason, may be made up at a later date if there is an excess of streamflow after providing for minimum power demand and downstream minimum flow requirements.

8-04. During a critical low-water year on the Columbia River, scheduled filling of Cougar Reservoir may be curtailed to meet system firm power commitments. If this delay in filling results in a shortage of water for irrigation and other high-priority water users, then the deficiency, to the extent that power curtailed the normal filling, would be made up from exclusive power storage and possibly from dead storage. Power interests would be apprised of this possibility before effecting any special regulation that might jeopardize the normal filling of Cougar Reservoir.

8-05. Plate 13 illustrates a hypothetical seasonal regulation, based on monthly flows during a 30-year period, 1926-1955. The study shows that runoff during the filling season was sufficient to meet all water requirements and still fill the reservoir to maximum conservation pool, elevation 1690, in all but 6 years. In 1944, the most critical storing year, the reservoir filled only to elevation 1580, approximately one-third full. Plate 13 shows also the computed natural inflows, the regulated outflows, and the water stored. The storage capacity curve for Cougar Reservoir is also shown on the same plate. Table 14 shows the storage capacity in tabular form.

8-06. <u>Flexibility in seasonal filling schedule</u>. - Flexibility in the filling schedule for Cougar Reservoir makes it possible to generate extra power during the filling season when there is a surplus of water. Experience at Detroit and Lookout Point projects has established the desirability of flexibility in the conservation storing schedule so that power may be generated when it is most needed in the Federal system so long as the filling of the conservation storage is not jeopardized. This phase of flow regulation at Willamette Valley reservoirs will be given continuous attention.

8-07. The scheduled pool elevations, shown in figure 1, plate 11 or in table 9, should not be exceeded, except in case of a flood. The seasonal filling schedule provides sufficient storage space to regulate all but the most infrequent floods during the February-May storing period. Frequent forecasts of residual runoff into the reservoir will be made



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during the filling season in order to establish the minimum storing rate which will provide reasonable assurances of filling the reservoir. Accurate forecasts of seasonal runoff will be important in years when extra water during the filling season could be used to advantage for power generation.

8-08. Residual runoff forecasts after February. - Any deviation in the rate of filling of Cougar Reservoir will be made on the basis of residual runoff forecasts which will be made at about 15-day intervals, starting on 1 February. The forecasted runoff determined from chart 9 will be for the period between the date of forecast and the end of June. Enter chart 9 with the residual runoff for Lookout Point Reservoir to determine the expected runoff into Cougar Reservoir during the same forecast period.

## SECTION IX - UTILIZATION OF STORED WATER

9-01. General. - The 143,930 acre-feet of storage space between minimum flood control pool and maximum conservation pool, elevation 1532-1690, will be filled each spring following the major flood season for conservation use. The release of this stored water during the conservation release season, 11 May - 30 November, will benefit the following interests: fish life, irrigation, navigation, water quality and power. Nearly all the conservation benefits from the Cougar project, with the exception of recreation and power will be realized downstream from the reservoir along the McKenzie and Willamette Rivers.

9-02. Demands for stored water during the low-water season will vary from year to year as well as within the year. Because of the variable demand and variations in precipitation and streamflow, it is not practicable to establish a rigid schedule of reservoir releases for the low-water season. The conservation release schedule, which will be based on available stored water, forecasted streamflow, and estimated demands for stored water, will be reviewed periodically during the season and revisions in the release schedule will be made to meet any changed conditions. The basic water-use policy will be to provide an optimum of conservation benefits and at the same time comply with the state water laws and the authorized project functions.

9-03. During the conservation release season, stored water will not be retained in Cougar Reservoir above the pool level reserved for flood regulation or later than indicated by the schedule shown in table 15 and in figure 1 on plate 11, except in case of a flood. Should a flood occur during the conservation release season, the reservoir will be evacuated to the maximum pool level for that date as soon as practical.

9-04. Water-use priorities: The priority of the use of stored water in Cougar Reservoir, consistent with serving authorized project functions, is as follows:

1. Domestic and municipal water supply
2. Maintenance of minimum flows
3. Irrigation
4. Power
5. Navigation
6. Water quality control
7. Recreation

The above priorities on stored water are not inconsistent with State Water Laws or policy. At the present time there is no demand or plans for reserving stored water in Cougar Reservoir for domestic or municipal water supply. The project is committed to maintaining downstream passage of fingerlings, and maintaining minimum flows for fish life below the dam. Irrigation has a high priority on stored water and the Bureau of Reclamation will probably file on all the multi-use storage in Cougar Reservoir for irrigation. However, at the present time no contracts have been negotiated with irrigators for stored water from Cougar Reservoir. An effort will be made to supply early season irrigation requirements from non-power reservoirs, reserving storage in Cougar Reservoir to supplement generation from Columbia River plants after 1 September. Releases for power generation in the Willamette Basin usually don't become significant until after the first of September. Except for the flow necessary to pass downstream migrants, most of the stored water in Cougar Reservoir will be released through the generators to produce hydroelectric energy. No specific amount of storage is reserved for navigation or water quality control. Releases made for power and other non-consumptive uses will benefit both navigation and water quality control. Recreation, although not an authorized primary project function, will be extended as much consideration as possible so long as it does not jeopardize the functions which were used to justify the project.

9-05. Prior water rights. - The water laws of the State of Oregon provide that water from all natural sources of supply within the State belongs to the public. Subject to existing rights, all natural flow within the State may be appropriated for beneficial use. Such appropriations must be made in strict accordance with the statutory provisions governing such matters. The administration of the water laws of the State of Oregon is vested in the State Engineer, who issues permits for the use of water and is generally recognized as the authority on matters concerning adjudication, appropriation, and administration of water rights in the State of Oregon. Since January 1956, a seven-man Water Resources Board, created by the 1955 session of the Oregon State Legislature, has assumed major responsibilities in the water resources field. Water rights for natural flows granted in accordance with Oregon law will be honored at all times to the extent that they can be satisfied from natural flow. The minimum scheduled release from Cougar Reservoir is in excess of existing water rights on the South Fork McKenzie River below

Cougar Dam and no problems associated with appropriated flows are anticipated in the regulation of Cougar Reservoir.

9-06. - Minimum low-water release. - In the interest of maintaining an adequate flow of water below the dam to sustain fish life during the low-water season, a minimum regulated release of 200 c.f.s. from Cougar Reservoir has been adopted. This minimum release was determined in cooperation with the U. S. Fish and Wildlife Service, the Oregon State Game Commission, and the Oregon Fish Commission. Past streamflow records show the observed minimum mean daily discharge of the South Fork of McKenzie River at the damsite to be 200 c.f.s. Chart 4 shows a frequency curve of minimum mean daily flows. A release in excess of 200 c.f.s. may be required, however, for operation of the fingerling by-pass system as described in paragraph 9-20.

9-07. Irrigation. - Since precipitation and natural flow of Willamette River and tributaries is low in July and August, irrigation is becoming more dependent on storage as the acreage under irrigation increases. At the present time about 200,000 acres are being irrigated in the Willamette Valley. If the anticipated growth in irrigation continues, full development will be reached about the year 2010. Of the 552,300 acres of irrigable area in the Willamette River Basin, the Bureau of Reclamation estimates that 455,200 productive acres could ultimately be irrigated. Eighty-eight thousand five hundred acres of this total will be irrigated with McKenzie River water, which includes the Springfield and Coburg projects. The average annual diversion requirement from storage for the Springfield and Coburg projects is estimated to be 92,000 acre-feet. Approximately 11 percent, or 10,000 acre-feet, will be provided from Cougar Reservoir. In addition, Cougar Reservoir ultimately will be expected to supply about 10 percent of the water required to irrigate 20,000 acres along the main stem of Willamette River below Eugene.

9-08. Under existing State law, irrigation has the highest priority on stored water of any of the major conservation interests. If irrigation demands should develop, in the interim before all the recommended reservoirs in the McKenzie River Basin are built, Cougar Reservoir could be called upon to furnish a greater amount of stored water for irrigation than planned under full basin development. Such a demand would have a temporary detrimental effect on power benefits.

9-09. The Bureau of Reclamation has filed with the State Engineer on all conservation storage in five existing Willamette River Basin reservoirs (Lookout Point, Dorena, Cottage Grove, Fern Ridge, and Detroit) except exclusive power storage and will be responsible for the sale of the stored water for irrigation and will receive all payments for the United States Government. No filing has been made on storage in Hills Creek or Cougar. The Bureau will keep the Portland District informed of irrigation needs, so that both long-range and day-to-day reservoir regulation scheduling can include the irrigators' requirements. The Corps of Engineers will release water for the irrigators on a day-to-day basis at the request of the Bureau of Reclamation.

9-10. <u>Power</u>. - The power installation at Cougar Dam consists of two 12,500-killowatt units, which will operate at heads ranging from 263 to 499 feet. No reregulating reservoir is presently located below Cougar

Dam. Therefore, in the interim until the Strube reregulating reservoir is constructed, the powerplant will operate at an 80-percent daily load factor. The rate of increase in releases during the low-water season will normally not exceed 200 c.f.s. per hour. Since Bonneville Power Administration is responsible for the sale and distribution of power generated at Cougar Dam, they will be consulted on a day-to-day basis as to the generation to be effected at Cougar.

9-11. Between minimum power pool, elevation 1516, and minimum flood-control pool, elevation 1532, there is 9,900 acre-feet of exclusive power storage. This storage will be used only in years of critical power shortage, a situation that might occur on the average of once in 10 years. Bonneville Power Administration, the Federal Government's marketing agency in the Pacific Northwest, would participate in any decision to use the exclusive power storage. Stored water above elevation 1532 is multiple-purpose storage. Stored water released for power will also benefit navigation and water quality control. Because of the seasonal streamflow regimen of the Columbia River, which normally peaks in June and sustains a moderately high flow until early fall, the release of stored water from Cougar Reservoir for power will not occur until after 1 September. By supplying most of the Willamette River Basin conservation demands in July and August from non-power reservoirs, it will be possible to conserve much of the stored water in Cougar Reservoir until September.

9-12. - Until Blue River Reservoir becomes operative, the early-season conservation water to be provided from storage in the South Fork

McKenzie Basin will come from Cougar Reservoir. In the interest of power generation, Cougar Reservoir is held as high as possible until 1 September, after which the primary flood-control storage is evacuated by 15 November. The remaining 29,680 acre-feet in secondary flood-control storage will be evacuated after 15 November, at a rate dependent on the firm power demand and the runoff forecast for the Columbia River.

9-13. Normally, the secondary flood-control storage in Cougar Reservoir will be evacuated during the last half of November. The releases will be adjusted so as to best satisfy the requirements of power and other conservation uses, consistent with the flood-control rule curves. If power is critical in the Northwest power pool area, secondary flood-control space in the reservoir will be reserved for use between 16 November and 31 January provided the forecasted meteorological and hydrologic conditions indicate a very low flood risk and no serious flood potential exists in the Willamette River Basin.

9-14. The maximum flood potential in western Oregon is in December and January and the maximum flood-control storage reservation will be made available during this period if power requirements are such that secondary flood-control storage space can be evacuated before December. On the basis of past records, a critical power year will occur, on the average, 1 year out of 4. Records indicate that past deficient power years, resulting from low Columbia River flows, were also years when below-normal flooding was experienced in the Willamette River Basin. Primary flood-control space is more than adequate to regulate all floods of record on the South Fork McKenzie River that have occurred concurrently with a low-water year on the Columbia River.

9-15. Navigation. - Natural flows during the summer and early fall are inadequate for navigation downstream from Corvallis, and the situation is growing more critical as the result of increased pumping from the river for irrigation. Scheduled release of stored water from Cougar Reservoir, in coordination with releases from the other reservoirs in the Willamette River Basin, will be made to provide increased flows for navigation.

9-16. When the authorized system of reservoirs is in operation, minimum flows of 5,000 c.f.s. at Albany and 6,000 c.f.s. at Salem, will be maintained in all but the most critical low-water years. A system study, for the period 1926-1955, of the 14 reservoirs proposed for the Willamette River Basin, showed that the above minimum flows could have been maintained in all but 3 years in that period. In the interim, lower minimum flows will be scheduled. The interim objective is to maintain as high a flow in the main stem of Willamette River during the low-water season as is possible with the available volume of stored water.

9-17. Water quality control. - Non-consumptive releases from Cougar Reservoir will benefit stream purification by diluting the domestic and industrial wastes that are discharged into McKenzie and Willamette Rivers. In recent years the sanitary condition of Willamette River has improved as the result of increased treatment of wastes and increased low-water flows maintained with stored water released from existing upstream reservoirs. No special regualtion of Cougar Reservoir is contemplated for water quality control.



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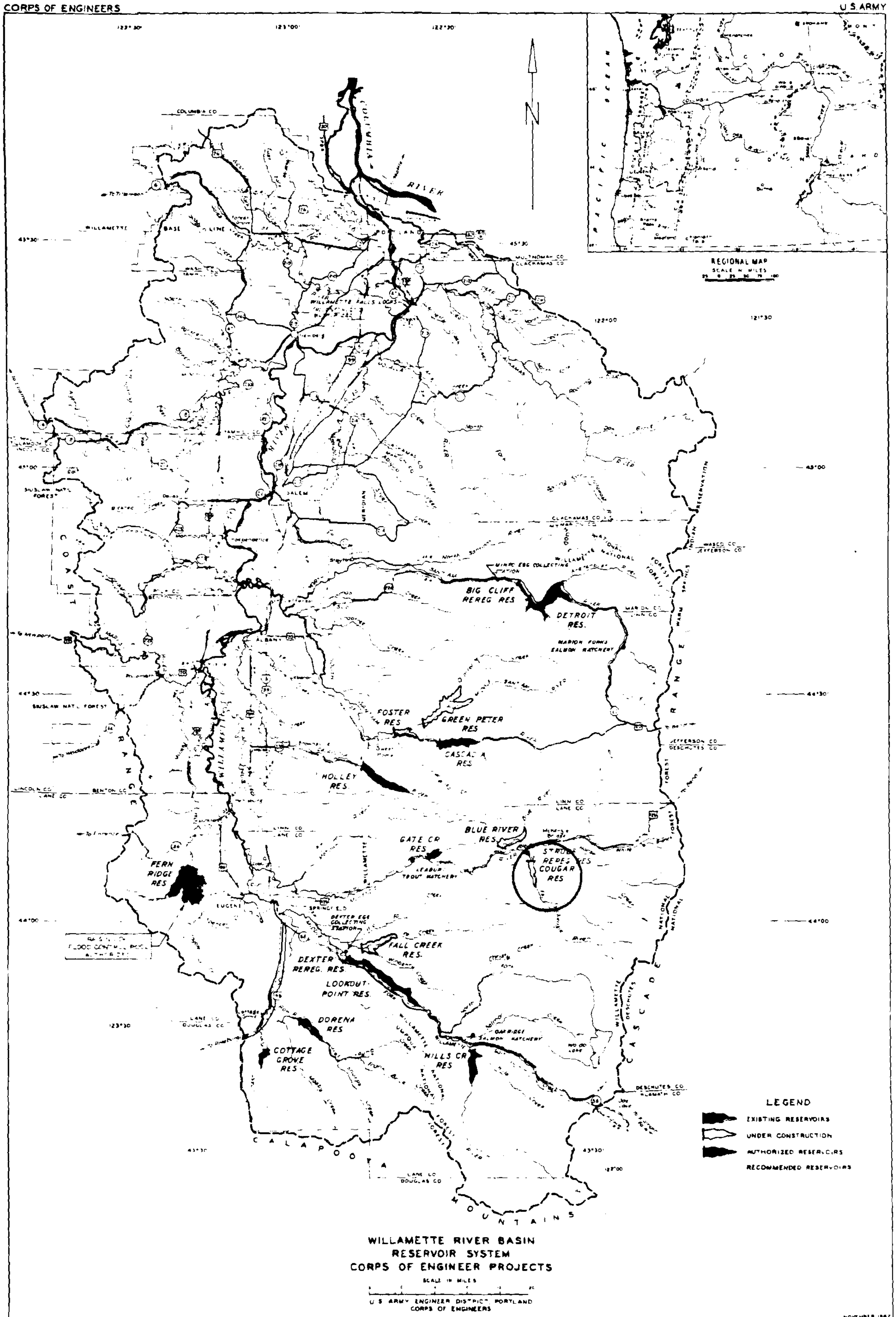



WILLAMETTE RIVER BASIN
RESERVOIR SYSTEM
CORPS OF ENGINEER PROJECTS

U.S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

9-18. Recreation. - The addition of Cougar Reservoir to the system of reservoirs in Willamette Basin will enhance the recreational opportunities to the public. The general plan for regulating Cougar Reservoir is favorable for recreation in that major releases of stored water will occur after the end of the recreation season, 1 September. During the summer, Cougar Reservoir will be relatively full. No special regulation is planned for recreation but every consideration will be given to maintaining a favorable pool level through the summer months and public-use facilities will be provided for the use and comfort of those visiting Cougar Reservoir. The U. S. Forest Service will be responsible for the development and management of all recreational facilities in the reservoir area. Preliminary plans show 10 camping and picnicking sites around the reservoir.

9-19. Mosquito control. - Indications are that malaria will not be a problem at Cougar Reservoir, because of the steep terrain and the absence of population along the reservoir shores. The U. S. Public Health Service in reporting on Lookout Point Reservoir indicated a steep terrain and sparsely settled area is relatively free of malaria. Establishment of a special reservoir schedule of Cougar Reservoir for mosquito control will be resorted to if malaria should become a problem and other methods prove ineffectual. In most years the required conservation releases will lower Cougar Reservoir gradually during the low-water season. A fluctuating or rapid rate of drawdown would eliminate mosquito breeding areas.

9-20. Fingerling by-pass. - Cougar is the first Willamette Project to provide facilities for the transporting of adult anadromous fish to the head of a reservoir for natural spawning and the downstream passage of the fingerlings. The downstream passage is accomplished with a fingerling collection system that discharges through the outlets. See plates 14 and 15. During the periods the fingerlings are migrating downstream the collection system will be operating. It may require as much as 300 c.f.s. to satisfactorily operate the collection system, which has one of the highest priorities on water released from the reservoir. Chart 18 shows a rating curve for a single fingerling by-pass intake. Operation of the fingerling by-pass will require coordination with the Oregon Fish and Game Commissions.

9-21 ENVIRONMENTAL FLOW IMPLEMENTATION

1. Background. The Sustainable Rivers Program (SRP) began in 2002 as a partnership between TNC and the Corps with the objective of developing, implementing and refining a framework for beneficial flows downstream of dams. TNC and the Corps have signed memorandums of agreements (MOAs) at the national level as well as the district level to study current hydro regulation operations. SRP efforts in the Willamette River Basin focus on identifying opportunities to improve overall downstream ecosystem health and resiliency by modifying dam releases within the existing operational constraints. The releases that benefit downstream ecosystem health are termed environmental flows (e-flows). The e-flows targets were developed through a process of collecting and synthesizing relevant hydrologic and ecological information and expert knowledge into a set of e-flow recommendations.

2. Purpose of E-flows. Flow recommendations focused on fall flows (October-November), winter high flows (November-February) and smaller spring bankfull flows (flows at Action Stage, as identified by the National Weather Service) (March-June). Each seasonal flow is important to some aspect of ecosystem health. Fall flows enhance channel habitat and provide flows for outmigration. Winter high flows provide benefits to habitat by modifying channel features and recruiting large woody debris. Spring time flows are important for providing out-migration flows as well as scouring and flushing during bank full events.

3. Implementation. The general intent is to maximize opportunities for achieving e-flows at the Willamette Valley projects considering operational constraints and forecast uncertainty. Exhibit 2 provides the discussion and procedure for their implementation.

## SECTION X - HYDROMETEOROLOGICAL FACILITIES

10-01. General. - In regulating Cougar Reservoir, reservoir regulation personnel will utilize short- and long-range weather forecasts and daily quantitative precipitation forecasts for all zones in western Oregon and southwestern Washington during the rainy season, October through March. These forecasts are prepared in the Seattle office of the Weather Bureau and are relayed to the District office through the Weather Bureau office in Portland over the District teletype circuit.

10-02. In addition to the Weather Bureau forecasts, supplementary forecasts will be made by District meteorologists as required. Weather maps are received in the District office over the weather facsimile circuit, which provides a service 24 hours a day, 7 days a week. Normally, one set of surface and upper air charts is received each morning, Monday through Friday. During critical flood situations additional sets of weather charts are made available at 6-hour intervals and over weekends. In addition, there is close coordination with the local Weather Bureau offices during flood periods, so that special reservoir, hydrologic, and weather information can be interchanged with a minimum of delay.

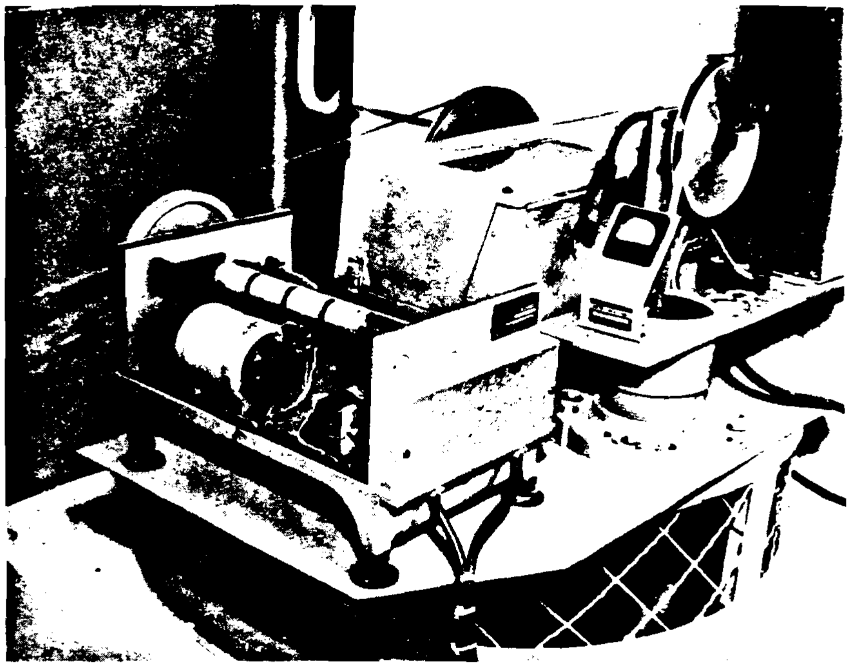
10-03. Project weather station. - Maintenance and operation of the weather station at Cougar Project is the responsibility of the Project Engineer. The station is equipped with a manual and a recording precipitation gage, a snowboard, wind instrument, maximum and minimum thermometers, one hygrothermograph, and a psychrometer.

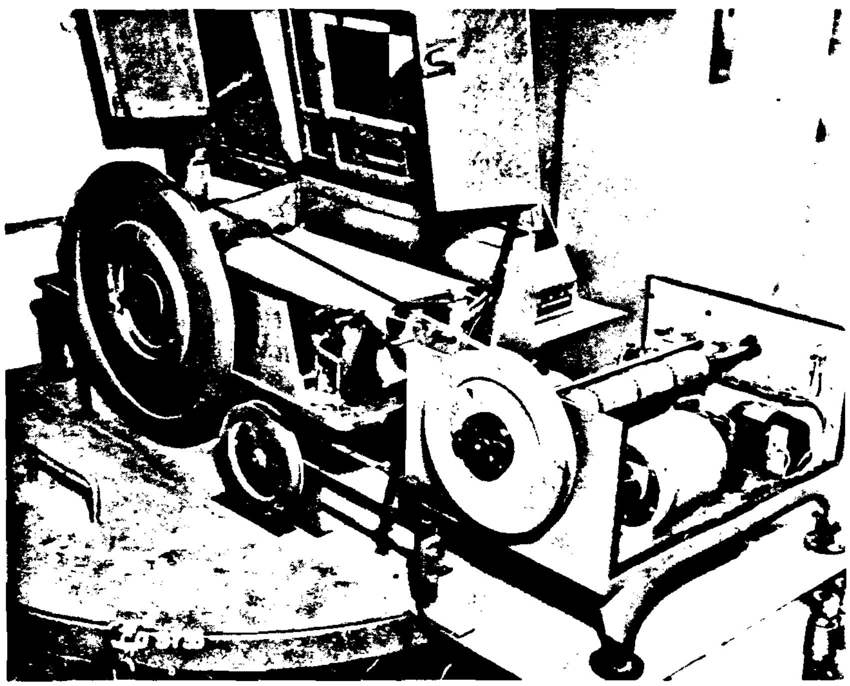
10-04. Snow courses. - Snow depth and its water equivalent are measured at a number of snow courses in the general area of Cougar

Project. None of the snow courses are within the basin tributary to Cougar Dam. Eventually, 1 or 2 radio reporting snow courses will be established in the project basin. Location, elevation, and period of record of pertinent snow courses are shown on plate 1. When necessary, aerial snow reconnaissance flights will be made to define the areal cover. These flights will increase the accuracy of the residual runoff forecasts for the project basin and will facilitate an efficient regulation of Cougar Reservoir during the filling season.

10-05. Water stage recorders. - River gage heights and pool elevation data necessary to regulate Cougar Reservoir are obtained by remote control from four water-level recording stations. The water level at each station is continuously recorded in the powerhouse control room. One station is located immediately upstream from the head of Cougar Reservoir and provides an index to the reservoir inflow. A downstream station located about 1 mile below Cougar Dam records the reservoir releases. A water-level recorder located on top of the dam in the intake structure provides a continuous record of pool elevations, and the one in the stilling basin records the tailwater elevation.

10-06. The gaging station, at Coburg, about 50 miles downstream from Cougar Dam, is used as an index station in scheduling releases from Cougar Reservoir for flood control. In addition, the flows at Eugene, Harrisburg and Albany on the main stem of the Willamette River, just above and below the mouth of McKenzie River, are taken into consideration in regulating Cougar Reservoir for flood control. The water stage recorders at Coburg and Harrisburg are equipped with telemarks





FOREBAY GAGING EQUIPMENT
Water Level Recorder, Electric Contact Gage, and Telemark. (Leupold and Stevens Company)

which enable the reservoir regulation personnel to obtain river stages at these two key locations by telephone. All hydrologic and meteorologic stations used in the regulation of Cougar Reservoir are found on plate 1.

10-07. Tables 10, 11, 12, and 13 are discharge rating tables for McKenzie River and Willamette River gaging stations that are pertinent to the regulation of Cougar Reservoir. Table 14 is an elevation-capacity table for Cougar Reservoir.

10-08. River temperature recorders. - Inflow and outflow water temperatures are recorded continuously at the gaging station at the head of the reservoir and the gaging station 1 mile below the dam. The U. S. Geological Survey services these stations and publishes the recorded data.

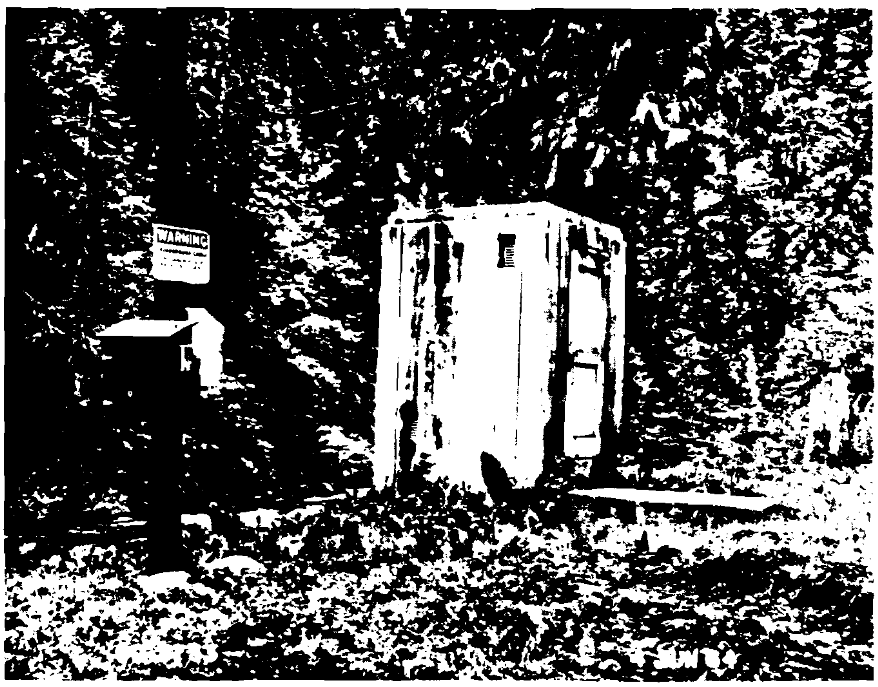
10-09. Communications. - Normal communications between the dam and the District Office is by telephone. Plans are to augment the telephone service with high frequency 2-way radio for emergency situations. Pertinent gage heights and pool elevations are brought into the powerhouse control room by telemetering facilities.

10-10. Hydrologic reporting network. - The Willamette River and Rainfall Reporting Network, FC-5, is operated cooperatively by the Corps of Engineers and the U. S. Weather Bureau for the purpose of collecting basic hydrologic data required for forecasting floods and operating flood-control reservoirs in the Willamette River Basin. Stations in this network report precipitation, temperature, reservoir data, river stage, current weather, and related data in accordance with prescribed instructions. Three categories of stations are included in the network: stations which are operated by the Corps of Engineers, stations which are operated by the Weather Bureau without reimbursement, and the stations operated by the Weather Bureau under transfer of funds from the Corps of Engineers. A free and continuous exchange of information obtained from all types of stations is maintained between the two agencies. Reports from the first type of stations are usually transmitted to the Portland District Office through Corps of Engineers channels. Reports from the other types of stations are usually transmitted to the Portland office by a special teletype circuit.

10-11. Data and forecasts thus exchanged are utilized in the regulation of Cougar Reservoir. The following tabulation lists the stations in the reporting network that are most pertinent to the regulation of Cougar Reservoir. The stations are shown on plate 1.

| Station Number | Station | Stream or watershed | Communication | Information reported |
|---|---|---|---|---|
| 1592 | Above Cougar Res | South Fk McKenzie R | Telemetering[1/] | River(reservoir inflow) |
| 1594 | Cougar Dam | South Fk McKenzie R | Telemetering[1/] | Pool elevation |
| 1914 | Cougar Dam | South Fk McKenzie R | Telephone[2/] | Precip., temp.,weather, pool & river data |
| - | Cougar Dam | South Fk McKenzie R | Telemetering[1/] | Tailwater elevation (Powerhouse) |
| 1595 | Rainbow (near) | South Fk McKenzie R | Telemetering[1/] | River(reservoir releases) |
| 1655 | Coburg (near) | McKenzie R | Telemark[3/] | River stage |
| 1660 | Harrisburg | Willamette R | Telemark[3/] | River stage |
| 2709 | Eugene | Willamette R | Teletype | Precip.,temp.,weather, (First Order U.S.W.B. Station) |

UPSTREAM CABLEWAY




UPSTREAM GAGING STATION
South Fork McKenzie River above Cougar Reservoir,
near Rainbow, Oregon

| Station Number | Station | Stream or watershed | Communication | Information reported |
|---|---|---|---|---|
| 21 E7 | McKenzie | McKenzie R | Bi-monthly 4/ Jan - Apr | Snow water equiv. |
| 22 E5 | McKenzie Bridge | McKenzie R | Bi-monthly 4/ Jan - Apr | Snow water equiv. |
| 21 E6 | Hogg Pass | Santiam R | Bi-monthly 4/ Jan - Apr | Snow water equiv. |
| 21 E5 | Santiam Junction | Santiam R | Bi-monthly 4/ Jan - Apr | Snow water equiv. |

Notes: 1/ Data transmitted by telemetering from observation station to dam and in return relayed to District Office by dam personnel.

2/ Dam personnel telephones all climatic and hydrologic data observed and collected at dam to District Office.

3/ River data collected by U.S. Weather Bureau and relayed to District Office by teletype. Station can be contacted direct by telephone.

4/ Snow data received by telephone and mail from Soil Conservation Service.

## SECTION XI - RESPONSIBILITIES AND EMERGENCY INSTRUCTIONS

11-01. Organization for reservoir regulation. - Under authority contained in Sections 1 and 2 of the Flood Control Act of 22 June 1936, the Chief of Engineers is responsible for establishing overall policy for the regulation of reservoirs for flood control. In the Portland District, reservoir regulation plans and schedules for flood-control projects are formulated in the Engineering Division in accordance with instructions contained in Engineering Manual 1110-2-3600, dated May 1959, and are submitted through the North Pacific Division to the Office, Chief of Engineers, for approval. Any future changes in the reservoir regulation plan that affect the authorized functions of the reservoirs, or constitute major changes in the approved regulation plan, will be submitted through the North Pacific Division to the Office, Chief of Engineers, for approval prior to field use.

11-02. Organization of the Portland District for the regulation of Cougar project is shown on chart 17, which shows names and telephone numbers of personnel and the lines of communications by which instructions are transmitted both administratively and for water management. (Regulation for hydroelectric power production requires close coordination with Bonneville Power Administration, the marketing agency for power generated at all Federal projects in the Pacific Northwest.) Coordination and liaison are maintained with the U. S. Weather Bureau and U. S. Geological Survey at all times for the purpose of obtaining basic meteorologic and hydrologic data essential to the regulation of Cougar and other multiple-purpose reservoirs in Willamette River Basin.

11-03. Engineering Division. - In accordance with the provisions of Chapter 2 of EM 1110-2-3600, "Reservoir Regulation," functional regulation of Cougar Reservoir and other multiple-purpose reservoirs in the Portland District is the responsibility of the Engineering Division with the primary responsibility delegated to the Water Control Section of the Project Planning Branch. Within the Water Control Section are personnel assigned to reservoir regulation and power scheduling. The project engineer will be furnished with the names of District personnel authorized to issue reservoir regulation and power generation instructions to the project. This list will be revised as changes in personnel assigned to reservoir regulation occur. All significant reservoir regulation instructions issued by the Water Control Section will be confirmed in writing.

11-04. Duties of Engineering Division personnel assigned to regulation of Cougar Reservoir are:

a. Develop plan of operation including regulation schedules and rule curves which incorporate the concept of system regulation.

b. Maintain a continuing program of study to improve reservoir regulation technique and rule curves for more efficient operation of Cougar Reservoir for flood control, power, and conservation uses of water.

c. Prepare and distribute reservoir regulation manuals and make revisions when necessary.

d. Direct the functional regulation of the reservoir. During flood periods, Cougar Reservoir will be subject to 24-hour surveillance whereas water conservation is normally a day-to-day operation.

e. Develop schedules and coordinate the use of water impounded in Cougar Reservoir. The Bureau of Reclamation is the Government agency responsible for the sale of stored water for irrigation. Stored water dispatched from Cougar Reservoir for this purpose will be at the Bureau of Reclamation's request. Bonneville Power Administration will be consulted in scheduling power releases at Cougar as it is the Government agency responsible for the sale and distribution of power generated at Federal plants.

f. Develop a training program to improve technical proficiency and to enable the normal staff of reservoir regulation personnel to be supplemented during flood emergencies. Participate in mock-flood exercises to test the reservoir regulation training program, the flood emergency plan, reservoir regulation methods and schedules, and data reporting.

g. Prepare charts of Monthly Reservoir Regulation and provide applicable portions of special flood reports, survey reports, definite project reports, and design memoranda.

11-05. During the flood season, hydrologic reports are collected and analyzed on a continuous basis. Personnel assigned to reservoir regulation are responsible for keeping a constant surveillance of weather and streamflow conditions. Normally, a reduced staff is assigned to weekend and holiday duty with the off-duty personnel subject to call in an emergency. The employee on duty has authority to direct operation of the reservoir in accordance with the schedules in the manual, but is required to obtain approval of the Chief, Water Control Section, or if he is not available, the Chief, Reservoir

Regulation Subsection, before initiating significant deviations from the approved flood regulation or power generation schedules.

11-06. Operations Division. - Physical operation and maintenance of multiple-purpose projects in the Portland District are the responsibility of the Operations Division under the direct supervision of the Project Engineer, who is responsible to the Chief of Multiple Purpose Projects Branch in the Operations Division of the District office. Damtenders and powerhouse operators are under the supervision of the Project Engineer. Reservoir regulation instructions are normally issued to one of the powerhouse operators but may be transmitted to the Project Engineer. All instructions pertaining to the regulation of Cougar Reservoir shall be logged by the dam attendant receiving the instructions and confirmed in writing by the party issuing the instructions. Date, time, and names of persons giving and receiving the instructions will be included in the confirmation, Form NPP FL 54 (Rev) July 1963. See chart 12.

11-07. Forms and reports. - Several reports will be prepared by personnel at Cougar project. These reports are to keep the many interested parties informed on project activities and to provide a permanent record of these activities. In general, these reports are made on standard forms and have a prescribed distribution. Some reports are for project use only; others are prescribed by regulations and require off-the-project distribution. This manual is primarily concerned with those reports pertaining to flood control and power that have an off-the-project distribution. The standard forms pertinent to this manual are shown in charts 12 through 16, and are listed in the following tabulation:

| Forms for Reports | |
|---|---|
| **Form Number** | **Description and Disposition** |
| NPP FL 54 (Rev) 1963 | Confirmation of Reservoir and Power Regulation Instructions. |
| Copies | 2 |
| Routing | 1 - Cougar Dam; 1 - Office File |
| Frequency | Following each significant instruction to project |
| NPP 34e RCS-NPPEN-PP-42(R2) | Cougar Project Daily Hydrometeorological and Power Data. |
| Copies | 3 |
| Routing | 1 - Operations Division; 1 - Engineering Division; 1 - File at Cougar Dam. |
| Frequency | Daily |
| NPP 315 RCS-ENGCW-E-6 | Monthly Reservoir Regulation. |
| Copies | 11 |
| Routing | 1 - Office, Chief of Engineers; 1 - North Pacific Division; 1 - Mail and Records; 1 - Operations Division; 1 - Engineering Division; 2 - Cougar Dam; 4 - Outside Agencies. (Distribution will be made by Reservoir Regulation Subsection.) |
| Frequency | Monthly |
| NPP 252 (Rev) RCS-NPPVK-57 | Power Production Report. |
| Copies | 6 |
| Routing | 1 - Office, Chief of Engineers; 1 - Multiple Purpose Projects Branch; 1 - Engineering Division; 1 - Operations Division; 2 - Bonneville Power Administration |
| Frequency | Monthly |

| Forms for Reports | |
|---|---|
| Form Number | Description and Disposition |
| F.P.C. No. 4 (FPC-1001) | Monthly Power Plant Report. |
| Copies | 2 |
| Routing | 1 - Federal Power Commission; 1 - Cougar Project Office |
| Frequency | Monthly |

11-08. Responsibilities for maintenance of hydrologic and meteorologic stations. - Maintenance and operation of the weather station at Cougar project is the responsibility of the Project Engineer. Project personnel will receive instructions from the U. S. Weather Bureau and the Reservoir Regulation Subsection regarding the method of taking and recording observations. They will also collect and transmit to the Reservoir Regulation Subsection, river and reservoir stage data used in the regulation of Cougar Reservoir. Project personnel will be responsible for making occasional inspections of the water stage and weather stations and report to the Reservoir Regulation Subsection any equipment malfunction they are unable to repair. In addition, the project personnel will take special observations as needed by the Reservoir Regulation Subsection for study purposes.

11-09. The Corps of Engineers contributes funds to the U. S. Weather Bureau, U. S. Geological Survey, and Soil Conservation Service for installing, servicing, maintaining, processing, and disseminating the hydrologic and meteorologic data required for the regulation of Cougar Reservoir. These agencies are responsible for instructing the project personnel regarding the care and operation of the instruments and the type and method of observations. Each agency inspects from time to time the condition of the equipment and makes the necessary repairs and replacements deemed necessary to minimize failures. All supplies, such as parts, charts, forms, etc., necessary for recording and disseminating the hydrologic and meteorologic data are furnished by these agencies. They also supply the Corps of Engineers with special reports and publications needed in the regulation of Cougar project and for study of special problems.

11-10. Collection and transmission of data. - The following hydrologic and power generation data are collected and transmitted to the Reservoir Regulation Subsection in the District office:

a. Reservoir inflow, outflow, and pool elevations. These data are automatically recorded in the Cougar powerhouse control room.

b. Gross and net hourly power generation delivered to Bonneville Power Administration.

c. Weather data received from the project including precipitation, current weather conditions, maximum and minimum air temperatures, and wind. Normally, this information is furnished daily with the morning report, although when required, weather information will be furnished on call. Other weather information, such as humidity and snow depth, are included in the weather report when pertinent.

d. Temperature of the released water.

11-11. During major storm periods, meteorological and hydrological reports may be required hourly, particularly if figure 3, on plate 11, is being used. Generally, 6-hourly reports are adequate for flood regulation. During nonflood periods, daily reports, other than power generation instructions, are adequate. Power scheduling may require contacting the powerhouse superintendent or operators several times during a day, but usually two contacts a day are adequate. Special river and weather reports are sent to the Reservoir Regulation Subsection on request.

11-12. For the immediate future, the telephone will be the principal means of communicating between Cougar Dam and the District office. Ultimately radio will be provided to back up the telephone and for emergency situations when the normal communications are not functioning.

11-13. Emergency instructions. - It is not possible to anticipate every unusual flood, power emergency, or combination of events that will require special regulation, therefore, general instructions are provided for such contingencies. Should an emergency develop or appear imminent, the Project Engineer, or a subordinate, will promptly contact the District office, report existing field conditions, and request instructions. In event of a communication failure, repeated efforts will be made to contact the District office. If all efforts fail, the decision as to the action to be taken must be made in the field. Should such an event occur, all circumstances and emergency actions taken will be reported in writing as soon as possible.

11-14. Should communications to Portland fail during a flood, but remain operative to the stream-gaging stations at Coburg and the inflow stations, the Project Engineer or powerhouse superintendent will direct the regulation of Cougar Reservoir, using the schedules shown on plate 11. Precipitation observed at the project weather station will be used in computing the precipitation index.

11-15. In the event of complete failure of wire communications to the District office and key stream-gaging stations above and below Cougar Dam, the outflow from the project will be reduced to a minimum. Minimum flood control releases from Cougar Reservoir are 750 c.f.s. if power is being generated or 100 c.f.s. if power is not being generated. The reduced outflows will be maintained until communications are restored and downstream stages have receded sufficiently to permit greater releases, or until greater releases are indicated by the special curves shown on figure 3 of plate 11.

11-16. When the pool elevation and rate of rise indicates the special curves are applicable, the reservoir release will be increased to the discharge indicated on the horizontal scale, but the rate of increase should not exceed 750 c.f.s. in any 1-hour period. Rate of pool rise and outflow determinations will be made at 2-hour intervals. Should a subsequent release determination indicate a lower discharge, no change in release should be effected until this trend is verified over the subsequent 2-hour period. This will avoid erratic adjustments in the releases. After the reservoir starts to fall, current gate openings will be maintained by adjusting the reservoir release to equal the reservoir inflow until normal post-flood evacuation is initiated.

## TABLES

TABLE 1

Climatological Summary
McKenzie Bridge Ranger Station
(Elevation 1375 feet)

| Item and Description | Period of record | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | **Precipitation** | | | | | | | | | |
| Normal, inches | #1931-55 | 10.62 | 8.15 | 6.14 | 4.76 | 3.64 | 2.95 | 0.53 | 0.69 | 2.23 | 6.54 | 9.74 | 12.[illegible] | 68.99 |
| Percent of normal annual | | 15 | 12 | 12 | 7 | 5 | 4 | 1 | 1 | 3 | 9 | 14 | 17 | 100 |
| Maximum, inches | #1931-61 | 23.62 | 19.07 | 18.12 | 10.97 | 9.39 | 7.59 | 2.80 | 3.87 | 6.74 | 18.27 | 22.54 | 25.04 | 93.29 |
| Year of Maximum | | 1953 | 1961 | 1932 | 1937 | 1960 | 1937 | 1902 | 1912 | 1959 | 1950 | 1942 | 1942 | 1953 |
| Minimum, inches | #1931-61 | 3.10 | 2.27 | 1.41 | 0.00 | 0.50 | 0.00 | 0.00 | 0.00 | 0.35 | 0.12 | 0.22 | 3.16 | 43.38 |
| Year of Minimum | | 1949 | 1905 | 1941 | 1950 | 1935 | 1951 | 1906+ | 1931+ | 1942+ | 1936 | 1936 | 1944 | 1935 |
| Greatest in 24 hours, inches | #1931-61 | 4.41 | 4.38 | 3.05 | 3.21 | 2.81 | 2.14 | 1.54 | 1.41 | 1.70 | 3.76 | 5.40 | 5.28 | 5.40 |
| Year of greatest 24 hours | | 1903 | 1961 | 1932 | 1937 | 1949 | 1933 | 1904 | 1953 | 1941 | 1947 | 1909 | 1945 | Nov. 1909 |
| Avg. No. days with .01" or more | 1931-52 | 18 | 17 | 18 | 15 | 11 | 9 | 2 | 3 | 7 | 12 | 15 | 18 | 145 |
| Average snowfall, inches | #1931-52 | 13.2 | 7.4 | 2.4 | 0.7 | T | | | | | 0.2 | 1.3 | 6.0 | 31.2 |
| Maximum snowfall, inches | #1931-61 | 61.0 | 41.5 | 17.0 | 8.0 | T | | | | | 3.5 | 5.7 | 41.8 | 97.2 |
| Year of maximum snowfall | | 1935 | 1939 | 1935 | 1961 | 1942+ | | | | | 1935 | 1931 | 1948 | 1937 |
| | | | | | **Temperature** | | | | | | | | | |
| Normal, °F. | 1931-55 | 35.0 | 38.5 | 43.7 | 49.8 | 55.1 | 59.7 | 66.2 | 64.5 | 59.3 | 51.7 | 41.6 | 36.5 | 51.1 |
| Average daily maximum, °F. | 1931-61 | 42.5 | 48.1 | 55.0 | 63.[illegible] | 70.4 | 75.4 | 85.0 | 84.2 | 75.0 | 65.5 | 51.4 | 43.7 | 63.6 |
| Average daily minimum, °F. | 1931-61 | 27.5 | 29.3 | 31.4 | 35.1 | 41.1 | 44.7 | 47.1 | 44.9 | 41.7 | 37.7 | 32.1 | 29.5 | 36.8 |
| Absolute maximum, °F. | 1931-61 | 66 | 71 | 83 | 91 | 97 | 108 | 106 | 106 | 102 | 96 | 76 | 61 | 108 |
| Year of absolute maximum | | 1961 | 1938 | 1961 | 1947+ | 1941+ | 1961 | 1946 | 1935 | 1955 | 1952 | 1949 | 1933 | July 1946+ |
| Absolute minimum, °F. | 1931-61 | -7 | 0 | 16 | 23 | 22 | 30 | 31 | 28 | 26 | 21 | 5 | 2 | -7 |
| Year of absolute minimum | | 1950 | 1939 | 1955+ | 1939 | 1954 | 1931+ | 1954 | 1957 | 1934 | 1935 | 1951 | 1932 | Jan. 1950 |
| | | | | | **Miscellaneous Data** | | | | | | | | | |
| Average number of days clear | 1931-47 | 9 | 6 | 9 | 11 | 14 | 13 | 22 | 22 | 17 | 13 | 11 | 8 | 155 |
| Average number of days partly cloudy | 1931-47 | 5 | 6 | 6 | 7 | 6 | 7 | 6 | 5 | 6 | 6 | 5 | 5 | 70 |
| Average number of days cloudy | 1931-47 | 17 | 16 | 16 | 13 | 11 | 10 | 3 | 4 | 7 | 12 | 15 | 18 | 142 |
| Prevailing wind direction | 1931-47 | SW | SW | SW | W | NW | W | NW | NW | W | W | SW | SW | SW |

+ Later years also.

# Records from 1902 to 1913 included.

STATION HISTORY

| Station Name Assigned | Dates | | Location | | Elevation Feet |
|---|---|---|---|---|---|
| | From | To | Lat. | Long. | |
| McKenzie Bridge | Feb. 1,1902 | Nov. 30,1913 | 44 10' | 122 10' | 1400 |
| McKenzie Bridge Fox Ranch | Jan. 14,1931 | June 30,1932 | 44 11' | 122 13' | 1200 |
| Rainbow | Oct. 1,1932 | June 30,1935 | 44 11' | 122 14' | 1200 |
| McKenzie Bridge | July 24,1935 | Present * | 44 10' | 122 10' | 1375 |

* Name changed to McKenzie Bridge Ranger Station on July 1, 1948 without change in location.

TABLE 2

Climatological Summary
Leaburg, Oregon
(Elevation 67[illegible] feet)

| Item and Description | Period of Record | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Precipitation | | | | | | | | |
| Normal, inches | 1934-55 | 7.56 | 6.96 | 6.21 | 4.71 | 3.19 | 2.70 | 0.75 | 0.67 | 2.06 | 5.4[illegible] | 8.44 | 8.76 | 57.94 |
| Percent of normal annual | | 13 | 12 | 11 | 8 | 6 | 5 | 1 | 1 | 4 | 9 | 15 | 15 | 100 |
| Maximum, inches | 1934-61 | 15.28 | 16.79 | 12.46 | 10.53 | 8.10 | 7.[illegible] | 2.4[illegible] | 2.7[illegible] | 5.3[illegible] | 12.7[illegible] | 16.5[illegible] | 18.73 | 84.15 |
| Year of Maximum | | 1953 | 1961 | 1938 | 1955 | 1961 | 1947 | 1947 | 1943 | 1955 | 1947 | 1942 | 1955 | 1956 |
| Minimum, inches | 1934-61 | 2.79 | 2.05 | 2.53 | 1.54 | [illegible] | 0.17 | [illegible] | 0.01 | 0.77 | [illegible] | 1.43 | 3.37 | 41.23 |
| Year of Minimum | | 1949 | 1934 | 1941 | [illegible] | 1935 | 1941 | [illegible] | 1936+ | 1943 | 1936 | 1946 | 1944 | 1944 |
| Greatest in 24 hours | 1934-61 | 3.73 | 4.41 | 2.13 | 2.05 | 2.02 | 1.40 | 1.14 | 1.4[illegible] | 1.62 | 2.6[illegible] | 4.37 | 4.33 | 4.41 |
| Year of greatest 24 hours | | 1948 | 1961 | 1937 | 1937 | 1949 | 1947 | 1947 | 1960 | [illegible] | 1947 | 1961 | 1955 | Feb. 1961 |
| Avg. No. days with .01" or more | 1934-52 | 18 | 16 | 19 | 15 | 12 | 10 | 3 | 3 | 7 | 14 | 20 | 19 | 154 |
| Average snowfall, inches | 1934-52 | 9.0 | 3.5 | 2.0 | 0.2 | T | | | | | 0.2 | T | 1.7 | 16.6 |
| Maximum snowfall, inches | 1934-53 | 56.0 | 17.0 | 23.5 | 3.5 | T | | | | | 2.0 | 9. | 9.0 | 5[illegible].5 |
| Year of maximum snowfall | | 1950 | 1949 | 1951 | 1948 | 1953+ | | | | | 1942 | 1955 | 1956 | 1950 |
| | | | | | | Temperature | | | | | | | | |
| Normal, °F. | 1934-55 | 40.4 | 43.6 | 47.5 | 52.4 | 57.5 | 61.5 | 67.2 | 66.5 | 62.5 | 54.1 | [illegible] | 41.7 | [illegible] |
| Average daily maximum, °F. | 1934-61 | 46.1 | 50.6 | 55.5 | 62.3 | 69.4 | 74.3 | 82.9 | 82.2 | 76.5 | 63.7 | 53.0 | 47.6 | [illegible] |
| Average daily minimum, °F. | 1934-61 | 33.6 | 35.6 | 36.9 | 40.3 | 44.6 | 48.7 | 51.[illegible] | 51.4 | 48.2 | 44.1 | 39.1 | 35.8 | 41.3 |
| Absolute maximum, °F. | 1934-61 | 69 | 70 | 79 | 89 | 93 | 106 | 115 | 102 | 102 | 95 | 7[illegible] | 64 | [illegible] |
| Year of absolute maximum | | 1961 | 1950 | 1944 | 1934 | 1939 | 1951 | 1961 | 1935 | 1934 | 1934 | 1949 | 1937+ | July 1961 |
| Absolute minimum, °F. | 1934-61 | 6 | 5 | 24 | 29 | 30 | 37 | 40 | 39 | 34 | 27 | 18 | 2[illegible] | |
| Year of absolute minimum | | 1937 | 1950 | 1944+ | 1936+ | 1954 | 1936+ | 1935+ | 1935 | 1934 | 1949 | 1955 | 1955 | Feb. 1950 |
| | | | | | Miscellaneous Data | | | | | | | | | |
| Average number of days clear | 1934-47 | 6 | 5 | 7 | 6 | 11 | 11 | 19 | 20 | 17 | 1[illegible] | 6 | 5 | 127 |
| Average number of days partly cloudy | 1934-47 | 7 | 8 | 9 | 9 | 8 | 8 | 8 | 7 | 6 | 6 | 6 | 7 | 84 |
| Average number of days cloudy | 1934-47 | 18 | 15 | 15 | 15 | 12 | 11 | 4 | 4 | 7 | 15 | 16 | 19 | 14[illegible] |
| Prevailing wind direction | 1934-47 | NE | SW | SW | SW | SW | SW | SW | SW | SW | SW | SW | NE | SW |

\+ Later years also

STATION HISTORY

Station is known as Leaburg Power Plant located at 44 [illegible]'N Lat. and 122 [illegible]'W Long. (Sec.[illegible], T.17S. R.[illegible]). 3/4 mile southwest of Leaburg. First observation began December 1, 19[illegible].

TABLE 3

Climatological Summary
Eugene, Oregon
(Elevation 361 feet)

| Item and description | Period of record | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Precipitation | | | | | | | |
| Normal, inches | 1921-50 | 5.41 | 4.54 | 3.56 | 2.54 | 1.99 | 1.37 | 0.26 | 0.38 | 1.60 | 3.57 | 5.69 | 6.60 | 37.51 |
| Percent of normal annual | | 14 | 13 | 10 | 7 | 5 | 4 | 1 | 1 | 4 | 10 | 15 | 16 | 100 |
| Maximum, inches | 1891-1961 | 12.92 | 12.10 | 10.49 | 7.17 | 4.76 | [illegible] | 3.38 | 3.14 | 5.21 | 12.66 | 12.02 | 19.49 | 55.21 |
| Year of Maximum | | 1950 | 1904 | 1904 | 1937 | 1915 | 1937 | 1916 | 1899 | 1927 | 1950 | 1950 | 1955 | 1937 |
| Minimum, inches | 1891-1961 | 1.68 | 0.10 | 0.40 | 0.43 | 0.19 | T | 0.01 | 0.00 | 0.06 | T | .25 | 2.01 | 23.26 |
| Year of Minimum | | 1949 | 1920 | 1926 | 1909 | 1931 | 1951 | 1906+ | 1909+ | 1942+ | 1895 | 1891 | 1931 | 1944 |
| Greatest in 24 hours, inches | 1891-1961 | 3.39 | 4.17 | 1.94 | 1.79 | 1.49 | 2.37 | 1.59 | 1.54 | 1.74 | 3.85 | 4.53 | 4.82 | 4.82 |
| Year of greatest 24 hours | | 1933 | 1961 | 1916 | 1907 | 1949 | 1952 | 1916 | 1896 | 1941 | 1955 | 1961 | 1955 | Dec.1955 |
| Avg. No. days with .01" or more | [illegible] | 19 | 16 | 18 | 13 | 11 | 8 | 2 | 4 | 5 | 12 | 15 | 19 | 142 |
| Average snowfall, inches | 1891-1961 | 3.0 | 1.1 | 0.9 | T | | | | | | T | T | 0.8 | 5.8 |
| Maximum snowfall, inches | 1891-1961 | 36.1 | 22.7 | 15.7 | 2.0 | | | | | | 1.0 | 5.0 | 8.5 | 44.9 |
| Year of maximum snowfall | | 1950 | 1917 | 1916 | 1911 | | | | | | 1935 | 1955 | 1919+ | 1916 |
| Greatest 24 hour snowfall, inches | 1891-1961 | 7.3 | 10.1 | 10.7 | 2.0 | | | | | | 1.0 | 5.0 | 6.5 | 10.7 |
| Year of greatest 24 hour snowfall | | 1916 | 1917 | 1916 | 1911 | | | | | | 1935 | 1955 | 1924 | Mar.1916 |
| | | | | | | | Temperature | | | | | | | |
| Normal, °F. | 1921-50 | 38.2 | 42.7 | 46.7 | 51.9 | 56.4 | 61.3 | 66.6 | 66.1 | 61.9 | 52.7 | 45.3 | 40.6 | 52.4 |
| Normal daily maximum, °F. | 1921-50 | 44.8 | 50.4 | 56.2 | 62.0 | 68.6 | 74.6 | 82.4 | 82.0 | 75.5 | 63.5 | 51.7 | 47.3 | 63.3 |
| Normal daily minimum, °F. | 1921-50 | 31.6 | 34.9 | 37.1 | 39.5 | 44.2 | 48.0 | 50.7 | 50.0 | 46.2 | 41.9 | 37.9 | 33.9 | 41.4 |
| Absolute maximum, °F. | 1891-1961 | 69 | 78 | [illegible] | 89 | 92 | 101 | 105 | 100 | 101 | 91 | 75 | 67 | 105 |
| Year of absolute maximum | | 1931 | 1932 | 1923 | 1926 | 1931 | 1925+ | 1946+ | 1932+ | 1944 | 1934 | 1936 | 1926+ | July 1946+ |
| Absolute minimum, °F. | 1891-1961 | -4 | -3 | 18 | 25 | 28 | 34 | 39 | 35 | 30 | 24 | 10 | -4 | -4 |
| Year of absolute minimum | | 1957 | 1950 | 1923 | 1936 | 1954 | 1913+ | 1926+ | 1914 | 1926 | 1949 | 1896 | 1924 | Dec.1924+ |
| | | | | | | | Miscellaneous Data | | | | | | | |
| Average number of days clear | 1891-1947 | 4 | 5 | 7 | 8 | 10 | 12 | 20 | 14 | 15 | 10 | 6 | 3 | 118 |
| Average number of days partly cloudy | 1891-1947 | 7 | 8 | 9 | 9 | 10 | 9 | 7 | 8 | 8 | 9 | 7 | 7 | 98 |
| Average number of days cloudy | 1891-1947 | 20 | 15 | 15 | 13 | 11 | 9 | 4 | 4 | 7 | 12 | 15 | 21 | 149 |
| Prevailing wind direction | 1891-1947 | S | S | SW | NW | NW | NW | NW | NW | NW | NW | S | S | SW |

\+ Later dates also.

STATION HISTORY

| Location | Period |
|---|---|
| University of Oregon Campus | October 1891 to March 1912 |
| 533 East 10th Street | April 1912 to Aug. 13, 1914 |
| Kincaid Park | Aug. 13, 1914 to Sept. 1917 |
| Mill Race and Alder | Oct. 1917 to Nov. 1924 |
| 477 3rd Ave. East | Dec. 1924 to Jan. 1, 1935 |
| Eugene Air Park | Jan. 1, 1935 to Dec. 20, 1942 |
| Eugene Airport | Dec. 21, 1942 to Present |

TABLE 4

Climatological Summary - Selected Stations

| ITEM | Station, elevation, and period of record | | | |
|---|---|---|---|---|
| | Eugene 361 ft. 1891-1961 | Leaburg 675 ft. 1934-61 | Marcola 530 ft. 1941-61 | McKenzie Bridge R.S. 1375 ft. +1931-61 |
| | Precipitation | | | |
| Normal annual precipitation, inches | 37.51 | 57.54 | 57.97 | 69.99 |
| Maximum annual precipitation, inches | 55.21 | 84.15 | 77.49 | 93.29 |
| Year of maximum annual precipitation | 1937 | 1953 | 1953 | 1953 |
| Minimum annual precipitation, inches | 23.26 | 41.23 | 33.99 | 43.38 |
| Year of minimum annual precipitation | 1944 | 1944 | 1944 | 1935 |
| Maximum Monthly Precipitation, inches | 19.49 | 19.73 | 20.74 | 25.04 |
| Month and year of maximum monthly precipitation | Dec. 1955 | Dec. 1955 | Dec. 1955 | Dec. 1942 |
| Maximum 1-day recorded precipitation, inches | 4.82 | 4.41 | 4.90 | 5.40 |
| Month and year of maximum 1-day precipitation | Dec. 1955 | Feb. 1961 | Dec. 1941 | Nov. 1909 |
| Greatest annual snowfall, inches | 44.9 | 50.5 | | 97.2 |
| Year of greatest snowfall | 1916 | 1950 | | 1937 |
| | Temperature | | | |
| Normal annual temperature, °F. | 52.4 | 53.4 | No temperature data | 50.1 |
| Average annual maximum temperature, °F. | 63.3 | 63.7 | | 63.6 |
| Average annual minimum temperature, °F. | 41.4 | 42.3 | | 36.8 |
| Absolute maximum temperature, °F. | 105 | 105 | | 108 |
| Month and year of maximum temperature | July 1946* | July 1961 | | July 1946* |
| Absolute minimum temperature, °F. | -4 | 5 | | -7 |
| Month and year of minimum temperature | Dec. 1924* | Feb. 1950 | | Jan. 1950 |
| January average temperature, °F. | 38.2 | 40.4 | | 35.0 |
| July average temperature, °F. | 66.6 | 67.1 | | 66.2 |
| Difference, July-January temperature, °F. | 28.4 | 26.7 | | 31.2 |

\+ Records from 1902 to 1913 included.

* Identical extreme experienced in subsequent years.

TABLE 5

Snow Survey Summary - Selected Stations

| Item | Station and Elevation | | | | | |
|---|---|---|---|---|---|---|
| | Dead Horse Grade 3800 | Hogg Pass 4755 | Lost Creek Ranch 1746 | McKenzie 4800 | McKenzie Bridge 1372 | White Branch Slide 2800 |
| **February 1** | | | | | | |
| * Length of record, years | 13 | 25 | 11 | 19 | 14 | 14 |
| Average snow depth, inches | 39 | 76 | 10 | 72 | 6 | 19 |
| Average water equivalent, inches | 13.7 | 25.0 | 3.2 | 26.7 | 1.7 | 5.9 |
| Highest water equivalent, inches | 37.8 | 49.1 | 12.7 | 42.7 | 8.7 | 21.7 |
| Year of highest | 1950 | 1952 | 1952 | 1952 1/ | 1950 | 1950 |
| Lowest water equivalent, inches | 0 | 7.5 | 0 | 5.0 | 0 | 0 |
| Year of lowest | 1961 | 1959 | 1953 1/ | 1940 | 1953 1/ | 1953 1/ |
| **March 1** | | | | | | |
| * Length of record, years | 12 | 22 | 9 | 13 | 13 | 12 |
| Average snow depth, inches | 51 | 96 | 6 | 104 | 5 | 18 |
| Average water equivalent, inches | 17.9 | 37.0 | 2.1 | 41.1 | 1.3 | 5.7 |
| Highest water equivalent, inches | 38.0 | 70.9 | 10.8 | 64.2 | 5.5 | 16.0 |
| Year of highest | 1950 | 1949 | 1956 | 1949 | 1952 | 1956 |
| Lowest water equivalent, inches | 5.0 | 16.8 | 0 | 18.7 | 0 | 0 |
| Year of lowest | 1961 | 1945 | 1953 1/ | 1959 | 1953 1/ | 1954 |
| **April 1** | | | | | | |
| * Length of record, years | 13 | 24 | 11 | 22 | 12 | 13 |
| Average snow depth, inches | 56 | 108 | 2 | 104 | 0 | 14 |
| Average water equivalent, inches | 22.5 | 44.3 | 0.9 | 44.2 | 0 | 5.3 |
| Highest water equivalent, inches | 43.3 | 73.5 | 6.0 | 70.5 | | 16.4 |
| Year of highest | 1950 | 1956 | 1956 | 1956 | | 1955 |
| Lowest water equivalent, inches | 10.1 | 18.6 | 0 | 14.8 | | 0 |
| Year of lowest | 1959 | 1941 | 1951 1/ | 1941 | | 1953 1/ |

* Through 1962

1/ Later years also

TABLE 6

Evaporation and Related Data

| Month | At Fern Ridge Dam: Years of record[1] | Average wind speed m.p.h.[2] | Mean air temperature °F. | Class A pan evaporation inches | Pan coefficient[3] | Cougar Reservoir evaporation[4]: Inches | Acre-feet |
|---|---|---|---|---|---|---|---|
| January | 5 | 2.43 | 41.0 | 0.34 | 0.50 | 0.17 | 10 |
| February | 5 | 2.16 | 40.9 | 0.58 | 0.35 | 0.20 | 12 |
| March | 7 | 2.78 | 43.8 | 1.44 | 0.40 | 0.58 | 47 |
| April | 11 | 2.44 | 49.7 | 2.76 | 0.45 | 1.24 | 116 |
| May | 18 | 2.29 | 55.9 | 4.75 | 0.60 | 2.85 | 290 |
| June | 18 | 2.20 | 60.7 | 5.79 | 0.70 | 4.05 | 415 |
| July | 18 | 2.38 | 66.2 | 8.21 | 0.75 | 6.16 | 625 |
| August | 19 | 2.27 | 65.8 | 6.87 | 0.75 | 5.16 | 520 |
| September | 19 | 2.24 | 62.2 | 4.55 | 0.85 | 3.87 | 364 |
| October | 7 | 1.71 | 54.4 | 1.95 | 0.90 | 1.76 | 141 |
| November | 6 | 1.72 | 45.3 | 0.52 | 1.20 | 0.62 | 40 |
| December | 5 | 2.33 | 41.0 | 0.34 | 1.00 | 0.34 | 20 |
| Year | | | | 38.10 | 0.71 | 27.00 | 2600 |

Notes:

1 Ending in 1961.

2 Wind speed measured 6 inches above rim of pan.

3 Pan coefficients are based on "Lake Hefner Study," U. S. Geological Survey Professional Paper No. 269.

4 Based on average scheduled pool elevations at Cougar Reservoir.

TABLE 7

Monthly Discharge Data
South Fork McKenzie River near Rainbow (Below Cougar Dam)
Drainage Area = 208 Square Miles

| Water Year | Mean monthly flows in c.f.s. | | | | | | | | | | | | Mean annual | Extremes of discharge | | | | | | Annual runoff | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | Max. Inst. | | Max. daily | | Min. daily | | | |
| | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | c.f.s. | Date | C.f.s. | Date | C.f.s. | Month | C.f.s. | Acre-feet | Inches |
| 1926 | 233 | 403 | 800 | 558 | 1870 | 634 | 450 | 350 | 212 | 177 | 170 | 193 | 504 | Feb. 6 | 6,600 | | | | | 364,900 | 32.89 |
| 1927 | 250 | 940 | 970 | 1150 | 1860 | 990 | 862 | 1245 | 1025 | 334 | 240 | 335 | 850 | Feb. 20 | 17,500 | | | | | 615,400 | 55.47 |
| 1928 | 584 | 1870 | 910 | 1560 | 610 | 1410 | 1375 | 868 | 327 | 261 | 212 | 212 | 850 | Nov. 29 | 8,300 | | | | | 615,400 | 55.47 |
| 1929 | 225 | 285 | 388 | 510 | 411 | 920 | 1040 | 1180 | 825 | 288 | 198 | 182 | 538 | Mar. 21 | 4,700 | | | | | 389,500 | 35.11 |
| 1930 | 187 | 173 | 800 | 413 | 1600 | 541 | 423 | 450 | 320 | 182 | 152 | 155 | 450 | Dec. 18 | 8,900 | | | | | 325,800 | 29.37 |
| 1931 | 175 | 280 | 319 | 440 | 360 | 1060 | 1430 | 387 | 255 | 185 | 149 | 148 | 432 | Apr. 1 | 12,100 | | | | | 312,800 | 28.20 |
| 1932 | 237 | 425 | 538 | 861 | 570 | 2270 | 1560 | 1490 | 925 | 333 | 225 | 210 | 804 | Mar. 18 | 11,800 | | | | | 582,100 | 52.47 |
| 1933 | 224 | 825 | 784 | 880 | 603 | 982 | 1275 | 1545 | 2540 | 535 | 285 | 280 | 897 | June 9 | 6,800 | | | | | 649,400 | 58.54 |
| 1934 | 282 | 314 | 1510 | 1680 | 579 | 789 | 675 | 355 | 264 | 199 | 175 | 174 | 585 | Jan. 23 | 7,100 | | | | | 422,100 | 38.05 |
| 1935 | 313 | 1120 | 1340 | 830 | 932 | 646 | 1160 | 1060 | 605 | 299 | 215 | 200 | 727 | Dec. 20 | 6,100 | | | | | 526,300 | 47.44 |
| 1936 | 226 | 285 | 369 | 1940 | 752 | 855 | 1200 | 1100 | 1180 | 290 | 217 | 210 | 719 | Jan. 4 | 8.000 | | | | | 520,600 | 46.93 |
| 1937 | 198 | 178 | 304 | 226 | 453 | 1080 | 1950 | 1740 | 1350 | 384 | 240 | 215 | 693 | Apr. 24 | 6,900 | | | | | 501,700 | 45.23 |
| 1938 | 281 | 1140 | 1220 | 1370 | 907 | 1330 | 1680 | 1315 | 556 | 285 | 227 | 217 | 877 | Jan. 22 | 8,500 | | | | | 634,900 | 57.23 |
| 1939 | 217 | 493 | 817 | 629 | 810 | 1220 | 1070 | 670 | 423 | 245 | 182 | 180 | 580 | Dec. 2 | 5,850 | | | | | 419,900 | 37.85 |
| 1940 | 214 | 183 | 511 | 520 | 1290 | 1150 | 682 | 385 | 220 | 167 | 146 | 158 | 469 | Feb. 10 | 3,150 | | | | | 339,600 | 30.61 |
| 1941 | 188 | 554 | 592 | 811 | 461 | 341 | 332 | 483 | 340 | 189 | 151 | 200 | 387 | Nov. 29 | 3,100 | | | | | 280,000 | 25.26 |
| 1942 | 242 | 800 | 1430 | 766 | 883 | 520 | 480 | 688 | 505 | 262 | 178 | 164 | 577 | Nov. 15 | 6,500 | | | | | 417,700 | 37.65 |
| 1943 | 179 | 1880 | 2620 | 1750 | 1390 | 885 | 1760 | 930 | 1060 | 403 | 280 | 241 | 1,115 | Jan. 1 | 16,400 | | | | | 807,300 | 72.77 |
| 1944 | 380 | 646 | 470 | 453 | 587 | 556 | 784 | 536 | 354 | 197 | 158 | 160 | 439 | Nov. 4 | 5,300 | | | | | 317,800 | 28.65 |
| 1945 | 167 | 252 | 260 | 819 | 1650 | 794 | 1290 | 1580 | 480 | 235 | 183 | 180 | 658 | Feb. 13 | 7,400 | | | | | 476,400 | 42.94 |
| 1946 | 181 | 896 | 1670 | 1710 | 867 | 1130 | 895 | 1175 | 770 | 347 | 236 | 239 | 843 | Dec. 22 | 24,500 | | | | | 610,300 | 55.02 |
| 1947 | 360 | 1280 | 1830 | 893 | 1100 | 961 | 1250 | 520 | 540 | 301 | 227 | 215 | 790 | Dec. 14 | 12,600 | | | | | 572,000 | 51.56 |
| 1948 | 864 | 1289 | 795 | 1731 | 1311 | 850 | 1173 | 1571 | 1087 | 395 | 292 | 291 | 969 | Jan. 7 | 10,400 | Jan. 7 | 8,440 | Oct. | 211 | 703,600 | 63.43 |
| 1949 | 361 | 870 | 1501 | 465 | 1274 | 1252 | 1747 | 2175 | 777 | 323 | 263 | 237 | 935 | Dec. 12 | 10,700 | Dec. 12 | 6,960 | Sept. | 219 | 676,700 | 61.00 |
| 1950 | 305 | 481 | 619 | 926 | 1563 | 1777 | 1603 | 1685 | 1794 | 542 | 314 | 262 | 984 | Feb. 24 | [illegible] | Feb. 2[illegible] | [illegible] | Oct. | [illegible] | 712,600 | 64.21 |
| 1951 | 1081 | 1804 | 1697 | 1901 | 1935 | 915 | 1336 | 1196 | 457 | 291 | 267 | 239 | 1,088 | Oct. 29 | 11,400 | Oct. 29 | 9,160 | Sept. | [illegible] | 787,600 | 71.00 |
| 1952 | 833 | 962 | 1279 | 638 | 1439 | 1023 | 1686 | 1501 | 840 | 417 | 294 | 265 | 929 | Oct. 23 | 5,480 | Oct. 23 | 4,040 | Sept. | 233 | 674,300 | 60.78 |
| 1953 | 242 | 265 | 520 | 2809 | 2190 | 881 | 979 | 1406 | 1195 | 449 | 308 | 277 | 953 | Jan. 18 | 16,400 | Jan. 18 | 13,600 | Oct.-Nov. | 237 | 691,000 | 62.20 |
| 1954 | 311 | 1351 | 2134 | 1314 | 1598 | 815 | 1190 | 861 | 934 | 402 | 302 | 314 | 956 | Nov. 23 | 14,600 | Nov. 23 | 10,600 | Oct.-Nov. | [illegible] | 691,9[illegible] | 62.36 |
| 1955 | 365 | 418 | 587 | 683 | 768 | 793 | 1172 | 1547 | 1593 | 506 | 292 | 280 | 748 | Dec. 30 | 3,790 | Dec. 31 | 3,280 | Sept. | 261 | 542,200 | 48.88 |
| 1956 | 503 | 1718 | 3484 | 2173 | 759 | 1149 | 1704 | 1860 | 1154 | 440 | 323 | 284 | 1,300 | Dec. 22 | 17,400 | Dec. 22 | 14,300 | Oct. | [illegible] | 942,[illegible] | 85.07 |
| 1957 | 471 | 692 | 1782 | 489 | 1359 | 1921 | 1216 | 1002 | 486 | 303 | 257 | 220 | 849 | Dec. 11 | 17,600 | Dec. 11 | 11,400 | Sept. | 221 | 613,900 | 55.34 |
| 1958 | 292 | 406 | 1608 | 1525 | 2095 | 756 | 1307 | 1065 | 677 | 343 | 261 | 248 | 874 | Feb. 16 | 8,980 | Feb. 16 | 7,520 | Nov. | 220 | [illegible] | 57.06 |
| 1959 | 266 | 1269 | 1056 | 1275 | 895 | 956 | 1057 | 924 | 512 | 278 | 228 | 307 | 750 | Jan. 27 | 5,560 | Jan. 27 | 3,930 | Sept. | 21[illegible] | 543,300 | 48.97 |
| 1960 | 551 | 549 | 444 | 494 | 1149 | 1607 | 1644 | 1704 | 844 | 301 | 262 | 234 | 813 | Feb. 8 | 3,620 | Feb. 8 | 3,030 | Sept. | [illegible] | 591,600 | 53.24 |
| 1961 | 285 | 1439 | 919 | 724 | 2279 | 1410 | 1074 | 1186 | 573 | 272 | 248 | 246 | 877 | Nov. 24 | 10.000 | Feb. 10 | 8.760 | Oct. | 200 | 635,100 | 57.24 |
| 1962 | 350 | 985 | 1589 | 1017 | 779 | 1006 | 1827 | 1323 | 782 | 332 | 285 | 261 | 878 | Nov. 22 | 8,440 | Nov. 22 | 4,990 | Oct. | 219 | [illegible] | 57.28 |
| Mean | 341 | 803 | 1094 | 1052 | 1133 | 1032 | 1198 | 1110 | 777 | 316 | 234 | 228 | 775 | | | | | | | [illegible] | 50.62 |

NOTE: Runoff and discharges for the period 1926-1947 are based on correlations with runoff and discharges of Blue River near Blue River and McKenzie River near Vida.
Maximum instantaneous discharges in 1861 and 1890 are estimated at 25,000 and 23,800 c.f.s., respectively.
Underscored values are extremes.
Drainage area was revised in 1959 from 211 to 208 square miles.
Runoff in inches based on revised drainage area of 208 square miles.

TABLE 8

COUGAR RESERVOIR

Service Outlet Rating Table
(Both Gates Open)

| Gate Opening ft. | Pool Elevation in Feet, M.S.L. | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1510 | 1520 | 1530 | 1540 | 1550 | 1560 | 1570 | 1580 | 1590 | 1600 | 1610 | 1620 | 1630 | 1640 | 1650 | 1660 | 1670 | 1680 | 1690 | 1699 |
| 0.1 | 38 | 45 | 52 | 58 | 63 | 68 | 72 | 76 | 80 | 85 | 88 | 91 | 95 | 97 | 100 | 104 | 106 | 108 | 111 | 113 |
| 0.2 | 76 | 90 | 104 | 116 | 126 | 135 | 144 | 152 | 160 | 170 | 176 | 182 | 190 | 194 | 200 | 208 | 212 | 216 | 222 | 226 |
| 0.3 | 114 | 135 | 156 | 174 | 189 | 203 | 216 | 228 | 240 | 255 | 264 | 273 | 285 | 291 | 300 | 312 | 318 | 324 | 333 | 339 |
| 0.4 | 152 | 180 | 208 | 232 | 252 | 270 | 288 | 304 | 320 | 340 | 352 | 364 | 380 | 388 | 400 | 416 | 424 | 432 | 444 | 452 |
| 0.5 | 198 | 225 | 260 | 290 | 315 | 338 | 360 | 380 | 400 | 425 | 440 | 455 | 475 | 485 | 500 | 520 | 530 | 540 | 555 | 565 |
| 0.6 | 228 | 270 | 312 | 348 | 378 | 405 | 432 | 456 | 480 | 510 | 528 | 546 | 570 | 582 | 600 | 624 | 636 | 648 | 666 | 678 |
| 0.7 | 266 | 315 | 364 | 406 | 441 | 473 | 504 | 532 | 560 | 595 | 616 | 637 | 665 | 679 | 700 | 728 | 742 | 756 | 777 | 791 |
| 0.8 | 304 | 360 | 416 | 464 | 504 | 540 | 576 | 608 | 640 | 680 | 704 | 728 | 760 | 776 | 800 | 832 | 848 | 864 | 888 | 904 |
| 0.9 | 342 | 405 | 468 | 522 | 567 | 608 | 648 | 684 | 720 | 765 | 792 | 819 | 855 | 873 | 900 | 936 | 954 | 972 | 999 | 1017 |
| 1.0 | 380 | 450 | 520 | 580 | 630 | 675 | 720 | 760 | 800 | 850 | 880 | 910 | 950 | 970 | 1000 | 1040 | 1060 | 1080 | 1110 | 1130 |
| 1.1 | 425 | 498 | 573 | 638 | 692 | 743 | 790 | 834 | 878 | 930 | 964 | 998 | 1040 | 1063 | 1097 | 1140 | 1163 | 1187 | 1215 | 1242 |
| 1.2 | 469 | 546 | 626 | 696 | 754 | 810 | 860 | 908 | 955 | 1010 | 1048 | 1086 | 1130 | 1156 | 1193 | 1240 | 1266 | 1294 | 1328 | 1354 |
| 1.3 | 514 | 594 | 679 | 754 | 816 | 878 | 930 | 982 | 1033 | 1090 | 1132 | 1174 | 1220 | 1249 | 1290 | 1340 | 1369 | 1401 | 1437 | 1466 |
| 1.4 | 558 | 642 | 732 | 812 | 878 | 945 | 1000 | 1056 | 1110 | 1170 | 1216 | 1262 | 1310 | 1342 | 1386 | 1440 | 1472 | 1508 | 1546 | 1578 |
| 1.5 | 603 | 690 | 785 | 870 | 940 | 1013 | 1070 | 1130 | 1188 | 1250 | 1300 | 1350 | 1400 | 1435 | 1483 | 1540 | 1575 | 1615 | 1655 | 1690 |
| 1.6 | 647 | 738 | 838 | 928 | 1002 | 1080 | 1140 | 1204 | 1265 | 1330 | 1384 | 1438 | 1490 | 1528 | 1579 | 1640 | 1678 | 1722 | 1764 | 1802 |
| 1.7 | 692 | 786 | 891 | 986 | 1064 | 1148 | 1210 | 1278 | 1343 | 1410 | 1468 | 1526 | 1580 | 1621 | 1676 | 1740 | 1781 | 1829 | 1873 | 1914 |
| 1.8 | 736 | 834 | 944 | 1044 | 1126 | 1215 | 1280 | 1352 | 1420 | 1490 | 1552 | 1614 | 1670 | 1714 | 1772 | 1840 | 1884 | 1936 | 1982 | 2026 |
| 1.9 | 781 | 882 | 997 | 1102 | 1188 | 1283 | 1350 | 1426 | 1498 | 1570 | 1636 | 1702 | 1760 | 1807 | 1869 | 1940 | 1987 | 2043 | 2091 | 2138 |
| 2.0 | 825 | 930 | 1050 | 1160 | 1250 | 1350 | 1420 | 1500 | 1575 | 1650 | 1720 | 1790 | 1850 | 1900 | 1965 | 2040 | 2090 | 2150 | 2200 | 2250 |
| 2.1 | 865 | 978 | 1105 | 1219 | 1314 | 1417 | 1492 | 1575 | 1655 | 1732 | 1806 | 1879 | 1942 | 1996 | 2064 | 2141 | 2191 | 2257 | 2310 | 2362 |
| 2.2 | 905 | 1026 | 1160 | 1278 | 1378 | 1484 | 1564 | 1650 | 1734 | 1814 | 1891 | 1968 | 2034 | 2092 | 2162 | 2242 | 2298 | 2364 | 2420 | 2474 |
| 2.3 | 945 | 1074 | 1215 | 1337 | 1442 | 1551 | 1636 | 1725 | 1814 | 1896 | 1977 | 2057 | 2126 | 2188 | 2261 | 2343 | 2402 | 2471 | 2530 | 2586 |
| 2.4 | 985 | 1122 | 1270 | 1396 | 1506 | 1618 | 1708 | 1800 | 1893 | 1978 | 2062 | 2146 | 2218 | 2284 | 2359 | 2444 | 2506 | 2578 | 2640 | 2698 |
| 2.5 | 1025 | 1170 | 1325 | 1455 | 1570 | 1685 | 1780 | 1875 | 1973 | 2060 | 2148 | 2235 | 2310 | 2380 | 2458 | 2545 | 2610 | 2685 | 2750 | 2810 |
| 2.6 | 1065 | 1218 | 1380 | 1514 | 1634 | 1752 | 1852 | 1950 | 2052 | 2142 | 2233 | 2324 | 2402 | 2476 | 2556 | 2646 | 2714 | 2792 | 2860 | 2922 |
| 2.7 | 1105 | 1266 | 1435 | 1573 | 1698 | 1819 | 1924 | 2025 | 2132 | 2224 | 2319 | 2413 | 2494 | 2572 | 2655 | 2747 | 2818 | 2899 | 2970 | 3034 |
| 2.8 | 1145 | 1314 | 1490 | 1632 | 1762 | 1886 | 1996 | 2100 | 2210 | 2306 | 2404 | 2502 | 2586 | 2668 | 2753 | 2848 | 2922 | 3006 | 3080 | 3146 |
| 2.9 | 1185 | 1362 | 1545 | 1691 | 1826 | 1953 | 2068 | 2175 | 2291 | 2388 | 2490 | 2591 | 2678 | 2776 | 2852 | 2949 | 3026 | 3113 | 3190 | 3258 |
| 3.0 | 1225 | 1410 | 1600 | 1750 | 1890 | 2020 | 2140 | 2250 | 2370 | 2470 | 2575 | 2680 | 2770 | 2860 | 2950 | 3050 | 3130 | 3221 | 3300 | 3370 |
| 3.1 | 1265 | 1459 | 1655 | 1810 | 1956 | 2090 | 2215 | 2328 | 2453 | 2556 | 2664 | 2772 | 2865 | 2959 | 3053 | 3155 | 3239 | 3331 | 3414 | 3488 |
| 3.2 | 1305 | 1508 | 1710 | 1870 | 2022 | 2160 | 2290 | 2405 | 2537 | 2642 | 2752 | 2864 | 2960 | 3058 | 3155 | 3260 | 3347 | 3441 | 3528 | 3606 |
| 3.3 | 1345 | 1557 | 1765 | 1930 | 2088 | 2230 | 2365 | 2483 | 2619 | 2728 | 2841 | 2956 | 3055 | 3157 | 3258 | 3365 | 3456 | 3552 | 3642 | 3724 |
| 3.4 | 1385 | 1606 | 1820 | 1990 | 2154 | 2300 | 2440 | 2560 | 2702 | 2814 | 2929 | 3048 | 3150 | 3256 | 3360 | 3470 | 3564 | 3662 | 3756 | 3842 |
| 3.5 | 1425 | 1655 | 1875 | 2050 | 2220 | 2370 | 2515 | 2638 | 2785 | 2900 | 3018 | 3140 | 3245 | 3355 | 3463 | 3575 | 3673 | 3773 | 3870 | 3960 |
| 3.6 | 1465 | 1704 | 1930 | 2110 | 2286 | 2440 | 2590 | 2715 | 2868 | 2986 | 3106 | 3232 | 3340 | 3454 | 3565 | 3680 | 3781 | 3883 | 3984 | 4078 |
| 3.7 | 1505 | 1753 | 1985 | 2170 | 2352 | 2510 | 2665 | 2793 | 2951 | 3072 | 3195 | 3324 | 3435 | 3553 | 3668 | 3785 | 3890 | 3994 | 4098 | 4196 |
| 3.8 | 1545 | 1802 | 2040 | 2230 | 2418 | 2580 | 2741 | 2871 | 3034 | 3158 | 3283 | 3416 | 3530 | 3652 | 3770 | 3890 | 3998 | 4104 | 4212 | 4314 |
| 3.9 | 1585 | 1851 | 2095 | 2290 | 2484 | 2650 | 2815 | 2948 | 3117 | 3244 | 3372 | 3508 | 3625 | 3751 | 3873 | 3995 | 4107 | 4215 | 4326 | 4432 |
| 4.0 | 1625 | 1900 | 2150 | 2350 | 2550 | 2720 | 2890 | 3025 | 3200 | 3330 | 3460 | 3600 | 3720 | 3850 | 3975 | 4100 | 4215 | 4335 | 4440 | 4550 |
| 4.5 | 1850 | 2140 | 2405 | 2640 | 2855 | 3048 | 3235 | 3400 | 3585 | 3740 | 3890 | 4045 | 4185 | 4330 | 4468 | 4610 | 4730 | 4853 | 4983 | 5100 |
| 5.0 | 2075 | 2380 | 2660 | 2930 | 3160 | 3375 | 3580 | 3775 | 3970 | 4150 | 4320 | 4490 | 4650 | 4810 | 4960 | 5120 | 5245 | 5380 | 5525 | 5650 |
| 5.5 | 2218 | 2585 | 2905 | 3215 | 3480 | 3718 | 3950 | 4168 | 4380 | 4575 | 4765 | 4950 | 5125 | 5295 | 5460 | 5630 | 5782 | 5933 | 6093 | 6235 |
| 6.0 | 2360 | 2790 | 3150 | 3500 | 3800 | 4060 | 4320 | 4560 | 4790 | 5000 | 5210 | 5410 | 5600 | 5780 | 5960 | 6240 | 6320 | 6485 | 6660 | 6820 |
| 6.5 | 2580 | 3020 | 3430 | 3790 | 4115 | 4410 | 4690 | 4965 | 5215 | 5450 | 5675 | 5895 | 6105 | 6305 | 6500 | 6695 | 6890 | 7073 | 7255 | 7430 |
| 7.0 | 2800 | 3250 | 3710 | 4080 | 4430 | 4760 | 5060 | 5370 | 5640 | 5900 | 6140 | 6380 | 6610 | 6830 | 7040 | 7250 | 7460 | 7660 | 7850 | 8040 |
| 7.5 | 2988 | 3475 | 3965 | 4380 | 4765 | 5115 | 5445 | 5765 | 6060 | 6355 | 6615 | 6875 | 7125 | 7365 | 7595 | 7815 | 8045 | 8260 | 8465 | 8670 |
| 8.0 | 3175 | 3700 | 4220 | 4680 | 5100 | 5470 | 5830 | 6160 | 6480 | 6810 | 7090 | 7370 | 7640 | 7900 | 8150 | 8380 | 8630 | 8860 | 9080 | 9300 |
| 8.5 | 3400 | 3960 | 4530 | 5015 | 5465 | 5870 | 6240 | 6580 | 6905 | 7225 | 7510 | 7795 | 8070 | 8340 | 8600 | 8850 | 9100 | 9350 | 9585 | 9825 |
| 9.0 | 3625 | 4220 | 4830 | 5350 | 5830 | 6270 | 6650 | 7000 | 7330 | 7640 | 7930 | 8220 | 8500 | 8780 | 9050 | 9320 | 9570 | 9840 | 10090 | 10350 |
| 9.5 | 3837 | 4460 | 5055 | 5580 | 6050 | 6485 | 6875 | 7238 | 7585 | 7905 | 8205 | 8510 | 8790 | 9075 | 9345 | 9615 | 9870 | 10135 | 10380 | 10625 |
| 10.0 | 4050 | 4700 | 5280 | 5810 | 6270 | 6700 | 7100 | 7475 | 7840 | 8170 | 8480 | 8800 | 9080 | 9370 | 9640 | 9910 | 10170 | 10430 | 10670 | 10900 |
| 10.5 | 4165 | 4850 | 5425 | 5943 | 6405 | 6838 | 7245 | 7628 | 8000 | 8348 | 8675 | 9005 | 9305 | 9600 | 9875 | 10155 | 10425 | 10690 | 10945 | 11150 |
| 11.0 | 4280 | 5000 | 5570 | 6075 | 6540 | 6975 | 7390 | 7780 | 8160 | 8525 | 8870 | 9210 | 9530 | 9830 | 10110 | 10400 | 10680 | 10951 | 11220 | 11460 |
| 11.5 | 4280 | 5050 | 5654 | 6167 | 6650 | 7100 | 7520 | 7920 | 8303 | 8673 | 9027 | 9363 | 9687 | 9993 | 10227 | 10570 | 10857 | 11133 | 11410 | 11657 |
| 12.0 | 4280 | 5100 | 5724 | 6259 | 6760 | 7225 | 7650 | 8060 | 8446 | 8821 | 9184 | 9516 | 9844 | 10154 | 10441 | 10749 | 11034 | 11316 | 11600 | 11854 |
| 12.5 | 4280 | 5150 | 5800 | 6350 | 6870 | 7350 | 7780 | 8200 | 8590 | 8970 | 9340 | 9670 | 10000 | 10320 | 10610 | 10910 | 11210 | 11500 | 11790 | 12050 |

Source of data: Regulating Outlet Discharge Rating Curves - 13 Aug. 1963

TABLE 10

**Corps of Engineers, U. S. Army**
**Portland, Oregon District**

*Sheet No.* ..........
Field file no.: 14-1592.00

*Rating table for* South Fork McKenzie River above Cougar Reservoir, near Rainbow, Oregon

*from* Dec. 20, 1961, *to* .........., 19...

| Gauge height (Feet) | Discharge (Sec-ft) | Difference (Sec-ft) | Gauge height (Feet) | Discharge (Sec-ft) | Difference (Sec-ft) | Gauge height (Feet) | Discharge (Sec-ft) | Difference (Sec-ft) | Gauge height (Feet) | Discharge (Sec-ft) | Difference (Sec-ft) | Gauge height (Feet) | Discharge (Sec-ft) | Difference (Sec-ft) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| .00 | | | 4.00 | 450 | 30 | 6.00 | 1,300 | 60 | 8.00 | 2,900 | 100 | 10.00 | 5,480 | 160 |
| .10 | | | .10 | 480 | | .10 | 1,360 | | .10 | 3,000 | | .10 | 5,640 | |
| .20 | | | .20 | 510 | | .20 | 1,420 | | .20 | 3,100 | | .20 | 5,800 | |
| .30 | | | .30 | 540 | | .30 | 1,480 | | .30 | 3,200 | | .30 | 5,960 | |
| .40 | | | .40 | 570 | 30 | .40 | 1,540 | 60 | .40 | 3,300 | 100 | .40 | 6,120 | |
| .50 | | | .50 | 600 | 40 | .50 | 1,600 | 80 | .50 | 3,400 | 120 | .50 | 6,280 | |
| .60 | | | .60 | 640 | | .60 | 1,680 | | .60 | 3,520 | | .60 | 6,440 | |
| .70 | | | .70 | 680 | | .70 | 1,760 | | .70 | 3,640 | | .70 | 6,600 | |
| .80 | | | .80 | 720 | | .80 | 1,840 | | .80 | 3,760 | | .80 | 6,760 | 160 |
| .90 | | | .90 | 760 | | .90 | 1,920 | | .90 | 3,880 | 120 | .90 | 6,920 | 180 |
| 3.00 | 210 | 20 | 5.00 | 800 | 40 | 7.00 | 2,000 | | 9.00 | 4,000 | 140 | 11.00 | 7,100 | |
| .10 | 230 | | .10 | 840 | 50 | .10 | 2,080 | | .10 | 4,140 | | .10 | 7,280 | |
| .20 | 250 | 20 | .20 | 890 | | .20 | 2,160 | | .20 | 4,280 | | .20 | 7,460 | |
| .30 | 270 | 25 | .30 | 940 | | .30 | 2,240 | | .30 | 4,420 | | .30 | 7,640 | |
| .40 | 295 | | .40 | 990 | | .40 | 2,320 | 80 | .40 | 4,560 | | .40 | 7,820 | 180 |
| .50 | 320 | | .50 | 1,040 | | .50 | 2,400 | 100 | .50 | 4,700 | 140 | .50 | 8,000 | 200 |
| .60 | 345 | | .60 | 1,090 | | .60 | 2,500 | | .60 | 4,840 | 160 | .60 | 8,200 | |
| .70 | 370 | | .70 | 1,140 | | .70 | 2,600 | | .70 | 5,000 | | .70 | 8,400 | |
| .80 | 395 | 25 | .80 | 1,190 | 50 | .80 | 2,700 | | .80 | 5,160 | | .80 | 8,600 | |
| .90 | 420 | 30 | .90 | 1,240 | 60 | .90 | 2,800 | 100 | .90 | 5,320 | 160 | .90 | 8,800 | 200 |
| | | | | | | | | | | | | 12.00 | 9,000 | |

The above table should not be used for flows under ice conditions or with channel otherwise obstructed. It is based on 9 discharge measurements made during period Jan. 15 to Dec. 12, 1962 (39-47) and one older measurement (24)

and is .......... well defined between 210 second-feet and 5,000 second-feet.

Same as rating 2 above 7.6 ft.
(copied from U. S. Geological Survey table no. 3)

*Computed by* ..........

*Checked by* ..........

*Date* ..........

NPP RF 90
Dec 52

TABLE 11

**Corps of Engineers, U. S. Army**
**Portland, Oregon District**

*Sheet No.* ..............

Field file No.: 14-1595.00

*Rating table for* South Fork McKenzie River near Rainbow, Oregon

*from* Dec. 20, 19 61, *to* ..............., 19......

| Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feet | Sec-ft | Sec-ft | Feet | Sec-ft | Sec-ft | Feet | Sec-ft | Sec-ft | Feet | Sec-ft | Sec-ft | Feet | Sec-ft | Sec-ft |
| .00 | | | 2.00 | 820 | 80 | 4.00 | 3,500 | 200 | 6.00 | 8,200 | 300 | 8.00 | 15,000 | 400 |
| .10 | | | .10 | 900 | 90 | .10 | 3,700 | | .10 | 8,500 | | .10 | 15,400 | |
| .20 | | | .20 | 990 | 90 | .20 | 3,900 | | .20 | 8,800 | | .20 | 15,800 | |
| .30 | | | .30 | 1,080 | 100 | .30 | 4,100 | | .30 | 9,100 | | .30 | 16,200 | |
| .40 | | | .40 | 1,180 | | .40 | 4,300 | 200 | .40 | 9,400 | | .40 | 16,600 | |
| .50 | | | .50 | 1,280 | 100 | .50 | 4,500 | 220 | .50 | 9,700 | | .50 | 17,000 | |
| .60 | | | .60 | 1,380 | 120 | .60 | 4,720 | | .60 | 10,000 | | .60 | 17,400 | 400 |
| .70 | | | .70 | 1,500 | | .70 | 4,940 | | .70 | 10,300 | 300 | .70 | 17,800 | |
| .80 | | | .80 | 1,620 | 120 | .80 | 5,160 | | .80 | 10,600 | 350 | .80 | | |
| .90 | 190 | 40 | .90 | 1,740 | 140 | .90 | 5,380 | 220 | .90 | 10,950 | | .90 | | |
| 1.00 | 230 | 40 | 3.00 | 1,880 | | 5.00 | 5,600 | 250 | 7.00 | 11,300 | | .00 | | |
| .10 | 270 | 50 | .10 | 2,020 | | .10 | 5,850 | | .10 | 11,650 | | .10 | | |
| .20 | 320 | | .20 | 2,160 | 140 | .20 | 6,100 | | .20 | 12,000 | | .20 | | |
| .30 | 370 | 50 | .30 | 2,300 | 160 | .30 | 6,350 | | .30 | 12,350 | | .30 | | |
| .40 | 420 | 60 | .40 | 2,460 | | .40 | 6,600 | | .40 | 12,700 | | .40 | | |
| .50 | 480 | | .50 | 2,620 | 160 | .50 | 6,850 | | .50 | 13,050 | 350 | .50 | | |
| .60 | 540 | 60 | .60 | 2,780 | 180 | .60 | 7,100 | | .60 | 13,400 | 400 | .60 | | |
| .70 | 600 | 70 | .70 | 2,960 | | .70 | 7,350 | 250 | .70 | 13,800 | | .70 | | |
| .80 | 670 | 70 | .80 | 3,140 | | .80 | 7,600 | 300 | .80 | 14,200 | | .80 | | |
| .90 | 740 | 80 | .90 | 3,320 | 180 | .90 | 7,900 | 300 | .90 | 14,600 | 400 | .90 | | |

The above table should not be used for flows under ice conditions or with channel otherwise obstructed. It is based on 8 discharge measurements made during period Jan. 15 to Dec. 12, 1962 (146-151, 153, 154)

and is ............ well defined between 260 second-feet and 10,000 second-feet.

Same as rating 4 above 1.7 ft.

(Copied from U.S. Geological Survey table No. 5)

*Computed by* ..............

*Checked by* ..............

*Date* ..............

NPP RF 90
Dec 52

TABL

TABLE 12

# Corps of Engineers, U. S. Army
# Portland, Oregon District

Sheet No. 1 of 2
Field File No.: 14-1655.00

Rating table for McKenzie River near Coburg, Oregon

from Dec. 20, 19 61, to ____, 19 ____

| Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. |
| 0.00 | | | 2.00 | 3800 | 200 | 4.00 | 9300 | 300 | 6.00 | 16,800 | 400 | 8.00 | 26,000 | 500 |
| .10 | | | .10 | 4000 | 250 | .10 | 9600 | | .10 | 17,200 | | .10 | 26,500 | |
| .20 | | | .20 | 4250 | | .20 | 9900 | | .20 | 17,600 | | .20 | 27,000 | |
| .30 | | | .30 | 4500 | | .30 | 10,200 | | .30 | 18,000 | | .30 | 27,500 | |
| .40 | | | .40 | 4750 | | .40 | 10,500 | 300 | .40 | 18,400 | | .40 | 28,000 | |
| .50 | | | .50 | 5000 | | .50 | 10,800 | 400 | .50 | 18,800 | | .50 | 28,500 | |
| .60 | | | .60 | 5250 | | .60 | 11,200 | | .60 | 19,200 | | .60 | 29,000 | |
| .70 | 1510 | 140 | .70 | 5500 | | .70 | 11,600 | | .70 | 19,600 | 400 | .70 | 29,500 | |
| .80 | 1650 | 150 | .80 | 5750 | 250 | .80 | 12,000 | | .80 | 20,000 | 500 | .80 | 30,000 | |
| .90 | 1800 | | .90 | 6000 | 300 | .90 | 12,400 | | .90 | 20,500 | | .90 | 30,500 | 500 |
| 1.00 | 1950 | | 3.00 | 6300 | | 5.00 | 12,800 | | 7.00 | 21,000 | | 9.00 | 31,000 | 600 |
| .10 | 2100 | | .10 | 6600 | | .10 | 13,200 | | .10 | 21,500 | | .10 | 31,600 | |
| .20 | 2250 | 150 | .20 | 6900 | | .20 | 13,600 | | .20 | 22,000 | | .20 | 32,200 | |
| .30 | 2400 | 200 | .30 | 7200 | | .30 | 14,000 | | .30 | 22,500 | | .30 | 32,800 | |
| .40 | 2600 | | .40 | 7500 | | .40 | 14,400 | | .40 | 23,000 | | .40 | 33,400 | |
| .50 | 2800 | | .50 | 7800 | | .50 | 14,800 | | .50 | 23,500 | | .50 | 34,000 | |
| .60 | 3000 | | .60 | 8100 | | .60 | 15,200 | | .60 | 24,000 | | .60 | 34,600 | |
| .70 | 3200 | | .70 | 8400 | | .70 | 15,600 | | .70 | 24,500 | | .70 | 35,200 | |
| .80 | 3400 | | .80 | 8700 | | .80 | 16,000 | | .80 | 25,000 | | .80 | 35,800 | |
| .90 | 3600 | 200 | .90 | 9000 | 300 | .90 | 16,400 | 400 | .90 | 25,500 | 500 | .90 | 36,400 | 600 |

The above table should not be used for flows under ice conditions or with channel otherwise obstructed. It is based on 8 discharge measurements made during period Dec. 20, 1961 to Dec. 20, 1962 (178, 179, 182-187)

and is ____ well defined between 1,700 second-feet and 40,000 second-feet.

Shift adjustment +0.2

8/14/62 HCL

(Copied from U. S. Geological Survey table no. 9)

Computed by ____

Checked by ____

Date ____

NPP OT Sept. 63 39-63

TABLE

TABLE 12

# Corps of Engineers, U. S. Army
## Portland, Oregon District

*Sheet No.* 2 of 2

Field File No.: 14-1655.00

*Rating table for* McKenzie River near Coburg, Oregon

*from* Dec. 20, *19* 61, *to* ________, *19* ____

| Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. |
| 10.00 | 37,000 | 600 | .00 | | | .00 | | | .00 | | | .00 | | |
| .10 | 37,600 | | .10 | | | .10 | | | .10 | | | .10 | | |
| .20 | 38,200 | | .20 | | | .20 | | | .20 | | | .20 | | |
| .30 | 38,800 | | .30 | | | .30 | | | .30 | | | .30 | | |
| .40 | 39,400 | | .40 | | | .40 | | | .40 | | | .40 | | |
| .50 | 40,000 | 600 | .50 | | | .50 | | | .50 | | | .50 | | |
| .60 | 40,600 | | .60 | | | .60 | | | .60 | | | .60 | | |
| .70 | | | .70 | | | .70 | | | .70 | | | .70 | | |
| .80 | | | .80 | | | .80 | | | .80 | | | .80 | | |
| .90 | | | .90 | | | .90 | | | .90 | | | .90 | | |
| .00 | | | .00 | | | .00 | | | .00 | | | .00 | | |
| .10 | | | .10 | | | .10 | | | .10 | | | .10 | | |
| .20 | | | .20 | | | .20 | | | .20 | | | .20 | | |
| .30 | | | .30 | | | .30 | | | .30 | | | .30 | | |
| .40 | | | .40 | | | .40 | | | .40 | | | .40 | | |
| .50 | | | .50 | | | .50 | | | .50 | | | .50 | | |
| .60 | | | .60 | | | .60 | | | .60 | | | .60 | | |
| .70 | | | .70 | | | .70 | | | .70 | | | .70 | | |
| .80 | | | .80 | | | .80 | | | .80 | | | .80 | | |
| .90 | | | .90 | | | .90 | | | .90 | | | .90 | | |

The above table should not be used for flows under ice conditions or with channel otherwise obstructed. It is based on ________ discharge measurements made during ________

and is ________ well defined between ________ second-feet and ________ second-feet.

*Computed by* ________

*Checked by* ________

*Date* ________

TABLE 13

# Corps of Engineers, U. S. Army
# Portland, Oregon District

*Sheet No.* 1 of 2
Field File No.: 14-1660

*Rating table for* Willamette River at Harrisburg, Oregon

*from* March 26, *19*63, *to* , *19*

| Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Feet* | *Sec.-ft.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Sec.-ft.* | *Feet* | *Sec.-ft.* | *Sec.-ft.* |
| 0.00 | | | 2.00 | 6,100 | 260 | 4.00 | 12,650 | 390 | 6.00 | 21,750 | 500 | 8.00 | 32,700 | 580 |
| .10 | | | .10 | 6,360 | 270 | .10 | 13,040 | 400 | .10 | 22,250 | 510 | .10 | 33,280 | 580 |
| .20 | | | .20 | 6,630 | 280 | .20 | 13,440 | 410 | .20 | 22,760 | 520 | .20 | 33,860 | 580 |
| .30 | | | .30 | 6,910 | 290 | .30 | 13,850 | 420 | .30 | 23,280 | 520 | .30 | 34,440 | 590 |
| .40 | | | .40 | 7,200 | 295 | .40 | 14,270 | 430 | .40 | 23,800 | 525 | .40 | 35,030 | 590 |
| .50 | | | .50 | 7,495 | 295 | .50 | 14,700 | 430 | .50 | 24,325 | 525 | .50 | 35,620 | 590 |
| .60 | | | .60 | 7,790 | 300 | .60 | 15,130 | 440 | .60 | 24,850 | 530 | .60 | 36,210 | 590 |
| .70 | | | .70 | 8,090 | 310 | .70 | 15,570 | 450 | .70 | 25,380 | 530 | .70 | 36,800 | 600 |
| .80 | 3,690 | 150 | .80 | 8,400 | 320 | .80 | 16,020 | 460 | .80 | 25,910 | 540 | .80 | 37,400 | 600 |
| .90 | 3,840 | 160 | .90 | 8,720 | 330 | .90 | 16,480 | 470 | .90 | 26,450 | 550 | .90 | 38,000 | 600 |
| 1.00 | 4,000 | 170 | 3.00 | 9,050 | 340 | 5.00 | 16,950 | 470 | 7.00 | 27,000 | 560 | 9.00 | 38,600 | 600 |
| .10 | 4,170 | 180 | .10 | 9,390 | 350 | .10 | 17,420 | 470 | .10 | 27,560 | 560 | .10 | 39,200 | 610 |
| .20 | 4,350 | 190 | .20 | 9,740 | 350 | .20 | 17,890 | 480 | .20 | 28,120 | 560 | .20 | 39,810 | 610 |
| .30 | 4,540 | 200 | .30 | 10,090 | 360 | .30 | 18,370 | 480 | .30 | 28,680 | 570 | .30 | 40,420 | 610 |
| .40 | 4,740 | 210 | .40 | 10,450 | 360 | .40 | 18,850 | 480 | .40 | 29,250 | 570 | .40 | 41,030 | 620 |
| .50 | 4,950 | 210 | .50 | 10,810 | 360 | .50 | 19,330 | 480 | .50 | 29,820 | 570 | .50 | 41,650 | 620 |
| .60 | 5,160 | 220 | .60 | 11,170 | 360 | .60 | 19,810 | 480 | .60 | 30,390 | 570 | .60 | 42,270 | 630 |
| .70 | 5,380 | 230 | .70 | 11,530 | 370 | .70 | 20,290 | 480 | .70 | 30,960 | 580 | .70 | 42,900 | 630 |
| .80 | 5,610 | 240 | .80 | 11,900 | 370 | .80 | 20,770 | 490 | .80 | 31,540 | 580 | .80 | 43,530 | 630 |
| .90 | 5,850 | 250 | .90 | 12,270 | 380 | .90 | 21,260 | 490 | .90 | 32,120 | 580 | .90 | 44,160 | 640 |

The above table should not be used for flows under ice conditions or with channel otherwise obstructed. It is based on 10 discharge measurements ~~made during~~ 47, 68, 75, 122 and 164-169, the last six made during period February-September 1963.

and is well defined between second-feet and second-feet.

U. S. Geological Survey measurements

*Computed by* HCL
*Checked by*
*Date* 4 October 1963

TABLE 13

**Corps of Engineers, U. S. Army**
**Portland, Oregon District**

*Sheet No.* 2 of 2
Field File No.: 14-1660

*Rating table for* Willamette River at Harrisburg, Oregon

from .......... 19 ....., to .......... 19 .....

| Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference | Gauge height | Discharge | Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. | Feet | Sec.-ft. | Sec.-ft. |
| 10.00 | 44,800 | 640 | 12.00 | 58,900 | 790 | 14.00 | 77,000 | 1090 | 16.00 | 103,050 | 1590 | 18.00 | 141,780 | |
| .10 | 45,440 | 640 | .10 | 59,690 | 800 | .10 | 78,090 | 1110 | .10 | 104,640 | 1630 | .10 | | |
| .20 | 46,080 | 650 | .20 | 60,490 | 810 | .20 | 79,200 | 1130 | .20 | 106,270 | 1660 | .20 | | |
| .30 | 46,730 | 660 | .30 | 61,300 | 820 | .30 | 80,330 | 1150 | .30 | 107,930 | 1690 | .30 | | |
| .40 | 47,390 | 670 | .40 | 62,120 | 830 | .40 | 81,480 | 1170 | .40 | 109,620 | 1720 | .40 | | |
| .50 | 48,060 | 670 | .50 | 62,950 | 830 | .50 | 82,650 | 1190 | .50 | 111,340 | 1750 | .50 | | |
| .60 | 48,730 | 680 | .60 | 63,780 | 840 | .60 | 83,840 | 1210 | .60 | 113,090 | 1780 | .60 | | |
| .70 | 49,410 | 690 | .70 | 64,620 | 850 | .70 | 85,050 | 1230 | .70 | 114,870 | 1810 | .70 | | |
| .80 | 50,100 | 700 | .80 | 65,470 | 860 | .80 | 86,280 | 1250 | .80 | 116,680 | 1840 | .80 | | |
| .90 | 50,800 | 700 | .90 | 66,330 | 870 | .90 | 87,530 | 1270 | .90 | 118,520 | 1870 | .90 | | |
| 11.00 | 51,500 | 700 | 13.00 | 67,200 | 890 | 15.00 | 88,800 | 1290 | 17.00 | 120,390 | 1910 | .00 | | |
| .10 | 52,200 | 710 | .10 | 68,090 | 910 | .10 | 90,090 | 1320 | .10 | 122,300 | 1950 | .10 | | |
| .20 | 52,910 | 720 | .20 | 69,000 | 930 | .20 | 91,410 | 1350 | .20 | 124,250 | 1990 | .20 | | |
| .30 | 53,630 | 730 | .30 | 69,930 | 950 | .30 | 92,260 | 1380 | .30 | 126,240 | 2040 | .30 | | |
| .40 | 54,360 | 740 | .40 | 70,880 | 970 | .40 | 94,140 | 1410 | .40 | 128,280 | 2090 | .40 | | |
| .50 | 55,100 | 740 | .50 | 71,850 | 990 | .50 | 95,550 | 1440 | .50 | 130,370 | 2150 | .50 | | |
| .60 | 55,840 | 750 | .60 | 72,840 | 1010 | .60 | 96,990 | 1470 | .60 | 132,520 | 2210 | .60 | | |
| .70 | 56,590 | 760 | .70 | 73,850 | 1030 | .70 | 98,460 | 1500 | .70 | 134,730 | 2270 | .70 | | |
| .80 | 57,350 | 770 | .80 | 74,880 | 1050 | .80 | 99,960 | 1530 | .80 | 137,000 | 2360 | .80 | | |
| .90 | 58,120 | 780 | .90 | 75,930 | 1070 | .90 | 101,490 | 1560 | .90 | 139,360 | 2420 | .90 | | |

The above table should not be used for flows under ice conditions or with channel otherwise obstructed. It is based on 10 discharge measurements ~~made during~~ 47, 68, 47, 122 and 164-169, the last six made during period February-September 1963.

and is .......... well defined between .......... second-feet and .......... second-feet.

U. S. Geological Survey measurements.

*Computed by* HCL

*Checked by* ..........

*Date* 4 October 1963

Cougar Reservoir

Seasonal Filling Schedule

Revised February 1970

| Date | February | | March | | April | | May | |
|---|---|---|---|---|---|---|---|---|
| | Elev. | Storage | Elev. | Storage | Elev. | Storage | Elev. | Storage |
| Jan 31 | 1532.00 | 63,904 | | | | | | |
| 1 | 1535.45 | 66,117 | 1613.86 | 127,029 | 1650.44 | 162,781 | 1681.43 | 197,379 |
| 2 | 1538.82 | 68,331 | 1615.13 | 128,182 | 1651.54 | 163,934 | 1682.40 | 198,532 |
| 3 | 1542.13 | 70,544 | 1616.38 | 129,336 | 1652.63 | 165,087 | 1683.36 | 199,686 |
| 4 | 1545.39 | 72,757 | 1617.63 | 130,489 | 1653.72 | 166,241 | 1684.32 | 200,839 |
| 5 | 1548.61 | 74,970 | 1618.88 | 131,642 | 1654.81 | 167,394 | 1685.28 | 201,992 |
| 6 | 1551,78 | 77,184 | 1620.12 | 132,796 | 1655.89 | 168,547 | 1686.23 | 203,146 |
| 7 | 1554.92 | 79,397 | 1621.35 | 133,949 | 1656.96 | 169,700 | 1687.18 | 204,299 |
| 8 | 1558.01 | 81,610 | 1622.58 | 135,102 | 1658.03 | 170,854 | 1688.12 | 205,452 |
| 9 | 1561.06 | 83,824 | 1623.80 | 136,255 | 1659.10 | 172,007 | 1689.06 | 206,605 |
| 10 | 1564.08 | 86,037 | 1625.01 | 137,409 | 1660.16 | 173,160 | 1690.00 | 207,759 |
| 11 | 1567.05 | 88,250 | 1626.22 | 138,562 | 1661.22 | 174,314 | | |
| 12 | 1569.99 | 90,463 | 1627.43 | 139,715 | 1662.27 | 175,467 | | |
| 13 | 1572.89 | 92,677 | 1628.63 | 140,868 | 1663.32 | 176,620 | | |
| 14 | 1575.75 | 94,890 | 1629.82 | 142,022 | 1664.36 | 177,773 | | |
| 15 | 1578.58 | 97,103 | 1631.01 | 143,175 | 1665.40 | 178,927 | | |
| 16 | 1581.37 | 99,316 | 1632.19 | 144,328 | 1666.43 | 180,080 | | |
| 17 | 1584.14 | 101,530 | 1633.37 | 145,482 | 1667.46 | 181,233 | | |
| 18 | 1586.86 | 103,743 | 1634.55 | 146,635 | 1668.49 | 182,387 | | |
| 19 | 1589.56 | 105,956 | 1635.71 | 147,788 | 1669.51 | 183,540 | | |
| 20 | 1592.23 | 108,170 | 1636.88 | 148,941 | 1670.52 | 184,693 | | |
| 21 | 1594.87 | 110,383 | 1638.04 | 150,095 | 1671.54 | 185,846 | | |
| 22 | 1597.48 | 112,596 | 1639.19 | 151,248 | 1672.54 | 187,000 | | |
| 23 | 1600.07 | 114,809 | 1640.34 | 152,401 | 1673.55 | 188,153 | | |
| 24 | 1602.62 | 117,023 | 1641.48 | 153,555 | 1674.55 | 189,306 | | |
| 25 | 1605.15 | 119,236 | 1642.62 | 154,708 | 1675.54 | 190,460 | | |
| 26 | 1607.66 | 121,449 | 1643.75 | 155,861 | 1676.53 | 191,613 | | |
| 27 | 1610.14 | 123,663 | 1644.88 | 157,014 | 1677.52 | 192,766 | | |
| 28 | 1612.59 | 125,876 | 1646.00 | 158,168 | 1678.51 | 193,919 | | |
| 29 | | | 1647.12 | 159,321 | 1679.49 | 195,073 | | |
| 30 | | | 1648.23 | 160,474 | 1680.46 | 196,226 | | |
| 31 | | | 1649.34 | 161,628 | | | | |

Notes:

1. Pool elevation and corresponding acre-feet applicable to the midnight observation.
2. In leap years reservoir will be one day ahead of above schedule after 28 February.
3. February filling rate = 2213.3 acre-feet/day = 1116 c.f.s./day 1107
   March-May filling rate =1153 acre-feet/day = 581 c.f.s./day ~~576~~ 577

Cougar Reservoir

Evacuation Schedule

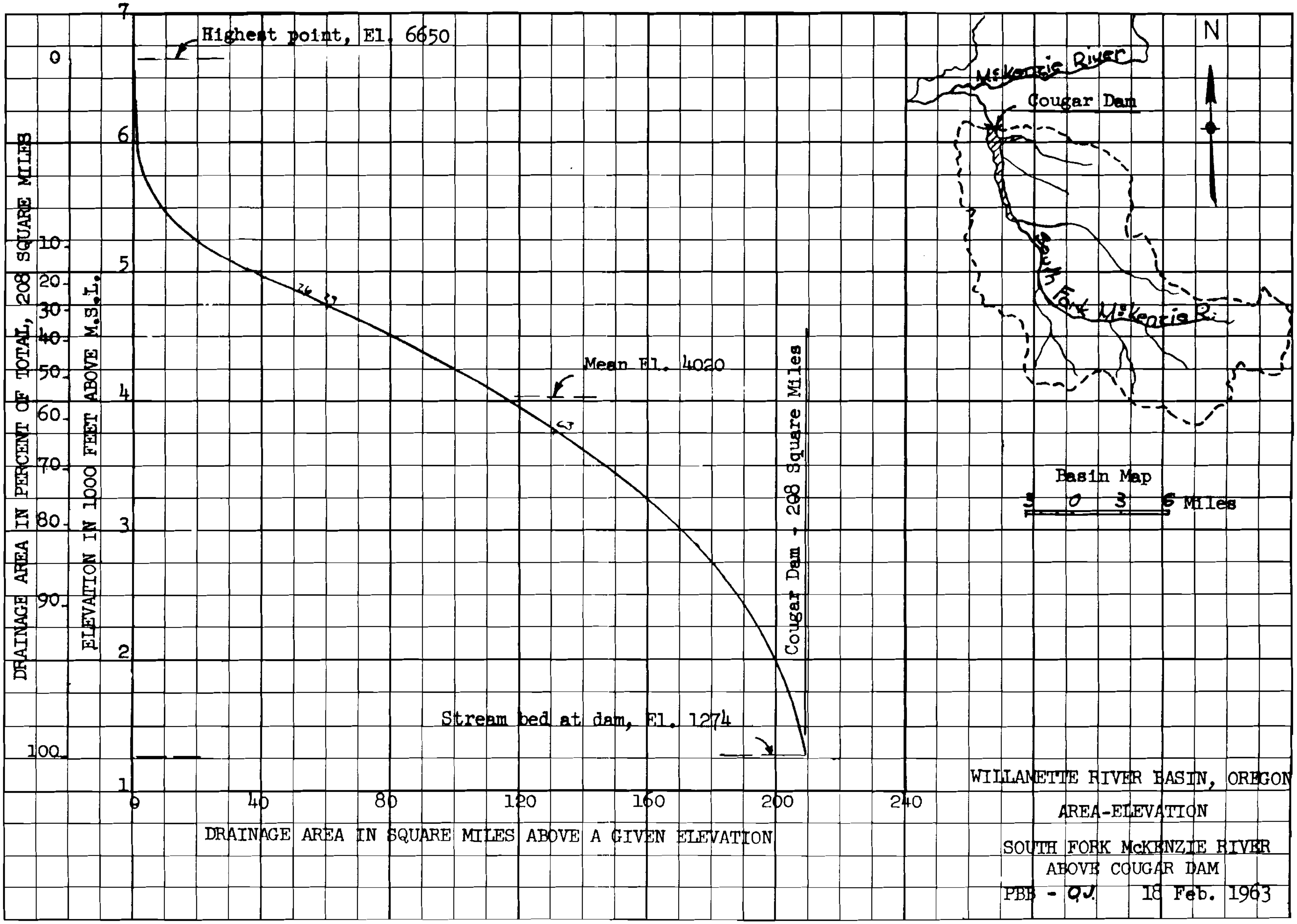
Revised February 1970

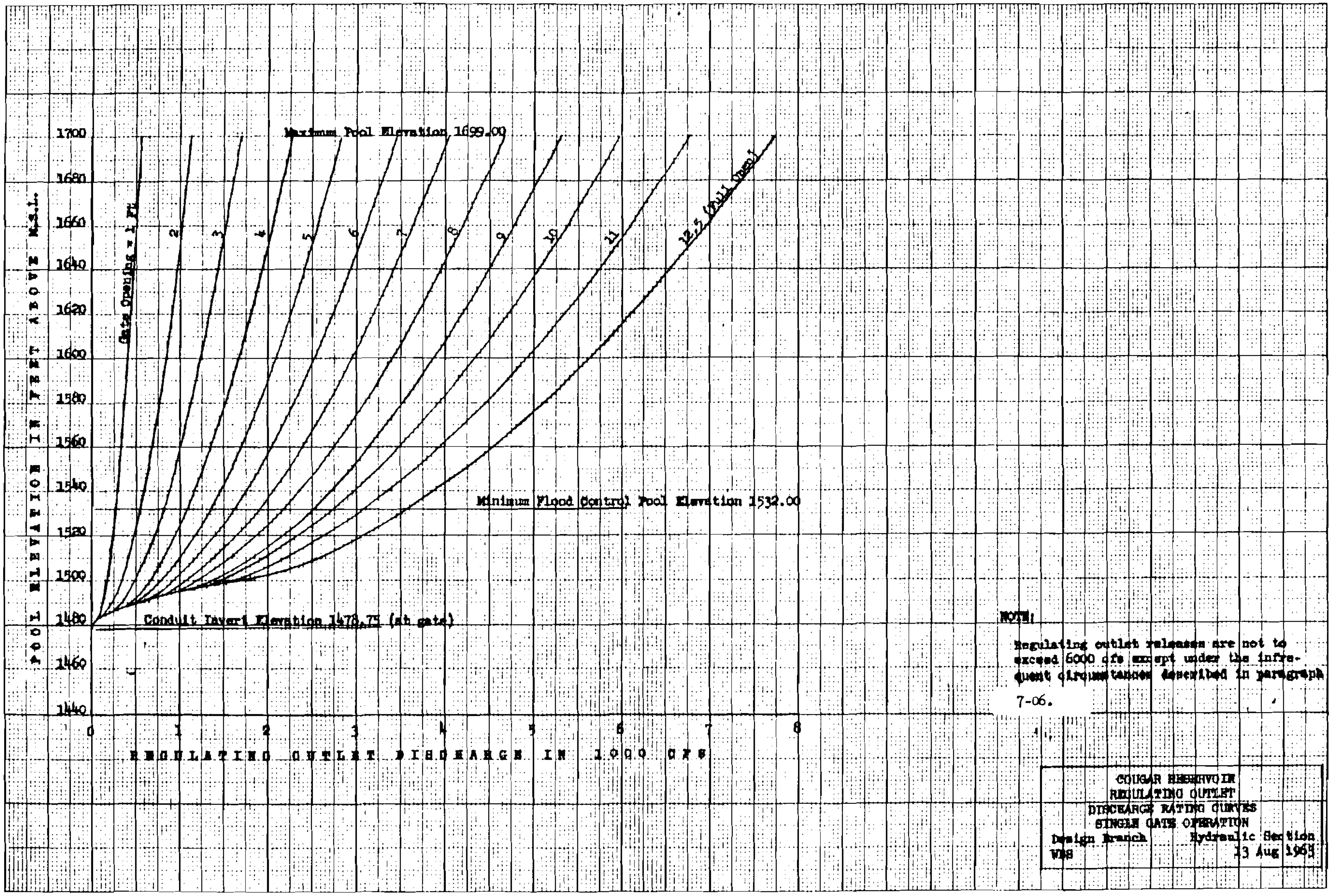
| Date | September | | October | | November | | November | |
|---|---|---|---|---|---|---|---|---|
| | Elev. | Storage | Elev. | Storage | Elev. | Storage | Elev. | Storage |
| Aug 31 | 1690.00 | 207,759 | | | | | | |
| 1 | 1688.78 | 206,257 | 1648.92 | 161,188 | 1599.84 | 114,616 | | |
| 2 | 1687.55 | 204,754 | 1647.47 | 159,685 | 1598.09 | 113,114 | | |
| 3 | 1686.32 | 203,252 | 1646.02 | 158,183 | 1596.33 | 111,612 | | |
| 4 | 1685.08 | 201,750 | 1644.55 | 156,681 | 1594.55 | 110,110 | | |
| 5 | 1683.83 | 200,248 | 1643.08 | 155,178 | 1592.76 | 108,607 | | |
| 6 | 1682.58 | 198,745 | 1641.60 | 153,676 | 1590.95 | 107,105 | | |
| 7 | 1681.32 | 197,243 | 1640.11 | 152,174 | 1589.14 | 105,603 | | |
| 8 | 1680.05 | 195,741 | 1638.61 | 150,672 | 1587.30 | 104,100 | | |
| 9 | 1678.78 | 194,238 | 1637.11 | 149,169 | 1585.46 | 102,598 | | |
| 10 | 1677.50 | 192,736 | 1635.59 | 147,667 | 1583.60 | 101,096 | | |
| 11 | 1676.21 | 191,234 | 1634.07 | 146,165 | 1581.72 | 99,593 | | |
| 12 | 1674.91 | 189,731 | 1632.54 | 144,662 | 1579.83 | 98,091 | | |
| 13 | 1673.61 | 188,229 | 1631.00 | 143,160 | 1577.92 | 96,589 | | |
| 14 | 1672.31 | 186,727 | 1629.45 | 141,658 | 1576.00 | 95,086 | | |
| 15 | 1670.99 | 185,224 | 1627.89 | 140,156 | 1574.06 | 93,584 | | |
| 16 | 1669.67 | 183,722 | 1626.32 | 138,653 | | | 1571.49 | 91,606 |
| 17 | 1668.34 | 182,220 | 1624.74 | 137,151 | | | 1568.88 | 89,627 |
| 18 | 1667.00 | 180,718 | 1623.16 | 135,649 | | | 1566.25 | 87,648 |
| 19 | 1665.66 | 179,215 | 1621.56 | 134,146 | | | 1563.58 | 85,670 |
| 20 | 1664.30 | 177,713 | 1619.95 | 132,644 | | | 1560.88 | 83,691 |
| 21 | 1662.94 | 176,211 | 1618.34 | 131,142 | | | 1558.15 | 81,712 |
| 22 | 1661.58 | 174,708 | 1616.71 | 129,639 | | | 1555.39 | 79,734 |
| 23 | 1660.20 | 173,206 | 1615.08 | 128,137 | | | 1552.60 | 77,755 |
| 24 | 1658.82 | 171,704 | 1613.43 | 126,635 | | | 1549.77 | 75,776 |
| 25 | 1657.43 | 170,202 | 1611.77 | 125,132 | | | 1546.91 | 73,798 |
| 26 | 1656.03 | 168,699 | 1610.10 | 123,630 | | | 1544.02 | 71,819 |
| 27 | 1654.62 | 167,197 | 1608.42 | 122,128 | | | 1541.08 | 69,840 |
| 28 | 1653.21 | 165,695 | 1606.73 | 120,626 | | | 1538.11 | 67,861 |
| 29 | 1651.79 | 164,192 | 1605.03 | 119,123 | | | 1535.09 | 65,883 |
| 30 | 1650.36 | 162,690 | 1603.31 | 117,621 | | | 1532.00 | 63,904 |
| 31 | | | 1601.58 | 116,119 | | | | |

Notes:

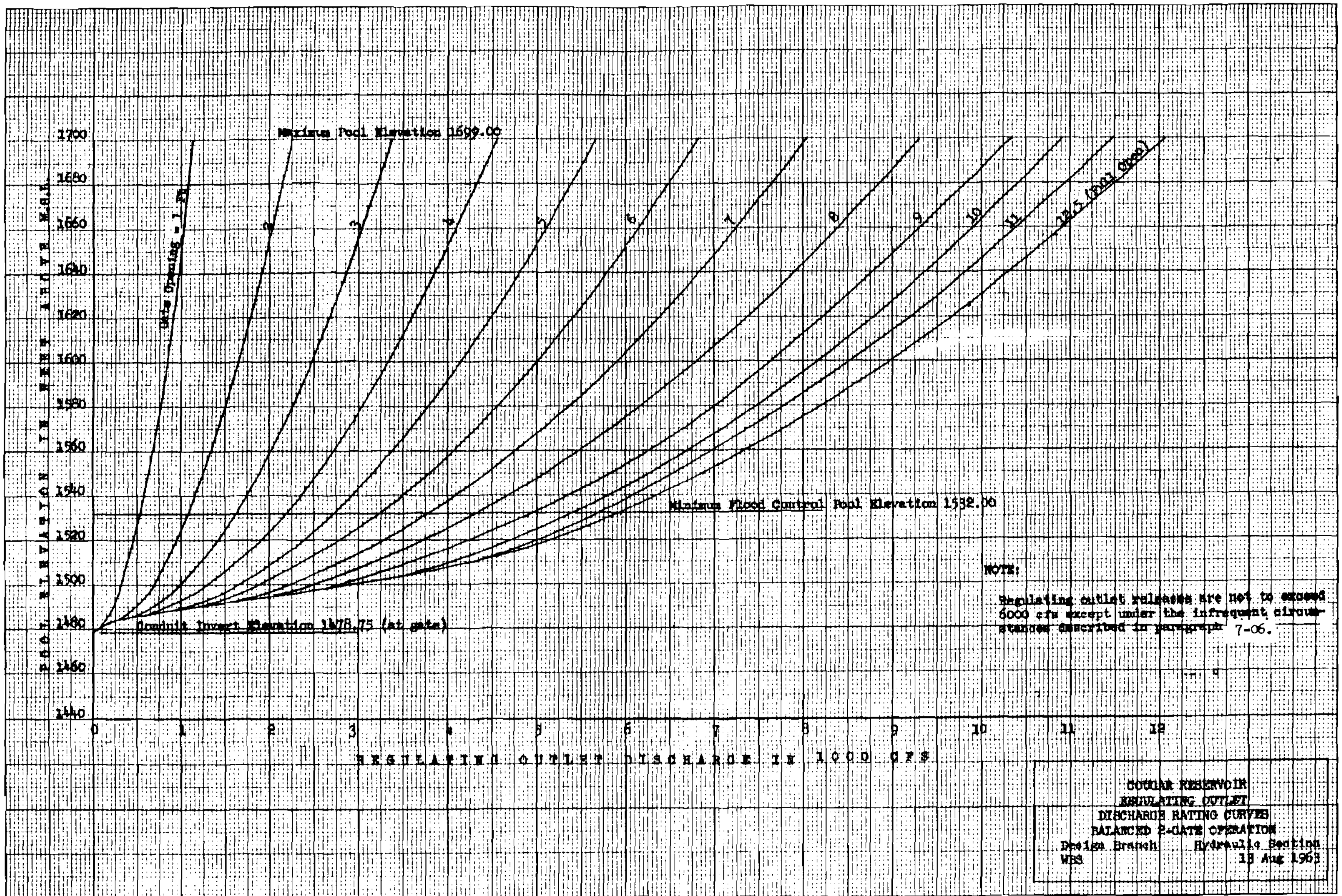
1. Pool elevation above mean sea level and corresponding storage in acre-feet applicable to the midnight observation.
2. 1 Sep-15 Nov. evacuation rate = 1502 acre-feet/day = 757 c.f.s./day. [illegible]
   16-30 Nov. evacuation rate = 1979 acre-feet/day = 998 c.f.s./day. 989

## CHARTS


Highest point, El. 6650
Mean El. 4020
Stream bed at dam, El. 1274
Cougar Dam - 208 Square Miles
DRAINAGE AREA IN PERCENT OF TOTAL, 208 SQUARE MILES
ELEVATION IN 1000 FEET ABOVE M.S.L.
DRAINAGE AREA IN SQUARE MILES ABOVE A GIVEN ELEVATION
McKenzie River
Cougar Dam
South Fork McKenzie R.
N
Basin Map
3 0 3 6 Miles
WILLAMETTE RIVER BASIN, OREGON
AREA-ELEVATION
SOUTH FORK McKENZIE RIVER
ABOVE COUGAR DAM
PBB - QJ 18 Feb. 1963



Maximum Pool Elevation 1699.00
Gate Opening = 1 Ft.
2
3
4
5
6
7
8
9
10
11
12.5 (Full Open)
Minimum Flood Control Pool Elevation 1532.00
Conduit Invert Elevation 1478.75 (at gate)
POOL ELEVATION IN FEET ABOVE M.S.L.
1700
1680
1660
1640
1620
1600
1580
1560
1540
1520
1500
1480
1460
1440
0
1
2
3
4
5
6
7
8
REGULATING OUTLET DISCHARGE IN 1000 CFS
NOTE:
Regulating outlet releases are not to exceed 6000 cfs except under the infrequent circumstances described in paragraph 7-06.
COUGAR RESERVOIR
REGULATING OUTLET
DISCHARGE RATING CURVES
SINGLE GATE OPERATION
Design Branch
Hydraulic Section
WBS
13 Aug 1963




CU-20-16/9 CHART 3

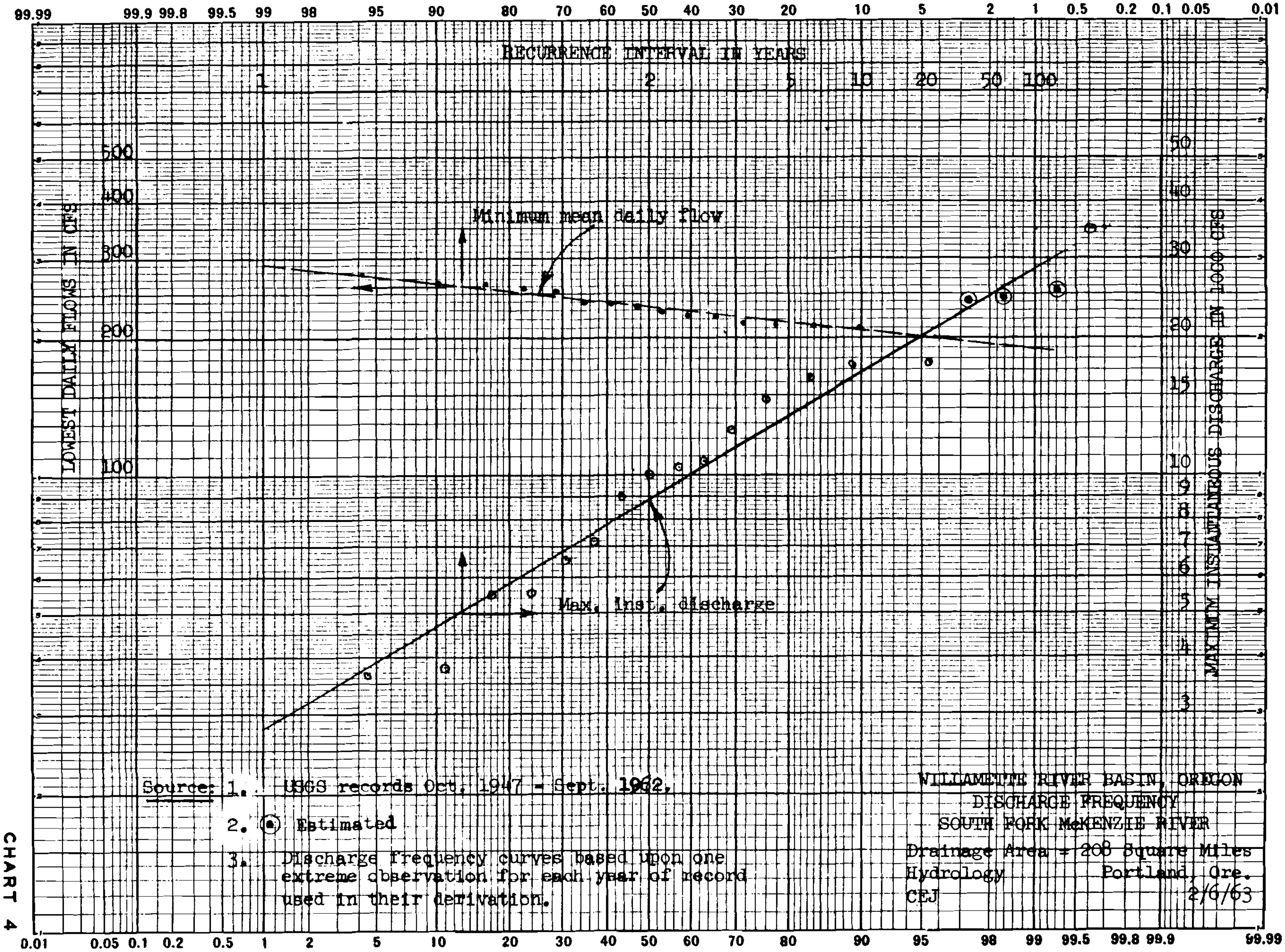
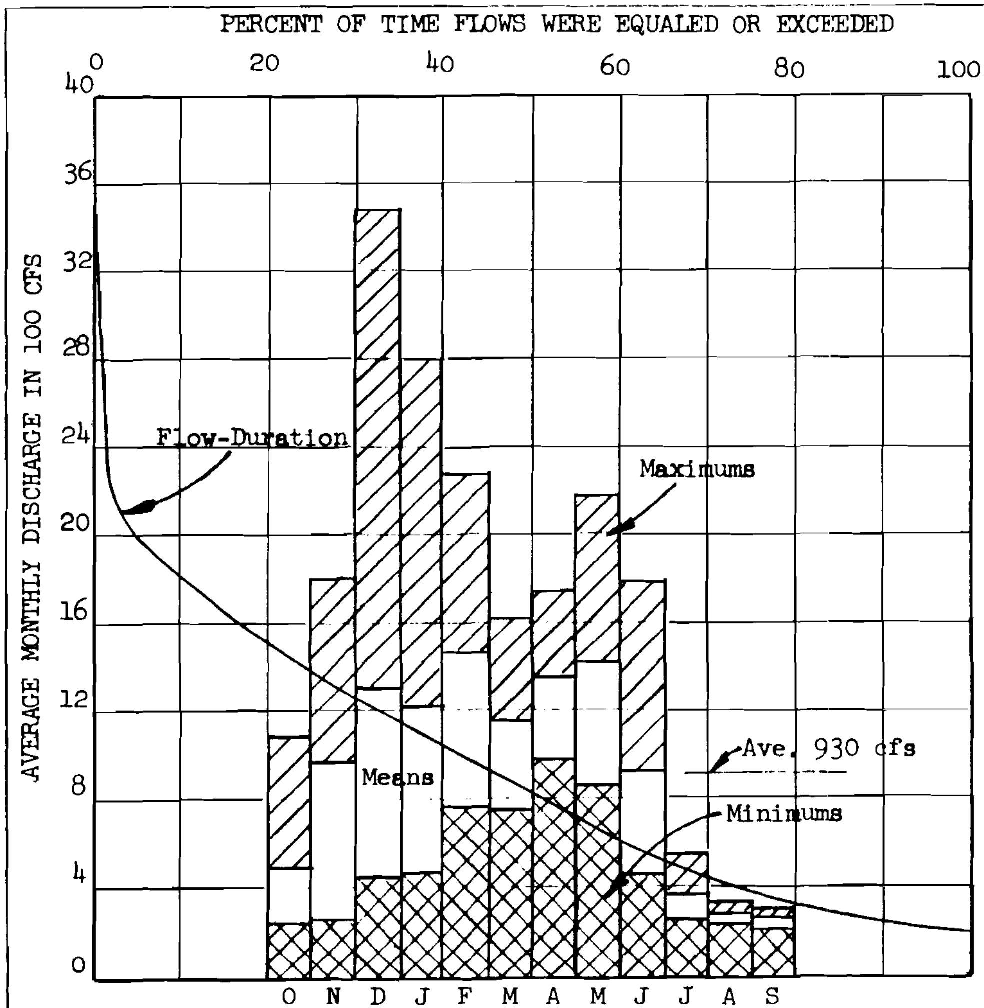


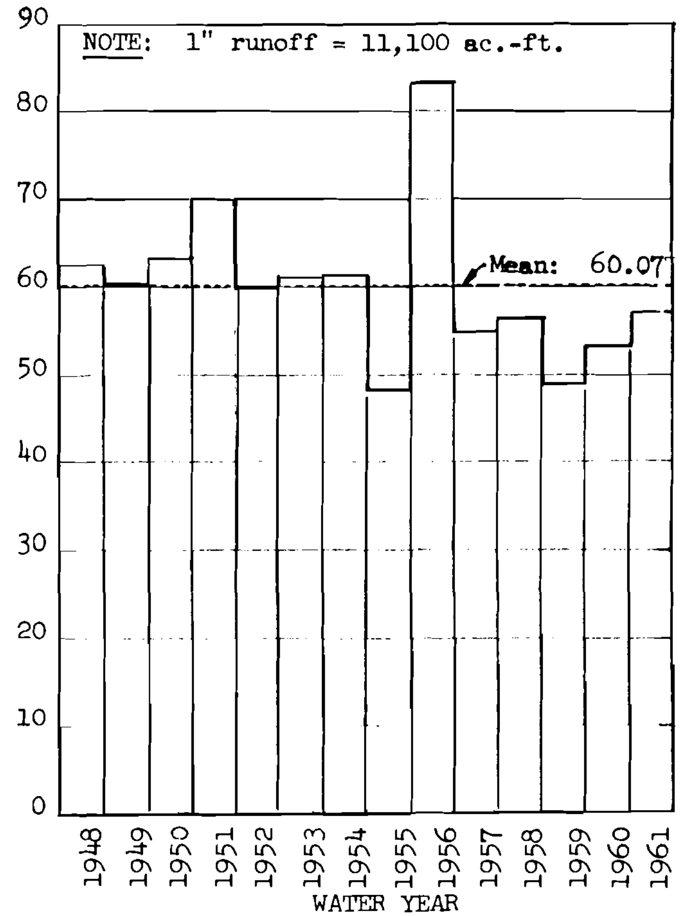

CHART 4

CU-20-16/10 CHART 4




Based on mean monthly discharges.

Records available: Oct. 1947 - Sept. 1961
Max. of record: 3484 cfs in Dec. 1956
Min. of record: 220 cfs in Sept. 1957

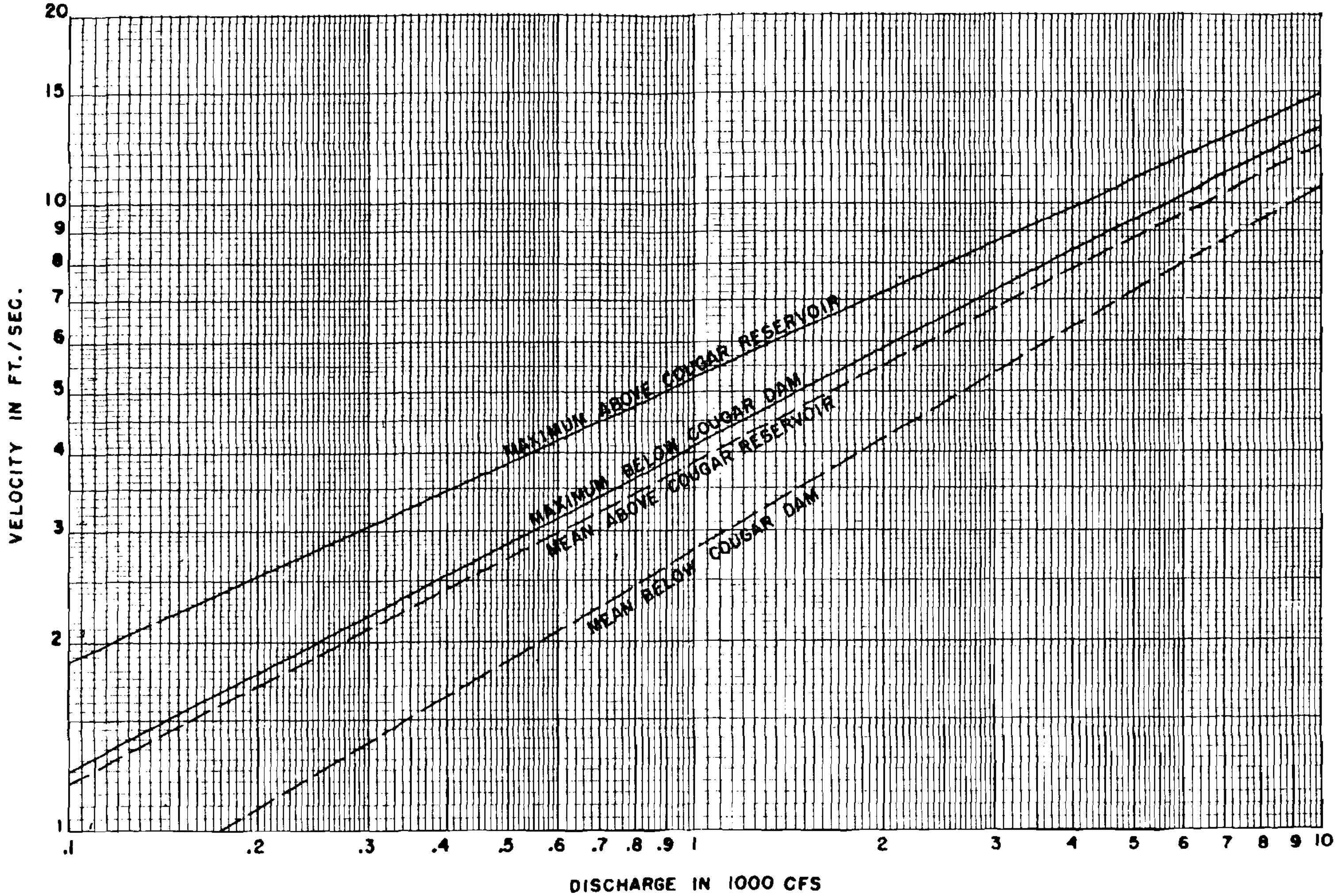



WILLAMETTE RIVER BASIN, OREGON

RUNOFF SUMMARY
SOUTH FORK McKENZIE RIVER
NEAR RAINBOW
Drainage Area = 208 Square Miles
OJ 2/18/63



CHART 5




**Note:**

Velocity data obtained from U. S. Geological Survey discharge measurements made at the following gaging stations:

1. Above Cougar Reservoir (D.A. 160 Square Miles)
2. Below Cougar Dam (D.A. 208 Square Miles)

WILLAMETTE RIVER BASIN, OREGON
SOUTH FORK McKENZIE RIVER

## VELOCITY CURVES

U.S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

PBB — 18 FEB. 63

CU-20-18/12 CHART 6

TABLE NO. 14
CAPACITY OF COUGAR RESERVOIR
IN ACRE-FEET

Sheet 1 of 4

| El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1510.0 | 50,626 | 58 | 1515.0 | 53,554 | 59 | 1520.0 | 56,552 | 61 | 1525.0 | 59,624 | 62 | 1530.0 | 62,764 | 64 | 1535.0 | 65,984 | 65 | 1540.0 | 69,280 | 67 | 1545.0 | 72,656 | 68 | 1550.0 | 76,095 | 70 | 1555.0 | 79,615 | 71 |
| .1 | 50,684 | | .1 | 53,613 | | .1 | 56,613 | | .1 | 59,686 | | .1 | 62,828 | | .1 | 66,049 | | .1 | 69,347 | | .1 | 72,723 | | .1 | 76,165 | | .1 | 79,786 | |
| .2 | 50,742 | | .2 | 53,672 | | .2 | 56,674 | | .2 | 59,748 | | .2 | 62,892 | | .2 | 66,114 | | .2 | 69,414 | | .2 | 72,791 | | .2 | 76,235 | | .2 | 79,757 | |
| .3 | 50,800 | | .3 | 53,731 | | .3 | 56,735 | | .3 | 59,810 | | .3 | 62,956 | | .3 | 66,179 | 65 | .3 | 69,481 | | .3 | 72,859 | | .3 | 76,305 | | .3 | 79,828 | |
| .4 | 50,858 | | .4 | 53,790 | | .4 | 56,796 | | .4 | 59,872 | | .4 | 63,020 | | .4 | 66,244 | 66 | .4 | 69,548 | | .4 | 72,927 | | .4 | 76,375 | | .4 | 79,899 | |
| .5 | 50,916 | | .5 | 53,849 | | .5 | 56,857 | | .5 | 59,934 | | .5 | 63,084 | | .5 | 66,310 | | .5 | 69,615 | | .5 | 72,995 | | .5 | 76,445 | | .5 | 79,970 | 71 |
| .6 | 50,974 | | .6 | 53,908 | 59 | .6 | 56,918 | | .6 | 59,996 | | .6 | 63,148 | | .6 | 66,376 | | .6 | 69,682 | | .6 | 73,063 | | .6 | 76,515 | | .6 | 80,041 | 72 |
| .7 | 51,032 | | .7 | 53,967 | 60 | .7 | 56,979 | | .7 | 60,058 | | .7 | 63,212 | | .7 | 66,442 | | .7 | 69,749 | | .7 | 73,131 | | .7 | 76,585 | | .7 | 80,113 | |
| .8 | 51,090 | | .8 | 54,027 | | .8 | 57,040 | | .8 | 60,120 | | .8 | 63,276 | | .8 | 66,508 | | .8 | 69,816 | | .8 | 73,199 | | .8 | 76,655 | | .8 | 80,185 | |
| .9 | 51,148 | | .9 | 54,087 | | .9 | 57,101 | | .9 | 60,182 | 62 | .9 | 63,340 | | .9 | 66,574 | | .9 | 69,883 | | .9 | 73,267 | | .9 | 76,725 | | .9 | 80,257 | |
| 1511.0 | 51,206 | | 1516.0 | 54,147 | | 1521.0 | 57,162 | | 1526.0 | 60,244 | 63 | 1531.0 | 63,404 | | 1536.0 | 66,640 | | 1541.0 | 69,950 | | 1546.0 | 73,335 | | 1551.0 | 76,795 | | 1556.0 | 80,329 | |
| .1 | 51,264 | | .1 | 54,207 | | .1 | 57,223 | | .1 | 60,307 | | .1 | 63,468 | | .1 | 66,706 | | .1 | 70,017 | | .1 | 73,403 | | .1 | 76,865 | | .1 | 80,401 | |
| .2 | 51,322 | | .2 | 54,267 | | .2 | 57,284 | | .2 | 60,370 | | .2 | 63,532 | | .2 | 66,772 | | .2 | 70,084 | | .2 | 73,471 | | .2 | 76,935 | | .2 | 80,473 | |
| .3 | 51,380 | | .3 | 54,327 | | .3 | 57,345 | | .3 | 60,433 | | .3 | 63,596 | | .3 | 66,838 | | .3 | 70,151 | | .3 | 73,539 | | .3 | 77,005 | | .3 | 80,545 | |
| .4 | 51,438 | | .4 | 54,387 | | .4 | 57,406 | | .4 | 60,496 | | .4 | 63,660 | | .4 | 66,904 | | .4 | 70,218 | | .4 | 73,607 | | .4 | 77,075 | | .4 | 80,617 | |
| .5 | 51,496 | | .5 | 54,447 | | .5 | 57,467 | | .5 | 60,559 | | .5 | 63,724 | | .5 | 66,970 | | .5 | 70,285 | | .5 | 73,675 | 68 | .5 | 77,145 | | .5 | 80,689 | |
| .6 | 51,554 | | .6 | 54,507 | | .6 | 57,528 | | .6 | 60,662 | | .6 | 63,788 | | .6 | 67,036 | | .6 | 70,352 | | .6 | 73,744 | 69 | .6 | 77,215 | | .6 | 80,761 | |
| .7 | 51,612 | | .7 | 54,567 | | .7 | 57,589 | | .7 | 60,685 | | .7 | 63,852 | | .7 | 67,102 | | .7 | 70,419 | | .7 | 73,813 | | .7 | 77,285 | | .7 | 80,833 | |
| .8 | 51,670 | | .8 | 54,627 | | .8 | 57,650 | | .8 | 60,748 | | .8 | 63,916 | | .8 | 67,168 | | .8 | 70,486 | | .8 | 73,882 | | .8 | 77,355 | | .8 | 80,905 | |
| .9 | 51,728 | | .9 | 54,687 | | .9 | 57,711 | | .9 | 60,811 | | .9 | 63,980 | | .9 | 67,234 | | .9 | 70,553 | | .9 | 73,951 | | .9 | 77,425 | | .9 | 80,977 | |
| 1512.0 | 51,786 | | 1517.0 | 54,747 | | 1522.0 | 57,772 | | 1527.0 | 60,874 | | 1532.0 | 64,044 | | 1537.0 | 67,300 | | 1542.0 | 70,620 | | 1547.0 | 74,020 | | 1552.0 | 77,495 | | 1557.0 | 81,049 | |
| .1 | 51,844 | 58 | .1 | 54,807 | | .1 | 57,833 | | .1 | 60,937 | | .1 | 64,108 | | .1 | 67,366 | | .1 | 70,687 | | .1 | 74,089 | | .1 | 77,565 | | .1 | 81,121 | |
| .2 | 51,902 | 59 | .2 | 54,867 | | .2 | 57,894 | | .2 | 61,000 | | .2 | 64,172 | | .2 | 67,432 | | .2 | 70,754 | | .2 | 74,158 | | .2 | 77,635 | | .2 | 81,193 | |
| .3 | 51,961 | | .3 | 54,927 | | .3 | 57,955 | | .3 | 61,063 | | .3 | 64,236 | | .3 | 67,498 | | .3 | 70,821 | | .3 | 74,227 | | .3 | 77,705 | | .3 | 81,265 | |
| .4 | 52,020 | | .4 | 54,987 | | .4 | 58,016 | | .4 | 61,126 | | .4 | 64,300 | | .4 | 67,564 | | .4 | 70,888 | | .4 | 74,296 | | .4 | 77,775 | | .4 | 81,337 | |
| .5 | 52,079 | | .5 | 55,047 | | .5 | 58,077 | | .5 | 61,189 | | .5 | 64,364 | | .5 | 67,630 | | .5 | 70,955 | 67 | .5 | 74,365 | | .5 | 77,845 | | .5 | 81,409 | |
| .6 | 52,138 | | .6 | 55,107 | | .6 | 58,138 | | .6 | 61,252 | | .6 | 64,428 | | .6 | 67,696 | | .6 | 71,023 | 68 | .6 | 74,434 | | .6 | 77,915 | | .6 | 81,481 | |
| .7 | 52,197 | | .7 | 55,167 | | .7 | 58,199 | 61 | .7 | 61,315 | | .7 | 64,492 | | .7 | 67,762 | | .7 | 71,091 | | .7 | 74,503 | | .7 | 77,985 | | .7 | 81,553 | |
| .8 | 52,256 | | .8 | 55,227 | | .8 | 58,260 | 62 | .8 | 61,378 | | .8 | 64,556 | | .8 | 67,828 | | .8 | 71,159 | | .8 | 74,572 | | .8 | 78,055 | | .8 | 81,625 | |
| .9 | 52,315 | | .9 | 55,287 | | .9 | 58,322 | | .9 | 61,441 | | .9 | 64,620 | 64 | .9 | 67,894 | | .9 | 71,227 | | .9 | 74,641 | | .9 | 78,125 | 70 | .9 | 81,697 | |
| 1513.0 | 52,374 | | 1518.0 | 55,347 | | 1523.0 | 58,384 | | 1528.0 | 61,504 | | 1533.0 | 64,684 | 65 | 1538.0 | 67,960 | | 1543.0 | 71,295 | | 1548.0 | 74,710 | | 1553.0 | 78,195 | 71 | 1558.0 | 81,769 | |
| .1 | 52,433 | | .1 | 55,407 | | .1 | 58,446 | | .1 | 61,567 | | .1 | 64,749 | | .1 | 68,026 | | .1 | 71,363 | | .1 | 74,779 | | .1 | 78,266 | | .1 | 81,841 | |
| .2 | 52,492 | | .2 | 55,467 | | .2 | 58,508 | | .2 | 61,630 | | .2 | 64,814 | | .2 | 68,092 | | .2 | 71,431 | | .2 | 74,848 | | .2 | 78,337 | | .2 | 81,913 | |
| .3 | 52,551 | | .3 | 55,527 | | .3 | 58,570 | | .3 | 61,693 | | .3 | 64,879 | | .3 | 68,158 | | .3 | 71,499 | | .3 | 74,917 | | .3 | 78,408 | | .3 | 81,985 | |
| .4 | 52,610 | | .4 | 55,587 | | .4 | 58,632 | | .4 | 61,756 | | .4 | 64,944 | | .4 | 68,224 | | .4 | 71,567 | | .4 | 74,986 | | .4 | 78,479 | | .4 | 82,057 | |
| .5 | 52,669 | | .5 | 55,647 | | .5 | 58,694 | | .5 | 61,819 | | .5 | 65,009 | | .5 | 68,290 | | .5 | 71,635 | | .5 | 75,055 | | .5 | 78,550 | | .5 | 82,129 | |
| .6 | 52,728 | | .6 | 55,707 | | .6 | 58,756 | | .6 | 61,882 | | .6 | 65,074 | | .6 | 68,356 | | .6 | 71,703 | | .6 | 75,124 | | .6 | 78,621 | | .6 | 82,201 | |
| .7 | 52,787 | | .7 | 55,767 | | .7 | 58,818 | | .7 | 61,945 | | .7 | 65,139 | | .7 | 68,422 | | .7 | 71,771 | | .7 | 75,193 | | .7 | 78,692 | | .7 | 82,273 | 72 |
| .8 | 52,846 | | .8 | 55,827 | | .8 | 58,880 | | .8 | 62,008 | | .8 | 65,204 | | .8 | 68,488 | | .8 | 71,839 | | .8 | 75,262 | | .8 | 78,763 | | .8 | 82,345 | 73 |
| .9 | 52,905 | | .9 | 55,887 | | .9 | 58,942 | | .9 | 62,071 | | .9 | 65,269 | | .9 | 68,554 | | .9 | 71,907 | | .9 | 75,331 | | .9 | 78,834 | | .9 | 82,418 | |
| 1514.0 | 52,964 | | 1519.0 | 55,947 | | 1524.0 | 59,004 | | 1529.0 | 62,134 | | 1534.0 | 65,334 | | 1539.0 | 68,620 | | 1544.0 | 71,975 | | 1549.0 | 75,400 | | 1554.0 | 78,905 | | 1559.0 | 82,491 | |
| .1 | 53,023 | | .1 | 56,007 | | .1 | 59,066 | | .1 | 62,197 | | .1 | 65,399 | | .1 | 68,686 | | .1 | 72,043 | | .1 | 75,469 | | .1 | 78,976 | | .1 | 82,564 | |
| .2 | 53,082 | | .2 | 56,067 | | .2 | 59,128 | | .2 | 62,260 | | .2 | 65,464 | | .2 | 68,752 | | .2 | 72,111 | | .2 | 75,538 | | .2 | 79,047 | | .2 | 82,637 | |
| .3 | 53,141 | | .3 | 56,127 | | .3 | 59,190 | | .3 | 62,323 | | .3 | 65,529 | | .3 | 68,818 | | .3 | 72,179 | | .3 | 75,607 | | .3 | 79,118 | | .3 | 82,710 | |
| .4 | 53,200 | | .4 | 56,187 | 60 | .4 | 59,252 | | .4 | 62,386 | | .4 | 65,594 | | .4 | 68,884 | | .4 | 72,247 | | .4 | 75,676 | | .4 | 79,189 | | .4 | 82,783 | |
| .5 | 53,259 | | .5 | 56,247 | 61 | .5 | 59,314 | | .5 | 62,449 | | .5 | 65,659 | | .5 | 68,950 | | .5 | 72,315 | | .5 | 75,745 | 69 | .5 | 79,260 | | .5 | 82,856 | |
| .6 | 53,318 | | .6 | 56,308 | | .6 | 59,376 | | .6 | 62,512 | | .6 | 65,724 | | .6 | 69,016 | | .6 | 72,383 | | .6 | 75,815 | 70 | .6 | 79,331 | | .6 | 82,929 | |
| .7 | 53,377 | | .7 | 56,369 | | .7 | 59,438 | | .7 | 62,575 | | .7 | 65,789 | | .7 | 69,082 | | .7 | 72,451 | | .7 | 75,885 | | .7 | 79,402 | | .7 | 83,002 | |
| .8 | 53,436 | | .8 | 56,430 | | .8 | 59,500 | | .8 | 62,638 | | .8 | 65,854 | | .8 | 69,148 | | .8 | 72,519 | | .8 | 75,955 | | .8 | 79,473 | | .8 | 83,075 | |
| .9 | 53,495 | | .9 | 56,491 | | .9 | 59,562 | | .9 | 62,701 | | .9 | 65,919 | | .9 | 69,214 | | .9 | 72,587 | | .9 | 76,025 | | .9 | 79,544 | | .9 | 83,148 | |
| 1515.0 | 53,554 | 59 | 1520.0 | 56,552 | 61 | 1525.0 | 59,624 | 62 | 1530.0 | 62,764 | 63 | 1535.0 | 65,984 | 65 | 1540.0 | 69,280 | 66 | 1545.0 | 72,655 | 68 | 1550.0 | 76,095 | 70 | 1555.0 | 79,615 | 71 | 1560.0 | 83,221 | 73 |

Remarks:

Minimum Power Pool ......... 1516 ft.
Minimum Flood Control Pool ......... 1532 "
Maximum Conservation Pool ......... 1690 "
Full and Maximum Pool ......... 1699 "

Compiled by G.E.G. - J.W.H.
Checked by H.C.L.
Date Oct. 1963 (1)

TABLE NO. 14
CAPACITY OF COUGAR RESERVOIR
IN ACRE-FEET

Sheet 2 of 4

| El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1560.0 | 83,221 | 73 | 1565.0 | 86,898 | 74 | 1570.0 | 90,661 | 76 | 1575.0 | 94,498 | 78 | 1580.0 | 98,422 | 79 |
| .1 | 83,294 | | .1 | 86,972 | | .1 | 90,737 | | .1 | 94,576 | | .1 | 98,501 | |
| .2 | 83,367 | | .2 | 87,046 | 74 | .2 | 90,813 | | .2 | 94,654 | | .2 | 98,580 | |
| .3 | 83,440 | | .3 | 87,120 | 75 | .3 | 90,889 | | .3 | 94,732 | | .3 | 98,659 | |
| .4 | 83,513 | | .4 | 87,195 | | .4 | 90,965 | | .4 | 94,810 | | .4 | 98,738 | |
| .5 | 83,586 | | .5 | 87,270 | | .5 | 91,041 | | .5 | 94,888 | | .5 | 98,817 | 79 |
| .6 | 83,659 | | .6 | 87,345 | | .6 | 91,117 | | .6 | 94,966 | | .6 | 98,896 | 80 |
| .7 | 83,732 | | .7 | 87,420 | | .7 | 91,193 | | .7 | 95,044 | | .7 | 98,976 | |
| .8 | 83,805 | | .8 | 87,495 | | .8 | 91,269 | | .8 | 95,122 | | .8 | 99,056 | |
| .9 | 83,878 | | .9 | 87,570 | | .9 | 91,345 | | .9 | 95,200 | | .9 | 99,136 | |
| 1561.0 | 83,951 | | 1566.0 | 87,645 | | 1571.0 | 91,421 | | 1576.0 | 95,278 | | 1581.0 | 99,216 | |
| .1 | 84,024 | | .1 | 87,720 | | .1 | 91,497 | | .1 | 95,356 | | .1 | 99,296 | |
| .2 | 84,097 | | .2 | 87,795 | | .2 | 91,573 | | .2 | 95,434 | | .2 | 99,376 | |
| .3 | 84,170 | | .3 | 87,870 | | .3 | 91,649 | | .3 | 95,512 | | .3 | 99,456 | |
| .4 | 84,243 | | .4 | 87,945 | | .4 | 91,725 | | .4 | 95,590 | | .4 | 99,536 | |
| .5 | 84,316 | | .5 | 88,020 | | .5 | 91,801 | | .5 | 95,668 | | .5 | 99,616 | |
| .6 | 84,389 | | .6 | 88,095 | | .6 | 91,877 | 76 | .6 | 95,746 | | .6 | 99,696 | |
| .7 | 84,462 | | .7 | 88,170 | | .7 | 91,953 | 77 | .7 | 95,824 | | .7 | 99,776 | |
| .8 | 84,535 | | .8 | 88,245 | | .8 | 92,030 | | .8 | 95,902 | | .8 | 99,856 | |
| .9 | 84,608 | | .9 | 88,320 | | .9 | 92,107 | | .9 | 95,980 | | .9 | 99,936 | |
| 1562.0 | 84,681 | | 1567.0 | 88,395 | | 1572.0 | 92,184 | | 1577.0 | 96,058 | | 1582.0 | 100,016 | |
| .1 | 84,754 | | .1 | 88,470 | | .1 | 92,261 | | .1 | 96,136 | | .1 | 100,096 | |
| .2 | 84,827 | 73 | .2 | 88,545 | | .2 | 92,338 | | .2 | 96,214 | | .2 | 100,176 | |
| .3 | 84,900 | 74 | .3 | 88,620 | | .3 | 92,415 | | .3 | 96,292 | | .3 | 100,256 | |
| .4 | 84,974 | | .4 | 88,695 | | .4 | 92,492 | | .4 | 96,370 | | .4 | 100,336 | |
| .5 | 85,048 | | .5 | 88,770 | | .5 | 92,569 | | .5 | 96,448 | 78 | .5 | 100,416 | |
| .6 | 85,122 | | .6 | 88,845 | | .6 | 92,646 | | .6 | 96,526 | 79 | .6 | 100,496 | |
| .7 | 85,196 | | .7 | 88,920 | | .7 | 92,723 | | .7 | 96,605 | | .7 | 100,576 | |
| .8 | 85,270 | | .8 | 88,995 | | .8 | 92,800 | | .8 | 96,684 | | .8 | 100,656 | |
| .9 | 85,344 | | .9 | 89,070 | | .9 | 92,877 | | .9 | 96,763 | | .9 | 100,736 | |
| 1563.0 | 85,418 | | 1568.0 | 89,145 | | 1573.0 | 92,954 | | 1578.0 | 96,842 | | 1583.0 | 100,816 | |
| .1 | 85,492 | | .1 | 89,220 | | .1 | 93,031 | | .1 | 96,921 | | .1 | 100,896 | |
| .2 | 85,566 | | .2 | 89,295 | | .2 | 93,108 | | .2 | 97,000 | | .2 | 100,976 | 80 |
| .3 | 85,640 | | .3 | 89,370 | 75 | .3 | 93,185 | | .3 | 97,079 | | .3 | 101,056 | 81 |
| .4 | 85,714 | | .4 | 89,445 | 76 | .4 | 93,262 | | .4 | 97,158 | | .4 | 101,137 | |
| .5 | 85,788 | | .5 | 89,521 | | .5 | 93,339 | | .5 | 97,237 | | .5 | 101,218 | |
| .6 | 85,862 | | .6 | 89,597 | | .6 | 93,416 | | .6 | 97,316 | | .6 | 101,299 | |
| .7 | 85,936 | | .7 | 89,673 | | .7 | 93,493 | | .7 | 97,395 | | .7 | 101,380 | |
| .8 | 86,010 | | .8 | 89,749 | | .8 | 93,570 | | .8 | 97,474 | | .8 | 101,461 | |
| .9 | 86,084 | | .9 | 89,825 | | .9 | 93,647 | | .9 | 97,553 | | .9 | 101,542 | |
| 1564.0 | 86,158 | | 1569.0 | 89,901 | | 1574.0 | 93,724 | | 1579.0 | 97,632 | | 1584.0 | 101,623 | |
| .1 | 86,232 | | .1 | 89,977 | | .1 | 93,801 | | .1 | 97,711 | | .1 | 101,704 | |
| .2 | 86,306 | | .2 | 90,053 | | .2 | 93,878 | | .2 | 97,790 | | .2 | 101,785 | |
| .3 | 86,380 | | .3 | 90,129 | | .3 | 93,955 | | .3 | 97,869 | | .3 | 101,866 | |
| .4 | 86,454 | | .4 | 90,205 | | .4 | 94,032 | | .4 | 97,948 | | .4 | 101,947 | |
| .5 | 86,528 | | .5 | 90,281 | | .5 | 94,109 | 77 | .5 | 98,027 | | .5 | 102,028 | |
| .6 | 86,602 | | .6 | 90,357 | | .6 | 94,186 | 78 | .6 | 98,106 | | .6 | 102,109 | |
| .7 | 86,676 | | .7 | 90,433 | | .7 | 94,264 | | .7 | 98,185 | | .7 | 102,190 | |
| .8 | 86,750 | | .8 | 90,509 | | .8 | 94,342 | | .8 | 98,264 | | .8 | 102,271 | |
| .9 | 86,824 | 74 | .9 | 90,585 | 76 | .9 | 94,420 | 78 | .9 | 98,343 | 79 | .9 | 102,352 | 81 |
| 1565.0 | 86,898 | | 1570.0 | 90,661 | | 1575.0 | 94,498 | | 1580.0 | 98,422 | | 1585.0 | 102,433 | |

| El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1585.0 | 102,433 | 81 | 1590.0 | 106,521 | 83 | 1595.0 | 110,696 | 84 | 1600.0 | 114,959 | 86 | 1605.0 | 119,306 | 88 |
| .1 | 102,514 | | .1 | 106,604 | | .1 | 110,780 | | .1 | 115,045 | | .1 | 119,394 | |
| .2 | 102,595 | | .2 | 106,687 | | .2 | 110,864 | | .2 | 115,131 | | .2 | 119,482 | |
| .3 | 102,676 | | .3 | 106,770 | | .3 | 110,948 | 84 | .3 | 115,217 | | .3 | 119,570 | |
| .4 | 102,757 | | .4 | 106,853 | | .4 | 111,032 | 85 | .4 | 115,303 | | .4 | 119,658 | |
| .5 | 102,838 | | .5 | 106,936 | | .5 | 111,117 | | .5 | 115,389 | | .5 | 119,746 | |
| .6 | 102,919 | | .6 | 107,019 | | .6 | 111,202 | | .6 | 115,475 | | .6 | 119,834 | |
| .7 | 103,000 | | .7 | 107,102 | | .7 | 111,287 | | .7 | 115,561 | | .7 | 119,922 | |
| .8 | 103,081 | | .8 | 107,185 | | .8 | 111,372 | | .8 | 115,647 | | .8 | 120,010 | |
| .9 | 103,162 | | .9 | 107,268 | | .9 | 111,457 | | .9 | 115,733 | 86 | .9 | 120,098 | |
| 1586.0 | 103,243 | | 1591.0 | 107,351 | | 1596.0 | 111,542 | | 1601.0 | 115,819 | 87 | 1606.0 | 120,186 | |
| .1 | 103,324 | | .1 | 107,434 | | .1 | 111,627 | | .1 | 115,906 | | .1 | 120,274 | |
| .2 | 103,405 | | .2 | 107,517 | | .2 | 111,712 | | .2 | 115,993 | | .2 | 120,362 | |
| .3 | 103,486 | | .3 | 107,600 | | .3 | 111,797 | | .3 | 116,080 | | .3 | 120,450 | |
| .4 | 103,567 | | .4 | 107,683 | | .4 | 111,882 | | .4 | 116,167 | | .4 | 120,538 | |
| .5 | 103,648 | 81 | .5 | 107,766 | | .5 | 111,967 | | .5 | 116,254 | | .5 | 120,626 | |
| .6 | 103,729 | 82 | .6 | 107,849 | | .6 | 112,052 | | .6 | 116,341 | | .6 | 120,714 | |
| .7 | 103,811 | | .7 | 107,932 | | .7 | 112,137 | | .7 | 116,428 | | .7 | 120,802 | |
| .8 | 103,893 | | .8 | 108,015 | | .8 | 112,222 | | .8 | 116,515 | | .8 | 120,890 | |
| .9 | 103,975 | | .9 | 108,098 | | .9 | 112,307 | | .9 | 116,602 | | .9 | 120,978 | 88 |
| 1587.0 | 104,057 | | 1592.0 | 108,181 | | 1597.0 | 112,392 | | 1602.0 | 116,689 | | 1607.0 | 121,066 | 89 |
| .1 | 104,139 | | .1 | 108,264 | | .1 | 112,477 | | .1 | 116,776 | | .1 | 121,155 | |
| .2 | 104,221 | | .2 | 108,347 | | .2 | 112,562 | | .2 | 116,863 | | .2 | 121,244 | |
| .3 | 104,303 | | .3 | 108,430 | | .3 | 112,647 | | .3 | 116,950 | | .3 | 121,333 | |
| .4 | 104,385 | | .4 | 108,513 | 83 | .4 | 112,732 | | .4 | 117,037 | | .4 | 121,422 | |
| .5 | 104,467 | | .5 | 108,596 | 84 | .5 | 112,817 | | .5 | 117,124 | | .5 | 121,511 | |
| .6 | 104,549 | | .6 | 108,680 | | .6 | 112,902 | | .6 | 117,211 | | .6 | 121,600 | |
| .7 | 104,631 | | .7 | 108,764 | | .7 | 112,987 | | .7 | 117,298 | | .7 | 121,689 | |
| .8 | 104,713 | | .8 | 108,848 | | .8 | 113,072 | | .8 | 117,385 | | .8 | 121,778 | |
| .9 | 104,795 | | .9 | 108,932 | | .9 | 113,157 | | .9 | 117,472 | | .9 | 121,867 | |
| 1588.0 | 104,877 | | 1593.0 | 109,016 | | 1598.0 | 113,242 | | 1603.0 | 117,559 | | 1608.0 | 121,956 | |
| .1 | 104,959 | | .1 | 109,100 | | .1 | 113,327 | | .1 | 117,646 | | .1 | 122,045 | |
| .2 | 105,041 | | .2 | 109,184 | | .2 | 113,412 | 85 | .2 | 117,733 | | .2 | 122,134 | |
| .3 | 105,123 | | .3 | 109,268 | | .3 | 113,497 | 86 | .3 | 117,820 | | .3 | 122,223 | |
| .4 | 105,205 | | .4 | 109,352 | | .4 | 113,583 | | .4 | 117,907 | | .4 | 122,312 | |
| .5 | 105,287 | | .5 | 109,436 | | .5 | 113,669 | | .5 | 117,994 | | .5 | 122,401 | |
| .6 | 105,369 | | .6 | 109,520 | | .6 | 113,755 | | .6 | 118,081 | | .6 | 122,490 | |
| .7 | 105,451 | | .7 | 109,604 | | .7 | 113,841 | | .7 | 118,168 | | .7 | 122,579 | |
| .8 | 105,533 | | .8 | 109,688 | | .8 | 113,927 | | .8 | 118,255 | | .8 | 122,668 | |
| .9 | 105,615 | | .9 | 109,772 | | .9 | 114,013 | | .9 | 118,342 | | .9 | 122,757 | |
| 1589.0 | 105,697 | | 1594.0 | 109,856 | | 1599.0 | 114,099 | | 1604.0 | 118,429 | | 1609.0 | 122,846 | |
| .1 | 105,779 | | .1 | 109,840 | | .1 | 114,185 | | .1 | 118,516 | | .1 | 122,935 | |
| .2 | 105,861 | | .2 | 110,024 | | .2 | 114,271 | | .2 | 118,603 | 87 | .2 | 123,024 | |
| .3 | 105,943 | | .3 | 110,108 | | .3 | 114,357 | | .3 | 118,690 | 88 | .3 | 123,113 | |
| .4 | 106,025 | | .4 | 110,192 | | .4 | 114,443 | | .4 | 118,778 | | .4 | 123,202 | |
| .5 | 106,107 | 82 | .5 | 110,276 | | .5 | 114,529 | | .5 | 118,866 | | .5 | 123,291 | |
| .6 | 106,189 | | .6 | 110,360 | | .6 | 114,615 | | .6 | 118,954 | | .6 | 123,380 | |
| .7 | 106,272 | | .7 | 110,444 | | .7 | 114,701 | | .7 | 119,042 | | .7 | 123,469 | |
| .8 | 106,355 | | .8 | 110,528 | | .8 | 114,787 | | .8 | 119,130 | | .8 | 123,558 | |
| .9 | 106,438 | 83 | .9 | 110,612 | 84 | .9 | 114,873 | 86 | .9 | 119,218 | 88 | .9 | 123,647 | 89 |
| 1590.0 | 106,521 | | 1595.0 | 110,696 | | 1600.0 | 114,959 | | 1605.0 | 119,306 | | 1610.0 | 123,736 | |

Remarks:

Compiled by G.E.G.-J.W.H.
Checked by H.C.L.
Date Oct. 1963 (2)

TABLE 14

# TABLE NO. 14
## CAPACITY OF COUGAR RESERVOIR
### IN ACRE-FEET

Sheet 3 of 4

| El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1610.0 | 123,736 | 90 | 1615.0 | 128,261 | 91 | 1620.0 | 132,872 | 93 | 1625.0 | 137,583 | 95 | 1630.0 | 142,380 | 97 |
| .1 | 123,826 | | .1 | 128,352 | | .1 | 132,965 | | .1 | 137,678 | | .1 | 142,477 | |
| .2 | 123,916 | | .2 | 128,443 | | .2 | 133,058 | | .2 | 137,773 | | .2 | 142,574 | |
| .3 | 124,006 | | .3 | 128,534 | | .3 | 133,151 | | .3 | 137,868 | | .3 | 142,671 | |
| .4 | 124,096 | | .4 | 128,625 | 91 | .4 | 133,244 | 93 | .4 | 137,963 | | .4 | 142,768 | |
| .5 | 124,186 | | .5 | 128,716 | 92 | .5 | 133,337 | 94 | .5 | 138,058 | | .5 | 142,865 | |
| .6 | 124,276 | | .6 | 128,808 | | .6 | 133,431 | | .6 | 138,153 | | .6 | 142,962 | |
| .7 | 124,366 | | .7 | 128,900 | | .7 | 133,525 | | .7 | 138,248 | | .7 | 143,059 | |
| .8 | 124,456 | | .8 | 128,992 | | .8 | 133,619 | | .8 | 138,343 | | .8 | 143,156 | |
| .9 | 124,546 | | .9 | 129,084 | | .9 | 133,713 | | .9 | 138,438 | | .9 | 143,253 | |
| 1611.0 | 124,636 | | 1616.0 | 129,176 | | 1621.0 | 133,807 | | 1626.0 | 138,533 | | 1631.0 | 143,350 | |
| .1 | 124,726 | | .1 | 129,268 | | .1 | 133,901 | | .1 | 138,628 | | .1 | 143,447 | |
| .2 | 124,816 | | .2 | 129,360 | | .2 | 133,995 | | .2 | 138,723 | | .2 | 143,544 | |
| .3 | 124,906 | | .3 | 129,452 | | .3 | 134,089 | | .3 | 138,818 | | .3 | 143,641 | |
| .4 | 124,996 | | .4 | 129,544 | | .4 | 134,183 | | .4 | 138,913 | 95 | .4 | 143,738 | 97 |
| .5 | 125,086 | | .5 | 129,636 | | .5 | 134,277 | | .5 | 139,008 | 96 | .5 | 143,835 | 98 |
| .6 | 125,176 | | .6 | 129,728 | | .6 | 134,371 | | .6 | 139,104 | | .6 | 143,933 | |
| .7 | 125,266 | | .7 | 129,820 | | .7 | 134,465 | | .7 | 139,200 | | .7 | 144,031 | |
| .8 | 125,356 | | .8 | 129,912 | | .8 | 134,559 | | .8 | 139,296 | | .8 | 144,129 | |
| .9 | 125,446 | | .9 | 130,004 | | .9 | 134,653 | | .9 | 139,392 | | .9 | 144,227 | |
| 1612.0 | 125,536 | | 1617.0 | 130,096 | | 1622.0 | 134,747 | | 1627.0 | 139,488 | | 1632.0 | 144,325 | |
| .1 | 125,626 | | .1 | 130,188 | | .1 | 134,841 | | .1 | 139,584 | | .1 | 144,423 | |
| .2 | 125,716 | | .2 | 130,280 | | .2 | 134,935 | | .2 | 139,680 | | .2 | 144,521 | |
| .3 | 125,806 | | .3 | 130,372 | | .3 | 135,029 | | .3 | 139,776 | | .3 | 144,619 | |
| .4 | 125,896 | 90 | .4 | 130,464 | | .4 | 135,123 | | .4 | 139,872 | | .4 | 144,717 | |
| .5 | 125,986 | 91 | .5 | 130,556 | | .5 | 135,217 | | .5 | 139,968 | | .5 | 144,815 | |
| .6 | 126,077 | | .6 | 130,648 | | .6 | 135,311 | | .6 | 140,064 | | .6 | 144,913 | |
| .7 | 126,168 | | .7 | 130,740 | | .7 | 135,405 | | .7 | 140,160 | | .7 | 145,011 | |
| .8 | 126,259 | | .8 | 130,832 | | .8 | 135,499 | | .8 | 140,256 | | .8 | 145,109 | |
| .9 | 126,350 | | .9 | 130,924 | | .9 | 135,593 | | .9 | 140,352 | | .9 | 145,207 | |
| 1613.0 | 126,441 | | 1618.0 | 131,016 | | 1623.0 | 135,687 | | 1628.0 | 140,448 | | 1633.0 | 145,305 | |
| .1 | 126,532 | | .1 | 131,108 | | .1 | 135,781 | | .1 | 140,544 | | .1 | 145,403 | |
| .2 | 126,623 | | .2 | 131,200 | | .2 | 135,875 | | .2 | 140,640 | | .2 | 145,501 | |
| .3 | 126,714 | | .3 | 131,292 | 92 | .3 | 135,969 | 94 | .3 | 140,736 | | .3 | 145,599 | |
| .4 | 126,805 | | .4 | 131,384 | 93 | .4 | 136,063 | 95 | .4 | 140,832 | | .4 | 145,697 | |
| .5 | 126,896 | | .5 | 131,477 | | .5 | 136,158 | | .5 | 140,928 | | .5 | 145,795 | |
| .6 | 126,987 | | .6 | 131,570 | | .6 | 136,253 | | .6 | 141,024 | | .6 | 145,893 | |
| .7 | 127,078 | | .7 | 131,663 | | .7 | 136,348 | | .7 | 141,120 | | .7 | 145,991 | |
| .8 | 127,169 | | .8 | 131,756 | | .8 | 136,443 | | .8 | 141,216 | 96 | .8 | 146,089 | |
| .9 | 127,260 | | .9 | 131,849 | | .9 | 136,538 | | .9 | 141,313 | 97 | .9 | 146,187 | 98 |
| 1614.0 | 127,351 | | 1619.0 | 131,942 | | 1624.0 | 136,633 | | 1629.0 | 141,410 | | 1634.0 | 146,285 | 99 |
| .1 | 127,442 | | .1 | 132,035 | | .1 | 136,728 | | .1 | 141,507 | | .1 | 146,384 | |
| .2 | 127,533 | | .2 | 132,128 | | .2 | 136,823 | | .2 | 141,604 | | .2 | 146,483 | |
| .3 | 127,624 | | .3 | 132,221 | | .3 | 136,918 | | .3 | 141,701 | | .3 | 146,582 | |
| .4 | 127,715 | | .4 | 132,314 | | .4 | 137,013 | | .4 | 141,798 | | .4 | 146,681 | |
| .5 | 127,806 | | .5 | 132,407 | | .5 | 137,108 | | .5 | 141,895 | | .5 | 146,780 | |
| .6 | 127,897 | | .6 | 132,500 | | .6 | 137,203 | | .6 | 141,992 | | .6 | 146,879 | |
| .7 | 127,988 | | .7 | 132,593 | | .7 | 137,298 | | .7 | 142,089 | | .7 | 146,978 | |
| .8 | 128,079 | | .8 | 132,686 | | .8 | 137,393 | | .8 | 142,186 | | .8 | 147,077 | |
| .9 | 128,170 | | .9 | 132,779 | | .9 | 137,488 | | .9 | 142,283 | | .9 | 147,176 | |
| 1615.0 | 128,261 | 91 | 1620.0 | 132,872 | •93 | 1625.0 | 137,583 | 95 | 1630.0 | 142,380 | 97 | 1635.0 | 147,275 | 99 |

| El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1635.0 | 147,275 | 99 | 1640.0 | 152,264 | 101 | 1645.0 | 157,353 | 103 | 1650.0 | 162,538 | 105 | 1655.0 | 167,828 | 107 |
| .1 | 147,374 | | .1 | 152,365 | | .1 | 157,456 | | .1 | 162,643 | | .1 | 167,935 | |
| .2 | 147,473 | | .2 | 152,466 | | .2 | 157,559 | | .2 | 162,748 | | .2 | 168,042 | |
| .3 | 147,572 | | .3 | 152,567 | | .3 | 157,662 | | .3 | 162,853 | | .3 | 168,149 | |
| .4 | 147,671 | | .4 | 152,668 | | .4 | 157,765 | | .4 | 162,958 | | .4 | 168,256 | |
| .5 | 147,770 | | .5 | 152,769 | | .5 | 157,868 | | .5 | 163,063 | | .5 | 168,363 | |
| .6 | 147,869 | | .6 | 152,870 | | .6 | 157,971 | | .6 | 163,168 | | .6 | 168,470 | |
| .7 | 147,968 | | .7 | 152,971 | | .7 | 158,074 | | .7 | 163,273 | | .7 | 168,577 | |
| .8 | 148,067 | | .8 | 153,072 | | .8 | 158,177 | | .8 | 163,378 | | .8 | 168,684 | |
| .9 | 148,166 | | .9 | 153,173 | | .9 | 158,280 | | .9 | 163,483 | | .9 | 168,791 | |
| 1636.0 | 148,265 | | 1641.0 | 153,274 | | 1646.0 | 158,383 | | 1651.0 | 163,588 | | 1656.0 | 168,898 | |
| .1 | 148,364 | | .1 | 153,375 | | .1 | 158,486 | | .1 | 163,693 | | .1 | 169,005 | |
| .2 | 148,463 | | .2 | 153,476 | | .2 | 158,589 | | .2 | 163,798 | | .2 | 169,112 | |
| .3 | 148,562 | | .3 | 153,577 | | .3 | 158,692 | | .3 | 163,903 | | .3 | 169,219 | |
| .4 | 148,661 | | .4 | 153,678 | | .4 | 158,795 | | .4 | 164,008 | | .4 | 169,326 | |
| .5 | 148,760 | | .5 | 153,779 | 101 | .5 | 158,898 | | .5 | 164,113 | | .5 | 169,433 | |
| .6 | 148,859 | | .6 | 153,880 | 102 | .6 | 159,001 | | .6 | 164,218 | | .6 | 169,540 | |
| .7 | 148,958 | 99 | .7 | 153,982 | | .7 | 159,104 | | .7 | 164,323 | | .7 | 169,647 | |
| .8 | 149,058 | 100 | .8 | 154,084 | | .8 | 159,207 | | .8 | 164,428 | | .8 | 169,754 | |
| .9 | 149,158 | | .9 | 154,186 | | .9 | 159,310 | | .9 | 164,533 | 105 | .9 | 169,861 | 107 |
| 1637.0 | 149,258 | | 1642.0 | 154,288 | | 1647.0 | 159,413 | | 1652.0 | 164,638 | 106 | 1657.0 | 169,968 | 108 |
| .1 | 149,358 | | .1 | 154,390 | | .1 | 159,516 | 103 | .1 | 164,744 | | .1 | 170,076 | |
| .2 | 149,458 | | .2 | 154,492 | | .2 | 159,619 | 104 | .2 | 164,850 | | .2 | 170,184 | |
| .3 | 149,558 | | .3 | 154,594 | | .3 | 159,723 | | .3 | 164,956 | | .3 | 170,292 | |
| .4 | 149,658 | | .4 | 154,696 | | .4 | 159,827 | | .4 | 165,062 | | .4 | 170,400 | |
| .5 | 149,758 | | .5 | 154,798 | | .5 | 159,931 | | .5 | 165,168 | | .5 | 170,508 | |
| .6 | 149,858 | | .6 | 154,900 | | .6 | 160,035 | | .6 | 165,274 | | .6 | 170,616 | |
| .7 | 149,958 | | .7 | 155,002 | | .7 | 160,139 | | .7 | 165,380 | | .7 | 170,724 | |
| .8 | 150,058 | | .8 | 155,104 | | .8 | 160,243 | | .8 | 165,486 | | .8 | 170,832 | |
| .9 | 150,158 | | .9 | 155,206 | | .9 | 160,347 | | .9 | 165,592 | | .9 | 170,940 | |
| 1638.0 | 150,258 | | 1643.0 | 155,308 | | 1648.0 | 160,451 | | 1653.0 | 165,698 | | 1658.0 | 171,048 | |
| .1 | 150,358 | | .1 | 155,410 | | .1 | 160,555 | | .1 | 165,804 | | .1 | 171,156 | |
| .2 | 150,458 | | .2 | 155,512 | | .2 | 160,659 | | .2 | 165,910 | | .2 | 171,264 | |
| .3 | 150,558 | | .3 | 155,614 | | .3 | 160,763 | | .3 | 166,016 | | .3 | 171,372 | |
| .4 | 150,658 | | .4 | 155,716 | | .4 | 160,867 | | .4 | 166,122 | | .4 | 171,480 | |
| .5 | 150,758 | | .5 | 155,818 | | .5 | 160,971 | | .5 | 166,228 | | .5 | 171,588 | |
| .6 | 150,858 | | .6 | 155,920 | | .6 | 161,075 | | .6 | 166,334 | | .6 | 171,696 | |
| .7 | 150,958 | | .7 | 156,022 | | .7 | 161,179 | | .7 | 166,440 | | .7 | 171,804 | |
| .8 | 151,058 | | .8 | 156,124 | | .8 | 161,283 | | .8 | 166,546 | | .8 | 171,912 | |
| .9 | 151,158 | | .9 | 156,226 | | .9 | 161,387 | | .9 | 166,652 | 106 | .9 | 172,020 | 108 |
| 1639.0 | 151,258 | | 1644.0 | 156,328 | | 1649.0 | 161,491 | | 1654.0 | 166,758 | 107 | 1659.0 | 172,128 | 109 |
| .1 | 151,358 | | .1 | 156,430 | | .1 | 161,595 | | .1 | 166,865 | | .1 | 172,237 | |
| .2 | 151,458 | | .2 | 156,532 | | .2 | 161,699 | 104 | .2 | 166,972 | | .2 | 172,346 | |
| .3 | 151,558 | 100 | .3 | 156,634 | | .3 | 161,803 | 105 | .3 | 167,079 | | .3 | 172,455 | |
| .4 | 151,658 | 101 | .4 | 156,736 | 102 | .4 | 161,908 | | .4 | 167,186 | | .4 | 172,564 | |
| .5 | 151,759 | | .5 | 156,838 | 103 | .5 | 162,013 | | .5 | 167,293 | | .5 | 172,673 | |
| .6 | 151,860 | | .6 | 156,941 | | .6 | 162,118 | | .6 | 167,400 | | .6 | 172,782 | |
| .7 | 151,961 | | .7 | 157,044 | | .7 | 162,223 | | .7 | 167,507 | | .7 | 172,891 | |
| .8 | 152,062 | | .8 | 157,147 | | .8 | 162,328 | | .8 | 167,614 | | .8 | 173,000 | |
| .9 | 152,163 | | .9 | 157,250 | | .9 | 162,433 | | .9 | 167,721 | | .9 | 173,109 | |
| 1640.0 | 152,264 | 101 | 1645.0 | 157,353 | 103 | 1650.0 | 162,538 | 105 | 1655.0 | 167,828 | 107 | 1660.0 | 173,218 | 109 |

Remarks:

Compiled by G.E.G. - J.W.H.
Checked by H.C.L.
Date Oct. 1963 (3)

TABLE NO. 14
CAPACITY OF COUGAR RESERVOIR
IN ACRE-FEET

Sheet 4 of 4

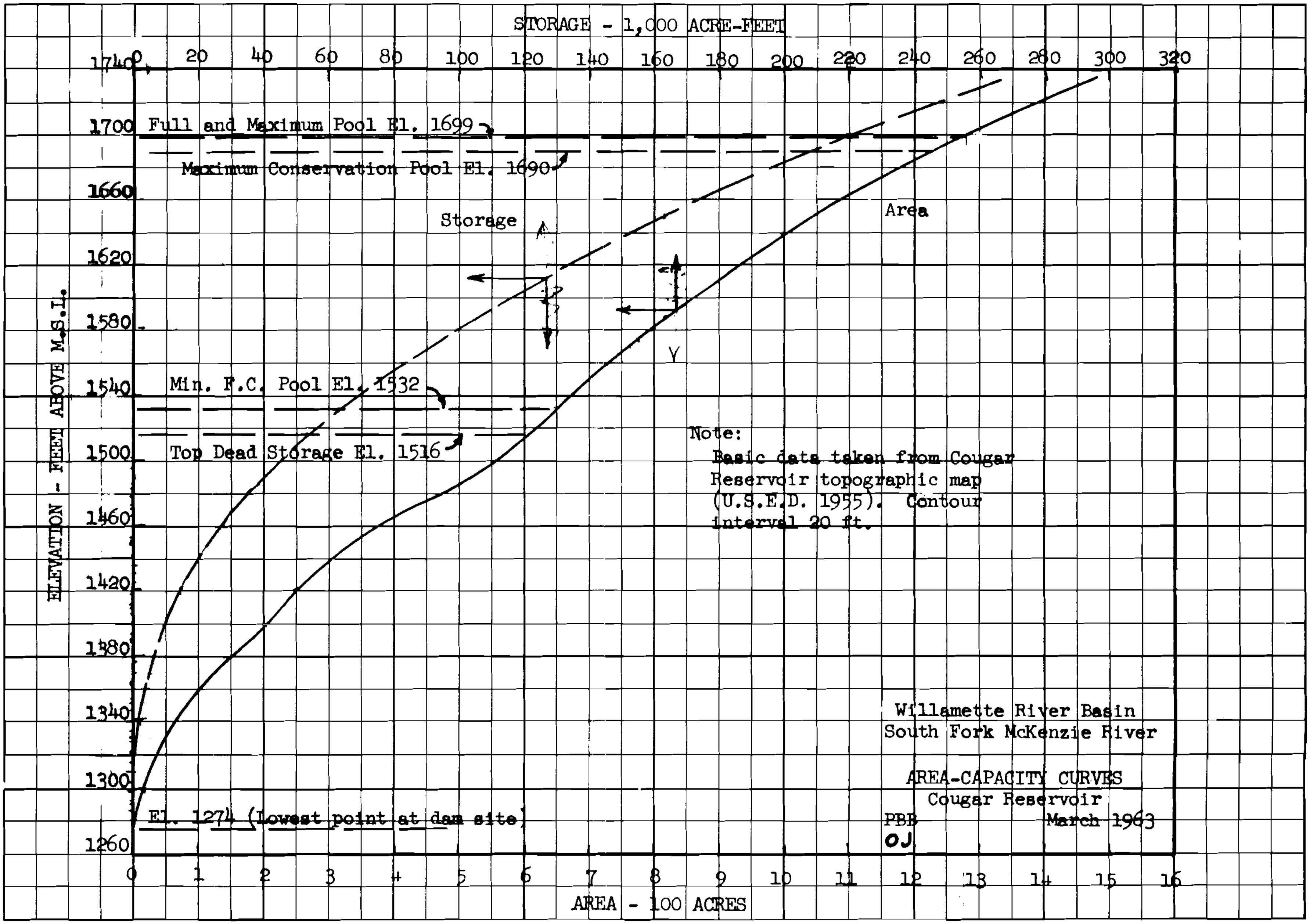
| El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. |
|---|---|---|---|---|---|---|---|---|
| 1660.0 | 173,218 | 109 | 1665.0 | 178,718 | 111 | 1670.0 | 184,335 | 113 |
| .1 | 173,327 | | .1 | 178,829 | | .1 | 184,448 | |
| .2 | 173,436 | | .2 | 178,940 | | .2 | 184,561 | |
| .3 | 173,545 | | .3 | 179,051 | | .3 | 184,674 | |
| .4 | 173,654 | | .4 | 179,162 | | .4 | 184,787 | 113 |
| .5 | 173,763 | | .5 | 179,273 | | .5 | 184,900 | 114 |
| .6 | 173,872 | | .6 | 179,384 | | .6 | 185,014 | |
| .7 | 173,981 | | .7 | 179,495 | 111 | .7 | 185,128 | |
| .8 | 174,090 | | .8 | 179,606 | 112 | .8 | 185,242 | |
| .9 | 174,199 | 109 | .9 | 179,718 | | .9 | 185,356 | |
| 1661.0 | 174,308 | 110 | 1666.0 | 179,830 | | 1671.0 | 185,470 | |
| .1 | 174,418 | | .1 | 179,942 | | .1 | 185,584 | |
| .2 | 174,528 | | .2 | 180,054 | | .2 | 185,698 | |
| .3 | 174,638 | | .3 | 180,166 | | .3 | 185,812 | |
| .4 | 174,748 | | .4 | 180,278 | | .4 | 185,926 | |
| .5 | 174,858 | | .5 | 180,390 | | .5 | 186,040 | |
| .6 | 174,968 | | .6 | 180,502 | | .6 | 186,154 | |
| .7 | 175,078 | | .7 | 180,614 | | .7 | 186,268 | |
| .8 | 175,188 | | .8 | 180,726 | | .8 | 186,382 | |
| .9 | 175,298 | | .9 | 180,838 | | .9 | 186,496 | |
| 1662.0 | 175,408 | | 1667.0 | 180,950 | | 1672.0 | 186,610 | |
| .1 | 175,518 | | .1 | 181,062 | | .1 | 186,724 | |
| .2 | 175,628 | | .2 | 181,174 | | .2 | 186,838 | 114 |
| .3 | 175,738 | | .3 | 181,286 | | .3 | 186,952 | 115 |
| .4 | 175,848 | | .4 | 181,398 | 112 | .4 | 187,067 | |
| .5 | 175,958 | | .5 | 181,510 | 113 | .5 | 187,182 | |
| .6 | 176,068 | | .6 | 181,623 | | .6 | 187,297 | |
| .7 | 176,178 | | .7 | 181,736 | | .7 | 187,412 | |
| .8 | 176,288 | | .8 | 181,849 | | .8 | 187,527 | |
| .9 | 176,398 | | .9 | 181,962 | | .9 | 187,642 | |
| 1663.0 | 176,508 | | 1668.0 | 182,075 | | 1673.0 | 187,757 | |
| .1 | 176,618 | | .1 | 182,188 | | .1 | 187,872 | |
| .2 | 176,728 | | .2 | 182,301 | | .2 | 187,987 | |
| .3 | 176,838 | | .3 | 182,414 | | .3 | 188,102 | |
| .4 | 176,948 | | .4 | 182,527 | | .4 | 188,217 | |
| .5 | 177,058 | | .5 | 182,640 | | .5 | 188,332 | |
| .6 | 177,168 | | .6 | 182,753 | | .6 | 188,447 | |
| .7 | 177,278 | | .7 | 182,866 | | .7 | 188,562 | |
| .8 | 177,388 | | .8 | 182,979 | | .8 | 188,677 | |
| .9 | 177,498 | 110 | .9 | 183,092 | | .9 | 188,792 | |
| 1664.0 | 177,608 | 111 | 1669.0 | 183,205 | | 1674.0 | 188,907 | |
| .1 | 177,719 | | .1 | 183,318 | | .1 | 189,022 | |
| .2 | 177,830 | | .2 | 183,431 | | .2 | 189,137 | |
| .3 | 177,941 | | .3 | 183,544 | | .3 | 189,252 | |
| .4 | 178,052 | | .4 | 183,657 | | .4 | 189,367 | 115 |
| .5 | 178,163 | | .5 | 183,770 | | .5 | 189,482 | 116 |
| .6 | 178,274 | | .6 | 183,883 | | .6 | 189,598 | |
| .7 | 178,385 | | .7 | 183,996 | | .7 | 189,714 | |
| .8 | 178,496 | | .8 | 184,109 | | .8 | 189,830 | |
| .9 | 178,607 | | .9 | 184,222 | | .9 | 189,946 | |
| 1665.0 | 178,718 | 111 | 1670.0 | 184,335 | 113 | 1675.0 | 190,062 | 116 |

| El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. |
|---|---|---|---|---|---|---|---|---|
| 1675.0 | 190,062 | 116 | 1680.0 | 195,910 | 118 | 1685.0 | 201,875 | 121 |
| .1 | 190,178 | | .1 | 196,028 | | .1 | 201,996 | |
| .2 | 190,294 | | .2 | 196,146 | | .2 | 202,117 | |
| .3 | 190,410 | | .3 | 196,264 | | .3 | 202,238 | |
| .4 | 190,526 | | .4 | 196,382 | | .4 | 202,359 | |
| .5 | 190,642 | | .5 | 196,500 | | .5 | 202,480 | |
| .6 | 190,758 | | .6 | 196,618 | | .6 | 202,601 | |
| .7 | 190,874 | | .7 | 196,736 | 118 | .7 | 202,722 | |
| .8 | 190,990 | | .8 | 196,854 | 119 | .8 | 202,843 | |
| .9 | 191,106 | | .9 | 196,973 | | .9 | 202,964 | |
| 1676.0 | 191,222 | | 1681.0 | 197,092 | | 1686.0 | 203,085 | |
| .1 | 191,338 | | .1 | 197,211 | | .1 | 203,206 | |
| .2 | 191,454 | | .2 | 197,330 | | .2 | 203,327 | |
| .3 | 191,570 | | .3 | 197,449 | | .3 | 203,448 | |
| .4 | 191,686 | 116 | .4 | 197,568 | | .4 | 203,569 | |
| .5 | 191,802 | 117 | .5 | 197,687 | | .5 | 203,690 | |
| .6 | 191,919 | | .6 | 197,806 | | .6 | 203,811 | 121 |
| .7 | 192,036 | | .7 | 197,925 | | .7 | 203,932 | 122 |
| .8 | 192,153 | | .8 | 198,044 | | .8 | 204,054 | |
| .9 | 192,270 | | .9 | 198,163 | | .9 | 204,176 | |
| 1677.0 | 192,387 | | 1682.0 | 198,282 | | 1687.0 | 204,298 | |
| .1 | 192,504 | | .1 | 198,401 | | .1 | 204,420 | |
| .2 | 192,621 | | .2 | 198,520 | | .2 | 204,542 | |
| .3 | 192,738 | | .3 | 198,639 | | .3 | 204,664 | |
| .4 | 192,855 | | .4 | 198,758 | | .4 | 204,786 | |
| .5 | 192,972 | | .5 | 198,877 | | .5 | 204,908 | |
| .6 | 193,089 | | .6 | 198,996 | 119 | .6 | 205,030 | |
| .7 | 193,206 | | .7 | 199,115 | 120 | .7 | 205,152 | |
| .8 | 193,323 | | .8 | 199,235 | | .8 | 205,274 | |
| .9 | 193,440 | | .9 | 199,355 | | .9 | 205,396 | |
| 1678.0 | 193,557 | | 1683.0 | 199,475 | | 1688.0 | 205,518 | |
| .1 | 193,674 | | .1 | 199,595 | | .1 | 205,640 | |
| .2 | 193,791 | | .2 | 199,715 | | .2 | 205,762 | |
| .3 | 193,908 | | .3 | 199,835 | | .3 | 205,884 | |
| .4 | 194,025 | | .4 | 199,955 | | .4 | 206,006 | |
| .5 | 194,142 | | .5 | 200,075 | | .5 | 206,128 | |
| .6 | 194,259 | 117 | .6 | 200,195 | | .6 | 206,250 | |
| .7 | 194,376 | 118 | .7 | 200,315 | | .7 | 206,372 | 122 |
| .8 | 194,494 | | .8 | 200,435 | | .8 | 206,494 | 123 |
| .9 | 194,612 | | .9 | 200,555 | | .9 | 206,617 | |
| 1679.0 | 194,730 | | 1684.0 | 200,675 | | 1689.0 | 206,740 | |
| .1 | 194,848 | | .1 | 200,795 | | .1 | 206,863 | |
| .2 | 194,966 | | .2 | 200,915 | | .2 | 206,986 | |
| .3 | 195,084 | | .3 | 201,035 | | .3 | 207,109 | |
| .4 | 195,202 | | .4 | 201,155 | | .4 | 207,232 | |
| .5 | 195,320 | | .5 | 201,275 | | .5 | 207,355 | |
| .6 | 195,438 | | .6 | 201,395 | | .6 | 207,478 | |
| .7 | 195,556 | | .7 | 201,515 | | .7 | 207,601 | |
| .8 | 195,674 | | .8 | 201,635 | | .8 | 207,724 | |
| .9 | 195,792 | | .9 | 201,755 | | .9 | 207,847 | |
| 1680.0 | 195,910 | 118 | 1685.0 | 201,875 | 120 | 1690.0 | 207,970 | 123 |

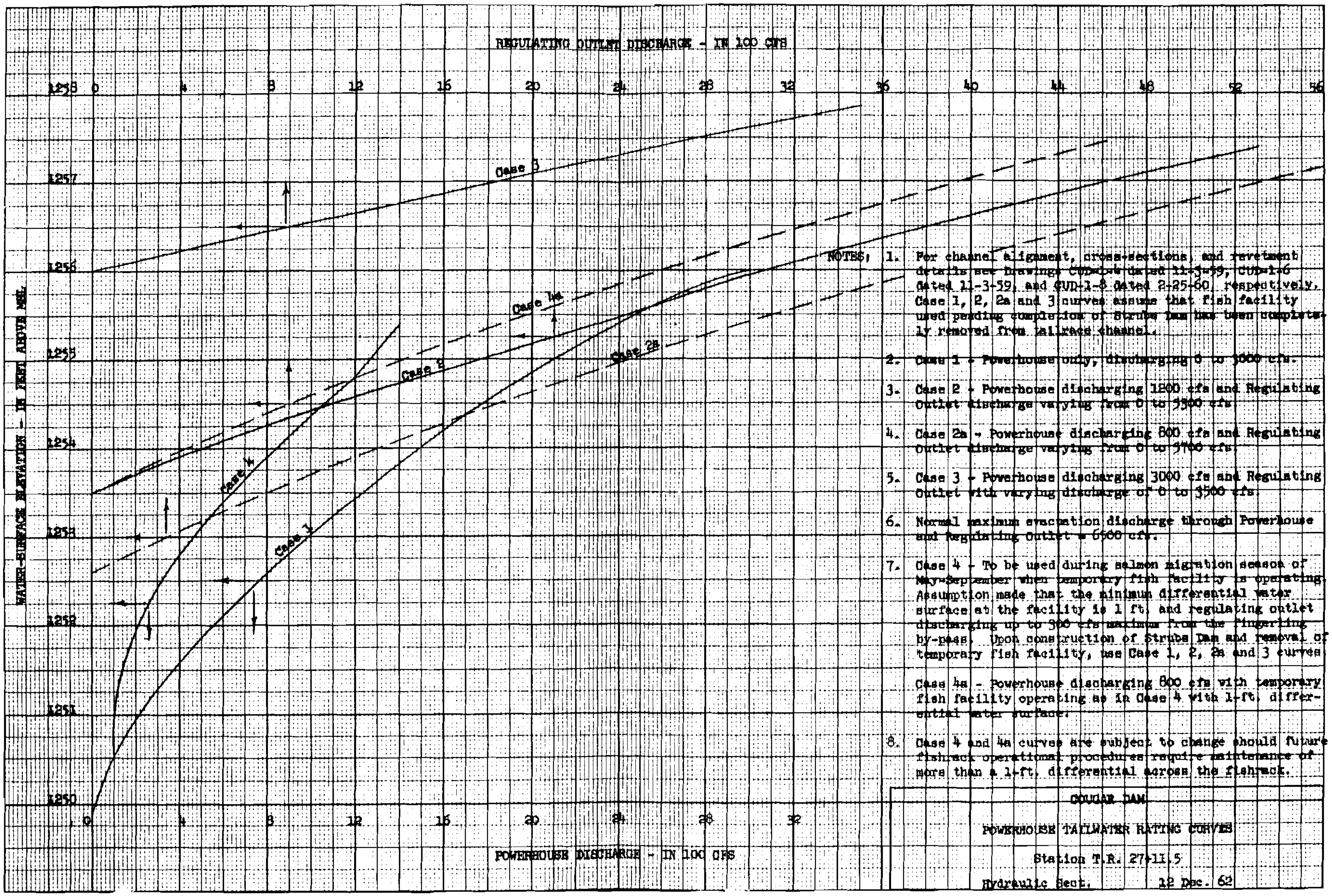
| El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. | El. in ft. | Capacity | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1690.0 | 207,970 | 123 | 1695.0 | 214,193 | 126 | 1700.0 | 220,554 | 129 | | | |
| .1 | 208,093 | | .1 | 214,319 | | .1 | 220,683 | | | | |
| .2 | 208,216 | | .2 | 214,445 | | .2 | 220,812 | | | | |
| .3 | 208,339 | | .3 | 214,571 | | .3 | 220,941 | | | | |
| .4 | 208,462 | | .4 | 214,697 | | .4 | 221,070 | | | | |
| .5 | 208,585 | | .5 | 214,823 | | .5 | 221,199 | | | | |
| .6 | 208,708 | 123 | .6 | 214,949 | | .6 | 221,328 | | | | |
| .7 | 208,831 | 124 | .7 | 215,075 | | .7 | 221,457 | | | | |
| .8 | 208,955 | | .8 | 215,201 | | .8 | 221,586 | | | | |
| .9 | 209,079 | | .9 | 215,327 | | .9 | 221,715 | | | | |
| 1691.0 | 209,203 | | 1696.0 | 215,453 | | 1701.0 | 221,844 | | | | |
| .1 | 209,327 | | .1 | 215,579 | 126 | .1 | 221,973 | | | | |
| .2 | 209,451 | | .2 | 215,705 | 127 | .2 | 222,102 | | | | |
| .3 | 209,575 | | .3 | 215,832 | | .3 | 222,231 | | | | |
| .4 | 209,699 | | .4 | 215,959 | | .4 | 222,360 | | | | |
| .5 | 209,823 | | .5 | 216,086 | | .5 | 222,489 | | | | |
| .6 | 209,947 | | .6 | 216,213 | | .6 | 222,618 | 129 | | | |
| .7 | 210,071 | | .7 | 216,340 | | .7 | 222,747 | 130 | | | |
| .8 | 210,195 | | .8 | 216,467 | | .8 | 222,877 | | | | |
| .9 | 210,319 | | .9 | 216,594 | | .9 | 223,007 | | | | |
| 1692.0 | 210,443 | | 1697.0 | 216,721 | | 1702.0 | 223,137 | | | | |
| .1 | 210,567 | | .1 | 216,848 | | .1 | 223,267 | | | | |
| .2 | 210,691 | | .2 | 216,975 | | .2 | 223,397 | | | | |
| .3 | 210,815 | | .3 | 217,102 | | .3 | 223,527 | | | | |
| .4 | 210,939 | | .4 | 217,229 | | .4 | 223,657 | | | | |
| .5 | 211,063 | 124 | .5 | 217,356 | | .5 | 223,787 | | | | |
| .6 | 211,187 | 125 | .6 | 217,483 | | .6 | 223,917 | | | | |
| .7 | 211,312 | | .7 | 217,610 | 127 | .7 | 224,047 | | | | |
| .8 | 211,437 | | .8 | 217,737 | 128 | .8 | 224,177 | | | | |
| .9 | 211,562 | | .9 | 217,865 | | .9 | 224,307 | | | | |
| 1693.0 | 211,687 | | 1698.0 | 217,993 | | 1703.0 | 224,437 | | | | |
| .1 | 211,812 | | .1 | 218,121 | | .1 | 224,567 | | | | |
| .2 | 211,937 | | .2 | 218,249 | | .2 | 224,697 | | | | |
| .3 | 212,062 | | .3 | 218,377 | | .3 | 224,827 | | | | |
| .4 | 212,187 | | .4 | 218,505 | | .4 | 224,957 | 130 | | | |
| .5 | 212,312 | | .5 | 218,633 | | .5 | 225,087 | 131 | | | |
| .6 | 212,437 | | .6 | 218,761 | | .6 | 225,218 | | | | |
| .7 | 212,562 | | .7 | 218,889 | | .7 | 225,349 | | | | |
| .8 | 212,687 | | .8 | 219,017 | | .8 | 225,480 | | | | |
| .9 | 212,812 | | .9 | 219,145 | | .9 | 225,611 | | | | |
| 1694.0 | 212,937 | | 1699.0 | 219,273 | | 1704.0 | 225,742 | | | | |
| .1 | 213,062 | | .1 | 219,401 | | .1 | 225,873 | | | | |
| .2 | 213,187 | | .2 | 219,529 | | .2 | 226,004 | | | | |
| .3 | 213,312 | 125 | .3 | 219,657 | | .3 | 226,135 | | | | |
| .4 | 213,437 | 126 | .4 | 219,785 | | .4 | 226,266 | | | | |
| .5 | 213,563 | | .5 | 219,913 | | .5 | 226,397 | | | | |
| .6 | 213,689 | | .6 | 220,041 | | .6 | 226,528 | | | | |
| .7 | 213,815 | | .7 | 220,169 | | .7 | 226,659 | | | | |
| .8 | 213,941 | | .8 | 220,297 | 128 | .8 | 226,790 | | | | |
| .9 | 214,067 | | .9 | 220,425 | 129 | .9 | 226,921 | | | | |
| 1695.0 | 214,193 | 126 | 1700.0 | 220,554 | | 1705.0 | 227,052 | 131 | | | |

Remarks:

Compiled by G.E.G. - J.W.H.
Checked by H.C.L.
Date Oct. 1963 (4)



STORAGE - 1,000 ACRE-FEET
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
1740
1700
1660
1620
1580
1540
1500
1460
1420
1380
1340
1300
1260
ELEVATION - FEET ABOVE M.S.L.
Full and Maximum Pool El. 1699
Maximum Conservation Pool El. 1690
Storage
Area
Min. F.C. Pool El. 1532
Top Dead Storage El. 1516
Note:
Basic data taken from Cougar Reservoir topographic map (U.S.E.D. 1955). Contour interval 20 ft.
El. 1274 (Lowest point at dam site)
Willamette River Basin
South Fork McKenzie River
AREA-CAPACITY CURVES
Cougar Reservoir
PBB
OJ
March 1963
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
AREA - 100 ACRES




NOTES:

1. For channel alignment, cross-sections, and revetment details see Drawings CUD-1-4 dated 11-3-59, CUD-1-6 dated 11-3-59, and CUD-1-8 dated 2-25-60, respectively. Case 1, 2, 2a and 3 curves assume that fish facility used pending completion of Strube Dam has been completely removed from tailrace channel.
2. Case 1 - Powerhouse only, discharging 0 to 3000 cfs.
3. Case 2 - Powerhouse discharging 1200 cfs and Regulating Outlet discharge varying from 0 to 3300 cfs.
4. Case 2a - Powerhouse discharging 800 cfs and Regulating Outlet discharge varying from 0 to 3700 cfs.
5. Case 3 - Powerhouse discharging 3000 cfs and Regulating Outlet with varying discharge of 0 to 3500 cfs.
6. Normal maximum evacuation discharge through Powerhouse and Regulating Outlet = 6500 cfs.
7. Case 4 - To be used during salmon migration season of May-September when temporary fish facility is operating. Assumption made that the minimum differential water surface at the facility is 1 ft, and regulating outlet discharging up to 300 cfs maximum from the fingerling by-pass. Upon construction of Strube Dam and removal of temporary fish facility, use Case 1, 2, 2a and 3 curves.

   Case 4a - Powerhouse discharging 800 cfs with temporary fish facility operating as in Case 4 with 1-ft. differential water surface.
8. Case 4 and 4a curves are subject to change should future fishrack operational procedures require maintenance of more than a 1-ft. differential across the fishrack.

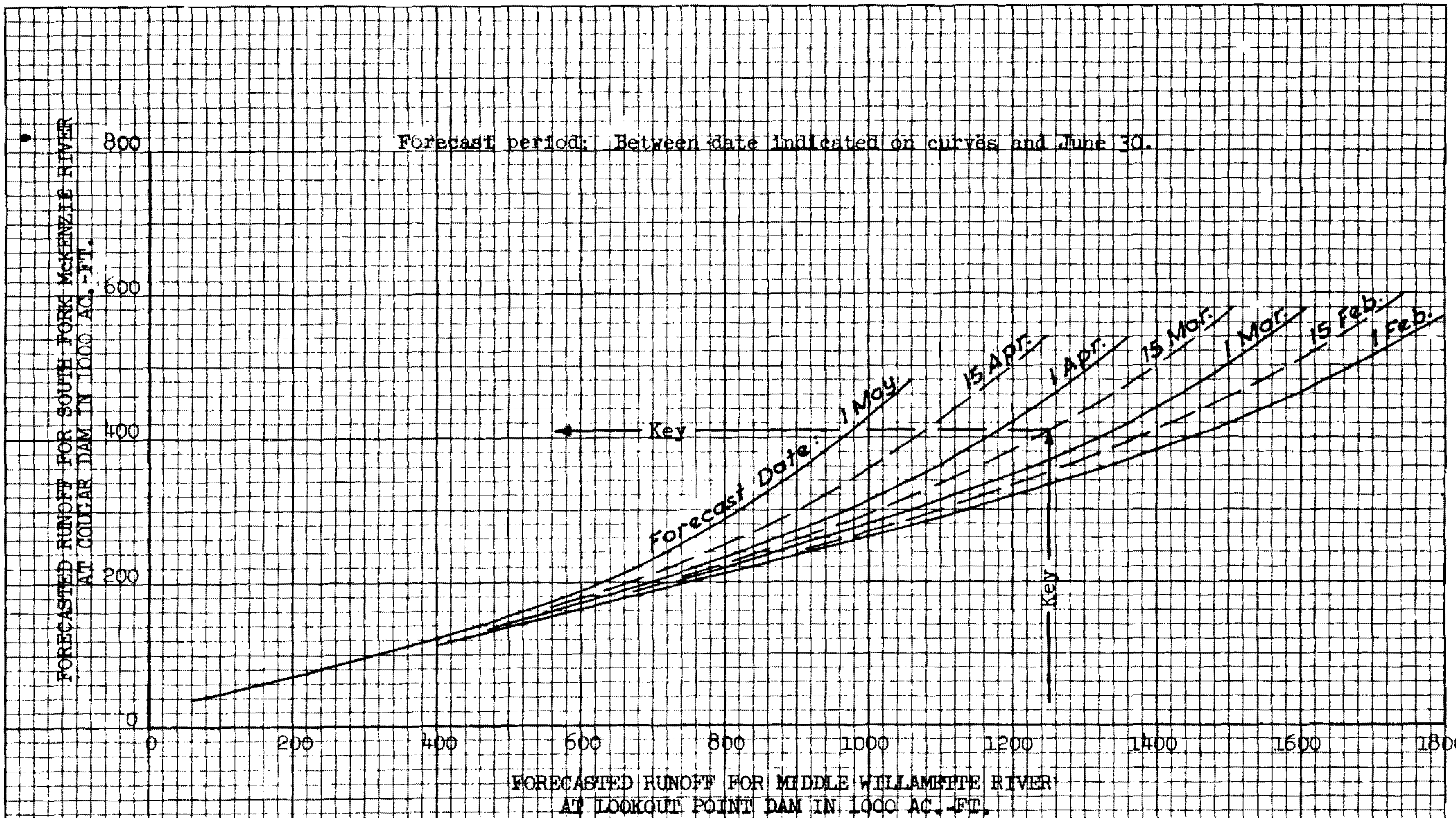
COUGAR DAM

POWERHOUSE TAILWATER RATING CURVES

Station T.R. 27+11.5

Hydraulic Sect. 12 Dec. 62

CU-20-16/14 CHART 8




Note: Chart prepared from observed runoffs beginning with the indicated date of forecast through 30 June for years 1949 through 1961. Enter chart with the forecasted runoff for Lookout Point Dam to determine the corresponding forecast for Cougar Dam.

Willamette River Basin
South Fork McKenzie River

SEASONAL RUNOFF FORECAST
Cougar Reservoir

Drainage Area = 208 Square Miles
SM 20 April 1963

CHART 9

CORPS OF ENGINEERS, U. S. ARMY PORTLAND, OREGON DISTRICT

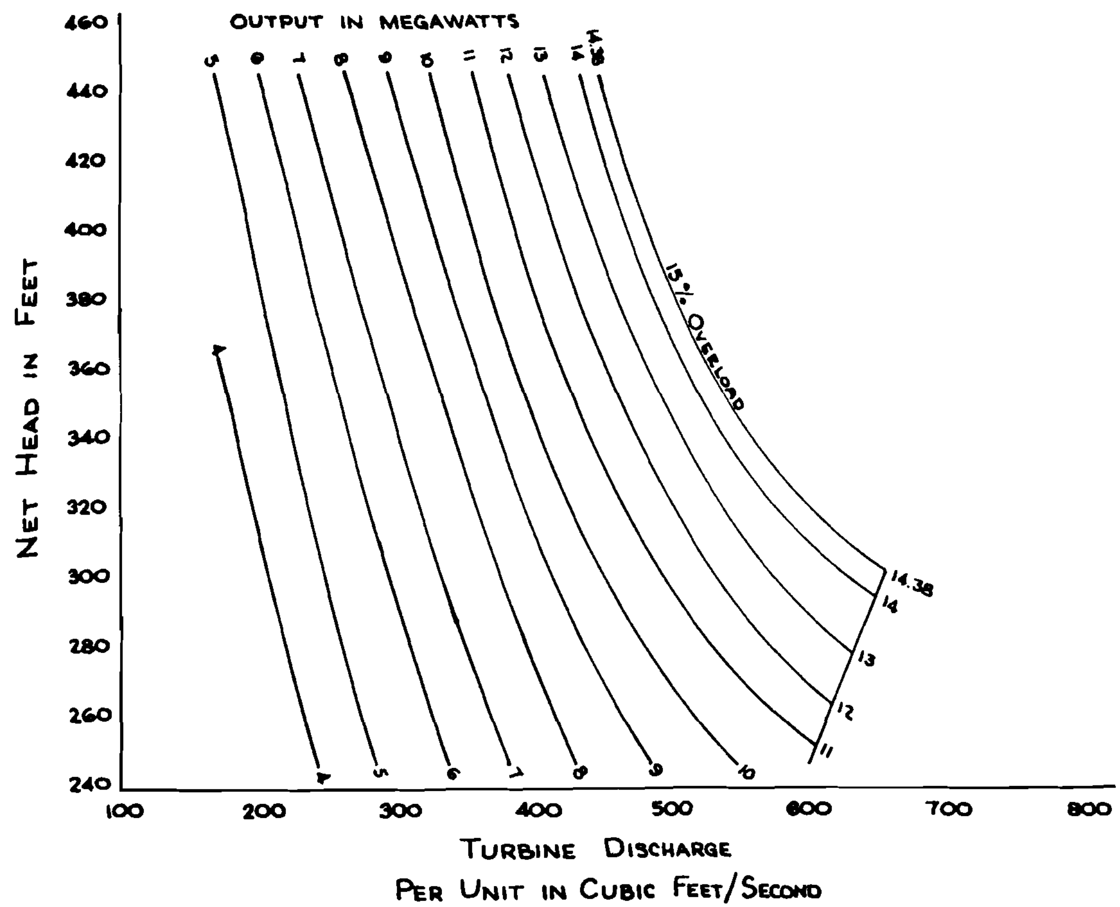
ENGINEERING DIV. PLANNING BRANCH PROJECT PLAN. SECTION

PROJECT Cougar Reservoir

SUBJECT Preliminary Operation Curves

BY R.M.S. DATE 25 Oct 60 CHECKED PART PAGE OF

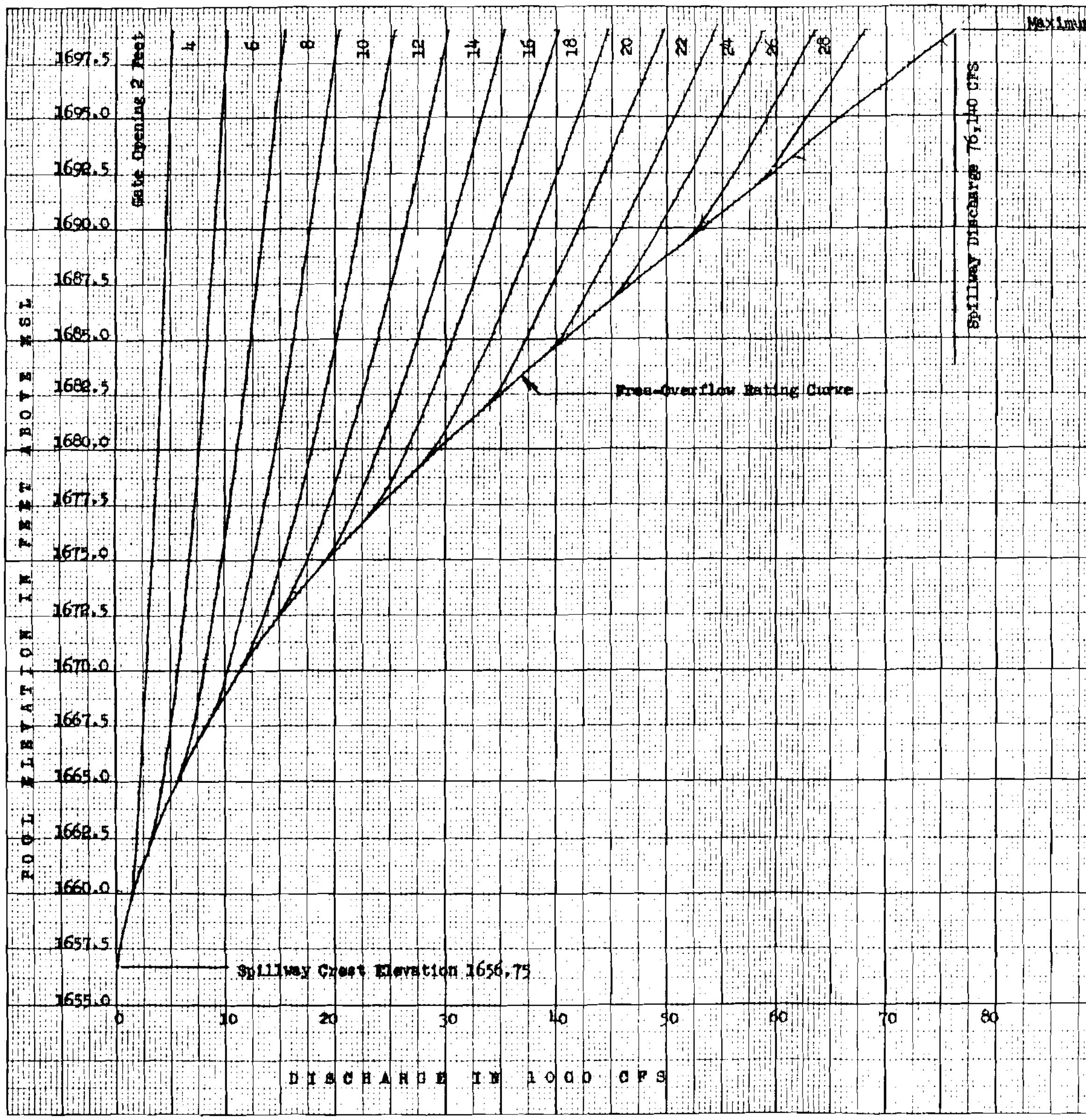
NOTE:
BASED ON MANUFACTURER'S EXPECTED PERFORMANCE CURVES




COUGAR RESERVOIR
OPERATION CURVES

Army-Port. Dist., Oreg
NPP Form 118 b DEC - 49

CU-20-16/16 CHART 10




NOTES

1. Gate opening is the vertical distance in feet between the gate lip and gate seat.
2. Pool elevation is the elevation of the reservoir pool U/S of the excavated spillway approach channel (may be obtained at the regulating outlet intake tower still-well or staff gage).

COUGAR RESERVOIR

SPILLWAY DISCHARGE RATING CURVE

2-BAY OPERATION

Design Branch — Hydraulic Section
WB3 — 23 July 1963

NPPEN-PP-2 No. ________

SUBJECT: Confirmation of Reservoir Regulation / Power Operation instructions.

TO:

THROUGH: Multiple Purpose Projects Branch, Operations Division

1. This is to confirm oral instructions from ____________________

to ________________________________________ at ____________ PST

__________________________, regarding operation of the reservoir(s)

indicated below:

| | | | |
|---|---|---|---|
| ( ) Fern Ridge | ( ) Dorena | ( ) Detroit | ( ) Lookout Point |
| ( ) Cottage Grove | ( ) Cougar | ( ) Big Cliff | ( ) Dexter |
| | | | ( ) Hills Creek |

2. The following instructions were issued:

Chief, Engineering Division

NPP FL 54
~~JUL 63~~

CHART 12

*(Letter of Transmittal Unnecessary)*

**To: Reservoir Regulation Subsection,**
**Operations Division**

# COUGAR PROJECT DAILY HYDROMETEOROLOGICAL & POWER DATA

RCS NPPEN-PP-42(R2)

Called in by: ____________ Received by: ____________ Time: ________ Date: ____________

| TIME | COUGAR | | | | | | | STREAM & PRECIPITATION DATA | | | | | | | TIME |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | GENERATION M.W. | | | DISCHARGE | | ELEVATION | | S.F. McKENZIE U/S | | S.F. McKENZIE D/S | | COBURG | | POWER HOUSE | |
| | UNIT 1 | UNIT 2 | TOTAL | TURBINES C.F.S. | GATES C.F.S. | POOL FT. | T. W. FT. | GAGE FT. | DISCHARGE C.F.S. | GAGE FT. | DISCHARGE C.F.S. | GAGE FT. | DISCHARGE C.F.S. | Precip. Inches | |
| 01 | | | | | | | | | | | | | | | 01 |
| 02 | | | | | | | | | | | | | | | 02 |
| 03 | | | | | | | | | | | | | | | 03 |
| 04 | | | | | | | | | | | | | | | 04 |
| 05 | | | | | | | | | | | | | | | 05 |
| 06 | | | | | | | | | | | | | | | 06 |
| 07 | | | | | | | | | | | | | | | 07 |
| 08 | | | | | | | | | | | | | | | 08 |
| 09 | | | | | | | | | | | | | | | 09 |
| 10 | | | | | | | | | | | | | | | 10 |
| 11 | | | | | | | | | | | | | | | 11 |
| 12 | | | | | | | | | | | | | | | 12 |
| 13 | | | | | | | | | | | | | | | 13 |
| 14 | | | | | | | | | | | | | | | 14 |
| 15 | | | | | | | | | | | | | | | 15 |
| 16 | | | | | | | | | | | | | | | 16 |
| 17 | | | | | | | | | | | | | | | 17 |
| 18 | | | | | | | | | | | | | | | 18 |
| 19 | | | | | | | | | | | | | | | 19 |
| 20 | | | | | | | | | | | | | | | 20 |
| 21 | | | | | | | | | | | | | | | 21 |
| 22 | | | | | | | | | | | | | | | 22 |
| 23 | | | | | | | | | | | | | | | 23 |
| 24 | | | | | | | | | | | | | | | 24 |
| Totals | | | | | | | | | | | | | | | Totals |
| Means | | | | | | | | | | | | | | | Means |
| Sta. Serv. | | | | | | | | | | | | | | | |

## OBSERVED STREAM DATA

| STATION | TIME | TAPE | CHART | STAFF | P. H. | PEAK & TIME |
|---|---|---|---|---|---|---|
| S.F. McK. U/S | | | | | | |
| S.F. McK. D/S | | | | | | |
| Coburg | | | | | | |

## HYDROMETEOROLOGICAL DATA

| Temperature | | | Current Weather | Curr. Wind | Hum. Low | Precipitation | |
|---|---|---|---|---|---|---|---|
| Max. | Min. | Curr. | | | | Sta. | P.H. |
| | | | | | | | |
| Evap. | | Diff. | | Net Head | | | |
| Anem. | | Diff. | | | | | |

NPP Form 34e Nov. 1963 (Translucent)

## COUGAR GATE SETTINGS

| TIME | Gate | Feet | TIME | Gate | Feet | TIME | Gate | Feet |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
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| | | | | | | | | |
| | | | | | | | | |

O - OUTLET S - SPILLWAY

## MID. TO MID. DATA

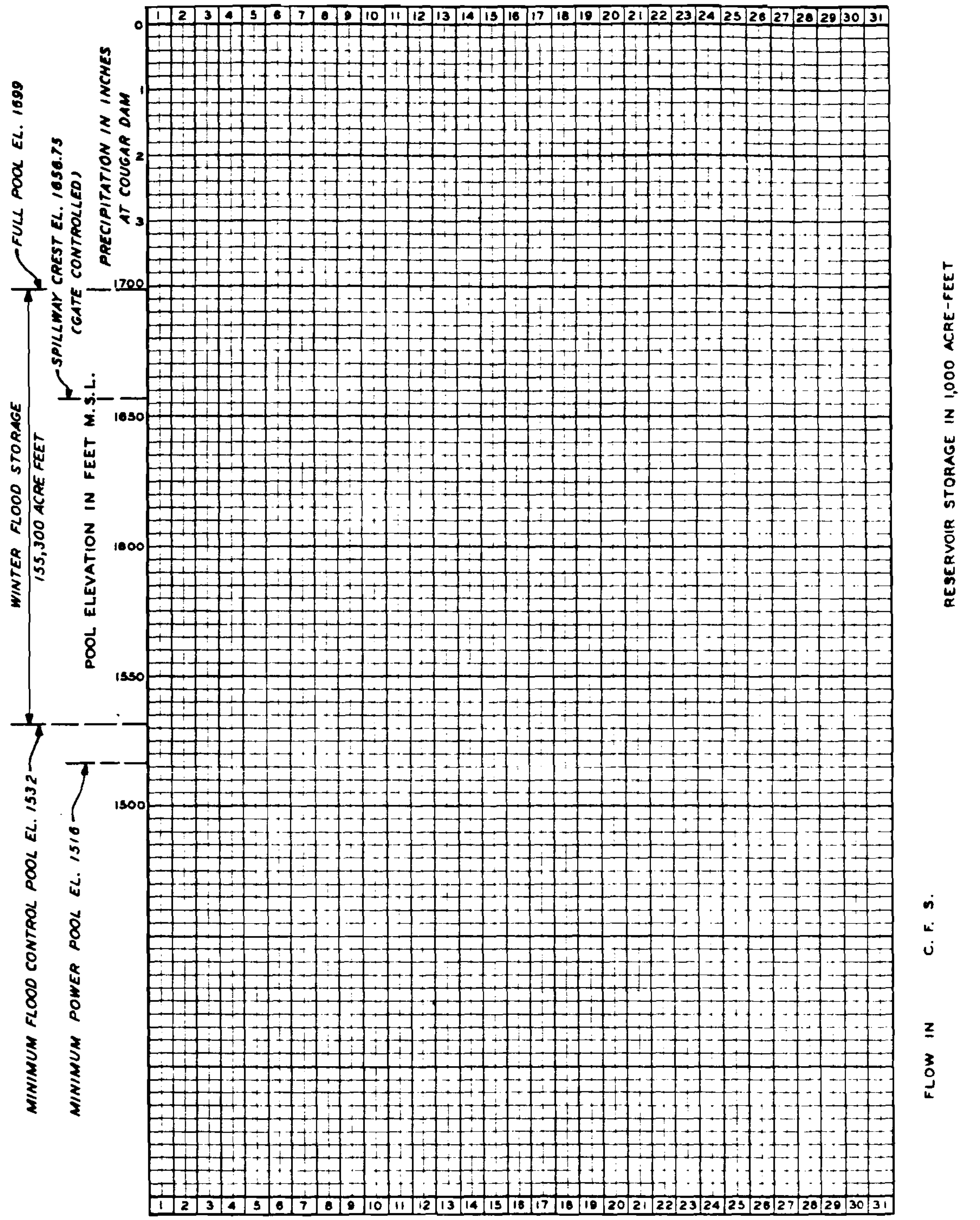
| POOL FT. | STORAGE AC. FT. | INFLOW C.F.S. | WIND |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| 1/2 Diff. | | | |

DATE: ____________

CHART 13

CORPS OF ENGINEERS | U. S. ARMY

Reports Control Symbol ENGCW-E-6




MONTH OF 19

| | EL. IN FEET ABOVE M. S. L. | GROSS STORAGE AC. FT. |
|---|---|---|
| MINIMUM POWER POOL | 1516 | 54,100 |
| MIN. FLOOD CONTROL POOL | 1532 | 64,000 |
| MAX. CONSERVATION POOL | 1690 | 208,000 |
| MAXIMUM AND FULL POOL | 1699 | 219,300 |

TOTAL OUTLET CAPACITY AT FULL POOL 12,050 C.F.S.
MAXIMUM PLANNED RELEASE 6,500 C.F.S.

## MONTHLY RESERVOIR REGULATION

### COUGAR RESERVOIR

SOUTH FORK McKENZIE RIVER BASIN
DRAINAGE AREA ABOVE COUGAR DAM 208 SQ. MI.

NORTH PACIFIC DIVISION, PORTLAND DISTRICT

NPP Form 315 Jan. 62

CHART 14

NPP Form
Mar. 1961 252(Rev.)

| TO: Multiple Purpose Projects Branch, Operations Division | POWER PRODUCTION REPORT | |
|---|---|---|
| | Month & Year | Reports Control Symbol NPPVK - 57 |
| District: PORTLAND, OREGON | Project & Location: | |

| GENERATION | | | | DISPOSITION | | |
|---|---|---|---|---|---|---|
| GENERATOR NUMBER | MWH | GENERATOR NUMBER | MWH | LOCATION | LOCAL USE MWH | TO BPA MWH |
| 1 | | 12 | | STATION | | |
| 2 | | 13 | | PROJECT | | |
| 3 | | 14 | | NAVIGATION LOCK | | |
| 4 | | 15 | | SPILLWAY | | |
| 5 | | 16 | | FISHWAY | | |
| 6 | | | | BUILDINGS AND GROUNDS | | |
| 7 | | | | TO OTHERS | | |
| 8 | | | | UNACCOUNTED AND LOSSES | | |
| 9 | | | | | | |
| 10 | | | | | | |
| 11 | | | | | | |
| TOTAL GENERATION | | | | TOTALS | | |

| CONDENSER POWER | | OTHER DATA | | | |
|---|---|---|---|---|---|
| UNIT | MWH | SUBJECT | MWH | TIME | DATE |
| 1 | | 5 Minute Peak | | M. | |
| 2 | | Clock Hour Peak | | M. | |
| 3 | | PLANT FACTOR: TOTAL GENERATION / (N.P. Rating X Total Hours in the Month) % | | | |

TOTAL IN-SERVICE HOURS (All Units Except House Units)

NET GENERATION REPORTED ON FPC FORM 4 -

Remarks:

| Distribution: | Project Engineer: |
|---|---|

CHART 15

F.P.C. Form No. 4 | Budget Bureau No. 54-R014.4

# FEDERAL POWER COMMISSION
## MONTHLY POWER PLANT REPORT

**INSTALLED CAPACITY** - The kilowatt capacity of each plant listed should represent total name-plate rating of generators exclusive of auxiliary or house units. Revise to include any additions, retirements, or re-ratings. State below or on reverse side, the kilowatt amount, nature and approximate date of each change. New plants should be added. If plant has been sold give name and address of purchaser.

**GENERATION** - Report net generation (gross less use by power plant for auxiliary equipment) by water power and by Each Kind of Fuel — anthracite, bituminous or lignite coal, coke, fuel oil, natural gas or other (Specify). Please give estimates if exact figures are not available.

**FUEL CONSUMED** - Report actual or estimated amount of fuel used in generating electric energy including fuel for maintenance of standby service. Report to nearest whole unit - short ton, 42 gal. bbl., or Mcf.

**FUEL STOCKS** - Enter coal and fuel oil held for electric energy generation including regular stocks at plant and in cars or barges at plant site. Amounts held in central storage yards should be included with appropriate note. Report to nearest whole unit.

UNITED STATES ARMY ENGINEERS

BONNEVILLE, OREGON

241

36-640

REPORT FOR

OCTOBER 1960

→ PLEASE RETURN ONE COPY BEFORE THE 10TH OF THE MONTH

| PLANT NAME AND CODE NUMBERS | PRIME MOVER TYPE AND KIND OF FUEL | INSTALLED CAPACITY (Name-Plate Rating) KILOWATTS | NET GENERATION KILOWATT-HOURS | FUEL FOR GENERATION INCLUDING STANDBY SERVICE Nearest Short Ton; 42 Gal. Bbl.; Mcf. | |
|---|---|---|---|---|---|
| | | | | Consumed During Month | Stocks End of Month |
| BONNEVILLE 92<br>36 7 1 640*001 | WATER PWR | 518,400 | 297,078,961 | | |
| | | | | | |
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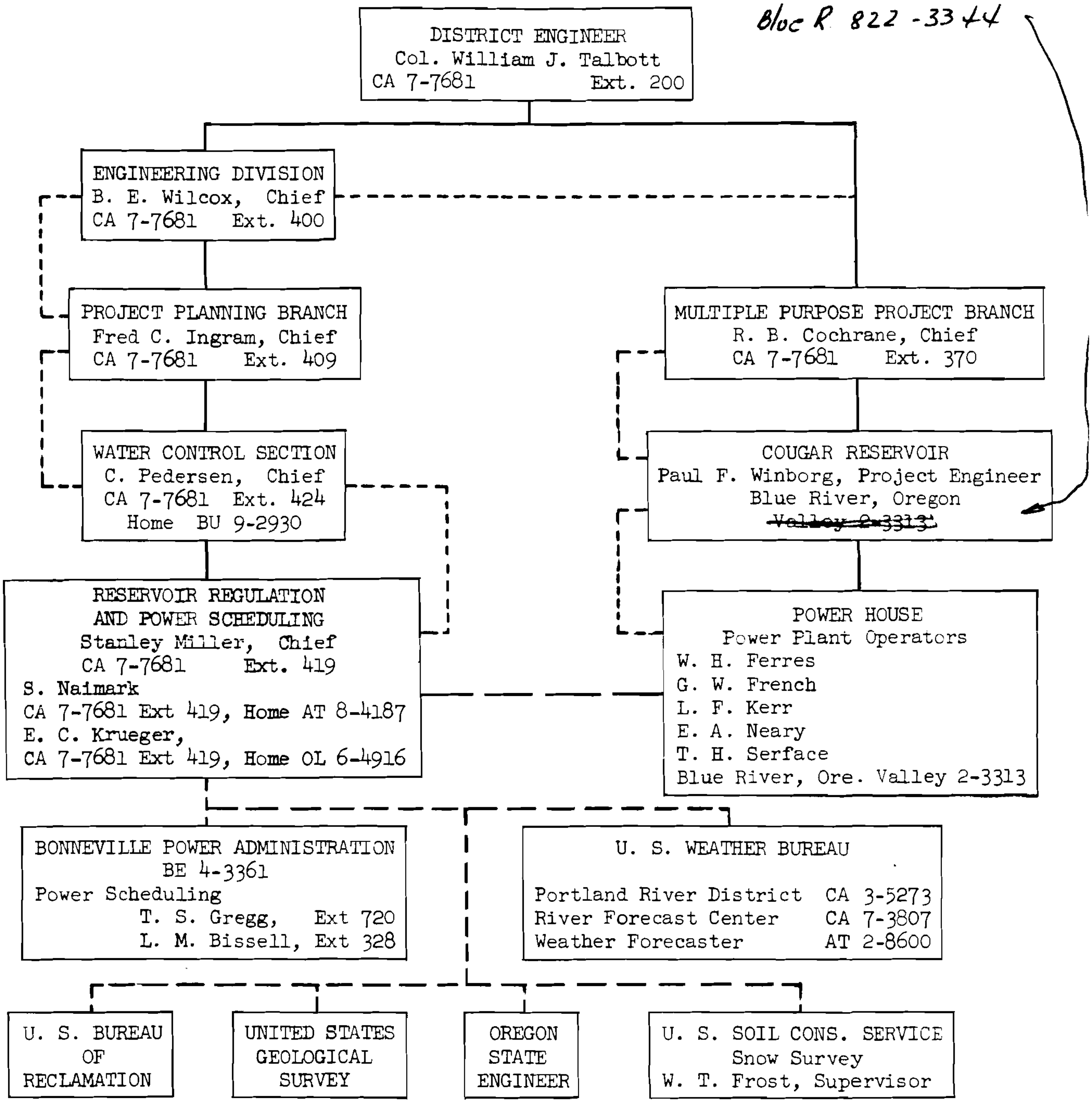
→ PLEASE REPORT CAPACITY CHANGES - SEE INSTRUCTIONS

CHART 16

# C O U G A R   P R O J E C T

## Organization for Functional Regulation

FTS 8-226-3361
Bloc R 822-3344

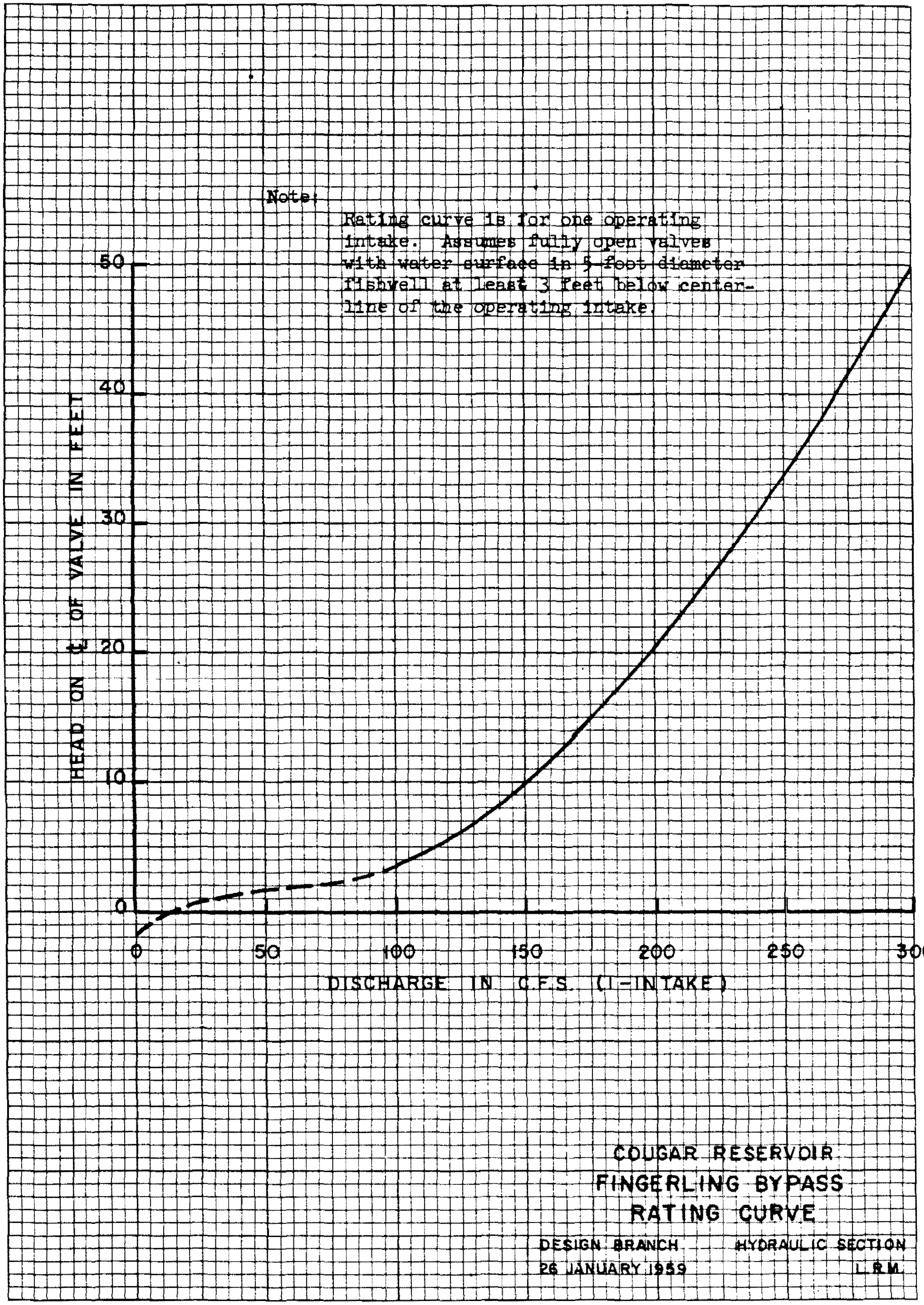



LEGEND

- ———— Supervisory and Administration
- — — — Functional Reservoir Regulation Instructions
- - - - - Regulation Confirmation
- — — — — Coordination and Liaison

ORGANIZATION
for
Reservoir Regulation
Portland District July 1964

CHART 17




CU-20-16/18 CHART 18

## PLATES

CORPS OF ENGINEERS  U. S. ARMY

## STREAM GAGING STATIONS

| MAP NO. | MAP REF. | STATION | USGS NO. | ZERO OF GAGE[1] | DRAINAGE AREA SQ. MI. | PERIOD OF RECORD WATER YEARS |
|---|---|---|---|---|---|---|
| 101 | [illegible] | McKENZIE RIVER AT OUTLET CLEAR LAKE | [illegible] | [illegible] | 92.4 | [illegible] |
| 102(d) | [illegible] | McKENZIE RIVER NEAR BELKNAP SPRINGS | [illegible] | [illegible] | [illegible] | [illegible] 1962 |
| 103 | [illegible] | SMITH RIVER ABOVE SMITH RIVER RESERVOIR NEAR BELKNAP SPRINGS | [illegible] | [illegible] | [illegible] | [illegible] TO DATE |
| 104 | [illegible] | McKENZIE RIVER BELOW TRAIL BRIDGE DAM NEAR BELKNAP SPRINGS | [illegible] | [illegible] | [illegible] | [illegible] TO DATE |
| 105 | [illegible] | McKENZIE RIVER AT McKENZIE BRIDGE | [illegible] | [illegible] | [illegible] | [illegible] TO DATE |
| 106 | R | SOUTH FORK McKENZIE RIVER ABOVE COUGAR RESERVOIR NEAR RAINBOW | [illegible] | [illegible] | [illegible] | [illegible] TO DATE |
| 107 | R | SOUTH FORK McKENZIE RIVER NEAR RAINBOW | [illegible] | [illegible] | [illegible] | [illegible] TO DATE |
| 108(d) | [illegible] | [illegible] CREEK NEAR McKENZIE BRIDGE | [illegible] | [illegible] | [illegible] | [illegible] |
| 109(d) | [illegible] | [illegible] CREEK NEAR McKENZIE BRIDGE | [illegible] | [illegible] | [illegible] | [illegible] |
| 110(d) | [illegible] | BLUE RIVER ABOVE [illegible] CREEK | [illegible] | [illegible] | [illegible] | [illegible] |
| 111 | [illegible] | LOOKOUT CREEK NEAR BLUE RIVER | [illegible] | 1377.51 | [illegible] | [illegible] TO DATE |
| 112 | [illegible] | BLUE RIVER NEAR BLUE RIVER | [illegible] | [illegible] | [illegible] | [illegible] TO DATE |
| 113 | R | McKENZIE RIVER NEAR VIDA | [illegible] | [illegible] | [illegible] | [illegible] TO DATE |
| 114(d) | [illegible] | GATE CREEK AT VIDA | [illegible] | [illegible] | [illegible] | [illegible] |
| 115 | R-4 | MOHAWK RIVER NEAR SPRINGFIELD | [illegible] | [illegible] | 177 | 1936-52, 1961 TO DATE |
| 116 | R-4 | McKENZIE RIVER NEAR COBURG | [illegible] | [illegible] | [illegible] | [illegible] TO DATE |
| 117 | [illegible] | BLUE R BELOW TIDBITS CREEK NEAR BLUE RIVER | 1611 | 1396.90 | 45.8 | [illegible] TO DATE |
| 118(P) | [illegible] | BLUE RIVER [illegible] BLUE RIVER | [illegible] | [illegible] | [illegible] | [illegible] |
| 120 | [illegible] | WILLAMETTE RIVER AT HARRISBURG | 663 | [illegible] | [illegible] | [illegible] TO DATE |
| 121 | [illegible] | HORSE CREEK NEAR BLUE RIVER | 1591 | 429.17 | 149 | 1963 TO DATE |

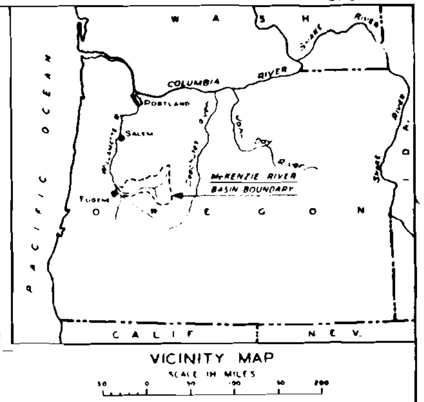
1. 1929 ADJUSTMENT EXCEPT AS NOTED
2. 1947 SUPPLEMENTING ADJUSTMENT

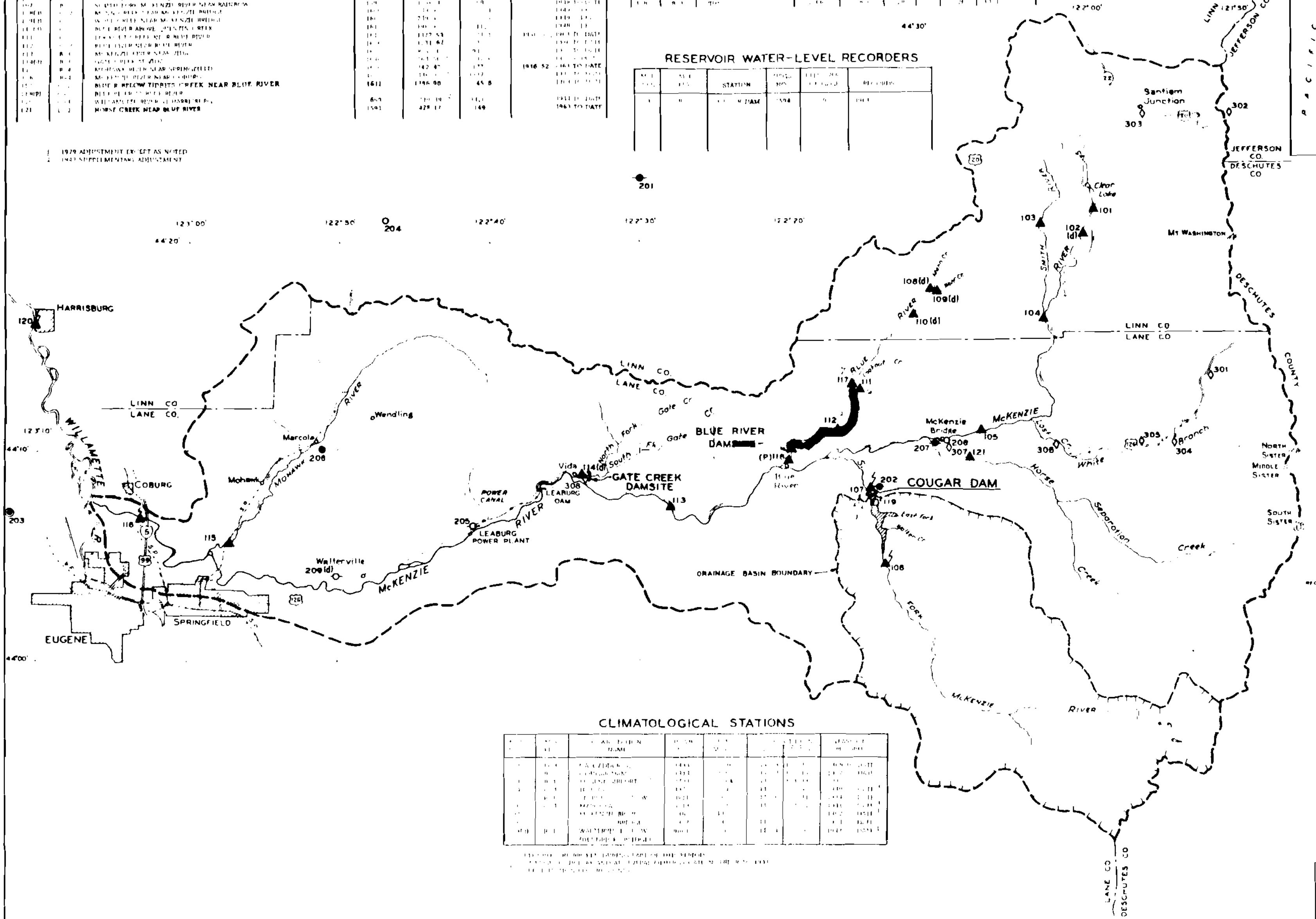
## SNOW SURVEY COURSES

| MAP NO. | MAP REF. | COURSE | [illegible] | ELEV. | [illegible] | | | YEARS OF RECORD |
|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

## RESERVOIR WATER-LEVEL RECORDERS

| MAP NO. | MAP REF. | STATION | [illegible] | [illegible] | RECORDS |
|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] DAM | [illegible] | [illegible] | [illegible] |




## LEGEND

| RECORDING | NON-RECORDING | |
|---|---|---|
| ● | ○ | PRECIPITATION STATION |
| ◆ | -○- | PRECIPITATION AND TEMPERATURE |
| | ◊ | SNOW SURVEY COURSE |
| ◉ | | COMPLETE METEOROLOGICAL STATION |
| ◘ | | RESERVOIR OR LAKE GAGE |
| ▲ | | RIVER GAGE, RATED |
| ϟ | | WHEN USED IN COMBINATION WITH OTHER SYMBOLS AS ▲ INDICATES TELEPHONIC OR REMOTE WIRED RECORDER |
| (d) | (d) | DISCONTINUED |
| (P) | (P) | PROPOSED |

## CLIMATOLOGICAL STATIONS

| MAP NO. | MAP REF. | STATION NAME | [illegible] | [illegible] | [illegible] | YEARS OF RECORD |
|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

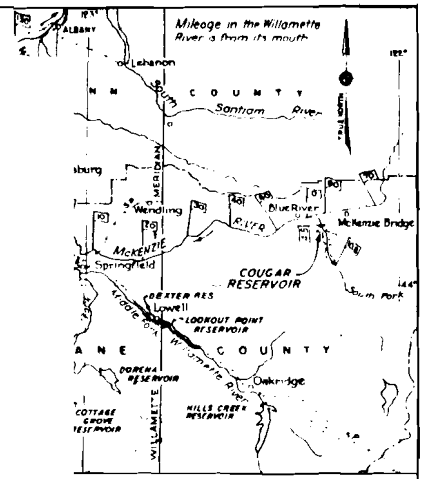
REVISED FEBRUARY 1964

WILLAMETTE RIVER BASIN, OREGON
SOUTH FORK McKENZIE RIVER
COUGAR RESERVOIR
**BASIN MAP AND HYDROLOGIC STATIONS**
SCALES AS SHOWN
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

PREPARED: CHIEF, WATER CONTROL SECTION — RECOMMENDED
SUBMITTED: CHIEF, PROJECT PLANNING BRANCH — APPROVED: DISTRICT ENGINEER
DRAWN SM P&B — TRACED — CHECKED C.P.
TRANSMITTED WITH REPORT DATED DEC 1963

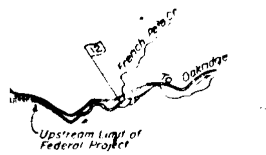
CU-20-18/1

PLATE I




VICINITY MAP

SCALE IN MILES




FLOOD CONTROL
WILLAMETTE RIVER BASIN, OREGON

COUGAR RESERVOIR

SOUTH FORK McKENZIE RIVER

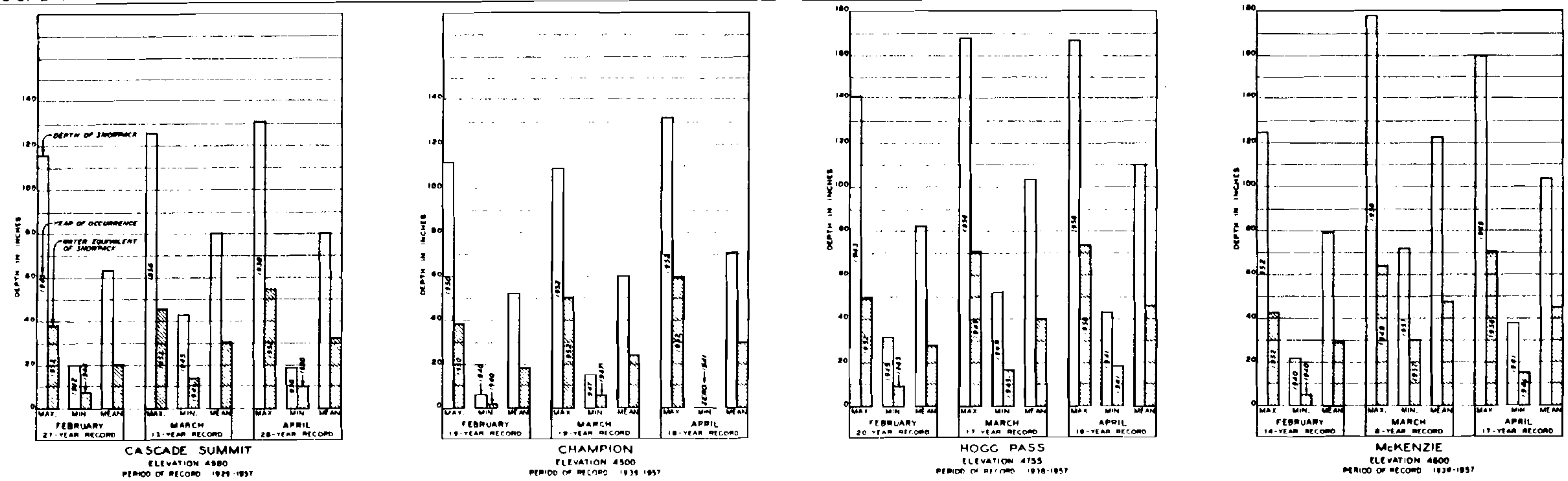
GENERAL PLAN AND SECTIONS

SCALES AS SHOWN

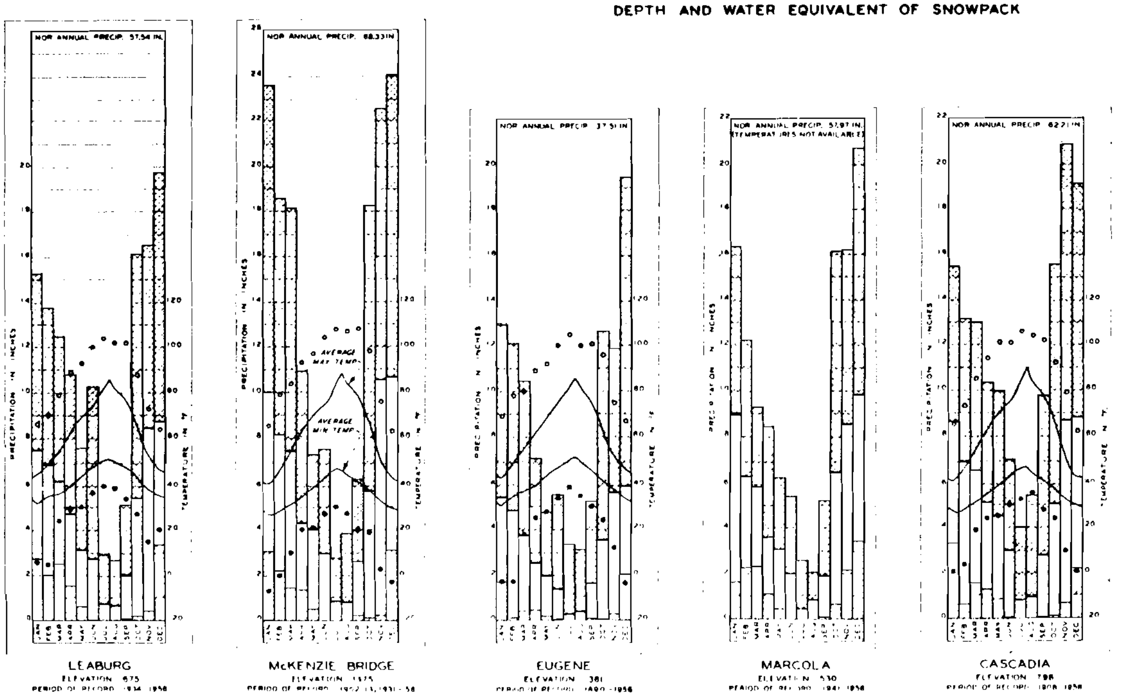
ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

CU-20-16/2

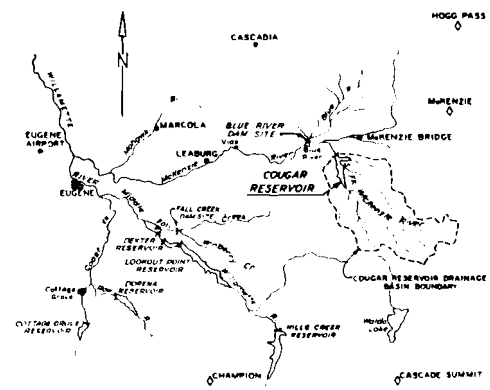
CORPS OF ENGINEERS U. S. ARMY




DEPTH AND WATER EQUIVALENT OF SNOWPACK




MONTHLY PRECIPITATION AND TEMPERATURE




VICINITY MAP

SCALE IN MILES

NOTE:

1. SNOW DATA FROM U.S. SOIL CONSERVATION SERVICE
2. SNOW SURVEYS MADE ABOUT THE FIRST OF FEBRUARY, MARCH AND APRIL.
3. PRECIPITATION AND TEMPERATURE DATA FROM RECORDS OF U.S. WEATHER BUREAU

LEGEND

- MAXIMUM PRECIPITATION
- AVERAGE PRECIPITATION
- MINIMUM PRECIPITATION
- o ABSOLUTE MAXIMUM TEMPERATURE
- ● ABSOLUTE MINIMUM TEMPERATURE

WILLAMETTE RIVER BASIN, OREGON
SOUTH FORK McKENZIE RIVER

COUGAR RESERVOIR

## CLIMATIC CHARACTERISTICS

DRAINAGE BASIN AREA 208 SQUARE MILES

SCALES AS SHOWN

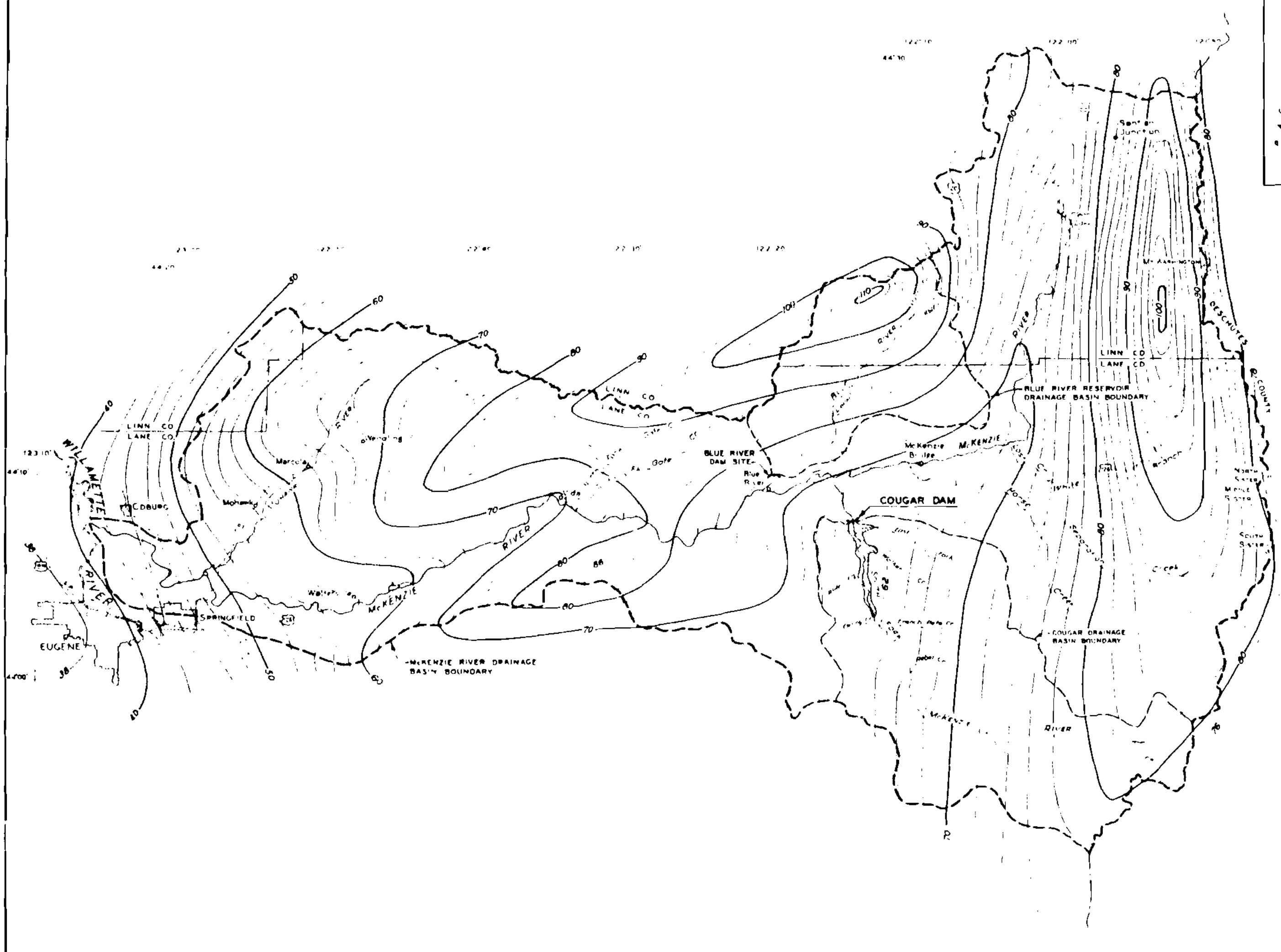
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

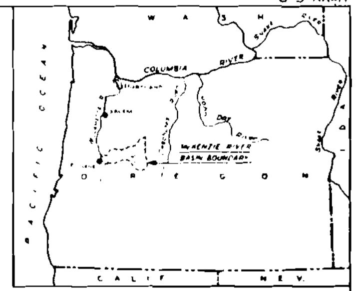
CU-20-16/3

PLATE 3

CORPS OF ENGINEERS

U S ARMY




VICINITY MAP

SCALE IN MILES

*Note*

*Isolines denote normal annual precipitation in inches*

*The normal annual precipitation pattern was determined by adjusting precipitation and runoff data to long-period normals by the double-mass curve method*

*Normal annual precipitation in the drainage basin above Cougar Dam is 71 inches.*

SCALE IN MILES

WILLAMETTE RIVER BASIN, OREGON
SOUTH FORK McKENZIE RIVER

COUGAR RESERVOIR

ISOHYETAL MAP

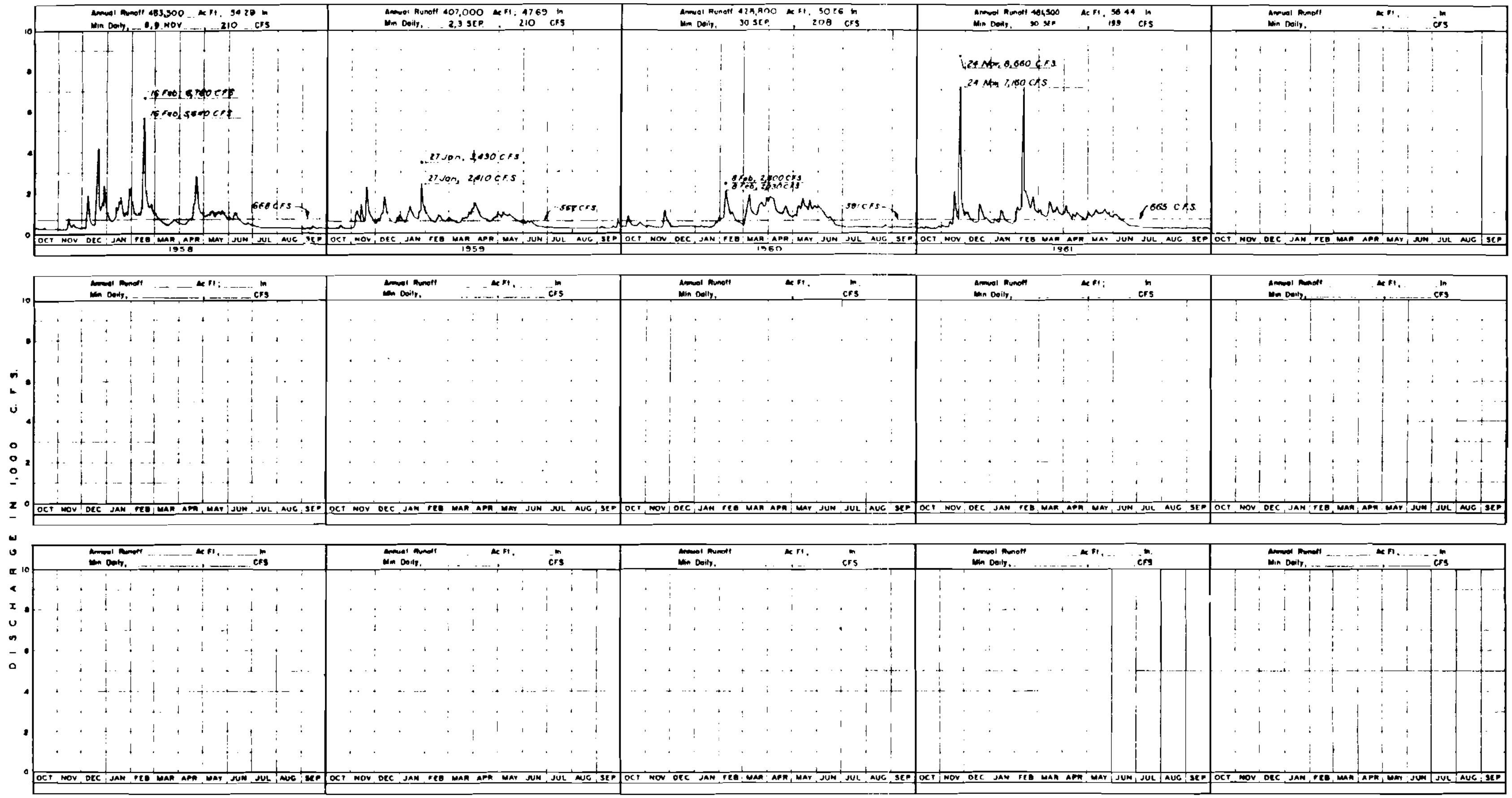
NORMAL ANNUAL PRECIPITATION

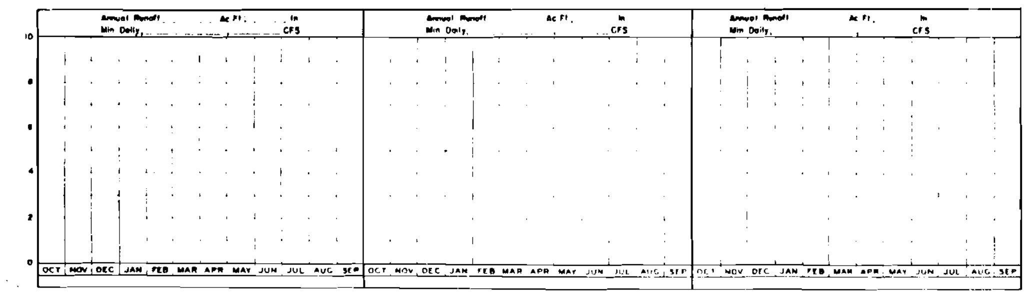
DRAINAGE BASIN AREA 208 SQUARE MILES

U S ARMY ENGINEER DISTRICT PORTLAND
CORPS OF ENGINEERS

CU-20-16/4

PLATE 4




### STATION DESCRIPTION

| Station | Dr Area Sq Miles | Records Available | Records Character | Type of Gage | Location | Datum MSL |
|---|---|---|---|---|---|---|
| South Fork McKenzie River above Cougar Res near Rainbow Ore | 160[1] | Oct 1957 | Continuous | Recorder | T17S, R5E (Un surveyed) On rt bank, 1/2 mi above Tipsoo Creek, miles south of Rainbow, Oregon | |

[1] Drainage area at cableway, 0.1 mile downstream from recorder house, where all measurements are made

### LEGEND

- • MAXIMUM INSTANTANEOUS DISCHARGE
- ← MAXIMUM DAILY DISCHARGE
- - - - - MEAN DISCHARGE

WILLAMETTE RIVER BASIN, OREGON

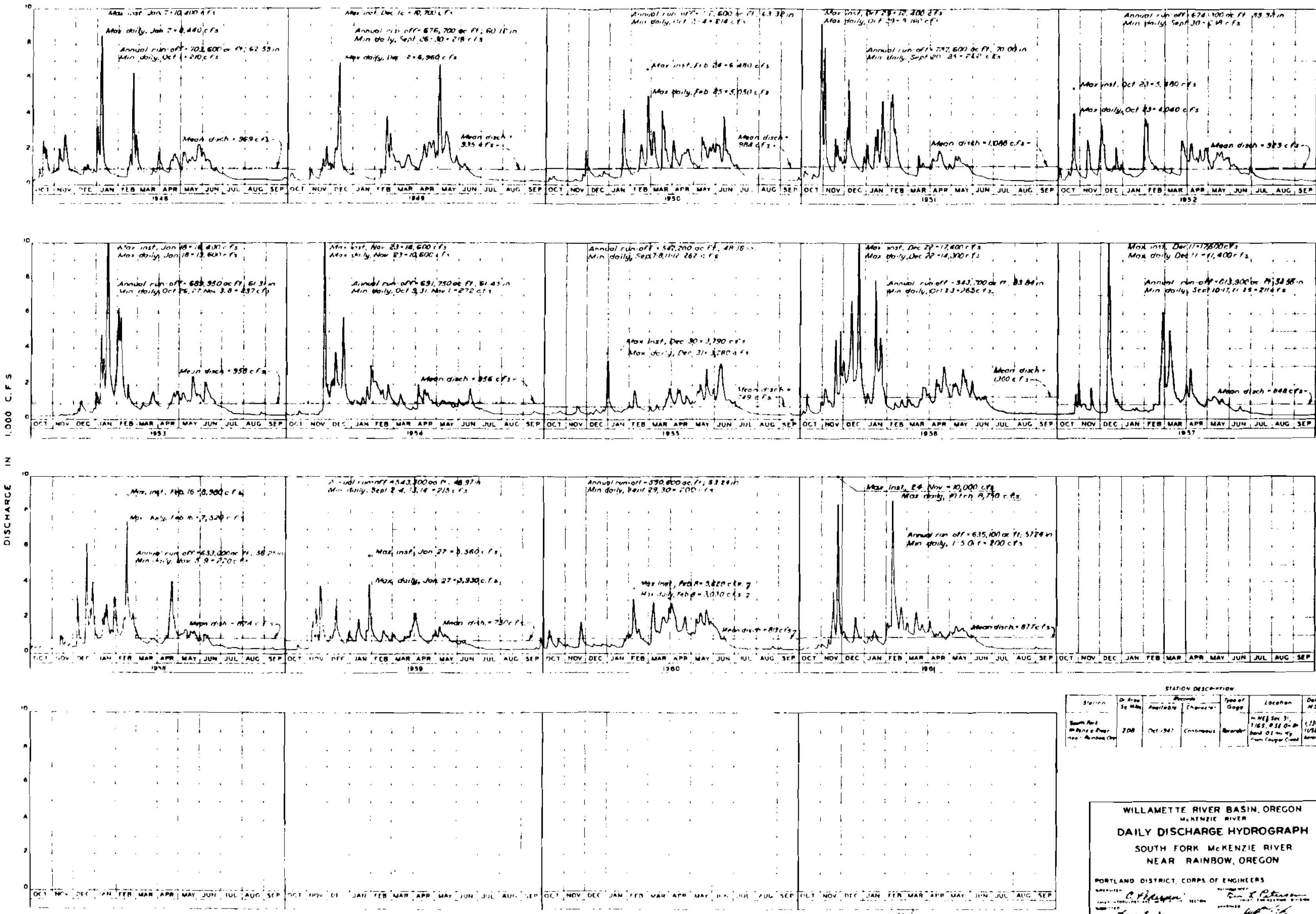
## DAILY DISCHARGE HYDROGRAPH

SOUTH FORK McKENZIE RIVER ABOVE COUGAR RESERVOIR NEAR RAINBOW, OREGON

U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

SUPERVISED: Chief, Hydrology and Hydraulics Section
RECOMMENDED: Chief, Engineering Division
SUBMITTED: Chief, Planning Branch
APPROVED: District Engineer
DRAWN J W N
TRACED
CHECKED J W N.

PD-25-24




STATION DESCRIPTION

| Station | Dr. Area Sq. Miles | Records Available | Records Character | Type of Gage | Location | Datum MSL |
|---|---|---|---|---|---|---|
| South Fork McKenzie River near Rainbow, Ore. | 208 | Oct. 1947 | Continuous | Recorder | In NE¼ Sec. 31, T.16S., R.5E. On Rt. bank 0.1 mi. Up from Cougar Creek | 1,136.47 USBPR bench mark |

**WILLAMETTE RIVER BASIN, OREGON**
McKENZIE RIVER

## DAILY DISCHARGE HYDROGRAPH

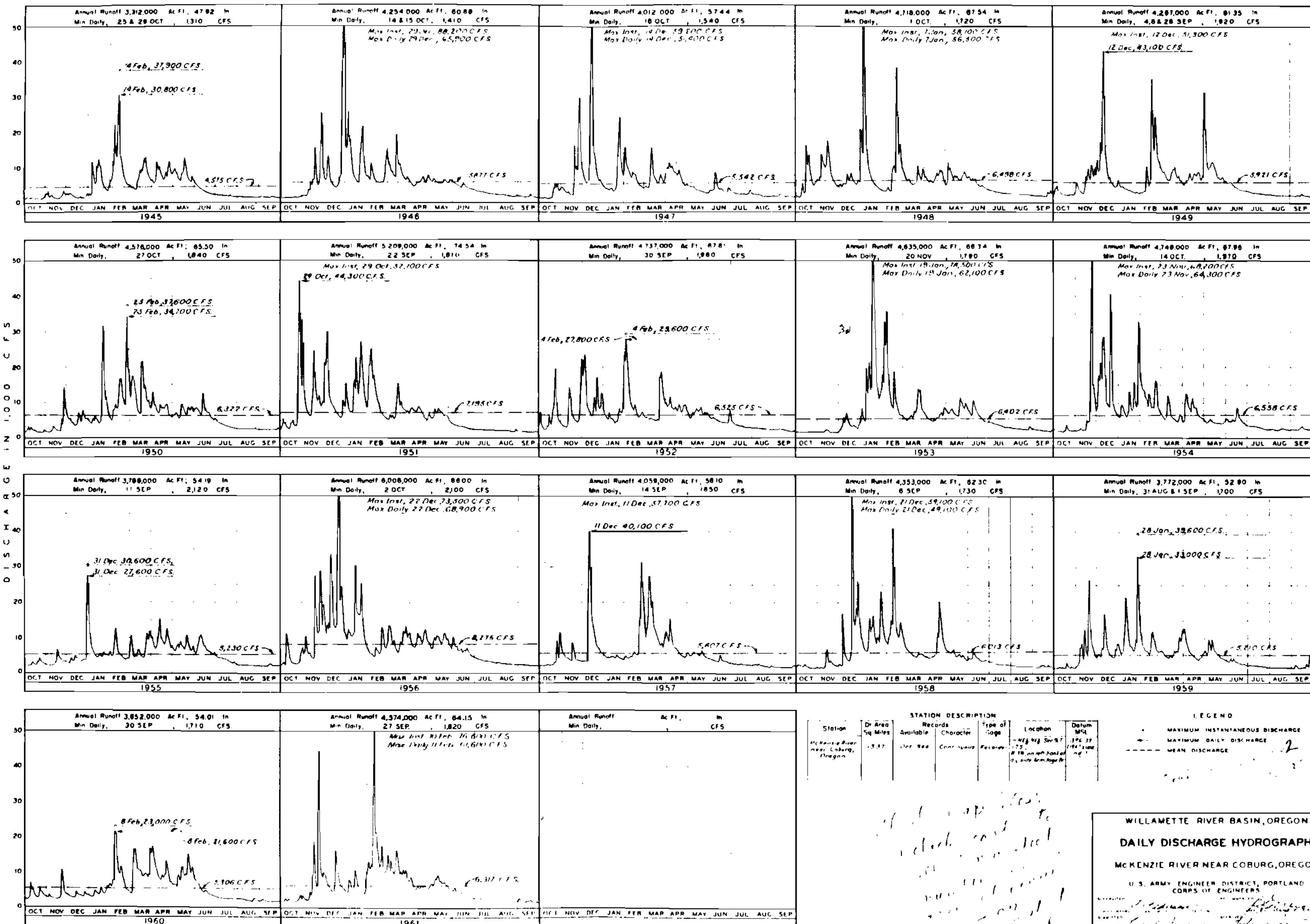
SOUTH FORK McKENZIE RIVER
NEAR RAINBOW, OREGON

PORTLAND DISTRICT, CORPS OF ENGINEERS

DRAWN BY J.W.H.
TRACED BY
CHECKED BY J.W.H.

PD-25-4

PLATE 6




STATION DESCRIPTION

| Station | Dr Area Sq Miles | Records Available | Records Character | Type of Gage | Location | Datum MSL |
|---|---|---|---|---|---|---|
| McKenzie River near Coburg, Oregon | [illegible] | Oct 1944 | Continuous | Recorder | NE¼ NE¼ Sec 9, T 17 S, R 3 W, on left bank at d.s. side Armitage Br. | 396.37 |

LEGEND

- • MAXIMUM INSTANTANEOUS DISCHARGE
- ← MAXIMUM DAILY DISCHARGE
- ----- MEAN DISCHARGE

WILLAMETTE RIVER BASIN, OREGON

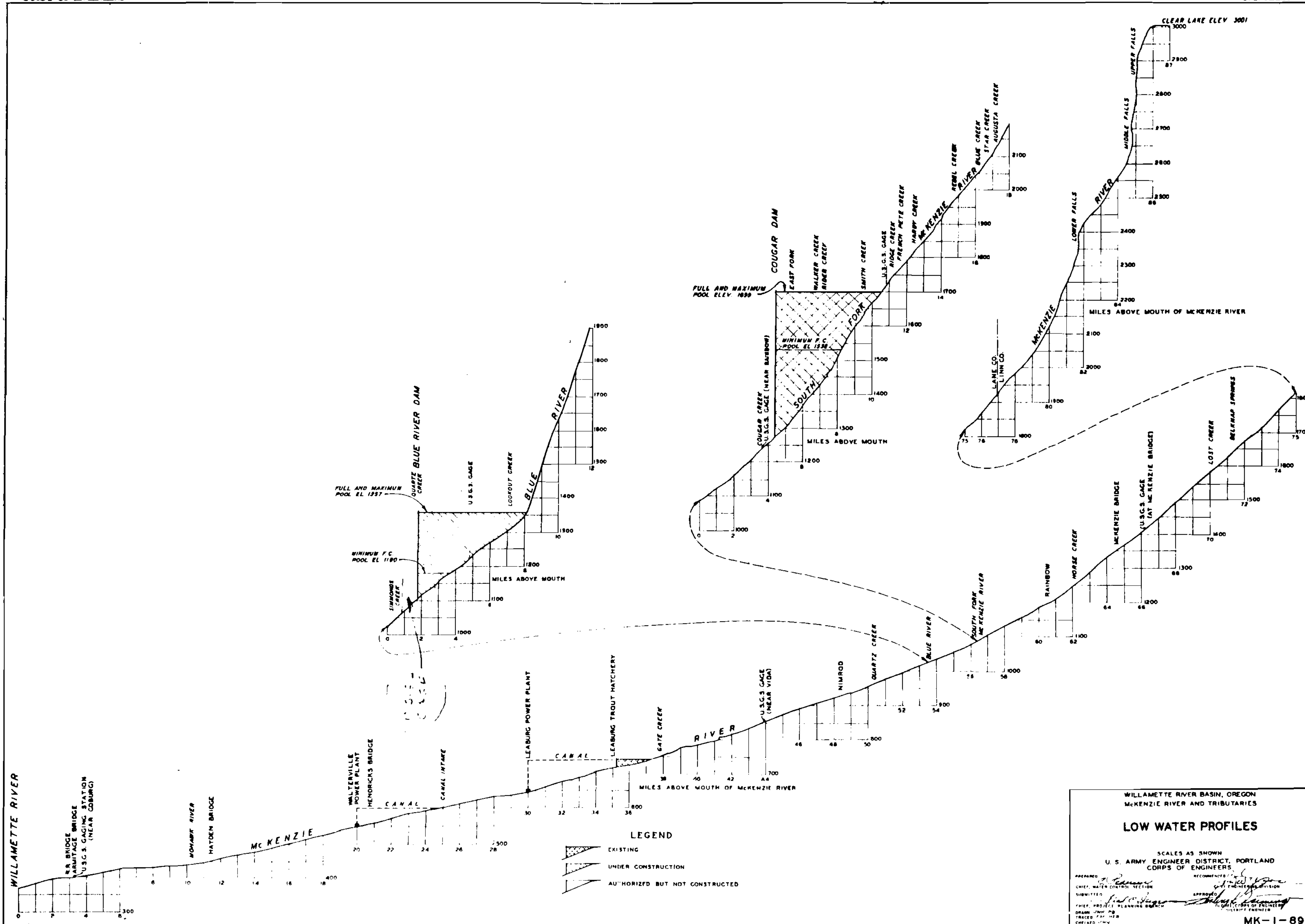
# DAILY DISCHARGE HYDROGRAPH

McKENZIE RIVER NEAR COBURG, OREGON

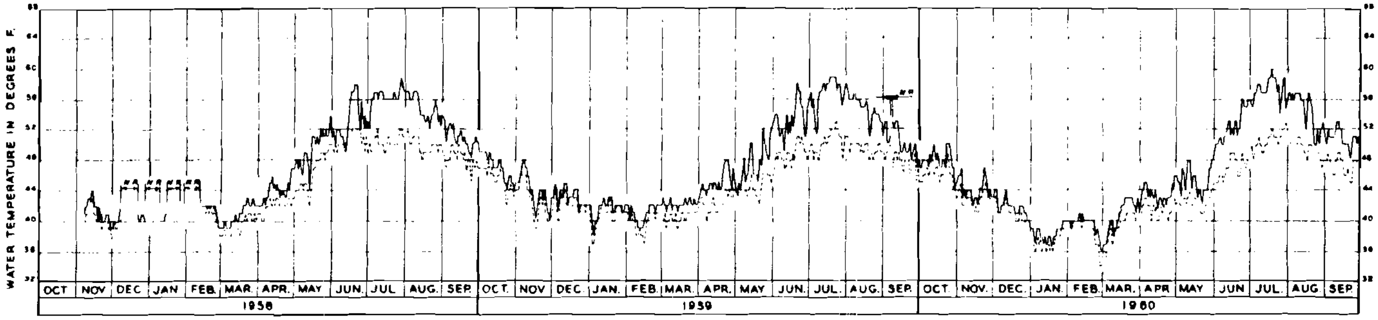
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

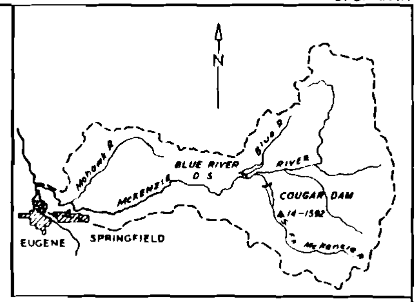
PD-25-23

PLATE 7


WILLAMETTE RIVER
R.R. BRIDGE
ARMITAGE BRIDGE
U.S.G.S. GAGING STATION (NEAR COBURG)
MOHAWK RIVER
HAYDEN BRIDGE
McKENZIE
WALTERVILLE POWER PLANT
HENDRICKS BRIDGE
CANAL
CANAL INTAKE
LEABURG POWER PLANT
CANAL
LEABURG TROUT HATCHERY
GATE CREEK
RIVER
U.S.G.S. GAGE (NEAR VIDA)
NIMROD
QUARTZ CREEK
BLUE RIVER
SOUTH FORK McKENZIE RIVER
RAINBOW
HORSE CREEK
McKENZIE BRIDGE
U.S.G.S. GAGE (AT McKENZIE BRIDGE)
LOST CREEK
BELKNAP SPRINGS
MILES ABOVE MOUTH OF McKENZIE RIVER
BLUE RIVER DAM
FULL AND MAXIMUM POOL EL 1357
MINIMUM F.C. POOL EL 1180
SIMMONDS CREEK
QUARTZ CREEK
U.S.G.S. GAGE
LOOKOUT CREEK
BLUE RIVER
MILES ABOVE MOUTH
COUGAR DAM
FULL AND MAXIMUM POOL ELEV. 1699
MINIMUM F.C. POOL EL 1532
EAST FORK
WALKER CREEK
RIDER CREEK
SMITH CREEK
U.S.G.S. GAGE
RIDGE CREEK
FRENCH PETE CREEK
HARDY CREEK
COUGAR CREEK
U.S.G.S. GAGE (NEAR RAINBOW)
SOUTH FORK McKENZIE RIVER
REBEL CREEK
BLUE CREEK
STAR CREEK
AUGUSTA CREEK
MILES ABOVE MOUTH
CLEAR LAKE ELEV. 3001
UPPER FALLS
MIDDLE FALLS
LOWER FALLS
McKENZIE RIVER
LANE CO.
LINN CO.
MILES ABOVE MOUTH OF McKENZIE RIVER
LEGEND
EXISTING
UNDER CONSTRUCTION
AUTHORIZED BUT NOT CONSTRUCTED
WILLAMETTE RIVER BASIN, OREGON
McKENZIE RIVER AND TRIBUTARIES
LOW WATER PROFILES
SCALES AS SHOWN
U. S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS
PREPARED
CHIEF, WATER CONTROL SECTION
RECOMMENDED
CHIEF, ENGINEERING DIVISION
SUBMITTED
CHIEF, PROJECT PLANNING BRANCH
APPROVED
COLONEL, CORPS OF ENGINEERS DISTRICT ENGINEER
MK-1-89

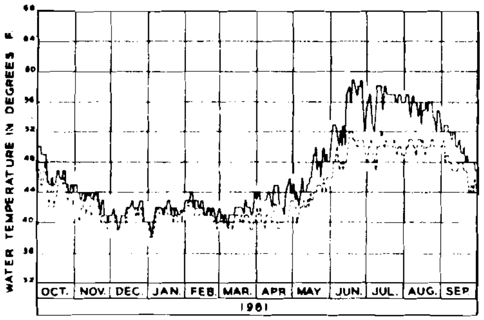
CORPS OF ENGINEERS U. S. ARMY




McKENZIE RIVER BASIN

SCALE IN MILES




LEGEND

—— MAXIMUM DAILY WATER TEMPERATURES

- - - MINIMUM DAILY WATER TEMPERATURES

** NO RECORD

NOTES

1. PLOTTED FROM U.S. GEOLOGICAL SURVEY WATER TEMPERATURE RECORDS FOR STATION NO. 14 - 1592. LOCATION IS SHOWN ON VICINITY MAP. WATER TEMPERATURE RECORD AT THIS STATION BEGAN 7 NOVEMBER 1957

2. DRAINAGE AREA 160 SQUARE MILES

WILLAMETTE RIVER BASIN, OREGON

DAILY MAXIMUM AND MINIMUM WATER TEMPERATURES

SOUTH FORK McKENZIE RIVER ABOVE COUGAR RESERVOIR NEAR RAINBOW, OREGON

SCALES AS SHOWN

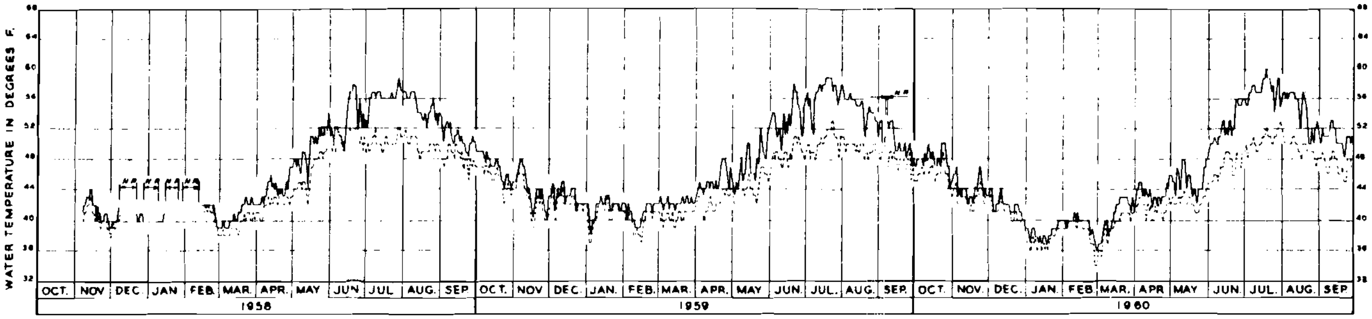
U.S. ARMY ENGINEER DISTRICT, PORTLAND CORPS OF ENGINEERS

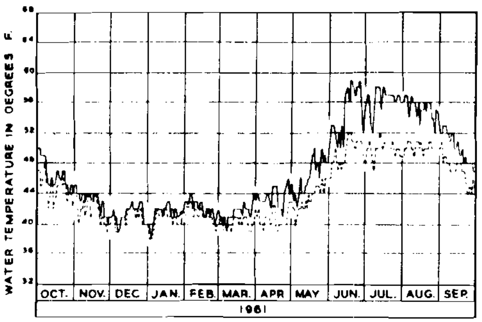
PREPARED RECOMMENDED

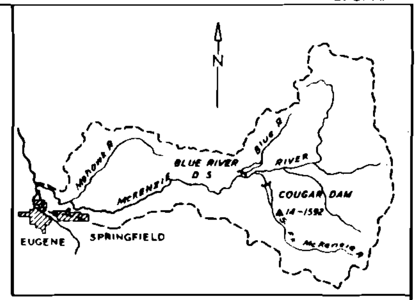
SUBMITTED APPROVED

DRAWN D.J.
TRACED R.C.D.
CHECKED

MK-1-87




McKENZIE RIVER BASIN

SCALE IN MILES

### LEGEND

—— MAXIMUM DAILY WATER TEMPERATURES

--- MINIMUM DAILY WATER TEMPERATURES

NR NO RECORD

### NOTES

1 PLOTTED FROM U.S. GEOLOGICAL SURVEY WATER TEMPERATURE RECORDS FOR STATION NO. 14 - 1592.
LOCATION IS SHOWN ON VICINITY MAP.
WATER TEMPERATURE RECORD AT THIS STATION BEGAN 7 NOVEMBER 1957

2. DRAINAGE AREA 160 SQUARE MILES

WILLAMETTE RIVER BASIN, OREGON

DAILY MAXIMUM AND MINIMUM WATER TEMPERATURES

SOUTH FORK McKENZIE RIVER ABOVE COUGAR RESERVOIR NEAR RAINBOW, OREGON

SCALES AS SHOWN

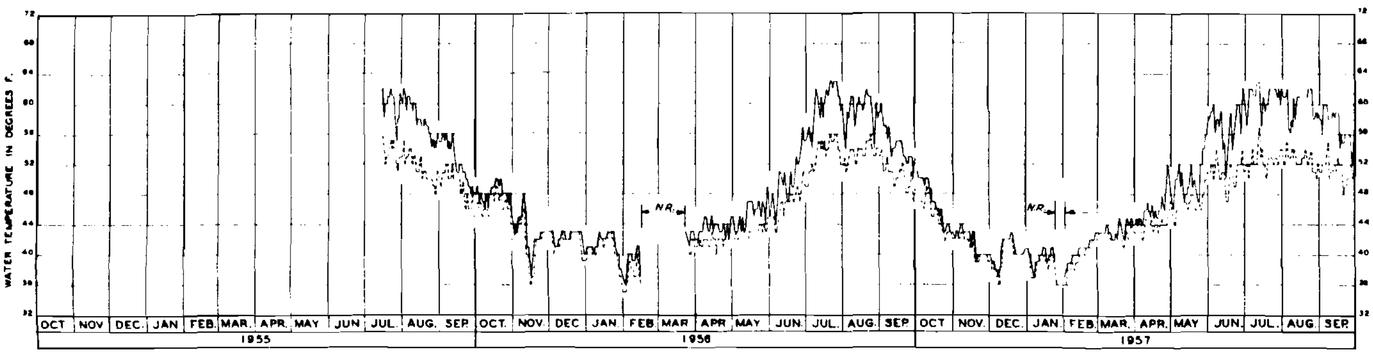
U.S. ARMY ENGINEER DISTRICT, PORTLAND CORPS OF ENGINEERS

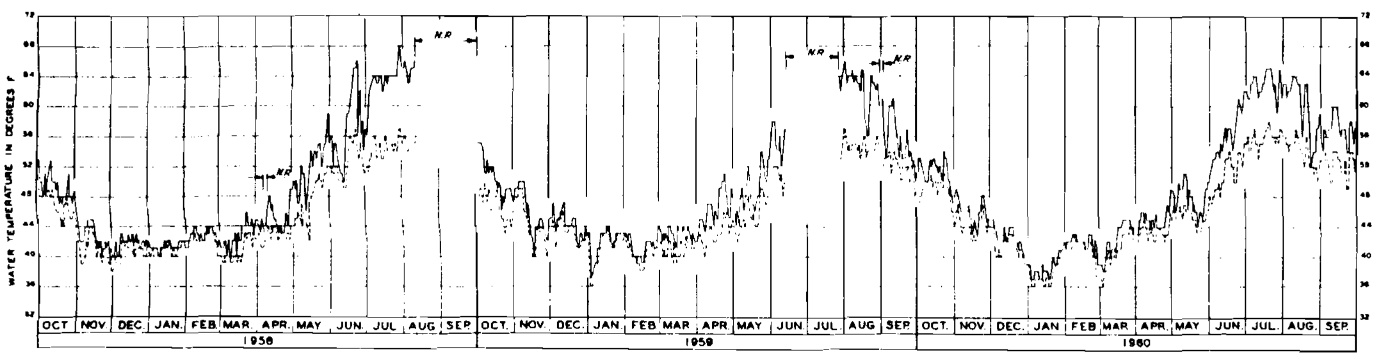
PREPARED RECOMMENDED SUBMITTED APPROVED

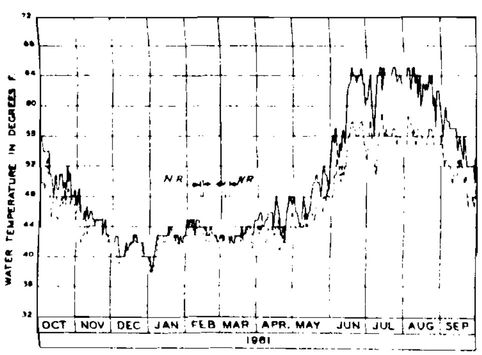
DRAWN D.J. TRACED R.G.A. CHECKED

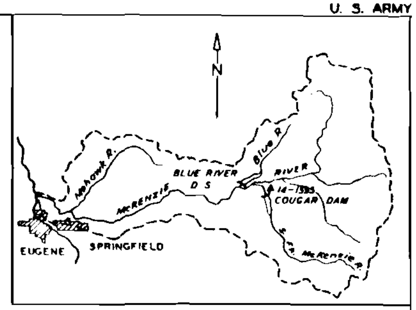
MK-1-87

CORPS OF ENGINEERS | U. S. ARMY




McKENZIE RIVER BASIN

SCALE IN MILES

### LEGEND

— MAXIMUM DAILY WATER TEMPERATURES

--- MINIMUM DAILY WATER TEMPERATURES

N.R. NO RECORD

### NOTES

1. PLOTTED FROM U.S. GEOLOGICAL SURVEY WATER TEMPERATURE RECORDS FOR STATION NO. 14 - 1595. LOCATION IS SHOWN ON VICINITY MAP. WATER TEMPERATURE RECORD AT THIS STATION BEGAN 15 JULY 1954.
2. DRAINAGE AREA 208 SQUARE MILES.

WILLAMETTE RIVER BASIN, OREGON

**DAILY MAXIMUM AND MINIMUM WATER TEMPERATURES**

SOUTH FORK McKENZIE RIVER NEAR RAINBOW, OREGON

SCALES AS SHOWN

U S ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

PREPARED — RECOMMENDED
SUBMITTED — APPROVED
DRAWN TRACED CHECKED

MK - 1 - 88

PLATE 10

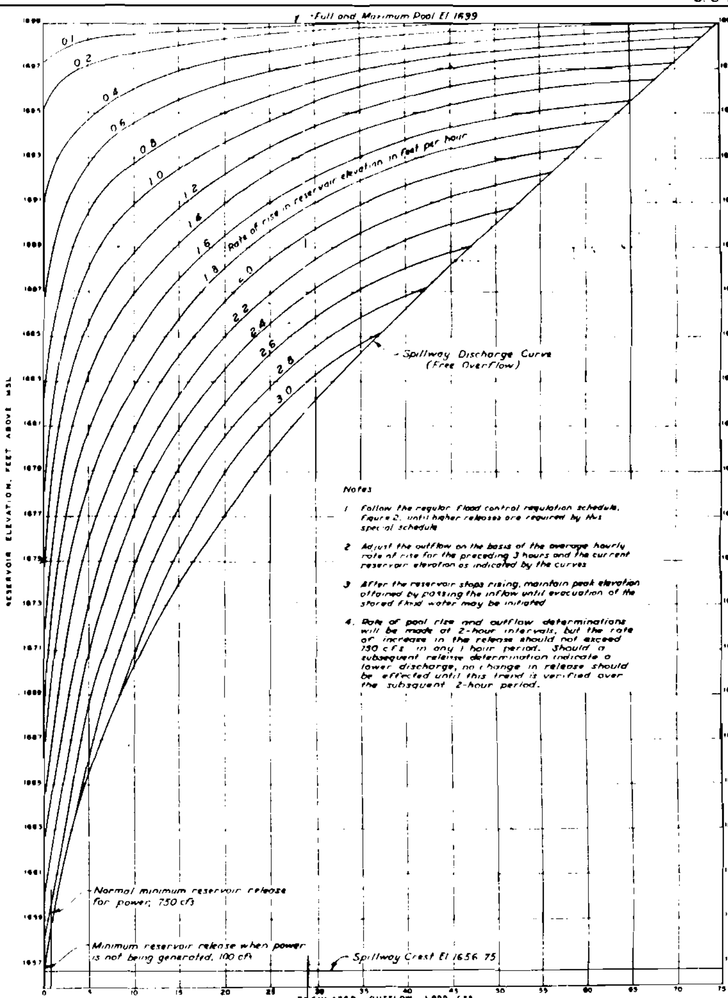



FIGURE 3

SPECIAL FLOOD CONTROL REGULATION SCHEDULE

Notes

1. Follow the regular flood control regulation schedule, Figure 2, until higher releases are required by this special schedule.
2. Adjust the outflow on the basis of the average hourly rate of rise for the preceding 3 hours and the current reservoir elevation as indicated by the curves.
3. After the reservoir stops rising, maintain peak elevation attained by passing the inflow until evacuation of the stored flood water may be initiated.
4. Rate of pool rise and outflow determinations will be made at 2-hour intervals, but the rate of increase in the release should not exceed 750 c.f.s. in any 1 hour period. Should a subsequent release determination indicate a lower discharge, no change in release should be effected until this trend is verified over the subsequent 2-hour period.

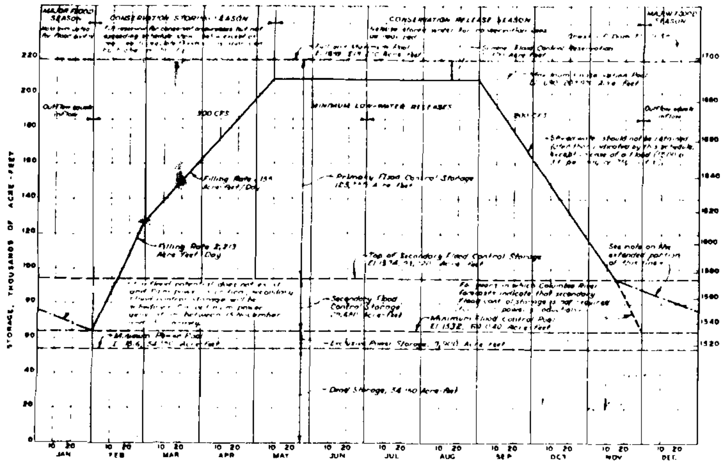
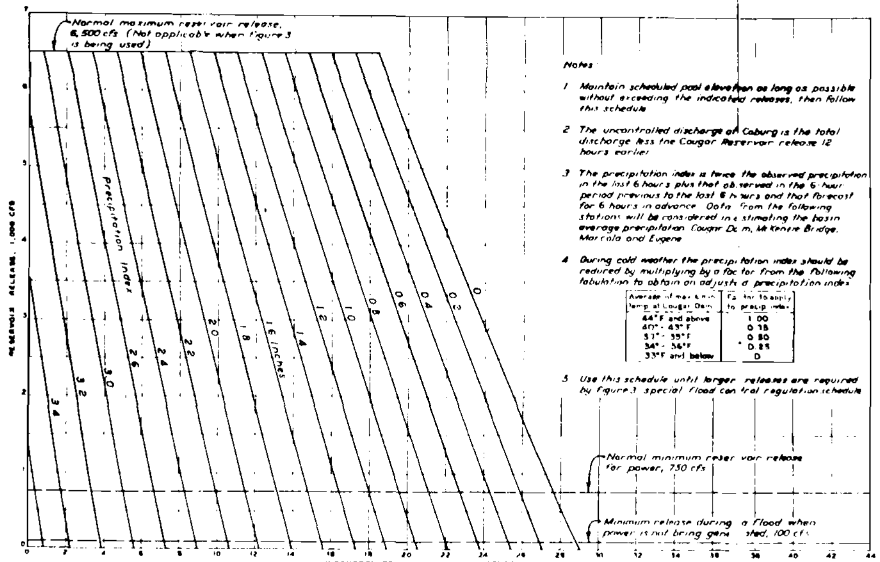



FIGURE 1

SEASONAL REGULATION SCHEDULE




Notes

1. Maintain scheduled pool elevation as long as possible without exceeding the indicated releases, then follow this schedule.
2. The uncontrolled discharge at Coburg is the total discharge less the Cougar Reservoir release 12 hours earlier.
3. The precipitation index is twice the observed precipitation in the last 6 hours plus that observed in the 6-hour period previous to the last 6 hours and that forecast for 6 hours in advance. Data from the following stations will be considered in estimating the basin average precipitation: Cougar Dam, McKenzie Bridge, Marcola and Eugene.
4. During cold weather the precipitation index should be reduced by multiplying by a factor from the following tabulation to obtain an adjusted precipitation index.

| Average of max & min temp at Cougar Dam | Factor to apply to precip index |
|---|---|
| 44°F and above | 1.00 |
| 40° - 43°F | 0.78 |
| 37° - 39°F | 0.80 |
| 34° - 36°F | 0.85 |
| 33°F and below | 0 |

5. Use this schedule until larger releases are required by Figure 3 special flood control regulation schedule.

FIGURE 2

FLOOD CONTROL REGULATION SCHEDULE

REVISED FEBRUARY 1964

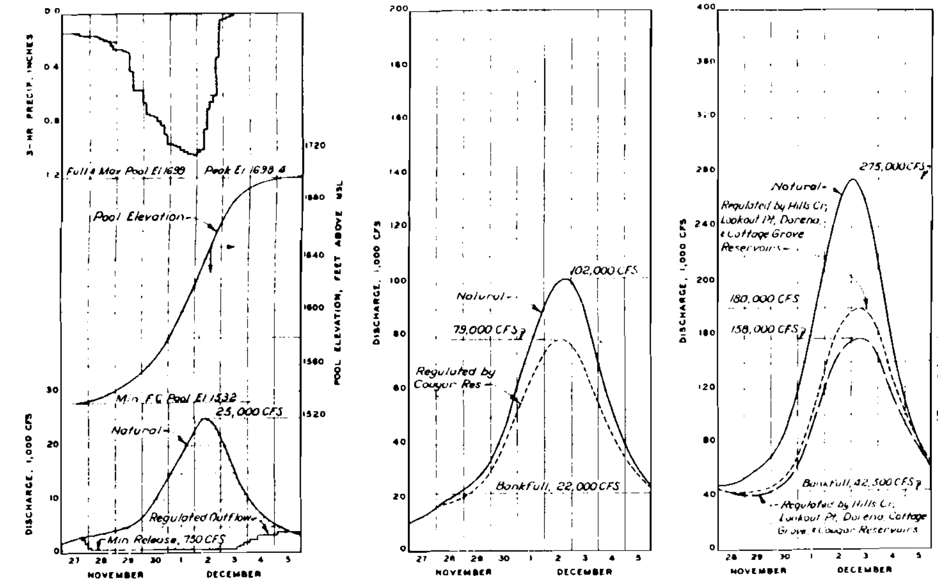
WILLAMETTE RIVER BASIN, OREGON
SOUTH FORK McKENZIE RIVER
COUGAR RESERVOIR

**REGULATION SCHEDULES**

SCALES AS SHOWN
U. S. ARMY ENGINEER DISTRICT PORTLAND
CORPS OF ENGINEERS

TRANSMITTED WITH REPORT DATED DEC 1962

CU-20-16/5

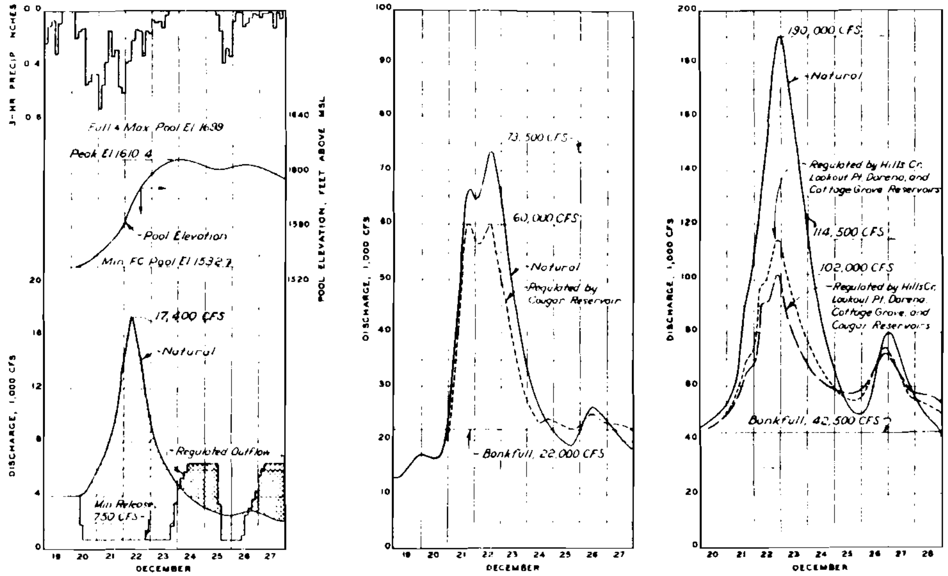



SOUTH FORK McKENZIE RIVER
AT COUGAR DAM
DRAINAGE AREA 208 SQ MI

McKENZIE RIVER
NEAR COBURG, OREGON
DRAINAGE AREA 1,337 SQ MI

WILLAMETTE RIVER
AT HARRISBURG, OREGON
DRAINAGE AREA 3,420 SQ MI

**FLOOD OF NOVEMBER – DECEMBER 1861**

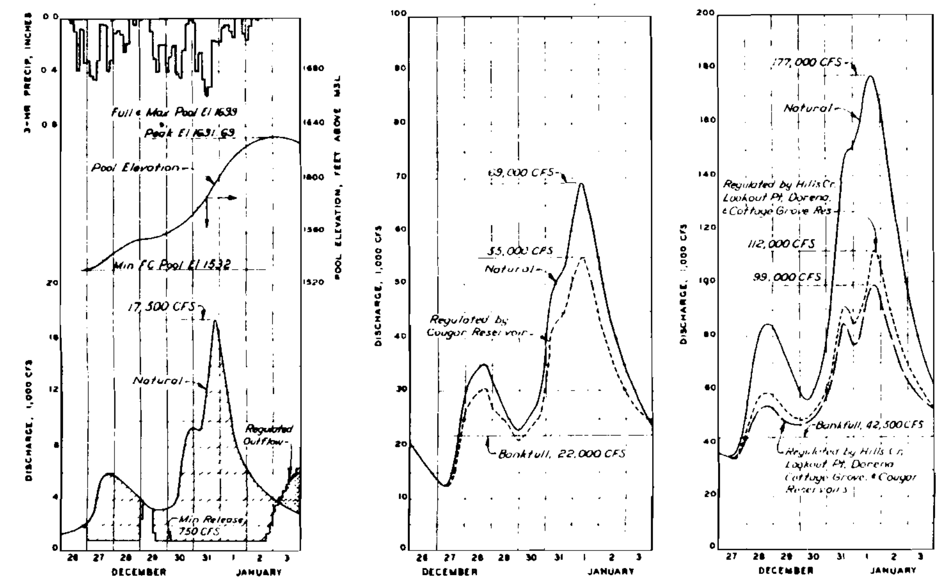



SOUTH FORK McKENZIE RIVER
AT COUGAR DAM
DRAINAGE AREA 208 SQ MI

McKENZIE RIVER
NEAR COBURG, OREGON
DRAINAGE AREA 1,337 SQ MI

WILLAMETTE RIVER
AT HARRISBURG, OREGON
DRAINAGE AREA 3,420 SQ MI

**FLOOD OF DECEMBER 1955**

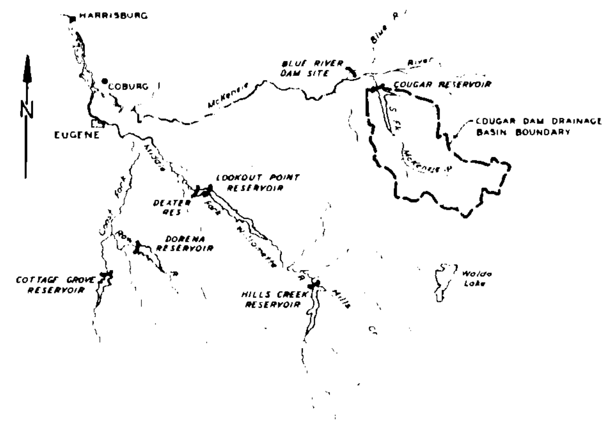



SOUTH FORK McKENZIE RIVER
AT COUGAR DAM
DRAINAGE AREA 208 SQ MI

McKENZIE RIVER
NEAR COBURG, OREGON
DRAINAGE AREA 1,337 SQ MI

WILLAMETTE RIVER
AT HARRISBURG, OREGON
DRAINAGE AREA 3,420 SQ MI

**FLOOD OF DECEMBER 1942 – JANUARY 1943**




LOCATION MAP
SCALE IN MILES

| FLOOD CONTROL STORAGE RESERVOIRS ABOVE HARRISBURG | |
|---|---|
| RESERVOIR | FLOOD CONTROL STORAGE ACRE-FEET |
| COTTAGE GROVE * | 30,000 |
| DORENA * | 70,000 |
| LOOKOUT POINT * | 337,000 |
| HILLS CREEK * | 200,000 |
| COUGAR * | 155,000 |
| BLUE RIVER + | 85,000 |
| TOTAL | 877,000 |

* EXISTING RESERVOIR
\+ UNDER CONSTRUCTION

LEGEND

- HYDROGRAPH OF NATURAL DISCHARGE
- HYDROGRAPH OF REGULATED FLOW WITH EXISTING STORAGE PLUS HILLS CREEK
- HYDROGRAPH OF REGULATED FLOW WITH EXISTING STORAGE PLUS HILLS CREEK AND COUGAR
- HYDROGRAPH OF REGULATED OUTFLOW AT DAM
- WATER STORED IN RESERVOIR
- WATER IN EXCESS OF INFLOW RELEASED FROM RESERVOIR

WILLAMETTE RIVER BASIN, OREGON
SOUTH FORK McKENZIE RIVER
COUGAR RESERVOIR

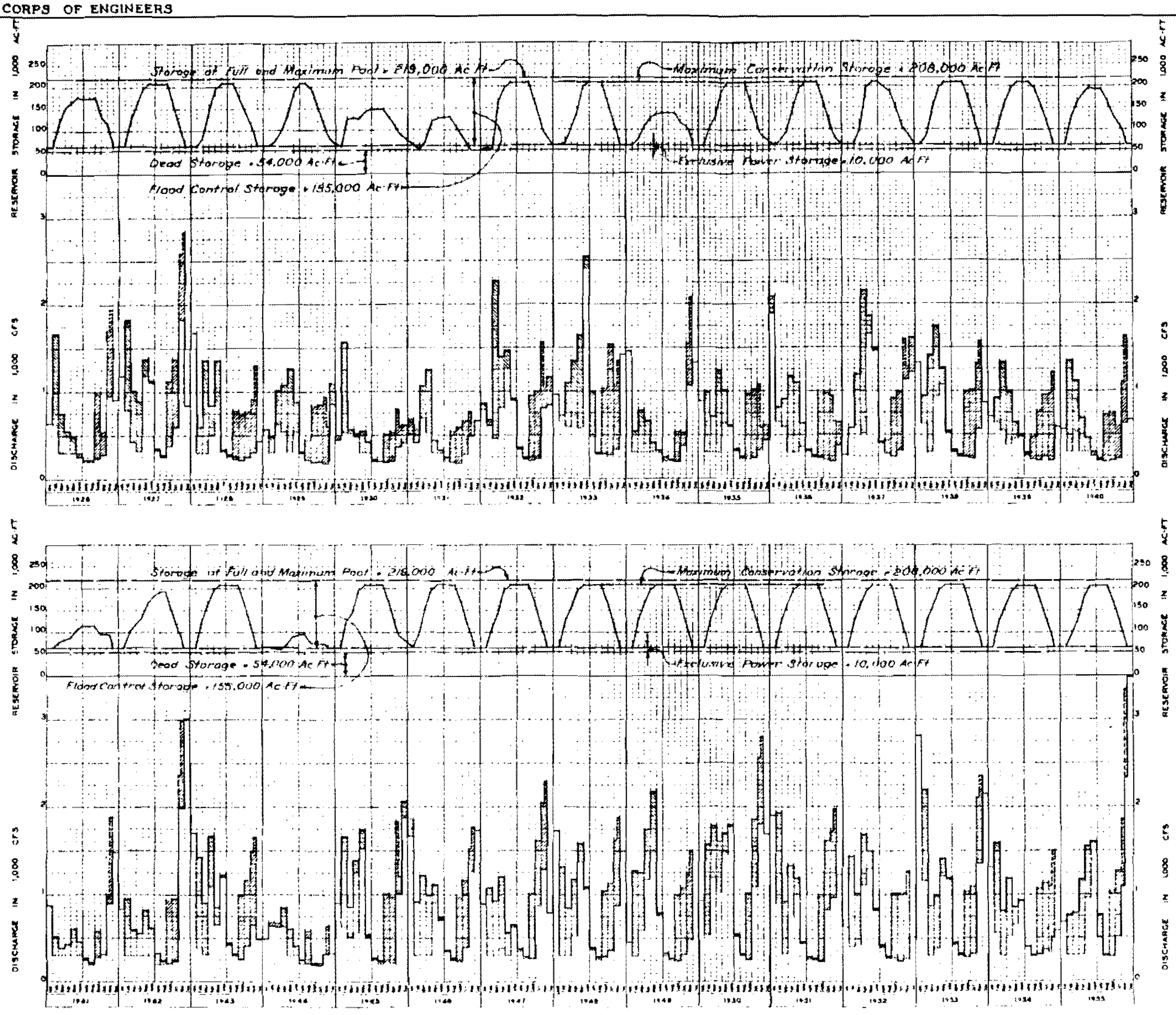
## EXAMPLES OF REGULATION

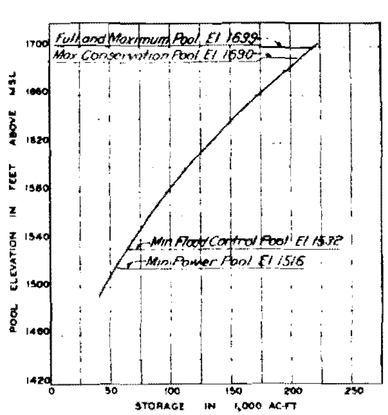
SCALES AS SHOWN
U.S. ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS

PREPARED — CHIEF, WATER CONTROL SECTION
RECOMMENDED — CHIEF, ENGINEERING DIVISION
SUBMITTED — CHIEF, PROJECT PLANNING BRANCH
APPROVED — COLONEL, CORPS OF ENGINEERS, DISTRICT ENGINEER
DRAWN
TRACED
CHECKED
WITH REPORT

CU-20-18

PLATE




STORAGE CAPACITY

## LEGEND

NATURAL INFLOW

REGULATED OUTFLOW

WATER STORED IN RESERVOIR

WATER RELEASED FROM RESERVOIR

## NOTES

1. This chart illustrates the inflow, outflow, and reservoir contents as affected by a plan of ultimate development of the water resources in the Willamette Basin.
2. Cougar is one of the fourteen multi-purpose reservoirs recommended for the Willamette Basin.
3. Flood control regulation is illustrated on Plate 11.
4. See text for detailed explanation of seasonal reservoir regulation.

WILLAMETTE RIVER BASIN, OREGON
SOUTH FORK McKENZIE RIVER

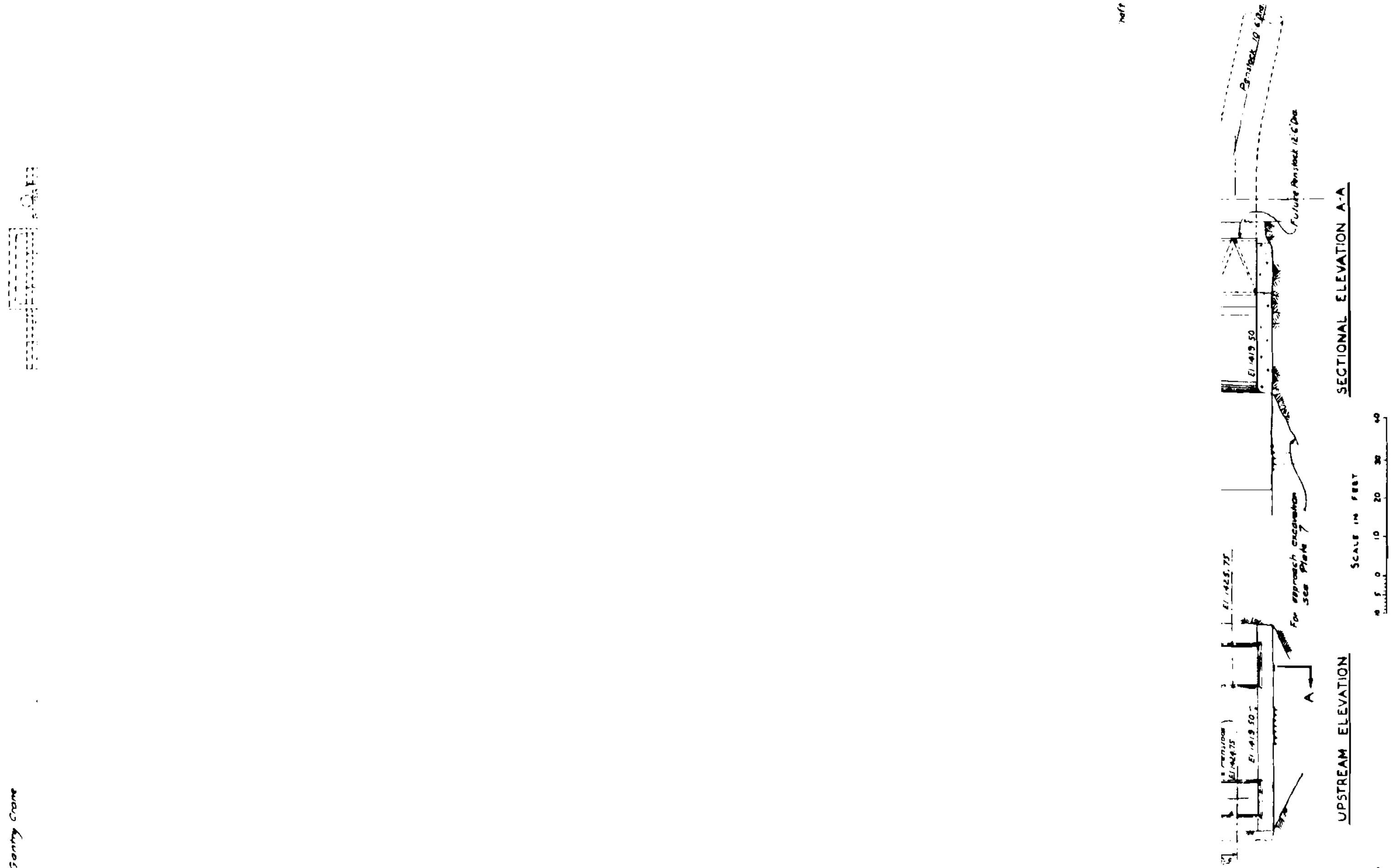
COUGAR RESERVOIR

SEASONAL RESERVOIR REGULATION
1926 — 1955

SCALES AS SHOWN

PORTLAND DISTRICT, CORPS OF ENGINEERS MAY 1, 1956

CU-20-3/3

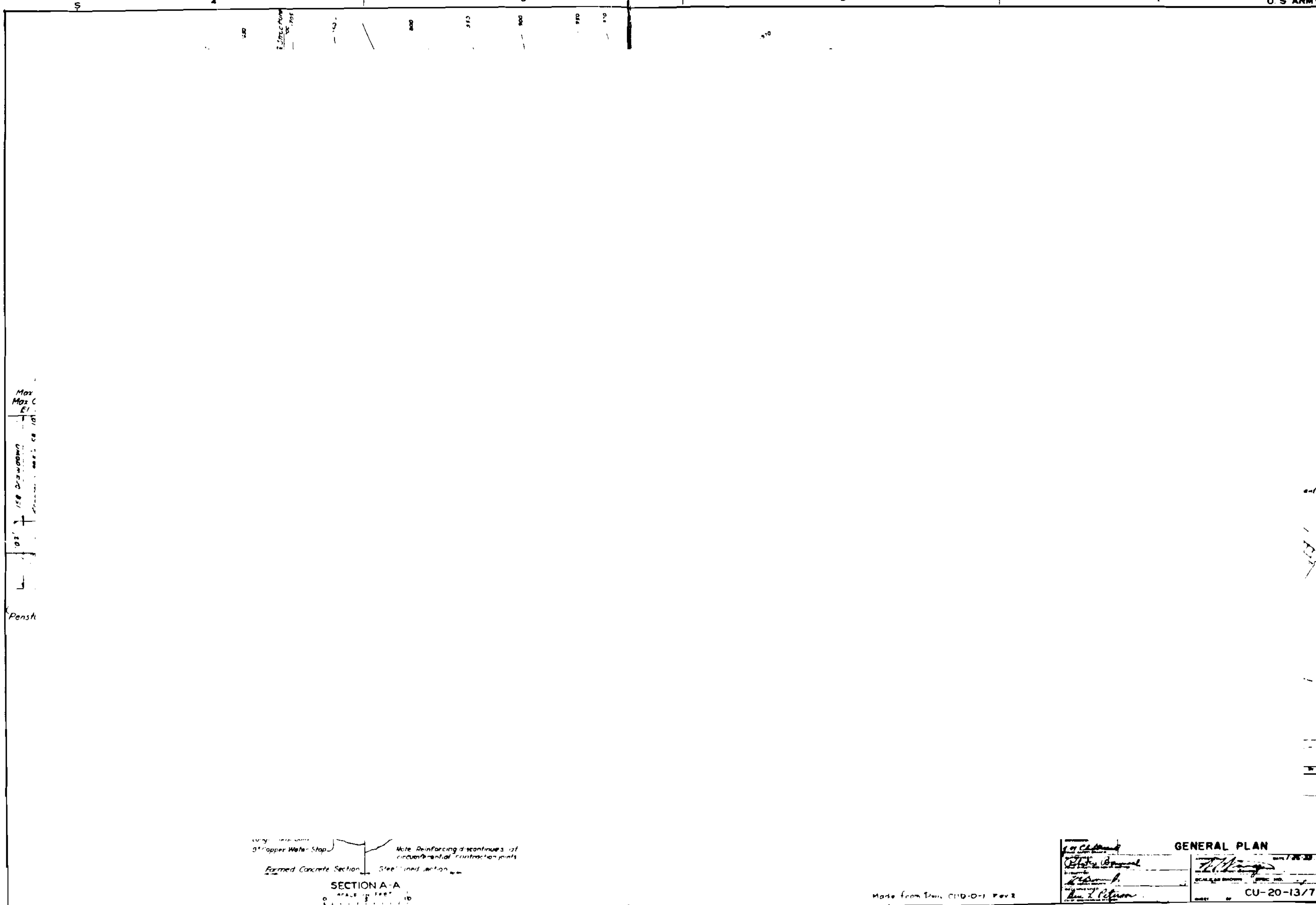



Made from Dwg. CUO-2-8A

U S ARMY ENGINEER DISTRICT, PORTLAND
CORPS OF ENGINEERS
OFFICE OF THE DISTRICT ENGINEER PORTLAND OREGON

WILLAMETTE RIVER BASIN, OREGON
SOUTH FORK McKENZIE RIVER
COUGAR RESERVOIR
INTAKE STRUCTURE
ELEVATIONS

CU-20-13/8


U. S. ARMY
9" Copper Water Stop
Note: Reinforcing discontinuous at circumferential contraction joints
Formed Concrete Section
Steel Lined Section
SECTION A-A
SCALE IN FEET
0
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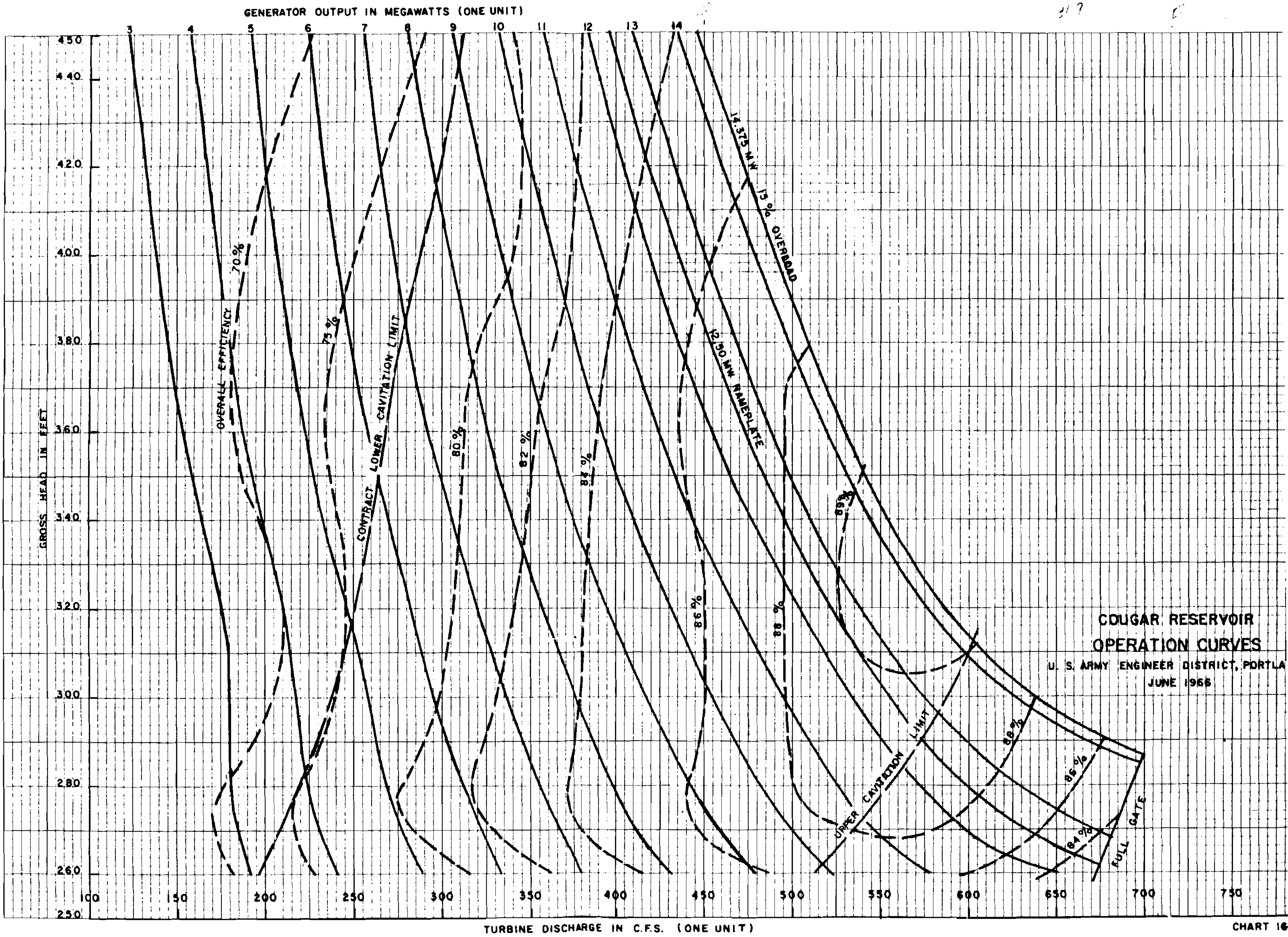
Made from Dwg. CUD-O-1 Rev 2
GENERAL PLAN
SCALE AS SHOWN
SPEC. NO.
CU-20-13/7
PLATE 15




COUGAR RESERVOIR
OPERATION CURVES
U. S. ARMY ENGINEER DISTRICT, PORTLA
JUNE 1966

CHART 16

US Army Corps of Engineers®
Portland District

# EXHIBIT A

# DROUGHT CONTINGENCY PLAN FOR THE WILLAMETTE VALLEY PROJECT

Detroit reservoir at minimum power pool, after the 2015 Drought (Oct 17, 2015)

# Drought Contingency Plan for the Willamette Valley Project

## Table of Contents

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|---|---|



| Figures | Page |
|---|---|

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# 1.0 Introduction.

1-01. Purpose. The purpose of this document is to provide a drought contingency plan (DCP) for USACE reservoirs in the Willamette Valley Project.

1-02. Requirements. This DCP for the Willamette Valley Project meets the requirements of ER 1110-2-1941, *Development of Drought Contingency Plans*, dated 15 September, 1981. Engineering Regulation (ER) 1110-2-240, *Water Control Management*, dated 30 May 2016, Section 2-3.i, states that water control management policies and procedures, including project regulation, shall be evaluated for adaptation to climate change. A vulnerability assessment by the USACE, summarized in two reports, the 2011 and 2012 *USACE Climate Change Adaptation Plans and Report*, dated September 2011, and June 2012, respectively, identified drought as a source of continuing vulnerability in the future. Updated policy and guidance regarding DCP updates to account for climate change is planned as stated in the CWTS[1] Report 15-15, *USACE Drought Contingency Planning in the Context of Climate Change, U.S. Army Corps of Engineers: Washington DC*, dated September 2015 (Pinson et al., 2015).

1-03. Background. This 2017 DCP update provides a description of historical droughts, drought signals and indicators, drought trends in the context of climate change, water uses and availability, flow and drought management for the Willamette Valley Project, and addresses coordination and communications to take place during a drought situation. This DCP will be included as an exhibit to the Willamette Master Manual and the individual water control manuals upon approval. As of 2017, the Willamette Master Manual draft, dated March 2015, is awaiting the updated NEPA documentation on the operations and maintenance of the Willamette Valley Project.

1-04. Responsibilities. The Portland District Reservoir Regulation & Water Quality Section (CENWP-EC-HR) is responsible for preparation, revision, and implementation of the DCP. The Northwestern Division Water Management, Columbia Basin (CENWD-PDW) is responsible for oversight and approval of this DCP.

# 2.0 Authorities

The following list of authorities is pertinent to the preparation of drought contingency plans and drought related activities:

- Section 6 of the Flood Control Act of 1944, 33 U.S.C. § 708, provides authority for the Secretary of the Army to enter into agreements for surplus water with states, municipalities, private concerns, or individuals at such prices and on such terms as he may deem reasonable for domestic, municipal, and industrial uses (but not for crop irrigation), for surface water that may be available at any reservoir under the control of the Department of the Army, and provides adequate authority to permit temporary withdrawal of water from USACE projects to supplement normal supplies.

[1] “CWTS” is Civil Works Technical Series

- Flood Control Act of 1941, Pub. L. No. 84-99, 33 U.S.C. § 701n, as amended by Section 82 of the Water Resources Development Act of 1974, Pub. L. No. 93-251, grants the Chief of Engineers discretionary authority to provide emergency supplies of clean water. Work under this authority requires a request from the governor of the affected state. This law authorizes an emergency fund to be expended in preparation for emergency response to natural disasters, including drought, and authorizes the Chief of Engineers to perform emergency work and to provide emergency supplies of clean water on such terms as he determines to be advisable as a result of drought.
- Pub. L. No. 95-51, Disaster Relief Act of 1974 Appropriations Act, amended the Flood Control Act of 1941 to provide for disaster relief, and authorized the Secretary of the Army to construct wells and transport water to farmers, ranchers, and political subdivisions within areas determined to be drought distressed.
- The National Drought Policy Act of 1998, Pub. L. No. 105-199, established the National Drought Policy Commission to provide advice and recommendations on creation of an integrated coordinated Federal policy designed to prepare for and respond to serious drought emergencies.
- ER 1110-2-1941, *Development of Drought Contingency Plans*, dated 15 September 1981, provides policy and guidance for the preparation of drought contingency plans as part of the USACE over-all water management activities.
- ER 1110-2-240, *Water Control Management*, dated 30 May 2016, describes the policies and procedures to be followed in water management activities, including special regulations to be conducted during droughts. It also sets the responsibility and approval authority in development of water control plans.
- ER 500-1-1, *Emergency Employment of Army and Other Resources*, dated 30 September 2001, prescribes policies for the Civil Emergency Management Program of the USACE under the Flood Control Act of 1941. Section II of this ER describes the policy for the USACE to provide assistance during drought, the level of assistance authorized in providing emergency water, and funding procedures for emergency water activities.
- ER 405-1-12, *Real Estate Handbook*, dated 20 November 1985, provides guidance for issuing an appropriate real estate instrument for water withdrawal users who will be installing water lines or other facilities or equipment.
- EM 1110-2-3600, *Management of Water Control Systems*, 30 November 1987 requires that the drought management plan be incorporated into the project water control manuals and master water control manuals. It also provides guidance in formulating strategies for project regulation during droughts.

The USACE Institute for Water Resources, *Water Supply Handbook*, *Report 96-PS-4*, dated December 1998, Chapter 2, provides the authorities, policies and procedures for the different types of water during a drought. This includes storage costs, restrictions, disaster relief, emergency water supply planning and other water uses during a state of emergency, including drought conditions.

# 3.0 Droughts

3-01. Definition of Drought. The CWTS report 15-15 (referred to in Section 1-02), classifies three types of drought: meteorological, agricultural, and hydrologic. Socioeconomic and ecological droughts are other types described by the National Drought Mitigation Center. These types of droughts are described follows:

- **Meteorological** drought is a period of months to years in which precipitation is below normal. It can be accompanied by above-normal temperatures and other factors. It can precede and cause the other types of drought.
- **Agricultural or soil-moisture** drought is a period with dry soils which can reduce crop production and plant growth. Soil-moisture drought can result from below-normal precipitation, above-normal evaporation, or intense but less-frequent precipitation events. Susceptibility to soil-moisture drought can depend on crop or vegetation type.
- **Hydrologic** drought refers to a period when river streamflow and water storages in aquifers, lakes and reservoirs fall below long-term mean levels. It can develop slowly as stored water is used but not replenished.
- **Socioeconomic** droughts occur when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply. The supply of economic goods, such as water, forage, food grains, fish and hydropower depends on weather. Because of the natural variability of climate, water supply is ample in some years, but not able to meet human and environmental needs in other years.
- **Ecological** drought is a prolonged and widespread deficit in naturally available water supplies, which include changes in natural and managed hydrology and create multiple stresses across ecosystems.

3-02. Historical Oregon Droughts. Droughts in Oregon occur in all parts of the state and in both winter and summer months. The region east of the Cascade Mountain Range is the most vulnerable to drought with localized risks statewide where climate is influenced by local topographical features. Water is often in short supply in much of Oregon during the low flow months of July through September. Figure 3-1 is reproduced from the draft Willamette Master Manual, dated March 2015, which shows the low precipitation during the summer months compared to the rest of the year. This condition has been described as Oregon's seasonal "drought". Droughts appear to be cyclic and can have an effect on the economy, particularly on the hydropower and agricultural sectors. Environmental consequences include insect infestations in forests and reduced water availability for endangered fish. Severe drought conditions have preceded major forest fires. Water allocation continues to be controversial.

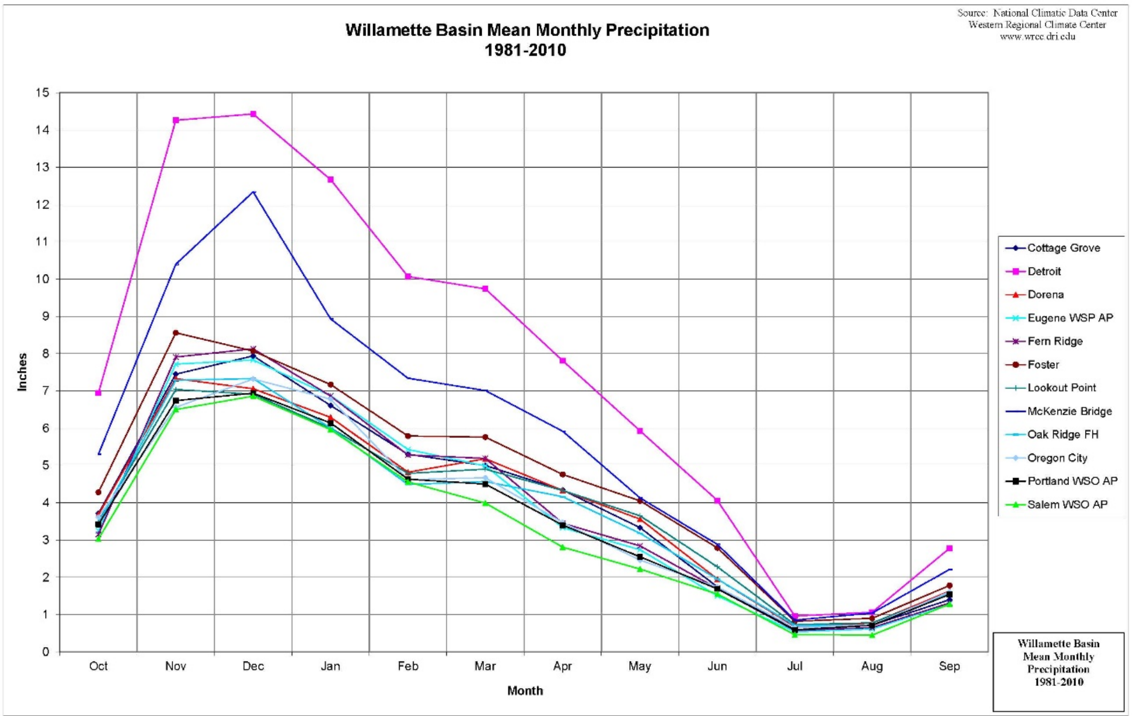



Figure 3-1. Willamette Basin Monthly Precipitation

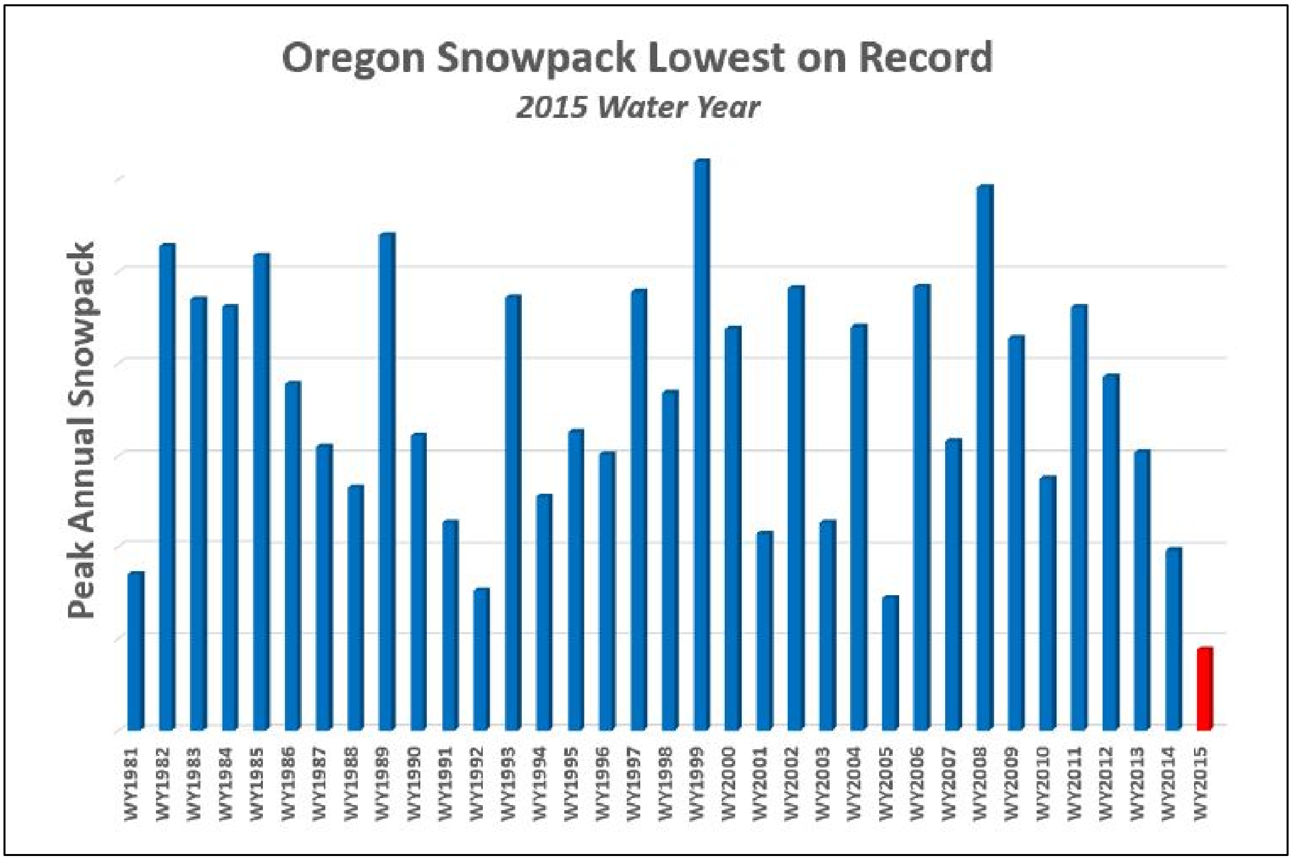
Eight significant hydrologic drought periods have occurred in Oregon since 1900 (*Oregon Emergency Management Plan*, *Natural Hazards Mitigation Plan*, *Drought Chapter*, February 2012, and the *2015 Drought After Action Report for Portland District Reservoir Operations*.).

1904-1905: Drought period of about 18 months
1917-1931: Very dry period punctuated by brief wet spells (1920-21, 1927)
1939-1941: Three year intense drought
1976-1977: Brief, but intense statewide drought
1985-1994: Generally dry period, with statewide droughts in 1992 and 1994
2001-2002: Second most intense drought in Oregon's history
2005: Drought affected at least eleven of Oregon's thirty-six counties
2015: El Niño brought dry and very warm conditions from February thru October

The most recent drought year occurred in water year 2015, and was a low water year for the history books with record low snowpack and streamflows along with record high temperatures that combined to create drought conditions across Oregon.

Based on the Oregon Surface Water Supply Index (SWSI) (see section 3-04.c), water year 2014 began quite dry, became normal in June and July, and then became dry again in September, resulting in an extremely dry start to water year 2015. The 2015 statewide snowpack set new record lows, replacing the previous low-snow years of 1977, 1981, 1992 and 2005. Many snow sites set records for the lowest peak snowpack and earliest melt-out date since measurements began. Figure 3-2 shows the relative, state-wide peak annual snowpack for each water year, 1981 through 2015, showing that 2015 was the lowest for this period.

For the period May 2015 through July 2015, Oregon recorded the warmest average temperatures since 1895 when record keeping began. By 1 September 2015, the SWSI for the entire state ranged from -1.65 to -3.78 (recalibrated as of September 2016), with the Willamette Basin at 3.78. By the end of September, the U.S. Drought Monitor showed the Willamette Basin to be in a D2 Severe Drought condition and 25 of Oregon's 36 counties had requested and received drought declarations from the Governor. Reservoirs fell to unprecedented levels, irrigators stopped irrigation early in the season, and some cities implemented water restrictions.




Source: Drought Annex, State of Oregon Emergency Operations Plan, January 2016

Figure 3-2. Peak Annual Oregon Snowpack 1981-2015

3-03. Drought Signals and Indicators. A key to understanding the impacts of a drought is to evaluate the specific components of the hydrologic cycle. Precipitation and snow can be considered the carrier of the drought signal, while hydrologic processes such as snowpack accumulation and melt, runoff, evaporation rates, soil moisture, streamflow magnitudes, and groundwater content and flow can be viewed as the indicators revealing the drought presence.

The El Niño Southern Oscillation Index (ENSO) refers to the cyclical conditions that occur across the equatorial Pacific Ocean due to natural interactions between the ocean and atmosphere. El Niño is the warm phase of the ENSO cycle and the La Niña, is the cool phase. A major El Niño event generally occurs every 3 to 7 years and tends to bring drier winters to the Pacific Northwest which could signal a potential drought. La Niña conditions in the Pacific Northwest are often, but not always, characterized by cold air temperatures starting in November and December, high snowpack conditions in the mountains and low elevation snowfall in the valleys, and reduced snowmelt in the mountains until late spring.

There does not appear to be a viable connection with ENSO for short term or sustained drought for Western Oregon. The overall warm signal for the Pacific Northwest during ENSO is marginal for Western Oregon at best. El Niño warmth may suggest higher snow levels, producing a less reliable snowmelt in the spring, which could be a factor for refill of the reservoirs. The La Niña (ENSO) phase, does lean wetter for the Willamette and might be considered to not produce a drought situation; however, caution should be used when considering the use of ENSO, as the resolution in climate models is low, there are lots of uncertainty, and the opposite of what might be expected in a La Niña or El Niño year does occur.

A discussion of the up-to-date ENSO status is issued monthly by NOAA's Climate Prediction Center and the International Research Institute for Climate and Society. The discussions and data can be accessed at the Climate Prediction Center's website provided in the Weblinks section of this document.

3-04. Drought Monitoring and Climate Forecasts. The United States Department of Agriculture (USDA) and the Natural Resources Conservation Service (NRCS) provide climate forecasts that include indicators of drought. Regulators monitor and use these to aid in making water management decisions.

a. USDA Drought Monitor. The USDA provide maps, data, and forecasts related to drought through the Drought Monitor website. The U.S. Drought Monitor is a weekly product that provides a general summary of current drought conditions. Various indices, outlooks, field reports, and news accounts are reviewed and synthesized. Policymakers and the media use the information in discussions of drought and in allocating drought relief. The Drought Monitor provides a color coded map of the U.S. that shows levels of drought intensities by region. The Drought Monitor Update Report for Oregon can be accessed at the weblink provided in the Weblinks section of this document.

b. Natural Resources Conservation Service Oregon. The NRCS Oregon provides snow and precipitation data for current water year, water supply outlook reports, climate, and soil moisture/temperature data for their SNOTEL sites. Snow survey products and water supply outlook reports for Oregon are provided through maps and graphs, and can be accessed at the weblink provided in the Weblinks section of this document.

The water supply outlook reports include the Oregon Basin Outlook Report, streamflow forecast tables and maps, daily water supply forecasts, reservoir reports, and the Surface Water Supply Index. The Oregon Basin Outlook Report provides a monthly update (January through June) of the water supply for select basins across Oregon and includes the current status of the snowpack and long term water supply forecasts.

c. Drought Severity. Drought is typically measured in terms of water availability in a defined geographical area. It is common to express drought with a numerical index that ranks severity. NOAA uses the Palmer Drought Severity Index that provides data back to 1900. Most federal agencies use the Palmer Method. This method uses precipitation, runoff, evaporation, and soil moisture as variables. Because the method does not use snowpack as a variable, the Palmer index does not provide an accurate indication of drought in the Pacific Northwest and Oregon; however, it can be useful because of its long term historical record of wet and dry conditions back to 1900.

The Oregon Water Resources Department uses the Surface Water Supply Index (SWSI) to help assess drought conditions. The SWSI is developed by the NRCS. The SWSI is calculated using mountain snowpack, precipitation, reservoir storage, and streamflow data to predict the anticipated water availability for the upcoming year. The SWSI scale measures anticipated water supply by drainage basin, ranging from a +4.1 representing extremely wet conditions to -4.1, representing extremely dry conditions. The SWSI calculations use different equations for each month, all available data, an objective method to determine coefficients, and a 5-month running average to smooth the effects between months. Figure 3-3 shows the 14 river basins within Oregon used to evaluate state-wide drought conditions. The up-to-date and historic SWSI values can be accessed at the weblink provided in the Weblinks section of this document.

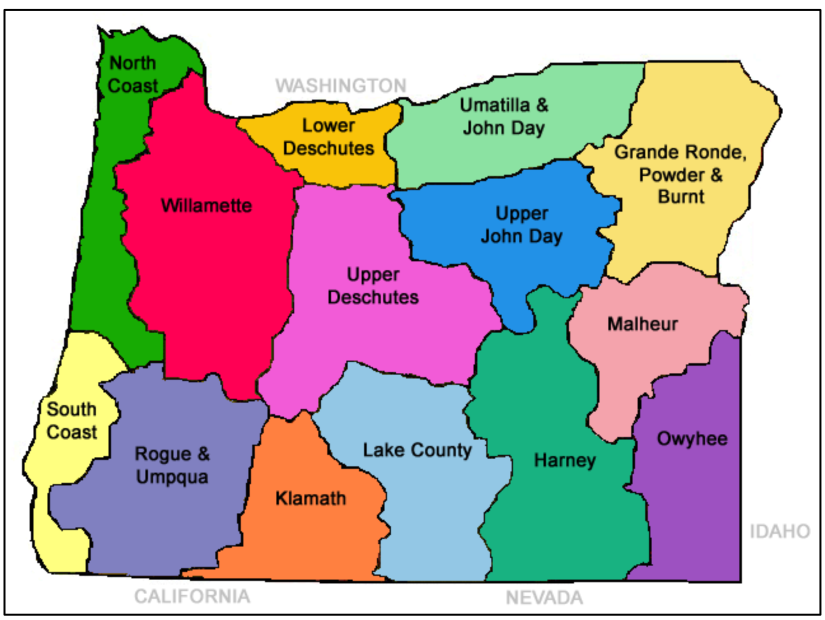


Figure 3-3. Oregon River Basins to Evaluate Drought Conditions

3-05. Drought in the Context of Climate Change. Drought contingency plans are a critical element of flexible water management when combined with water control manuals and the operation deviation process. The following describes efforts to include climate change in DCPs, climate and streamflow projections in Oregon, and implications to future operations of the Willamette Valley Project.

a. Drought Contingency Planning for Climate Change. The CTWS Report 15-15, contains an overview of climate change and drought in the U.S. to aid in planning for current and future droughts at USACE projects. As of 2017, the report may be accessed at the weblink provided in the Weblinks section of this document. Table 1 of the CTWS Report 15-15, shows that the prediction for the Northwest is for a possible increase in summer drought conditions, and increased hydrologic drought due to changes in mountain snowpack. Appendix B of the report provides a summary of the climate change impacts for six regions in the U.S., including the Northwest.

b. Climate and Streamflow Projections. The report prepared for the CENWP by the Oregon Climate Change Research Institute, *Historical Trends and Future Projections of Climate and Streamflow in the Willamette Valley and Rogue River Basins,* dated June 2015 and revised March 3, 2016, examines observed changes in temperature, precipitation, snowpack, and streamflow in the Willamette and Rogue River Basins, provides projections of the future changes of these variables based on global climate model (GCM) simulations, and addresses implications to water management. The following is a summary of the findings of this study. Refer to the report for details.

1) Temperature. The temperature trend analysis shows, that the minimum and maximum temperatures are projected to increase year-round with greater warming in June through August periods. There is a high degree of confidence in the temperature increases because all models agree with the trend.

2) Precipitation. Some model predictions show an increase and some show a decrease in precipitation. The average multi-model projection change is small in each season, with slightly more precipitation in the winter and less in the summer. While the average multi-model projection change is small, the range of plausible outcomes should be considered.

3) Snowpack. Snow water equivalent as a portion of cumulative precipitation is expected to decline across the region. The North Santiam sub-basins which historically receive the most snow, show a projected December through February decline. The Middle Willamette sub-basin generally receives less snow compared to the other basins and future trend is to receive even less snow. In addition, the small increases in total winter precipitation are projected to potentially equate to very little snow in the future due to the increase in winter temperatures.

4) Streamflow. Changes in streamflow are primarily driven by decreases in snow accumulation, and secondarily by seasonal variation in precipitation change. Models show that mean winter flows will increase and summer flows will decrease, with the magnitude of change mainly determined by the basin’s sensitivity to a decline in snow accumulation. The North Santiam is considered sensitive to the snowpack. In this basin, the mean flow is projected to increase significantly during the winter and decrease in the spring and summer, whereas, in the

Middle Fork, the winter flows are projected to increase slightly with small changes during the rest of the year.

Annual peak flows are projected to increase in the future with the peak flows with lower return periods to increase more than those with higher return periods. For rain driven basins, annual peak flows of are of short duration (1 to 5 days), and are projected to occur up to 5 days earlier in the water year. For basins with a larger snowmelt component such as in the North Santiam, peaks are expected to occur up to 2 weeks earlier.

c. Implications for Water Management. The probability of drought is projected to increase under future climate change if drought were defined as prolonged periods of demand exceeding supply. As of 2017, it is not clear if current operations provide enough flexibility to manage hydrological changes.

# 4.0 Basin Description

4-01. Willamette Basin Description. The Willamette Basin is an 11,200 square mile watershed that is a major tributary to the Columbia River and is located entirely within the state of Oregon. The basin has a maximum north-south length of about 150 miles, averages about 75 miles in width, and encompasses 12 percent of the state. The basin is bound by three mountain ranges: the Cascade Range to the east, the Coast Range to the west, and the Calapooya Mountains to the south. Maximum elevations exceed 10,000 feet in the Cascade Range, 4,000 feet in the Coast Range, and 6,000 feet in the Calapooya Mountains. Thirteen of Oregon's thirty-six counties intersect or lie within the boundary of the basin and nearly seventy percent of Oregon's population lives within the basin.

Principal tributaries of the Willamette River originate in the Cascade Range and have headwater elevations generally around 6,000 feet (see figure 4-1). In the upper reaches, these tributaries flow in narrow valleys with steep gradients. The major Cascade Range tributaries include the Santiam, McKenzie, Middle Fork of the Willamette, Molalla, and Clackamas Rivers. The Willamette River is also fed by major tributaries from the Coast Range, including the Long Tom, Marys, Luckiamute, Yamhill, and Tualatin rivers. At the south end of the basin, the Coast Fork of the Willamette River emerges from the Calapooya Mountains and joins the mainstem Willamette River near the City of Springfield (near Eugene).

Precipitation ranges from 40 to 200 inches in the Willamette Basin. Based on computations from USGS data, the average annual flow at Salem (river mile 84, drainage area of 7,280 square miles) for the water years 1910-2015 is 23,300 cfs, or about 16.9 million acre-feet per year. The minimum daily flow at Salem was 2,480 cfs on 27 August 1940. This flow occurred before the USACE dams were completed and operational. The minimum regulated flow for the period 1970-2016 after all of the USACE dams in the Willamette Basin became operational, was 4,140 cfs which occurred on February 20$^{th}$, 1977.

4-02. Willamette Reservoir System. The USACE operates 13 dams in the Willamette Basin. The system of 13 dams is referred to as the Willamette Valley Project. Eleven of the USACE dams are operated as multiple purpose storage projects and two are strictly reregulating dams for hydropower production. The locations of the individual dams are shown on figure 4-1. The USACE' reservoirs in the Willamette Valley Project can store up to approximately 1.6 million acre-feet of usable water. This represents about 9 percent of the average annual runoff of the Willamette River at Salem. The 13 USACE dams manage about 27 percent of the entire drainage area above Portland and 42 percent of the drainage area above Salem.

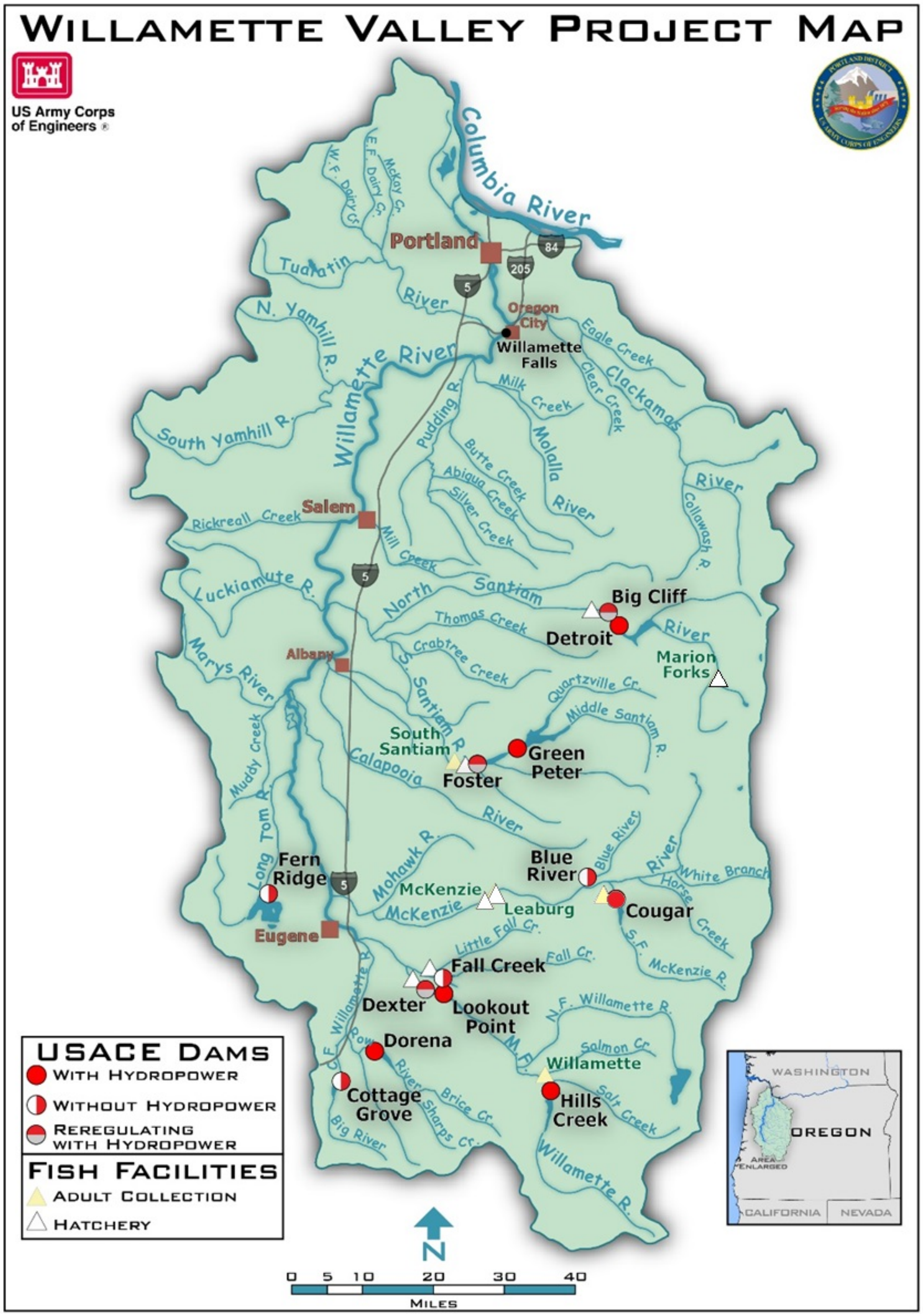



Figure 4-1. Willamette Valley Project Map

4-03. <u>USACE Projects in the Willamette Valley Project</u>. The list of 13 USACE projects in the Willamette Basin are shown on table 4-1. Each water control manual is an appendix to the draft

Willamette Master Manual. As of 2017, the Willamette Master Manual is in draft form while awaiting updated NEPA documentation on the operations and maintenance of the Willamette Valley Project, which is required for approval of the Master Manual. The location of each project is shown on Figure 4-1. A description of each project can be found in their respective water control manuals. Three projects have reregulation dams downstream of them; Big Cliff is the reregulation dam for Detroit; Dexter is the reregulation dam for Lookout Point; and Foster is the reregulation dam for Green Peter, but also has storage capability.

Table 4-1. List of Willamette Valley Project Water Control Manuals

| Appendix | Project |
|---|---|
| -- | Willamette Master Manual |
| 1-A | Blue River Lake |
| 1-B | Cottage Grove Lake |
| 1-C | Cougar Lake |
| 1-D | Detroit and Big Cliff Lakes |
| 1-E | Dorena Lake |
| 1-F | Fall Creek lake |
| 1-G | Fern Ridge Lake |
| 1-H | Foster Lake |
| 1-I | Green Peter Lake |
| 1-J | Hills Creek Lake |
| 1-K | Lookout Point and Dexter Project |

# 5.0 Water Uses and Availability

5-01. Water Uses. Water that is stored in the Willamette Valley Project is currently (2017) used for irrigation, fishery enhancement, recreation, hydropower, and environmental flows. Future water storage allocations may include municipal and industrial water supply. It is increasingly important to plan for providing adequate flows for multiple water uses. Informed decision making is accomplished through coordination of the Willamette Conservation Plan (see Section 7-02). The following is a brief description of water use in the Willamette Basin. In addition the effect on cultural resources as a result of low pool levels is provided.

a. Irrigation. According to House Document (HD) 531 that provides authorization for the Willamette Valley Project, irrigation was anticipated to be a significant use of water stored in the Project reservoirs. The U.S. Bureau of Reclamation (Reclamation) administers water service contracts for irrigators within 15 water service contract reaches. Irrigation use in the Willamette Basin has not occurred as initially projected and is not expected to occur in the future at levels near the scope and scale originally envisioned. As of February 2017, nearly 75,000 acre-feet of water (less than 5% of the conservation storage) is contracted for irrigation. Table 5-1 shows the number of contracts within each reach, volume of water contracted, and the acres served for each reach in the Willamette Basin. Figure 5-1 shows the reach locations.

Table 5-1. Willamette System Irrigation Contract Data

| | Reach | Reservoirs Providing Water | Number of Contracts | Acre-Feet Contracted | Acres Served |
|---|---|---|---|---|---|
| 1 | Willamette River | All Reservoirs | 45 | 22,825 | 11,289 |
| 2 | Santiam River | All Reservoirs on North and South Santiam Rivers | 3 | 242 | 323 |
| 3 | North Santiam River | Big Cliff, Detroit | 29 | 11,375 | 6,584 |
| 4 | South Santiam River | Foster, Green Peter | 13 | 914 | 492 |
| 5 | Willamette River | All Reservoirs Except Santiam Reservoirs | 28 | 15,603 | 11,015 |
| 6 | Long Tom River | Fern Ridge | 55 | 19,715 | 8,379 |
| 7 | Willamette River | All Reservoirs Except Santiam and Fern Ridge | 9 | 749 | 458 |
| 8 | McKenzie River | Blue River, Cougar | 31 | 1,772 | 911 |
| 10 | Middle Fork Willamette River | Fall Creek, Dexter, Lookout Point, Hills Creek | 2 | 911 | 472 |
| 11 | Middle Fork Willamette River | Dexter, Lookout Point, Hills Creek | 2 | 92 | 37 |
| 12 | Fall Creek | Fall Creek | 3 | 11 | 5 |
| 13 | Coast Fork Willamette River and Row River | Dorena, Cottage Grove | 6 | 581 | 233 |
| 14 | Row River | Dorena | 1 | 51 | 20 |
| 15 | Coast Fork Willamette River | Cottage Grove | 1 | 56 | 45 |
| | **Total** | | **228** | **74,899** | **40,262** |

Source: Reclamation, as of February, 2017

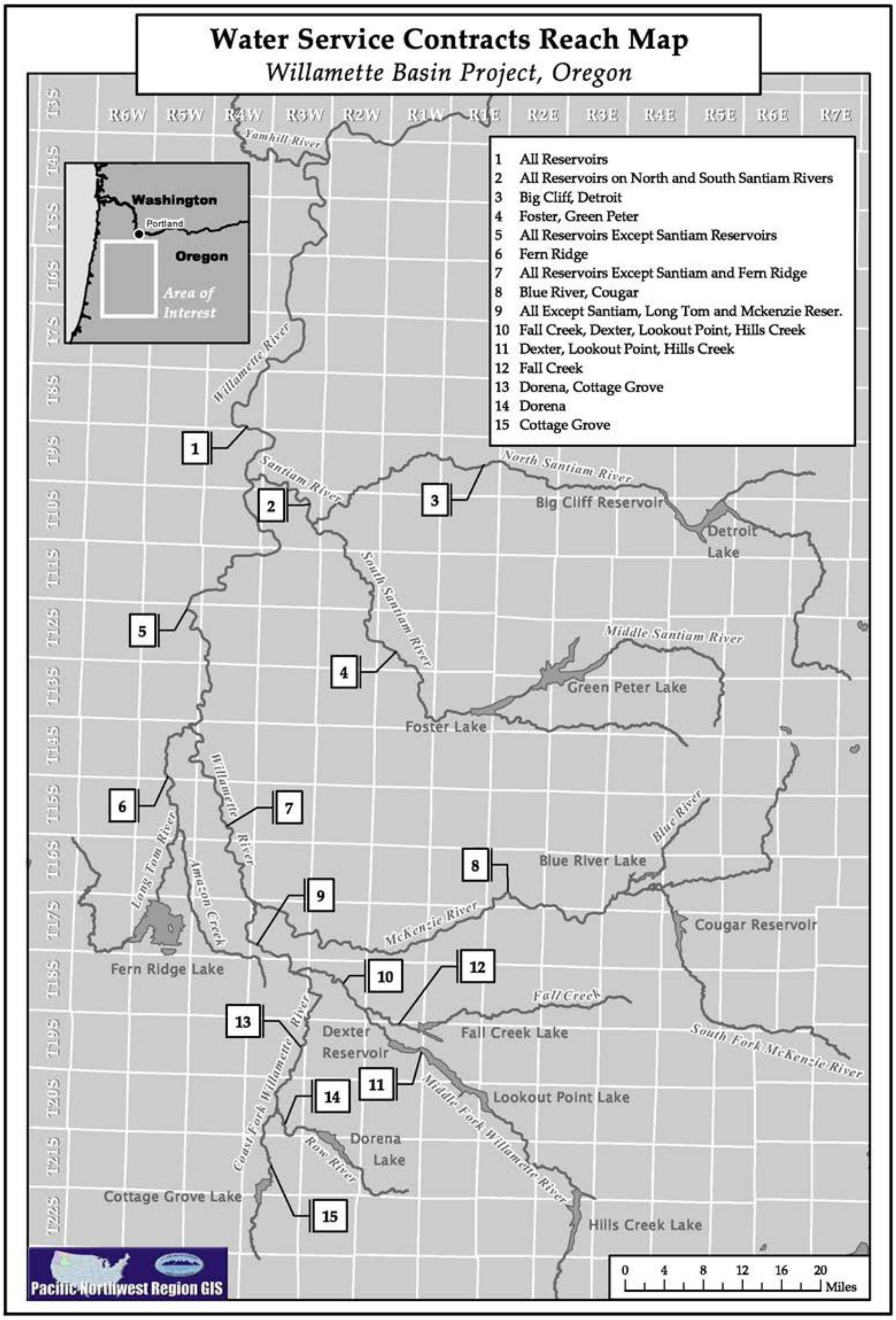



Figure 5-1. Water Service Contracts Reach Map

b. Fishery Enhancement. State and federal fishery resource agencies have identified a number of fish species in the Willamette Basin that are of regional or national significance. Upper Willamette River (UWR) winter steelhead, UWR Spring Chinook salmon, and bull trout are listed as "threatened" under the national Endangered Species Act. Oregon chub was listed as threatened but was delisted in 2015. As habitat degradation and water quality problems, including temperature, affect fish populations, it will be increasingly important to provide for adequate flows in the Willamette Basin.

c. Recreation. Reservoir recreation such as boating and water skiing are major revenue sources for many basin communities. Peak demand for these activities often coincides with the driest point of the summer season, when water for irrigation and in-stream needs is most critical. In some years as early as July, some reservoirs may be drawn down to levels too low to allow use of boat ramps; however, these same summer releases may provide flows for fishing, kayaking, and other recreation on rivers like the McKenzie and North Santiam. The reservoirs are not operated to meet recreation needs during a drought.

d. Hydropower. Eight of the Willamette Valley Project dams have a federal hydropower facility. These dams provide enough power to service 300,000 homes. Generation from the peaking projects are often based upon load throughout the day or week and are subject to frequent fluctuations. The reregulation reservoirs are used to absorb the fluctuations in flows from their upstream peaking projects and release flows at a more uniform level. The generation at the baseload projects provides uniform generation supply. Monthly generation can change drastically from year to year depending on the amount of runoff which occurs in the basin. A non-federal hydropower facility was added to Dorena Dam in 2014. The Dorena water control plan has not been altered due to installation of the hydropower facility. All flow releases from Dorena Dam are as determined by CENWP-EC-HR and reservoir regulations are documented in the Dorena Water Control Manual.

e. Environmental. A set of environmental flow recommendations (e-flows) were developed through the Sustainable Rivers Project, a USACE and The Nature Conservancy partnership. The purpose and benefits of the e-flows are to improve habitats on the flood plain margins, re-establish some river dynamism such as increasing river sediment transport, thereby encouraging re-formation of pools and riffles, re-establishing extant flood plain connection and smoothing the flow transitions after winter high flow events to facilitate lateral movement between refugia, seed dispersal, and birdnesting, etc. These operations are targeted for winter and spring months and use water that would need to be released to stay within the rule curve elevations. The e- flow operations provide ecological benefits while affecting minimal change to flood risk reduction, water quality, hydropower and meeting biological opinion flow objectives. E-flow targets are for the Middle Fork Willamette River at Jasper (outflows from Fall Creek and Dexter), South Fork McKenzie outflows from Cougar, and the North Santiam at Mehama (outflows from Big Cliff) and have been incorporated into the respective water control manuals.

f. Municipal and Industrial Water Supply. Some of the largest cities in the Willamette Basin rely on the Willamette River and its tributaries for drinking water. As population increases throughout the valley, and as environmental and financing issues reduce the likelihood that municipalities will build new reservoirs for drinking water, river flow and existing reservoirs will continue to be an important water source.

Throughout the basin, employers such as pulp and paper mills use river water directly without purchasing through a municipal provider. In addition, high-tech industries have grown and have a significant demand for water. Although most of the high-tech industries receive their water through a municipal system, it is important to include all industry needs when planning for dry season uses of reservoir water.

As of 2017, the Willamette River Basin Review Feasibility Study is assessing the feasibility of reallocating storage in the Willamette Valley Project reservoirs from general joint-use to specific originally authorized purposes, including municipal and industrial (M&I) water supply, irrigation, and fish and wildlife. Any reallocation plan will require approval from Congress as the volume of storage exceeds the limits for local approval. Once the storage is reallocated and state issued water rights are modified, storage will be available for M&I use. The amount of storage and water expected to be needed for M&I is higher than listed in HD 531, but still much less than irrigation.

g. Navigation. Navigation is an authorized purpose of the Willamette Valley Project, but the project flows are no longer regulated for navigation use above the Willamette Falls Lock at Oregon City. Project authorizing documents (HD 544, 75th Congress, third session, March 16, 1938) stipulated a minimum flow of 5,000 cfs between Albany and the Santiam River, and 6,500 cfs downstream to Salem to provide navigation depths of 6 feet and 5 feet, respectively, above Willamette Falls. These minimum flows have been adopted for water quality purposes (see section 5-01.h). Over the years, the ODEQ has issued wastewater discharge permits based on a 7Q10 flow (the EPA definition: the lowest 7-day regulated average flow that occurs on average once every 10 years), which is approximately 5,500 cfs near Salem. The USACE continues to attempt to meet these flows to aid in water quality and fisheries enhancement in compliance with the 2008 Biological Opinion.

h. Water Quality. The minimum congressional flows of 5,000 cfs at Albany and 6,500 cfs at Salem were established for the purposes of navigation, but have become base flows used to maintain water quality standards in the mainstem Willamette. Both water quantity and quality were of great concern, particularly in watersheds with salmon and other fish species listed as endangered or threatened under the Endangered Species Act. Many streams in Oregon do not meet water quality standards during the summer due to high water temperatures, but release of water from reservoirs provide some aid in reducing water temperatures downstream of the dams. Water quality standards are also limited due to inadequate riparian zones and increasing problems associated with agriculture and forestry chemicals.

i. Effects on Cultural Resources. The USACE Willamette Valley Projects Dams lies within the traditional lands for four federally recognized Native American Tribes, the Confederated Tribes of the Grand Ronde Community of Oregon, the Confederated Tribes of the Siletz Indians, the Cow Creek Tribes of Umpqua Indians, and the Confederated Tribes of the Warm Springs Reservation of Oregon. The tributaries that the dams block are used traditionally by these tribes (historically and today) for the gathering of plants for food and fiber, fish, and other wildlife associated with the watershed. The projects also have inundated hundreds of historic and Native American archaeological sites. Drought situations where water levels are altered, such as being lower for longer periods of time, might affect the archaeological resources due to exposure, wave action, recreational uses, and vandalism / looting. It also has the potential to have an additional negative effect on subsistence fishing utilized by the Tribes. The USACE has a responsibility to the protection of these resources, archaeological and historic under the National Historic Preservation Act. Tribal traditional cultural properties are included under the NHPA, as well as the consultation and coordination under the Executive Order 13175, Department of Defense (DoD) American Indian and Alaska Native Policy, 2004; Department of the Army American Indian and Alaska Native Policy, 24 Oct 2012; Tribal Consultation, Presidential Memorandum, 5 Nov 2009: USACE Memorandum, Sovereignty and Government-to-Government Relations with American Indian and Alaska Native Tribal Governments: USACE Tribal Policy Principles, 10 May 2010; and USACE Tribal Consultation Policy, 1 Nov 2012.

5-02. Available Storage. The storage of water in the Willamette Valley Project is based on seasonal regulation schedules established according to each project's rule curve. The Willamette Valley Project can store up to approximately 1.6 million acre-feet of water within the conservation pool. The ability to use water from inactive storage, power pool storage, and uncontracted stored water is described below.

a. Quantity of Inactive Storage. For projects with hydropower that have regulating outlets (Hills Creek, Lookout Point, Cougar, Green Peter, and Detroit), the inactive storage is the reservoir capacity between the minimum power pool and the lowest regulating outlet invert elevation. For projects without USACE operated hydropower (Fall Creek, Cottage Grove, Dorena, Fern Ridge, and Blue River), the inactive storage is the reservoir capacity between the minimum flood pool and lowest regulating outlet invert elevations. For reregulation projects (Dexter, Foster, and Big Cliff), the inactive storage is the reservoir capacity between the minimum power pool and the spillway crest. The total inactive storage for the Willamette Valley Project reservoirs is approximately 359,999 acre-feet. Table 5-2 shows the percent of inactive storage by project.

b. Ability to Use Inactive Storage. Under no circumstances should the inactive storage be used for power generation, as operating to the low heads could cause damage to the turbines. In 2015, most of the Willamette Valley Project reservoirs dipped into inactive storage to meet minimum flow with little impact. The impact of drafting into the inactive storage is an increased risk of not refilling the reservoir. Fall Creek Project uses 9,505 acre-feet of inactive storage in winter for a maximum of two weeks to pass predatory fish in order to reduce predation on salmonids in the reservoir.

Table 5-2. Inactive Storage Volume by Project[1]

| Project | Inactive Storage Volume (Acre-Feet) | Inactive Storage (Percent) |
|---|---|---|
| Hills Creek | 6,600 | 1.8% |
| Lookout Point | 19,194 | 5.3% |
| Dexter | 97,644 | 27.1% |
| Fall Creek | 9,505 | 2.6% |
| Cottage Grove | 3,139 | 0.9% |
| Dorena | 7,355 | 2.0% |
| Fern Ridge | 2,802 | 0.8% |
| Cougar | 16,700 | 4.6% |
| Blue River | 3,430 | 1.0% |
| Green Peter | 71,220 | 19.8% |
| Foster | 10,980 | 3.1% |
| Detroit | 109,700 | 30.5% |
| Big Cliff | 1,730 | 0.5% |
| **Total** | **359,999** | 100.0% |

[1]Volumes derived based on reservoir storage capacity tables located on the CENWP-EC-HR weblink, as of June 2017.

c. Ability to Use Power Pool Storage. The power pool is the reservoir capacity between the minimum flood pool and the minimum power pool. Table 5-3 shows the powerpool storage by project (Dexter and Big Cliff do not have flood pools, therefore they are not shown). Under project authorities, the power pool is reserved exclusively for power generation. Infrequent, limited (or modest) drafting into the power pool on a case-by-case basis may be accomplished pursuant to project authorities. This decision must be coordinated with the Bonneville Power Administration to ensure that any decision to use the power pool has taken into consideration power requirements. The decision should also consider how critical the need is to draft (e.g., biological need to provide minimum flows at the time).

If reservoirs draft to the minimum power pool level, generation will be stopped to avoid damage to the generating units. Station service will be supplied to the plants from the transmission grid. Regulating outlets will be used to maintain streamflow.

Table 5-3. Powerpool Storage Volume by Project[1]

| Project | Powerpool Storage Volume (Acre-Feet) | Powerpool Storage (Percent) |
|---|---|---|
| Hills Creek | 48,800 | 28.5% |
| Lookout Point | 11,377 | 6.6% |
| Cougar | 8,700 | 5.1% |
| Green Peter | 62,600 | 36.5% |
| Foster | 3,600 | 2.1% |
| Detroit | 36,375 | 21.2% |
| **Total** | **171,452** | **100.0%** |

[1]Volumes derived based on reservoir storage capacity tables located on the CENWP-EC-HR weblink, as of June 2017.

d. Quantity of Uncontracted Water Supply Storage. The Reclamation holds two water rights with the State of Oregon to store 1.64 million acre-ft (applications filed in 1954 and 1968) of water in the Willamette Valley Project reservoirs for irrigation use only. As of February 2017, there are only 74,899 acre-feet of water actually contracted, therefore the uncontracted storage is about 95% of the water rights storage. It is important to note that the entirety of the conservation storage volume remains is in the joint-use purpose. As of 2017, the conservation storage volume in the Willamette Valley Project is 1.6 million acre-ft. See section 6-03 for more information on irrigation contracts.

e. Ability to Use Uncontracted Water and Procedures to Obtain Water. The withdrawal of water from streams, lakes, and reservoirs, is regulated by the OWRD under the state water law. An applicant must file for a water right with the OWRD. Any withdrawal permit for stored water will be issued subject to a contract or agreement with the owner/operator of the facility (such as the USACE).

f. Use of Surplus Water. Section 6 of the Flood Control Act of 1944 (Public Law 78-534) authorized the Secretary of the Army to enter into agreements for use of surplus water for temporary drought relief, and for purposes other than crop irrigation. Surplus water will only be declared available when the use would not significantly affect other authorized purposes. When stored water is in excess of meeting the authorized project purposes it can be identified as surplus water available for use on a temporary (5 years, with the ability for one 5-year extension). Surplus water withdrawn from the streams below USACE projects will require a signed agreement accompanied by a brief letter report documenting how and why stored water is determined to be available as surplus. The level of detail will be commensurate with the amount of water to be used, time of use, and economic and environmental effects. Authority to sign these agreements by the District Commander requires approval from USACE Headquarters. As of December 2016, the price of the available water is based on the updated cost of storage (highest of four cost methods for the Willamette Valley Project), as required for reallocated storage, though draft rule making issued in December 2016 may change this methodology. A template for a surplus water agreement for use of water from USACE reservoirs is provided in Attachment 1.

# 6.0 Oregon Water Rights

6-01. Appropriation Doctrine. Water rights in Oregon are managed by the OWRD. Refer to the *Water Rights in Oregon, An Introduction to Oregon's Water Laws*, by the OWRD, dated November 2013. In Oregon, the prior appropriation doctrine has been law since February 24, 1909 when the first unified water code introduced state control over the right to use water. The principle of prior appropriation means the first person to obtain a water right on a stream is the last to be shut off in times of low streamflows. Before 1909, water users had to depend on themselves or local courts to defend their rights to water. The appropriation doctrine holds that a water right is limited to the quantity of water which is beneficially used, without waste. In 1935, an Oregon Revised Statute (ORS 537.1 0) concerning public ownership of water was established. The statute stated that "All water within the state from all sources belongs to the public." During times of low streamflows, the appropriator with the oldest date of priority can demand water specified in their water right permit obtained from the Department, regardless of the needs of other users. The date of priority, determined by the date of application for the permit, determines the seniority of the appropriators' right. The more senior the water right, the longer water is available during periods of low streamflow.

6-02. Instream Water Rights. An instream water right law was enacted in Oregon via Senate Bill 140 during 1987. The Oregon legislation recognized that public uses are beneficial uses, as defined by the appropriation doctrine. The act allows the Departments of Fish and Wildlife, Environmental Quality, and Parks and Recreation to request instream water rights from the Department. The law gives instream water rights the same status as other water rights, except that municipal uses may have priority over these rights. In a Governor declared drought, Oregon law allows the Department to give preference to human consumption and livestock watering over other uses. Unlike minimum perennial streamflows, the commission cannot waive the instream right in favor of later water rights during the periods of low streamflow. Instream water rights have a priority date, and are regulated in the same way as other water rights. An instream water right cannot affect a use of water with a senior priority date. In the Willamette Basin, the majority of the minimum perennial streamflows established in 1964 have not been converted to instream water rights. Once converted the instream water rights will have a priority date of 1964.

Instream water rights do not guarantee that a specified quantity of water will be maintained in a stream or is available for use. When the water level in a stream is below the instream water right level, holders of junior water rights are required to stop using the water. A holder of a water right to the natural flow of the stream has no right to stored water in a reservoir without an additional water right for use of stored water.

6-03. Irrigation Contracts. The Reclamation implements and manages the sale of irrigation water for the Federal government. The Reclamation filed applications for water rights in 1954 and 1968 on behalf of the federal government. Subsequent state water right certificates have been issued to the Reclamation authorizing all of the 1.64 million acre-feet of system conservation pool storage for irrigation uses (Certificates 72755 and 72756). Currently, irrigators have contracted for less than five percent of the 1.64 million acre-feet; however, agricultural needs may increase in the future. To use the stored water, a contract holder with the Reclamation must obtain a state permit to withdraw the water from an Oregon stream, referred to as a secondary water right.

The storage of water in the Willamette Valley Project is based on the seasonal regulation schedules established according to the rule curve for each dam. The USACE coordinates with the multiple federal and state agencies when releasing stored water at projects to meet secondary project purposes.

# 7.0 Flow Management

7-01. Reservoir Regulation Seasons. Reservoir regulation activities occur over three regulation seasons; major flood, conservation storage, and conservation release. The major flood season is from mid-November through January. During the major flood season, reservoirs are kept at their minimum flood pool to capture high inflows in order to reduce the risk of downstream flooding. The conservation storage season is from February through about mid-May. During this period, the reservoirs fill to their maximum conservation pool level to store water for the conservation release season. During the conservation release season from mid-May through mid-November, water stored within the conservation pool is released for multiple uses, including hydropower, fisheries enhancement, water quality, environmental purposes, recreation, and consumptive use for irrigation.

7-02. Willamette Conservation Plan. The Willamette Conservation Plan (WCP) is the annual water management plan for the Willamette Valley Project and identifies flow and storage needs for each tributary and reservoir in the Willamette Valley Project. Forecasts in April, of runoff volume and system-wide volume storage in the Willamette Valley Project by mid-May are used to set minimum flow objectives for April through October on the mainstem Willamette River, which is central to the WCP. The WCP includes estimates of mainstem flows and reservoir storage volumes likely to occur over the conservation season based on forecasts, system operational alternatives, and constraints through modeling. Reservoir modeling considers the likelihood of meeting the tributary flow objectives in table 7-1 and the mainstem flow objectives in table 7-3. Adaptive management (see section 7-07) may be used to adjust operations within authorized project purposes due to changing conditions and with new knowledge that is gained from ongoing operating experience or studies. Refer to the most recent WCP for the up-to-date minimum flow objectives, as they vary from year-to-year depending on water availability. The WCP may be obtained from the CENWP-EC-HR.

The WCP is coordinated to meet the ESA and all other purposes of the Willamette Valley Project. The Willamette Action Team for Ecosystem Restoration (WATER) is a forum of the Action Agencies (USACE, Reclamation, and BPA), Services (USFWS and NOAA Fisheries), state agencies, and tribes, responsible for planning and implementing flow management in the Willamette Basin. The Flow Management Committee is the technical committee under WATER to coordinate the development of and implement the WCP. The WCP is updated annually during the conservation storage season based on the April forecast made in early April, and anticipated total system storage in mid-May. The plan is fine-tuned in early June after spring refill.

7-03. Forecasts. Forecasts are required during the conservation storage period to assess the timing and capability of refilling to the desired maximum conservation storage elevation of individual projects. The benefits of an accurate forecast are twofold: (1) minimum flow requirements less than normal minimum releases can be requested through the OWRD if insufficient inflows are forecasted and (2) probability of lake refill and timing can be estimated in order to inform lake users. Projections of lake levels during the summer and fall periods are also useful for the same reasons. Adaptive management (see section 7-07) allows for adjustments in reservoir operations if unexpected hydrologic changes were to occur.

NOAA's Climate Prediction Center Seasonal Drought Outlook or the Department of Agriculture's drought indices can be used as an indicator of a short-term drought in consideration of planning for operations in meeting minimum flow objectives without much base-flow or rain. If rainfall and runoff forecasts show that the Willamette Valley Project reservoirs may not fill to the maximum conservation pool levels, a potential drought situation may be indicated. Drought forecasting in the Willamette Basin is most useful in preparing for and during the conservation release season.

Beginning in January, the USACE uses NRCS's April-September water supply volume forecasts issued monthly, and may use Ensemble Streamflow Prediction (ESP) forecasts issued by the Northwest River Forecast Center of the National Weather Service, as input in modeling of the reservoir system. The ESP forecasts use historical meteorological data to represent possible future conditions for probabilistic analyses. These forecasts help estimate how full the reservoirs may be in May and June and how much stored water may be available for release during the conservation season.

7-04. Methods and Tools. Methods and tools are discussed in individual project water control manuals or as described in the *Standard Procedures for Regulation of the Willamette Basin Projects* (contact CENWP-EC-HR for the most up-to-date version). The tools assist in developing estimates of reservoir refill during the conservation filling period.

For long-term planning (greater than 6 months) and for use in the Willamette Conservation Plan, the CENWP-EC-HR runs the USACE's Hydrologic Engineering Center (HEC), reservoir simulation model, HEC-ResSim, to evaluate the water supply forecasts. Water supply volumes are input to the ResSim model to estimate how full the reservoirs may be in May and how much stored water will be available for the release season.

For shorter-term planning, as of 2017, the USACE and Northwest River Forecast Center (NWRFC) use the Community Hydrologic Prediction System (CHPS) reservoir system simulation model, a product of the NWRFC. The USACE provides reservoir regulation information as input to the model while the NWRFC provides weather sequences of given probabilities, soil moisture and ground water conditions. Model runs are made with these parameters and assumptions, and the output are forecasts of lake inflows, streamflows, and lake elevations. The model is used to inform project operational decisions.

During the summer and during drought situations, the CHPS model is run twice a week to ensure the summer flow objectives are met. In addition, the water travel time during the summer is longer due to lower flows, and the CHPS forecast model runs help ensure the flow objectives are met with proper timing.

7-05. Project Minimum Flows. Throughout the year, water is passed through the dams to meet or exceed the congressionally authorized minimum flows. Due to developments in the basin to meet Endangered Species Act needs, a set of minimum flow objectives were recommended by the NOAA's National Marine Fisheries Service Biological Opinion, *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation, Consultation on the "Willamette River Basin Flood Control Project,"* dated 11 July 2008. The Congressional minimum flows as stated in House Document 531, Volume V (Appendix J) and the biological opinion objective flows are provided in table 7-1.

The operational flow objectives and the associated flow management guidelines are intended to balance the risks to listed fish species under low water year conditions with the risks to other uses authorized by Congress for the Willamette Valley Project. Key among these authorized uses are those significant to human health and safety, including flood risk management, hydropower production, and summer and fall low flow augmentation for maintenance of water quality.

7-06. <u>System Minimum Flow Objectives</u>. In addition to the project minimum flows discussed in section 7-05, the 2008 Biological Opinion provides Willamette River mainstem minimum flow objectives at Salem and Albany. Because the water supply in the Willamette can vary significantly from year to year, the 2008 Biological Opinion allows for adaptive management (see section 7-07) of the reservoir system dependent upon predicted system water availability by mid-May. The 2008 Biological Opinion designates four levels of water availability, in terms of forecasted volume of storage in the Willamette Valley Project reservoirs by mid-May. The designation of a conservation season runoff forecast as "abundant", "adequate", "insufficient", or "deficit" will lead to differing management approaches.

Table 7-2 summarizes the designation of Willamette Basin runoff observed over a 64-year period of record. Table 7-3 shows the minimum flow objectives for Salem in "deficit" years (column 6), and for "abundant" and "adequate" years (column 5). Minimum flow objectives for insufficient years are based on a sliding scale between columns 5 and 6. The minimum flow objective for Albany is the same for all years. The flow objectives for April through June are flow objectives for fish while the summer and fall flows at Albany help maintain water quality. For years designated as "abundant" or "adequate", minimum flow objectives during spring, summer, and fall would be expected to be met or exceeded whenever possible (e.g., considering factors such as the accuracy of weather forecasts, constraints in the accuracy of operational adjustments at dams, and delayed system response time between the points of storage release and Salem), therefore these years would not be considered drought years. For years designated as "insufficient" or "deficit", the minimum flow objectives are not expected to be met, and these would be considered drought years. The mainstem spring flow objectives may be temporary actions and are subject to review and revision in accordance with results of appropriate monitoring and evaluation.

Table 7-1. 2008 Biological Opinion and Congressional Minimum Reservoir Outflow

| Location | 2008 NMFS Biological Opinion | | | Water Control Manual | | House Document No. 531 Volume V | |
|---|---|---|---|---|---|---|---|
| | Date | Minimum Flow (cfs) | Remarks | Date | Minimum Flow (cfs) | Date | Minimum Flow for Fish[1] |
| **Detroit/Big Cliff** | 1 Feb - 15 Mar | 1000 | Rearing/adult migration | Feb-Jun | 1,000 | Feb-Jun | 1,000 |
| | 16 Mar - 31 May | 1500 | steelhead spawning | Jul-Nov | 750 | Jul - Nov | 750 |
| | 1 Jun - 15 Jul | 1200 | steelhead incubation | | | | |
| | 16 Jul - 31 Aug | 1000 | rearing | | | | |
| | 1 Sep - 15 Oct | 1500 | chinook spawning | | | | |
| | 16 Oct - 31 Jan | 1200 | chinook incubation | | | | |
| **Blue River** | 1 Feb - 31 Aug | 50 | rearing | Jul-Nov | 50 | Feb-Jun | 30 |
| | 1 Sep - 15 Oct | 50 | chinook spawning | | | Jul - Nov | 30 |
| | 16 Oct - 31 Jan | 50 | chinook incubation | | | | |
| **Cottage Grove** | 1 Feb - 30 Jun | 75 | | Feb-Jun | 75 | Feb-Jun | 75 |
| | 1 Jul - 31 Oct | 50 | | Jul-Oct | 50 | Jul - Nov | 50 |
| | 1 Nov - 31 Jan | inflow | | | | | |
| **Cougar** | 1 Feb - 31 May | 300 | rearing | Feb-Jun | 300 | Feb-Jun | 300 |
| | 1 Jun - 30 Jun | 400 | rearing adult migration | | | Jul - Nov | 200 |
| | 1 Jul - 31 Aug | 300 | rearing | | | | |
| | 1 Sep - 15 Oct | 300 | chinook spawning | | | | |
| | 16 Oct - 31 Jan | 300 | chinook incubation | | | | |
| **Dorena** | 1 Feb - 30 Jun | 190 | | Feb-Jun | 190 | Feb-Jun | 190 |
| | 1 Jul - 31 Oct | 100 | | Jul-Oct | 100 | Jul - Nov | 100 |
| | 1 Nov - 31 Jan | inflow | | | | | |
| **Fall Creek** | 1 Feb - 31 Mar | 50 | rearing | 1 Feb - 15 Nov | 30 | Feb-Jun | 30 |
| | 1 Apr - 31 Aug | 80 | rearing, adult migration (Jun) | | | Jul - Nov | 30 |
| | 1 Sep - 15 Oct | 200 | chinook spawning | | | | |
| | 16 Oct - 31 Jan | 50 | chinook incubation | | | | |
| **Fern Ridge** | 1 Feb - 30 Jun | 50 | | Dec-Jun | 50 | Feb-Jun | 50 |
| | 1 Jul - 31 Oct | 30 | | Jul-Nov | 30 | Jul - Nov | 30 |
| | 1 Nov - 31 Jan | inflow | | | | | |
| **Green Peter/Foster** | 1 Feb - 15 Mar | 800 | Rearing/adult migration | Feb-Arp | 800 | Feb-Apr | 500 |
| | 16 Mar - 15 May | 1500 | steelhead spawning | May | 750 | May | 450 |
| | 16 May - 30 Jun | 1100 | steelhead incubation | 1 Jul - 15 Nov | 400 | Jun | 300 |
| | 1 Jul - 31 Aug | 800 | rearing | | | Jul - Nov | 300 |
| | 1 Sep - Oct 15 | 1500 | chinook spawning | | | | |
| | 16 Oct - 31 Jan | 1100 | chinook incubation | | | | |
| **Hills Creek** | 1 Feb - 31 Aug | 400 | rearing | Feb-Nov | 100 | Feb-Jun | 100 |
| | 1 Sep - 31 Jan | 400 | migration and rearing | | | Jul - Nov | 100 |
| **Lookout Point/Dexter** | 1 Feb - 31 Aug | 1200 | rearing | Feb-Jun | 1,200 | Feb-Jun | 1,200 |
| | 1 Sep - 15 Oct | 1200 | chinook spawning | 1 Jul - 15 Nov | 1,000 | Jul - Nov | 1,000 |
| | 16 Oct - 31 Jan | 1200 | chinook incubation | | | | |

[1] *House Document 531, Review Report on Columbia River and Tributaries, Appendix J, Willamette River Basin*, Table III-1. Minimum flows were adopted for the preservation of fish. At the power reservoirs (Hills Creek, Cougar, Green Peter, and Detroit) the releases during the power season (October - March, inclusive) are substantially greater than the minimum regulated flows shown.

Table 7-2. Evaluation of Spring Runoff and Conservation Operation

| Volume in Storage by 10-20 May (MAF) | Designation | Occurrences (years)[1] | Percent of Years |
|---|---|---|---|
| < 0.9 | Deficit | 10 | 16 |
| 0.9 – 1.19 | Insufficient | 6 | 9 |
| 1.20 – 1.48 | Adequate | 11 | 17 |
| > 1.48 | Abundant | 37 | 58 |
| 1.59 | Maximum[2] | --- | --- |

[1] Period of record 1936-1999 using flow objectives in columns 2, 4, and 5 in Table 7-3
[2] Maximum usable conservation storage.

Table 7-3. Minimum Mainstem Threshold Flows for Albany and Salem (cfs)

| | Albany | | Salem | | | |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Period | Minimum Average Flow[1] | HD 531[2] | Minimum Instantaneous Flow[3] | Minimum Weekly Flow Threshold Abundant and Adequate[4] | Minimum Weekly Flow Threshold Deficit Years[4] | HD 531[2] |
| April | -- | | 14,300 | 17,800[3] | 15,000 | |
| May | -- | | 12,000 | 15,000[3] | 15,000 | |
| 1 – 15 June | 4,500 | | 10,500 | 13,000[3] | 11,000 | |
| 16 – 30 June | 4,500 | | 7,000 | 8,700[3] | 5,500 | |
| July | 4,500 | 5,000 | -- | 6,000[1] | 5,000 | 6,500 |
| 1 – 15 August | 5,000 | | -- | 6,000[1] | 5,000 | |
| 16 – 31 August | 5,000 | | -- | 6,500[1] | 5,000 | |
| September | 5,000 | | -- | 7,000[1] | 5,000 | |
| October | 5,000 | | -- | 7,000[1] | 5,000 | |

[1] 2008 Biological Opinion Appendix D, Table D-2.
[2] Congressional minimum flows from House Document (HD) 531, Volume 5, paragraph 88.
[3] 2008 Biological Opinion Appendix D, Table D-1, biologically based minimum flow objectives.
[4] 2008 Biological Opinion Appendix D, Table D-4. Flows in Column 5 are for "Abundant", and "Adequate" years. Flows for "Insufficient" years are based on a sliding scale between Columns 5 and 6.

7-07. Adaptive Management. Adaptive management of flow objectives involve making adjustments to reservoir operations and flow releases based on changing conditions and changing forecasted hydrologic conditions. Current volume forecast methods do not differentiate between the significant contribution of snowmelt and the highly variable rainfall contribution which makes it difficult to forecast runoff volumes. It is not possible to foresee, describe, and model all of the possible management scenarios and contingencies. In a rain-driven system like the Willamette Basin the best available hydrologic modeling early in the season may result in forecasts that differ significantly from actual conditions later in the conservation season. Since the plan calls for setting operational flow objectives at Salem beginning on 1 April based on a storage forecast for mid-May, flow objectives may need to be adjusted throughout the conservation release season. The availability of water will be re-assessed monthly (or as necessary) and related changes in management strategy will be made.

Adaptive management allows for spreading the risk of insufficient water among all authorized project purposes. Adaptive management is especially important during low water years to balance needs for flows during spring that support spawning and incubation of ESA-listed winter steelhead, needs for storage that provide flows during summer for water quality, and for fall spawning and incubation of ESA-listed Spring Chinook salmon.

# 8.0 Drought Management

8-01. Reservoir Regulation in Drought Conditions. Drought-related water management work is integrated within the overall USACE water management responsibilities and associated activities, which play a major role in characterizing drought conditions in the Willamette Basin. The Willamette Conservation Plan, consistent with the 2008 Biological Opinion, is the vehicle that sets the operational flow objectives in all water year conditions, including drought years. As drought conditions and priorities may vary from year to year, reservoir operational agreements will be made dependent upon the WCP and agreements made under the WATER forum and Flow Management Committee coordination, therefore a prescriptive procedure is not provided in this document. Operations in past drought years may provide an indication for operational strategies for future drought years. Operations used in past years is provided in the following paragraphs.

8-02. Flow Objectives in Past Drought Years. In previous years of extreme drought, interagency agreements resulted in minimum flow objectives at Salem that were less than the Congressional minimum flows at Albany and Salem of 6,500 cfs and 5,000 cfs, respectively. Tables 8-1 and 8-2 show the minimum flow objectives for Albany and Salem, respectively, in various drought years.

Table 8-1. Past Drought Year Interagency Minimum Flow Objectives, Albany

| **Period** | **Drought Years** | | | | |
|---|---|---|---|---|---|
| | **1977** | **1987** | **1988-91** | **1992** | **2015** |
| **June** | 4,000 | 4,000 | 4,500 | 4,000 | 3,500 |
| **July 1-15** | 4,000 | 4,000 | 4,500 | 4,000 | 3,500 |
| **July 16-31** | 4,000 | 4,500 | 4,500 | 4,000 | 3,500 |
| **August 1-15** | 4,000 | 4,500 | 5,000 | 4,500 | 3,500 |
| **August 16-31** | 5,000 | 4,500 | 5,000 | 4,500 | 3,500 |
| **September** | 5,000 | 4,800 | 5,000 | 4,500 | 3,500 |

Table 8-2. Past Drought Year Interagency Minimum Flow Objectives, Salem

| **Period** | **Drought Years** | | | | | |
|---|---|---|---|---|---|---|
| | **1977** | **1987** | **1988-91** | **1992** | **2001** | **2015** |
| **June 1-15** | 5,000 | 5,000 | 6,000 | 5,500 | 11,000 | 5,000 |
| **June 16-30** | 5,000 | 5,000 | 6,000 | 5,500 | 5,500 | 5,000 |
| **July 1-15** | 5,000 | 5,000 | 6,000 | 5,500 | 5,000 | 5,000 |
| **July 16-31** | 5,000 | 5,500 | 6,000 | 5,500 | 5,000 | 5,000 |
| **August 1-15** | 5,000 | 5,500 | 6,000 | 5,500 | 5,000 | 5,000 |
| **August 16-31** | 6,000 | 5,500 | 6,500 | 5,500 | 5,000 | 5,000 |
| **September** | 7,000 | 7,000 | 7,000 | 6,000 | 5,000 | 5,000 |

8-03. Reservoir Regulations in Past Drought Years. The following is a description of reservoir operations and coordination used in recent low water years in the Willamette Basin in drought years.

a. Reducing Minimum Winter Flow. Refill of the reservoirs begins on 1 February. When the observed elevation was below an individual project's rule curve and the forecast was for dry weather, the USACE requested a reduced minimum flow from NOAA Fisheries.

b. Winter Steelhead in the Santiam Basin. In the Santiam Basin, Big Cliff and Foster Dams released minimum flows of 1,500 cfs for winter steelhead spawning. The release periods are from 16 March through 15 May for Foster and from 16 March through 31 May for Big Cliff. During low water years (drought), discussions with NOAA Fisheries took place as modeling showed reservoir levels well below the rule curve. In past years, NOAA Fisheries has agreed to reduce spawning flows to about 1,200 cfs below Big Cliff and 1,100 cfs below Foster.

After steelhead spawning, the steelhead incubation period occurs. This incubation period occurs from 16 May through 30 June at Foster, and from 1 June through 15 July for Big Cliff. In the past, NOAA Fisheries had agreed to reduce incubation flows to be equal to the reduced spawning flows minus 200 cfs.

Rearing flows are maintained during the dry season. Past operations have met the minimum biological opinion rearing flows or released higher flows in order to meet mainstem flows. The ODFW and the NOAA Fisheries have supported steady tributary flows that draft the projects to minimum conservation pool by 1 October without maintaining the mainstem minimum flows.

c. Chinook Spawning in the Santiam Basin. Chinook spawning occurs from 1 September – 15 October. For Big Cliff and Foster Dams, even when pool levels were low, the fisheries agencies preferred to release spawning flows. Although the preference is to provide the spawning flow (1,500 cfs), flows have been reduced by 200-300 cfs, have begun later, or have been stepped-up from the summer flow to the spawning flow over a week.

By the end of spawning, in years of little precipitation and when projects were near or at minimum conservation pool, NOAA Fisheries had expressed a need to use power pool storage and inactive pool storage to provide water for fish. Under this condition, major impacts could occur. Any use of power pool water must be discussed and agreed upon by the BPA.

d. Mainstem Flows. Projects outside of the Santiam Basin have operated to minimum flows. Fisheries agencies have agreed to reduce mainstem flows slightly after April 1. When the observed elevation was below an individual project's rule curve and the forecast was for dry weather, the USACE requested a reduced mainstem flow from NOAA Fisheries. NOAA Fisheries has agreed to lower flows in April and May for the Willamette River at Salem as well as a fixed release from the projects and the elimination of minimum flows for the months of June thru September. The amount that NOAA Fisheries has reduced the mainstem flow requirement has varied from year-to-year based on the extent to which the reservoirs have drafted below rule curve.

8-04. Determination of Interim Draft Limits. Reservoir-specific interim draft limits will be used to avoid over-draft of stored water during the early part of the flow management season. The interim draft limits conserve water in order to meet minimum tributary and mainstem flows later in the summer and early fall. Beginning in May, regulators can use a spreadsheet to back calculate, from October to May, the required storage in the reservoirs at month-end throughout the spring and summer to meet the 2008 Biological Opinion flow objectives at Salem and Albany through 31 October. Modeling may include the use of 90% exceedance inflows from the Period of Record data; however, users can test different levels of inflow and outflow to see resulting reservoir levels within the spreadsheet for a risk assessment.

8-05. Priorities. In both "insufficient" and "deficit" year cases, recreational use would be considered a low priority. Hydropower generation, irrigation, and other authorized uses will be met to the fullest extent possible through both discharges of reservoir inflows during spring and release of storage during summer and fall to meet mainstem flow management objectives. Priority will be given to those flow needs directly related to human health and safety. Reservoir inflow in excess of that needed to meet the mainstem operational flow objectives during spring will be stored in a manner that maximizes the likelihood of being able to meet minimum discharge rates, mainstem Willamette River flow objectives at Albany and Salem during June through October, and Willamette Basin hydropower production needs.

As of 2017, due to low level of use for water service contracts, the USACE does not make special operational adjustments, such as increasing flow releases, to meet contract requirements at most projects with the exception of Fern Ridge and Detroit. However, in "deficit" water years, the National Marine Fisheries Service's (NOAA Fisheries) Reasonable and Prudent Alternative (RPA) requires the Reclamation to curtail water contract diversions. In other years, the RPA requires the USACE to release more than minimum flow to ensure the contract users do not take water intended for fish purposes from Fern Ridge and Detroit. In "deficit" water years, a partial water supply or no water supply may be available to satisfy irrigation contracts. Water deliveries may be ceased or curtailed under these conditions, per RPA 3.4.

# 9.0. USACE’s Emergency Navigation

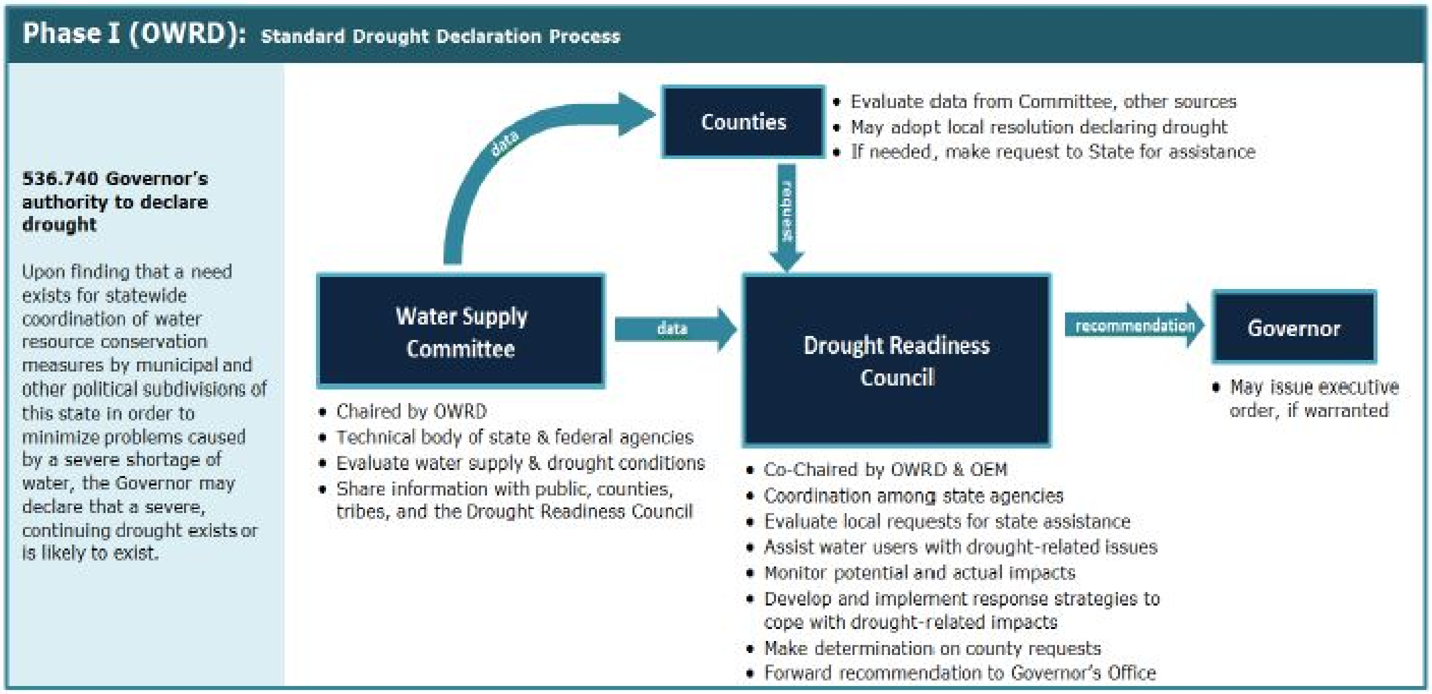
Although there is authorization for navigation in the mainstem Willamette River, there is currently little to no actual navigation for commercial purposes. There is no opportunity to move boats around the Willamette Falls at Oregon City except by trailer. Navigation did not seem to be an issue during the drought of 2001 or 2015. In December of 2011, the Willamette Falls Locks were placed in a non-operational status because of safety issues.

# 10.0 State of Oregon Drought Management

10-01. Authorities. The legal authorities for the State of Oregon’s drought mitigation and response functions are found in ORS 536.700 - 536.780 and Oregon Administrative Rules (OAR) Chapter 690, Division 19. The Governor, through the request of a local jurisdiction, can declare an emergency under ORS 401.165. Under ORS 536.740, the Governor has authority to declare that a severe, continuing drought exists, or may exist, in any (or all) of the drainage basins in Oregon. Based on that declaration, the Governor or the Oregon Water Resources Commission can also direct state agencies and political subdivisions to implement a water conservation plan or water curtailment plan. Additionally, ORS 536.750 states that a drought declaration by the Governor allows the Water Resources Department to provide existing water right holders with access to temporary water management tools, described in OAR 690-019.

The Water Resources Commission is made up of seven members who represent different areas of the state. The commission is a citizen body that sets state water policy and oversees activities of the Water Resources Department. WRC meetings are held regularly at different locations around the state and is open to the public. The region areas in the Willamette Valley are the Northwest Region and the West Central Region.

10-02. Declaration of Drought. The declaration of drought in Oregon is performed by the Governor on a county-by-county or on a state-wide basis. The Governor's technical advisory group is the Oregon Drought Readiness Council (DRC) (see 10-02.a), and the interagency Water Supply Availability Committee (WSAC) (see 10-02.b) reports to the DRC. The two interagency groups evaluate water supply conditions and help assess and communicate potential drought related impacts. The State of Oregon’s drought declaration process is shown on figure 10-1. A description of the DRC and WSAC and their activities are provided in the following sections, along with the State’s drought strategy. The USACE does not make a declaration of drought conditions associated with its reservoirs in the Willamette Basin.




Source: Drought Annex, State of Oregon Emergency Operations Plan, January 2016.

Figure 10-1. Standard Drought Declaration Process

a. Drought Readiness Council. The DRC relies on information from the WSAC to assess how conditions may affect various sectors across the state, including instream and out-of-stream uses. The DRC reviews local requests for assistance and makes recommendations to the Governor regarding the need for state drought declarations. The DRC is responsible for ensuring coordination among state agencies and help water users access drought related information and assistance programs. The DRC consists of nine state agencies with natural resources management, public health, or emergency services expertise. Co-chairs of the Drought Readiness Council is the Administrator, Technical Services Division of the OWRD, and the Section Manager of the Office of Emergency Management.

b. Water Supply Availability Committee. The WSAC consists of ten state and federal science and emergency preparedness agencies that meet throughout the year to evaluate the potential for drought conditions. If drought is likely, monthly meetings occur shortly after release of the NRCS Water Supply Outlook reports to assess conditions. The WSAC communicates through the OWRD, the status of drought conditions to local, state, and tribal agencies. The WSAC is responsible for providing updates and reports on conditions to the Drought Readiness Council. As of 2016, the chair of the Water Supply Availability Committee is the Surface Water Hydrology Manager of the OWRD. The Chief of CENWP-EC-HR or designee represents the USACE on this committee.

10-03. Drought Strategies. Because of the 2015 drought, the Governor signed Executive Order 15-09, to direct state agencies to plan for resiliency to drought to meet the challenge that a changing climate brings. The document, *Report to the Governor Kate Brown, Implementation of Executive Order No. 15-09 Directing State Agencies to Plan for Resiliency to Drought*, dated 1 November 2015 (Report to the Governor) is in response to the Executive Order, and contains an overview of activities that Oregon's agencies, boards, and commissions are to do to prepare for and respond to drought now and in the future. The weblink for the Executive Order is provided in the Weblinks section of this document.

The Executive Order also directed the Office of Emergency Management and the Oregon Water Resources Department (OWRD) to update the *Drought Annex* to the State's *Emergency Operations Plan*. The *Drought Annex*, dated January 2016, was prepared by the Oregon Office of Emergency Management, OWRD. The purpose of the annex is to coordinate state and federal agency response to drought emergencies and to provide emergency water supplies for human consumption under conditions of inadequate supply. The annex outlines steps and lists responsibilities of various federal, state, and local jurisdictions. It also includes a description of federal drought assistance programs and guidelines for water curtailment planning and program development. The *Emergency Operations Plan* and the *Drought Annex* are provided in the Weblinks section of the document.

Two other state of Oregon strategies support the Drought Annex. The first, is the 2015 *Natural Hazards Mitigation Plan*, dated September 2015, which contains an up-to-date description of Oregon's natural hazards and their probability, the state's vulnerabilities, and its mitigation strategies and implementation capability. Cities and counties can use this information when preparing local natural hazard mitigation plans. The second, is the *Oregon's 2012 Integrated Water Resources Strategy*, dated August 2012. The purpose of the document is to describe the water needs of Oregon and to provide a strategy to meet those needs. The intent of the strategy is to provide a blueprint for future actions.

# 11.0 Coordination

11-01. USACE. The Chief, CENWP-EC-HR updates the Corporate Board (District Commander, Deputy District Engineer, and other CENWP Chiefs) of the drought situation, typically on a monthly basis. The reservoir regulation team, along with CENWD water management will meet at least weekly to discuss the drought situation, decisions to be made and the possible impacts of those decisions. Reports of the drought situation are prepared by the CENWP-EC-HR, and may be provided to USACE Headquarters (CECW-EC), through the CENWD. CENWP-EC-HR also reports to the Portland District Readiness Section (CENWP-OD-SE), who coordinates with the CENWD Regional Contingency Office (CENWD-RCO), for upward reporting to Head Quarters Emergency Management. The CENWP-EC-HR also coordinates with Portland District Public Affairs (CENWP-PA) to develop talking points for news releases and public inquiries (see section 12.0).

11-02. Regional. The USACE coordinates with the region on reservoir operations to meet the ESA and all other purposes of the Willamette Valley Project through the WATER forum. WATER works as a collaborative regional forum among the sovereign governments (federal/state/tribal) with responsibility for assisting the federal Action Agencies (USACE, BPA, and Reclamation) in the coordinated implementation of the ESA and related measures. WATER is also responsible for making recommendations to the Action Agencies in implementing the Willamette Biological Opinions' RPA.

11-03. State of Oregon. The WSAC meets nearly monthly and discuss the status of water supply conditions across the state. The members of the WSAC are: NOAA, NRCS, Oregon Climate Change Research Institute, Oregon Department of Agriculture, Oregon Department of Forestry, Oregon Office of Emergency Management, Oregon Water Resources Department, USACE (CENWP-EC-HR), Reclamation, and the U.S. Geological Survey. The CENWP-EC-HR provides the status of the reservoirs and an assurance that project outflow will not be zero cfs, that in fact the rivers below USACE dams will still contain water. The Chief, CENWP-EC-HR coordinates with the State Engineer for the OWRD.

11-04. County Emergency Managers. The WSAC provides data to the counties and other sources. The counties may adopt a local resolution declaring a drought. If needed, counties make a request to the Drought Readiness Council for assistance. The Drought Readiness Council evaluates the local requests for assistance, and makes recommendations to the Governor, who in turn may make a request to the USACE for assistance.

# 12.0 Internal and External Communication

12-01. Congressional Briefs and Public Officials. The Deputy District Engineer for Program and Project Management (DDEPPM) meets with congressional representatives when requested. The Chiefs of CENWP-EC-H and CENWP-HR support the DDEPPM by providing technical information on specific questions they may have. Senior Management will maintain open communication with local officials and staff as needed, including the city and county commissioners and selected officials from the governor's office.

12-02. Public Communication. The CENWP-EC-HR coordinates with the CENWP-PA to provide the news media and the general public with water resources information related to the Willamette Valley Project, using a positive approach to deal with drought distress situations. The Willamette Valley Project staff and CENWP-EC-HR staff should attend watershed council meetings, chambers of commerce, and City Council meetings and civic organizations to help reinforce understanding of competing demands of authorized purposes on reservoirs. The CENWP-PA may attend public meetings and provide support to the Willamette Valley Project staff and CENWP-EC-HR by disseminating information through social media and by printing flyers and other materials. As required, news releases containing updated water resources facts concerning the drought, as they relate to USACE reservoir conditions, will be prepared and distributed by the CENWP-PA.

12-03. Internet. Reservoir levels, recreation updates, current issues, and other information will be posted on the District internet site. The internet is one of the District's most comprehensive public resources for information on USACE activities. The weblink for this information is provided in the Weblinks section of this document. In a drought year, the CENWP will create a public web page to share drought related information. Drought information include forecasts and impacts, current reservoir data, information on emergency water assistance, and links to State of Oregon and other federal agency websites. Current conditions related to drought is provided in the weblink in the Weblinks section of this document.

# 13.0 Emergency Assistance for Drought

The USACE authority for Drought Assistance is contained in section 6-5, Policy – Emergency Water Assistance Due to Drought, of Engineering Regulation 500-1-1, *Emergency Employment of Army and Other Resources*, *Civil Emergency Management Program*, dated 30 September, 2001. The Portland District, Business Operations Branch, Readiness Section (CENWP-OD-SE), is the point of contact for drought assistance.

The USACE is authorized to transport emergency supplies of clean drinking water for human consumption to any locality designated as a drought distressed area, and to construct wells in such drought distressed areas. Assistance will only be to meet minimum public health and welfare requirements. Assistance may be in the form of emergency supply of clean drinking water for human consumption, and construction of wells (at state/local expense) if not commercially possible. Water normally provided by tank trucks or small diameter pipelines. Beneficiaries are any locality faced with a threat to public health and welfare from a drought situation affecting the water system.

Application for program assistance to the CENWP must be initiated by the Governor or his/her authorized representative, but assistance is subject to approval at a higher level. The impacted area must be designated as a "drought distressed" area by Assistant Secretary of the Army for Civil Works. For other details on obtaining assistance during a drought, contact CENWP-OD-SE.

<u>REFERENCES</u>

NOAA's National Marine Fisheries Service, *Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation, Consultation on the "Willamette River Basin Flood Control Project,"* 11 July 2008.

Oregon Office of Emergency Management, Oregon Water Resources Department, *Drought Annex, State of Oregon Emergency Operations Plan*, January 2016,

Oregon Partnership for Disaster Resilience for the State of Oregon, Oregon Emergency Management, *Natural Hazards Mitigation Plan, Drought Chapter*, February 2012,

Oregon Water Resources Department, *Water Rights in Oregon, An Introduction to Oregon's Water Laws*, November 2013.

Oregon Climate Change Research Institute, *Historical Trends and Future Projections of Climate and Streamflow in the Willamette Valley and Rogue River Basins*, June 2015 and revised March 3, 2016.

Pinson, A., A. Jordan, B. Baker, K. D. White, R. Vermeeren, and K. Fagot (2015), *USACE Drought Contingency Planning in the Context of Climate Change*, Civil Works Technical Report, CWTS 15-15, US Army Corps of Engineers: Washington, DC, September 2015.

U.S. Army Corps of Engineers, *2011 USACE Climate Change Adaptation Plans and Report*, dated September 2011.

U.S. Army Corps of Engineers, *2012 USACE Climate Change Adaptation Plans and Report*, dated June 2012.

U.S. Fish and Wildlife Service and Oregon Fish and Wildlife Office, *Final Biological Opinion on the Willamette River Basin Flood Control Project, Biological Opinion on the Continued Operation and Maintenance of the Willamette Basin River Project and Effects to Oregon Chub, Bull Trout and Bull Trout Critical Habitat Designated Under the Endangered Species Act*, 11 July 2008.

WEBLINKS (as of May 2017)

NOAA's Climate Prediction Center ENSO status:
http://www.cpc.ncep.noaa.gov/products/expert_assessment/ENSO_DD_archive.shtml

Drought Monitor Update Report for Oregon:
http://droughtmonitor.unl.edu/Home/StateDroughtMonitor.aspx?OR

NRCS Oregon Snow Survey Reports: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/or/snow/

Oregon Water Supply Outlook Reports:
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/or/snow/waterproducts/?cid=nrcs142p2_048083

Oregon Surface Water Supply Index (SWSI):
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/or/snow/waterproducts/?cid=stelprdb1244919

CWTS Report 15-15: http://www.corpsclimate.us/ccaupddr.cfm.

The State of Oregon's Governor Executive Order:
http://www.oregon.gov/owrd/pages/wr/drought.aspx#Implementing_the_Drought_Executive_Order.

State of Oregon's Emergency Operations Plan and the Drought Annex:
http://www.oregon.gov/OMD/OEM/Pages/plans_train/EOP.aspx.

Portland District internet site: http://www.nwp.usace.army.mil/

Portland District current conditions related to drought:
http://www.nwp.usace.army.mil/Missions/Water/Drought.

Reservoir storage capacity tables:
http://wmlocal.nwd.usace.army.mil/nwp/ratings/www/index.html

# Attachment 1

# USACE-City Agreement Template
# Temporary Withdrawal of Water

AGREEMENT
BETWEEN
THE DEPARTMENT OF THE ARMY
AND
[CITY]
FOR
TEMPORARY WITHDRAWAL OF WATER
FROM
[RESERVOIR], [STATE]
PURSUANT TO
SECTION 6 OF THE FLOOD CONTROL ACT OF 1944

THIS AGREEMENT, entered into this ____ day of MONTH, YEAR, by and between the DEPARTMENT OF THE ARMY (hereinafter called the "Government") represented by the District Engineer executing this Agreement, and CITY, (hereinafter called the "User"*);

WITNESSETH THAT:

WHEREAS, pursuant to the Flood Control Acts of 1938 (Public Law 75-761) and 1950 (Public Law 81-516), the Government has constructed and is operating [Project] on the [waterway], (hereinafter called the "Project"); and

WHEREAS, Section 6 of the Flood Control Act of 1944 (Public Law 78-534), as amended (33 U.S.C. 708), provides that the Secretary of the Army is authorized to enter into agreements with states, municipalities, private concerns, or individuals, at such prices and on such terms as the Secretary may deem reasonable, for domestic and industrial uses for surplus water that may be available at any reservoir under the Secretary's control provided that no agreements for such water shall adversely affect the existing lawful uses of such water; and

WHEREAS, pursuant to Section 6 of the Flood Control Act of 1944, as amended, the Government has determined that up to [volume] acre-feet of storage, as described in the [supporting document] (hereinafter called the "Report"), approved [date], is available at the Project as surplus water for municipal and industrial use, as the withdrawal of such amount will not interfere with Project purposes, nor adversely affect the existing lawful uses of water from the Project; and

WHEREAS, the User desires to enter into an agreement with the Government for the withdrawal of up to [volume] acre-feet of surplus water downstream from the Project for municipal purposes; and

WHEREAS, the User, as shown in Exhibit "A", attached to and made a part of this Agreement, is empowered to enter into an agreement with the Government and is vested with all necessary powers of accomplishment of the purposes of this Agreement.

NOW, THEREFORE, the parties do mutually agree as follows:

ARTICLE 1 - Withdrawal of Surplus Water

a. The Government grants the User the right to withdraw water from the Project, or request releases to be made by the Government through the outlet works of the Project, for municipal use, subject to the User's compliance with its responsibility for water rights as set out in Article 3 of this Agreement.

The rate of such withdrawal shall not exceed [rate], and the volume shall not to exceed [volume] acre-feet per year, during the term of this Agreement as specified in Article 5 hereof.

b. The User's rights under this Agreement are subject to the Government's control and use of any or all storage in the Project to fulfill the authorized purposes of the Project. In the event that the Government determines that withdrawals of any or all of the surplus water identified in the Report are resulting in unexpected adverse impacts to other Project purposes or operations, the User shall immediately suspend withdrawals.

c. The Government further reserves the right to take such measures as it determines in its sole discretion to be necessary to inspect, operate, maintain, and repair the Project, including taking any and all measures necessary to protect life and property.

d. The water which may be available for withdrawal by the User pursuant to this Agreement is raw water only. The Government makes no representation with respect to the quality of water which may be available and assumes no responsibility therefore, or for treatment of the water.

e. The Government makes no guarantee with respect to the availability of water. The water level of the Project will be maintained at elevations which the Government deems will best serve the authorized purposes of the Project, and this Agreement shall not be construed as giving the User any rights to have the water level maintained at any elevation.

ARTICLE 2 – Metering and Recordkeeping

For the purpose of maintaining an accurate record of the water withdrawn from the Project, the User agrees to furnish and install, or cause to be installed, meters or measuring devices satisfactory to the District Engineer, without cost to the Government. Such devices shall be available for inspection by Government representatives at all reasonable times. The User agrees to furnish to the District Engineer: (i) advance estimates of need; and (ii) records of the quantity of water actually withdrawn as requested by the District Engineer, but in any event no less frequently than once a year.

ARTICLE 3 - Regulation of and Right to the Use of Water

The regulation of the use of water withdrawn or released from the storage space under this Agreement shall be the sole responsibility of the User. The User has the full responsibility to acquire in accordance with applicable law, and if necessary to establish or defend, any and all water rights needed for the water withdrawn or released from the Project under this Agreement. The Government shall not be responsible for the use of water by the User, nor will it become a party to any controversies involving the water use, except as such controversies may affect the operations of the Project.

ARTICLE 4 - Consideration and Payment

a. In consideration of the right to withdraw [volume] acre-feet between [timeframe] per year for a period not to exceed five (5) years from the Project for municipal and industrial water supply purposes, the User shall pay the Government $[capital cost] per year in capital costs, the first of which shall be due and payable within thirty (30) days of the effective date of the Agreement as set forth in Article 5 herein. In addition to the annual capital cost payment, the User shall be responsible for a share of the Operations and Maintenance (O&M) costs of the Project. The first payment will be for $[O&M cost] and is due within thirty (30) days of the effective date of the Agreement. Future capital and O&M payments thereafter will be due and payable on the anniversary date the first payment is due.

b. The repayment amount shown in Article 4(a) is based upon joint use and specific water supply construction costs updated to [month year] price levels using appropriate indices and the Fiscal Year [FY] water supply interest rate of [interest rate] percent as computed by the Secretary of the Treasury in accordance with Section 932 of the Water Resources Development Act of 1986 (Public Law 99-662).

c. If the User shall fail to make any payment under this Agreement within thirty (30) days of the date due, the delinquent payment shall be charged interest at the Current Value of Funds Rate, as determined by the Secretary of the Treasury that is applicable on the date that the payment became delinquent, with such penalty interest as may be required by Federal law or regulation. This provision shall not be construed as waiving any other rights the Government may have in the event of default by the User, including but not limited to the right to terminate this Agreement for default.

ARTICLE 5 - Duration of Agreement

This agreement shall become effective upon the date it is signed by the Government, and shall continue in full force and effect under the conditions set forth herein for a period of not to exceed five (5) years from the said date of approval. Upon expiration, this agreement may be extended by mutual agreement for additional periods of not to exceed five (5) years each. All such agreement extensions shall be subject to recalculation of reimbursement. Nothing in this agreement, nor in any extension thereto, shall imply a permanent right to utilize the storage space.

ARTICLE 6 - Termination of Agreement

a. The User may terminate the Agreement upon fourteen (14) days written notice.

b. The Government may terminate this Agreement upon thirty (30) days written notice in the event the Government determines that withdrawals of any or all of the surplus water identified in the Report are resulting in unexpected adverse impacts to other Project purposes or operations.

c. The Government may terminate this Agreement and the User's right to withdraw water upon thirty (30) days written notice if the User shall default in performance of any obligation of this Agreement. Upon such a termination, the User shall continue to be liable to the Government for any monies owed and for any costs incurred by the Government as a result of the default.

d. In the event of any termination pursuant to this Article or Article 5, User shall, upon request of the Government, promptly remove, at User's expense, any facilities constructed on Project land for water withdrawal and restore premises around the removed facilities to a condition satisfactory to the Government.

e. Not later than ten (10) calendar days from the date of the written notice to terminate, the Government shall commence a final accounting of the financial obligations of the User under Article 4.a. of this Agreement. The results of the final accounting will be furnished by written notice to the User.

(i) Should the final accounting show that the User owes the Government further payment under this Agreement, the User, not later than ninety (90) calendar days after receipt of the written notice from the Government, shall provide the Government with the full amount by delivering a check payable to "FAO. USAED, Portland" to the District Engineer, or by providing an Electronic Funds Transfer of the required funds in accordance with procedures established by the Government.

(ii) Should the final accounting show that the amount of funds provided by the User exceeds its financial obligations under this Agreement, the Government, subject to the availability of funds, shall refund the excess amount to the User within ninety (90) calendar days of the date of completion of the final accounting, or if funds are not available, shall seek such appropriations as are necessary to make the refund.

ARTICLE 7 - Rights-of-Way

Occupancy and use of Project lands shall be in accordance with any permits, rights-of-way, or easements granted to the User by the Government.

ARTICLE 8 - Release of Claims

The User shall hold and save the Government, including its officers, agents, and employees, harmless from liability of any nature or kind for or on account of any claim for damages which may be filed or asserted as a result of the withdrawal or release of water from the Project made pursuant to the terms of the Agreement, or as a result of the construction, operation or maintenance of any facilities or appurtenances owned and operated by the User except for damages due to the fault or negligence of the Government or its contractors.

ARTICLE 9 - Transfer or Assignment

The User shall not transfer or assign this Agreement nor any rights acquired thereunder, nor grant any interest, privilege or license whatsoever in connection with this Agreement, without the approval of the Secretary of the Army or his duly authorized representative, provided that this restriction shall not be construed to apply to any water withdrawn or obtained from the Project and furnished by the User to any third party or parties, or to the rates charged therefor.

ARTICLE 10 - Officials Not to Benefit

No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this Agreement if made with a corporation for its general benefit.

ARTICLE 11 - Covenant Against Contingent Fees

The User warrants that no person or selling agency has been employed or retained to solicit or secure this Agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees or bona fide established commercial or selling agencies by the User for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this Agreement without liability, or in its discretion, to add to the Agreement price or consideration the full amount of such commission, percentage, brokerage, or contingent fee.

ARTICLE 12 - Environmental Quality

During any construction, operation, and maintenance by the User of any facilities, specific actions will be taken to control environmental pollution which could result from such activity and to comply with applicable Federal, State and local laws and regulations concerning environmental pollution. Particular attention should be given to (1) reduction of air pollution by control of burning, minimization of dust, containment of chemical vapors, and control of engine exhaust gases, and of smoke from temporary heaters; (2) reduction of water pollution by control of sanitary facilities, storage of fuels and other contaminants, and control of turbidity and siltation from erosion; (3) minimization of noise levels; (4) onsite and offsite disposal of water and spoil; and (5) prevention of landscape defacement and damage.

ARTICLE 13 - Civil Rights Assurance and Certification Regarding Lobbying

a. The User furnishes, as part of the Agreement, an assurance (Exhibit C) that it will comply with Title VI of the Civil Rights Act of l964 (78 Stat. 252; 42 U.S.C. 2000d, et seq.) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 195 of Title 32, Code of Federal Regulations.

b. The user furnishes, as part of this Agreement, a certification (Exhibit D) that no appropriated funds have been paid or will be paid to an officer or employee of a Federal agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the execution of this Agreement; and that any funds other than appropriated funds that have been paid or will be paid to such persons will be disclosed on the appropriate form.

ARTICLE 14 - Approval of Agreement

This Agreement shall be subject to the written approval of the Secretary of the Army or his duly authorized representative and shall not be binding until so approved.

IN WITNESS WHEREOF, the parties have executed this Agreement as of the day and year first above written.

| FOR THE DEPARTMENT OF THE ARMY | FOR THE [CITY] |
|---|---|
| By ______________________________ | By __________________________ |
| [Commander]<br>Colonel, U.S. Army<br>District Engineer<br>U.S. Army Engineer District<br>Portland, Oregon | [name of signatory]<br>[position or title] |
| DATE:____________________________ | DATE:_______________________ |

EXHIBIT A: CERTIFICATION

I ___________________________, Attorney for the [ENTITY], have reviewed the foregoing agreement executed by __________________________________ and, as principal legal officer for the [ENTITY], certify that the [ENTITY] is legally and financially capable of entering into the contractual obligations contained in the foregoing agreement and that, upon acceptance by the Department of the Army, it will be legally enforceable.

Given under my hand, this _______ day of ________________ [YEAR].

_______________________________________

Attorney for [ENTITY]

EXHIBIT B

The cost charged to the user for [volume] acre-feet of storage for five years is $[total cost], plus an annual O&M fee. For a surplus water supply agreement, the user will pay the annual fees as listed in the table below.

TOTAL ANNUAL COST TO USER
FOR SURPLUS WATER SUPPLY STORAGE

| Item | Type of Use | Computation | Cost |
|---|---|---|---|
| Interest and amortization | Annual cost of storage space | $[cost per acre-foot] x [acre-feet], (based on 30 year repayment plan) and 5 payments at interest rate of [interest rate]%. | $[total cost] |
| Operation and maintenance [1] | Joint-use actual for FY [previous FY] | [ ]% [2] x $[total joint-use O&M for previous FY] | $[share of O&M] |
| Repair, rehabilitation and replacement [3] | Joint-use actual for FY [previous FY] | [ ]% [2] x $[total joint-use O&M for previous FY] | $[share of RR&R] |

Notes:
1 Payment due and payable on the date specified in Article 4(a).
2 Percent of Users share of the Usable storage space in the project.
3 Repair, rehabilitation and replacement costs are payable only when incurred as specified in Article 5(b).

## EXHIBIT C:  ASSURANCE OF COMPLIANCE

ASSURANCE OF COMPLIANCE WITH THE DEPARTMENT OF DEFENSE DIRECTIVE UNDER TITLE VI OF THE CIVIL RIGHTS ACT OF 1964, AS AMENDED; THE AGE DISCRIMINATION ACT OF 1975; AND THE REHABILITATION ACT OF 1973, AS AMENDED

The party executing this assurance, being the applicant recipient of Federal financial assistance under the instrument to which this assurance is attached hereby agrees that, as a part of its obligations under the aforesaid instrument, it will comply with Title VI of the Civil Rights Act of 1964 (P.L. 88-352), as amended (42 U.S.C. 2000d), and all requirements imposed by or pursuant to the Directive of the Department of Defense (32 CFR Part 195), issued as Department of Defense Directive 5500.11 pursuant to that title; The Age Discrimination Act of 1975 (42 U.S.C. 6102); the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), to the end that in accordance with the aforementioned Title, Directive and Acts, no person in the United States shall on the ground of race, color, age, sex, religion, handicap or national origin be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which the Applicant-Recipient receives Federal financial assistance from the Department of the Army and gives assurances that it will immediately take any measures necessary to effectuate this agreement.

If any personal property or real property, or interest therein, or structure thereon is provided or improved with the aid of Federal financial assistance extended to the applicant-recipient by the Department of the Army, or if such assistance is in the form of personal property or real property, or interest therein or structure thereon, then this assurance shall obligate the applicant-recipient or in the case of any transfer of such property, any transferee, for the period during which the property is used for a purpose for which the Federal financial assistance is extended or for another purpose involving the provision of similar services or benefits, or for the period during which it retains ownership or possession of the property whichever is longer. In all other cases, this assurance shall obligate the applicant-recipient for the period during which the Federal financial assistance is extended to it by the Department of the Army. The Department of the Army representatives will be allowed to visit the recipient's facilities. They will inspect the facilities to ensure that there are no barriers to impede the handicap's accessibility in either programs or activities.

This assurance is given in consideration of and for the purpose of obtaining any and all Federal grants, loans, contracts, property, discounts or other Federal financial assistance extended after the date hereof to the applicant-recipient by the Department of the Army, including installment payments after such date on account of arrangements for Federal financial assistance which were approved before such date. The applicant-recipient recognizes and agrees that such Federal financial assistance will be extended in reliance on the representations and agreements made in this assurance, and that the United States shall have the right to seek judicial enforcement of this assurance. This assurance is binding on the applicant-recipient, its successors, transferees, and assignees, and the person or persons whose signatures appear below are authorized to sign this assurance on behalf of the applicant.

Date ____________________ By __________________________________

[position/title]
[entity]

Mailing Address:
[ ]

# EXHIBIT D: CERTIFICATION REGARDING LOBBYING

The undersigned certifies, to the best of his or her knowledge and belief that:

(1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

___________________________

[position/title]
[entity]

DATE: ___________________

CENWP-EC-HY 7 July 2015

MEMORANDUM FOR RECORD

SUBJECT: Implementation of Environmental Flows in the Willamette Valley

1. Purpose. This memorandum summarizes guidance for implementing environmental flows (e-flows) in the Willamette River Basin reaches; specifically the Middle Fork, McKenzie and the North and South Fork Santiam Rivers.

The U.S. Army Corps of Engineers Portland District (Corps) with the Nature Conservancy (TNC) developed an implementation plan for environmental flows at multiple projects within the basin. The SRP's goal is to 'operationalize' the environmental flow recommendations into acceptable guidance and recommendations for Willamette reservoir regulators and project operators for implementation. In order to achieve the project goal, this project's objectives were twofold:

1) Identify biological criteria and priorities (e.g., e-flow targets and benefits).
2) Given biological understanding and priority of different biological goals, outline the relevant items important to regulators tasked with implementing e flows.

The proposed environmental flow implementation described in this MFR has been found to conform to operational constraints as outlined in the Water Control Manuals. This has been verified through previous studies and analyses described in greater detail below.

Environmental flow implementation falls under the range of flood reduction operations outlined in the Water Control Manuals. Flood reduction operations occur primarily in the wintertime period (December through February). E-flow releases are not to be performed if they contradict NWP flood operation constraints. Flood operation considerations applicable to the e-flow implementation are summarized in Tables 1 through 4 below.

Upon acceptance of this Memorandum for the Record (MFR), the Water Control Manuals will be updated to incorporate operations for environmental flows.

2. Background. The Sustainable Rivers Program (SRP) began in 2002 as a partnership between TNC and the Corps with the objective of developing, implementing and refining a framework for beneficial flows downstream of dams. TNC and the Corps have signed memorandums of agreements (MOAs) at the national level as well as the district level to study current hydro regulation operations. SRP efforts in the Willamette River Basin focus on identifying opportunities to improve overall downstream ecosystem health and resiliency by modifying dam releases within the existing operational constraints. The releases that benefit downstream ecosystem health are termed environmental flows (e-flows). The e-flows targets were developed through a process of collecting and synthesizing relevant hydrologic and ecological information and expert knowledge into a set of e-flow recommendations.

a. Purpose of E-flows. Flow recommendations focused on fall flows (October-November), winter high flows (November-February) and smaller spring bankfull flows (flows at Action Stage, as identified by the National Weather Service) (March-June). Each seasonal flow is important to some aspect of ecosystem health. Fall flows enhance channel habitat and provide flows for outmigration. Winter high flows provide benefits to habitat by modifying channel features and recruiting large woody debris. Spring time flows are important for providing out-migration flows as well as scouring and flushing during bank full events.

b. Environmental Flow Recommendations. Environmental flow recommendations have been developed for the Middle Fork Willamette River, McKenzie River and the North, South and mainstem Santiam Rivers. The flow recommendations were defined by 1) event duration; 2) number of events per year; 3) range of flow magnitude; and 4) frequency. Summary reports were completed for each river system (also see References):

- Santiam Basin: *Summary Report: Environmental Flows Workshop for the Santiam River Basin, 2013.*
- Middle Fork and Coast Fork: *Summary Report Environmental Flows Workshop for the Middle Fork and Coast Fork of the Willamette River, 2007.*
- McKenzie River: *Environmental Flow Recommendations Workshop for the McKenzie River, Oregon, 2010.*

c. Constraints. The e-flow operations are constrained by Water Control Manual operational requirements for each project and the system as well as the Willamette Biological Opinions (BiOp) (National Marine Fisheries Service and U.S. Fish and Wildlife Service) implementation.

d. Forecast Uncertainty Analysis. The forecast uncertainty analysis performed by the Corps in 2011suggests that maximizing the number of e-flow discharges is feasible; however, evaluations of forecast error indicate that the release of e-flows should not be taken lightly. If anything, the modeling exercise emphasized the intricacy of the hydrologic and operational complexities of the Willamette system.

e. HEC-ResSim Analysis. HEC-ResSim was used to model potential operational changes to provide e-flows. The resulting report prepared in 2013, *Evaluation of E-Flow Implementation and Effects in the Willamette Basin using ResSim Modeling,* addressed concerns about potential increased flood risk and other adverse impacts from e-flow operations and provided recommendations on potential operational approaches. Two approaches were evaluated to determine how Willamette Valley Project operations could be modified to realize e-flow benefits within the constraints of the WCM: 1) Release More and 2) Store More. Both approaches modified the maximum evacuation release rule, as a function of elevation, from the baseline condition at the three projects, Lookout Point/Dexter on the Middle Fork Willamette, Cougar on the South Fork McKenzie River, and Detroit/Big Cliff on the North Santiam River.

The Release More scenario was recommended as a starting point for a strategy to implement e-flow releases in the Willamette River basin. The Release More scenario provided an overall increase in e-flow events (benefits) while affecting minimal change to flood risk reduction, water quality, hydropower and meeting BiOp targets. An unforeseen benefit from implementing the

Release More option was that flood storage availability increased under this alternative. The Store More option did not produce significant changes to total e-flows compared to the baseline. Further, the Store More option potentially increases flood risk by holding water longer and reducing the flood storage space during the wetter times of the year.

3. Implementation. The general intent is to maximize opportunities for achieving e-flows at the Willamette Valley projects considering operational constraints and forecast uncertainty. The following discussion of implementation provides guidance for reservoir regulators and project operators; however, implementation of e-flows is based on regulator/operator judgment and is not a highly prescriptive process.

E-flow operations require use of stored water to achieve environmental goals. The e-flow operation absorbs the incoming event then releases post event to minimize downstream flood risk. Once downstream gages have peaked and are receding below action stage (bankfull) levels, e-flow operations can commence. All intentional e-flow operations must operate below flood stage and within action stage (bankfull) constraints. That is, it is ok to release to bankfull, with some allowance for exceedance, but not to release to flood stage for e-flow purposes.

Just as for any high flow release scenario, error in forecasts should be considered when implementing e-flow operations. Release of large volumes of water combined with an error in the forecast can unintentionally result in reaching flood stage downstream. Previous SRP work has more fully quantified forecast uncertainty in the Middle Fork/Coast Fork Willamette and ReSim modeling has shown that e-flow releases are feasible within the uncertainty of forecasts without exceeding project water management constraints.

There may be high flow events where a sufficiently high volume will have to be passed with the result that the project release 'naturally' exceeds action stage (bank full)/flood stage. Although this could result in e-flows benefits, it is not the intent of e-flow operations to realize benefits in this manner (i.e., to purposely exceed action or flood stages). Rather e-flow operation seeks to obtain benefits while operating under the WCM and other operational constraints.

Flow recommendations focus on winter high flows (15-November through 15-February) and spring bankfull flows (15-March though 30 June). It is cautioned that e-flows cannot be guaranteed every year. The e-flow operations are 'opportunity driven' and would first be indicated by a forecast of a substantial weather system headed for the Willamette Valley and the three sub-basins of interest.

Overall, the e-flow benefit expected from the preferred e-flow operation is an increased number of wintertime events. Spring time e-flow events are expected to be minimally increased. Table 1 lists the range of e-flow operation goals downstream.

Maximizing e-flows is important to effectively manage aquatic habitat. The higher flows provide the mechanism for creating and managing fish spawning/incubation and other aquatic habitat needs over time. Salmon populations and other aquatic organisms are adapted to these variable flow conditions. Active management by fisheries and other technical experts should be part of the protocol.

*Table 1. MF WILLAMETTE AT JASPER Maximum Flow and Duration E-Flow Objectives below Projects*

| **Middle Fork Willamette River at Jasper USGS 14152000** | | |
|---|---|---|
| **Winter E-Flow Target 1** | | |
| **(15-Nov through 15-Feb)** | | **Operational Considerations** |
| Flow Above (cfs) | 17,000 | Releases from Fall Creek and Dexter may be combined to achieve these flows at Jasper. |
| Duration (days) | 1 | |
| **Winter E-Flow Target 2:** | | |
| Min Flow (cfs) | 15,000 | |
| Max Flow (cfs) | 17,000 | |
| Duration (days) | 3 | |
| **Winter E-Flow Target 3:** | | |
| Min Flow (cfs) | 12,000 | |
| Max Flow (cfs) | 15,000 | |
| Duration (days) | 4 | |
| **Spring E-Flow Target A** | | |
| ***(15-Mar through 30 June)*** | | **Operational Considerations** |
| Flow Above (cfs) | 15,000 | Releases from Fall Creek and Dexter may be combined to achieve these flows at Jasper. |
| Duration (days) | 1 | |
| **Spring E-Flow Target B** | | |
| Min Flow (cfs) | 12,000 | |
| Max Flow (cfs) | 15,000 | |
| Duration (days) | 3 | |
| **Spring E-Flow Target C** | | |
| Min Flow (cfs) | 10,000 | |
| Max Flow (cfs) | 12,000 | |
| Duration (days) | 4 | |

*Table 2. SF MCKENZIE AT COUGAR DAM Maximum Flow and Duration E-Flow Objectives below Projects*

| South Fork McKenzie River below Cougar Dam<br>USGS 14159500 | | |
|---|---|---|
| **Winter E-Flow Target 1** | | |
| **(15-Nov through 15-Feb)** | | **Operational Considerations** |
| Flow Above (cfs) | 6,000 | Outflow above 5,000 cfs will inundate the adult fish collection facility's facility water system (FWS) intake structure which includes electrical gear and air burst system equipment.<br><br>Outflow above 5,000 cfs may scour redds (October – January). |
| Duration (days) | 1 | |
| **Winter E-Flow Target 2:** | | |
| Min Flow (cfs) | 4,000 | |
| Max Flow (cfs) | 6,000 | |
| Duration (days) | 3 | |
| **Winter E-Flow Target 3:** | | |
| Min Flow (cfs) | 3,000 | |
| Max Flow (cfs) | 4,000 | |
| Duration (days) | 4 | |
| **Spring E-Flow Target A** | | |
| ***(15-Mar through 30 June)*** | | **Operational Considerations** |
| Flow Above (cfs) | 4,000 | |
| Duration (days) | 1 | |
| **Spring E-Flow Target B** | | |
| Min Flow (cfs) | 2,500 | |
| Max Flow (cfs) | 4,000 | |
| Duration (days) | 3 | |
| **Spring E-Flow Target C** | | |
| Min Flow (cfs) | 1,500 | |
| Max Flow (cfs) | 2,500 | |
| Duration (days) | 4 | |

*Table 3. NO SANTIAM AT MEHAMA Maximum Flow and Duration E-Flow Objectives below Projects*

| North Santiam River at Mehama<br>USGS 14183000 | | |
|---|---|---|
| **Winter E-Flow Target 1** | | |
| **(15-Nov through 15-Feb)** | | **Operational Considerations** |
| Flow Above (cfs) | 15,000 | Fishermen's Bend resident owners should be notified by the shift operator via phone when Big Cliff (BCL) outflow will exceed 10,000 cfs.<br><br>E-flow operations necessitating releases at BCL greater than 10,000 cfs should not be undertaken because this MAY cause adverse flooding downstream at Fishermen's Bend. It should be noted that BCL outflow may exceed 10,000 cfs as part of normal flood operations.<br><br>Operational Considerations for Fishermen's Bend may be amended pending future analyses to quantify potential impacts.<br><br>High flows may impact the Minto Facility. Notify ODFW prior to increasing outflow. |
| Duration (days) | 1 | |
| **Winter E-Flow Target 2:** | | |
| Min Flow (cfs) | 12,000 | |
| Max Flow (cfs) | 15,000 | |
| Duration (days) | 3 | |
| **Winter E-Flow Target 3:** | | |
| Min Flow (cfs) | 10,000 | |
| Max Flow (cfs) | 12,000 | |
| Duration (days) | 4 | |
| **Spring E-Flow Target A** | | |
| ***(15-Mar through 30 June)*** | | **Operational Considerations** |
| Flow Above (cfs) | 12,000 | From March 15 – May 15 flows above 3,000 cfs will require a higher incubation release during the summer which would impact keeping the lake full for recreation and operational temperature control.<br><br>E-flow operations necessitating releases at BCL greater than 10,000 cfs should not be undertaken because this MAY cause adverse flooding downstream at Fishermen's Bend. It should be noted that BCL outflow may exceed 10,000 cfs as part of normal flood operations.<br><br>Releases higher than 3,000 cfs are allowed in the BiOp only if the lake elevation is above rule curve |
| Duration (days) | 1 | |
| **Spring E-Flow Target B** | | |
| Min Flow (cfs) | 10,000 | |
| Max Flow (cfs) | 12,000 | |
| Duration (days) | 3 | |
| **Spring E-Flow Target C** | | |
| Min Flow (cfs) | 8,000 | |
| Max Flow (cfs) | 10,000 | |
| Duration (days) | 4 | |

a. Operational Details. Implementation of e-flows is event driven, based on regulator/operator judgment and is not a highly prescriptive process. The preferred e-flow operation is to release stored flood water during the high water months (usually the winter and early spring). Under this operation, stored flood waters are released earlier by allowing the maximum outflows to go higher when the lake elevation is lower than current practice. This e-flow operation does not change project operating rules, in terms of release rate and normal operations during flood control season as identified in the Water Control Manuals.

Ramp rates must also be monitored to not exceed those identified in the Water Control Manuals and the Biological Opinions. If ramp rates are excessive, there may are adverse biological impacts.

The regulator should always exercise discretion. For example, it may be that the start of release be at an elevation above the secondary flood control pool. For example, Lookout Point elevation would be 856 feet and at Detroit reservoir, 1484.5 feet. Releases below these elevations should be capped at powerhouse capacity. Also, when scheduling releases one has to assure that there is enough stored water to ramp flows back down to inflow without drafting into the power pool and without violating ramp rates.

4. Communication. Normal coordination and communication procedures shall be followed as outlined in the *Standard Procedures for Regulation of the Willamette Basin Projects*.

a. Internal Communication. EC-H will pre-coordinate e-flow operations similar to how it coordinates operations related to BiOp implementation. Notification of pending opportunities for e-flow releases will be included in the normal Corps communication channels such as the Corps Weather and River Updates which indicate expected increases in river flows, such as bankfull or flood levels.

Each year, hydrologic conditions and information on fish spawning activity should be reviewed prior to initiating a high e-flow by consulting technical experts (hydrologists, biologists and operating engineers) in order to balance mission needs within and across years. This could be accomplished in a meeting at the start of each hydrologic year.

During e-flow releases, Corps staff may be directed to monitor downstream conditions to minimize any potential adverse impacts such as bank erosion. It is assumed that notifications may be updated frequently due to changing weather and river conditions.

b. External Communication. Additional external parties may desire to be notified of pending e-flow releases. For example the environmental flow representative at the TNC should be contacted when e-flow releases are likely, in order to monitor potentially beneficial downstream impacts. Other interested parties may be added upon request.

5. Monitoring. Monitoring of ecological benefits is part of the adaptive management process to help inform and refine e-flow targets over time. The SRP team is in the process of developing a monitoring plan for the Middle Fork, McKenzie and Santiam Rivers that focuses on geomorphic and vegetative responses to e-flow implementation. This includes development of a geodatabase and evaluation of indicators (e.g., channel bar formation, side channel inundation, vegetation changes, etc.) using aerial photos, ground survey and LiDAR. In order to maximize the monitoring process, it is foreseen that the Corps/stakeholder interaction should be more collaborative and informative. To this end, Corps reservoir regulators will provide early

indication when e-flow operations are pending in sufficient time for others to set up monitoring of specific indicators of interest.

6. Environmental Considerations. In a memorandum dated 2 June 2015, the implementation of the Sustainable Rivers Project Environmental Flows in the Willamette River was reviewed by PM-E.

7. References.

a. Bach, L., Nuckols, J. and Blevins, E. 2013. Summary Report: Environmental Flows Workshop for the Santiam River Basin, Oregon. The Nature Conservancy, Portland, OR.

b. Gregory, Stan, Ashkenas, Linda and Nygaard, Chris, 2007a. Summary Report to Assist Development of Ecosystem Flow Recommendations for the Coast Fork and Middle Fork of the Willamette River, Oregon. Oregon State University, Corvallis, OR.

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